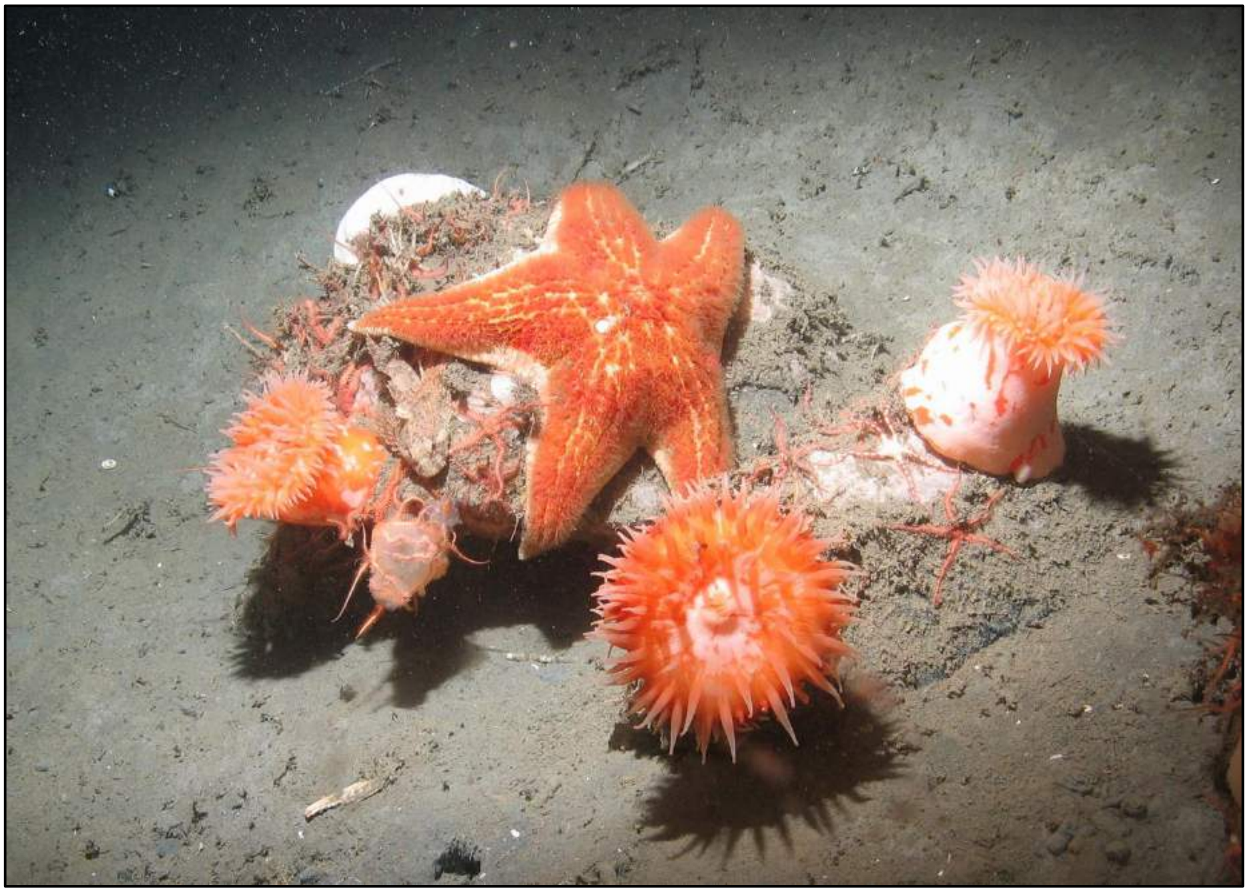
North Coast Baseline Program Final Report: Mid-depth and Deep Subtidal Ecosystems



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Final Report: Mid-depth and Deep Subtidal Ecosystems - 2017

Baseline Characterization and Monitoring of the MPAs along the North Coast: ROV Surveys of the Subtidal (20-500 m)

Final Technical Report to Sea Grant
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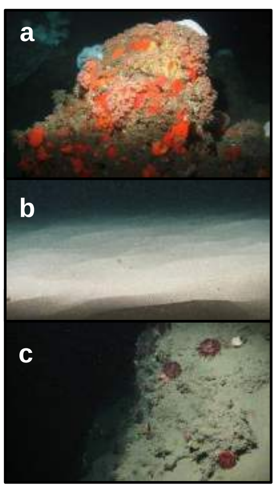
EXECUTIVE SUMMARY

School of Shortbelly Rockfish

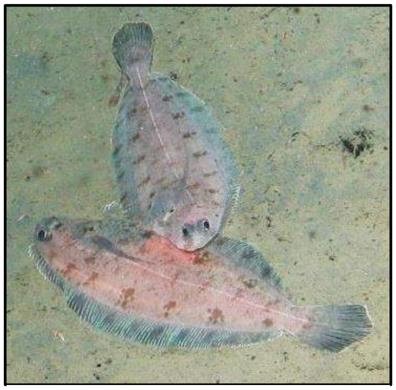
California's network of Marine Protected Areas makes up 16% of the states coastal waters. This network was implemented in four uniquely distinct coastal regions. The final region to be implemented, the North Coast Study Region (NCSR), extends from the California-Oregon border to Alder Creek, Mendocino County. The NCSR has some of the least developed coastal areas in the state due to the remote, rugged coastline and frequently unfavorable ocean conditions, which limit access to much of the coastal and offshore waters. The NCSR lies within one of only four major temperate upwelling systems in the world, making it one of the most highly productive ecosystems that supports diverse and abundant assemblages of fish and invertebrate species.



Marine Applied Research and Exploration (MARE) preformed quantitative baseline surveys within the NCSR in 2014 and 2015 with the overall goal to describe the condition of three distinctive priority ecosystem features within four MPAs and their adjacent reference study areas: a) mid-depth rock ecosystems, b) soft-bottom subtidal ecosystems, and c) deep ecosystems (including canyons). Long-term monitoring trends within these habitats will be compared to baseline conditions, assisting in evaluating MPA effectiveness. The four MPAs chosen for evaluation include: Point St. George Reef Offshore SMCA, Reading Rock State Marine Reserve, Mattole Canyon State Marine Reserve and Ten Mile State Marine Reserve. Outside reference areas with similar habitats and depths were also surveyed for comparison.

Greenspotted Rockfish,
red sea star and *Henricia* star

During the first two years following implementation, benthic visual surveys were conducted using a remotely operated vehicle (ROV) to assess initial changes in fishes, macro-invertebrates and associated seafloor habitats. The ROV collected video and still imagery while moving along a fixed path (transect) along the sea floor. Video imagery collected was analyzed to characterize substrate, habitat types, habitat complexity (rugosity), and estimate finfish and macro-invertebrate distribution, relative abundance and density. In total, 60 ROV dives were completed surveying more than 106 km (19 ha) between 13 and 421 m deep. In addition, over 16,500 still photos were taken.



Rex Sole

Of the 101,666 fish observed over both years, over 85% were rockfish. Young of year rockfish (YOY) were the most numerous rockfish grouping observed; with over 61,000 recorded individuals, accounting for 60% of all of the fish observations. Larger rockfish represented only 14% of the rockfish identified, with four species/groupings accounting for 80% of the observations: Blue, Olive/Yellowtail, unidentified and Canary Rockfishes. Non-rockfish species represented 15% of the fish identifications, with two groupings accounting for 71% of the total observations: unidentified smelt and flatfish. Overall, fish species composition and density was similar between all MPA and reference area pairs within rocky reef and soft bottom habitats. One exception was documented at Point St. George Reef Offshore SMCA within rocky reef habitats, where rockfish densities were significantly lower in the reference area than the MPA (Figure E1). In addition, Point St. George Reef Offshore SMCA had the highest density of Yelloweye Rockfish, over two times more than any other study area (Figure E1).

Juvenile Yelloweye Rockfish

California sea cucumber

Of the 124,064 individual invertebrates enumerated, seven species/groupings represented the majority of the observations (approximately 89%) within the NCSR: white-plumed anemones, slipper and California sea cucumbers, short red gorgonians, California hydrocoral, sea stars, sea whips and sea pens. Overall, invertebrate species composition and density was similar between all MPA and reference pairs within rocky reef habitats (Figure E2). However, within soft-bottom habitats species composition and abundance varied greatly across study locations.

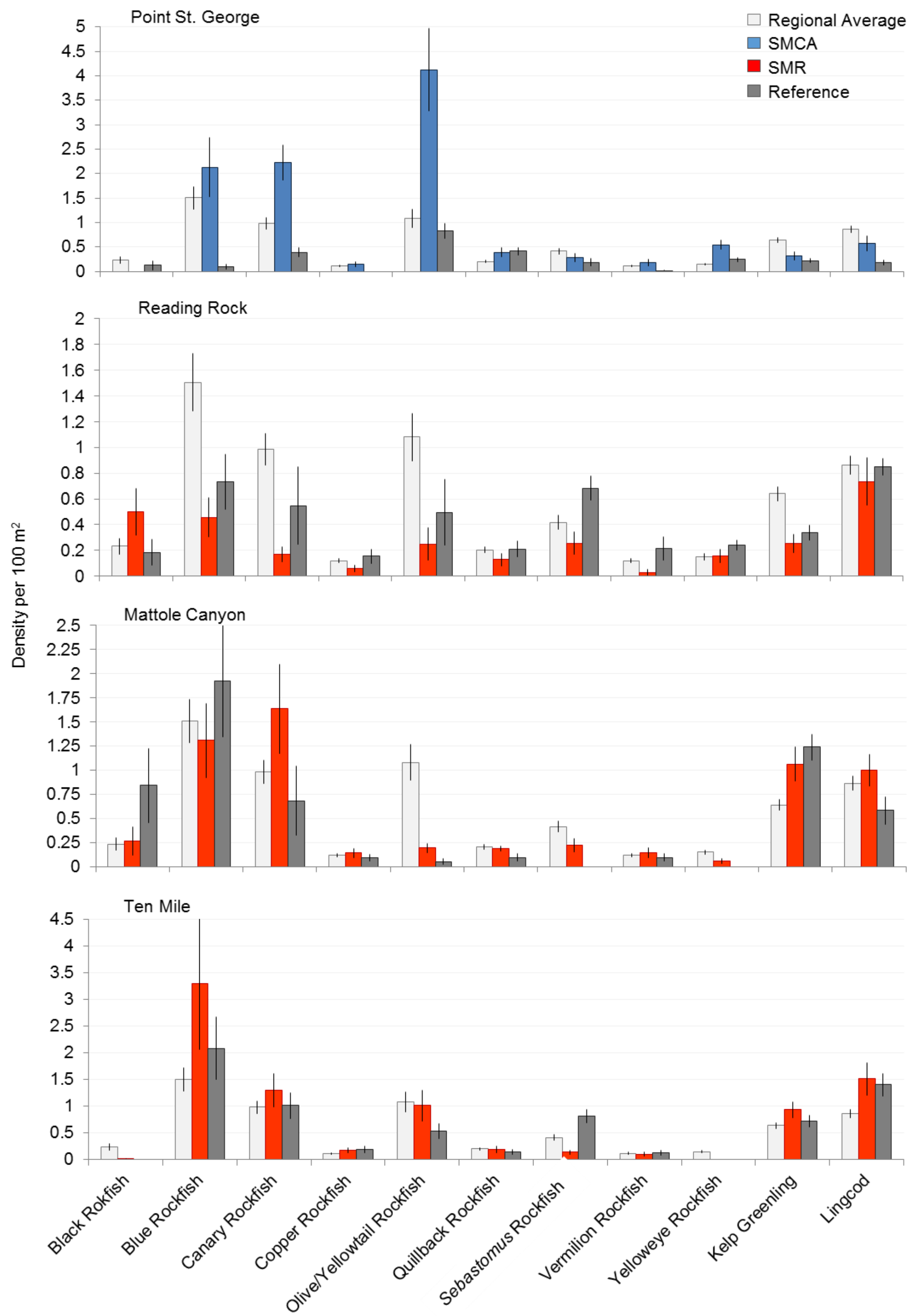


Figure E1. Mean densities per 100 m^2 of selected rocky reef rockfish, Kelp Greenling and Lingcod for regional averages for the NCSR (white) compared to Point St. George Reef Offshore SMCA (blue), Reading Rock SMR (red), Mattole Canyon SMR (red) and Ten Mile SMR (red), and their respective reference areas (gray). Error bars represent ± 1 standard error.

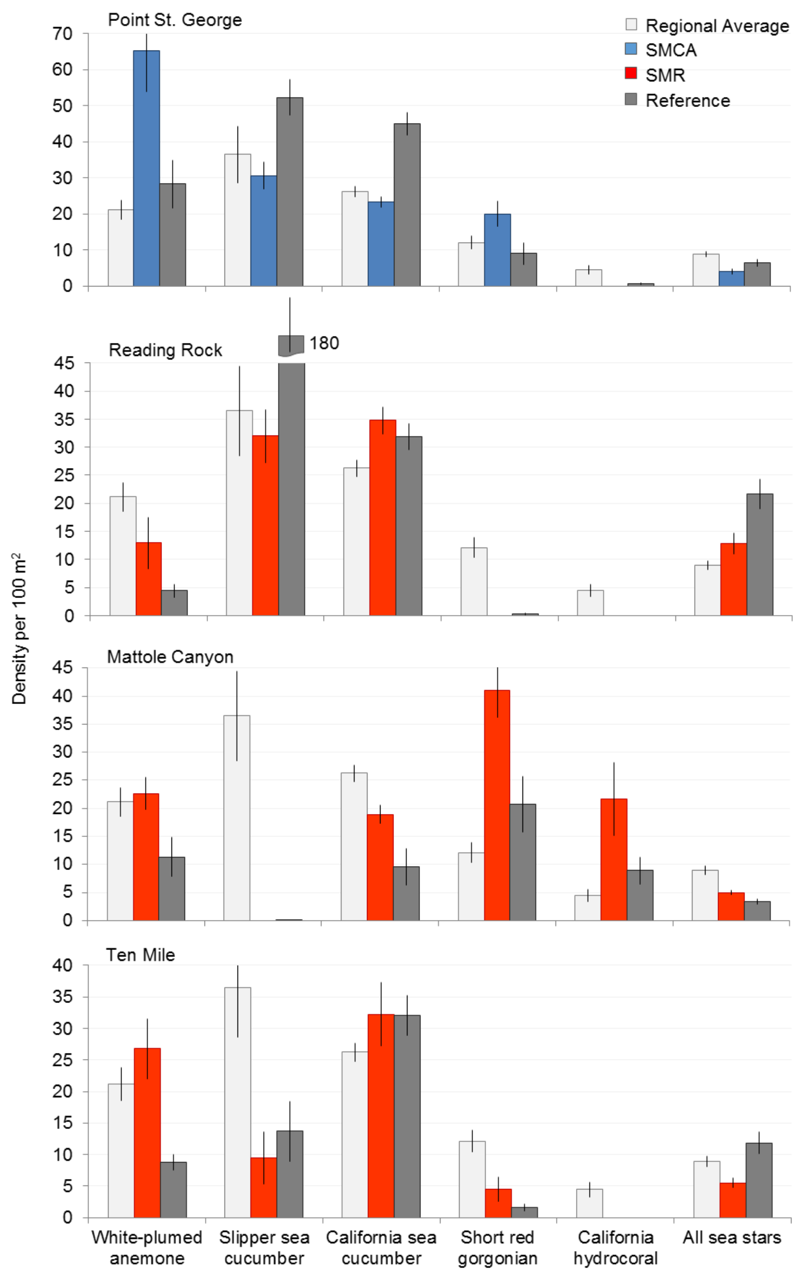


Figure E2. Mean densities per 100 m^2 of selected rocky reef invertebrate species for regional averages for the NCSR (white) compared to Point St. George Reef Offshore SMCA (blue), Reading Rock SMR (red), Mattole Canyon SMR (red) and Ten Mile SMR (red), and their respective reference areas (gray). Error bars represent ± 1 standard error.

Initial changes between sampling years were compared for fish and invertebrate species abundance and distribution. Overall, there were few significant differences for either fish or invertebrate species, with most having low initial variability. One of the exceptions was a considerable decline in sea star species across all sites within the NCSR from 2014 to 2015. During the 2014 survey, active signs of sea star wasting disease were observed in several species of sea stars. When we returned to the same locations in 2015, these same species were observed in very low numbers, or not at all.

Sunflower star with signs of sea star wasting disease

Based on survey results in the NCSR, candidate indicators were identified based on their abundance, ease of identification and management concern for inclusion in a video-based surveying program for future monitoring and management efforts in the region. They are listed by ecosystem type below:

Recommended Fish:

Mid-depth Rock Ecosystems

- Canary Rockfish
- Copper Rockfish
- Quillback Rockfish
- Vermillion Rockfish
- Yelloweye Rockfish
- Lingcod
- Kelp Greenling

Soft-bottom Subtidal Ecosystems

- Flatfish

Deep Canyon Ecosystems

- Greenstriped Rockfish
- Shortspine Thornyheads
- Longspine Thornyheads
- Sablefish
- Flatfish

Recommended Invertebrates:

Mid-depth Rock Ecosystems

- White-plumed anemones
- CA sea cucumbers
- Short red gorgonians
- Sea stars (all species)
- Basket stars

Soft-bottom Subtidal Ecosystems

- White sea pen
- Orange sea pen
- Sea whip
- Red octopus
- Dungeness crabs

Deep Canyon Ecosystems

- White-plumed anemones
- Short red gorgonians
- Mushroom soft coral

While a set of indicator species was given, due to the limited knowledge we have about mid-depth and deep ecosystems it is highly recommended that long-term sampling continue to identify all fish and macro-invertebrate species and physical habitat characteristics as completed during the baseline assessment.

INTRODUCTION

Background

California's diverse marine territory stretches 13,688 square kilometers, with over 70% of the state's marine seafloor habitats exceeding depths of 30 m. Vast stretches of unconsolidated sediment give way to patches of rocky outcroppings, pinnacles and steep walled canyons. More than 550 marine fish species and thousands of marine invertebrate species are found in California's territorial waters (Froese 2016). Many of these species are only found within deep subtidal ecosystems, extending well beyond the reach of conventional SCUBA surveys.

These deep marine ecosystems are only effectively accessible via manned or unmanned submersibles. Although less is known about California's deep ecosystems than kelp forest ecosystems, they have been long targeted by commercial and recreational fisheries. Due to historic commercial fishing effort, many species were overfished, including Cowcod (*Sebastes levis*), Canary Rockfish (*Sebastes pinniger*), and Yelloweye Rockfish (*Sebastes ruberrimus*). The impacts on these fisheries were further exacerbated by California's growing recreational fleet (Schroeder and Love 2002).

Federal regulations now prohibit bottom fishing within certain depths. In response to critically low population sizes of seven overfished rockfish species, the Pacific Fishery Management Council enacted area closures in September of 2002. These areas, called the Rockfish Conservation Areas (RCAs), prohibit the take of groundfish across vast stretches of the west coast continental shelf. Within Northern California, RCA closures limit bottom fishing to waters shallower than 20 fathoms (~37 m). While current regulations protect much of Northern California's deepwater fish populations, they still remain poorly studied.

Recognizing the lack of visual data available on deep subtidal habitats, Marine Applied Research and Exploration (MARE) was founded in 2003 to explore and document deepwater ecosystems to assist in their conservation and management. MARE works collaboratively with state and federal agencies, academic institutions, and other non-governmental organizations. To date, MARE has documented over 2,700 kilometers of seafloor off California's coast alone—much of which had never been viewed before.

Study Region

In December 2012, the fourth California Marine Protected Area (MPA) region was implemented along the North coast of California. The North Coast Study Region (NCSR) extends from the California-Oregon border to Alder Creek, Mendocino County, encompassing 2,660 square kilometers of coastal waters (CMLPAI 2010). The remote coastal areas of the NCSR are some of the least populated in the state, with vast stretches of coastal mountains having little to no development, reducing access to much of the regions shoreline. Three major river systems discharge into the northern half of the NCSR: the Smith, Klamath, and Eel rivers. The Eel River has an average annual sediment discharge greater than any other river of its size in the contiguous United States (Wolman et al. 1990), impacting nearshore marine ecosystems of the NCSR.

Soft-bottom habitats are the most common within the study region, while hard-bottom and deep submarine canyon habitats add relief and structural complexity. Strong onshore winds drive nutrient rich upwelling that combines with the California Current Large Marine Ecosystem to support an abundance of marine life. These oceanographic conditions of the NCSR support highly productive and diverse marine ecosystems.

The remote, rugged coastline and frequently unfavorable ocean conditions limit access to much of the region. Historical data for deep subtidal ecosystems within the NCSR are primarily limited to fisheries-dependent data from the commercial and recreational sectors. Very few fisheries-independent surveys have been conducted within the NCSR prior to MPA implementation.

Goals and Objectives

This report presents findings from visual surveys conducted as part of a two-year baseline study of selected MPAs within the NCSR. The data collected during this study has been integrated into a statewide dataset to provide a benchmark for evaluating the effectiveness of MPAs. The overall goal of this project is to describe the condition of three priority ecosystems within MPAs and adjacent reference study areas: mid-depth rock ecosystems, soft-bottom subtidal ecosystems, and deep ecosystems (including canyons). The specific objectives of this project include:

1) Produce a quantitative baseline characterization of selected MPAs across the NCSR.
2) Assess initial changes in fishes, macro-invertebrates and associated seafloor habitats in select MPAs during the first two years following implementation.
3) Identify candidate system indicators for the NCSR.
4) Inform future monitoring and management efforts in the region.

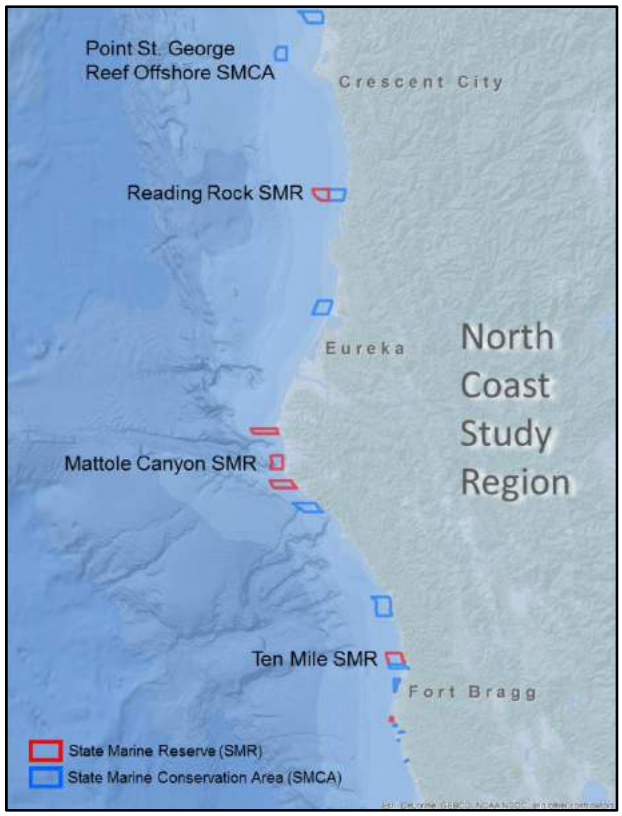
METHODS

Study Design

Benthic visual surveys of North coast MPAs were conducted using a remotely operated vehicle (ROV) that is owned and operated by MARE. The ROV configuration and sampling protocols for this project were based on those developed by the project's principal investigators in partnership with the California Department of Fish and Wildlife. The baseline assessment protocols have been used to survey MPAs of the northern Channel Islands as well as North central coast, Central coast, and South coast MPA study regions. To date, over 1,800 km of seafloor have been surveyed statewide using similar survey design and data collection protocols.

Study Locations

For this baseline assessment, four MPAs were selected to cover both the northern and southern bioregions of the NCSR: Point St. George Reef Offshore State Marine Conservation Area, Reading Rock State Marine Reserve, Mattole Canyon State Marine Reserve and Ten Mile State Marine Reserve. Outside reference areas with similar habitats and depths were also surveyed for comparison.



Transect Selection

Two different sampling techniques were used to capture video imagery, characterization transects and index site transects. At each location we collected video across two different habitat types (rocky reef and soft bottom) for use in developing a basic characterization of the benthic habitat structures and species assemblages present. We also captured additional video data within defined rocky habitat sites (index sites) to increase the statistical power specifically for monitoring changes in species density at those sites.

At each location, long characterization transect lines (~1 km) were planned both inside and outside of the MPA, to transverse rocky reef and soft bottom habitats. Within the rocky reef, transects were distributed to cover both the interior reef, as well as the transitional habitats found on the edges of the rocky reef (Figure 1). Transects were chosen based on the distribution of habitat types within each MPA and reference area. When possible, transects were placed near each other to maximize ROV bottom time. This sampling approach provided information that was used in the descriptive characterization of each MPA and reference area.

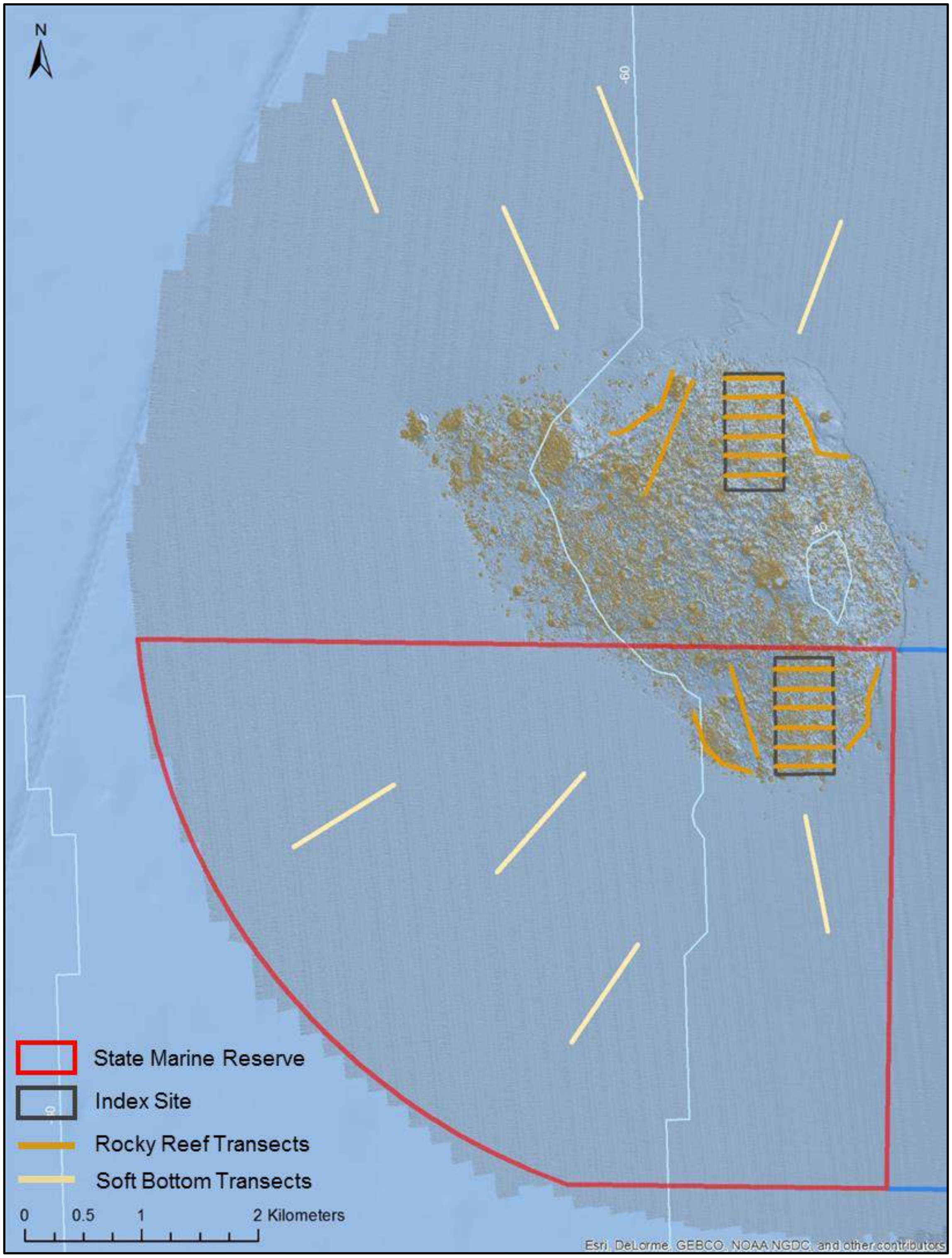


Figure 1. Example of transect allocation within soft bottom and rocky reef habitats (including index sites) inside and outside the Reading Rock SMR.

At each study location, a 500 m wide by 1,000 m long index site was placed over selected rocky habitat (Figure 1). Six 500 m long transects stretching across the width of the site were selected each sampling year using a systematic random approach, in which the start location of the shallowest line was selected randomly and the remaining transects were equally spaced thereafter. This survey design has been used to monitor changes in species density for use in evaluation of MPA effectiveness and fisheries management throughout California's MPA network. To date, 178 index sites have been established and surveyed statewide, some having been resurveyed up to seven times.

Data Collection

ROV Equipment

MARE's observation class ROV, *Beagle*, was used to complete benthic surveys of select North coast MPAs. The ROV was equipped with a three-axis autopilot including a rate gyro-damped compass and altimeter. Together, these allowed the pilot to maintain a constant heading (± 1 degree) and constant altitude (± 0.3 m) with minimal corrections. In addition, a forward speed control was used to help the pilot maintain a consistent forward velocity between 0.25 and 0.5 m/sec. A pair of Tritech® 500 kHz ranging sonars, which measure distance across a range of 0.1–10 m using a 6° conical transducer, were used as the primary method for measuring transect width for both the forward and downward facing video. Each transducer was pointed at the center of the viewing area in each camera and was used to calculate the distance to middle of screen, which was subsequently converted to width using the known properties of each cameras field of view. Readings from these sonars were averaged five times per second and recorded at a one-second interval with all other sensor data. Measurements of transect width using a ranging sonar are accurate to ± 0.1 m (Karpov et al. 2006).

An ORE Offshore Trackpoint III® ultra-short baseline acoustic positioning system with ORE Offshore Motion Reference Unit (MRU) pitch and roll sensor was used to reference the ROV position relative to the ship's Wide Area Augmentation System Global Positioning System (WAAS GPS). The ship's heading was determined using a KVH magnetic compass. The Trackpoint III® positioning system calculated the XY position of the ROV relative to the ship at approximately two-second intervals. The ship-relative position was corrected to real world position and recorded in meters as X and Y using the World Geodetic System (WGS)1984 Universal Transverse Mercator (UTM) coordinate system using HYPACK® 6.2 hydrographic survey and navigation software. Measurements of ROV heading, depth, altitude, water temperature, camera tilt and ranging sonar distance both forward and downward to the substrate, were averaged over a one-second period and recorded along with the position data.

The ROV was equipped with six cameras, including two standard definition primary cameras, two standard definition stereo sizing cameras, one high definition (HD) video camera and one HD still camera. The primary data collection cameras were oriented forward and down, with slightly overlapping fields of view. Both still and video HD cameras were oriented forward. Video for both cameras was captured on SONY® DSR 45 digital video tape recorders and Pioneer DVR510 digital video disc recorders. The two stereo sizing cameras were oriented forward facing with overlap for use in standardizing size measurements of fishes. All video and still images were linked using UTC timecode recorded as a video overlay or using the camera's built-in time stamp which was set to UTC time each day.

GPS time was used to provide a basis for relating position, sensor data and video observations (Veisze and Karpov 2002). A Horita® GPS3 and WG-50 were used to generate on screen displays of GPS time, as well as output Society of Motion Picture and Television Engineers (SMPTE) linear time-code (LTC) for capture on SONY® DSR audio tracks at an interval of 1/30th of a second. This method was improved by customizing HYPACK® navigational software to link all data collected in the field to the GPS time. ROV tracked position and sensor data were recorded directly by HYPACK® as a time-linked text file. A redundant one-second time code file of sensor data was also collected in the field using a custom built on-screen display and operating system software with time code extracted from the system's internal clock which was synced to GPS time.

All data collected by the ROV, along with subsequent observations extracted during post-processing of the video, was linked in a Microsoft Access® database using GPS time. Data management software was used to expand all data records to one second of Greenwich Mean Time (GMT) time code. During video post-processing, a Horita® Time Code Wedge (model number TCW50) was used in conjunction with a customized computer keyboard to record the audio time code in a Microsoft Access® database.

ROV Beagle was also equipped with two sets of parallel lasers, three sonar units, and a Sea-Bird CTD with dissolved oxygen sensor. The parallel lasers were set with a 10 cm spread and positioned to be visible in the field of view of the primary forward and down facing cameras. These lasers provided a scalable reference of size when reviewing the video. The two ranging sonars also aligned with the forward and down facing cameras, allowed the ROV pilot to maintain a constant height off the bottom; they were also used to calculate the area covered (Karpov et al. 2006).

ROV Applications

ROVs are a non-obtrusive monitoring tool that can be used to collect detailed information on the entire benthic ecosystem, rather than just select metrics or indicators. ROVs can be equipped with not only cameras, but also monitoring probes such as oxygen and salinity sensors. This enables them to collect additional information from the surrounding environment beyond video. Additionally, ROVs can be equipped with manipulating arms that can be used to collect samples from the environment. These features make ROVs an all-around good choice for monitoring benthic ecosystems.

ROVs however are not currently very effective at collecting video data on fishes that school off the bottom. Therefore, data collected using the ROVs may not provide an accurate measure of biomass on epibenthic schooling fish species like Blue, Black and Olive/Yellowtail Rockfishes that tend to school around tall rock outcroppings

ROV Sampling Operations

R/V Miss Linda, a 24 m research vessel owned and operated by Captain Robert Pedro, was used to complete both the 2014 and 2015 surveys. Surveys were conducted between the hours of 0800 and 1700 PST to avoid the low light conditions of dawn and dusk that might affect finfish abundance measurements and underwater visibility. At each site, the ROV was piloted along pre-planned transect lines and was flown off the vessel's port side using a "live boat" technique that employed a 317.5 kg (700 lb) clump weight. Using this method, all but 45 m of the ROV umbilical was isolated from current-induced drag by coupling it with the clump weight cable and suspending the clump weight at least 10 m off the seafloor. The 45 m tether allowed the ROV pilot sufficient maneuverability to maintain a constant speed (0.5 to 0.75 m/sec) and a straight course down the planned survey line.

The ship remained within 35 m of the ROV position at all times. To achieve this, an acoustic tracking system was used to calculate the position of the ROV relative to the ship. ROV position was calculated every two seconds and recorded along with UTC timecode using navigational software. Additionally, the ROV pilot and ship captain utilized real-time video displays of the location of the ship and the ROV, in relation to the planned transect line. A consistent transect width, from the forward camera's field of view, was achieved using the ranging sonars to maintain a constant distance and altitude from the substrate. The ranging sonars were fixed below and parallel to the camera between two forward-facing red lasers spaced 100 mm apart. The ROV pilot used the sonar readings to sustain a consistent transect width by maintaining the distance from the camera to the substrate (at the screen horizontal mid-point) between 1.5 and 3 m. In areas with low visibility, a BlueView multibeam sonar was used to navigate hazardous terrain. All sonar and CTD data were recorded at one second intervals along with UTC timecode.

Post-Processing

Following the survey, the ROV position data was processed to remove outliers and data anomalies caused by acoustic noise and vessel movement, which are inherent in these systems (Karpov et al. 2006). In addition, deviations from sampling protocols such as pulls (ROV pulled by the ship), stops (ROV stops to let the ship catch up), or loss of target altitude caused by traveling over backsides of high relief structures, were identified in the data and not used in calculations of density for fish and invertebrate species.

Substrate and Habitat

For each study area, all video collected was reviewed for up to six different substrate types: rock, boulder, cobble, gravel, sand and mud (Green et al. 1999). Each substrate patch was recorded as discrete segments by entering the beginning and ending UTC timecode. Substrate annotation was completed in a multi-viewing approach, in which each substrate type was recorded independently, enabling us to capture the often overlapping segments of substrates (Figure 2). These overlapping substrate segments allowed identification of mixed substrate areas along the transect line.

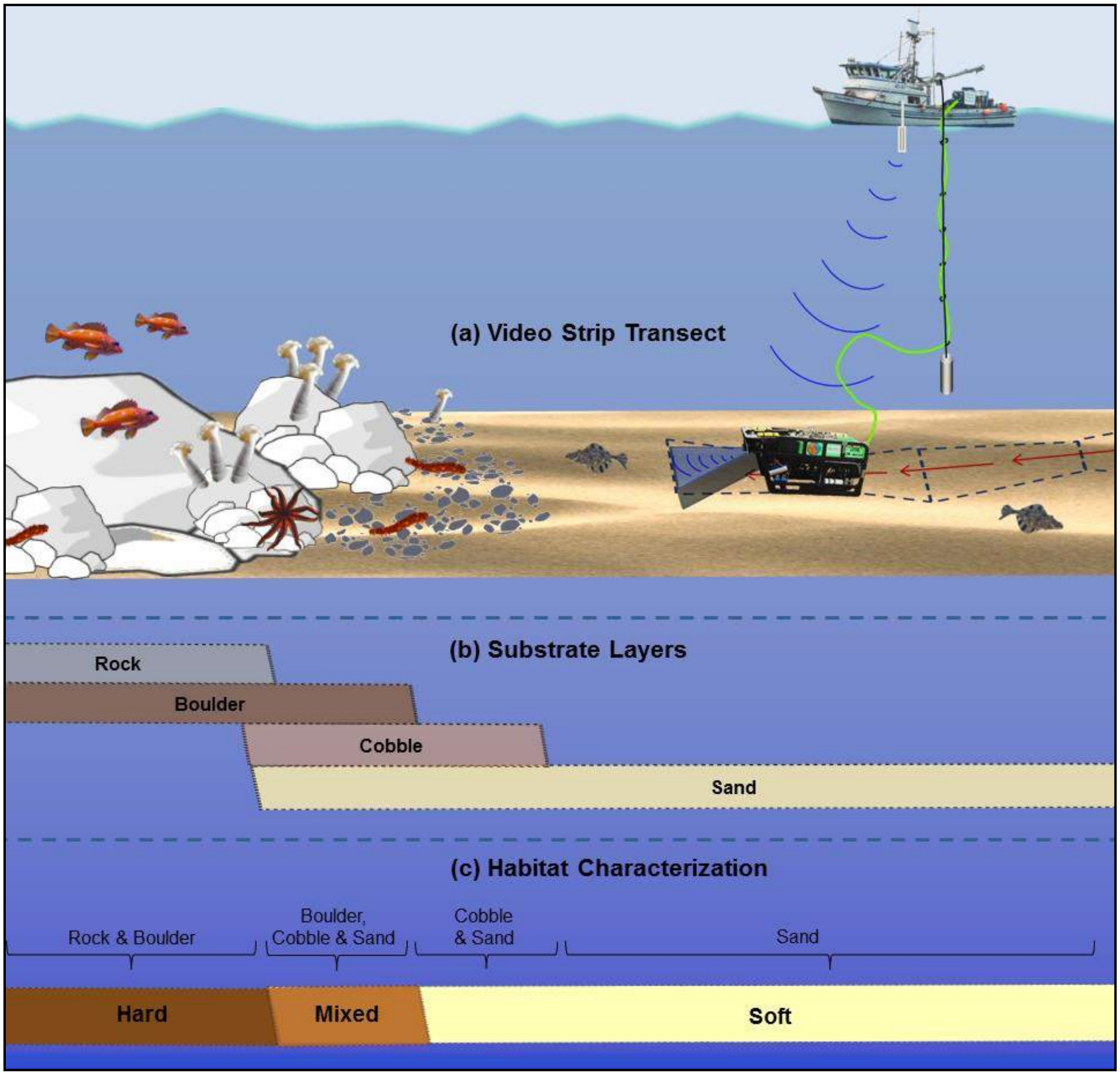


Figure 2. (a) Basic ROV strip transect methodology used to collect video data along the sea floor, (b) overlapping base substrate layers produced during video processing and (c) habitat types (hard, mixed soft) derived from the overlapping base substrate layers after video processing is completed.

After the video review process, the substrate data was combined to create three independent habitat types: hard, soft, and mixed habitats (Figure 2). Rock and boulder were categorized as hard substrate types, while cobble, gravel, sand, and mud were all considered to be unconsolidated substrates and categorized as soft. Hard habitat was defined as any combination of the hard substrates, soft habitat as any combination of soft substrates, and mixed habitat as any combination of hard and soft substrates.

The video record was then reviewed two more times to identify the primary and secondary substrates along the survey line, and to capture the habitat complexity (rugosity). The video was also reviewed to classify the complexity of the habitat as it relates to fish and their ability to find refuge. Four levels of rugosity were used, and include: no rugosity (no refuge), low rugosity (refuge for 5-15 cm fish), medium rugosity (refuge for 15-25 cm fish), and high rugosity (refuge for >25 cm fish). Only base substrate, habitat, and rugosity data are presented in this report. Primary/secondary substrate data are provided as part of the final data submission for use in future analysis.

Finfish and Invertebrate Enumeration

After completion of habitat and substrate review, video was processed to collect data for use in estimating finfish and macro-invertebrate distribution, relative abundance and density. During the review process, both the forward and down video files were simultaneously reviewed, yielding a continuous and slightly overlapping view of what was present in front of and below the ROV. This approach effectively increased the resolution of the visual survey, by identifying animals that were difficult to recognize in the forward camera, but were clearly visible and identifiable in the down camera.

During multiple subsequent viewings, finfish and macro-invertebrates were classified to the lowest taxonomic level possible. Observations that could not be classified to species level were identified to a taxonomic complex, or recorded as unidentified (UI). During video review, both the HD video and HD still imagery were used to aid in species identification. Each fish or invertebrate observation was entered into a Microsoft Access database along with UTC timecode, taxonomic name/grouping, sex/developmental stage (when applicable), and count. Fish, were sized using the two sets of parallel lasers to estimate total length. Not all fish were sizeable due to their position within the field of view of the ROV.

All clearly visible finfish and macro-invertebrates were enumerated from the video record. Invertebrate species that typically form large colonial mats or cover large areas and could not be counted individually were instead recorded as invertebrate layers (with discrete start and stop points and percent cover estimates for each segment).

Invertebrate patch segments were coded for percent cover using four groupings: 1) less than 25% cover, 2) 25% to 50% cover, 3) 50% to 75% cover and 4) greater than 75% cover. Only data on individual invertebrate observations are presented in this report. Invertebrate patch data are provided as part of the final data submission for use in future analysis.

Analysis

Characterization of MPAs and Reference Areas

For each MPA and paired reference area, baseline data collected over the 2014 and 2015 sampling years were combined to describe the physical and biological characteristics of three ecosystem features: mid-depth rock and soft bottom habitats, and deep canyon habitats. Data were summarized to highlight the profundity of information generated from this baseline project. Characterizations are restricted to describing species composition and abundance within each study area, as well as the similarities and differences between MPA pairs, and not to compare regional MPAs to each other. Abbreviated descriptions highlighting key findings at each study location are given in the main body of this report. Detailed characterizations are also provided in Appendix 3, which include fish and invertebrate species counts and mean densities for each MPA and reference area.

Derived habitats are summarized by transect type (rocky reef, soft bottom and canyon) and presented as a percentage of the total transect distance for all transects combined. Fish and invertebrate mean densities for each habitat type (presented in Appendix 1 for fish and Appendix 2 for invertebrates) were calculated for each transect as: total individuals / total area of transect and expressed as individuals/100 m^2.

For each study area, fish and invertebrate densities were summarized into subgroupings. Each fish and invertebrate subgroup was selected for the purposes of displaying all fish and invertebrate density data and were not based on management importance. All fish observed were summarized into one of seven subgroups that include rockfish (schooling and non-schooling larger species), small schooling rockfish (dwarf type species), young of year rockfish (YOY), Lingcod (*Ophiodon elongatus*), Kelp Greenling (*Hexagrammos decagrammus*), flatfish (Pleuronectidae) and 'all other fish'.

Invertebrates were grouped into seven mobile and seven sessile macro-invertebrate subgroupings. Mobile subgroups include California sea cucumbers (*Parastichopus californicus*), octopuses, sea stars, urchins, Dungeness crabs (*Cancer magister*), basket stars (*Gorgonocephalus eucnemis*), and 'other mobile invertebrates'. Sessile subgroups include white-plumed anemones (*Metridium farcimen*), branched sea cucumbers, whips and pens, gorgonians, sponges, and 'other sessile invertebrates'. For breakdown of taxonomic composition of subgroups see Table 2 for fish and Table 3 for invertebrates.

Analysis of Index Sites

To assess the relationship between occupancy and abundance of fishes across the NCMPA region, and within each of the selected MPAs and their outside reference areas, analyses were conducted on the combined 2014-2015 dataset at three different levels of ecological organization: 1) all fishes combined to represent the entire assemblage (multivariate analyses), 2) fishes separated into taxonomic or functional groups (multivariate analyses) and 3) individual species analyses for the 10 most abundant, reliably identifiable fish species. Additionally these groups were evaluated at three levels: regional (MPA location), treatment (inside/outside of MPA pairs), and habitat (rock, soft and canyon). The canyon habitat was considered unique, and was evaluated separately as the depth range and topography were significantly different from rock and soft shelf habitats.

Multivariate analyses – The initial objective was to characterize the overall similarity of MPA locations and their paired reference site in the NCSR. Average agglomerative clustering of taxa densities at the transect level was used to determine how overall assemblage structure varied by MPA (regional), treatments (inside and outside reference) and habitats (rock, soft and canyon); and to evaluate the similarity of assemblages among MPA locations. We did this by grouping all ROV transect data in two ways. Mean densities for each group or species observed were calculated for soft, rock and canyon habitat transects, inside and outside each MPA. Densities were calculated by dividing the number of individuals observed by the area covered for each transect, creating a density matrix. Square root transformed densities were used to calculate a Bray-Curtis Similarity (Krebs 1999) matrix, used for average agglomerative clustering.

A number of individual taxa had very low numbers of observations, or were difficult to identify to species level. Therefore, we completed the same analysis for taxa densities after grouping all species into higher level taxa such as genus, family, or functional group, including: Chondrichthyans (sharks, rays and ratfish), flatfishes, young of the year rockfish (YOY), *Sebastomus* Rockfish, small schooling rockfish (Pygmy, Halfbanded, Squarespot, Shortbelly, and unidentified small schooling), demersal non-aggregating rockfishes (Aurora, Brown, China, Copper, Darkblotched, Gopher, Greenspotted, Greenstriped, Quillback, Redbanded, Sharpchin, Stripetail, Tiger, and Yelloweye), epibenthic aggregating rockfishes (Black, Blue, Bocaccio, Canary, Chilipepper, Olive/Yellowtail, Vermilion and Widow), seaperches, combfishes, small benthic fishes (eelpouts, gobies, sculpins, and poachers), other benthic fishes (Sablefish, hagfishes, thornyheads and sand lance), and other fishes (Pacific Tomcod, Pacific Hake, salmonids, smelts, sunfish, and cods).

Similar analyses were completed using only index site species occurrence data. Mean densities and frequency of occurrence were calculated for each species or taxon within each of the index sites. Similarity analyses and statistical comparisons were restricted to species or species groups that occurred on ROV transects within the index sites, and those species considered resident or semi-resident. Migratory or highly mobile species such as Ocean Sunfish, Sixgill Shark, Sablefish, smelts, Shortbelly Rockfish, and other schooling pelagics were removed. Individual species or taxa were grouped as previously described either taxonomically or functionally when observations were low. Similarly, small schooling rockfishes, other than Shortbelly Rockfish, were grouped for analyses as they have similar appearance and they occupy similar habitat in loosely aggregated schools. Kelp Greenling and Lingcod were analyzed as individual taxa due to occupying different ecological niches. At the depths in which the index sites were located (20-70 m), two *Sebastomus* species were expected to be observed – Starry and Rosy Rockfishes. These two species were combined with the *Sebastomus* Rockfish complex (hereafter referred to as *Sebastomus* Rockfish) to reduce ambiguity in calculations. Unidentified taxa were either eliminated or incorporated into appropriate higher level taxonomic groups. Analyses were conducted for transect-level densities, as well as individually for each substrate type.

Individual species analyses - General linear modeling (GLM) was used with analysis of variance (ANOVA) and post-hoc multiple comparisons to investigate the relationships among square root transformed densities of individual fish species by treatment, MPA and between the two sample years. Species were selected based on abundance and frequency of observation in index sites and restricted to resident or semi-resident species.

ODDS Analyses - We used odds-ratio analysis to determine if individual species were using hard substrates similarly among the four MPAs in the paired Index sites. This analysis is used to measure the odds of an outcome (yes or no) given a two-way treatment. We used number of observations over hard substrate (number of yes's) or not (number of no's) in Index sites as the outcomes in each treatment - inside and outside the MPAs. The resulting number is calculated: Odds ratio = A*D/B*C. A result near 1 would indicate that a species is observed over substrates similarly both inside and outside the MPA. Greater than 1 would indicate that the species is more likely to use hard substrates inside than outside and less than one more likely to use hard substrates in the outside treatment. The results of this analysis are not included in the main body of this report.

A full report on analyses conducted in the evaluation of index sites can be found in Appendix 4.

Fish Depth Distribution

The depth distribution of selected fish species across all rocky reef transects (characterization and index site transects combined) was assessed for all MPA and reference areas in the NCSR. Depth distribution of select fish species across the Mattole Canyon SMR was assessed using only those transects that targeted the canyon.

Fishes that were relatively high in abundance, and were of management concern, were selected for enumeration. Fish assessed from rocky reef transects include: Black Rockfish, Canary Rockfish, Copper Rockfish, Quillback Rockfish, *Sebastomus* Rockfish, Vermilion Rockfish, Yelloweye Rockfish, Lingcod, and Kelp Greenling. Fish assessed in canyon transects include all of the aforementioned species, as well as the following abundant, relatively deep water species: Greenstriped Rockfish, thornyhead complex (which includes Shortspine Thornyheads, and Longspine Thornyheads), and flatfish (including, Rock Sole, Slender Sole, Curlfin Turbot, Spotted Turbot, Pacific Halibut, Dover Sole, unidentified sanddabs, English Sole, Petrale Sole, and Rex Sole, as well as unidentified flatfish). Additionally, five flatfish species/groupings that had a higher identification rate were shown and include: Dover Sole, unidentified sanddabs, English Sole, Petrale Sole, and Rex Sole.

To account for differences in density of fish along a depth gradient, transects in rocky reefs were stratified into 10 m depth bins. Transects targeting canyons were stratified into either 10 or 50 m bins. For the shallower portion of the canyon (50 to 149 m), depth was broken into 10 m bins; for the deeper portions of the canyon (150 to 450 m), 50 m depth bins were used. The total usable transect area was summarized within each depth bin (see ROV Positional Data methods section). Only those depth bins in which at least 200 m^2 was surveyed were used for density calculations. Density was calculated as: total fish observed/total area surveyed and was expressed as fish/100 m^2, for each depth bin.

Regional Fish Size Distribution

Fish size (total length) was approximated using two parallel lasers mounted to the ROV's forward and down facing cameras. The lasers were placed 10 cm apart in the center of the video-viewing screen providing a scalable reference size. Estimates of fish total length were made using the lasers as a guide (laser-based size estimate) when the lasers made contact with the fish or when the lasers were visible on adjacent substrate or other fish. Length measurements were made to the nearest 1 cm and applied to all fish deemed sizeable by the trained video analysts.

Ten species were selected for analysis: Black Rockfish, Blue Rockfish, Canary Rockfish, Copper Rockfish, Olive/Yellowtail Rockfish, Quillback Rockfish, Vermilion Rockfish, Yelloweye Rockfish, Lingcod, and Kelp Greenling (see table 2 for species names). Mean laser-based size estimates for these species were calculated for each MPA and reference area. Because there was little difference overall in mean total length between MPA and reference areas for the ten fish species presented, length data for MPA and reference area pairs were combined to show the size frequency for each of the four study locations in the NCSR. Percent size frequency is presented in 5 cm bins, and size at which 50% of the females of the population reach sexual maturity, is referenced for each species/grouping presented (Love et al. 2002; Thorson and Wetzel 2016; MacCall 2005; Stewart 2009; CDFW 2016f).

To test the accuracy of the laser-based sizing technique used in this report, stereo video that was collected concurrently with the primary forward facing video was compared by independent analysts. Fish size (total length) was measured using commercially available SeaGIS EventMeasure® software (www.seagis.com.au/event). Eleven fish species were selected for comparison and include: Lingcod, Kelp Greenling, and the following rockfishes: Black, Blue, Canary, Copper, Olive/Yellowtail, Quillback, Rosy, Vermillion, and Yelloweye Rockfish.

Video collected using the ROV Beagle's stereo-video cameras was provided to Moss Landing Marine Lab (MLML) analysts for processing. Fish that were previously given a laser-based size estimate were located in the stereo-video files using the same timecode that was recorded in the primary forward-facing camera. Using EventMeasure® software, fish that appeared to be the same individual as previously sized using the laser-based method were measured. Only fish that met the software requirement of head and tail being visible in both cameras simultaneously were sized. To assess potential differences between the two techniques:

1) Mean total lengths of fish species measured using both methods were compared using two-tailed paired-sample t-tests.
2) Laser-estimated total lengths were subtracted from stereo-estimates of fish species measured using both methods. Then we looked at the mean proportional differences, using the equation:

   *Proportional difference = (difference / stereo measurement) * 100*

Between Year Comparison

The differences between 2014 and 2015 baseline survey years were compared for select MPAs and their respective reference areas. Two types of transects were analyzed for the between year comparisons: transects surveyed in the rocky reef index sites and transects surveyed in soft bottom habitats. Fish and macro-invertebrate species abundance were analyzed for between year differences at each survey location. As there were no substantial differences in habitat composition between 2014 and 2015 for any of the survey locations, habitat will not be compared between years.

To show the percentage difference between the two sampling years for both rocky reef index and soft bottom transects, *Initial Variability* was calculated with the equation:

Absolute value of ((mean density 2015 – mean density 2014) / mean density 2014)

For rocky reef index sites only, we tested for differences in density between years inside the MPAs and their reference sites using t-tests for select fish and invertebrate species (soft bottom sample sizes were insufficient). Tables with initial variability and t-test results are in Appendices 5-8.

Fish species/groupings were chosen for between year comparison totaling the counts of all fish species for all sites and looking at species that were relatively high in abundance and of management concern. Fish species chosen for between year comparisons in rocky reef index sites include the following rockfish species: Black, Blue, Brown, Canary, Copper, Olive/Yellowtail, Quillback, *Sebastomus*, Shortbelly, small schooling, Vermilion, Yelloweye, unidentified (UI), young of year (YOY); and the following non-rockfish species: Kelp Greenling, Lingcod, and flatfish. Fish species chosen for between year comparisons in soft bottom transects include: combfish complex, Dover Sole, English Sole, Lingcod, Pacific Hake, Petrale Sole, Rex Sole, UI cod, UI eel pout, UI flatfish, UI sanddab, UI small benthic fish and UI smelt (see table 2 for scientific names).

Select macro-invertebrate species that were relatively high in abundance were also chosen for comparison. Macro-invertebrate species selected for between year comparisons in rocky reef index sites include the following: basket star, California hydrocoral, California sea cucumber, cushion star, fish eating star, *Henricia* complex, leather star, rainbow star, red sea star, red sea urchin, short red gorgonian, short spined sea star, slipper sea cucumber, spiny/thorny star complex, Stimson's sun star, sunflower star, white branched cucumber, and white-plumed anemone. Macro-invertebrate species chosen for between year comparisons in soft bottom transects include: Dungeness crab, orange sea pen, *Pleurobranchaea californica*, red octopus, sand star, sand-rose anemone, sea whip, white sea pen and white-plumed anemone (see table 3 for scientific names).

RESULTS AND DISCUSSION

Baseline Survey Totals

The baseline assessment of deep subtidal ecosystems within the North Coast Study Region was conducted between September 12 and October 9 2014, and October 6 to October 18 2015. Surveys were completed over a total of 24 operational days at sea (excluding weather and travel days) and covered nine different study areas: Point St. George SMCA and reference area, Reading Rock SMR and reference area, Mattole Canyon SMR and reference area, Sea Lion Gulch SMR, and Ten Mile SMR and reference area (Figure 3). In 2014, 31 ROV dives were completed, surveying over 59 km of benthic habitats between 13 and 421 meters in depth. In 2015 we returned to the same sites and completed 29 dives, surveying 47 km of transects between 24 and 364 meters in depth.

Poor weather conditions and reduced visibility did not allow subsequent surveys of the 2015 planned transects within the Point St. George SMCA reference area. Therefore, two dives inside the Sea Lion Gulch SMR were re-surveyed within a site previously surveyed in 2014 as part of a CDFW statewide survey contract. Sea Lion Gulch SMR results are presented in this section only.

In total, 60 ROV dives were completed covering more than 106 km (19 ha) of sea floor (Table 1). Over 101,000 fish and 124,000 invertebrates were enumerated from the videos. In addition, over 16,500 HD still photos were taken during 2014-2015 survey.

Table 1. Survey totals for ROV dives at Point St. George, Reading Rock, Mattole Canyon, Sea Lion Gulch and Ten Mile MPAs and paired reference areas for the 2014 and 2015 sampling years combined.

Study Area		No. of Dives	No. of Transects	Total km	Total Area (ha)	Count of Fish	Count of Inverts	Depth (m)		
								Max	Min	Avg
Point St. George	SMCA	6	22	14.1	2.5	4,703	21,973	111	37	69
	Reference	9	17	11.0	1.9	1,973	13,815	96	36	63
	Total:	*15*	*39*	*25.1*	*4.4*	*6,676*	*35,788*			
Reading Rock	SMR	8	19	11.9	1.8	6,314	9,222	75	34	54
	Reference	7	19	12.3	2.1	3,000	25,146	71	35	54
	Total:	*15*	*38*	*24.2*	*3.9*	*9,314*	*34,368*			
Mattole Canyon	SMR	8	22	18.7	3.1	18,555	22,909	421	36	133
	Reference	4	15	9.0	1.7	8,369	6,352	364	18	69
	Total:	*12*	*37*	*27.8*	*4.8*	*26,924*	*29,261*			
Sea Lion Gulch	SMR	2	6	3.2	0.8	1,432	2,925	249	62	82
	Total:	*2*	*6*	*3.2*	*0.8*	*1,432*	*2,925*			
Ten Mile	SMR	8	20	13.6	2.6	29,074	10,875	97	13	51
	Reference	8	19	12.6	2.5	28,246	10,848	99	27	59
	Total:	*16*	*39*	*26.2*	*5.1*	*57,320*	*21,723*			
Grand Totals:		***60***	***159***	***106.5***	***19.1***	***101,666***	***124,064***			

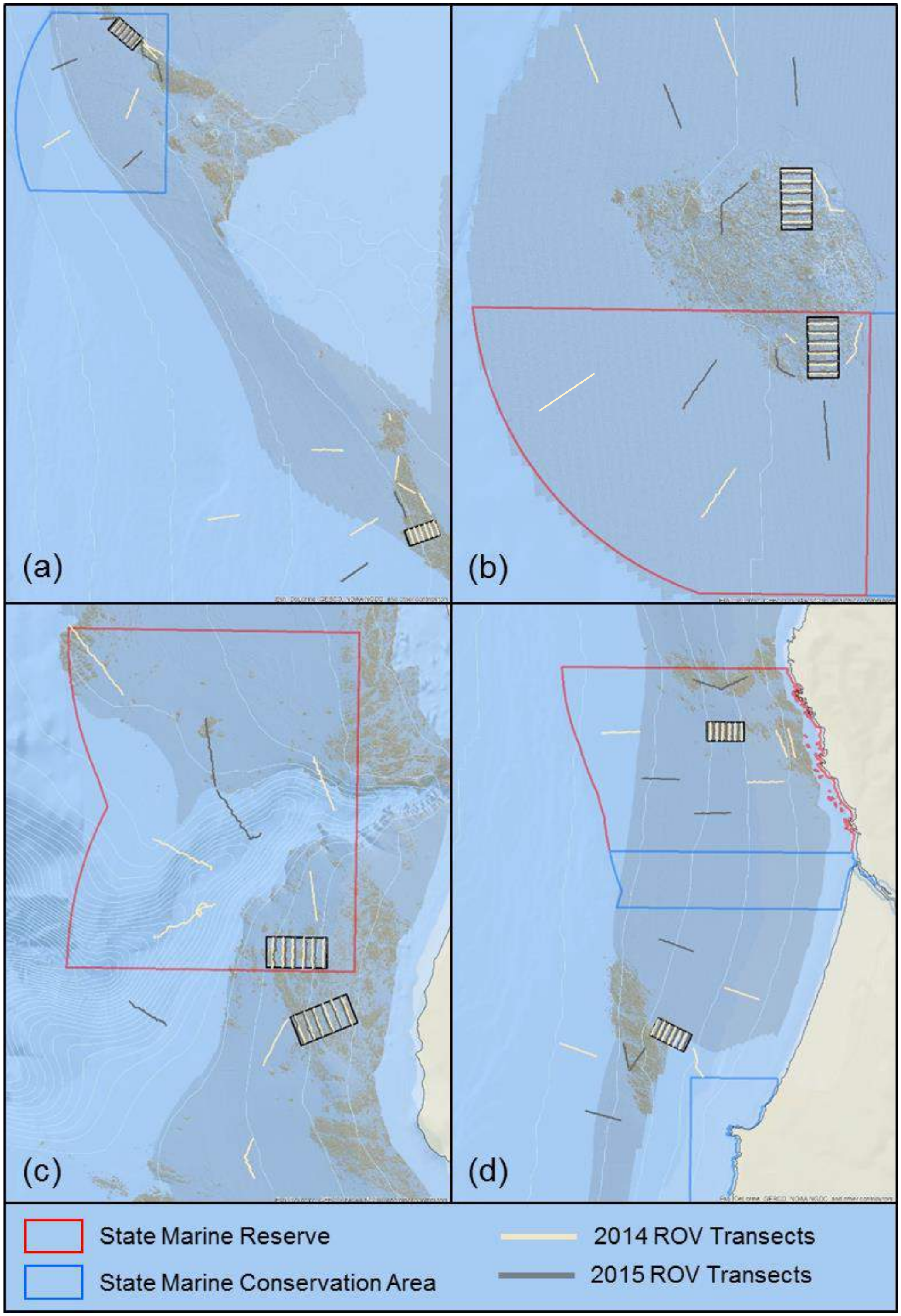


Figure 3. ROV transect lines completed in 2014 and 2015 at (a) Point St. George Reef Offshore SMCA and reference area, (b) Reading Rock SMR and reference area, (c) Mattole Canyon SMR and reference area and (d) Ten Mile SMR and reference area.

Fish Totals

For a full list of scientific names, see Table 2; fish will be referred to by common name throughout this report. For all sites and survey years combined, a total of 66 individual fish species and another 26 groupings were identified (Table 2). Of the 101,666 fish observed over both years, over 85% were rockfish. Young of year rockfish (YOY) were the most numerous fish observed; with over 61,000 recorded individuals, they accounted for 60% of all of the fish observations, and 71% of all rockfish observations. Small schooling rockfish were also abundant and with over 14,500 observed across both years, accounted for 17% of the rockfish observations. Small schooling rockfish include Shortbelly, Halfbanded, Squarespot, and Pygmy Rockfishes, as well as those fish that could only be classified as unidentified small schooling rockfish.

Observations of larger rockfish (both aggregating and non-aggregating species/groupings) represented only 14% of the total rockfish observations, with four species/groupings accounting for 80% of the observations: Blue, Olive/Yellowtail, unidentified and Canary Rockfishes. Canary Rockfish, a species that was listed as overfished until the end of 2016, was one of the more abundant species identified, with almost 1,600 individuals observed over the length of the survey. Yelloweye Rockfish, a currently listed overfished species, accounted for 220 individuals.

Non-rockfish species represented 15% of the total fish identified, with two groupings accounting for 71% of the total observations: unidentified smelt and flatfish (all species/groupings combined). Unidentified smelt had the highest count within the non-rockfish grouping, with just under 7,000 observed individuals. A total of 14 species/groupings of flatfish were observed with combined total counts equaling 4,171 fish.

For a full list of fish species and their overall densities by study site (MPA or reference) and transect type (rocky reef, soft bottom, or canyon), see Appendix 3.

Table 2. Total count, estimated size and depth of all fish observed from video collected in 2014 and 2015 within the NCSR.

Common Name	Species/Grouping/Complex	Total Count	Size (cm)			Depth (m)		
			Avg	Max	Min	Avg	Max	Min
YOY	Young of year rockfish	61,150	8	9	3	51	118	15
Shortbelly Rockfish	*Sebastes jordani*	9,199	10	21	8	59	286	40
UI smelt	Unidentified Osmeridae	6,996	14	35	9	67	98	53
Small schooling rockfish	Schooling rockfish (10-15cm)	4,679	11	15	10	49	81	27
UI flatfish	Unidentified Pleuronectiformes	3,669	13	95	5	74	401	21
Blue Rockfish	*Sebastes mystinus*	3,021	26	50	6	49	81	14
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	2,182	36	60	8	64	112	27
UI rockfish	Unidentified *Sebastes sp.*	1,877	17	50	10	60	354	14
Canary Rockfish	*Sebastes pinniger*	1,595	26	62	7	61	111	26
Lingcod	*Ophiodon elongatus*	1,253	45	85	8	57	286	14
Kelp Greenling	*Hexagrammos decagrammus*	750	35	60	8	50	93	18
Halfbanded Rockfish	*Sebastes semicinctus*	697	7	11	6	54	93	47
UI fish	Unidentified fish	493	15	60	5	115	419	30
Sebastomus Rockfish	Subgenus *Sebastomus*	355	20	45	9	63	211	42
UI eel pout	Unidentified Zoarcidae	332	13	21	7	91	111	49
Black Rockfish	*Sebastes melanops*	297	36	46	20	42	61	13
UI schooling pelagic	Unidentified schooling pelagic fish	296	15	20	14	54	78	28
Quillback Rockfish	*Sebastes maliger*	286	34	48	18	58	117	26
Yelloweye Rockfish	*Sebastes ruberrimus*	220	30	58	10	62	110	38
UI sanddab	Unidentified *Citharichthys sp.*	200	14	30	5	68	243	44
Widow Rockfish	*Sebastes entomelas*	193	24	45	8	54	79	34
Rosy Rockfish	*Sebastes rosaceus*	167	21	36	10	59	104	40
UI small benthic fish	Unidentified small benthic fish	161	13	35	4	84	360	35
Vermilion Rockfish	*Sebastes miniatus*	156	40	55	13	53	91	20
Copper Rockfish	*Sebastes caurinus*	144	36	55	12	52	76	31
Pacific Sand Lance	*Ammodytes hexapterus*	126	12	14	6	65	67	63
UI cod	Unidentified Gadidae	97	28	55	14	289	420	63
Rex Sole	*Glyptocephalus zachirus*	88	20	34	8	138	333	61
Spiny Dogfish	*Squalus acanthias*	75	49	55	33	244	352	198
English Sole	*Parophrys vetulus*	72	24	43	10	109	306	36
Dover Sole	*Microstomus pacificus*	60	25	36	12	202	402	50
Petrale Sole	*Eopsetta jordani*	56	24	35	12	84	181	53
Pacific Hake	*Merluccius productus*	56	35	60	14	292	419	71
Squarespot/Widow Rockfish	*Sebastes hopkinsi* or *entomelas*	54	20	36	1	73	226	41
Combfish complex	*Zaniolepis frenata* or *latipinnis*	50	13	24	8	79	143	49
Black/Blue Rockfish	*Sebastes melanops* or *mystinus*	44	30	38	25	24	67	14
Brown Rockfish	*Sebastes auriculatus*	42	33	41	21	56	66	28
Shortspine Thornyhead	*Sebastolobus alascanus*	36	24	52	13	288	417	191
UI goby	Unidentified Gobiidae	34	12	19	10	63	102	51
Painted Greenling	*Oxylebius pictus*	29	12	15	10	49	58	34
Shiner Surfperch	*Cymatogaster aggregata*	26	10	12	9	56	80	32
Greenstriped Rockfish	*Sebastes elongatus*	25	22	32	14	146	201	87
Tiger Rockfish	*Sebastes nigrocinctus*	24	33	40	23	56	68	42
China Rockfish	*Sebastes nebulosus*	23	32	40	24	47	61	31
Spotted Ratfish	*Hydrolagus colliei*	23	42	50	28	177	355	74
Canary/Vermilion Rockfish	*Sebastes pinniger* or *miniatus*	21	33	45	23	59	80	42
Sablefish	*Anoplopoma fimbria*	19	40	53	29	245	359	60
Greenspotted Rockfish	*Sebastes chlorostictus*	13	28	40	18	87	94	48

Table 2. Continued.

Common Name	Species/Grouping/Complex	Total Count	Size (cm)			Depth (m)		
			Avg	Max	Min	Avg	Max	Min
Thornyhead complex	*Sebastolobus altivelis* or *alascanus*	13	18	32	12	218	288	66
Pink Surfperch	*Zalembius rosaceus*	12	14	20	10	57	67	49
Striped Surfperch	*Embiotoca lateralis*	11	16	32	12	20	25	17
Longnose Skate	*Raja rhina*	10	57	95	43	244	355	40
Rock Sole	*Lepidopsetta bilineata*	10	27	41	10	69	95	47
UI poacher	Unidentified Agonidae	10	17	21	12	204	263	157
Pacific Hagfish	*Eptatretus stoutii*	9	43	60	25	186	338	64
UI skate	Unidentified *Raja sp.*	9	34	70	8	93	244	35
UI surfperch	Unidentified Embiotocidae	9	10	14	8	56	80	25
Stripetail Rockfish	*Sebastes saxicola*	8	19	24	12	227	303	157
Cabezon	*Scorpaenichthys marmoratus*	8	40	58	18	43	58	25
Ocean Sunfish	*Mola mola*	7	78	120	50	47	52	45
Squarespot Rockfish	*Sebastes hopkinsi*	7	21	30	16	66	67	66
Pacific Sanddab	*Citharichthys sordidus*	6	19	21	12	74	92	66
Wolf Eel	*Anarrhichthys ocellatus*	6	95	95	95	53	58	47
Chilipepper Rockfish	*Sebastes goodei*	6	19	26	12	195	248	159
Staghorn Sculpin	*Leptocottus armatus*	6	24	32	20	54	58	43
UI sculpin	Unidentified Cottidae	6	15	23	11	99	198	55
UI hexagrammid	Unidentified Hexagrammidae	5	-	-	-	49	63	39
Slender Sole	*Lyopsetta exilis*	4	23	25	21	171	180	166
Redbanded Rockfish	*Sebastes babcocki*	4	43	55	27	289	355	238
Big Skate	*Raja binoculata*	3	78	100	35	75	81	73
Bocaccio	*Sebastes paucispinis*	3	47	57	29	99	135	79
Darkblotched Rockfish	*Sebastes crameri*	3	25	36	14	314	420	183
Pygmy Rockfish	*Sebastes wilsoni*	3	11	12	10	92	92	91
Starry Rockfish	*Sebastes constellatus*	3	25	28	22	64	83	50
Starry Flounder	*Platichthys stellatus*	2	32	38	26	69	72	65
Longspine Thornyhead	*Sebastolobus altivelis*	2	31	32	30	254	257	251
Pinkrose Rockfish	*Sebastes simulator*	2	22	25	18	168	204	132
Sharpchin Rockfish	*Sebastes zacentrus*	2	22	22	21	208	225	191
UI salmonid	Unidentified Salmonidae	2	45	50	40	74	81	66
Buffalo Sculpin	*Enophrys bison*	2	26	27	25	19	19	19
Sixgill Shark	*Hexanchus griseus*	1	210	210	210	52	52	52
Starry Skate	*Raja stellulata*	1	52	52	52	64	64	64
UI shark	Unidentified shark	1	-	-	-	95	95	95
Curlfin Turbot	*Pleuronichthys decurrens*	1	22	22	22	161	161	161
Pacific Halibut	*Hippoglossus stenolepis*	1	110	110	110	67	67	67
Speckled Sanddab	*Citharichthys stigmaeus*	1	12	12	12	72	72	72
Spotted Turbot	*Pleuronichthys ritteri*	1	18	18	18	79	79	79
Pacific Tomcod	*Microgadus proximus*	1	19	19	19	66	66	66
Aurora Rockfish	*Sebastes aurora*	1	10	10	10	292	292	292
Gopher Rockfish	*Sebastes carnatus*	1	33	33	33	38	38	38
Rosethorn Rockfish	*Sebastes helvomaculatus*	1	28	28	28	200	200	200
Speckled Rockfish	*Sebastes ovalis*	1	-	-	-	67	67	67
	Total:	***101,666***						

Invertebrate Totals

For a full list of scientific names, see Table 3; invertebrates will be referred to by common name throughout this report. For all sites and survey years combined, a total of 70 individual macro-invertebrate species and another 29 groupings were identified (Table 3). Of the 124,064 individual invertebrates enumerated, seven species/groupings represented the majority of the observations (approximately 89%). Over 27% of the invertebrates identified were white-plumed anemones, which accounted for 86% of all anemone observations. The next most abundant invertebrates were slipper and California sea cucumbers, which combined, accounted for 40% of the total invertebrate observations. Two rocky reef coral species were also commonly observed: the short red gorgonian and California hydrocoral. Combined, these two species accounted for 11% of the total invertebrate observations. Sea stars represented 8% of the total invertebrate observations, with two species/groupings accounting for 61% of the total sea star observations: red sea stars and the *Henricia* complex. Lastly, two soft bottom coral species, sea whips and sea pens, accounted for 3% of the total invertebrate observations.

For a full list of macro-invertebrate species and their overall densities by study area (MPA or reference) and transect type (rocky reef, soft bottom, or canyon), see Appendix 3.

Table 3. Total count and depth range of all invertebrates observed from video collected in 2014 and 2015 within the NCSR.

Common Name	Species/Grouping/Complex	Total Count	Depth Range (m)		
			Avg.	Max.	Min.
White-plumed anemone	*Metridium farcimen*	33,830	62	351	14
Slipper sea cucumber	*Psolus chitonoides*	27,474	53	74	27
California sea cucumber	*Parastichopus californicus*	22,437	54	275	19
Short red gorgonian	*Swiftia spauldingi*	9,324	57	399	28
Red sea star	*Mediaster aequalis*	3,986	53	249	24
California hydrocoral	*Stylaster californicus*	3,122	48	87	22
White sea pen	*Stylatula elongata*	2,267	71	399	53
Henricia complex	*Henricia sp.*	1,806	51	304	16
UI anemone 4	Unidentified anemone species #4	1,763	202	419	48
Red sea urchin	*Mesocentrotus franciscanus*	1,754	28	191	13
Red octopus	*Octopus rubescens*	1,521	106	350	27
Basket star	*Gorgonocephalus eucnemis*	1,398	67	280	38
Sea whip	*Halipteris californica*	1,095	87	111	27
White branched sea cucumber	*Cucumaria piperata*	1,054	52	292	42
UI anemone	Unidentified anemone	795	159	406	20
UI anemone 3	Unidentified anemone species #3	790	229	401	62
Sand-rose anemone	*Urticina columbiana*	696	61	249	27
UI branched sponge	Unidentified branched sponge	675	60	207	31
Orange puffball sponge	*Tethya aurantia*	632	45	98	21
Fish eating anemone	*Urticina piscivora*	534	50	82	19
Acorn barnacle	*Balanus nubilus*	532	44	62	21
UI nipple sponge	Unidentified nipple sponge	520	44	183	22
Sand star	*Luidia foliolata*	509	72	277	41
Leather star	*Dermasterias imbricata*	421	55	301	18
Gray puffball sponge	*Craniella arb*	416	32	207	19
UI sea star	Unidentified sea star	334	63	334	23
UI lobed sponge/tunicate	Unidentified lobed sponge/tunicate	324	77	207	31
Fish eating star	*Stylasterias forreri*	305	74	324	26
UI tube dwelling anemone	Unidentified tube dwelling anemone	289	57	300	39
Frilled anemone	*Metridium senile*	238	56	99	43
Pleurobranchaea californica	*Pleurobranchaea californica*	238	103	339	55
Dungeness crab	*Metacarcinus magister*	231	61	92	27
Fragile pink urchin	*Strongylocentrotus fragilis*	208	181	418	56
Cushion star	*Pteraster tesselatus*	164	57	303	23
UI anemone 6	Unidentified anemone species #6	161	207	326	131
UI branched sea cucumber	Unidentified branched sea cucumber	152	54	57	53
UI sea jelly	Unidentified sea jelly	150	54	407	21
Orange sea cucumber	*Cucumaria miniata*	149	56	183	29
Short spined sea star	*Pisaster brevispinus*	145	53	167	15
Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	140	80	251	26
UI sand dwelling anemone	Unidentified sand dwelling anemone	130	103	306	28
UI branched bryozoan	Unidentified branching bryozoan	103	33	98	25
Mushroom soft coral	*Anthomastus ritteri*	102	314	416	195
UI sea pen	*Virgularia sp.*	99	78	105	61
UI anemone 5	Unidentified anemone species #5	98	219	405	62
Market squid	*Loligo opalescens*	88	76	94	29
UI anemone 1	Unidentified anemone species #1	80	81	419	24
Rainbow star	*Orthasterias koehleri*	67	54	190	36
Orange sea pen	*Ptilosarcus gurneyi*	62	60	95	28
Stimpson's sun star	*Solaster stimpsoni*	60	50	64	27
UI nudibranch	Unidentified nudibranch	47	47	68	19

Table 3. Continued.

Common Name	Species/Grouping/Complex	Total Count	Depth Range (m)		
			Avg.	Max.	Min.
Thorny sea star	*Poraniopsis inflata*	38	58	109	37
Purple sea urchin	*Strongylocentrotus purpuratus*	37	21	43	17
Sunflower star	*Pycnopodia helianthoides*	35	65	250	44
UI scallop	Unidentified scallop	31	58	69	52
Solaster sun star complex	*Solaster sp.*	31	54	71	41
Cookie star	*Ceramaster patagonicus*	29	70	168	42
Purple/red urchin complex	*Strongylocentrotus purpuratus or Mesocentrotus franciscanus*	28	20	38	18
UI anemone 2	Unidentified anemone species #2	27	125	317	27
UI yellow boot sponge	Unidentified yellow boot sponge	23	68	83	48
Swimming anemone	*Stomphia didemon*	18	102	217	54
Orange-peel nudibranch	*Tochuina tetraquetra*	17	54	67	22
UI gorgonian	Unidentified Gorgonacea	14	64	79	37
Giant Pacific octopus	*Enteroctopus dofleini*	14	122	399	41
Trumpet sponge	*Stylissa stipitata*	14	63	86	33
UI tubeworm	Unidentified tubeworm	13	63	76	47
Gray moon sponge	*Spheciospongia confoederata*	12	156	173	132
Spiny red star	*Hippasteria spinosa*	12	89	160	69
Sunflower star complex	*Rathbunaster californicus* or *Pycnopodia helianthoides*	12	46	66	41
UI whelk	Unidentified whelk	11	140	402	42
Long legged sunflower star	*Rathbunaster californicus*	11	266	401	61
Stalked tunicate	*Styela montereyensis*	11	29	47	24
Ochre star	*Pisaster ochraceus*	9	19	38	14
Decorator crab	*Loxorhynchus crispatus*	8	90	207	25
Pink tritonia	*Tritonia diomedea*	8	69	84	60
Bat star	*Asterina miniata*	8	47	69	27
Spot prawn	*Pandalus platyceros*	7	177	220	93
Light edged ribbon worm	*Cerebratulus californiensis*	7	189	337	62
Northern staghorn bryozoan	*Heteropora pacifica*	6	29	30	26
Bat star/red star complex	*Asterina miniata* or *Mediaster aequalis*	6	48	58	45
Dawson's sun star	*Solaster dawsoni*	6	52	61	48
White-spotted rose anemone	*Urticina lofotensis*	5	57	69	45
Cancer complex	*Cancer sp.*	5	70	86	39
Puget Sound king crab	*Lopholithodes mandtii*	5	57	67	36
UI boot sponge	Unidentified boot sponge	5	65	71	54
Red rock crab	*Cancer productus*	4	63	67	58
UI crab	Unidentified crab	4	107	273	43
UI salp	Unidentified salp	3	75	84	60
Stubby rose anemone	*Urticina coriacea*	2	51	52	50
Noble sea lemon	*Peltodoris nobilis*	2	47	50	44
Swimming nudibranch	*Dendronotus iris*	2	59	62	57
Rock scallop	*Crassedoma giganteum*	2	59	67	51
Crested sea star	*Lophaster furcilliger*	2	83	83	83
Clown nudibranch	*Triopha catalinae*	1	48	48	48
Striped nudibranch	*Armina californica*	1	59	59	59
UI trumpet sponge	Unidentified trumpet sponge	1	52	52	52
Giant spined star	*Pisaster giganteus*	1	13	13	13
Pisaster complex	*Pisaster sp.*	1	45	45	45
Rose star	*Crossaster papposus*	1	185	185	185
	Total:	***124,064***			

BASELINE CHARACTERIZATION OF STUDY AREAS

The following MPA and reference area characterizations are abbreviated descriptions which include key findings for both the 2014 and 2015 survey years combined. In-depth characterizations for each MPA and reference pair are presented in Appendix 3.

Point St. George Reef Offshore SMCA and Reference Area

Located northeast of Crescent City, California, the Point St. George Reef Offshore State Marine Conservation Area (PSG SMCA) protects 24.7 square kilometers of marine habitats with depths ranging from 55 to 125 m (CDFW 2016b). The MPA is predominantly soft habitat (96%), but also protects the tip of a large offshore rocky reef (Figure 4). All fishing is prohibited within the SMCA with the exceptions of salmon by trolling and Dungeness crab by trapping. In addition to these exceptions, two federally recognized tribes, Elk Valley Rancheria and Tolowa Dee-ni' Nation, are exempt from the area and take regulations of the PSG SMCA, but still must comply with all other existing regulations, including the Rockfish Conservation Areas, which have prohibited the take of groundfish in depths exceeding 20 fathoms (~37 m) since 2002.

Located 6.3 km southeast of the PSG SMCA, a rocky reef and the surrounding soft bottom habitats were selected as a reference area for comparison (Figure 4). The reference area was selected based on similar habitats and depths (determined from multibeam mapping imagery) as inside its corresponding MPA. There are no state regulations specific to the reference area, but federal regulations prohibit the take of groundfish as part of the Rockfish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMCA.

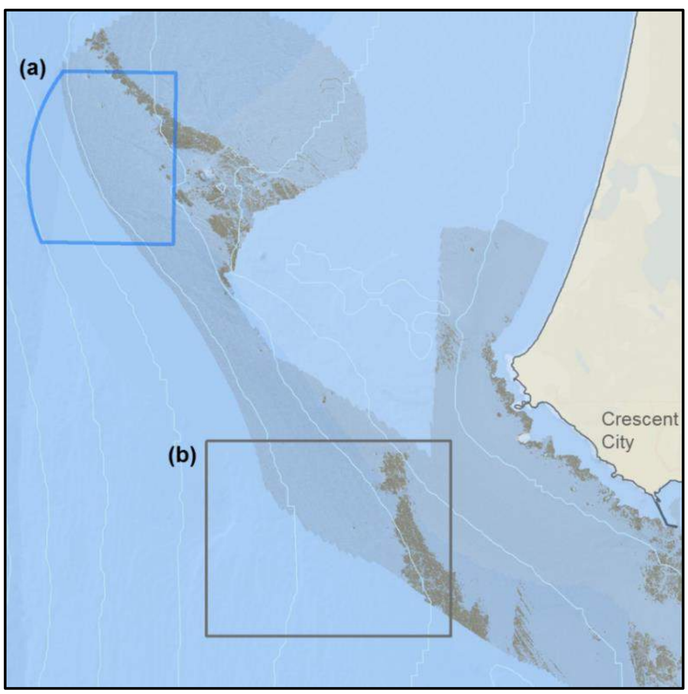


Figure 4. Point St. George study area showing the rocky reef and surrounding soft bottom habitats in (a) the SMCA and (b) reference area.

Substrate

Inside the SMCA and reference area, transects that targeted the rocky reef were primarily composed of rock and mud, while soft bottom transects were mainly composed of mud (Figure 5). Rocky reef habitats within both study areas were heavily influenced by sedimentation. Fine particulate material was suspended a few meters off the sea floor, and covered both rock and soft bottom surfaces in a thick layer of fine sediment and detritus. Only the vertical surfaces or tops of the highest relief rock outcroppings were free of these deposits. The density of suspended material was dependent on ocean conditions. Sampling at the reference site in 2015 was halted when large ocean swells moved into the study location causing visibility to decrease from a few meters to zero overnight. Future monitoring of the Point St. George study areas may encounter similar conditions.

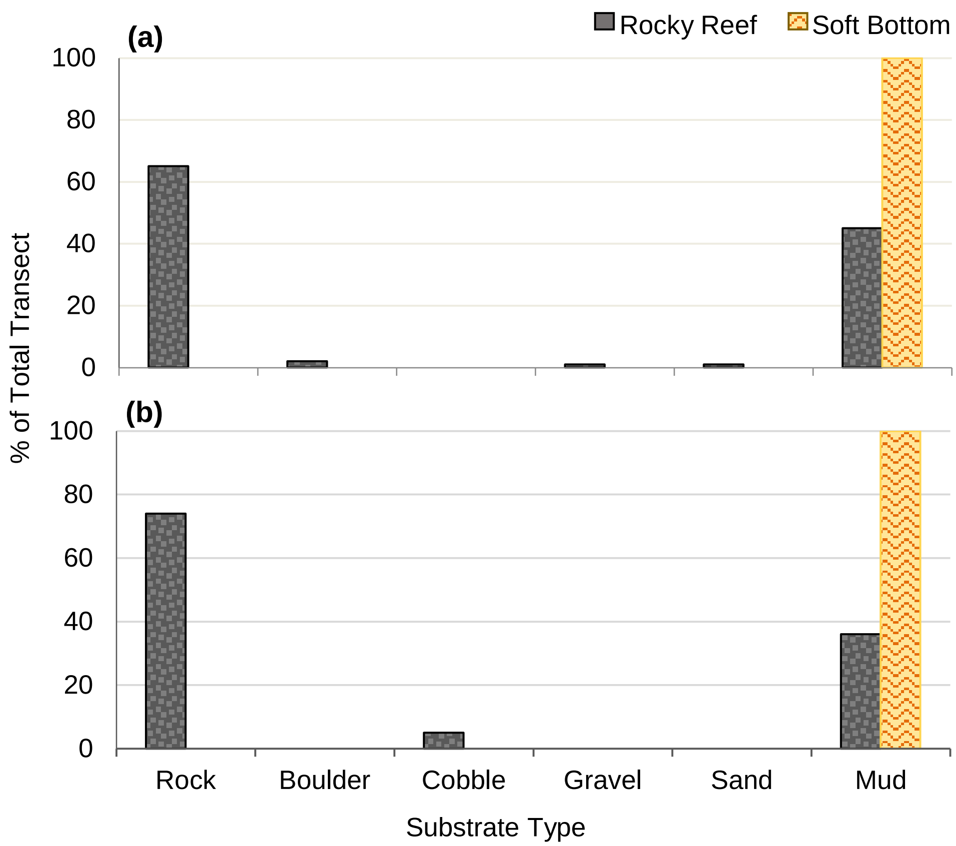


Figure 5. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef and soft bottom) for survey lines inside the (a) Point St. George SMCA and (b) reference area.

Habitat

Overall, inside the SMCA and reference area, the habitat and rugosity within both rocky reef and soft bottom transects were comparable (Figure 6). Within the rocky reef, both study areas were mainly composed of hard and soft habitats, which combined represented 89% of the habitat at the SMR and 86% at the reference area. Outside the rocky reef transects targeting soft bottom habitats within the SMR and reference area were classified as 100% soft habitat.

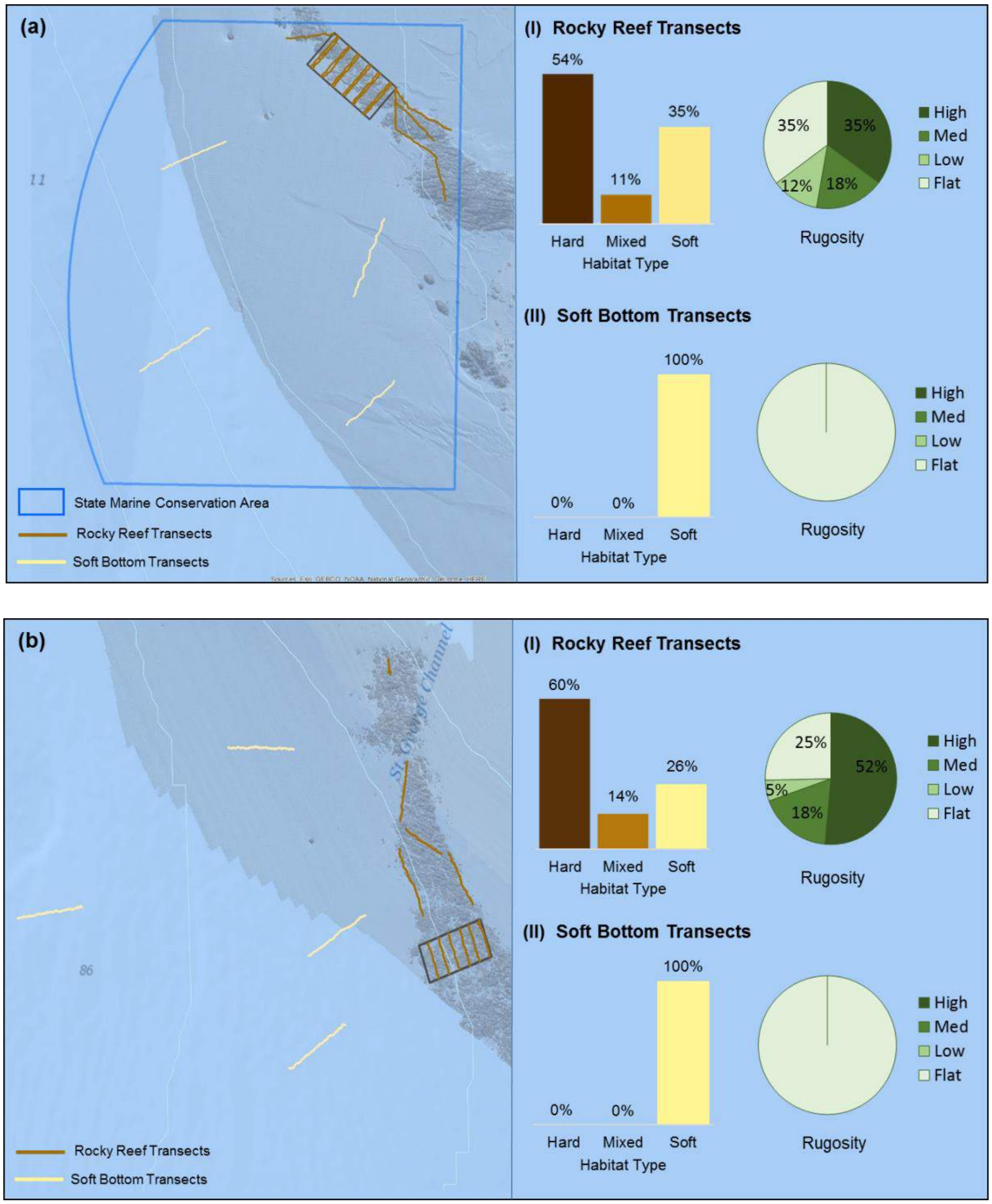


Figure 6. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Point St. George Reef Offshore SMCA and (b) reference area for transect lines targeting: (I) the rocky reef and (II) the soft bottom habitats.

Fish

The rocky reef of both study areas was characterized by rockfish species, Lingcod and Kelp Greenling (Figure 7). Rockfish densities were approximately three times lower in the rocky reef of the reference area, when compared to the SMCA. In addition, observed rockfish species richness was lower inside the reference area. The majority of rockfish identified within both study areas were epibenthic aggregating species such as Black, Blue and Olive/Yellowtail Rockfish, which were observed in large numbers near the tops of high relief rocky outcroppings. Canary Rockfish, a semi-aggregating species, were observed in high densities near the bottom, especially around sand channels within the rocky reef. Yelloweye and Quillback Rockfish were also common, with the highest regional rocky reef density of both species occurring at these two study areas. Yelloweye Rockfish densities within the SMCA were two times higher than observed anywhere else during this project. Soft bottom habitats were dominated by few species compared to rocky habitats, with flatfish and unidentified eel pouts being characteristic of both areas.

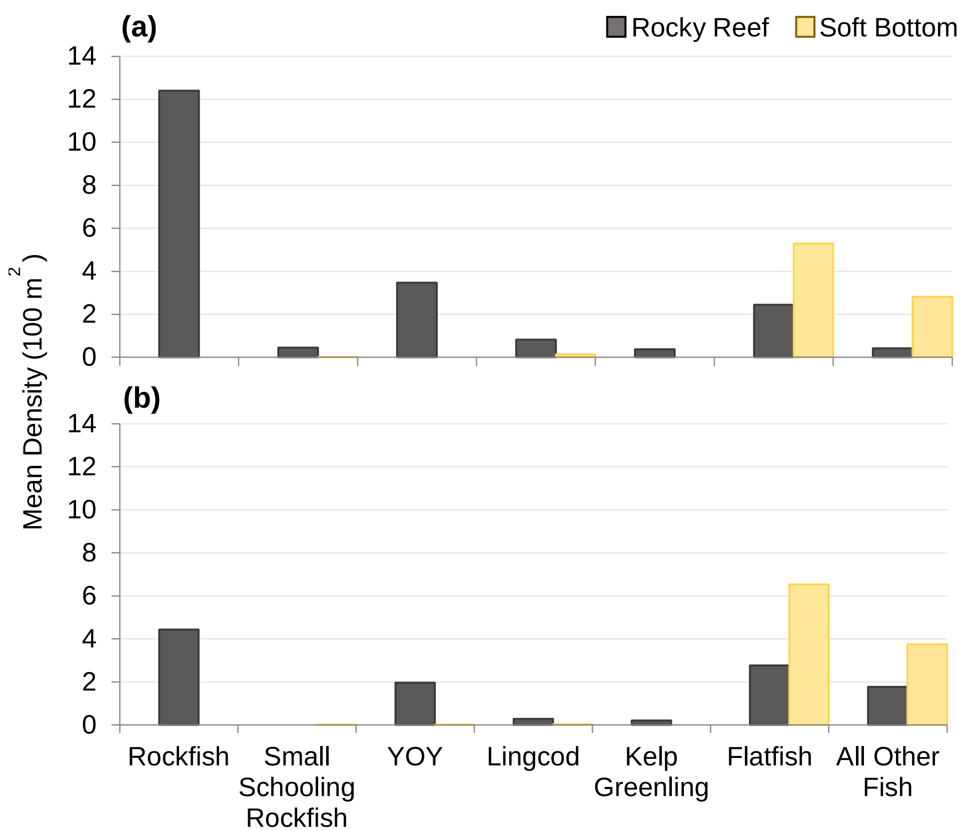


Figure 7. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Point St. George SMCA and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

Invertebrates

Invertebrate species composition within rocky reef habitats of both study areas was similar (Figure 8). Five macro-invertebrate species dominated observations within the rocky reef of both the SMCA and reference area: white-plumed anemones, slipper sea cucumbers, California sea cucumbers, short red gorgonians and red sea stars. While not characteristic of both study areas, basket stars were also common within the rocky reef of the SMCA.

Soft bottom habitats were dominated by few species compared to rocky habitats (Figure 8). Dungeness crabs and red octopus were characteristic of both study areas accounting for over 80% of the total mobile invertebrate density. While, two groups, sea whips and pens, and white-plumed anemones accounted for 97% of the total sessile invertebrate density.

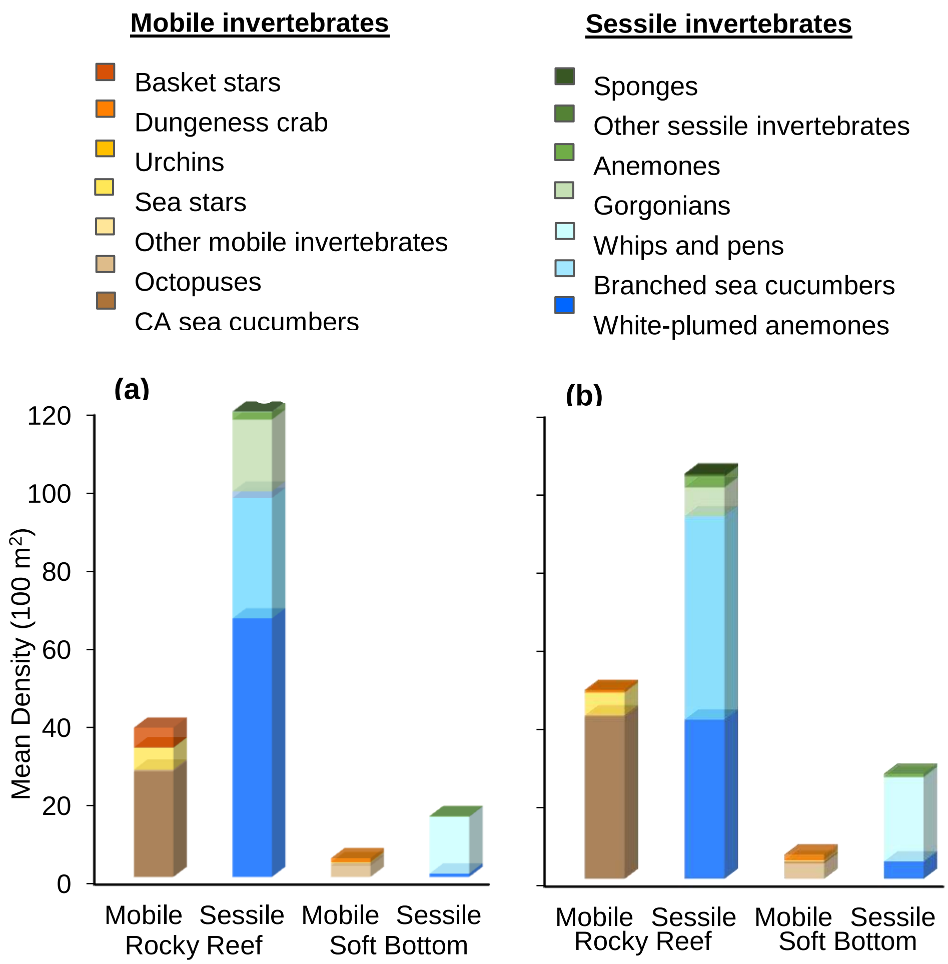


Figure 8. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside (a) Point St. George SMCA and (b) reference area. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

Reading Rock SMR and Reference Area

Reading Rock State Marine Reserve (SMR) is located just south of Reading Rock approximately 8 kilometers off the coast of Prairie Creek Redwoods State Park, in Humboldt County, CA (Figure 9). The SMR encompasses approximately 25 square kilometers of sea floor with depths ranging from 44 m to 77 m. It is mainly comprised of soft bottom habitats (98%), but also includes a small portion of rocky reef habitat (2%) that encompasses Reading Rock, but does not include the above-surface visible portion of the rock (CDFW 2016c).

The Reading Rock reference area is located 0.95 kilometers north of the Reading Rock SMR. The reference area was selected to encompass similar habitats and depths (determined from multibeam mapping imagery) as those found within the MPA. There are no state regulations specific to the reference area, but federal regulations prohibit commercial or recreational the take of groundfish as part of the Rockfish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMR.

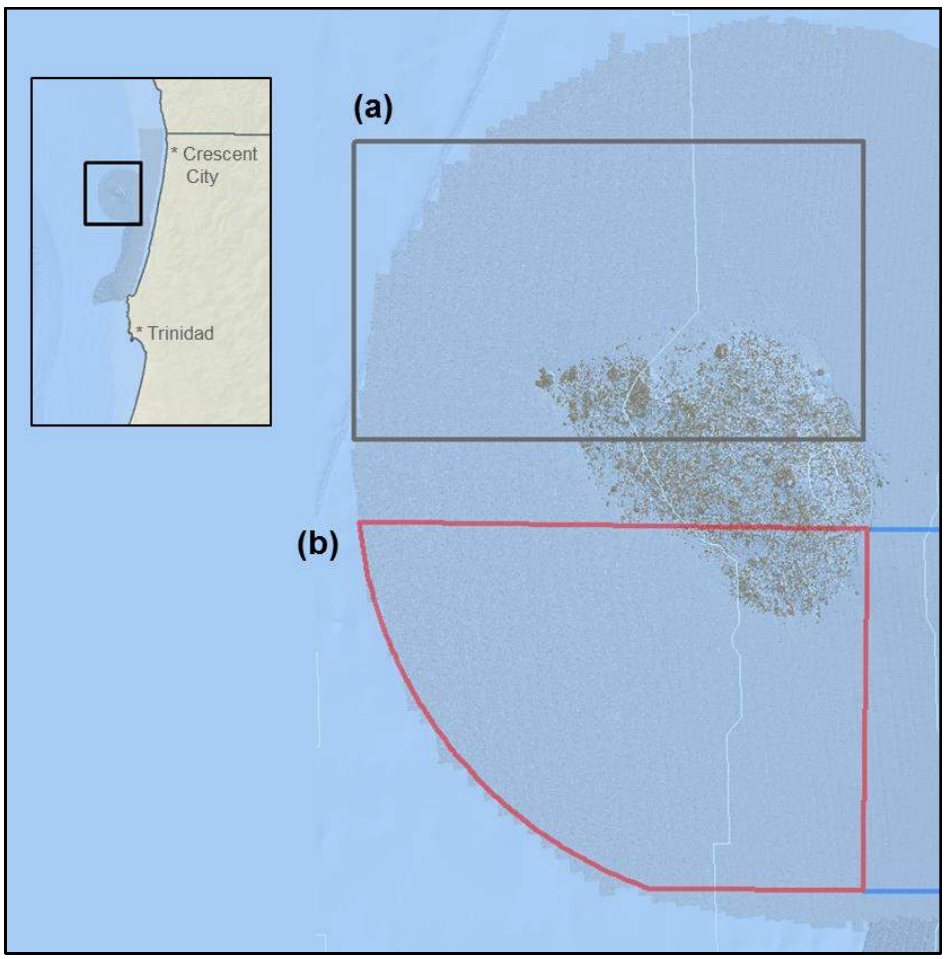


Figure 9. Reading Rock study location showing rocky reef and soft bottom habitats in (a) the reference area and (b) SMR.

Substrate

Inside the SMR and reference area, transects that targeted the rocky reef were composed of all 6 substrate types (Figure 10). However, the reference area contained greater amounts of boulder, cobble and gravel at the transitional portions of the rocky reef than the SMR. Transects targeting soft bottom habitats within the SMR and reference area were entirely composed of mud substrate.

During both survey years, there was better visibility at the reference area than inside the SMR. Visibility at the SMR ranged from 1 to 1.5 m, while at the reference area it ranged from 2 to 2.5 m. In addition, rocky substrates observed within the reference area were less sediment impacted than those within the SMR. These observations may indicate that the reference area, located on the north side of the rocky reef, may be subject to heavy currents and/or storm surges that carry away loose sediment and detritus which is deposited on the southern side of the reef in the SMR.

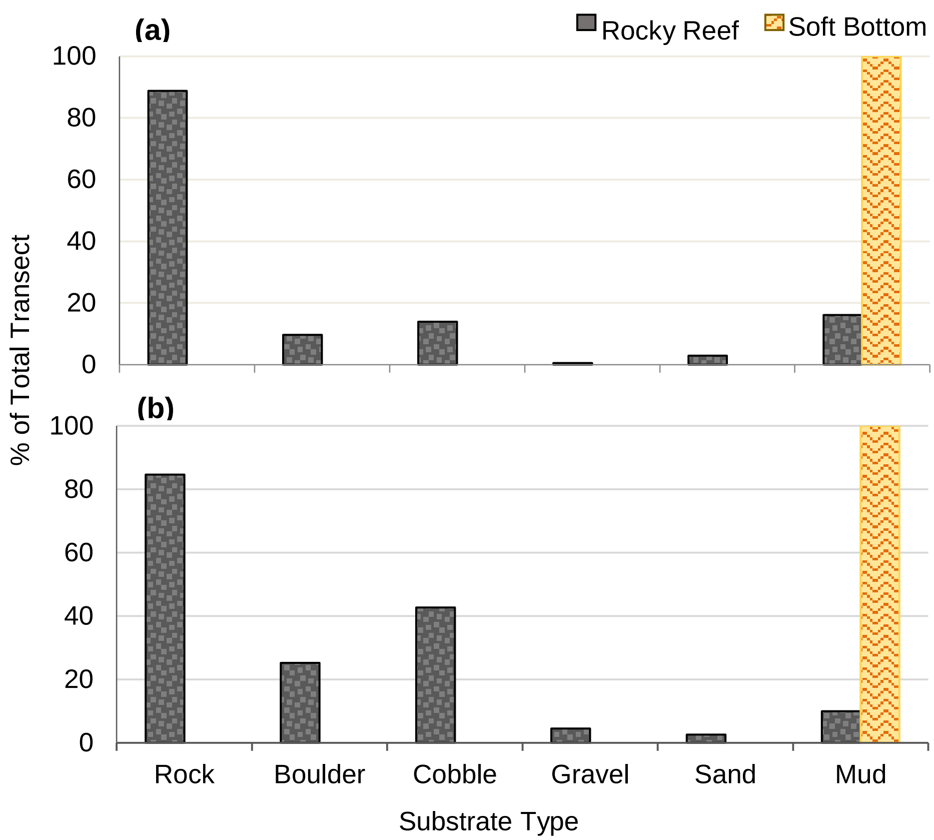


Figure 10. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef and soft bottom) for survey lines inside the Reading Rock SMR and (b) refernce area.

Habitat

Overall, inside the SMCA and reference area, the habitat and rugosity within both rocky reef and soft bottom transects were comparable (Figure 11). Rocky reef transects within the SMR and reference areas were predominantly hard and mixed habitat combined, while soft bottom transects within the SMR and reference area were classified as 100% soft habitat.

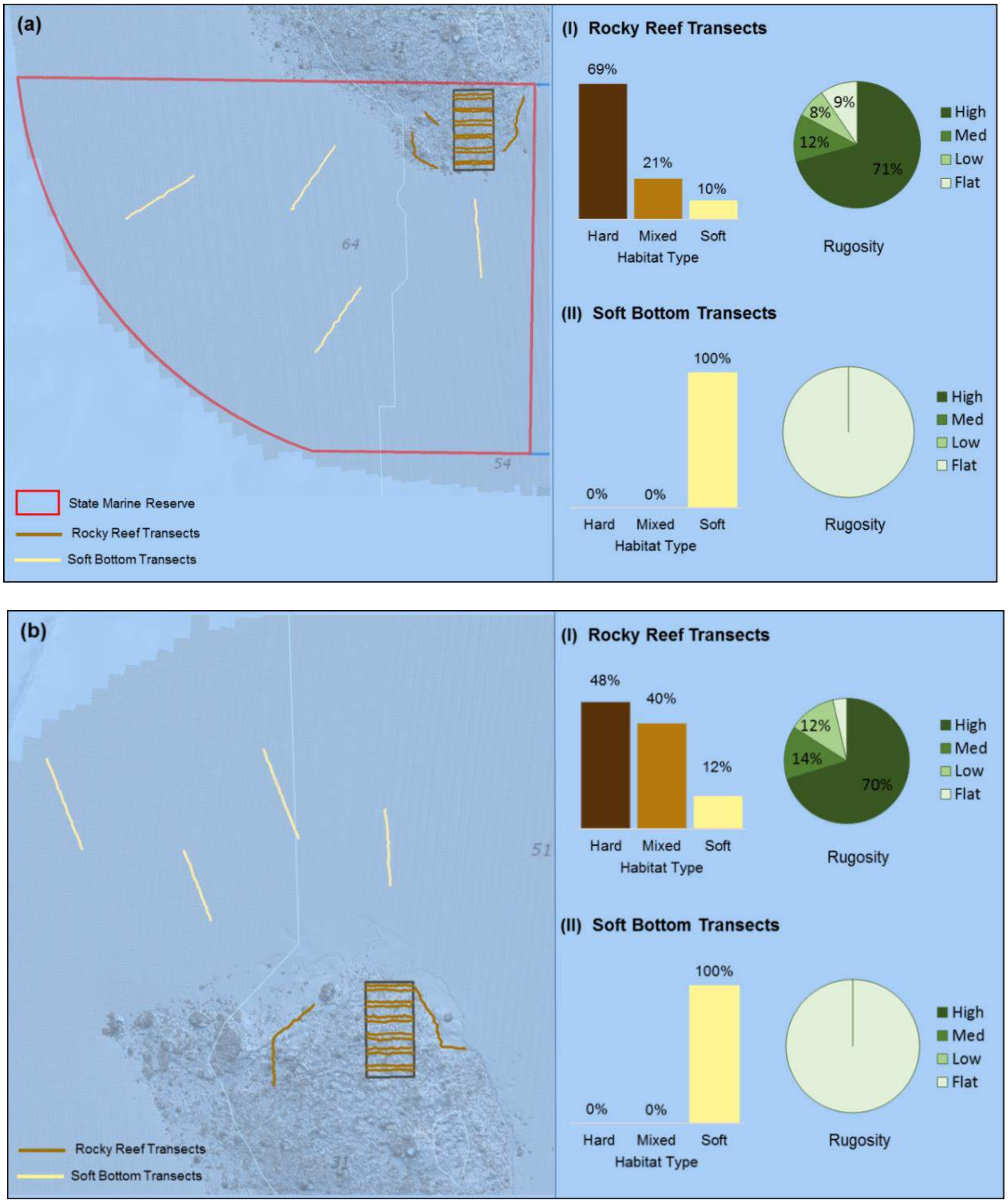


Figure 11. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Reading Rock SMR and (b) reference area, for transect lines targeting (I) rocky reef and (II) soft bottom habitats.

Fish

Fish species composition between the two study areas was similar. Rockfish species, Lingcod and Kelp Greenling characterized the rocky reef, even though their densities were quite low (Figure 12). Five species/groupings of rockfish accounted for 76% of the overall rockfish subgrouping density in the SMR, and over 65% in the reference area: unidentified rockfish, Olive/Yellowtail, Black, Blue, and Canary Rockfish. The epibenthic aggregating species including Blue Rockfish and Olive/Yellowtail Rockfish were commonly observed schooling around the tops of larger rock outcroppings. Another semi-aggregating species, the Canary Rockfish, was observed schooling near the sea floor close to the transition from soft bottom to rocky reef. Canary Rockfish were also observed within the rocky reef itself, but in lower numbers. Additional benthic rockfish species, such as Yelloweye Rockfish, Quillback Rockfish, Vermilion Rockfish and Rosy Rockfish, were observed intermixed throughout the rocky reef in both study areas.

Surveys of soft bottom habitat were primarily dominated by flatfish and the ‘all other fish’ subgroup, of which unidentified smelt represented over 98% of the observations within both study areas. Smelt may be characteristic of the soft bottom habitats surrounding Reading Rock and are known to spawn on the nearby beaches.

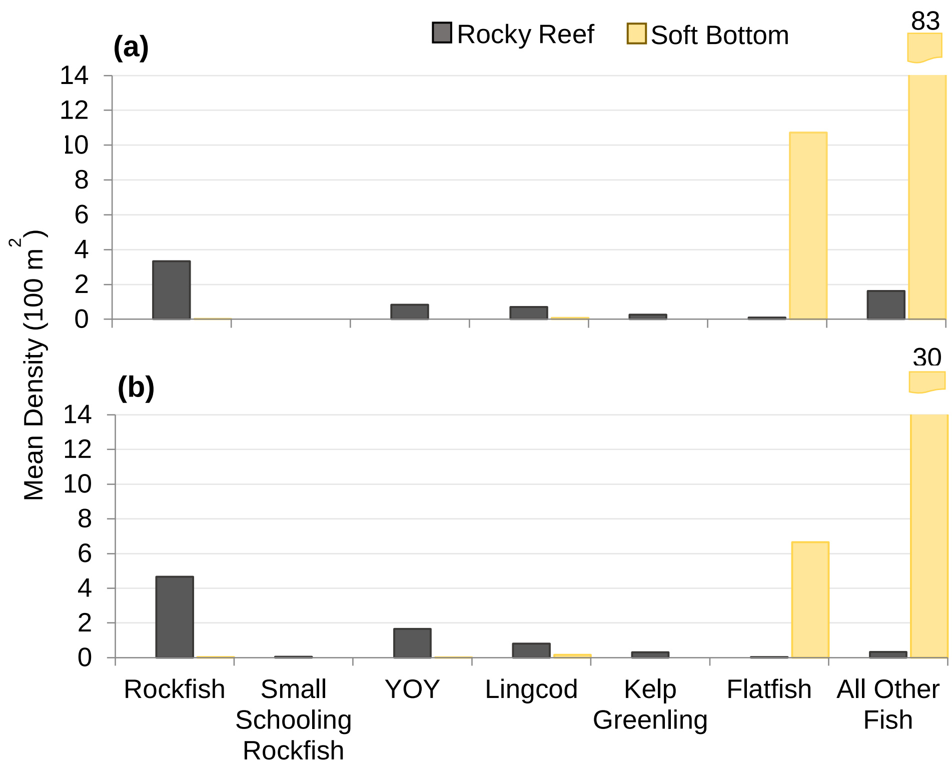


Figure 12. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Reading Rock SMR and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

Invertebrates

There were approximately 2.7 times as many invertebrates enumerated at the reference area as the SMR, however species composition was similar within both study areas (Figure 13). Within both areas, five macro-invertebrate species/groupings characterized the rocky reef: slipper sea cucumber, white-plumed anemone, California sea cucumber, red sea star and the *Henricia* sea star complex.

Soft bottom habitats at the SMR and reference area were also characterized by few species. Sea whips and pens, and white-plumed anemones were the dominant sessile invertebrates, accounting for over 99% of the total sessile invertebrate density in soft bottom habitats at both areas. While no rocky substrates were observed on soft bottom transects, it is possible that cobble or large shell debris are buried just beneath the surface of the mud, providing attachment structure for the white-plumed anemones. The dominant mobile invertebrates included red octopus and *Pleurobranchaea californica,* which occurred in similar densities at both study areas. Sand stars were also common, but were three times as numerous at the reference area as the SMR.

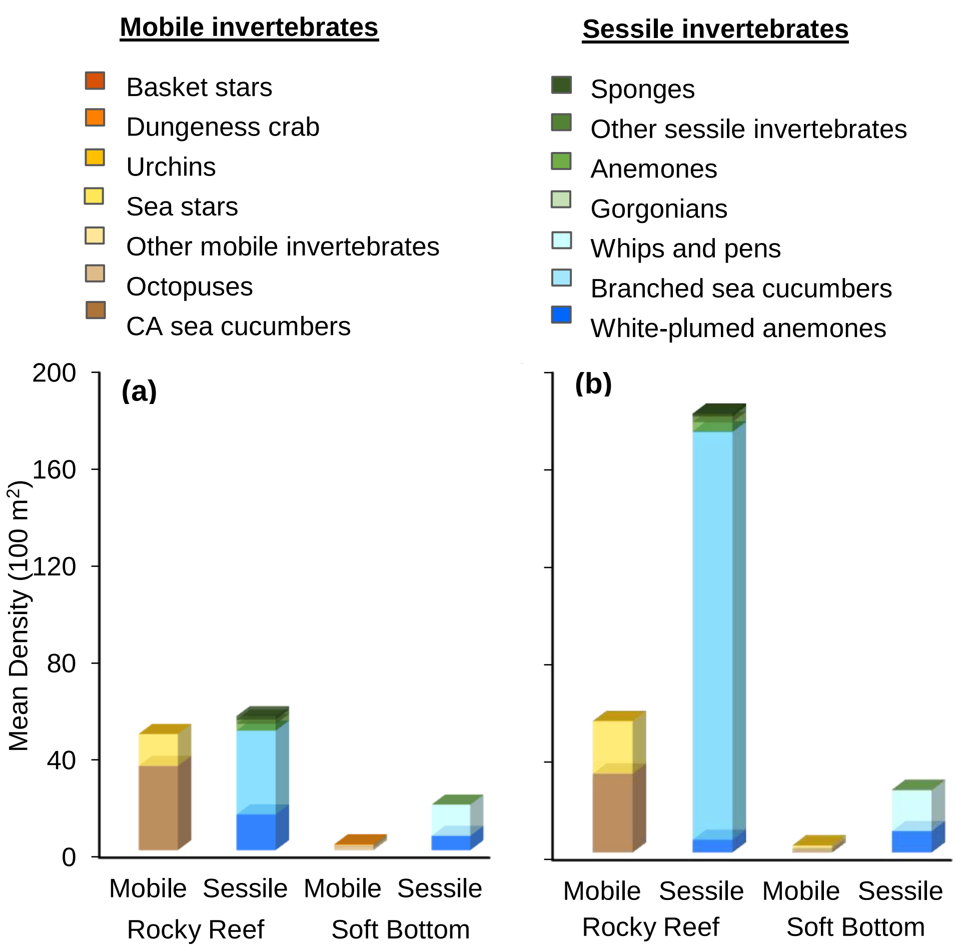


Figure 13. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside (a) Reading Rock SMR and (b) reference area. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

Mattole Canyon SMR and Reference Area

Mattole Canyon State Marine Reserve is located offshore of the Mattole River estuary and California's Lost Coast region, a portion of California's North Coast that is sparsely populated with limited coastal access (Figure 14). Mattole Canyon SMR protects 25.4 square kilometers of marine habitats ranges in depth from 25 m to 502 m (CDFW 2016a). The SMR is predominately soft habitat (94%), but it also includes several rocky habitats (6%). Approximately 14% of the area of the SMR is deep submarine canyons, which makes it unlike any other MPA we surveyed within the NCSR.

The Mattole Canyon reference area is located just 0.3 kilometers south of Mattole Canyon SMR and includes a portion of the same rocky reef structure (Figure 14). The reference area was selected to encompass similar habitats and depths (determined from multibeam mapping imagery) as those found within the MPA. There are no state regulations specific to the reference area, but federal regulations prohibit the take of groundfish as part of the Rock Fish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMR.

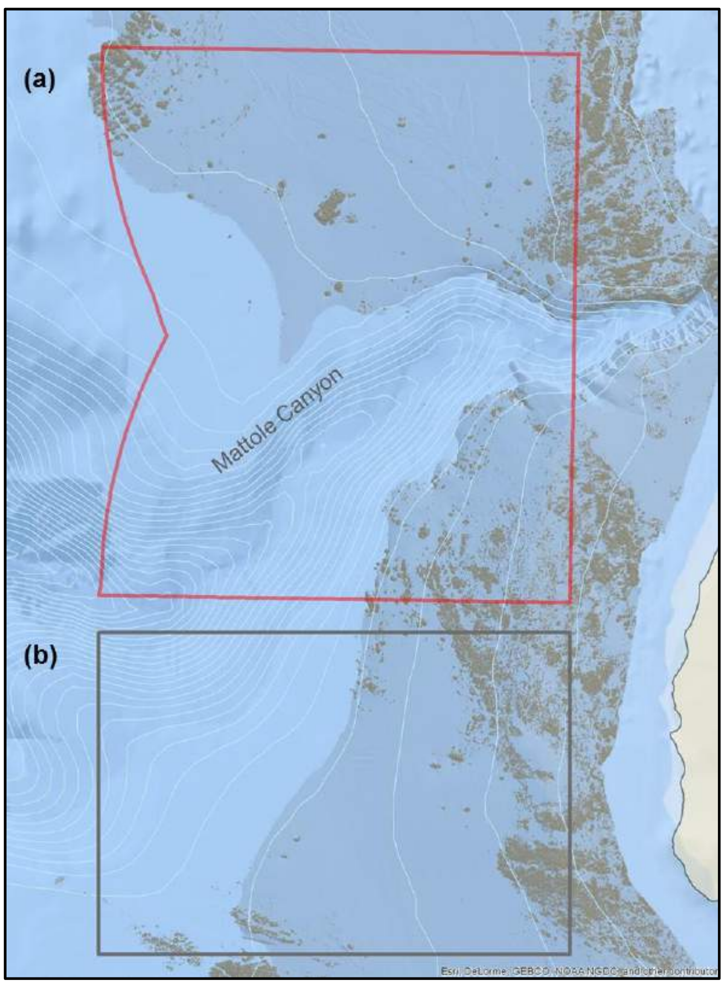


Figure 14. Mattole Canyon study area showing the rocky reef and surrounding soft bottom habitats in (a) the SMR and (b) reference area.

Substrate

Within both study areas, transects targeting the rocky reef were similar, and were primarily composed of rock with sand and mud (Figure 15). Transects that targeted the canyon were also similar, and were mainly composed of mud with smaller amounts of rock and cobble depending on the study area. In contrast, soft bottom habitats in the two areas were distinctly different. The SMR had large amounts of scattered exposed rocky patches, creating mixed habitats unlike any other soft bottom area we surveyed regionally, including the reference area which was mainly composed of sand.

Strong currents and large swells were common during our surveys of this location, along with strong afternoon winds and seas. These currents appeared to be characteristic of the area, as evident by the large, deep scour depressions around rock outcroppings and near the transitions between soft bottom and rocky reef. Dives targeting the canyon wall were difficult to complete due to the strong currents that swept across the shelf and accelerated down into the canyon. On the canyon floor we observed currents flushing organic materials out into deeper waters. Weather conditions changed rapidly and were not always consistent with predicted weather reports, making it a difficult location to sample. The typical work day for Mattole Canyon was short, requiring additional days beyond what was planned for this study location.

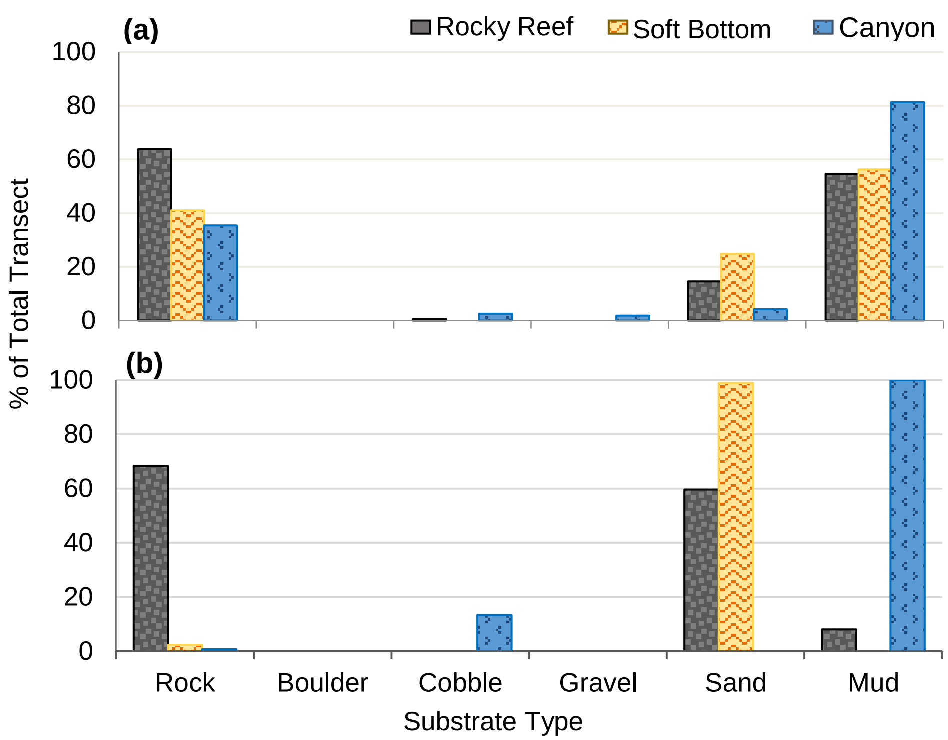


Figure 15. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef, soft bottom and canyon) for survey lines inside (a) Mattole Canyon SMR and (b) refernce area.

Habitat

Inside the SMR and reference area, transects targeting the rocky reef were composed of nearly equal parts of hard, mixed and soft habitats and were similar in rugosity (Figure 16). However, transects targeting soft bottom and canyon transects at the two study areas were not similar. In the SMR, both transect types were mainly composed of soft habitats with smaller amounts of mixed and hard habitats. Whereas, at the reference area, both transect types were almost exclusively soft only habitat.

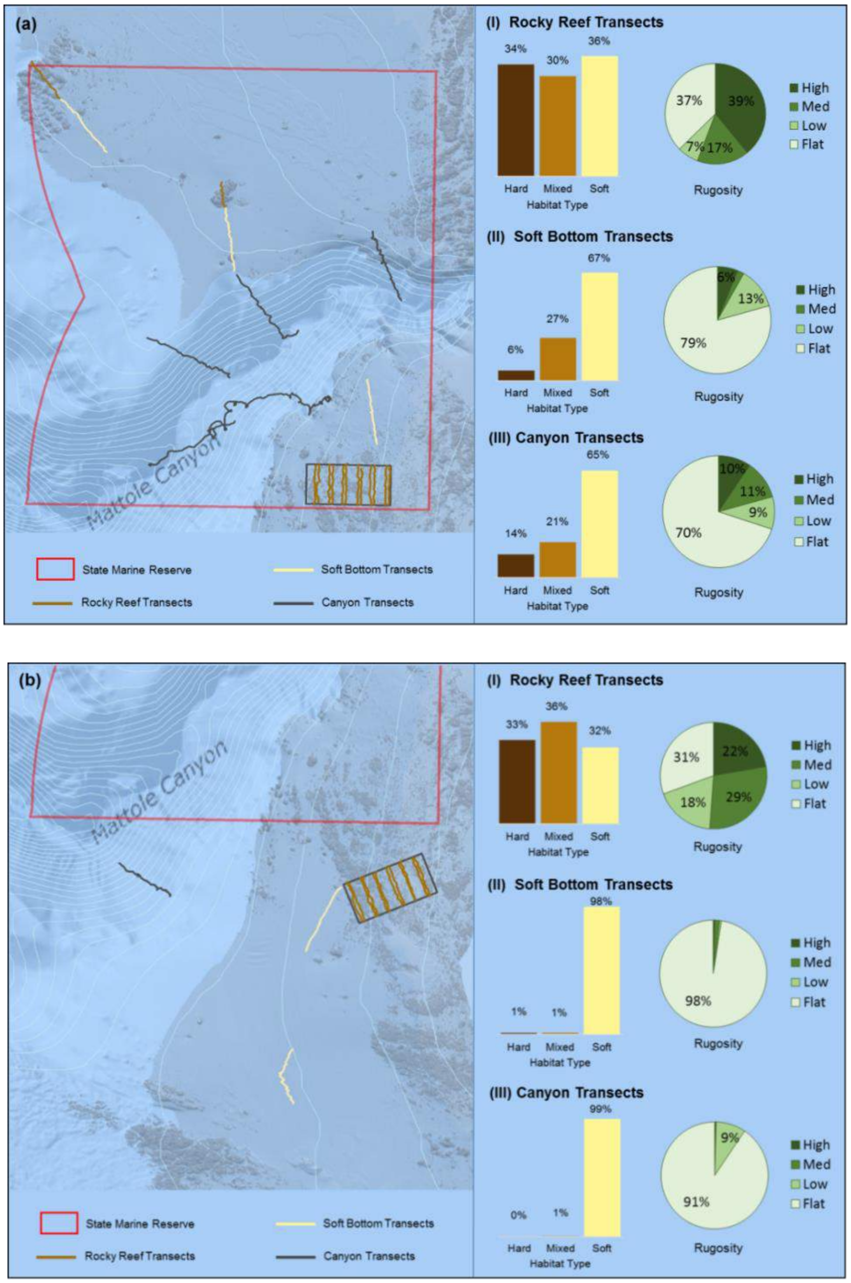


Figure 16. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Mattole Canyon SMR (b) reference area for transects lines targeting: (I) the rocky reef, (II) soft bottom and (III) canyon habitats.

Fish

Fish species composition on rocky reef transects was similar in both study areas (Figure 17). YOY was the most abundant subgrouping and accounting for half of the total fish density at both areas. While, the same species of aggregating rockfish: Blue, Black, Canary, Widow and Olive/Yellowtail Rockfishes accounted for 75% and 85% of the rockfish observations in the reference area and SMR respectively.

Transects targeting soft bottom habitats inside the SMR had the highest observed densities of rockfish, compared to all other study areas and habitat types. YOY rockfish densities were also 1.7 times higher than any other study area surveyed. Shortbelly Rockfish accounted for the majority of the small schooling rockfish observations in both study areas, but were twice as abundant in the reference area than the SMR.

At the SMR, Sablefish and skates were commonly observed on dives that targeted the canyon floor. Moving up the sides of the canyon, rock outcroppings and compacted sediment shelves broke up the otherwise steep walls of the canyon where thornyheads, Greenstriped Rockfish and flatfish species were common. Just below the transitional point between the flat shelf and canyon, Canary, Olive/Yellowtail and Yelloweye Rockfishes were found sheltering from stronger currents above. Only one canyon dive was completed in the reference area. The slope of the canyon wall was considerably less steep, and currents there were greatly reduced. Spiny Dogfish, flatfish and Pacific Hake were the most abundant fish.

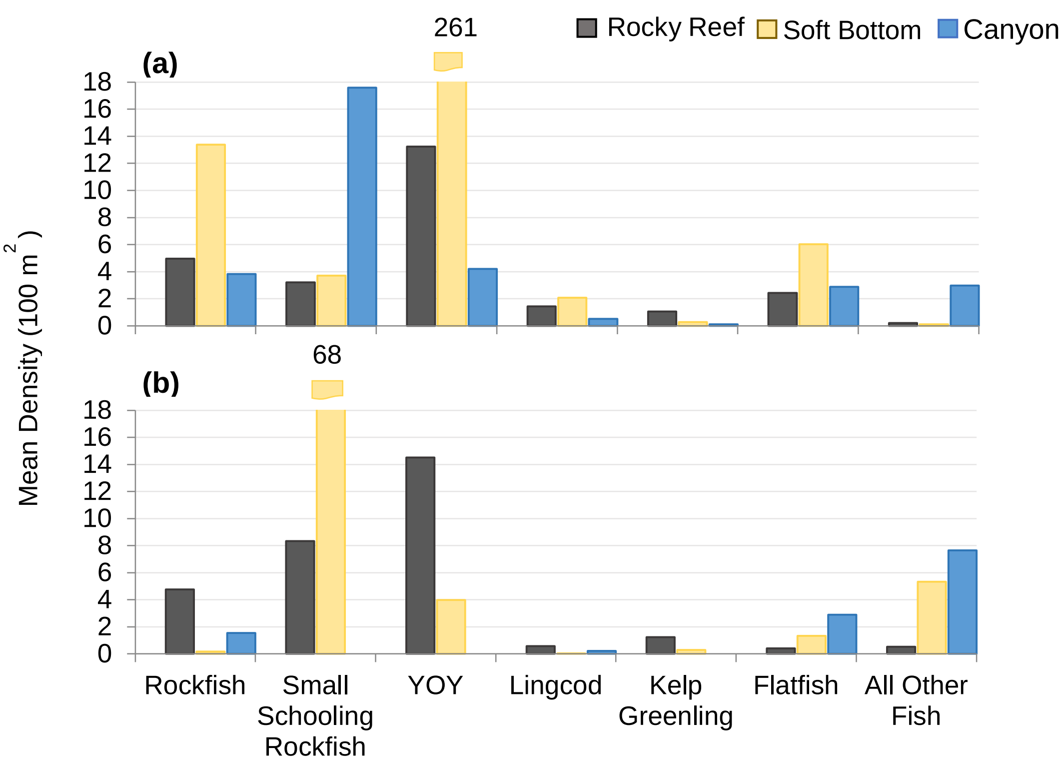


Figure 17. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Mattole Canyon SMR and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

Invertebrates

Invertebrate species composition within transects targeting the rocky reef of both study areas was similar (Figure 18). White-plumed anemones, California sea cucumbers, short red gorgonians and California hydrocorals were among the most abundant species observed at both areas. Sea star species and sponges were also common.

Species composition on transects targeting soft bottom habitats within the SMR and reference area were fairly different. This was likely due to the differences in substrate composition between the two areas, with the SMR having many scattered rocky patches that hosted a greater abundance and diversity of sea stars, anemones, sponges and other invertebrates than the reference area that was composed of only soft habitats.

The same was true for transect targeting the canyon, with the SMR having a greater number and abundance of species than the reference area. However, anemones, white plumed anemones and red octopus were common in both study areas.

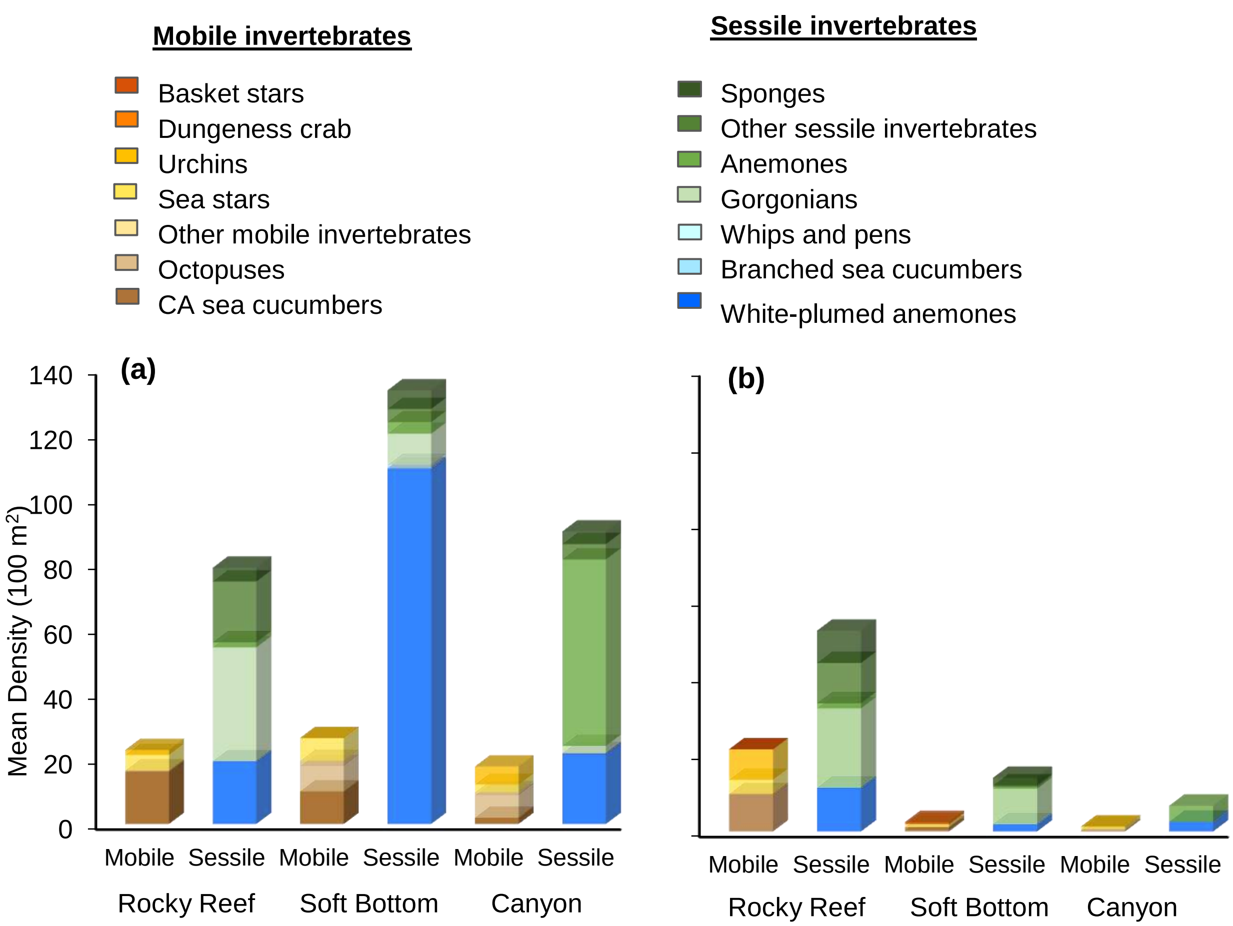


Figure 18. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside the (a) Mattole Canyon SMR and (b) reference area. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

Ten Mile State Marine Reserve and Reference Area

The Ten Mile State Marine Reserve (TM SMR) is located approximately 14.5 kilometers north of Fort Bragg, California, and encompasses 31 square kilometers of marine habitats (CDFW 2016d). The SMR spans 5 km of shoreline and shares its southern border with Ten Mile Beach State Marine Conservation Area. With depths ranging from 0 to 105 meters, the SMR is comprised of approximately 86% soft habitat, 8% rocky habitat and 6% unidentified habitat (Figure 19). The Ten Mile SMR was the only MPA we surveyed as part of the baseline program that previously was open to bottom fishing in its shallower waters prior to MPA implementation in 2014. Fishing deeper than 37 m was prohibited in 2002 through implementation of the Rockfish Conservation Areas by Pacific States Marine Fisheries Council.

Located 2.2 kilometers south of TM SMR, a rocky reef and surrounding soft bottom habitats were selected as the Ten Mile reference area for comparison (Figure 19). The reference area was selected based on similar habitats and depths (determined from multibeam mapping imagery) as inside its corresponding SMR. There are no state regulations specific to the reference area, but federal regulations prohibit the take of groundfish deeper than 37 m as part of the Rock Fish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMR.

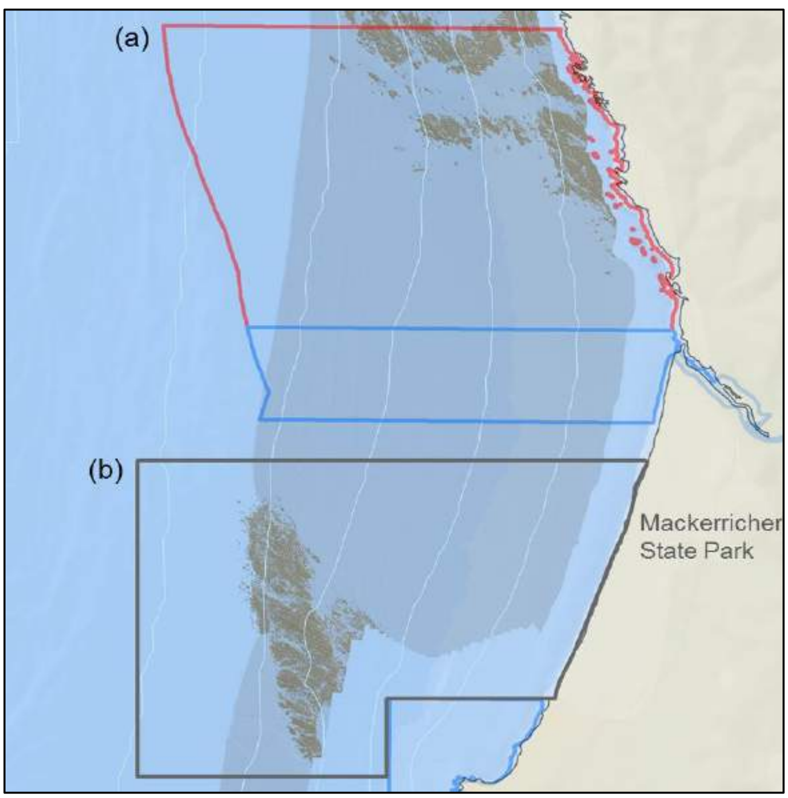
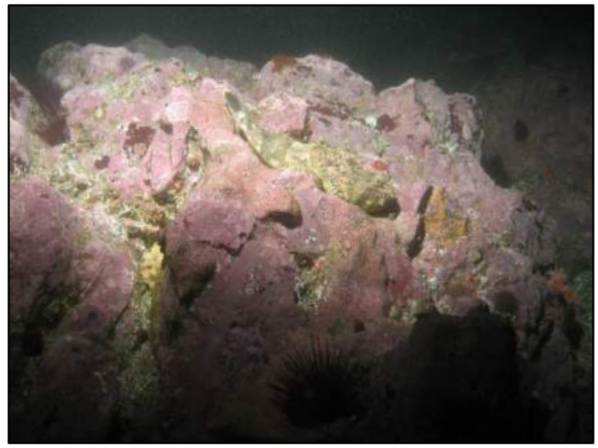


Figure 19. Ten Mile study location showing rocky and soft bottom habitats in (a) the SMR and (b) reference area.

Substrate



Overall, substrate composition at the SMR and reference area was similar (Figure 20). At both areas, transects that targeted the rocky reef were mainly composed of rock with smaller amounts of sand and mud. Rock surfaces had less sedimentation and detritus buildup than the two northernmost study locations. These cleaner rocky surfaces hosted encrusting coralline algae in the shallower portions of the rocky reef, which was not observed at any of the other study locations. We also observed less suspended fine particulate material, which may have accounted for the better water visibility, that was typically 4 to 6 m, compared to 1 to 3 m observed at other locations such as Point St. George. Transects that targeted the soft bottom were composed exclusively of sand or mud at both study areas.

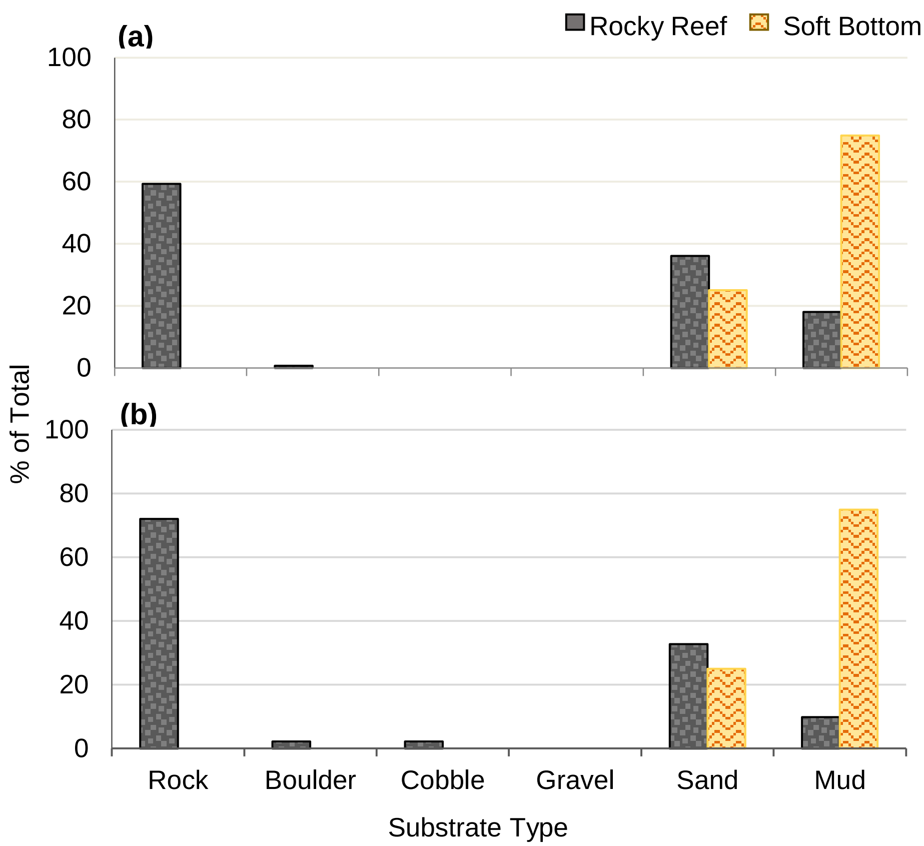


Figure 20. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef and soft bottom) for survey lines inside the (a) Ten Mile SMR and (b) reference area.

Habitat

Overall, inside the SMR and reference area, transects that targeted the rocky reef and soft bottom habitats and rugosity were comparible (Figure 21). Rocky reef transects within the SMR and reference areas were mainly composed of hard and soft habitats, which combined represented, 84% of the habitat at the SMR and 88% at the reference area. While soft bottom transects within the SMR and reference area were classified as 100% soft habitat.

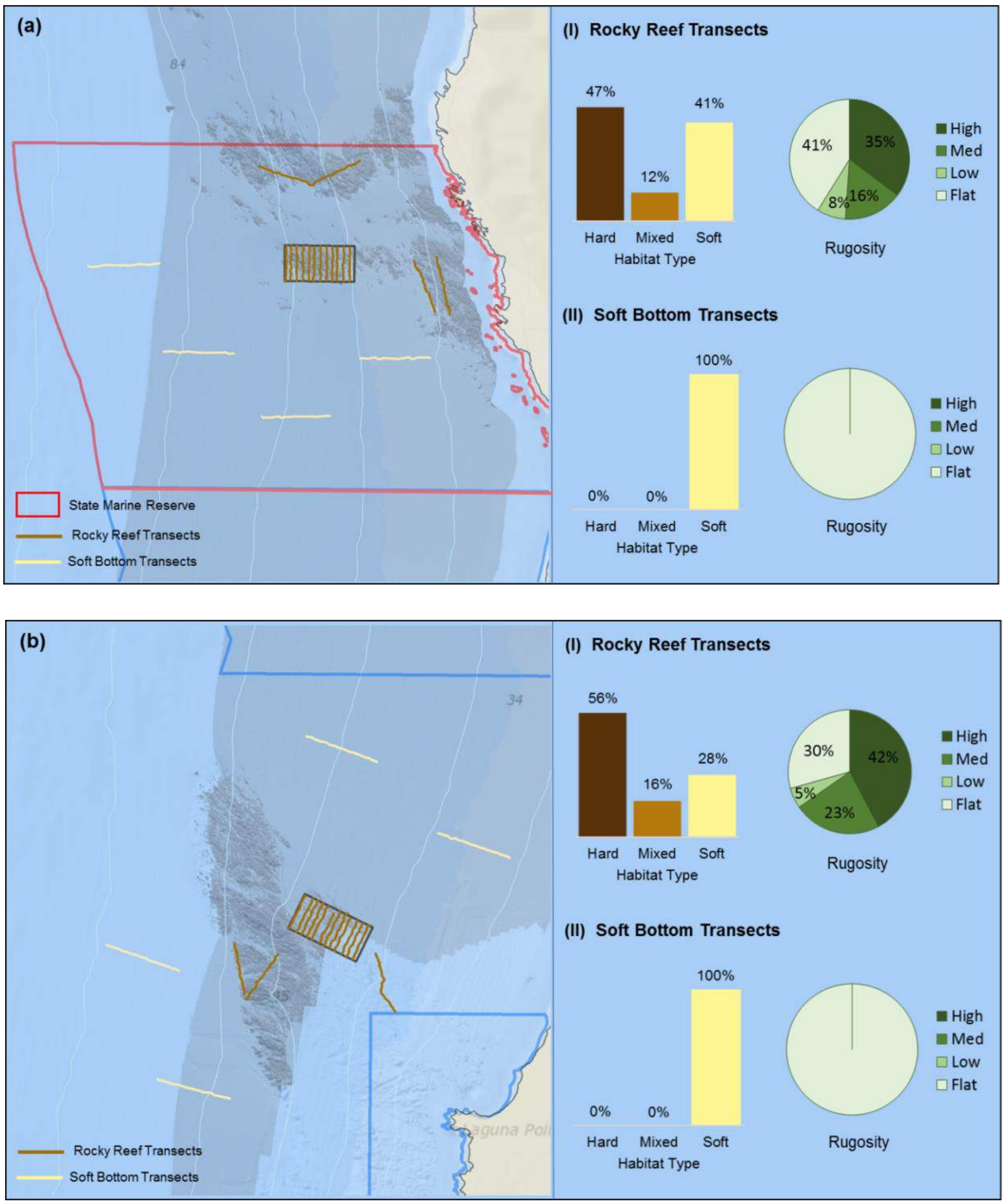
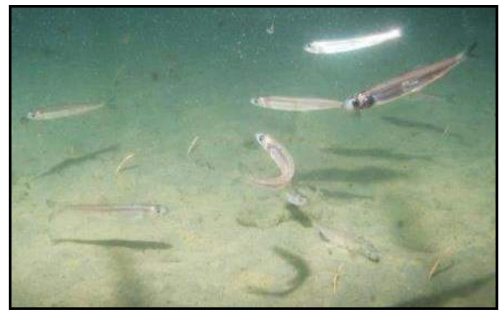


Figure 21. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Ten Mile SMR and (b) reference area, for transect lines targeting (I) the rocky reef and (II) the soft bottom habitats.

Fish

Fish species composition and abundance were similar within the SMR and reference area (Figure 22). Rockfish were common and, along with Lingcod and Kelp Greenling, characterized the rocky reef. Epibenthic aggregating rockfish species were the most abundant rockfish, with Blue, Canary and unidentified rockfish being the most common species at both study locations. YOY were also very common within the rocky reef, with densities higher than at any other study are pair.

Fish observed in the soft bottom habitats were similar within both study areas, and were mainly composed of flatfish and 'all other fish'. The 'all other fish' subgroup was most notably different between the two areas. Unidentified smelt were observed in large numbers at the reference area accounting for 90% of the 'all other fish' density, compared to only 18% within the SMCA.



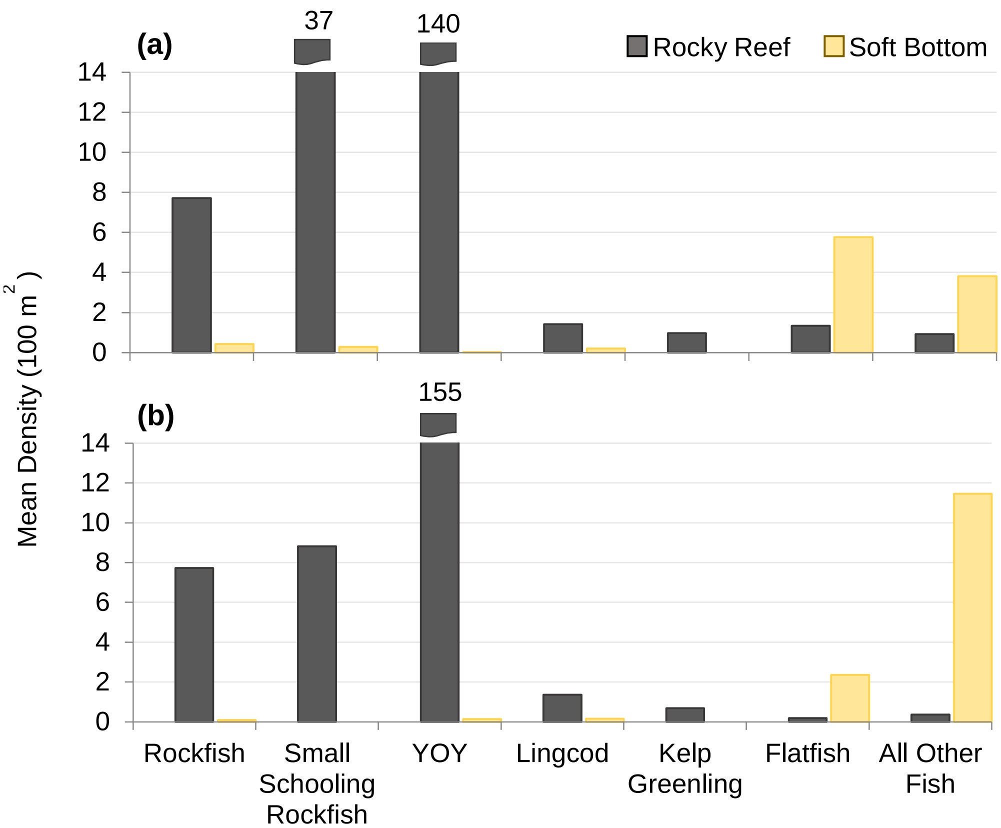


Figure 22. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Ten Mile SMR and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

Invertebrates

Invertebrate species composition within both the rocky reef and soft bottom habitats was similar between the two study areas (Figure 23). Within the rocky reef, like the northernmost two MPAs we studied, white-plumed anemones and slipper sea cucumbers were the characteristic sessile macro-invertebrates, while California sea cucumbers were the characteristic mobile invertebrate. However, unlike the northernmost MPAs, sponges and other anemones were also abundant in the rocky reef at the Ten Mile study location.

Within the SMR, red sea urchins were also observed in much higher densities than compared to the reference area. The higher urchin observations are likely a result of the shallower depths surveyed at the SMR, compared to the reference area, where very few red urchins were observed.

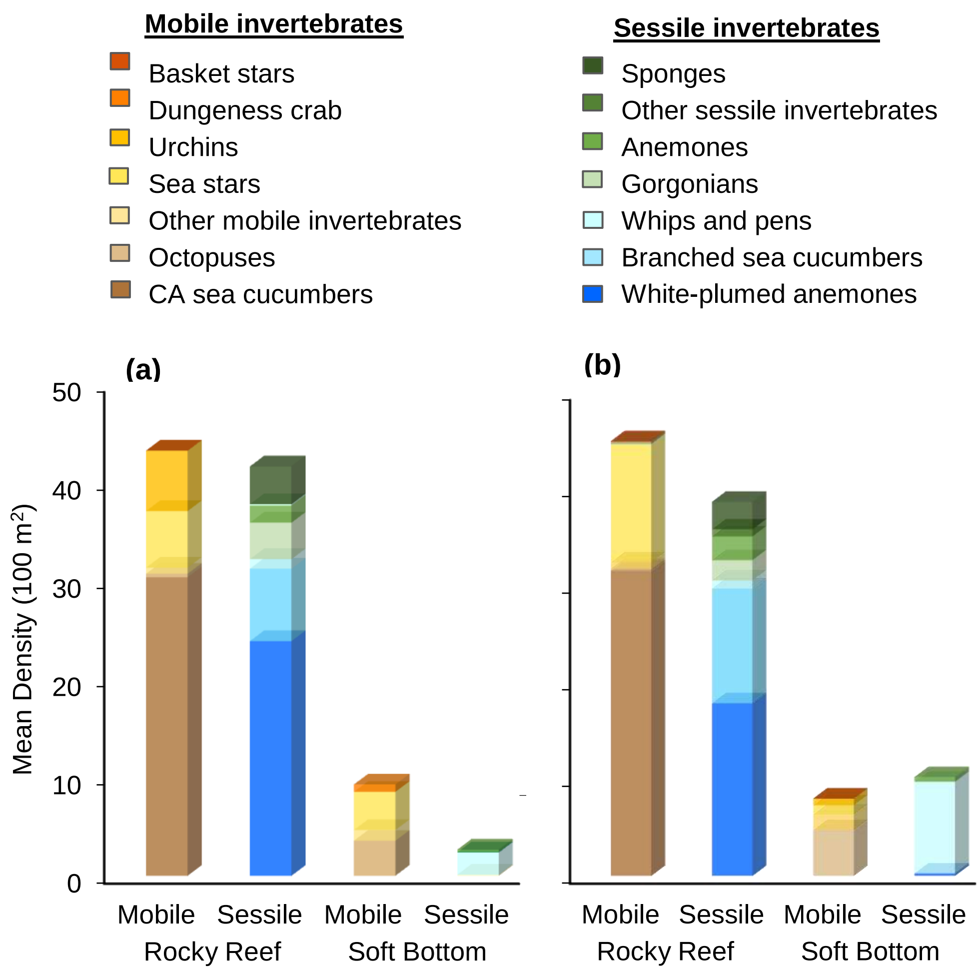


Figure 23. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside the (a) Ten Mile SMR and (b) reference area. For a breakdown of the taxonomic composition of subgroups, see Appendix 3.

ANALYSIS OF INDEX SITES

Fish species distribution and abundance are important considerations for MPA placement; they influence their effectiveness and are characteristics used to assess MPA performance. We used visual species observations directed at paired index sites to establish nearshore rocky reef fish assemblage metrics. These metrics can be monitored over time to inform performance assessment and adaptive management. The paired index sites where chosen to be representative of the general rocky reef habitat at each of the four locations (Point St. George, Reading Rock, Mattole Canyon and Ten Mile), inside the MPAs and outside of the MPAs in their respective reference areas. Ten rocky reef fish species/groupings were selected for in-depth density analyses to establish baseline metrics for future comparisons (Table 4).

Table 4. Number of observations and mean density at all index sites per 100 m^2 (±SE) for ten fish species selected for statistical comparisons among MPAs and their respective reference areas. Proportion of obs. is the proportion of non-YOY observations in the index sites only. Frequency of observation (FO) is the proportion of ROV transects in index sites in which the species occurred at least once.

Species	Total Observations	Overall Mean Density (no. 100 m-2) ±SE	Porportion of observations	FO (% of transects observed)
Black Rockfish	205	0.25 + 0.07	1.5	31
Blue Rockfish	1263	1.61 + 0.24	9.1	87
Canary Rockfish	847	1.04 + 0.13	6.1	86
Copper Rockfish	102	0.13 + 0.02	0.7	54
Kelp Greenling	542	0.67 + 0.06	3.9	92
Lingcod	747	0.90 + 0.08	5.4	94
Olive/Yellowtail Rockfish	721	0.95 + 0.18	5.2	72
Quillback Rockfish	170	0.21 + 0.02	1.2	71
Vermilion Rockfish	98	0.12 + 0.02	0.7	47
Yelloweye Rockfish	120	0.15 + 0.03	0.9	46

Fish Densities

Overall, individual species densities were low at all locations (<1 per 100 m^2), with the highest densities occurring at Point St. George SMCA and Ten Mile SMR (Figure 24). While densities differed significantly for nearly all species among the MPA locations, they were the same inside each MPA and reference area pair except Point St. George. The Olive/Yellowtail Rockfish was common, and observed in the highest density at Point St. George.

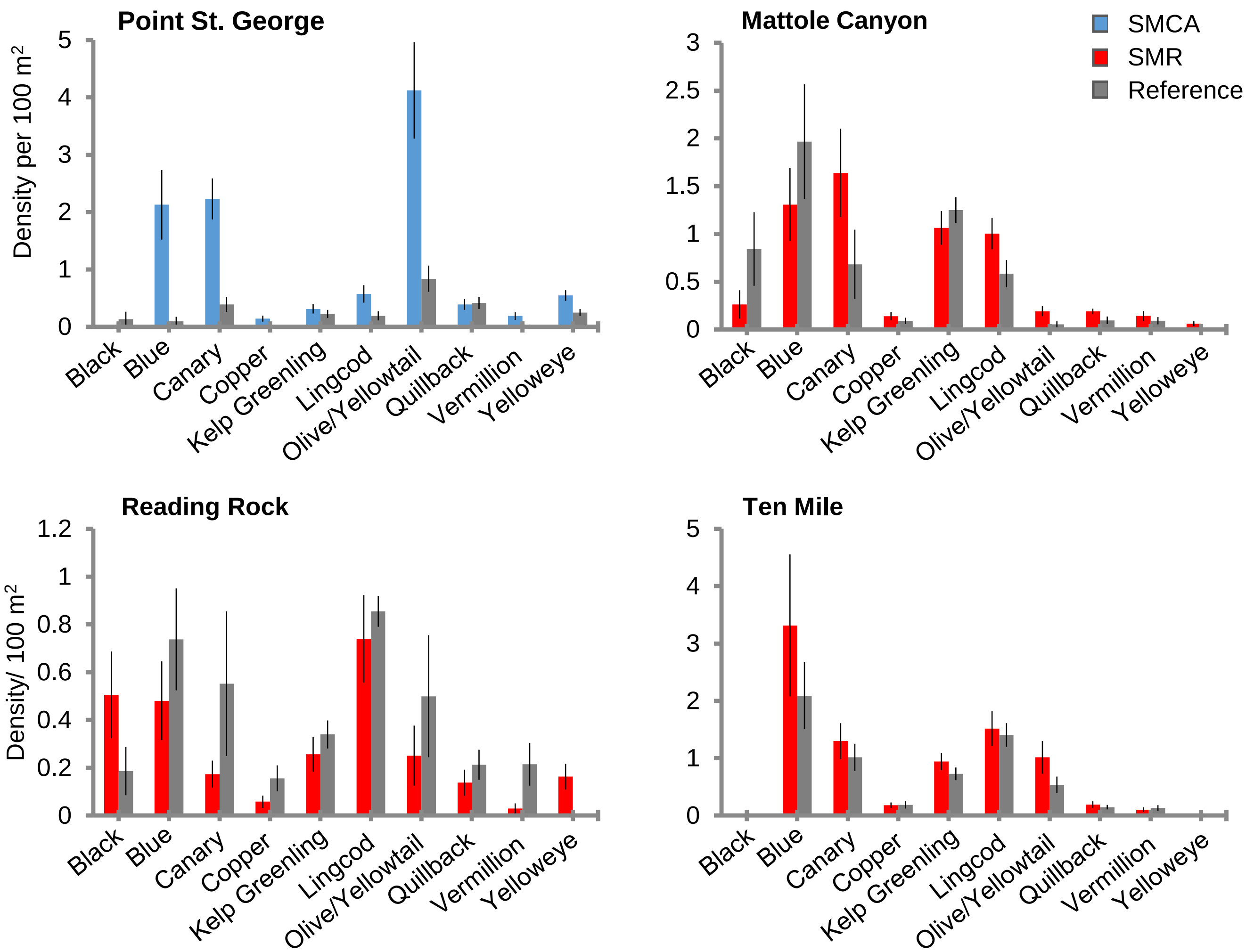


Figure 24. Density per 100 m^2 of select rocky reef fishes at each MPA (SMR or SMCA) and reference area index site pair at Point St. George, Reading Rock, Mattole Canyon and Ten Mile.

Similarity Test

Based on the results of the Bray-Curtis Similarity Test (group average agglomerative clustering) among index site fish assemblages we found three of the four MPA and reference area index site pairs were well placed, which will allow for robust comparisons in long-term monitoring in the North Coast Study Region. However, assemblage similarity was the lowest between the Point St. George SMCA and reference area index sites.

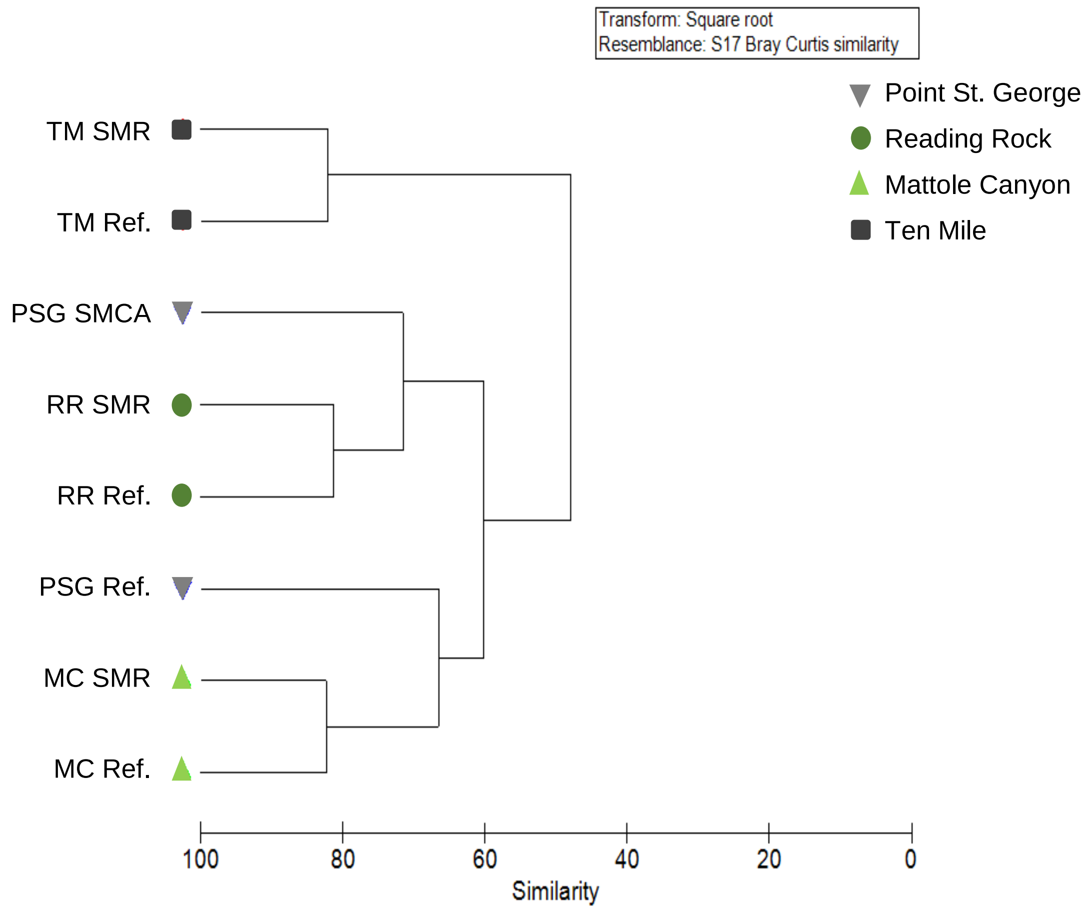


Figure 25. Similarity (group average agglomerative clustering) among index site fish assemblages in MPA and reference area pairs, for Point St. George, Reading Rock, Mattole Canyon and Ten Mile. Analyses are based on densities for individual species and taxonomic groups (see methods for full list of taxonomic groups). Data were combined for observations over all substrates.

Point St. George Index Sites

The Point St. George SMCA index site spans the most exposed portion of the reef. The reference area index site is located approximately 16 km southeast along another strip of reef that is somewhat protected from the predominant northwest winds and currents. The two index sites both range from 50-70 m in depth.

The SMCA and reference area index sites showed the least similarity between fish species assemblages (60% overall and 40% over rock substrates) and the most significant differences in species densities of any other MPA/reference area index site pair. The highest densities of Canary, Blue and Olive/Yellowtail Rockfish were observed at the SMCA index site, while the lowest densities of Kelp Greenling and Lingcod were also observed there. Additionally, Copper and Widow Rockfish were observed at the SMCA index site but were absent at the reference site. Black Rockfish were also present at the reference site, but not at the SMCA site. While a greater percentage of hard rocky habitats were surveyed at the reference site, generally higher densities of most rockfishes, flatfishes, Lingcod, and Kelp Greenling were observed at the SMCA site. Only Tiger Rockfish, Quillback Rockfish, and small benthic fishes showed higher densities at the reference area index site.

Differences in geographical orientation and resulting physical conditions may have influenced the differences observed between the index sites at Point St. George. The SMCA's position at the outer edge of the reef makes it difficult to find a reference site with similar habitat conditions. It is recommended that the Point St. George reference area be re-evaluated and potentially moved to a location closer to the MPA to increase comparability to the SMCA in both assemblage and species densities, but this may not be feasible. During the 2014 cruise, several other locations near the PSG SMCA were surveyed with the ROV as a part of a California Department of Fish and Wildlife survey of the North Coast Region. Two additional sites located off Point St. George SMCA and two sites just south of Crescent City were surveyed using the ROV. These locations were also considered as a possible reference area for the SMCA, though none of them were a suitable match. Even though there are differences in the fish species assemblages and habitat conditions, the baseline data collected at each site should still provide some metrics for monitoring change over time.

Reading Rock Index Sites

Reading Rock's SMR index site is positioned on the southern tip of a small offshore elliptical reef and the reference area index site is located on the northern edge of the same reef just 1,500 m from the SMR site. Species assemblages were more than 80% similar at the SMR and reference area index sites. All fish species densities were low at both Reading Rock index sites. Lingcod and Blue Rockfish exhibited the highest densities both at the SMR and reference site. Black Rockfish were more common at the SMR site, and Canary Rockfish were more common at the reference site. All ten species chosen for metric establishment were observed in small numbers at Reading Rock. Statistical differences in densities were observed for Vermilion Rockfish (none observed at the SMR site) and Black Rockfish; density for both species was higher at the SMR index site.

Mattole Canyon Index Sites

Mattole Canyon's two index sites were positioned less than 500 m apart on the southern side of the canyon head, with depths ranging from 20-60 m. Index site assemblages at this location were very similar overall, greater than 80%. Blue, Black, and Canary Rockfish, as well as Kelp Greenling and Lingcod, were observed in the highest densities at these sites. Kelp Greenling densities at Mattole Canyon were highest of all four MPA locations. There were no density differences between the SMR and reference area sites at this location for the ten selected species.

Ten Mile Index Sites

Ten Mile's SMR index site is located offshore of the Ten Mile estuary and contains a higher percentage of rocky reef than the other MPA's surveyed. The SMR index site is located on the southern edge of the reef, while the reference site is located approximately 8 km south on the north edge of another reef in the same depth range (40-60 m). At Ten Mile, we found relatively high densities of Blue and Canary Rockfish in both index sites, many of which were juvenile and sub-adult fishes. A very large number of YOY and various small individuals were also observed at the Ten Mile location compared to the other three sites.

Of the four MPA locations surveyed, the highest density of Lingcod occurred at both Ten Mile index sites. Kelp Greenling and Olive/Yellowtail Rockfish were also common. There were no observations of Yelloweye Rockfish, only one Black Rockfish, and small numbers of other rockfish species observed at both sites. There were no density differences for the ten selected species between the SMR and reference area index sites.

FISH DEPTH DISTRIBUTION

The depth distribution of select fish species/groupings across rocky reef transects are presented here for Point St. George, Reading Rock, Mattole Canyon and Ten Mile MPAs and their paired reference areas (see methods for a list of fish species). In addition, the depth distribution of select fish across canyon transects are shown for Mattole Canyon SMR. Only one exploratory canyon transect was surveyed in the Mattole Canyon reference area, therefore the depth distribution of fish within the canyon of the reference area are not presented. Due to an absence in species diversity, with 2 categories 'unidentified flatfish' and 'all other fish' accounting for 98% of the fish observed on soft bottom transects, results for soft bottom transects are not shown.

Depth distributions of select fish species are presented for all rocky reef transects surveyed (index sites and characterization transects combined) for each study area. During the planning phase, effort was made to place index sites in the most prominent rocky reef habitat within the 40-60 m depth range in each MPA. Index site placement was not intended to cover the full range of depths in which rocky habitat was predicted (using multibeam mapping) in each MPA, but to cover similar depth ranges at all study areas. Paired reference areas were subsequently selected to provide comparable rocky habitat within the same depth range as the MPA index site.

The total area and range of depths surveyed for each MPA and reference area pair, and the depth range of each index site is given in Table 5. Effort was made to survey a similar amount of area within each MPA and reference area pair and to survey, as much as possible, the full range of depths in which rocky habitat was predicted using characterization transects. Additionally, we attempted to survey similar depth ranges between each MPA pair, although this was not always possible as rocky reef and canyon habitat did not always occur within the same range of depths. For shallower rocky habitat, the ROV's operational capacity was limited to approximately 15 m.

Table 5. The total area and depth range surveyed from rocky reef and canyon transects inside MPAs (SMCA or SMR) and their associated reference areas for Point St. George, Reading Rock, Mattole Canyon and Ten Mile.

Sites		Area surveyed (m^2)	Surveyed depth range (m)	Index site depth range (m)
Rocky Transects				
Point St. George	SMCA	16,308.3	41 - 75	58 - 73
	Reference	10,502.0	45 - 66	45 - 66
Reading Rock	SMR	10,611.7	34 - 61	34 - 60
	Reference	14,536.6	35 - 59	35 - 58
Mattole Canyon	SMR	12,775.5	37 - 80	37 - 66
	Reference	11,253.0	21 - 52	21 - 52
Ten Mile	SMR	16,226.2	13 - 69	35 - 67
	Reference	15,488.7	34 - 83	44 - 62
Canyon Transects				
Mattole Canyon	SMR	8,983.2	52- 420	N/A

To show the density of fish along a vertical gradient, depth was stratified into 10 m bins for rocky reef transects and 10 and 50 m bins for canyon transects. The total area surveyed per depth bin at each site is shown in Figure 26 for rocky habitat transects and Figure 31 for canyon transects. The distribution and density of select fish species were plotted for each depth bin and are shown in Figures 27-30.

Rocky Reef Transects

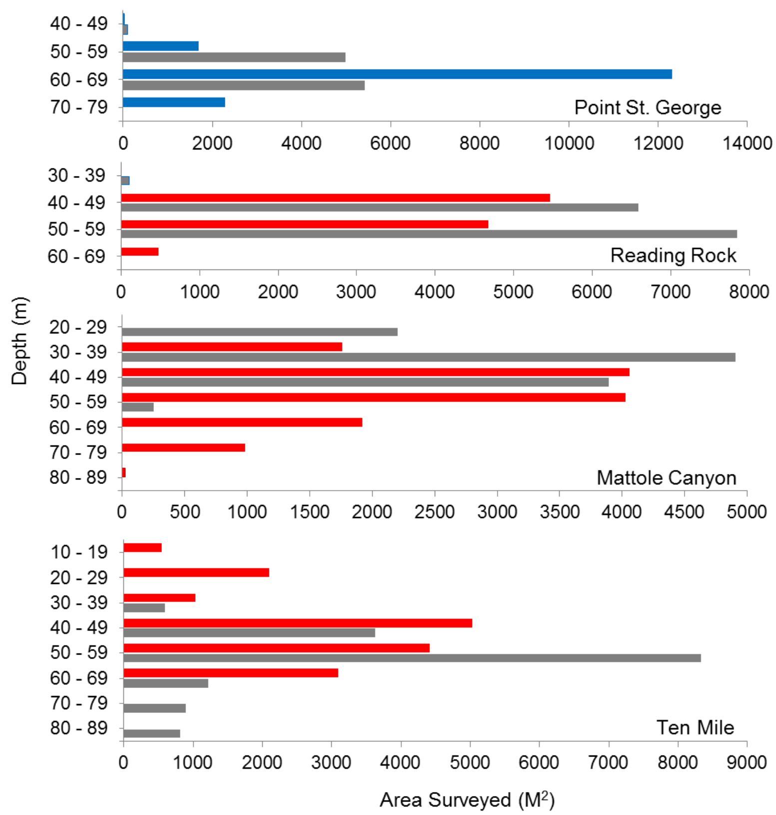


Figure 26. The total area of rocky reef transects surveyed per depth bin for each MPA for Point St. George SMCA (blue), and Reading Rock SMR, Mattole Canyon SMR and Ten Mile SMR (all SMRs in red) and their reference areas (gray).

Depth distributions for select fish species are presented for all MPA and reference area pairs surveyed. Data is presented as a reference for the depths surveyed within the rocky habitat, and to show overall density by species/grouping across those depths. Additionally, the depth range for index sites within each study area are presented to show the expected distribution of select fish within each index site at paired MPA and reference areas.

Point St. George - Rocky Reef

Rocky reef habitat at Point St. George SMCA and reference area encompass a limited range of depths (Figure 26). Less than 200 m^2 was surveyed in the 40-49 m bin at both the SMCA and references areas, therefore, these data were not included in Figure 27. Depth bins ranged from 50-79 m at the SMCA and from 50-69 m at the reference area. The depth range of the Index site placed over rocky features within reference area overlap the depths surveyed within the SMCA and appear to be representative of the distribution of rocky habitats within both study areas.

Overall, the SMCA and reference area appeared to have similar distributions of fish in each of the depth stratified bins. The most notable difference was for Olive/Yellowtail Rockfish, where at the SMR densities are greater in the 50-59 m depth bin, while at the reference area they are greater in the 60-69 m depth bin.

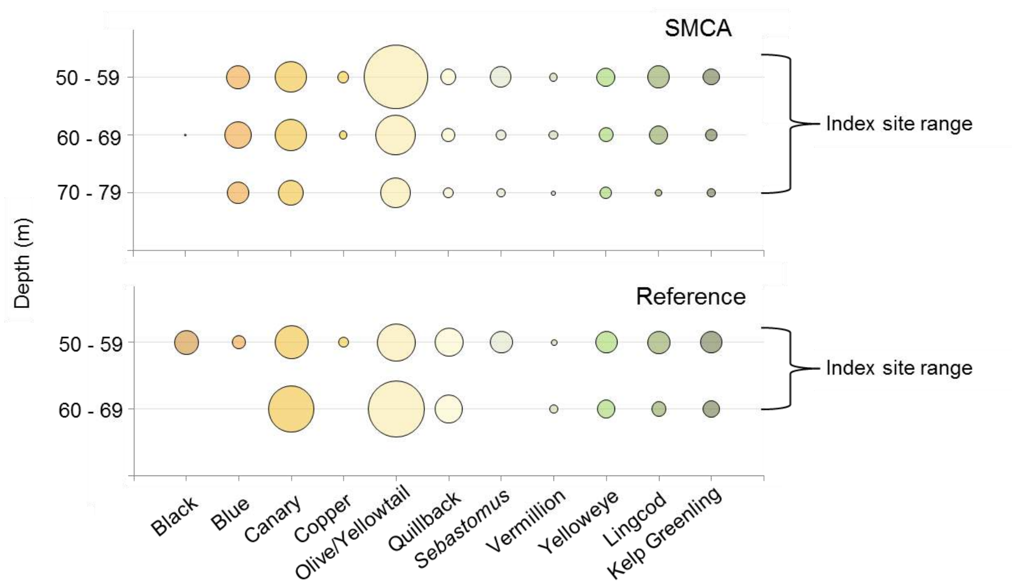


Figure 27. Density of select fish species per depth stratified bin, with bubble size representing their relative density for Point St. George SMCA and reference area.

Reading Rock - Rocky Reef

Reading Rock SMR and reference area also encompass a limited range of depths (Figure 26). At these two study areas, less than 200 m^2 were surveyed in the 30-39 m bin in the SMR, and in the 30-39 and 60-69 m depth bins in the reference area. Consequently, this data was not included in density calculations for Figure 28. Depth bins in the SMR ranged from 40-69 m, and 40-59 m in the reference area. The depth range of index sites placed over rocky features within the SMR and reference area overlapped much of the depths surveyed within the SMR and are more representative of the distribution of rocky habitats within both study areas.

Again, the SMR and reference sites appeared to have similar distributions of fish in each of the depth stratified bins. The most notable differences are for Blue Rockfish, where densities appear to be higher in the 40-49 m depth bins and for Canary Rockfish and the Olive/Yellowtail Rockfish complex, where density appears to increase with depth. Also notable, there are no observations of Black, Blue, Copper, Quillback or *Sebastomus* Rockfish in the 60-69 m depth bin within the SMR.

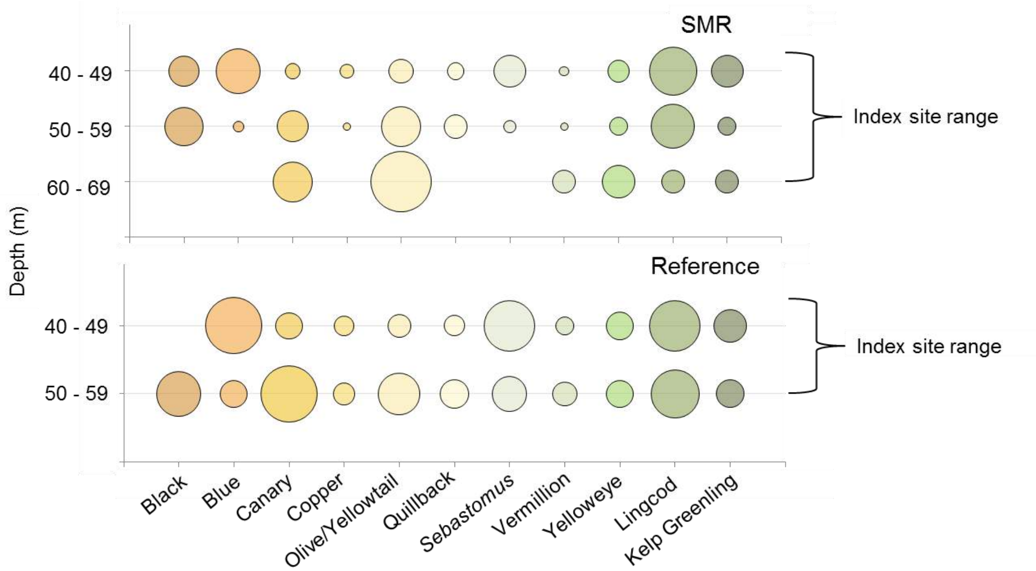


Figure 28. Density of select fish species per depth stratified bin, with bubble size representing their relative density for Reading Rock SMR and reference area.

Mattole Canyon - Rocky Reef

Mattole Canyon rocky reef habitat encompassed a wider range of depths than the northern two sites (Figure 29). Less than 200 m^2 was surveyed in the 20-29 m and 80-89 m depth bins at the SMR site, and in the 60-69 m, 70-79 m and 80-89 m depth bins at the reference site; these data were not included in density calculations for Figure 29. Depth bins ranged from 30-79 m at the SMR and 20-59 m at the reference area.

Overall, the following notable trends were seen at Mattole Canyon SMR and reference sites: *Sebastomus*, Vermilion, and Yelloweye Rockfish were present at nearly all depths in the SMR site; however, they were not observed at the reference site, with the exception of Vermilion Rockfish being present in one depth bin (30-39 m). Olive/Yellowtail Rockfish density increased with depth at the SMR site, but at the reference site, density remained low across most depth bins. Kelp Greenling and Lingcod were present at all depths in both the SMR and reference sites with Lingcod density increasing with depth. Canary Rockfish were common at both the SMR and reference sites in all depth bins 30 m and deeper.
Index sites placed in the Mattole Canyon SMR did not fully overlap the surveyed depth range, and are therefore not completely representative of the available rocky reef habitat within the SMR. Additionally, the index site placed at the reference area

covered a shallower range of depths than the index site within the SMR. Overall fish distribution also appears to be different within each site, with fewer species observed at the reference site. These differences are most notable for some of the non-aggregating rockfish species, such as *Sebastomus*, Vermilion, and Yelloweye Rockfish. Given these differences, future monitoring plans should consider expanding the range of depths surveyed beyond the index sites to capture the full distribution of species within the SMR and reference area at the Mattole Canyon study location.

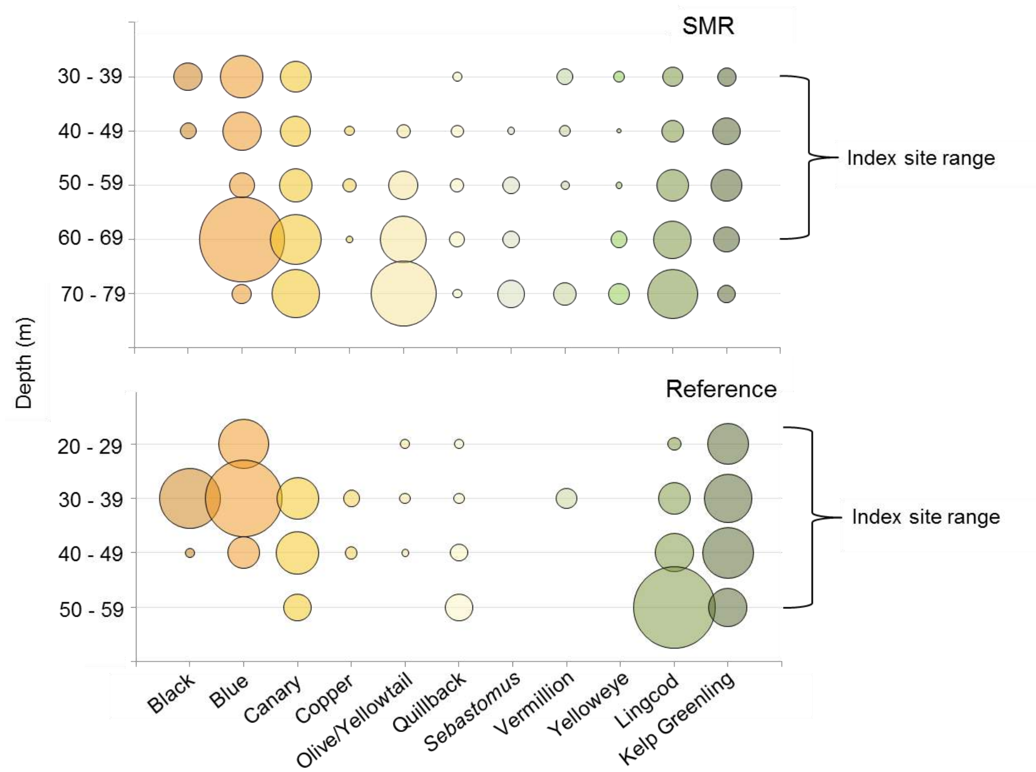


Figure 29. Density of select fish species per depth stratified bin, with bubble size representing their relative density for Mattole Canyon SMR and reference area.

Ten Mile - Rocky Reef

Ten Mile's rocky reef habitat encompassed a wider range of depths than the other sites surveyed (Figure 26). Less than 200 m^2 were surveyed in the 70-79 m and 80-89 m depth bins in SMR, and 10-19 m and 20-29 m depth bins in the reference area; these data were not included in density calculations for Figure 30. Depth bins ranged from 10-69 m deep in the SMR and 30-89 m deep in the reference area.

For both the SMR and reference area, Blue Rockfish densities increased as depth decreased, while Canary Rockfish showed the opposite, and increased in density with depth. Black Rockfish were only observed in the SMR and only at depths shallower than 49 m, with the highest densities observed at the shallowest depth bin surveyed

(10-19 m). The *Sebastomus* Rockfish complex was observed at both sites, but only at depths greater than 40 m.

The index site placed in the Ten Mile SMR did not fully overlap the surveyed depth range, and is therefore not representative of the available rocky reef habitat (for depths greater than 20 m) within the SMR. The index site placed within the reference area did fully overlap with the depth range of the SMR index site, as did the fish distributions observed within both sites. As currently situated, both index sites are a good match and will allow for monitoring long-term trends in both areas.

Within the SMR, available rocky reef habitats extend shallower than the range of depths at the index site. Therefore the index site may not be suitable for detecting the shallower range of species observed in the SMR. For example, Black Rockfish, which were more abundant in the shallow areas of the rocky reef, may not be observed within the index site. The opposite occurred at the reference area, where surveyed depths extended deeper than the index site. Given these differences, future monitoring plans should consider expanding the range of depths surveyed beyond the index site to capture the full distribution of species within the SMR and reference area.

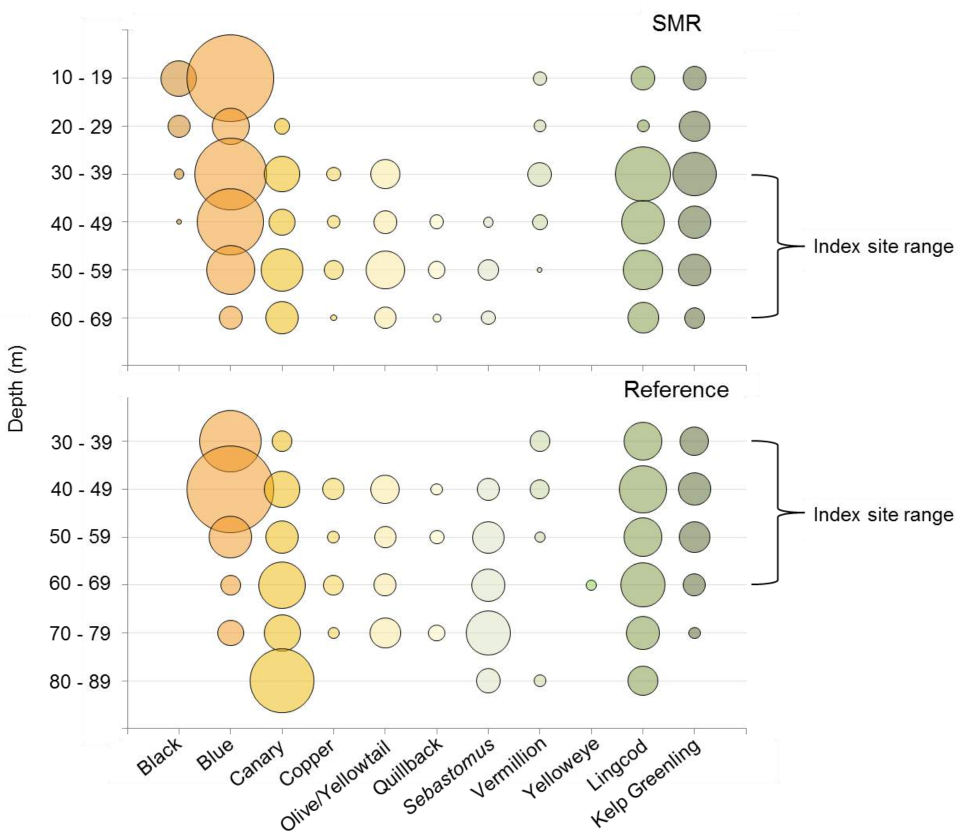


Figure 30. Density of select fish species per depth stratified bin, with bubble size representing their relative density for Ten Mile SMR and reference area.

Canyon Transects

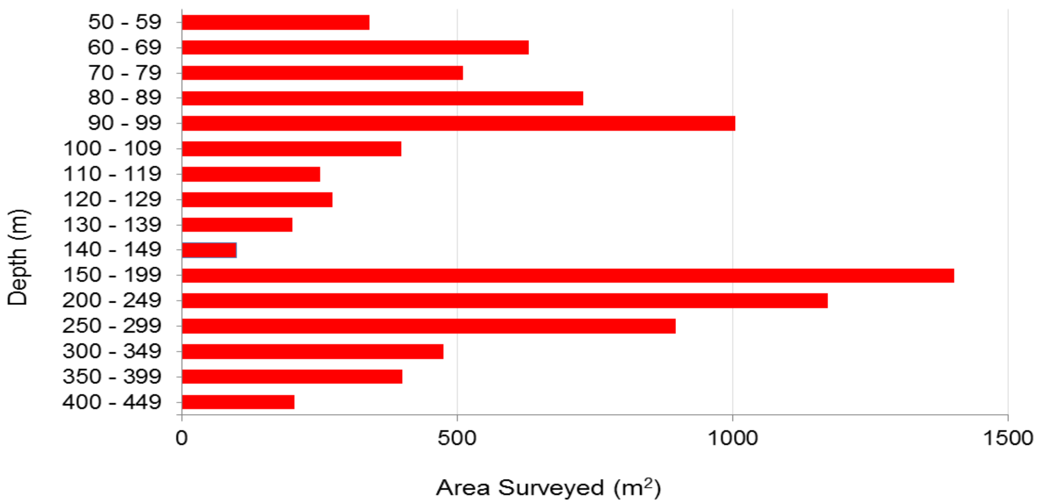


Figure 31. The total area surveyed per depth bin for canyon transects at Mattole Canyon SMR.

Mattole Canyon - Canyon

Within the Mattole Canyon SMR transects, canyon habitat depths ranged from 52-420 m. Effort is shown in Figure 31 and surveyed depths are broken into 10 m bins from 50-149 m, and into 50 m bins from 150-449 m in depth. Less than 200 m^2 were surveyed in the 140-149 m bin. As a result, these data were not included in density calculations for Figure 32. Although index sites were not placed in the canyon, Figure 32 shows the distribution at which select species occur in the canyon, which may be used for future monitoring.

Overall, the occurrence and relative densities of several species showed marked differences between shallow (<100 m) and deep zones (>100 m) where the shelf/canyon interface occurs (indicated by a red line in Figure 32). The following notable trends were present in the rockfish species surveyed: Canary Rockfish are relatively high in density in the shallower depth bins surveyed and decrease in density until just after the shelf/canyon break at 110-119 m, where they were no longer present. Olive/Yellowtail Rockfish showed the highest density around the shelf/canyon interface, but were also observed in the shallowest depth bin (50-59 m). Yelloweye Rockfish were observed with similar densities around the shelf/canyon break from 80-119 m, while Greenstriped Rockfish occurred from just above the shelf break down to 249 m. Black, Blue, Copper, and Vermilion Rockfish were not present on any of the canyon transects.

Thornyheads occurred exclusively in the deeper ranges of the canyon, within the typical range expected. Lingcod occurred in a wide range of depths, but were observed in much higher densities in the shallower (50-89 m) depth bins. While Lingcod densities were lower around the shelf/canyon break, they were observed to a depth of 300 m. No Lingcod were observed between 120 m and 139 m. Kelp Greenling were only observed in the shallowest depth bins, from 50-89 m.

The ‘all flatfish’ grouping shown in Figure 32 includes all observations of unidentified flatfish plus all flatfish identified to species level (see Appendix 6 for a full list of species). Additionally, the five more commonly observed flatfish species that were identified to species level are also shown, although their densities only represent the proportion that was identified. Overall, flatfish were observed from 70-449 m, with the highest density of flatfish observed in the 150-199 m depth range. Dover Sole only occurred at the canyon-shelf interface and deeper, while sanddabs only occurred at the canyon-shelf interface, and shallower. English Sole and Petrale Sole were observed mainly in the mid-ranged depths, while the Rex Sole was observed exclusively in the deeper ranges of the canyon.

Overall, the interface between the shelf and canyon appears to be an important habitat feature for some of the species presented. Yelloweye Rockfish were only observed near the canyon-shelf interface, from 80 to 119 m. For other species, such as Canary and Olive/Yellowtail Rockfish, densities decrease with depth and eventually disappear at the canyon-shelf interface. The opposite was true for Greenstriped Rockfish and Dover Sole, which increased in density deeper than the canyon-shelf interface. Future monitoring plans for Mattole Canyon SMR should consider capturing the full extent of the canyon, with importance placed on capturing information on either side of the canyon-self interface.

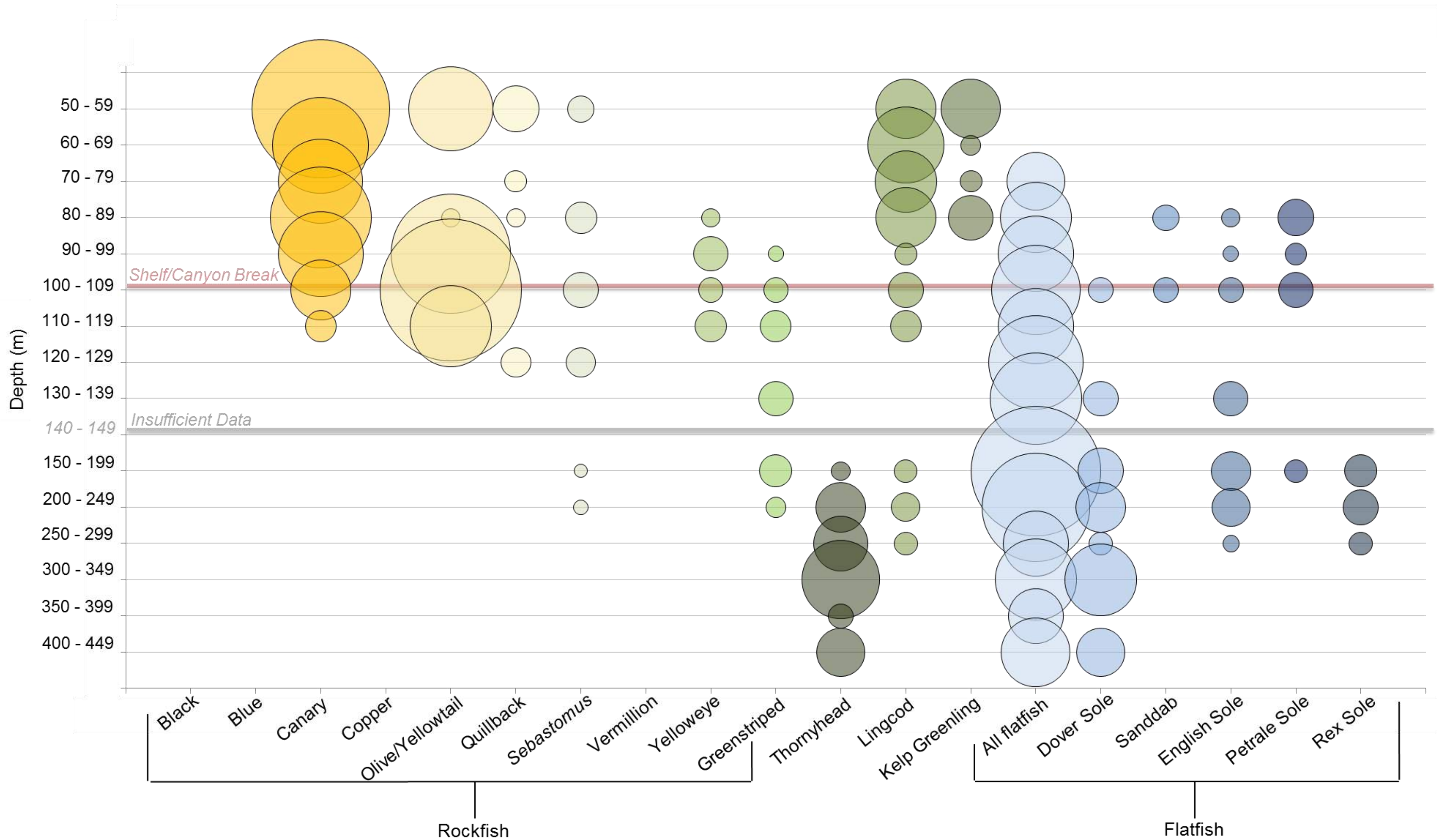


Figure 32. The density of select fish species per depth stratified bin, with bubble size as the relative density of fish in that depth bin. There was insufficient data (less than 200 m surveyed) for the 140-149 meter depth bin (indicated by the gray line). The shelf/canyon break occurred at about the 100 m mark (indicated by the red line).

FISH SIZE DISTRIBUTION

Laser-based Size Estimates

Mean visual size estimates for ten select species of fish (Black, Blue, Canary, Copper, Olive/Yellowtail, Quillback, Vermillion, and Yelloweye Rockfish, and Lingcod and Kelp Greenling) are presented in Table 7.

Table 6. The mean total length of select fish species within each MPA (SMCA & SMR) and reference (Ref.) area: Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). A dash mark indicates no individuals were counted at that study area. 'N/A' indicates too few fish were counted to report a mean.

Species	Point St. George		Reading Rock		Mattole Canyon		Ten Mile		Average
	SMCA	Reference	SMR	Reference	SMR	Reference	SMR	Reference	
Black	36.0	39.1	36.1	39.9	38.1	34.8	35.3	—	37.1
Blue	32.7	32.0	28.5	26.3	28.6	16.7	23.7	23.1	26.5
Canary	27.4	30.4	23.9	27.9	24.4	24.1	27.4	24.7	26.3
Copper	35.6	34.8	31.6	36.2	38.9	37.5	34.5	34.8	35.5
Olive/yellowtail	36.0	34.1	30.8	33.9	39.4	N/A	28.7	31.2	33.4
Quillback	36.2	36.9	31.4	33.6	35.2	34.6	28.8	29.6	33.3
Vermillion	40.2	38.0	40.1	41.6	40.3	40.2	39.4	40.2	40.0
Yelloweye	29.4	27.1	25.4	24.7	37.7	—	—	42.5	31.1
Lingcod	49.9	52.1	53.4	55.7	37.7	48.3	40.7	41.9	47.5
Kelp Greenling	36.3	34.9	33.8	33.7	34.6	34.5	35.0	34.4	34.7

Overall, the ten species show little difference in mean total length between MPA and reference area pairs. For the rockfish species, the largest mean size difference between a MPA and reference area was found at Mattole Canyon, where Blue Rockfish mean total lengths differed by 11.9 cm. Surveys at the Mattole Canyon reference area had a shallower depth range than Mattole Canyon SMR (see table 5 in the depth section). Since smaller juvenile Blue Rockfish were typically seen at shallower depths, this likely accounts for the large difference in the mean density between the two areas. All other rockfish mean differences ranged from 0.2 cm to 4.6 cm.

Lingcod showed a large difference in mean total length between study areas at Mattole Canyon, where the means differed by 10.6 cm. At all other study area pairs, the difference in the means was 2.3 cm or less. Kelp Greenling showed the smallest difference in mean total length between study areas, with a 1.4 cm difference at Point St. George, and a 0.1 cm to 0.6 cm difference at all other study areas.

Because there was little difference overall in mean total length between MPA and reference areas for the ten fish species presented, lengths for MPA and reference pairs were combined to show the size frequency for each of the 4 study locations: Point St. George, Reading Rock, Mattole Canyon and Ten Mile (Figures 33-42). Percent size frequency is presented in 5 cm bins and size at which 50% of the females of the population reach sexual maturity is referenced in each of the size frequency graphs with dashed lines (Love et al. 2002; Thorson and Wetzel 2016; MacCall 2005; Stewart 2009; CDFW 2016f).

Black Rockfish

No smaller size classes (10-19 cm) of Black Rockfish were identified at any of the four study locations (Figure 33). Mature fish over 35 cm represented 72% to 100% of the population depending on the location. There were no Black Rockfish observations at the Ten Mile reference area, while Point St. George and Ten Mile SMR had relatively few observations of Black Rockfish at 20 and 22 fish respectively, when compared with Reading Rock and Mattole Canyon that had 97 and 138 fish respectively.

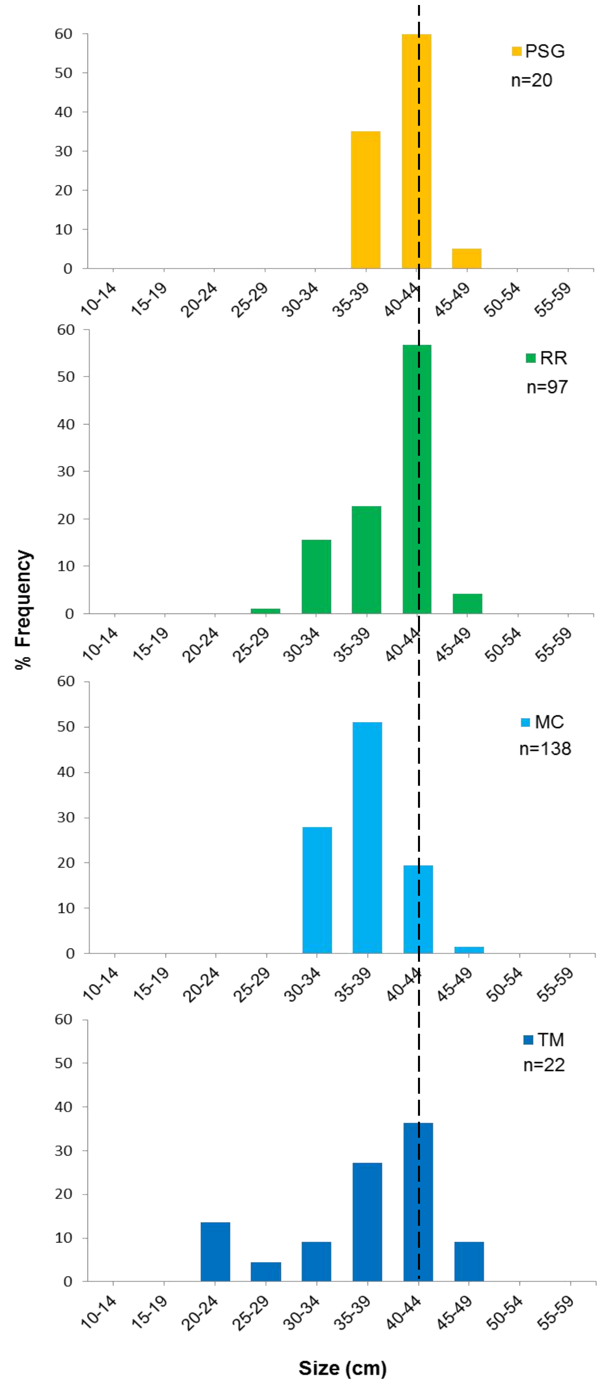
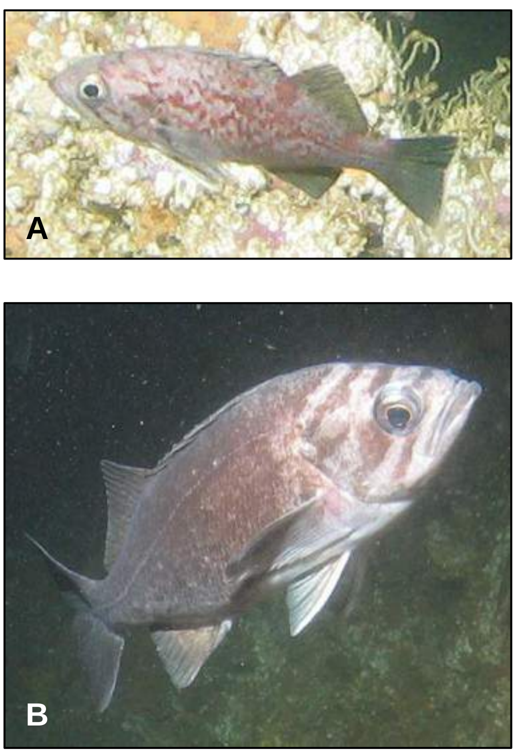


Figure33. Percent (%) size frequency of Black Rockfish at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 41 cm (---) for females (Love et al. 2002).

The above photo is a 44 cm Black Rockfish from Mattole Canyon.

Blue Rockfish

Mattole Canyon and Ten Mile locations had the highest proportion of smaller size classes (10 - 24 cm) of Blue Rockfish, representing 39% to 51% of the population at each site respectively (Figure 34). This result was expected, as Mattole Canyon and Ten Mile surveys encompassed a shallower range of depths, where smaller juvenile Blue Rockfish were typically observed. Mature fish over 29 cm represented 41% to 62% of the population depending on the site.



Juvenile Blue Rockfish, as seen in Photo A of a 13 cm Blue Rockfish from Ten Mile, were commonly observed at the two southern sites, Mattole Canyon and Ten Mile. Photo B is of a 33 cm Blue Rockfish from Ten Mile.

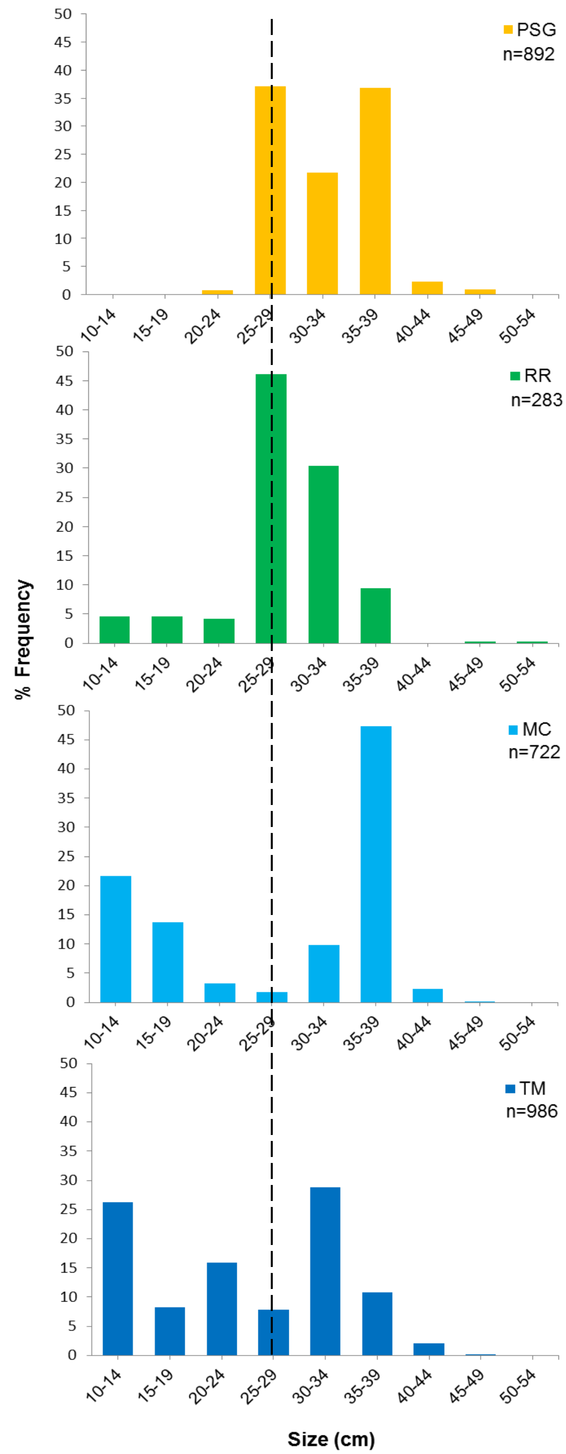


Figure 34. Percent (%) size frequency of Blue Rockfish at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 29 cm (---) for females (CDFW 2016f).

Canary Rockfish

The majority of Canary Rockfish seen, 90% to 97% depending on the site, were less than 39 cm in total length (Figure 35). Depending on the study location, only 3% to 11% of the population represented sexually mature fish over 40 cm. At the Reading Rock study location, the smaller size class (10-14 cm) represented nearly 20% of total observations, while they represented less than 10% of the observations at the other three study areas.

Juvenile Canary Rockfish exhibit a large black spot on the spiny dorsal fin as seen in Photo A of a 13 cm Canary Rockfish from Ten Mile. As Canary Rockfish mature they may retain remnants of the black spot as seen in Photo B of a 26 cm sub adult from Ten Mile. Photo C is a 45 cm adult, the size at which 50% of females are sexually mature.

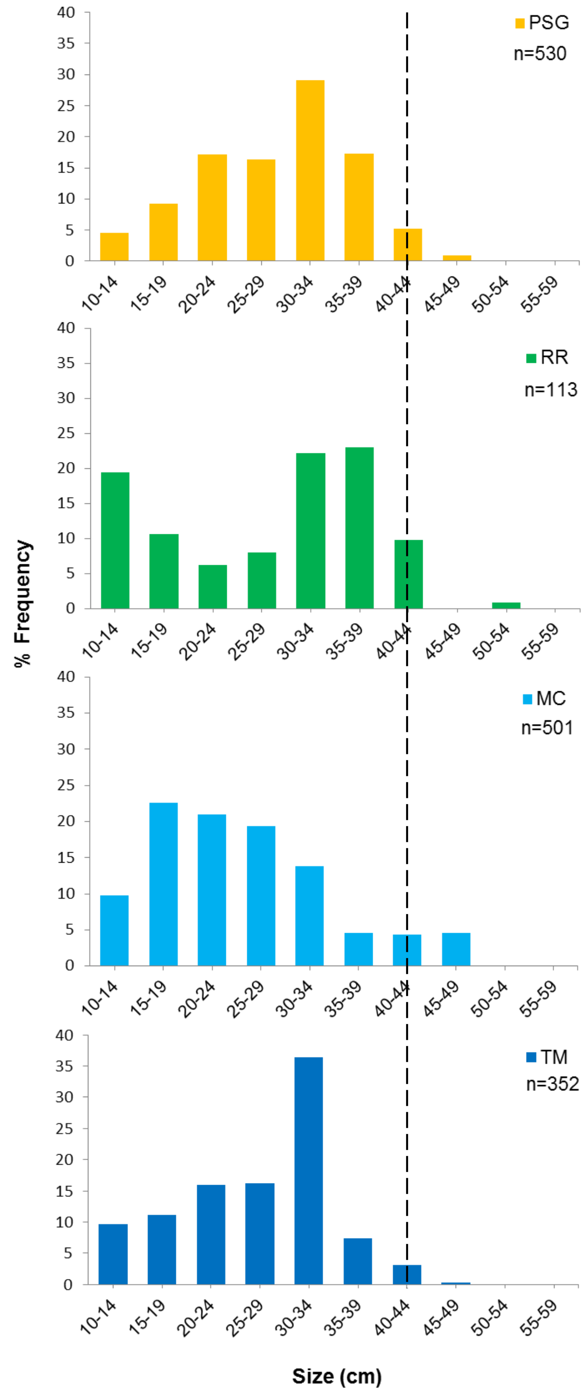


Figure 35. Percent (%) size frequency of Canary Rockfish at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 44.5 cm (---) for females (Stock assessment; Thorson and Wetzel 2016).

Copper Rockfish

There were few smaller size classes (<20 cm) of Copper Rockfish observed in the region. Sizes less than 25 cm were only observed at the Point St. George and Ten Mile study locations, at 13.8% and 1.9% respecitvely (Figure 36). Sexually mature fish over 30 cm represented 79 to 100% of the observations depending upon the site.

Copper Rockfish exhibit different color variations as seen in Photo A of a 36 cm Copper Rockfish and Photo B of a 43 cm Copper Rockfish. Photo C is a 55 cm Copper Rockfish from Point St. George, which is the only site Copper Rockfish, were observed from this size class.

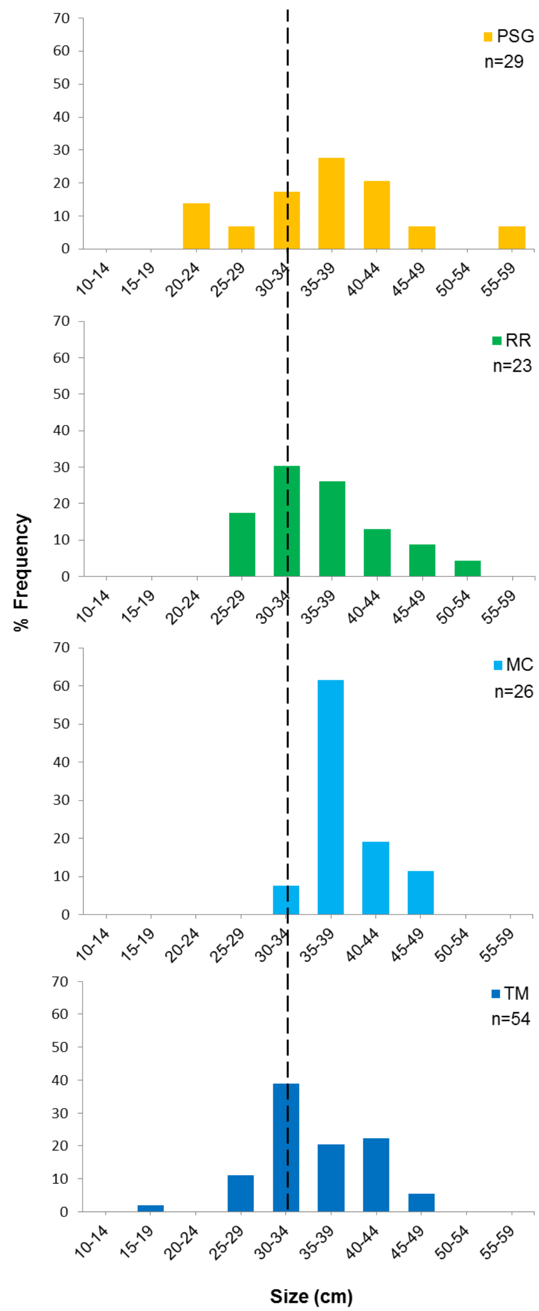


Figure 36. The percent (%) frequency of size (cm) of Copper Rockfish at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 31.4 cm for females (---) (Love et al. 2002).

Olive/Yellowtail Rockfish

Olive Rockfish and Yellowtail Rockfish are grouped into one species complex. For all practical purposes the species cannot be separated during video processing, as they are markedly similar in appearance and size. Their ranges overlap in depth and distribution within the NCSR. Consequently, we are likely seeing a fair mixture of both species. Therefore, we present the size frequency distributions shown in Figure 37 for the species complex.

When water conditions are good, the species become more discernable: Photo A is likely an Olive Rockfish showing drab olive sides measuring 36 cm, while Photo B is likely a Yellowtail Rockfish, showing brown flecking on its sides measuring 45 cm. Both fish were observed at Mattole Canyon.

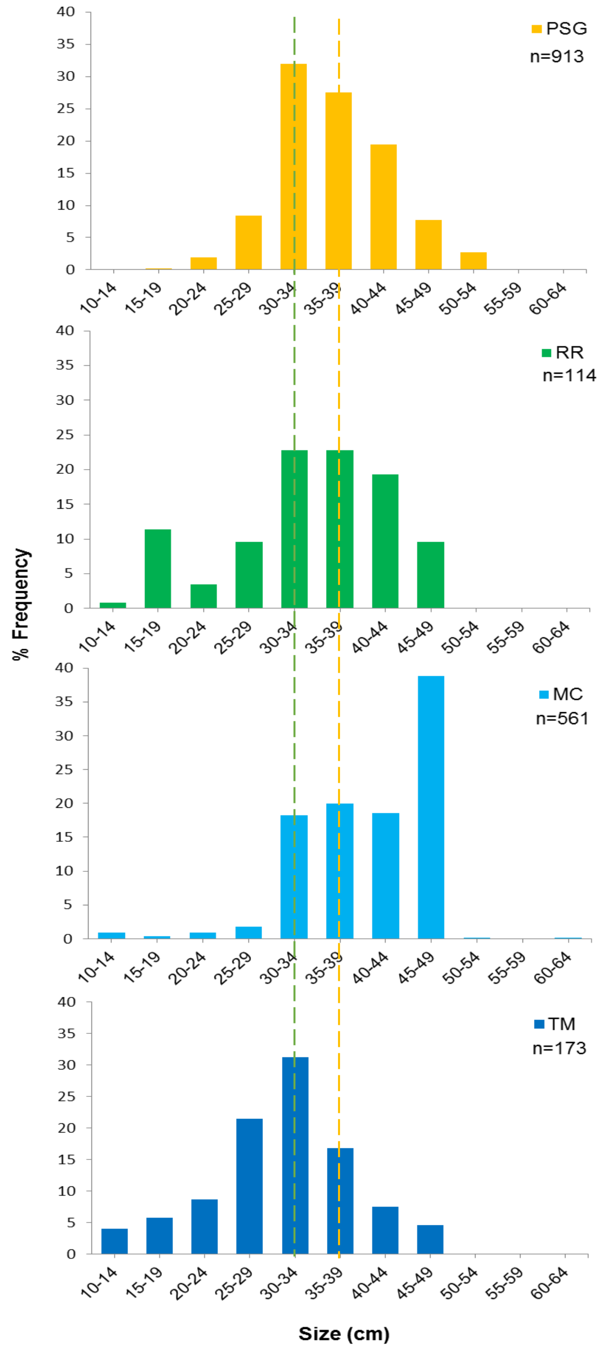


Figure 37. Percent (%) size frequency of Olive/Yellowtail Rockfish at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 33-35 cm (---) for female Olive Rockfish and 36-45 cm (---) for female Yellowtail Rockfish (Love et al. 2002).

Quillback Rockfish

Sub-adult Quillback Rockfish under 24 cm were only seen at Mattole Canyon and Ten Mile, and represented a small percentage of the population at 2.1% and 16.3% respectively (Figure 38). Most (83.7% - 97.6%) of the Quillback Rockfish observations were larger, sexually mature individuals between 25 cm and 44 cm.

Photo A is a 20 cm Quillback Rockfish from Mattole Canyon, Photo B is a 30 cm Quillback Rockfish from Ten Mile and Photo C is a 41 cm Quillback Rockfish from Mattole Canyon.

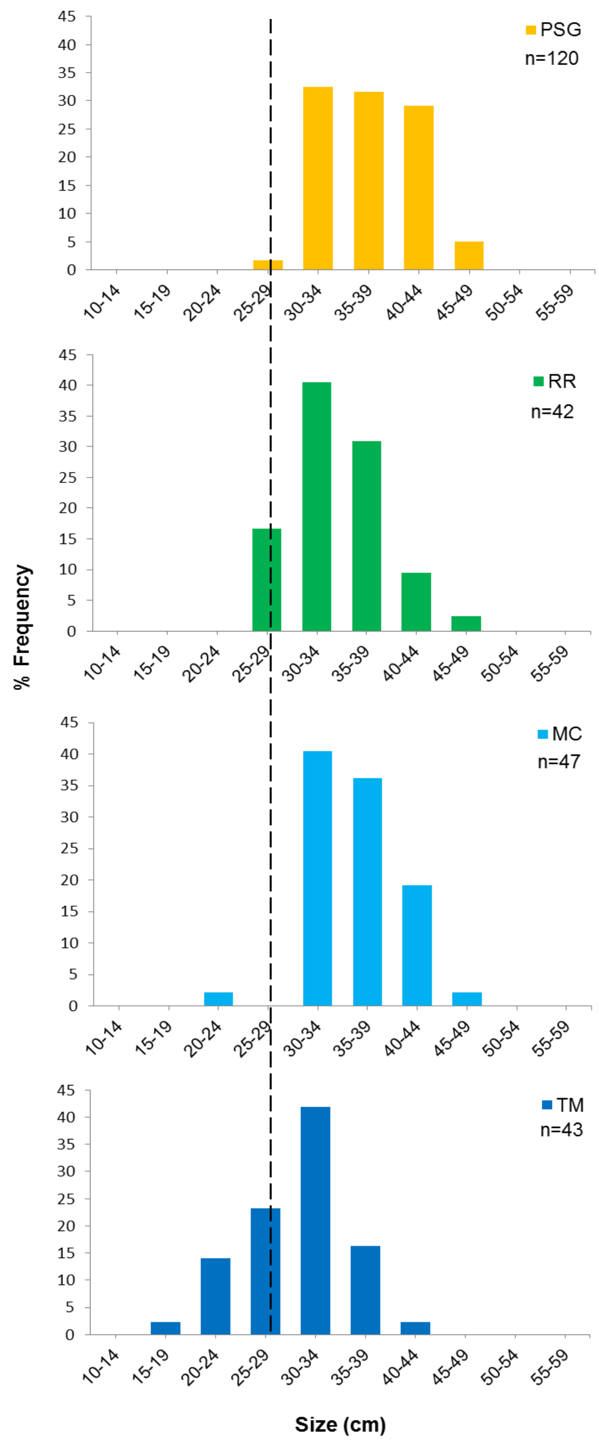


Figure 38. Percent (%) size frequency of Quillback Rockfish at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 28 cm for females (---) (Love et al. 2002).

Vermillion Rockfish

Between 84.5% and 92.5% of Vermillion Rockfish seen were sexually mature individuals, 35 cm or larger (Figure 39). Smaller size classes (10 cm-24 cm) were seen at Mattole Canyon and Ten Mile only.

Vermillion Rockfish exhibit different color patterns, as seen in Photo A of a 35 cm brick red individual, and Photo B of a 45 cm mottled individual (both fish were observed at Ten Mile). Photo C is a 52 cm Vermillion Rockfish from Mattole Canyon.

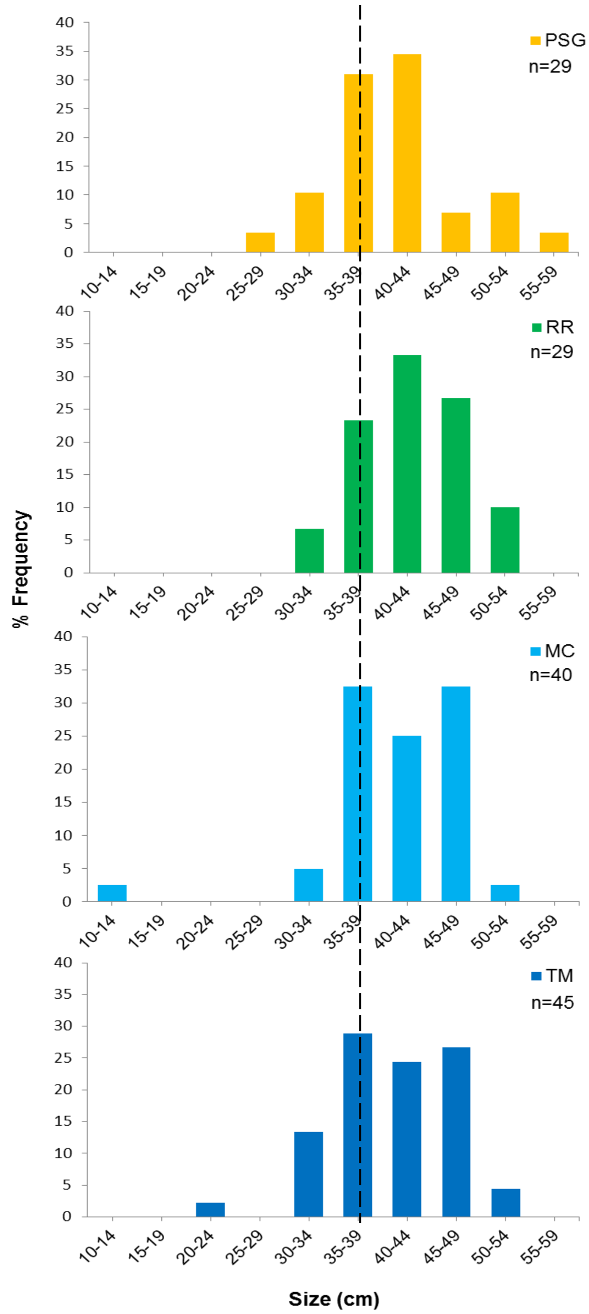


Figure 39. Percent (%) size frequency of Vermillion Rockfish at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity (---) is 38.2 cm for females (Stock assessment, MacCall 2005).

Yelloweye Rockfish

Only two Yelloweye Rockfish were observed at the Ten Mile study location, and are therefore not presented here. The majority of sexually mature yelloweye, 40 cm and larger, represented a larger proportion of the population (48.6%) at Mattole Canyon than the other two locations (Figure 40). Conversely, Point St. George and Reading Rock had a higher proportion of smaller size classes, less than 39 cm, at 85.3% and 87.7% respectively.

Photo A is a 20 cm juvenile Yelloweye Rockfish from Point St. George exhibiting two horizontal white stripes on either side of the lateral line. As Yelloweye Rockfish mature, the stripes fade, though the fins may still be fringed white, as seen in Photo B of a 36 cm Yelloweye Rockfish. Photo C is a 58 cm mature adult. Fish of this size class were only seen at Point St. George and Mattole Canyon, and only represented a small portion of the population at 0.9% and 5.4% respectively.

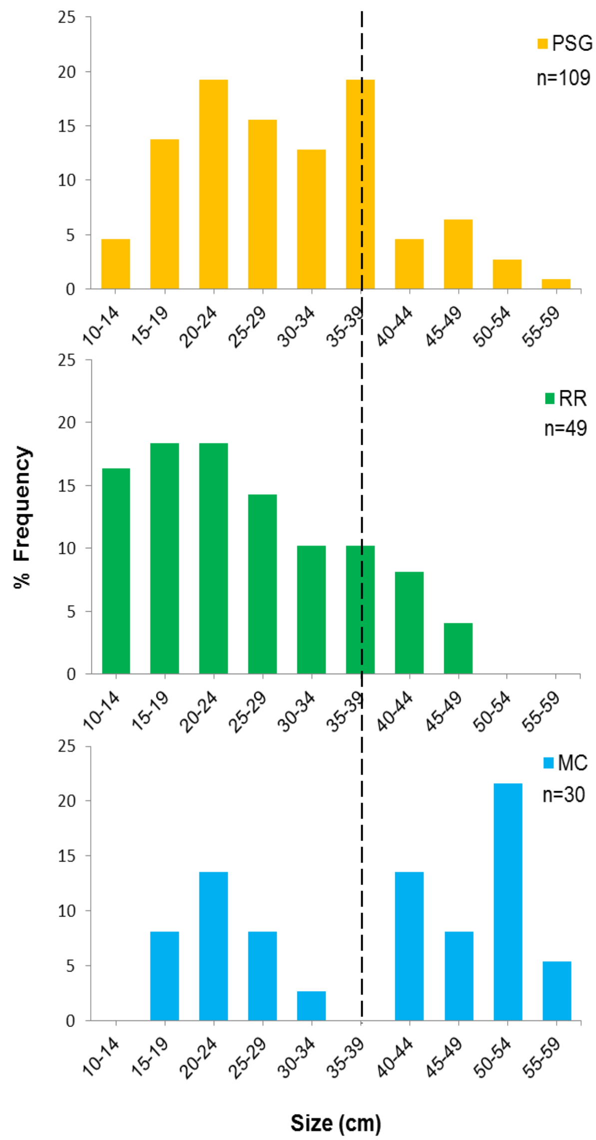


Figure 40. Percent (%) size frequency of Yelloweye Rockfish at Point St. George (PSG), Reading Rock (RR) and Mattole Canyon (MC). Size at 50% sexual maturity is 39.6 cm (---) for females (Stock assessment, Stewart 2009).

Lingcod

The northern two study locations, Point St. George and Reading Rock, had a higher proportion of larger (45 cm or greater) sexually mature Lingcod than the southern two study locations at 74.3% and 89.2% respectively (Figure 41). Smaller size classes, less than 44 cm, appeared in higher numbers in the southern two study locations, Mattole Canyon (59.4%) and Ten Mile (46.1%). A potential year class for Lingcod was observed in the 20-24 cm bin at the southern two study locations.

Photo A is a 20 cm Lingcod from Ten Mile, where 13.4% of the Lingcod were from this size class. Photo B is a 55 cm Lingcod from Reading Rock, which is approximately the size at which 50% of females reach sexual maturity and the recreational minimum size.

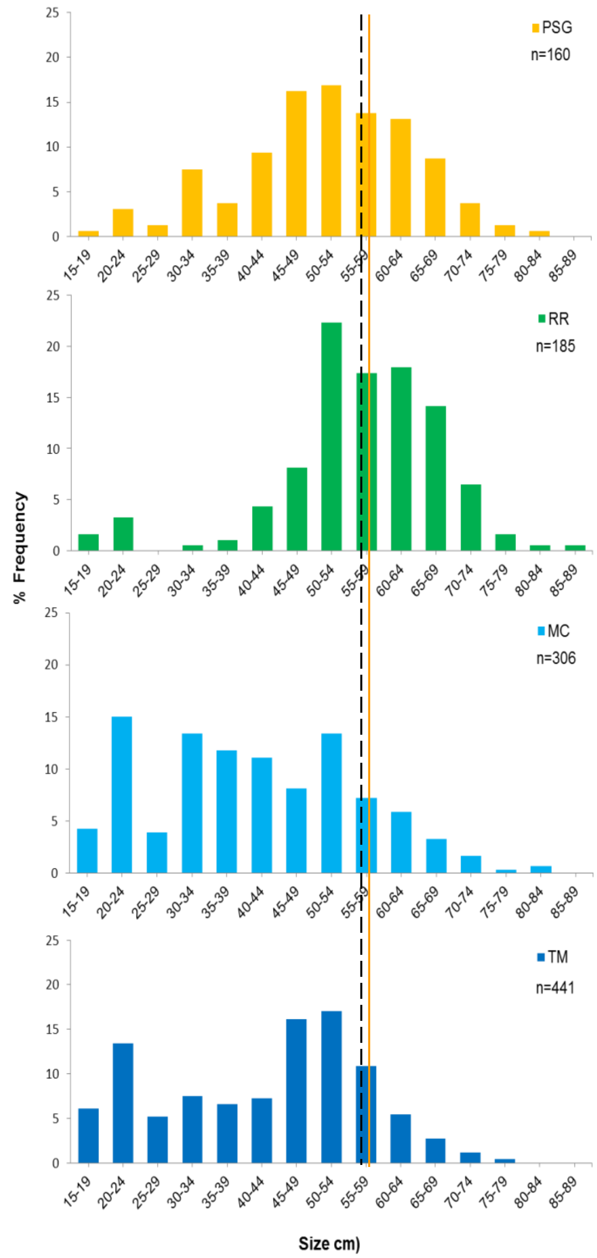
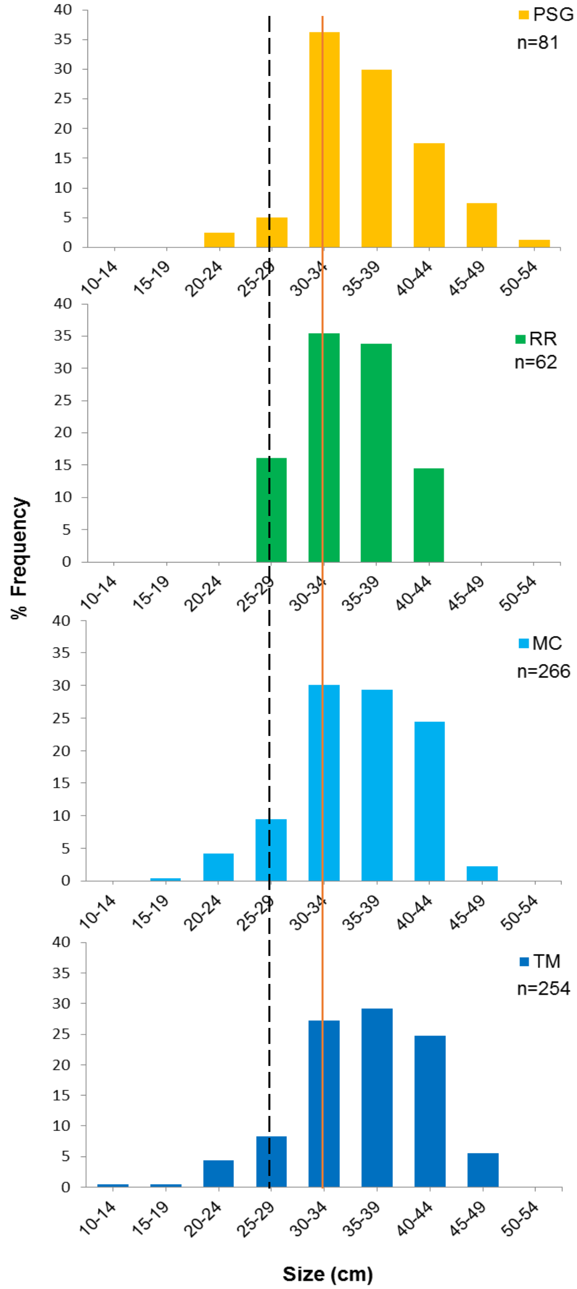


Figure 41. Percent (%) size frequency of Lingcod at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 57.1 cm (---) for females (Stock assessment, Hamel et al. 2009). The recreational minimum size is 55.88 cm (——) (CDFW 2016e).

Kelp Greenling

Juvenile Kelp Greenling under 19 cm were only seen at Mattole Canyon and Ten Mile (Figure 42), and represented less than 1% of the population at each site. Sexually mature fish over 30 cm represented the majority (83.9% to 92.5%) of the population depending on the site.



Sexually dimorphic Kelp Greenling: Photo A is a 36 cm female, while Photo B is a 38 cm male. Both fish were observed at Mattole Canyon.

Figure 42. Percent (%) size frequency of Kelp Greenling at Point St. George (PSG), Reading Rock (RR), Mattole Canyon (MC) and Ten Mile (TM). Size at 50% sexual maturity is 29.5 cm (---) for females (CDFW 2016f). The recreational minimum size is 30.48 cm (——) (CDFW 2016f).

Overall, each of the four survey locations exhibited variable differences in species size frequency structures (Figures 33 - 42). Across all four study areas, we found Black, Blue, Copper, Olive/Yellowtail, Quillback, and Vermilion Rockfish populations were comprised of larger, sexually mature size classes, whereas Canary and Yelloweye Rockfish populations were mostly comprised of smaller, juvenile and sub-adult size classes. Lingcod show a distinct split between the northern two study locations and the southern two locations, with mostly larger, sexually mature fishes at Point St. George and Reading Rock, and smaller size classes at Mattole Canyon and Ten Mile.

As a baseline study, these data are presented to show general size frequency across the study region. Notable differences in size frequency structure were not observed during this baseline period at the site pair level. These data, combined with selective stereo-video measurements during future monitoring, will allow researchers and managers to detect MPA related size distribution shifts.

Analysis of Laser-based Sizing Technique

Comparisons between laser size estimates and stereo-estimates revealed that no consistent bias was apparent when all species measurements were combined. When evaluated individually, four species' length estimates were unbiased, including Black Rockfish, Lingcod, Quillback Rockfish, and Rosy Rockfish (Table 7). Three species showed a bias toward over-estimated laser-sizes relative to stereo-sizes, including Blue Rockfish, Kelp Greenling and Olive/Yellowtail Rockfish. Four species were biased toward under-estimated laser-sizes relative to stereo-sizes, including, Canary, Copper, Vermillion and Yelloweye Rockfishes. Of the three species biased toward over-estimation, two were epi-benthic schooling species with probable size variability within the school. Measurement bias of these species likely reflects two effects; 1) providing an average size for the portions of the school, rather than each individual observation, and 2) the difficulty in estimating size when the laser references have no solid, stationary impact point. Of the 4 species biased toward under-estimated laser sizes relative to stereo sizes, the mean coarse size estimate was only 1.5 cm – 4.4 cm smaller relative to stereo-estimates.

Table 7. Mean length comparison between laser-length-estimates and stereo-video measurements. P-value refers to the probability that the two methods were the same (Ho: μ1=μ2) using two-tailed paired-sample t-tests. Measurements are all in centimeters. Bolded numbers indicate significant differences at a probability of 0.05. Difference shows the difference between the means and the signs indicate direction of the laser-length-estimate difference relative to stereo-measurements.

Common Name	n	Stereo-estimate mean ± SD	Laser-estimate mean ± SD	Difference (cm)	P-value
Black Rockfish	43	39.6 ± 4.4	38.3 ± 4.7	-1.3	0.146
Blue Rockfish	278	24.0 ± 8.7	26.1 ± 9.9	2.1	**<0.001**
Canary Rockfish	276	28.0 ± 11.5	26.5 ± 10.3	-1.5	**<0.001**
Copper Rockfish	33	41.5 ± 8.3	37.1 ± 7.6	-4.4	**<0.001**
Kelp Greenling	125	32.9 ± 5.6	35.5 ± 6.2	+3.5	**<0.001**
Lingcod	150	47.1 ± 16.9	47.0 ± 16.0	-0.1	0.981
Olive/Yellowtail Rockfish	203	34.0 ± 8.4	37.0 ± 8.1	+3.0	**<0.001**
Quillback Rockfish	49	37.7 ± 5.4	37.5 ± 4.3	-0.2	0.847
Rosy Rockfish	46	22.5 ± 4.2	23.0 ± 4.4	+0.5	0.333
Vermilion Rockfish	42	46.1 ± 4.9	43.5 ± 4.7	-3.4	**0.002**
Yelloweye Rockfish	31	35.1 ± 16.6	32.8 ± 14.5	-2.3	**0.013**
Total	***1276***		***Average***	***-1.4***	

Mean proportional differences from stereo-measurements ranged from 10-18% with an overall mean difference of 13.1% (Table 8). The smallest proportional differences were observed for Vermilion and Quillback Rockfishes, both large epi-benthic species, between 10 and 11%. The highest proportional differences were observed for the Olive/Yellowtail and Blue Rockfish, both semi-pelagic species, at 17.1 and 18.7%.

Table 8. Mean proportional difference in total length for laser-estimates from stereo-estimates by species for all analysts combined.

Common Name	Number of measurements	Mean proportional difference (%)	SD (%)
Black Rockfish	43	11.0	9.9
Blue Rockfish	278	18.7	16.7
Canary Rockfish	276	12.4	10.6
Copper Rockfish	33	14.0	11.1
Kelp greenling	125	14.2	15.3
Lingcod	150	13.1	13.2
Olive/yellowtail RF	203	17.1	17.8
Quillback Rockfish	49	10.5	8.7
Rosy Rockfish	46	11.3	7.5
Vermilion Rockfish	42	10.3	6.6
Yelloweye Rockfish	31	11.5	7.6
Total	***1276***	***13.1***	***11.4***

While results show that there were significant differences in laser-based size estimates when compared to stereo size estimates, overall the difference was small (averaging -1.4 cm or 13.1% of the total length). Additionally, it is important to take into consideration that both methods have their associated errors. For example, in an initial calibration of the stereo-video system using known-size targets of various lengths, a total of 68% of measurements fell within 1 cm and 95% fell within 5 cm of the actual length. Additionally, in a variation test using stereo-video measurements of 46 Canary Rockfish by five analysts, 96% of measurements were within 4 cm, 98% within 5 cm, for all five analysts combined. When these methods are compared, the errors associated with both may be compounded and reflected as the error in the laser-based method.

Based on the results of the comparison, laser-based sizing can be a relatively good method for providing a broad qualitative assessment of the size structure of a population within and across MPAs. This method can be useful for applications such as estimating the proportion of mature individuals in the population when assessing reproductive output but not recommended for monitoring changes in size distribution where more precise measurements are required.

BETWEEN YEAR COMPARISON

Rocky Reef Index Sites

A total of 84 transects were analyzed in the eight index sites for changes in fish and macro-invertebrate species abundances between the 2014 and 2015 survey years. Due to unfavorable ocean conditions, no transects inside the PSG reference area were surveyed in 2015, therefore no between year comparisons could be made. Between year comparison of rocky reef index sites were made for 17 select fish species/groupings, and 18 select invertebrate species/groupings (see methods for a full list of species).

We saw low initial variability for both fish and invertebrates at all index sites between 2014 and 2015 (see Appendices 6 - 9 for values). Additionally, no significant differences were observed in mean densities for any of the select fish or invertebrates between sampling years at both the Mattole Canyon SMR and its paired reference site. Description of observed differences in mean densities for fish and invertebrates for all other sites are given:

Fish

Initial variability and statistical results (P-values) between sampling years for rocky reef fish are given in Appendix 6. Overall, initial variability was low between years for all fish species, with an average range of 57% to 252% across all sites. As expected, statistical analysis and calculation of initial variability of fish species within rocky reef index sites showed little variability between years. For the more common non-aggregating rockfish species, variability was low, averaging from 42% to 124%. For the larger aggregating rockfish species, variability ranged from 63% to 405%.

In addition, only five species/groupings showed significant differences in their mean densities between sampling years within some of the index sites: YOY, UI rockfish, Lingcod, flatfish, and Yelloweye Rockfish. YOY were significantly different at the PSG SMCA site between 2014 and 2015, with less YOY seen in 2015. UI rockfish significantly decreased in 2015 at both the TM SMR and TM reference site. Lingcod densities increased significantly in 2015 at both the PSG SMCA and RR SMR sites. Flatfish also increased in 2015 at the TM SMR site, as did Yelloweye Rockfish at the RR SMR site.

Invertebrates

Initial variability and statistical results (P-values) between sampling years for rocky reef invertebrates are given in Appendix 7. Overall, initial variability was low between years for all invertebrate species, with an average range of 47% to 103% across all sites. There were many significant differences in the mean densities of several sea star species, sea cucumber species, and one anemone species.

From 2014 to 2015, 8 species/groupings of sea stars showed significant decreases in their mean densities (see Appendix 7 for list of sites). This trend was expected, as active signs of sea star wasting disease were noted in 2014 (Figure 53), especially at both Point St. George study areas. In 2014 we saw a total of 224 Stimpson's sun stars, sunflower stars, and short spined sea stars combined within all study areas, compared to only 16 observations in 2015. Other sea stars that showed significant declines in their densities include: the cushion star, fish eating star, red star, spiny/thorny star complex, and rainbow star.

Figure 43. Comparisons of healthy (left photo) and wasting (right photo) sea stars including: (a) Stimpson's sun star, (b) sunflower star, and (c) the short spined sea star.

In addition to differences observed in sea stars, one anemone species and three sea cucumber species also showed significant differences in their mean densities between years. The white-plumed anemone decreased in 2015 at the Ten Mile SMR site. The white branched sea cucumber decreased in 2015 at the PSG SMCA and TM SMR sites. The California sea cucumber and the white-plumed anemone also significantly decreased in 2015 at the Ten Mile reference site. Only the RR SMR site saw a significant increase in 2015 for both the California sea cucumber and the white branched sea cucumber. Slipper sea cucumbers also decreased significantly in 2015 at both the Ten Mile SMR and reference sites.

Although, we found the slipper cucumbers at the Ten Mile location were significantly different between 2014 and 2015, a closer examination of some of the still photographs revealed that during the sampling days in 2015 their tentacles were not exposed. Since exposed tentacles are the only way to distinguish them from the base substrate they are attached to they were not enumerated during video processing.

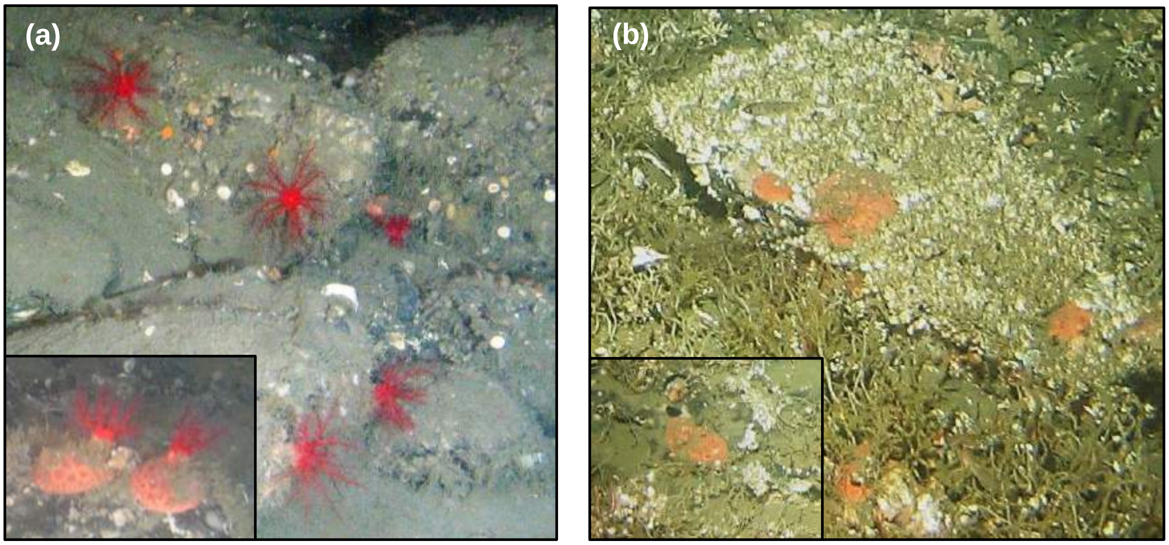


Figure 44. Comparison of slipper sea cucumbers in (a) 2014 with their tentacles exposed, and (b) 2015 with their tentacles retracted.

Soft Bottom Transects

Annual sampling within soft bottom transects was typically two per year, therefore a total of only 29 soft bottom transects were analyzed in the eight index sites for changes in fish and macro-invertebrate species abundances between 2014 and 2015 survey years. The low number of transects sampled did not allow for statistical comparison between years but initial variability between sampling years for soft bottom transects is given in Appendix 8 for fish and Appendix 9 for macro-invertebrates.

Overall, fish and invertebrate species presence and abundance greatly varied throughout sites and between years in soft bottom transects. The most commonly observed fish species/grouping, flatfish, showed very little initial variability, ranging from 14% to 71% across all sites. All other fish species showed greater variability between years. For the most commonly observed invertebrate species: sea whips, sea pens and white-plumed anemones, the combined average initial variability ranged from 47% to 470%. For all other invertebrate species, initial variability was generally low.

MONITORING RECOMMENDATIONS

With the baseline assessment of the North Coast Study Region (NCSR) complete, long-term monitoring can now be considered. All four coastal MPA study regions are fully implemented, statewide monitoring of MPAs is set to begin and recommendations made from regional baseline assessments will influence much of the decisions ahead. During the baseline period, the best available monitoring approaches were used and now set the benchmark for developing a long-term monitoring program. Careful consideration of cost and efficiency to adequately track and evaluate deep water habitats within California's MPA network will be required to develop a long-term monitoring plan.

Several well established monitoring programs exist for shallow water (less than 20 meters) and intertidal ecosystems, including citizen science programs that help reduce monitoring costs and provide opportunities for engagement by the public. However, no programs have been fully established to address deepwater monitoring priorities. As much of the rocky habitat within MPAs is deeper than 20 meters, data from within these deep subtidal ecosystems are critical for evaluating the effectiveness of MPAs, especially in rocky habitats.

With over 75% of California's territorial waters beyond the reach of conventional SCUBA based survey methods, few data collection options are available for deepwater ecosystems. Increasingly visual sampling techniques have become the standard for collecting non-lethal information on deepwater habitats. Visual sampling can be conducted using various techniques and platforms, but each can be limiting in the types of information that they collect. Camera sleds perform well in flat soft bottom habitats, but are not suitable for rugose rocky reef habitats. Drop cameras are effective at collecting data on fish species composition, size and abundance, but are not effective in collecting detailed data on invertebrates and habitat characteristics. Manned submersibles, ROVs and autonomous underwater vehicles collect detailed information on the entire benthic ecosystem, rather than just select metrics or indicators. ROVs have already been widely used to monitor MPAs beyond the MPA baseline program by Marine Applied Research and Exploration and California Department of Fish and Wildlife, who have collected over 1,800 km of video imagery from 178 MPAs and reference sites statewide.

Given the limited knowledge of mid-depth and deep subtidal ecosystems, including trophic changes that may occur related to MPA implementation, we recommend continuing visual ROV surveys of select MPAs and reference areas. Video processing methods should continue to identify all fish and macro-invertebrate species in a similar manner as conducted by this project. Minimal cost savings could be achieved by selecting fewer key species but at the cost of not fully understanding these mostly unexplored habitats. The methods and techniques utilized by this project are, at present, the most cost effective and thorough. When considering the relatively large areas of deep water rocky habitats that will need to be monitored, we feel that ROV survey methods costs are comparable to SCUBA base surveys.

Presented below is a set of suggested indicator species listed by habitat type that are abundant within the NCSR and are easily identifiable using video imagery alone. Based on the results of this project, we recommend prioritizing monitoring efforts of rocky reef ecosystems over soft bottom and deep canyon ecosystems for two reasons, 1) rocky reefs support a greater diversity and abundance of economically important species and 2) there are additional challenges associated with soft bottom and deep canyon monitoring efforts.

Monitoring of soft bottom habitats may be less likely to detect biologically important differences in MPA effects over time when compared to rocky reef habitats due to the species observed there. The ‘all other fish’ and flatfish subgroupings accounted for the majority of observations within all study locations. Species within the ‘all other fish’ subgrouping were inconsistent across sites, and therefore are not suitable for monitoring of long term MPA trends since they cannot be compared across sites and between years. While flatfish were frequently unable to be identified to the species level due to their cryptic concealment and habit of lying just beneath the surrounding sandy substrate.

Though deep canyon ecosystems hosted a diversity and abundance of rockfish, flatfish and other species, it may be difficult to find comparable habitats for reference areas, as each canyon is distinctly unique. Therefore, due to the additional effort which would be required to identify suitable reference sites, we do not recommend prioritizing monitoring of deep canyon ecosystems given any limit of time or budget constraints.

We recommend the following species/groupings:

<u>Recommended Fish:</u>

Mid-depth Rock Ecosystems
- Canary Rockfish
- Copper Rockfish
- Quillback Rockfish
- Vermillion Rockfish
- Yelloweye Rockfish
- Lingcod
- Kelp Greenling

Soft-bottom Subtidal Ecosystems
- Flatfish

Deep Canyon Ecosystems
- Greenstriped Rockfish
- Shortspine Thornyheads
- Longspine Thornyheads
- Sablefish
- Flatfish

<u>Recommended Invertebrates:</u>

Mid-depth Rock Ecosystems
- White-plumed anemones
- CA sea cucumbers
- Short red gorgonians
- Sea stars (all species)
- Basket stars

Soft-bottom Subtidal Ecosystems
- White sea pen
- Orange sea pen
- Sea whip
- Red octopus
- Dungeness crabs

Deep Canyon Ecosystems
- White-plumed anemones
- Short red gorgonians
- Mushroom soft coral

It is expected that changes over time for these species will be easily detectable using the recommended surveying and video processing methods. Many of the species/groupings are also common within the North Central Coast, Central Coast and South Coast study regions, allowing for comparison of trends statewide.

For fish, Yelloweye and Canary Rockfishes should be prioritized for monitoring as indicators of fishing pressure, as the Pacific Fishery Management Council (PFMC) has identified marine reserves as valuable management tools for species currently or formerly experiencing population declines due to overfishing. The next priority for monitoring, are those fish species identified as important to commercial and/or recreational fisheries by the PFMC which include all other fish species listed.

For macro-invertebrates, we suggest prioritizing monitoring the coral species listed, as they are sensitive to many environmental factors, and should be indicative of overall ecosystem health. It would also be prudent to include all sea stars in any monitoring plan, since they are an apex predator and their recent vast declines may also be indicative of overall ecosystem health. Fisheries managers may want to consider California sea cucumbers as the next monitoring priority as they are a minor fishery within the region.

Dungeness crabs were abundant throughout our study area and are an important fishery in the NCSR, so they were included in the monitoring list. However, although fluctuations in their abundance may be indicative of fishing pressure when comparing MPAs to reference sites, managers should keep in mind the potential difficulties using them as an indicator species due to their natural fluctuations in abundance over time.

FINANCIAL REPORT

The following funds and descriptions refer to expenditures as of 2/28/2017:

Budget Category	Budgeted Amount	Actual Expenditures	Balance	Variance
Salaries	$ 198,202.52	$ 202,535.75	$ (4,333.23)	-2.2%
Benefits	$ 48,248.00	$ 47,969.64	$ 278.36	0.6%
Supplies	$ 8,650.00	$ 5,427.30	$ 3,222.70	37.3%
Travel	$ 14,900.00	$ 14,065.67	$ 834.33	5.6%
Other Costs	$ 49,760.00	$ 49,760.00	$ -	0.0%
Ship Time	$ 89,713.48	$ 89,713.48	$ -	0.0%
Direct Cost Total:	$ 409,474.00	$ 409,471.84	$ 2.16	0.0%
Indirect Costs	$ 79,940.00	$ 79,939.58	$ 0.42	0.0%
Total	*$ 489,414.00*	*$ 489,411.42*	*$ 2.58*	*0.0%*

Salary and benefits - Spending on salary closely matched the budgeted amount over the course of the grant period. In general, salaries were paid to the PI for project supervision and oversight including operations at sea and in the post-processing laboratory, to offshore operations staff for ROV data collection, to research staff for data management, data entry, analysis, reporting, QA/QC checking of baseline survey data and writing of the Final Report.

Supplies - Funding was spent on a navigation computer, portable hard drives and tapes for data (imagery) storage, video recording equipment, at-sea consumables such as hose clamps, zip-ties and duct tape, and other items required for collecting data in the field and processing imagery in the lab.

Travel – Funding supported staff and equipment transport to and from study sites for data collection, and it supported travel costs to send the PI to meetings for sharing of results and collaborative discussions, including meetings with associates at Moss Landing Marine Laboratories.

Other Costs – Funding supported ROV equipment day rate for the Beagle ROV equipped with high definition video and digital still imagery.

Ship Time – Funding supported lease of the 85 foot, research vessel the Miss Linda, for two separate expeditions, one in 2014 and one in 2015.

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APPENDIX 1. NCSR Fish Mean Densities (100 m2) by Transect Type for 2014 and 2015.

Not Observed	>1 and ≤3	>5 and ≤10
>0 and ≤1	>3 and ≤5	>10

Grouping	Common Name	Point St. George				Reading Rock				Mattole Canyon						Ten Mile			
		MPA		Reference		MPA		Reference		MPA			Reference			MPA		Reference	
		Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Canyon	Rock	Soft	Canyon	Rock	Soft	Rock	Soft
Rockfish	Aurora Rockfish											0.010							
	Black Rockfish	0.004		0.437		0.440		0.305		0.263			0.844			0.089			
	Black/Blue Rockfish	0.021						0.015		0.017						0.004			
	Blue Rockfish	2.025		0.085		0.411		0.656		1.307	4.341		1.927	0.084		3.120		2.359	
	Bocaccio										0.020	0.007							
	Brown Rockfish					0.129		0.023								0.137		0.007	
	Canary Rockfish	2.312		0.924		0.224		0.636		1.639	2.110	1.143	0.683	0.042		1.110		1.138	
	Canary/Vermilion Rockfish	0.025		0.010		0.006		0.036		0.009						0.004			
	Chilipepper Rockfish											0.028			0.142				
	China Rockfish	0.006						0.008		0.007						0.043		0.086	
	Copper Rockfish	0.150		0.049		0.046		0.149		0.140			0.090			0.166		0.189	
	Darkblotched Rockfish											0.009			0.071				
	Gopher Rockfish																	0.004	
	Greenspotted Rockfish																		
	Greenstriped Rockfish											0.136			0.283				
	Olive/Yellowtail Rockfish	4.414		1.101		0.487		0.429		0.192	4.883	0.840	0.052			0.803		0.480	
	Pinkrose Rockfish											0.019							
	Quillback Rockfish	0.407		0.457		0.151		0.221		0.189	0.234	0.053	0.095			0.162		0.131	
	Red Banded Rockfish											0.029							
	Rosethorn Rockfish											0.010							
	Rosy Rockfish	0.119		0.010		0.087		0.258		0.097	0.236	0.037				0.045		0.260	
	Sebastomus Rockfish	0.231		0.133		0.118		0.366		0.122	0.179	0.074				0.128		0.551	
	Sharpchin Rockfish											0.017							
	Squarespot/Widow Rockfish	0.207		0.011		0.031		0.014			0.020	0.029				0.016		0.008	
	Starry Rockfish	0.004																0.007	
	Stripetail Rockfish											0.085			0.142				
	Tiger Rockfish	0.055		0.080		0.008		0.041											
	Vermilion Rockfish	0.178		0.026		0.039		0.178		0.142	0.142		0.094			0.127		0.138	
	Widow Rockfish	0.059				0.043		0.075			0.020		0.024			0.094		1.042	
	Yelloweye Rockfish	0.520		0.248		0.144		0.241		0.060	0.260	0.061						0.005	
	UI rockfish	1.660		0.866		0.965	0.026	1.010	0.043	0.785	0.929	0.463	0.948	0.042	0.496	1.660	0.424	1.321	0.098
	Halfbanded Rockfish		0.015		0.019					0.018						3.450		0.838	
	Pygmy Rockfish																		
	Shortbelly Rrckfish									0.625		17.307	2.288	67.479		7.850	0.081	7.304	
	Squarespot Rockfish	0.037																	
	UI small schooling rockfish	0.418						0.049		2.576	3.710	0.277	6.047			25.500	0.211	0.678	
	YOY	3.474		1.970	0.019	0.840		1.655	0.022	13.246	260.748	4.218	14.513	3.979		140.000	0.035	155.009	0.147
Hexagrammids	Combfish complex	0.018	0.375	0.070	0.031	0.018		0.011			0.016	0.007					0.143	0.008	0.022
	Kelp Greenling	0.373		0.214		0.256		0.317		1.064	0.285	0.113	1.238	0.295		0.967		0.681	
	Lingcod	0.820	0.145	0.290	0.030	0.712	0.083	0.808	0.158	1.004	2.085	0.535	0.584	0.042	0.212	1.430	0.209	1.368	0.160
	Painted Greenling									0.007						0.084		0.083	
	UI hexagrammid	0.006				0.009		0.016		0.009									
Flatfish	Curlfin Turbot											0.007							
	Dover Sole	0.023			0.019		0.024					0.427			0.354	0.013	0.057	0.012	
	English Sole	0.070	0.015	0.013	0.046		0.184		0.090	0.026	0.028	0.161	0.024		0.283	0.027	0.040		0.010
	Pacific Halibut	0.007																	
	Pacific Sanddab						0.117					0.010							
	Petrale Sole	0.084	0.063	0.005			0.083		0.067	0.028	0.070	0.093			0.142	0.004	0.085		0.010
	Rex Sole	0.031	0.273		0.270		0.182		0.068			0.151			1.345	0.004	0.028		
	Rock Sole						0.015			0.019		0.015	0.010	0.084					
	Slender Sole											0.032							
	Speckled Sanddab						0.023												
	Spotted Turbot										0.014								
	Starry Flounder																0.026		
	UI flatfish	2.110	4.617	2.743	5.834	0.084	9.887	0.026	6.377	2.145	5.707	1.967	0.370	1.263	0.779	1.070	5.122	0.147	2.322
	UI sanddab	0.116	0.324	0.005	0.363	0.009	0.214		0.045	0.206	0.197	0.022	0.008			0.222	0.415	0.024	0.021

Appendix 1. Continued.

Grouping	Common Name	Point St. George				Reading Rock				Mattole Canyon						Ten Mile			
		MPA		Reference		MPA		Reference		MPA			Reference			MPA		Reference	
		Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Canyon	Rock	Soft	Canyon	Rock	Soft	Rock	Soft
Sculpins	Buffalo Sculpin															0.009			
	Cabezon					0.010				0.017			0.025			0.010			
	Staghorn Sculpin						0.046										0.045		
	UI sculpin			0.008		0.013	0.024		0.023			0.019							
Other benthic fish	Pacific Hagfish	0.020		0.005								0.078			0.071				
	Pacific Sand Lance													5.285					
	Pacific Tomcod						0.024												
	Sablefish											0.044			0.496	0.008	0.041		0.022
	Thornyhead complex	0.008										0.192							
	UI cod				0.016		0.013		0.044			0.852					0.263		0.218
	UI eel pout	0.025	2.226	0.162	2.928	0.041	0.046	0.009	0.022	0.009		0.023					0.547	0.046	0.109
	UI goby	0.042		0.010		0.008		0.084				0.007						0.012	
	UI poacher											0.062			0.071				
	UI small benthic fish	0.124	0.090		0.303	0.052	0.013	0.095		0.035	0.070	0.164	0.033		0.496	0.130	0.186	0.032	0.031
Surfperch	Pink Surfperch			0.020												0.069		0.005	
	Shiner Surfperch						0.264										0.149		
	Striped Surfperch															0.050			
	UI surfperch	0.005	0.015				0.037			0.017			0.008			0.008	0.012		
Schooling	Pacific Hake				0.035							0.312			0.850		0.122		0.044
	UI salmonid		0.015				0.013												
	UI schooling pelagic		0.015	1.266		0.800							0.410			0.390			
	UI smelt					0.017	81.678	0.004	29.074								0.689		10.330
Other	Ocean Sunfish									0.018								0.007	
	Wolf Eel					0.008		0.007										0.028	
	UI fish	0.175	0.062	0.238	0.403	0.645	0.574	0.101	0.435	0.102	0.035	1.124	0.036	0.042	0.142	0.173	1.499	0.131	0.669
Chondrichthyans	Big Skate				0.031												0.014		
	Longnose Skate								0.023			0.177	0.010						
	Sixgill Shark					0.009													
	Spiny Dogfish														5.169				
	Spotted Ratfish											0.112			0.354			0.005	
	UI shark																0.020		
	UI skate		0.016				0.023					0.007					0.079		0.014

APPENDIX 2. NCSR Invertebrate Mean Densities (100 m2) by Transect Type for 2014 and 2015.

Not Observed	>1 and ≤3	>5 and ≤10
>0 and ≤1	>3 and ≤5	>10

Grouping	Common Name	Point St. George				Reading Rock				Mattole Canyon						Ten Mile			
		MPA		Refernce		MPA		Reference		MPA			Reference			MPA		Reference	
		Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Canyon	Rock	Soft	Canyon	Rock	Soft	Rock	Soft
Sponges	Gray moon sponge											0.160							
	Gray puffball sponge							0.020		0.220	0.150	0.010	1.610	0.120		1.900			
	Orange puffball sponge	0.050		0.190		0.360		0.160		1.060	0.170	0.010	2.430	0.180		1.800		0.490	
	Trumpet sponge									0.060	0.040		0.030						
	UI boot sponge			0.010							0.090								
	UI branched sponge	0.010		0.040						1.820	3.380	1.490	0.170	0.720		0.060		2.170	
	UI nipple sponge			0.010		0.730		0.340		0.680	1.250	0.050	3.590	0.960		0.060		0.110	
	UI stalked boot sponge										0.650								
	UI trumpet sponge											0.010							
Anemones	Fish eating urticina	0.180		0.175		0.508		1.174		0.517	0.440	0.039	0.688			0.453		1.041	
	Frilled anemone	0.490		0.380		0.770		0.210		0.370		0.030				0.010	0.020	0.030	
	Sand-rose anemone	0.940	0.080	1.510		0.630	0.033	0.790	0.058	0.250	0.600	0.270	0.060			0.770	0.190	1.210	0.260
	Stubby rose anemone										0.080								
	Swimming anemone	0.010		0.070		0.030		0.020							0.700				
	White-plumed anemone	66.020	0.870	40.650	4.430	14.820	5.944	5.270	8.798	19.390	109.580	21.740	11.350	1.850	2.510	23.940	0.100	17.960	0.260
	White-spotted rose anemone	0.010		0.030		0.010		0.010											
	UI anemone	0.180	0.020	0.400	0.020	0.260		0.180	0.064	0.040	0.470	9.440	0.330	0.480	0.500	0.090		0.090	0.020
	UI sand dwelling anemone	0.010	0.060	0.030	0.810	0.010		0.010	0.097		0.270	0.620	0.020		1.000	0.030	0.060		0.190
	UI tube dwelling anemone	0.070		0.070	0.030	0.520		1.380		0.320	0.420	0.130				0.220		0.030	
	UI anemone 1	0.010		0.050		0.010		0.030		0.020	0.510	0.220	0.190		0.300	0.160		0.040	0.030
	UI anemone 2			0.030						0.020	0.130	0.300	0.030			0.020			
	UI anemone 3											12.060			0.200				
	UI anemone 4	0.010		0.030		0.010		0.010			0.620	30.660			0.100				
	UI anemone 5			0.020								1.500			1.400				
	UI anemone 6											2.190							
Corals	California hydrocoral			0.410						18.540	4.060	0.220	8.930	0.420					
	Mushroom soft coral											4.350							
	Short red gorgonian	18.380		7.270		0.010		0.260		35.210	9.600	2.190	20.770	9.260		3.700	0.030	2.040	
	UI gorgonian	0.010		0.100									0.010					0.040	
	Orange sea pen	0.050	0.020				0.109		0.233	0.070	0.250		0.010	0.060		0.030	0.130	0.020	0.180
	Sea whip	0.390	12.360		2.670		0.775		0.515							0.180	1.740	0.600	7.860
	White sea pen	1.240	2.050		18.910		10.366		16.177	0.020	0.790	0.170				0.580	0.400	0.210	0.690
	UI sea pen		0.060				1.663			0.050	0.030					0.180			0.800
Sea slugs and hares	Clown nudibranch										0.040								
	Noble sea lemon					0.040													
	Orange-peel nudibranch	0.030				0.050		0.040		0.010			0.050					0.020	
	Pink *Tritonia*						0.018		0.064							0.030	0.040		
	Pleurobranchaea californica	0.010	0.530		0.340		0.748		0.630	0.030	0.530	0.550			0.400	0.190	0.220	0.130	0.270
	Striped nudibranch								0.029										
	Swimming nudibranch							0.010										0.010	
	UI nudibranch	0.030		0.120		0.040		0.110		0.010	0.120					0.100			
Cepha-lopods	Giant Pacific octopus	0.040				0.010				0.010		0.090						0.010	
	Market squid	0.090	0.020		0.050		0.033		0.097		0.960					0.050	0.540	0.030	0.290
	Red octopus	0.210	2.800	0.150	3.970	0.010	1.128		0.932	0.250	7.840	6.820	0.060	0.770	0.200	0.350	3.570	0.200	4.780
Crustaceans	Acorn barnacle					1.320		2.310		0.050			0.070			0.050		0.730	
	Cancer complex		0.100							0.010									
	Decorator crab	0.010										0.030	0.020			0.010			
	Dungeness crab	0.050	0.960	0.390	1.510		0.219		0.209				0.010				0.760		0.670
	Puget Sound king crab															0.030			
	Red rock crab	0.010		0.010			0.018									0.010			
	Spot prawn											0.090							
	UI crab					0.030						0.010	0.010						
Cucumbers	California sea cucumber	26.950		41.480		34.810		32.450	0.096	16.220	10.070	1.940	9.630	0.300		30.410		31.600	
	Orange sea cucumber	0.220		0.640		0.490		0.120		0.020	0.030	0.010	0.050			0.100		0.110	
	Slipper sea cucumber	29.370		51.020		31.420		159.590					0.040			7.110		11.460	
	White branched sea cucumber	1.200		0.430		1.040		7.600				0.070				0.120		0.240	
	UI branched cucumber					1.810		0.040											

Appendix 2. Continued.

Grouping	Common Name	Point Saint George				Reading Rock				Mattole Canyon						Ten Mile			
		MPA		Refernce		MPA		Reference		MPA			Reference			MPA		Reference	
		Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Rock	Soft	Canyon	Rock	Soft	Canyon	Rock	Soft	Rock	Soft
Urchins	Fragile pink urchin	0.020								0.060	0.080	5.600			0.100				
	Purple sea urchin									0.010						0.230			
	Purple/red urchin complex									0.010						0.160			
	Red sea urchin	0.030				0.020		0.010		1.470		0.010	7.940			5.730		0.220	
Sea stars	Basket star	5.040		0.300						1.330	3.010	1.220	0.040	0.540		0.020		0.090	0.030
	Bat star	0.010						0.040					0.020						
	Bat star/red star complex	0.010						0.050											
	Cookie star	0.030				0.050		0.060		0.020	0.120	0.070						0.040	
	Crested sea star																		
	Cushion star	0.170		0.340		0.550		0.550		0.080	0.230	0.140	0.070	0.060		0.010		0.020	
	Dawson's sun star	0.010				0.030		0.030											
	Fish eating star	0.550		0.600		0.840		0.520		0.110	0.350	0.550	0.140			0.050		0.010	
	Giant spined star															0.010			
	Henricia complex	0.640		0.510		4.140		5.810		1.600	3.260	0.380	1.340	0.480	0.100	0.990		1.580	
	Leather star	0.210		0.390		0.390		0.270	0.032	0.580	0.500	0.090	0.710	0.180	0.100	0.890		0.690	
	Long legged sunflower star											0.240			0.100				
	Ochre star															0.040		0.010	
	Pisaster complex															0.010			
	Rainbow star	0.010		0.240		0.240		0.130		0.020		0.010	0.040			0.030		0.100	
	Red sea star	3.150		1.980		5.810		12.880		0.830	1.160	0.200	0.620	0.060		2.930		9.110	
	Rose star														0.100				
	Sand star	0.100	0.320	0.040	0.140		0.237	0.010	0.818	0.810	0.340	0.090	0.150			0.520	3.910	0.230	0.960
	Short spined sea star	0.250		1.020	0.140	0.010		0.020		0.030	0.350	0.010	0.040			0.080		0.160	
	Solaster sun star complex	0.040		0.030		0.110		0.110			0.030		0.010						
	Spiny red star											0.010			0.100				
	Spiny/thorny star	0.040		0.010		0.170		0.170		0.090	0.040	0.260	0.010			0.030		0.040	
	Stimpson's sun star	0.030		0.200		0.310		0.100		0.050			0.110			0.010		0.020	
	Sunflower star	0.100		0.260	0.020	0.020		0.010				0.010	0.010					0.010	
	Sunflower star complex							0.010					0.120						
	Thorny sea star	0.030		0.060				0.020		0.070	0.170	0.020	0.110			0.040		0.010	
	UI sea star	0.160		0.170	0.020	0.560		0.910	0.032	0.520	0.460	0.330	0.230		0.100	0.080		0.170	0.010
Other inverts	Light edged ribbon worm											0.130							
	Northern staghorn bryozoan												0.080						
	Rock scallop	0.010														0.010			
	Stalked tunicate									0.010			0.010			0.060			
	UI branched bryozoan					0.210				0.080		0.160	1.410						
	UI sea jelly		0.020				0.067	0.010	0.032	0.020		0.030		0.060		0.200	0.270	0.460	1.050
	UI lobed sponge/tunicate					0.370		0.560		0.380		2.130	0.560			0.010		0.080	
	UI salp									0.010							0.040		
	UI scallop	0.050				0.280		0.020											
	UI tubeworm	0.040		0.070				0.010											
	UI whelk	0.020						0.020				0.090	0.010						

APPENDIX 3. Full Baseline Characterizations by Study Location.

Figure numbers in this section match those in the brief characterizations in the main body of the document for ease of reference.

Point St. George Reef Offshore SMCA and Reference Area

Located northeast of Crescent City, California, the Point St. George Reef Offshore State Marine Conservation Area (PSG SMCA) protects 24.7 square kilometers of marine habitats with depths ranging from 55 to 125 m (CDFW 2016b). The MPA is predominantly soft habitat (96%), but also protects the tip of a large offshore rocky reef (Figure 4). All fishing is prohibited within this SMCA with the exceptions of salmon by trolling and Dungeness crab by trapping. In addition to these exceptions, two federally recognized tribes, Elk Valley Rancheria and Tolowa Dee-ni' Nation, are exempt from the area and take regulations of the PSG SMCA, but still must comply with all other existing regulations, including the Rockfish Conservation Areas, which have prohibited the take of groundfish in depths exceeding 20 fathoms (~37 m) since 2002.

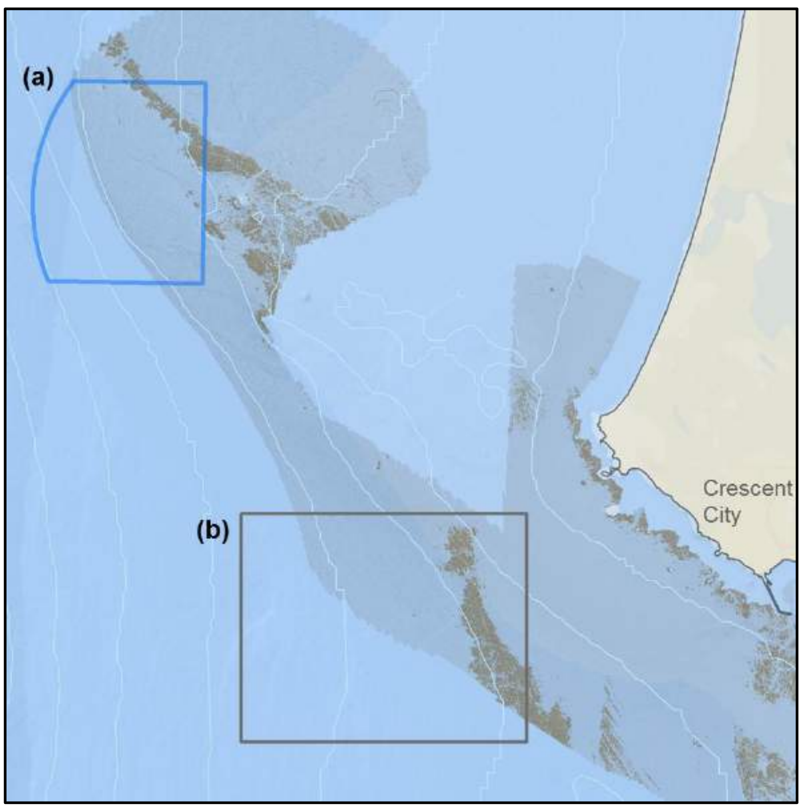

Figure 4. Point St. George study area showing the rocky reef and surrounding soft bottom habitats in (a) the SMCA and (b) reference area.

Located 6.3 km southeast of the PSG SMCA, a rocky reef and the surrounding soft bottom habitats were selected as a reference area for comparison (Figure 4). The reference area was selected based on similar habitats and depths (determined from multibeam mapping imagery) as inside its corresponding MPA. There are no state regulations specific to the reference area, but federal regulations prohibit the take of groundfish as part of the Rock Fish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMCA.

Survey Totals

Total sampling effort inside the Point St. George SMCA and reference area for both 2014 and 2015 survey years are presented in Table 1. Over the two sampling years, sampling effort within each study area was different. At the reference area, six transects targeting rocky reef habitat inside the index site were not surveyed due to unfavorable ocean conditions and reduced water visibility.

Table 1. Survey totals for Point St. George SMCA and reference area for rocky reef and soft bottom transects, including hours of video (per camera), total number of photos on transect, number of transects, total kilometers surveyed and depth (average, max and min).

Study Area	Survey Year	Hours of Video	No. of Photos	Rocky Reef		Soft Bottom		Depth Range (m)		
				No. of Transects	Total km	No. of Transects	Total km	Avg	Min	Max
SMCA	2014	6.8	758	8	4.9	2	2.1	65	37	111
	2015	5.5	1,028	10	5.4	2	1.0	66	41	88
	Totals	***12.3***	***1,786***	***18***	***10.3***	***4***	***3.1***			
Reference	2014	7.8	861	10	5.7	3	3.2	58	36	96
	2015	1.8	326	2	1.0	2	1.1	67	59	72
	Totals	***9.6***	***1,187***	***12***	***6.7***	***5***	***4.3***			

Substrate

Substrate types observed on transects are not mutually exclusive and represent the proportion of the total surveyed transect distance that has a given substrate present (see methods for full description). Inside the SMCA and reference area, transects that targeted the rocky reef were primarily composed of rock and mud (Figure 5). Other substrates were less common at both study areas, with the exception of cobble at the reference area, which was observed on 5% of the rocky reef. Transects targeting soft bottom habitats within both the SMCA and reference area were composed mostly of mud with some sand substrate.

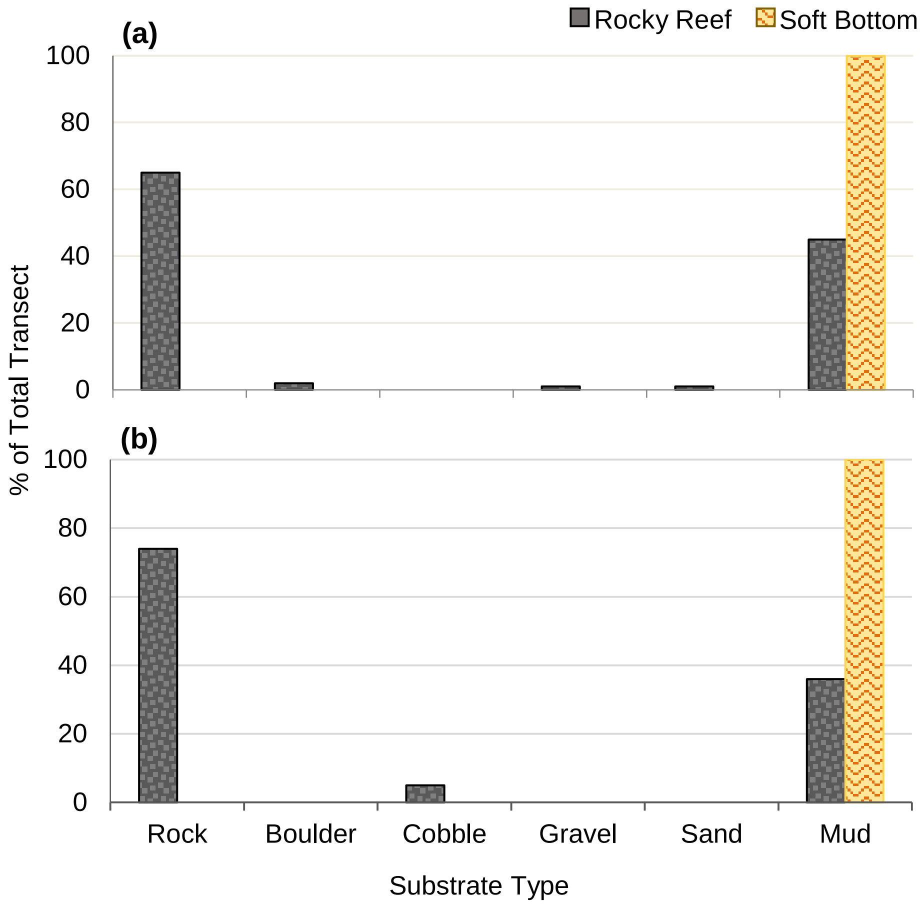

Figure 5. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef and soft bottom) for survey lines inside the (a) Point St. George SMCA and (b) reference area.

Habitat

Habitat types derived from substrate data collected from both rocky reef and soft bottom transects are show in in Figure 6. Overall, the rocky reef and soft bottom habitats were comparable. Within the rocky reef, the SMR and reference area were mainly composed of hard and soft habitats, which combined represented, 89% of the habitat at the SMR and 86% at the reference area. Mixed habitats were least common in both the SMR and reference area. Outside the rocky reef, transects targeting soft bottom habitats within the SMR and reference area were classified as 100% soft habitat.

Habitat rugosity was however different between the two study areas (Figure 6). Within the rocky reef of the SMCA, lower proportions of both medium and high rugosity and increased proportions of low rugosity and flat bottom habitats were observed, compared to the reference area. At both study areas, the habitats classified as being flat bottom were associated with only portions of transects that were classified as soft habitat. Outside the rocky reef, transects targeting soft bottom were entirely comprised of flat rugosity habitats at both the SMR and reference area.

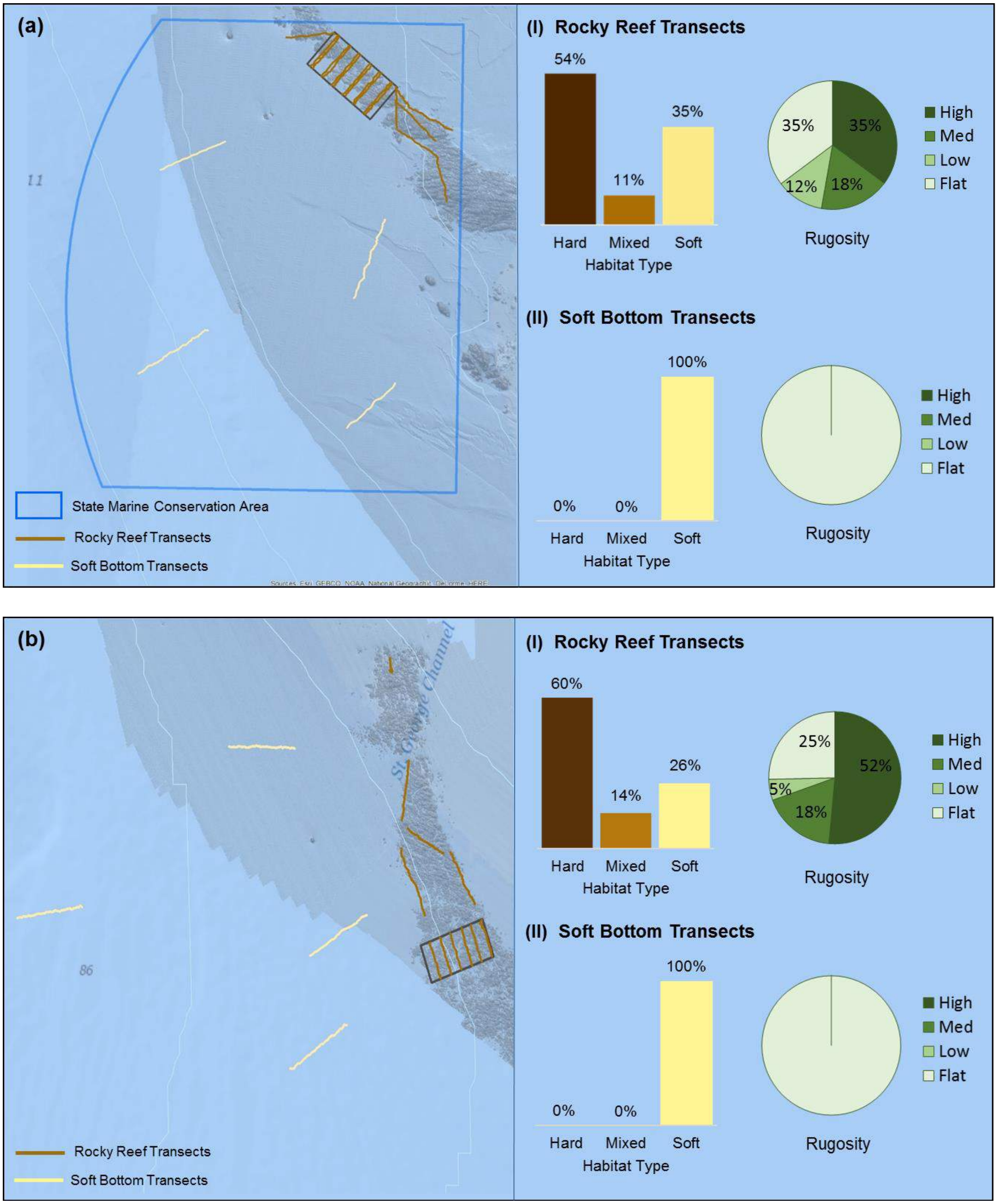

Figure 6. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Point St. George Reef Offshore SMCA and (b) reference area for transect lines targeting: (I) the rocky reef and (II) the soft bottom habitats.

Fish

Fish were summarized into seven taxonomic subgroupings for comparison between the Point St. George SMCA and reference area and are presented by transect habitat type in Figure 7. A full list of observed fish species/groupings enumerated on both rocky reef and soft bottom transects for both the SMCA and reference area is shown in Tables 2 & 3. At the SMCA, 4,706 fish were observed from 44 species/groupings within rocky reef and soft bottom transects combined. The reference area had under half the observations, with 1,973 fish observations from 36 species/groupings. When sampling level are considered, the reference area's total counts are approximately 20% less than the SMCA.

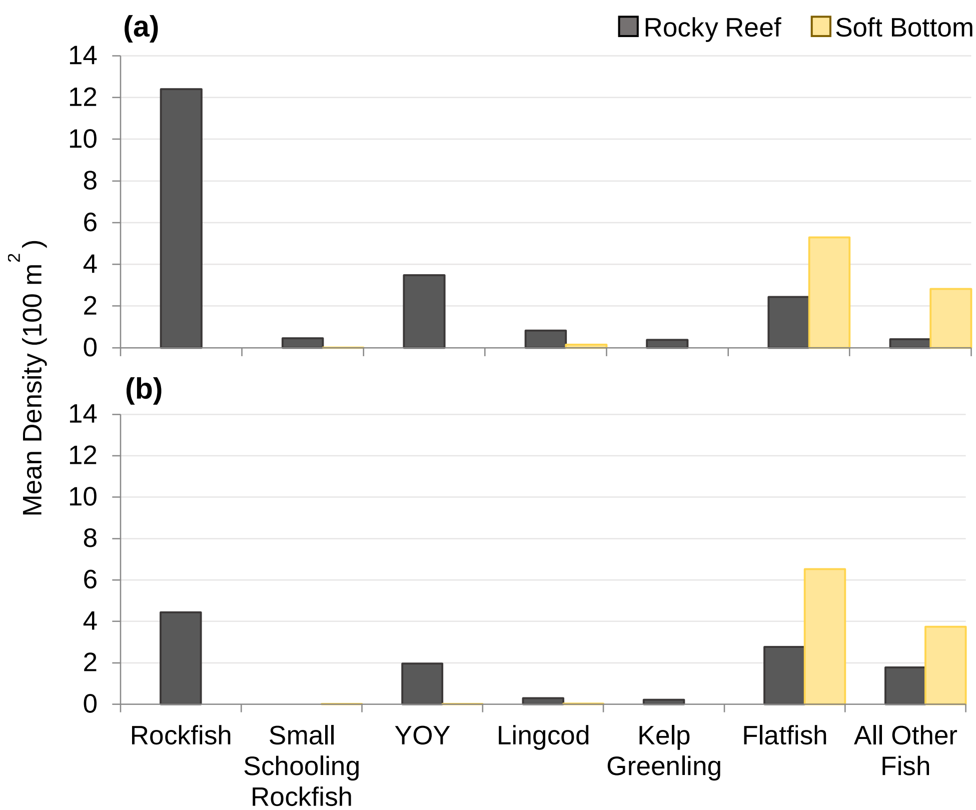

Figure 7. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Point St. George SMCA and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Tables 2 & 3.

Table 2. Total count, average density and standard deviation of fish by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Point St. George SMCA.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD		Size (cm)		
			Rocky Reef (n=18)	Soft Bottom (n=4)	Avg	Max	Min
Rockfish							
Blue Rockfish	*Sebastes mystinus*	904	2.025 ± 1.965	- -	33	50	12
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	845	4.414 ± 3.000	- -	36	54	17
Canary Rockfish	*Sebastes pinniger*	439	2.312 ± 1.945	- -	28	47	10
UI rockfish	Unidentified *Sebastes sp.*	371	1.660 ± 1.165	- -	20	46	10
Yelloweye Rockfish	*Sebastes ruberrimus*	96	0.520 ± 0.387	- -	29	57	11
Quillback Rockfish	*Sebastes maliger*	78	0.407 ± 0.333	- -	36	48	28
Sebastomus Rockfish	Subgenus *Sebastomus*	39	0.231 ± 0.322	- -	21	28	9
Squarespot/Widow Rockfish	*Sebastes hopkinsi or entomelas*	36	0.207 ± 0.797	- -	21	36	7
Vermilion Rockfish	*Sebastes miniatus*	29	0.178 ± 0.191	- -	40	55	29
Copper Rockfish	*Sebastes caurinus*	27	0.150 ± 0.168	- -	38	55	20
Rosy Rockfish	*Sebastes rosaceus*	20	0.119 ± 0.161	- -	22	30	14
Widow Rockfish	*Sebastes entomelas*	15	0.059 ± 0.101	- -	33	45	14
Tiger Rockfish	*Sebastes nigrocinctus*	9	0.055 ± 0.105	- -	34	40	23
Canary/Vermilion Rockfish	*Sebastes pinniger or miniatus*	6	0.025 ± 0.043	- -	31	40	25
Black/Blue Rockfish	*Sebastes melanops or mystinus*	3	0.021 ± 0.071	- -	26	26	26
Black Rockfish	*Sebastes melanops*	1	0.004 ± 0.019	- -	36	36	36
China Rockfish	*Sebastes nebulosus*	1	0.006 ± 0.024	- -	-	-	-
Speckled Rockfish	*Sebastes ovalis*	1	n/a	-	-	-	-
Starry Rockfish	*Sebastes constellatus*	1	0.004 ± 0.019	- -	28	28	28
Small Schooling Rockfish							
Small schooling rockfish	Schooling rockfish (10-15cm)	127	0.418 ± 1.387	- -	11	15	10
Squarespot Rockfish	*Sebastes hopkinsi*	7	0.037 ± 0.156	- -	21	30	16
Halfbanded Rockfish	*Sebastes semicinctus*	1	- -	0.015 ± 0.030	9	9	9
Young of the year rockfish	Young of year rockfish	567	3.474 ± 4.699	- ± -	8	9	3
Lingcod	*Ophiodon elongatus*	158	0.820 ± 0.747	0.145 ± 0.236	50	80	20
Kelp Greenling	*Hexagrammos decagrammus*	66	0.373 ± 0.262	- -	36	50	23
Flatfish							
UI flatfish	Unidentified Pleuronectiformes	561	2.110 ± 1.756	4.617 ± 2.398	13	40	5
UI sanddab	Unidentified *Citharichthys sp.*	37	0.116 ± 0.214	0.324 ± 0.501	13	24	5
Rex Sole	*Glyptocephalus zachirus*	21	0.031 ± 0.076	0.273 ± 0.314	15	25	8
Petrale Sole	*Eopsetta jordani*	17	0.084 ± 0.096	0.063 ± 0.085	20	32	12
English Sole	*Parophrys vetulus*	12	0.070 ± 0.128	0.015 ± 0.030	20	28	10
Dover Sole	*Microstomus pacificus*	4	0.023 ± 0.065	- -	23	33	18
Pacific Halibut	*Hippoglossus stenolepis*	1	0.007 ± 0.031	- -	110	110	110
All Other Fish							
UI eel pout	Unidentified Zoarcidae	106	0.025 ± 0.064	2.226 ± 4.452	13	16	8
UI fish	Unidentified fish	33	0.175 ± 0.268	0.062 ± 0.083	13	33	6
UI small benthic fish	Unidentified small bottom fish	26	0.124 ± 0.174	0.090 ± 0.180	11	21	5
Combfish complex	*Zaniolepis frenata or latipinnis*	22	0.018 ± 0.077	0.375 ± 0.749	11	13	8
UI goby	Unidentified Gobiidae	6	0.042 ± 0.093	- -	11	13	10
Pacific Hagfish	*Eptatretus stoutii*	3	0.020 ± 0.047	- -	38	50	25
UI surfperch	Unidentified Embiotocidae	2	0.005 ± 0.022	0.015 ± 0.030	9	10	8
Thornyhead Rockfish	*Sebastolobus alascanus* or *altivelis*	1	0.008 ± 0.035	- -	13	13	13
UI greenling	Unidentified Hexagrammidae	1	0.006 ± 0.025	- -	-	-	-
UI skate	Unidentified *raja sp.*	1	- -	0.016 ± 0.032	70	70	70
UI salmonid	Unidentified Salmonidae	1	- -	0.015 ± 0.030	50	50	50
UI schooling pelagic	Unidentified schooling pelagic fish	1	- -	0.015 ± 0.030	15	15	15

Table 3. Total count, average density and standard deviation of fish by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Point St. George reference area.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD		Size (cm)		
			Rocky Reef (n=12)	Soft Bottom (n=5)	Avg	Max	Min
Rockfish							
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	176	1.101 ± 1.011	- -	34	48	21
UI rockfish	Unidentified *Sebastes sp.*	126	0.866 ± 0.513	- -	17	40	10
Canary Rockfish	*Sebastes pinniger*	122	0.924 ± 0.875	- -	30	42	12
Quillback Rockfish	*Sebastes maliger*	53	0.457 ± 0.242	- -	37	47	30
Yelloweye Rockfish	*Sebastes ruberrimus*	25	0.248 ± 0.159	- -	27	45	15
Black Rockfish	*Sebastes melanops*	22	0.437 ± 1.124	- -	39	45	35
Blue Rockfish	*Sebastes mystinus*	19	0.085 ± 0.168	- -	32	38	18
Sebastomus Rockfish	Subgenus *Sebastomus*	13	0.133 ± 0.217	- -	20	28	10
Tiger Rockfish	*Sebastes nigrocinctus*	8	0.080 ± 0.147	- -	34	38	32
Copper Rockfish	*Sebastes caurinus*	4	0.049 ± 0.114	- -	35	38	27
Vermilion Rockfish	*Sebastes miniatus*	3	0.026 ± 0.061	- -	38	40	36
Canary/Vermilion Rockfish	*Sebastes pinniger* or *miniatus*	1	0.010 ± 0.034	- -	-	-	-
Rosy Rockfish	*Sebastes rosaceus*	1	0.010 ± 0.032	- -	20	20	20
Squarespot/Widow Rockfish	*Sebastes hopkinsi* or *entomelas*	1	0.011 ± 0.035	- -	12	12	12
Small Schooling Rockfish							
Halfbanded Rockfish	*Sebastes semicinctus*	1	- -	0.019 ± 0.038	8	8	8
Young of year rockfish	Young of year rockfish	201	1.970 ± 1.909	0.019 ± 0.038	7	9	4
Lingcod	*Ophiodon elongatus*	28	0.290 ± 0.380	0.030 ± 0.061	52	76	15
Kelp Greenling	*Hexagrammos decagrammus*	24	0.214 ± 0.151	- -	35	48	28
Flatfish							
UI flatfish	Unidentified Pleuronectiformes	694	2.743 ± 4.830	5.834 ± 4.705	11	25	6
UI sanddab	Unidentified *Citharichthys sp.*	25	0.005 ± 0.016	0.363 ± 0.726	13	22	10
Rex Sole	*Glyptocephalus zachirus*	17	- -	0.270 ± 0.314	14	24	10
English Sole	*Parophrys vetulus*	5	0.013 ± 0.030	0.046 ± 0.093	19	23	16
Dover Sole	*Microstomus pacificus*	1	- -	0.019 ± 0.038	14	14	14
Petrale Sole	*Eopsetta jordani*	1	0.005 ± 0.016	- -	21	21	21
All Other Fish							
UI eel pout	Unidentified Zoarcidae	176	0.162 ± 0.204	2.928 ± 4.906	13	21	7
UI schooling pelagic	Unidentified schooling pelagic fish	140	1.266 ± 4.199	- -	16	20	14
UI fish	Unidentified fish	48	0.238 ± 0.311	0.403 ± 0.688	12	33	7
UI small benthic fish	Unidentified small bottom fish	20	- -	0.303 ± 0.605	10	14	9
Combfish complex	*Zaniolepis frenata* or *latipinnis*	9	0.070 ± 0.091	0.031 ± 0.035	13	18	10
Big Skate	*Raja binoculata*	2	- -	0.031 ± 0.062	100	100	100
Pacific Hake	*Merluccius productus*	2	- -	0.035 ± 0.041	36	43	29
Pink Surfperch	*Zalembius rosaceus*	2	0.020 ± 0.065	- -	12	12	12
Pacific Hagfish	*Eptatretus stoutii*	1	0.005 ± 0.016	- -	50	50	50
UI cod	Unidentified Gadidae	1	- -	0.016 ± 0.033	30	30	30
UI goby	Unidentified Gobiidae	1	0.010 ± 0.032	- -	10	10	10
UI sculpin	Unidentified Cottidae	1	0.008 ± 0.027	- -	12	12	12

Rocky Reef Fish

On rocky reef transects inside the SMCA and in the reference area, rockfish were the most abundant subgroup, accounting for 61% of the total rocky reef fish density inside the SMCA and 39% at the reference area (Figure 7). Inside the SMCA, the rockfish subgroup included 20 species/groupings; as well as fish that could only be classified as unidentified rockfish (excluding small schooling rockfish and YOY). At the reference area, the rockfish subgroup included observations from 14 species/groupings.

Between the two study areas, differences in overall density of the rockfish subgroup were most notable, with almost three times the rockfish density within the SMCA. Over 90% of the rockfish subgroup density was comprised of six species/groupings, five of which are common to both study areas: Olive/Yellowtail, Canary, Yelloweye, Quillback and unidentified rockfish. Within the SMCA, Blue Rockfish and within the reference area Black Rockfish account for the sixth species/grouping.

YOY were also observed at both study areas, while small schooling rockfish were only observed within the SMCA. Other fish species observed within the rocky reef included Lingcod and Kelp Greenling. Flatfish were fairly common within the rocky reef and associated with the portions of the transects that were defined as soft habitat.

Soft Bottom Fish

Surveys of soft bottom habitat were dominated by the flatfish and the ‘all other fish’ subgroupings, which accounted for over 98% of the total soft bottom fish density at both study areas (Figure 7). Flatfish were the most abundant and observed with similar densities at both sites, though at the reference area densities were slightly higher. Within the ‘all other fish’ subgroup, unidentified eel pouts represented almost 80% of the observations within both study areas.

Invertebrates

Invertebrates were placed into seven mobile and seven sessile macro-invertebrate subgroupings for comparison between the Point St. George SMCA and reference area and are presented by transect habitat type in Figure 8. Full lists of observed sessile and mobile macro-invertebrate species/groupings enumerated on both rocky reef and soft bottom transects for both the SMCA and reference area are shown in Tables 4 & 5. For both rocky reef and soft bottom transects combined, 21,975 individuals from 58 species/groupings were enumerated at the SMCA and 13,815 individuals from 48 species/groupings were enumerated at the reference area. When sampling levels are considered, the total counts are approximately equal.

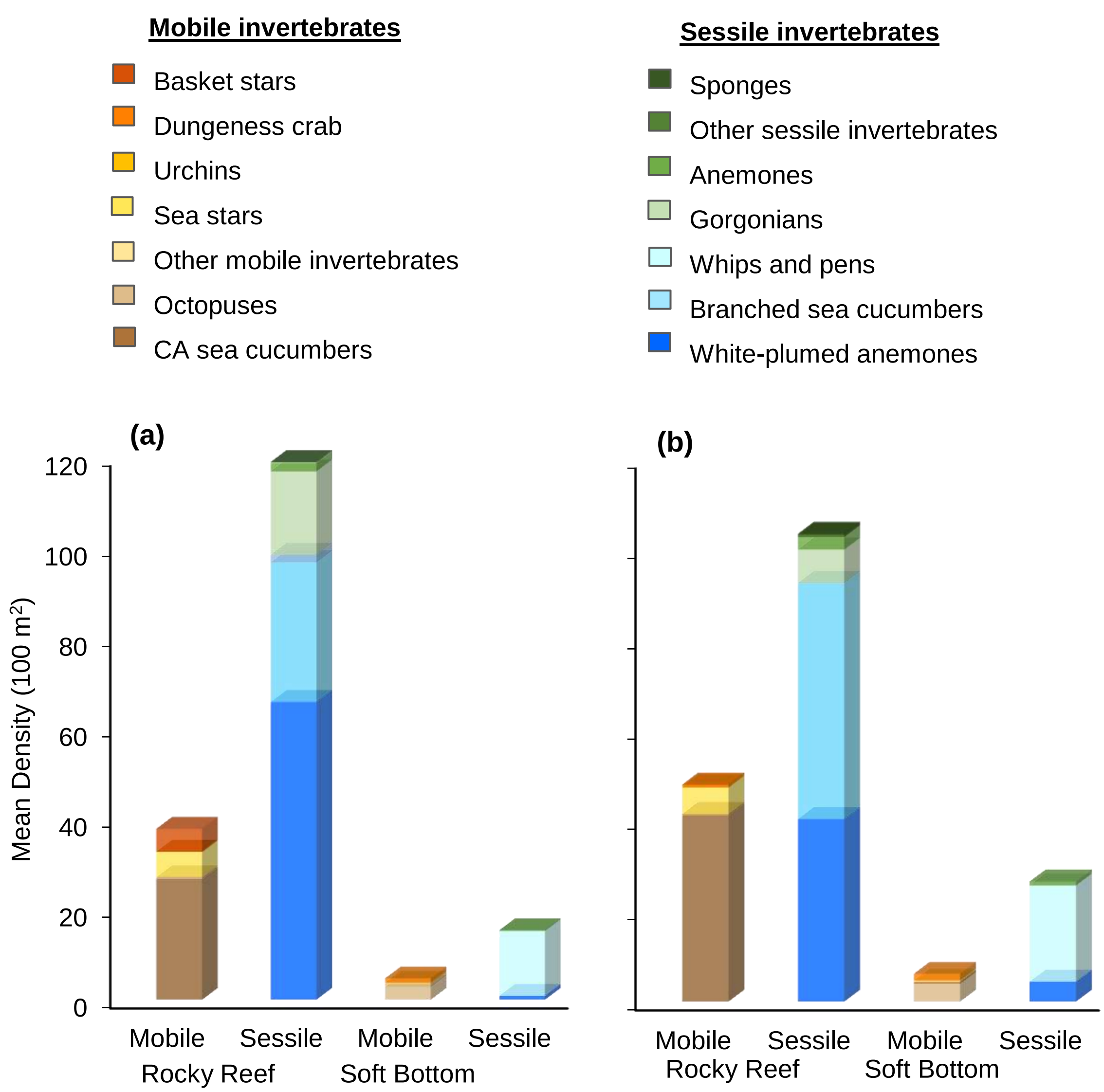

Figure 8. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside (a) Point St. George SMCA and (b) reference area. For a breakdown of the taxonomic composition of subgroups, see Tables 4 & 5.

Table 4. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom habitat transects surveyed within the Point St. George SMCA.

	Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD Rocky Reef (n=18)	Density (100 m^2) ± 1SD Soft Bottom (n=4)
Mobile Invertebrates	**Basket stars**	*Gorgonocephalus eucnemis*	672	5.040 ± 1.905	- -
	Dungeness crab	*Metacarcinus magister*	46	0.050 ± 0.116	0.960 ± 1.305
	Urchins				
	Red sea urchin	*Mesocentrotus franciscanus*	3	0.030 ± 0.071	- -
	Fragile pink urchin	*Strongylocentrotus fragilis*	2	0.020 ± 0.062	- -
	Sea stars				
	Red sea star	*Mediaster aequalis*	411	3.150 ± 2.617	- -
	Henricia complex	*Henricia sp.*	78	0.640 ± 0.697	- -
	Fish eating star	*Stylasterias forreri*	62	0.550 ± 0.706	- -
	Short spined sea star	*Pisaster brevispinus*	37	0.250 ± 0.442	- -
	Leather star	*Dermasterias imbricata*	27	0.210 ± 0.256	- -
	Sand star	*Luidia foliolata*	23	0.100 ± 0.189	0.320 ± 0.359
	UI sea star	Unidentified sea star	22	0.160 ± 0.184	- -
	Cushion star	*Pteraster tesselatus*	21	0.170 ± 0.176	- -
	Sunflower star complex	*Rathbunaster californicus or Pycnopodia helianthoides*	10	0.100 ± 0.155	- -
	Solaster sun star complex	*Solaster sp.*	6	0.040 ± 0.089	- -
	Stimpson's sun star	*Solaster stimpsoni*	5	0.030 ± 0.066	- -
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	4	0.040 ± 0.081	- -
	Thorny sea star	*Poraniopsis inflata*	4	0.030 ± 0.065	- -
	Cookie star	*Ceramaster patagonicus*	3	0.030 ± 0.087	- -
	Rainbow star	*Orthasterias koehleri*	3	0.010 ± 0.040	- -
	Bat star	*Asterina miniata*	1	0.010 ± 0.049	- -
	Bat star/red star complex	*Asterina miniata* or *Mediaster aequalis*	1	0.010 ± 0.027	- -
	Dawson's sun star	*Solaster dawsoni*	1	0.010 ± 0.022	- -
	Other mobile inverts				
	Pleurobranchaea californica	*Pleurobranchaea californica*	24	0.010 ± 0.031	0.530 ± 0.551
	Market squid	*Loligo opalescens*	10	0.090 ± 0.231	0.020 ± 0.042
	Cancer complex	*Cancer sp.*	4	- -	0.100 ± 0.141
	UI nudibranch	Unidentified nudibranch	4	0.030 ± 0.081	- -
	Orange-peel nudibranch	*Tochuina tetraquetra*	3	0.030 ± 0.067	- -
	Decorator crab	*Loxorhynchus crispatus*	1	0.010 ± 0.035	- -
	Red rock crab	*Cancer productus*	1	0.010 ± 0.046	- -
	UI sea jelly	Unidentified sea jelly	1	- -	0.020 ± 0.042
	Octopuses				
	Red octopus	*Octopus rubescens*	111	0.210 ± 0.413	2.800 ± 5.293
	Giant Pacific octopus	*Enteroctopus dofleini*	4	0.040 ± 0.103	- -
	California sea cucumber	*Parastichopus californicus*	3,282	26.950 ± 8.317	- -
Sessile Invertebrates	**Sponges**				
	Orange puffball sponge	*Tethya aurantia*	6	0.050 ± 0.111	- -
	UI branched sponge	Unidentified branched sponge	1	0.010 ± 0.027	- -
	Other sessile inverts				
	UI scallop	Unidentified scallop	7	0.050 ± 0.087	- -
	UI tubeworm	Unidentified tubeworm	4	0.040 ± 0.138	- -
	UI whelk	Unidentified whelk	3	0.020 ± 0.065	- -
	Rock scallop	*Crassedoma giganteum*	1	0.010 ± 0.046	- -
	Anemones				
	Sand-rose anemone	*Urticina columbiana*	117	0.940 ± 0.738	0.080 ± 0.118
	Frilled anemone	*Metridium senile*	61	0.490 ± 1.312	- -
	Fish eating urticina	*Urticina piscivora*	26	0.180 ± 0.368	- -
	UI anemone	Unidentified anemone	22	0.180 ± 0.227	0.020 ± 0.042
	UI tube dwelling anemone	Unidentified tube dwelling anemone	10	0.070 ± 0.156	- -
	UI sand dwelling anemone	Unidentified sand dwelling anemone	3	0.010 ± 0.035	0.060 ± 0.125
	Swimming anemone	*Stomphia didemon*	1	0.010 ± 0.037	- -
	UI anemone 1	Unidentified anemone species #1	1	0.010 ± 0.046	- -
	UI anemone 4	Unidentified anemone species #4	1	0.010 ± 0.027	- -
	White-spotted rose anemone	*Urticina lofotensis*	1	0.010 ± 0.039	- -
	Gorgonians				
	Short red gorgonian	*Swiftia spauldingi*	2,139	18.380 ± 11.701	- -
	UI gorgonian	Unidentified Gorgonacea	1	0.010 ± 0.050	- -
	Whips and pens				
	Sea whip	*Halipteris californica*	494	0.390 ± 0.365	12.360 ± 13.251
	White sea pen	*Stylatula elongata*	203	1.240 ± 2.456	2.050 ± 1.658
	Orange sea pen	*Ptilosarcus gurneyi*	7	0.050 ± 0.120	0.020 ± 0.046
	UI sea pen	*Virgularia sp.*	2	- -	0.060 ± 0.125
	Branched sea cucumbers				
	Slipper sea cucumber	*Psolus chitonoides*	3,400	29.370 ± 12.499	- -
	White branched sea cucumber	*Cucumaria piperata*	123	1.200 ± 1.637	- -
	Orange sea cucumber	*Cucumaria miniata*	26	0.220 ± 0.274	- -
	White-plumed anemone	*Metridium farcimen*	10,426	66.020 ± 35.320	0.870 ± 0.194

Table 5. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom habitat transects surveyed within the Point St. George reference area.

	Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD Rocky Reef (n=12)	Density (100 m^2) ± 1SD Soft Bottom (n=5)
Mobile Invertebrates	**Basket stars**	*Gorgonocephalus eucnemis*	24	0.300 ± 0.493	
	Dungeness crab	*Metacarcinus magister*	98	0.390 ± 1.278	1.510 ± 2.134
	Sea stars				
	Red sea star	*Mediaster aequalis*	142	1.980 ± 2.841	- -
	Short spined sea star	*Pisaster brevispinus*	52	1.020 ± 1.925	0.140 ± 0.112
	Fish eating star	*Stylasterias forreri*	44	0.600 ± 0.570	- -
	Henricia complex	*Henricia sp.*	36	0.510 ± 0.442	- -
	Leather star	*Dermasterias imbricata*	26	0.390 ± 0.338	- -
	Cushion star	*Pteraster tesselatus*	20	0.340 ± 0.379	- -
	Sunflower star complex	*Rathbunaster californicus or Pycnopodia helianthoides*	20	0.260 ± 0.219	0.020 ± 0.046
	Rainbow star	*Orthasterias koehleri*	15	0.240 ± 0.236	- -
	Stimpson's sun star	*Solaster stimpsoni*	11	0.200 ± 0.298	- -
	Sand star	*Luidia foliolata*	9	0.040 ± 0.090	0.140 ± 0.117
	UI sea star	Unidentified sea star	9	0.170 ± 0.283	0.020 ± 0.043
	Thorny sea star	*Poraniopsis inflata*	4	0.060 ± 0.078	- -
	Solaster sun star complex	*Solaster sp.*	2	0.030 ± 0.063	- -
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	1	0.010 ± 0.048	- -
	Other mobile inverts				
	Pleurobranchaea californica	*Pleurobranchaea californica*	16	- -	0.340 ± 0.686
	UI nudibranch	Unidentified nudibranch	9	0.120 ± 0.270	- -
	Market squid	*Loligo opalescens*	2	- -	0.050 ± 0.106
	Red rock crab	*Cancer productus*	1	0.010 ± 0.046	- -
	Octopuses				
	Red octopus	*Octopus rubescens*	178	0.150 ± 0.284	3.970 ± 4.311
	California sea cucumber	*Parastichopus californicus*	2,955	41.480 ± 18.557	- -
Sessile Invertebrates	**Sponges**				
	Orange puffball sponge	*Tethya aurantia*	14	0.190 ± 0.642	- -
	UI branched sponge	Unidentified branched sponge	3	0.040 ± 0.137	- -
	UI boot sponge	Unidentified boot sponge	1	0.010 ± 0.043	- -
	UI nipple sponge	Unidentified nipple sponge	1	0.010 ± 0.046	- -
	Other sessile inverts				
	California hydrocoral	*Stylaster californicus*	28	0.410 ± 0.636	- -
	UI tubeworm	Unidentified tubeworm	3	0.070 ± 0.151	- -
	Anemones				
	Sand-rose anemone	*Urticina columbiana*	108	1.510 ± 1.005	- -
	Frilled anemone	*Metridium senile*	45	0.380 ± 0.769	- -
	UI sand dwelling anemone	Unidentified sand dwelling anemone	41	0.030 ± 0.092	0.810 ± 1.132
	UI anemone	Unidentified anemone	33	0.400 ± 0.569	0.020 ± 0.046
	Fish eating urticina	*Urticina piscivora*	10	0.175 ± 0.200	- -
	UI tube dwelling anemone	Unidentified tube dwelling anemone	6	0.070 ± 0.114	0.030 ± 0.053
	Swimming anemone	*Stomphia didemon*	5	0.070 ± 0.109	- -
	UI anemone 1	Unidentified anemone species #1	5	0.050 ± 0.119	- -
	UI anemone 2	Unidentified anemone species #2	3	0.030 ± 0.085	- -
	UI anemone 4	Unidentified anemone species #4	2	0.030 ± 0.064	- -
	UI anemone 5	Unidentified anemone species #5	2	0.020 ± 0.077	- -
	White-spotted rose anemone	*Urticina lofotensis*	2	0.030 ± 0.092	- -
	Gorgonians				
	Short red gorgonian	*Swiftia spauldingi*	483	7.270 ± 8.585	- -
	UI gorgonian	Unidentified Gorgonacea	5	0.100 ± 0.147	- -
	Whips and pens				
	White sea pen	*Stylatula elongata*	843	- -	18.910 ± 14.457
	Sea whip	*Halipteris californica*	113	- -	2.670 ± 2.823
	Branched sea cucumbers				
	Slipper sea cucumber	*Psolus chitonoides*	3,655	51.020 ± 21.835	- -
	Orange sea cucumber	*Cucumaria miniata*	41	0.640 ± 0.393	- -
	White branched sea cucumber	*Cucumaria piperata*	31	0.430 ± 0.463	- -
	White-plumed anemone	*Metridium farcimen*	4,658	40.650 ± 29.823	4.430 ± 3.940

Rocky Reef Invertebrates

Within both Point St. George study areas, mobile macro-invertebrates observed on rocky reef transects were similar in density (Figure 8). California sea cucumbers were the most abundant at both locations, with densities in the reference area about 1.5 times higher than inside the SMCA. The next most abundant subgroup were the sea stars with densities that were almost the same within the SMCA and reference area (5.54 vs 5.85 stars per 100 m^2). Within the rocky reef of the SMCA, basket stars were also observed with similar densities as the sea stars subgroup, but were not very abundant at the reference area.

Sessile macro-invertebrates on rocky reef transects within the SMR and reference area were similar in density and predominantly comprised of three subgroupings: white-plumed anemones, branched sea cucumbers (comprised of over 95% slipper sea cucumbers), and gorgonians accounted for 97% of the total sessile invertebrate density at both study areas. While species composition was similar, overall densities were different between each study area. At the SMCA, white-plumed anemones and gorgonians were observed with higher densities than at the reference area. At the reference area, slipper cucumbers were observed with a higher density than in the SMCA.

Soft Bottom Invertebrates

Soft bottom mobile invertebrate densities in the SMR and reference area were similar in total density with two subgroupings accounting for over 80% of the total mobile density: octopuses and Dungeness crabs (Figure 8). The octopus subgrouping (all red octopuses) was the most abundant, with densities just slightly higher in the reference area. Dungeness crabs were similar, with densities slightly higher in the reference area as well.

From transects targeting soft bottom habitats at both the SMR and reference area, two subgroupings of macro-invertebrates accounted for over 97% of the total sessile invertebrate density: sea whips/pens, and white-plumed anemones. The whips and pens subgroup was the most abundant at both study areas and observed with similar densities, but species composition was different. At the SMCA, the whips and pens subgroup was over 85% sea whips. At the reference over 87% of the whips and pens subgroup was identified as the white sea pen. White plumed anemones were observed at both study areas, but densities were five times higher at the reference area.

Reading Rock SMR and Reference Area

Reading Rock is located approximately 8 kilometers off the coast of Prairie Creek Redwoods State Park, in Humboldt County, CA. The Reading Rock State Marine Reserve (SMR) is located just south of Reading Rock and does not include the visible portion of the rock, but encompasses a portion of the rocky habitat surrounding it (Figure 9). The SMR encompasses approximately 25 square kilometers of sea floor with depths ranging from 44 m to 77 m, and it is comprised of 98% soft bottom habitats and 2% rocky reef habitats (CDFW 2016c).

The Reading Rock reference area is located 0.95 kilometers north of the Reading Rock SMR. This reference area was selected to encompass similar habitats and depths (determined from multibeam mapping imagery) as those found within the MPA. There are no state regulations specific to the reference area, but federal regulations prohibit the commercial or recreational take of groundfish as part of the Rockfish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMR.

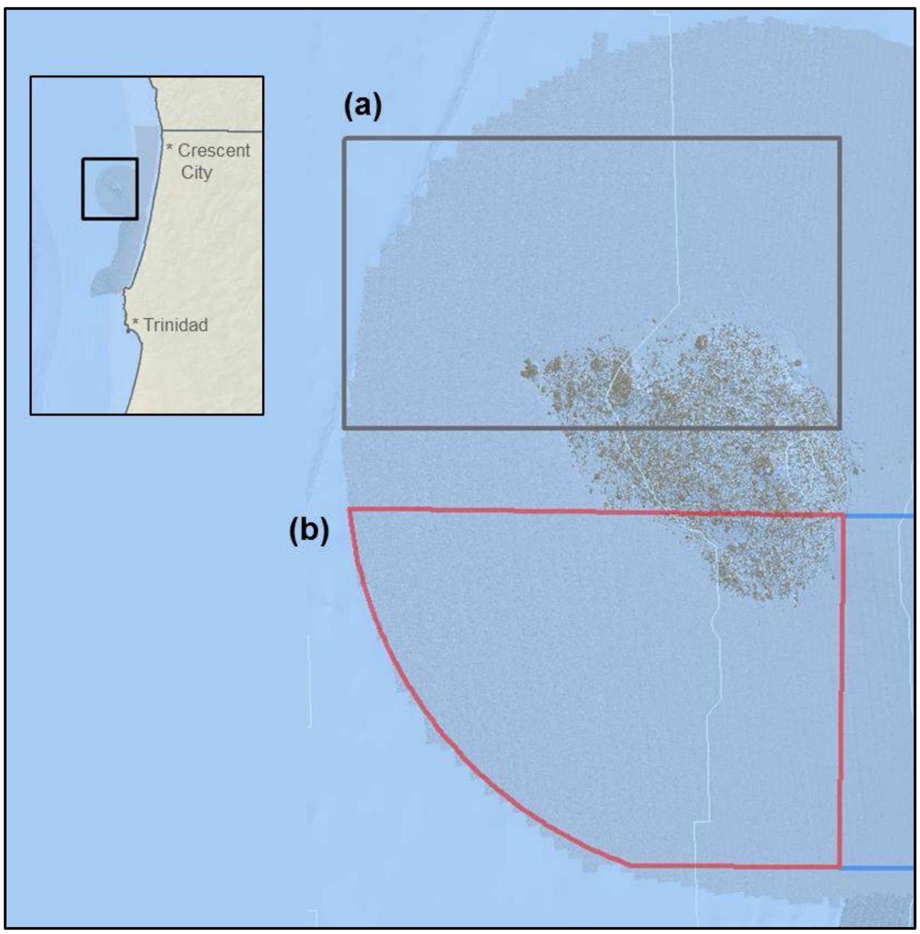

Figure 9. Reading Rock study location showing rocky reef and soft bottom habitats in (a) the reference area and (b) SMR.

Survey Totals

Total sampling effort inside the Reading Rock SMR and reference area for both 2014 and 2015 survey years are presented in Table 6. Over the two survey years, similar sampling effort occurred within both study areas.

Table 6. Survey totals for Reading Rock SMR and reference area for rocky reef and soft bottom transects, including hours of video (per camera), total number of photos on transect, number of transects, total kilometers surveyed and depth (average, max and min).

Study Area	Survey Year	Hours of Video	No. of Photos	Rocky Reef		Soft Bottom		Depth Range (m)		
				No. of Transects	Total km	No. of Transects	Total km	Avg	Min	Max
SMR	**2014**	5.4	696	8	4.4	2	2.1	50	39	67
	2015	4.1	982	7	3.7	2	2.0	50	34	68
	Totals	***9.5***	***1,678***	***15***	***8.1***	***4***	***4.1***			
Reference	**2014**	4.5	1,118	7	4.4	2	2.1	52	39	75
	2015	3.8	845	8	4.2	2	1.6	49	35	67
	Totals	***8.3***	***1,963***	***15***	***8.6***	***4***	***3.7***			

Substrate

Substrate types observed on transects were not mutually exclusive, and represented the proportion of the total surveyed transect distance that had a given substrate present (see methods for full description). Inside the SMR, transects that targeted the rocky reef were primarily composed of rock, while mud, cobble, and boulder were also relatively common (Figure 10). Similarly, rocky reef transects at the reference area were primarily composed of rock with increased levels of cobble and boulder, and decreased levels of mud substrates throughout. Transects targeting soft bottom habitats within the SMR and reference area were entirely composed of mud substrate.

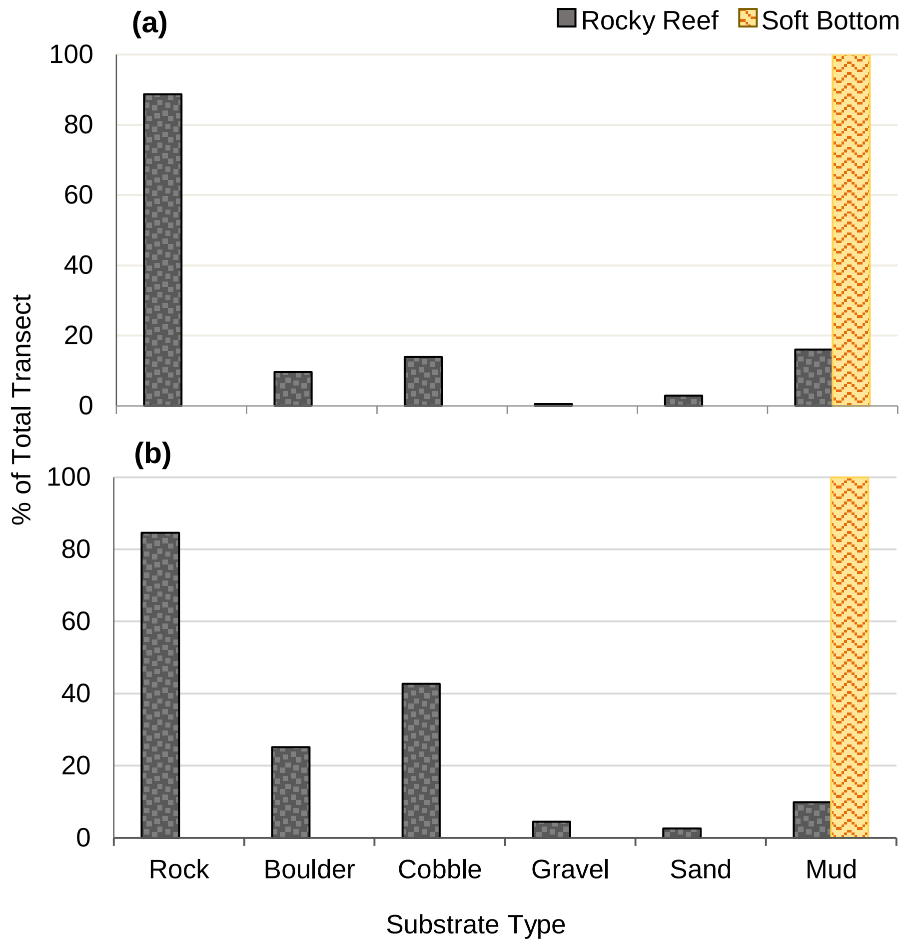

Figure 10. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef and soft bottom) for survey lines inside the Reading Rock SMR and (b) refernce area.

Habitat

Habitat types derived from substrate data collected on rocky reef and soft bottom transects at both Reading Rock study areas are shown in Figure 11. Overall, the rocky reef and soft bottom habitats were comparible. Rocky reef transects within the SMR and reference areas were predominantly hard only habitat. Soft only habitat was the least encountered habitat type at both study areas. Mixed habitat was however much more common at the reference area than inside the MPA. Soft bottom transects within the SMR and reference area were classified as 100% soft habitat.

Overall, habitat rugosity was similar at both study areas. Rocky reef transects at the SMR and reference area were comprised of comparable percentages of rugosity, with just over 80% of the transect distance providing medium to high rugosity. The reference area had higher amounts of low rugosity habitat and the SMR had higher amounts of flat rugosity. Outside the rocky reef, transects targeting soft bottom were entirely comprised of flat rugosity habitats at both the SMR and reference area.

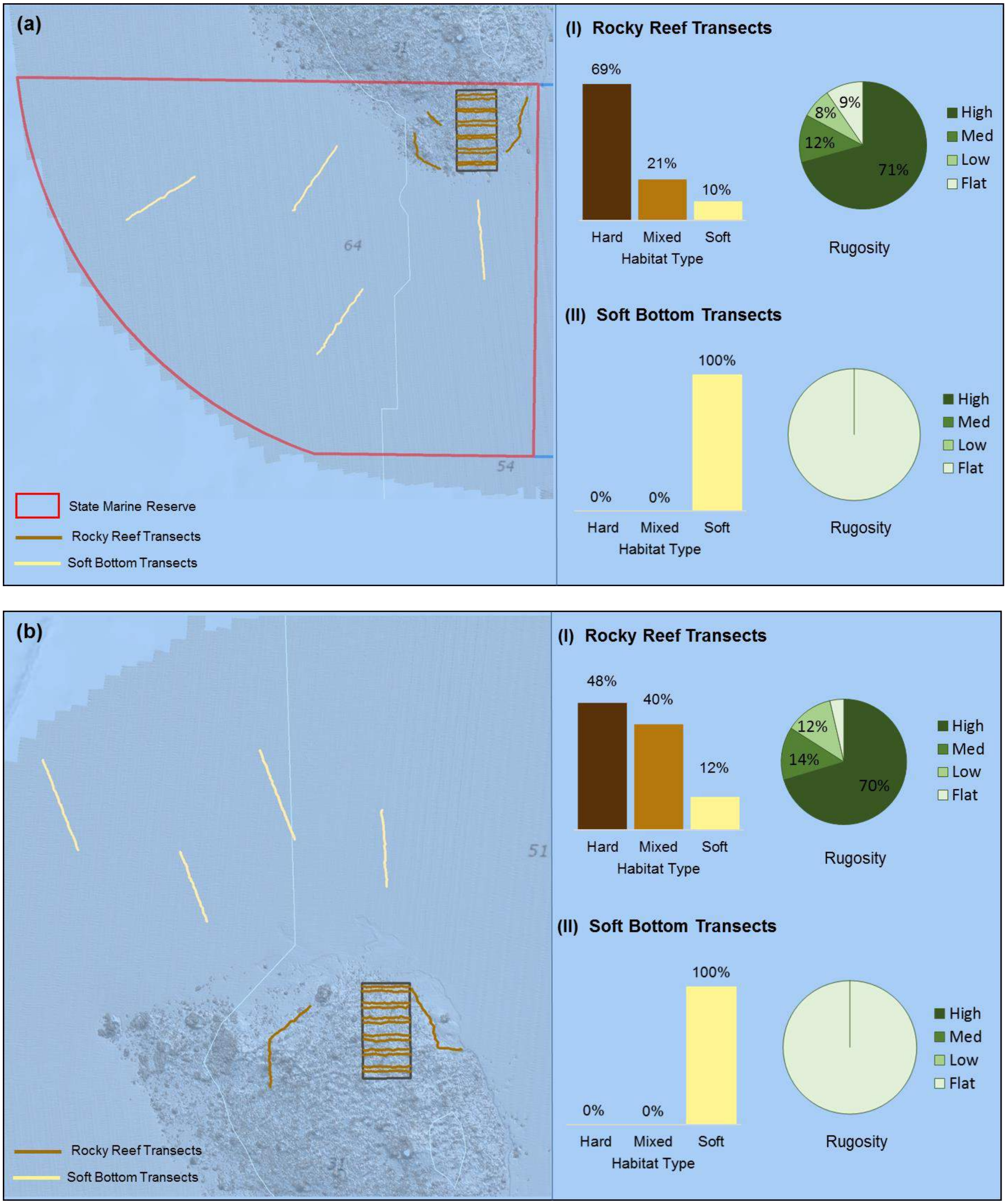

Figure 11. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Reading Rock SMR and (b) reference area, for transect lines targeting (I) rocky reef and (II) soft bottom habitats.

Fish

Fish were summarized into seven taxonomic subgroupings for comparison between the SMR and reference area and are presented by transect habitat type in Figure 12. A full list of observed fish species/groupings enumerated on both rocky reef and soft bottom transects for both the SMR and reference area are shown in Tables 7 & 8. Within the SMR, 6,312 fish were observed from 47 species/groupings within rocky reef and soft bottom transects combined. The reference area had fewer than half of the observations, with 3,034 fish observations from 38 species/groupings.

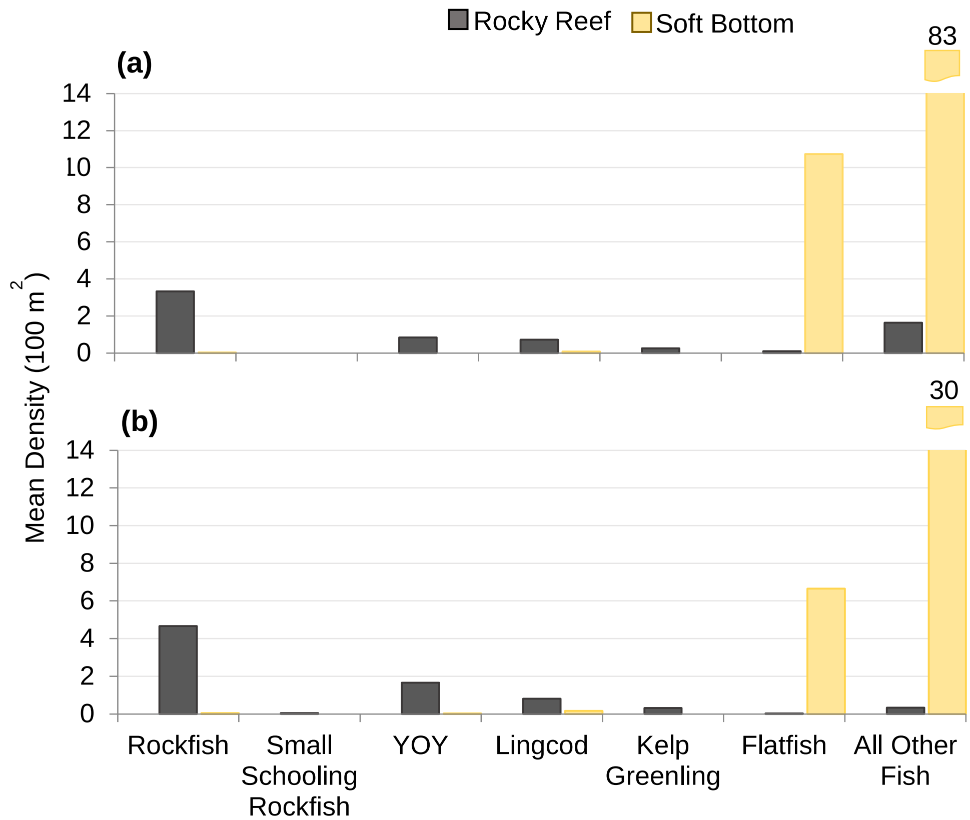

Figure 12. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Reading Rock SMR and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Tables 7 & 8.

Table 7. Total count average density and standard deviation of fish by common name for all rocky reef and soft bottom transects (n) surveyed within the Reading Rock SMR.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD Rocky Reef (n=15)	Density (100 m^2) ± 1SD Soft Bottom (n=4)	Size (cm) Avg	Size (cm) Max	Size (cm) Min
Rockfish							
UI Rockfish	Unidentified *Sebastes sp.*	163	0.965 ± 0.546	0.026 0.052	18	50	10
Blue Rockfish	*Sebastes mystinus*	77	0.411 ± 0.501	- -	29	50	9
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	64	0.487 ± 0.790	- -	31	41	15
Black Rockfish	*Sebastes melanops*	59	0.440 ± 0.582	- -	36	45	25
Canary Rockfish	*Sebastes pinniger*	27	0.224 ± 0.274	- -	24	36	10
Yelloweye Rockfish	*Sebastes ruberrimus*	18	0.144 ± 0.172	- -	25	48	14
Brown Rockfish	*Sebastes auriculatus*	16	0.129 ± 0.232	- -	32	38	25
Quillback Rockfish	*Sebastes maliger*	16	0.151 ± 0.175	- -	31	40	25
Sebastomus Rockfish	Subgenus *Sebastomus*	14	0.118 ± 0.179	- -	21	30	9
Rosy Rockfish	*Sebastes rosaceus*	11	0.087 ± 0.169	- -	21	26	18
Vermilion Rockfish	*Sebastes miniatus*	7	0.039 ± 0.073	- -	40	47	35
Squarespot/Widow Rockfish	*Sebates hopkinsi* or *entomelas*	6	0.031 ± 0.067	- -	23	25	18
Widow Rockfish	*Sebastes entomelas*	6	0.043 ± 0.141	- -	30	32	27
Copper Rockfish	*Sebastes caurinus*	5	0.046 ± 0.081	- -	32	40	25
Canary/Vermilion Rockfish	*Sebastes pinniger* or *miniatus*	1	0.006 ± 0.024	- -			
Tiger Rockfish	*Sebastes nigrocinctus*	1	0.008 ± 0.030	- -	33	33	33
Young of year rockfish	Young of year rockfish	94	0.840 ± 0.763	- -	7	9	4
Lingcod	*Ophiodon elongatus*	93	0.712 ± 0.575	0.083 ± 0.078	52	75	10
Kelp Greenling	*Hexagrammos decagrammus*	29	0.256 ± 0.225	- -	34	44	25
Flatfish							
UI flatfish	Unidentified Pleuronectiformes	507	0.084 ± 0.209	9.887 ± 7.280	13	35	5
UI sanddab	Unidentified *Citharichthys sp.*	17	0.009 ± 0.036	0.214 ± 0.317	13	22	6
Rex Sole	*Glyptocephalus zachirus*	10	- -	0.182 ± 0.126	15	23	9
English Sole	*Parophrys vetulus*	9	- -	0.184 ± 0.136	19	22	13
Pacific Sanddab	*Citharichthys sordidus*	5	- -	0.117 ± 0.139	19	21	12
Petrale Sole	*Eopsetta jordani*	5	- -	0.083 ± 0.078	20	25	14
Dover Sole	*Microstomus pacificus*	1	- -	0.024 ± 0.048	18	18	18
Rock Sole	*Lepidopsetta bilineata*	1	- -	0.015 ± 0.031	20	20	20
Speckled Sanddab	*Citharichthys stigmaeus*	1	- -	0.023 ± 0.046	12	12	12
All Other Fish							
UI smelt	Unidentified Osmeridae	4,870	0.017 ± 0.067	81.678 ± 66.339	11	18	9
UI fish	Unidentified fish	83	0.645 ± 1.501	0.574 ± 0.668	15	35	10
UI schooling pelagic	Unidentified schooling pelagic fish	50	0.800 ± 3.100	- -	14	14	14
Shiner Surfperch	*Cymatogaster aggregata*	16	- -	0.264 ± 0.410	10	10	10
UI small benthic fish	Unidentified small bottom fish	8	0.052 ± 0.085	0.013 ± 0.026	12	15	10
UI eel pout	Unidentified Zoarcidae	5	0.041 ± 0.126	0.046 ± 0.092	13	18	8
Staghorn Sculpin	*Leptocottus armatus*	3	- -	0.046 ± 0.093	20	20	20
Combfish complex	*Zaniolepis frenata* or *latipinnis*	2	0.018 ± 0.070	- -	15	15	15
UI sculpin	Unidentified Cottidae	2	0.013 ± 0.049	0.024 ± 0.048	13	14	11
UI surfperch	Unidentified Embiotocidae	2	- -	0.037 ± 0.046	11	11	10
Cabezon	*Scorpaenichthys marmoratus*	1	0.010 ± 0.038	- -	18	18	18
Pacific Tomcod	*Microgadus proximus*	1	- -	0.024 ± 0.048	19	19	19
Sixgill Shark	*Hexanchus griseus*	1	0.009 ± 0.033	- -	210	210	210
UI cod	Unidentified Gadidae	1	- -	0.013 ± 0.026	14	14	14
UI goby	Unidentified Gobiidae	1	0.008 ± 0.032	- -	13	13	13
UI greenling	Unidentified Hexagrammidae	1	0.009 ± 0.036	- -			
UI salmonid	Unidentified Salmonidae	1	- -	0.013 ± 0.026	40	40	40
UI skate	Unidentified *Raja sp.*	1	- -	0.023 ± 0.046	8	8	8
Wolf Eel	*Anarrhichthys ocellatus*	1	0.008 ± 0.032	- -			

Table 8. Total count average density and standard deviation of fish by common name for all rocky reef and soft bottom transects (n) surveyed within the Reading Rock reference area.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD		Size (cm)		
			Rocky Reef (n=15)	Soft Bottom (n=4)	Avg	Max	Min
Rockfish							
Blue Rockfish	*Sebastes mystinus*	223.5	0.656 ± 0.689	- -	26	38	10
UI rockfish	Unidentified *Sebastes sp.*	170	1.010 ± 1.496	0.043 ± 0.086	21	45	10
Canary Rockfish	*Sebastes pinniger*	103	0.636 ± 1.026	- -	28	62	9
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	73	0.429 ± 0.798	- -	34	49	12
Black Rockfish	*Sebastes melanops*	58	0.305 ± 0.651	- -	40	45	35
Sebastomus Rockfish	Subgenus *Sebastomus*	52	0.366 ± 0.358	- -	20	30	10
Rosy Rockfish	*Sebastes rosaceus*	36	0.258 ± 0.226	- -	22	32	16
Yelloweye Rockfish	*Sebastes ruberrimus*	35	0.241 ± 0.114	- -	25	45	10
Quillback Rockfish	*Sebastes maliger*	33	0.221 ± 0.204	- -	34	45	25
Vermilion Rockfish	*Sebastes miniatus*	26	0.178 ± 0.285	- -	42	52	30
Copper Rockfish	*Sebastes caurinus*	23	0.149 ± 0.174	- -	37	50	27
Widow Rockfish	*Sebastes entomelas*	11	0.075 ± 0.262	- -	27	30	25
Canary/Vermilion Rockfish	*Sebastes pinniger* or *miniatus*	7	0.036 ± 0.054	- -	39	45	35
Tiger Rockfish	*Sebastes nigrocinctus*	6	0.041 ± 0.053	- -	30	32	28
Brown Rockfish	*Sebastes auriculatus*	3	0.023 ± 0.065	- -	32	36	27
Black/Blue Rockfish	*Sebastes melanops* or *mystinus*	2	0.015 ± 0.056	- -	33	38	27
Squarespot/Widow Rockfish	*Sebastes hopkinsi* or *entomelas*	2	0.014 ± 0.053	- -	20	25	14
China Rockfish	*Sebastes nebulosus*	1	0.008 ± 0.031	- -	24	24	24
Small schooling rockfish	Schooling rockfish (10-15cm)	6	0.049 ± 0.189	- -	11	11	11
Young of year rockfish	Young of year rockfish	247	1.655 ± 0.776	0.022 ± 0.043	8	9	4
Lingcod	*Ophiodon elongatus*	125	0.808 ± 0.216	0.158 ± 0.261	55	85	13
Kelp Greenling	*Hexagrammos decagrammus*	45	0.317 ± 0.202	- -	34	40	25
Flatfish							
UI flatfish	Unidentified Pleuronectiformes	287	0.026 ± 0.060	6.377 ± 5.597	14	33	5
English Sole	*Parophrys vetulus*	4	- -	0.090 ± 0.074	21	23	17
Petrale Sole	*Eopsetta jordani*	3	- -	0.067 ± 0.087	22	27	20
Rex Sole	*Glyptocephalus zachirus*	3	- -	0.068 ± 0.087	16	21	12
UI sanddab	Unidentified *Citharichthys sp.*	2	- -	0.045 ± 0.091	12	14	10
All Other Fish							
UI smelt	Unidentified Osmeridae	1,362	0.004 ± 0.017	29.074 ± 32.333	15	25	9
UI fish	Unidentified fish	42	0.101 ± 0.167	0.435 ± 0.189	13	25	6
UI goby	Unidentified Gobiidae	18	0.084 ± 0.270	- -	12	14	10
UI small benthic fish	Unidentified small bottom fish	13	0.095 ± 0.176	- -	15	35	10
UI eel pout	Unidentified Zoarcidae	3	0.009 ± 0.034	0.022 ± 0.043	12	15	10
Combfish complex	*Zaniolepis frenata or latipinnis*	2	0.011 ± 0.031	- -	11	11	11
UI cod	Unidentified Gadidae	2	- -	0.044 ± 0.051	32	41	22
UI hexagrammid	Unidentified Hexagrammidae	2	0.016 ± 0.063	- -			
Longnose Skate	*Raja rhina*	1	- -	0.023 ± 0.046			
UI sculpin	Unidentified Cottidae	1	- -	0.023 ± 0.045	12	12	12
Wolf Eel	*Anarrhichthys ocellatus*	1	0.007 ± 0.027	- -			

Rocky Reef Fish

On rocky reef transects inside the SMR and in the reference area, rockfish were the most abundant subgroup (Figure 12). Inside the SMR, the rockfish subgroup included 16 species/groupings; as well as fish that could only be classified as unidentified rockfish (excluding small schooling rockfish and YOY). At the reference area, the rockfish subgroup included observations from 18 species/groupings.

Five species/groupings within the rockfish subgroup accounted for 76% of the overall density in the SMR: unidentified rockfish, Olive/Yellowtail, Black, Blue, and Canary Rockfish. The same five species/groupings were also abundant at the reference area and accounted for 65% of the overall rockfish subgroup density. Yelloweye Rockfish, a listed overfished species, were observed at both the SMR and the reference area and accounted for approximately 5% of the subgroup density at both study areas.

YOY were observed at both study areas and accounted for 12% of the total fish density from rocky reef transects inside the SMR, and 21% in the reference area. Other fish species observed within the rocky reef included Lingcod and Kelp Greenling, which combined, accounted for 14% of the total fish density at each study area. The ‘all other fish’ subgroup accounted for 24% of the total fish density from transects targeting rocky reef inside the SMR, of which 89% were unidentified schooling pelagic fish or unidentified fish. At the SMR, the ‘all other fish’ subgroup represented 4% of the total observed fish density in the rocky reef.

Soft Bottom Fish

Surveys of soft bottom habitat were primarily dominated by the ‘all other fish’ subgroup, which accounted for over 80% of the total soft bottom fish density at both study areas (Figure 12). Within the ‘all other fish’ subgroup, unidentified smelt represented over 98% of the observations within both study areas. Flatfish densities were similar at both study areas, though at the SMR densities were a bit higher. Lingcod and unidentified rockfish were present on soft bottom transects at both Reading Rock study areas, but only accounted for less than 1% of the overall soft bottom fish density per study area.

Invertebrates

Invertebrates were placed into seven mobile and seven sessile macro-invertebrate subgroupings for comparison between the SMR and reference area and are presented by transect habitat type in Figure 13. Full lists of observed sessile and mobile macro-invertebrate species/groupings enumerated on both rocky reef and soft bottom transects for both the SMR and reference area are shown in Tables 9 & 10. In total, 9,222 invertebrates were recorded from 55 species/groupings inside the SMR, while at the reference area a total of 25,146 invertebrate observations were recorded from 59 species/groupings, more than twice as many as the MPA.

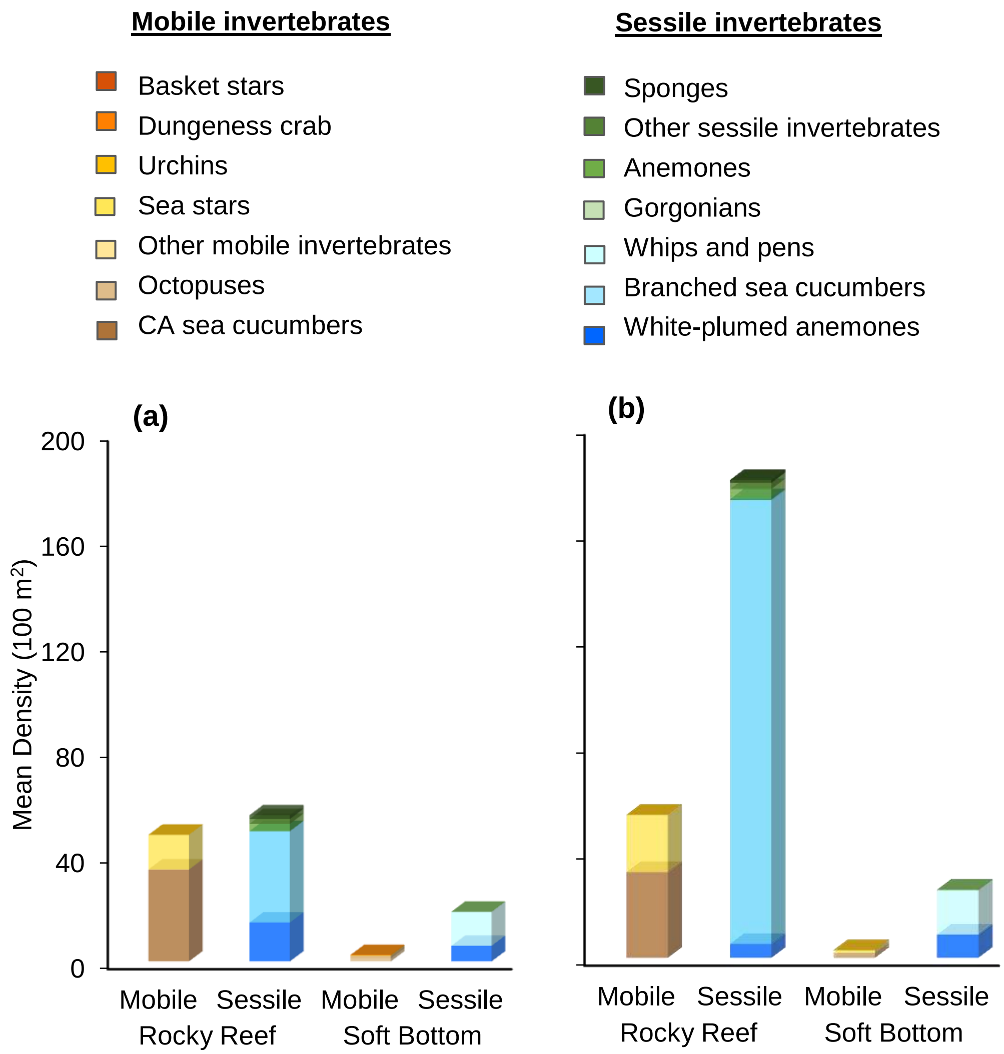

Figure 13. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside (a) Reading Rock SMR and (b) reference area. For a breakdown of the taxonomic composition of subgroups, see Tables 9 & 10.

Table 9. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Reading Rock SMR.

	Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD Rocky Reef (n=15)	Density (100 m^2) ± 1SD Soft Bottom (n=4)
Mobile Invertebrates	**Dungeness crab**	*Metacarcinus magister*	10	- -	0.219 ± 0.437
	Urchins				
	Red sea urchin	*Mesocentrotus franciscanus*	1	0.020 ± 0.087	- -
	Sea stars				
	Red sea star	*Mediaster aequalis*	419	5.810 ± 4.753	- -
	Henricia complex	*Henricia sp.*	316	4.140 ± 1.701	- -
	Fish eating star	*Stylasterias forreri*	49	0.840 ± 0.936	- -
	UI sea star	Unidentified sea star	48	0.560 ± 0.493	- -
	Cushion star	*Pteraster tesselatus*	37	0.550 ± 0.438	- -
	Leather star	*Dermasterias imbricata*	26	0.390 ± 0.407	- -
	Stimpson's sun star	*Solaster stimpsoni*	18	0.310 ± 0.423	- -
	Rainbow star	*Orthasterias koehleri*	15	0.240 ± 0.369	- -
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	13	0.170 ± 0.441	- -
	Sand star	*Luidia foliolata*	9	- -	0.237 ± 0.157
	Solaster sun star complex	*Solaster sp.*	7	0.110 ± 0.194	- -
	Cookie star	*Ceramaster patagonicus*	3	0.050 ± 0.130	- -
	Dawson's sun star	*Solaster dawsoni*	2	0.030 ± 0.071	- -
	Short spined sea star	*Pisaster brevispinus*	1	0.010 ± 0.049	- -
	Sunflower star complex	*Rathbunaster californicus or Pycnopodia helianthoides*	1	0.020 ± 0.061	- -
	Other Mobile Inverts				
	Pleurobranchaea californica	*Pleurobranchaea californica*	36	- -	0.748 ± 0.912
	Orange-peel nudibranch	*Tochuina tetraquetra*	4	0.050 ± 0.120	- -
	UI nudibranch	Unidentified nudibranch	3	0.040 ± 0.106	- -
	Noble sea lemon	*Peltodoris nobilis* or *Anisodoris nobilis*	2	0.040 ± 0.133	- -
	UI crab	Unidentified crab	2	0.030 ± 0.101	- -
	UI sea jelly	Unidentified sea jelly	2	- -	0.067 ± 0.077
	Market squid	*Loligo opalescens*	1	- -	0.033 ± 0.065
	Pink *Tritonia*	*Tritonia diomedea*	1	- -	0.018 ± 0.037
	Red rock crab	*Cancer productus*	1	- -	0.018 ± 0.037
	Octopuses				
	Red octopus	*Octopus rubescens*	38	0.010 ± 0.043	1.128 ± 1.038
	Giant Pacific octopus	*Enteroctopus dofleini*	1	0.010 ± 0.034	- -
	California sea cucumber	*Parastichopus californicus*	2,685	34.810 ± 8.989	- -
Sessile Invertebrates	**Sponges**				
	UI nipple sponge	Unidentified nipple sponge	52	0.730 ± 0.951	- -
	Orange puffball sponge	*Tethya aurantia*	25	0.360 ± 0.663	- -
	UI lobed sponge/tunicate	Unidentified lobed sponges/tunicate	14	0.370 ± 1.276	- -
	Other Sessile Inverts				
	Acorn barnacle	*Balanus nubilus*	113	1.320 ± 2.245	- -
	UI scallop	Unidentified scallop	22	0.280 ± 0.778	- -
	UI branched bryozoan	Unidentified branching bryozoan	7	0.210 ± 0.767	- -
	Anemones				
	Frilled anemone	*Metridium senile*	67	0.770 ± 1.611	- -
	Sand-rose anemone	*Urticina columbiana*	50	0.630 ± 0.721	0.033 ± 0.065
	Fish eating urticina	*Urticina piscivora*	41	0.508 ± 0.521	- -
	UI tube dwelling anemone	Unidentified tube dwelling anemone	37	0.520 ± 0.519	- -
	UI anemone	Unidentified anemone	22	0.260 ± 0.286	- -
	Swimming anemone	*Stomphia didemon*	2	0.030 ± 0.067	- -
	UI sand dwelling anemone	Unidentified sand dwelling anemone	1	0.010 ± 0.051	- -
	UI anemone 1	Unidentified anemone species #1	1	0.010 ± 0.054	- -
	UI anemone 4	Unidentified anemone species #4	1	0.010 ± 0.054	- -
	White-spotted rose anemone	*Urticina lofotensis*	1	0.010 ± 0.043	- -
	Gorgonians				
	Short red gorgonian	*Swiftia spauldingi*	1	0.010 ± 0.034	- -
	Whips and pens				
	White sea pen	*Stylatula elongata*	509	- -	10.366 ± 15.280
	UI sea pen	Unidentified sea pen	51	- -	1.663 ± 3.326
	Sea whip	*Halipteris californica*	25	- -	0.775 ± 1.228
	Orange sea pen	*Ptilosarcus gurneyi*	5	- -	0.109 ± 0.219
	Branched sea cucumbers				
	Slipper sea cucumber	*Psolus chitonoides*	2,349	31.420 ± 16.378	- -
	UI branched sea cucumber	Unidentified branched sea cucumber	148	1.810 ± 6.907	- -
	White branched sea cucumber	*Cucumaria piperata*	82	1.040 ± 1.418	- -
	Orange sea cucumber	*Cucumaria miniata*	38	0.490 ± 0.547	- -
	White-plumed anemone	*Metridium farcimen*	1,807	14.820 ± 15.926	5.944 ± 6.798

Table 10. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Reading Rock reference area.

	Common Name	Species/Grouping/Complex	Total Count	Density ($100\ m^2$) ± 1SD Rocky Reef (n=15)	Density ($100\ m^2$) ± 1SD Soft Bottom (n=4)
Mobile Invertebrates	**Dungeness crab**	*Metacarcinus magister*	7	- -	0.209 ± 0.196
	Urchins				
	Red sea urchin	*Mesocentrotus franciscanus*	1	0.010 ± 0.043	- -
	Sea stars				
	Red sea star	*Mediaster aequalis*	1,313	12.880 ± 6.881	- -
	Henricia complex	*Henricia sp.*	607	5.810 ± 2.671	- -
	UI sea star	Unidentified sea star	91	0.910 ± 1.000	0.032 ± 0.064
	Fish eating star	*Stylasterias forreri*	67	0.520 ± 0.971	- -
	Cushion star	*Pteraster tesselatus*	57	0.550 ± 0.573	- -
	Leather star	*Dermasterias imbricata*	29	0.270 ± 0.320	0.032 ± 0.064
	Sand star	*Luidia foliolata*	27	0.010 ± 0.039	0.818 ± 0.872
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	21	0.170 ± 0.293	- -
	Rainbow star	*Orthasterias koehleri*	14	0.130 ± 0.181	- -
	Solaster sun star complex	*Solaster sp.*	12	0.110 ± 0.108	- -
	Stimpson's sun star	*Solaster stimpsoni*	10	0.100 ± 0.151	- -
	Cookie star	*Ceramaster patagonicus*	6	0.060 ± 0.120	- -
	Bat star/red star complex	*Asterina miniata* or *Mediaster aequalis*	5	0.050 ± 0.193	- -
	Bat star	*Asterina miniata*	4	0.040 ± 0.154	- -
	Dawson's sun star	*Solaster dawsoni*	3	0.030 ± 0.061	- -
	Short spined sea star	*Pisaster brevispinus*	2	0.020 ± 0.054	- -
	Thorny sea star	*Poraniopsis inflata*	2	0.020 ± 0.052	- -
	Sunflower star	*Pycnopodia helianthoides*	1	0.010 ± 0.038	- -
	Sunflower star complex	*Rathbunaster californicus* or *Pycnopodia helianthoides*	1	0.010 ± 0.036	- -
	Other Mobile Inverts				
	Pleurobranchaea californica	*Pleurobranchaea californica*	20	- -	0.630 ± 0.976
	UI nudibranch	Unidentified nudibranch	11	0.110 ± 0.182	- -
	Orange-peel nudibranch	*Tochuina tetraquetra*	4	0.040 ± 0.090	- -
	Market squid	*Loligo opalescens*	3	- -	0.097 ± 0.194
	UI sea jelly	Unidentified sea jelly	3	0.010 ± 0.039	0.032 ± 0.065
	Pink *Tritonia*	*Tritonia diomedea*	2	- -	0.064 ± 0.129
	UI whelk	Unidentified whelk	2	0.020 ± 0.055	- -
	Striped nudibranch	*Armina californica*	1	- -	0.029 ± 0.058
	Swimming nudibranch	*Dendronotus iris*	1	0.010 ± 0.039	- -
	Octopuses				
	Red octopus	*Octopus rubescens*	29	- -	0.932 ± 1.164
	California sea cucumber	*Parastichopus californicus*	3,322	32.450 ± 9.646	0.096 ± 0.193
Sessile Invertebrates	**Sponges**				
	UI lobed sponge/tunicate	Unidentified lobed sponge/tunicate	50	0.560 ± 1.588	- -
	UI nipple sponge	Unidentified nipple sponge	33	0.340 ± 0.475	- -
	Orange puffball sponge	*Tethya aurantia*	18	0.160 ± 0.343	- -
	Gray puffball sponge	*Craniella arb*	2	0.020 ± 0.080	- -
	Other Sessile Inverts				
	Acorn barnacle	*Balanus nubilus*	256	2.310 ± 3.961	- -
	UI scallop	Unidentified scallop	2	0.020 ± 0.044	- -
	UI tubeworm	Unidentified tubeworm	1	0.010 ± 0.039	- -
	Anemones				
	UI tube dwelling anemone	Unidentified tube dwelling anemone	168	1.380 ± 2.049	- -
	Fish eating urticina	*Urticina piscivora*	117	1.174 ± 0.947	- -
	Sand-rose anemone	*Urticina columbiana*	93	0.790 ± 1.209	0.058 ± 0.116
	UI anemone	Unidentified anemone	23	0.180 ± 0.233	0.064 ± 0.129
	Frilled anemone	*Metridium senile*	20	0.210 ± 0.338	- -
	UI sand dwelling anemone	Unidentified sand dwelling anemone	4	0.010 ± 0.024	0.097 ± 0.123
	UI anemone 1	Unidentified anemone species #1	3	0.030 ± 0.080	- -
	Swimming anemone	*Stomphia didemon*	2	0.020 ± 0.078	- -
	UI anemone 4	Unidentified anemone species #4	1	0.010 ± 0.043	- -
	White-spotted rose anemone	*Urticina lofotensis*	1	0.010 ± 0.024	- -
	Gorgonians				
	Short red gorgonian	*Swiftia spauldingi*	26	0.260 ± 0.431	- -
	Whips and pens				
	White sea pen	*Stylatula elongata*	513	- -	16.177 ± 18.183
	Sea whip	*Halipteris californica*	16	- -	0.515 ± 0.950
	Orange sea pen	*Ptilosarcus gurneyi*	8	- -	0.233 ± 0.388
	Branched sea cucumbers				
	Slipper sea cucumber	*Psolus chitonoides*	16,339	159.590 ± 145.897	- -
	White branched sea cucumber	*Cucumaria piperata*	784	7.600 ± 9.331	- -
	Orange sea cucumber	*Cucumaria miniata*	16	0.120 ± 0.255	- -
	UI branched sea cucumber	Unidentified branched sea cucumber	4	0.040 ± 0.155	- -
	White-plumed anemone	*Metridium farcimen*	968	5.270 ± 6.138	8.798 ± 10.435

Rocky Reef Invertebrates

Within both Reading Rock study areas, mobile macro-invertebrates observed on rocky reef transects were similar and composed of two subgroups: California sea cucumbers, and the sea stars (Figure 13). The California sea cucumber was the most abundant rocky reef mobile invertebrate, with similar densities within the SMR and reference area (31.4 and 34.8 cucumbers per 100 m^2 respectively). The sea stars subgrouping accounted for the remaining rocky reef mobile invertebrate total density at both study areas. A total of 14 species/groupings of sea stars were identified within the rocky reef at the SMR, and 19 within the reference area. Within both study areas, the red sea star and the *Henricia* complex accounted for over 75% of the sea star subgroups total density. At the SMR, red sea stars were over two times higher in density.

Sessile macro-invertebrates on rocky reef transects within the SMR and reference area were predominantly comprised of two subgroupings: branched cucumbers, and white-plumed anemones, which accounted for 89% and 96% respectively, of the total sessile invertebrate density. The branched cucumber subgrouping was composed of over 90% slipper sea cucumbers. Densities of slipper sea cucumbers were very different between the SMR and reference area, with over five times more slipper sea cucumbers observed at the reference area. White-plumed anemones were the second most abundant sessile invertebrate observed within the rocky reef. Densities of white-plumed anemones were about three times higher in the SMR. The sponges, ‘other sessile invertebrates’ and anemone subgroupings were also observed, with densities that were similar between the SMR and reference area.

Soft Bottom Invertebrates

Soft bottom mobile invertebrate densities in the SMR and reference area were similar, with a total density of 2.47 and 2.97 invertebrates per 100 m^2 respectively. Four subgroupings of mobile invertebrates found on soft bottom transects within the SMR accounted for 100% of the observations: octopuses, ‘other mobile inverts’, sea stars and Dungeness crabs. Similarly, at the reference area, the same four invertebrate subgroupings accounted for 97% of the observations.

The octopuses subgroup (all identified as red octopus) and the ‘other mobile invertebrates’ subgroup, which was mostly comprised of *Pleurobranchaea californica*, were the most abundant subgroupings observed at both study areas. Densities of these two subgroupings were similar within both the SMR and reference area, with a combined density of 1.78 and 2.01 per 100 m^2 respectively. The sea stars subgroup, almost entirely sand stars, was the most different with densities over three times higher at the reference area. Dungeness crab densities from soft bottom transects were nearly identical at both sites, with 0.22 crabs/100 m^2 within the SMR and 0.21 crabs/100 m^2 in the reference area.

From transects targeting soft bottom habitats at both the SMR and reference area, two subgroupings of macro-invertebrates accounted for over 99% of the total sessile invertebrate density: sea whips/pens, and white-plumed anemone (Figure 13). The sea whips/pens subgrouping was the most abundant and accounted for over 65% of the sessile soft bottom invertebrates observed within the SMR and reference area. The white sea pen was the most common and accounted for over 80% of the subgrouping's total density at both study areas. White-plumed anemones were also common and represented approximately 30% of the soft bottom sessile invertebrate observations within the SMR and reference area.

Mattole Canyon SMR and Reference Area

Mattole Canyon is located offshore of the Mattole River estuary and what is known as California's Lost Coast region. This portion of California's North Coast is sparsely populated and coastal access is limited. Mattole Canyon SMR protects 25.4 square kilometers of marine habitat with depths ranging from 25 m to 502 m (CDFW 2016a).

The Mattole Canyon reference area is located 0.3 kilometers south of Mattole Canyon SMR (Figure 14). This reference area was selected to encompass similar habitats and depths (determined from multibeam mapping imagery) as those found within the MPA. There are no state regulations specific to the reference area, but federal regulations prohibit the take of groundfish as part of the Rock Fish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMR.

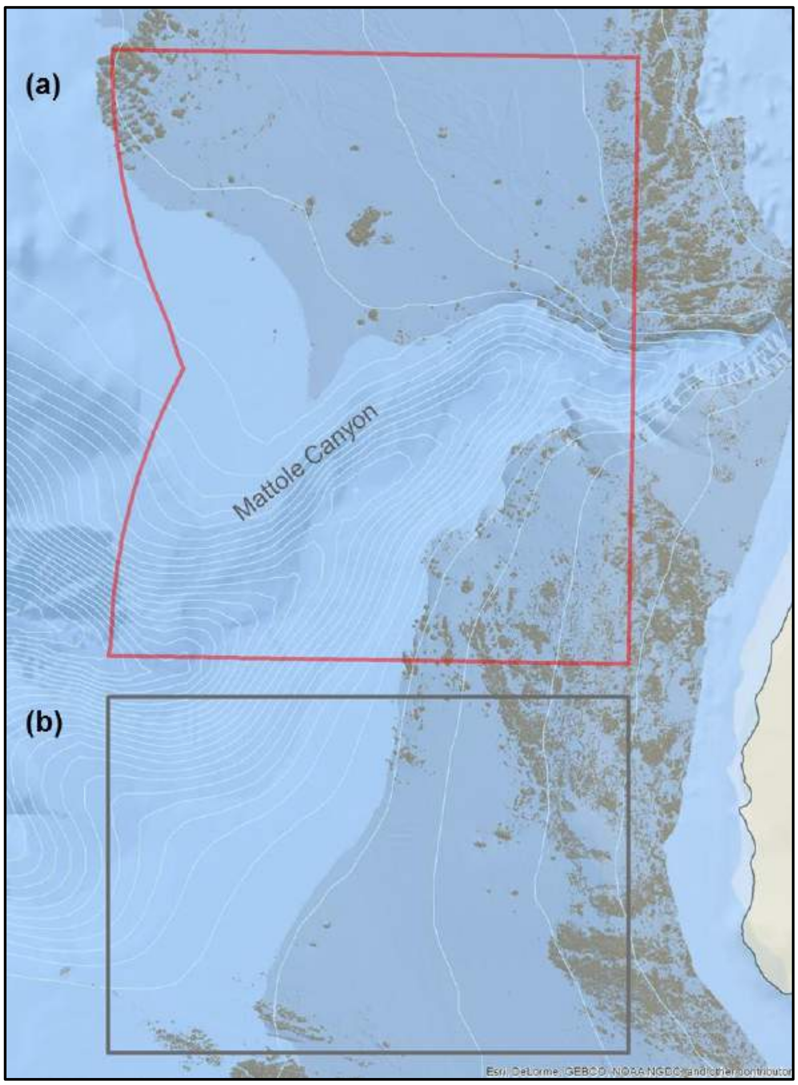

Figure 14. Mattole Canyon study area showing the rocky reef and surrounding soft bottom habitats in (a) the SMR and (b) reference area.

Survey Totals

Total sampling effort inside the Mattole Canyon SMR and reference area for both 2014 and 2015 survey years are presented in Table 11. Over the two sampling years, sampling effort within each study area was different. At the SMR, an additional two rocky reef, one soft bottom and four canyon transects were surveyed, compared to transects surveyed in the reference area.

Table 11. Survey totals for Mattole Canyon SMR and reference area for rocky reef and soft bottom transects, including hours of video (per camera), total number of photos on transect, number of transects, total kilometers surveyed and depth (average, max and min).

Study Area	Survey Year	Hours of Video	No. of Photos	Rocky Reef		Soft Bottom		Canyon		Depth Range (m)		
				No. of Transects	Total km	No. of Transects	Total km	No. of Transects	Total km	Avg	Min	Max
SMR	**2014**	10.6	1,493	7	3.8	2	1.8	4	7.4	92	38	421
	2015	4.7	1,364	7	3.5	1	0.9	1	1.5	76	36	307
	Totals	***15.3***	***2,857***	***14***	***7.3***	***3***	***2.7***	***5***	***8.9***			
Reference	**2014**	3.7	680	6	3.2	2	1.8	0	0.0	41	18	67
	2015	2.7	669	6	3.1	0	0.0	1	1.0	51	24	364
	Totals	***6.4***	***1,349***	***12***	***6.3***	***2***	***1.8***	***1***	***1***			

Substrate

Substrate types observed on transects are not mutually exclusive and represent the proportion of the total surveyed transect distance that has a given substrate present (see methods for full description). Inside the SMR, transects that targeted the rocky reef were primarily composed of rock and mud substrates, with lower amounts of sand substrate (Figure 15). At the reference area, rocky reef transects were primarily composed of rock and sand substrates, with lower amounts of mud substrate. Transects targeting soft bottom habitats at Mattole Canyon SMR and reference area were the most different. At the SMR, soft bottom transects were mostly mud and rock, with lower amounts of sand substrate also observed. At the reference area, soft bottom transects were almost entirely composed of sand substrate, with very little rock. Canyon transects surveyed at both at the SMR and reference area were predominantly composed of mud, though rock substrate was also common inside the SMR. Cobble, gravel and sand substrates were less commonly observed on canyon transects at both study areas.

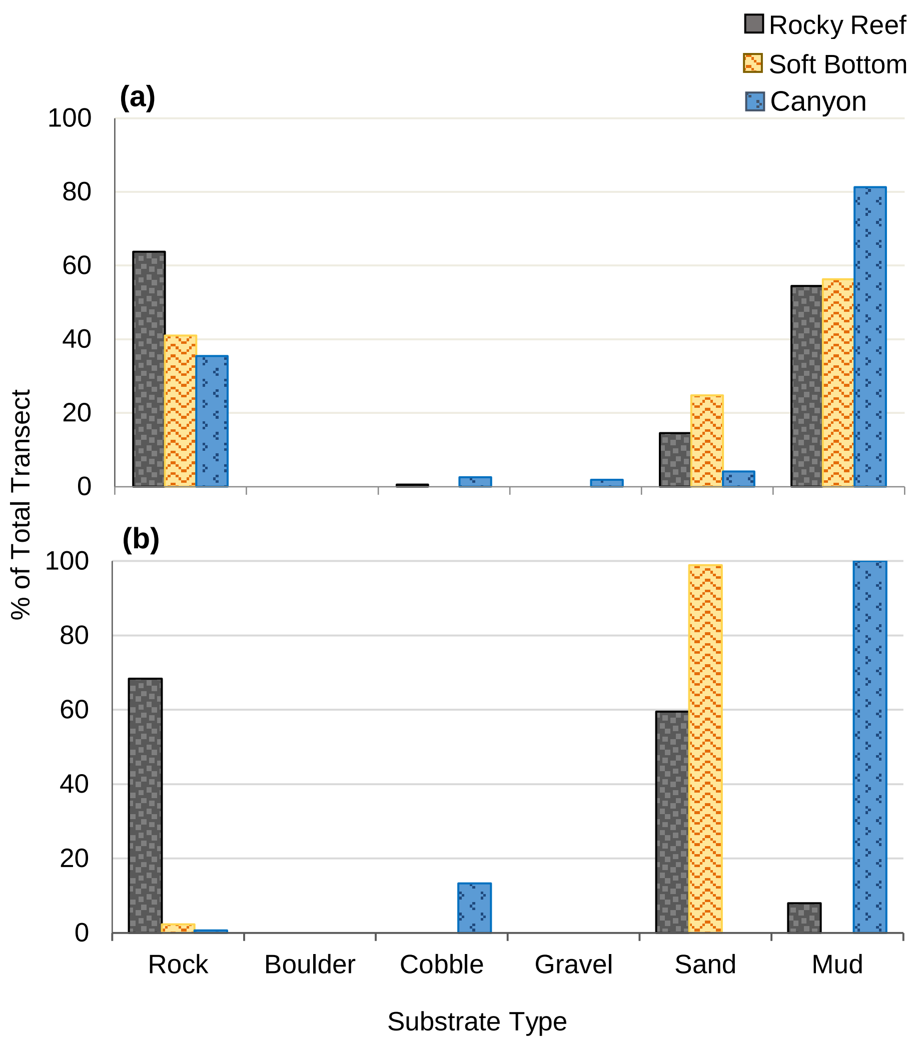

Figure 15. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef, soft bottom and canyon) for survey lines inside (a) Mattole Canyon SMR and (b) reference area.

Habitat

Habitat types derived from substrate data collected on rocky reef, soft bottom, and canyon transects at both Mattole Canyon study areas are shown in Figure 16. Overall, transects targeting the rocky reef were similar for both the SMR and reference area. Equal parts of hard, mixed and soft habitats were observed on rocky reef transects at both study areas. However, transects targeting soft bottom and canyon habitats at both study areas were different. Within the SMR, hard and mixed habitats were observed on soft bottom transects, accounting for almost 1/3 the habitat encountered. At the reference area, almost 100% of the soft bottom transects habitat was defined as soft. SMR canyon transects were similar to SMR soft bottom transects, with 1/3 the total transect distance defined as hard and mixed habitat and the rest as soft habitat. At the reference area, the canyon transect was almost entirely composed of soft habitat.

Habitat rugosity was quite different between all transect types and study areas. Transects targeting the rocky reef at the SMR had higher amounts of high rugosity, while the reference area had higher amounts of medium and low rugosity. Flat habitat was commonly observed on rocky reef transects at both study areas. Transects targeting soft bottom habitats at the SMR and reference area were mostly composed of flat habitats, with the SMR having some area also composed of high and medium rugosity habitat. Transects targeting the canyon had similar rugosity as their respective soft bottom transects, with increased amounts of medium and high rugosity at the SRM and increased amounts of low rugosity at the reference area.

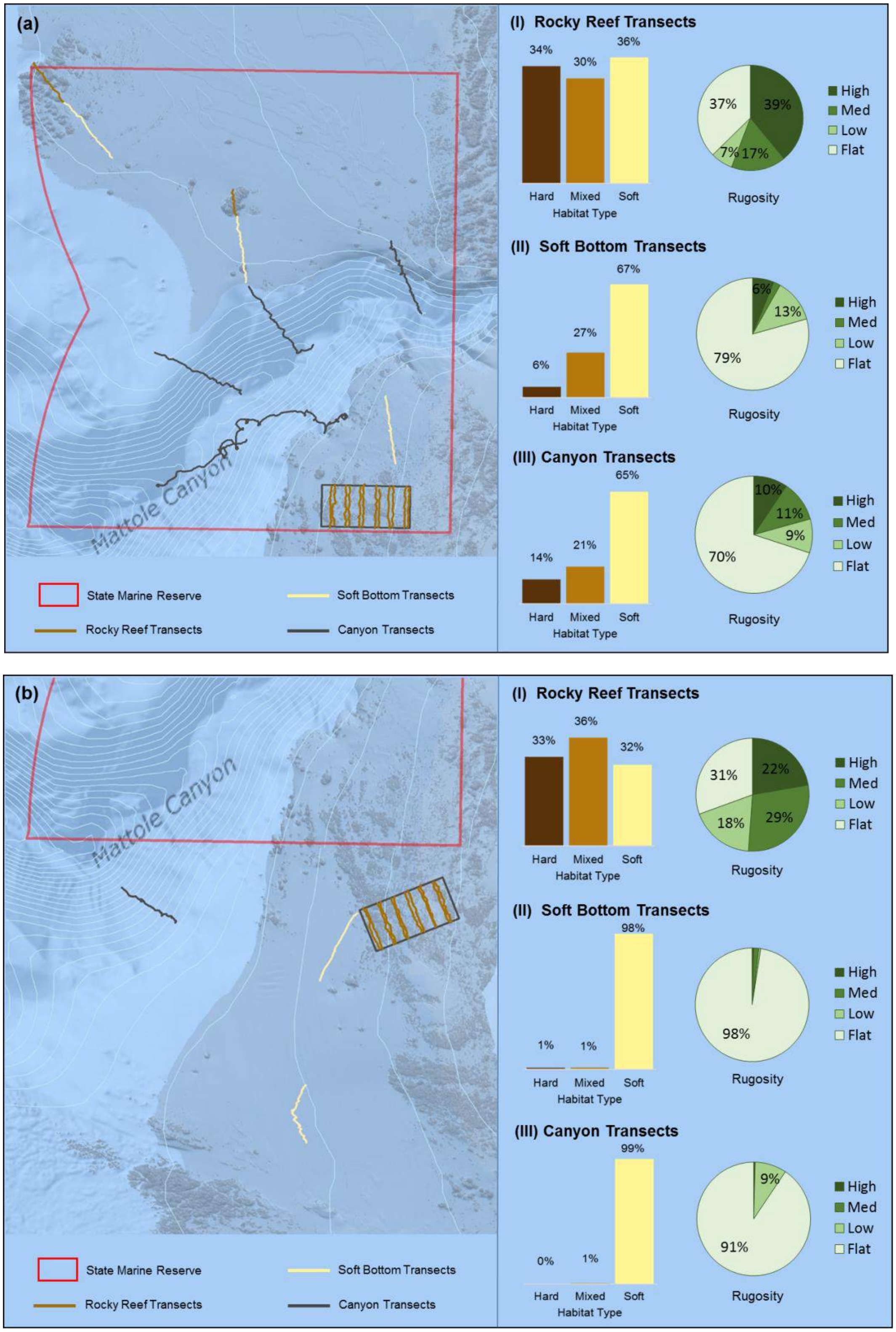

Figure 16. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Mattole Canyon SMR (b) reference area for transects lines targeting: (I) the rocky reef, (II) soft bottom and (III) canyon habitats.

Fish

Fish were summarized into seven taxonomic subgroupings for comparison between the SMR and reference area and are presented by transect habitat type in Figure 17. A full list of observed fish species/groupings enumerated on rocky reef, soft bottom and canyon transects for both the SMR and reference area are shown in Tables 12 & 13. In total, 65 fish species/groupings were observed on transects targeting the rocky reef, soft bottom, and canyon transects combined in the SMR and 39 species/groupings were observed in the reference area.

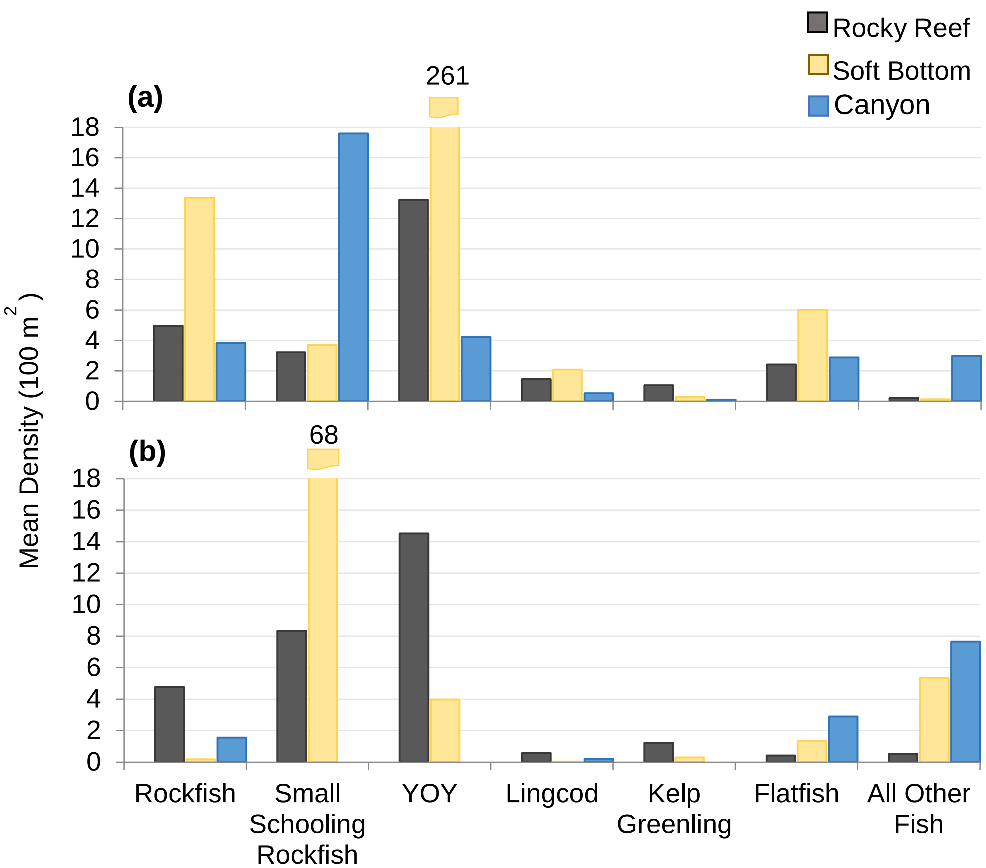

Figure 17. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Mattole Canyon SMR and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Tables 12 & 13.

Table 12. Total count, average density and standard deviation of fish by subgrouping for all rocky reef and soft bottom transects surveyed (n) within the Mattole Canyon SMR.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD			Size (cm)		
			Rocky Reef (n=14)	Soft Bottom (n=3)	Canyon (n=5)	Avg	Max	Min
Rockfish								
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	574	0.192 ± 0.178	4.883 ± 4.885	0.840 ± 1.776	39	60	12
Blue Rockfish	*Sebastes mystinus*	516	1.307 ± 1.326	4.341 ± 8.598	- -	29	45	8
Canary Rockfish	*Sebastes pinniger*	436	1.639 ± 1.602	2.110 ± 1.512	1.143 ± 1.886	25	48	8
UI rockfish	Unidentified *Sebastes sp.*	262	0.785 ± 0.415	0.929 ± 0.635	0.463 ± 0.395	19	38	10
Quillback Rockfish	*Sebastes maliger*	40	0.189 ± 0.097	0.234 ± 0.162	0.053 ± 0.086	35	45	20
Black Rockfish	*Sebastes melanops*	35	0.263 ± 0.515	- -	- -	38	45	32
Sebastomus Rockfish	Subgenus *Sebastomus*	31	0.122 ± 0.149	0.179 ± 0.227	0.074 ± 0.101	21	33	12
Yelloweye Rockfish	*Sebastes ruberrimus*	31	0.060 ± 0.086	0.260 ± 0.484	0.061 ± 0.125	38	58	15
Vermilion Rockfish	*Sebastes miniatus*	30	0.142 ± 0.179	0.142 ± 0.317	- -	40	52	13
Rosy Rockfish	*Sebastes rosaceus*	26	0.097 ± 0.167	0.236 ± 0.358	0.037 ± 0.067	23	30	12
Copper Rockfish	*Sebastes caurinus*	15	0.140 ± 0.153	- -	- -	39	48	31
Greenstriped Rockfish	*Sebastes elongatus*	15	- -	- -	0.136 ± 0.228	21	30	14
Stripetail Rockfish	*Sebastes saxicola*	6	- -	- -	0.085 ± 0.116	18	22	12
Chilipepper Rockfish	*Sebastes goodei*	4	- -	- -	0.028 ± 0.050	17	20	12
Redbanded Rockfish	*Sebastes babcocki*	4	- -	- -	0.029 ± 0.071	43	55	27
Squarespot/Widow Rockfish	*Sebastes hopkinsi* or *entomelas*	4	- -	0.020 ± 0.045	0.029 ± 0.071	25	30	22
Widow Rockfish	*Sebastes entomelas*	3	- -	0.020 ± 0.045	- -	32	35	30
Black/Blue Rockfish	*Sebastes melanops* or *mystinus*	2	0.017 ± 0.039	- -	- -	30	30	30
Bocaccio	*Sebastes paucispinis*	2	- -	0.020 ± 0.045	0.007 ± 0.018	42	55	29
Darkblotched Rockfish	*Sebastes crameri*	2	- -	- -	0.009 ± 0.023	14	14	14
Pinkrose Rockfish	*Sebastes simulator*	2	- -	- -	0.019 ± 0.047	22	25	18
Sharpchin Rockfish	*Sebastes zacentrus*	2	- -	- -	0.017 ± 0.027	22	22	21
Aurora Rockfish	*Sebastes aurora*	1	- -	- -	0.010 ± 0.024	10	10	10
Canary/Vermilion Rockfish	*Sebastes pinniger* or *miniatus*	1	0.009 ± 0.030	- -	- -	23	23	23
China Rockfish	*Sebastes nebulosus*	1	0.007 ± 0.026	- -	- -	33	33	33
Rosethorn Rockfish	*Sebastes helvomaculatus*	1	- -	- -	0.010 ± 0.024	28	28	28
Small schooling rockfish								
Shortbelly Rockfish	*Sebastes jordani*	2,066	0.625 ± 2.166	- -	17.307 ± 42.190	11	21	11
Small schooling rockfish	Schooling rockfish (10-15cm)	537	2.576 ± 7.676	3.710 ± 8.295	0.277 ± 0.679	11	14	10
Halfbanded Rockfish	*Sebastes semicinctus*	2	0.018 ± 0.061	- -	- -	8	8	8
Young of year rockfish	Young of year rockfish	12,164	13.246 ± 12.376	260.748 ± 562.829	4.218 ± 10.020	8	9	4
Lingcod	*Ophiodon elongatus*	257	1.004 ± 0.569	2.085 ± 3.101	0.535 ± 0.585	38	80	15
Kelp Greenling	*Hexagrammos decagrammus*	144	1.064 ± 0.608	0.285 ± 0.282	0.113 ± 0.218	35	46	8
Flatfish								
UI flatfish	Unidentified Pleuronectiformes	821	2.145 ± 2.585	5.707 ± 3.938	1.967 ± 0.876	14	40	6
Dover Sole	*Microstomus pacificus*	41	- -	- -	0.427 ± 0.132	27	35	15
UI sanddab	Unidentified *Citharichthys sp.*	41	0.206 ± 0.438	0.197 ± 0.440	0.022 ± 0.055	15	30	10
English Sole	*Parophrys vetulus*	26	0.026 ± 0.063	0.028 ± 0.063	0.161 ± 0.300	28	35	18
Petrale Sole	*Eopsetta jordani*	20	0.028 ± 0.072	0.070 ± 0.157	0.093 ± 0.175	27	35	16
Rex Sole	*Glyptocephalus zachirus*	15	- -	- -	0.151 ± 0.202	22	31	8
Rock Sole	*Lepidopsetta bilineata*	4	0.019 ± 0.044	- -	0.015 ± 0.036	29	32	24
Slender Sole	*Lyopsetta exilis*	4	- -	- -	0.032 ± 0.055	23	25	21
Curlfin Turbot	*Pleuronichthys decurrens*	1	- -	- -	0.007 ± 0.018	22	22	22
Pacific Sanddab	*Citharichthys sordidus*	1	- -	- -	0.010 ± 0.024	20	20	20
Spotted Turbot	*Pleuronichthys ritteri*	1	- -	0.014 ± 0.031	- -	18	18	18
All Other Fish								
UI fish	Unidentified fish	127	0.102 ± 0.153	0.035 ± 0.048	1.124 ± 1.643	17	60	8
UI cod	Unidentified Gadidae	69	- -	- -	0.852 ± 1.935	33	55	20
Pacific Hake	*Merluccius productus*	34	- -	- -	0.312 ± 0.533	37	60	24
UI small benthic fish	Unidentified small bottom fish	32	0.035 ± 0.069	0.070 ± 0.157	0.164 ± 0.401	12	18	4
Shortspine Thornyhead	*Sebastolobus alascanus*	30	- -	- -	0.566 ± 0.638	24	52	13
Thornyhead complex	*Sebastolobus altivelis or alascanus*	12	- -	- -	0.192 ± 0.281	18	32	12
UI poacher	Unidentified Agonidae	9	- -	- -	0.062 ± 0.066	17	21	12
Longnose Skate	*Raja rhina*	8	- -	- -	0.177 ± 0.218	52	60	43
Spotted Ratfish	*Hydrolagus colliei*	8	- -	- -	0.112 ± 0.112	38	50	28
Sablefish	*Anoplopoma fimbria*	7	- -	- -	0.044 ± 0.074	35	46	29
Ocean Sunfish	*Mola mola*	6	0.018 ± 0.061	- -	- -	63	70	50
Pacific Hagfish	*Eptatretus stoutii*	4	- -	- -	0.078 ± 0.126	40	50	33
UI eel pout	Unidentified Zoarcidae	4	0.009 ± 0.030	- -	0.023 ± 0.037	13	15	10
Cabezon	*Scorpaenichthys marmoratus*	2	0.017 ± 0.041	- -	- -	54	55	52
Combfish complex	*Zaniolepis frenata* or *latipinnis*	2	- -	0.016 ± 0.036	0.007 ± 0.018	14	14	13
Longspine Thornyhead	*Sebastolobus altivelis*	2	- -	- -	0.019 ± 0.047	31	32	30
UI sculpin	Unidentified Cottidae	2	- -	- -	0.019 ± 0.029	22	23	20
UI surfperch	Unidentified Embiotocidae	2	0.017 ± 0.060	- -	- -	9	9	8
Painted Greenling	*Oxylebius pictus*	1	0.007 ± 0.026	- -	- -	10	10	10
UI goby	Unidentified Gobiidae	1	- -	- -	0.007 ± 0.018	10	10	10
UI hexagrammid	Unidentified Hexagrammidae	1	0.009 ± 0.031	- -	- -	-	-	-
UI skate	Unidentified *Raja sp.*	1	- -	- -	0.007 ± 0.017	40	40	40

Table 13. Total count, average density and standard deviation of fish by subgrouping for all rocky reef and soft bottom transects surveyed (n) within the Mattole Canyon reference area.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD: Rocky Reef (n=12)	Soft Bottom (n=2)	Canyon (n=1)		Size (cm): Avg	Max	Min
Rockfish									
Blue Rockfish	*Sebastes mystinus*	240	1.927 ± 2.012	0.084 ± 0.119	-	N/A	17	40	8
UI rockfish	Unidentified *Sebastes sp.*	115	0.948 ± 1.228	0.042 ± 0.060	0.496	N/A	13	40	10
Black Rockfish	*Sebastes melanops*	106	0.844 ± 1.331	- -	-	N/A	35	44	30
Canary Rockfish	*Sebastes pinniger*	88	0.683 ± 1.249	0.042 ± 0.060	-	N/A	24	40	10
Copper Rockfish	*Sebastes caurinus*	12	0.090 ± 0.114	- -	-	N/A	37	43	35
Quillback Rockfish	*Sebastes maliger*	11	0.095 ± 0.134	- -	-	N/A	35	40	30
Vermilion Rockfish	*Sebastes miniatus*	11	0.094 ± 0.132	- -	-	N/A	40	46	30
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	5	0.052 ± 0.109	- -	-	N/A	10	11	9
Greenstriped Rockfish	*Sebastes elongatus*	4	- -	- -	0.283	N/A	24	32	20
Widow Rockfish	*Sebastes entomelas*	3	0.024 ± 0.084	- -	-	N/A	8	8	8
Chilipepper Rockfish	*Sebastes goodei*	2	- -	- -	0.142	N/A	26	26	26
Stripetail Rockfish	*Sebastes saxicola*	2	- -	- -	0.142	N/A	24	24	23
Darkblotched Rockfish	*Sebastes crameri*	1	- -	- -	0.071	N/A	36	36	36
Small schooling rockfish									
Shortbelly Rockfish	*Sebastes jordani*	4,351	2.288 ± 6.170	67.479 ± 95.429	-	N/A	8	11	8
Small schooling rockfish	Schooling rockfish (10-15cm)	746	6.047 ± 13.688	- -	-	N/A	10	13	10
Young of year rockfish	Young of year rockfish	2,025	14.513 ± 21.492	3.979 ± 5.271	-	N/A	8	9	4
Lingcod	*Ophiodon elongatus*	74	0.584 ± 0.496	0.042 ± 0.060	0.212	N/A	48	80	17
Kelp Greenling	*Hexagrammos decagrammus*	150	1.238 ± 0.461	0.295 ± 0.417	-	N/A	35	47	20
Flatfish									
UI flatfish	Unidentified Pleuronectiformes	86	0.370 ± 0.369	1.263 ± 0.361	0.779	N/A	15	35	5
Rex Sole	*Glyptocephalus zachirus*	19	- -	- -	1.345	N/A	31	34	27
English Sole	*Parophrys vetulus*	7	0.024 ± 0.043	- -	0.283	N/A	35	43	25
Dover Sole	*Microstomus pacificus*	5	- -	- -	0.354	N/A	31	36	26
Rock Sole	*Lepidopsetta bilineata*	3	0.010 ± 0.034	0.084 ± 0.000	-	N/A	25	41	10
Petrale Sole	*Eopsetta jordani*	2	- -	- -	0.142	N/A	33	33	32
UI sanddab	Unidentified *Citharichthys sp.*	1	0.008 ± 0.029	- -	-	N/A	24	24	24
All Other Fish									
Pacific Sand Lance	*Ammodytes hexapterus*	126	- -	5.285 ± 7.474	-	N/A	12	14	6
Spiny Dogfish	*Squalus acanthias*	75	- -	- -	5.169	N/A	49	55	33
UI schooling pelagic	Unidentified schooling pelagic fish	45	0.410 ± 1.421	- -	-	N/A	14	14	14
Pacific Hake	*Merluccius productus*	12	- -	- -	0.850	N/A	43	52	34
UI small benthic fish	Unidentified small bottom fish	11	0.033 ± 0.089	- -	0.496	N/A	14	22	7
Sablefish	*Anoplopoma fimbria*	8	- -	- -	0.496	N/A	47	53	36
UI fish	Unidentified fish	7	0.036 ± 0.072	0.042 ± 0.059	0.142	N/A	18	45	7
Shortspine Thornyhead	*Sebastolobus alascanus*	6	- -	- -	0.425	N/A	27	30	22
Spotted Ratfish	*Hydrolagus colliei*	5	- -	-	0.354	N/A	45	50	40
Cabezon	*Scorpaenichthys marmoratus*	3	0.025 ± 0.046	- -	-	N/A	43	58	32
Longnose Skate	*Raja rhina*	1	0.010 ± 0.035	- -	-	N/A	95	95	95
Pacific Hagfish	*Eptatretus stoutii*	1	- -	- -	0.071	N/A	60	60	60
UI poacher	Unidentified Agonidae	1	- -	- -	0.071	N/A	16	16	16
UI surfperch	Unidentified Embiotocidae	1	0.008 ± 0.028	- -	-	N/A	14	14	14

Rocky Reef Fish

On rocky reef transects inside the SMR and reference area, YOY were the most abundant subgroup and accounted for half the total fish density from rocky reef transects at both sites (Figure 17). The rockfish subgroup was observed with similar densities at both study areas, with aggregating species such as Blue, Black, Canary, Widow and Olive/Yellowtail Rockfishes accounting for 85% of the rockfish density inside the SMR and 75% at the reference area. Copper, Quillback and Vermilion Rockfishes had very similar densities at each study area, with slightly higher densities in the SMR. Yelloweye Rockfish were only observed inside the SMR.

Other fish species were also observed on transects that targeted rocky reef habitats in both study areas and include Lingcod, Kelp Greening and flatfish. Densities of Lingcod and Kelp Greenling were similar between the SMR and reference area, with slightly higher Lingcod densities observed inside the SMR. Densities of the flatfish subgroup were different between the two sites, with nearly six times higher densities observed on rocky reef transects inside the SMR.

Soft Bottom Fish

Surveys of soft bottom habitats inside the SMR were primarily dominated by the YOY subgroup, which accounted for 91% of the total fish density, compared to 5% in the reference area (Figure 17). In contrast, the small schooling rockfish subgroup accounted for 86% of the total soft bottom transect density in the reference area and only 1% in the SMR. The rockfish subgroup was also abundant in the SMR, with densities almost 80 times higher than those observed in the reference area. Densities of the rockfish subgroup on soft bottom transects in the SMR were also almost three times higher than those observed on rocky reef transects in the SMR.

Other subgroupings observed on soft bottom transects, also showed differences in density between the two study areas. Flatfish densities were higher inside the SMR, with almost 5 times higher densities in the SMR compared to the reference area. The ‘all other fish’ subgroup at the reference area, almost entirely Pacific Sand Lance, had densities similar to the flatfish subgroup observed inside the SMR. Lingcod were present on soft bottom transects at both areas, but within the SMR densities were much higher within the SMR than in the reference area.

Canyon Fish

Results from transects targeting the canyon within both the SMR and reference area are presented. A total of four canyon transects were completed inside the SMR and only one transect targeting the canyon was completed inside the reference area. Therefore, results from the reference area canyon transect should be interpreted with caution.

On canyon transects inside the SMR, the three rockfish subgroupings (small schooling rockfish, YOY and rockfish) were the most abundant (Figure 17). The small schooling rockfish subgroup accounted for 55% of the total fish density. YOY and the rockfish subgroups had similar densities, and combined accounted for 25% of the total canyon fish density. The rockfish subgroup included 21 species/groupings, from which Canary and Olive/Yellowtail Rockfishes were the most abundant, accounting for 61% of the total density. Yelloweye rockfish were observed at Mattole Canyon SMR and accounted for 2% of the rockfish subgroup density.

The flatfish and 'all other fish' subgroupings were also observed and each accounted for 9% of the fish density. Eight different species of flatfish were identified on canyon transects in the SMR, five more than in rocky reef or soft bottom transects at this site. Several deep water species were also observed on canyon transects in the SMR and include: Redbanded, Aurora and Rosethorn Rockfishes, thornyheads, Pacific Hake, Sablefish and unidentified cod.

On the canyon transect at the reference area, the 'all other fish' subgrouping had the highest total density and accounted for 66% of the total fish density for the transect (Figure 17). Within this subgrouping, almost 68% of the density came from Spiny Dogfish observations. Flatfish were the next most commonly observed subgroup, of which 46% were identified as Rex Soles. Rockfish observations at the reference area accounted for 9% of the total canyon habitat fish density and included observations from 5 species/groupings. Small schooling rockfish and young of year rockfish were not observed on this transect. Lingcod were observed and accounted for 2% of the overall fish density.

Invertebrates

Invertebrates were grouped into seven mobile and seven sessile macro-invertebrates for comparison between the Mattole Canyon SMR and reference area and are presented by transect habitat type in Figure 18. Full lists of observed sessile and mobile macro-invertebrate species/groupings enumerated on both rocky reef and soft bottom transects for both the SMCA and reference area are shown in Tables 14 & 15. In total, 73 invertebrate species/groupings were observed on transects targeting the rocky reef, soft bottom and canyon transects combined in the SMR, and 79 species/groupings were observed in the reference area.

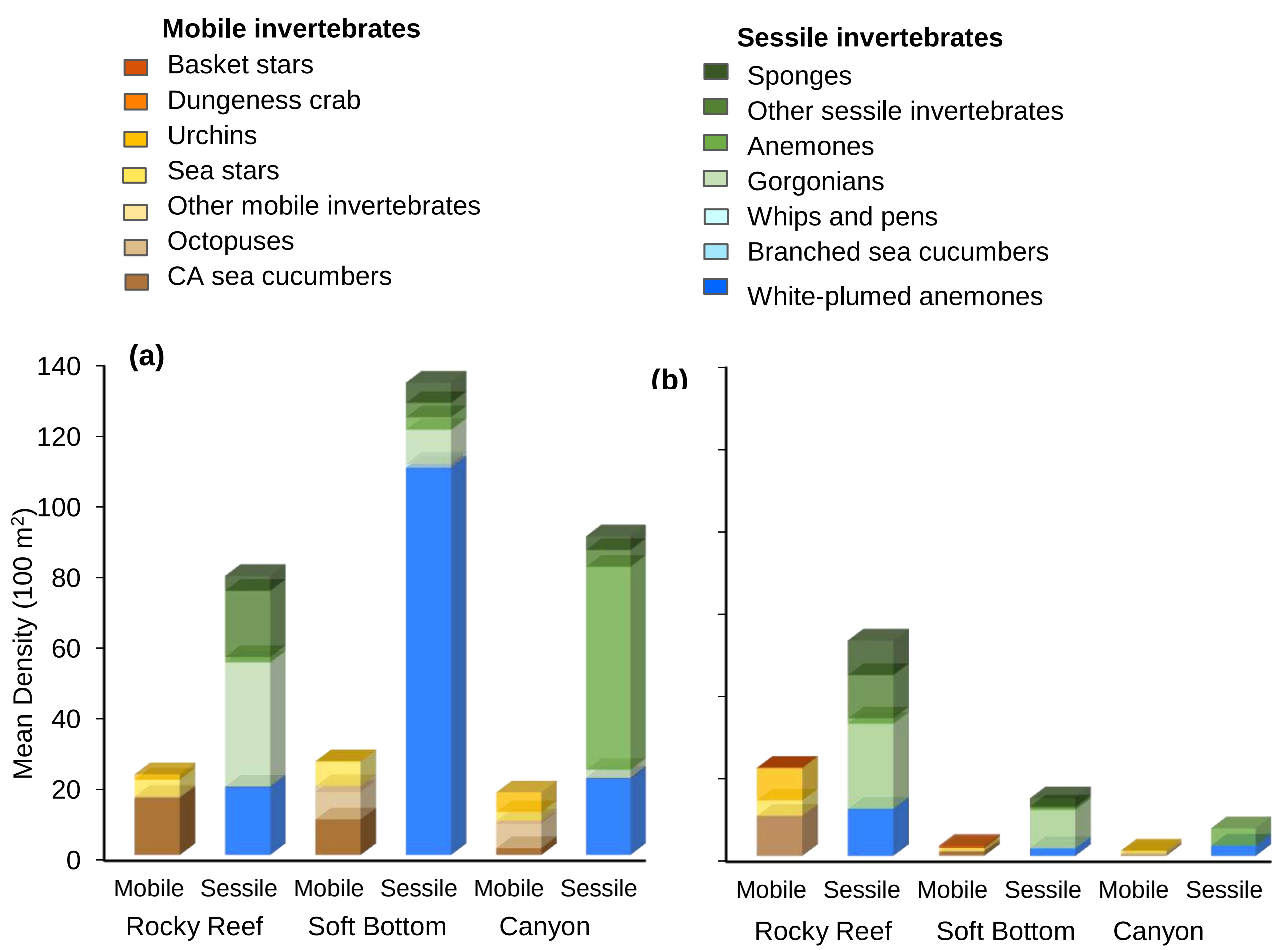

Figure 18. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside the (a) Mattole Canyon SMR and (b) reference area. For a breakdown of the taxonomic composition of subgroups, see Tables 14 & 15.

Table 14. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Mattole Canyon SMR.

	Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD		
				Rocky Reef (n=14)	Soft Bottom (n=3)	Canyon (n=5)
Mobile Invertebrates	**Basket stars**	*Gorgonocephalus eucnemis*	317	1.330 ± 1.180	3.010 ± 2.308	1.220 ± 1.788
	Urchins					
	Red sea urchin	*Mesocentrotus franciscanus*	152	1.470 ± 2.328	- -	0.010 ± 0.032
	Fragile pink urchin	*Strongylocentrotus fragilis*	140	0.060 ± 0.168	0.080 ± 0.068	5.600 ± 12.011
	Purple sea urchin	*Strongylocentrotus purpuratus*	1	0.010 ± 0.037	- -	- -
	Purple/red urchin complex	*Strongylocentrotus franciscanus* or *purpuratus*	1	0.010 ± 0.040	- -	- -
	Sea stars					
	Henricia complex	*Henricia sp.*	278	1.600 ± 1.234	3.260 ± 3.149	0.380 ± 0.547
	Red sea star	*Mediaster aequalis*	129	0.830 ± 0.995	1.160 ± 1.384	0.200 ± 0.266
	Sand star	*Luidia foliolata*	93	0.810 ± 1.473	0.340 ± 0.198	0.090 ± 0.127
	UI sea star	Unidentified sea star	80	0.520 ± 0.666	0.460 ± 0.401	0.330 ± 0.310
	Leather star	*Dermasterias imbricata*	78	0.580 ± 0.543	0.500 ± 0.134	0.090 ± 0.161
	Fish eating star	*Stylasterias forreri*	62	0.110 ± 0.169	0.350 ± 0.605	0.550 ± 0.703
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	30	0.090 ± 0.195	0.040 ± 0.067	0.260 ± 0.309
	Cushion star	*Pteraster tesselatus*	20	0.080 ± 0.140	0.230 ± 0.205	0.140 ± 0.177
	Short spined sea star	*Pisaster brevispinus*	13	0.030 ± 0.088	0.350 ± 0.599	0.010 ± 0.024
	Thorny sea star	*Poraniopsis inflata*	13	0.070 ± 0.230	0.170 ± 0.288	0.020 ± 0.037
	Cookie star	*Ceramaster patagonicus*	11	0.020 ± 0.089	0.120 ± 0.132	0.070 ± 0.131
	Long legged sunflower star	*Rathbunaster californicus*	10	- -	- -	0.240 ± 0.378
	Stimpson's sun star	*Solaster stimpsoni*	5	0.050 ± 0.085	- -	- -
	Rainbow star	*Orthasterias koehleri*	3	0.020 ± 0.058	- -	0.010 ± 0.032
	Solaster sun star complex	*Solaster sp.*	2	- -	0.030 ± 0.058	- -
	Spiny red star	*Hippasteria spinosa*	1	- -	- -	0.010 ± 0.034
	Sunflower star	*Pycnopodia helianthoides*	1	- -	- -	0.010 ± 0.024
	Other Mobile Inverts					
	Pleurobranchaea californica	*Pleurobranchaea californica*	72	0.030 ± 0.088	0.530 ± 0.920	0.550 ± 1.283
	Market squid	*Loligo opalescens*	29	- -	0.960 ± 1.668	- -
	Light edged ribbon worm	*Cerebratulus californiensis*	7	- -	- -	0.130 ± 0.184
	Spot prawn	*Pandalus platyceros*	7	- -	- -	0.090 ± 0.198
	UI sea jelly	Unidentified sea jelly	6	0.020 ± 0.058	- -	0.030 ± 0.041
	UI nudibranch	Unidentified nudibranch	4	0.010 ± 0.037	0.120 ± 0.200	- -
	UI whelk	Unidentified whelk	4	- -	- -	0.090 ± 0.131
	Decorator crab	*Loxorhynchus crispatus*	2	- -	- -	0.030 ± 0.064
	Cancer complex	*Cancer sp.*	1	0.010 ± 0.040	- -	- -
	Clown nudibranch	*Triopha catalinae*	1	- -	0.040 ± 0.067	- -
	Orange-peel nudibranch	*Tochuina tetraquetra*	1	0.010 ± 0.041	- -	- -
	UI crab	Unidentified crab	1	- -	- -	0.010 ± 0.026
	UI salp	Unidentified salp	1	0.010 ± 0.041	- -	- -
	Octopuses					
	Red octopus	*Octopus rubescens*	768	0.250 ± 0.407	7.840 ± 6.734	6.820 ± 7.157
	Giant Pacific octopus	*Enteroctopus dofleini*	5	0.010 ± 0.046	- -	0.090 ± 0.130
	California sea cucumber	*Parastichopus californicus*	1,997	16.220 ± 8.575	10.070 ± 8.679	1.940 ± 3.276
Sessile Invertebrates	**Sponges**					
	UI branched sponge	Unidentified branched sponge	361	1.820 ± 2.030	3.380 ± 4.528	1.490 ± 3.566
	UI lobed sponge/tunicate	Unidentified lobed sponge/tunicate	196	0.380 ± 1.007	- -	2.130 ± 5.212
	UI nipple sponge	Unidentified nipple sponge	106	0.680 ± 0.780	1.250 ± 0.338	0.050 ± 0.128
	Orange puffball sponge	*Tethya aurantia*	105	1.060 ± 1.154	0.170 ± 0.302	0.010 ± 0.026
	Gray puffball sponge	*Craniella arb*	25	0.220 ± 0.434	0.150 ± 0.266	0.010 ± 0.032
	UI stalked boot sponge	Unidentified yellow stalked sponge	16	- -	0.650 ± 0.426	- -
	Gray moon sponge	*Spheciospongia confoederata*	12	- -	- -	0.160 ± 0.402
	Trumpet sponge	*Stylissa stipitata*	6	0.060 ± 0.119	0.040 ± 0.067	- -
	UI boot sponge	Unidentified boot sponge	2	- -	0.090 ± 0.151	- -
	UI trumpet sponge	Unidentified trumpet sponge	1	- -	- -	0.010 ± 0.032
	Other Sessile Inverts					
	California hydrocoral	*Stylaster californicus*	1,900	18.540 ± 22.137	4.060 ± 3.563	0.220 ± 0.543
	Mushroom soft coral	*Anthomastus ritteri*	102	- -	- -	4.350 ± 6.505
	UI branched bryozoan	Unidentified branching bryozoan	22	0.080 ± 0.258	- -	0.160 ± 0.388
	Acorn barnacle	*Balanus nubilus*	5	0.050 ± 0.170	- -	- -
	Stalked tunicate	*Styela montereyensis*	1	0.010 ± 0.034	- -	- -
	Anemones					
	UI anemone 4	Unidentified anemone species #4	1,757	- -	0.620 ± 0.834	30.660 ± 33.146
	UI anemone 3	Unidentified anemone species #3	788	- -	- -	12.060 ± 12.344
	UI anemone	Unidentified anemone	622	0.040 ± 0.070	0.470 ± 0.501	9.440 ± 14.242
	UI anemone 6	Unidentified anemone species #6	161	- -	- -	2.190 ± 5.280
	UI anemone 5	Unidentified anemone species #5	82	- -	- -	1.500 ± 1.014
	Fish eating urticina	*Urticina piscivora*	65	0.517 ± 0.484	0.440 ± 0.405	0.040 ± 0.096
	Sand-rose anemone	*Urticina columbiana*	61	0.250 ± 0.383	0.600 ± 0.441	0.270 ± 0.468
	UI sand dwelling anemone	Unidentified sand dwelling anemone	52	- -	0.270 ± 0.374	0.620 ± 0.925
	UI tube dwelling anemone	Unidentified tube dwelling anemone	45	0.320 ± 0.376	0.420 ± 0.543	0.130 ± 0.169
	Frilled anemone	*Metridium senile*	39	0.370 ± 0.936	- -	0.030 ± 0.078
	UI anemone 1	Unidentified anemone species #1	25	0.020 ± 0.061	0.510 ± 0.669	0.220 ± 0.308
	UI anemone 2	Unidentified anemone species #2	16	0.020 ± 0.059	0.130 ± 0.227	0.300 ± 0.368
	Stubby rose anemone	*Urticina coriacea*	2	- -	0.080 ± 0.133	- -
	Gorgonians					
	Short red gorgonian	*Swiftia spauldingi*	3,703	35.210 ± 21.469	9.600 ± 5.417	2.190 ± 2.023
	Whips and pens					
	White sea pen	*Stylatula elongata*	36	0.020 ± 0.054	0.790 ± 1.055	0.170 ± 0.178
	Orange sea pen	*Ptilosarcus gurneyi*	12	0.070 ± 0.143	0.250 ± 0.215	- -
	UI sea pen	*Virgularia sp.*	5	0.050 ± 0.178	0.030 ± 0.058	- -
	Sea whip	*Halipteris californica*	1	- -	- -	- -
	Branched sea cucumbers					
	Orange sea cucumber	*Cucumaria miniata*	4	0.020 ± 0.057	0.030 ± 0.058	0.010 ± 0.024
	White branched sea cucumber	*Cucumaria piperata*	1	- -	- -	0.070 ± 0.169
	White-plumed anemone	*Metridium farcimen*	8,225	19.390 ± 12.268	109.580 ± 108.606	21.740 ± 30.720

Table 15. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Mattole Canyon reference area.

	Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD		
				Rocky Reef (n=12)	Soft Bottom (n=2)	Canyon (n=1)
Mobile Invertebrates	**Basket stars**	*Gorgonocephalus eucnemis*	12	0.040 ± 0.067	0.540 ± 0.760	- -
	Dungeness crab	*Metacarcinus magister*	1	0.010 ± 0.045	- -	- -
	Urchins					
	Red sea urchin	*Mesocentrotus franciscanus*	615	7.940 ± 11.466	- -	- -
	Fragile pink urchin	*Strongylocentrotus fragilis*	1	- -	- -	0.100 N/A
	Sea stars					
	Henricia complex	*Henricia sp.*	113	1.340 ± 0.761	0.480 ± 0.676	0.100 N/A
	Leather star	*Dermasterias imbricata*	61	0.710 ± 0.505	0.180 ± 0.253	0.100 N/A
	Red sea star	*Mediaster aequalis*	50	0.620 ± 0.663	0.060 ± 0.084	- -
	UI sea star	Unidentified sea star	19	0.230 ± 0.300	- -	0.100 N/A
	Sand star	*Luidia foliolata*	13	0.150 ± 0.339	- -	- -
	Fish eating star	*Stylasterias forreri*	11	0.140 ± 0.194	- -	- -
	Sunflower star complex	*Rathbunaster californicus* or *Pycnopodia helianthoides*	10	0.120 ± 0.413	- -	- -
	Stimpson's sun star	*Solaster stimpsoni*	8	0.110 ± 0.165	- -	- -
	Thorny sea star	*Poraniopsis inflata*	8	0.110 ± 0.286	- -	- -
	Cushion star	*Pteraster tesselatus*	5	0.070 ± 0.198	0.060 ± 0.084	- -
	Rainbow star	*Orthasterias koehleri*	3	0.040 ± 0.104	- -	- -
	Short spined sea star	*Pisaster brevispinus*	3	0.040 ± 0.064	- -	- -
	Bat star	*Asterina miniata*	2	0.020 ± 0.079	- -	- -
	Long legged sunflower star	*Rathbunaster californicus*	1	- -	- -	0.100 N/A
	Rose star	*Crossaster papposus*	1	- -	- -	0.100 N/A
	Solaster sun star complex	*Solaster sp.*	1	0.010 ± 0.049	- -	- -
	Spiny red star	*Hippasteria spinosa*	1	- -	- -	0.100 N/A
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	1	0.010 ± 0.040	- -	- -
	Sunflower star	*Pycnopodia helianthoides*	1	0.010 ± 0.041	- -	- -
	Other Mobile Inverts					
	Pleurobranchaea californica	*Pleurobranchaea californica*	4	- -	- -	0.400 N/A
	Orange-peel nudibranch	*Tochuina tetraquetra*	3	0.050 ± 0.112	- -	- -
	UI whelk	Unidentified whelk	2	0.010 ± 0.041	- -	- -
	Decorator crab	*Loxorhynchus crispatus*	1	0.020 ± 0.066	- -	- -
	UI crab	Unidentified crab	1	0.010 ± 0.049	- -	- -
	UI sea jelly	Unidentified sea jelly	1	- -	0.060 ± 0.084	- -
	UI nudibranch	Unidentified nudibranch	1	- -	- -	- -
	Octopuses					
	Red octopus	*Octopus rubescens*	19	0.060 ± 0.196	0.770 ± 0.925	0.200 N/A
	California sea cucumber	*Parastichopus californicus*	817	9.630 ± 11.235	0.300 ± 0.422	- -
Sessile Invertebrates	**Sponges**					
	UI nipple sponge	Unidentified nipple sponge	305	3.590 ± 3.434	0.960 ± 1.351	- -
	Orange puffball sponge	*Tethya aurantia*	193	2.430 ± 2.340	0.180 ± 0.253	- -
	Gray puffball sponge	*Craniella arb*	116	1.610 ± 2.233	0.120 ± 0.169	- -
	UI lobed sponge/tunicate	Unidentified lobed sponge/tunicate	46	0.560 ± 1.326	- -	- -
	UI branched sponge	Unidentified branched sponge	27	0.170 ± 0.554	0.720 ± 1.014	- -
	Trumpet sponge	*Stylissa stipitata*	2	0.030 ± 0.063	- -	- -
	Other Sessile Inverts					
	California hydrocoral	*Stylaster californicus*	659	8.930 ± 8.214	0.420 ± 0.591	- -
	UI branched bryozoan	Unidentified branching bryozoan	74	1.410 ± 4.881	- -	- -
	Northern staghorn bryozoan	*Heteropora pacifica*	6	0.080 ± 0.230	- -	- -
	Acorn barnacle	*Balanus nubilus*	5	0.070 ± 0.133	- -	- -
	Stalked tunicate	*Styela montereyensis*	1	0.010 ± 0.048	- -	- -
	Anemones					
	Fish eating urticina	*Urticina piscivora*	59	0.688 ± 0.479	- -	- -
	UI anemone	Unidentified anemone	37	0.330 ± 0.397	0.480 ± 0.673	0.500 N/A
	UI anemone 1	Unidentified anemone species #1	19	0.190 ± 0.252	- -	0.300 N/A
	UI anemone 5	Unidentified anemone species #5	14	- -	- -	1.400 N/A
	UI sand dwelling anemone	Unidentified sand dwelling anemone	12	0.020 ± 0.079	- -	1.000 N/A
	Swimming anemone	*Stomphia didemon*	7	- -	- -	0.700 N/A
	Sand-rose anemone	*Urticina columbiana*	5	0.060 ± 0.077	- -	- -
	UI anemone 2	Unidentified anemone species #2	3	0.030 ± 0.113	- -	- -
	UI anemone 3	Unidentified anemone species #3	2	- -	- -	0.200 N/A
	UI anemone 4	Unidentified anemone species #4	1	- -	- -	0.100 N/A
	Gorgonians					
	Short red gorgonian	*Swiftia spauldingi*	1,909	20.770 ± 17.119	9.260 ± 13.092	- -
	UI gorgonian	Unidentified Gorgonacea	1	0.010 ± 0.048	- -	- -
	Whips and pens					
	Orange sea pen	*Ptilosarcus gurneyi*	2	0.010 ± 0.045	0.060 ± 0.084	- -
	Branched sea cucumbers					
	Orange sea cucumber	*Cucumaria miniata*	3	0.050 ± 0.107	- -	- -
	Slipper sea cucumber	*Psolus chitonoides*	3	0.040 ± 0.147	- -	- -
	White-plumed anemone	*Metridium farcimen*	1,051	11.350 ± 11.874	1.850 ± 2.618	2.510 N/A

Rocky Reef Invertebrates

Mobile invertebrates observed on rocky reef transects at the study areas were similar in overall density, with three subgroupings accounting for around 90% of the mobile invertebrate observations: California sea cucumber, sea stars, and urchins. At both the SMR and reference area, California sea cucumbers were the most abundant, with densities almost two times higher in the SMR. Sea stars had similar densities within the rocky reef at each study area. The urchins subgroup, almost entirely red sea urchin, was observed in much higher densities inside the reference area, when compared to the SMR.

Sessile invertebrates on rocky reef transects within the SMR and reference area were predominantly comprised of four subgroupings, which accounted for over 97% of the total sessile invertebrate density: white-plumed anemones, gorgonians, other sessile invertebrates, and sponges. Overall, densities of sessile invertebrates were similar at both study areas, with slightly higher overall densities observed in the SMR.

The gorgonian subgroup, which accounted for 44% of the overall sessile invertebrate density in the SMR and 40% at the reference area, was over 99% composed of short red gorgonians at both study areas. White-plumed anemones accounted for 24% of the sessile invertebrate density on rocky reef surveys in the SMR and 22% at the reference area.

Soft Bottom Invertebrates

Overall, mobile invertebrate density was dissimilar for soft bottom transects at the two Mattole Canyon study areas (MPA= 29.66/100 m^2, ref= 2.45/100 m^2). The top three subgroupings of mobile invertebrates found on soft bottom transects within Mattole Canyon SMR accounted for 84% of the observations: California sea cucumbers, octopuses and sea stars. At the nearby reference area, sea stars, octopuses and basket stars accounted for 85% of the observations. The octopuses subgrouping, all identified as red octopus both inside the MPA and at the reference area, represented 26% and 31% respectively of the total soft bottom mobile invertebrate observations by site. Sea stars were more commonly observed inside the MPA and accounted for 24% of the mobile invertebrate density in soft bottom transects, 63% of which were identified as the *Henricia* complex or red sea stars.

Sessile invertebrate densities from soft bottom transects were also different between the two study area, with 133.61/100 m^2 in the SMR compared to 14.05/100 m^2 in the reference area. For transects targeting soft bottom habitats, over 82% of the sessile invertebrates enumerated in the SMR were identified as white-plumed anemones (Figure 18); almost 93% were observed on hard only habitat that occurred on soft bottom transects. At the reference area, gorgonians were the most commonly observed sessile invertebrate and accounted for almost 66% of the sessile invertebrate observations. Sponges and white-plumed anemones represented the remaining sessile invertebrate observations at the SMR and reference area respectively.

Canyon Invertebrates

From transects targeting the canyon at both study areas, total invertebrate density was quite different, with densities inside Mattole Canyon SMR higher than in the reference area (109.3 inverts/100 m^2 and 8.0 invert/100 m^2 respectively). Mobile invertebrates observed on canyon transects at the SMR were primarily composed of two subgroupings: octopuses and urchins. Octopuses accounted for 36% of the total mobile invertebrate density at the SMR; almost 99% were identified as the red octopus. The urchins subgroup, entirely composed of fragile pink urchin, was commonly observed on canyon surveys within the SMR and contributed 29% to the total mobile invertebrate density. In the reference area, sea stars accounted 46% of the mobile invertebrate density on canyon transects and included six different species/groupings. The 'other mobile inverts' subgrouping accounted for 31% of the mobile invertebrate density in the reference area and was entirely composed of *Pleurobranchaea californica.*

Sessile invertebrate composition was similar within the SMR and area reference, but overall density was quite different (90.32/100 m^2 and 6.71/100 m^2 respectively). Two subgroupings accounted for the majority of the total sessile invertebrate density in both study areas: 'anemones' and white-plumed anemones. The anemones subgroup accounted for over 60% of the canyon sessile invertebrate density in both study areas. Sponges and 'other sessile invertebrates' (mostly mushroom coral) were observed on canyon transects only within the SMR.

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Ten Mile State Marine Reserve and Reference Area

The Ten Mile State Marine Reserve (TM SMR) is located approximately 14.5 kilometers north of Fort Bragg, California, and encompasses 31 square kilometers of marine habitats (CDFW 2016d). The SMR spans 5 km of shoreline and shares its southern border with Ten Mile Beach State Marine Conservation Area. With depths ranging from 0 to 105 meters, the SMR is comprised of approximately 86% soft habitat, 8% rocky habitat and 6% unidentified habitat (Figure 19). The Ten Mile SMR was the only MPA we surveyed as part of the baseline program that previously was open to bottom fishing in its shallower waters prior to MPA implementation in 2014. Fishing deeper than 37 m was prohibited in 2002 through implementation of the Rockfish Conservation Areas by Pacific States Marine Fisheries Council.

Located 2.2 kilometers south of TM SMR, a rocky reef and surrounding soft bottom habitats were selected as the Ten Mile reference area for comparison (Figure 19). The reference area was selected based on similar habitats and depths (determined from multibeam mapping imagery) as inside its corresponding SMR. There are no state regulations specific to the reference area, but federal regulations prohibit the take of groundfish deeper than 37 m as part of the Rock Fish Conservation Areas. Annual sampling within the reference area was planned to mirror survey efforts inside the SMR.

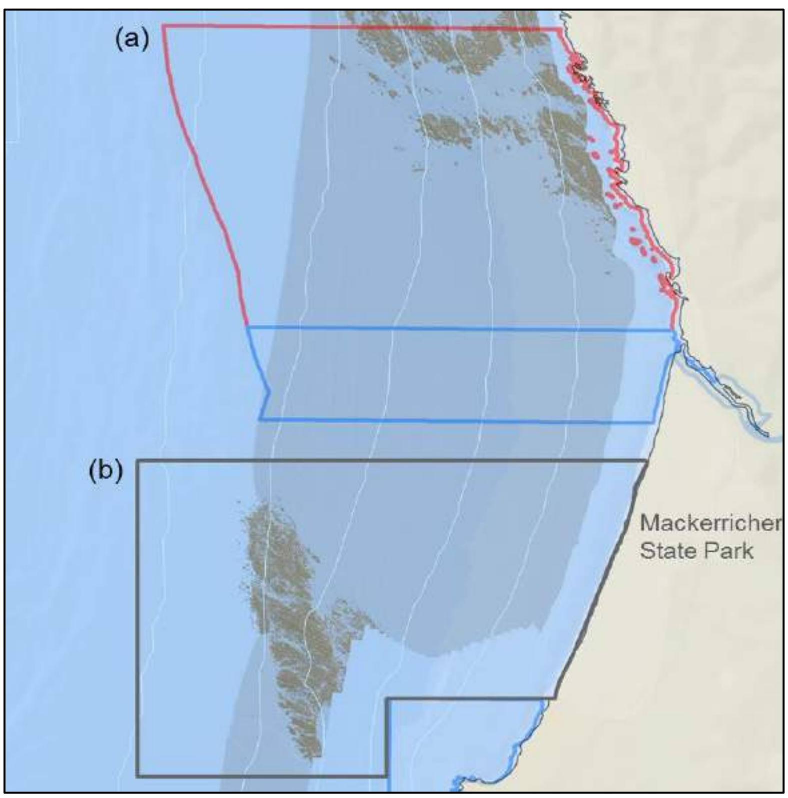


Figure 19. Ten Mile study location showing rocky and soft bottom habitats in (a) the SMR and (b) reference area.

Survey Totals

Total sampling effort inside the Ten Mile SMR and reference area for both 2014 and 2015 survey years are presented in Table 16. Over the two sampling years, similar sampling effort was made in both study areas. At the SMR, one additional rocky reef transect was surveyed.

Table 16. Survey totals for Ten Mile SMR and reference area for rocky reef and soft bottom transects, including hours of video (per camera), total number of photos on transect, number of transects, total kilometers surveyed and depth (average, max and min).

Study Area	Survey Year	Hours of Video	No. of Photos	Rocky Reef		Soft Bottom		Depth Range (m)		
				No. of Transects	Total km	No. of Transects	Total km	Avg	Min	Max
SMR	**2014**	5.1	963	8	4.8	2	2.1	47	13	97
	2015	4.3	1,101	8	4.7	2	2.0	54	29	84
	Totals	***9.4***	***2,064***	***16***	***9.5***	***4***	***4.1***			
Reference	**2014**	3.9	886	7	3.9	2	2.1	54	34	99
	2015	4.4	993	8	4.6	2	2.0	57	34	89
	Totals	***8.3***	***1,879***	***15***	***8.5***	***4***	***4.1***			

Substrate

Substrate types observed on transects are not mutually exclusive and represent the proportion of the total surveyed transect distance that has a given substrate present (see methods for full description). Inside the SMR, transects that targeted the rocky reef were primarily composed of rock, while sand and mud were relatively common as well (Figure 20). Similarly, rocky reef transects at the reference area were primarily composed of rock with similar proportions of sand and mud. Other substrates were less common at both study areas. Transects targeting soft bottom habitats within both the SMR and reference area were composed mostly of mud with some sand substrate.

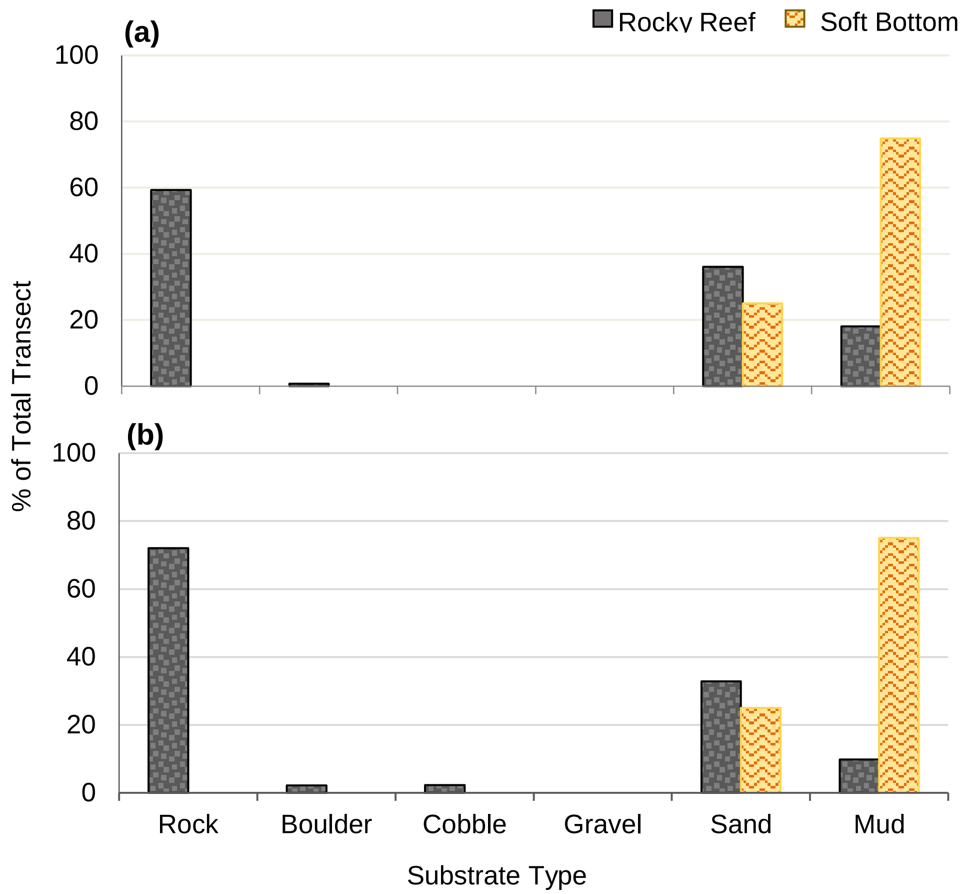
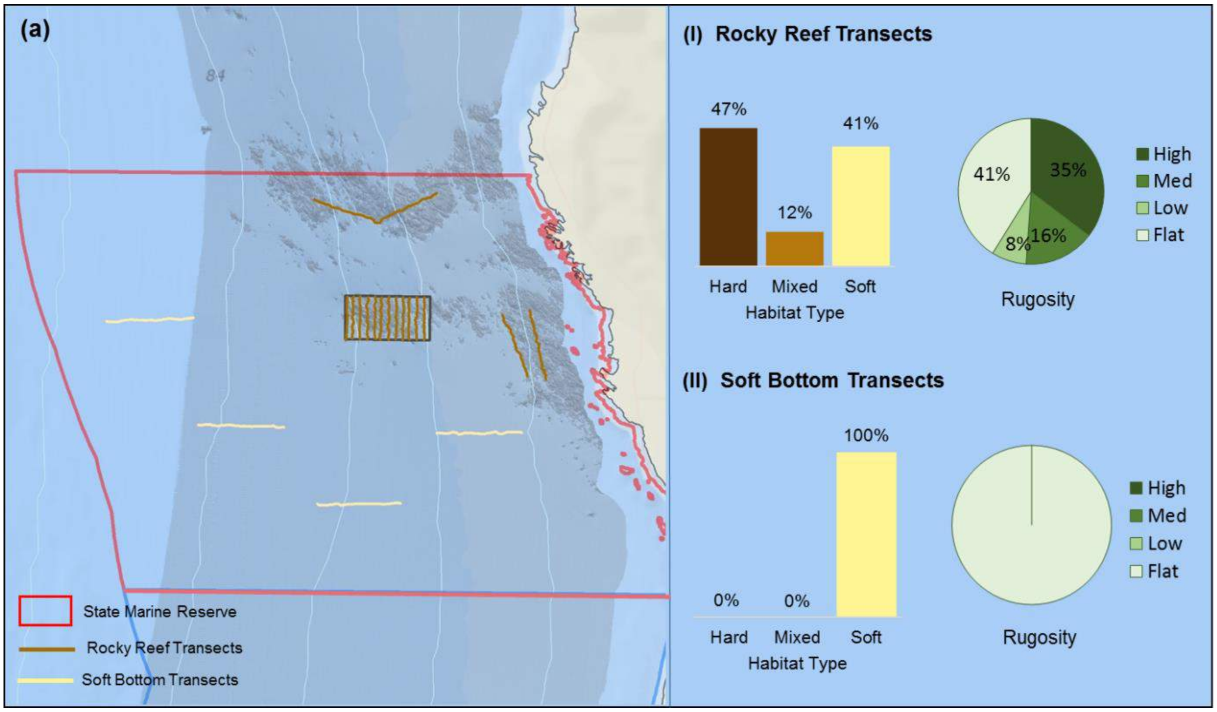


Figure 20. Percent substrate (rock, boulder, cobble, gravel, sand and mud) by transect type (rocky reef and soft bottom) for survey lines inside the (a) Ten Mile SMR and (b) reference area.

Habitat

Habitat types derived from substrate data collected from both rocky reef and soft bottom transects are showin in Figure 21. Overall, the rocky reef and soft bottom habitats were comparable. Within the rocky reef, the SMR and reference area were mainly composed of hard and soft habitats, which combined represented, 84% of the habitat at the SMR and 88% at the reference area. Soft habitat was however observed in higher amounts at the SMR, compared to the reference area. Mixed habitats were least common in both the SMR and reference area. Outside the rocky reef, transects targeting soft bottom habitats within the SMR and reference area were classified as 100% soft habitat.

Overall, habitat rugosity was similar at both study areas. Rocky reef transects at the SMR and reference area were comprised of comparable percentages of high rugosity habitat, while medium rugosity was higher at the reference area (Figure 21). A small percentage of the rocky reef habitat was classified as low rugosity at both study areas. Soft only habitat recorded on rocky reef transects accounted for almost the entire observed habitat with no rugosity. Outside the rocky reef, transects targeting soft bottom were entirely comprised of flat rugosity habitats at both the SMR and reference area.



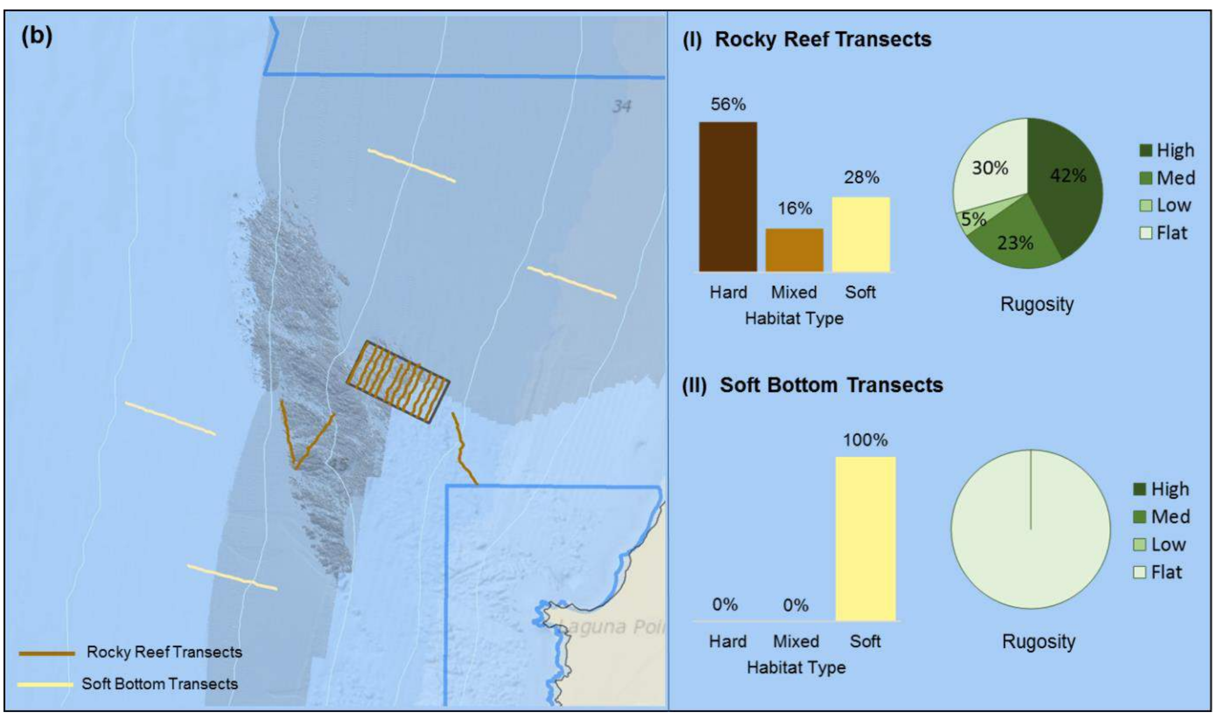


Figure 21. Percent habitat type (hard, mixed and soft) and percent rugosity (high, medium, low and flat) at (a) Ten Mile SMR and (b) reference area, for transect lines targeting (I) the rocky reef and (II) the soft bottom habitats.

Fish

Fish were summarized into seven taxonomic subgroupings for comparison between the SMR and reference area and are presented by transect habitat type in Figure 22. A full list of observed fish species/groupings enumerated on both rocky reef and soft bottom transects for both the SMR and reference area are shown in Tables 17 & 18. For both rocky reef and soft bottom transects combined, 52 species/groupings were enumerated at the SMR and 43 were enumerated at the reference area. Though more species/groupings were observed at the SMR, a similar number of fish (total count) were observed at the SMR and reference area, 29,073 and 28,246 fish respectively.

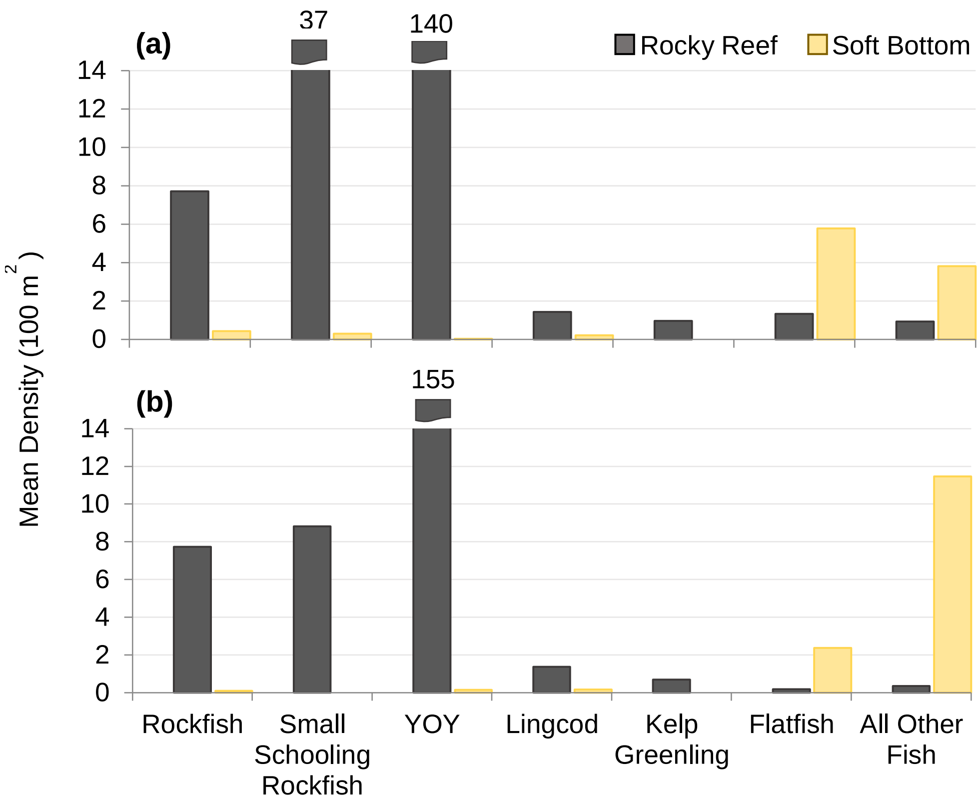


Figure 22. Mean density of fish subgroupings observed within rocky reef and soft bottom transects at (a) Ten Mile SMR and (b) reference area for 2014 and 2015. For a breakdown of the taxonomic composition of subgroups, see Tables 17 & 18.

Table 17. Total count, average density and standard deviation of fish by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Ten Mile SMR.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD		Size (cm)		
			Rocky Reef (n=16)	Soft Bottom (n=4)	Avg	Max	Min
Rockfish							
Blue Rockfish	*Sebastes mystinus*	610	3.120 ± 3.724	- -	24	42	6
UI rockfish	Unidentified *Sebastes sp.*	302	1.660 ± 1.318	0.424 ± 0.474	14	35	10
Canary Rockfish	*Sebastes pinniger*	188	1.110 ± 1.010	- -	26	45	7
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	130	0.803 ± 0.938	- -	29	45	10
Black/Blue Rockfish	*Sebastes melanops* or *mystinus*	37	0.004 ± 0.018	- -	30	30	25
Copper Rockfish	*Sebastes caurinus*	31	0.166 ± 0.158	- -	34	44	12
Quillback Rockfish	*Sebastes maliger*	26	0.162 ± 0.188	- -	29	41	18
Sebastomus Rockfish	Subgenus *Sebastomus*	25	0.128 ± 0.167	- -	19	32	11
Vermilion Rockfish	*Sebastes miniatus*	24	0.127 ± 0.138	- -	40	50	30
Black Rockfish	*Sebastes melanops*	22	0.089 ± 0.239	- -	35	46	20
Brown Rockfish	*Sebastes auriculatus*	22	0.137 ± 0.199	- -	34	41	21
Widow rockfish	*Sebastes entomelas*	12	0.094 ± 0.272	- -	23	30	8
Rosy Rockfish	*Sebastes rosaceus*	9	0.045 ± 0.104	- -	20	27	14
China Rockfish	*Sebastes nebulosus*	7	0.043 ± 0.069	- -	33	38	27
Squarespot/Widow Rockfish	*Sebastes hopkinsi* or *entomelas*	2	0.016 ± 0.043	- -	8	15	1
Canary/Vermilion Rockfish	*Sebastes pinniger* or *miniatus*	1	0.004 ± 0.015	- -	-	-	-
Greenspotted Rockfish	*Sebastes chlorostictus*	1	N/A	N/A	24	24	24
Small schooling rockfish							
Small schooling rockfish	Schooling rockfish (10-15cm)	3,153	25.500 ± 88.057	0.211 ± 0.421	10	13	10
Shortbelly Rockfish	*Sebastes jordani*	976	7.850 ± 31.395	0.081 ± 0.162	11	12	10
Halfbanded Rockfish	*Sebastes semicinctus*	568	3.450 ± 12.828	- -	7	7	6
Young of year rockfish	Young of year rockfish	21,560	140.000 ± 224.154	0.035 ± 0.070	8	9	3
Lingcod	*Ophiodon elongatus*	257	1.430 ± 1.060	0.209 ± 0.250	41	70	11
Kelp Greenling	*Hexagrammos decagrammus*	164	0.967 ± 0.520	- -	35	48	12
Flatfish							
UI flatfish	Unidentified Pleuronectiformes	497	1.070 ± 1.125	5.122 ± 3.072	14	30	7
UI sanddab	Unidentified *Citharichthys sp.*	70	0.222 ± 0.434	0.415 ± 0.597	14	29	8
English Sole	*Parophrys vetulus*	8	0.027 ± 0.061	0.040 ± 0.054	22	27	12
Petrale Sole	*Eopsetta jordani*	7	0.004 ± 0.015	0.085 ± 0.170	26	35	20
Dover Sole	*Microstomus pacificus*	6	0.013 ± 0.035	0.057 ± 0.113	16	22	12
Rex Sole	*Glyptocephalus zachirus*	3	0.004 ± 0.015	0.028 ± 0.057	16	25	10
Starry Flounder	*Platichthys stellatus*	2	- -	0.026 ± 0.030	32	38	26
All Other Fish							
UI fish	Unidentified fish	100	0.173 ± 0.239	1.499 ± 2.998	13	35	5
UI schooling pelagic	Unidentified schooling pelagic fish	60	0.390 ± 1.562	- -	15	15	15
UI small benthic fish	Unidentified small bottom fish	36	0.130 ± 0.210	0.186 ± 0.242	13	25	6
UI smelt	Unidentified Osmeridae	34	- -	0.689 ± 1.377	21	25	20
UI eel pout	Unidentified Zoarcidae	27	- -	0.547 ± 1.094	17	20	12
Painted Greenling	*Oxylebius pictus*	16	0.084 ± 0.143	- -	12	13	10
UI cod	Unidentified Gadidae	13	- -	0.263 ± 0.527	20	30	15
Combfish complex	*Zaniolepis frenata* or *latipinnis*	11	- -	0.143 ± 0.171	16	24	11
Striped Surfperch	*Embiotoca lateralis*	11	0.050 ± 0.179	- -	16	32	12
Shiner Surfperch	*Cymatogaster aggregata*	10	- -	0.149 ± 0.176	10	12	9
Pink Surfperch	*Zalembius rosaceus*	9	0.069 ± 0.187	- -	13	18	10
Pacific Hake	*Merluccius productus*	6	- -	0.122 ± 0.243	16	22	15
UI skate	*Unidentified Raja sp.*	5	- -	0.079 ± 0.080	23	30	20
Sablefish	*Anoplopoma fimbria*	3	0.008 ± 0.031	0.041 ± 0.081	30	30	30
Staghorn Sculpin	*Leptocottus armatus*	3	- -	0.045 ± 0.063	26	32	20
Buffalo Sculpin	*Enophrys bison*	2	0.009 ± 0.036	- -	26	27	25
Cabezon	*Scorpaenichthys marmoratus*	2	0.010 ± 0.040	- -	35	40	30
UI surfperch	Unidentified Embiotocidae	2	0.008 ± 0.032	0.012 ± 0.023	11	11	11
Big Skate	*Raja binoculata*	1	- -	0.014 ± 0.028	35	35	35
UI shark	Unidentified shark	1	- -	0.020 ± 0.041	-	-	-

Table 18. Total count, average density and standard deviation of fish by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Ten Mile reference area.

Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD		Size (cm)		
			Rocky Reef (n=15)	Soft Bottom (n=4)	Avg	Max	Min
Rockfish							
Blue Rockfish	*Sebastes mystinus*	425	2.359 ± 2.771	- -	23	45	6
UI rockfish	Unidentified *Sebastes sp.*	270	1.321 ± 0.999	0.098 ± 0.115	15	40	10
Canary Rockfish	*Sebastes pinniger*	181	1.138 ± 0.893	- -	23	40	7
Widow Rockfish	*Sebastes entomelas*	143	1.042 ± 3.802	- -	18	20	8
Sebastomus Rockfish	Subgenus *Sebastomus*	87	0.551 ± 0.403	- -	20	45	10
Olive/Yellowtail Rockfish	*Sebastes serranoides* or *flavidus*	76	0.480 ± 0.465	- -	31	45	14
Rosy Rockfish	*Sebastes rosaceus*	40	0.260 ± 0.177	- -	19	30	10
Copper Rockfish	*Sebastes caurinus*	29	0.189 ± 0.198	- -	35	45	17
Vermilion Rockfish	*Sebastes miniatus*	23	0.138 ± 0.177	- -	40	50	20
Quillback Rockfish	*Sebastes maliger*	21	0.131 ± 0.134	- -	30	37	20
China Rockfish	*Sebastes nebulosus*	13	0.086 ± 0.101	- -	32	40	24
Canary/Vermilion Rockfish	*Sebastes pinniger* or *miniatus*	3			33	35	30
Yelloweye Rockfish	*Sebastes ruberrimus*	2	0.005 ± 0.020	- -	43	50	35
Brown Rockfish	*Sebastes auriculatus*	1	0.007 ± 0.026	- -	33	33	33
Gopher Rockfish	*Sebastes carnatus*	1	0.004 ± 0.017	- -	33	33	33
Squarespot/Widow Rockfish	*Sebastes hopkinsi* or *entomelas*	1	0.008 ± 0.031	- -	-	-	-
Starry Rockfish	*Sebastes constellatus*	1	0.007 ± 0.028	- -	25	25	25
Small schooling rockfish							
Shortbelly Rockfish	*Sebastes jordani*	1,632	7.304 ± 28.290	- -	9	14	8
Halfbanded Rockfish	*Sebastes semicinctus*	124	0.838 ± 2.143	- -	8	10	6
Small schooling rockfish	Schooling rockfish (10-15cm)	110	0.678 ± 1.717	- -	11	12	10
Young of year rockfish	Young of year rockfish	23,671	155.009 ± 318.627	0.147 ± 0.240	8	9	3
Lingcod	*Ophiodon elongatus*	235	1.368 ± 0.662	0.160 ± 0.165	41	75	8
Kelp Greenling	*Hexagrammos decagrammus*	109	0.681 ± 0.382	- -	34	45	20
Flatfish							
UI flatfish	Unidentified Pleuronectiformes	199	0.147 ± 0.205	2.322 ± 1.050	15	95	6
UI sanddab	Unidentified *Citharichthys sp.*	6	0.024 ± 0.093	0.021 ± 0.042	15	20	10
Dover Sole	*Microstomus pacificus*	2	0.012 ± 0.046	- -	21	22	20
English Sole	*Parophrys vetulus*	1	- -	0.010 ± 0.021	17	17	17
Petrale Sole	*Eopsetta jordani*	1	- -	0.010 ± 0.021	20	20	20
All Other Fish							
UI smelt	Unidentified Osmeridae	729	- -	10.330 ± 17.931	27	35	13
UI fish	Unidentified fish	52	0.131 ± 0.257	0.669 ± 1.123	18	44	8
Painted Greenling	*Oxylebius pictus*	12	0.083 ± 0.171	- -	13	15	10
UI cod	Unidentified Gadidae	11	- -	0.218 ± 0.435	27	38	16
UI eel pout	Unidentified Zoarcidae	11	0.046 ± 0.126	0.109 ± 0.218	15	20	10
UI small benthic fish	Unidentified small bottom fish	9	0.032 ± 0.048	0.031 ± 0.063	16	20	10
Wolf Eel	*Anarrhichthys ocellatus*	4	0.028 ± 0.066	- -	95	95	95
Combfish complex	*Zaniolepis frenata* or *latipinnis*	2	0.008 ± 0.029	0.022 ± 0.044	14	17	11
Pacific Hake	*Merluccius productus*	2	- -	0.044 ± 0.087	16	18	14
UI goby	Unidentified Gobiidae	2	0.012 ± 0.046	- -	14	14	13
Ocean Sunfish	*Mola mola*	1	0.007 ± 0.028	- -	120	120	120
Pink Surfperch	*Zalembius rosaceus*	1	0.005 ± 0.020	- -	20	20	20
Sablefish	*Anoplopoma fimbria*	1	- -	0.022 ± 0.044	40	40	40
Spotted Ratfish	*Hydrolagus colliei*	1	0.005 ± 0.020	- -	45	45	45
UI skate	Unidentified *Raja sp.*	1	- -	0.014 ± 0.027	50	50	50

Rocky Reef Fish

Within the rocky reef, rockfish were the most commonly observed fish type at both study areas, accounting for 98% of the total fish density at the SMR and 99% at the reference area (Figure 22). YOY were the most abundant subgroup at both study areas, with mean densities exceeding 140 fish per 100 m^2. The small schooling rockfishes were the next most abundant subgroup within the rocky reef at both study areas, with observed densities over 4 times higher inside the SMR than the reference area. At both the SMR and reference area, the 'rockfish' subgrouping had similar densities, with a total density of 7.71 and 7.73 rockfish per 100 m^2 respectively.

Within the rockfish subgroup, a total of 17 rockfish species/groupings were observed at both study areas. At the SMR, four species/groupings made up 87% of the rockfish subgroup density and include: Blue Rockfish, Canary Rockfish, Olive/Yellowtail Rockfish and unidentified rockfish. Similarly at the reference area four species accounted for 76% of the subgroup density; Blue Rockfish, Canary Rockfish, Widow Rockfish and unidentified rockfish. Yelloweye Rockfish were only observed at the reference area (2 total).

Few non-rockfish species were observed in the rocky reef at both study areas. Lingcod and Kelp Greenling were observed with similar densities at both study areas, accounting for just over 1% of the total fish density within the SMR and reference area combined. All remaining fish observations accounted for less than 1% of the total density within the rocky reef at both study areas.

Soft Bottom Fish

Two subgroupings dominated soft bottom habitat transects, flatfish and 'other fish'. Inside the SMR, flatfish densities were 2.4 times higher than in the reference area. The 'all other fish' subgroup was most notably different between the two study areas. Large numbers of unidentified smelt were observed at the reference area, which represented 90% of the total 'all other fish' density, compared to 18% within the SMCA

Invertebrates

Invertebrates were grouped into seven mobile and seven sessile macro-invertebrate groups for comparison between the SMR and reference area and are presented by transect habitat type in Figure 23. Full lists of observed sessile and mobile macro-invertebrate species/groupings enumerated on rocky reef and soft bottom transects for both the SMR and reference area are shown in Tables 19 & 20. For both rocky reef and soft bottom transects combined, 56 species/groupings were enumerated at the SMR and 48 were enumerated at the reference area. Though more species/groupings were observed at the SMR, nearly the same number (total count) of invertebrates were observed at the SMR and reference area, 10,875 and 10,848 invertebrates respectively.

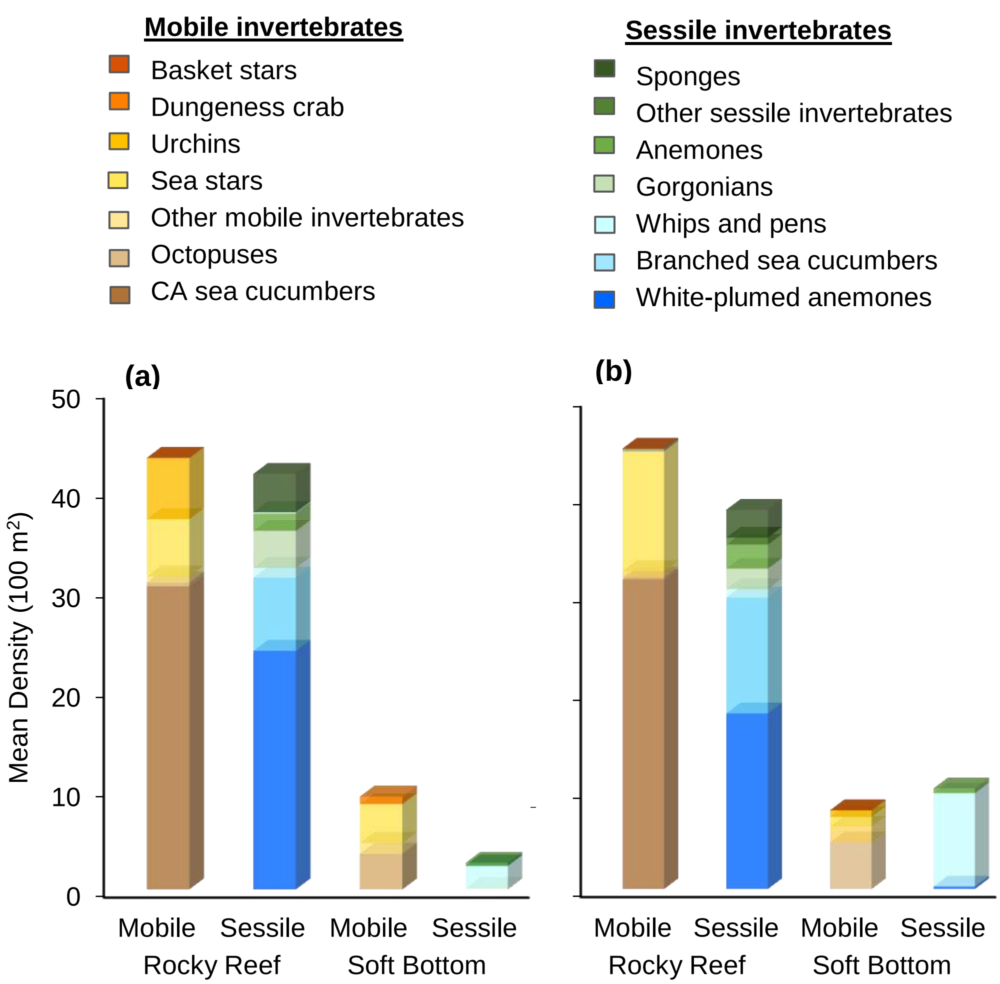


Figure 23. Mobile and sessile invertebrate mean densities for rocky reef and soft bottom transects inside the (a) Ten Mile SMR and (b) reference area**.** For a breakdown of the taxonomic composition of subgroups, see Tables 19 & 20.

Table 19. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom transects (n) surveyed within the Ten Mile SMR.

	Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD Rocky Reef (n=16)	Density (100 m^2) ± 1SD Soft Bottom (n=4)
Mobile Invertebrates	**Basket stars**	*Gorgonocephalus eucnemis*	3	0.020 ± 0.064	- -
	Dungeness crab	*Meracarcinus magister*	37	- -	0.760 ± 0.901
	Urchins				
	Red sea urchin	*Mesocentrotus franciscanus*	938	5.730 ± 22.349	- -
	Purple sea urchin	*Strongylocentrotus purpuratus*	36	0.230 ± 0.913	- -
	Purple/red urchin complex	*Strongylocentrotus franciscanus* or *purpuratus*	27	0.160 ± 0.634	- -
	Sea stars				
	Red sea star	*Mediaster aequalis*	332	2.930 ± 2.296	- -
	Sand star	*Luidia foliolata*	254	0.520 ± 1.318	3.910 ± 4.988
	Henricia complex	*Henricia sp.*	124	0.990 ± 0.683	- -
	Leather star	*Dermasterias imbricata*	101	0.890 ± 0.584	- -
	Short spined sea star	*Pisaster brevispinus*	12	0.080 ± 0.205	- -
	UI sea star	Unidentified sea star	11	0.080 ± 0.114	- -
	Ochre star	*Pisaster ochraceus*	8	0.040 ± 0.177	- -
	Fish eating star	*Stylasterias forreri*	6	0.050 ± 0.103	- -
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	4	0.030 ± 0.070	- -
	Thorny sea star	*Poraniopsis inflata*	4	0.040 ± 0.100	- -
	Rainbow star	*Orthasterias koehleri*	3	0.030 ± 0.071	- -
	Cushion star	*Pteraster tesselatus*	1	0.010 ± 0.051	- -
	Giant spined star	*Pisaster giganteus*	1	0.010 ± 0.025	- -
	Pisaster complex	*Pisaster sp.*	1	0.010 ± 0.036	- -
	Stimpson's sun star	*Solaster stimpsoni*	1	0.010 ± 0.028	- -
	Other Mobile Inverts				
	Pleurobranchaea californica	*Pleurobranchaea californica*	36	0.190 ± 0.389	0.220 ± 0.302
	UI sea jelly	Unidentified sea jelly	33	0.200 ± 0.294	0.270 ± 0.333
	Market squid	*Loligo opalescens*	28	0.050 ± 0.125	0.540 ± 0.560
	UI nudibranch	Unidentified nudibranch	13	0.100 ± 0.258	- -
	Pink Tritonia	*Tritonia diomedea*	5	0.030 ± 0.082	0.040 ± 0.080
	Puget Sound king crab	*Lopholithodes mandtii*	5	0.030 ± 0.081	- -
	Decorator crab	*Loxorhynchus crispatus*	1	0.010 ± 0.028	- -
	Red rock crab	*Cancer productus*	1	0.010 ± 0.037	- -
	Octopuses				
	Red octopus	*Octopus rubescens*	170	0.350 ± 0.549	3.570 ± 5.274
	California sea cucumber	*Parastichopus californicus*	3,449	30.410 ± 17.976	- -
Sessile Invertebrates	**Sponges**				
	Gray puffball sponge	*Craniella arb*	270	1.900 ± 7.073	- -
	Orange puffball sponge	*Tethya aurantia*	209	1.800 ± 2.625	- -
	UI branched sponge	Unidentified branched sponge	7	0.060 ± 0.152	- -
	UI nipple sponge	Unidentified nipple sponge	7	0.060 ± 0.105	- -
	UI lobed sponge/tunicate	Unidentified lobed sponge/tunicate	1	0.010 ± 0.037	- -
	Other Sessile Inverts				
	Stalked tunicate	*Styela montereyensis*	9	0.060 ± 0.256	- -
	Acorn barnacle	*Balanus nubilus*	7	0.050 ± 0.125	- -
	UI salp	Unidentified salp	2	- -	0.040 ± 0.080
	Rock scallop	*Crassedoma giganteum*	1	0.010 ± 0.044	- -
	Anemones				
	Sand-rose anemone	*Urticina columbiana*	99	0.770 ± 0.483	0.190 ± 0.271
	Fish eating urticina	*Urticina piscivora*	62	0.453 ± 0.348	- -
	UI anemone 1	Unidentified anemone species #1	20	0.160 ± 0.403	- -
	UI tube dwelling anemone	Unidentified tube dwelling anemone	18	0.220 ± 0.585	- -
	UI anemone	Unidentified anemone	11	0.090 ± 0.119	- -
	UI sand dwelling anemone	Unidentified sand dwelling anemone	6	0.030 ± 0.078	0.060 ± 0.120
	Frilled anemone	*Metridium senile*	2	0.010 ± 0.051	0.020 ± 0.040
	UK anemone 2	Unknown anemone species #2	2	0.020 ± 0.043	- -
	Gorgonians				
	Short red gorgonian	*Swiftia spauldingi*	375	3.700 ± 6.052	0.030 ± 0.057
	Whips and pens				
	White sea pen	*Stylatula elongata*	99	0.580 ± 1.152	0.400 ± 0.504
	Sea whip	*Halipteris californica*	92	0.180 ± 0.352	1.740 ± 1.721
	UI sea pen	*Virgularia sp.*	15	0.180 ± 0.710	- -
	Orange sea pen	*Ptilosarcus gurneyi*	10	0.030 ± 0.061	0.130 ± 0.105
	Branched sea cucumbers				
	Slipper sea cucumber	*Psolus chitonoides*	622	7.110 ± 12.889	- -
	White branched seacucumber	*Cucumaria piperata*	10	0.120 ± 0.321	- -
	Orange sea cucumber	*Cucumaria miniata*	9	0.100 ± 0.207	- -
	White-plumed anemone	*Metridium farcimen*	3,265	23.940 ± 15.337	0.100 ± 0.116

Table 20. Total count, average density and standard deviation of mobile and sessile invertebrates by subgrouping for all rocky reef and soft bottom transects surveyed (n) within the Ten Mile reference area.

	Common Name	Species/Grouping/Complex	Total Count	Density (100 m^2) ± 1SD					
				Rocky Reef (n=15)			Soft Bottom (n=4)		
Mobile Invertebrates	**Basket stars**	*Gorgonocephalus eucnemis*	13	0.090	±	0.296	0.030	±	0.062
	Dungeness crab	*Metacarcinus magister*	32	-		-	0.670	±	0.883
	Urchins								
	Red sea urchin	*Mesocentrotus franciscanus*	34	0.220	±	0.835	-		-
	Sea stars								
	Red sea star	*Mediaster aequalis*	981	9.110	±	4.784	-		-
	Henricia complex	*Henricia sp.*	167	1.580	±	0.872	-		-
	Sand star	*Luidia foliolata*	77	0.230	±	0.753	0.960	±	1.839
	Leather star	*Dermasterias imbricata*	73	0.690	±	0.418	-		-
	Short spined sea star	*Pisaster brevispinus*	25	0.160	±	0.614	-		-
	UI sea star	Unidentified sea star	20	0.170	±	0.093	0.010	±	0.030
	Rainbow star	*Orthasterias koehleri*	10	0.100	±	0.170	-		-
	Cookie star	*Ceramaster patagonicus*	4	0.040	±	0.123	-		-
	Spiny/thorny star complex	*Poraniopsis inflata* or *Hippasteria spinosa*	4	0.040	±	0.093	-		-
	Cushion star	*Pteraster tesselatus*	2	0.020	±	0.055	-		-
	Stimpson's sun star	*Solaster stimpsoni*	2	0.020	±	0.045	-		-
	Fish eating star	*Stylasterias forreri*	1	0.010	±	0.044	-		-
	Ochre star	*Pisaster ochraceus*	1	0.010	±	0.025	-		-
	Sunflower star	*Pycnopodia helianthoides*	1	0.010	±	0.041	-		-
	Thorny sea star	*Poraniopsis inflata*	1	0.010	±	0.033	-		-
	Other Mobile Inverts								
	UI sea jelly	Unidentified sea jelly	104	0.460	±	1.280	1.050	±	1.350
	Pleurobranchaea californica	*Pleurobranchaea californica*	30	0.130	±	0.459	0.270	±	0.318
	Market squid	*Loligo opalescens*	15	0.030	±	0.132	0.290	±	0.407
	Orange-peel nudibranch	*Tochuina tetraquetra*	2	0.020	±	0.089	-		-
	Swimming nudibranch	*Dendronotus iris*	1	0.010	±	0.044	-		-
	Octopuses								
	Red octopus	*Octopus rubescens*	208	0.200	±	0.562	4.780	±	6.216
	Giant Pacific octopus	*Enteroctopus dofleini*	1	0.010	±	0.025	-		-
	California sea cucumber	*Parastichopus californicus*	3,481	31.600	±	11.710	-		-
Sessile Invertebrates	**Sponges**								
	UI branched sponge	Unidentified branched sponge	211	2.170	±	4.782	-		-
	Orange puffball sponge	*Tethya aurantia*	51	0.490	±	0.377	-		-
	UI nipple sponge	Unidentified nipple sponge	12	0.110	±	0.143	-		-
	UI lobed sponge/tunicate	Unidentified lobed sponge/tunicate	8	0.080	±	0.241	-		-
	Other Sessile Inverts								
	Acorn barnacle	*Balanus nubilus*	146	0.730	±	2.625	-		-
	Anemones								
	Sand-rose anemone	*Urticina columbiana*	149	1.210	±	0.669	0.260	±	0.350
	Fish eating urticina	*Urticina piscivora*	122	1.041	±	0.523	-		-
	UI anemone	Unidentified anemone	12	0.090	±	0.171	0.020	±	0.039
	UI sand dwelling anemone	Unidentified sand dwelling anemone	10	-		-	0.190	±	0.340
	UI anemone 1	Unidentified anemone species #1	6	0.040	±	0.089	0.030	±	0.062
	Frilled anemone	*Metridium senile*	3	0.030	±	0.090	-		-
	UI tube dwelling anemone	Unidentified tube dwelling anemone	3	0.030	±	0.062	-		-
	Gorgonians								
	Short red gorgonian	*Swiftia spauldingi*	266	2.040	±	2.285	-		-
	UI gorgonian	*Unidentified Gorgonacea*	7	0.040	±	0.164	-		-
	Whips and pens								
	Sea whip	*Halipteris californica*	354	0.600	±	2.336	7.860	±	13.239
	White sea pen	*Stylatula elongata*	62	0.210	±	0.788	0.690	±	1.198
	UI sea pen	*Virgularia sp.*	26	-		-	0.800	±	1.602
	Orange sea pen	*Ptilosarcus gurneyi*	15	0.020	±	0.051	0.180	±	0.356
	Branched sea cucumbers								
	Slipper sea cucumber	*Psolus chitonoides*	1,106	11.460	±	15.399	-		-
	White branched sea cucumber	*Cucumaria piperata*	23	0.240	±	0.369	-		-
	Orange sea cucumber	*Cucumaria miniata*	12	0.110	±	0.212	-		-
	White-plumed anemone	*Metridium farcimen*	2,954	17.960	±	25.158	0.260	±	0.404

Rocky Reef Invertebrates

Mobile invertebrates observed in the rocky reef were similar for both the SMR and reference area. One species, the California sea cucumber, accounted for 70% of the total mobile invertebrate density at both study areas. Within the SMR, next most commonly observed mobile invertebrates were the urchins and sea stars subgroupings. Within the urchin subgroup, the red sea urchin accounted for nearly 94% of the observations and within the sea star subgroup, the red sea star accounted for 51%. At the reference area, sea stars (of which the red sea star accounted for nearly 72%) were more abundant and accounted for 27% of the total mobile invertebrate density.. Very few urchins were observed at the reference area.

Overall, species composition and densities of sessile invertebrates in the rocky reef were similar between the two study areas. Two subgroupings, white-plumed anemones and the branched sea cucumber were the most common. Within the branched sea cucumber subgroup, over 96% were identified as the slipper sea cucumber. Other sessile invertebrates observed in the rocky reef included sponges, anemones and gorgonians. Within the sponges subgroup, 97% were identified as gray puffball or orange puffball sponges at the SMR, while at the reference area, 76% were identified as UI branched sponges. Within the anemones subgroup, the sand-rose and fish eating anemones accounted for 70% of the subgroupings density at the SMR and 92% at the reference area. At both study areas, the gorgonians subgroup was almost entirely identified as the short red gorgonian.

Soft Bottom Invertebrates

Mobile invertebrates observed on soft bottom transects at the SMR and reference area were similar in overall density and species composition. The red octopus was commonly observed in both areas, with densities that were similar between the SMR and the reference area. Within the SMR, the sea stars subgroup accounted for 42% of the total mobile soft bottom observations, while at the reference area sea stars accounted for 12%. At both study areas, 99% of the soft bottom sea stars were identified as the sand star, which were four times higher in density within the SMR. Dungeness crabs were also observed within both the SMR and reference area, with similar densities at both areas, 0.76 and 0.67 crabs per 100 m^2, respectively.

Sessile invertebrates observed in soft bottom transects were dominated by ‘whips and pens’, which accounted for approximately 84% of the total sessile invertebrate density in soft bottom transects at the SMR and 95% at the reference area. Within the whips and pens subgroup, over 75% of the observations were identified as the sea whip at both study areas. Overall, densities of sea whips were 4.5 times higher at the reference area compared to densities within the SMR.

APPENDIX 4. Rocky Reef Fish Communities and Analysis of Index Sites.

North Coast MPA rocky reef fish communities

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January 31, 2017

Introduction

Key aspects of marine protected areas (MPA) that may influence effectiveness and outcome measures used to assess performance include where and what fish species are present and in what numbers they occur. How these parameters change over time, inside and outside MPAs, are important considerations for adaptive management as well. This report summarizes the results of two years of visual surveys of nearshore fish communities located at four specific sites in North California Coast MPAs that were identified as “Index Sites” and an additional four sites outside of the MPAs that were selected as reference sites. These data will be important in future years so that conditions can be evaluated and referenced to these baseline characteristics to assess fish population status, MPA performance and inform adaptive management.

Study sites

Four of the 20 designated MPAs in Northern California were selected to represent the broad latitudinal range of the North Coast MPA (NCMPA) Study Region. From north to south they are Point St. George State Marine Conservation Area (SMCA), Reading Rock State Marine Reserve (SMR), Mattole Canyon SMR, and Ten Mile SMR. Mattole Canyon SMR was selected as a potentially important coastal feature that could be advantageous for long-term monitoring in addition to its distributive representation of the overall coastline. ROV transects aimed at general data collection were distributed across the MPAs and surrounding areas to broadly characterize the fish communities present at each location. Also, two 500 by 1000 m sites were selected at each location, one inside the MPA, and one outside the MPA, in rocky reef habitat, to establish baseline statistical metrics for rocky reef assemblages. Randomly placed transverse (500 m) transects (six yearly) were conducted to collect imagery from which the data were collected. We refer to these sites as “Index sites” throughout this report and the bulk of our statistical analyses were aimed at fish observation data collected within these sites.

Objective

Our specific objective for this report to characterize rocky reef fish communities inside the State Marine Reserves (SMR)/Conservation Areas (SMCA) and outside reference sites at the time of implementation and document similarities and differences among locations and between sites.

To do this, we asked the following questions:

Multivariate assemblages:

1. Are there differences in fish species assemblage among Index sites?
2. Do fish communities at the chosen Index sites reflect the same similarity or dissimilarity as the overall fish community?
3. Are habitat-based descriptions of fish communities in Index sites similar across the region?

4. Are fish communities in the paired Index sites similar inside and outside each MPA?

Individual species:

1. What are the most abundant fish species and frequency of occurrence of each fish species in the Index sites?
2. For select species, are relative abundances similar among MPA locations?
3. For select species, are relative abundances similar inside and outside of the MPAs?
4. Are individuals using hard substrates similarly among sites?
5. Are the odds of observing a species the same in Index sites as they are across the MPA locations?

Methods

Data collection

Species occurrence was recorded from video into an access database by analysts from Marine Applied Research and Exploration (MARE). A detailed description of data collection rules and procedures are supplied in the primary North California Coast MPA Baseline Report to which this is attached. All analyses described here are based upon summary data supplied by MARE.

Data analyses

To assess the relationship between occupancy and abundance of fishes across the NCMPA region and within each of the selected marine protected areas and their outside reference sites, we conducted analyses on the combined 2014-2015 dataset at three different levels of ecological organization, 1) all fishes combined to represent the entire assemblage (multivariate analyses), 2) fishes separated into taxonomic or functional groups (multivariate analyses) and 3) individual species analyses for the 10 most abundant, reliably identified fished species. We additionally evaluated these groups at three scales – regional (MPA location), treatment (inside/outside of MPA pairs), and habitat (rock, sand, canyon). The canyon habitat was considered unique enough to evaluate separately as the depth range and topography were significantly different from rock and sand shelf habitats.

Multivariate analyses

Our first goal was to characterize relative overall similarity among MPA locations and treatments surveyed by the ROV in the North California Coast region. We used average agglomerative clustering of taxa densities at the transect level to determine how overall assemblage structure varied by MPA, treatments (inside and outside reference) and habitats (rock, sand, canyon), and to evaluate the resemblance of assemblages among MPA locations. We did this by grouping all ROV transect data in two ways. Mean densities of individual taxa for each group or species observed were calculated based on ROV transects by dividing the number of individuals observed by the area covered for each transect, creating a density matrix. Square-root transformed densities were used to calculate a Bray-Curtis Similarity (Krebs 1999) matrix used for average agglomerative clustering.

A number of individual taxa had either very low numbers of observations or very low rate of identification to species level. Therefore, we completed the same analysis for taxa densities after grouping all species into higher level taxa such as genus, family, or functional group. These groups are listed in Table 1 with the number of observations at each MPA location. Chondrichthyans included all sharks, rays and Ratfish. All Flatfishes were combined because species identification rate was very low. Rockfishes were divided into young of the year (YOY), Sebastomus (unidentified Sebastomus, Rosy, Starry, Pinkrose and Rosethorn Rockfishes), Small schoolers or dwarf rockfishes (Pygmy, Halfbanded, Squarespot, Shortbelly and unidentified small schooling), demersal non-aggregating rockfishes (Aurora, Brown, China, Copper, Darkblotched, Gopher, Greenspotted, Greenstriped, Quillback, Redbanded, Sharpchin, Stripetail, Tiger, and Yelloweye), and epibenthic aggregating rockfishes (Black, Blue, Bocaccio, Canary, Chilipepper, Olive/Yellowtail, Vermilion and Widow). Seaperches observed included Pink, Shiner, Striped and unidentified seaperches. Combfishes, Eelpouts, Gobies, Sculpins and Poachers were grouped as small benthic fishes. Other benthic fishes included Sablefish, Hagfishes, Thornyheads and Sand Lance. Other fishes included most of the migratory and highly mobile species; Pacific Tomcod, Pacific hake, Salmonids, Smelts, Sunfish, and Cods.

Table 1. Taxonomic groups, functional groups, and individual species used in multivariate agglomerative cluster analyses. Numbers represent overall number of observations by marine protected area (MPA), all transect data included.

	Point St. George	Reading Rock	Mattole Canyon	Ten Mile
Chondrichthyans	3	3	97	9
Flatfishes	1390	852	1072	794
Kelp Greenling	87	74	287	264
Lingcod	177	74	314	264
Seaperches	4	18	3	33
Small benthic fishes	367	59	65	104
Other benthic fishes	5	2	194	8
YOY Rockfishes	748	339	11,038	42,768

Dwarf (Small schooling) RF	108	12	4991	6566
Demersal non-aggregating RF	280	156	139	146
Sebastomus RF	74	112	55	158
Epibenthic aggregating RF	1833	534	1598	1616
Other fishes	145	6287	102	853

Secondly, we completed similar analyses using only species occurrence data at Index sites. We calculated mean densities and frequency of occurrence for each species or taxon within each of the Index sites. We restricted our similarity analyses and statistical comparisons to only the species or species groups that occurred on ROV transects within the Index sites and to those species considered resident or semi-resident. Migratory or highly mobile species such as Sunfish (*Mola mola*), Sixgill shark (*Hexanchus griseus*), Sablefish (Anoplopoma fimbria), smelts (Osmeridae), Shortbelly Rockfish (*Sebastes jordani*) and other schooling pelagics were removed. Individual species or taxa were grouped as previously described either taxonomically or functionally when observations or identification rate were low. Similarly, small schooling rockfishes, other than Shortbelly Rockfish (*Sebastes jordani*), were grouped for analyses as they have similar appearance, many were not identified to species and they occupy similar habitat in loosely aggregated schools. Kelp Greenling (*Hexagrammos decagrammus*) and Lingcod (*Ophiodon elongatus*) were analyzed as individual taxa due to identifiability and different functional niche. At the depths within which the Index sites were located (20-70 m), two Sebastomus species were expected and identified – Starry (*S. constellatus*) and Rosy (*S. rosaceus*) Rockfishes. The two were combined with the unidentified Sebastomus group to reduce ambiguity in calculations. In general, Starry are less abundant than Rosy and this group can be assumed to consist primarily of Rosy Rockfish, though Rosethorn Rockfish (*S. helvomaculatus*) can be observed in the depth range and cannot be ruled out. Unidentified taxa and questionable identifications were either eliminated or incorporated into appropriate higher level taxonomic groups (Table 2). Analyses were conducted for transect-level densities as well as for each substrate type individually.

Table 2. Overall mean species densities per 100 m^2 surveyed for taxa that were observed and identified in Index sites (all substrates combined). Data are displayed by marine protected area (MPA) location ($\pm$SE), inside and outside MPA treatments combined. Species with fewer than 5 observations in all Index sites combined were eliminated, as were migratory or highly mobile non-resident species. Comparisons among sites, between treatments, and among substrates were restricted to this list. OYT Complex refers to the Olive/Yellowtail Rockfishes which are difficult to distinguish in video and co-occur in the depths surveyed.

	Point St. George	Reading Rock	Mattole Canyon	Ten Mile
Chondrichthyans	0	0.01 ± 0.01	0.01 ± 0.01	0
Flatfishes	2.55 ± 0.48	0.07 ± 0.04	1.42 ± 0.48	0.87 ± 0.28
Kelp Greenling	0.29 ± 0.06	0.30 ± 0.05	1.16 ± 0.11	0.83 ± 0.09
Lingcod	0.45 ± 0.11	0.80 ± 0.10	0.79 ± 0.12	1.46 ± 0.18
Small benthic fishes	0.27 ± 0.05	0.10 ± 0.03	0.04 ± 0.02	0.14 ± 0.04
Rockfishes				
YOY	2.88 ± 0.87	1.24 ± 0.17	13.89 ± 3.50	163.3 ± 61.4
Dwarf (Small schooling) Rockfishes	0.61 ± 0.37	0.05 ± 0.03	4.33 ± 2.25	22.9 ± 15.1
Black Rockfish	0.04 ± 0.04	0.35 ± 0.11	0.55 ± 0.21	0.004 ± 0.004
Blue Rockfish	1.45 ± 0.46	0.61 ± 0.13	1.64 ± 0.35	2.70 ± 0.68
Brown Rockfish	0	0.05 ± 0.03	0	0.08 ± 0.03
Canary Rockfish	1.62 ± 0.32	0.36 ± 0.16	1.16 ± 0.30	1.16 ± 0.20
China Rockfish	0	0.01 ± 0.01	0.004 ± 0.004	0.07 ± 0.02
Copper Rockfish	0.09 ± 0.04	0.11 ± 0.03	0.12 ± 0.03	0.19 ± 0.04
OYT Complex	3.03 ± 0.67	0.37 ± 0.14	0.12 ± 0.03	0.77 ± 0.16
Quillback Rockfish	0.40 ± 0.07	0.17 ± 0.04	0.14 ± 0.03	0.17 ± 0.03
Sebastomus (Rosy/Starry)	0.25 ± 0.07	0.48 ± 0.10	0.11 ± 0.04	0.48 ± 0.10
Tiger Rockfish	0.06 ± 0.03	0.03 ± 0.01	0	0
Vermilion Rockfish	0.13 ± 0.05	0.12 ± 0.05	0.12 ± 0.03	0.12 ± 0.03
Widow Rockfish	0.05 ± 0.02	0.02 ± 0.02	0.01 ± 0.01	0.71 ± 0.61
Yelloweye Rockfish	0.45 ± 0.07	0.20 ± 0.03	0.03 ± 0.01	0

Individual species analyses

We used general linear modeling (GLM) with analysis of variance (ANOVA) and post-hoc multiple comparisons to investigate the relationships among square-root transformed densities of individual fish species by treatment and MPA and between the two years sampled. Species were selected based on abundance and frequency of observation in Index sites and restricted to resident or semi-resident species.

ODDS Analyses

We used odds-ratio analysis to determine if individual species were using hard substrates similarly among the four MPAs in the paired Index sites. This analysis is used to measure the odds of an outcome (yes or no) given a two-way treatment. We used number of observations over hard substrate (number of yes's) or not (number of no's) in Index sites as the outcomes in each treatment - inside and outside the MPAs. The resulting number is calculated: Odds ratio = A*D/B*C. A result near 1 would indicate that a species is observed over substrates similarly both inside and outside the MPA. Greater than 1 would indicate that the species is more likely to use hard substrates inside than outside and less than one more likely to use hard substrates in the outside treatment.

	Rock	Not
Inside	A	B
Outside	C	D

We also used this technique to evaluate whether odds of observing a species on transects conducted in the chosen Index sites was the same as in the broader MPA location inside and outside of the MPAs. We did this to estimate whether Index site species densities might be sufficiently representative of the broader area for each MPA.

Results

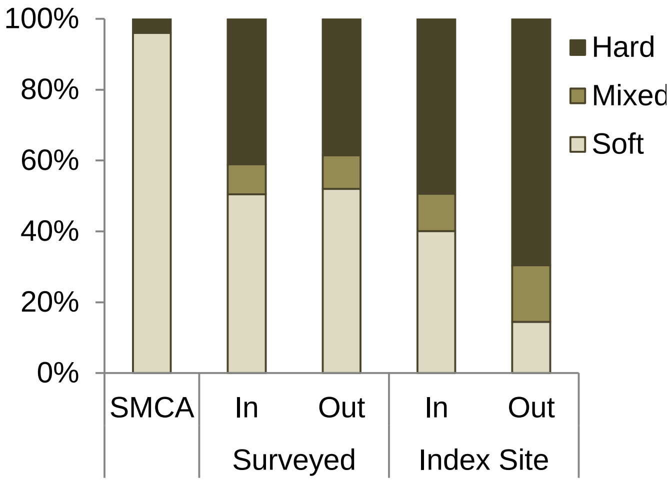
Area and habitat surveyed

Overall, 151 transects were conducted across the four MPA locations for a total of 16 ha^2 surveyed (Table 3). A total of 12 transects, six each year, was completed in each of the Index sites except Point St. George Reference (outside the MPA). At Point St. George the ROV was only able to survey in 2014, not in 2015, and therefore only completed six transects. Areal coverage over the two years of imagery collection was similar over the four MPA locations, ranging from 3.5 to 4.5 hectares for all transects combined. Within Index sites, area surveyed ranged from 1.5 to 2.2 ha^2 for a total of 7.9 ha^2 over all of the Index sites.

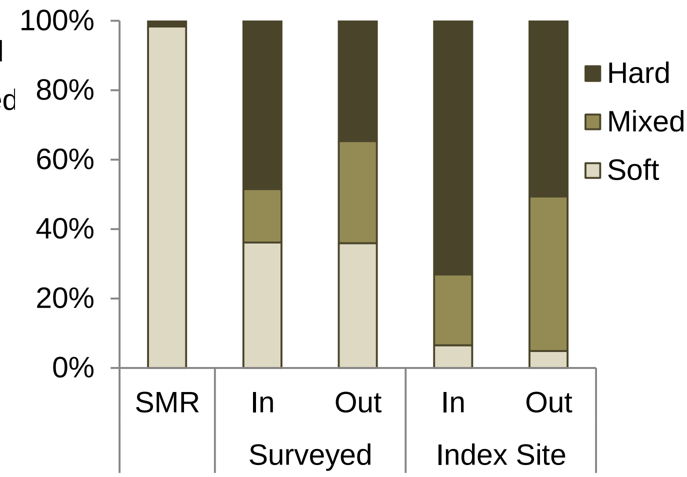
Table 3. Completed transects [number (area surveyed in ha^2, 10^4 m^2)] by marine protected area (MPA) or group, only within Index sites and overall. MPA's are listed as they are located from north to south within the North Coast MPA region.

	Inside MPA		Reference		Total	
	Index	Other	Index	Other	Index	Overall
Point St. George	12 (1.0)	10 (1.3)	6 (0.5)	9 (1.1)	18 (1.5)	37 (3.9)
Reading Rock	12 (0.9)	6 (0.6)	12 (1.1)	8 (0.9)	24 (2.0)	38 (3.5)
Mattole Canyon	12 (1.1)	10 (1.5)	12 (1.1)	3 (0.4)	24 (2.2)	37 (4.1)
Ten Mile	12 (1.1)	8 (1.2)	12 (1.2)	7 (1.2)	24 (2.2)	39 (4.5)
TOTAL	48	34	42	27	90 (7.9)	151 (16.0)

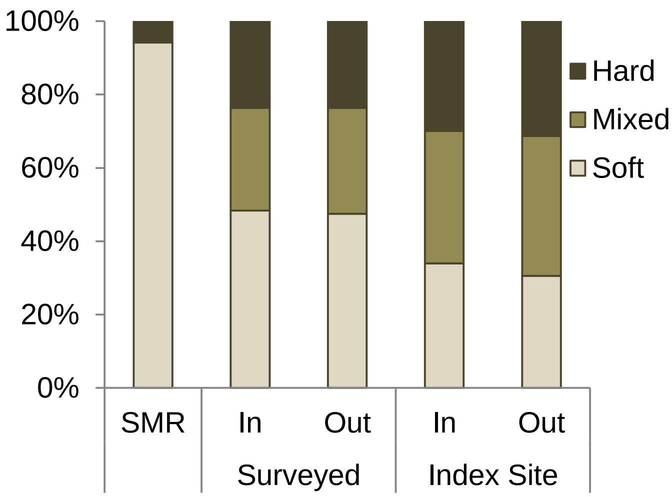
While all four MPAs are composed primarily of sandy bottom habitat, hard rocky reef habitat was targeted for placement of Index sites, inside and outside the MPAs (Fig. 1). Therefore, with the exception of Mattole Canyon, proportional distributions of substrates sampled in general reflect that aim and substrate surveyed was proportionally higher over hard substrate in Index sites (Table 4). Mattole Canyon differed in that the distribution among the three substrate types surveyed was more equivalent. Rocky habitat in that location was less dense and included more sand and rubble patches interspersed with the rock. However, the paired Index sites were comparable in composition. In addition, at both Point St. George and the Ten Mile location, sandy substrates were proportionally higher in the Index site inside the MPAs than that observed outside the MPAs and thus hard rocky habitat was a higher proportion of the survey outside the MPAs.



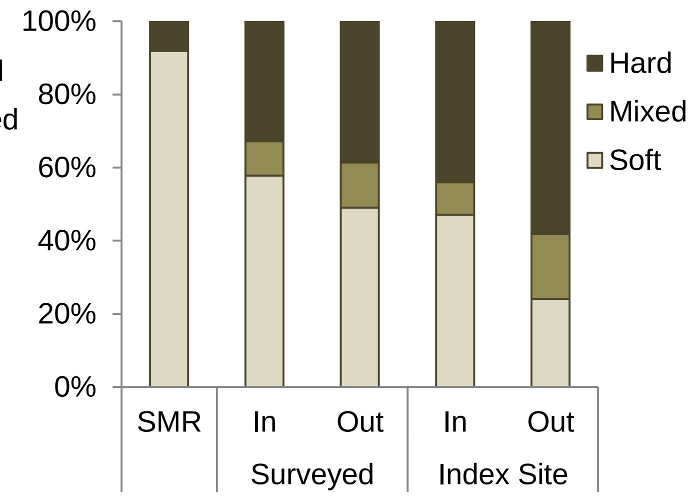
Point St. George SMCA



Reading Rock SMR



Mattole Canyon SMR



Ten Mile SMR

Table 4. Proportional distribution (% of total habitat surveyed) of habitats in completed transects within paired Index sites by marine protected area (MPA) group.

	Inside MPA			Outside Reference		
	Sand	Mixed	Rock	Sand	Mixed	Rock
Point St. George	40	11	49	15	16	70
Reading Rock	7	20	73	5	45	51

Mattole Canyon	34	36	30	31	38	31
Ten Mile	47	9	44	24	18	58
Overall	33	20	48	19	31	50

Alternate Table 4. Proportional distribution (% of total habitat surveyed) of habitats in completed transects within Index sites by marine protected area (MPA) group.

		Inside MPA			Outside Reference		
		Sand	Mixed	Rock	Sand	Mixed	Rock
Point St. George	SMCA	96	-	4			
	All surveyed	50	8	41	52	9	39
	Index site	40	11	49	15	16	70
Reading Rock	SMR	98	-	2			
	All surveyed	36	15	48	36	29	35
	Index site	7	20	73	5	45	51
Mattole Canyon	SMR	94	-	6			
	All surveyed	48	28	24	47	29	24
	Index site	34	36	30	31	38	31
Ten Mile	SMR	92	-	8			
	All surveyed	58	9	33	49	12	39
	Index site	47	9	44	24	18	58

Assemblage Comparison

A total of 92 taxa occurred throughout the study area in video transects. Those taxa included 67 identified to the species level. Fifty-four of the 92 taxa were observed in the chosen treatment Index sites with 38 taxa occurred only outside the Index sites. Cluster analyses using all completed transects and taxa-level data (Fig. 2) showed a clear division between rock and sand habitats for transects completed both inside and outside the MPAs. Treatment assemblages (inside and outside MPAs) clustered most closely together in most cases with >75% similarity. Ten Mile sand assemblages were the exception with only 40% similarity between the MPA and reference areas. The Mattole Canyon MPA assemblage clustered more closely with the rock assemblages (75% similarity) whereas the outside reference clustered more closely with the sand assemblages, though with relatively low similarity (40%). Sand assemblages at that location showed relatively low similarity as well, approximately 40%, and were more closely related to rock assemblages from other MPAs than to other sand assemblages. Rock assemblages clustered most closely by MPA with the nearest neighbors geographically with Point St. George most closely related to Reading Rock, with Mattole Canyon next highest similarity and Ten Mile the most different from all three other groups. No geographical pattern was evident for the sand assemblages.

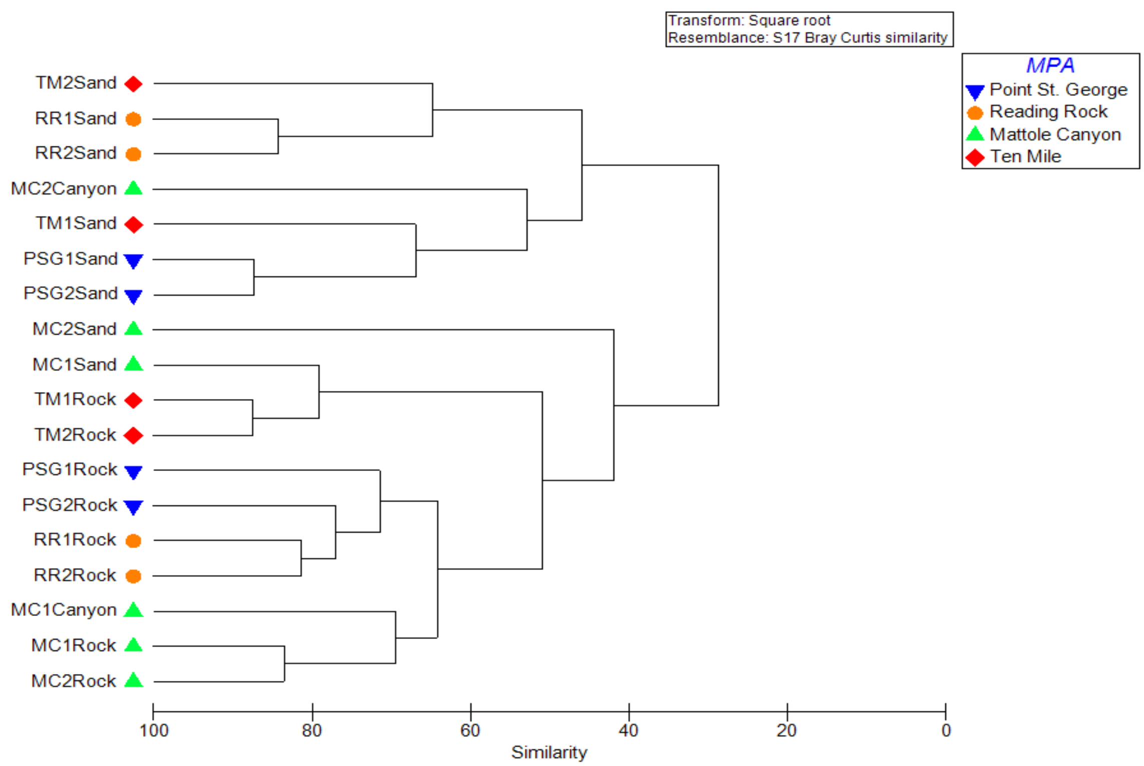
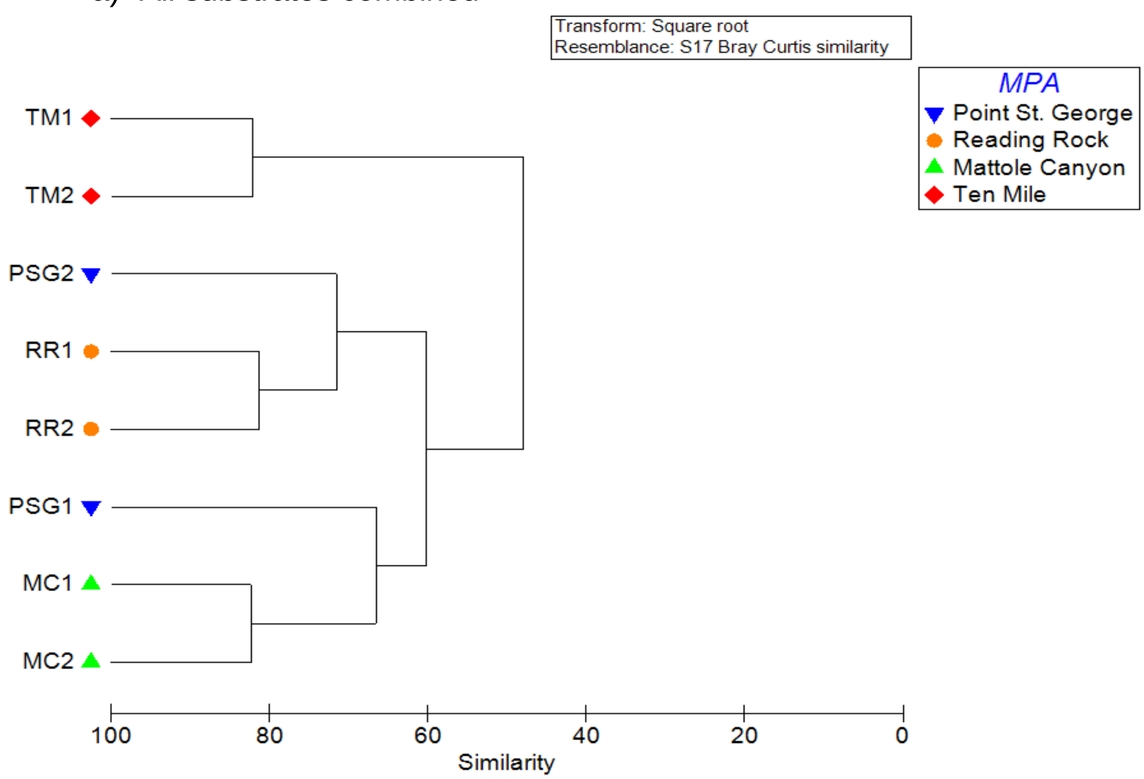


Figure 2. Group average agglomerative cluster analysis for all transects including those both inside and outside Index sites. Similarity is based on mean taxa density by habitat (sand, rock or canyon habitat) inside (1) and outside (2) of each marine protected area. Similarity is shown for grouped taxa only. Results for the analyses based on data composed of all species or higher taxa densities individually clustered similarly with some differences in level of similarity.

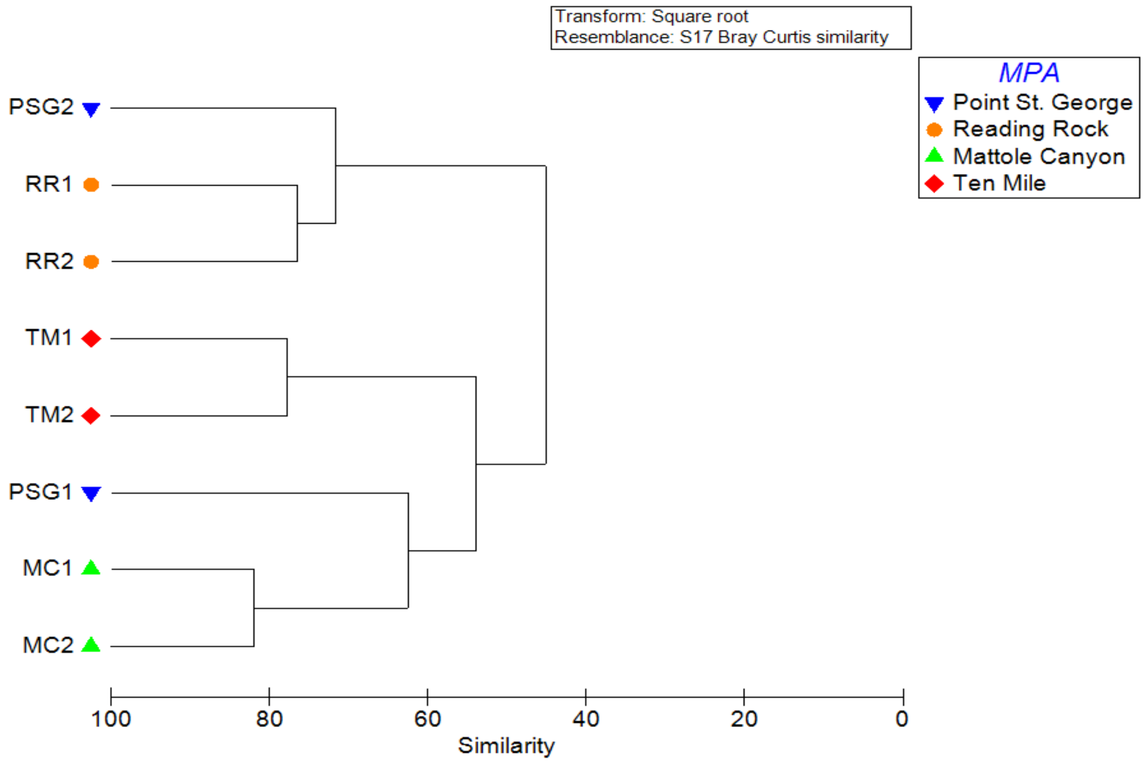
Index Site Comparison

Overall, paired Index site fish assemblages were >80% similar at three of the four MPA locations (Fig. 3a). The exception was the Point St. George pair, located furthest north on the coast, where they were only 60% similar. The difference was driven primarily by the assemblages observed over hard (Fig. 3b) and mixed substrates (Fig. 3c), the soft substrate assemblages were >75% similar. The inside treatment more closely resembled the Mattole Canyon Index pair whereas the outside treatment more closely resembled the Reading Rock pair which was located nearest to Point St. George. The only other notable difference was between the Ten Mile Index site sand assemblages at 60% where the others were all greater than 75% similar. However, the differences in both cases were small, 15-20% lower similarity than other paired sites, and may be reflective the proportional sampling difference among substrates surveyed in the two Index sites.

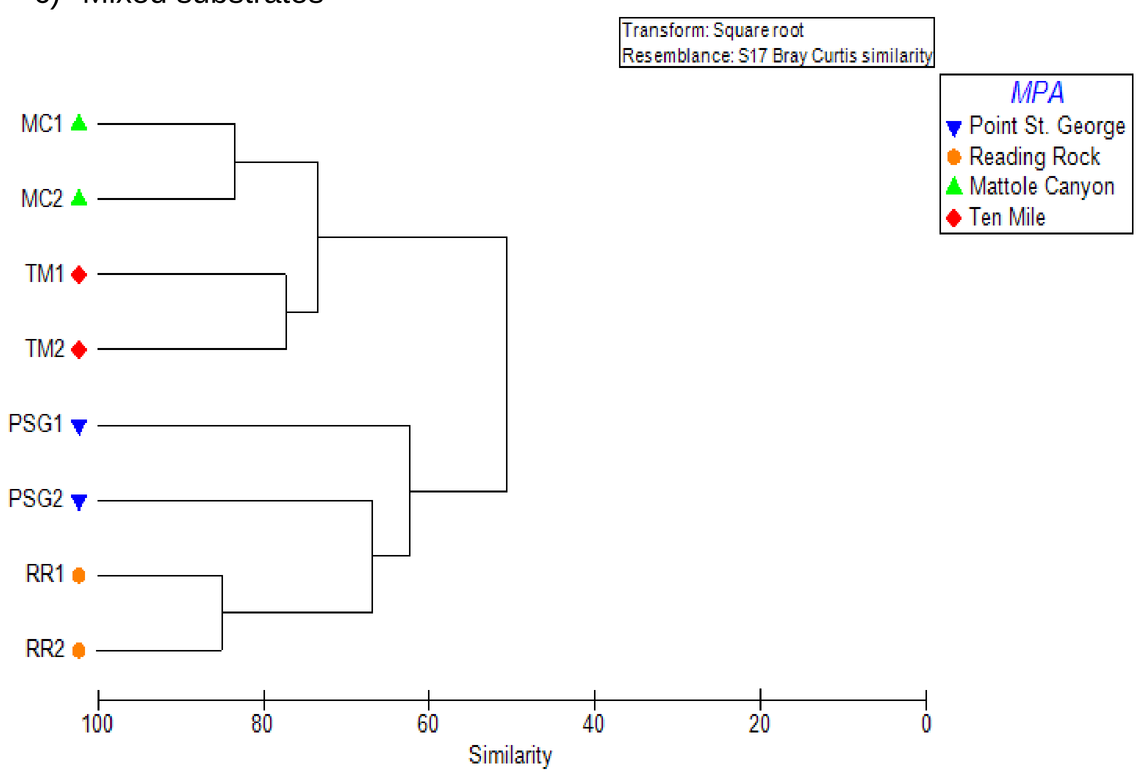
a) All substrates combined



b) Rock substrates



c) Mixed substrates



d) Sand substrates

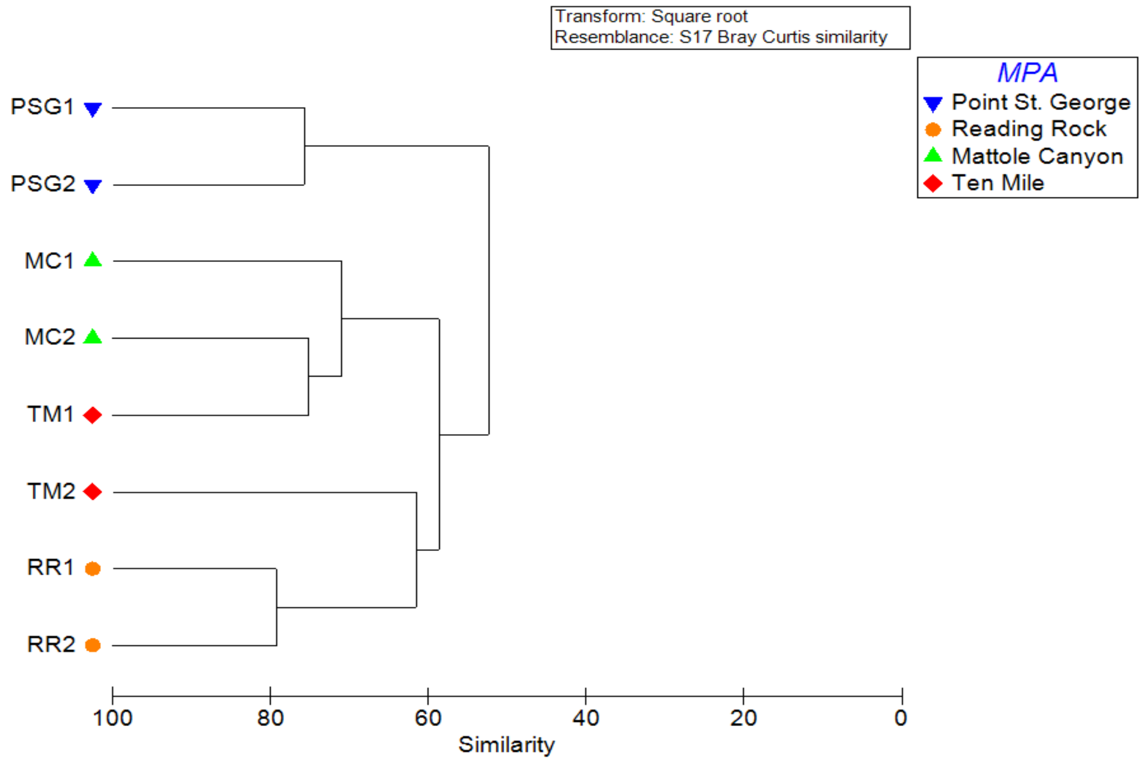


Figure 3. Results of similarity analyses (group average agglomerative clustering) for Index site fish assemblages by marine protected area (MPA) treatment (1=inside, 2=outside reference site). Analyses are based on densities for individual species and taxonomic groups listed in Table 2 (grouped taxa = Chondrichthyans, Flatfishes, Sebastomus, Small Schooling Rockfishes, Small Benthic Fishes etc.). Data were combined for observations over all substrates (a) and then substrate data were evaluated separately, hard (b) mixed (c), and soft (d).

Treatment and Species' Comparisons

We tabulated the number of fish within each species for which we had observations and the proportion of Index transects within which they were observed (Appendix A). Overall, the highest number of fish observed was young-of-the-year rockfishes, over 37,000 observations and more than 72% of the total 51,245 fishes observed. Though all four MPA locations contained significant numbers of YOY that were observed in nearly every transect completed, the Ten Mile Index sites had two orders of magnitude higher numbers than the others. When YOY were removed from the calculations, 45% of all remaining fish observations were small schooling rockfishes including Halfbanded, Squarespot, Pygmy, and Shortbelly. Blue and Canary Rockfishes were the most abundant large rockfish at 9.1% and 6.1% of observations.

Species selected for statistical comparisons among sites were chosen based on occurrence in all marine protected areas (MPAs), number of observations (>100 overall) and frequency of occurrence within the Index site transects (>45% overall) (Tables 5 & 6). Vermilion Rockfish, Yelloweye Rockfish and Black Rockfish were added in spite of not meeting all criteria because they are important fishery species of interest to managers. All species on the list are targeted on California's North Coast Region.

Table 5. Mean density in Index sites per 100 m^2 ($\pm$SE), proportion of non-YOY observations in the Index sites, and proportion of ROV transects in Index sites in which the species occurred at least once for species selected for statistical comparisons. FO = frequency of observation. A complete list of all species observed in Index sites is available in Appendix A to this report.

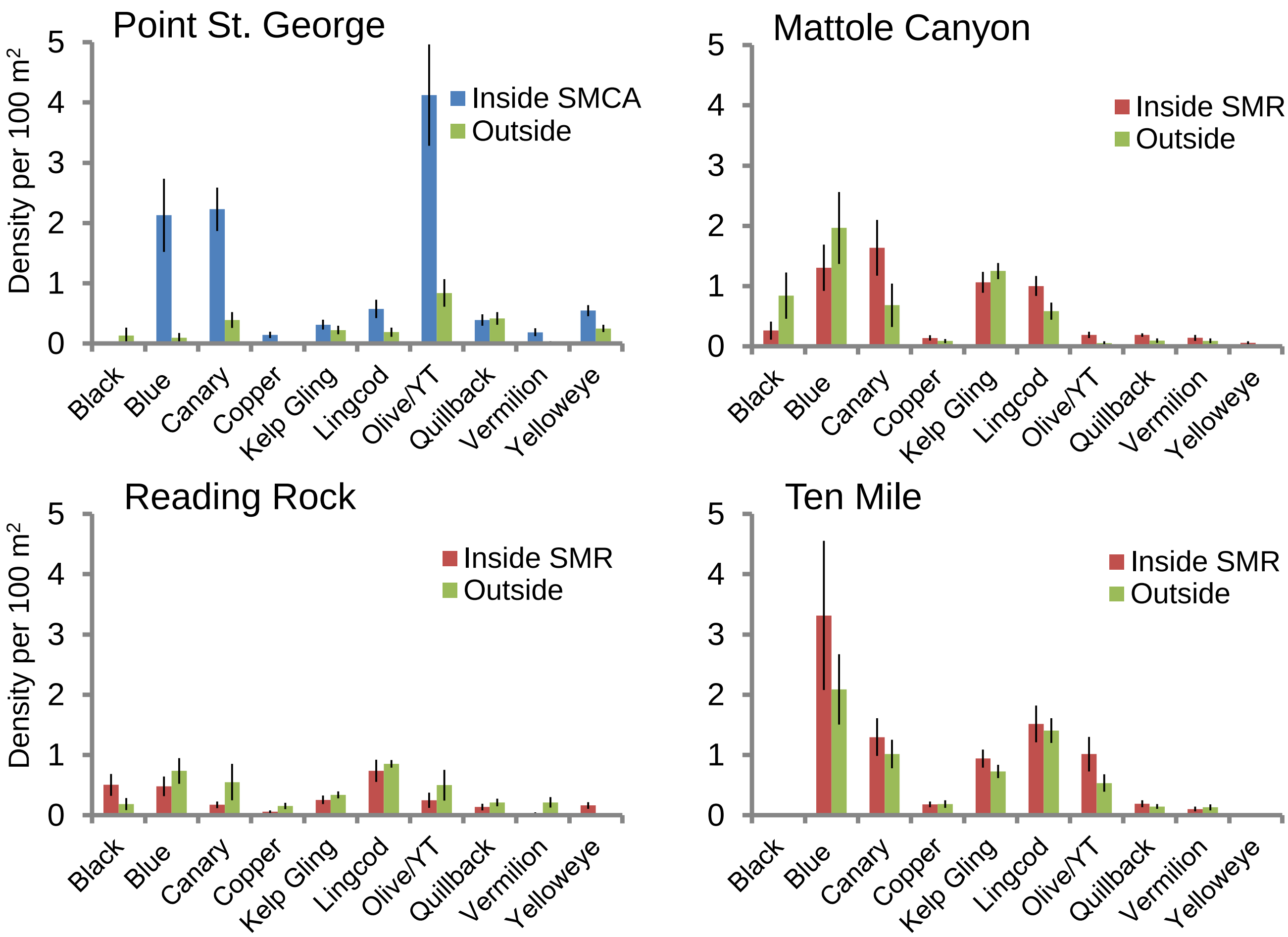
Species	Common name	Total obs.	Mean density (no. 100 m^{-2})	Proportion of obs.	FO (% of transects observed)
Sebastes melanops	Black rockfish	205	0.25 $\pm$ 0.07	1.5	31
Sebastes mystinus	Blue rockfish	1263	1.61 $\pm$ 0.24	9.1	87
Sebastes pinniger	Canary rockfish	847	1.04 + 0.13	6.1	86
Sebastes caurinus	Copper rockfish	102	0.13 $\pm$ 0.02	0.7	54
Hexagrammos decagrammus	Kelp Greenling	542	0.67 $\pm$ 0.06	3.9	92
Ophiodon elongatus	Lingcod	747	0.90 $\pm$ 0.08	5.4	94
Sebastes serranoides/flavidus	OYT complex	721	0.95 $\pm$ 0.18	5.2	72
Sebastes maliger	Quillback Rockfish	170	0.21 $\pm$ 0.02	1.2	71
Sebastes miniatus	Vermilion rockfish	98	0.12 $\pm$ 0.02	0.7	47
Sebastes ruberrimus	Yelloweye rockfish	120	0.15 $\pm$ 0.03	0.9	46

Table 6. Number of observations of comparison species in Index sites by marine protected area (MPA) location and proportion of ROV transects (%FO) completed in the Index sites in which the species occurred at least once. OYT refers to the Olive/Yellowtail Rockfish complex. Note that the Sea Lion Gulch site was not included because only one treatment was surveyed in that area.

	Point St. George		Mattole Canyon		Reading Rock		Ten Mile	
Number of transects		18		24		24		24
Taxa	Obs.	%FO	Obs.	%FO	Obs.	%FO	Obs.	%FO
Black rockfish	7	6	133	46	64	63	1	4
Blue rockfish	218	78	358	92	119	79	568	96
Canary rockfish	249	94	267	79	77	75	254	96
Copper rockfish	14	33	25	58	22	50	41	71
Kelp Greenling	44	83	253	100	62	83	183	100
Lingcod	70	89	180	100	166	92	331	100
OYT complex	452	100	26	46	78	63	165	88
Quillback Rockfish	66	83	32	71	35	67	37	67
Vermilion rockfish	18	50	28	46	26	38	26	54
Yelloweye rockfish	71	100	7	21	42	75	0	0

Treatment Comparison (Inside/Outside MPAs)

When comparing the mean densities of the ten most commonly observed species, Blue, Canary, and Olive/Yellowtail Rockfishes had the highest densities at Point St. George with the highest densities inside the SMCA (Fig. 4). All other species were observed at fewer than 1 fish per 100 m^2. Reading Rock Index sites had consistently low densities (<1 per 100 m^2) for all 10 species both inside and outside the SMR. Black, Blue, and Canary Rockfishes, as well as Lingcod and Kelp Greenling dominated the numbers at Mattole Canyon Index sites. Blue and Canary Rockfishes were the most commonly observed species at Ten Mile but substantial numbers of Lingcod, Kelp Greenling, and Olive/Yellowtail Rockfish occurred as well.



ANOVA

To further define observed patterns, we compared mean densities by species between inside MPA and outside MPA treatments by MPA location. ANOVA revealed statistical differences in mean density by MPA and treatment, and both, for some species (Table 7). In general, but with some exceptions, species densities differed primarily by MPA location. Point St. George Index site densities were the most different where five species, Blue, Canary, Olive/Yellowtail, Vermilion and Yelloweye Rockfishes, showed significant density differences (Table 9). At Reading Rock, two species showed density differences – Black and Vermilion, but sample sizes were low, especially for Vermilion.

Table 7. Mean density comparisons among marine protected area (MPA) locations, treatments, and between years of data collection in the North California coast region using general linear modeling (GLM) of square-root transformed densities with Analysis of Variance (ANOVA). Numbers under each variable are probabilities that the areas, treatments, year or the interactions were statistically the same using an F-test. Bolded numbers indicate significant differences at a probability of 0.05. R^2 is the proportion of variability explained by the relationship. RF is Rockfish. Location differences (Diff) were

identified using post-hoc comparisons (MPA abbreviations: TM - Ten Mile, PSG – Point St. George, RR – Reading Rock, and MC – Mattole Canyon).

Species	n	MPA Location	Treatment	Year	Interaction	R^2
Black RF	205	**<0.001**	0.61	0.13	**0.024**[1]	0.29
Blue RF	1263	**0.001**	0.336	0.20	**0.006**[2]	0.18
Canary RF	847	**0.003**	**0.016**	0.27	**0.014**[2]	0.28
Copper RF	102	0.24	0.74	0.97	0.13	0.16
Kelp Greenling	542	**<0.001**	0.99	0.26	0.34	0.49
Lingcod[3]	747	**<0.001**	0.12	**<0.001**[3]	0.42	0.50
Olive/Yellowtail	721	**<0.001**	**0.008**	0.43	**<0.001**[2]	0.55
Quillback RF	170	**<0.001**	0.76	0.62	0.78	0.22
Vermilion RF	98	0.99	0.72	0.82	**0.025**[1,2]	0.11
Yelloweye RF[4]	120	**<0.001**	**0.006**	0.08	**0.002**[2]	0.61

[1]*Reading Rock densities differed inside and outside the MPA.*
[2]*Point St. George densities differed inside and outside the MPA. T-tests between in/out treatments for only 2014 data supported the results (Blue (P=0.044), Canary (P=0.034), OYT (P=0.012), Vermilion (P=0.11), Yelloweye (P=0.048)).*
[3]*Lingcod densities were an order of magnitude higher in 2015 than 2014 at all Index sites.*
[4]*ANOVA results are for three MPAs. The Ten Mile location had no observations.*

Table 8. Mean relative abundance (density/100 m^2) in Index sites for each species (RF=Rockfish) by Marine Protected Area (MPA) treatment (in = Index site inside the MPA, out = Index site outside the MPA). Statistical differences between treatments are indicated in the final column using MPA initials (PSG=Point St. George SMCA, RR=Reading Rock SMR, MC=Mattole Canyon SMR, TM=Ten Mile SMR).

Taxa	Point St. George		Mattole Canyon		Reading Rock		Ten Mile		Statistically different
	In	Out	In	Out	In	Out	In	Out	
Black rockfish	0	0.13	0.26	0.84	0.50	0.19	0.01	0	RR
Blue rockfish	2.13	0.10	1.31	1.97	0.48	0.74	3.31	2.09	PSG
Canary rockfish	2.23	0.39	1.64	0.68	0.17	0.55	1.29	1.02	PSG
Copper rockfish	0.14	0	0.14	0.09	0.06	0.16	0.18	0.19	-
Kelp Greenling	0.31	0.23	1.06	1.25	0.26	0.34	0.94	0.73	-
Lingcod	0.57	0.19	1.00	0.59	0.74	0.85	1.16	1.4	-
OYT complex	4.12	0.84	0.19	0.05	0.25	0.50	1.01	0.54	PSG
Quillback rockfish	0.39	0.42	0.19	0.10	0.14	0.21	0.19	0.15	-
Vermilion RF	0.19	0.02	0.14	0.09	0.03	0.22	0.10	0.13	PSG, RR
Yelloweye RF	0.55	0.25	0.06	0	0.16	0.24	0	0	PSG

Odds analyses

Individual species appear to be utilizing hard habitats in the Index sites in accordance with habitat availability and species known affinity. Results must be viewed in light of the fact that sample sizes were highly variable and often differed between inside and outside treatments. Also, a greater proportion of rocky habitat was surveyed inside the MPAs at Reading Rock and outside the MPAs at Point St. George and Ten Mile MPAs. Mattole Canyon surveys were nearly equally distributed among the three habitat types which would result in one third the habitat available for the analyses as opposed to 50-75% of the survey at the other three sites. Density differences were noted for a number of species between treatment sites at Point St. George and Reading Rock. With that in mind, though no startlingly obvious differences in habitat use between the two treatments were revealed, some trends were apparent. Lingcod and Kelp Greenling odds were highly variable among the MPAs but overall near 1 reflecting those species' use of a variety of habitats both inside and outside the MPAs.

Odds ratios for Black, Blue, Olive/Yellowtail, and Yelloweye Rockfishes were all >1.5 overall indicating that those species were more likely to be observed over hard rocky habitat inside MPAs than outside. This was driven primarily by the Reading Rock location, where a majority of the habitat surveyed inside the MPA was hard rock and a greater proportion than that surveyed in the outside Index site. The inside Index site is also located on the down-current side of the reef whereas the outside site is on the up-current side. With the exception of Yelloweye Rockfish, these are schooling species that as a rule aggregate over rocky reefs when outside of kelp beds and their odds ratios for rocky habitat were higher in locations where a greater proportion of rocky habitat was surveyed (Reading Rock) as opposed to locations where a lower proportion was surveyed (Mattole Canyon).

Quillback Rockfish's odds varied around 1 over the four sites but the overall ratio is very close to 1. Copper Rockfish, a species associated with rocky habitat but can venture into adjacent habitats had odds consistently less than 1. Canary Rockfish are likewise associated with rock habitat as a rule but are known to venture out over adjacent habitats. Canary odds ratios, though not far above 1, were consistently greater. Vermilion Rockfish sample sizes were quite low so results are only presented for all sites combined and the result was near 1.

Table 9. Odds ratios for select species by marine protected area location. Numbers are species number of observations over hard rock and any other habitat, inside and outside the marine protected areas (MPA). Numbers near one indicate that the species is observed on substrates similarly both inside and outside of the MPA. Numbers greater than one indicate the species is proportionally more commonly observed over hard rocky substrates inside the MPA than outside and numbers less than 1 indicate the reverse. Missing numbers indicate that there were zero observations in one or more cells in the analysis preventing calculation.

	All Index site transects	Point St. George	Reading Rock	Mattole Canyon	Ten Mile
Black Rockfish	1.8	-	5.3	0.9	-
Blue Rockfish	2.0	-	4.8	0.6	2.8
Canary Rockfish	1.4	1.2	1.4	1.5	1.3
Copper Rockfish	0.5	-	0.6	0.9	0.2
Kelp Greenling	0.9	1.3	2.5	0.5	1.1
Lingcod	1.0	0.3	2.3	0.5	0.7
OYT Complex	2.9	0.5	4.4	0.7	3.8
Quillback Rockfish	0.9	1.8	0.7	0.6	1.2
Vermilion Rockfish	0.6	-	-	-	-
Yelloweye Rockfish	1.6	0.7	2.3	-	-

Canary Rockfish were nearly twice as likely to occur on transects conducted inside the Index sites than throughout the broader MPA and reference area (Table 10). Blue Rockfish, Copper Rockfish, Kelp Greenling, Lingcod and Vermilion Rockfish were all slightly less likely to be observed in Index sites though ratios were near 1. Other species were equally likely to be observed in Index sites and across the broader area covered.

Table 10. Presence odds ratios for ROV transects inside and outside of marine protected areas. Odds are based on the number of completed transects on which the species was and was not observed inside or outside of MPAs. Odds are presented for all transects and for only those that were conducted inside the paired Index sites.

	All transects	Index site transects
Black Rockfish	1.1	1.0
Blue Rockfish	1.0	0.5
Canary Rockfish	1.6	3.0
Copper Rockfish	1.0	0.4
Kelp Greenling	0.9	0.2
Lingcod	1.8	0.8
OYT Complex	1.4	1.7
Quillback Rockfish	1.5	1.5
Vermilion Rockfish	1.4	0.9
Yelloweye Rockfish	1.2	1.3

Conclusions

Following are the questions addressed by the preceding analyses with our interpreted responses:

Multivariate assemblages:

1. Are there differences in fish species assemblage among study sites?

Species assemblages were approximately 40% similar across the region with a distinct pattern of similarity from north to south in the rocky reef communities with Point St. George and Reading Rock possessing the most similar assemblages at 75%

similarity. Sandy habitat assemblages did not exhibit the same pattern and were, in general, more variable. Flatfishes, YOY and epibenthic aggregating rockfishes were the most commonly observed fishes.

2. Do the chosen Index site fish communities reflect the same similarity or dissimilarity as the overall fish community?

Similarity patterns within Index sites were the same as the regional pattern with one major exception. Paired Index site assemblages other than those at Point St. George were greater than 80% similar. The Point St. George outside Index site assemblage was 60% similar to the inside site whereas the overall assemblage was 75% similar. All other patterns were the same and similarities higher in Index sites than the overall location assemblages.

3. Are fish communities in the paired Index sites similar inside and outside each MPA?

Overall, paired Index site assemblages were greater than 80% similar at all location except Point St. George where the sites were 60% similar. Paired sites at the Reading Rock and Mattole Canyon locations were >75% similar over all three substrates - hard rock, mixed and sandy. The Ten Mile sites were 80% similar over hard and mixed substrates but less similar on sand at 60%. Point St. George assemblages were the most different over hard rock substrates, only 40% similarity. Mixed substrate assemblages were 60% similar and sandy substrates >75%.

4. Are habitat-based fish assemblages in Index sites similar across the region?

Hard substrate assemblages showed 40-50% overlap across the region. The mixed substrate assemblages were more similar between Mattole Canyon and Ten Mile (75%), the two most southerly MPAs. Point St. George and Reading Rock, the two most northerly locations, less so at 60% similarity. Assemblages over sandy substrates varied more and did not show a latitudinal pattern but overall similarity was higher at greater than 50%.

Individual species':

1. What are the most abundant fish species and frequency of observations of each fish species in the Index sites?

The most abundant fish taxa observed in all of the Index sites was Young of the Year (YOY) rockfishes. Numbers were in the hundreds for Point St. George SMCA and Reading Rock SMR, an order of magnitude larger at Mattole Canyon SMR, and two orders of magnitude larger at Ten Mile SMR. Other than YOY, small schooling Rockfishes and Shortbelly Rockfish were highly abundant, especially at Mattole Canyon and Ten Mile SMRs as well. Excluding these small species, the species that occurred in highest abundances included schooling rockfishes (Blue, Canary, Olive/Yellowtail, Black, and Widow), Lingcod and Kelp Greenling, and benthic non-aggregating rockfishes (Sebastomus, Quillback, Yelloweye and Copper).

2. For select species, are relative abundances similar among MPA locations?

Densities for all species were consistently low (<5 per 100 m^2) across the region. Point St. George SMCA (inside) had relatively high densities of Blue, Canary, and Olive/Yellowtail Rockfishes. Blue and Canary Rockfish were also some of the most abundant at Mattole Canyon and Ten Mile SMRs.

3. For select species, are relative abundances similar inside and outside of the MPAs?

Though relative abundances across the region differed for nearly all species, most species abundances were the same inside and outside of paired Index sites at each location. Exceptions were Black and Vermilion Rockfishes at the Reading Rock SMR but sample sizes were low. The Point St. George paired sites were the most different and may indicate reconsideration. Five of the ten species tested showed significantly lower densities at the outside site than in the inside site.

4. Are individuals using hard substrates similarly among sites?

Overall, most species were using substrates similarly at both treatment Index sites based on their affinity for rocky substrate and the relative availability in each site. Olive/Yellowtail, Black and Blue Rockfishes all had high overall odds of being observed over hard substrates inside MPAs, driven primarily by the Reading Rock and Ten Mile pairs. The higher odds may be influenced by the substrate distributions at those sites.

5. Are the odds of observing a species the same in Index sites as they are across the MPA locations?

Canary Rockfish were more likely to be observed in the inside Index sites than inside the MPA over the broader region. However, Blue and Copper Rockfishes and Kelp Greenling were less likely to be observed inside Index sites than inside MPAs overall. While these differences are notable, they are more likely the result of surveyed habitat differences inside and outside of the MPAs and are not of sufficient magnitude to be of concern to analyses.

Summary

Where fish occur, what species are present and in what numbers they occur are aspects of MPAs that may influence effectiveness and outcome measures used to assess performance. We used visual species observations, directed at paired permanent Index sites at each of our four MPA locations, inside and outside of the MPAs, to establish fish assemblage metrics that can monitored over time to inform performance assessment and adaptive management. We selected ten rocky reef fish species, all targeted locally by fishers, for in-depth density analyses to establish baseline metrics for future comparisons.

Index site placement was chosen and thought to be representative of the general rocky reef habitat in each MPA location and habitat similarity inside and outside of each MPA. We found that for three of the four MPAs, Index site placement was good and will allow for robust comparisons in long-term monitoring. However, the Point St. George paired sites showed some differences that warrant reconsideration in placement of the outside site. Overall assemblage similarity was the lowest between treatments at that location and five of the ten species' that we investigated statistically had significantly lower densities in the outside treatment.

Overall individual species densities were low at all locations (<1 per 100 m^2) but were highest at Point St. George SMCA and Ten Mile SMR. While densities differed significantly for nearly all species among the MPA locations, they were the same inside and outside of each MPA except Point St. George SMCA. Additionally, only Lingcod densities were different between the two years of the baseline study, increasing by an order of magnitude at all Index sites in 2015. More than 75% of fish observations in all Index sites were YOY rockfishes. Of the other species observed in Index sites, small schooling rockfishes represented 45%, Blue Rockfish 9.1%, Flatfishes 6.3% and Canary Rockfish 6.1%. Olive/Yellowtail Rockfishes were common and observed in the highest density at Point St. George SMCA.

MPA Summaries

Point St. George Index Sites

The Point St. George SMCA is located, as the name implies, on the outer reaches of a projecting point of land north of Crescent City, CA. The SMCA covers mostly sand habitat with a rocky strip of reef that is less than 500 m wide projecting across the northeast corner of the MPA. The inside Index site straddles the reef at the most exposed portion of the point. The outside site is located approximately 16 km southeast along another strip of reef that is somewhat protected by the point from the predominant northwest winds and currents. The two Index sites both range from 50-70 m in depth.

The Index sites at Point St. George SMCA showed the least similarity between assemblages (60% overall and 40% over rock substrates) and the most significant differences in species' densities inside and outside the MPA. The highest densities of Canary, Blue and Olive/Yellowtail Rockfishes were observed inside the MPA at this location and the lowest densities of Kelp Greenling and Lingcod. Additionally, Copper and Widow Rockfishes were observed inside the MPA but were absent at the outside site, and Black Rockfish were present outside but not inside the MPA. While a greater percentage of hard rocky habitat was surveyed at the outside site, generally higher densities of most Rockfishes, Lingcod and Kelp Greenling were observed inside the MPA, as well as Flatfishes. Only Tiger and Quillback Rockfishes and small benthic fishes showed higher densities in the outside treatment.

Reading Rock Index Sites

Reading Rock is a small, elliptical offshore reef and the SMR extends over the southern tip that represents about 25% of the reef. It is located offshore of the SMCA in a depth range of 40-60 m. The SMR is composed of mostly sandy bottom with only the small, approximately 1000 X 1000 m portion of the reef falling inside the boundaries. The inside Index site is positioned on that portion of the reef and the outside Index site is located on the northern edge just 1500 m distant from the inside site. Species assemblages were more than 80% similar inside and outside the SMR.

All fish species densities were low at Reading Rock. Lingcod and Blue Rockfish occurred in the highest density, both inside and outside the SMR. Black Rockfish were more common inside the MPA and Canary Rockfish were seen more outside the MPA. Small numbers of all of the ten species chosen for metric establishment were observed. Statistical differences in densities were observed for Vermilion Rockfish (none observed inside the MPA) and Black Rockfish which was slightly higher inside the MPA.

Mattole Canyon Index Sites

The Mattole Canyon SMR is centered on the canyon head outside of the 20 m depth contour. The two Index sites were positioned less than 500 m apart on the southern side of the canyon in depths of 20-60 m. The outside site is located south of the inside Index site an in slightly shallower depth range at 20-50 m. The inside site is situated in 40-60 m.

Index site assemblages at this location were very similar overall at >80%. Species densities were an order of magnitude higher for both YOY and small schooling rockfishes than Point St. George SMCA or Reading Rock SMR. Additionally, densities for both groups doubled from 2014 to 2015. Blue, Black and Canary Rockfishes, as well as Kelp Greenling and Lingcod were observed in the highest densities at these sites. Kelp Greenling densities were highest of all four MPA locations at Mattole Canyon. There were no density differences between the inside and outside treatments at this location for the ten selected species.

Ten Mile Index Sites

The Ten Mile SMR is located offshore of the Ten Mile Estuary SMCA and north of the Ten Mile Beach SMCA. It encompasses a higher percentage of rocky reef than do the other MPAs surveyed at 40%. The inside Index site is located on the southern edge of the reef in 40-60 m depths. The outside Index site is located about 8 km south on the north edge of another reef in the same depths. The two Ten Mile Index site assemblages were very similar at >80% and had high densities of both YOY and small schooling rockfishes. YOY observations were an order of magnitude higher than Mattole Canyon SMR and two orders of magnitude higher than Point St. George SMCA and Reading Rock SMR. In addition, densities in 2014 were double that in 2015. Densities of small schooling rockfishes were an order of magnitude higher inside the SMR than outside and inter-annual differences were different inside and outside the MPA.

At Ten Mile, we found relatively high densities of Blue and Canary Rockfishes in both treatments, many of which were juvenile and sub-adult fishes. Of the four MPA locations surveyed, the highest density of Lingcod occurred at Ten Mile. Kelp Greenling and Olive/Yellowtail Rockfishes were also common. There were no observations of Yelloweye Rockfish, only one Black Rockfish and small numbers of other rockfish species. There were no density differences for the ten selected species between the inside and outside treatments at Ten Mile.

The very large number of YOY and small rockfishes, including juvenile Blues and Canaries, observed at the Ten Mile location indicates that there is something different about its location from the other three. It could mean that the rocky reef habitat that was surveyed at Ten Mile in some way differs from the reefs in the other locations. It could also be indicative of a series of recent recruitment pulses that may be valuable to monitor in upcoming years.

With the exception of Point St. George SMCA, the paired Index sites at each of the MPA locations appear to be representative of the rocky reef communities targeted for protection at their locations in the North California Coast region and will be good targets for long-term monitoring in the area. The Point St. George sites, however, may require re-evaluation and possibly relocation. Substrate differences, the 16 km distance between the two Index sites, and differences in geographical orientation and resulting physical conditions, may influence the differences observed between the Index sites at Point St. George. The MPA's position at the outer edge of a geographical point makes it difficult to replicate conditions but a position in closer proximity to the MPA would provide for better assemblage and species density comparisons, as well as more efficient data acquisition, if it can be identified.

Recommendations

1. We recommend that the Point St. George outside Index site location be re-evaluated and potentially moved to a location closer to the MPA to increase comparability to the SMCA in both assemblage and species densities. We recognize that this may not be possible but because the metrics in the outside Index site consistently differ from the inside site, it may not be a good choice as a reference site for long-term monitoring.

2. We recommend that a second pair of Index sites be established at each MPA location in sandy habitat so that similar fish assemblage metrics can be established for the soft bottom communities as well as the rocky reef communities. In concert with that, we recommend that monitors continue to use a downward-facing camera in that habitat to facilitate identification of flatfishes that are very difficult to identify in forward-facing video.

Appendix A. Fish species abundance (number of overall observations, Obs.), and proportion of ROV transects where the species was observed at least once. Numbers are for all species observed within marine protected area (MPA) index sites by location, for both inside and outside treatments combined. %FO: percent frequency of occurrence in ROV transects completed. The dashed line indicates the minimum number of observations considered for further analyses. Individual species selected for more in-depth investigation were chosen from the list above this line.

	Point St. George		Mattole Canyon		Reading Rock		Ten Mile		Sea Lion Gulch		All Index sites	
Number of transects	Obs	18	Obs	24	Obs	24	Obs	24	Obs	6	Obs	96
Taxa		%FO		%FO		%FO		%FO		%FO		%FO
YOY	463	94	3255	100	253	92	33426	100	565	100	37396	91
Small schooling RF	61	17	983	29	6	4	3238	29	0	0	4288	19
Shortbelly rockfish	0	0	301	13	0	0	972	4	175	17	1273	4
Blue rockfish	218	78	358	92	119	79	568	96	7	33	1263	81
UI rockfish	218	100	191	88	180	100	323	100	66	100	912	92
Canary rockfish	249	94	267	79	77	75	254	96	12	83	847	81
UI flatfish	323	78	273	88	10	17	157	75	15	67	763	59
Lingcod	70	89	180	100	166	92	331	100	20	100	747	90
Olive/yellowtail complex	452	100	26	46	78	63	165	88	212	100	721	69
Halfbanded Rockfish	0	0	2	4	0	0	662	29	1	17	664	8
Kelp Greenling	44	83	253	100	62	83	183	100	18	83	542	88
Black rockfish	7	6	133	46	64	63	1	4	0	0	205	29
Sebastomus Rockfish	28	61	13	25	58	58	73	71	89	100	172	50
Widow Rockfish	7	28	3	4	6	8	154	17	0	0	170	13
Quillback Rockfish	66	83	32	71	35	67	37	67	10	83	170	68
UI schooling pelagic	0	0	45	4	50	4	60	4	0	0	155	3
UI fish	38	53	15	33	48	58	32	50	0	0	133	48
Yelloweye rockfish	71	100	7	21	42	75	0	0	10	67	120	44
Rosy rockfish	14	44	10	17	43	54	38	54	24	83	105	40
Copper rockfish	14	33	25	58	22	50	41	71	0	0	102	51
Vermilion rockfish	18	50	28	46	26	38	26	54	7	100	98	44
UI sanddab	17	28	24	25	1	4	33	25	1	17	75	19
UI small benthic fish	14	32	8	21	11	29	23	42	6	50	56	31
Sqspot/widow cmplx	26	11	0	0	4	13	3	13	0	0	33	8
UI eel pout	16	32	1	4	3	8	6	8	0	0	26	12
Brown rockfish	0	0	0	0	8	17	15	33	0	0	23	13
Painted greenling	0	0	1	4	0	0	22	29	0	0	23	8
Tiger rockfish	13	33	0	0	6	25	0	0	0	0	19	13
China rockfish	0	0	1	4	1	4	16	46	0	0	18	14
English sole	9	22	6	21	0	0	3	8	0	0	18	11
Petrale sole	10	44	3	8	0	0	0	0	0	0	13	10
Pink surfperch	2	6	0	0	0	0	9	13	0	0	11	4
UI goby	6	21	0	0	3	13	2	4	5	33	11	9
Combfish complex	6	22	0	0	1	4	1	4	0	0	8	6
Black/blue complex	2	6	2	8	2	4	0	0	0	0	6	4
Canary/vermilion cmplx	1	6	1	4	4	17	0	0	1	17	6	6
Cabezon	0	0	5	21	1	4	0	0	0	0	6	6
Wolf eel	0	0	0	0	2	8	4	13	0	0	6	5
Squarespot rockfish	5	6	0	0	0	0	0	0	0	0	5	1
UI greenling	1	6	1	4	3	8	0	0	0	0	5	4
Rex sole	5	17	0	0	0	0	0	0	0	0	5	3
UI surfperch	0	0	3	8	0	0	1	4	0	0	4	3
Dover sole	2	6	0	0	0	0	2	8	0	0	4	3
Pacific hagfish	3	17	0	0	0	0	0	0	0	0	3	3
Ocean sunfish	0	0	2	4	0	0	1	4	0	0	3	2
Rock sole	0	0	3	13	0	0	0	0	2	33	3	3
UI smelt	0	0	0	0	2	4	0	0	0	0	2	1
UI sculpin	0	0	0	0	1	4	0	0	0	0	1	1
Thornyhead complex	1	5	0	0	0	0	0	0	0	0	1	1
Starry rockfish	0	0	0	0	0	0	1	4	1	17	1	1
Sixgill shark	0	0	0	0	1	4	0	0	0	0	1	1
Sablefish	0	0	0	0	0	0	1	4	0	0	1	1
Pacific halibut	1	5	0	0	0	0	0	0	0	0	1	1
Longnose skate	0	0	1	4	0	0	0	0	0	0	1	1
Total (non-YOY)	2038		3207		1147		7458		682		13850	

APPENDIX 5. Rock Reef Fish - Between Year Comparisons by Study Location.

Between year comparisons showing initial variability and t-test significance of selected fish mean densities (100 m^2) for rocky reef index site transects (n) at Point St. George SMCA and reference area.

	SMCA				Reference Area			
	Mean Density (100 m^2) ± 1SD				Mean Density (100 m^2) ± 1SD			
Species	2014 (n=6)	2015 (n=6)	Initial Variability	T-test Significance (n=12)	2014 (n=6)	2015 (n=0)	Initial Variability	T-test Significance
Black Rockfish	— ± —	— ± —	—	—	0.126 ± 0.309	— ± —	—	—
Blue Rockfish	1.784 ± 1.526	2.475 ± 2.662	39%	no	0.099 ± 0.194	— ± —	—	—
Brown Rockfish	— ± —	— ± —	—	—	— ± —	— ± —	—	—
Canary Rockfish	1.941 ± 1.331	2.519 ± 1.198	30%	no	0.390 ± 0.320	— ± —	—	—
Copper Rockfish	0.117 ± 0.140	0.167 ± 0.227	43%	no	— ± —	— ± —	—	—
Olive/Yellowtail Rockfish	3.803 ± 1.959	4.445 ± 3.816	17%	no	0.829 ± 0.552	— ± —	—	—
Quillback Rockfish	0.454 ± 0.290	0.332 ± 0.379	27%	no	0.416 ± 0.255	— ± —	—	—
Sebstomus Rockfish	0.271 ± 0.235	0.295 ± 0.367	9%	no	0.190 ± 0.262	— ± —	—	—
Shortbelly Rockfish	— ± —	— ± —	—	—	— ± —	— ± —	—	—
Small schooling rockfish	0.115 ± 0.281	1.005 ± 2.408	776%	no	— ± —	— ± —	—	—
Unidentified rockfish	2.119 ± 1.583	1.268 ± 1.123	40%	no	0.918 ± 0.650	— ± —	—	—
Vermilion Rockfish	0.258 ± 0.306	0.119 ± 0.111	54%	no	0.018 ± 0.044	— ± —	—	—
Yelloweye Rockfish	0.513 ± 0.234	0.581 ± 0.408	13%	no	0.249 ± 0.146	— ± —	—	—
YOY rockfish	5.962 ± 5.105	0.452 ± 0.430	92%	yes, P=0.0250	2.202 ± 0.960	— ± —	—	—
Kelp Greenling	0.456 ± 0.346	0.172 ± 0.119	62%	no	0.225 ± 0.173	— ± —	—	—
Lingcod	0.140 ± 0.087	1.008 ± 0.399	619%	yes, P=0.0004	0.187 ± 0.183	— ± —	—	—
Flatfish	3.183 ± 1.847	3.019 ± 1.781	5%	no	1.090 ± 1.745	— ± —	—	—

Appendix 5. Continued. Between year comparisons showing initial variability and t-test significance of selected fish mean densities (100 m^2) for rocky reef index site transects (n) at Reading Rock SMR and reference area.

Species	SMR								Reference Area							
	Mean Density (100 m^2) ± 1SD							T-test	Mean Density (100 m^2) ± 1SD							T-test
	2014 (n=6)			2015 (n=6)			Initial Variability	Significance (n=12)	2014 (n=6)			2015 (n=6)			Initial Variability	Significance (n=12)
Black Rockfish	0.236	±	0.131	0.759	±	0.833	221%	no	0.262	±	0.458	0.107	±	0.213	59%	no
Blue Rockfish	0.651	±	0.674	0.264	±	0.268	59%	no	0.395	±	0.423	1.069	±	0.863	171%	no
Brown Rockfish	0.040	±	0.097	0.136	±	0.230	242%	no	—	±	—	0.018	±	0.044	N/A	no
Canary Rockfish	0.107	±	0.125	0.234	±	0.242	118%	no	0.918	±	1.436	0.178	±	0.179	81%	no
Copper Rockfish	0.078	±	0.088	0.037	±	0.091	52%	no	0.140	±	0.197	0.170	±	0.194	22%	no
Olive/Yellowtail Rockfish	0.089	±	0.219	0.410	±	0.555	359%	no	0.844	±	1.179	0.148	±	0.212	82%	no
Quillback Rockfish	0.138	±	0.196	0.120	±	0.156	13%	no	0.261	±	0.304	0.161	±	0.090	38%	no
Sebstomus Rockfish	0.206	±	0.320	0.307	±	0.285	48%	no	0.604	±	0.369	0.765	±	0.307	27%	no
Shortbelly Rockfish	—	±	—	—	±	—	—	—	—	±	—	—	±	—	—	—
Small schooling rockfish	—	±	—	—	±	—	—	—	—	±	—	0.122	±	0.298	N/A	no
Unidentified rockfish	1.057	±	0.672	0.664	±	0.400	37%	no	0.489	±	0.431	1.519	±	2.265	211%	no
Vermilion Rockfish	0.040	±	0.097	0.020	±	0.048	50%	no	0.228	±	0.414	0.202	±	0.196	11%	no
Yelloweye Rockfish	0.056	±	0.137	0.258	±	0.164	362%	yes, P=0.0430	0.262	±	0.105	0.218	±	0.152	17%	no
YOY rockfish	0.635	±	0.891	1.208	±	0.664	90%	no	1.508	±	1.002	1.546	±	0.644	2%	no
Kelp Greenling	0.165	±	0.149	0.341	±	0.314	107%	no	0.315	±	0.247	0.359	±	0.174	14%	no
Lingcod	0.348	±	0.492	1.121	±	0.541	223%	yes, P=0.0268	0.805	±	0.223	0.889	±	0.239	10%	no
Flatfish	0.079	±	0.194	0.116	±	0.283	46%	no	0.035	±	0.086	0.018	±	0.044	50%	no

Appendix 5. Continued. Between year comparisons showing initial variability and t-test significance of selected fish mean densities (100 m^2) for rocky reef index site transects (n) at Mattole Canyon SMR and reference area.

	SMR				Reference Area			
	Mean Density (100 m^2) ± 1SD			T-test	Mean Density (100 m2) ± 1SD			T-test
Species	2014 (n=6)	2015 (n=6)	Initial Variability	Significance (n=12)	2014 (n=6)	2015 (n=6)	Initial Variability	Significance (n=12)
Black Rockfish	0.038 ± 0.093	0.489 ± 0.672	1,189%	no	0.542 ± 0.711	1.145 ± 1.782	111%	no
Blue Rockfish	1.159 ± 1.133	1.455 ± 1.591	26%	no	2.179 ± 2.457	1.674 ± 1.649	23%	no
Brown Rockfish	— ± —	— ± —	—	—	— ± —	— ± —	—	—
Canary Rockfish	1.930 ± 2.168	1.348 ± 0.861	30%	no	0.060 ± 0.100	1.306 ± 1.578	2,094%	no
Copper Rockfish	0.194 ± 0.195	0.086 ± 0.079	56%	no	0.115 ± 0.146	0.065 ± 0.077	44%	no
Olive/Yellowtail Rockfish	0.212 ± 0.203	0.171 ± 0.166	19%	no	0.105 ± 0.139	— ± —	N/A	no
Quillback Rockfish	0.193 ± 0.103	0.186 ± 0.100	4%	no	0.046 ± 0.073	0.144 ± 0.169	210%	no
Sebstomus Rockfish	0.334 ± 0.283	0.104 ± 0.129	69%	no	— ± —	— ± —	—	—
Shortbelly Rockfish	— ± —	1.250 ± 3.063	N/A	no	4.576 ± 8.437	— ± —	N/A	no
Small schooling rockfish	0.682 ± 1.067	4.470 ± 10.949	555%	no	3.307 ± 6.250	8.787 ± 18.845	166%	no
Unidentified rockfish	0.608 ± 0.248	0.962 ± 0.491	58%	no	1.625 ± 1.458	0.272 ± 0.305	83%	no
Vermilion Rockfish	0.092 ± 0.144	0.192 ± 0.209	110%	no	0.104 ± 0.168	0.083 ± 0.101	20%	no
Yelloweye Rockfish	0.040 ± 0.062	0.081 ± 0.106	103%	no	— ± —	— ± —	—	—
YOY rockfish	9.967 ± 14.710	16.524 ± 9.736	66%	no	8.985 ± 9.481	20.041 ± 29.205	123%	no
Kelp Greenling	1.363 ± 0.687	0.765 ± 0.354	44%	no	1.349 ± 0.507	1.128 ± 0.426	16%	no
Lingcod	0.737 ± 0.531	1.271 ± 0.510	72%	no	0.428 ± 0.377	0.739 ± 0.584	73%	no
Flatfish	2.017 ± 2.008	2.382 ± 3.347	18%	no	0.303 ± 0.390	0.484 ± 0.372	60%	no

Appendix 5. Continued. Between year comparisons showing initial variability and t-test significance of selected fish mean densities (100 m^2) for rocky reef index site transects (n) at Ten Mile SMR and reference area.

Species	SMR Mean Density (100 m^2) ± 1SD 2014 (n=6)	SMR Mean Density (100 m^2) ± 1SD 2015 (n=6)	SMR Initial Variability	SMR T-test Significance (n=12)	Reference Area Mean Density (100 m^2) ± 1SD 2014 (n=6)	Reference Area Mean Density (100 m^2) ± 1SD 2015 (n=6)	Reference Area Initial Variability	Reference Area T-test Significance (n=12)
Black Rockfish	— ± —	0.017 ± 0.042	N/A	no	— ± —	— ± —	—	—
Blue Rockfish	4.845 ± 5.316	1.755 ± 2.375	64%	no	2.934 ± 2.450	1.244 ± 1.125	58%	no
Brown Rockfish	0.161 ± 0.279	0.121 ± 0.122	25%	no	— ± —	0.017 ± 0.041	N/A	no
Canary Rockfish	1.120 ± 0.832	1.473 ± 1.359	31%	no	0.996 ± 0.904	1.037 ± 0.824	4%	no
Copper Rockfish	0.127 ± 0.076	0.237 ± 0.219	87%	no	0.231 ± 0.268	0.145 ± 0.172	37%	no
Olive/Yellowtail Rockfish	0.981 ± 0.369	1.046 ± 1.422	7%	no	0.711 ± 0.632	0.359 ± 0.301	49%	no
Quillback Rockfish	0.192 ± 0.249	0.189 ± 0.151	1%	no	0.128 ± 0.175	0.163 ± 0.098	27%	no
Sebstomus Rockfish	0.081 ± 0.126	0.203 ± 0.141	150%	no	0.655 ± 0.393	0.979 ± 0.401	50%	no
Shortbelly Rockfish	20.930 ± 51.267	— ± —	N/A	no	— ± —	— ± —	—	—
Small schooling rockfish	67.841 ± 140.778	— ± —	N/A	no	0.090 ± 0.220	1.605 ± 2.547	1,685%	no
Unidentified rockfish	2.935 ± 1.260	0.912 ± 0.553	69%	yes, P=0.0048	2.034 ± 1.037	0.439 ± 0.175	78%	yes, P=0.0040
Vermilion Rockfish	0.107 ± 0.097	0.101 ± 0.170	6%	no	0.172 ± 0.242	0.092 ± 0.082	46%	no
Yelloweye Rockfish	— ± —	— ± —	—	—	— ± —	— ± —	—	—
YOY rockfish	241.088 ± 325.742	109.679 ± 147.566	55%	no	285.733 ± 479.563	15.064 ± 8.892	95%	no
Kelp Greenling	1.036 ± 0.451	0.842 ± 0.606	19%	no	0.545 ± 0.376	0.908 ± 0.331	67%	no
Lingcod	0.985 ± 0.532	2.046 ± 1.233	108%	no	1.104 ± 0.476	1.706 ± 0.822	55%	no
Flatfish	0.566 ± 0.495	2.054 ± 1.265	263%	yes, P=0.0229	0.121 ± 0.243	0.159 ± 0.184	32%	no

APPENDIX 6. Rocky Reef Invertebrates - Between Year Comparisons by Study Location.

Between year comparisons showing initial variability and t-test significance of selected invertebrate mean densities (100 m^2) for rocky reef index site transects (n) at Point St. George SMCA and reference area.

Species	SMCA: Mean Density ($100m^2$) ± 1SD, 2014 (n=6)	SMCA: 2015 (n=6)	SMCA: Initial Variability	SMCA: T-test Significance (n=12)	Reference Area: Mean Density ($100m^2$) ± 1SD, 2014 (n=6)	Reference Area: 2015 (n=0)	Reference Area: Initial Variability	Reference Area: T-test Significance
Basket star	4.822 ± 2.100	4.941 ± 1.565	2%	no	0.219 ± 0.399	— ± —	—	—
California hydrocoral	— ± —	— ± —	—	—	0.680 ± 0.765	— ± —	—	—
California sea cucumber	25.627 ± 5.572	21.236 ± 3.439	17%	no	45.083 ± 10.923	— ± —	—	—
Cushion star	0.265 ± 0.161	0.051 ± 0.125	81%	yes, P=0.0276	0.269 ± 0.194	— ± —	—	—
Fish eating star	1.148 ± 0.882	0.106 ± 0.130	91%	yes, P=0.0168	0.554 ± 0.493	— ± —	—	—
Henricia complex	0.516 ± 0.499	0.400 ± 0.320	22%	no	0.738 ± 0.415	— ± —	—	—
Leather star	0.062 ± 0.097	0.264 ± 0.185	323%	yes, P=0.0400	0.378 ± 0.330	— ± —	—	—
Rainbow star	— ± —	— ± —	—	—	0.186 ± 0.237	— ± —	—	—
Red sea star	3.402 ± 1.440	1.037 ± 0.511	70%	yes, P=0.0035	3.418 ± 3.251	— ± —	—	—
Red sea urchin	0.070 ± 0.109	— ± —	N/A	no	0.000 ± 0.000	— ± —	—	—
Short red gorgonian	26.812 ± 12.072	13.256 ± 8.761	51%	no	9.070 ± 10.529	— ± —	—	—
Short spined sea star	0.227 ± 0.147	— ± —	N/A	yes, P=0.0035	0.426 ± 0.128	— ± —	—	—
Slipper sea cucumber	37.245 ± 10.739	24.038 ± 11.662	35%	no	52.344 ± 17.207	— ± —	—	—
Spiny/thorny star complex	0.100 ± 0.110	— ± —	N/A	yes, P=0.0496	0.027 ± 0.066	— ± —	—	—
Stimpson's sun star	— ± —	— ± —	—	—	0.189 ± 0.189	— ± —	—	—
Sunflower star	0.265 ± 0.161	— ± —	N/A	yes, P=0.0024	0.244 ± 0.177	— ± —	—	—
White branched cucumber	2.708 ± 2.050	0.112 ± 0.201	96%	yes, P=0.0115	0.692 ± 0.458	— ± —	—	—
White-plumed anemone	67.274 ± 34.211	63.057 ± 46.611	6%	no	28.302 22.874	— ± —	—	—

Appendix 6. Continued. Between year comparisons showing initial variability and t-test significance of selected invertebrate mean densities (100 m^2) for rocky reef index site transects (n) at Reading Rock SMR and reference area.

Species	SMR				Reference Area			
	Mean Density (100m^2) ± 1SD		Initial Variability	T-test Significance (n=12)	Mean Density (100m^2) ± 1SD		Initial Variability	T-test Significance (n=12)
	2014 (n=6)	2015 (n=6)			2014 (n=6)	2015 (n=6)		
Basket star	— ± —	— ± —	—	—	— ± —	— ± —	—	—
California hydrocoral	— ± —	— ± —	—	—	— ± —	— ± —	—	—
California sea cucumber	29.478 ± 5.887	40.146 ± 6.813	36%	yes, P=0.0158	35.256 ± 5.494	28.408 ± 9.281	19%	no
Cushion star	0.994 ± 0.270	0.151 ± 0.138	85%	yes, P=0.00004	1.033 ± 0.562	0.156 ± 0.245	85%	yes, P=0.0056
Fish eating star	1.420 ± 0.857	0.029 ± 0.072	98%	yes, P=0.0027	0.623 ± 0.769	0.024 ± 0.060	96%	no
Henricia complex	4.258 ± 1.420	4.684 ± 2.006	10%	no	6.062 ± 3.333	5.602 ± 2.280	8%	no
Leather star	0.234 ± 0.320	0.328 ± 0.268	40%	no	0.250 ± 0.409	0.153 ± 0.165	39%	no
Rainbow star	0.464 ± 0.487	0.029 ± 0.072	94%	no	0.301 ± 0.172	— ± —	N/A	yes, P=0.0016
Red sea star	9.116 ± 5.682	3.063 ± 1.936	66%	yes, P=0.0331	20.115 ± 4.742	8.441 ± 1.304	58%	yes, P=0.0001
Red sea urchin	0.056 ± 0.138	— ± —	N/A	no	— ± —	— ± —	—	no
Short red gorgonian	— ± —	— ± —	—	—	0.174 ± 0.177	0.414 ± 0.648	138%	no
Short spined sea star	— ± —	— ± —	—	—	0.051 ± 0.079	— ± —	N/A	no
Slipper sea cucumber	32.843 ± 20.343	31.175 ± 13.565	5%	no	211.649 ± 190.875	147.952 ± 112.378	30%	no
Spiny/thorny star complex	0.085 ± 0.132	0.029 ± 0.072	65%	no	0.174 ± 0.290	0.050 ± 0.123	71%	no
Stimpson's sun star	0.668 ± 0.458	0.033 ± 0.080	95%	yes, P=0.0074	0.194 ± 0.174	0.049 ± 0.119	75%	no
Sunflower star	0.040 ± 0.097	— ± —	N/A	no	0.025 ± 0.060	— ± —	N/A	no
White branched cucumber	— ± —	2.065 ± 1.558	N/A	yes P=0.0087	10.921 ± 12.098	6.711 ± 7.865	39%	no
White-plumed anemone	10.097 ± 8.677	15.809 ± 21.340	57%	no	4.562 ± 5.033	4.237 ± 2.618	7%	no

Appendix 6. Continued. Between year comparisons showing initial variability and t-test significance of selected invertebrate mean densities (100 m^2) for rocky reef index site transects (n) at Mattole Canyon SMR and reference area.

	SMR				Reference Area			
	Mean Density ($100m^2$) ± 1SD			T-test	Mean Density ($100m^2$) ± 1SD			T-test
Species	2014 (n=6)	2015 (n=6)	Initial Variability	Significance (n=12)	2014 (n=6)	2015 (n=6)	Initial Variability	Significance (n=12)
Basket star	1.851 ± 1.179	1.246 ± 1.089	33%	no	0.028 ± 0.068	0.046 ± 0.071	66%	no
California hydrocoral	29.210 ± 27.246	14.050 ± 15.281	52%	no	13.174 ± 9.058	4.679 ± 4.804	64%	no
California sea cucumber	18.353 ± 6.730	19.491 ± 4.727	6%	no	6.660 ± 7.512	12.601 ± 14.146	89%	no
Cushion star	0.139 ± 0.194	0.048 ± 0.075	65%	no	0.137 ± 0.274	— ± —	N/A	no
Fish eating star	0.155 ± 0.228	0.099 ± 0.122	36%	no	0.112 ± 0.202	0.159 ± 0.202	42%	no
Henricia complex	1.382 ± 0.562	2.350 ± 1.375	70%	no	1.452 ± 0.995	1.233 ± 0.506	15%	no
Leather star	0.818 ± 0.652	0.543 ± 0.372	34%	no	0.580 ± 0.420	0.848 ± 0.585	46%	no
Rainbow star	0.053 ± 0.083	— ± —	N/A	no	0.084 ± 0.140	— ± —	N/A	no
Red sea star	1.408 ± 1.284	0.526 ± 0.371	63%	no	0.842 ± 0.875	0.390 ± 0.281	54%	no
Red sea urchin	0.301 ± 0.456	3.127 ± 2.843	940%	no	5.619 ± 11.712	10.270 ± 11.793	83%	no
Short red gorgonian	47.809 ± 15.928	34.355 ± 16.044	28%	no	20.240 ± 15.983	21.299 ± 19.713	5%	no
Short spined sea star	0.078 ± 0.127	— ± —	N/A	no	0.049 ± 0.076	0.022 ± 0.053	56%	no
Slipper sea cucumber	— ± —	— ± —	—	—	0.085 ± 0.208	— ± —	N/A	no
Spiny/thorny star complex	0.170 ± 0.283	0.051 ± 0.080	70%	no	— ± —	0.023 ± 0.056	N/A	no
Stimpson's sun star	0.025 ± 0.060	0.090 ± 0.107	266%	no	0.194 ± 0.198	0.023 ± 0.056	88%	no
Sunflower star	— ± —	— ± —	—	—	— ± —	0.024 ± 0.058	N/A	no
White branched cucumber	— ± —	— ± —	—	—	— ± —	— ± —	—	—
White-plumed anemone	26.103 ± 12.280	19.142 ± 6.000	27%	no	11.613 ± 13.318	11.080 ± 11.516	5%	no

Appendix 6. Continued. Between year comparisons showing initial variability and t-test significance of selected invertebrate mean densities (100 m^2) for rocky reef index site transects (n) at Ten Mile SMR and reference area.

Species	SMR				Reference Area			
	Mean Density ($100m^2$) ± 1SD			T-test	Mean Density ($100m^2$) ± 1SD			T-test
	2014 (n=6)	2015 (n=6)	Initial Variability	Significance (n=12)	2014 (n=6)	2015 (n=6)	Initial Variability	Significance (n=12)
Basket star	0.034 ± 0.083	— ± —	N/A	no	0.029 ± 0.070	— ± —	N/A	no
California hydrocoral	— ± —	— ± —	—	—	— ± —	— ± —	—	—
California sea cucumber	40.775 ± 19.007	23.755 ± 11.690	42%	no	40.686 ± 3.914	23.491 ± 8.584	42%	yes, P=0.0012
Cushion star	0.034 ± 0.083	— ± —	N/A	no	0.052 ± 0.081	— ± —	N/A	no
Fish eating star	0.120 ± 0.145	— ± —	N/A	no	0.029 ± 0.070	— ± —	N/A	no
Henricia complex	0.918 ± 0.295	0.603 ± 0.396	34%	no	2.174 ± 0.653	1.351 ± 0.727	38%	no
Leather star	1.094 ± 0.538	0.659 ± 0.414	40%	no	0.865 ± 0.559	0.689 ± 0.257	20%	no
Rainbow star	0.063 ± 0.098	0.024 ± 0.059	62%	no	0.212 ± 0.220	— ± —	N/A	yes, P=0.0397
Red sea star	4.502 ± 2.380	1.576 ± 0.866	65%	yes, P=0.0178	13.180 ± 3.893	4.962 ± 1.654	62%	yes, P=0.0008
Red sea urchin	— ± —	— ± —	—	—	— ± —	— ± —	—	—
Short red gorgonian	6.633 ± 8.957	2.328 ± 2.870	65%	no	2.657 ± 2.225	0.608 ± 0.547	77%	no
Short spined sea star	0.029 ± 0.071	— ± —	N/A	no	— ± —	— ± —	—	—
Slipper sea cucumber	18.879 ± 15.252	— ± —	N/A	yes, P=0.0126	27.433 ± 12.011	— ± —	N/A	yes, P=0.0002
Spiny/thorny star complex	0.059 ± 0.091	— ± —	N/A	no	0.106 ± 0.127	— ± —	N/A	no
Stimpson's sun star	— ± —	— ± —	—	—	0.025 ± 0.062	— ± —	N/A	no
Sunflower star	— ± —	— ± —	—	—	0.027 ± 0.065	— ± —	N/A	no
White branched cucumber	0.310 ± 0.486	— ± —	N/A	no	0.612 ± 0.335	— ± —	N/A	yes, P=0.0012
White-plumed anemone	35.935 ± 14.227	17.693 ± 13.995	51%	yes, P=0.0491	11.040 ± 4.436	6.474 ± 2.956	41%	no

APPENDIX 7. Soft Bottom Fish - Between Year Comparisons by Study Location.

Between year comparisons showing initial variability of selected fish mean densities (100 m^2) for soft bottom habitat transects (n) at Point St. George SMCA and reference area.

Species	SMCA Mean Density (100m^2) ± 1SD 2014 (n=2)			SMCA 2015 (n=2)			SMCA Initial Variability	Reference Area Mean Density (100m^2) ± 1SD 2014 (n=3)			Reference Area 2015 (n=1)			Reference Area Initial Variability
Combfish complex	0.749	±	1.060	—	±	—	N/A	0.021	±	0.036	0.061	±	—	193%
Dover Sole	—	±	—	—	±	—	—	0.025	±	0.043	—	±	—	N/A
English sole	—	±	—	0.030	±	0.042	N/A	0.062	±	0.107	—	±	—	N/A
Lingcod	0.044	±	0.062	0.247	±	0.349	459%	—	±	—	0.121	±	—	N/A
Pacific Hake	—	±	—	—	±	—	—	0.047	±	0.041	—	±	—	N/A
Petrale Sole	—	±	—	0.125	±	0.077	N/A	—	±	—	—	±	—	—
Rex Sole	0.044	±	0.062	0.502	±	0.286	1,039%	0.118	±	0.093	0.726	±	—	518%
UI cod	—	±	—	—	±	—	—	0.022	±	0.038	—	±	—	N/A
UI eel pout	4.452	±	6.296	—	±	—	N/A	3.903	±	5.512	—	±	—	N/A
UI flatfish	6.281	±	1.715	2.953	±	1.801	53%	3.682	±	2.329	—	±	—	N/A
UI sanddab	—	±	—	0.648	±	0.578	N/A	—	±	—	1.453	±	—	N/A
UI small benthic fish	—	±	—	0.180	±	0.254	N/A	—	±	—	1.211	±	—	N/A
UI smelt	—	±	—	—	±	—	—	—	±	—	—	±	—	—

Appendix 7. Continued. Between year comparisons showing initial variability of selected fish mean densities (100 m^2) for soft bottom habitat transects (n) at Reading Rock SMR and reference area.

Species	SMR							Reference Area						
	Mean Density (100m^2) ± 1SD							Mean Density (100m^2) ± 1SD						
	2014 (n=2)			2015 (n=2)			Initial Variability	2014 (n=2)			2015 (n=2)			Initial Variability
Combfish complex	—	±	—	—	±	—	—	—	±	—	—	±	—	—
Dover Sole	0.048	±	0.068	—	±	—	N/A	—	±	—	—	±	—	—
English Sole	0.280	±	0.125	0.088	±	0.051	69%	0.134	±	0.068	0.045	±	0.064	66%
Lingcod	0.048	±	0.068	0.118	±	0.094	147%	0.043	±	0.061	0.272	±	0.385	532%
Pacific Hake	—	±	—	—	±	—	—	—	±	—	—	±	—	—
Petrale Sole	0.048	±	0.068	0.118	±	0.094	147%	0.043	±	0.061	0.091	±	0.128	111%
Rex Sole	0.234	±	0.060	0.129	±	0.183	45%	0.046	±	0.064	0.091	±	0.128	99%
UI cod	—	±	—	0.026	±	0.037	N/A	0.089	±	0.004	—	±	—	N/A
UI eel pout	0.092	±	0.130	—	±	—	N/A	0.043	±	0.061	—	±	—	N/A
UI flatfish	15.309	±	3.290	4.464	±	5.528	71%	8.723	±	6.485	4.030	±	5.469	54%
UI sanddab	—	±	—	0.429	±	0.344	N/A	—	±	—	0.091	±	0.128	N/A
UI small benthic fish	—	±	—	0.026	±	0.037	N/A	—	±	—	—	±	—	—
UI smelt	53.763	±	52.854	109.594	±	85.393	104%	37.025	±	52.362	21.122	±	11.900	43%

Appendix 7. Continued. Between year comparisons showing initial variability of selected fish mean densities (100 m^2) for soft bottom habitat transects (n) at Mattole Canyon SMR and reference area.

Species	SMR							Reference Area						
	Mean Density (100m^2) ± 1SD							Mean Density (100m^2) ± 1SD						
	2014 (n=2)			2015 (n=1)			Initial Variability	2014 (n=2)			2015 (n=0)			Initial Variability
Combfish complex	0.041	±	0.058	—	±	—	N/A	—	±	—	—	±	—	—
Dover Sole	—	±	—	—	±	—	—	—	±	—	—	±	—	—
English Sole	—	±	—	0.141	±	—	N/A	—	±	—	—	±	—	—
Lingcod	0.418	±	0.330	1.406	±	—	2.364	0.042	±	0.060	—	±	—	—
Pacific Hake	—	±	—	—	±	—	—	—	±	—	—	±	—	—
Petrale Sole	—	±	—	0.352	±	—	N/A	—	±	—	—	±	—	—
Rex Sole	—	±	—	—	±	—	—	—	±	—	—	±	—	—
UI cod	—	±	—	—	±	—	—	—	±	—	—	±	—	—
UI eel pout	—	±	—	—	±	—	—	—	±	—	—	±	—	—
UI flatfish	6.667	±	3.905	9.210	±	—	0.381	1.263	±	0.361	—	±	—	—
UI sanddab	—	±	—	0.984	±	—	N/A	—	±	—	—	±	—	—
UI small benthic fish	—	±	—	0.352	±	—	N/A	—	±	—	—	±	—	—
UI smelt	—	±	—	—	±	—	—	—	±	—	—	±	—	—

Appendix 7. Continued. Between year comparisons showing initial variability of selected fish mean densities (100 m^2) for soft bottom habitat transects (n) at Ten Mile SMR and reference area.

	SMR							Reference Area						
	Mean Density (100m^2) ± 1SD							Mean Density (100m^2) ± 1SD						
Species	2014 (n=2)			2015 (n=2)			Initial Variability	2014 (n=2)			2015 (n=2)			Initial Variability
Combfish complex	—	±	—	0.287	±	0.074	N/A	0.044	±	0.062	—	±	—	N/A
Dover Sole	—	±	—	0.113	±	0.160	N/A	—	±	—	—	±	—	N/A
English Sole	—	±	—	0.080	±	0.047	N/A	—	±	—	0.021	±	0.030	N/A
Lingcod	0.041	±	0.057	0.377	±	0.267	830%	0.087	±	0.123	0.233	±	0.211	168%
Pacific Hake	0.243	±	0.344	—	±	—	N/A	0.087	±	0.123	—	±	—	N/A
Petrale Sole	—	±	—	0.170	±	0.240	N/A	—	±	—	0.021	±	0.030	N/A
Rex Sole	—	±	—	0.057	±	0.080	N/A	—	±	—	—	±	—	—
UI cod	0.527	±	0.745	—	±	—	N/A	0.435	±	0.615	—	±	—	—
UI eel pout	1.094	±	1.547	—	±	—	N/A	0.218	±	0.308	—	±	—	N/A
UI flatfish	5.509	±	5.157	4.736	±	1.062	14%	1.432	±	0.067	3.212	±	0.368	124%
UI sanddab	—	±	—	0.831	±	0.615	N/A	—	±	—	0.042	±	0.059	N/A
UI small benthic fish	—	±	—	0.372	±	0.194	—	—	±	—	0.063	±	0.089	N/A
UI smelt	1.377	±	1.948	—	±	—	N/A	2.132	±	3.014	18.529	±	26.203	769%

APPENDIX 8. Soft Bottom Invertebrates - Between Year Comparisons by Study Location.

Between year comparisons showing initial variability of selected invertebrate mean densities (100 m^2) for soft bottom habitat transects (n) at Point St. George SMCA and reference area.

Species	SMCA							Reference Area						
	Mean Density (100m^2) ± 1SD							Mean Density (100m^2) ± 1SD						
	2014 (n=2)			2015 (n=2)			Initial Variability	2014 (n=3)			2015 (n=1)			Initial Variabilit
Dungeness crab	1.381	±	1.953	0.549	±	0.776	60%	1.925	±	2.406	0.257	±	—	87%
Orange sea pen	0.046	±	0.065	—	±	—	N/A	—	±	—	—	±	—	—
Pleurobranchaea californica	0.062	±	0.088	1.001	±	0.146	1,504%	—	±	—	1.372	±	—	N/A
Red octopus	5.370	±	7.595	0.235	±	0.092	96%	4.867	±	4.803	1.287	±	—	74%
Sand star	0.171	±	0.112	0.475	±	0.530	178%	0.100	±	0.107	0.257	±	—	157%
Sand-rose anemone	0.125	±	0.177	0.042	±	0.060	66%	—	±	—	—	±	—	—
Sea whip	17.734	±	20.134	6.978	±	2.388	61%	3.530	±	2.739	0.086	±	—	98%
White sea pen	1.357	±	1.789	2.745	±	1.765	102%	23.669	±	13.327	4.631	±	—	80%
White-plumed anemone	0.943	±	0.098	0.796	±	0.285	16%	5.500	±	4.044	1.201	±	—	78%

Appendix 8. Continued. Between year comparisons showing initial variability of selected invertebrate mean densities (100 m^2) for soft bottom habitat transects (n) at Reading Rock SMR and reference area.

Species	SMR							Reference Area						
	Mean Density (100m^2) ± 1SD							Mean Density (100m^2) ± 1SD						
	2014 (n=2)			2015 (n=2)			Initial Variability	2014 (n=2)			2015 (n=2)			Initial Variabilit
Dungeness crab	—	±	—	0.437	±	0.618	N/A	0.122	±	0.173	0.295	±	0.236	142%
Orange sea pen	—	±	—	0.219	±	0.309	N/A	0.061	±	0.086	0.404	±	0.572	562%
Pleurobranchaea californica	0.339	±	0.480	1.156	±	1.264	241%	—	±	—	1.260	±	1.128	N/A
Red octopus	1.999	±	0.245	0.256	±	0.362	87%	1.414	±	1.654	0.450	±	0.636	68%
Sand star	0.264	±	0.181	0.211	±	0.195	20%	0.614	±	0.686	1.022	±	1.282	66%
Sand-rose anemone	0.065	±	0.092	—	±	—	N/A	—	±	—	0.116	±	0.163	N/A
Sea whip	1.440	±	1.653	0.110	±	0.155	92%	1.030	±	1.283	—	±	—	N/A
White sea pen	4.549	±	6.433	16.183	±	22.886	256%	12.616	±	12.728	19.738	±	27.914	56%
White-plumed anemone	8.324	±	9.927	3.564	±	4.176	57%	12.492	±	15.840	5.103	±	4.603	59%

Appendix 8. Continued. Between year comparisons showing initial variability of selected invertebrate mean densities (100 m^2) for soft bottom habitat transects (n) at Mattole Canyon SMR and reference area.

Species	SMR Mean Density (100m^2) ± 1SD 2014 (n=2)			SMR Mean Density (100m^2) ± 1SD 2015 (n=1)			SMR Initial Variability	Reference Area Mean Density (100m^2) ± 1SD 2014 (n=2)			Reference Area Mean Density (100m^2) ± 1SD 2015 (n=0)			Reference Area Initial Variability
Dungeness crab	—	±	—	—	±	—	—	—	±	—	—	±	—	—
Orange sea pen	0.369	±	0.033	—	±	—	—	0.060	±	0.084	—	±	—	—
Pleurobranchaea californica	—	±	—	1.594	±	—	—	—	±	—	—	±	—	—
Red octopus	11.605	±	2.337	0.299	±	—	97%	0.773	±	0.925	—	±	—	—
Sand star	0.254	±	0.196	0.498	±	—	96%	—	±	—	—	±	—	—
Sand-rose anemone	0.854	±	0.097	0.100	±	—	88%	—	±	—	—	±	—	—
Sea whip	—	±	—	—	±	—	—	—	±	—	—	±	—	—
White sea pen	0.196	±	0.278	1.992	±	—	914%	—	±	—	—	±	—	—
White-plumed anemone	120.005	±	151.452	88.716	±	—	26%	1.851	±	2.618	—	±	—	—

Appendix 8. Continued. Between year comparisons showing initial variability of selected invertebrate mean densities (100 m^2) for soft bottom habitat transects (n) at Ten Mile SMR and reference area.

Species	SMR Mean Density (100m^2) ± 1SD 2014 (n=2)			SMR Mean Density (100m^2) ± 1SD 2015 (n=2)			SMR Initial Variability	Reference Area Mean Density (100m^2) ± 1SD 2014 (n=2)			Reference Area Mean Density (100m^2) ± 1SD 2015 (n=2)			Reference Area Initial Variabilit
Dungeness crab	1.094	±	1.385	0.419	±	0.253	62%	1.042	±	1.300	0.305	±	0.322	71%
Orange sea pen	0.162	±	0.096	0.100	±	0.141	38%	—	±	—	0.356	±	0.503	N/A
Pleurobranchaea californica	0.115	±	0.162	0.321	±	0.453	179%	0.308	±	0.436	0.232	±	0.329	25%
Red octopus	5.671	±	7.887	1.469	±	1.889	74%	6.532	±	9.238	3.020	±	4.271	54%
Sand star	1.205	±	1.704	6.606	±	6.524	448%	0.062	±	0.087	1.859	±	2.628	2,916%
Sand-rose anemone	0.381	±	0.273	—	±	—	N/A	0.370	±	0.523	0.155	±	0.219	58%
Sea whip	2.045	±	2.626	1.428	±	1.268	30%	13.804	±	19.522	1.923	±	1.881	86%
White sea pen	0.287	±	0.406	0.521	±	0.737	82%	—	±	—	1.387	±	1.543	N/A
White-plumed anemone	0.115	±	0.162	0.080	±	0.113	30%	0.483	±	0.537	0.039	±	0.055	92%