# Monitoring and Evaluation of Kelp Forest Ecosystems in the MLPA Marine Protected Area Network

A report submitted to:
**California Sea Grant**
**Ocean Protection Council Marine Protected Areas (MPA) Monitoring Program**
**California Department of Fish and Wildlife**
**Marine Resources Division**

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30 December 2021

# EXECUTIVE SUMMARY

*Project Description and Background -* Kelp forest and nearshore rocky reef ecosystems are among the most productive in the world and provide numerous important services to humans. Because of their great productivity, biodiversity, and associated ecosystem services, they were targeted for protection by the MLPA planning process. A consortium of academic monitoring programs and a citizen science program was formed to conduct kelp forest monitoring across the network. The kelp forest monitoring datasets are among the longest time series in California for MPA evaluation and many were established at the time of MPA implementation. These surveys enumerate nearly all of the components of the ecosystem including fishes and invertebrates that are targeted by fishing and those that are not fished. These aspects allowed us to create a framework to test for MPA effects that takes into account the trajectories of species that are expected to be affected by cessation of fishing (Targeted species) and those that are not expected to be directly influenced (Non-targeted species). Using this framework, we can test the effects of cessation of fishing, while controlling for changing environmental conditions independent of MPA effects. The kelp forest monitoring is the only program that can utilize this accurate, albeit strict, test of MPA performance. In addition to the *in situ* ecological monitoring, this program also conducted a) *in situ* environmental monitoring (OAH and water temperature) at select sites throughout California and b) analysis of a long-term, large scale database of remotely-sensed kelp canopy cover.

*Methods* - To quantitatively characterize species size and abundances, the ecological community and geological features at each site, we conduct visual SCUBA diver surveys. From the data recorded by diver surveys, we calculated biomass, density and size frequencies of focal species and species groups, metrics of diversity, community composition, and response ratios (i.e., magnitude of the difference between MPAs and paired Ref sites). We focused this report on 20 MPAs across the state for which we had sufficient time series for analysis. We assessed changes in these metrics over time and across space in four bioregions, along with potential explanatory variables such as MPA attributes and seawater temperature.

*Key Findings*

- MPA effects vary across species, biogeographic regions, MPAs, and time periods. No statewide trends emerged. Analyses at and across regional scales proved more insightful than combined state-wide analyses.
- In general, of those sites with sufficient time series, the strongest population responses were in the Northern Channel Islands MPAs and South Coast MPAs and the weakest in Northern California MPAs (ES Figure 1). However, there was substantial variation in these responses among MPAs within each region (ES Figure 2). These same patterns were also reflected in mean biomass response ratios across years (ES Figure 3)
    - Strong positive responses in the Northern Channel Islands and South Coast MPAs are likely due to moderate to high fishing pressure outside the MPAs and high statistical power to detect responses (i.e., many MPA replicates with good time series).

  - Responses in the Central Coast MPAs were highly variable. Positive responses in this region were found largely in two southernmost MPAs (Pt. Sur and Pt. Buchon).
  - Because the North Coast MPAs are very difficult to access for SCUBA surveys and monitoring has been limited, we found no clear MPA effects in this region. However, environmental disturbance during the monitoring period caused dramatic changes to the kelp forest ecosystem in the region and these large-scale events likely swamped any MPA effects that might have occurred.

Focal species that are heavily fished, particularly those in southern California, tended to show greater responses to protection. These include several species that have been previously documented as responding positively to MPAs (i.e. CA Sheephead, Kelp Bass, California spiny lobster).

We did not detect any influence of MPA design attributes on the response of fishes targeted by fishing across the entire statewide network, whether categorical (e.g., SMR vs. SMCA, clustered or individual MPA) or continuous (e.g., MPA size, distance to port, habitat diversity). We detected large regional variation in species responses and tests of design attributes will best be made within regions. However, within each region, there is not sufficient replication of any categorical design attribute (e.g., SMR vs. SMCA) to statistically test for their effects.

A key variable that should be further considered is fishing mortality at scales relevant to the MPAs. We found no relationship in MPA response with distance to nearest port across all regions, but when comparing MPA responses by the identity of the nearest port, we found that MPAs closest to the four southernmost ports (Morro Bay, Santa Barbara, Channel Islands and San Pedro) showed greater positive MPA responses than those nearest Ft. Bragg, Bodega Bay, and Monterey in northern and central California.

Temporal patterns of diversity and richness differed among regions with the North Coast showing declines, though non-significantly, for all four assemblage types (i.e., fish, algae, invertebrates and UPC organisms) and the Northern Channel Islands and South Coast remaining more stable or increasing over time relative to the Central Coast. These regional patterns of diversity trends across the four assemblages suggest community-wide responses to the 2014-2016 marine heatwave and geographic differences in trophic interactions enabled by the MPAs.

We found a relationship between a simple measure of MPA response over time for species targeted by fisheries and annual patterns of sea surface temperature across the state. Within each region, the relationships, although not significant, were complex. Understanding the effects of both secular change in environmental conditions and extreme events such as heatwaves on MPA performance is a future research area.

Environmental monitoring at select sites throughout California found high coherence in conditions across the North Coast and across the Central Coast but high variability in the South Coast for temperature, pH and $O_2$.

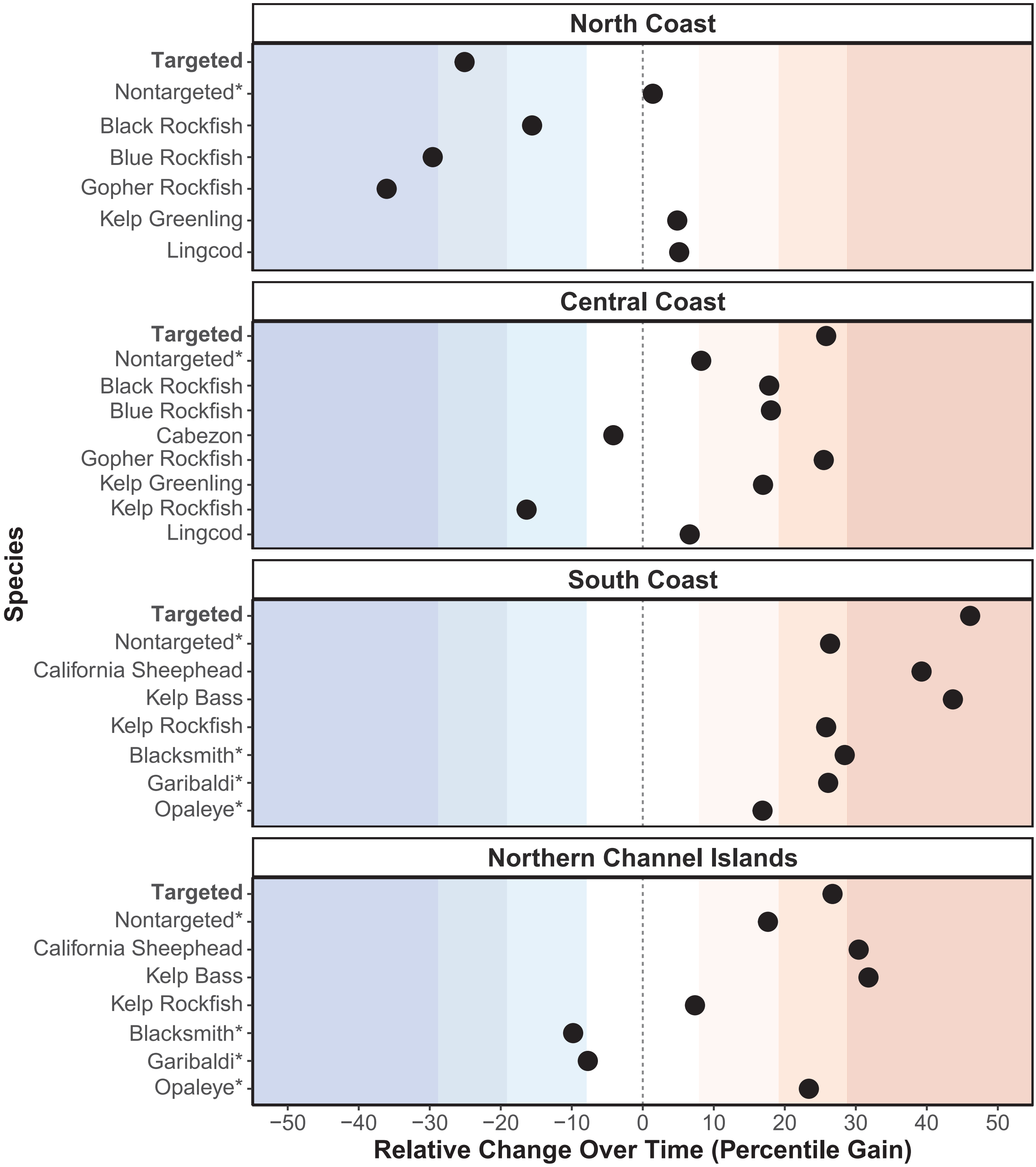
Environmental monitoring was able to measure exposure of MPA sites to potentially stressful pH and dissolved oxygen conditions. Exposure was highest in the North Coast and lowest in the South Coast with Central Coast MPAs intermediate in exposure.

- Kelp canopy monitoring from Landsat remote sensing did not detect a strong effect of MPA protection on average kelp canopy area. However, kelp abundance did appear to exhibit higher resilience on average to the 2014-2016 marine heatwave inside MPAs as compared to reference areas.

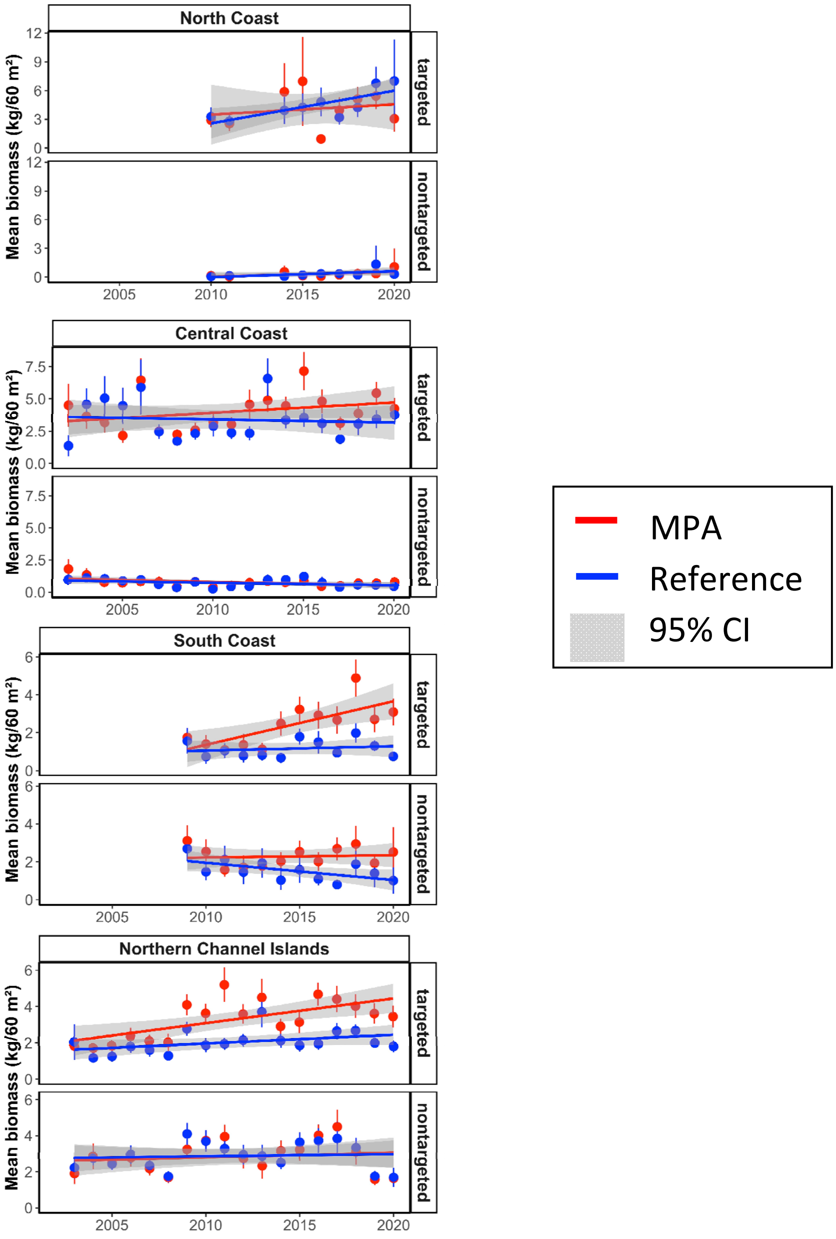
*Key Recommendations*

- **Consider regionally tailored network management.** Although one of the most important design attributes of the MLPA network is its integration across all of California's coastal waters, the results of this study strongly suggest a management program tailored to the regional ecological and human differences across the network may be more effective, efficient and potentially nimble. We found strong geographic differences in MPA responses as well as in data availability, mirroring geographic differences in the magnitude and types of fishing, fisheries management, human densities, stakeholder interests, among others. Potential regional MPA management decisions (e.g., relative levels of monitoring, enforcement, outreach, forms of partnerships between CDFW and types and amount of monitoring) parallel current, regionally-based management of many state fisheries and, as such, may facilitate the integration of MPA and fisheries management.
- **Continue robust long-term monitoring of kelp forest ecosystems and environmental conditions** but make realistic, science-informed decisions about the geographic scale of monitoring and the distribution of sites. Prioritize long-term series and minimize overlapping programs.As ecological and environmental disturbances are predicted to increase in the future with climate change, continued monitoring will become ever more important and serve multiple purposes across dimensions of fisheries management and biodiversity conservation.
- To better understand how fishing shapes populations relative to MPAs, **accurate, spatially explicit fishing data near MPAs** is needed. Consider providing more focused and dedicated resources to the sampling design and analysis of the state's fishing data.
- **Prioritize future research** that builds on the wealth of data from California's MPA network. In particular,
    - More detailed analyses building on the results from this report would be valuable.
    - Promoting research that favors aggregation of existing nearshore OAH observations and develops synergies with ongoing regional modeling efforts should be a high priority.
    - Incorporate LANDSAT and other remote sensing approaches into routine monitoring.
    - New research on seascape composition and spillover would help to contextualize observed MPA responses as CA MPAs mature.
    - New theoretical studies that leverage these empirical data and lay out realistic expectations for how populations should change in MPAs relative to disturbance, recruitment, and other factors known to influence the timing and detection of potential MPA effects.

  This body of research can guide monitoring decisions in the future and also **provide key information for communications to stakeholders as well as managers**.
- **Continue and build on existing partnerships**. In particular, partnerships between CDFW and academic institutions could be strengthened and resource sharing improved towards more cost-effective long-term monitoring.



**ES Figure 1.** Relative change in fish biomass inside and outside of MPAs over time for each region. Relative change (slope) for MPAs and Refs were calculated using Hedges' g and expressed as percentile gain. Positive values mean average change in biomass over time (slope) for a group in MPA sites is higher than average slope in reference sites. Negative values mean the slope in reference sites is higher than average slope in MPA sites. An asterisk after the name or grouping indicates species which are not targeted by fishing. Shading indicates the magnitude of the effect size (or difference between MPA and Refs) with small, medium, and large effect represented by successively darker shading.



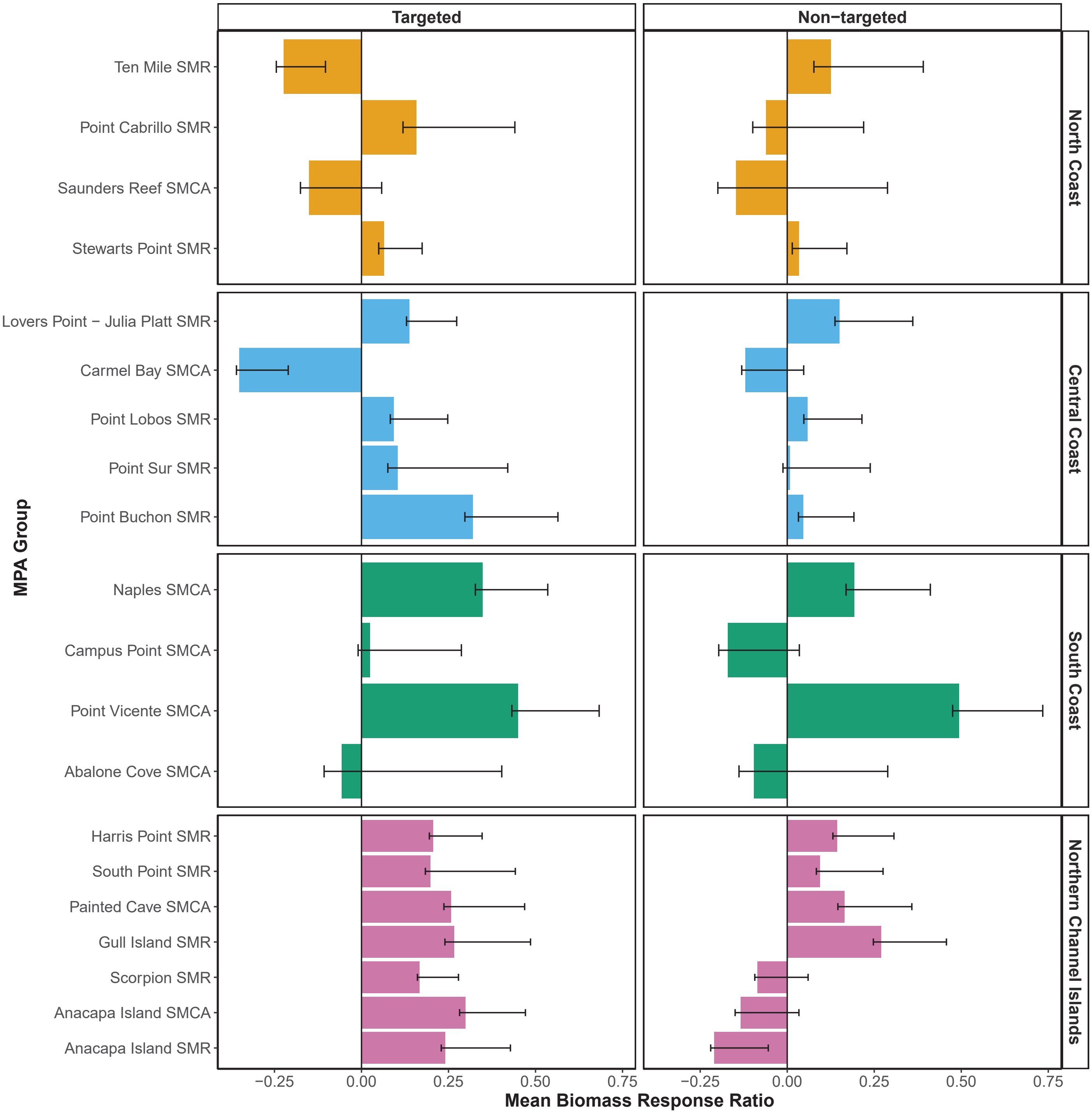
**Baseline years:**
2010-2011 / 2014-2015,
**MPAs established:**
2010 / 2012

**Baseline years:**
2011-2012
**MPAs established:**
2012

**Baseline years:**
2007-2008
**MPAs established:**
2007

**Baseline years:**
2005-2006 **MPAs**
**established:** 2003

**ES Figure 2.** Trajectories of average biomass (kg/60m2) per region for Targeted and Non-targeted fish groups. Data for targeted and non-targeted are divided into two sub-figures with targeted on the top and non-targeted on the bottom. Legend key: Each data point represents average biomass across region within MPA or REF. Error bars on each data point are 95% confidence intervals (CIs) with sites as replicates. Data points are fitted with a regression line (red line = MPA and blue line = REF). Gray shading represents 95% CI for the slope of a regression line.



**ES Figure 3.** Mean biomass response ratio (log (Biomass $_{\text{MPA}}$/Biomass $_{\text{Ref}}$) with standard error over the time series for targeted (left) and non-targeted (right) fishes.

# INTRODUCTION

California's network of marine protected areas (MPAs) were established by the Marine Life Protection Act (MLPA) using guidance of the MLPA Master Plan created during the planning process. Both the MLPA and Master Plan specify that the performance of individual MPAs and the network be evaluated with respect to the Act's six overarching goals. Performance evaluations are meant to inform managers (California Department of Fish and Wildlife [CDFW]), policy makers, and stakeholders of how well the MPA network is achieving the goals of the MLPA and the adaptive management of the network. To this end, CDFW, in collaboration with the California Ocean Protection Council (OPC), developed the MPA Monitoring Action Plan. The MPA Action Plan identified evaluation questions that are linked directly to the goals and objectives of the MLPA. Recently, CDFW and OPC convened the Decadal Evaluation Working Group (DEWG) to provide further guidance for evaluating the MPA network. Together, the Action Plan and DEWG report articulate the evaluation questions that have guided the design and analyses of the MPA monitoring and evaluation studies. In 2018, with administrative support provided by California Sea Grant, CDFW and the OPC funded a number of monitoring and analysis projects to inform the first MLPA decadal evaluation. This report presents the results and interpretation of ongoing long-term monitoring studies designed to address the evaluation questions posed by the Action Plan and DEWG for kelp forest ecosystems across the MLPA network.

Kelp forest and nearshore rocky reef ecosystems are among the most productive in the world and provide numerous important services to humans in the form of recreational and commercial fisheries, shoreline protection, non-consumptive recreational opportunities and maintenance of biodiversity (Smale et al. 2013). Kelps are considered to be a key biogenic habitat, providing habitat and food to a large number of associated species (Graham 2004, Byrnes et al. 2011, Carr and Reed 2016, Castorani et al. 2018, Miller et al. 2018). Kelp forest ecosystems are distributed along the coast of California from the Oregon to Mexican border and all offshore islands. Because of their great productivity, biodiversity, and associated ecosystem services, they were targeted for protection by the MLPA planning process (MLPA Master Plan). The planning process also recognized differences in the species composition and community structure of kelp forests along the coast and this geographic pattern delineating northern (OR border to SF Bay), central (SF Bay to Point Conception), and southern (Point Conception to Mexican border) California "ecoregions" has been characterized by subsequent studies (Carr and Reed 2016, Beas-Luna et al. 2020). As such, the MLPA MPA network distributed MPAs across the three ecoregions to protect the breadth of diversity and functioning of these ecosystems. Most notably, the predominant canopy-forming kelp that is the foundation of these ecosystems is the giant kelp, *Macrocystis pyrifera*, to the south of Monterey Bay and the bull kelp, *Nereocystis luetkeana*, to the north of Monterey Bay (Carr and Reed 2016). These geographic patterns contributed to the regional design and analysis of the kelp forest monitoring program.

To conduct kelp forest monitoring studies across the MLPA network, a consortium of academic monitoring programs and a citizen science program was established. The academic monitoring programs include the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) at the University of California, Santa Barbara and the University of California, Santa Cruz, the Vantuna Research Group (VRG) at Occidental College, and Humboldt State University (HSU). The academic programs rely on a mix of paid academic researchers and student and post-grad volunteers. Reef Check California (RCCA) conducts a citizen science-based monitoring program that relies on a mix of paid staff and volunteer divers. The four academic institutions use the same sampling design and protocols, and the citizen science program uses a derivative of the academic design and protocols (Text Box 1). Other academic (Santa Barbara Channel Long-term Ecological Research program at U.C. Santa Barbara) and federal (Channel Islands National Park) programs conduct long-term kelp forest monitoring based on very different sampling designs and protocols, which are difficult to reconcile with the data used here and are not presented in this report.

In addition to the in situ ecological monitoring conducted by the consortium, the kelp forest program also supported two other related projects. To incorporate an in-situ Ocean acidification and hypoxia (OAH) and water temperature monitoring component, we built upon a field program initiated with previous OPC funding led by Dr. Kristy Kroeker (UCSC) and Dr. Jan Freiwald (RCCA) with engineering support from Dr. Yui Takeshita (MBARI). In addition, to leverage existing and future time series of Landsat imagery of kelp canopy cover, we included Dr. Kyle Cavanaugh (UCLA). These data were used to evaluate responses of the two canopy-forming kelps - giant kelp, *Macrocystis pyrifera*, and the bull kelp, *Nereocystis luetkeana* - to the establishment of MPAs.

The overarching goal of our project is to inform the evaluation and adaptive management of California’s network of MPAs, with a focus on the network review in 2022. Our specific goals and objectives are largely defined by the evaluation questions from the DEWG report that pertain to shallow rocky reef and kelp forest ecosystems. The questions that we address in this report are listed in Text Box 2 below.

The key objectives of this project were to (1) conduct ecological monitoring of kelp forests at select MPAs throughout the coast of California in 2020 and 2021, (2) include a citizen science monitoring component that increases citizen engagement and understanding of MPAs and monitoring studies, (3) create two historic long-term MPA monitoring datasets: one that integrates data across the academic monitoring programs (UCSB, UCSC, VRG, HSU), and another for the RCCA monitoring program. (4) upload these datasets into the DataOne data repository identified by the State, and (5) conduct analyses that characterize ecological responses to MPAs.

## Structure of the report

We first present background on the theory and analytical design of MPA monitoring and evaluation programs that are the basis for the monitoring design and analyses presented in the report. We summarize key geographic patterns of the coastal ocean environment and kelp forests, and characterize the climatic events that have influenced kelp forest ecosystems over the monitoring period. We describe the general design, sampling methods and statistical analyses applied to evaluate many of the questions addressed by the monitoring program. We then present the results of each question addressed from the DEWG evaluation questions (based on the Action Plan), and interpret the results in the context of MPA performance. The report closes with a discussion on the general interpretation of the results, including factors that complicate these interpretations, and recommendations for future evaluation and analysis efforts.

# BACKGROUND

## MPA evaluation theory and analytical frameworks

There is a rich literature on the design of MPA evaluation studies from which recognized criteria for evaluating MPA performance have developed. Nonetheless, the global field of MPA evaluation studies continues to evolve with growing understanding of the complex ecological responses to the establishment of MPAs. We briefly summarize the analytical framework we apply here to clarify the basis of our approach and conclusions of MPA performance. The overarching goal of evaluation analyses is to accurately attribute observed ecological responses (e.g. changes in species populations, communities and ecosystems) to the establishment of an MPA, controlling or accounting for the many other environmental, ecological and anthropogenic factors that simultaneously influence these responses. Therefore, the design of monitoring programs emulates large-scale field experiments similarly intended to test hypotheses that infer causal effects of MPAs on the variety of response variables (performance metrics) directly linked to the goals and objectives of the MPA.

One preferred design of a monitoring program to evaluate MPA performance involves monitoring some performance metric (e.g. fish density or biomass) at multiple replicate MPAs and paired reference sites, prior to and after the establishment of the MPAs. However, across the CA network, few MPA sites have been monitored prior to the establishment of an MPA. Rather, as is the case for most MPAs around the world, kelp forest monitoring was initiated at or soon after the establishment of the MPA (the “baseline”) with the assumption that the state of the response variable is comparable to its state prior to MPA establishment. The trajectory of the response variable through time is compared with ‘natural controls’ (sites outside of the MPA) with the assumption that these ‘reference’ sites are of somewhat similar ecological and environmental conditions as those found within the MPA and also reflect past states of the response variable at those sites. Another key assumption of reference sites is that they are subjected to and reflect rates of fishing mortality of targeted species in areas of the network outside of the MPAs.

As illustrated graphically in Figure 1, for species targeted by fisheries (hereafter ‘Targeted’), the trajectories of the means of a given response variable (e.g. density, biomass, length) in the MPA and the Reference sites (hereafter ‘Ref’) are predicted to initially diverge from one another. If the site was fished prior to MPA establishment, the divergence should reflect the reduced fishing mortality at the MPA relative to continued fishing mortality at the Ref (Figure 1A). Subsequently, if the abundance of a Targeted species grows to the carrying capacity of the MPA, the differences between the MPA and Ref will no longer diverge and can begin to converge with the eventual movement of individuals from the MPA to the Ref (‘spillover’). If instead the MPA and Ref were not fished prior to MPA establishment, divergence is predicted only if and when new fishing mortality is initiated at Ref sites relative to the MPA (Figure 1B). Eventually, with continued fishing effort, the MPA and Ref populations will stabilize and no longer diverge.

Thus, this divergence in trends of Targeted species inside and outside of MPAs is a key prediction in support of MPA performance. In addition, the response of Targeted species and those not targeted by fisheries (hereafter ‘Non-targeted’) are predicted to diverge over time inside the MPAs as well, reflecting differences in their response to the reduced fishing mortality. It is assumed that Non-targeted species will reflect any changes in the environment similarly inside and outside the MPA, while Targeted species will reflect changes in fishing mortality.

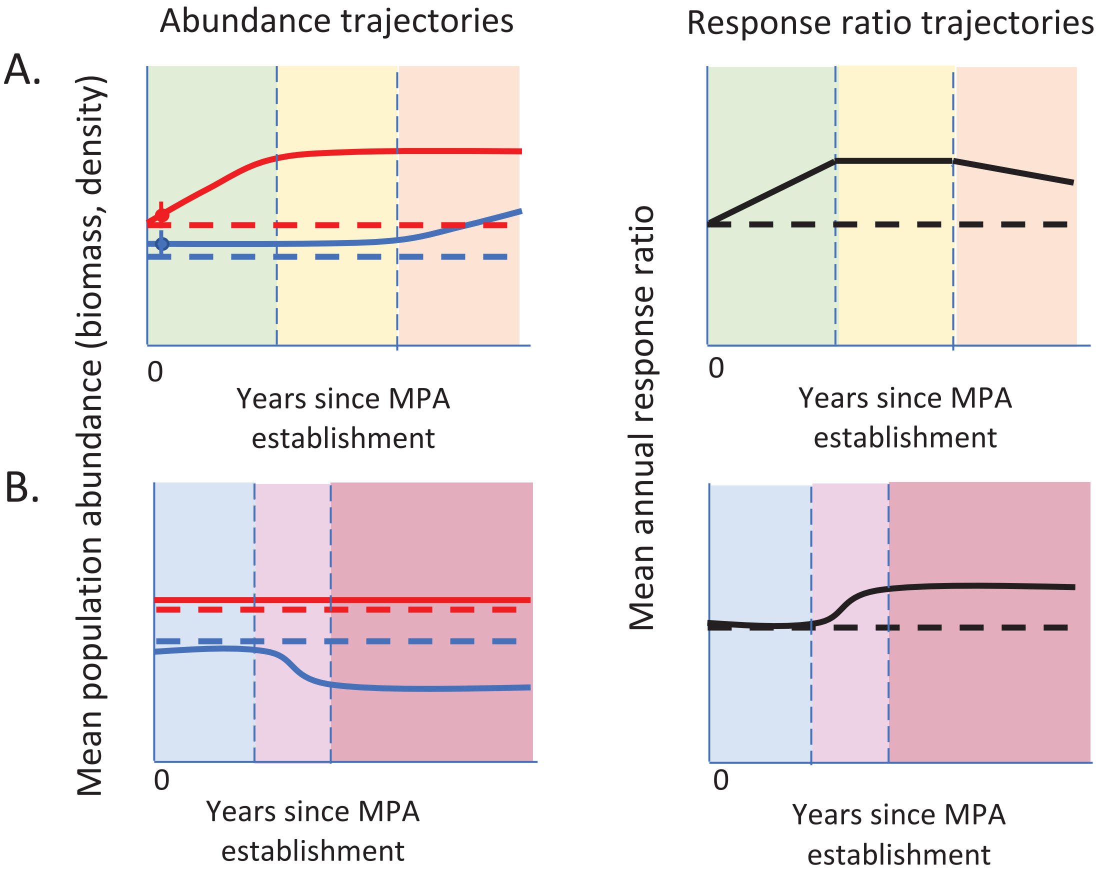


**Figure 1.** Predicted responses of fished (targeted) and non-fished (non-targeted) species inside and outside of MPAs over years since establishment (left to right) of an MPA.

**Scenario A** Fished populations (solid lines) at MPA (red) and reference sites (blue) are subjected to comparable fishing levels prior to MPA establishment. Subsequent to MPA establishment, mean population abundance (biomass , density) of fished species increases in MPAs with reduced rates of fishing mortality while fished populations at reference sites continue to experience fishing pressure (green region), fished populations in MPA achieve carrying capacity while fished populations in reference sites continue to experience fishing mortality (yellow region), and fished populations within MPA continue at carrying capacity while populations at reference sites increase in response to ‘spillover’ (orange region). Response ratios of fished species increase (black line) while differences in abundances diverge between MPA and reference sites (green area), level when populations in MPAs achieve carrying capacity (yellow region), and decrease as population abundance in MPAs and reference sites converge. Mean abundances of non-fished species (dashed lines) remain “constant” over time both in MPAs and at reference sites, as do their response ratios.

**Scenario B** Fished populations (solid lines) within MPAs and reference sites experience comparable rates of fishing mortality prior to and just after establishment of MPA (blue region). Subsequent onset of fishing outside MPAs causes fishing mortality to increase at reference sites while populations within MPAs continue to experience little fishing mortality (pink region). Population abundances of fished species outside MPAs subsequently level at new population equilibrium (maroon region). Response ratios of fished species remain ‘constant’ while comparable rates of fishing mortality continue inside and outside MPAs (blue region), then increase with onset and continued greater rates of fishing mortality in reference sites (pink region), and level when fished populations outside MPAs level at new population equilibrium (maroon region). Mean abundances of non-fished species (dashed lines) remain ‘constant’ over time both in MPAs and at reference sites, as do their response ratios.

Thus, Non-targeted species are assumed to act as controls for changing environmental conditions independent of MPA effects. Therefore, the most robust inference of an MPA effect occurs both when (i) the response of Targeted species diverges inside and outside the MPA, (ii) Targeted species diverge from Non-targeted species within the MPA, and (iii) Non-targeted species exhibit similar trajectories inside and outside of the MPA. These predictions assume that Ref areas are representative of fishing mortality rates outside of MPAs, differences between Targeted and Non-targeted species responses only reflect their differences in changes to fishing mortality, and that populations inside and outside of MPAs are still in a period of predicted divergence. The quantitative metrics and statistical analyses to assess these responses are described in the analyses section below.

## Accounting for environmental and ecological influencing factors

### *Geographic variation*

California's network of MPAs and kelp forests are distributed across two well-recognized biogeographic regions, each of which encompass smaller "ecoregions" distinguished by persistent differences in ocean temperatures and species composition (Briggs, 1974, Horn et al. 2006, Blanchette et al. 2008). The San Diegan Province extends from the southern end of the Baja California peninsula, Mexico, north to Point Conception, United States. The Oregonian Province extends from Point Conception to the northern end of Vancouver Island, Canada. The Oregonian region includes a "Montereyan Pacific Transition" zone that is further delineated into a Central California (CenCA) ecoregion extending from Point Conception to Pigeon Point, CA, and a Northern California (NorCA) ecoregion that extends from Pigeon Point to just above Point Mendocino. In addition to persistent differences in oceanographic conditions (e.g., water temperature, coastal upwelling), the coastal geomorphology varies among provinces and ecoregions. These geomorphological differences include the width of the continental shelf (and coastal upwelling), the exposure of the shoreline to ocean swell, the steepness of subtidal rocky reefs, turbidity, and the composition, vertical relief and rugosity of the rocky reef substratum. Separately and in combination, these oceanographic and geomorphological features generate persistent geographic patterns of the community structure and dynamics of kelp forest ecosystems (Carr and Reed 2016, Beas-Luna et al. 2020). These influences are especially evident between the Northern Channel Island archipelago and the mainland, and across the archipelago. These geographic differences must be accounted for in the monitoring design, analyses, and evaluation of MPA performance (Hamilton et al. 2010). Generally, the regions of the MPA Action Plan correspond with this geographic variation, however, geographic variation in each of the ecosystems targeted by the monitoring program exhibit differences in their finer scale variation (e.g., Northern Channel Island archipelago and the mainland). Therefore, we analyze MPA performance at two scales: individual MPAs and multiple MPAs within ecoregions. Our approach to defining the geographic variation of kelp forest communities is described in the Methods section.

### *Ecological and climatic perturbations*

Kelp forests across the MLPA network were subjected to two unprecedented perturbations that influenced kelp forest species and ecosystems over the monitoring period. Sea star wasting disease (SSWD) spread along the California coast in 2013, resulting in dramatic declines in several species of sea stars. Mortality rates of the giant sunflower star, *Pycnopodia* *helianthoides*, led to regional near-extinction in shallow rocky reefs and kelp forests along the entire coast of California (Rogers-Bennett and Catton 2019, Harvell et al. 2019, Beas-Luna et al. 2020, McPherson et al. 2021, Gravem et al. 2021). *Pycnopodia* abundances remain at near-zero levels along California to this day. Onset of the SSWD was immediately followed by the 2014-16 North Pacific Marine Heatwave.

The 2014–2016 North Pacific Marine Heatwave (MHW) persisted for almost two years, with temperatures reaching 3 standard deviations above average in the northeast Pacific (Bond et al., 2015). The MHW was the consequence of two environmental anomalies, the 2014–2015 ocean temperature anomaly, known as “the Blob”, and the 2015–2016 El Niño Southern Oscillation (ENSO) event (Bond et al., 2015, Di Lorenzo and Mantua, 2016; Gentemann et al., 2017). Water temperature in southern California reached 5ºC above average (Zaba and Rudnick, 2016). One fundamental consequence of increased water temperatures is the reduced nitrate content of coastal upwelled waters (Jacox et al., 2018b). Increases in water temperature and associated declines in nitrate levels both impair the productivity of kelps. With reduced productivity and production of kelp blades, which litter the forest floor, purple sea urchins began foraging on live kelps and other macroalgae, creating “urchin barrens” devoid of macroalgae in central (Smith et al. 2021) and northern (McPherson et al. 2021) California. Over 90% of bull kelp beds were lost along the north coast of California, and massive areas of giant kelp forests shifted to urchin barrens in central California (Rogers-Bennett and Catton 2019, McPherson et al. 2021, Smith et al. 2021). As described in this report, these dramatic shifts from forested to barren states led to marked changes in kelp forest communities in northern and central kelp forests, making the evaluation of MPA performance based on population and community trajectories in time more difficult.

## *MPA attributes*

The MLPA planning process created MPAs of varying levels of protection to species and ecosystems based on allowable activities within each MPA. For the purposes of this evaluation program, two MPA categories are especially relevant. State Marine Reserves (SMR) allow access but prohibit take of any kind, including impacts to the seafloor. State Marine Conservation Areas (SMCA) allow the take of particular species. SMCAs vary greatly in allowed take. Some SMCAs allow all recreational take of finfishes, whereas others only allow the take of specific species (e.g. salmon, pelagic species, lobster). Those SMCAs that allow take of species that interact little with kelp forest ecosystems can afford levels of protection for kelp forests equivalent to SMRs. We have identified those SMCAs and consider them “de facto SMRs” for analyses that consider the relative effects of SMR and SMCAs on ecological responses. In doing so, there are very few SMCAs that allow kelp forest fish fishing and they are all in the Central Coast region. We do compare these levels of protection but lack of replicate MPAs limits inference. MPA age has been shown to influence responses to protection (Molloy et al., 2009, Friedlander et al. 2017). However, MPA age is difficult to test in California because of the implementation schedule of the network across geographic regions. While each region of the network was established at different times, the timing is confounded by the species composition and environmental differences among regions. Because MPAs within each region were established at the same time (with the exception of some older MPAs in the central and southern region), the effects of MPA age can’t be evaluated by comparing responses among MPAs within each region.

Some SMRs and SMCAs are located adjacent to one another, forming spatial “clusters” that by their combined greater area or addition of habitat types might impart greater protection for populations and communities in either MPA relative to isolated SMRs or SMCAs. Past research has found that the effectiveness of a moderately regulated area (equivalent to an SMCA in California) can be enhanced by the presence of an adjacent fully protected area (equivalent to SMR in CA) (Zupan et al. 2018). After having identified many SMCAs as “de facto SMRs” for kelp forest organisms across the network, our assessment of the “cluster effect” is limited to a handful of SMCAs and SMRs in the Central Coast region.

MPAs vary in area within each region and across the network. MPA theory and empirical studies suggest that larger MPAs can support greater population densities because of lower proportionate rates of emigration (spillover) (Claudet et al. 2008). Similarly, the overall area of shallow rocky reef and kelp forests vary among MPAs as does habitat diversity and richness within each MPA. The range of sizes of California’s MPAs allows the evaluation of MPA size on population and community responses. We tested several population metrics against these and other MPA attributes provided by the California Department of Fish and Wildlife (see methods). We note that testing aspects of ‘network design’ requires connectivity estimates using circulation models and is currently being done as part of a separate project.

## Covid-19 impacts on survey coverage and frequency

The Covid-19 pandemic created logistical and financial impediments to our ability to conduct surveys in the summer of 2020. For all of the academic institutions, state, county and institutional regulations restricted the number of individuals per vehicle and vessel, which required increases in vehicle and vessel use and prolonging the field season. Increases in vessel use required some institutions to hire more field technicians. Two conditions affected UCSB in particular. First, UCSB forbade the use of both volunteers and undergraduate students in 2020, requiring paid staffers to conduct monitoring and reducing the future groups of divers trained on survey protocols. Second, historically, UCSB relied on use of larger vessels to conduct overnight surveys at distant sites and these were (and remain) unavailable. In combination, these created significant budget shortfalls. The impact was exacerbated for Humboldt State University, which experienced travel restrictions between counties and prevented access to MPAs along the north-central coast (i.e. Sonoma County). This had a substantial impact on the time series of surveys for MPAs in that region. Nonetheless, with the exception of HSU, the number of sites surveyed by academic institutions in 2020 was only marginally reduced. Impacts to RCCA were especially great because of the inability to conduct in-person training of citizen science divers in 2020. Typically, RCCA trains approximately 150 new volunteer divers per year, some of whom go on to donate their time conducting RCCA surveys over multiple years. This, as well as the limited availability of existing volunteers, not only eliminated these personnel contributions, but resulted in greater contributions (and costs) of staff to compensate for these losses. In addition, because RCCA charges volunteers to participate in trainings, there was an estimated financial loss of $25,000 to the program. Longer-term impacts are difficult to predict, but some of these divers might have become long-term volunteers. In addition to impacts to diving capacity, Covid-19 affected boat operations (especially in the South) resulting in multiple day trips rather than more productive overnight trips, typical for places like the Northern Channel Islands, Catalina Island, and the Big Sur coast.

## Reef Check California (RCCA) Data Availability

Kelp forest monitoring data collected by RCCA is not presented on it's own in an appendix of this report due to issues with RCCA's database that became apparent during the preparation of the data for this report and that could not be addressed in time for the inclusion in the main body of this report. To address data issues, RCCA has completed the development of a new database that has replaced its previous database which had become corrupted leading to missing data and some inconsistencies in data from recent years. These issues are being addressed and the QA/QC'ed data with metadata will be available in 2022. We include RCCA methods and side-by-side comparison of methods to Academic data collection in the Methods section.

# METHODS

### Ecological monitoring – *in situ* surveys

### *Spatial and temporal sampling design*

Based on the analytical framework and geographic variation in kelp forest community structure described in the Background section, there are three important spatial scales of the sampling design: 1) network-wide geographic distribution of MPAs surveyed, 2) distribution of sampling sites inside and outside of individual MPAs, and 3) the distribution of transects within sampling sites.

1) *Network-wide geographic distribution*. At the broadest geographic scale, MPAs were surveyed throughout the network, in each of the regions defined by the MLPA implementation and the clustering analysis of the kelp forest communities (Figure 2). MPAs were prioritized by the CDFW's MPA priority tiers, which included both SMRs and SMCAs. Following that, we selected MPAs based on the length of previous time series (from historical and more recent surveys) and accessibility. For logistical reasons, especially the Covid-19 pandemic, not all MPAs were surveyed every year. For the breakdown of sites per year of this grant (2019-2020) per region see Table 1 and Table 2. For a complete history of the kelp forest monitoring done since 1999 by Academic programs and RCCA, see Table 3 and Table 4. In general, we had excellent coverage of MPAs in Southern and Central California with less coverage in the difficult to access region of Northern California. For information on how we chose the MPAs with adequate time series for analysis see Analysis Section below.

2) *Distribution of sampling sites inside and outside of individual MPAs.* At the spatial scale of individual MPAs, replicate sampling sites were distributed within each MPA and at nearby "reference" sites of comparable habitat characteristics to those inside the MPA, enabling analyses according to the framework described in the Background section. Each survey site typically consists of a rectangular area, extending 150 m parallel with the shore. The onshore-offshore dimension varies depending on the width of the reef and the offshore distance of the 20 m isobath (depth). Typically, two to four sites inside and two to four sites outside each MPA were surveyed by the academic programs, with the number and shape of sites varying depending on habitat (e.g. onshore-offshore steepness of the reef) and longshore width of the MPA. Typically, one to two sites inside and one to two sites outside were surveyed by RCCA. Not all MPAs have distinct reference sites, such that some MPAs share reference sites in common. In other cases, adjacent SMCAs were used as reference sites for SMRs. For

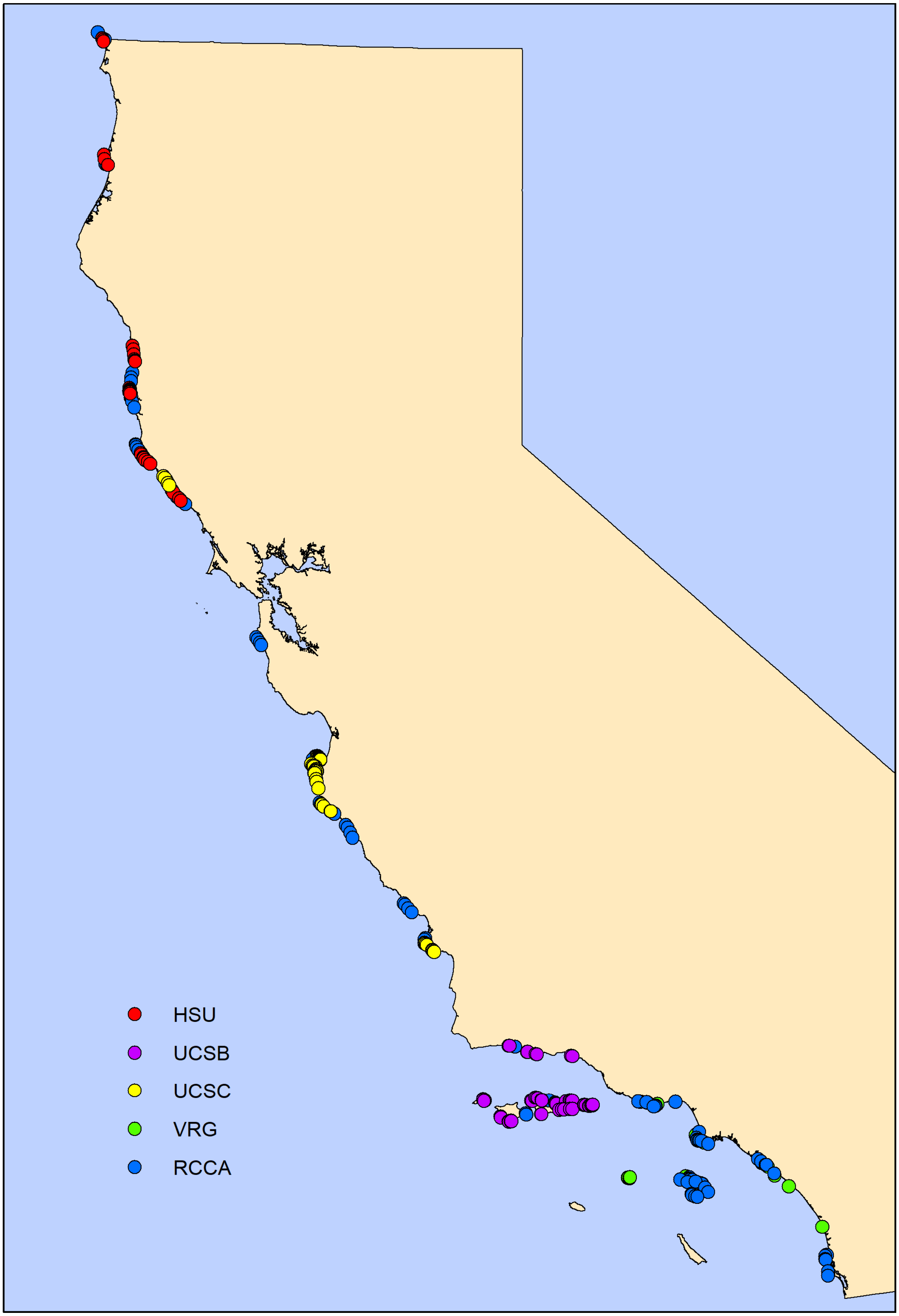


**Figure 2a**. Distribution of survey sites across the California coastline. Colors indicate the institution conducting surveys at each site.

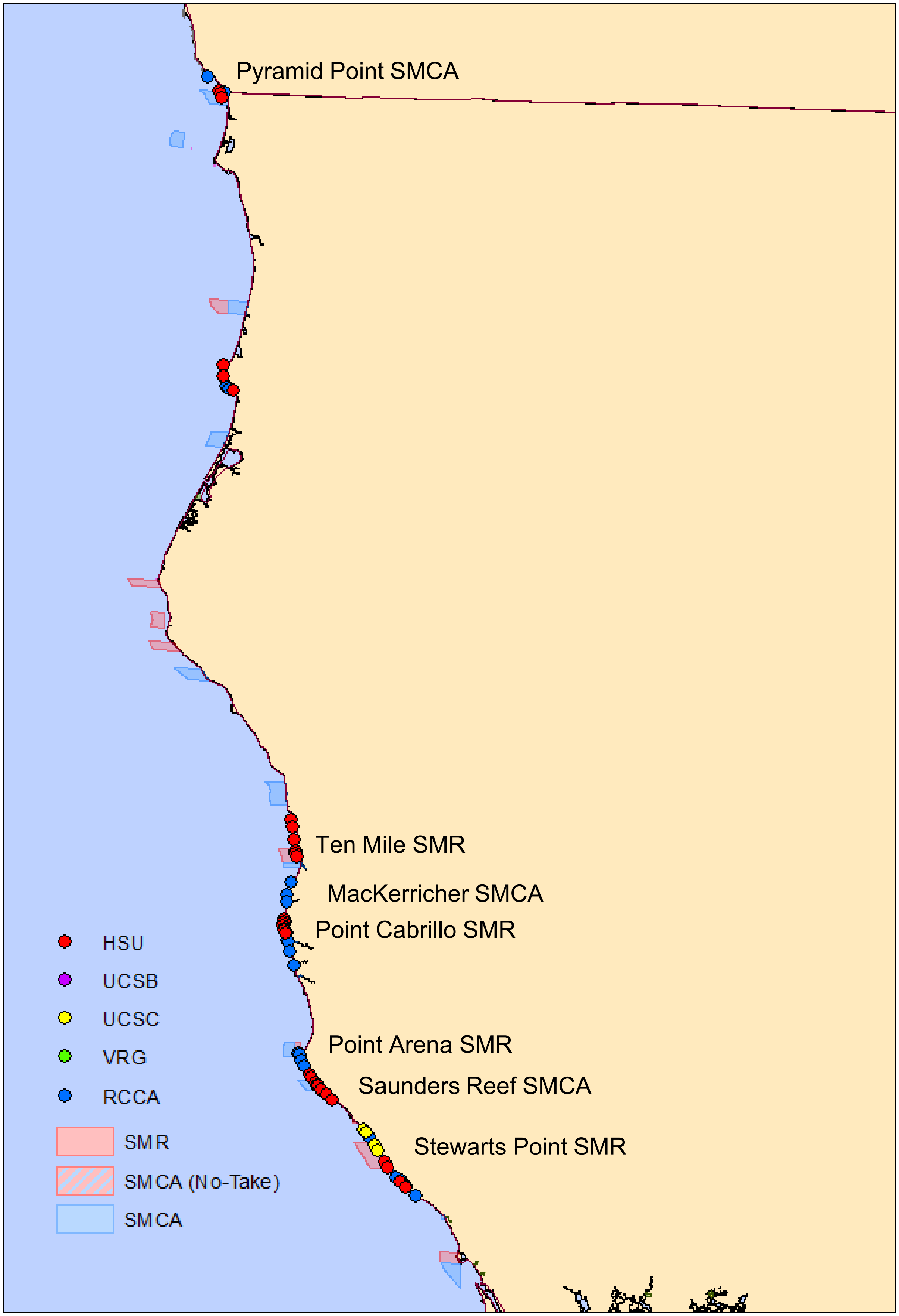


**Figure 2b**. Distribution of survey sites across the northern California coastline. Colors indicate the institution conducting surveys at each site. Marine Protected Areas are indicated by shaded areas indicating reserve designation.

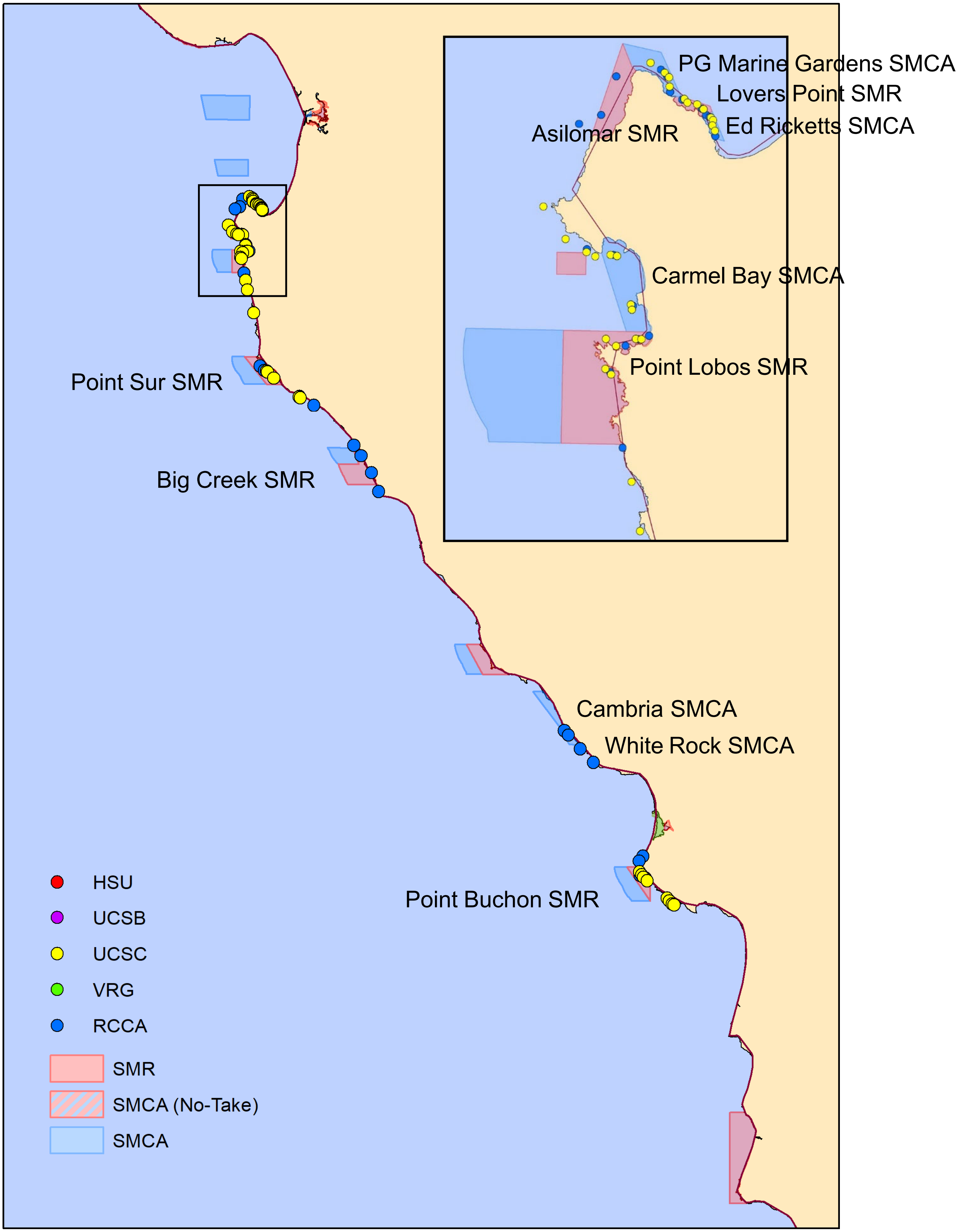


**Figure 2c**. Distribution of survey sites across the Central California coastline. Colors indicate the institution conducting surveys at each site. Marine Protected Areas are indicated by shaded areas indicating reserve designation.

**Figure 2d**. Distribution of survey sites across the California coastline. Colors indicate the institution conducting surveys at each site.

example, the Lovers Point - Julia Platt SMR in southern Monterey Bay is flanked by two SMCAs (Edward F. Ricketts and Pacific Grove Marine Gardens), both of which allow the recreational take of finfishes. Application of the SMCAs as references for Lovers Point - Julia Platt SMR allows assessment of the effects of recreational fishing.

3) *Distribution of transects within sampling sites.* To characterize the ecological community throughout each sampling site, survey transects are distributed from the offshore to inshore edges of the forest and across any depth gradient from the 5 m to the 20 m isobath at each site (Figure 3A,B). The number and distribution of depth strata differs among the sampling methods as described below in the survey protocols.

*Temporal scales of sampling.* For the academic programs, surveys are typically conducted in 1-2 visits to a site per year from June/July through October/November each year (Figure 4A). RCCA typically completes an entire survey in one visit to the site, generally between late spring and late fall (Figure 4B). There is variation among academic campuses in this schedule but typically ‘Academic’ surveys are more seasonally constrained than RCCA surveys.

## *Survey protocols*

***Academic programs*** - To characterize the ecological community and geological features at each site, we conduct four types of diver surveys: 1) density and size distribution of *all conspicuous fishes* are recorded along transects at all three levels (bottom, midwater, canopy) in the water column, 2) density of large invertebrates and stipitate algae identified to species are recorded along swath transects on the reef, 3) percent cover of sessile invertebrates, turf algae, and geologic habitat characteristics are estimated from uniform point contact (UPC) at 1 m increments along each transect on the reef and 4) size frequency for the commercially and ecologically important invertebrates and algae such as red and purple urchins, abalone, lobsters, giant kelp, and other key species. More detail for each of the methods described below are described in the metadata associated with the dataset generated by each method and the training material on the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) website (http://www.piscoweb.org/kelp-forest-sampling-protocols) and Malone et al. (In Press).

*Fish surveys:* The density of all conspicuous fishes (i.e. species whose adults are longer than 10 cm and visually detectable by SCUBA divers) are visually recorded along replicate 2 m wide by 2 m tall by 30 m long (120 $m^3$) transects. In pairs, one diver surveys this volume along the reef surface, while another surveys the same volume roughly one third to one half up into the water column above the benthic diver, depending on visibility and bottom depth. For analyses, these two transects are combined into a single 240 $m^3$ volume and expressed as the 60 $m^2$ of reef surface. Typically, three transects are distributed end-to-end and 5-10 m apart at each of the 5 m, 10 m, 15 m, and 20 m isobaths. This usually generates 12 replicate transects for each site. Fish transects are only conducted with 3 m of horizontal visibility. The total length of each fish observed is estimated to the closest 1 cm.

*Benthic swaths for algae and invertebrate densities:* The density of conspicuous, individually distinguishable macroalgae and macroinvertebrates (i.e. organisms larger than 2.5 cm greatest length and visually detectable by SCUBA divers) are visually recorded along replicate 2 m wide by 30 m long (60 $m^2$) transects. For select species (e.g., sea urchins), high densities are spatially subsampled to allow extrapolation to 60 $m^2$ area. Typically, two 30 m long transects are distributed end-to-end and 5-10 m apart at each of the 5 m, 12.5 m, and 20 m isobaths. This usually generates six replicate transects for each site.

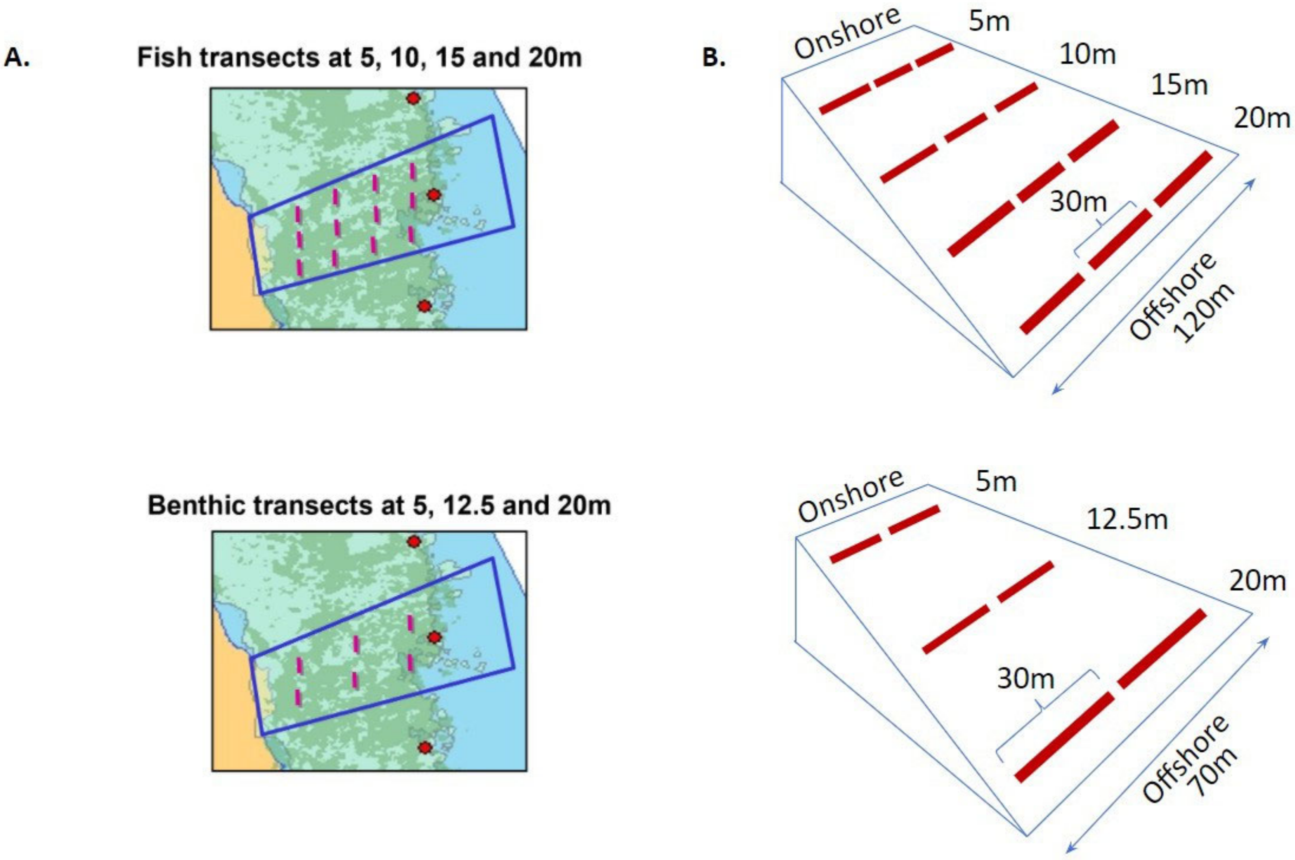


**Figure 3**. Distribution of transects within sampling sites for the ‘Academic surveys’. Survey transects are distributed from the offshore to inshore edges of the forest (A) and across any depth gradient from the 5m to the 20m isobaths at each site (B). Fish transects are done at 5, 10, 15 and 20 meters depth (top figures) while benthic (swath and UPC) transects are done at 5, 12.5 and 20 meters depth (bottom figures).

A.

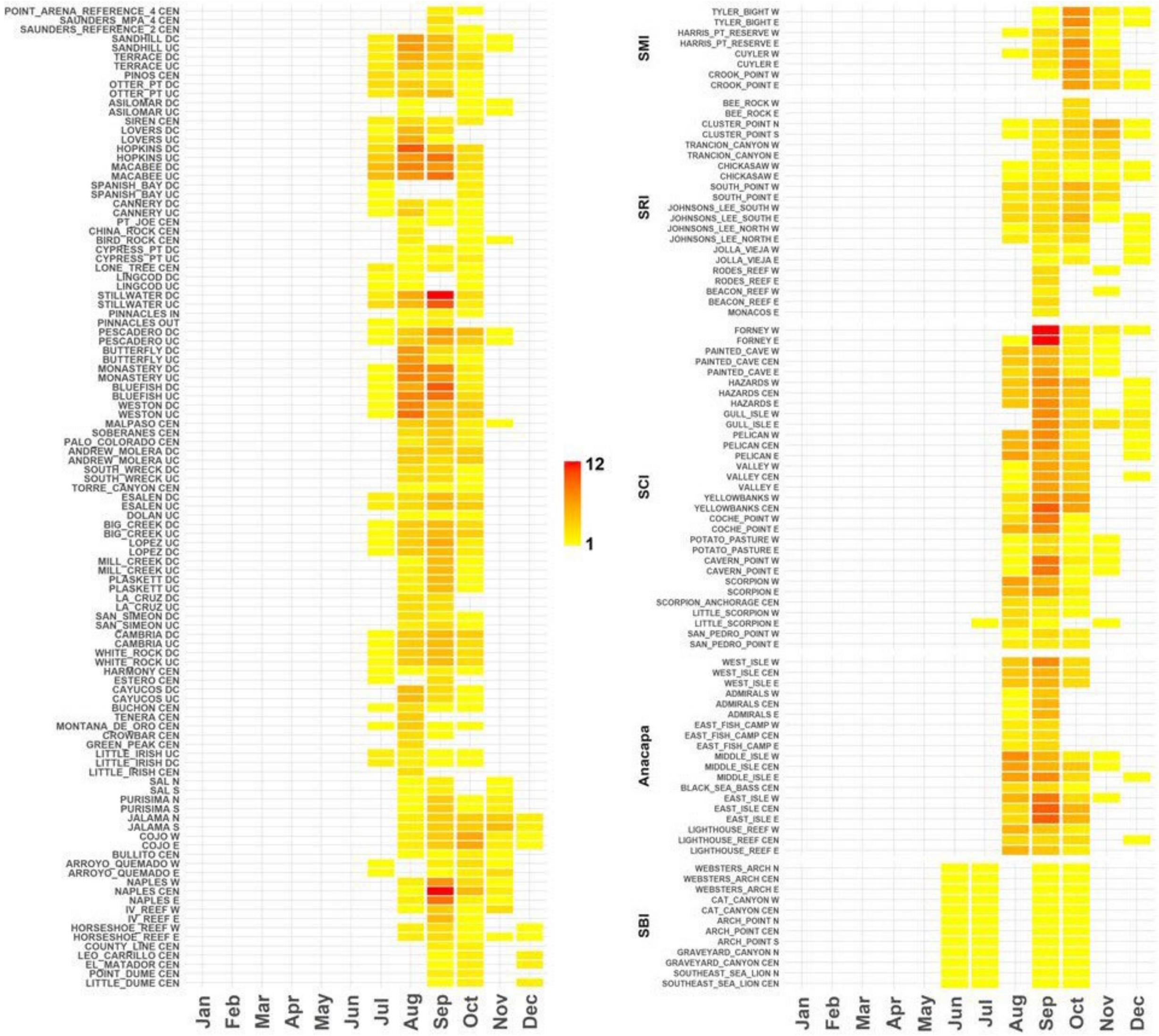


**Figure 4.** Seasonality of fish sampling for A) PISCO surveys from 1999-2016 and B) or Reef Check CA from 2006-2016. Sites ordered North to South on the mainland coast (left panel) and roughly NW to SE on the islands (right panel). Only sites with greater than 2 years of monitoring are shown. Color scale indicates number of annual surveys and is different for the two programs. SMI= San Miguel island, SRI=Santa Rosa island, SCI = Santa Cruz island, SBI=Santa Barbara island, ANAC = Anacapa island, CAT=Catalina island. Figure from Caselle and Cabral (2018).

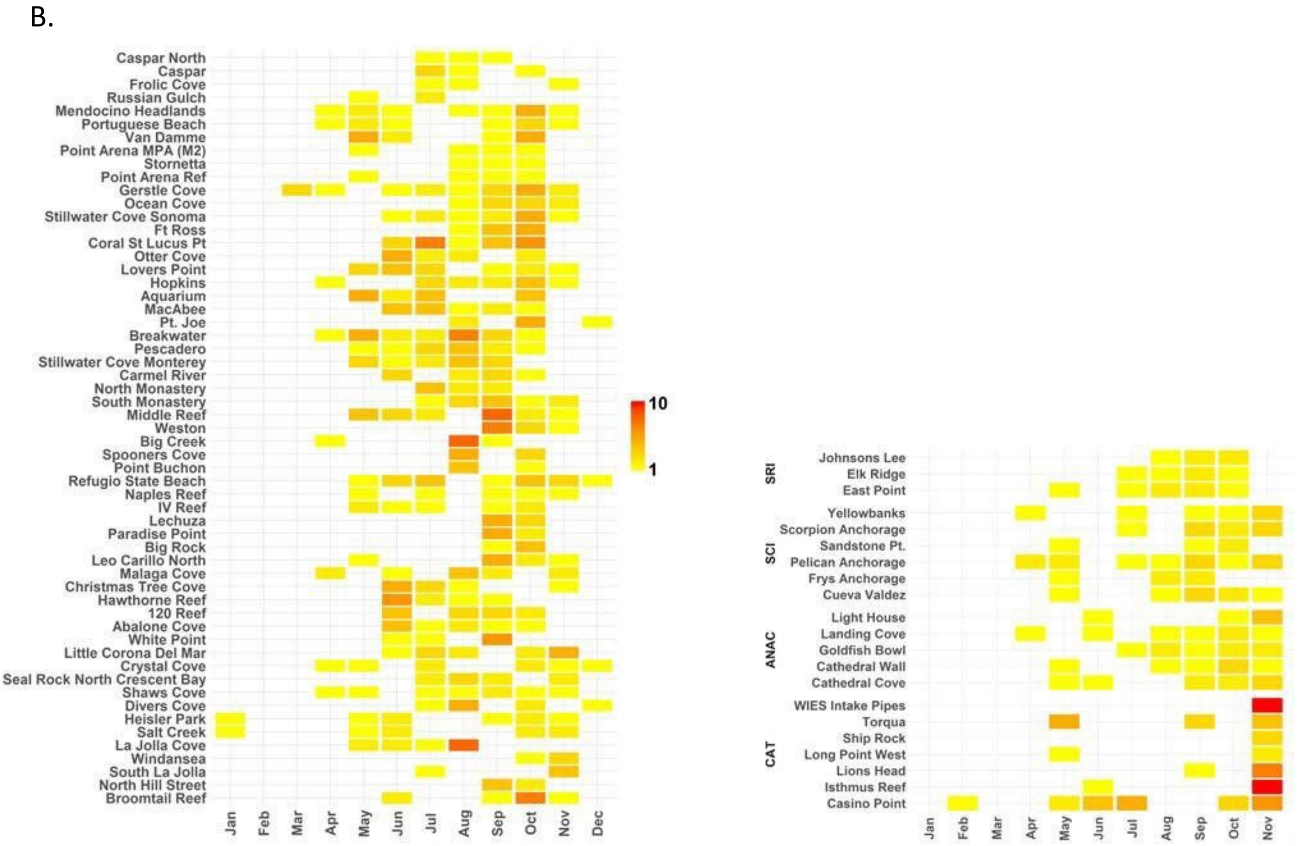


**Figure 4.** continued

*Benthic uniform point contact for algae and invertebrate percent cover (UPC):* The percent cover of sessile non-individually distinguishable macroalgae and macroinvertebrates (e.g. colonial invertebrates, foliose macroalgae) are visually recorded along the same replicate 2 m wide by 30 m long (60 $m^2$) transects used to conduct benthic swath surveys. UPC organisms are typically recorded to species, with higher level taxonomic or functional resolution for some groups (e.g. foliose red algae. Typically, two 30 m long transects are distributed end-to-end and 5-10 m apart at each of the 5 m, 12.5 m, and 20 m isobaths. This usually generates six replicate transects for each site.

*Size surveys for selected algae and invertebrates:* Stipe counts are used to size giant kelp (*Macrocystis pyrifera*). Abalones (*Haliotis* spp.), red and purple sea urchins (*Mesocentrotus franciscanus* and *Strongylocentrotus purpuratus*, respectively), California spiny lobsters (*Panulirus interruptus*), select species of sea stars, and some whelks are sized to the nearest centimeter. These data are collected from the benthic swaths or haphazard surveys across depth zones of each survey site.

**Reef Check California (RCCA) -** *We include methodology for RCCA surveys here in anticipation of potential inclusion of those data in future reports and for discussion of future long-term monitoring. Note that RCCA results are in Appendix 2.*

The RCCA sampling design and methods are designed to mimic the PISCO protocols as closely as possible, with spatial and taxonomic modifications intended to make the program accessible to trained volunteers. PISCO principal investigators advised on the original development of the RCCA protocols and PISCO scientists and staff continue to collaborate actively with and participate in RCCA surveys. More detail for each of the methods described below are described in the RCCA website (http://www.reefcheck.org/california/monitoring-protocol/).

*RCCA spatial sampling design:* Within each site, surveys consist of two core strata, inshore and offshore, between 5 and 18 m depth. Nine transects are conducted in each stratum. Transects are laid out in a stratified random design, with multiple nonpermanent transects located in each depth stratum. Three core transects are conducted in each stratum consisting of both fish and benthic (invertebrate, macroalgae, geological habitat) surveys and six additional fish-only transects are surveyed inshore and offshore of each of the two core strata. At each site, this results in a total of six benthic and 18 fish transects, each measuring 30 m × 2 m × 2 m and conducted along the bottom.

*RCCA sampling methods:* RCCA divers are trained to record the presence of a subset of the species counted by PISCO (35 fish species, 30 invertebrate species, and 9 algae species) in an effort to simplify the amount of required taxonomic skill and to focus on taxa that are most commonly observed, protected, actively fished, or of ecological importance statewide. Similar to PISCO, RCCA conducts 4 types of diver surveys to characterize the rocky reef and kelp forest ecosystem: 1) density and size distribution of fishes (sized to 1cm) are recorded along transects on the bottom only, 2) density of large (> 2.5 cm) invertebrates and stipitate algae identified to species are recorded along swath transects, 3) percent cover of sessile invertebrates, algae, and geologic habitat characteristics are estimated from uniform point contact (UPC) at 1 meter increments along transects. These UPC groupings are simplified from PISCO UPC surveys into 10 higher level taxonomic groups in a way that makes the two species list compatible, and 4) size frequency measurements are made for red and purple sea urchins and red abalone.

## Key similarities and differences between Academic and RCCA surveys

There are a number of key differences between the programs that in some cases can make joint analysis challenging (Text Box 1). Both programs use fixed georeferenced anchor points for site relocation and use a similar sampling approach employing a stratified random sampling design with non-permanent transects in fixed depth strata. The main difference is that for fishes, academic programs sample transects along the seafloor as well as in the water column and just below the surface whereas RCCA only samples along the seafloor. RCCA uses species lists for fishes, invertebrates and algae that are subsets of the species counted by academic programs but the taxonomic resolution for all three groups is the same (i.e., species) with the exception of juvenile rockfish. Academic programs identify juvenile rockfish to the species, whereas RCCA only records them as juvenile rockfish (YOY). For uniform point contact (UPC) surveys, RCCA categories species at higher taxonomic levels compared to academic programs. While RCCA was originally designed with a potential for combined analysis with the academic programs, in practice, this has not been achieved. However, there have been several side-by-side comparisons of the two programs (Caselle and Cabral 2018, Gillett et al. 2012, Hernan et al. in review).

**Box 1.** Key methodological differences between the ‘Academic’ kelp forest monitoring programs (following PISCO protocols) and the Reef Check California (RCCA) kelp forest monitoring program:

**Key Differences**

*Taxonomic resolution.* RCCA uses a closed species list (35 species) for fishes, Academic is open - meaning any fish observed is sized and counted (with the exception of small, cryptic species). For invertebrates and algae, both programs used closed species lists but these lists differ in taxonomic resolution.

*Taxonomic resolution.* Academic programs endeavor to identify all juvenile fishes to species, RCCA uses YOY for all rockfish juveniles.

*Fish Sizing.* Academic programs size all fish to the nearest centimeter, RCCA used size bins (<15cm, 15-30cm, >30cm) prior to 2013 and 1 cm resolution from 2013 onwards, as much as possible.

*Survey strata.* Academic programs survey three strata throughout the water column: bottom, midwater and canopy. RCCA survey bottom only.

*Timing of surveys*: Academic program surveys are constrained to the same season with benthic surveys in the early-late summer and fish surveys following in the late summer to fall. RCCA surveys occur across a broader range of seasons.

**Key similarities:**

*Sampling Approach*. Both programs employ a stratified random sampling approach, with non-permanent transects in fixed depth strata.

*Georeferencing*: Both programs use fixed georeferenced anchor points for site relocation.

*Transect dimension*. Both programs have identical transect dimensions (30m x 2m x 2m).

*Training*. Both programs conduct training programs and testing with divers prior to taking data. Training occurs annually for both programs although the duration of training may differ.

## Data processing and database upload for Ecological monitoring

Statewide analysis of ecological responses in kelp forests to MPA establishment required the integration of historic datasets generated by the partner academic institutions. These included data from the regional Baseline MPA programs, more recent OPC funded data and long-term data collected by PISCO (UCSB, UCSC) and the Vantuna research group (VRG-Occidental college). Because of fundamental differences between the academic and RCCA sampling programs, we do not integrate the academic datasets with RCCA datasets. Note that for the period of this report, we were not able to access the RCCA data due to issues with their data management protocols and their database.

For the academic datasets we employ rigorous QA/QC standards and resulting datasets are managed and analyzed using R, SAS, PRIMER and ArcGIS. The data package, including merged data tables for each survey type and all years 1999-2020 is now updated on DataOne and publicly available here: https://opc.dataone.org/view/MLPA_kelpforest.metadata.2. RCCA data for years 2006-2019 is also available on DataOne at doi:10.25494.

As described above, RCCA results are presented in an Appendix to this report due to issues with RCCA's database that became apparent during the preparation of the data for this report and that could not be addressed in time for the completion of this report. Field sampling was conducted as proposed in 2019 and 2020, however data entry was not completed in time and issues with missing or inconsistent data in the RCCA database prevented our using this data in analyses with the Academic data. Note that RCCA has received supplemental funding (2021, 2022) and field surveys are continuing as planned. RCCA is currently addressing these issues and has assured that the QA/QC will be complete and data will be available in 2022.

## Kelp canopy - Landsat remote sensing

We used Landsat satellite imagery to monitor giant kelp canopy area and biomass for the Southern and Central California regions and bull kelp canopy area for the North Central and Northern California regions. This dataset covered the entirety of these regions at 30 m resolution on seasonal timescales from 1984 to 2020. A description of the methods for the giant kelp canopy area and biomass data can be found in Cavanaugh et al. (2011) and Bell et al. (2020). These methods were recently extended to include bull kelp (Hamilton et al. 2020). Note that bull kelp cannot be distinguished from giant kelp from these methods. As a result, we only produced canopy biomass data for the Southern and Central regions, which we assumed to be dominated by giant kelp. The canopy area methods are the same for both giant kelp and bull kelp, and so estimates of total canopy area should not be majorly impacted by mixed forests that contain both species.

We developed seasonal time series of giant kelp canopy area and biomass and bull kelp canopy area summed across each MPA and associated reference region (see below for how reference regions were identified). From the seasonal data we calculated time series of annual maximums (Appendix Figure 10). We also produced time series for areas around each survey site sampling location. At each site polygons were created with a width of 200 m in the alongshore direction to encompass the area in which transects are surveyed. These polygons extended from the inshore edge of each site (defined by the 5 m bathymetric contour) to the offshore edge of the site (defined by the waypoint for the outer zone of transects or the 20 m bathymetric contour, whichever was closer to shore).

*Identification of kelp canopy reference regions for each MPA*

We used our satellite-based kelp canopy time series data to identify optimal reference regions for each MPA, with respect to kelp dynamics. This was performed for each MPA with at least 9000 $m^2$ (10 Landsat pixels) of potential kelp habitat. Kelp habitat was defined as any pixel that contained a kelp canopy at some point during the time series (1984-2020). For each MPA we identified a region outside of MPA protection that exhibited high correlation in kelp dynamics prior to the establishment of the MPA. We compared each MPA time series to time series made up of contiguous regions within ~50 km of the MPA. Each potential reference site had the same area of kelp habitat as the MPA. Potential reference sites had to be contiguous, with the exception that they could be split by the MPA, so half of the reference site was upcoast of the MPA and half was downcoast. We calculated the correlation between the annual MPA kelp canopy data and each potential reference region for the time period before MPA implementation and selected the reference region with the highest correlation. Figure 5 provides an example of the reference site identified for the Salt Point SMCA (Fig. 5A) and the time series of the kelp canopy area inside the MPA and reference site (Fig. 5B).

## Environmental monitoring - OAH and temperature

In November of 2017, a network of pH, dissolved oxygen and temperature sensors were established within kelp forests along the California coast (Figure 6). Custom pH sensors utilizing the Honeywell Durafet combination pH electrode (developed by Yui Takeshita and Ken Johnson at MBARI) are deployed alongside optical dissolved oxygen sensors (MiniDOT, PME) at six sites at approximately 40 feet depth, spanning the state’s coastline. Sites for sensor package placements were chosen to fill-in substantial geographic gaps in California's OAH monitoring network. In each region of northern, central and southern California, a sensor package was deployed at two sites. We targeted one site with strong upwelling and another with weaker upwelling based on a downscaled ROMS model with a biogeochemical component for the California Current (ROMS-NEMUCSC; Fiechter et al. 2018). All sensors were deployed in MPAs monitored by the RCCA kelp forest monitoring program in order to investigate the effects of changes in ocean chemistry on the kelp forest community and to allow better interpretation of MPA effectiveness in light of rapidly accelerating global climate change.

All sensor packages measure pH, dissolved oxygen, and temperature every 10 minutes. In October 2020, salinity measurements were added to the observing network. The sensor

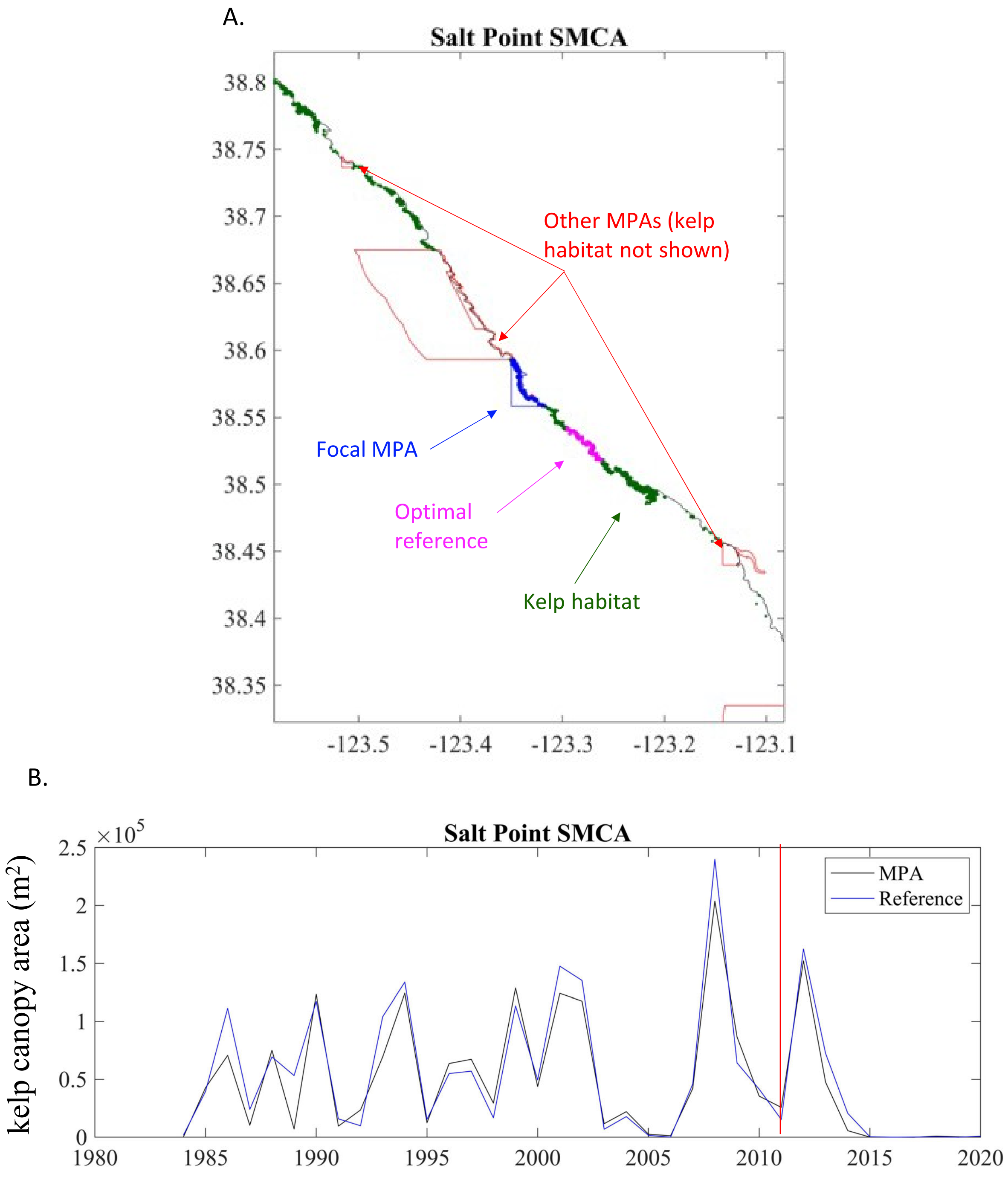


**Figure 5**. (a) Map of the Salt Point SMCA (blue) and reference region (pink) identified based on our correlation maximum algorithm. (b) Time series of kelp canopy area in the Salt Point SMCA and associated reference region.

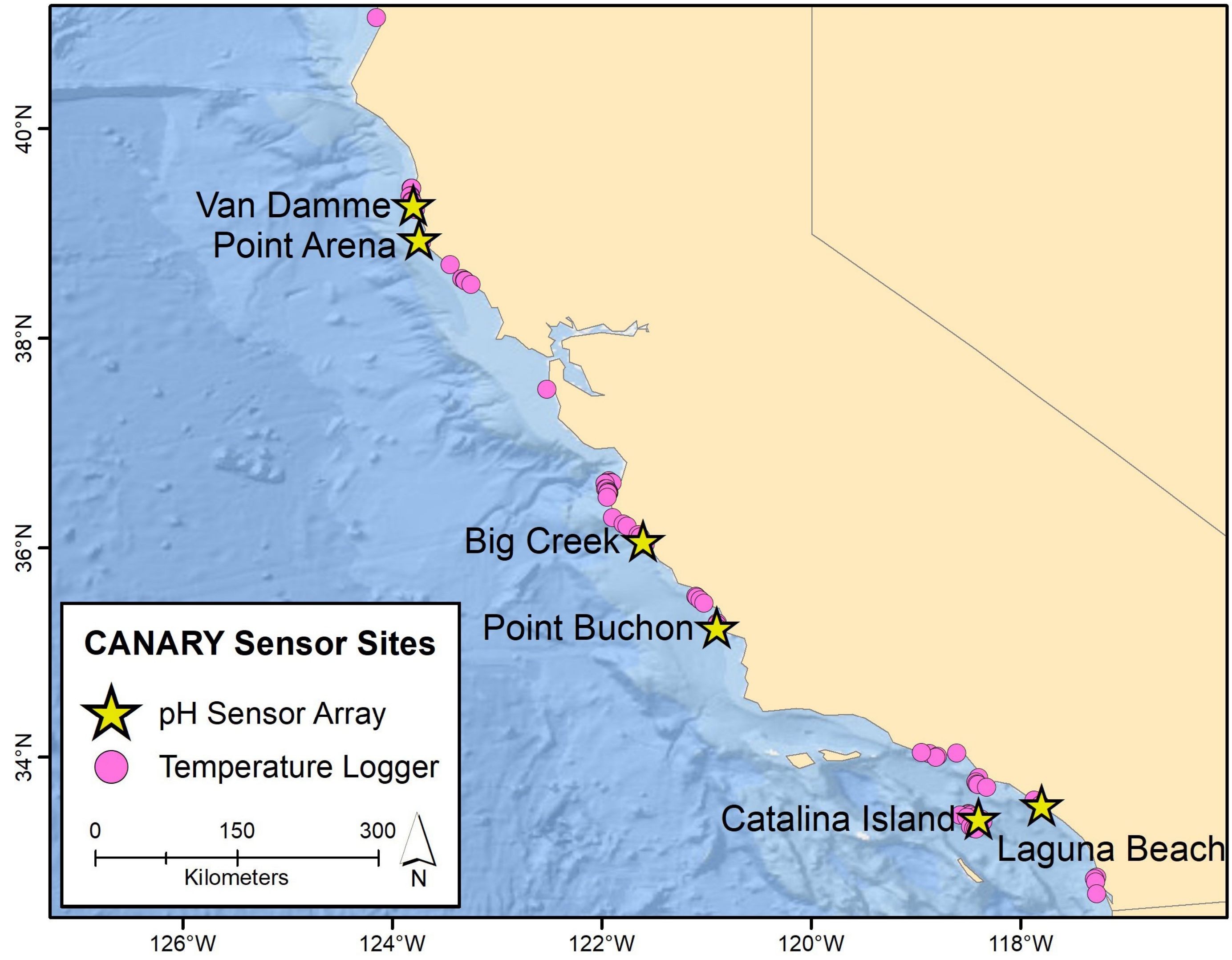


**Figure 6.** OAH monitoring network (pH, dissolved oxygen, and temperature sensors) established within kelp forests along the California coast.

packages are swapped by RCCA technicians and volunteers every 2-3 months. Factory calibrations are used for temperature and salinity, oxygen sensors are calibrated in the lab prior to each deployment, and an *in-situ* calibration method was developed and implemented for the pH sensors that is conducted by RCCA technicians at deployment and recovery. After retrieval, the sensors are shipped back to the lab, where the sensor data are downloaded, and data are quality controlled.

Previous studies have demonstrated that optode dissolved oxygen sensors can exhibit large drift during storage, but are stable once deployed (D'Asaro and McNeil, 2013). The errors can be as large as 10's of percent, thus it is critical to correct for this storage drift. Fortunately, the optodes can be accurately corrected using a gain-only correction (Bittig et al.2018):

$$O_{2,corr} = G \text{ x } O_{2,uncorr}$$

where G represents a gain factor established during pre-deployment calibration. G was established prior to each deployment by making measurements in 100% saturated water that was prepared by gently bubbling atmospheric air near the surface of the solution (to prevent oversaturation). Dissolved oxygen sensors were typically calibrated within 1-2 months prior to deployment, thus, we believe the dissolved oxygen is accurate to ± 1%.

The pH sensors were calibrated *in situ* using an equimolar Tris buffer in artificial seawater (referred to as Tris hereafter), a standard solution for seawater pH measurements. This calibration is conducted at time of deployment and recovery. Calibration at recovery produces more accurate pH data as the pH sensor is fully thermally equilibrated, thus, the calibration coefficient (k0) obtained at recovery is preferentially used. However, when a sensor failed during deployment such that a recovery calibration was not available, then the k0 obtained at time of deployment is used. The calibration protocol is as follows. At the beginning of the dive, the diver detaches an antifouling copper cap and attaches a custom flow cell that encapsulates the sensing elements of the Durafet. The flow cell is simple, and it consists of two luer lock fittings for the inlet and outlet, with an internal volume of ~5 mL. One-way valves are attached to each port to prevent seawater from diffusing back into the flow cell after Tris has been injected using a plastic syringe. In order to ensure that the flow cell is properly flushed with Tris, we have chosen a syringe size (60 ml) that is > 10 times the volume of the flow cell. At the end of the dive, the diver reattaches the anti-fouling copper cap (for deployment calibrations), or brings up the sensor with the flow cell attached (for recovery calibrations). The pH sensors make measurements at 10-minute intervals, and a typical dive time for RCCA is ~45 minutes. Therefore, each calibration produces 3-4 k0, and the average value is used.

*Temperature monitoring* - Starting in 2018, thermistors (HOBO Pendant® Temperature/Light 64K Data Logger) were deployed on the benthos at approximately 40 feet depth in 75 locations, including 40 thermistors deployed inside marine protected areas (Figure 6, Table 5). The thermistors were calibrated by submerging the sensors (measuring temperature every 5 minutes) in a water bath and exposing them to a temperature ramp (25, 20, 15, 10, 5, 10, 15, 20, 25 °C) for two hours at each temperature. Preliminary data suggested that temperature accuracy was independent of temperature across the range of temperatures used in calibration, therefore an average offset between measured and true temperature during calibration was calculated for each thermistor. Sensor specific offsets were then used to correct *in situ* temperature measurements with an accuracy of ± 0.1 C.

# ANALYSES

Applying the sampling design and protocols described above, we designed and conducted the analyses described below to address specific questions developed in the Monitoring Action Plan and the Decadal Evaluation Working Group (Box 2).

**Box 2**. List of DEWG questions answered in this report along with their respective hypothesis and justification.

| MLPA Goal-DEWG Question | Question | Hypotheses | Justification |
|---|---|---|---|
| **Targeted vs Non-targeted - Abundance** | | | |
| **G1-1h** | [Extended] Does the difference between MPAs and reference sites in overall biomass of fished species increase over time relative to species that are not fished? | Responses of fished species will diverge over time inside and outside the MPAs with higher biomass inside the MPAs. Non-fished species will exhibit similar trajectories inside and outside of the MPAs. | Because of the protection provided by MPAs, fished species survival and longevity increase within MPAs, thus contributing to higher biomass. |
| **G1-3a** | [Refined] Is there a positive relationship between the density (cover or biomass) of any given focal species and habitat diversity across MPAs of similar protection levels? | Biomass of fished species will increase with increasing habitat diversity. | MPAs with multiple types of habitats can support more species with different niches, thus contributing to greater overall fish biomass. |
| **Focal Species - Abundance** | | | |
| **G1-1b** | [Refined] Does the difference between MPAs and reference sites in **density** (or proportionate cover) of a **focal and/or protected species** increase over time? | Responses of a focal/protected species will diverge over time inside and outside the MPAs with higher abundance (or rate of response) inside the MPAs. The degree of responses will vary among species. | Because of the protection provided by MPAs, focal species survival and longevity increase within MPAs, thus contributing to higher abundance. |
| **G1-1c** | [Refined] Does the difference between MPAs and reference sites in biomass of a focal and/or protected species increase over time? | | |
| **G1-1f** | [Extended] Does the difference between MPAs and reference sites in the **size of populations of a focal and/or protected species** increase | | |

| MLPA Goal-DEWG Question | Question | Hypotheses | Justification |
|---|---|---|---|
| | over time? | | |
| **G1-1g** | [Extended] Does the difference between MPAs and reference sites in overall abundance of focal and/or protected species increase over time? | | |
| **G2-7b** | [Extended] How do changes in abundance differ among species? (assess within an MPA) | | |
| **G4-23a** | [Refined] Has the difference between MPAs and reference areas in the **abundance** of **endangered** species increased over time? | | |
| **G4-23b** | [Refined] Has the difference between MPAs and reference areas in the **abundance** of **culturally significant** species increased over time? (e.g. species used by the Tribes) | | |
| **G4-23c** | [Refined] Has the difference between MPAs and reference areas in the **size of endangered species** increased over time? | | |
| **G5-32a** | [Refined] Is there an increase over time in the difference between MPAs and reference sites in abundance (density, cover, biomass) of focal species and if so is the difference in combined SMR/SMCA clusters greater than in | | |

| **MLPA Goal-DEWG Question** | **Question** | **Hypotheses** | **Justification** |
|---|---|---|---|
| | stand-alone MPAs of similar size and protection? | | |
| **G5-32c** | [Refined] Does the difference between MPAs and reference sites in density (or proportionate cover) of a focal and/or protected species increase over time? | | |
| **Focal Species - Size** | | | |
| **G1-1a** | [Refined] Does the difference between MPAs and reference sites in the **size of individuals of a focal and/or protected species** increase over time? | Size distributions in MPAs should exhibit a disproportionate number of larger individuals compared to Refs and the rate of response should be higher inside the MPAs. The degree of size responses will vary among species. | Because of the protection provided by MPAs, species survival and longevity increase within MPAs, thus contributing to larger individuals. |
| **G2-7b** | [Extended] How do changes in size differ among species? (assess within an MPA) | | |
| **G3-1a** | [Refined] Does the difference between MPAs and reference sites in the **size of individuals of a focal and/or protected species** increase over time? | | |
| **G3-20b** | [Refined] Has the difference between MPAs and reference areas in the **mean size of recreationally fished species** increased over time? | | |
| **G3-20d** | [Extended] Has the difference between MPAs and reference areas in the **mean size of culturally valued species** | | |

| MLPA Goal-DEWG Question | Question | Hypotheses | Justification |
|---|---|---|---|
| | increased over time? (non-consumptive species) | | |
| **G3-20a** | [Refined] Has the difference between MPAs and reference areas in the **size of recreationally fished species** increased over time? | | |
| **G3-20c** | [Extended] Has the difference between MPAs and reference areas in the **size of culturally valued species** increased over time? (non-consumptive species) | | |
| **G4-20b** | [Refined] Has the difference between MPAs and reference areas in the **mean size of recreationally fished species** increased over time? | | |
| **G4-23d** | [Refined] Has the difference between MPAs and reference areas in the **size of culturally significant species** increased over time? (e.g. species used by the Tribes) | | |
| **G5-20d** | [Extended] Has the difference between MPAs and reference areas in the **mean size of culturally valued species** increased over time? (non-consumptive species) | | |
| **G5-32b** | [Refined] Is there an increase over time in the difference between MPAs and reference sites in **size of focal species** | The greater overall protection in combined SMR/SMCA clusters will exhibit greater differences over time | Species responses in an MPA should benefit from the collective protection effects of SMR/SMCA clusters and |

| MLPA Goal-DEWG Question | Question | Hypotheses | Justification |
|---|---|---|---|
| | and if so is the difference in combined **SMR/SMCA clusters greater than in stand-alone MPAs** of similar size and protection? | in the size of focal species relative to stand-alone MPAs of similar size and protection. | this should be realized in stronger size responses of focal species in clusters versus stand-alone MPAs over time. |
| **Focal Species-Larval Production** | | | |
| **G1-1d** | [Extended] Does the difference between MPAs and reference sites in **larval production of a focal and/or protected species** increase over time? | Larval production will be higher inside MPAs; however, the degree of production will vary among species. | Because of the protection provided by MPAs, more individuals can grow older and larger, thus increasing their reproductive capacity. |
| **Community-Species Diversity and Richness** | | | |
| **G1-2a** | [Refined] Does the difference between MPAs and reference sites in **species diversity within any given functional group** increase over time? | The species diversity of a functional group will increase more in an MPA relative to reference sites over time. | Direct effects of reduced mortality of targeted species could increase evenness of population sizes in an MPA, thereby increasing diversity of a functional group. |

## Ecological monitoring – in situ surveys

### *Ecologically-defined geographic regions*

As described in the Background section, geographic variation in kelp forest communities needs to be accounted for when evaluating regional differences in MPA performance and how design attributes (e.g., MPA size or level of protection) influence performance. To identify the geographic regions in which MPAs of comparable community structure should be evaluated, we created a community-wide taxonomic characterization of community structure that merged species density and percent cover across all survey sites. As a first step, the lists of species recorded on all surveys by each of the academic institutions were merged and consolidated. Species not occurring within a region were recorded as absent where appropriate, and species not searched for by all institutions were removed from the analysis. To identify persistent patterns of community structure over time, all years surveyed at each site were averaged together. In order to combine data from different survey types, species density data for all fish, invertebrates, and algae and percent cover data for sessile/colonial invertebrates and understory algae were normalized by converting all observations to z-scores ( $Z = \frac{x - \mu}{\sigma}$ , observation minus the mean of all observations for that species divided by the standard deviation among those observations). This approach equalizes the magnitude and range of observations for all species, and allows each species to contribute equally to defining the patterns of similarity among sites regardless of their relative abundance. To prevent species that are extremely rare from having undue influence on patterns of community similarity, all species occurring on less than 5% of the surveys across all sites and years were removed from analysis. We conducted a cluster analysis using a Euclidean distance-based matrix for all sites (PRIMER 7, Clarke and Gorley 2015). Cluster groupings were generated using group average linking and group distinctions were tested for significance using Type 1 Simprof at P<0.05.

### *Selection of MPAs for analysis*

We visually inspected the available data for all sites for all years (Table 3) to select individual MPAs that provided enough temporal coverage to allow the analysis of temporal trends. Our criteria included a) only MPAs with appropriate paired reference sites, b) only years that included sampling both in and out of the MPA, c) at least two years of data in a 'baseline period' and 3 years of data in a 'recent' period, and d) greater than one replicate site within the MPA and the Ref area. Some North Coast sites had either short monitoring history and/or l arge gaps between baseline monitoring and present, so time series for these MPAs must be interpreted with caution.

### *Taxonomic groupings and focal species selection*

A focus of our analysis is to compare the responses of species that are fished to responses of species that are not fished. For fishes, we grouped all species into 'Targeted' or 'Non-Targeted' and presented results for these groups (Table 6). We gathered information on fishing from the literature, CDFW reports and other sources. We also selected individual focal fish, invertebrate and algae species using criteria derived from the Action Plan and DEWG report including: high abundance, ecological importance, protection status, threatened or endangered status, fisheries importance, and cultural importance (Table 7).

## Response Metrics

We applied our analytical framework as described in the Introduction to a selection of response variables collected by the academic institutions. These included biomass (kg per 60 $m^2$) and density (number of species per 60 $m^2$) for Targeted and Non-Targeted fishes and focal fishes, invertebrates and algae. These select response variables also included size (cm) of focal fishes and invertebrates, and species richness and Shannon diversity for each community of organisms.

Using the analytical framework on these response variables, we hypothesized that the cessation of fishing mortality on species targeted by fisheries would lead to differences in the biomass, density and size frequency distribution of populations within MPAs versus Ref areas. That difference should increase over time as the number and size of larger individuals accumulate in the MPA. For size specifically, size distributions in MPAs should exhibit a disproportionate number of larger individuals as survival and longevity increase within MPAs.

*MPA Attributes* - We collected MPA attributes such as MPA size, latitude, and area of rock habitat from the California Department of Fish and Wildlife. The hypotheses and “justifications” (i.e. rationale for predicted species responses) are derived from the DEWG report (Table 2). Generally, we predicted that population and community responses would increase with MPA size, area of rocky habitat, and habitat diversity and richness. In addition, we hypothesized that the magnitude of response would increase with fishing effort either prior to or after MPA establishment. As a proxy for fishing effort, we calculated the distance to the nearest port and the nearest port identity. Generally, fishing effort declines with increasing distance from ports (e.g., Stuart-Smith et al 2008, Cabral et al 2017), referred to as “friction of distance” (Caddy and Carocci 1999). Finally, using data provided for all of the habitat types we calculated habitat diversity (Shannon index) and habitat richness (number of habitats) for each MPA.

*Environmental Variables* - Environmental data (sea surface temperature, net primary production, wind speed, significant wave height and wave orbital velocity) were extracted from the Central and Northern California Ocean Observing System (CenCOOS) Repository. Sea Surface Temperature (˚C; SST) was originally collected from the Advanced Very High-Resolution Radiometer instrument aboard NOAA’s Polar Operational Environmental Satellites. SST measurements were collected daily from 2004–2020 at a 1.47 km spatial resolution. Values are accurate to ± 0.7˚C. In this report we analyzed SST only. Future work will explore other environmental variables.

### Fish Metric

Fish biomass was calculated using length-weight relationships compiled from Fishbase and primary literature by monitoring groups (PISCO, VRG). We summed up biomass values from the bottom and midwater transects. Canopy transects were excluded since they were not conducted on all transects. In addition to biomass calculations, fish species were identified as either being targeted by fishing or non-targeted by fishing. Observations of young-of-year (YOY) fishes and fish “biomass busters” — fish species that could skew biomass calculations such as those that travel in dense aggregations (e.g., sardines and mackerel) or those that are large bodied (e.g., giant sea bass) — were removed. Small, cryptic species (e.g. gobies, clinids, small sculpins) are not sampled effectively and also excluded.

### *Biomass by Target Status*

To assess MPA effectiveness on fish biomass over time, we ran Analysis of Covariance (ANCOVA) and Linear Regression (LR) by each MPA group and region. ANCOVA was used to compare the responses between target status (Targeted and Non-targeted species) over time. The model included target status (fixed effect), year (covariate), target status x year (interaction), and $\text{Log}(\text{Biomass}_{\text{MPA}}/\text{Biomass}_{\text{REF}})$ (response). LR was used to determine if each target status is increasing or decreasing significantly over time. Year was a fixed effect and $\text{Log}(\text{Biomass}_{\text{MPA}}/\text{Biomass}_{\text{REF}})$ was a response variable.

We also assessed the effects of MPA on fish biomass on a year-by-year basis by looking at whether abundances inside and outside each MPA significantly diverge from each other. To appropriately represent the "no difference" (i.e., fish biomass did not differ between inside and outside of the MPA), we pooled all of the inside and outside MPA results for each year and used bootstrap resampling to randomly pair inside and outside results to generate "no difference" response ratios. This resampling technique generated confidence intervals to represent a range of ratios that are considered "no difference." If the actual (unpooled) response ratio falls outside the bootstrap 95% confidence interval, then the response ratio has a significant effect in either direction (i.e., fish biomass in either MPA or Ref is significantly more than the other).

### *Biomass and Density by Focal Species*

To assess MPA effectiveness over time for each focal species (fish, invertebrate and algae), we ran LR by each MPA. LR was used to determine if the response of a focal species is increasing or decreasing significantly over time. Year was a fixed effect and $\text{Log}(\text{Biomass}_{\text{MPA}}/\text{Biomass}_{\text{REF}})$ (for fish) or $\text{Log}(\text{Density}_{\text{MPA}}/\text{Density}_{\text{REF}})$ (for invertebrate and algae) was a response variable.

### *Size Distribution by Focal Species*

We tested for differences in size distributions in three ways. First, we generated size frequency distributions for each focal species by MPA and year. Years are presented in two-year intervals for presentation. We calculated and graphically compared the upper 10th percentile of the frequency distributions between MPA and Ref over time. We also generated frequency distributions for the combined recent years (2016-2020). To compare whether focal fish and invertebrate sizes have responded differently between MPA and Ref in the recent years (2016 to 2020), we ran nonparametric two-sample Kruskal-Wallis ANOVA (K-W) and Kolmogorov-Smirnov test (K-S) because size data were not normally distributed. K-W was used to test for difference in medians when MPA and Ref distributions are similar in shape, and tests for dominance in the relative position of distributions when the shape of the distributions differ. K-S was used to test for distribution differences in location, dispersion and shape. Prior to conducting the tests, we removed targeted YOY fish and kept YOYs for Non-targeted fish because we are particularly interested in the fished size range of species targeted by fisheries and the more general size responses of non-fished species. We also removed fish biomass busters (rare, very large species) and kept all invertebrate observations.

### *Larval Production by Select Focal Species*

We calculated larval production (number of eggs per 60 $m^2$) of a select few focal fish species (Lingcod, Kelp Rockfish, California Sheephead, and Kelp Bass). We used batch fecundity equations from Hart 1967 (Lingcod), Romero 1988 (Kelp Rockfish), Loke-Smith et al. 2012 (California Sheephead) and Claisse et al. 2012 (Kelp Bass) to convert fish length (mm) to fecundity (number of eggs), and summed larval production of individual fish to transect level (60 $m^2$).

### *Species Diversity and Richness by Community*

To assess MPA effectiveness on community diversity and richness (fish, invertebrate, and algae) over time, we ran a Mixed Model with Repeated Measures (MMRM) by each region for each community. MMRM was used to compare the responses between site status (MPA and Ref) over time. The model included site status (fixed effect), MPA group (random effect), site (repeated), site status x year (interaction), and Shannon diversity index or richness (response). The interaction term was dropped from the model if it was deemed insignificant. Species diversity and richness were calculated separately for four communities: fish, algae, invertebrate and uniform point contact organisms. Only fish surveys count all species (with few exceptions) while benthic surveys have closed species lists.

## *MPA Attributes*

To analyze the relationship between MPA attributes and Targeted fish biomass metrics, we identified two response variables: (1) change in absolute biomass over time (slope) for Targeted species, and (2) mean log response ratio across years ($\log(\text{Biomass}_{MPA}/\text{Biomass}_{REF})$) for Targeted species. The former gives information about the rate of change in biomass between MPA and Ref over time while the latter measures the degree of divergence in MPA and Ref responses. We also identified a suite of MPA attributes: MPA size ($km^2$), distance to nearest port (km), latitude (°N), area of rocky reef from 0-30 m depth ($km^2$), habitat richness (number of discrete habitats within an MPA), habitat diversity (Shannon index), identity (name) of the nearest port, and proximity to other MPAs (solitary vs cluster). We ran LR examining the relationship between each of the first six MPA attributes identified above and each of the response variables. For the second to last MPA attribute (nearest port), we ran ANOVA comparing the effects of site status (MPA and Ref) on absolute biomass slope for each of the nearest ports. The model included site status and nearest port (fixed effects), and site status x nearest port (interaction). We also ran ANOVA and Tukey post-hoc comparisons among ports for mean biomass response ratio. For the last MPA attribute on the list (proximity to other MPAs), we ran a two-sample t-test comparing MPAs that are adjacent to other MPAs (cluster MPAs) and MPAs that are solitary (solitary MPAs) for mean biomass response ratio, and a two-sample Wilcoxon signed-rank test comparing the same attribute for absolute biomass slope. The Wilcoxon test was implemented because the data was not normally distributed. We did not run an analysis comparing protection levels (SMR, de facto SMR and fished SMR) for either of the response variables due to a limited number of replicates.

## *Sea Surface Temperature*

To analyze the relationship between annual mean sea surface temperature (SST) and annual Targeted fish response ratio($\log(\text{Biomass}_{MPA}/\text{Biomass}_{REF})$) across all regions, we ran a Kendall Tau correlation analysis. The nonparametric analysis was used because the data was not normally-distributed.

All statistical analyses were conducted in R Studio (RStudio Team 2020, Version 1.4.1717, Package: stats, Function: kruskal.test, ks.test, cor.test) and SAS Enterprise Guide (SAS Institute Inc. 2013, Version 7.1, Procedure: ANOVA, ANCOVA, GLM, MIXED).

## Kelp canopy - Landsat remote sensing

We used a BACI analysis to compare the impacts of MPA protection on kelp area. Following Wauchope et al. 2021, we used a generalized linear model to find the best fit to the equation,

$$Value_{i,j} = \beta_0 + \beta_1 BA_i + \beta_2 CI_j + \beta_3 BA_i CI_j + \epsilon$$

where $Value$ is the time series in time step *i* and location *j*, the BA term is 0 before MPA implementation and 1 after, and the CI term is 0 for the control (reference) time series and 1 for the MPA time series. The coefficient of the interaction term, $\beta_3$, gives the BACI contrast. A positive value of $\beta_3$ indicates a positive impact of MPA protection on average kelp area.

We also characterized the resilience of kelp abundance in each MPA and references site to the 2014-2016 marine heatwave, following Cavanaugh et al. (2019). Resilience was calculated as the mean annual maximum kelp canopy area from 2016-2020 (post-heatwave) compared to the mean annual maximum kelp canopy in the 10-year period prior to the heatwave (2004-2013). This resilience metric provides a measure of the degree to which kelp recovered to pre-heatwave levels following the 2014-2016 heatwave. We then conducted a rank sum test to determine if resilience differed between MPA and references sites. Finally, we compared resilience for each MPA and associated reference site by dividing the MPA resilience by the reference site resilience. Values > 1 indicate higher resilience inside the MPA and values < 1 indicate higher resilience in the reference site.

## Environmental monitoring – ocean acidification, hypoxia and temperature

Our observational OAH data was quality controlled in multiple steps. First, we visually inspected each deployment using pH, dissolved oxygen and temperature data to assess whether data showed similar patterns. Next, data were flagged if they fell outside ranges of possible values (pH = 7.3 - 8.7; DO % saturation = 0 - 150% ; Temperature = 5 - 35 C). Finally, we ran a despiking filter in Matlab to flag data spikes. Summary statistics were created for each site with a full sensor package, as well as at each thermistor location. To assess the relationships between pH, dissolved oxygen, and temperature at each site, we plotted the relationships using Matlab.

Given pH and dissolved oxygen in the CA Current are highly influenced by upwelling and are therefore variable on daily and seasonal timescales, we also calculated several summary statistics that represented the exposure to potentially biologically-stressful pH and dissolved oxygen conditions relevant to marine organisms. Summary statistics were calculated based on daily averaged observations from 2017-2020. In particular, we calculated the severity, duration and intensity of exposure events below predetermined threshold values in pH and dissolved oxygen. Duration is defined as the number of days conditions remain below the threshold for a given low pH or low dissolved oxygen event (unit = days). Intensity is defined as the threshold minus the average conditions in pH or dissolved oxygen during a given event (unitless). Severity is defined as the product of duration and intensity (unit = days). Thresholds for pH and dissolved oxygen were chosen to represent ecologically relevant conditions. A pH threshold of 7.7 was chosen to represent the saturation state of 1 based on an uncertainty analysis of assumed TA. Saturation state was computed using sensor pH and TA ranging from 2200-2300, a substantially larger range of TA than would be expected to produce a conservative estimate. Based on this analysis, on average, pH of 7.7 corresponded to a saturation state of 1 ± 0.15 (range). Exposure to conditions below the saturation state of 1 have been shown to favor dissolution over calcification of calcium carbonate, although values above this may also be physiologically stressful. A dissolved oxygen threshold of 4.6 mg/L was chosen based on the results of a meta-analysis that indicated biological effects are first apparent at this threshold (Vaquer-Sunyer & Duarte 2008). It is important to note that these conditions are not universally stressful to all organisms, but the summary statistics provide insight into exposure to potentially stressful conditions relevant to marine organisms writ large. Because the observational time series are limited to 2017-2021, we then compared the observational data to model output from a high-resolution (3km) coupled physical-biogeochemical model, ROMS-NEMUCSC (Cheresh & Fiechter, 2020), to assess whether the patterns in the observational data aligned with model output from a different time period. In particular, daily model output from the ROMS-NEMUCSC model was extracted at the closest grid cell to land at the latitudes corresponding to the six OAH observational stations, and the same summary statistics were calculated for the period of 1988-2010.

Last, we created a temperature heat map of thermistor data using Ocean Data View. Temperature time series were averaged to daily means at each site and separated into three regions (North, Central, Southern Mainland). Within each region, data were interpolated across latitude and time using DIVA gridding and minimum x and y-scale length to complete coverage across each region. Data were filtered at three standard deviations to minimize the influence of data anomalies. *In situ* data are presented as white transects within each heat map.

# RESULTS

## Ecological monitoring – in situ surveys

### *Ecologically-defined geographic regions*

The community-wide characterization of kelp forest community structure, based on the combined fish, algal, and invertebrate assemblages, identified seven geographic regions of distinct community structure (Figure 7). Seven regions of similar community structure were identified: North Coast, Central Coast, two South Coast Mainland regions, Southern Channel Islands, and two Northern Channel Islands regions. Because of the few MPAs within the five smaller regions off southern California, we combine the two Northern Channel Island regions, the two South Coast Mainland regions, and often combine the Southern Channel Islands with the South Coast Mainland regions for analyses. Results are presented in the context of these four broader regions.

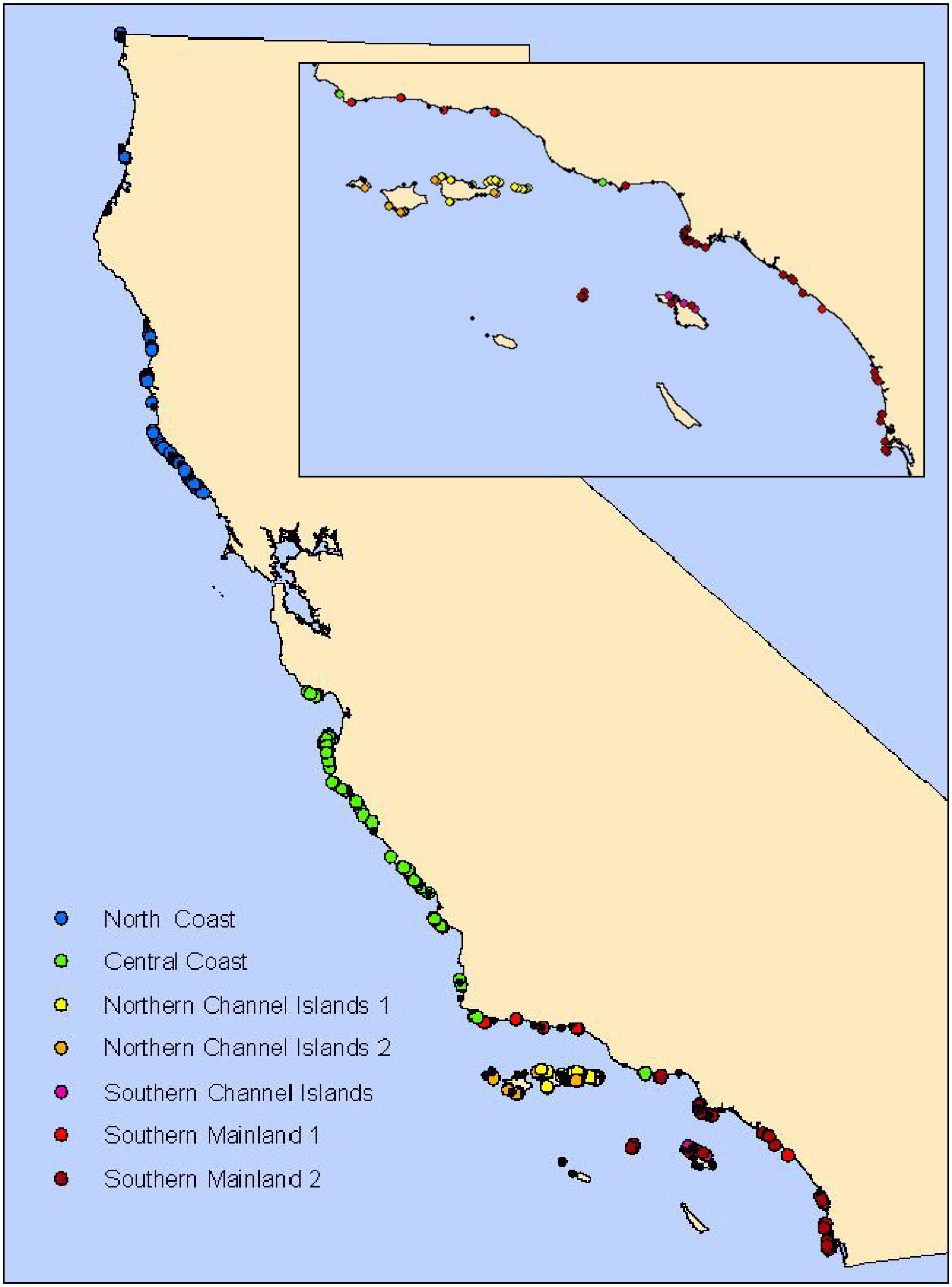


**Figure 7.** Geographic patterns of kelp forest communities based on the community-wide taxonomic characterization of community structure. Sites of the same color share similar community structure. Inset illustrates the five regions identified off southern California. Seven geographic regions are defined. For analyses, the two South Coast Mainland and Southern Channel Islands regions are usually combined, and the two Northern Channel Island regions are combined.

To convey the geographic patterns of species composition of the fish assemblages measured, we present the biomass and density of fish species for the top 15 greatest biomass and density summed by region (Table 8) and by MPA (Table 9)

## *Population responses*

### *Trends in Targeted and Non-targeted Fish Biomass Responses*

[These analyses address DEWG question G1-1h]

As described in the Background and Analyses sections, we attribute positive effects of MPAs on the overall biomass of species targeted by fisheries only when (i) the overall biomass of Targeted species within MPAs and reference areas exhibit positive divergence from one another since the establishment of the MPA resulting in a significant positive slope of the response ratio of Targeted species over time (i.e., [$\text{Targeted}_{\text{MPA}}/\text{Targeted}_{\text{REF}}$]), (ii) when the response ratios of species Targeted by fisheries and species Non-targeted by fisheries within the MPA [(i.e., [$\text{Targeted}_{\text{MPA}}/\text{Non-Targeted}_{\text{MPA}}$]) exhibit positive divergence from one another since the establishment of the MPA, and (iii) Non-Targeted species exhibit similar trajectories inside and outside of the MPA. We only infer positive MPA effects when three criteria are met.

Of the many MPAs monitored over the study period, two MPAs in the North Coast region, two in the North Central Coast region, five in the Central Coast region, four in the South Coast region, and seven in the Northern Channel Islands region (20 MPAs total) had sufficient time series to test for temporal trends in response ratios. Because of the small sample size, we did not observe distinct region-wide response patterns. (Figure 8, Table 10). Only two regions (South Coast and Northern Channel Islands) exhibited a significant target status x time interaction (Figure 8, Table 10). Although the biomass of Targeted species within these MPAs significantly diverged in a positive direction from Targeted species at their respective reference areas over time (criterion i, Table 11), the response ratios of the Targeted species within the MPAs did not diverge significantly in a positive direction from the trend in the response ratios of the Non-targeted species within the MPAs (criterion ii; Table 10), with the exception of the Northern Channel islands where the interaction between year and target status was marginally non-significant (p=0.08).

While noting the high variability and largely non-significant region-wide responses, we explored the magnitude of the difference between MPA and Ref responses using Hedges' g. In each region except for the North Coast, the biomass of Targeted species is increased more (or decreased less) over time inside MPAs than the non-targeted species (Figure 9).

At the individual MPA scale, none of the 20 individual MPAs that had sufficient time series to evaluate these criteria fulfilled the criteria to infer an MPA effect, though one MPA (Gull Island SMR) verged on fulfilling these criteria (target status x year interaction: p= 0.0673) (Appendix Figure 1, Table 12). Short of fulfilling these criteria, we detected significant positive trends in the response ratios of Targeted species biomass at several MPAs (Point Buchon SMR, Point Vicente SMCA, Abalone Cove SMCA, Painted Cave SMCA, Gull Island SMR; Appendix Figure 1, Table 13). And high variance in biomass in two other MPAs (Point Sur SMR and Naples SMCA) precluded significantly positive trends in the response ratios of Targeted species biomass (p= 0.059 and p= 0.05, respectively; Table 13). Targeted species exhibited a significant negative response in one MPA (Point Cabrillo). Otherwise, the remaining 12 MPAs exhibited no evidence of a positive trend in the response ratios of Targeted species biomass over the

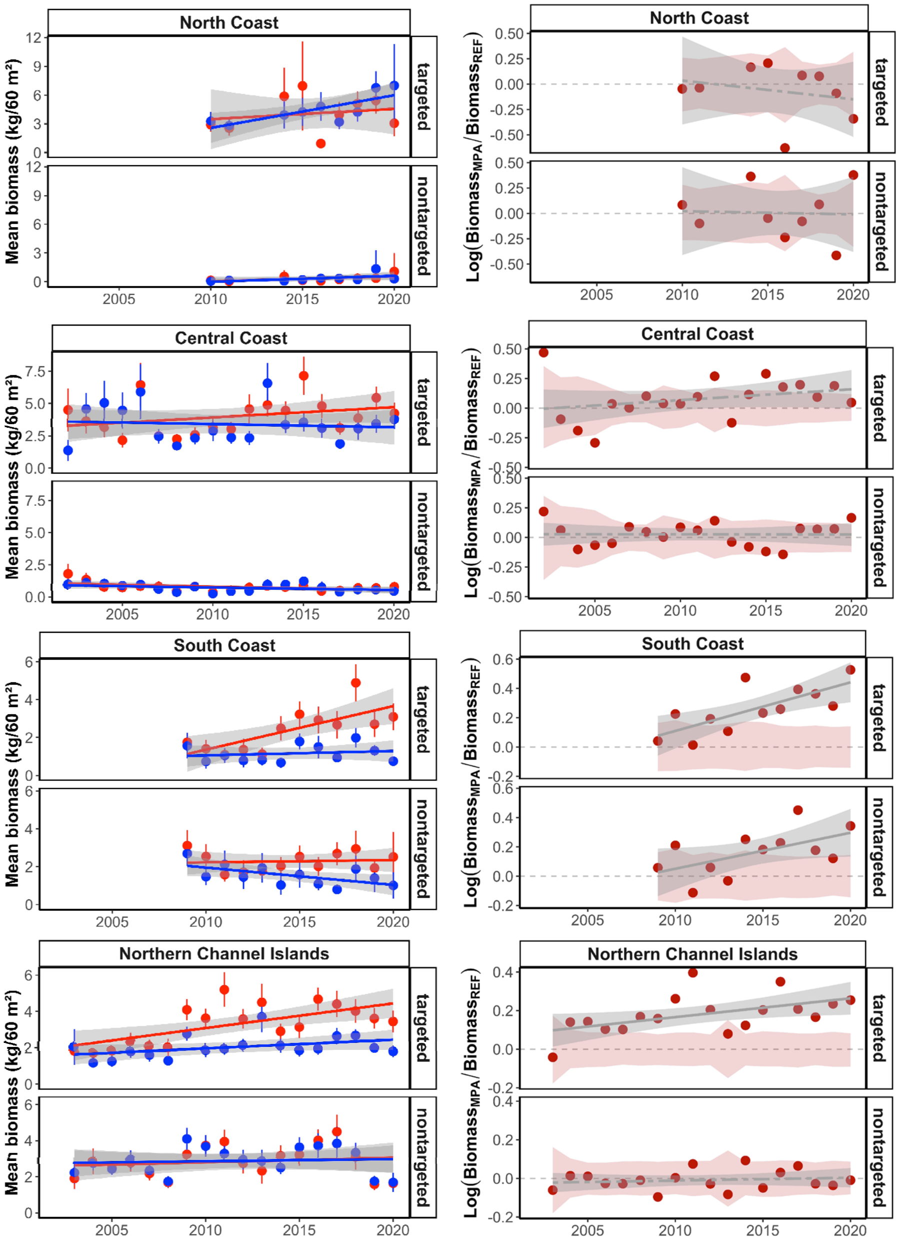
**Figure 8.**

**Baseline years:**
2010-2011 / 2014-2015,
**MPAs established:**
2010 / 2012

Baseline years:
2007-2008
MPAs established:
2007

**Baseline years:**
2011-2012
**MPAs established:**
2012

**Baseline years:**
2005-2006
**MPAs established:**
2003



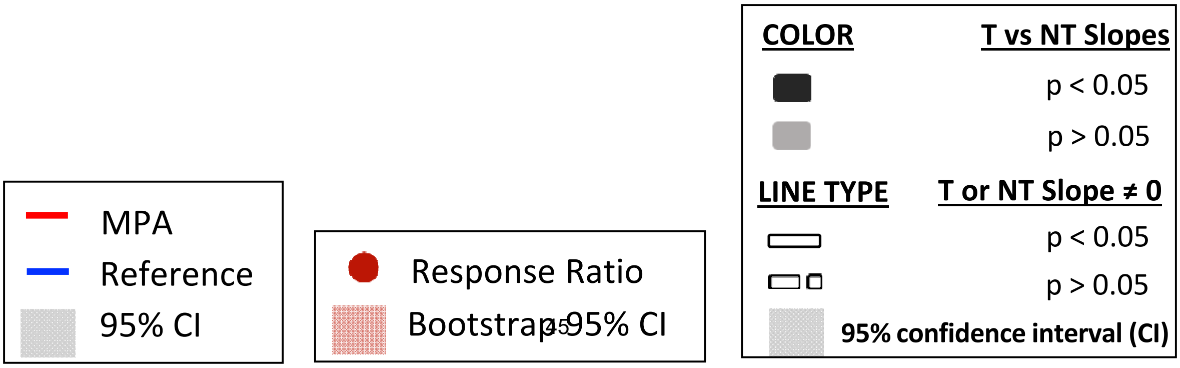


**Figure 8.** Left panels: Trajectories of average biomass (kg/60m2) per region for Targeted and Non-targeted fish group. Right panels: Log response ratios (Log($Biomass_{MPA}$/$Biomass_{REF}$) for Targeted and Non-targeted fish groups by region. Data for targeted and non-targeted are divided into two sub-figures with targeted on the top and non-targeted on the bottom. Legend key for left panels: Each data point represents average biomass across region within MPA or REF. Error bars on each data point are 95% confidence intervals (CIs) with sites as replicates. Data points are fitted with a regression line (red line = MPA and blue line = REF). Gray shading represents 95% CI for the slope of a regression line. Legend key for right panels: Each data point represents biomass response ratio between MPA and REF across region. Red shading is bootstrap 95% CIs and the shading represents a range of ratios that are considered “no difference” between MPA and REF. Gray shading represents 95% CI for the slope of a regression line. Line color represents ANCOVA results comparing the responses between targeted and non-targeted. A significant difference in responses between targeted and non-targeted ($P < 0.05$) is shown as black lines. A non-significant difference ($P > 0.05$) is shown as gray lines. Line type represents linear regression results examining whether response of each target status over time (slope) is significantly different from zero. A significant slope departure from zero ($P < 0.05$) is represented as a solid line. A non-significant departure ($P > 0.05$) is represented as a dashed line. Key details are visually depicted on the bottom of each figure. For Statistical Output see Table 5. For interpretation see report text.

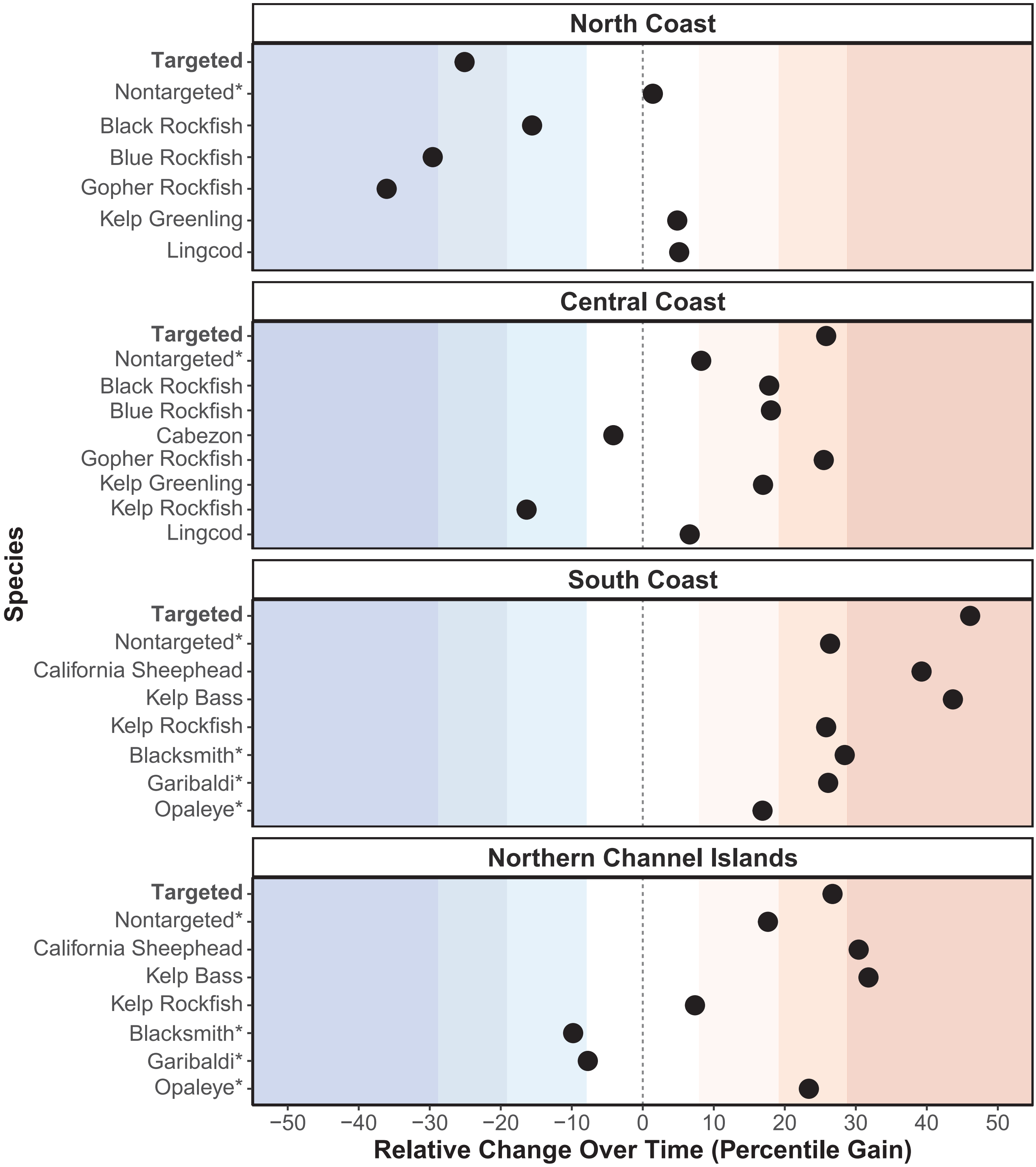


**Figure 9.** Relative change in fish biomass inside and outside of MPAs over time for each region. Relative change (slope) for MPAs and Refs were calculated using Hedges' g and expressed as percentile gain. Positive values mean average change in biomass over time (slope) for a group in MPA sites is higher than average slope in reference sites. Negative values mean the slope in reference sites is higher than average slope in MPA sites. An asterisk after the name or grouping indicates species which are not targeted by fishing. Shading indicates the magnitude of the effect size (or difference between MPA and Refs) with small, medium, and large effect represented by successively darker shading.

monitoring period. While these biomass estimates aggregated across species Targeted by fisheries and those not targeted by fisheries were thought to provide more robust (i.e. lower variance) estimates of species responses relative to individual species, several cases of positive MPA effects were in fact detected for focal species (next section). Trends of Targeted and Non-Targeted species for MPAs monitored by RCCA but not included in these analyses are shown in Appendix 2.

Using the 20 MPAs where we had a sufficient time series, we compared how many MPAs exhibited greater biomass on average inside the MPA compared to its associated Ref site for both Targeted and Non-targeted species. We found that 16 of the 20 MPAs (80%) had positive response ratios for Targeted species, indicating higher abundance on average inside the MPAs, while only 4 MPAs exhibited negative response ratios (two in the North Coast and one each in the Central and South Coasts; Figure 10). For Non-targeted species, the distribution of positive and negative response ratios was random, with 12 MPAs showing positive responses and 8 MPAs showing negative responses.

### *Relationship with explanatory variables*

We explored the influence of a set of explanatory variables related to MPA location, size, habitat and proxies for fishing effort on two metrics of MPA effectiveness, a) the rate of change in fish biomass and b) the average response ratio for fish biomass. In these analyses we used the Targeted species biomass as these are the species most likely to respond to MPA protection.

#### *MPA attributes (location, size, habitat) and Fishing pressure*

[These analyses address DEWG questions: G1-3a, G5-32a for fisheries Targeted species]

*Rate of change* - We asked whether the rate of change in biomass of Targeted fish species was influenced by MPA attributes such as location (latitude), size and habitat. We hypothesized that the rate of change in biomass over time should increase with increasing MPA size, habitat diversity, habitat richness and area of rock reef. If distance to nearest port is a proxy for fishing pressure, likewise the rate of change in biomass in the MPAs should increase with distance to nearest port. We have no a priori prediction of the relationship with latitude. To test these hypotheses, we plotted the slopes of biomass over time versus each MPA attribute for both MPA and Ref areas and tested for significant positive linear relationships between the biomass response and the MPA attribute. We found no clear relationships with any of these MPA attributes tested (Figure 11, Table 14, 15). There was a trend towards faster rate of change of Targeted species biomass with increasing latitude but only in the Ref areas (Figure 11a). There was a slight trend towards decreasing rate of change in biomass with increasing habitat diversity and habitat richness (Figure 11c,d). There was no trend for MPA size or amount of rocky reef habitat in the MPA (Figure 11b,f)) or distance to nearest port (Figure 11e). In summary, the lack of relationships between the rate of change in biomass and MPA attributes is likely due to the high variability in the actual biomass trends over time, which makes the highly variable linear slopes of these times series a poor indicator of rate of change. In contrast to the results of MPA distance to nearest port irrespective of the port, we did find differences in the relative change in fish biomass between MPA and Ref areas in proximity to some ports, but not others (Figure 12, Table 16). The relative change in fish biomass over time was greater in MPAs relative to their paired Ref area in proximity to Morro Bay, Santa Barbara and San Pedro (Figure 12, Table 16) compared to Ft. Bragg, Bodega Bay, Monterey and the Channel Islands.

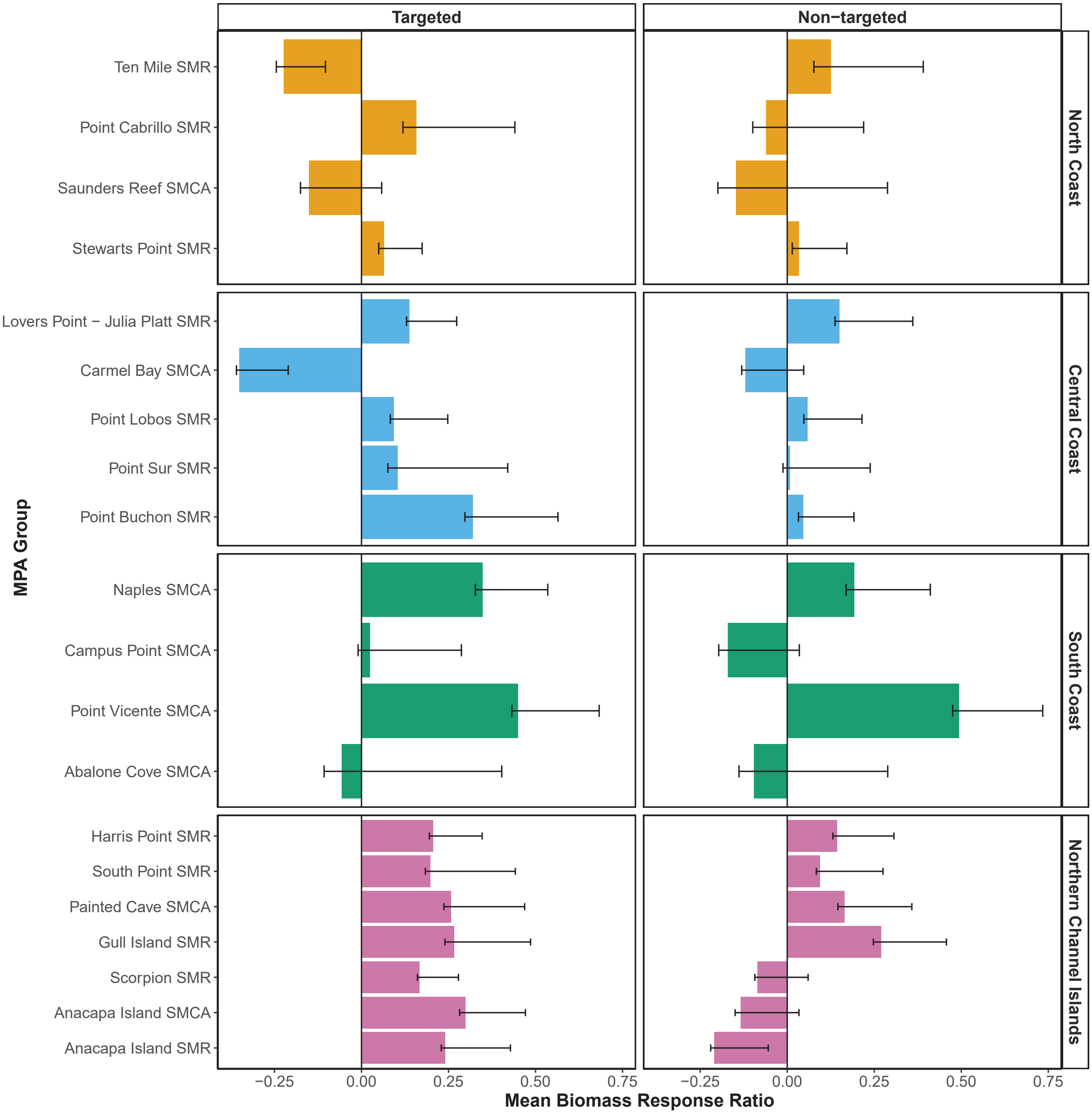


**Figure 10.** Mean biomass response ratio (log (Biomass $_{MPA}$/Biomass $_{Ref}$) with standard error over the time series for targeted (left) and non-targeted (right) fishes.

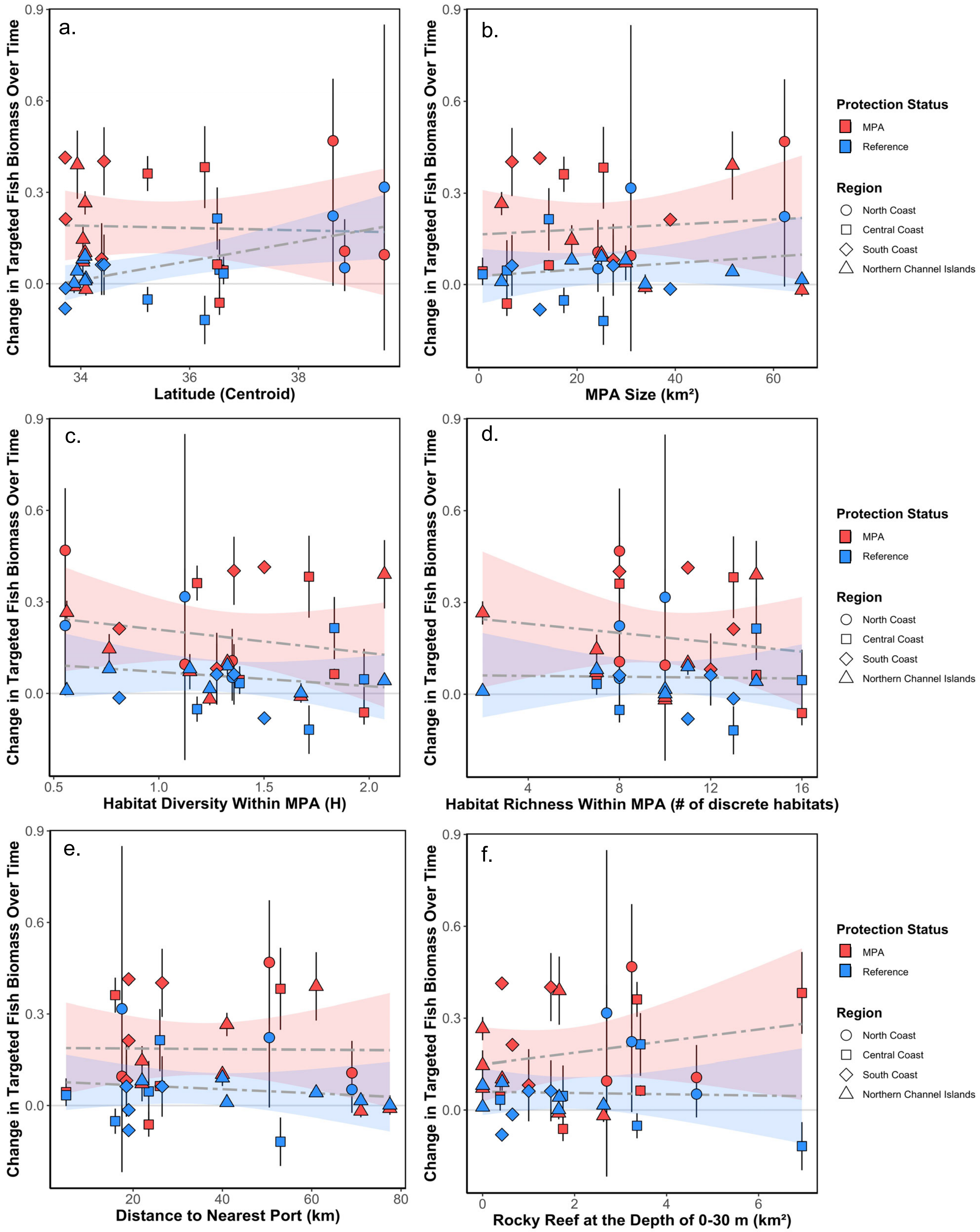


**Figure 11.** Relationship between the slopes of biomass of Targeted species (a measure of rate of change) and MPA attributes. a) Latitude, b) MPA size (km$^2$), c. Habitat diversity in MPA, d) habitat richness in MPA, e) distance to nearest port, and f) area of rocky reef from 0-30m depth. Data points are mean slope in MPA and REF. Error bars on each data point are standard error with sites as replicates. The points are represented by color (red = MPA and blue = REF) and shape (circle = North Coast, square = Central Coast, diamond = South Coast, triangle = Northern Channel Islands). Each group of data points (MPA and REF) are fitted with a regression line. Shading represents 95% confidence interval for the slope of a regression line. Line color represents ANCOVA results comparing the responses between MPA and REF. A significant difference in responses between MPA and REF (P < 0.05) is shown as black lines. A non-significant difference (P > 0.05) is shown as gray lines. Line type represents linear regression results examining whether response of each protection level over time (slope) is significantly different from zero. A significant slope departure from zero (P < 0.05) is represented as a solid line. A non-significant departure (P > 0.05) is represented as a dashed line.

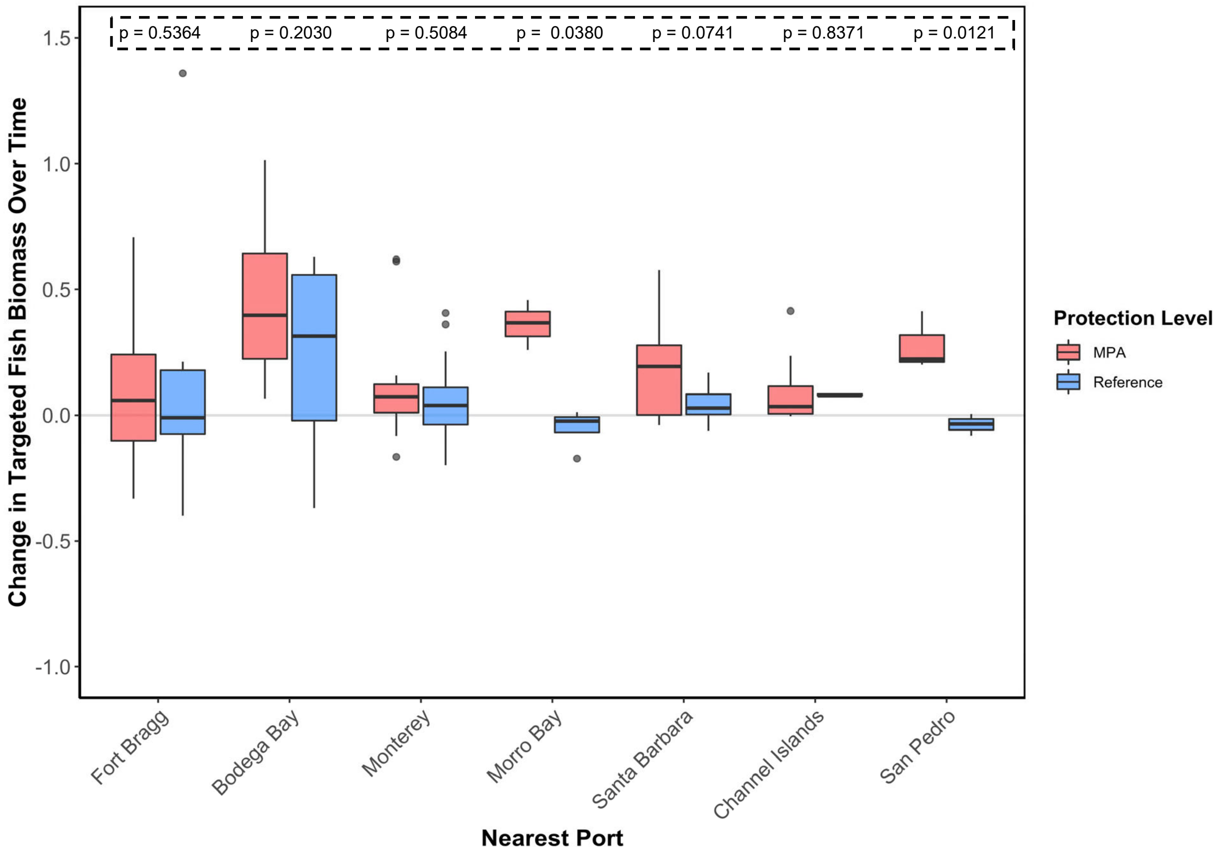


**Figure 12.** Slope of biomass of Targeted fish species (a measure of rate of change) plotted against nearest port for MPA (red) and REF (blue) areas. Data in boxplots represent sites in MPA and REF. P-values from an ANOVA model comparing protection level for each of the nearest ports are placed on the top of the figure.

*Average response ratios* - We then asked whether the difference in fish biomass inside MPAs relative to outside MPAs was influenced by the same MPA attributes. To do this we used the mean biomass response ratio (RR) over the entire time series relative to MPA attributes. (Figure 13, Table 17). We hypothesized that the average response ratio over time should increase with increasing MPA size, habitat diversity, habitat richness and area of rock reef. Again, if distance to nearest port is a proxy for fishing pressure, likewise the rate of change in biomass in the MPAs should increase with distance to nearest port. We have no *a priori* prediction of the relationship with latitude. The mean RR showed a steep decline with increasing latitude, clearly demonstrating greater MPA response in the South Coast and Northern Channel Islands as noted earlier in the report (Figure 13a). The Central Coast MPAs showed intermediate responses with the weakest responses in the North Coast. For MPA size, we found a trend of greater MPA response with increasing size but this was not significant and variability was high (Figure 13b, Table 17). This trend was not due to systematic differences among regions as MPAs of all sizes occur in each region. MPA responses declined with increasing habitat diversity, habitat richness and amount of rock reef in MPAs (Figure 13c,d,f). While not significant, this result is intriguing and warrants further investigation. We saw no clear relationship between MPA response and distance to nearest port (Figure 13e), but when mean RR are plotted against port identity, we see a clear pattern of stronger MPA response in the southern part of the state (Figure 14). Log RRs greater than zero (more biomass in MPAs) occurred at MPAs with Morro Bay, Santa Barbara, Channel Islands and San Pedro as their closest port.

In summary, we found that distance to port may not be a good measure of fishing mortality, especially when at the statewide scale. It will be important in the future to have a finer spatial scale measure of fishing pressure. Nonetheless, these results of greater responses in the southern regions, especially by species known to be highly favored by commercial and recreational fisheries (e.g., California Sheephead, Kelp Bass, spiny lobster), suggest that the regional patterns of species responses correspond with regional patterns of fishing pressure (see Discussion).

### Levels of protection

Using the same two metrics described above for MPA attributes (i.e., rate of change in biomass and average biomass response ratio over time), we investigated the effect of levels of protection by comparing SMRs, de facto SMRs and fished SMCAs (Figure 15A and 16A). As described above in “Methods”, we chose not to conduct statistical analyses on levels of protection because we classified SMCAs that do not allow any fishing on kelp forest related species as *de facto* SMRs, leaving an insufficient number of replicates for fished SMCAs (only in the Central Coast). Instead, we describe qualitative differences among the levels of protection for each region.

*Rate of change* - We found that in general, de facto SMRs perform similarly to SMRs (Figure 15A). Interestingly, the rate of change in target fish species biomass in the fished SMCA was lower than its paired reference area, a pattern not observed for de facto SMRs or SMRs in any of the regions. However, as noted, there are very few fished SMCAs to compare and these results must be interpreted with caution.

*Average response ratios* - For average response ratios (Figure 16a) the patterns are more clear, again de facto SMRs do not appear to perform any differently than SMRs and the fished SMCAs in the Central Coast have much lower biomass response ratios than either form of SMRs.

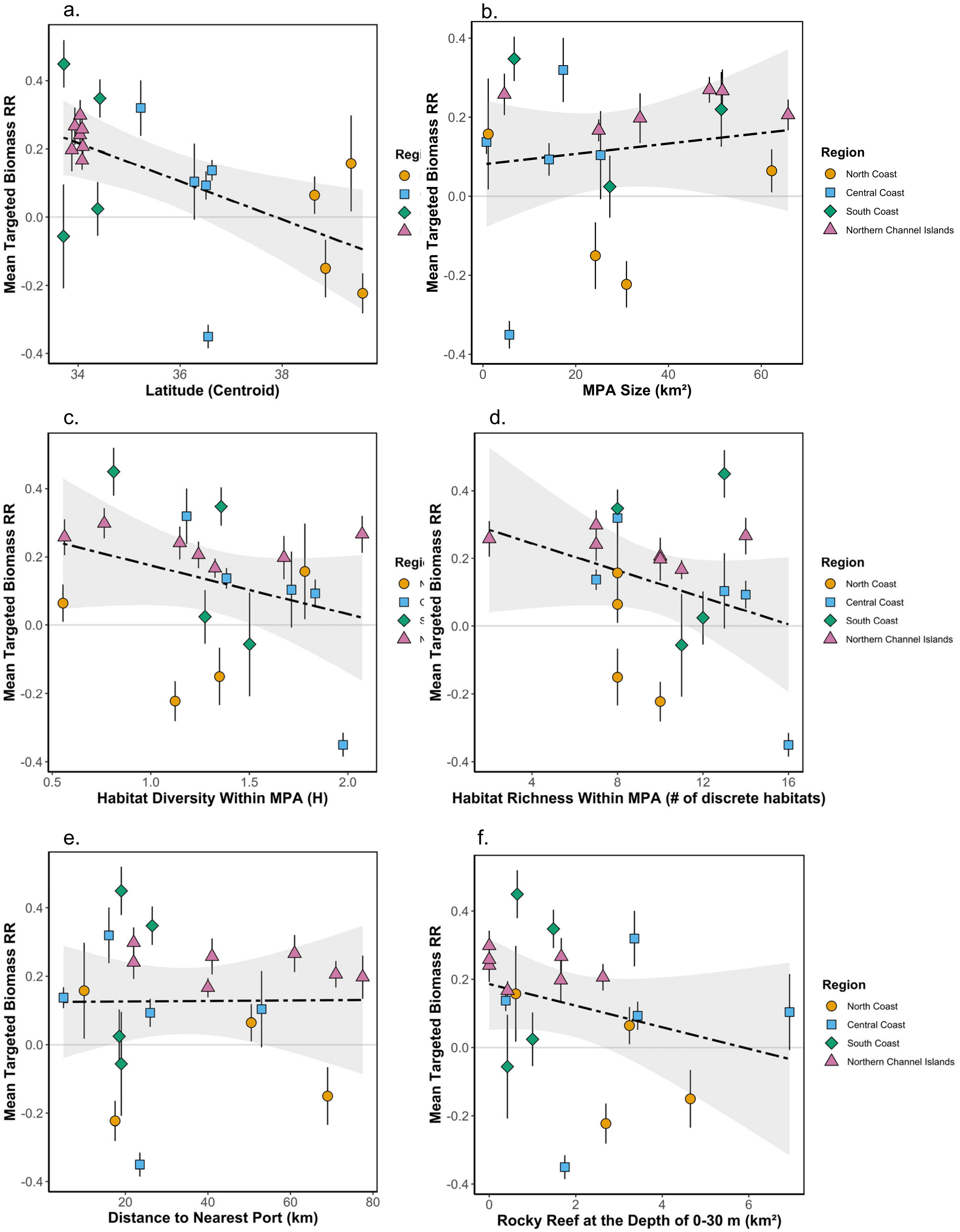


**Figure 13.** Relationship between the mean Response Ratios of Targeted fish species and MPA attributes: a) Latitude, b) MPA size (km$^2$), c) Habitat diversity in MPA, d) habitat richness in MPA, e) distance to nearest port, and f) area of rocky reef from 0-30m depth. Data points are mean response ratios for each MPA group across years. Error bars on each data point are standard error with year as replicates. The points are represented by color and shape (yellow circle = North Coast, blue square = Central Coast, green diamond = South Coast, purple triangle = Northern Channel Islands). Data points are fitted with a regression line. Shading represents 95% confidence interval for the slope of a regression line. Line type represents linear regression results examining whether the relationship between an MPA attribute and Targeted response ratio over time (slope) is significantly different from zero. A significant slope departure from zero ($P < 0.05$) is represented as a solid line. A non-significant departure ($P > 0.05$) is represented as a dashed line.

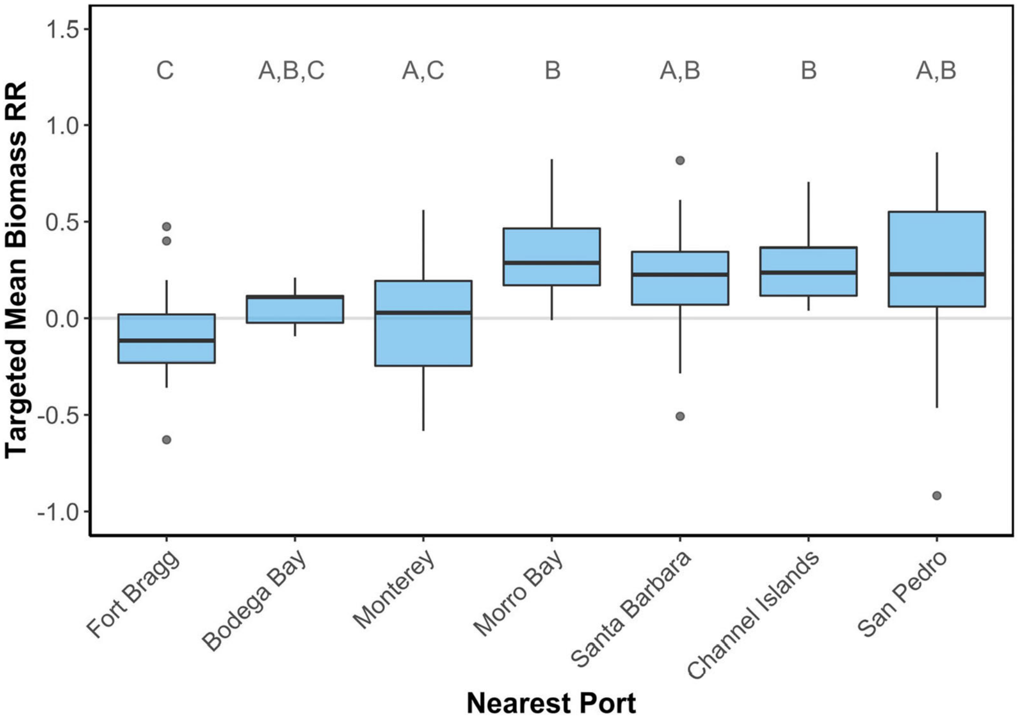


**Figure 14.** Mean Response Ratios of Targeted species plotted against nearest port for MPAs across the California coast. Letters on the top of the figure indicate differences in means with the same letter indicating no difference from Tukey's tests.

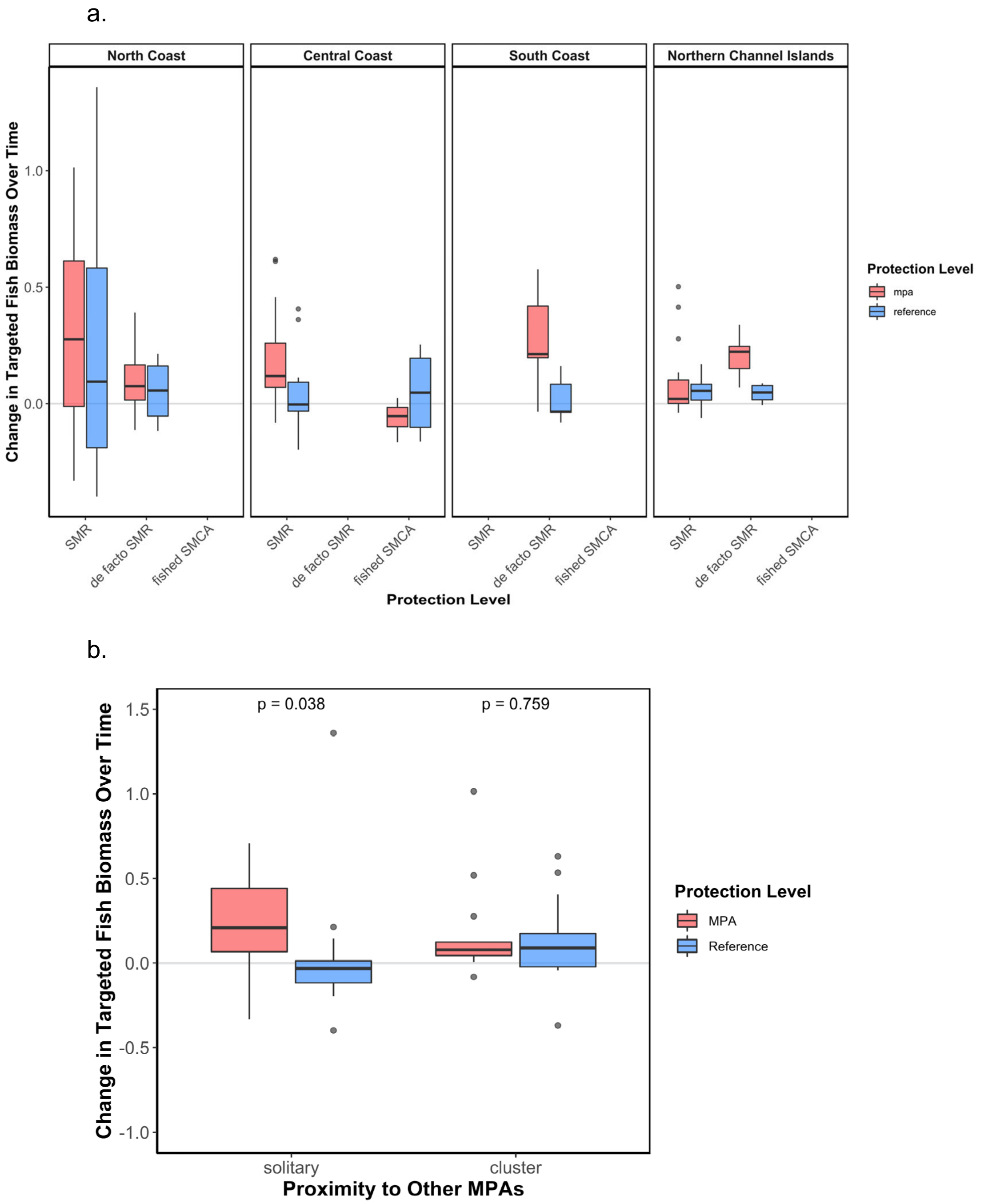


**Figure 15**. Slope of biomass of Targeted species (a measure of rate of change): a) plotted by region against level of protection within marine reserves (SMR = no fishing allowed, de facto SMR = SMCA that bans fishing for kelp forest species, fished SMCA = SMCA where fishing is allowed); b) plotted by whether an MPA is adjacent to a fished SMCA (cluster) vs. not adjacent to a fished SMCA (solitary). In panel b data are limited to where this occurs, only in the North and Central Coast regions. Data in boxplots represent sites in MPA and REF. For panel b, P-values from a two-sample Wilcoxon signed-rank test comparing protection level (MPA and REF) for each proximity are placed on the top of the figure.

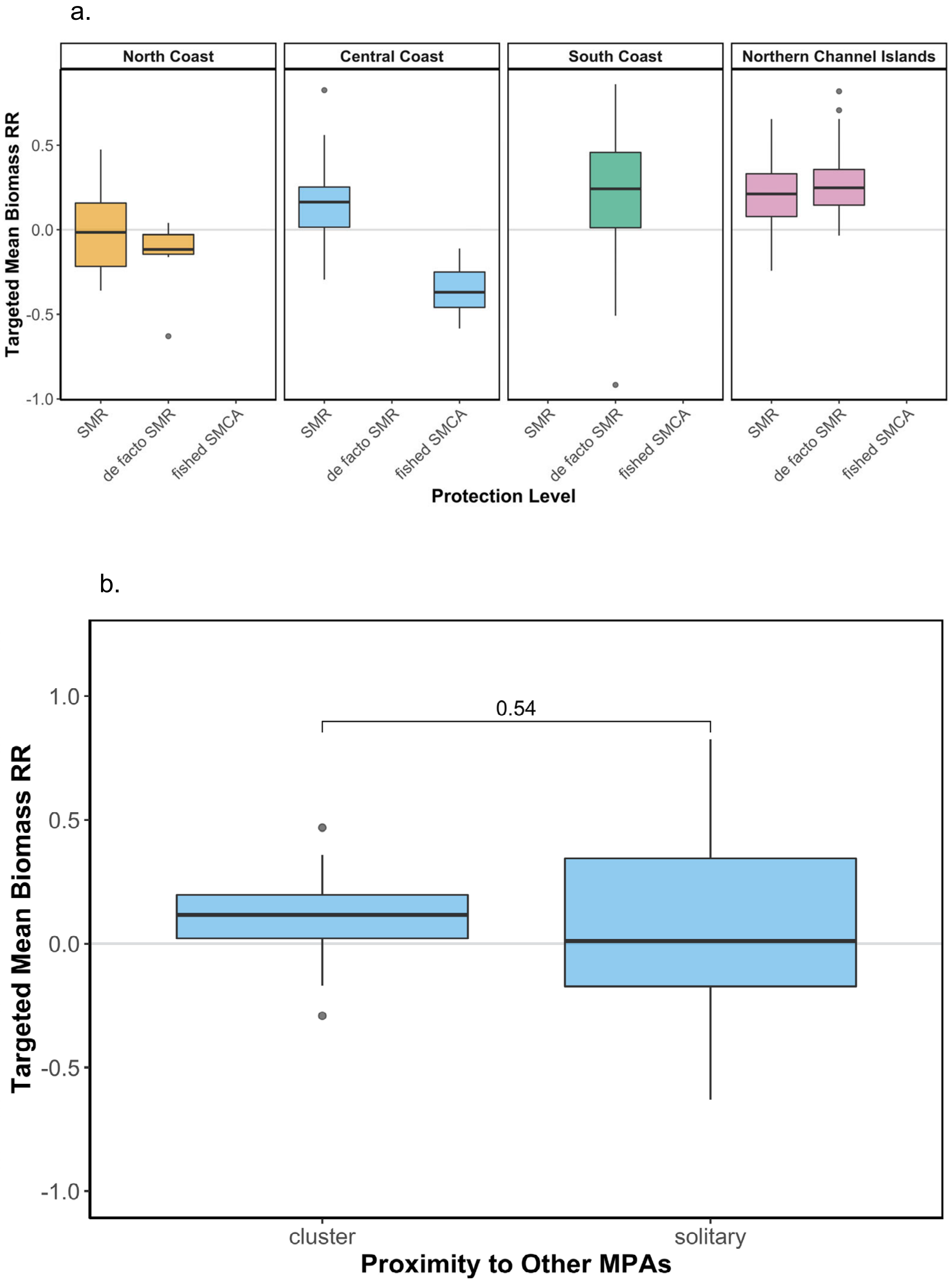


**Figure 16.** Mean Response Ratios of Targeted species: a) plotted by region against level of protection within marine reserves (SMR = no fishing allowed, de facto SMR = SMCA that bans fishing for kelp forest species, fished SMCA = SMCA where fishing is allowed); b) plotted by whether an MPA is adjacent to a fished SMCA (cluster) vs. not adjacent to a fished SMCA (solitary). In panel b data are limited to where this occurs, only in the North and Central Coast regions, and a P-value from a two sample t-test comparing cluster and solitary is placed on the top of the figure.

### *MPA clusters*

We defined clustered MPAs based on the presence of adjacent MPAs of different levels of protection. Having distinguished *de facto* SMRs (those SMCAs that provide comparable protection to kelp forest species as SMRs), we identified adjacent SMR-SMCA clusters for comparison of Targeted fish responses (rate of change of biomass, average response ratio) between nine solitary SMRs and three clustered SMRs. We found a significant difference in rate of biomass change between MPA and Ref for solitary sites, but not for cluster sites (Figure 15b, Table 18). Note, the rate was highly variable for solitary MPAs compared to Refs. The average response ratio shows the response was highly variable for solitary sites and was not significantly different from cluster sites (Figure 16b, Table 18).

### *Environmental Variables*

We limited our analysis of environmental variables to the effect of sea surface temperature on fish biomass annual response ratio for Targeted species (Figure 17). Sea temperature is a well-known driver of kelp forest dynamics and if we are unable to find a relationship with it and MPA responses, it is unlikely any other environmental variables would yield relationships. For all regions combined we found a strong correlation between sea temperature and MPA response ($r=0.22$, $p<0.001$), despite large variability in annual responses. Within each region, fits were more variable, which is likely due to using an annual mean temperature rather than SST data at higher temporal resolutions (e.g. monthly). However, there are indications of co-variance, to varying degrees, between SST and the MPA response as measured by the average response ratio. This is especially evident for North, Central and South Coast regions, although not for the Northern Channel Islands. To further delineate and interpret the possible co-variance between SST and response ratio, we need to acquire monthly temperature data (which was not available at the time of analyses) and explore the relationships between SST and response ratio and absolute biomass inside and outside of MPAs.

## *Trends in Focal Species Abundance Responses*

[These analyses address DEWG Questions: G1-1b, G1-1c, G2-7b, G4-23a, G4-23b, G5-32c]

The number of MPAs in each region with sufficient time series to test for temporal trends in response ratios was the same as for the Targeted and Non-targeted analyses; however, the number of MPAs with sufficient time series varied among focal species depending on each species' geographic distribution across regions.

### *Focal Fish Biomass*

Observed responses of the 12 focal fish species were attributed to MPA effects only if the trajectories of response ratios (inside vs. outside MPAs) had significant positive slopes (i.e., in the direction predicted by an MPA effect). Based on this criterion, three general patterns emerged from the temporal responses in biomass across the 12 focal finfishes examined (Figure 9, Appendix Figure 2, Table 19). First, there were clear differences in responses among species. Second, there were strong regional differences in focal species responses. Third, responses varied markedly among MPAs even within regions. In each region except for the North Coast, the biomass of each focal species is increasing more (or decreasing less) over time inside MPAs (Figure 9). Statistically speaking, there were no significant focal species responses detected in Northern CA MPAs. However, non-significant positive responses were apparent for

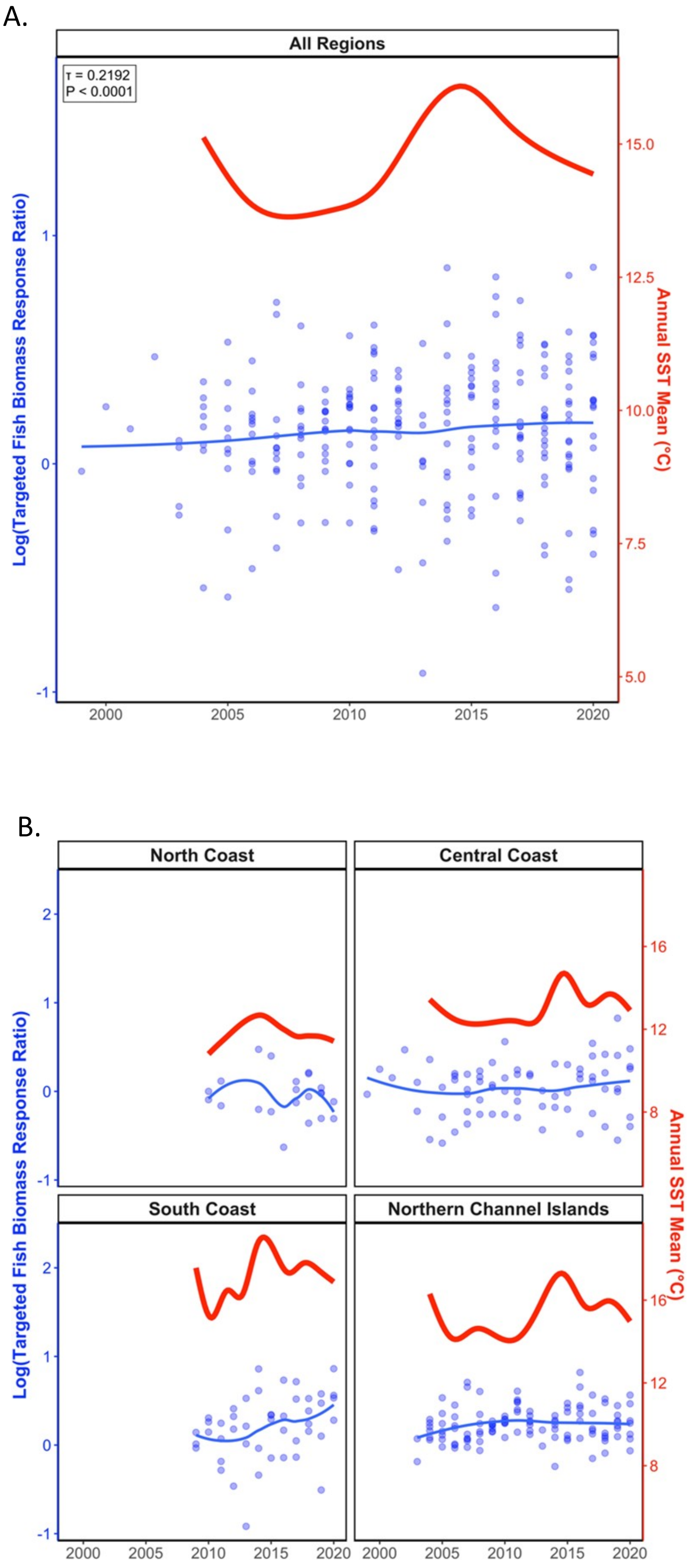


**Figure 17**. Relationship between log response ratio for fish biomass (biomass$_{MPA}$/Biomass$_{REF}$) for targeted species (blue) versus annual mean sea surface temperature (SST) (red). A) Model for all regions combined. B) Model for each region separately. Data points are biomass response ratio for each MPA group and mean SST. The points are fitted with a Generalized Additive Model smoothing function. For panel A, the relationship between response ratio and SST for all regions combined is calculated by Kendall's Tau and the results are shown on the top left of the figure.

several species in several MPAs, that might be detected with longer time series (Appendix Figure 2). More significant positive responses were detected in Central CA. In contrast, significant positive responses were detected for many species across many South Coast and Northern Channel Island MPAs. Trends for the same focal species for MPAs monitored by RCCA but not included in these analyses are shown in Appendix 2.

Turning to the response of focal species across MPAs, Black Rockfish is an abundant recreationally and commercially important species across the Northern and Central Coast regions. Across the nine MPAs examined, none exhibited significant positive trends in response ratios, while three MPAs exhibited non-significant positive trends and one MPA (Point Cabrillo SMR) exhibited a significant negative trend (Appendix Figure 2, Table 19).

Blue Rockfish is an abundant recreationally and commercially important species across the Northern and Central Coast regions. It is also an ecologically important planktivore in kelp forests and shallow rocky reefs. Across the nine MPAs examined, only one (Point Buchon SMR) exhibited a significant positive trend in response ratios, while two other MPAs (Stewarts Point SMR and Point Sur SMR) exhibited non-significant positive trends associated with high variance within the MPA, and one MPA (Point Cabrillo SMR) exhibited a significant negative trend (Appendix Figure 2, Table 19).

Gopher Rockfish is an abundant recreationally and commercially important species across the Northern and Central Coast regions. It exhibited a significant positive response ratio in only one (Point Sur SMR) of the nine MPAs examined (Appendix Figure 2, Table 19).

Kelp Greenling is an abundant recreationally and commercially important species across the Northern and Central Coast regions. In only one of the MPAs (Lovers Point - Julia Platt SMR) did we detect a significant trend in response ratios and it was negative (Appendix Figure 2. Table 19). In the same Central Coast region, response ratios increased dramatically until 2015 in the Carmel Bay SMCA, then dropped and trended lower post marine heatwave. Through this period, mean biomass declined at a greater rate in reference sites than in the MPA.

Lingcod is an abundant and ecologically important piscivore in kelp forests and shallow rocky reefs and important recreational and commercial species across the Northern and Central Coast regions. We detected a significant trend in response ratio in only one (Pt Lobos SMR) of the nine MPAs. Though abundant regionally, it is encountered in very low numbers on surveys (Appendix Figure 2, Table 19).

Cabezon is an abundant recreationally and commercially important species, restricted to the Central Coast region. No significant trend in response ratios was detected across the five MPAs examined. Like Lingcod, it is encountered in very low numbers on surveys (Appendix Figure 2, Table 19).

Kelp Rockfish is an abundant recreationally and commercially important species, across the Central Coast, South Coast, and Northern Channel Islands regions. It exhibited no significant response in the Central Coast region, but significant positive responses in two of four South Coast MPAs, two of seven Northern Channel Island MPAs, and a non-significant positive trend in Anacapa Island SMCA associated with very high variance in the MPA (Appendix Figure 2, Table 19).

Blacksmith is a very abundant ecologically important planktivore in the two southern California regions. It is not targeted by commercial fisheries and minimally by recreational fisheries.

Across the 11 MPAs examined, it exhibited a significant negative trend in response ratios in one MPA (Scorpion SMR) and non-significant positive trends associated with high variance within four other MPAs (Naples SMCA, Point Vicente SMCA, Abalone Cove SMCA and South Point SMR; Appendix Figure 2, Table 19).

California Sheephead is an abundant ecologically important predator of sea urchins and is highly targeted by both recreational and commercial fisheries in the two southern California regions. Across the 11 MPAs examined, it exhibited a significant positive trend in response ratios in one of four South Coast MPAs (Abalone Cove SMCA) and non-significant trends associated with high variance within two others (Appendix Figure 2, Table 19). It exhibited significant positive trends in one (Gull Island SMR) of seven Northern Channel Islands MPAs, non-significant trend associated with high variance within one other MPA (Painted Cave SMCA), and a non-significant negative trend in one MPA (Anacapa Island SMR).

Garibaldi is an abundant protected species in both southern regions. It exhibited no significant response to the presence of any of the 11 MPAs, but exhibited non-significant positive trends in Painted Cave SMR and Anacapa Island SMCA (Appendix Figure 2, Table 19).

Kelp Bass is a very abundant ecologically important piscivore and highly targeted recreational species in both southern regions. It exhibited significant positive trends in response ratios in three of the four South Coast MPAs, and three of seven Northern Channel Island MPAs (Appendix Figure 2, Table 19).

Opaleye is an abundant ecologically important herbivore that is taken recreationally in low numbers in both of the southern regions. It exhibited a significant positive trend in response ratios in only one of the 11 MPAs examined (Appendix Figure 2, Table 19).

Taken together, of the six *ecologically significant* focal fishes, three species (Lingcod, California Sheephead and Kelp Bass) exhibited significant positive responses at some MPAs. The one *culturally significant* and *protected* fish species (Garibaldi) did not exhibit a significant positive response to MPAs. This result is not surprising, given that Garibaldi are protected from fishing. No fish is *endangered* in California kelp forests. Of the nine *recreationally important* focal fishes, seven species (Blue Rockfish, Gopher Rockfish, Kelp Rockfish, Kelp Greenling, Lingcod, California Sheephead, and Kelp Bass) exhibited positive responses to some MPAs. Of the eight *commercially important* focal fishes, seven of these same species (Blue Rockfish, Gopher Rockfish, Kelp Rockfish, Lingcod, Kelp Greenling, California Sheephead) exhibited positive responses to some MPAs.

One notable attribute of the three species (California Sheephead, Kelp Bass, Kelp Rockfish) that exhibited the strongest positive MPA effects (i.e. significant responses in multiple MPAs) is that they are among the most highly targeted by recreational fisheries, and that California Sheephead is also highly targeted by the nearshore commercial fishery. Responses of these three species were in strong contrast to the other focal fishes for which only a few if any significant positive responses were detected. Some of these other species are also targeted by recreational and the nearshore commercial fisheries (e.g., Black Rockfish, Gopher Rockfish, Cabezon, Lingcod), whereas others (Garibaldi, Blacksmith, Opaleye) are not. Another notable attribute of these species is their high abundances (density and biomass) in contrast to many of the other focal species examined (e.g., Cabezon, Lingcod).

We also detected substantial variation among MPAs in the responses of focal fishes. No significant focal fish responses were detected at MPAs in the North Coast region. Those species with significant positive responses each occurred in different MPAs of the Central Coast. In contrast, significant positive responses were detected for multiple species in particular South Coast MPAs: Naples SMCA (two species), Point Vicente SMCA (two species), Painted Cave SMCA (four species), Scorpion SMR (two species), Abalone Cove SMCA (two species), and Gull Island SMR (two species). In addition, non-significant positive responses associated with high variance within MPAs were detected for additional species in Naples SMCA, Point Vicente SMCA, Painted Cave SMCA, and Abalone Cove SMCA.

### *Focal Invertebrate and Algae Density*

We summarized response ratios for focal invertebrates and algae by averaging over the entire time series at each MPA (Figure 18) and found very strong regional differences. In the North Coast, both red and purple urchins and bull kelp were on average more abundant in MPAs relative to reference areas over the course of the time series. In the South Coast, all focal invertebrates except purple urchins were more abundant in MPAs relative to Ref areas. The species that showed the strongest responses in the South Coast are fished (i.e. CA lobster, red urchin, sea cucumbers). Notably, the response ratios for CA spiny lobster (positive), purple urchins (negative) and giant kelp (positive) may indicate trophic cascades as has been previously observed in southern CA MPAs (Caselle et al. 2018, Eisaguirre et al. 2020) (see section '*Community level consequences of species responses*' below). In the Central Coast, all focal invertebrates except red abalone, had negative response ratios, indicating greater abundance in reference areas relative to MPAs.

We summarised the trajectories over time (shown below) for invertebrates and algae using effect size as done for fishes. In the North and Central coasts, the density of abalones and sunflower stars is increasing more (or decreasing less) over time inside MPAs (Appendix Figure 3). Spiny lobsters and sea cucumbers have similar responses in the South Coast and Northern Channel Islands. Purple and red urchins are notably increasing more outside of MPAs in all of the regions, with an exception of purple urchin in the North Coast.

Observed responses of the eight focal invertebrate species groups were attributed to MPA effects only if the trajectories of response ratios (inside vs. outside MPAs) had significant positive slopes (i.e. in the direction predicted by an MPA effect). Based on this criterion, three general trends again emerged from the temporal responses in density across the eight focal invertebrates examined: clear differences in responses among species, among MPAs, which in combination led to strong regional differences in responses of some focal species (Appendix Figure 3, Table 20).

Purple urchins are key detritivores, herbivores, and ecological engineers in kelp forests. Purple urchins exhibited significant negative trends in seven of the 20 MPAs analyzed across the network (Appendix Figure 3, Table 20). This included no MPAs on the North Coast, one on the Central Coast (Point Sur SMR), one on the South Coast (Point Vicente SMCA), and five of the seven MPAs examined in the Northern Channel Islands. In addition, two other MPAs on the South Coast exhibited non-significant negative responses associated with high variance within MPAs. Significant positive responses were detected in one MPA in each of the North Coast and the Central Coast. The large number of negative trends suggests that the community structure that developed or was maintained within MPAs has contributed to declines in this herbivore responsible for the deforestation of shallow rocky reefs in many areas of Northern and Central California.

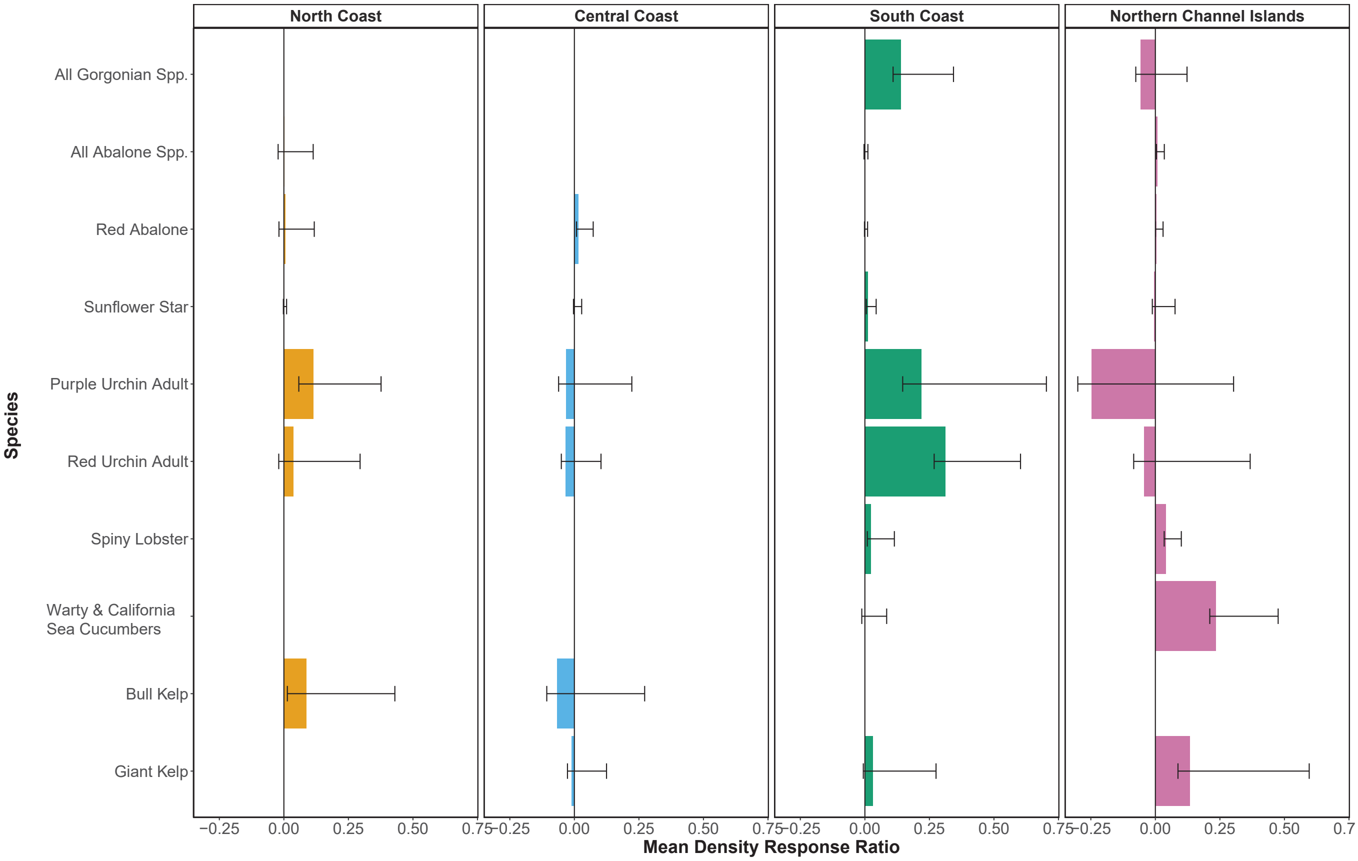


**Figure 18**. Mean density response ratio (log (Density $_{MPA}$/Density $_{REF}$) with standard error over the time series for North Coast, Central Coast and South Coast (includes Channel Islands).

Red sea urchins are an ecological engineer and commercially fished species. Red sea urchins exhibited similar patterns as purple urchins, with significant negative trends in eight of the 20 MPAs analyzed across the network (Appendix Figure 3, Table 20). This included no MPAs on the North Coast, one on the Central Coast (Point Sur SMR), two on the South Coast (Campus Point SMCA and Abalone Cove SMCA), and four of the seven MPAs examined in the Northern Channel Islands. In contrast, red urchins exhibited a significant positive response in Point Vicente SMCA on the South Coast. The large number of negative trends suggests that the community structure that developed or was maintained within MPAs has contributed to declines in this herbivore on the South Coast and Northern Channel Islands, where it supports a commercial fishery.

The giant sunflower star, *Pycnopodia helianthoides*, is a keystone predator that contributes to the control of sea urchin numbers and foraging behavior. Throughout the entire network, sunflower star numbers plummeted to zero simultaneously inside and outside of MPAs (Appendix Figure 3, Table 20). Across the entire network, the dramatic decline in counts corresponded with the 2013-14 arrival of the Sea Star Wasting Disease (SSWD).

Abalone (genus *Haliotis*) are culturally significant, threatened, and protected species, and the red abalone, *Haliotis rufescens*, is also recreationally important in the North and North Central regions of the coast. Species of abalone other than the red abalone are most abundant in the southern regions of the MPA network. For all these species combined, including red abalone, none of the four MPAs in the South Coast exhibited positive response ratios, whereas three of the seven MPAs in the Northern Channel Islands region did exhibit significant response ratios for all abalone species combined Appendix Figure 3, Table 20). In contrast to the patterns of all abalone species combined, no MPAs exhibited positive response ratios for the red abalone except for two MPAs in the Central Coast region, of which one was significant (Lovers Point – Julia Platt SMR) and the other exhibited a non-significant positive trend associated with high variance within the MPA (Appendix Figure 3, Table 20). Notably, however, for one MPA in the North Central region (Saunders Reef SMCA), when counts of other abalone were added to red abalone, a significant positive response ratio was detected.

Gorgonians (Alcyonacea), or “soft corals” are an order of corals that are ecologically significant as habitat formers and abundant planktivores in some areas of the South Coast and Northern Channel Island regions. All four species (*Muricea fruticosa*, *Muricea californica*, *Eugorgia rubens*, and *Leptogorgia chilensis*, are threatened. Because of their low abundances, counts of all gorgonian species are combined. Across the MPAs of the South Coast and the Northern Channel Islands, only one MPA (Abalone Cove SMCA) exhibited a significant negative trend in response ratios, whereas another MPA (Harris Point SMR) exhibited a significant positive trend in response ratios (Appendix Figure 3, Table 20).

The California spiny lobster is an abundant, culturally, ecologically, recreationally, and commercially significant species in the South Coast and Northern Channel Islands regions. Its ecological significance includes its role as an abundant predator of a diversity of invertebrates, including sea urchins. A significant positive trend in response ratios was detected in one of the four South Coast MPAs and three of the seven Northern Channel Island MPAs (Appendix Figure 3, Table 20).

The warty and California sea cucumbers are abundant, culturally and commercially significant species in the South Coast and Northern Channel Islands regions. Counts of the two species are combined. Only one (Campus Point SMCA) of four MPAs in the South Coast region exhibited a significant positive trend in response ratios, while three of the seven MPAs in the Northern Channel Island region exhibited significant positive trend in response ratios (Appendix Figure 3, Table 20).

In summary, similar to population trends of focal fishes, particular species exhibited stronger responses to MPAs and these responses varied among regions. Like fishes, the strongest responses for both sea urchin species, spiny lobster, sea cucumbers, and all abalone species combined occurred in the two southern regions. Potential explanations for these geographic patterns are discussed in the Discussion section.

As highly productive primary producers that also create habitat for numerous species, bull kelp, *Nereocystis luetkeana*, and giant kelp, *Macrocystis pyrifera*, are abundant ecologically significant foundation species and ecosystem engineers. They are culturally, recreationally, and commercially important species across their respective ranges. In addition, bull kelp is considered threatened on the North and North Central coasts since dramatic regional declines in 2014. In these two regions, the density of bull kelp is increasing more (or decreasing less) over time inside MPAs (Figure 19). In only one MPA (Saunders Reef SMCA) was a non-significant positive trend associated with high variance within the MPA observed (Appendix Figure 4, Table 20). In the Central Coast, the response is reversed with the density increasing more (or decreasing less) over time outside MPAs (Figure 19). A significant negative trend in response ratios was detected in the Point Sur SMR.

Giant kelp had a consistent response in all of the regions except for the North Coast with the density increasing more (or decreasing less) over time inside MPAs (Figure 19). The species exhibited a significant positive trend in response ratios in one (Carmel Bay SMCA) of the five Central Coast MPAs, and a non-significant positive trend associated with high variance within one (Abalone Cove SMCA) of the four South Coast MPAs. In contrast, we detected significant positive trends in response ratios of giant kelp in five of the seven MPAs in the Northern Channel Islands regions (Appendix Figure 4, Table 20).

In summary, bull kelp exhibited little positive response to MPAs across its geographic range, whereas giant kelp, like focal fishes and invertebrates, exhibited strong geographic variation in responses with more frequent positive responses in the Northern Channel Islands compared to the other three regions. This pattern might reflect community level consequences associated with MPAs as described below. More thorough assessments of kelp responses are presented in the LANDSAT analyses.

### *Trends in Focal Species Size Responses*

[These analyses address DEWG questions: G1-1a, G1-1f, G2-7b, G3-1a, G3-20a, G3-20b, G3-20c, G3-20d, G4-20b, G4-23c, G4-23d, G5-20d, G5-32b]

#### *Focal fish size frequency and total length*

Like their biomass responses, the 12 focal finfishes varied in the response of their size distributions to the establishment of the MPAs. For presentation, we constructed and present size distributions using measurements from consecutive two-year intervals across the entire monitoring time series (Appendix Figure 5). We also present size frequency distributions from pooled fish length observations in recent years (2016 - 2020; Appendix Figure 6). For brevity, we summarize only trends for species targeted by fisheries. Because we only constructed size

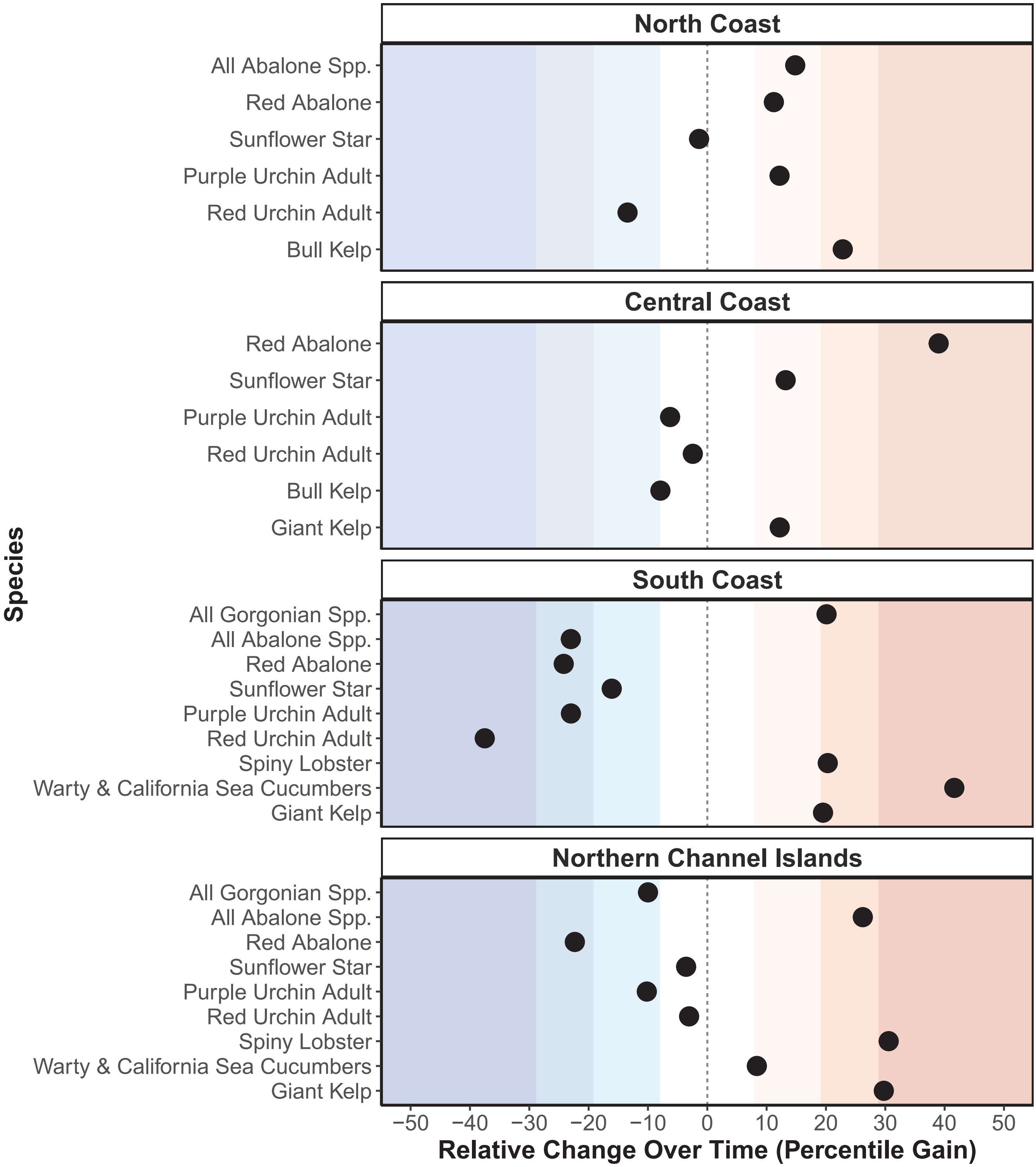


**Figure 19.** Relative change in focal invertebrate and algae density inside and outside of MPAs over time for each region. Relative change (slope) for MPAs and Refs were calculated using Hedges' g and expressed as percentile gain. Positive values mean average change in biomass over time (slope) for a group in MPA sites is higher than average slope in reference sites. Negative values mean the slope in reference sites is higher than average slope in MPA sites. Shading indicates the magnitude of the effect size (or difference between MPA and Refs) with small, medium, and large effect represented by successively darker shading.

distributions with 10 or more total fish individuals, there are some years for a few species in which comparisons could not be made. In addition to the comparison of size distributions inside and outside of MPAs, temporal trends in size frequencies illustrate recruitment events and subsequent shifts in the size distribution of cohorts, reflecting annual growth rates.

Black rockfish

North Coast – The upper 10th percentile of Total Length was greater in MPAs in all years surveyed until the final year (2020) when it was greater in Ref sites (Appendix Figure 5). Shapes of the size frequency distributions of the combined recent years (2016 - 2020; Appendix Figure 6) were significantly different (Table 21A, K-S test, D= 0.131, p< 0.0001) and the median Total Length was significantly greater in the MPA than the Refs (Table 21B, K-W test, Chi-Sq= 67.2, DF= 1, p<0.0001).

Central Coast – The upper 10th percentiles of Total Length were quite similar between MPAs and Ref sites throughout the monitoring period except for 2011-12 and again in 2017-18 when the upper 10th percentile was greater in the Refs and the MPAs, respectively (Appendix Figure 5). These appear to reflect the culmination of earlier strong recruitment events. Shapes of the size frequency distributions of the combined recent years (2016 - 2020; Appendix Figure 6) were not significantly different (Table 21A, K-S test, D= 0.094, p= 0.1952), nor was the median Total Length (Table 21B, K-W test, Chi-Sq= 0.471, DF= 1, p= 0.4925).

Blue Rockfish

North Coast - In contrast to Black Rockfish, the upper 10th percentile of Total Length of Blue Rockfish in the North Coast was larger in MPAs in earlier years, but the upper 10th percentile was much greater in Refs by the last year of sampling (2020; Appendix Figure 5). Shapes of the size frequency distributions of the combined recent years (Appendix Figure 6) were significantly different (Table 21A, K-S test, D= 0.0548, p<0.0001) and the median Total Length was greater in the Refs (Table 21B, K-W test, Chi-Sq= 15.70, DF= 1, p<0.0001).

Central Coast - Results were similar to the North Coast, with the upper 10th percentile of Total Length varying from year to year between MPAs and Refs with no consistent trend (Appendix Figure 5). Similarly, shapes of the size frequency distributions of the combined recent years (Appendix Figure 6) were practically identical yet significantly different (Table 21A, K-S test, D= 0.022, p= 0.0011), with the size distribution greater in the Refs, as was the median Total Length (Table 21B, K-W test, Chi-Sq= 4.055, DF= 1, p= 0.044).

Gopher Rockfish

North Coast - The upper 10th percentile of Total Length shifted from being quite similar in MPAs and Refs in early years to greater in Refs by the end of the monitoring period (2020, Appendix Figure 5). Likewise, shapes of the size frequency distributions of the combined recent years (Appendix Figure 6) were practically identical and not significantly different (Table 21A, K-S test, D= 0.1108, p= 0.1315), with the size distribution slightly greater in the Refs, nor was the median Total Length different Table 21B, (K-W test, Chi-Sq= 3.3974, DF= 1, p= 0.0653).

Central Coast - The upper 10th percentile of Total Length shifted back and forth over the study period (Appendix Figure 5). Likewise, shapes of the size frequency distributions of the combined recent years (Appendix Figure 6) were practically identical (Table 21A, K-S test, D= 0.046, p=

0.706), as was the median Total Length (Table 21B, K-W test, Chi-Sq= 0.0191, DF= 1, p= 0.890).

Kelp Greenling

In the North Coast, the upper 10th percentile of Total Length has been similar or slightly higher in Refs than MPAs throughout the monitoring period (Appendix Figure 5). On the Central Coast, the upper 10th percentile of Total Length was greater in MPAs initially, but became very similar over most of the study period (Appendix Figure 5). Similarly, shapes of the size frequency distributions of the combined recent years (Appendix Figure 6) were practically identical (Table 21A; North Coast: K-S test, D= 0.0625, p= 0.277; Central Coast: K-S test, D= 0.0956, p= 0.4464), as was the median Total Length (Table 21B; North Coast: K-W test, Chi-Sq= 3.421, DF= 1, p= 0.0644; Central Coast: K-W test, Chi-Sq= 1.343, DF= 1, p= 0.2466).

Lingcod

On the North and Central Coasts, the upper 10th percentile of Total Length was similar throughout the study period until the final survey years when it was substantially greater in MPAs (Appendix Figure 5). Shapes of the size frequency distributions of the combined recent years (Appendix Figure 6) were not significantly different (Table 21A; North Coast: K-S test, D= 0.2008, p= 0.0823; Central Coast: K-S test, D= 0.189, p= 0.0769), but the median Total Length was only significantly greater in the MPAs on the North Coast (Table 21B; K-W test, Chi-Sq= 3.421, DF= 1, p= 0.0412) but not on the Central Coast (K-W test, Chi-Sq= 1.983, DF= 1, p= 0.1591).

Cabezon

Central Coast - The upper 10th percentile of Total Length has consistently been greater in the MPAs than Refs throughout the monitoring period (Appendix Figure 5). Similarly, shapes of the size frequency distributions of the combined recent years (2016 - 2020) exhibit larger Total Length in the Central Coast MPAs (Appendix Figure 6) and both the shapes (Table 21A, K-S test, D= 0.4833, p= 0.0018) and the medianTotal Length (Table 21B, K-W test, Chi-Sq= 13.54, DF= 1, p<0.0001) are significantly different.

Kelp Rockfish

Central Coast - The upper 10th percentile of Total Length was largely similar or greater in Refs relative to MPAs throughout the monitoring period (Appendix Figure 5). Shapes of the size frequency distributions of the combined recent years (Appendix Figure 6) were not different (Table 21A, K-S test, D= 0.0467, p= 0.3777), nor were the median lengths (Table 21B, K-W test, Chi-Sq= 2.2317, DF= 1, p= 0.1352).

South Coast – In contrast, the upper 10th percentile of Total Length shifted from being greater in Refs to MPAs over the monitoring period (Appendix Figure 5). This was reflected in the shapes of the size frequency distributions of the combined recent years (Appendix Figure 6), which were significantly different (Table 21A, K-S test, D= 0.4011, p<0.0001), and the median lengths was greater in the MPAs (Table 21B, K-W test, Chi-Sq= 70.523, DF= 1, p<0.0001).

Northern Channel Islands - Although the upper 10th percentile of Total Length was greater in MPAs relative to Refs in many years over the monitoring period (Appendix Figure 5), the size frequency distributions of the combined recent years (Appendix Figure 6), was disproportionately greater in Refs ( Table 21A,K-S test, D= 0.1263, p= 0.013) as was the median length (Table 21B, K-W test, Chi-Sq= 12.481, DF= 1, p= 0.0004).

California Sheephead

South Coast – The upper 10th percentile of Total Length has consistently been greater in the MPAs than Refs throughout the monitoring period (Appendix Figure 5). This was reflected in the size frequency distributions of the combined recent years (Appendix Figure 6), which were significantly different (Table 21A, K-S test, D= 0.2394, p<0.0001), as was the median length greater in the MPAs (Table 21B, K-W test, Chi-Sq= 138.62, DF= 1, p<0.0001).

Northern Channel Islands – The upper 10th percentile of Total Length shifted from being greater in the Refs earlier in the monitoring period (1999-2008) to greater in the MPAs in more recent years (Appendix Figure 5), including the combined recent years (Appendix Figure 6). The size distribution (Table 21A, K-S test, D= 0.121, p<0.0001) and the median length (Table 21B, K-W test, Chi-Sq= 135.946, DF= 1, p<0.0001) were both significantly greater in the MPAs.

Southern Channel Islands – Like the Northern Channel Islands, the upper 10th percentile of Total Length shifted from the being greater in the Refs in the earliest survey to being greater in MPAs through much of the monitoring program (Appendix Figure 5) including the combined recent years (Appendix Figure 6) in which the size frequency distribution was significantly different (Table 21A, K-S test, D= 0.1469, p<0.0001) though the median lengths were not (Table 21B, K-W test, Chi-Sq= 0.6823, DF= 1, p= 0.41).

Kelp Bass

South Coast – The upper 10th percentile has almost always been greater in the MPAs than the Refs over the study period (Appendix Figure 5). This is further evident in the combined recent years (Appendix Figure 6) in which both the size frequency distribution (Table 21A, K-S test, D= 0.1934, p<0.0001) and median length (Table 21B, K-W test, Chi-Sq= 295.4, DF= 1, p<0.0001) was greater in the MPAs.

Northern Channel Islands – Similar to the South Coast, the upper 10th percentile of Total Length was consistently greater in MPAs throughout the monitoring period (Appendix Figure 5) and this was reflected in the combined recent years (Appendix Figure 6) in which the size frequency distributions were significantly different ( Table 21A, K-S test, D= 0.057, p<0.0001), though the median length (Table 21B, K-W test, Chi-Sq= 1.784, DF= 1, p= 0.1817) was not greater in the MPAs.

Southern Channel Islands - The upper 10th percentile of Total Length shifted back and forth between the MPAs and Refs throughout the study period (Appendix Figure 5). Though the shape of the size distributions differed between MPA and Refs in recent years (Table 21A, K-S test, D= 0.0827, p<0.04), the median length did not (Table 21B, K-W test, Chi-Sq= 1.1, DF= 1, p= 0.295).

In summary, the upper 10th percentile of Total Length of some species targeted by fisheries shifted, as predicted, in some regions from being similar or greater in Refs early in the monitoring period to being greater in MPAs in later years of the monitoring period. Other species and regions were largely greater in Refs or MPAs throughout the monitoring period, and in a few species and regions, the upper 10$^{th}$ percentile shifted from being greater in the MPAs to the Refs over time. Trends varied between regions for many species.

*Focal invertebrate size*

Purple urchins

North Coast - Over the monitoring years, the upper 10th percentile shifted from being greater in the MPAs to being more similar in MPAs and Refs in later years (Appendix Figure 7), however, the size distributions and median sizes remained significantly greater in MPAs the most recent years (2016-2020; Appendix Figure 8; Table 22A K-S test, D= 0.048, p<0.0001; Table 22B K-W test, Chi-Sq= 174.5, DF= 1, p<0.0001).

Central Coast - The upper 10th percentile of size distributions shifted back and forth between MPAs and reference sites over the monitoring period (Appendix Figure 7), culminating in larger sizes in MPAs in the most recent years (Appendix Figure 8; Table 22A K-S test, D= 0.033, p<0.0001; Table 22B K-W test, Chi-Sq= 275.55, DF= 1, p<0.0001).

South Coast - The upper 10th percentile was almost always greater at reference sites over the monitoring period (Appendix Figure 7), culminating with greater sizes at reference sites in recent years (Appendix Figure 8; Table 22A K-S test, D= 0.179, p<0.0001; Table 22B K-W test, Chi-Sq= 34.622, DF= 1, p<0.0001).

Northern Channel Islands - The upper 10th percentile shifted from MPAs to reference sites over time (Appendix Figure 7), but culminated in being much larger in MPAs in the most recent years (Appendix Figure 8; Table 22A K-S test, D= 0.179, p<0.0001; Table 22B K-W test, Chi-Sq= 34.622, DF= 1, p<0.0001).

Red sea urchins

North Coast - Over the monitoring years, the upper 10th percentile became greater in reference sites (Appendix Figure 7), culminating in larger sizes in reference sites in recent years (Appendix Figure 8; Table 22A K-S test, D= 0.107, p= 0.38; Table 22B K-W test, Chi-Sq= 295.8, DF= 1, p<0.0001).

Central Coast - Over the monitoring years, the upper 10th percentile was generally similar in MPAs and reference sites (Appendix Figure 7), but shifted to slightly larger sizes in MPAs in recent years (Appendix Figure 8; Table 22A K-S test, D= 0.113, p<0.0001; Table 22B K-W test, Chi-Sq= 704.3, DF= 1, p<0.0001).

South Coast and Northern Channel Islands - Both regions exhibited similar patterns of shifting from larger red urchins at reference sites over the monitoring period (Appendix Figure 7) to larger sizes in MPAs in the most recent years (Appendix Figure 8; South Coast: Table 22A K-S test, D= 0.247, p<0.0001; Table 22B K-W test, Chi-Sq= 45.2, DF= 1, p<0.0001; Northern Channel Islands: Table 22A K-S test, D= 0.102, p<0.0001; Table16B K-W test, Chi-Sq= 20.84, DF= 1, p<0.0001).

All abalone

We only recorded sufficient numbers of “all abalone” species combined in the North Coast and Northern Channel Islands regions.

North Coast - The upper 10th percentiles were initially very similar in the MPAs and reference sites, but gradually diverged to larger sizes in the MPAs in the latter half of the monitoring program (Appendix Figure 7). This resulted in a slight (2-3 cm) but significantly greater median size in MPAs in recent years (Appendix Figure 8; Table 22A K-S test, D= 0.167, p<0.0001; Table 22B K-W test, Chi-Sq= 29.21, DF= 1, p<0.0001).

Northern Channel Islands - In years with sufficient numbers to compare size distributions, the upper 10th percentile was greater in MPAs (Appendix Figure 7), though the shape and median of the size distributions in the most recent years were not statistically different (Appendix Figure 8; Table 22A K-S test, D= 0.089, p= 0.93; Table 22B K-W test, Chi-Sq= 0.016, DF= 1, p= 0.90).

Red abalone

Red abalone were recorded in sufficient numbers to construct size distributions only in the North Coast, Central Coast, and Northern Channel Islands.

North Coast - Like “all abalone”, the upper 10th percentiles were initially very similar in the MPAs and reference sites, but gradually diverged to larger sizes in the MPAs in the latter half of the monitoring program (Appendix Figure 7). This resulted in slightly larger 2-3 cm red abalone in MPAs in recent years (Appendix Figure 8; Table 22A K-S test, D= 0.158, p<0.0001; Table 22B K-W test, Chi-Sq= 25.2, DF= 1, p<0.0001).

Central Coast - The greater of the upper 10th percentile of size distributions shifted back and forth between MPAs and reference sites over the monitoring period (Appendix Figure 7), culminating in larger sizes at reference sites in the most recent years (Appendix Figure 8; Table 22A K-S test, D= 0.155, p<0.0001; Table 22B K-W test, Chi-Sq= 17.3, DF= 1, p<0.0001).

Northern Channel Islands - In the few years in which there was sufficient numbers to compare, size distributions were very similar between MPAs and reference sites (Appendix Figure 7), including the recent years (2016-2020) during which the shape and median size were not statistically distinguishable (Appendix Figure 8; Table 22A K-S test, D= 0.227, p= 0.47; Table 22B K-W test, Chi-Sq= 2.99, DF= 1, p= 0.084).

Spiny lobster

South Coast - The upper 10th percentile of size was greater in reference sites in 3 of 4 time periods (Appendix Figure 7), culminating in no difference in the shape or median of the size distributions over the most recent years (Appendix Figure 8, Table 22A,B; K-S test, D= 0.107, p= 0.38; Table 22B K-W test, Chi-Sq= 0.606, DF= 1, p= 0.436).

Northern Channel Islands - Although too few lobster were observed at reference sites to construct size distributions in the early sampling period, the upper 10th percentile has always been greater in the MPAs in later years(Appendix Figure 7), culminating in significantly greater sizes in MPAs over the most recent years (Appendix Figure 8; Table 22A K-S test, D= 0.107, p= 0.38; Table 22B K-W test, Chi-Sq= 38.02, DF= 1, p<0.0001).

In summary, sizes of many of the focal invertebrates were eventually greater in MPAs than in reference sites. Where the red sea urchin was commercially fished, it exhibited shifts to greater sizes within MPAs in the southern regions but not in the North Coast. With the exception of the

South Coast, sizes of purple urchins gradually increased in MPAs relative to reference sites through time, resulting in larger sizes within MPAs in the most recent years. This trend was most evident in the Northern Coast and Northern Channel Islands. Red abalone and all abalone combined exhibited the trend toward larger sizes in MPAs in the North Coast but not the Northern Channel Islands. Spiny lobster was the exception, neither showing this trend toward larger sizes in the South Coast, or always being larger in the Northern Channel Islands.

### *Larval Production by Select Focal Species*

[These analyses address DEWG Question: G1-1d]

To be expected, the patterns of response of larval production among the four select species (Lingcod, Kelp Rockfish, California Sheephead, and Kelp Bass) reflect patterns of biomass response among those species and among regions. Larval production of the three species (Kelp Rockfish, California Sheephead, and Kelp Bass) that occur in the southern regions (South Coast and Northern Channel Islands) exhibited the strongest positive responses to MPAs.

Lingcod larval production on the North Coast was always greater in MPAs with no significant change in the response ratio over time (Appendix Figure 9, Table 23). However, on the Central Coast, while larval production in REFs declined over time, it increased in MPAs leading to a significant increase in the response ratio of larval production over time (Appendix Figure 9, Table 23). Kelp rockfish exhibited marked differences among regions where it occurs. The response ratio of larval production actually declined (i.e. decreased more within MPAs relative to Refs) significantly on the Central Coast, increased significantly on the South Coast as production declined in Refs but remained level within MPAs, and stayed similar in the Northern Channel Islands as production in MPAs and Refs tracked one another with little change between the beginning and end of the study period (Appendix Figure 9, Table 23). California Sheephead exhibited positive trends in response ratios of larval production in all three regions (Central Coast, South Coast, Northern Channel Islands) though the trends were statistically significant only in the South Coast and Northern Channel Islands (Appendix Figure 9, Table 23). Kelp bass also exhibited positive trends in response ratios in larval production over time in both the South Coast and Northern Channel Islands, though the trend was only significant in the Northern Channel Islands (Appendix Figure 9, Table 23).

## *Community responses*

### *Diversity and richness*

We compared mean species diversity (Shannon index, H') and mean species richness for the four survey types in the monitoring (fish, algae, invertebrates, and percent cover from uniform point contact) (Figures 20-23). Because we know that both diversity and richness have a strong

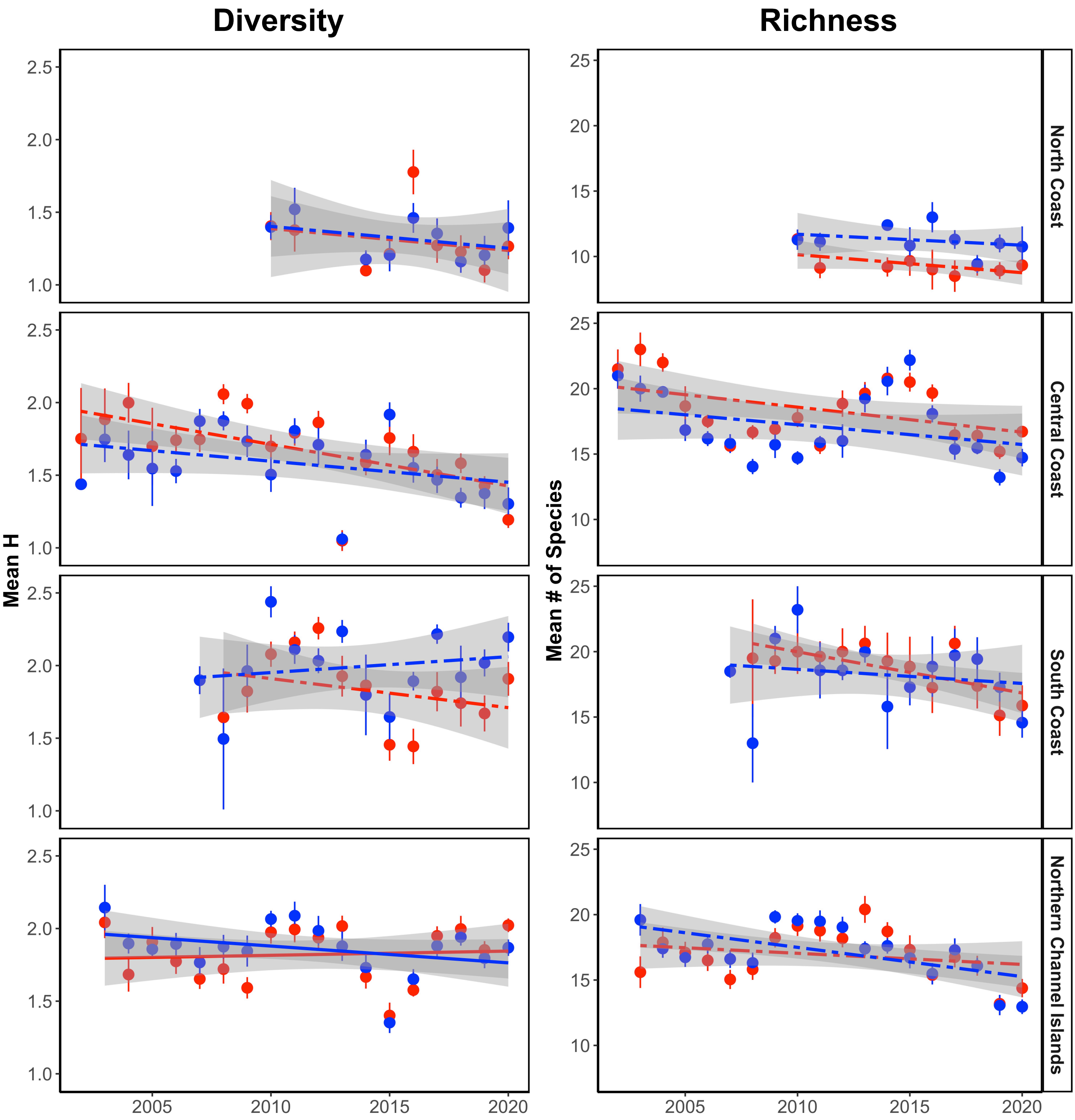


**Figure 20**. Mean species diversity (Shannon index, H') and species richness from fish surveys in the four regions over time. Species diversity and species richness are shown on the left and right panels respectively. Legend key: Each data point represents average metric across region within MPA or REF. Error bars on each data point are standard error with sites as replicates. Data points are fitted with a regression line (red line = MPA and blue line = REF. Gray shading represents 95% CI for the slope of a regression line. Line type represents Mixed Model with Repeated Measures results comparing the responses between site status (MPA and REF). A significant difference in responses between MPA and REF ($P < 0.05$) is shown as solid lines. A non-significant difference ($P > 0.05$) is shown as dashed lines.

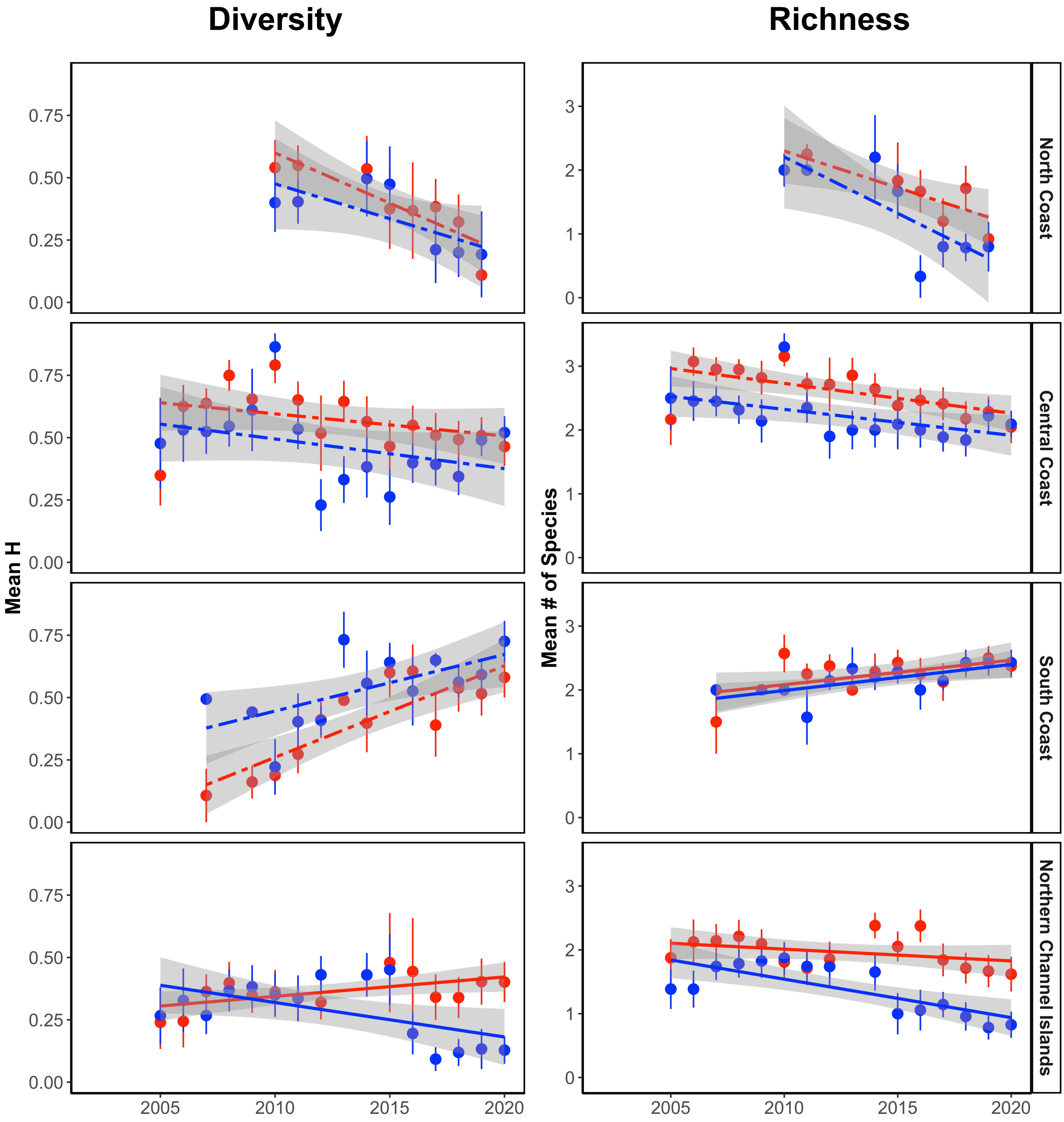


**Figure 21**. Mean species diversity (Shannon index, H') and species richness from algal surveys in the four regions over time. Species diversity and species richness are shown on the left and right panels respectively. Legend key: Each data point represents average metric across region within MPA or REF. Error bars on each data point are standard error with sites as replicates. Data points are fitted with a regression line (red line = MPA and blue line = REF. Gray shading represents 95% CI for the slope of a regression line. Line type represents Mixed Model with Repeated Measures results comparing the responses between site status (MPA and REF). A significant difference in responses between MPA and REF ($P < 0.05$) is shown as solid lines. A non-significant difference ($P > 0.05$) is shown as dashed lines.

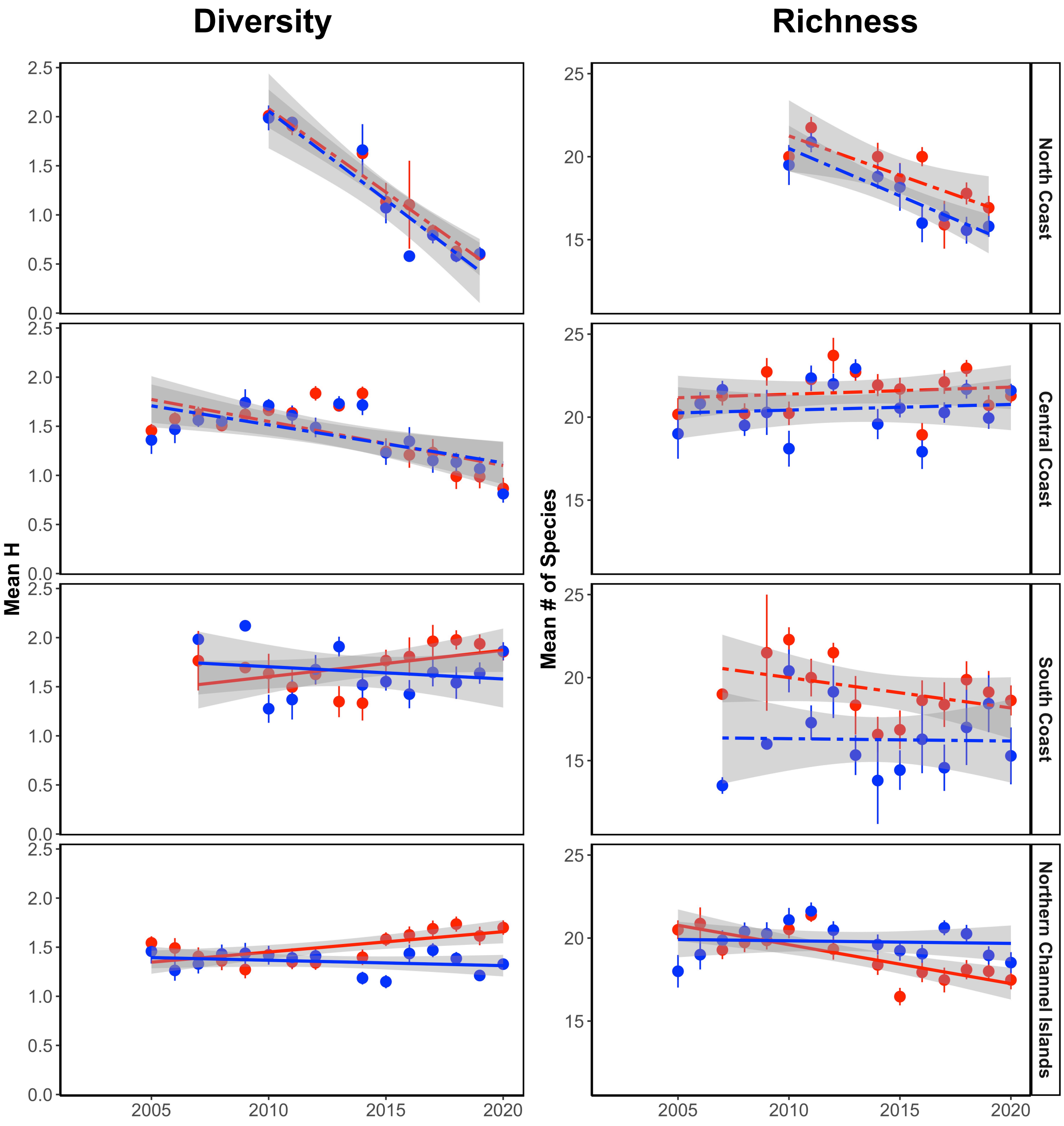


**Figure 22**. Mean species diversity (Shannon index, H') and species richness from invertebrate surveys in the four regions over time. Species diversity and species richness are shown on the left and right panels respectively. Legend key: Each data point represents average metric across region within MPA or REF. Error bars on each data point are standard error with sites as replicates. Data points are fitted with a regression line (red line = MPA and blue line = REF. Gray shading represents 95% CI for the slope of a regression line. Line type represents Mixed Model with Repeated Measures results comparing the responses between site status (MPA and REF). A significant difference in responses between MPA and REF (P < 0.05) is shown as solid lines. A non-significant difference (P > 0.05) is shown as dashed lines.

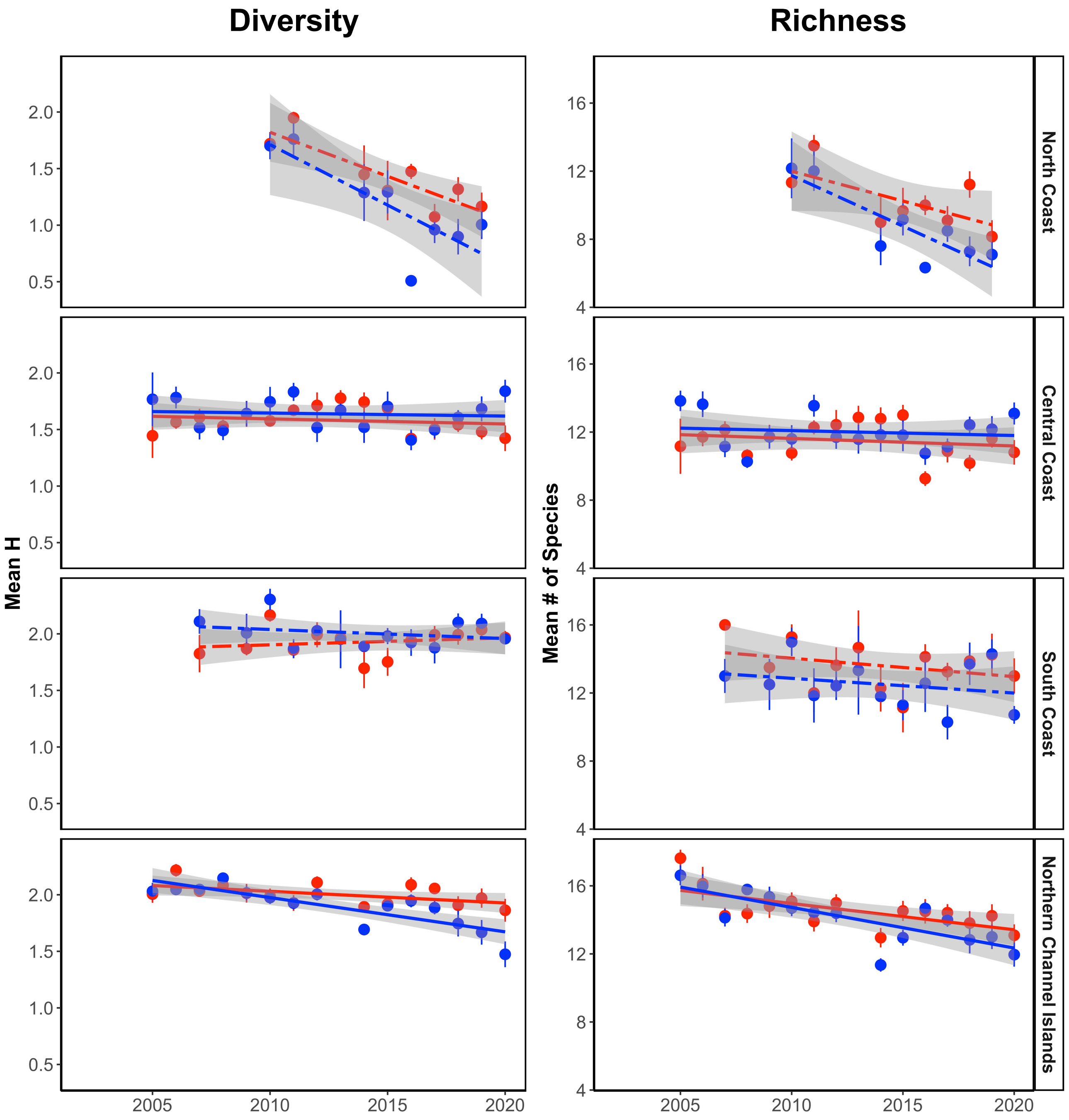


**Figure 23**. Mean species diversity (Shannon index, H') and species richness from uniform point contact surveys in the four regions over time. Species diversity and species richness are shown on the left and right panels respectively. Legend key: Each data point represents average metric across region within MPA or REF. Error bars on each data point are standard error with sites as replicates. Data points are fitted with a regression line (red line = MPA and blue line = REF. Gray shading represents 95% CI for the slope of a regression line. Line type represents Mixed Model with Repeated Measures results comparing the responses between site status (MPA and REF). A significant difference in responses between MPA and REF ($P < 0.05$) is shown as solid lines. A non-significant difference ($P > 0.05$) is shown as dashed lines.

regional signal and because of high variance expected at the individual MPA/Ref due to our sampling design, we calculated regional means for both metrics and present results separately by region. As with other analyses, we plotted the time series of both of these metrics for MPA and Ref sites and tested for differences in response between MPA and Ref.

*Fish* - Both fish diversity and fish species richness showed declining trends over the period of the monitoring for most regions, although most were not significant (Figure 20, Table 24). These declines occurred both inside and outside of MPAs somewhat equally. One exception was for fish diversity in the Northern Channel Islands, which increased over time in MPAs and declined in Ref areas. While the difference was significant between MPA and Ref, the slopes were small and the interannual variance was high.

Interestingly, during the period of the marine heatwave (2014-2016) we see qualitative differences among regions in the responses, primarily for species diversity. In the North and Central Coast, species diversity increased dramatically albeit temporarily during the heatwave. In the Northern Channel Islands and the South Coast, diversity declined dramatically during the heatwave. We did not observe an analogous heatwave effect for invertebrates, algae or UPC.

*Algae* - Trends in algal species diversity and richness varied between regions (Figure 21, Table 25). The North and Central Coast survey sites showed strong declines in both metrics with no effect of protection status. The North Coast decline very likely reflects the wholescale declines of many species of macroalgae as reefs transformed from forested states to urchin barrens devoid of many species. In the Northern Channel Islands we saw a positive MPA effect for both diversity and richness, where both metrics increased over time in MPAs and declined in Ref areas. In the South Coast, algal diversity and richness generally trended positively but no MPA effects were observed.

*Invertebrates* - Invertebrate diversity and richness showed fewer secular trends over the time series with the exception of the North Coast where both metrics declined steeply over time both in and out of MPAs Figure 22, Table 25). There were no temporal trends in the Central Coast nor differences with protection status, although diversity appeared to drop during the heatwave and has not increased in recent years. In the Northern Channel Islands and the South Coast, species diversity had a significant positive MPA effect, with diversity increasing over time inside MPAs and declining over time outside MPAs (Table 25). Species richness, however, showed the opposite pattern in the Northern Channel Islands, with richness increasing in Ref areas and declining in MPAs.

*Uniform Point Contact (UPC)* - The benthic organisms measured using the UPC surveys are sessile non-individually distinguishable macroalgae and macroinvertebrates (e.g. colonial invertebrates, foliose macroalgae). UPC organisms are typically recorded at higher taxonomic or functional resolution for most groups (e.g. foliose red algae, sponges, tunicates, bryozoans). Thus diversity and richness are calculated using taxonomic groupings in some cases and may not be as sensitive as the fish, algae and invertebrate diversity metrics. In the North Coast, both diversity and richness declined steeply both inside and outside MPAs. In the Central Coast, there was a significant negative effect of protection on both diversity and richness, with both metrics greater in Ref areas (Figure 23, Table 25). However, interannual variance was high and the differences slight (Figure 23). The Northern Channel Islands again showed a positive MPA effect (Figure 23). For the UPC organisms, both diversity and richness declined in this region but the decline was less in the MPAs relative to the Ref areas. In the South Coast, variability was high and there were no clear patterns over time or with protection status for either diversity or richness.

In summary, we found that the temporal patterns of diversity and richness differed among regions. The North Coast showed declines, though non-significantly, in these community metrics for all four assemblage types (i.e., fish, algae, invertebrates and UPC organisms). For the other three regions, different assemblages showed different trends over time but generally, the Northern Channel Islands and South Coast remained more stable or increased in diversity and richness over time relative to the Central Coast. In terms of MPA responses, only the Northern Channel Islands MPAs showed consistent positive responses - in diversity for fishes and invertebrates and both diversity and richness for algal and UPC organism assemblages. The only negative MPA effect in the Northern Channel Islands was for invertebrate richness. The only other positive MPA response was in the South Coast for invertebrate diversity while three negative responses were found: Central Coast UPC diversity and richness and South Coast algal richness.

There was to be an interesting effect of the marine heatwave (2014-2016) on fish diversity across the regions. In the North and Central coasts there was a transient increase in fish diversity during those years whereas in the Northern Channel Islands and South Coast there was a transient decrease in fish diversity in the same period. This may be a result of southern species moving northward as was documented in many systems in CA following the heatwave.

### *Community level consequences of species responses*

The numerical responses of some fish, invertebrate and algal species described above suggest important community-wide consequences in some MPAs. In some cases, species responses are irrespective of MPA effects and manifest similarly inside and outside of MPAs. For example, the declines in *Pycnopodia helianthoides* described above in conjunction with the low nutrient levels associated with the 2014-2016 marine heatwave resulted in cascading responses of purple sea urchins and giant kelp at two SMRs on the Central Coast (e.g. Figure 24A).

In contrast, MPA effects through the sustained or increased numbers of sea urchin predators (California sheephead and California spiny lobster, respectively) appear to have buffered or compensated for the loss of *Pycnopodia helianthoides* in some MPAs in southern regions by causing continued declines of purple sea urchins and increasing density of giant kelp over the study period (e.g., Figure 24B).

## Kelp abundance from LANDSAT imagery

Kelp abundance (area and biomass) was highly variable over the course of the Landsat time series (1984-2020). Giant kelp in the Southern California region declined during the 2014-2016 heatwave, with spatial variability in recovery following the heatwave. Bull kelp in the North Central region declined dramatically after 2014 and remained at historically low levels through 2020.

We identified 65 MPAs with > 9000 $m^2$ of kelp habitat. There was generally high correlation between time series of kelp area in the MPAs and their associated reference regions before MPA implementation (mean/median Pearson correlation coefficient = 0.72/0.80). Appendix Figure 10 provides a graph of annual maximum kelp area in each MPA and associated reference site

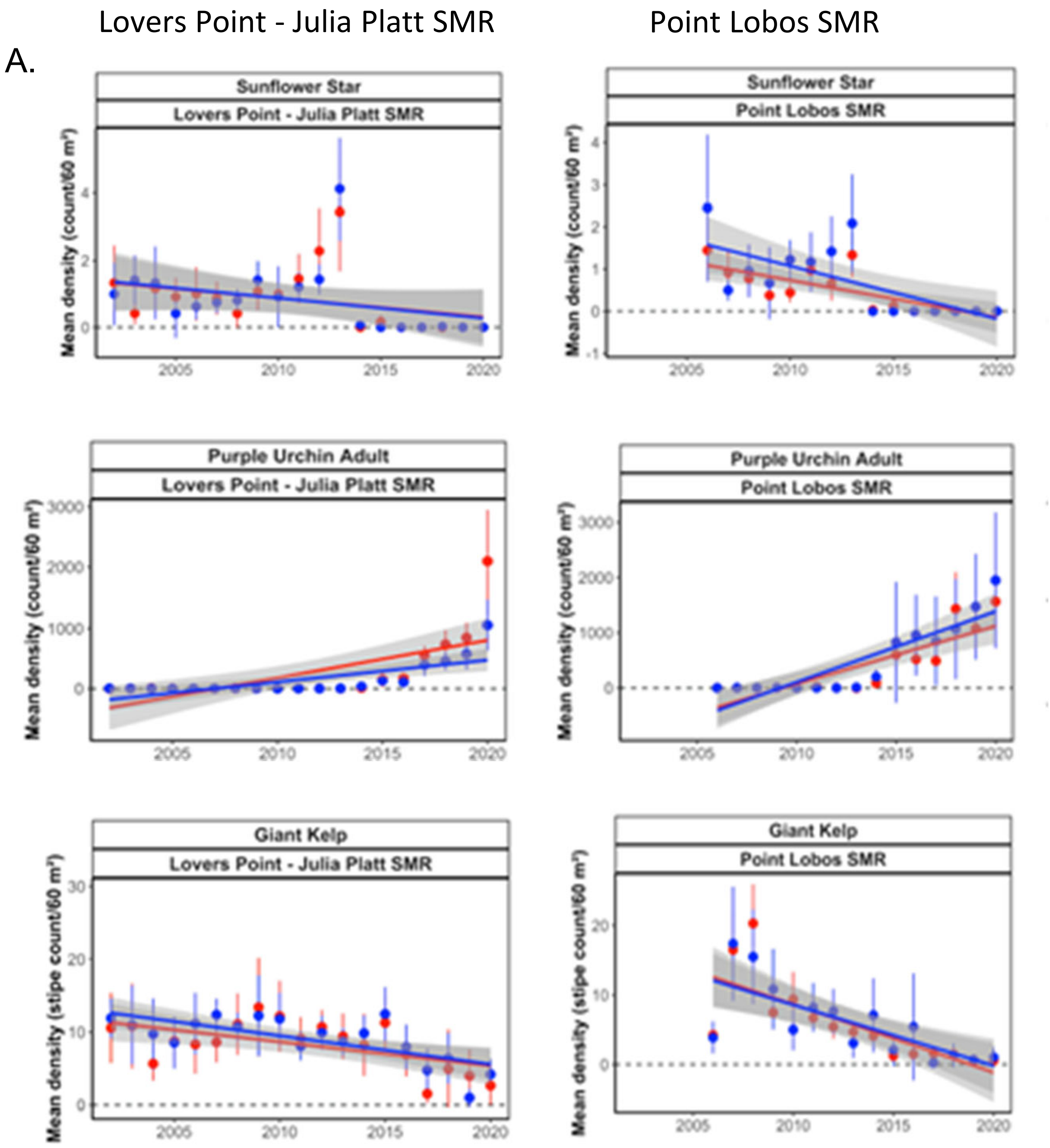


**Figure 24A.** Cascading effects in two Central Coast MPAs: simultaneous declines in density of sunflower star, increases in density of purple urchins, and declines in density of giant kelp.  Note that MPAs do not differ from their paired reference areas in these patterns.

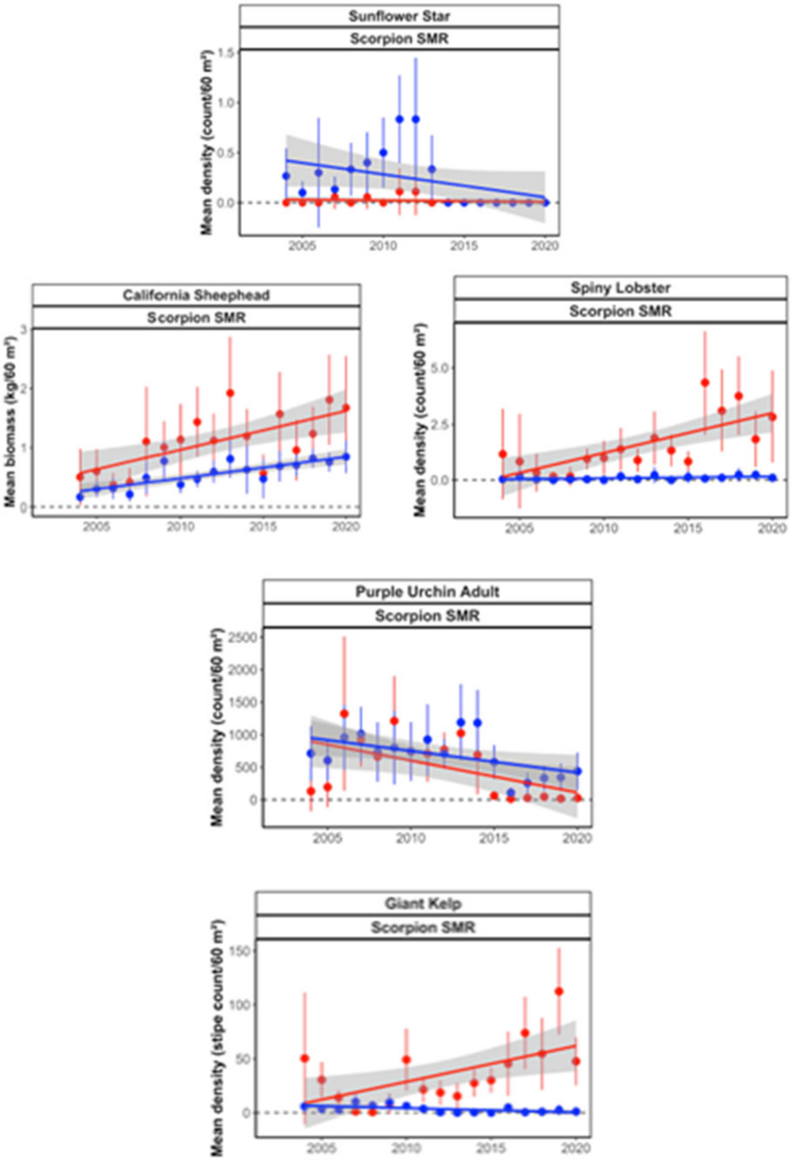


**Figure 24B.** Cascading effects in a Southern California MPA in the Northern Channel Islands: simultaneous decline in density of sunflower star, increase in density of two urchin predators (CA spiny lobster and CA Sheephead), decline in density of purple urchins, and increase in density of giant kelp. In contrast to Central Coast examples, note that the cascade is only manifest in MPAs where sea urchin predators increase.

The BACI analyses did not show strong MPA effects on mean kelp abundance after MPA implementation. Of the 65 MPAs that we analyzed, only 7 had a significant interaction term from the generalized linear model, with five MPAs showing a positive impact on kelp abundance and 2 showing a negative impact.

We did find that kelp forests within MPAs showed significantly higher resilience to the 2014-2016 heatwave than reference sites. Mean/median resilience in MPAs was 2.2/0.6 vs. 0.7/0.2 in the reference sites (Figure 25). Higher resilience inside MPAs was observed across all regions, and was particularly pronounced in parts of the northern Channel Islands, Monterey Peninsula, and North Central Coast (i.e. orange and yellow sites in Figure 26).

## Environmental Monitoring - Ocean acidification and hypoxia (OAH) and temperature

### *OAH Monitoring*

Mean pH, dissolved oxygen and temperature were lowest in the northern California sites and highest in the southern California sites (Table 26). Similarly, variability in pH and dissolved oxygen was highest in the northern California sites and lowest in the southern sites. Excursions below the predetermined, ecologically relevant “thresholds” in pH (<7.7) and dissolved oxygen (<4.6 mg/L) were most frequent in northern California sites, less frequent in central California sites, and almost entirely absent from the southern California sites (Figure 27, 28). In contrast to the patterns in pH and dissolved oxygen, high-frequency variability (variability that is < 1 day, driven by diel biological cycles or internal tides and bores) in temperature was highest in southern California sites (Figure 27, 28). The relationships between pH, dissolved oxygen, and temperature were tightly coupled in the northern California sites, but this relationship became progressively less coupled moving south (Figure 29). The coherence between the two sites in each region was high (assessed visually and also by ROMS-NEMUCSC model output), thus, one site for each region is highlighted in the figures.

The severity, duration, and intensity of pH events below 7.7 varies through time and across sites (Figure 30). The sites in northern California generally show the longest duration and highest intensity events in late summer (July-September), resulting in similar temporal patterns in severity. At the central California sites, the duration of events below pH 7.7 are longest in spring months (April-May) and fall (October-November). Event intensity follows a similar temporal pattern to duration in central California, resulting in a peak of severity in spring and fall. The magnitude of the severity index was similar between northern and central California sites, due to higher intensity (e.g., lower pH conditions) in northern California versus longer duration events in central California. There were no recorded events below pH 7.7 in the southern California sites. The model output from ROMS-NEMUCSC had peaks in duration and severity in spring and summer months in northern and central California, but generally were lower in magnitude than the observational data.

The temporal patterns in severity, duration, and intensity of low dissolved oxygen events (defined here as <4.6 mg/L), qualitatively mirrored patterns from the low pH event analysis (Figure 31). The severity, duration, and intensity of low dissolved oxygen events peaked in late summer (July-September) in northern California, and peaked slightly earlier in central California (May-July). No events below the 4.6 mg/L threshold were observed in southern California. While the duration of low pH events was highest in magnitude at the central California sites, the

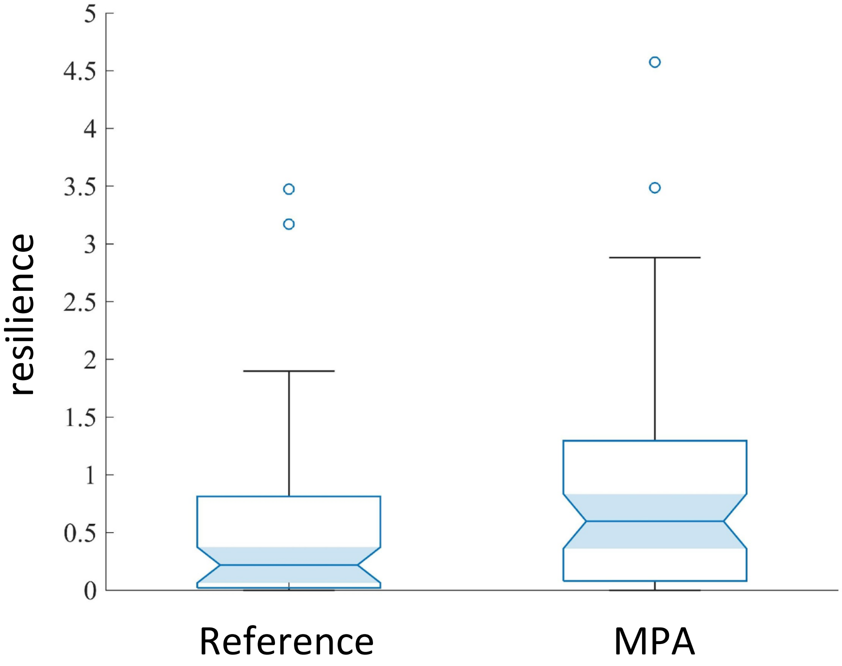


**Figure 25.** Boxplot of kelp resilience to 2014-2016 heatwave in MPAs and associated reference regions.

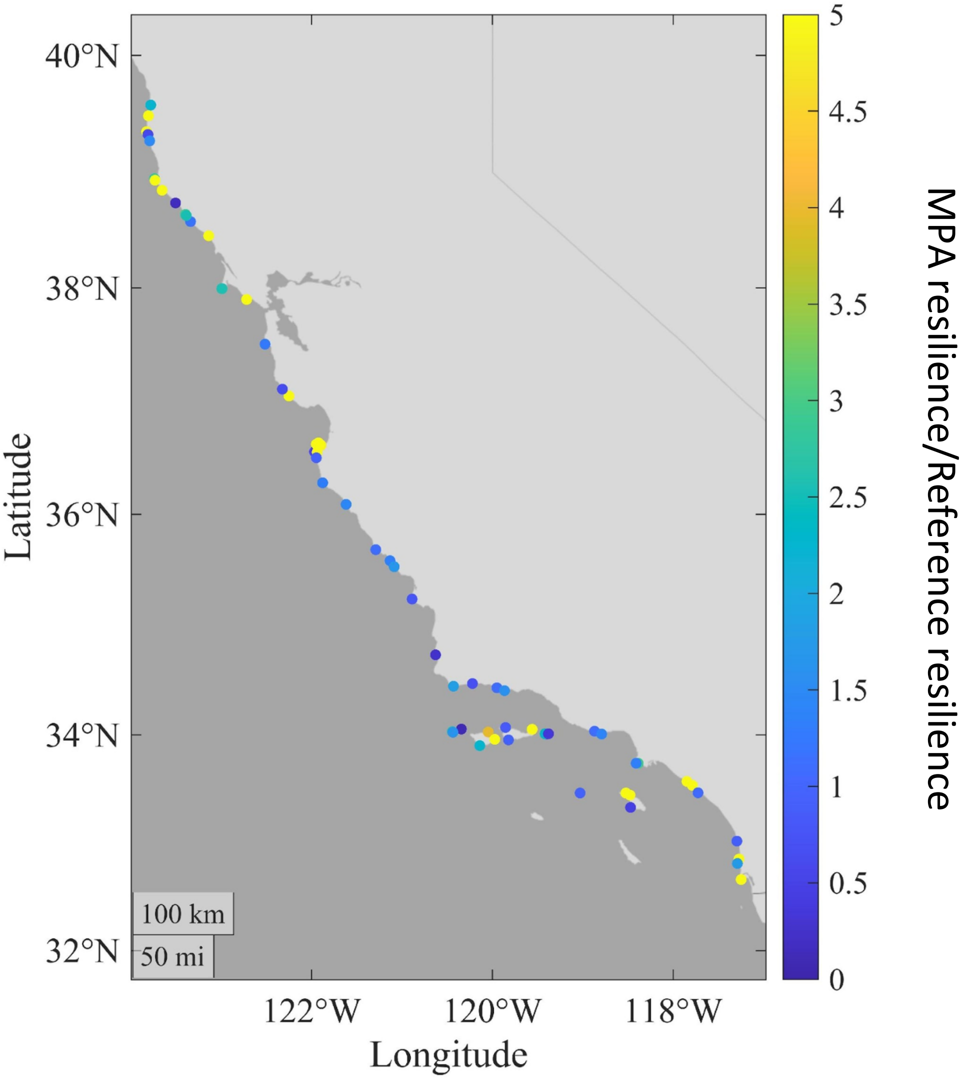


**Figure 26.** Map comparing resilience in MPAs with their paired reference regions.

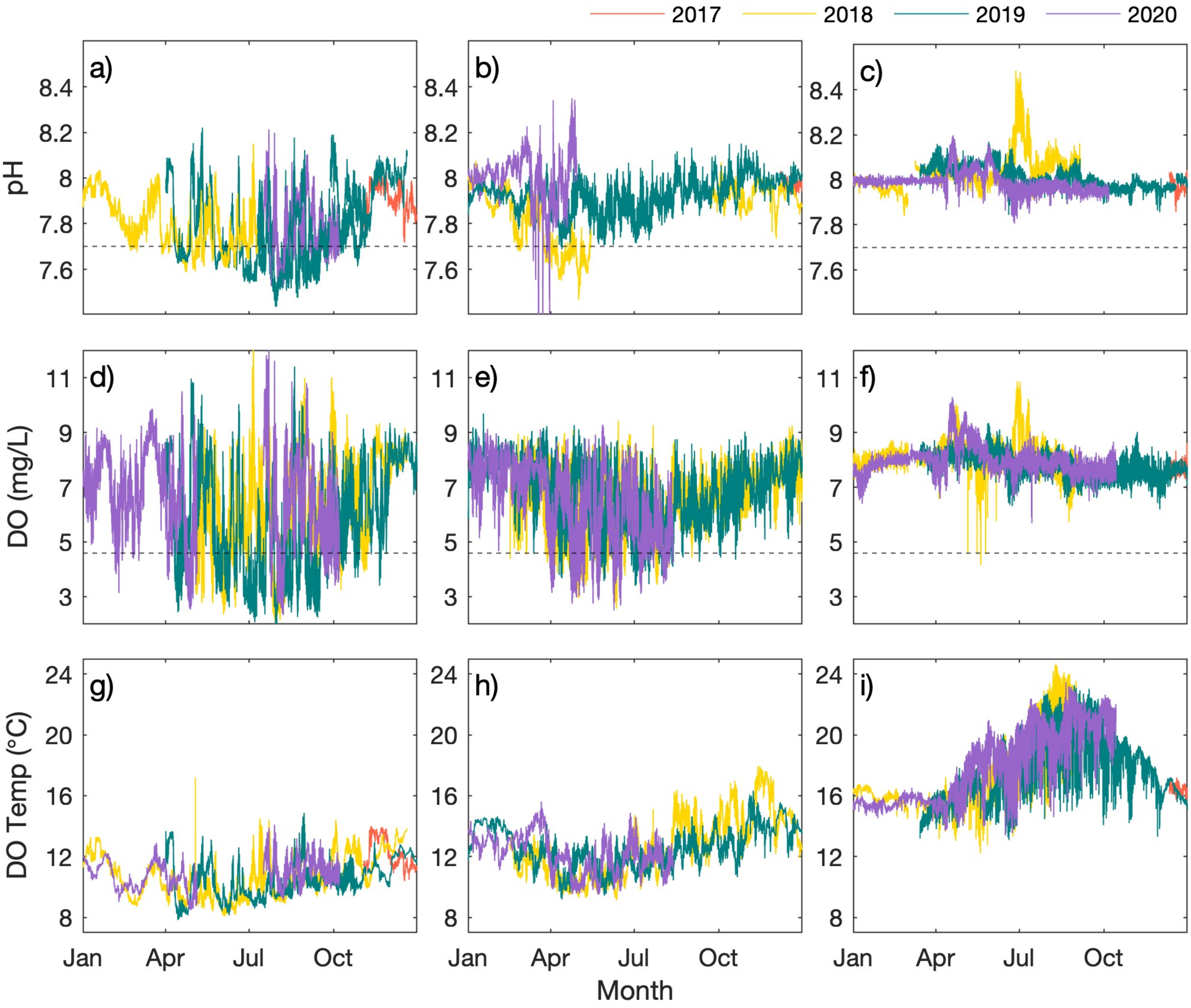


**Figure 27. Interannual and seasonal variability in key environmental parameters among the three regions (Northern, Central and Southern California).** Seasonal patterns in seawater pH, dissolved oxygen concentrations (DO) and temperature from November 2017 through 2020 from Point Arena (a, d, g), Point Buchon (b, e, h) and Catalina Island (c, f, i). The dotted lines indicate the predetermined hypothetical threshold values used in the event analyses (pH < 7.7 and DO < 4.6 mg/L).

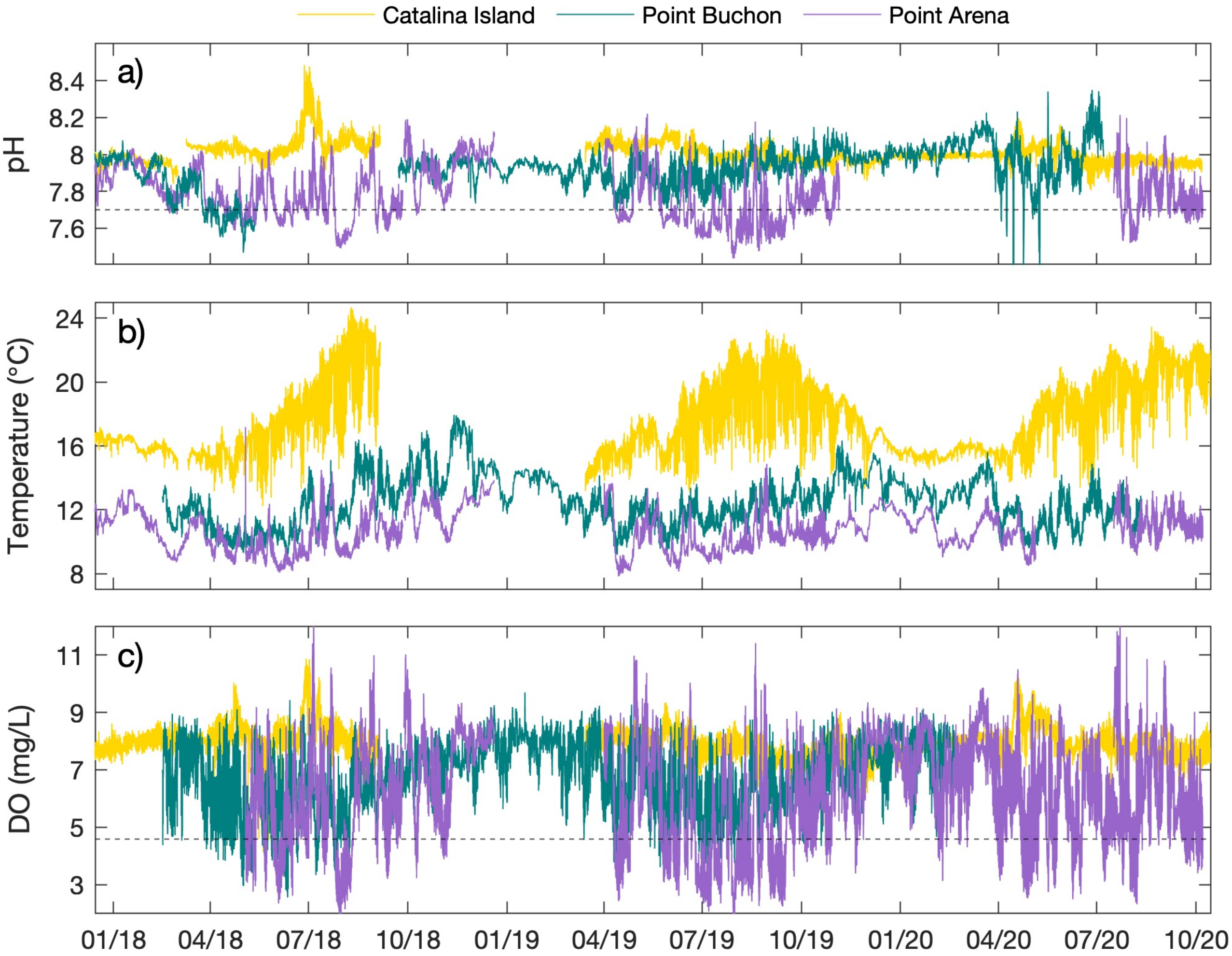


**Figure 28. Comparison of time series among regions for key environmental parameters.** Time series of seawater pH, temperature and dissolved oxygen (DO) from the northern (Point Arena; purple), central (Point Buchon; green) and southern California (Catalina Island; purple) regions. The time series highlights the differences in the high frequency variability of these variables through time among the regions. The dotted lines indicate the predetermined hypothetical threshold values used in the event analyses (pH < 7.7 and DO < 4.6 mg/L).

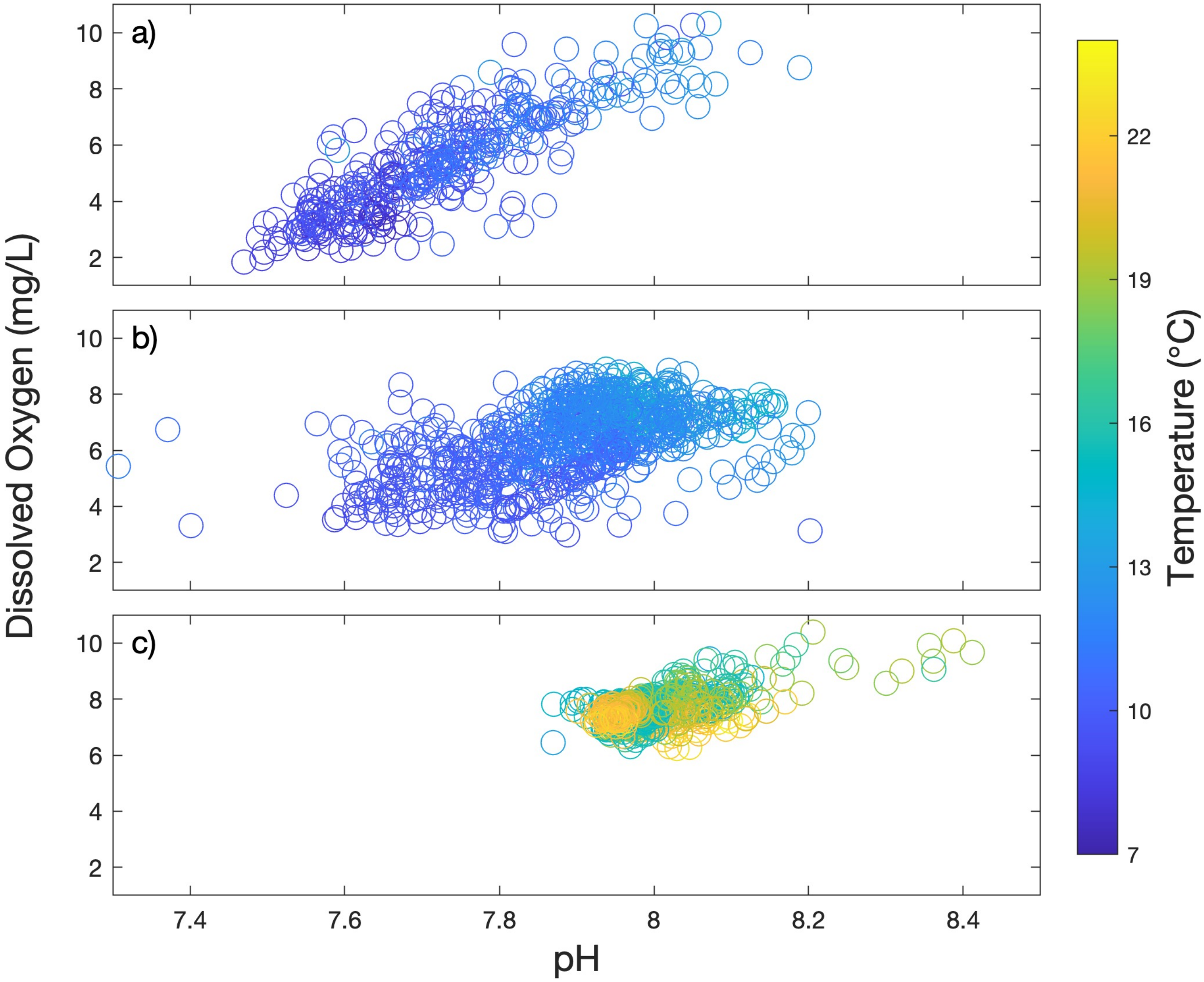


**Figure 29. Relationships between pH, dissolved oxygen, and temperature from Northern, Central and Southern California sites**. Data are daily means for each parameter from 2018 through 2020. Sites are a) Point Arena, b) Point Buchon, and c) Catalina Island.

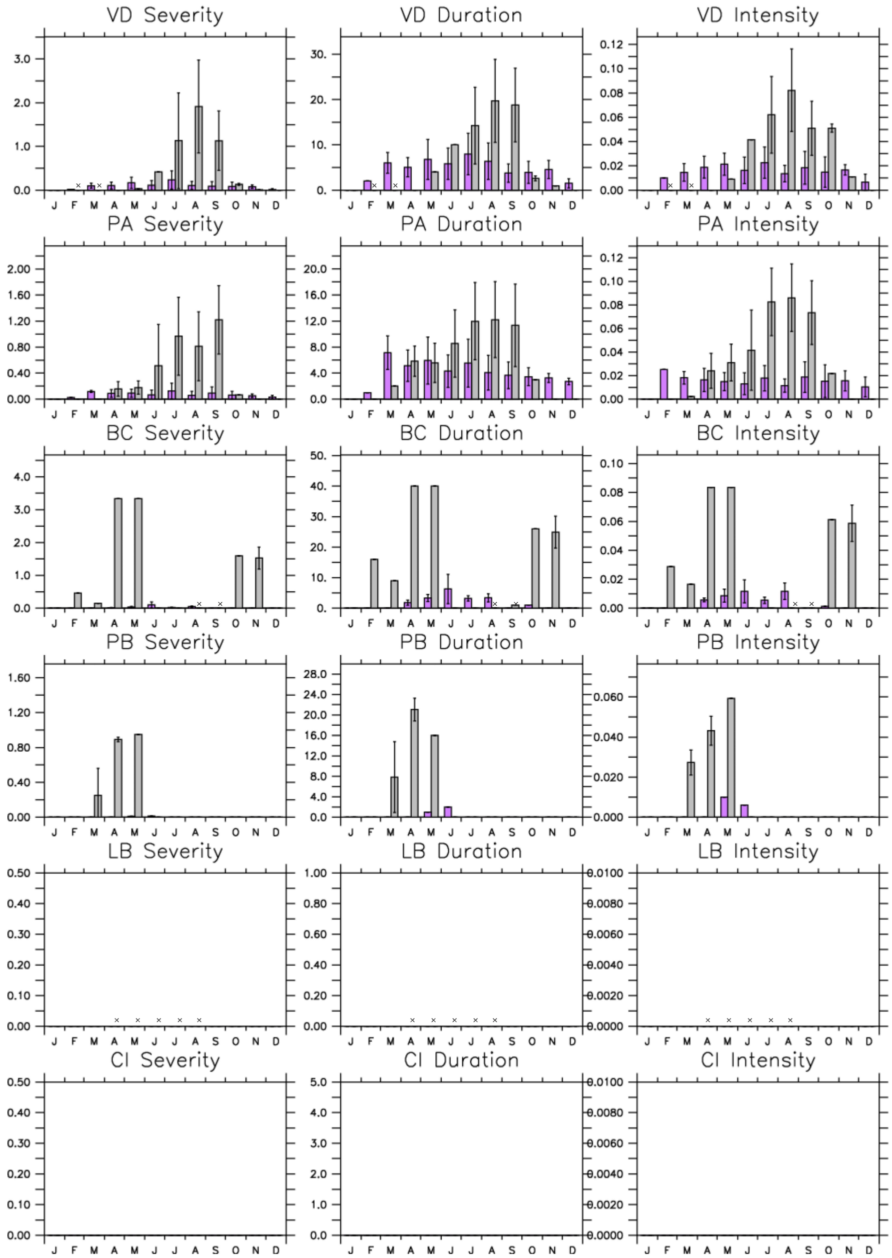


**Figure 30. Low pH events (pH < 7.7).** Climatological model (purple) and observational (grey) event severity (left), duration (middle) and intensity (right) for pH events below 7.7. The height of each bar represents the mean, while the black line shows +/- one standard deviation (centered at the mean value). Lack of a standard deviation indicates there was only one data point for that particular month. Lack of observational data for a particular month is represented by a blue X. Severity is defined as the product of duration and intensity. Duration is defined as the number of days conditions remained below the threshold for a given event (unit = days). Intensity is defined as the threshold minus the average pH during a given event. The six stations make up the six rows, from northernmost (VD = Van Damme) at the top, to southernmost (PB = Point Buchon) at the bottom (PA = Point Arena, BC = Big Creek). Catalina Island and Laguna Beach are not included because no events occurred in the observational data set nor the model output. Model output was extracted at the closest grid cell to land at the latitudes corresponding to the six observational stations.

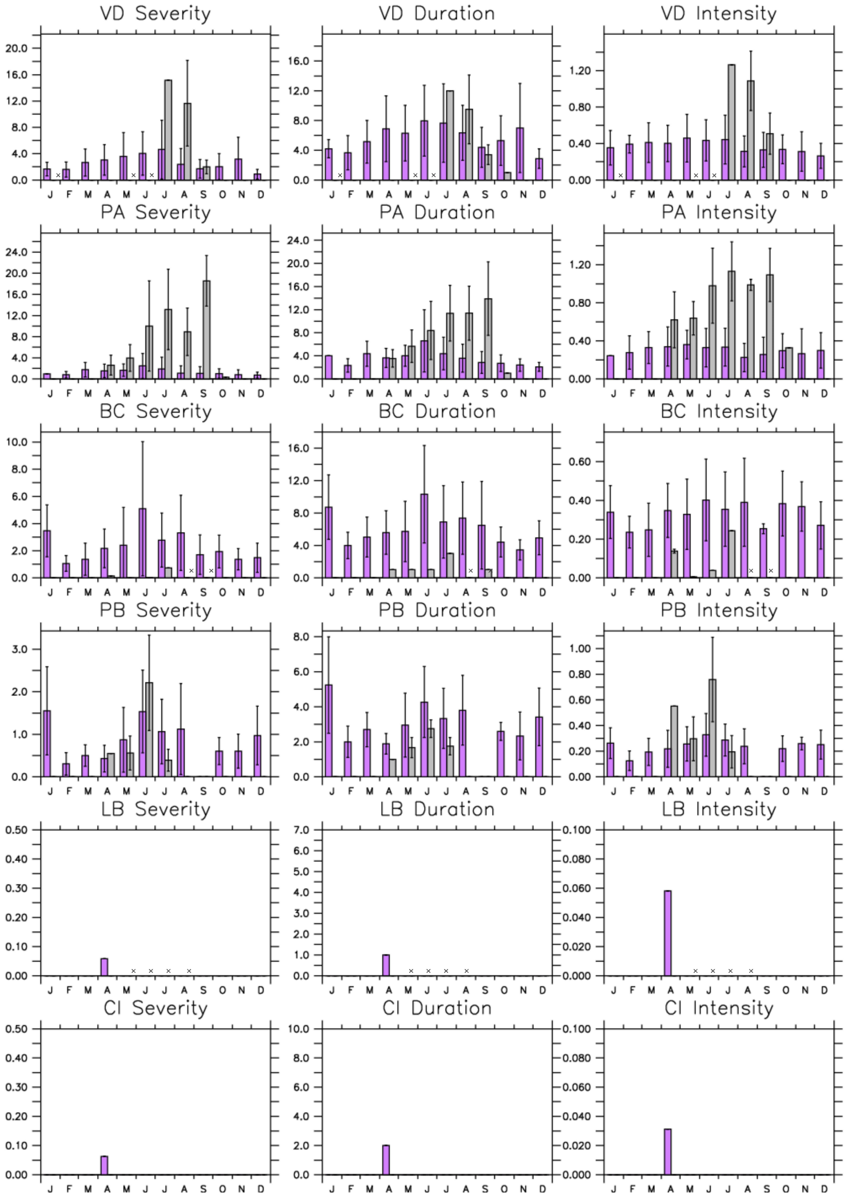


**Figure 31. Low dissolved oxygen events (DO < 4.6 mg/L).** Climatological model (purple) and observational (grey) event severity (left), duration (middle) and intensity (right). The height of each bar represents the mean, while the black line shows +/- one standard deviation (centered at the mean value). Lack of a standard deviation indicates there was only one data point for that particular month. Lack of observational data for a particular month is represented by a blue X. Severity is defined as the product of duration and intensity. Duration is defined as the number of days conditions remained below the threshold for a given event (unit = days). Intensity is defined as the threshold minus the average DO during a given event. The six stations make up the six rows, from northernmost (VD = Van Damme) at the top, to southernmost (LB = Laguna Beach) at the bottom (PA = Point Arena, BC = Big Creek, PB = Point Buchon, CI = Catalina Island). Model output was extracted at the closest grid cell to land at the latitudes corresponding to the six observational stations

duration and therefore severity of low dissolved oxygen events were highest at the northern California sites. In particular, severity was highest at one site in northern California (Point Arena), primarily driven by longer duration events. The model output from ROMS-NEMUCSC was generally lower in magnitude at the northern California sites in all three metrics (duration, intensity, and severity). The model output had much higher event duration, intensity, and severity metrics than the observational data at one site in central California (Big Creek), and aligned quite well with observed event metrics at the other central California site (Point Buchon). The model output exhibited a single low dissolved oxygen event in April in the southern California sites, which was low duration, intensity and severity.

### *Temperature monitoring*

Mean temperature from the thermistor data set ranged from 11.16-12.38 C in the Northern California region, 12.10-13.97 C in the Central California region, 14.99-18.02 C in the Southern California Mainland region, and 17.25-18.86 C in the Southern/Channel Islands region (Table 5). The sites in northern California exhibit similar patterns in temperature through time (i.e., high coherence), with temperatures regularly fluctuating between 10 and 14C from spring through fall (Figure 32a). The temporal patterns among sites in the Central California region were similar as well, but at slightly warmer temperatures (Figure 32b). Temperatures rose above ~17 C at sites in the southern end of this region in spring of 2018, and reached similar temperatures episodically at sites across the entire region several times in summer and fall of 2018. Sites in the Southern California Mainland region varied more in the range of temperatures experienced, with some sites in the northern portion of the range experiencing temperatures above 25C during summer months (Figure 32c).

## Reef Check CA Citizen Science

In 2019, RCCA trained 308 volunteers of which 157 were newly trained volunteers and 151 were returning volunteers. Twenty-two trainings were held for the public and 13 were conducted at partner institutions such as universities and public aquariums. In 2020, RCCA did not train any new volunteers due to COVID. Instead, a smaller group of long-term returning volunteers was re-trained and conducted surveys in small groups of staff and volunteers. Volunteers and staff conducted 118 and 108 surveys in 2019 and 2020, respectively. In 2019, a total of 217 volunteers participated in at least one day of surveying leading to a combined total of over 1100 volunteer days. In 2020, only 77 volunteers participated in surveys and their total contribution of days sank to just under 400 volunteer days. The reduction in numbers of volunteers did not have a large effect on the number of surveys done in 2020. The fact that staff worked with very experienced volunteers made up for the reduction in volunteer numbers. Outreach and educational aspects of RCCA's citizen science program were greatly reduced during COVID due to a lack of in-person training and outreach events. At the same time, many volunteers have taken their engagement with marine resource management further than volunteering with RCCA. They have become involved in the policy and conservation arena. Volunteers have become involved in the public meetings held by the California Fish and Game Commission, and it is not unusual for speakers to identify themselves as RCCA volunteers when making public comments. Their involvement in data collection and citizen science gives them confidence to speak out about their observations and opinions on how California's marine resources should be managed. A prime example of this is the engagement of RCCA volunteers in kelp forest restoration projects in Monterey. These have been developed and led by volunteers that have

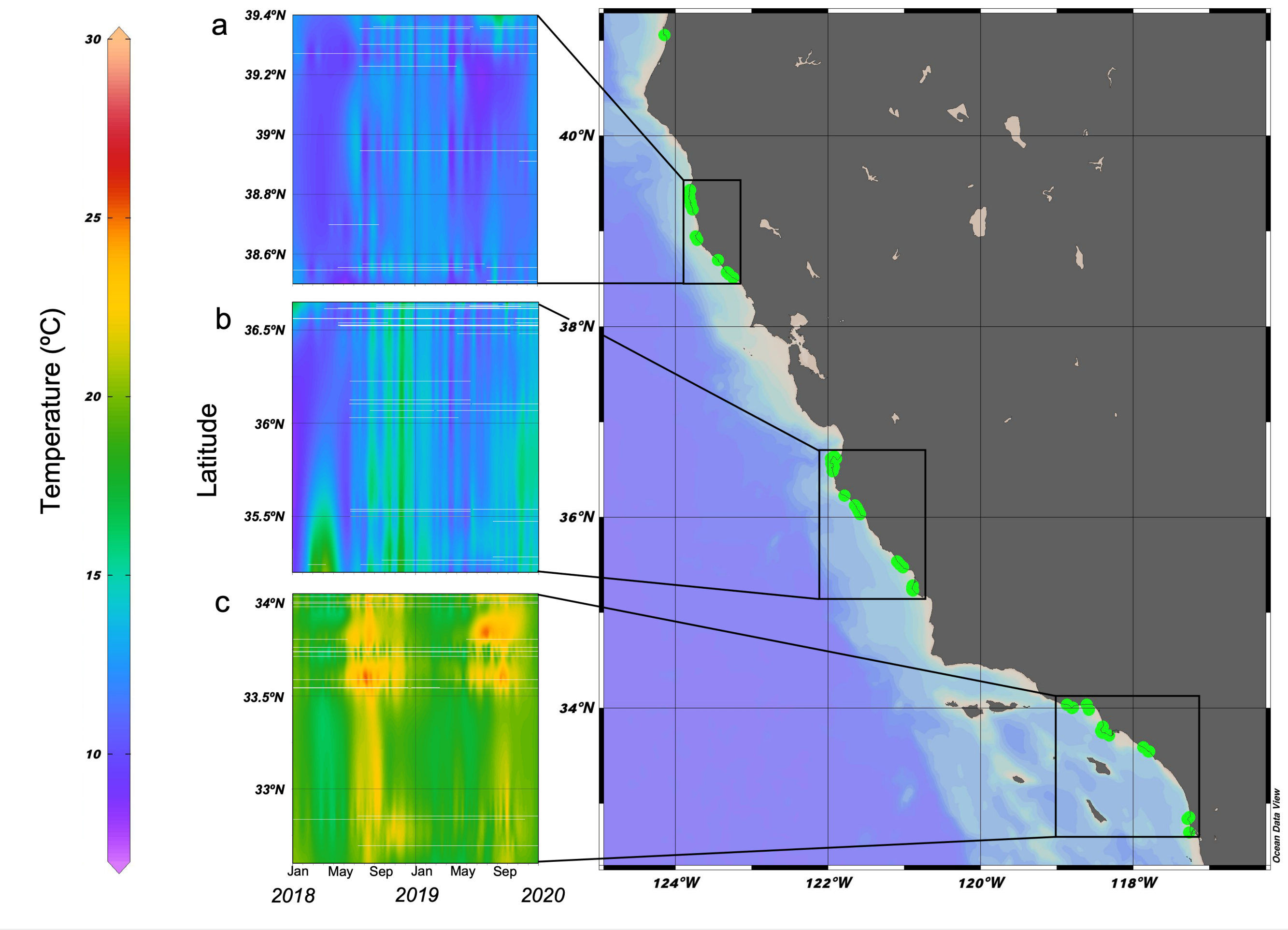


**Figure 32. Interpolated heat map of seawater temperature across Northern, Central and Southern California Mainland regions.** Heat maps are based on thermistor data from ~ 12m depth from 75 stations (green dots) deployed from January 2018 to December 2020. Within each region, data were interpolated across latitude and time using DIVA gridding and minimum x and y-scale length to complete coverage across each region in Ocean Data View. Data were filtered at three standard deviations to minimize the influence of outliers. In situ data are presented as white transects within each heat map.

taken it upon themselves to do something about the declines in kelp and the expansion of urchin barrens that they have witnessed during their time volunteering with RCCA. They successfully petitioned the commission to change the recreational fishing regulations so that they can remove sea urchins in the hope to help conserve the kelp forest habitat in Monterey. Regardless of the outcome of their project, their involvement with RCAA's monitoring program has made them engaged citizens, taking a proactive approach to addressing the environmental issues they see. Another example of how volunteering leads to public engagement in resource management is the participation of several RCCA volunteers in the public Project Team for the Red Abalone Fisheries Management Plan that was convened in 2019 where they advocated for a management approach that they deemed appropriate given the available data that they have helped to collected in years leading up to this Fisheries Management Plan development.

# DISCUSSION

## California's biogeography and MPA network responses

We conducted analyses on kelp forest community structure to refine the original MLPA regions. These analyses found generally similar regions to those used in the MLPA but we made further distinctions by separating the South Coast mainland from the Northern Channel Islands. In terms of community structure, the southern Channel Islands are also sufficiently different from the rest of the South Coast to merit their own grouping; low numbers of sampled MPAs precluded that division and the Southern Channel Islands were analyzed together with the South Coast. These regional patterns of kelp forest community structure have been previously well documented in southern CA (Claisse et al. 2018, Hamilton et al. 2010, Pondella et al. 2019) but less work has been done in central and northern CA, which did not show strong subregional divisions. The environmental monitoring done here supports this conclusion by finding that the MPAs in Northern and Central California had high coherence in environmental conditions, while southern CA sites were more variable and different to one another.

In general, the large variability in environmental conditions as well as in human usage of the ocean among California's regions is a challenge to statewide MPA effectiveness monitoring and analysis. We addressed this challenge in several ways. First, by creating functional groups of organisms such as Targeted and Non-targeted species or trophic designations, we can compare across regions that share very few species or taxonomic ranks. We also conducted specific, within-region analyses that take into account unique features of each region that might not be expected to act similarly in the different regions. For example, the effect of temperature on MPA performance might be positive in a region that is accustomed to warm temps (e.g. South Coast) but negative on responses in a region accustomed to cold water (e.g. North Coast). While this issue can be dealt with statistically (as detailed in Hamilton et al., 2010), in this study, highly uneven sampling in each region of CA makes this difficult. In many cases, separate analyses should be done by region, as we have done here.

## Data availability and confidence in MPA inferences

While California is considered a well-studied system for kelp forest ecology, monitoring data are uneven across space and time. Limitations on data, combined with our conservative analytical framework meant we had greater confidence in results from some regions relative to others, For

North Coast MPAs, established in 2012, lack of sufficient time series and very few Non-targeted species made assessment of MPA effects using our framework difficult. Only two MPAs in the North (Ten Mile SMR and Point Cabrillo SMR) were used for time series analysis yet the baseline time period was 2014-2015, in the middle of a marine heatwave period. Two North Central MPAs established in 2010 (Saunders Reef SMCA and Stewarts Point SMR) also provided a time series but both of these MPAs had two years of baseline (2010, 2011) and then no data until 2016 (Saunders) or 2017 (Stewarts Point). Thus a large data gap occurred during the marine heatwave. The effects of the MHW were very strong in both of these regions, resulting in the dramatic loss of bull kelp (Macpherson et al. 2021, Rogers-Bennett and Catton 2019) and a major shift in kelp forest communities. Inconsistent monitoring during this very dynamic period, lowers confidence in MPA evaluation for this region. The Landsat imagery for kelp canopy is a major addition to monitoring in this difficult to access region, at least for the foundation species kelps. The addition of RCCA data in the future also should help fill some of these data gaps. Future monitoring investments in this region should be carefully considered (see management recommendations). Our inferences about MPA responses in the remaining regions are much stronger. In the Central Coast, we assessed 5 MPAs with long and consistent time series and in the South Coast mainland we had 4 MPAs with solid time series. The Northern Channel Islands are the oldest MPAs (most established in 2003) and this region has the longest time series with consistent monitoring (7 MPAs). When considering future monitoring, the length of existing time series is a very important criteria for continued monitoring.

## Population responses

We found that population responses to MPAs varied greatly whether evaluated as combined taxa (Targeted and Non-targeted by fisheries), or individual focal species, or at single MPA or regional scales. Across these scales of taxonomic and spatial aggregation, two key related results emerged. The strongest positive responses to MPAs occurred at MPAs in the southern regions of the network (South Coast, Northern Channel Islands) and for species that are known to be heavily targeted by fisheries (California Sheephead, Kelp Bass). The geographic distribution of the two most strongly responding species is limited to the regions where MPA responses were strongest and explain the positive regional responses of Targeted species in those regions in contrast to the two northern regions (North Coast, Central Coast). Similar patterns emerged in the effects of MPAs on observed increases in larval production of the four select species examined. Although we were not able to analyze the CDFW microblock data to quantify the spatial variation in fishing mortality (or effort) at the scale of MPAs or regions, the greater nearshore fishing effort from southern to northern California has been described (Bennett et al 2004, Miller et al 2014) and mirrors CDFW's regional allocation of sampling relative to effort. These overall results reinforce the notion that positive population responses are greatest where fishing mortality was likely strongest at MPA sites prior to their establishment (White et al. 2021, Jaco and Steele 2020) and in reference areas after MPA establishment. We detected significant focal fish species responses more frequently than when species biomass was aggregated by their fished categorization. While useful for high-level summaries and cross-region comparisons, the Targeted grouping likely includes species that experience a range of fishing mortalities from low to very high. In addition, focal species for which we detected positive responses were large and abundant. Unfortunately, the few focal species for which positive responses were detected preclude a robust analysis of relationships between species attributes (e.g., recruitment rates, growth rates, home range, longevity) and population responses.

Like focal fishes, the most frequent significant MPA responses of focal invertebrates also occurred for particular species (both sea urchin species, spiny lobster, sea cucumbers and all abalone species combined) and these responses were also more frequent in the two southern regions, especially the Northern Channel Islands. Whereas the geographic pattern of spiny lobster and sea cucumber responses limited to the southern regions is obviously explained by the geographic distribution of the species and fishery, respectively. Red urchins are more broadly distributed and their geographic responses are most likely associated with geographic differences in fishing pressure. Finally, neither purple urchins or abalone are fished in southern regions, suggesting other drivers of their greater responses in the southern regions. While abalone exhibited positive responses, both sea urchins (purple and red) exhibited significantly greater declines in MPAs. These greater declines in MPAs compared to reference sites suggest the possible involvement of community level processes. Prior studies have linked the greater density and size of lobster and California Sheephead in some Northern Channel Island MPAs with greater rates of predation and reduced densities of the two urchin species (Eisaguirre et al. 2020, Caselle et al. 2018, Hamilton and Caselle 2015). This cascade is further suggested in the community level responses described in the Results. Notably, these declines were not observed in Central Coast and North Coast MPAs where CA sheephead and CA spiny lobsters are not present.

Overall interpretation of these population responses needs to recognize the very conservative criteria our analytical framework requires of MPA 'success'. Few other evaluation programs have the temporal datasets required for these analyses. Indeed, we did not conduct analyses for many of the MPAs that we have monitored in the past because they lacked sufficient consistency and duration for our analyses. Alternatively, if we were to relax our criteria to those applied to the vast majority of MPA studies globally and here in California (tests of a positive average response ratio over time), we do see that on average, response ratios are positive for fished species and show no pattern for non-fished species, which fits expectations. Our analyses also make the fundamental assumption that these temporal trajectories are in the divergence phase of a longer-term temporal response. Eventually, these analyses can be improved on by recognizing the potential for trajectories in response ratios to asymptote over time and even possibly decline due to spillover (as described in the Background section and Figure 1). Some MPAs in California (e.g. Northern Channel Islands, Point Lobos in Central California) are likely old enough to be in that phase of the response sequence. Detecting this will require a) longer time series and b) specific studies on spillover, fishing mortality near the MPA, and indirect effects of species interactions within MPAs as biomass builds up.

Size responses are expected to be faster and more direct than abundance responses, which are reliant on rates of larval recruitment. For fishes, size responses varied across species and regions with little consistent regional or species trends. Some species in some regions exhibited the predicted shifts to larger sizes in MPAs over time, but others showed no positive response to MPAs. For invertebrates, many species exhibited the predicted shifts to larger sizes in MPAs by the end of the monitoring period, but the patterns were not always consistent with regional patterns of presumed fishing pressure. One added value of our size distribution analyses is the detection of recruitment events (i.e. influx of the smallest size classes monitored) and how those events influence subsequent changes in size structure of populations as year classes move through a population over time. These events are important for interpreting population responses to MPAs (Hopf et al. 2021).

Of the MPA attributes we evaluated (MPA latitude, size, proximity to one another, habitat diversity, reef area, level of protection, distance to and identity of fishing ports) to further explain population responses of the Targeted fishes, we found that positive population responses (both the rate of change and the average response ratio) were related to the identity of nearest ports and levels of MPA protection. Those ports nearest to MPAs with significant population responses (Morro Bay, Santa Barbara, San Pedro) are likely sources of the greatest fishing pressure, and this relationship should receive greater evaluation with CDFW fishing data. Our reclassification of the many SMCAs that only allow fishing of species (salmon, transient pelagics) that have very little interaction with kelp forest species as “de facto SMRs” proved appropriate. Population responses were similar between SMRs and de facto SMRs, but were significantly different from the fished SMCAs. This supports the intent of allowing the take of particular species within SMCAs and informs future analyses of MPA performance. In contrast, we did not detect relationships between population responses and any of the other ecological or regulatory attributes of MPAs that we evaluated. However, these were rather simplistic analyses that warrant further analysis. Two overarching impediments to some of these analyses were the response variables and the number of replicate MPAs. The paucity of statistically significant relationships detected between the rate of change in biomass and MPA attributes might very well be due to the high variability in the actual biomass trends over time, which makes the highly variable linear slopes of these times series a challenging indicator of rate of change. This approach, requiring a substantial time series, also eliminated many MPAs thereby reducing the number of replicate MPAs within each geographic region. For example, having accounted for the de facto MPAs, we were left with no replicates of clustered SMCAs to compare with solitary SMCAs. These analytical constraints need to be recognized when interpreting many of these results. We reported on only one evaluation of environmental variables on MPA performance and this and other environmental variables will need greater evaluation in the near future.

Beyond these analytical constraints, there are other aspects of our analytical models and monitoring design that might have contributed to the lack of positive population responses detected in this study. First and foremost is the assumption that these MPAs are in the divergence phase of population responses to MPA establishment. Some of the older MPAs may be in later phases of population trajectories (Figure 1), but lacking monitoring data closer to the establishment of those MPAs currently prevents that assessment. Hopefully, continued monitoring of the recently established MPAs will define these population trajectories and allow inferences of the phase of the older MPAs. Moreover, if spillover from MPAs is substantial and influences population sizes in reference sites, population sizes in MPAs and reference sites should converge in time (Figure 1), complicating the value of their differences as a metric of performance. In addition, “edge effects” (i.e., effects on populations in close proximity to MPA boundaries) can diminish differences measured inside and outside of MPAs. Monitoring sites within MPAs that are too close to MPA boundaries can be influenced by fishing pressure adjacent to MPA boundaries (Ohoyan et al. 2021). Likewise, reference sites too close to MPA boundaries can be influenced by spillover (Halpern et al. 2010, Di Lorenzo et al. 2016, Kay et al. 2012). These confounding processes are exacerbated if MPAs are too small by design and underscore the importance of further evaluation of the effects of MPA sizes and clusters and studies designed to measure rates of spillover. Central to all of these considerations, regardless of the phase of population trajectories or the distribution of monitoring sites, is the magnitude of difference between populations in MPAs and reference sites that our monitoring design can detect, given the great spatial and temporal variability of species populations (Ovando et al 2021, Hopf et al 2021) and whether the realized differences among MPA and Ref sites is expected to be large. Refinement of monitoring designs, including reallocation of monitoring effort among MPAs, will need continued consideration.

Other factors beyond design and analysis constraints are those inherent to the ecological and fisheries systems. Low levels of fishing pressure in reference areas will diminish the magnitude of differences and hence, the response ratio (Pelc et al. 2010, Ovando et al. 2021). While this can be an inherent feature of well-managed fisheries, as California fisheries are thought to be, it can challenge evaluation programs. A separate issue is the challenge of locating reference sites that are representative of the fishing mortality generally experienced outside MPAs. Another management consideration and one which is less discussed in California is the level of poaching within MPAs. Recent theoretical models indicate this has not been the case in some California MPAs (White et al. 2021) but anecdotal evidence for poaching does exist. Data are being collected in California by enforcement agencies and could be useful for analyses of ecological and biological responses in the future. These considerations underscore the critical necessity of estimates of fishing effort and mortality at appropriate spatial scales to accurately estimate these metrics at reference sites and within MPAs (Ovando et al., DEWG report). Ecological complications that we encountered include the paucity of species not targeted by fisheries on the North Coast as environmental controls in our analytical framework. Another huge consideration that requires much more analysis is the effect of large-scale climate impacts, especially the 2014-2016 marine heatwave (MHW). There was clear evidence of species declines both in and out of MPAs associated with the MHW. These concurrent declines diminished population differences in and out of MPAs and these impacts can diminish community responses to MPAs when the species responses include foundation species, ecosystem engineers and keystone species as was observed in the North and Central Coasts. By “resetting” population trajectories, subsequent reestablishment of any differences in and out of MPAs may take many years to manifest. Environmental perturbations are especially insidious if they act at the spatial scale of MPAs and reference sites. Though highly unlikely, they are possible (Caselle et al. 2018).

## Community-level responses

With only one exception (Northern Channel Islands), fish diversity and richness declined, though not significantly, in both MPAs and Ref sites across the network. The regional scale of this trend and its occurrence both inside and outside of MPAs strongly suggest community-wide responses to a broad environmental driver. That environmental driver was most likely the 2014-2016 marine heatwave (MHW; Beas-Luna et al. 2020) and the qualitative geographic pattern of response of fish diversity is particularly interesting. Declines in the North Coast region may reflect the large regional loss of bull kelp across that region (Rogers-Bennett and Catton 2019, McPherson et al. 2021), and no evidence of an influx of warmer fish species. Similarly, the observed decline in fish diversity in the Central Coast might reflect the creation of a spatial mosaic of forests and urchin barrens there (Smith et al. 2021) and lower diversity of fishes within urchin barrens. Again, there was no evidence of an influx of warmer water species, which might counter these declines. In the South Coast, though not significant trends, the apparent greater decline of fish diversity within MPAs is perplexing and merits greater scrutiny of changes in and out of those coastal MPAs, especially with regard to changes in the relative abundance of fishes with warm versus cooler water affinities. Trends in the Northern Channel Islands indicate a brief and dramatic decline in fish diversity associated with the MHW (2015, 2016) followed by a dramatic recovery leading to an overall increase in diversity within MPAs. Although the longer-term trend in fish diversity in reference areas is significantly negative, Ref and MPAs populations track one another remarkably similarly.

Interestingly, overall trends in algae, macroinvertebrates and UPC species diversity largely mirrored regional patterns of fish diversity with declines in North Coast and Central Coast in both MPAs and reference sites, and more positive responses within Northern Channel Islands MPAs relative to reference areas. The North Coast and Central Coast declines very likely reflect the declines of many species of macroalgae and invertebrates in urchin barrens, though this requires further evaluation. Similarly, the more negative UPC response in the Central Coast MPAs might reflect a greater relative occurrence of urchin barrens in MPAs. The significant positive effect of MPAs on fishes, algae, invertebrate and UPC diversity in the Northern Channel Islands suggest responses to community-wide effects of MPAs there, as reflected by the trophic cascades observed and previously described in that region. In contrast, trends for algae and invertebrate diversity on the South Coast differ in the relative effects of MPAs. Increases in algal diversity in both MPAs and reference sites in the South Coast suggests a larger scale environmental driver and examination of whether this reflects shifts in the relative abundance of species with warm and cool water affinities is warranted. That the positive effect of MPAs on invertebrate diversity consistently increases through time suggests it may be a real consequence of MPAs and has little to do with environmental drivers.

Taken together, these regional patterns of diversity trends across the four assemblages reveal greater impacts of the MHW in the northern regions of the network and intriguing positive consequences of MPAs in the Northern Channel Islands. Potential mechanisms for these trends are suggested by patterns of response of key species in kelp forest ecosystems. Although *Pycnopodia helianthoides* experienced dramatic declines throughout the network, the impact of this on community structure differed markedly among regions. On the North Coast, where *Pycnopodia helianthoides* was the prominent sea urchin predator, purple sea urchin counts increased and bull kelp densities decreased dramatically both inside and outside of MPAs. On the Central Coast where the sea otter is abundant, the response of purple urchins and giant kelp was mixed. In the South Coast, and especially on the Northern Channel Islands, where both California Sheephead and California spiny lobster exhibited positive response ratios (greater increases in MPAs relative to reference sites), the response ratios of purple urchins actually declined over time and giant kelp abundance exhibited the least change. These results suggest geographic differences in trophic interactions enabled by the MPAs (i.e. protection of lobster and California Sheephead) might have contributed to the stability of the kelp forest community.

## Large-scale, long-term kelp monitoring - the importance of remote sensing

The Landsat satellite data enabled retrospective surveys of variability in kelp abundance over larger spatial scales than is possible with *in situ* monitoring. One benefit of the spatial and temporal coverage of this data is the ability to quantitatively identify potential reference areas for MPAs to control for environmental variability when assessing MPA impacts on kelp abundance. The high correlation between kelp dynamics in MPAs and the associated reference sites prior to MPA implementation indicates that similar factors influenced kelp abundance in the control and impact (MPA) areas. This helps improve confidence that divergence in kelp abundance between MPAs and their associated controls after the MPA implementations was caused by the MPA.

We did not find a strong effect of MPA protection on average kelp canopy area when conducting the BACI analysis. Giant kelp canopy abundance is naturally highly variable (Cavanaugh et al. 2011), which makes it difficult to identify trends and distinguish impacts of intervention (i.e. MPA protection) again background variability (Rassweiler et al. 2021). Furthermore, MPA protection is likely to have an indirect effect on kelp abundance through trophic cascades (Caselle et al. 2018, Eisaguirre et al. 2020, but see Malakoff and Miller 2021). MPA effects may have been overshadowed by other drivers of variability in kelp abundance. For example, large declines in kelp abundance occurred in many MPAs during the 2014-2016 heatwave.

However, kelp abundance did appear to exhibit higher resilience to the 2014-2016 marine heatwave inside MPAs as compared to reference regions. This major heatwave event led to declines in kelp abundance across California and Baja California (Cavanaugh et al. 2019; Arafeh-Dalmau et al. 2019; McPherson et al. 2021). Recovery of kelp in southern California was spatially variable (Cavanaugh et al. 2019). In northern California, the heatwave followed mass mortality of sea stars, an important predator of sea urchins, and this combination of stressors led to a large-scale decline in bull kelp (Rogers-Bennet & Catton 2019). The Landsat kelp canopy data showed little recovery in bull kelp during the six years following this collapse, however, recovery was significantly higher in MPAs than associated reference sites. A similar pattern was observed in parts of southern and central California. Indirect MPA effects on kelp may be more detectable following large disturbances like the 2014-2016 marine heatwave because kelp forests may be especially vulnerable to overgrazing during these periods. The initial heatwave-related decline in kelp abundance may lead to more active grazing by urchins (Harrold & Reed 1985), and increased grazing intensity prohibits recovery of kelp after the heatwave.

Landsat-derived kelp canopy data are a valuable complement to *in situ* monitoring due to the extensive spatial and temporal coverage of the dataset. The length of the time series (1984-present) enables retrospective surveys from periods prior to MPA implementation. As we have shown here, these data can be used to identify reference regions with respect to kelp dynamics. In addition, characterizing historical variability in kelp abundance is necessary if we are to identify MPA-related impacts on kelp abundance. The comprehensive spatial coverage of the Landsat data can be used to characterize spatial variability in MPA impacts on kelp abundance. Furthermore, kelp canopy data can be used as an input to models predicting the suitability or abundance of other kelp-associated species.

## Environmental monitoring - Ocean acidification, hypoxia, and temperature

The environmental data collected in the MPAs can provide important context for interpreting MPA effects. Continued ocean acidification, deoxygenation, and warming (including marine heatwaves) are happening in the background of MPA establishment and enforcement, and spatial and temporal variability in the exposure of different MPAS to ecologically stressful OAH or marine heat waves could obscure patterns associated with protection.

The data collected via the OAH and thermistor observing networks demonstrate the variability in environmental conditions organisms in California's MPA network currently experience. During the period of observations (2018-2021), the sites in northern California had cooler temperatures overall, but had higher exposure to potentially stressful pH and dissolved oxygen conditions. There was high coherence among sites in northern California, suggesting MPAs in this part of the network likely experience similar conditions to one another. In contrast, the sites in southern California were warmer overall, and more variable in temperature among sites. The sites in southern California were not exposed to conditions used to assess physiological stress in the event scale analyses (i.e., pH < 7.7 or DO < 4.6 mg/L). The sites in central California had temperatures that were cooler than southern California and experienced less potentially physiologically stressful OAH conditions than the sites in northern California. Similar to northern California, the coherence among sites in central California was high, suggesting MPAs in this region likely experience similar conditions.

The event analyses of OAH data highlight the importance of long-term monitoring in understanding exposure patterns of CA MPAs to OAH, now and in the future. Because exposure to low pH and low dissolved oxygen conditions in the Northern and Central California regions is associated with upwelling, exposure is and will continue to be highly variable through time with seasonal peaks in low pH and low dissolved oxygen conditions. Thus, summaries of mean conditions may not adequately capture ecologically relevant aspects of OAH exposure. For example, the mean pH at Big Creek of 7.84 does not capture that marine species at this site experienced conditions below pH 7.7 for over a week at a time during spring upwelling. Numerous studies have documented reductions in calcification and growth of species relevant to MPAs (e.g., abalone, urchins, lobster) with prolonged exposure to pH values that organisms in northern and central California regions are regularly experiencing during upwelling events. Although our understanding of how intermittent exposure to low pH conditions affects marine species is somewhat limited, our event analyses highlight the mean durations of events below pH 7.7 in the northern California sites during late summer range from 12-20 days on average. A better understanding of these patterns of exposure can provide critical insight into MPA performance, especially as OAH accelerates (Gruber et al. 2012; Hauri et al. 2013) and upwelling dynamics change with continued carbon dioxide emissions (Bakun et al. 2015, Wang et al. 2015). For example, if exposure to these low pH conditions causes reductions in species growth rates, then we might expect slower recovery in MPAs with more severe low pH events following a disturbance.

The variability in temperature among sites in the Southern California Mainland region also highlights the importance of maintaining environmental sensors within the MPA network to best interpret individual MPA performance. Although the current thermistor network was installed after the 2013-2015 marine heat wave, we detect several smaller marine heat waves (with temperature above 25C) in different locations and during different times of the year in southern California (Figure 32c). Prolonged exposure to these temperatures could affect the population dynamics of Targeted species through several mechanisms, including limiting successful recruitment and causing mortality. Similar to the OAH event analyses, understanding the exposure of marine organisms to potentially stressful high temperature events can provide critical information in MPA interpretation.

## Citizen science and MPA monitoring

Results from Reef Check's monitoring program are discussed in Appendix 2. Beyond the data collection, the involvement of citizen science in the MPA monitoring during the baseline and the long-term monitoring has engaged the public in the MLPA process. RCCA has trained over 2000 volunteers in its monitoring protocol and they have conducted over 1300 surveys at about 110 sites between San Diego and the Oregon border during the baseline and long-term on MPA monitoring programs. The program has grown geographically with every regional baseline monitoring program and maintained monitoring sites in all regions after baseline programs were completed. During the different baseline programs, RCCA has adapted its protocol and training to better meet the data needs of the long-term monitoring program (e.g., Freiwald et al. 2018). Further, citizen science projects enhance scientific literacy, environmental awareness and resource stewardship, and conducting research educates participants about the scientific process and creates trust between stakeholders and resource managers (Jordan et al. 2012, Cigliano et al. 2015). As such, the participation of volunteers in the monitoring has created an awareness of MPAs throughout the recreational dive community. Many RCCA volunteers have gone on to become involved in other aspects of marine resource management either as volunteers or professionally. RCCA has grown programmatically from ecosystem monitoring to environmental monitoring (OAH) and kelp restoration projects. While this has created more opportunities of public engagement, the financial commitment required for scuba diving presents a hurdle for participation leading to a relatively homogeneous body of volunteers with the required resources to volunteer their time and provide their equipment. Reef Check's recently launched Dive into Science program is designed to address this and increase opportunity for participation. This program is focused on diversity, inclusion and equity by providing pathways to college education and vocational training through training and mentorship for youth from communities that are typically underrepresented in marine sciences and resource management. By connecting this demographic to MPA monitoring, RCCA is building a more inclusive and diverse constituency with the hope it will better represent the diversity of California's population and ocean user community.

# MANAGEMENT RECOMMENDATIONS

The following recommendations in this section stem from the results presented in this report and our insights and experiences related to our roles and expertise in the monitoring and evaluation of the MLPA network of MPAs. As such, of the four pillars of California MLPA management (research and monitoring, enforcement and compliance, outreach and education, and policy and permitting), our recommendations pertain largely to the research and monitoring pillar and where research and monitoring intersect with the other three management pillars.

While we recognize the intent of our study to inform the adaptive management of the MPA network, especially with respect to network design (e.g. size, location, configuration, levels of protection), the results of our studies have shown the limitations in our ability to provide recommendations on these design attributes. These limitations reflect both analytical constraints that are inherent fromthe design of the network, as well as the results of our analyses of some of these attributes. For example, when we accounted for the realized heightened levels of protection for kelp forest ecosystems of many SMCAs (i.e. "de facto SMRs"), and the necessity to make such comparisons at the regional scale, there was insufficient replication of MPAs at each level of protection to make such comparisons. These considerations similarly prevented comparisons of stand-alone and clusters of MPAs. Our analyses that did test for relationships between species responses and continuous MPA attributes (e.g., MPA size, habitat diversity, distance from port) did not detect significant relationships, suggesting that these attributes did not influence species responses. Therefore, we cannot say whether any of these attributes should be considered for future management considerations. Moreover, such design considerations will require assessments across the multiple ecosystems targeted for protection, not just kelp forests. Instead of these MPA design considerations, we are best positioned to provide recommendations on the state's approach to monitoring and evaluating the network.

1) **Consider regionally tailored network management.** Although one of the most important design attributes of the MLPA network is its integration across all of California's coastal waters, the results of our study strongly suggest a management program tailored to the regional ecological and human differences across the network may be more effective, efficient and potentially nimble. We found strong geographic differences in MPA responses as well as in data availability, mirroring geographic differences in the magnitude and types of fishing, fisheries management, human densities, stakeholder interests, among others. Potential regional MPA management decisions (e.g., relative levels of monitoring, enforcement, outreach, forms of partnerships between CDFW and types and amount of monitoring) parallel current, regionally-based management of many state fisheries and, as such, may facilitate the integration of MPA and fisheries management.
2) **Continue robust long-term monitoring of kelp forest ecosystems and environmental conditions** but make realistic, science-informed decisions about the geographic scale of monitoring and the distribution of sites. The effects of multiple ecological and environmental disturbances (e.g., marine disease events, 2014-2016 marine heatwave) on kelp forest species, ecosystems, and MPA performance have been extremely well documented because of the MPA network monitoring program. California has some of the best data times series prior to and following these disturbances, in large part due to state-funded monitoring. California now has an unprecedented opportunity to examine resilience properties of these ecosystems and any contributions of MPAs. Climate-related anomalies are predicted to increase into the future and the MPA monitoring program is crucial to identifying the anomalies themselves and their ecological consequences and ecosystem service (e.g., fisheries) impacts.
3) **Leverage these results and those of other monitoring reports to make informed decisions about the geographic distribution and effort of monitoring.**
    a) Consider reducing investments in locations where *in situ* MPA sampling is disproportionately costly and less fruitful. For those locations (e.g., remote North Coast, distant islands) consider targeting a subset of scientific or management questions that might be less reliant on robust time series. For example, biodiversity monitoring might be achieved with less regular sampling or with technologies such as Landsat remote sensing or eDNA.
    a) Prioritize monitoring at locations with robust time series and where robust time series need to be further developed from existing time series. Our analytical framework is designed to unambiguously assign changes in populations and communities in MPAs to the effects of regulations but requires robust time series and proper counterfactuals (ie. non-fished species).

    b) We identified a large number of duplicate sites (surveyed by both academic programs and RCCA). While in some difficult to access locations such as the North Coast, redundancy might be warranted to increase the chances of a team being able to conduct surveys. In many other locations, redundancy should be eliminated.

4) **Leverage the impressive capacity of LANDSAT imagery** to monitor the state-wide distribution and dynamics of the canopy-forming kelps as critical foundation and ecosystem engineers of these ecosystems, and their own important ecosystem services. When and where necessary, augment these surveys with drone surveys.
5) **Invest in continued OAH and temperature monitoring,** including data management and quality control, within the MPA network. While the event analyses highlight the potential to use models to understand exposure to OAH and marine heat waves, current regional ocean models do not provide output in nearshore environments where many MPAs are located. Thus, more observational data is needed to better understand the utility of models in forecasting future conditions in CA MPAs. As OAH and marine heatwaves become more common, it will be critical to have data at the scale of geographically distributed individual MPAs for temperature, and at the regional scale for OAH, to better interpret MPA performance.
6) **Build stronger monitoring partnerships.** For all the values of a state-wide, long-term monitoring program described above, CDFW should build stronger partnerships (e.g., with academic institutions) by investing more resources into these partnerships. CDFW has already made substantial investments (e.g., RV *Mystinus* in the Central Coast) but has not realized this capacity because of shortfalls in dedicated personnel (e.g., vessel operators and trained monitoring staff). Investing in partnerships will establish a more cost-effective, sustainable monitoring program.
7) **Provide more focused and dedicated resources** (e.g., analysts, funding) **to the sampling design and analysis of the state's fishing data**. CDFW made a great start on processing and supplying some spatial fishing data, but estimating fishing mortality and catch at the scales relevant to the MPAs and for each of the different habitats (i.e., Deepwater, CCFRP, Kelp forest; all with different reference areas) appears to be a bigger project than expected. The current NCEAS working group may take on some aspects of this research, but we recommend that CDFW continue to support that effort by providing dedicated staff who can work closely with individual monitoring projects to ensure that the best available fishing data can be used.
8) **Generate and distribute enforcement metrics** which are critically important to the interpretation of the ecological performance of MPAs. Qualitative or quantitative metrics of enforcement of each MPA across the network would allow consideration or assessment of how variation in ecological responses and MPA performance correlate with levels of enforcement.
9) **Continue support for more detailed analysis of existing MPA data**. While some of this work will be done as part of the NCEAS working group, California has some of the most robust MPA datasets globally. In particular, more detailed research on the effects of disturbances (MHW, ENSO), functional trajectories and responses (e.g., thermal affinity, trophic level), interactions with invasive species, and relationships between species responses and environmental variables are all areas of future research.
10) **Invest in more theoretical/modeling research that lays out realistic expectations for how populations should be changing in MPAs** relative to disturbance (magnitude and frequency), recruitment, and other factors known to influence the timing and

detection of potential MPA effects. This research can guide monitoring decisions in the future and also **provide key information for communications to stakeholders as well as managers**.

11) **Support research to understand where, when and for what species, spillover might be a factor** in reducing the differences in abundance and biomass between MPAs and reference sites (i.e., response ratios). California has paid less attention to spillover in state-funded monitoring programs than other priorities. There has been some fundamental research on fish movement in CA, some in relation to MPAs but the work has been limited to date. Recent research has detected ‘edge effects’ of MPAs, that is, attenuated responses up to 1.5 km inside the boundaries of MPAs. Research on this and how seascape variables may enhance or decrease spillover and affect MPA performance is overdue. This work can leverage the extensive investment in seafloor mapping made by the state.

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# Tables

**Table 1.** Sites completed in the funding period by the academic groups (HSU, UCSC, UCSB and VRG). Sites and MPAs are generally ordered from North to South. Filled blocks were monitored in the indicated year, and the monitoring group is also shown. Sites surveyed for fishes and for benthic organisms (invertebrates, algae) are indicated in separate columns. MPA sites are shown in red, reference sites are shown in blue, and State Marine Conservation Area (SMCA) sites which are used as reference sites for a State Marine Reserves (SMR) are shown in purple. The general location (latitude, longitude), affiliated MPA (some reference sites are affiliated with multiple MPAs), Monitoring Action Plan priority tier, and MPA designation are all included, along with the MLPA long-term monitoring region and analysis region (Northern Channel Islands (NCI) and Southern Channel Islands (SCI) are separated from the rest of the South Coast).

| Site | Latitude | Longitude | Affiliated MPA(s) | Tier | MPA Designation | MLPA Long-term Region | Analysis Region | 2019 fish | 2020 fish | 2019 benthic | 2020 benthic |
|---|---|---|---|---|---|---|---|---|---|---|---|
| BROOKINGS_3 | 42.00195 | -124.24337 | Pyramid Point SMCA | III | reference | North Coast | North Coast | **HSU** |  | **HSU** |  |
| PYRAMID_POINT_1 | 41.99898 | -124.24377 | Pyramid Point SMCA | III | SMCA | North Coast | North Coast | **HSU** |  | **HSU** |  |
| PYRAMID_POINT_2 | 41.99057 | -124.23588 | Pyramid Point SMCA | III | SMCA | North Coast | North Coast | **HSU** |  | **HSU** |  |
| PYRAMID_POINT_3 | 41.97938 | -124.23073 | Pyramid Point SMCA | III | SMCA | North Coast | North Coast | **HSU** |  | **HSU** |  |
| TRINIDAD_1 | 41.12788 | -124.17548 | na | na | reference | North Coast | North Coast |  | **HSU** |  | **HSU** |
| TRINIDAD_2 | 41.09193 | -124.1701 | na | na | reference | North Coast | North Coast |  | **HSU** | **HSU** | **HSU** |
| TRINIDAD_3 | 41.04845 | -124.13105 | na | na | reference | North Coast | North Coast | **HSU** | **HSU** | **HSU** | **HSU** |
| ABALONE_POINT_1 | 39.6915 | -123.8141 | Ten Mile SMR | I | reference | North Coast | North Coast | **HSU** | **HSU** | **HSU** | **HSU** |
| ABALONE_POINT_2 | 39.66502 | -123.80435 | Ten Mile SMR | I | reference | North Coast | North Coast | **HSU** | **HSU** | **HSU** | **HSU** |
| ABALONE_POINT_3 | 39.62877 | -123.79658 | Ten Mile SMR | I | reference | North Coast | North Coast | **HSU** | **HSU** | **HSU** | **HSU** |
| TEN_MILE_1 | 39.59057 | -123.7899 | Ten Mile SMR | I | SMR | North Coast | North Coast | **HSU** | **HSU** | **HSU** | **HSU** |
| TEN_MILE_2 | 39.58253 | -123.78743 | Ten Mile SMR | I | SMR | North Coast | North Coast | **HSU** | **HSU** | **HSU** | **HSU** |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TEN_MILE_3 | 39.57333 | -123.78268 | Ten Mile SMR | I | SMR | North Coast | North Coast | HSU | HSU | HSU | HSU |
| CASPAR_1 | 39.37403 | -123.82683 | Point Cabrillo SMR | II | reference | North Coast | North Coast | HSU | HSU | HSU | HSU |
| CASPAR_2 | 39.36445 | -123.82388 | Point Cabrillo SMR | II | reference | North Coast | North Coast | HSU | HSU | HSU | HSU |
| CASPAR_3 | 39.35937 | -123.82807 | Point Cabrillo SMR | II | reference | North Coast | North Coast | HSU | HSU | HSU | HSU |
| POINT_CABRILLO_1 | 39.35348 | -123.82672 | Point Cabrillo SMR | II | SMR | North Coast | North Coast | HSU | HSU | HSU | HSU |
| POINT_CABRILLO_2 | 39.35083 | -123.82935 | Point Cabrillo SMR | II | SMR | North Coast | North Coast | HSU | | HSU | |
| POINT_CABRILLO_3 | 39.34447 | -123.82563 | Point Cabrillo SMR | II | SMR | North Coast | North Coast | HSU | | HSU | |
| RUSSIAN_GULCH_1 | 39.34039 | -123.82175 | Point Cabrillo SMR | II | reference | North Coast | North Coast | | | | |
| RUSSIAN_GULCH_3 | 39.33136 | -123.81697 | Point Cabrillo SMR | II | reference | North Coast | North Coast | | | | |
| POINT_ARENA_REFERENCE_3 | 38.88297 | -123.69522 | Saunders Reef SMCA | I | reference | North Coast | North Coast | HSU | HSU | HSU | |
| POINT_ARENA_REFERENCE_4 | 38.87487 | -123.68838 | Saunders Reef SMCA | I | reference | North Coast | North Coast | | | | |
| SAUNDERS_MPA_1 | 38.85587 | -123.66842 | Saunders Reef SMCA | I | SMCA | North Coast | North Coast | HSU | HSU | HSU | HSU |
| SAUNDERS_MPA_2 | 38.85035 | -123.66662 | Saunders Reef SMCA | I | SMCA | North Coast | North Coast | HSU | HSU | HSU | HSU |
| SAUNDERS_MPA_3 | 38.84695 | -123.66128 | Saunders Reef SMCA | I | SMCA | North Coast | North Coast | HSU | HSU | HSU | HSU |
| SAUNDERS_MPA_4 | 38.83573 | -123.64898 | Saunders Reef SMCA | I | SMCA | North Coast | North Coast | | | | |
| SAUNDERS_REFERENCE_1 | 38.82227 | -123.62233 | Saunders Reef SMCA | I | reference | North Coast | North Coast | | | | |
| SAUNDERS_REFERENCE_2 | 38.80408 | -123.5981 | Saunders Reef SMCA | I | reference | North Coast | North Coast | HSU | | HSU | |
| DEL_MAR_REFERENCE_2 | 38.71638 | -123.46883 | Stewarts Point SMR | I | reference | North Coast | North Coast | UCSC | | UCSC | |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DEL_MAR_REFERENCE_3 | 38.70397 | -123.4554 | Stewarts Point SMR | I | reference | North Coast | North Coast | UCSC | | UCSC | |
| STEWARTS_POINT_MPA_1 | 38.6668 | -123.42063 | Stewarts Point SMR | I | SMR | North Coast | North Coast | UCSC | | UCSC | |
| STEWARTS_POINT_MPA_2 | 38.65073 | -123.40953 | Stewarts Point SMR | I | SMR | North Coast | North Coast | UCSC | | UCSC | |
| STEWARTS_POINT_MPA_3 | 38.61415 | -123.37745 | Stewarts Point SMR | I | SMR | North Coast | North Coast | HSU | | HSU | |
| STEWARTS_POINT_MPA_4 | 38.59765 | -123.36372 | Stewarts Point SMR | I | SMR | North Coast | North Coast | HSU | | HSU | |
| SALT_POINT_REFERENCE_5 | 38.55382 | -123.30908 | Stewarts Point SMR | I | reference | North Coast | North Coast | | | | |
| SALT_POINT_REFERENCE_1 | 38.53723 | -123.28933 | Stewarts Point SMR | I | reference | North Coast | North Coast | | | | |
| PINOS | 36.64045 | -121.92873 | Pacific Grove Marine Gardens SMCA | II | SMCA/ reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| OTTER_PT_DC | 36.63648 | -121.92116 | Pacific Grove Marine Gardens SMCA | II | SMCA/ reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| OTTER_PT_UC | 36.63463 | -121.91893 | Pacific Grove Marine Gardens SMCA | II | SMCA/ reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| SIREN | 36.63073 | -121.91859 | Pacific Grove Marine Gardens SMCA | II | SMCA/ reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| LOVERS_DC | 36.62577 | -121.91074 | Lovers Point - Julia Platt SMR | III | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| LOVERS_UC | 36.62422 | -121.90908 | Lovers Point - Julia Platt SMR | III | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| HOPKINS_DC | 36.62359 | -121.9042 | Lovers Point - Julia Platt SMR | III | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| HOPKINS_UC | 36.62165 | -121.90079 | Lovers Point - Julia Platt SMR | III | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| MACABEE_DC | 36.61818 | -121.89684 | Edward F. Ricketts SMCA | III | SMCA/ reference | Central Coast | Central Coast | | UCSC | | UCSC |
| MACABEE_UC | 36.61715 | -121.8957 | Edward F. Ricketts SMCA | III | SMCA/ reference | Central Coast | Central Coast | | UCSC | | UCSC |
| CANNERY_DC | 36.61495 | -121.89604 | Edward F. Ricketts SMCA | III | SMCA/ reference | Central Coast | Central Coast | | UCSC | | UCSC |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| CANNERY_UC | 36.61264 | -121.89457 | Edward F. Ricketts SMCA | III | SMCA/ reference | Central Coast | Central Coast | | UCSC | | UCSC |
| CYPRESS_PT_DC | 36.57965 | -121.98247 | Carmel Bay SMCA | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| LONE_TREE | 36.56642 | -121.97069 | Carmel Bay SMCA | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| PESCADERO_UC | 36.56112 | -121.95976 | Carmel Bay SMCA | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| STILLWATER_UC | 36.56012 | -121.94732 | Carmel Bay SMCA | I | SMCA | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| STILLWATER_DC | 36.55973 | -121.94401 | Carmel Bay SMCA | I | SMCA | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| PESCADERO_DC | 36.55941 | -121.95519 | Carmel Bay SMCA | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| BUTTERFLY_UC | 36.53966 | -121.9363 | Carmel Bay SMCA | I | SMCA | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| BUTTERFLY_DC | 36.53744 | -121.93567 | Carmel Bay SMCA | I | SMCA | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| MONASTERY_DC | 36.52542 | -121.93332 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| MONASTERY_UC | 36.52527 | -121.93051 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| BLUEFISH_DC | 36.52514 | -121.94878 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| BLUEFISH_UC | 36.52223 | -121.94354 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| WESTON_UC | 36.51261 | -121.94877 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| WESTON_DC | 36.51035 | -121.94579 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| MALPASO | 36.46575 | -121.93398 | Point Lobos SMR | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| SOBERANES | 36.44534 | -121.92914 | Point Lobos SMR | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| PALO_COLORADO | 36.39772 | -121.91143 | Point Lobos SMR | II | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ANDREW_MOLERA_UC | 36.27769 | -121.87599 | Point Sur SMR | II | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| ANDREW_MOLERA_DC | 36.27609 | -121.87304 | Point Sur SMR | II | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| COOPER | 36.26315 | -121.85661 | Point Sur SMR | II | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| SOUTH_WRECK_UC | 36.2253 | -121.79055 | Point Sur SMR | II | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| SOUTH_WRECK_DC | 36.22386 | -121.78741 | Point Sur SMR | II | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| BUCHON | 35.24408 | -120.9011 | Point Buchon SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| TENERA | 35.23863 | -120.89548 | Point Buchon SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| MONTANA_DE_ORO | 35.23323 | -120.89081 | Point Buchon SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| CROWBAR | 35.22616 | -120.88143 | Point Buchon SMR | I | SMR | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| GREEN_PEAK | 35.1901 | -120.83069 | Point Buchon SMR | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| LITTLE_IRISH_UC | 35.18421 | -120.82508 | Point Buchon SMR | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| LITTLE_IRISH_CEN | 35.17806 | -120.81773 | Point Buchon SMR | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| LITTLE_IRISH_DC | 35.17593 | -120.8125 | Point Buchon SMR | I | reference | Central Coast | Central Coast | UCSC | UCSC | UCSC | UCSC |
| ARROYO_QUEMADO_W | 34.46835 | -120.12518 | Naples SMCA/Campus Point SMCA | III | reference | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| ARROYO_QUEMADO_E | 34.46628 | -120.11697 | Naples SMCA/Campus Point SMCA | III | reference | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| NAPLES_W | 34.42463 | -119.95532 | Naples SMCA | III | SMCA | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| NAPLES_E | 34.42333 | -119.95102 | Naples SMCA | III | SMCA | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| NAPLES_CEN | 34.42185 | -119.9515 | Naples SMCA | III | SMCA | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| IV_REEF_W | 34.40473 | -119.87628 | Campus Point SMCA | I | SMCA (No-Take) | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| IV_REEF_E | 34.40295 | -119.86452 | Campus Point SMCA | I | SMCA (No-Take) | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| HORSESHOE_REEF_W | 34.39173 | -119.5577 | na | I | reference | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| HORSESHOE_REEF_E | 34.38945 | -119.54477 | na | I | reference | South Coast | South Coast | UCSB | UCSB | UCSB | UCSB |
| NICHOLAS_CANYON_W | 34.03996 | -118.92427 | Point Dume SMCA | | reference | South Coast | South Coast | VRG | VRG | VRG | VRG |
| LECHUZA | 34.03186 | -118.86313 | Point Dume SMCA | | SMCA | South Coast | South Coast | VRG | VRG | VRG | VRG |
| ESCONDIDO_W | 34.02029 | -118.77356 | Point Dume SMR | | reference | South Coast | South Coast | VRG | VRG | VRG | VRG |
| LITTLE_DUME_W | 34.00654 | -118.79097 | POINT DUME SMR | | SMR | South Coast | South Coast | VRG | VRG | VRG | VRG |
| POINT_DUME | 33.99884 | -118.80659 | Point Dume SMR | | SMR | South Coast | South Coast | VRG | VRG | VRG | VRG |
| RIDGES_N | 33.78848 | -118.42323 | Point Vicente SMCA | II | reference | South Coast | South Coast | VRG | VRG | VRG | VRG |
| ROCKY_POINT_N | 33.78093 | -118.42999 | Point Vicente SMCA | II | reference | South Coast | South Coast | VRG | VRG | VRG | VRG |
| POINT_VICENTE_W | 33.73974 | -118.41369 | Point Vicente SMCA | II | SMCA | South Coast | South Coast | VRG | VRG | VRG | VRG |
| ABALONE_COVE_KELP_W | 33.73922 | -118.38789 | Abalone Cove SMCA | II | SMCA | South Coast | South Coast | VRG | VRG | VRG | VRG |
| LONG_POINT_E | 33.73595 | -118.40122 | Point Vicente SMCA | II | SMCA | South Coast | South Coast | VRG | VRG | VRG | VRG |
| BUNKER_POINT | 33.72465 | -118.35317 | Abalone Cove SMCA | II | reference | South Coast | South Coast | VRG | VRG | VRG | VRG |
| CRYSTAL_COVE | 33.56275 | -117.8377 | Crystal Cove SMCA | II | SMCA | South Coast | South Coast | VRG | VRG | VRG | VRG |
| HEISLER_PARK | 33.54039 | -117.79189 | Laguna Beach SMR | I | SMR | South Coast | South Coast | VRG | VRG | VRG | VRG |
| LAGUNA_BEACH | 33.53115 | -117.78048 | Laguna Beach SMR | I | SMR | South Coast | South Coast | VRG | VRG | VRG | VRG |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| DANA_POINT | 33.4616 | -117.72145 | Dana Point SMCA | I | SMCA | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| SAN_MATEO_KELP | 33.37883 | -117.59804 | Crystal Cove SMCA/Laguna Beach SMR/Dana Point SMCA | I | reference | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| LEUCADIA | 33.0636 | -117.30932 | Swami's SMCA | I | reference | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| SWAMIS | 33.03574 | -11730134 | Swami's SMCA | I | SMCA | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| CHILDRENS_POOL | 32.85167 | -117.27829 | Matlahuayl SMR | II | reference | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| MATLAHUAYL | 32.85116 | -117.27018 | Matlahuayl SMR | II | SMR | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| SOUTH_LA_JOLLA | 32.81593 | -117.286 | South La Jolla SMR | I | SMR | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| POINT_LOMA_CEN | 32.7121 | -117.26302 | South La Jolla SMR | I | reference | South Coast | South Coast | **VRG** | **VRG** | **VRG** | **VRG** |
| SMI_HARRIS_PT_RESERVE_W | 34.06368 | -120.35598 | Harris Point SMR | I | SMR | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SMI_HARRIS_PT_RESERVE_E | 34.05278 | -120.33738 | Harris Point SMR | I | SMR | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SMI_CUYLER_W | 34.05705 | -120.3526 | Harris Point SMR | I | reference | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SMI_CUYLER_E | 34.05172 | -120.34618 | Harris Point SMR | I | reference | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SRI_CLUSTER_POINT_N | 33.93167 | -120.19742 | South Point SMR | II | reference | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SRI_CLUSTER_POINT_S | 33.92383 | -120.192 | South Point SMR | II | reference | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SRI_SOUTH_POINT_W | 33.89417 | -120.12488 | South Point SMR | II | SMR | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SRI_SOUTH_POINT_E | 33.89157 | -120.1192 | South Point SMR | II | SMR | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SRI_JOHNSONS_LEE_SOUTH_W | 33.89513 | -120.10432 | South Point SMR | II | reference | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SRI_JOHNSONS_LEE_SOUTH_E | 33.89743 | -120.10038 | South Point SMR | II | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_FORNEY_W | 34.05388 | -119.9182 | Gull Island SMR | II | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_FORNEY_E | 34.05148 | -119.90967 | Gull Island SMR | II | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_GULL_ISLE_W | 33.94817 | -119.82795 | Gull Island SMR | II | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_GULL_ISLE_E | 33.94647 | -119.82318 | Gull Island SMR | II | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_PAINTED_CAVE_W | 34.07448 | -119.88213 | Painted Cave SMCA | III | SMCA | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_PAINTED_CAVE_CEN | 34.07287 | -119.87098 | Painted Cave SMCA | III | SMCA | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_PAINTED_CAVE_E | 34.0719 | -119.85755 | Painted Cave SMCA | III | SMCA | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_HAZARDS_W | 34.0581 | -119.82483 | Painted Cave SMCA | III | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_HAZARDS_CEN | 34.05658 | -119.82117 | Painted Cave SMCA | III | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_HAZARDS_E | 34.05438 | -119.81935 | Painted Cave SMCA | III | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_PELICAN_W | 34.03587 | -119.7023 | Scorpion SMR | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_PELICAN_CEN | 34.03065 | -119.69665 | Scorpion SMR | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_PELICAN_E | 34.02805 | -119.69092 | Scorpion SMR | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_COCHE_POINT_W | 34.04265 | -119.604 | Scorpion SMR | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_COCHE_POINT_E | 34.04493 | -119.6014 | Scorpion SMR | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_CAVERN_POINT_W | 34.05275 | -119.5713 | Scorpion SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_CAVERN_POINT_E | 34.05428 | -119.56687 | Scorpion SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SCI_SCORPION_W | 34.0525 | -119.55525 | Scorpion SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_SCORPION_E | 34.04847 | -119.54637 | Scorpion SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_VALLEY_W | 33.9817 | -119.6637 | na | na | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_VALLEY_CEN | 33.98362 | -119.6384 | na | na | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_VALLEY_E | 33.98355 | -119.62032 | na | na | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| SCI_YELLOWBANKS_W | 33.9893 | -119.56493 | na | na | reference | South Coast | NCI | UCSB | | UCSB | |
| SCI_YELLOWBANKS_CEN | 33.98853 | -119.54698 | na | na | reference | South Coast | NCI | UCSB | | UCSB | |
| ANACAPA_WEST_ISLE_W | 34.01742 | -119.43807 | Anacapa Island SMCA | I | SMCA | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_WEST_ISLE_CEN | 34.01698 | -119.43292 | Anacapa Island SMCA | I | SMCA | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_WEST_ISLE_E | 34.01608 | -119.42183 | Anacapa Island SMCA | I | SMCA | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_BLACK_SEA_BASS | 34.0126 | -119.38918 | Anacapa Island SMR | I | SMR | South Coast | NCI | UCSB | | | |
| ANACAPA_MIDDLE_ISLE_W | 34.00783 | -119.39447 | Anacapa Island SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_MIDDLE_ISLE_CEN | 34.00988 | -119.38833 | Anacapa Island SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_MIDDLE_ISLE_E | 34.0085 | -119.38817 | Anacapa Island SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_LIGHTHOUSE_REEF_W | 34.01078 | -119.3725 | Anacapa Island SMR/SMCA | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_LIGHTHOUSE_REEF_CEN | 34.01278 | -119.36313 | Anacapa Island SMR/SMCA | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_LIGHTHOUSE_REEF_E | 34.0139 | -119.36 | Anacapa Island SMR/SMCA | I | reference | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |
| ANACAPA_EAST_ISLE_W | 34.01587 | -119.37173 | Anacapa Island SMR | I | SMR | South Coast | NCI | UCSB | UCSB | UCSB | UCSB |

**Table 1.** Continued.

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ANACAPA_EAST_ISLE_CEN | 34.01767 | -119.36368 | Anacapa Island SMR | I | SMR | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| ANACAPA_EAST_ISLE_E | 34.01703 | -119.36113 | Anacapa Island SMR | I | SMR | South Coast | NCI | **UCSB** | **UCSB** | **UCSB** | **UCSB** |
| SBI_SUTIL | 33.46585 | -119.04821 | Santa Barbara Island SMR | II | reference | South Coast | SCI | **VRG** | | **VRG** | |
| SBI_CAT_CANYON | 33.46442 | -119.04408 | Santa Barbara Island SMR | II | reference | South Coast | SCI | **VRG** | | **VRG** | |
| SBI_SOUTHEAST_REEF | 33.46293 | -119.03127 | Santa Barbara Island SMR | II | SMR | South Coast | SCI | **VRG** | | **VRG** | |
| SBI_SOUTHEAST_SEALION | 33.46878 | -119.02882 | Santa Barbara Island SMR | II | SMR | South Coast | SCI | **VRG** | | **VRG** | |
| SCAI_IRON_BOUND_COVE | 33.4475 | -118.57515 | Cat Harbor SMCA | III | reference | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_CAT_HARBOR | 33.42609 | -118.51181 | Cat Harbor SMCA | III | SMCA | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_INDIAN_ROCK | 33.46887 | -118.52617 | Arrow Point to Lion Head Point SMCA | I | SMCA | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_SHIP_ROCK | 33.46302 | -118.4914 | Arrow Point to Lion Head Point SMCA/Blue Cavern Onshore SMCA | I | reference | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_BIRD_ROCK | 33.45217 | -118.48767 | Blue Cavern Onshore SMCA | I | SMCA | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_BLUE_CAVERN | 33.44802 | -118.47947 | Blue Cavern Onshore SMCA | I | SMCA | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_RIPPERS_COVE | 33.42815 | -118.43547 | Blue Cavern Onshore SMCA | I | reference | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_ITALIAN_GARDENS | 33.41073 | -118.37576 | Long Point SMR | II | SMR | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_HEN_ROCK | 33.4001 | -118.3669 | Long Point SMR | II | reference | South Coast | SCI | **VRG** | **VRG** | **VRG** | **VRG** |
| SCAI_CHINA_POINT | | | Farnsworth Onshore SMCA | | SMCA | | | **VRG** | | **VRG** | |
| SCAI_SALTA_VERDE | | | Farnsworth Onshore SMCA | | reference | | | **VRG** | | **VRG** | |

**Table 2.** Sites completed in the funding period by Reef Check California. Sites and MPAs are generally ordered from north to south. Filled blocks were monitored in the indicated year. RCCA generally monitors fish and benthic transects on the same survey day. MPA sites are shown in red, reference sites are shown in blue, and State Marine Conservation Area (SMCA) sites which are used as reference sites for State Marine Reserves (SMR) are shown in purple. The general location (latitude, longitude), affiliated MPA (some reference sites are affiliated with multiple MPAs), Monitoring Action Plan priority tier, and MPA designation are all included, along with the MLPA long-term monitoring region and analysis region (Northern Channel Islands (NCI) and Southern Channel Islands (SCI) are separated from the rest of the South Coast).

| Site | Latitude | Longitude | Affiliated MPA(s) | Tier | MPA Designation | MLPA Long-term Region | Analysis Region | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|
| Macklyn Cove | 42.045155 | -124.29472 | Pyramid Point SMCA | III | reference | North Coast | North Coast | 🟦 | 🟦 |
| Pyramid Pt | 41.994801 | -124.21731 | Pyramid Point SMCA | III | SMCA | North Coast | North Coast | 🟥 | benthic only |
| Flat Iron Rock | 41.0594 | -124.1578 | na | na | reference | North Coast | North Coast | 🟦 | |
| Trinidad | 41.0542 | -124.1447 | na | na | reference | North Coast | North Coast | 🟦 | 🟦 |
| MacKerricher North | 39.492823 | -123.80199 | MacKerricher SMCA | I | SMCA | North Coast | North Coast | 🟥 | benthic only |
| Glass Beach | 39.4523 | -123.8156 | MacKerricher SMCA | I | reference | North Coast | North Coast | 🟦 | benthic only |
| Noyo North | 39.4279 | -123.8134 | MacKerricher SMCA | I | reference | North Coast | North Coast | 🟦 | 🟦 |
| Caspar North | 39.364429 | -123.82133 | Point Cabrillo SMR | II | reference | North Coast | North Coast | 🟦 | 🟦 |
| Caspar | 39.361729 | -123.82245 | Point Cabrillo SMR | II | reference | North Coast | North Coast | 🟦 | 🟦 |
| Frolic Cove | 39.355026 | -123.82387 | Point Cabrillo SMR | II | SMR | North Coast | North Coast | 🟥 | 🟥 |
| Russian Gulch | 39.327984 | -123.8088 | Russian Gulch SMCA | III | SMCA | North Coast | North Coast | 🟥 | 🟥 |
| Mendocino Headlands | 39.305283 | -123.81122 | Russian Gulch SMCA | III | reference | North Coast | North Coast | 🟦 | |
| Portuguese Beach | 39.303234 | -123.8034 | Van Damme SMCA | III | reference | North Coast | North Coast | 🟦 | 🟦 |

**Table 2**. Continued.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Van Damme | 39.271915 | -123.79591 | Van Damme SMCA | III | SMCA | North Coast | North Coast | 🟥 | 🟥 |
| Albion Cove | 39.2283 | -123.7744 | Van Damme SMCA | III | reference | North Coast | North Coast | 🟦 | 🟦 |
| Point Arena Lighthouse | 38.95117 | -123.74404 | Point Arena SMR | II | SMR | North Coast | North Coast | 🟥 | 🟥 |
| Point Arena MPA (M2) | 38.944801 | -123.7405 | Point Arena SMR | II | SMR | North Coast | North Coast | | 🟥 |
| Monument | 38.92769 | -123.73447 | Point Arena SMR | II | reference | North Coast | North Coast | | 🟦 |
| Point Arena Ref | 38.908001 | -123.7191 | Point Arena SMR | II | reference | North Coast | North Coast | 🟦 | 🟦 |
| Pebble Beach | 38.691212 | -123.44167 | Stewarts Point SMR | I | reference | North Coast | North Coast | 🟦 | 🟦 |
| Gerstle Cove | 38.56646 | -123.32996 | Gerstle Cove SMR | III | SMR | North Coast | North Coast | 🟥 | 🟥 |
| Salt Point | 38.564899 | -123.329 | Salt Point SMCA | I | SMCA | North Coast | North Coast | 🟥 | 🟥 |
| Ocean Cove | 38.555119 | -123.30566 | Gerstle Cove SMR | III | reference | North Coast | North Coast | 🟦 | 🟦 |
| Stillwater Cove Sonoma | 38.540298 | -123.2888 | Gerstle Cove SMR | III | reference | North Coast | North Coast | 🟦 | 🟦 |
| Ft Ross | 38.510601 | -123.24506 | Gerstle Cove SMR | III | reference | North Coast | North Coast | 🟦 | 🟦 |
| Beach Street | 37.524437 | -122.52584 | Montara SMR | I | SMR | Central Coast | Central Coast | 🟥 | |
| Flat Rock | 37.509892 | -122.51556 | Montara SMR | I | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Half Moon Reef | 37.486328 | -122.49044 | Montara SMR | I | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Hurrican Ridge | 37.470132 | -122.47964 | Montara SMR | I | reference | Central Coast | Central Coast | 🟦 | |
| Coral St Lucus Pt | 36.637768 | -121.92322 | Pacific Grove Marine Gardens SMCA | II | SMCA | Central Coast | Central Coast | 🟥 | 🟥 |
| Otter Cove | 36.634933 | -121.91995 | Pacific Grove Marine Gardens SMCA | II | SMCA | Central Coast | Central Coast | 🟥 | 🟥 |

**Table 2**. Continued.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Asilomar | 36.634555 | -121.94626 | Asilomar SMR | II | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Lover's 3 | 36.6285 | -121.9182 | Pacific Grove Marine Gardens SMCA | II | SMCA | Central Coast | Central Coast | 🟥 | 🟥 |
| Lovers Point | 36.62545 | -121.91193 | Lovers Point - Julia Platt SMR | III | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Hopkins | 36.621849 | -121.90168 | Lovers Point - Julia Platt SMR | III | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Aquarium | 36.619232 | -121.89941 | Edward F. Ricketts SMCA/ Lovers Point - Julia Platt SMR | III | SMCA/ reference | Central Coast | Central Coast | 🟪 | 🟪 |
| MacAbee | 36.618401 | -121.89761 | Edward F. Ricketts SMCA/ Lovers Point - Julia Platt SMR | III | SMCA/ reference | Central Coast | Central Coast | 🟪 | 🟪 |
| Breakwater | 36.610451 | -121.89433 | Edward F. Ricketts SMCA/ Lovers Point - Julia Platt SMR | III | SMCA/ reference | Central Coast | Central Coast | 🟪 | 🟪 |
| Spanish Bay | 36.618332 | -121.95361 | Asilomar SMR | II | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Pt. Joe | 36.614449 | -121.965 | Asilomar SMR | II | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Pescadero | 36.562302 | -121.9596 | Carmel Bay SMCA | I | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Stillwater Cove Monterey | 36.5602 | -121.9459 | Carmel Bay SMCA/ Point Lobos SMR | I | SMCA/ reference | Central Coast | Central Coast | 🟪 | 🟪 |
| Carmel River | 36.539082 | -121.9351 | Carmel Bay SMCA/ Point Lobos SMR | I | SMCA/ reference | Central Coast | Central Coast | 🟪 | 🟪 |
| North Monastery | 36.526806 | -121.92654 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| South Monastery | 36.525299 | -121.9319 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Middle Reef | 36.522484 | -121.93861 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Weston | 36.5112 | -121.9463 | Point Lobos SMR | I | SMR | Central Coast | Central Coast | 🟥 | 🟥 |

**Table 2**. Continued.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Malpaso Creek | 36.479965 | -121.93905 | Point Lobos SMR | I | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Point Sur | 36.288082 | -121.89295 | Point Sur SMR | II | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Andrew Molera | 36.278454 | -121.88086 | Point Sur SMR | II | SMR | Central Coast | Central Coast | 🟥 | |
| South Wreck | 36.226425 | -121.78906 | Point Sur SMR | II | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Fullers | 36.208107 | -121.75217 | Point Sur SMR | II | reference | Central Coast | Central Coast | 🟦 | |
| Esalen | 36.125919 | -121.64741 | Big Creek SMR | II | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Dolan | 36.103851 | -121.62813 | Big Creek SMR | II | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Big Creek | 36.069183 | -121.6006 | Big Creek SMR | II | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Lopez | 36.03056 | -121.58084 | Big Creek SMR | II | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Daddy Bob | 35.537731 | -121.09663 | White Rock SMCA | III | SMCA | Central Coast | Central Coast | 🟥 | 🟥 |
| White Rocks | 35.527756 | -121.08564 | White Rock SMCA | III | SMCA | Central Coast | Central Coast | 🟥 | |
| Harmony | 35.500275 | -121.05493 | White Rock SMCA | III | reference | Central Coast | Central Coast | 🟦 | |
| Estero | 35.471779 | -121.02125 | White Rock SMCA | III | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Spooners Cove | 35.277134 | -120.8929 | Point Buchon SMR | I | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Corallina Cove | 35.266667 | -120.90194 | Point Buchon SMR | I | reference | Central Coast | Central Coast | 🟦 | 🟦 |
| Point Buchon | 35.237446 | -120.9 | Point Buchon SMR | I | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Montana De Oro | 35.2312 | -120.8853 | Point Buchon SMR | I | SMR | Central Coast | Central Coast | 🟥 | 🟥 |
| Refugio State Beach | 34.461056 | -120.06687 | Naples SMCA | III | reference | South Coast | South Coast | 🟦 | 🟦 |

**Table 2**. Continued.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Leo Carillo North | 34.043533 | -118.94495 | Point Dume SMCA | I | reference | South Coast | South Coast | 🟦 | 🟦 |
| Lechuza | 34.034035 | -118.87132 | Point Dume SMCA/SMR | I | SMCA/reference | South Coast | South Coast | 🟪 | |
| Big Rock | 34.035168 | -118.60809 | Point Dume SMR | I | reference | South Coast | South Coast | | |
| Paradise Point | 34.004128 | -118.7929 | Point Dume SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |
| Point Dume | 33.998533 | -118.80563 | Point Dume SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |
| Malaga Cove | 33.80365 | -118.39835 | Point Vicente SMCA | II | reference | South Coast | South Coast | 🟦 | 🟦 |
| Christmas Tree Cove | 33.760399 | -118.42105 | Point Vicente SMCA | II | reference | South Coast | South Coast | 🟦 | 🟦 |
| Hawthorne Reef | 33.747002 | -118.41589 | Point Vicente SMCA | II | reference | South Coast | South Coast | 🟦 | 🟦 |
| Point Vicente West | 33.7397 | -118.4137 | Point Vicente SMCA | II | SMCA (No-Take) | South Coast | South Coast | 🟥 | 🟥 |
| Point Vicente East | 33.736 | -118.4012 | Point Vicente SMCA | II | SMCA (No-Take) | South Coast | South Coast | 🟥 | 🟥 |
| 120 Reef | 33.737919 | -118.39201 | Abalone Cove SMCA/ Point Vicente SMCA | II | SMCA/ reference | South Coast | South Coast | 🟪 | 🟪 |
| Abalone Cove | 33.736149 | -118.37632 | Abalone Cove SMCA/ Point Vicente SMCA | II | SMCA/ reference | South Coast | South Coast | | 🟪 |
| White Point | 33.713509 | -118.3181 | Abalone Cove SMCA | II | reference | South Coast | South Coast | 🟦 | 🟦 |
| Little Corona Del Mar | 33.589802 | -117.8687 | Crystal Cove SMCA/ Laguna Beach SMR | II/I | SMCA/ reference | South Coast | South Coast | 🟪 | 🟪 |
| Crystal Cove | 33.57135 | -117.8411 | Crystal Cove SMCA/ Laguna Beach SMR | II/I | SMCA/ reference | South Coast | South Coast | 🟪 | |
| Seal Rock North Crescent Bay | 33.545547 | -117.8037 | Laguna Beach SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |
| Shaws Cove | 33.543961 | -117.79986 | Laguna Beach SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |
| Divers Cove | 33.543171 | -117.79658 | Laguna Beach SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |

**Table 2**. Continued.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Heisler Park | 33.542252 | -117.795 | Laguna Beach SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |
| Salt Creek | 33.47715 | -117.72736 | Dana Point SMCA/ Laguna Beach SMR | I | SMCA/ reference | South Coast | South Coast | 🟪 | |
| La Jolla Cove | 32.852165 | -117.26987 | Matlahuayl SMR | II | SMR | South Coast | South Coast | 🟥 | 🟥 |
| Windansea | 32.836601 | -117.288 | Matlahuayl SMR | II | reference | South Coast | South Coast | 🟦 | 🟦 |
| Kiddie Pool | 32.845033 | -117.28528 | Matlahuayl SMR | II | reference | South Coast | South Coast | 🟦 | 🟦 |
| Wipeout | 32.821133 | -117.28705 | South La Jolla SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |
| South La Jolla | 32.81345 | -117.28577 | South La Jolla SMR | I | SMR | South Coast | South Coast | 🟥 | 🟥 |
| North Hill Street | 32.728619 | -117.265 | South La Jolla SMR | I | reference | South Coast | South Coast | 🟦 | 🟦 |
| Broomtail Reef | 32.694233 | -117.26807 | South La Jolla SMR | I | reference | South Coast | South Coast | 🟦 | 🟦 |
| South Point | 33.895 | -120.125 | South Point SMR | II | SMR | South Coast | NCI | | |
| Johnsons Lee | 33.90155 | -120.1034 | South Point SMR | II | reference | South Coast | NCI | | |
| Elk Ridge | 33.953335 | -119.96909 | Skunk Point SMR | III | SMR | South Coast | NCI | | |
| East Point | 33.943966 | -119.96478 | Skunk Point SMR | III | reference | South Coast | NCI | | |
| Cueva Valdez | 34.055 | -119.81 | Scorpion SMR | I | reference | South Coast | NCI | 🟦 | |
| Frys Anchorage | 34.054161 | -119.756 | Scorpion SMR | I | reference | South Coast | NCI | 🟦 | |
| Pelican Anchorage | 34.035648 | -119.7025 | Scorpion SMR | I | reference | South Coast | NCI | 🟦 | |
| Scorpion Anchorage | 34.048515 | -119.5523 | Scorpion SMR | I | SMR | South Coast | NCI | 🟥 | 🟥 |
| Goldfish Bowl | 34.014729 | -119.4375 | Anacapa Island SMCA | I | SMCA | South Coast | NCI | 🟥 | 🟥 |

**Table 2**. Continued.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Cathedral Wall | 34.015751 | -119.3715 | Anacapa Island SMR | I | SMR | South Coast | NCI | 🟥 | 🟥 |
| Cathedral Cove | 34.016499 | -119.36839 | Anacapa Island SMR | I | SMR | South Coast | NCI | 🟥 | 🟥 |
| Landing Cove | 34.017467 | -119.3624 | Anacapa Island SMR | I | SMR | South Coast | NCI | 🟥 | 🟥 |
| Light House | 34.012634 | -119.3642 | Anacapa Island SMR/SMCA | I | reference | South Coast | NCI | 🟦 | 🟦 |
| Ship Rock | 33.462833 | -118.4916 | Blue Cavern Onshore SMCA | I | reference | South Coast | SCI | 🟦 | 🟦 |
| Lions Head | 33.451241 | -118.5021 | Blue Cavern Onshore SMCA | I | reference | South Coast | SCI | | 🟦 |
| Bird Rock | 33.450798 | -118.48754 | Blue Cavern Onshore SMCA | I | SMCA | South Coast | SCI | 🟥 | 🟥 |
| Isthmus Reef | 33.448318 | -118.4906 | Blue Cavern Onshore SMCA | I | reference | South Coast | SCI | 🟦 | 🟦 |
| WIES Intake Pipes | 33.446999 | -118.48485 | Blue Cavern Onshore SMCA | I | SMCA | South Coast | SCI | 🟥 | 🟥 |
| Blue Cavern | 33.44149 | -118.46539 | Blue Cavern Onshore SMCA | I | SMCA | South Coast | SCI | 🟥 | 🟥 |
| Iron Bound Cove | 33.4475 | -118.57515 | Cat Harbor SMCA | III | reference | South Coast | SCI | 🟦 | 🟦 |
| Cat Harbor | 33.426083 | -118.51182 | Cat Harbor SMCA | III | SMCA | South Coast | SCI | 🟥 | 🟥 |
| Twin Rocks | 33.417648 | -118.3978 | Long Point SMR | II | SMR | South Coast | SCI | 🟥 | 🟥 |
| West Long Point | 33.410526 | -118.3789 | Long Point SMR | II | SMR | South Coast | SCI | 🟥 | 🟥 |
| Rippers Cove | 33.42815 | -118.43547 | Long Point SMR | II | reference | South Coast | SCI | 🟦 | 🟦 |
| Torqua | 33.382999 | -118.35 | Long Point SMR | II | reference | South Coast | SCI | 🟦 | 🟦 |
| Casino Point | 33.349167 | -118.32497 | Casino Point SMCA | III | SMCA | South Coast | SCI | 🟥 | 🟥 |
| Salta Roja | 33.337833 | -118.47617 | Farnsworth Onshore SMCA | III | SMCA | South Coast | SCI | | |

**Table 2**. Continued.

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| China Point | 33.330317 | -118.46975 | Farnsworth Onshore SMCA | III | SMCA | South Coast | SCI | 🟥 | 🟥 |
| Bushings | 33.31786 | -118.4414 | Farnsworth Onshore SMCA | III | reference | South Coast | SCI | 🟦 | |
| Salta Verde | 33.314583 | -118.42152 | Farnsworth Onshore SMCA | III | reference | South Coast | SCI | 🟦 | 🟦 |

**Table 3.** History of surveys at all sites by the four academic institutions (HSU, UCSB, UCSC and VRG). Sites are grouped by MPA and region. Colored boxes indicate surveys done in different years in MPAs (red) and reference areas (blue). Grey shading on MPA names are the MPAs with adequate time series that are included in this report.

| Region | MPA Name | Group | Site |
|---|---|---|---|
| North Coast | Del Mar Landing SMR | UCSC | Del Mar MPA 1 |
| | | UCSC | Del Mar MPA 2 |
| | | UCSC | Del Mar MPA 3 |
| | | UCSC | Del Mar Reference 1 |
| | | UCSC | Del Mar Reference 4 |
| | Double Cone Rock SMCA | HSU | Double Cone 1 |
| | | HSU | Double Cone 2 |
| | Point Arena SMR | UCSC | Point Arena MPA 1 |
| | | UCSC | Point Arena MPA 2 |
| | | UCSC | Point Arena Reference 1 |
| | | UCSC | Point Arena Reference 2 |
| | Point Cabrillo SMR | HSU | Point Cabrillo 1 |
| | | HSU | Point Cabrillo 2 |
| | | HSU | Point Cabrillo 3 |
| | | HSU | Caspar 1 |
| | | HSU | Caspar 2 |
| | | HSU | Caspar 3 |
| | | HSU | Russian Gulch 1 |
| | | HSU | Russian Gulch 3 |
| | Pyramid Point SMCA | HSU | Pyramid Point 1 |
| | | HSU | Pyramid Point 2 |
| | | HSU | Pyramid Point 3 |
| | | HSU | Brookings 1 |
| | | HSU | Brookings 2 |
| | | HSU | Brookings 3 |
| | Salt Point SMCA | UCSC | Salt Point MPA 1 |
| | | UCSC | Salt Point MPA 2 |
| | | UCSC | Salt Point MPA 3 |
| | | UCSC | Salt Point Reference 2 |
| | | UCSC | Salt Point Reference 3 |
| | | UCSC | Salt Point Reference 4 |
| | Saunders Reef SMCA | HSU | Saunders MPA 1 |
| | | UCSC | Saunders MPA 1 |
| | | HSU | Saunders MPA 2 |
| | | UCSC | Saunders MPA 2 |
| | | HSU | Saunders MPA 3 |
| | | UCSC | Saunders MPA 3 |
| | | UCSC | Saunders MPA 4 |
| | | HSU | Point Arena Reference 3 |
| | | UCSC | Point Arena Reference 3 |
| | | UCSC | Point Arena Reference 4 |
| | | UCSC | Saunders Reference 1 |
| | | HSU | Saunders Reference 2 |
| | | UCSC | Saunders Reference 2 |
| | | UCSC | Saunders Reference 3 |
| | | UCSC | Saunders Reference 4 |
| | Sea Lion Cove SMCA | UCSC | Sea Lion MPA 1 |
| | | UCSC | Sea Lion Reference 1 |
| | Stewarts Point SMR | UCSC | Stewarts Point MPA 1 |
| | | UCSC | Stewarts Point MPA 2 |
| | | HSU | Stewarts Point MPA 3 |
| | | UCSC | Stewarts Point MPA 3 |
| | | HSU | Stewarts Point MPA 4 |
| | | UCSC | Stewarts Point MPA 4 |
| | | UCSC | Del Mar Reference 2 |
| | | UCSC | Del Mar Reference 3 |
| | | UCSC | Salt Point Reference 1 |
| | | UCSC | Salt Point Reference 5 |
| | Ten Mile SMR | HSU | Ten Mile 1 |
| | | HSU | Ten Mile 2 |
| | | HSU | Ten Mile 3 |
| | | HSU | Abalone Point 1 |
| | | HSU | Abalone Point 2 |
| | | HSU | Abalone Point 3 |
| | Van Damme SMCA | HSU | Elk Headlands 2 |
| | | HSU | Elk Headlands 3 |
| | | HSU | Trinidad 1 |
| | | HSU | Trinidad 2 |
| | | HSU | Trinidad 3 |
| | | HSU | Trinidad 4 |
| | | HSU | Trinidad 5 |
| Central Coast | Asilomar SMR | UCSC | Asilomar DC |
| | | UCSC | Asilomar UC |
| | | UCSC | Spanish Bay DC |
| | | UCSC | Spanish Bay UC |
| | | UCSC | Bird Rock |
| | | UCSC | China Rock |
| | | UCSC | Cypress Point UC |
| | | UCSC | Point Joe |
| | Big Creek SMR | UCSC | Big Creek DC |
| | | UCSC | Big Creek UC |
| | | UCSC | Dolan DC |
| | | UCSC | Dolan UC |
| | | UCSC | Esalen DC |
| | | UCSC | Esalen UC |
| | | UCSC | Lopez DC |
| | | UCSC | Lopez UC |
| | | UCSC | Lucia DC |
| | | UCSC | Lucia UC |
| | | UCSC | Mcway DC |
| | | UCSC | Mcway UC |
| | | UCSC | Partington |
| | Cambria SMCA | UCSC | Cambria DC |
| | | UCSC | Cambria UC |
| | | UCSC | Pico Creek DC |
| | | UCSC | Pico Creek UC |
| | | UCSC | San Simeon Bay |
| | | UCSC | San Simeon DC |
| | | UCSC | San Simeon UC |
| | Carmel Bay SMCA | UCSC | Butterfly DC |
| | | UCSC | Butterfly UC |
| | | UCSC | Carmel DC |
| | | UCSC | Carmel UC |
| | | UCSC | Stillwater DC |
| | | UCSC | Stillwater UC |
| | | UCSC | Cypress Point DC |
| | | UCSC | Lingcod DC |
| | | UCSC | Lingcod UC |
| | | UCSC | Lone Tree |
| | | UCSC | Pescadero DC |
| | | UCSC | Pescadero UC |
| | Carmel Pinnacles SMR | UCSC | Pinnacles IN |
| | | UCSC | Pinnacles OUT |
| | Edward F. Ricketts SMCA | UCSC | Cannery DC |
| | | UCSC | Cannery UC |
| | | UCSC | Macabee DC |
| | | UCSC | Macabee UC |

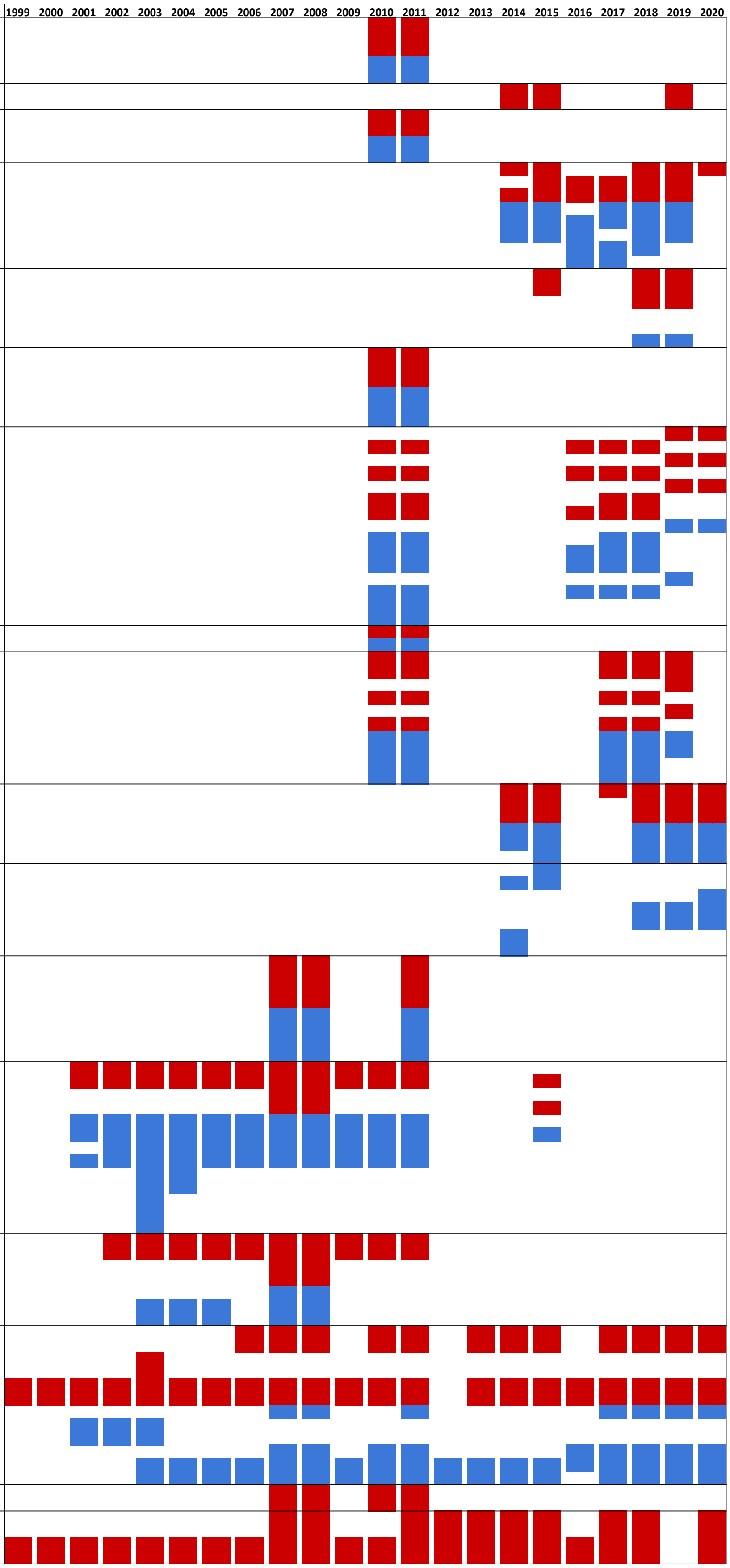

**Table 3.** continued.

| Region | MPA Name | Group | Site | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Central Coast Continued | Lovers Point - Julia Platt SMR | UCSC | Hopkins DC | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Hopkins UC | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Lovers DC | | | | | | | | | 🟥 | 🟥 | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Lovers UC | | | | | | | | | 🟥 | 🟥 | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | Natural Bridges SMR | UCSC | Sprouts | | | | | | | | | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSC | Terrace DC | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | |
| | | UCSC | Terrace UC | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | |
| | | UCSC | Three Mile | | | | | | | | | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSC | Saber Jets | | | | | | | | | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSC | Sandhill DC | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | |
| | | UCSC | Sandhill UC | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | |
| | | UCSC | Stockton | | | | | | | | | 🟦 | 🟦 | | | | | | | | | | | | |
| | Pacific Grove Marine Gardens SMCA | UCSC | Otter Point DC | | | | | | | | 🟦 | 🟦 | 🟦 | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Otter Point UC | | | | | | | | 🟦 | 🟦 | 🟦 | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Pinos | | | | | | | | | 🟦 | 🟦 | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Siren | | | | | | | | | 🟦 | 🟦 | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | Piedras Blancas SMR | UCSC | La Cruz DC | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSC | La Cruz UC | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSC | Duck Pond DC | | | | | 🟦 | 🟦 | | | | | | | | | | | | | | | | |
| | | UCSC | Duck Pond UC | | | | | 🟦 | 🟦 | | | | | | | | | | | | | | | | |
| | | UCSC | Mill Creek DC | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSC | Mill Creek UC | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSC | North San Simeon | | | | | | | | | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSC | Plaskett DC | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSC | Plaskett UC | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSC | Salmon Creek DC | | | | | 🟦 | 🟦 | | | | | | | | | | | | | | | | |
| | | UCSC | Salmon Creek UC | | | | | 🟦 | 🟦 | | | | | | | | | | | | | | | | |
| | | UCSC | Whaleboat DC | | | | | 🟦 | | | | | | | | | | | | | | | | | |
| | | UCSC | Whaleboat UC | | | | | 🟦 | | | | | | | | | | | | | | | | | |
| | Point Buchon SMR | UCSC | Buchon | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Crowbar | | | | | | | | | 🟥 | 🟥 | | | 🟥 | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Montana De Oro | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Tenera | | | | | | | | | 🟥 | 🟥 | | | 🟥 | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Green Peak | | | | | | | | | 🟦 | 🟦 | | | 🟦 | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Little Irish CEN | | | | | | | | | 🟦 | 🟦 | | | 🟦 | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Little Irish DC | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Little Irish UC | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | Pismo W | | | 🟦 | | | | | | | | | | | | | | | | | | | |
| | Point Lobos SMR | UCSC | Bluefish DC | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Bluefish UC | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Monastery DC | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Monastery UC | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Weston DC | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Weston UC | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSC | Bixby | | | | | | | | | 🟦 | 🟦 | | | | | | | | | | | 🟦 | 🟦 |
| | | UCSC | Malpaso | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Palo Colorado | | | | | | | | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | Soberanes | | | | | | | | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | Point Sur SMR | UCSC | Andrew Molera DC | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | 🟥 | 🟥 | | 🟥 | 🟥 |
| | | UCSC | Andrew Molera UC | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | 🟥 | 🟥 | | 🟥 | 🟥 |
| | | UCSC | Cooper | | | | | | | | | 🟥 | 🟥 | | | | | | | | | 🟥 | | 🟥 | 🟥 |
| | | UCSC | False Sur | | | | | | | | | 🟥 | 🟥 | | | | | | | | | | | 🟥 | 🟥 |
| | | UCSC | Point Sur DC | 🟥 | | | | | | | | | | | | | | | | | | | | | |
| | | UCSC | Point Sur UC | 🟥 | | | | | | | | | | | | | | | | | | | | | |
| | | UCSC | Fullers | | | | | | | | | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSC | South Wreck DC | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | | | | | | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSC | South Wreck UC | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | | | | | | 🟦 | | 🟦 | 🟦 |
| | | UCSC | Torre Canyon | | | | | | | | | 🟦 | 🟦 | | 🟦 | | | | | | | | | | |
| | Vandenberg SMR | UCSB | Purisima N | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | 🟥 | | | | | | | | | | | |
| | | UCSC | Purisima N | | | | | | | | | | 🟥 | | | | | | | | | | | | |
| | | UCSB | Purisima S | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | 🟥 | | | | | | | | | | | |
| | | UCSC | Purisima S | | | | | | | | | | 🟥 | | | | | | | | | | | | |
| | | UCSC | Surf | | | | | | | | | | 🟥 | | | | | | | | | | | | |
| | | UCSB | Vandenberg N | | | | | | | | | | | 🟥 | | | | | | | | | | | |
| | | UCSC | Vandenberg N | | | | | | | | | | 🟥 | | | | | | | | | | | | |
| | | UCSB | Arguello E | 🟦 | | | | | | | | | | | | | | | | | | | | | |
| | | UCSB | Arguello W | 🟦 | | | | | | | | | | | | | | | | | | | | | |
| | | UCSB | Dunes | | | | | | | | | | | 🟦 | | | | | | | | | | | |
| | | UCSC | Dunes | | | | | | | | | | 🟦 | | | | | | | | | | | | |
| | | UCSB | Jalama N | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | |
| | | UCSB | Jalama S | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | |
| | | UCSB | Sal CEN | | 🟦 | | | | | | | | | | | | | | | | | | | | |
| | | UCSB | Sal E | | | | 🟦 | | | | | | | | | | | | | | | | | | |
| | | UCSB | Sal Far West | | | | 🟦 | | | | | | | | | | | | | | | | | | |
| | | UCSB | Sal N | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | | | | | | | | | | | | | | | | |
| | | UCSB | Sal S | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | | | | | | | | | | | | | | | | |
| | | UCSB | Sal W | | | | 🟦 | | | | | | | | | | | | | | | | | | |
| | | UCSC | Vandenberg S | | | | | | | | | | 🟦 | | | | | | | | | | | | |
| | White Rock SMCA | UCSC | Paranoids | | | | | | | | | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSC | Radar | | | | | | | | | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSC | White Rock DC | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | |
| | | UCSC | White Rock UC | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | |
| | | UCSC | Cayucos DC | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSC | Cayucos UC | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSC | Estero | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | |
| | | UCSC | Harmony | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | |
| Northern Channel Islands | Anacapa Island SMCA | UCSB | AI - West Isle CEN | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - West Isle E | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - West Isle W | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | RCCA | Goldfish Bowl | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - Admirals CEN | 🟦 | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | AI - Admirals E | 🟦 | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | AI - Admirals W | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | Anacapa Island SMR | UCSB | AI - Black Sea Bass | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - East Isle CEN | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - East Isle E | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - East Isle W | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - Middle Isle CEN | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - Middle Isle E | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - Middle Isle W | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | AI - East Fish Camp CEN | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | AI - East Fish Camp E | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | AI - East Fish Camp W | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | AI - Lighthouse CEN | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | AI - Lighthouse E | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | AI - Lighthouse W | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | Carrington Point SMR | UCSB | SRI - Beacon Reef E | | | | | | 🟥 | 🟥 | | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSB | SRI - Beacon Reef W | | | | | | 🟥 | 🟥 | | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSB | SRI - Carrington CEN | | | | | 🟥 | | | | | | | | | | | | | | | | | |
| | | UCSB | SRI - Carrington E | | | | | 🟥 | | | | | | | | | | | | | | | | | |
| | | UCSB | SRI - Carrington W | | | | | 🟥 | | | | | | | | | | | | | | | | | |
| | | UCSB | SRI - Monacos E | | | | | | 🟦 | | | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSB | SRI - Monacos W | | | | | | | | | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSB | SRI - Rodes Reef E | | | | | | 🟦 | 🟦 | | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSB | SRI - Rodes Reef W | | | | | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | | | | | | | | | | | | |
| | Gull Island SMR | UCSB | SCI - Gull Isle E | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Gull Isle W | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Forney E | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Forney W | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |

**Table 3.** continued.

| Region | MPA Name | Group | Site | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Northern Channel Islands Continued | Harris Point SMR | UCSB | SMI - Bay Point | | | | | | | 🟥 | | | | | | | | | | | | | | | |
| | | UCSB | SMI - Hare Rock | | | | | 🟥 | | | | | | | | | | | | | | | | | |
| | | UCSB | SMI - Harris Point Reserve E | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | | 🟥 | | 🟥 | 🟥 | 🟥 |
| | | UCSB | SMI - Harris Point Reserve W | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | | 🟥 | | 🟥 | 🟥 | 🟥 |
| | | UCSB | SMI - Prince Island CEN | | | | | 🟥 | | | | | | | | | | | | | | | | | |
| | | UCSB | SMI - Prince Island N | | | | | 🟥 | | | | | | | | | | | | | | | | | |
| | | UCSB | SMI - Crook Point E | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | |
| | | UCSB | SMI - Crook Point W | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | |
| | | UCSB | SMI - Cuyler E | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | | 🟦 | | 🟦 | 🟦 | 🟦 |
| | | UCSB | SMI - Cuyler W | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | | 🟦 | | 🟦 | 🟦 | 🟦 |
| | | UCSB | SMI - Tyler Bight E | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | |
| | | UCSB | SMI - Tyler Bight W | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | |
| | Painted Cave SMCA | UCSB | SCI - Painted Cave CEN | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Painted Cave E | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Painted Cave W | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Hazards CEN | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Hazards E | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Hazards W | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | Scorpion SMR | UCSB | SCI - Cavern E | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Cavern W | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Potato Pasture E | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | | | |
| | | UCSB | SCI - Potato Pasture W | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | | | |
| | | UCSB | SCI - Scorpion Anchorage | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | | | |
| | | UCSB | SCI - Scorpion W | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SCI - Coche E | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Coche W | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Little Scorpion E | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | 🟦 | | | | | | | |
| | | UCSB | SCI - Little Scorpion W | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | 🟦 | | | | | | | |
| | | UCSB | SCI - Pelican CEN | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Pelican E | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Pelican Far West | | | 🟦 | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | 🟦 | | | | | | | |
| | | UCSB | SCI - Pelican W | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - San Pedro Point E | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | 🟦 | | | | | | | |
| | | UCSB | SCI - San Pedro Point W | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | 🟦 | | | | | | | |
| | | UCSB | SCI - Scorpion E | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | South Point SMR | UCSB | SRI - Chickasaw E | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | | | |
| | | UCSB | SRI - Chickasaw W | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | | | |
| | | UCSB | SRI - South Point E | | | | | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SRI - South Point W | | | | | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | UCSB | SRI - Trancion Canyon E | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | | | |
| | | UCSB | SRI - Trancion Canyon W | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | | 🟥 | | | | | | | |
| | | UCSB | SRI - Bee Rock E | | | | | | 🟦 | | | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | SRI - Bee Rock W | | | | | 🟦 | | | | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | SRI - Cluster Point N | | | | | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SRI - Cluster Point S | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SRI - Ford Point | | | | | | | | | 🟦 | | | | | | | | | | | | | |
| | | UCSB | SRI - Johnsons Lee North E | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | 🟦 | | | | | | | |
| | | UCSB | SRI - Johnsons Lee North W | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | 🟦 | | | | | | | |
| | | UCSB | SRI - Johnsons Lee South E | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SRI - Johnsons Lee South W | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SRI - Jolla Vieja E | | | | | | 🟦 | | | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | SRI - Jolla Vieja W | | | | | | 🟦 | | | 🟦 | 🟦 | 🟦 | | | | | | | | | | | |
| | | UCSB | SCI - Valley CEN | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Valley E | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Valley W | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | UCSB | SCI - Yellowbanks CEN | | | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | |
| | | UCSB | SCI - Yellowbanks E | | | 🟦 | 🟦 | | | | | | | | | | | | | | | | | | |
| | | UCSB | SCI - Yellowbanks W | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | |
| Southern Channel Islands | Arrow Point to Lion Head Point SMCA | VRG | SCAI - Indian Rock | | | | | | | | | | | | | 🟥 | 🟥 | | | | | | | 🟥 | 🟥 |
| | | VRG | SCAI - Lion Head | | | | | | | | | | 🟥 | | | | | | | | | | | | |
| | | VRG | SCAI - Johnson's Rocks | | | | | | 🟦 | | | | | | | | | | | | | | | | |
| | Begg Rock SMR | VRG | SNI - Begg Rock | | | | | | | | | | 🟥 | | | | 🟥 | | | | | | | | |
| | | VRG | SNI - Boilers | | | | | | | | | | | | | | 🟦 | | | | | | | | |
| | Blue Cavern Onshore SMCA | UCSB | Catalina Blue Cavern | | | | | | | 🟥 | | | | | | | | | | | | | | | |
| | | UCSB | Catalina Intake Pipes | | | | | | | 🟥 | | | | | | | | | | | | | | | |
| | | VRG | SCAI - Bird Rock | | | | | | | | | | | | | 🟥 | 🟥 | | | | | | | 🟥 | 🟥 |
| | | UCSB | SCAI - Blue Cavern | | | | | | | 🟥 | | | | | | | | | | | | | | | |
| | | VRG | SCAI - Blue Cavern | | | | | | | | | | | | | 🟥 | 🟥 | | | | | | | 🟥 | 🟥 |
| | | VRG | SCAI - West Quarry | | | | | | 🟥 | | | | | | | 🟥 | | | | | | | | | |
| | | VRG | SCAI - Ripper's Cove | | | | | | 🟦 | | | | 🟦 | | | 🟦 | 🟦 | | | | | | | 🟦 | 🟦 |
| | | VRG | SCAI - Ship Rock | | | | | | | | | | | | | 🟦 | 🟦 | | | | | | | 🟦 | 🟦 |
| | Casino Point SMCA | VRG | SCAI - Cat Harbor | | | | | | 🟥 | | | | | | | 🟥 | 🟥 | | | | | | | 🟥 | 🟥 |
| | | VRG | SCAI - Iron Bound Cove | | | | | | | | | | 🟦 | | | 🟦 | 🟦 | | | | | | | 🟦 | 🟦 |
| | | VRG | SCAI - Pin Rock | | | | | | 🟦 | | | | | | | | | | | | | | | | |
| | | VRG | SCAI - West Kelp | | | | | | 🟦 | | | | | | | | | | | | | | | | |
| | Farnsworth Onshore SMCA | VRG | SCAI - China Point | | | | | | | | | | | | | 🟥 | 🟥 | | | | | | | 🟥 | |
| | | VRG | SCAI - Banana Rock | | | | | | | | | | 🟦 | | | | | | | | | | | | |
| | | VRG | SCAI - Indian Head | | | | | | | | | | 🟦 | | | | | | | | | | | | |
| | | VRG | SCAI - Salta Verde | | | | | | | | | | | | | 🟦 | 🟦 | | | | | | | 🟦 | |
| | Judith Rock SMR | VRG | SCAI - Italian Gardens | | | | | | | | | | | | | 🟥 | | | | | | | | 🟥 | 🟥 |
| | | VRG | SCAI - Twin Rocks | | | | | | | | | | | | | | 🟥 | | | | | | | | |
| | | VRG | SCAI - Hen Rock | | | | | | | | | | | | | 🟦 | 🟦 | | | | | | | 🟦 | 🟦 |
| | Lover's Cove SMCA | VRG | SCAI - Lover's Cove | | | | | | | | | | | | | 🟥 | 🟥 | | | | | | | | |
| | | VRG | SCAI - East Quarry | | | | | | 🟦 | | | | 🟦 | | | | | | | | | | | | |
| | Santa Barbara Island SMR | UCSB | SBI - Graveyard Canyon | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | | | | |
| | | VRG | SBI - Graveyard Canyon | | | | | | | | | | | | | 🟥 | | | | | | | | | |
| | | UCSB | SBI - Graveyard Canyon N | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSB | SBI - Southeast Reef | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | | | | |
| | | VRG | SBI - Southeast Reef | | | | | | | | | | | | | | 🟥 | | | | | | | 🟥 | |
| | | UCSB | SBI - Southeast Reef S | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | | | | | | | | | | | | |
| | | UCSB | SBI - Southeast Sealion | | | | | | 🟥 | | | | | | | | | | | | | | | | |
| | | VRG | SBI - Southeast Sealion | | | | | | 🟥 | | | | | | | 🟥 | 🟥 | | | | | | | 🟥 | |
| | | UCSB | SBI - Arch Point | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | VRG | SBI - Arch Point | | | | | | 🟦 | | | | 🟦 | | | | | | | | | | | | |
| | | UCSB | SBI - Arch Point CEN | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSB | SBI - Arch Point S | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSB | SBI - Cat Canyon | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | VRG | SBI - Cat Canyon | | | | | | | | | | | | | 🟦 | | | | | | | | 🟦 | |
| | | UCSB | SBI - Cat Canyon CEN | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | VRG | SBI - Sutil | | | | | | | | | | 🟦 | | | 🟦 | 🟦 | | | | | | | 🟦 | |
| | | UCSB | SBI - Websters Arch CEN | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSB | SBI - Websters Arch E | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |
| | | UCSB | SBI - Websters Arch N | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | | | | | | | | | | | | |

**Table 3.** continued.

| Region | MPA Name | Group | Site | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Coast | Abalone Cove SMCA | VRG | Abalone Cove Kelp W |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | VRG | 3 Palms East |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | VRG | Bunker Point |  |  |  |  |  |  |  |  | 🟦 |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | VRG | Point Fermin |  |  |  |  |  |  |  |  |  | 🟦 |  |  | 🟦 | 🟦 |  |  |  |  |  |  |  |  |
|  |  | VRG | Whites Point |  |  |  |  |  |  |  |  |  | 🟦 |  |  | 🟦 | 🟦 |  |  |  |  |  |  |  |  |
|  | Cabrillo SMR | VRG | Cabrillo National Monument |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |  |  |  |  |  |  |  |  |
|  | Campus Point SMCA | UCSB | IV Reef E |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | UCSB | IV Reef W |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | VRG | Carp Reef |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | VRG | Lead Better Beach |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Crystal Cove SMCA | VRG | Crystal Cove |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | VRG | San Mateo Kelp |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |  |  |  |  |  | 🟦 | 🟦 |
|  | Dana Point SMCA | VRG | Dana Point |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |  |  |  |  |  |  | 🟥 | 🟥 |
|  | Laguna Beach SMR | VRG | Heisler Park |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | VRG | Laguna Beach |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |  |  | 🟥 | 🟥 |
|  | Matlahuayl SMR | VRG | Matlahuayl |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | VRG | Childrens Pool |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |  |  |  |  |  | 🟦 | 🟦 |
|  | Naples SMCA | UCSB | Naples CEN | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | UCSB | Naples E | 🟥 |  |  | 🟥 |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | UCSB | Naples W |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | UCSB | Arroyo Quemado E |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | UCSB | Arroyo Quemado W |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Point Conception SMR | UCSB | Cojo W | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |  | 🟥 |  |  |  |  |  |  |
|  |  | UCSB | Bullito |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  |  |  |  |  |  |
|  |  | UCSB | Cojo E | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  |  |  |  |  |  |  |  |
|  | Point Dume SMCA | UCSB | Lechuza |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 |  |  |  |  |  |  |  |
|  |  | VRG | Lechuza |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | UCSB | County Line |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 |  |  |  |  |  |  |  |
|  |  | VRG | Deep Hole East |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | VRG | Leo Carrillo |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | VRG | Nicholas Canyon East |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | UCSB | Nicholas Canyon W |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 |  |  |  |  |  |  |  |
|  |  | VRG | Nicholas Canyon W |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |
|  | Point Dume SMR | UCSB | Little Dume W |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 |  |  |  |  |  |  |  |
|  |  | VRG | Little Dume W |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | RCCA | Paradise Point/Little Dume |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 |  | 🟥 | 🟥 |  | 🟥 | 🟥 | 🟥 |  | 🟥 |  |
|  |  | UCSB | Point Dume |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 |  |  |  |  |  |  |  |
|  |  | VRG | Point Dume |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | VRG | Big Rock |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | VRG | Escondido W |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |
|  |  | VRG | Malibu Bluffs |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  | Point Vicente SMCA | VRG | Long Point E |  |  |  |  |  |  |  |  | 🟥 |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | VRG | Point Vicente W |  |  |  |  |  | 🟥 |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | VRG | Flat Rock N |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  | VRG | Hawthorne Reef |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |  |  |  |  |  |  |  |
|  |  | VRG | Lunada Bay |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |  |  |  |  |  |  |  |
|  |  | VRG | Resort Point |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  | 🟦 |  |  |  |  |  |  |  |  |
|  |  | VRG | Ridges N |  |  |  |  |  |  |  |  | 🟦 |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | VRG | Ridges S |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  | 🟦 |  |  |  |  |  |  |  |  |
|  |  | VRG | Rocky Point N |  |  |  |  |  | 🟦 |  |  | 🟦 | 🟦 | 🟦 |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | VRG | Rocky Point S |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |  |  |  |  |  |  |  |
|  |  | VRG | Underwater Arch |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |
|  | South La Jolla SMR | VRG | South La Jolla |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | VRG | Point Loma CEN |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |  |  |  |  |  | 🟦 | 🟦 |
|  |  | VRG | Point Loma South |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |
|  | Swamis SMCA | VRG | San Elijo |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |  |  |  |  |
|  |  | VRG | Swamis |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | VRG | Swamis |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | VRG | Leucadia |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |  |  |  |  |  | 🟦 | 🟦 |
|  |  | VRG | South Carlsbad |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  |  |  |  |  |  |

**Table 4.** History of surveys at all sites by ReefCheck CA (RCCA). Sites are grouped by MPA and region. Colored boxes indicate surveys done in different years in MPAs (red) and reference areas (blue).

| Region | MPA Name | Site | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| North Coast | Gerstle Cove SMR | Gerstle Cove |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Ocean Cove |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | Stillwater Sonoma |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | MacKerricher SMCA | MacKerricher North |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 |
|  |  | Glass Beach |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  | 🟦 | 🟦 |
|  |  | Noyo Harbor |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 |
|  | Montara SMR | Beach Street |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |  |
|  |  | Flat Rock |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Half Moon Reef |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | Hurricane Ridge |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  |
|  | Point Arena SMR | Point Arena Lighthouse |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 |
|  |  | Point Arena MPA 2 |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 |  |  | 🟥 |  | 🟥 |  | 🟥 |
|  |  | Monument |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 |  |  |
|  |  | Point Arena Ref |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 |  |  | 🟦 |  | 🟦 | 🟦 | 🟦 |
|  | Point Cabrillo SMR | Frolic Cove |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Caspar |  |  |  |  |  |  |  |  |  | 🟦 |  | 🟦 |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | Caspar North |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Pyramid Point SMCA | Pyramid Point |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  | 🟥 | 🟥 |
|  |  | Macklyn Cove |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 |  | 🟦 | 🟦 |
|  | Russian Gulch SMCA | Russian Gulch |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Mendocino Headlands |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  |
|  | Salt Point SMCA | Salt Point |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Ft Ross |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | Timber Cove |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 |  |  |
|  | Sea Lion Cove SMCA | Stornetta |  |  |  |  |  |  |  |  | 🟥 |  |  | 🟥 |  |  | 🟥 |  |  |  |  |  |  |  |
|  | Stewarts Point SMR | Pebble Beach |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Van Damme SMCA | Van Damme |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Albion Cove |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 |
|  |  | Portuguese Beach |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  | 🟦 |  |  | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | Trinidad |  |  |  |  |  |  |  |  |  | 🟦 |  |  |  |  | 🟦 |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 |
| Central Coast | Asilomar SMR | Asilomar |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 |
|  |  | Spanish Bay |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Point Joe |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Big Creek SMR | Big Creek |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Dolan |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Esalen |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | Lopez |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Carmel Bay SMCA | Carmel River |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |  | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Stillwater Monterey |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Pescadero |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Edward F. Ricketts SMCA | Breakwater |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Macabee |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Aquarium |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  | Lovers Point - Julia Platt SMR | Hopkins |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Lovers Point |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  | Natural Bridges SMR | Terrace |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  |  |  |  |  |
|  | Pacific Grove Marine Gardens SMCA | Coral Street |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Lover's 3 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 |
|  |  | Otter Cove |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  | Point Buchon SMR | Montana De Oro |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Point Buchon |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Corallina Cove |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 |
|  |  | Spooners |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Point Lobos SMR | Middle Reef |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | North Monastery |  |  |  |  |  |  |  |  |  | 🟥 |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | South Monastery |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Weston |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Malpaso Creek |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | Point Sur SMR | Andrew Molera |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  | 🟥 | 🟥 | 🟥 |  |
|  |  | Point Sur |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 |  | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | Fullers |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 |  |
|  |  | South Wreck |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  | White Rock SMCA | Daddy Bob |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
|  |  | White Rocks |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |  |
|  |  | Estero |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
|  |  | Harmony |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |  |

**Table 4.** Continued.

| Region | MPA Name | Site | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| South Coast | Abalone Cove SMCA | 120 Reef | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Abalone Cove | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | White Point | | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | Campus Point SMCA | IV Reef | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | | | 🟥 | | | | | |
| | Crystal Cove SMCA | Crystal Cove | | | | | | | | | | 🟥 | 🟥 | | 🟥 | 🟥 | | 🟥 | 🟥 | | 🟥 | | 🟥 | |
| | | Little Corona Del Mar | | | | | | | | | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | |
| | Dana Point SMCA | Salt Creek | | | | | | | | | | | 🟥 | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | |
| | Laguna Beach SMR | Diver's Cove | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | |
| | | Heisler Park | | | | | | | | | | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | | 🟥 | 🟥 | |
| | | Seal Rock/South Crescent Bay | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | |
| | | Shaw's Cove | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | |
| | Matlahuayl SMR | La Jolla Cove | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | |
| | | Kiddie Pool | | | | | | | | | | | | | | | | | | | | 🟦 | 🟦 | |
| | | Windansea | | | | | | | | | | | | | 🟦 | 🟦 | | 🟦 | 🟦 | | | 🟦 | 🟦 | |
| | Naples SMCA | Naples Reef | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | | | | | | | | |
| | | Refugio | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | |
| | Point Dume SMCA | Lechuza | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | | 🟥 | |
| | | Leo Carillo | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | 🟦 | 🟦 | 🟦 | | 🟦 | | 🟦 | |
| | Point Dume SMR | Paradise Point/Little Dume | | | | | | | | | | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | | 🟥 | |
| | | Point Dume | | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | |
| | | Big Rock | | | | | | | | | 🟦 | | 🟦 | 🟦 | | 🟦 | | | | 🟦 | 🟦 | | | |
| | Point Vicente SMCA | Point Vicente East | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Point Vicente West | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Christmas Tree Cove | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | Hawthorne Reef | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | Malaga Cove | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | South La Jolla SMR | South La Jolla | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Wipeout | | | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 |
| | | Broomtail Reef | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 |
| | | North Hill Street | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | | | 🟦 | | 🟦 | 🟦 | 🟦 |
| Northern Channel Islands | Anacapa Island SMCA | Goldfish Bowl | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | Anacapa Island SMR | Cathedral Cove | | | | | | | | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Cathedral Wall | | | | | | | | | | | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Landing Cove | | | | | | | | | | | 🟥 | 🟥 | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Light House | | | | | | | | | | 🟦 | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | | | 🟦 | 🟦 | 🟦 | 🟦 |
| | Scorpion SMR | Scorpion Anchorage | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Cueva Valdez | | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 | | 🟦 | | 🟦 | |
| | | Fry's Anchorage | | | | | | | | | | | | | | | | | | | | 🟦 | 🟦 | |
| | | Pelican Anchorage | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | |
| | Skunk Point SMR | Elk Ridge | | | | | | | | | 🟥 | 🟥 | | | | 🟥 | | 🟥 | 🟥 | | 🟥 | | | |
| | | East Point | | | | | | | | | 🟦 | 🟦 | 🟦 | | | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | | | |
| | South Point SMR | South Point | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | | | |
| | | Johnson's Lee | | | | | | | | | | | 🟦 | | | 🟦 | | 🟦 | 🟦 | 🟦 | 🟦 | | | |
| Southern Channel Islands | Blue Cavern Onshore SMCA | Bird Rock | | | | | | | | | | | | | 🟥 | 🟥 | | | | | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Blue Cavern | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | WIES Intake Pipes | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | | 🟥 | 🟥 |
| | | Isthmus Reef | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | 🟦 | 🟦 |
| | | Lion's Head | | | | | | | | | | | | | | | | | | | | 🟦 | | 🟦 |
| | | Rippers Cove | | | | | | | | | | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |
| | | Ship Rock | | | | | | | | | 🟦 | 🟦 | 🟦 | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 |
| | Casino Point SMCA | Casino Point | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | Cat Harbor SMCA | Cat Harbor | | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Iron Bound Cove | | | | | | | | | | | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 |
| | Farnsworth Onshore SMCA | China Point | | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Salta Roja | | | | | | | | | | | | | | | | | | | 🟥 | | | |
| | | Bushings | | | | | | | | | | | | | | | | | | | 🟦 | 🟦 | 🟦 | |
| | | Salta Verde | | | | | | | | | | | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 |
| | Judith Rock SMR | Judith Reserve San Miguel Island | | | | | | | | | 🟥 | | | | | | | | | | | | | |
| | Long Point SMR | Twin Rocks | | | | | | | | | | | | | | | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | West Long Point | | | | | | | | | | | | 🟥 | | 🟥 | | | | 🟥 | 🟥 | 🟥 | 🟥 | 🟥 |
| | | Torqua | | | | | | | | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 | | | 🟦 | 🟦 | 🟦 | 🟦 | 🟦 |

**Table 5.** Thermistor locations in California MPAs with dates of deployment and mean temperature at the site.

| Region | Site | Lat | Lon | MPA | Dates | Mn Temp (C) |
|---|---|---|---|---|---|---|
| Northern | Trinidad | 41.05472 | -124.1442 | | 10/2018-3/2020 | 11.54 |
| | Noyo Harbor Buoy | 39.42918 | -123.8142 | | 8/2020-7/2021 | 11.29 |
| | Noyo Harbor Jetty | 39.42828 | -123.8107 | | 6/2020-11/2020 | 12.20 |
| | Caspar | 39.36081 | -123.8193 | | 7/2019-8/2021 | 11.95 |
| | Frolic Cove | 39.35503 | -123.8239 | Point Cabrillo SMR | 7/2018-8/2020 | 12.00 |
| | Portuguese Beach | 39.30201 | -123.8037 | | 7/2018-8/2020 | 11.77 |
| | Van Damme | 39.27113 | -123.7948 | Van Damme SMCA | 11/2017-7/2021 | 11.49 |
| | Albion | 39.22831 | -123.774 | | 7/2018 - 5/2019 | 12.06 |
| | Point Arena | 38.94603 | -123.7389 | Point Arena SMR | 5/2018-7/2021 | 11.60 |
| | Point Arena Reference | 38.91031 | -123.7159 | | 11/2019-7/2021 | 11.16 |
| | Pebble Beach | 38.69814 | -123.4427 | | 4/2018-9/2018 | 11.54 |
| | Gerstle Cove | 38.56665 | -123.3303 | Gerstle Cove SMR | 7/2018-7/2019 | 12.38 |
| | Ocean Cove | 38.55474 | -123.306 | | 5/2018-9/2020 | 12.04 |
| | Stillwater Sonoma | 38.54601 | -123.2998 | | 4/2018-8/2019 | 12.26 |
| | Fort Ross | 38.5113 | -123.2438 | | 8/2019-10/2020 | 11.85 |
| Central | Coral Street | 36.63739 | -121.9257 | Pacific Grove Marine Gardens SMCA | 9/2019-7/2020 | 13.97 |
| | Otter Cove | 36.63488 | -121.9196 | Pacific Grove Marine Gardens SMCA | 9/2018-9/2019 | 13.42 |
| | Lovers 3 Target 16 | 36.62888 | -121.9159 | Lovers Point-Julia Platt SMR | 5/2020-5/2021 | 12.70 |
| | Lovers 3 Target 1 | 36.62787 | -121.915 | Lovers Point-Julia Platt SMR | 6/2019-5/2021 | 12.96 |
| | Lovers Point | 36.6253 | -121.912 | Lovers Point-Julia Platt SMR | 9/2018-11/2019 | 13.56 |
| | Spanish Bay | 36.61832 | -121.9536 | Asilomar SMR | 5/2018-4/2021 | 12.61 |
| | Macabee | 36.61679 | -121.897 | Edward F. Ricketts SMCA | 9/2018-4/2021 | 13.42 |
| | Point Joe | 36.61425 | -121.9648 | | 4/2018-4/2021 | 12.36 |
| | Pescadero | 36.56318 | -121.9593 | | 10/2017-4/2021 | 12.38 |
| | Stillwater Carmel | 36.5606 | -121.9467 | Carmel Bay SMCA | 10/2017-4/2021 | 12.38 |
| | Carmel River | 36.53867 | -121.9348 | Carmel Bay SMCA | 5/2018-5/2021 | 12.21 |
| | Monastery North | 36.52668 | -121.927 | Point Lobos SMR | 5/2018-5/2021 | 12.62 |
| | Monastery South | 36.52452 | -121.9333 | Point Lobos SMR | 5/2018-8/2020 | 12.65 |
| | Middle Reef | 36.5222 | -121.9393 | Point Lobos SMR | 5/2018-4/2021 | 12.56 |
| | Malpaso Creek | 36.48 | -121.9405 | | 5/2018-3/2021 | 12.10 |
| | South Wreck | 36.22576 | -121.7893 | | 6/2018-6/2019 | 13.00 |
| | Esalen | 36.12508 | -121.6481 | | 6/2018-6/2019 | 13.22 |
| | Dolan | 36.10345 | -121.6282 | Big Creek SMR | 6/2018-8/2020 | 12.86 |
| | Big Creek | 36.06848 | -121.6016 | Big Creek SMR | 8/2018-3/2021 | 12.94 |

## Table 5. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| Central, cont. | Lopez | 36.03019 | -121.5815 | | 6/2018-6/2019 | 13.27 |
| | Daddy Bob | 35.53794 | -121.0969 | White Rock SMCA | 6/2018-7/2020 | 13.33 |
| | White Rocks | 35.528 | -121.0859 | White Rock SMCA | 6/2018-6/2019 | 13.16 |
| | Harmony | 35.50014 | -121.0555 | | 6/2018-6/2019 | 13.10 |
| | Estero | 35.47338 | -121.0214 | | 8/2019-10/2020 | 13.30 |
| | Spooners Cove | 35.2826 | -120.8935 | | 8/2019-7/2020 | 13.52 |
| | Corallina Cove | 35.26594 | -120.8988 | | 9/2018-2/2020 | 13.82 |
| | Point Buchon | 35.24124 | -120.8955 | Point Buchon SMR | 2/2018-6/2021 | 13.34 |
| | Montana De Oro | 35.23097 | -120.8866 | Point Buchon SMR | 2/2020-8/2020 | 12.51 |
| Southern Mainland | Big Rock | 34.03513 | -118.6081 | | 8/2018-3/2020 | 16.97 |
| | Le Chuza | 34.03407 | -118.869 | Point Dume SMCA | 12/2017-3/2020 | 15.30 |
| | Paradise Point | 34.0049 | -118.791 | Point Dume SMR | 12/2017-3/2020 | 16.44 |
| | Point Dume | 33.99878 | -118.806 | Point Dume SMR | 12/2017-10/2020 | 16.39 |
| | Leo Carrillo North | 33.97975 | -118.582 | | 12/2017-3/2020 | 15.36 |
| | Malaga Cove | 33.80421 | -118.3992 | | 12/2017-11/2020 | 17.14 |
| | Christmas Tree Reef | 33.76152 | -118.4215 | | 12/2017-7/2021 | 15.78 |
| | Point Vicente West | 33.73998 | -118.414 | Point Vicente SMCA | 12/2017-7/2021 | 15.78 |
| | Point Vicente East | 33.73573 | -118.4016 | Point Vicente SMCA | 12/2017-7/2021 | 14.99 |
| | White Point | 33.71252 | -118.3185 | | 12/2017-9/2021 | 15.87 |
| | Little Corona | 33.58797 | -117.8693 | Crystal Cove SMCA | 12/2017-3/2021 | 18.02 |
| | Seal Rock | 33.545 | -117.8039 | Laguna Beach SMR | 12/2017-3/2019 | 16.90 |
| | Laguna Beach | 33.54213 | -117.7948 | Laguna Beach SMR | 11/2020-4/2021 | 16.66 |
| | Broomtail Reef | 32.69435 | -117.2679 | | 7/2018-7/2020 | 15.73 |
| | La Jolla Cove | 32.85419 | -117.2703 | Matlahuayl SMR | 7/2018-9/2020 | 15.90 |
| | Windansea | 32.83638 | -117.288 | | 11/2017-11/2019 | 16.06 |
| Southern Channel Islands | Bird Rock | 33.48674 | -118.4938 | Blue Cavern Onshore SMCA | 8/2018-3/2020 | 17.44 |
| | Ship Rock | 33.46319 | -118.4919 | | 10/2017-10/2020 | 18.78 |
| | Lions Head | 33.45343 | -118.5013 | rrow Point to Lions Head Point SMC | 12/2017-10/2020 | 17.85 |
| | Iron Bound Cove | 33.44758 | -118.5757 | | 10/2017-10/2020 | 18.06 |
| | Sea Fan Grotto | 33.44246 | -118.473 | Blue Cavern Onshore SMCA | 12/2019-10/2020 | 18.17 |
| | Blue Cavern | 33.44117 | -118.4654 | Blue Cavern Onshore SMCA | 10/2017-12/2019 | 18.67 |
| | Rippers Cove | 33.4283 | -118.4352 | | 10/2017-10/2020 | 18.44 |
| | Cat Harbor | 33.4258 | -118.5119 | Cat Harbor SMCA | 10/2017-10/2020 | 18.64 |
| | Twin Rocks | 33.41791 | -118.3979 | Long Point SMR | 10/2017-6/2018 | 17.31 |
| | Catalina Island | 33.41695 | -118.3977 | Long Point SMR | 6/2018-6/2021 | 18.05 |

**Table 5.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| Southern Channel Islands cont. | Long Point West | 33.41012 | -118.3788 | Long Point SMR | 10/2017-10/2020 | 18.66 |
| | Torqua | 33.38301 | -118.3584 | | 3/2019-10/2020 | 18.86 |
| | Salta Roja | 33.33783 | -118.4762 | Farnsworth Onshore SMCA | 10/2017-10/2020 | 17.79 |
| | China Point | 33.33028 | -118.4701 | | 10/2017-10/2018 | 17.79 |
| | Bushings | 33.31783 | -118.4393 | | 10/2017-10/2020 | 17.25 |
| | Salta Verde | 33.31468 | -118.4222 | | 10/2017-10/2020 | 17.73 |

**Table 6.** Fish species classified as targeted by fishing.

| Common Name | Scientific Name |
|---|---|
| Barred Sandbass | *Paralabrax nebulifer* |
| Barred Surfperch | *Amphistichus argenteus* |
| Black And Yellow Rockfish | *Sebastes chrysomelas* |
| Black Croaker | *Cheilotrema saturnum* |
| Black Rockfish | *Sebastes melanops* |
| Blue Rockfish | *Sebastes mystinus* |
| Bocaccio | *Sebastes paucispinis* |
| Brown Rockfish | *Sebastes auriculatus* |
| Cabezon | *Scorpaenichthys marmoratus* |
| Calico Rockfish | *Sebastes dallii* |
| California Scorpionfish | *Scorpaena guttata* |
| California Sheephead | *Semicossyphus pulcher* |
| Californian Salema | *Haemulon californiensis* |
| Canary Rockfish | *Sebastes pinniger* |
| China Rockfish | *Sebastes nebulosus* |
| Copper Rockfish | *Sebastes caurinus* |
| Flag Rockfish | *Sebastes rubrivinctus* |
| Gopher Rockfish | *Sebastes carnatus* |
| Grass Rockfish | *Sebastes rastrelliger* |
| Halfbanded Rockfish | *Sebastes semicinctus* |
| Honeycomb Rockfish | *Sebastes umbrosus* |
| Kelp Bass, Calico Bass | *Paralabrax clathratus* |
| Kelp Greenling | *Hexagrammos decagrammus* |
| Kelp Rockfish | *Sebastes atrovirens* |
| Lefteyed Flounders | *Bothidae* |
| Lingcod | *Ophiodon elongatus* |
| Monkeyface Eel | *Cebidichthys violaceus* |
| Ocean Whitefish | *Caulolatilus princeps* |
| Olive Or Yellowtail Rockfish | *Sebastes serranoides/flavidus* |
| Quillback Rockfish | *Sebastes maliger* |
| Righteyed Flounders | *Pleuronectidae* |
| Rock Greenling | *Hexagrammos lagocephalus* |
| Rosy Rockfish | *Sebastes rosaceus* |
| Sanddabs | *Citharichthys spp* |
| Spitnose Rockfish | *Sebastes diploproa* |
| Spotted Sandbass | *Paralabrax maculatofasciatus* |
| Squarespot Rockfish | *Sebastes hopkinsi* |
| Stripetail Rockfish | *Sebastes saxicola* |
| Treefish | *Sebastes serriceps* |
| Vermilion Rockfish | *Sebastes miniatus* |
| Widow Rockfish | *Sebastes entomelas* |
| Yellowfin drum | *Umbrina roncador* |

**Table 7.** Focal species identified in this study, listed with the regions in which they meet criteria for focal status.

| Common Name | Scientific Name | High Abundance | Ecologically Significant | Cultural Significant | Protected | Endangered or Threatened | Recreational Importance | Commercial Importance |
|---|---|---|---|---|---|---|---|---|
| Black Rockfish | *Sebastes melanops* | North, Central | | | | | North, Central | North, Central |
| Blacksmith | *Chromis punctipinnis* | South | South | | | | | |
| Blue Rockfish | *Sebastes mystinus* | North, Central | North, Central | | | | North, Central | Central |
| Cabezon | *Scorpaenichthys marmoratus* | Central | | | | | Central | Central |
| California Sheephead | *Semicossyphus pulcher* | South | South | | | | South | South |
| Garibaldi | *Hypsypops rubicundus* | South | | South | North, Central, South | | | |
| Gopher Rockfish | *Sebastes carnatus* | North, Central | | | | | North, Central | North, Central |
| Kelp Bass | *Paralabrax clathratus* | South | South | | | | South | |
| Kelp Greenling | *Hexagrammos decagrammus* | North, Central | | | | | North, Central | North, Central |
| Kelp Rockfish | *Sebastes atrovirens* | Central, South | | | | | Central, South | Central, South |
| Lingcod | *Ophiodon elongatus* | North, Central | North, Central | | | | North, Central | North, Central |
| Opaleye | *Girella nigricans* | South | South | | | | | |
| Bull Kelp | *Nereocystis leutkeana* | North, Central | North, Central | North | | North | | North |
| Giant Kelp | *Macrocystis pyrifera* | Central, South | Central, South | Central | | | Central, South | Central |
| Black Abalone | *Haliotis cracherodii* | | | North | North, Central, South | North | | |
| Brown Gorgonian | *Muricea fruticosa* | | South | | | South | | |
| California Golden Gorgonian | *Muricea californica* | | South | | | South | | |
| California Sea Cucumber | *Apostichopus californicus* | South | | South | | | | South |
| Flat Abalone | *Haliotis walallensis* | | | North | North, Central, South | North | | |
| Green Abalone | *Haliotis fulgens* | | | North | North, Central, South | North | | |
| Pink Abalone | *Haliotis corrugata* | | | North | North, Central, South | North | | |
| Pinto Abalone | *Haliotis kamtschatkana* | | | North | North, Central, South | North | | |
| Purple Gorgonian | *Eugorgia rubens* | | South | | | South | | |
| Purple Urchin Adult | *Strongylocentrotus purpuratus* | North, Central, South | North, Central, South | | | | | |
| Red Abalone | *Haliotis rufescens* | North | | North, Central, South | North, Central, South | North | North | |
| Red Gorgonian | *Leptogorgia chilensis* | | South | | | South | | |
| Red Urchin Adult | *Mesocentrotus franciscanus* | North, Central, South | North, Central, South | | | | | North, South |
| Spiny Lobster | *Panulirus interruptus* | South | South | South | | | South | South |
| Sunflower Star | *Pycnopodia helianthoides* | North | North, Central, South | | | North, Central, South | | |
| Warty & California Sea Cucumbers | *Apostichopus spp.* | South | | South | | | | South |
| Warty Sea Cucumber | *Apostichopus parvimensis* | South | | South | | | | South |

**Table 8.** Top 15 species in all MPAs and reference sites by region in terms of Biomass (kg/60m$^2$) and density (# of individuals per 60m$^2$)

## AVERAGE OF ANNUAL TOTALS

### FISH BIOMASS (kg/60m2)

| North Coast | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| Sebastes mystinus Sebastes | 1357.01 | Sebastes mystinus | 1254.39 |
| melanops Ophiodon | 739.00 | Sebastes melanops Ophiodon | 760.43 |
| elongatus Hexagrammos | 398.17 | elongatus Hexagrammos | 359.52 |
| decagrammus Embiotoca | 317.50 | decagrammus Sebastes | 324.51 |
| lateralis Sebastes carnatus | 123.71 | carnatus | 144.87 |
| Sebastes miniatus | 123.49 | Sebastes miniatus Embiotoca | 129.71 |
| Anarrhichthys ocellatus | 105.34 | lateralis Anarrhichthys | 128.75 |
| Sebastes nebulosus | 95.25 | ocellatus Sebastes nebulosus | 126.39 |
| Sebastes chrysomelas | 57.31 | Scorpaenichthys | 54.99 |
| Scorpaenichthys | 41.21 | marmoratus Sebastes | 47.44 |
| marmoratus Sebastes | 28.12 | chrysomelas Sebastes | 43.96 |
| serranoides,flavidus | 24.69 | pinniger | 22.84 |
| Sebastes | 14.72 | Sebastes | 20.50 |
| pinniger | 10.76 | serranoides,flavidus | 14.04 |
| Rhacochilus | 10.69 | Rhacochilus vacca | 8.45 |
| vacca Sebastes | | Oxylebius pictus | |

caurinus

| Central Coast | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| Sebastes mystinus Sebastes | 7423.07 | Sebastes mystinus | 5058.41 |
| atrovirens Ophiodon | 1515.55 | Sebastes | 807.17 |
| elongatus Sebastes | 1369.87 | atrovirens<br>Ophiodon elongatus Sebastes | 737.72 |
| serranoides,flavidus | 1052.09 | melanops Embiotoca | 565.30 |
| Embiotoca lateralis Sebastes | 859.75 | lateralis Sebastes | 548.50 |
| miniatus | 687.26 | serranoides,flavidus | 478.77 |
| Sebastes melanops Sebastes | 686.74 | Hexagrammos | 418.12 |
| chrysomelas Sebastes | 670.85 | decagrammus Sebastes | 380.97 |
| carnatus Hexagrammos | 589.09 | chrysomelas Rhacochilus | 356.82 |
| decagrammus Oxyjulis | 497.98 | vacca | 316.20 |
| californica Embiotoca jacksoni | 450.37 | Oxyjulis californica Embiotoca | 282.57 |
| Rhacochilus vacca | 418.07 | jacksoni Sebastes carnatus | 260.23 |
| Semicossyphus pulcher | 410.27 | Scorpaenichthys | 177.23 |
| Scorpaenichthys | 304.40 | marmoratus Sebastes | 127.84 |
| marmoratus | 296.80 | miniatus Anarrhichthys | 119.41 |
| | | ocellatus | |

### FISH DENSITY (# of individuals/60m2)

| North Coast | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Sebastes mystinus | 8209 | Sebastes mystinus | 7878 |
| Sebastes melanops | 2214 | Sebastes | 1853 |
| Sebastes serranoides,flavidus | 2159 | melanops | 1681 |
| Sebastes melanops | 1864 | Sebastes serranoides,flavidus | 1317 |
| Sebastes | 1766 | Sebastes<br>melanops | 1157 |
| atrovirens,carnatus,chrysomelas,caurinus | 875 | atrovirens,carnatus,chrysomelas,caurinus | 943 |
| Hexagrammos decagrammus | 543 | Hexagrammos decagrammus | 647 |
| Embiotoca lateralis | 470 | Embiotoca lateralis | 377 |
| Sebastes serranoides,flavidus,melanops | 316 | Sebastes carnatus | 310 |
| Sebastes carnatus | 209 | Aulorhynchus flavidus | 214 |
| Sebastes chrysomelas/carnatus young of year | 185 | Oxylebius pictus | 191 |
| Aulorhynchus flavidus | 178 | Sebastes serranoides,flavidus | 158 |
| Sebastes serranoides,flavidus | 152 | Sebastes serranoides,flavidus,melanops | 137 |
| Oxylebius pictus | 125 | Ophiodon elongatus | 112 |
| Ophiodon elongatus | 118 | Sebastes chrysomelas | 112 |
| Sebastes nebulosus | | Sebastes nebulosus | |

| Central Coast | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Sebastes mystinus | 46948 | Sebastes mystinus | 31821 |
| Oxyjulis californica | 19796 | Sebastes serranoides,flavidus | 14397 |
| Sebastes serranoides,flavidus | 16668 | Oxyjulis californica | 13735 |
| Sebastes | 6338 | Oxylebius pictus | 4362 |
| atrovirens,carnatus,chrysomelas,caurinus | 6255 | Sebastes | 4343 |
| Embiotoca lateralis | 5309 | Embiotoca lateralis<br>atrovirens,carnatus,chrysomelas,caurinus | 4043 |
| Oxylebius pictus | 5259 | Sebastes | 2862 |
| Sebastes atrovirens | 5060 | atrovirens | 2665 |
| Aulorhynchus flavidus | 4663 | Sebastes melanops<br>Sebastes serranoides,flavidus | 2579 |
| Sebastes chrysomelas/carnatus young of year | 4639 | Aulorhynchus flavidus | 2563 |
| Sebastes serranoides,flavidus | 2998 | Sebastes chrysomelas/carnatus young of | 2112 |
| Sebastes melanops | 2425 | year Sebastes melanops | 1797 |
| Sebastes melanops | 2289 | Rhacochilus vacca | 1706 |
| Sebastes carnatus | 2177 | Brachyistius frenatus | 1349 |
| Sebastes chrysomelas | 1922 | Sebastes chrysomelas | 1248 |
| Rhacochilus vacca | | | |

**Table 8.** continued

| South Coast | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Paralabrax clathratus** | 1232.83 | **Paralabrax clathratus** | 564.28 |
| **Semicossyphus pulcher** | 1143.61 | Oxyjulis californica | 412.86 |
| Chromis punctipinnis | 617.05 | **Semicossyphus pulcher** | 392.82 |
| Girella nigricans | 463.10 | Girella nigricans | 343.46 |
| Oxyjulis californica | 434.19 | Embiotoca jacksoni | 249.78 |
| Embiotoca jacksoni | 309.32 | Rhacochilus toxotes | 181.80 |
| Hypsypops rubicundus | 308.93 | **Paralabrax nebulifer** | 143.66 |
| Rhacochilus toxotes | 227.60 | Hypsypops rubicundus | 143.36 |
| **Paralabrax nebulifer** | 223.05 | Rhacochilus vacca | 93.02 |
| Rhacochilus vacca | 218.41 | **Sebastes atrovirens** | 86.71 |
| **Ophiodon elongatus** | 126.72 | Chromis punctipinnis | 83.56 |
| **Sebastes serranoides,flavidus** | 125.05 | Hypsurus caryi | 70.77 |
| Hypsurus caryi | 120.28 | Halichoeres semicinctus | 60.20 |
| **Sebastes atrovirens** | 108.58 | **Caulolatilus princeps** | 34.91 |
| Halichoeres semicinctus | 84.44 | Brachyistius frenatus | 29.22 |

| South Coast | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 20411 | Oxyjulis californica | 12730 |
| Oxyjulis californica | 15024 | Chromis punctipinnis | 4524 |
| **Paralabrax clathratus** | 4507 | **Paralabrax clathratus** | 2850 |
| Brachyistius frenatus | 3738 | Brachyistius frenatus | 2566 |
| **Semicossyphus pulcher** | 2445 | Embiotoca jacksoni | 1707 |
| Hypsurus caryi | 2312 | **Semicossyphus pulcher** | 1336 |
| Embiotoca jacksoni | 2092 | Hypsurus caryi | 1187 |
| Rhacochilus vacca | 1279 | **Haemulon californiensis** | 1132 |
| Halichoeres semicinctus | 1176 | Halichoeres semicinctus | 948 |
| Hypsypops rubicundus | 1147 | Girella nigricans | 934 |
| Oxylebius pictus | 1115 | Hypsypops rubicundus | 599 |
| **Sebastes mystinus** | 1084 | Cymatogaster aggregata | 536 |
| Girella nigricans | 983 | Rhacochilus vacca | 523 |
| **Sebastes serranoides,flavidus** | 921 | Phanerodon furcatus | 456 |
| Phanerodon furcatus | 899 | **Sebastes atrovirens** | 429 |

| Northern Channel Islands | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Semicossyphus pulcher** | 4725.42 | **Paralabrax clathratus** | 2710.04 |
| **Paralabrax clathratus** | 3888.61 | **Semicossyphus pulcher** | 2381.73 |
| Girella nigricans | 3173.26 | Girella nigricans | 2218.84 |
| Chromis punctipinnis | 2002.48 | Chromis punctipinnis | 2218.44 |
| Hypsypops rubicundus | 1235.55 | Hypsypops rubicundus | 1666.13 |
| Oxyjulis californica | 1029.57 | Embiotoca jacksoni | 1272.35 |
| Embiotoca jacksoni | 849.43 | Oxyjulis californica | 1022.22 |
| **Sebastes mystinus** | 830.40 | **Sebastes atrovirens** | 892.67 |
| **Sebastes atrovirens** | 593.27 | Rhacochilus vacca | 724.48 |
| Medialuna californiensis | 580.06 | Medialuna californiensis | 713.55 |
| Rhacochilus vacca | 569.55 | **Sebastes mystinus** | 688.10 |
| **Sebastes serranoides,flavidus** | 529.97 | Embiotoca lateralis | 489.95 |
| **Caulolatilus princeps** | 524.66 | Rhacochilus toxotes | 471.86 |
| Halichoeres semicinctus | 343.70 | **Sebastes serranoides,flavidus** | 432.52 |
| Embiotoca lateralis | 325.48 | **Caulolatilus princeps** | 332.51 |

| Northern Channel Islands | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 68188 | Chromis punctipinnis | 66042 |
| Oxyjulis californica | 42426 | Oxyjulis californica | 34225 |
| **Paralabrax clathratus** | 12331 | **Paralabrax clathratus** | 10998 |
| **Semicossyphus pulcher** | 7824 | Embiotoca jacksoni | 7861 |
| Embiotoca jacksoni | 7589 | Aulorhynchus flavidus | 5979 |
| Brachyistius frenatus | 7293 | Brachyistius frenatus | 5582 |
| Girella nigricans | 6181 | **Semicossyphus pulcher** | 5563 |
| Halichoeres semicinctus | 5635 | Girella nigricans | 5061 |
| **Sebastes mystinus** | 5157 | **Sebastes mystinus** | 4715 |
| Oxylebius pictus | 3903 | Hypsypops rubicundus | 4703 |
| Hypsypops rubicundus | 3793 | Oxylebius pictus | 4595 |
| Heterostichus rostratus | 3764 | Halichoeres semicinctus | 4034 |
| Embiotoca lateralis | 2732 | **Sebastes atrovirens** | 3750 |
| Rhacochilus vacca | 2604 | Embiotoca lateralis | 3098 |
| **Sebastes atrovirens** | 2278 | Rhacochilus vacca | 3022 |

**Table 9**. Top 15 species in each MPA and paired reference area in terms of biomass (kg/60m$^2$) and density (# of individuals per 60m$^2$)

### AVERAGE OF ANNUAL TOTALS

### FISH BIOMASS (kg/60m2)

| Ten Mile SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes melanops** | 28.82 | **Sebastes melanops** | 63.02 |
| Anarrhichthys ocellatus | 25.84 | **Sebastes mystinus** | 40.27 |
| **Ophiodon elongatus** | 17.99 | **Hexagrammos decagrammus** | 23.61 |
| **Hexagrammos decagrammus** | 13.42 | **Ophiodon elongatus** | 18.99 |
| **Sebastes mystinus** | 10.82 | Anarrhichthys ocellatus | 9.25 |
| Embiotoca lateralis | 3.13 | **Sebastes miniatus** | 8.44 |
| **Sebastes miniatus** | 2.31 | Embiotoca lateralis | 5.13 |
| **Sebastes pinniger** | 2.14 | **Scorpaenichthys marmoratus** | 3.69 |
| **Sebastes serranoides,flavidus** | 1.07 | **Sebastes serranoides,flavidus** | 3.59 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 0.90 | **Sebastes carnatus** | 2.66 |
| **Sebastes carnatus** | 0.88 | **Sebastes nebulosus** | 2.64 |
| **Scorpaenichthys marmoratus** | 0.76 | Phanerodon furcatus | 1.78 |
| **Sebastes melanops** | 0.75 | **Sebastes pinniger** | 1.41 |
| **Sebastes maliger** | 0.60 | **Sebastes chrysomelas** | 1.15 |
| **Sebastes nebulosus** | 0.55 | **Sebastes maliger** | 1.00 |

| Point Cabrillo SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 94.51 | **Sebastes mystinus** | 79.61 |
| **Sebastes melanops** | 36.76 | **Sebastes melanops** | 29.31 |
| **Ophiodon elongatus** | 14.30 | **Ophiodon elongatus** | 17.20 |
| **Hexagrammos decagrammus** | 11.69 | **Hexagrammos decagrammus** | 13.80 |
| Anarrhichthys ocellatus | 9.43 | Embiotoca lateralis | 7.18 |
| **Sebastes miniatus** | 7.32 | **Sebastes miniatus** | 6.45 |
| **Sebastes caurinus** | 4.36 | **Sebastes pinniger** | 3.45 |
| **Sebastes carnatus** | 4.14 | **Sebastes carnatus** | 2.87 |
| **Sebastes nebulosus** | 4.02 | **Sebastes chrysomelas** | 2.53 |
| Embiotoca lateralis | 2.49 | **Sebastes caurinus** | 2.15 |
| Rhacochilus vacca | 2.08 | **Scorpaenichthys marmoratus** | 1.61 |
| **Scorpaenichthys marmoratus** | 1.55 | **Sebastes nebulosus** | 1.00 |
| **Sebastes chrysomelas** | 1.45 | **Sebastes melanops** | 0.82 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 1.11 | **Sebastes serranoides,flavidus** | 0.51 |
| **Sebastes maliger** | 1.01 | Rhacochilus vacca | 0.43 |

### FISH DENSITY (# of individuals/60m2)

| Ten Mile SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes serranoides,flavidus** | 358 | **Sebastes mystinus** | 167 |
| **Sebastes melanops** | 200 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 163 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 100 | **Sebastes melanops** | 142 |
| **Sebastes mystinus** | 80 | Aulorhynchus flavidus | 129 |
| **Sebastes melanops** | 55 | **Sebastes melanops** | 93 |
| Aulorhynchus flavidus | 44 | **Sebastes serranoides,flavidus** | 66 |
| **Hexagrammos decagrammus** | 36 | **Hexagrammos decagrammus** | 60 |
| **Sebastes serranoides,flavidus,melanops** | 28 | Phanerodon furcatus | 50 |
| Embiotoca lateralis | 12 | Embiotoca lateralis | 25 |
| **Sebastes serranoides,flavidus** | 10 | **Sebastes caurinus** | 12 |
| **Ophiodon elongatus** | 5 | **Sebastes pinniger** | 10 |
| Oxylebius pictus | 3 | **Sebastes serranoides,flavidus** | 8 |
| **Sebastes carnatus** | 2 | **Ophiodon elongatus** | 8 |
| **Citharichthys spp** | 2 | **Sebastes serranoides,flavidus,melanops** | 8 |
| **Sebastes nebulosus** | 2 | **Sebastes carnatus** | 7 |

| Point Cabrillo SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes mystinus** | 559 | **Sebastes mystinus** | 549 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 362 | **Sebastes melanops** | 199 |
| **Sebastes melanops** | 225 | **Sebastes serranoides,flavidus** | 113 |
| **Sebastes serranoides,flavidus** | 192 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 90 |
| **Sebastes melanops** | 142 | **Sebastes melanops** | 81 |
| **Sebastes serranoides,flavidus,melanops** | 33 | **Hexagrammos decagrammus** | 38 |
| **Sebastes serranoides,flavidus** | 26 | Embiotoca lateralis | 34 |
| **Hexagrammos decagrammus** | 25 | **Sebastes serranoides,flavidus,melanops** | 11 |
| Rhacochilus vacca | 14 | **Sebastes serranoides,flavidus** | 9 |
| Embiotoca lateralis | 13 | Oxylebius pictus | 8 |
| **Sebastes carnatus** | 9 | **Sebastes carnatus** | 7 |
| Oxylebius pictus | 7 | **Sebastes miniatus** | 6 |
| **Sebastes nebulosus** | 6 | **Ophiodon elongatus** | 5 |
| **Ophiodon elongatus** | 5 | **Sebastes chrysomelas** | 4 |
| **Sebastes caurinus** | 5 | **Sebastes pinniger** | 4 |

**Table 9**. Continued.

| Saunders Reef SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes melanops** | 27.74 | Anarrhichthys ocellatus | 107.89 |
| **Sebastes mystinus** | 20.88 | **Sebastes mystinus** | 34.91 |
| **Hexagrammos decagrammus** | 10.23 | **Sebastes melanops** | 18.70 |
| **Ophiodon elongatus** | 9.70 | **Ophiodon elongatus** | 17.45 |
| Anarrhichthys ocellatus | 7.92 | **Sebastes carnatus** | 10.74 |
| Hypsurus caryi | 5.32 | **Hexagrammos decagrammus** | 8.36 |
| **Sebastes carnatus** | 5.29 | **Sebastes miniatus** | 7.57 |
| **Sebastes pinniger** | 3.24 | **Sebastes nebulosus** | 4.11 |
| Embiotoca lateralis | 3.05 | Embiotoca lateralis | 3.75 |
| **Sebastes chrysomelas** | 2.23 | **Sebastes chrysomelas** | 3.03 |
| **Sebastes nebulosus** | 1.82 | **Scorpaenichthys marmoratus** | 3.01 |
| **Sebastes auriculatus** | 1.78 | **Sebastes caurinus** | 1.31 |
| **Sebastes miniatus** | 1.71 | **Sebastes atrovirens** | 1.26 |
| **Scorpaenichthys marmoratus** | 1.65 | **Sebastes serranoides,flavidus** | 0.99 |
| **Pleuronectidae spp** | 0.93 | Rhacochilus vacca | 0.60 |

| Saunders Reef SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes chrysomelas/carnatus young of year** | 101 | **Sebastes mystinus** | 255 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 88 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 69 |
| **Sebastes mystinus** | 73 | **Sebastes serranoides,flavidus** | 57 |
| **Sebastes melanops** | 41 | Aulorhynchus flavidus | 50 |
| **Sebastes melanops** | 34 | **Sebastes melanops** | 42 |
| Aulorhynchus flavidus | 33 | **Sebastes serranoides,flavidus,melanops** | 41 |
| **Hexagrammos decagrammus** | 27 | **Hexagrammos decagrammus** | 28 |
| **Sebastes serranoides,flavidus,melanops** | 20 | **Sebastes carnatus** | 26 |
| **Sebastes serranoides,flavidus** | 19 | **Sebastes melanops** | 25 |
| **Sebastes carnatus** | 13 | **Sebastes serranoides,flavidus** | 17 |
| Embiotoca lateralis | 13 | Embiotoca lateralis | 15 |
| **Sebastes carnatus** | 10 | **Sebastes carnatus** | 12 |
| Hypsurus caryi | 9 | **Sebastes chrysomelas/carnatus young of year** | 11 |
| Oxylebius pictus | 5 | Oxylebius pictus | 9 |
| **Sebastes chrysomelas** | 5 | **Sebastes chrysomelas** | 8 |

| Stewarts Point SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 115.78 | **Sebastes mystinus** | 82.13 |
| **Ophiodon elongatus** | 32.10 | **Sebastes melanops** | 33.58 |
| **Sebastes melanops** | 30.26 | **Hexagrammos decagrammus** | 15.78 |
| **Hexagrammos decagrammus** | 19.04 | **Ophiodon elongatus** | 11.29 |
| Embiotoca lateralis | 13.74 | Embiotoca lateralis | 8.93 |
| **Sebastes carnatus** | 12.27 | **Sebastes carnatus** | 8.40 |
| **Sebastes miniatus** | 11.54 | **Sebastes nebulosus** | 3.35 |
| **Sebastes serranoides,flavidus** | 5.31 | **Sebastes miniatus** | 2.46 |
| **Sebastes nebulosus** | 5.04 | **Sebastes chrysomelas** | 2.21 |
| **Sebastes chrysomelas** | 4.11 | Rhacochilus vacca | 2.15 |
| **Scorpaenichthys marmoratus** | 2.46 | **Scorpaenichthys marmoratus** | 1.46 |
| **Sebastes pinniger** | 2.33 | **Hexagrammos spp** | 1.28 |
| Rhacochilus vacca | 1.57 | **Sebastes pinniger** | 0.88 |
| **Sebastes serranoides,flavidus** | 0.61 | Hypsurus caryi | 0.78 |
| Oxylebius pictus | 0.38 | Oxylebius pictus | 0.57 |

| Stewarts Point SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes mystinus** | 773 | **Sebastes mystinus** | 502 |
| **Sebastes serranoides,flavidus** | 166 | **Sebastes serranoides,flavidus** | 99 |
| **Sebastes serranoides,flavidus,melanops** | 88 | **Sebastes melanops** | 89 |
| **Sebastes melanops** | 79 | Embiotoca lateralis | 53 |
| **Hexagrammos decagrammus** | 64 | **Hexagrammos decagrammus** | 52 |
| Embiotoca lateralis | 61 | **Sebastes melanops** | 31 |
| **Sebastes melanops** | 43 | **Sebastes carnatus** | 26 |
| **Sebastes carnatus** | 33 | Oxylebius pictus | 17 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 14 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 15 |
| **Sebastes serranoides,flavidus** | 14 | Rhacochilus vacca | 14 |
| Oxylebius pictus | 12 | **Sebastes nebulosus** | 7 |
| **Sebastes nebulosus** | 12 | **Sebastes carnatus** | 7 |
| **Sebastes chrysomelas** | 12 | **Sebastes chrysomelas/carnatus young of year** | 7 |
| Rhacochilus vacca | 9 | **Sebastes chrysomelas** | 6 |
| **Ophiodon elongatus** | 8 | **Sebastes serranoides,flavidus** | 6 |

**Table 9**. Continued.

| Lovers Point - Julia Platt SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 25.35 | **Sebastes mystinus** | 42.61 |
| **Sebastes atrovirens** | 17.97 | **Sebastes atrovirens** | 20.09 |
| Embiotoca lateralis | 13.85 | Anarrhichthys ocellatus | 14.15 |
| **Sebastes chrysomelas** | 11.42 | **Ophiodon elongatus** | 13.10 |
| Embiotoca jacksoni | 9.97 | Rhacochilus vacca | 9.61 |
| **Ophiodon elongatus** | 8.73 | Embiotoca lateralis | 9.58 |
| **Sebastes serranoides,flavidus** | 8.47 | Oxyjulis californica | 9.36 |
| Oxyjulis californica | 8.18 | Embiotoca jacksoni | 8.64 |
| Rhacochilus vacca | 7.05 | **Sebastes melanops** | 8.31 |
| **Hexagrammos decagrammus** | 6.64 | **Hexagrammos decagrammus** | 7.18 |
| Girella nigricans | 5.47 | **Sebastes serranoides,flavidus** | 6.54 |
| Cephaloscyllium ventriosum | 5.21 | **Sebastes chrysomelas** | 5.34 |
| **Scorpaenichthys marmoratus** | 3.54 | **Scorpaenichthys marmoratus** | 4.08 |
| **Semicossyphus pulcher** | 3.51 | Girella nigricans | 3.89 |
| **Sebastes melanops** | 3.06 | Oxylebius pictus | 3.26 |

| Lovers Point - Julia Platt SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes serranoides,flavidus** | 391 | **Sebastes serranoides,flavidus** | 617 |
| Oxyjulis californica | 364 | Oxyjulis californica | 432 |
| **Sebastes mystinus** | 254 | **Sebastes mystinus** | 424 |
| **Sebastes chrysomelas/carnatus young of year** | 136 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 173 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 135 | Oxylebius pictus | 135 |
| Embiotoca lateralis | 95 | **Sebastes melanops** | 122 |
| Oxylebius pictus | 74 | **Sebastes atrovirens** | 75 |
| **Sebastes melanops** | 72 | Embiotoca lateralis | 75 |
| **Sebastes serranoides,flavidus** | 69 | **Sebastes serranoides,flavidus** | 68 |
| **Sebastes atrovirens** | 60 | **Sebastes chrysomelas/carnatus young of year** | 66 |
| Aulorhynchus flavidus | 59 | Brachyistius frenatus | 62 |
| **Sebastes caurinus** | 37 | Rhacochilus vacca | 45 |
| Rhacochilus vacca | 34 | **Sebastes entomelas** | 44 |
| **Sebastes chrysomelas** | 32 | **Sebastes caurinus** | 38 |
| Embiotoca jacksoni | 28 | Embiotoca jacksoni | 37 |

| Carmel Bay SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 40.48 | **Sebastes mystinus** | 112.62 |
| **Sebastes atrovirens** | 11.80 | **Ophiodon elongatus** | 18.76 |
| **Ophiodon elongatus** | 10.04 | **Sebastes melanops** | 11.89 |
| **Sebastes melanops** | 7.26 | **Sebastes atrovirens** | 11.17 |
| Embiotoca lateralis | 6.44 | Embiotoca lateralis | 9.60 |
| **Hexagrammos decagrammus** | 6.23 | **Sebastes serranoides,flavidus** | 9.29 |
| **Sebastes serranoides,flavidus** | 6.03 | **Sebastes chrysomelas** | 7.06 |
| **Sebastes carnatus** | 4.30 | **Hexagrammos decagrammus** | 6.56 |
| Rhacochilus vacca | 3.69 | Rhacochilus vacca | 4.80 |
| Oxyjulis californica | 3.50 | Rhacochilus toxotes | 4.76 |
| **Sebastes chrysomelas** | 3.02 | Oxyjulis californica | 3.17 |
| Anarrhichthys ocellatus | 2.96 | Embiotoca jacksoni | 2.98 |
| Embiotoca jacksoni | 2.86 | **Sebastes carnatus** | 2.85 |
| **Scorpaenichthys marmoratus** | 2.65 | **Scorpaenichthys marmoratus** | 2.83 |
| **Cebidichthys violaceus** | 1.72 | **Sebastes miniatus** | 2.12 |

| Carmel Bay SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes mystinus** | 373 | **Sebastes mystinus** | 670 |
| **Sebastes serranoides,flavidus** | 214 | Oxyjulis californica | 123 |
| **Sebastes chrysomelas/carnatus young of year** | 133 | Embiotoca lateralis | 68 |
| Oxyjulis californica | 126 | **Sebastes serranoides,flavidus** | 65 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 104 | Aulorhynchus flavidus | 41 |
| Aulorhynchus flavidus | 85 | **Sebastes atrovirens** | 41 |
| Embiotoca lateralis | 56 | Oxylebius pictus | 41 |
| Oxylebius pictus | 47 | **Sebastes melanops** | 37 |
| **Sebastes atrovirens** | 43 | **Sebastes chrysomelas/carnatus young of year** | 36 |
| **Sebastes melanops** | 43 | **Sebastes melanops** | 35 |
| **Sebastes serranoides,flavidus** | 38 | **Sebastes serranoides,flavidus** | 34 |
| **Sebastes melanops** | 29 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 26 |
| **Sebastes carnatus** | 26 | Rhacochilus vacca | 25 |
| Rhacochilus vacca | 22 | **Sebastes chrysomelas** | 22 |
| **Sebastes carnatus** | 18 | **Sebastes carnatus** | 13 |

**Table 9**. Continued.

| Point Lobos SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 176.90 | **Sebastes mystinus** | 83.37 |
| **Ophiodon elongatus** | 41.66 | **Ophiodon elongatus** | 10.57 |
| **Sebastes atrovirens** | 31.66 | Anarrhichthys ocellatus | 8.31 |
| **Sebastes serranoides,flavidus** | 21.18 | Embiotoca lateralis | 8.07 |
| **Sebastes miniatus** | 17.03 | **Sebastes melanops** | 7.37 |
| **Sebastes melanops** | 17.00 | **Sebastes atrovirens** | 7.07 |
| Embiotoca lateralis | 15.75 | **Sebastes chrysomelas** | 6.22 |
| **Sebastes carnatus** | 15.05 | **Sebastes serranoides,flavidus** | 6.06 |
| **Sebastes chrysomelas** | 12.25 | **Hexagrammos decagrammus** | 5.97 |
| **Sebastes caurinus** | 8.93 | **Sebastes carnatus** | 4.05 |
| **Hexagrammos decagrammus** | 8.37 | **Sebastes miniatus** | 2.57 |
| **Semicossyphus pulcher** | 8.05 | Oxyjulis californica | 2.55 |
| Anarrhichthys ocellatus | 6.84 | **Scorpaenichthys marmoratus** | 2.27 |
| Rhacochilus vacca | 6.70 | Embiotoca jacksoni | 2.07 |
| Oxyjulis californica | 6.00 | Rhacochilus vacca | 2.04 |

| Point Lobos SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes mystinus** | 1076 | **Sebastes mystinus** | 479 |
| Oxyjulis californica | 327 | **Sebastes chrysomelas/carnatus young of year** | 131 |
| **Sebastes serranoides,flavidus** | 211 | Oxyjulis californica | 105 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 201 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 77 |
| **Sebastes chrysomelas/carnatus young of year** | 166 | **Sebastes serranoides,flavidus** | 70 |
| **Sebastes atrovirens** | 113 | Embiotoca lateralis | 50 |
| Oxylebius pictus | 107 | Aulorhynchus flavidus | 40 |
| Embiotoca lateralis | 106 | **Sebastes serranoides,flavidus,melanops** | 34 |
| Aulorhynchus flavidus | 85 | Oxylebius pictus | 26 |
| **Sebastes serranoides,flavidus** | 77 | **Sebastes melanops** | 25 |
| Chromis punctipinnis | 59 | **Sebastes atrovirens** | 20 |
| **Sebastes carnatus** | 57 | **Sebastes serranoides,flavidus** | 20 |
| **Sebastes melanops** | 56 | **Sebastes carnatus** | 19 |
| **Sebastes melanops** | 56 | **Sebastes chrysomelas** | 18 |
| **Sebastes serranoides,flavidus,melanops** | 55 | **Sebastes melanops** | 17 |

| Point Sur SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 77.99 | **Sebastes mystinus** | 45.37 |
| Anarrhichthys ocellatus | 40.32 | **Sebastes carnatus** | 5.35 |
| **Sebastes serranoides,flavidus** | 13.10 | **Ophiodon elongatus** | 4.83 |
| **Sebastes miniatus** | 10.85 | **Hexagrammos decagrammus** | 4.34 |
| **Sebastes atrovirens** | 9.36 | **Sebastes serranoides,flavidus** | 3.37 |
| **Ophiodon elongatus** | 4.11 | **Sebastes miniatus** | 3.34 |
| **Sebastes carnatus** | 3.88 | Embiotoca lateralis | 3.08 |
| **Sebastes melanops** | 3.76 | **Sebastes atrovirens** | 3.02 |
| **Sebastes chrysomelas** | 3.65 | **Sebastes caurinus** | 2.26 |
| Cephaloscyllium ventriosum | 3.60 | **Sebastes chrysomelas** | 2.13 |
| **Scorpaenichthys marmoratus** | 3.17 | **Semicossyphus pulcher** | 2.02 |
| Embiotoca lateralis | 2.74 | **Sebastes melanops** | 2.00 |
| **Hexagrammos decagrammus** | 2.65 | **Sebastes pinniger** | 1.52 |
| **Semicossyphus pulcher** | 2.64 | Rhacochilus vacca | 1.50 |
| Rhacochilus toxotes | 2.58 | Oxyjulis californica | 1.30 |

| Point Sur SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes mystinus** | 350 | **Sebastes mystinus** | 155 |
| Aulorhynchus flavidus | 86 | **Sebastes serranoides,flavidus,melanops** | 107 |
| Oxyjulis californica | 49 | **Sebastes serranoides,flavidus** | 99 |
| **Sebastes serranoides,flavidus** | 47 | Aulorhynchus flavidus | 59 |
| **Sebastes serranoides,flavidus** | 30 | Oxyjulis californica | 58 |
| **Sebastes atrovirens** | 28 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 46 |
| Embiotoca lateralis | 23 | **Sebastes chrysomelas/carnatus young of year** | 37 |
| **Sebastes paucispinis** | 18 | **Sebastes melanops** | 27 |
| **Sebastes carnatus** | 17 | Embiotoca lateralis | 25 |
| **Sebastes melanops** | 14 | Oxylebius pictus | 21 |
| **Sebastes chrysomelas** | 13 | Cymatogaster aggregata | 19 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 11 | **Sebastes carnatus** | 17 |
| Embiotoca jacksoni | 11 | **Sebastes carnatus** | 14 |
| Oxylebius pictus | 11 | **Sebastes atrovirens** | 10 |
| **Sebastes miniatus** | 9 | **Hexagrammos decagrammus** | 10 |

**Table 9**. Continued.

| Point Buchon SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 110.96 | **Sebastes mystinus** | 43.22 |
| **Sebastes miniatus** | 14.83 | **Sebastes miniatus** | 5.72 |
| **Sebastes serranoides,flavidus** | 12.35 | **Sebastes melanops** | 5.01 |
| **Sebastes carnatus** | 7.87 | **Sebastes serranoides,flavidus** | 4.96 |
| **Ophiodon elongatus** | 7.86 | **Sebastes atrovirens** | 4.79 |
| **Semicossyphus pulcher** | 6.19 | **Ophiodon elongatus** | 4.77 |
| **Sebastes atrovirens** | 5.43 | Anarrhichthys ocellatus | 4.03 |
| Oxyjulis californica | 4.97 | **Sebastes carnatus** | 3.79 |
| **Sebastes chrysomelas** | 4.76 | **Sebastes chrysomelas** | 3.53 |
| **Sebastes melanops** | 4.41 | Rhacochilus vacca | 2.84 |
| Embiotoca lateralis | 3.75 | Rhacochilus toxotes | 2.65 |
| **Scorpaenichthys marmoratus** | 3.12 | Oxyjulis californica | 2.49 |
| Cephaloscyllium ventriosum | 2.31 | Embiotoca lateralis | 2.27 |
| Rhacochilus vacca | 1.66 | **Scorpaenichthys marmoratus** | 2.14 |
| **Sebastes serriceps** | 1.56 | **Semicossyphus pulcher** | 2.12 |

| Point Buchon SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| **Sebastes mystinus** | 530 | **Sebastes mystinus** | 212 |
| Aulorhynchus flavidus | 199 | Aulorhynchus flavidus | 112 |
| Oxyjulis californica | 155 | Oxyjulis californica | 85 |
| Embiotoca lateralis | 35 | Embiotoca lateralis | 24 |
| **Sebastes serranoides,flavidus** | 32 | Phanerodon furcatus | 20 |
| **Sebastes carnatus** | 30 | Oxylebius pictus | 19 |
| Oxylebius pictus | 22 | **Sebastes carnatus** | 16 |
| **Sebastes serranoides,flavidus** | 19 | **Sebastes serranoides,flavidus** | 15 |
| **Sebastes chrysomelas** | 19 | **Sebastes melanops** | 15 |
| **Sebastes atrovirens** | 18 | **Sebastes chrysomelas** | 14 |
| **Sebastes melanops** | 15 | **Sebastes atrovirens** | 14 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 14 | Rhacochilus vacca | 13 |
| **Sebastes miniatus** | 13 | **Sebastes serranoides,flavidus** | 13 |
| **Sebastes chrysomelas/carnatus young of year** | 8 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 12 |
| Rhacochilus vacca | 7 | **Sebastes serranoides,flavidus,melanops** | 11 |

| Naples SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Semicossyphus pulcher** | 31.44 | **Paralabrax clathratus** | 14.30 |
| **Paralabrax clathratus** | 28.94 | Oxyjulis californica | 12.04 |
| Oxyjulis californica | 12.69 | Embiotoca jacksoni | 8.51 |
| Embiotoca jacksoni | 9.18 | **Paralabrax nebulifer** | 8.03 |
| Rhacochilus toxotes | 7.96 | **Semicossyphus pulcher** | 6.20 |
| Rhacochilus vacca | 7.65 | **Caulolatilus princeps** | 5.42 |
| Chromis punctipinnis | 6.64 | Rhacochilus toxotes | 4.67 |
| Girella nigricans | 5.19 | Cephaloscyllium ventriosum | 4.47 |
| Hypsurus caryi | 4.89 | Rhacochilus vacca | 3.74 |
| **Sebastes atrovirens** | 3.26 | **Sebastes atrovirens** | 3.65 |
| **Ophiodon elongatus** | 2.55 | Girella nigricans | 2.96 |
| Medialuna californiensis | 2.48 | Hypsurus caryi | 2.52 |
| Phanerodon furcatus | 2.42 | Halichoeres semicinctus | 1.73 |
| **Sebastes mystinus** | 2.34 | **Sebastes auriculatus** | 1.47 |
| **Caulolatilus princeps** | 2.32 | Phanerodon furcatus | 1.20 |

| Naples SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Oxyjulis californica | 427 | Oxyjulis californica | 246 |
| Chromis punctipinnis | 167 | Brachyistius frenatus | 97 |
| Brachyistius frenatus | 107 | **Paralabrax clathratus** | 75 |
| **Paralabrax clathratus** | 105 | Aulorhynchus flavidus | 68 |
| Hypsurus caryi | 92 | Cymatogaster aggregata | 54 |
| **Semicossyphus pulcher** | 58 | Embiotoca jacksoni | 51 |
| Cymatogaster aggregata | 52 | Hypsurus caryi | 42 |
| Embiotoca jacksoni | 50 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 32 |
| Oxylebius pictus | 46 | Chromis punctipinnis | 31 |
| **Sebastes serranoides,flavidus** | 44 | **Semicossyphus pulcher** | 25 |
| Rhacochilus vacca | 41 | Halichoeres semicinctus | 23 |
| **Sebastes mystinus** | 40 | **Sebastes serranoides,flavidus** | 23 |
| Phanerodon furcatus | 39 | Phanerodon furcatus | 20 |
| Rhacochilus toxotes | 16 | Rhacochilus vacca | 20 |
| **Sebastes serranoides,flavidus** | 16 | **Sebastes atrovirens** | 18 |

**Table 9**. Continued.

| Campus Point SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Paralabrax clathratus** | 24.08 | **Paralabrax clathratus** | 14.30 |
| Rhacochilus toxotes | 6.37 | Oxyjulis californica | 12.04 |
| Oxyjulis californica | 6.07 | Embiotoca jacksoni | 8.51 |
| **Paralabrax nebulifer** | 4.95 | **Paralabrax nebulifer** | 8.03 |
| **Semicossyphus pulcher** | 3.85 | **Semicossyphus pulcher** | 6.20 |
| Girella nigricans | 3.27 | **Caulolatilus princeps** | 5.42 |
| Anisotremus davidsonii | 2.90 | Rhacochilus toxotes | 4.67 |
| Medialuna californiensis | 2.88 | Cephaloscyllium ventriosum | 4.47 |
| Embiotoca jacksoni | 2.76 | Rhacochilus vacca | 3.74 |
| Rhacochilus vacca | 2.31 | **Sebastes atrovirens** | 3.65 |
| Halichoeres semicinctus | 2.24 | Girella nigricans | 2.96 |
| **Ophiodon elongatus** | 2.13 | Hypsurus caryi | 2.52 |
| **Caulolatilus princeps** | 2.03 | Halichoeres semicinctus | 1.73 |
| **Sebastes atrovirens** | 1.62 | **Sebastes auriculatus** | 1.47 |
| Embiotoca lateralis | 1.38 | Phanerodon furcatus | 1.20 |

| Campus Point SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Oxyjulis californica | 204 | Oxyjulis californica | 246 |
| **Paralabrax clathratus** | 90 | Brachyistius frenatus | 97 |
| Brachyistius frenatus | 81 | **Paralabrax clathratus** | 75 |
| Halichoeres semicinctus | 33 | Aulorhynchus flavidus | 68 |
| Hypsurus caryi | 28 | Cymatogaster aggregata | 54 |
| Embiotoca jacksoni | 23 | Embiotoca jacksoni | 51 |
| Chromis punctipinnis | 22 | Hypsurus caryi | 42 |
| Medialuna californiensis | 19 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 32 |
| Rhacochilus toxotes | 17 | Chromis punctipinnis | 31 |
| Aulorhynchus flavidus | 15 | **Semicossyphus pulcher** | 25 |
| Rhacochilus vacca | 14 | Halichoeres semicinctus | 23 |
| Embiotoca lateralis | 13 | **Sebastes serranoides,flavidus** | 23 |
| Cymatogaster aggregata | 13 | Phanerodon furcatus | 20 |
| Oxylebius pictus | 12 | Rhacochilus vacca | 20 |
| **Sebastes atrovirens** | 11 | **Sebastes atrovirens** | 18 |

| Point Vicente SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Semicossyphus pulcher** | 24.16 | **Haemulon californiensis** | 12.14 |
| Chromis punctipinnis | 23.82 | **Semicossyphus pulcher** | 9.61 |
| Girella nigricans | 17.69 | Girella nigricans | 8.19 |
| Hypsypops rubicundus | 17.42 | **Paralabrax clathratus** | 7.34 |
| **Paralabrax clathratus** | 12.63 | Rhacochilus toxotes | 6.85 |
| **Sebastes serranoides,flavidus** | 9.04 | Oxyjulis californica | 5.27 |
| **Ophiodon elongatus** | 8.20 | Hypsypops rubicundus | 4.71 |
| **Paralabrax nebulifer** | 6.17 | Chromis punctipinnis | 3.72 |
| **Sebastes miniatus** | 6.13 | Heterodontus francisci | 3.43 |
| Oxyjulis californica | 5.23 | Anisotremus davidsonii | 1.84 |
| Heterodontus francisci | 5.17 | Embiotoca jacksoni | 1.53 |
| Embiotoca jacksoni | 4.79 | Halichoeres semicinctus | 1.20 |
| **Cheilotrema saturnum** | 3.23 | **Caulolatilus princeps** | 1.12 |
| Anisotremus davidsonii | 3.15 | **Ophiodon elongatus** | 0.74 |
| Halichoeres semicinctus | 2.71 | **Paralabrax nebulifer** | 0.66 |

| Point Vicente SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 904 | **Haemulon californiensis** | 566 |
| Oxyjulis californica | 201 | Oxyjulis californica | 304 |
| Brachyistius frenatus | 65 | Chromis punctipinnis | 204 |
| **Semicossyphus pulcher** | 61 | **Caulolatilus princeps** | 79 |
| Hypsypops rubicundus | 61 | **Paralabrax clathratus** | 43 |
| **Sebastes serranoides,flavidus** | 50 | **Semicossyphus pulcher** | 36 |
| **Paralabrax clathratus** | 46 | Girella nigricans | 30 |
| Girella nigricans | 46 | Halichoeres semicinctus | 24 |
| Embiotoca jacksoni | 44 | Hypsypops rubicundus | 23 |
| **Sebastes mystinus** | 42 | **Ophiodon elongatus** | 23 |
| Halichoeres semicinctus | 39 | Rhacochilus toxotes | 22 |
| **Sebastes miniatus** | 20 | **Sebastes hopkinsi** | 20 |
| Rhacochilus vacca | 17 | Embiotoca jacksoni | 18 |
| **Cheilotrema saturnum** | 16 | Brachyistius frenatus | 18 |
| **Paralabrax nebulifer** | 14 | Anisotremus davidsonii | 18 |

**Table 9**. Continued.

| Abalone Cove SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Paralabrax clathratus** | 10.71 | Girella nigricans | 18.51 |
| Chromis punctipinnis | 10.24 | **Semicossyphus pulcher** | 11.34 |
| Girella nigricans | 9.84 | **Paralabrax clathratus** | 10.09 |
| **Paralabrax nebulifer** | 5.79 | Hypsypops rubicundus | 6.36 |
| **Semicossyphus pulcher** | 3.94 | Oxyjulis californica | 4.08 |
| Hypsypops rubicundus | 3.22 | Rhacochilus toxotes | 3.54 |
| Heterodontus francisci | 1.77 | Anisotremus davidsonii | 2.95 |
| **Sebastes serranoides,flavidus** | 1.05 | **Paralabrax nebulifer** | 2.46 |
| Halichoeres semicinctus | 0.90 | Embiotoca jacksoni | 2.05 |
| Anisotremus davidsonii | 0.84 | Chromis punctipinnis | 1.79 |
| Rhacochilus toxotes | 0.83 | Halichoeres semicinctus | 1.31 |
| Phanerodon furcatus | 0.78 | Hypsurus caryi | 0.86 |
| Embiotoca jacksoni | 0.72 | Medialuna californiensis | 0.51 |
| **Sebastes atrovirens** | 0.64 | **Sebastes atrovirens** | 0.44 |
| Medialuna californiensis | 0.50 | Rhacochilus vacca | 0.37 |

| Abalone Cove SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 275 | Oxyjulis californica | 207 |
| **Paralabrax clathratus** | 39 | Chromis punctipinnis | 82 |
| **Paralabrax nebulifer** | 21 | Girella nigricans | 43 |
| Halichoeres semicinctus | 20 | **Paralabrax clathratus** | 37 |
| Oxyjulis californica | 18 | **Semicossyphus pulcher** | 27 |
| Hypsypops rubicundus | 17 | Hypsypops rubicundus | 21 |
| Phanerodon furcatus | 17 | Halichoeres semicinctus | 20 |
| Girella nigricans | 16 | Embiotoca jacksoni | 19 |
| **Semicossyphus pulcher** | 12 | Hypsurus caryi | 13 |
| Embiotoca jacksoni | 10 | Heterostichus rostratus | 12 |
| **Sebastes serranoides,flavidus** | 7 | Brachyistius frenatus | 9 |
| Brachyistius frenatus | 6 | Anisotremus davidsonii | 8 |
| Rhacochilus vacca | 4 | Rhacochilus toxotes | 8 |
| **Sebastes atrovirens** | 3 | **Paralabrax nebulifer** | 7 |
| **Sebastes auriculatus** | 2 | Rhacochilus vacca | 4 |

| Harris Point SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Sebastes mystinus** | 28.81 | **Sebastes mystinus** | 12.91 |
| Chromis punctipinnis | 16.73 | Embiotoca lateralis | 9.58 |
| **Semicossyphus pulcher** | 11.71 | **Sebastes atrovirens** | 7.33 |
| **Sebastes serranoides,flavidus** | 10.99 | **Sebastes serranoides,flavidus** | 5.78 |
| **Sebastes atrovirens** | 9.07 | **Ophiodon elongatus** | 5.53 |
| **Sebastes caurinus** | 7.91 | **Sebastes caurinus** | 5.03 |
| Embiotoca lateralis | 7.38 | **Caulolatilus princeps** | 3.65 |
| **Ophiodon elongatus** | 6.21 | Chromis punctipinnis | 3.65 |
| **Paralabrax clathratus** | 5.19 | **Semicossyphus pulcher** | 3.50 |
| Rhacochilus vacca | 4.72 | Oxyjulis californica | 3.09 |
| **Caulolatilus princeps** | 4.66 | **Sebastes pinniger** | 2.98 |
| Oxyjulis californica | 4.44 | Embiotoca jacksoni | 2.69 |
| Rhacochilus toxotes | 4.43 | **Paralabrax clathratus** | 2.16 |
| Embiotoca jacksoni | 3.79 | Rhacochilus vacca | 2.09 |
| **Scorpaenichthys marmoratus** | 2.24 | **Scorpaenichthys marmoratus** | 1.89 |

| Harris Point SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 244 | Aulorhynchus flavidus | 430 |
| **Sebastes mystinus** | 166 | Oxyjulis californica | 111 |
| Oxyjulis californica | 141 | **Sebastes mystinus** | 74 |
| Aulorhynchus flavidus | 105 | Embiotoca lateralis | 70 |
| Oxylebius pictus | 64 | Chromis punctipinnis | 52 |
| Embiotoca lateralis | 61 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 36 |
| **Sebastes serranoides,flavidus** | 44 | Oxylebius pictus | 35 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 39 | Brachyistius frenatus | 29 |
| Brachyistius frenatus | 34 | **Sebastes paucispinis** | 28 |
| **Sebastes atrovirens** | 32 | **Sebastes atrovirens** | 26 |
| Embiotoca jacksoni | 21 | **Sebastes atrovirens** | 25 |
| **Sebastes atrovirens** | 19 | **Sebastes chrysomelas/carnatus young of year** | 24 |
| **Sebastes chrysomelas/carnatus young of year** | 18 | **Sebastes serranoides,flavidus** | 23 |
| **Semicossyphus pulcher** | 17 | Hypsurus caryi | 19 |
| Rhacochilus vacca | 15 | Embiotoca jacksoni | 16 |

**Table 9**. Continued.

| South Point SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Semicossyphus pulcher** | 44.11 | **Semicossyphus pulcher** | 39.15 |
| **Sebastes mystinus** | 17.48 | **Sebastes mystinus** | 23.36 |
| **Sebastes serranoides,flavidus** | 14.11 | **Sebastes atrovirens** | 17.67 |
| **Sebastes atrovirens** | 13.41 | Oxyjulis californica | 13.57 |
| Oxyjulis californica | 10.13 | **Sebastes serranoides,flavidus** | 11.55 |
| Chromis punctipinnis | 7.12 | Girella nigricans | 11.05 |
| **Paralabrax clathratus** | 5.90 | Embiotoca lateralis | 10.47 |
| **Ophiodon elongatus** | 5.39 | **Paralabrax clathratus** | 7.20 |
| Embiotoca jacksoni | 5.33 | Rhacochilus vacca | 7.00 |
| Girella nigricans | 5.28 | Chromis punctipinnis | 6.76 |
| Embiotoca lateralis | 5.19 | Embiotoca jacksoni | 6.50 |
| Cephaloscyllium ventriosum | 4.04 | Cephaloscyllium ventriosum | 5.10 |
| Rhacochilus toxotes | 3.32 | Rhacochilus toxotes | 4.95 |
| Rhacochilus vacca | 3.16 | Anarrhichthys ocellatus | 4.73 |
| **Scorpaenichthys marmoratus** | 2.65 | **Caulolatilus princeps** | 4.02 |

| South Point SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Oxyjulis californica | 375 | Oxyjulis californica | 579 |
| Chromis punctipinnis | 148 | Chromis punctipinnis | 166 |
| **Sebastes mystinus** | 96 | **Sebastes mystinus** | 133 |
| Aulorhynchus flavidus | 95 | Aulorhynchus flavidus | 94 |
| **Semicossyphus pulcher** | 45 | Embiotoca lateralis | 71 |
| **Sebastes atrovirens** | 44 | Oxylebius pictus | 60 |
| Brachyistius frenatus | 44 | **Sebastes atrovirens** | 58 |
| Embiotoca lateralis | 41 | Brachyistius frenatus | 55 |
| **Sebastes serranoides,flavidus** | 35 | **Semicossyphus pulcher** | 52 |
| Embiotoca jacksoni | 32 | **Sebastes serranoides,flavidus** | 45 |
| Oxylebius pictus | 31 | Embiotoca jacksoni | 31 |
| **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 20 | Rhacochilus vacca | 27 |
| Rhacochilus vacca | 18 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 25 |
| Hypsurus caryi | 15 | Hypsurus caryi | 21 |
| **Paralabrax clathratus** | 11 | Girella nigricans | 18 |

| Painted Cave SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Semicossyphus pulcher** | 44.04 | **Paralabrax clathratus** | 21.26 |
| Girella nigricans | 33.52 | Chromis punctipinnis | 16.85 |
| **Paralabrax clathratus** | 27.91 | **Semicossyphus pulcher** | 14.93 |
| Rhacochilus vacca | 14.48 | Girella nigricans | 12.83 |
| Chromis punctipinnis | 14.46 | Embiotoca jacksoni | 8.67 |
| **Caulolatilus princeps** | 8.56 | Rhacochilus vacca | 7.26 |
| Oxyjulis californica | 7.91 | Gymnothorax mordax | 6.88 |
| Embiotoca jacksoni | 6.50 | **Sebastes atrovirens** | 6.79 |
| Embiotoca lateralis | 5.29 | Hypsypops rubicundus | 5.77 |
| Medialuna californiensis | 5.12 | Rhacochilus toxotes | 4.90 |
| **Sebastes mystinus** | 3.87 | **Caulolatilus princeps** | 4.63 |
| Rhacochilus toxotes | 3.79 | Oxyjulis californica | 4.01 |
| **Ophiodon elongatus** | 2.65 | Medialuna californiensis | 2.66 |
| Hypsypops rubicundus | 2.38 | Heterodontus francisci | 2.09 |
| **Sebastes atrovirens** | 2.14 | Embiotoca lateralis | 1.87 |

| Painted Cave SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 433 | Chromis punctipinnis | 394 |
| Oxyjulis californica | 280 | Aulorhynchus flavidus | 200 |
| Cymatogaster aggregata | 83 | Oxyjulis californica | 113 |
| Brachyistius frenatus | 79 | **Paralabrax clathratus** | 97 |
| **Semicossyphus pulcher** | 63 | Cymatogaster aggregata | 88 |
| Girella nigricans | 57 | Brachyistius frenatus | 85 |
| **Paralabrax clathratus** | 57 | Embiotoca jacksoni | 67 |
| Embiotoca jacksoni | 55 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 53 |
| Rhacochilus vacca | 54 | **Sebastes chrysomelas/carnatus young of year** | 42 |
| **Sebastes atrovirens** | 45 | Rhacochilus vacca | 40 |
| Embiotoca lateralis | 44 | **Sebastes atrovirens** | 40 |
| Oxylebius pictus | 37 | **Sebastes atrovirens** | 38 |
| **Sebastes mystinus** | 31 | Oxylebius pictus | 38 |
| Aulorhynchus flavidus | 23 | **Sebastes serranoides,flavidus** | 35 |
| Halichoeres semicinctus | 22 | Halichoeres semicinctus | 33 |

**Table 9**. Continued.

| Gull Island SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Semicossyphus pulcher** | 75.68 | **Semicossyphus pulcher** | 26.40 |
| Girella nigricans | 32.62 | **Paralabrax clathratus** | 17.72 |
| **Paralabrax clathratus** | 26.29 | Girella nigricans | 10.12 |
| Oxyjulis californica | 15.51 | Oxyjulis californica | 7.33 |
| Chromis punctipinnis | 13.75 | **Sebastes atrovirens** | 6.79 |
| Embiotoca jacksoni | 7.37 | Embiotoca lateralis | 6.58 |
| **Sebastes atrovirens** | 6.16 | Gymnothorax mordax | 5.93 |
| Medialuna californiensis | 6.01 | Embiotoca jacksoni | 5.74 |
| Rhacochilus toxotes | 5.55 | Chromis punctipinnis | 5.66 |
| Hypsypops rubicundus | 5.03 | Rhacochilus vacca | 4.12 |
| Rhacochilus vacca | 4.42 | Rhacochilus toxotes | 3.69 |
| **Ophiodon elongatus** | 4.39 | **Sebastes serranoides,flavidus** | 3.23 |
| **Sebastes serranoides,flavidus** | 4.29 | Medialuna californiensis | 3.10 |
| Gymnothorax mordax | 3.66 | **Caulolatilus princeps** | 2.75 |
| **Caulolatilus princeps** | 3.14 | **Scorpaenichthys marmoratus** | 1.68 |

| Gull Island SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Oxyjulis californica | 624 | Oxyjulis californica | 204 |
| Chromis punctipinnis | 447 | Chromis punctipinnis | 116 |
| **Semicossyphus pulcher** | 124 | Brachyistius frenatus | 83 |
| Brachyistius frenatus | 83 | **Paralabrax clathratus** | 45 |
| **Paralabrax clathratus** | 65 | Aulorhynchus flavidus | 41 |
| Girella nigricans | 53 | **Semicossyphus pulcher** | 36 |
| Embiotoca jacksoni | 51 | Embiotoca jacksoni | 27 |
| Oxylebius pictus | 31 | Oxylebius pictus | 26 |
| **Sebastes mystinus** | 26 | Embiotoca lateralis | 25 |
| **Sebastes atrovirens** | 26 | **Sebastes atrovirens** | 24 |
| Embiotoca lateralis | 24 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 23 |
| Medialuna californiensis | 18 | Hypsurus caryi | 23 |
| **Sebastes serranoides,flavidus** | 15 | Girella nigricans | 19 |
| Hypsypops rubicundus | 13 | Heterostichus rostratus | 18 |
| Halichoeres semicinctus | 12 | **Sebastes serranoides,flavidus** | 15 |

| Scorpion SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Paralabrax clathratus** | 59.74 | **Paralabrax clathratus** | 64.35 |
| **Semicossyphus pulcher** | 38.28 | Chromis punctipinnis | 53.11 |
| Girella nigricans | 32.94 | Hypsypops rubicundus | 52.99 |
| Chromis punctipinnis | 18.23 | **Semicossyphus pulcher** | 29.58 |
| Hypsypops rubicundus | 14.65 | Girella nigricans | 28.94 |
| Embiotoca jacksoni | 11.13 | Embiotoca jacksoni | 23.74 |
| Oxyjulis californica | 9.71 | Gymnothorax mordax | 15.73 |
| **Caulolatilus princeps** | 7.62 | Oxyjulis californica | 14.36 |
| Rhacochilus vacca | 5.28 | Rhacochilus vacca | 13.43 |
| Rhacochilus toxotes | 5.28 | Rhacochilus toxotes | 10.50 |
| Gymnothorax mordax | 5.13 | Anisotremus davidsonii | 10.48 |
| Halichoeres semicinctus | 4.98 | **Sebastes atrovirens** | 9.58 |
| Medialuna californiensis | 4.87 | Medialuna californiensis | 8.96 |
| **Ophiodon elongatus** | 3.63 | Halichoeres semicinctus | 5.91 |
| **Sebastes atrovirens** | 3.00 | **Caulolatilus princeps** | 3.57 |

| Scorpion SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 675 | Chromis punctipinnis | 1569 |
| Oxyjulis californica | 393 | Oxyjulis californica | 380 |
| **Paralabrax clathratus** | 208 | Cymatogaster aggregata | 307 |
| Embiotoca jacksoni | 103 | **Paralabrax clathratus** | 270 |
| Halichoeres semicinctus | 95 | Embiotoca jacksoni | 147 |
| **Semicossyphus pulcher** | 72 | Hypsypops rubicundus | 136 |
| Brachyistius frenatus | 69 | **Semicossyphus pulcher** | 105 |
| Girella nigricans | 68 | Halichoeres semicinctus | 79 |
| Cymatogaster aggregata | 62 | Oxylebius pictus | 62 |
| Hypsypops rubicundus | 44 | Girella nigricans | 62 |
| **Sebastes serranoides,flavidus** | 39 | Brachyistius frenatus | 55 |
| Oxylebius pictus | 36 | **Sebastes atrovirens** | 50 |
| Rhacochilus vacca | 34 | Rhacochilus vacca | 50 |
| Medialuna californiensis | 24 | **Sebastes atrovirens,carnatus,chrysomelas,caurinus** | 49 |
| **Sebastes atrovirens** | 23 | Medialuna californiensis | 45 |

**Table 9**. Continued.

| Anacapa Island SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Paralabrax clathratus** | 30.19 | Girella nigricans | 30.40 |
| **Semicossyphus pulcher** | 19.41 | Chromis punctipinnis | 15.09 |
| Girella nigricans | 19.21 | **Paralabrax clathratus** | 14.09 |
| Hypsypops rubicundus | 15.94 | Hypsypops rubicundus | 13.04 |
| Chromis punctipinnis | 15.49 | Medialuna californiensis | 12.54 |
| Gymnothorax mordax | 9.22 | Embiotoca jacksoni | 10.45 |
| Medialuna californiensis | 4.99 | **Semicossyphus pulcher** | 7.44 |
| Embiotoca jacksoni | 4.36 | Oxyjulis californica | 6.98 |
| Oxyjulis californica | 3.95 | Gymnothorax mordax | 6.08 |
| Halichoeres semicinctus | 3.71 | Rhacochilus toxotes | 3.18 |
| **Caulolatilus princeps** | 3.10 | Halichoeres semicinctus | 2.99 |
| Rhacochilus vacca | 1.26 | **Ophiodon elongatus** | 2.95 |
| Rhacochilus toxotes | 1.20 | **Caulolatilus princeps** | 2.81 |
| **Sebastes atrovirens** | 1.12 | Rhacochilus vacca | 2.48 |
| **Sebastes serriceps** | 0.77 | Heterodontus francisci | 2.06 |

| Anacapa Island SMCA | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 681 | Chromis punctipinnis | 599 |
| Oxyjulis californica | 240 | Oxyjulis californica | 269 |
| **Paralabrax clathratus** | 104 | Girella nigricans | 82 |
| Halichoeres semicinctus | 65 | **Paralabrax clathratus** | 67 |
| Heterostichus rostratus | 58 | Embiotoca jacksoni | 67 |
| **Semicossyphus pulcher** | 53 | Halichoeres semicinctus | 65 |
| Hypsypops rubicundus | 52 | Medialuna californiensis | 49 |
| Girella nigricans | 45 | Hypsypops rubicundus | 47 |
| Embiotoca jacksoni | 44 | Brachyistius frenatus | 35 |
| Medialuna californiensis | 23 | Heterostichus rostratus | 32 |
| Oxylebius pictus | 22 | **Semicossyphus pulcher** | 32 |
| Brachyistius frenatus | 20 | Oxylebius pictus | 22 |
| Cymatogaster aggregata | 20 | **Sebastes mystinus** | 19 |
| **Caulolatilus princeps** | 11 | Cymatogaster aggregata | 16 |
| Phanerodon furcatus | 11 | **Caulolatilus princeps** | 10 |

| Anacapa Island SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Biomass | Species | Biomass |
| **Paralabrax clathratus** | 57.99 | Girella nigricans | 30.40 |
| Girella nigricans | 48.75 | Chromis punctipinnis | 15.09 |
| **Semicossyphus pulcher** | 36.17 | **Paralabrax clathratus** | 14.09 |
| Chromis punctipinnis | 27.01 | Hypsypops rubicundus | 13.04 |
| Hypsypops rubicundus | 26.59 | Medialuna californiensis | 12.54 |
| Medialuna californiensis | 9.93 | Embiotoca jacksoni | 10.45 |
| **Caulolatilus princeps** | 9.90 | **Semicossyphus pulcher** | 7.44 |
| Embiotoca jacksoni | 9.40 | Oxyjulis californica | 6.98 |
| Halichoeres semicinctus | 8.06 | Gymnothorax mordax | 6.08 |
| Oxyjulis californica | 7.69 | Rhacochilus toxotes | 3.18 |
| Gymnothorax mordax | 6.04 | Halichoeres semicinctus | 2.99 |
| Heterodontus francisci | 2.61 | **Ophiodon elongatus** | 2.95 |
| Embiotocidae spp | 2.56 | **Caulolatilus princeps** | 2.81 |
| **Sebastes atrovirens** | 1.93 | Rhacochilus vacca | 2.48 |
| Brachyistius frenatus | 1.70 | Heterodontus francisci | 2.06 |

| Anacapa Island SMR | | | |
|---|---|---|---|
| MPA | | REF | |
| Species | Density | Species | Density |
| Chromis punctipinnis | 1103 | Chromis punctipinnis | 599 |
| Oxyjulis californica | 368 | Oxyjulis californica | 269 |
| **Paralabrax clathratus** | 211 | Girella nigricans | 82 |
| Heterostichus rostratus | 132 | **Paralabrax clathratus** | 67 |
| Halichoeres semicinctus | 121 | Embiotoca jacksoni | 67 |
| Brachyistius frenatus | 121 | Halichoeres semicinctus | 65 |
| Embiotoca jacksoni | 112 | Medialuna californiensis | 49 |
| Girella nigricans | 102 | Hypsypops rubicundus | 47 |
| Hypsypops rubicundus | 82 | Brachyistius frenatus | 35 |
| Cymatogaster aggregata | 79 | Heterostichus rostratus | 32 |
| **Semicossyphus pulcher** | 70 | **Semicossyphus pulcher** | 32 |
| Medialuna californiensis | 36 | Oxylebius pictus | 22 |
| **Caulolatilus princeps** | 25 | **Sebastes mystinus** | 19 |
| Oxylebius pictus | 22 | Cymatogaster aggregata | 16 |
| Rhacochilus vacca | 21 | **Caulolatilus princeps** | 10 |

**Table 10. ANCOVA Type III results for targeted and non-targeted fish biomass log response ratio by region.** The model includes target status (targeted/non-targeted) as a fixed effect, year as a covariate, and year x target status as an interaction term.

| Region | Source | DF | SS | MS | FValue | ProbF |
|---|---|---|---|---|---|---|
| **North Coast** | | | | | | |
| North Coast | target_status | 1 | 0.01100473 | 0.01100473 | 0.14 | 0.7102 |
| North Coast | year | 1 | 0.02220127 | 0.02220127 | 0.29 | 0.5986 |
| North Coast | year*target_status | 1 | 0.01105643 | 0.01105643 | 0.14 | 0.7096 |
| **Central Coast** | | | | | | |
| Central Coast | target_status | 1 | 0.01214873 | 0.01214873 | 0.45 | 0.5040 |
| Central Coast | year | 1 | 0.00669672 | 0.00669672 | 0.25 | 0.6194 |
| Central Coast | year*target_status | 1 | 0.01226975 | 0.01226975 | 0.46 | 0.5019 |
| **South Coast** | | | | | | |
| South Coast | target_status | 1 | 0.00521515 | 0.00521515 | 0.34 | 0.5666 |
| South Coast | year | 1 | 0.23859367 | 0.23859367 | 15.54 | 0.0008 |
| South Coast | year*target_status | 1 | 0.00527462 | 0.00527462 | 0.34 | 0.5644 |
| **Northern Channel Islands** | | | | | | |
| Northern Channel Islands | target_status | 1 | 0.01617651 | 0.01617651 | 3.08 | 0.0890 |
| Northern Channel Islands | year | 1 | 0.03059849 | 0.03059849 | 5.82 | 0.0218 |
| Northern Channel Islands | year*target_status | 1 | 0.01655281 | 0.01655281 | 3.15 | 0.0855 |

**Table 11. Slope estimates for targeted and non-targeted fish biomass log response ratio by region.** The linear regression model includes year x target status as an interaction term.

| Region | Label | Estimate | StdErr | DF | tValue | Probt |
|---|---|---|---|---|---|---|
| **North Coast** | | | | | | |
| North Coast | year*targeted slope | -0.01851 | 0.02850 | 14 | -0.65 | 0.5265 |
| North Coast | year*nontargeted slope | -0.00319 | 0.02850 | 14 | -0.11 | 0.9123 |
| **Central Coast** | | | | | | |
| Central Coast | year*targeted slope | 0.004577 | 0.005493 | 40 | 0.83 | 0.4097 |
| Central Coast | year*nontargeted slope | -0.00069 | 0.005493 | 40 | -0.13 | 0.9010 |
| **South Coast** | | | | | | |
| South Coast | year*targeted slope | 0.03318 | 0.01036 | 20 | 3.20 | **0.0045** |
| South Coast | year*nontargeted slope | 0.02459 | 0.01036 | 20 | 2.37 | 0.0278 |
| **Northern Channel Islands** | | | | | | |
| Northern Channel Islands | year*targeted slope | 0.009752 | 0.003294 | 32 | 2.96 | **0.0057** |
| Northern Channel Islands | year*nontargeted slope | 0.001486 | 0.003294 | 32 | 0.45 | 0.6549 |

**Table 12. ANCOVA Type III results for targeted and non-targeted fish biomass log response ratio by MPA group.**

| Region | MPAGroup | Source | DF | SS | MS | FValue | ProbF |
|---|---|---|---|---|---|---|---|
| **North Coast** | | | | | | | |
| | **Saunders Reef SMCA** | | | | | | |
| | | target_status | 1 | 0.0241 | 0.0241 | 0.1500 | 0.7030 |
| | | year | 1 | 0.0208 | 0.0208 | 0.1300 | 0.7226 |
| | | year*target_status | 1 | 0.0241 | 0.0241 | 0.1500 | 0.7031 |
| | **Stewarts Point SMR** | | | | | | |
| | | target_status | 1 | 0.0001 | 0.0001 | 0.0000 | 0.9505 |
| | | year | 1 | 0.0193 | 0.0193 | 0.8700 | 0.3881 |
| | | year*target_status | 1 | 0.0001 | 0.0001 | 0.0000 | 0.9510 |
| | **Ten Mile SMR** | | | | | | |
| | | target_status | 1 | 0.0041 | 0.0041 | 0.0600 | 0.8122 |
| | | year | 1 | 0.0034 | 0.0034 | 0.0500 | 0.8286 |
| | | year*target_status | 1 | 0.0042 | 0.0042 | 0.0600 | 0.8104 |
| **Central Coast** | | | | | | | |
| | **Carmel Bay SMCA** | | | | | | |
| | | target_status | 1 | 0.0867 | 0.0867 | 4.2100 | 0.0489 |
| | | year | 1 | 0.1021 | 0.1021 | 4.9600 | 0.0336 |
| | | year*target_status | 1 | 0.0877 | 0.0877 | 4.2600 | **0.0477** |
| | **Lovers Point – Julia Platt SMR** | | | | | | |
| | | target_status | 1 | 0.0006 | 0.0006 | 0.0200 | 0.8917 |
| | | year | 1 | 0.0191 | 0.0191 | 0.5600 | 0.4602 |
| | | year*target_status | 1 | 0.0007 | 0.0007 | 0.0200 | 0.8912 |
| | **Point Buchon SMR** | | | | | | |
| | | target_status | 1 | 0.0825 | 0.0825 | 2.8700 | 0.1095 |
| | | year | 1 | 0.2635 | 0.2635 | 9.1700 | 0.0080 |
| | | year*target_status | 1 | 0.0833 | 0.0833 | 2.9000 | 0.1079 |
| | **Point Lobos SMR** | | | | | | |
| | | target_status | 1 | 0.0768 | 0.0768 | 3.1000 | 0.0902 |
| | | year | 1 | 0.0026 | 0.0026 | 0.1000 | 0.7501 |
| | | year*target_status | 1 | 0.0767 | 0.0767 | 3.0900 | 0.0904 |
| | **Point Sur SMR** | | | | | | |
| | | target_status | 1 | 0.0879 | 0.0879 | 1.1900 | 0.2939 |
| | | year | 1 | 0.2439 | 0.2439 | 3.3000 | 0.0907 |
| | | year*target_status | 1 | 0.0882 | 0.0882 | 1.1900 | 0.2931 |
| **South Coast** | | | | | | | |
| | **Abalone Cove SMCA** | | | | | | |
| | | target_status | 1 | 0.0586 | 0.0586 | 0.5600 | 0.4656 |
| | | year | 1 | 1.8036 | 1.8036 | 17.2000 | 0.0008 |
| | | year*target_status | 1 | 0.0586 | 0.0586 | 0.5600 | 0.4654 |
| | **Campus Point SMCA** | | | | | | |
| | | target_status | 1 | 0.0012 | 0.0012 | 0.0200 | 0.8939 |
| | | year | 1 | 0.0037 | 0.0037 | 0.0600 | 0.8148 |
| | | year*target_status | 1 | 0.0011 | 0.0011 | 0.0200 | 0.8964 |

**Table 12** continued**.**

| Region | MPAGroup | Source | DF | SS | MS | FValue | ProbF |
|---|---|---|---|---|---|---|---|
| | **Naples SMCA** | | | | | | |
| | | target_status | 1 | 0.0013 | 0.0013 | 0.0400 | 0.8479 |
| | | year | | 0.2693 | 0.2693 | 7.5700 | 0.0123 |
| | | year*target_status | 1 | 0.0014 | 0.0014 | 0.0400 | 0.8452 |
| | **Point Vicente SMCA** | | | | | | |
| | | target_status | 1 | 0.0301 | 0.0301 | 0.6200 | 0.4420 |
| | | year | 1 | 0.3342 | 0.3342 | 6.8300 | 0.0166 |
| | | year*target_status | 1 | 0.0300 | 0.0300 | 0.6100 | 0.4425 |
| **Northern Channel Islands** | | | | | | | |
| | **Anacapa Island SMCA** | | | | | | |
| | | target_status | 1 | 0.0161 | 0.0161 | 0.5100 | 0.4829 |
| | | year | 1 | 0.0086 | 0.0086 | 0.2700 | 0.6072 |
| | | year*target_status | 1 | 0.0154 | 0.0154 | 0.4800 | 0.4934 |
| | **Anacapa Island SMR** | | | | | | |
| | | target_status | 1 | 0.0778 | 0.0778 | 2.6700 | 0.1138 |
| | | year | 1 | 0.0548 | 0.0548 | 1.8800 | 0.1815 |
| | | year*target_status | 1 | 0.0760 | 0.0760 | 2.6000 | 0.1178 |
| | **Gull Island SMR** | | | | | | |
| | | target_status | 1 | 0.1114 | 0.1114 | 3.6100 | 0.0673 |
| | | year | 1 | 0.3550 | 0.3550 | 11.4900 | 0.0020 |
| | | year*target_status | 1 | 0.1114 | 0.1114 | 3.6000 | **0.0673** |
| | **Harris Point SMR** | | | | | | |
| | | target_status | 1 | 0.0170 | 0.0170 | 0.6500 | 0.4288 |
| | | year | 1 | 0.0000 | 0.0000 | 0.0000 | 0.9802 |
| | | year*target_status | 1 | 0.0169 | 0.0169 | 0.6400 | 0.4302 |
| | **Painted Cave SMCA** | | | | | | |
| | | target_status | 1 | 0.0033 | 0.0033 | 0.1400 | 0.7143 |
| | | year | 1 | 0.6404 | 0.6404 | 26.1500 | <.0001 |
| | | year*target_status | 1 | 0.0034 | 0.0034 | 0.1400 | 0.7109 |
| | **Point Cabrillo SMR** | | | | | | |
| | | target_status | 1 | 0.0093 | 0.0093 | 0.1900 | 0.6758 |
| | | year | 1 | 0.4823 | 0.4823 | 10.0100 | 0.0195 |
| | | year*target_status | 1 | 0.0092 | 0.0092 | 0.1900 | 0.6768 |
| | **Scorpion SMR** | | | | | | |
| | | target_status | 1 | 0.0448 | 0.0448 | 2.8800 | 0.1001 |
| | | year | 1 | 0.0589 | 0.0589 | 3.7900 | 0.0611 |
| | | year*target_status | 1 | 0.0456 | 0.0456 | 2.9300 | 0.0974 |
| | **South Point SMR** | | | | | | |
| | | target_status | 1 | 0.0014 | 0.0014 | 0.0300 | 0.8725 |
| | | year | 1 | 0.0128 | 0.0128 | 0.2400 | 0.6248 |
| | | year*target_status | 1 | 0.0013 | 0.0013 | 0.0300 | 0.8748 |

**Table 13. Slope estimates for targeted and non-targeted fish biomass log response ratio by MPA group.**

| Region | MPAGroup | Label | Estimate | StdErr | DF | tValue | Probt |
|---|---|---|---|---|---|---|---|
| **North Coast** | | | | | | | |
| | **Saunders Reef SMCA** | | | | | | |
| | | year*targeted slope | 0.000795 | 0.0415 | 10 | 0.0200 | 0.9851 |
| | | year*nontargeted slope | -0.02222 | 0.0415 | 10 | -0.5400 | 0.6039 |
| | **Stewarts Point SMR** | | | | | | |
| | | year*targeted slope | 0.01093 | 0.0179 | 6 | 0.6100 | 0.5627 |
| | | year*nontargeted slope | 0.01255 | 0.0179 | 6 | 0.7000 | 0.5083 |
| | **Ten Mile SMR** | | | | | | |
| | | year*targeted slope | -0.00087 | 0.0500 | 6 | -0.0200 | 0.9867 |
| | | year*nontargeted slope | 0.01687 | 0.0500 | 6 | 0.3400 | 0.7475 |
| **Central Coast** | | | | | | | |
| | **Carmel Bay SMCA** | | | | | | |
| | | year*targeted slope | 0.000749 | 0.0065 | 30 | 0.1100 | 0.9093 |
| | | year*nontargeted slope | 0.01978 | 0.0065 | 30 | 3.0400 | **0.0049** |
| | **Lovers Point – Julia Platt SMR** | | | | | | |
| | | year*targeted slope | -0.00389 | 0.0062 | 38 | -0.6300 | 0.5357 |
| | | year*nontargeted slope | -0.00268 | 0.0062 | 38 | -0.4300 | 0.6695 |
| | **Point Buchon SMR** | | | | | | |
| | | year*targeted slope | 0.03802 | 0.0114 | 16 | 3.3500 | **0.0041** |
| | | year*nontargeted slope | 0.01065 | 0.0114 | 16 | 0.9400 | 0.3628 |
| | **Point Lobos SMR** | | | | | | |
| | | year*targeted slope | -0.00956 | 0.0094 | 26 | -1.0200 | 0.3190 |
| | | year*nontargeted slope | 0.01384 | 0.0094 | 26 | 1.4700 | 0.1533 |
| | **Point Sur SMR** | | | | | | |
| | | year*targeted slope | 0.03427 | 0.0167 | 14 | 2.0600 | 0.0588 |
| | | year*nontargeted slope | 0.008532 | 0.0167 | 14 | 0.5100 | 0.6166 |
| **South Coast** | | | | | | | |
| | **Abalone Cove SMCA** | | | | | | |
| | | year*targeted slope | 0.1234 | 0.0357 | 16 | 3.4600 | **0.0032** |
| | | year*nontargeted slope | 0.0857 | 0.0357 | 16 | 2.4000 | **0.0287** |
| | **Campus Point SMCA** | | | | | | |
| | | year*targeted slope | -0.00558 | 0.0214 | 20 | -0.2600 | 0.7967 |
| | | year*nontargeted slope | -0.0016 | 0.0214 | 20 | -0.0700 | 0.9412 |
| | **Naples SMCA** | | | | | | |
| | | year*targeted slope | 0.03289 | 0.0158 | 20 | 2.0900 | 0.0500 |
| | | year*nontargeted slope | 0.02848 | 0.0158 | 20 | 1.8100 | 0.0860 |
| | **Point Vicente SMCA** | | | | | | |
| | | year*targeted slope | 0.04443 | 0.0185 | 20 | 2.4000 | **0.0261** |
| | | year*nontargeted slope | 0.02393 | 0.0185 | 20 | 1.2900 | 0.2104 |

**Table 13.** Continued**.**

| Region | MPAGroup | Label | Estimate | StdErr | DF | tValue | Probt |
|---|---|---|---|---|---|---|---|
| **Northern Channel Islands** | | | | | | | |
| | **Anacapa Island SMCA** | | | | | | |
| | | year*targeted slope | -0.00109 | 0.0089 | 28 | -0.1200 | 0.9029 |
| | | year*nontargeted slope | 0.007603 | 0.0089 | 28 | 0.8600 | 0.3980 |
| | **Anacapa Island SMR** | | | | | | |
| | | year*targeted slope | -0.01787 | 0.0085 | 28 | -2.1100 | **0.0439** |
| | | year*nontargeted slope | 0.001459 | 0.0085 | 28 | 0.1700 | 0.8645 |
| | **Gull Island SMR** | | | | | | |
| | | year*targeted slope | 0.02994 | 0.0080 | 30 | 3.7400 | **0.0008** |
| | | year*nontargeted slope | 0.008442 | 0.0080 | 30 | 1.0500 | 0.3000 |
| | **Harris Point SMR** | | | | | | |
| | | year*targeted slope | -0.00494 | 0.0084 | 24 | -0.5900 | 0.5640 |
| | | year*nontargeted slope | 0.004641 | 0.0084 | 24 | 0.5500 | 0.5876 |
| | **Painted Cave SMCA** | | | | | | |
| | | year*targeted slope | 0.02766 | 0.0071 | 30 | 3.8800 | **0.0005** |
| | | year*nontargeted slope | 0.02389 | 0.0071 | 30 | 3.3500 | **0.0022** |
| | **Point Cabrillo SMR** | | | | | | |
| | | year*targeted slope | -0.1348 | 0.0529 | 6 | -2.5500 | **0.0437** |
| | | year*nontargeted slope | -0.102 | 0.0529 | 6 | -1.9300 | 0.1021 |
| | **Scorpion SMR** | | | | | | |
| | | year*targeted slope | -0.1348 | 0.0529 | 6 | -2.5500 | **0.0437** |
| | | year*nontargeted slope | -0.102 | 0.0529 | 6 | -1.9300 | 0.1021 |
| | **South Point SMR** | | | | | | |
| | | year*targeted slope | -0.00573 | 0.0124 | 28 | -0.4600 | 0.6476 |
| | | year*nontargeted slope | -0.00294 | 0.0124 | 28 | -0.2400 | 0.8142 |

**Table 14.** ANCOVA Type III results for targeted fish biomass slope. The models include protection level (MPA/REF) as a fixed effect, MPA attribute as a covariate, and protection level x MPA attribute as an interaction term.

| MPA Attribute | Source | DF | SS | MS | FValue | ProbF |
|---|---|---|---|---|---|---|
| **MPA Size** | | | | | | |
| | protection level | 1 | 0.0562 | 0.0562 | 2.71 | 0.1092 |
| | size | 1 | 0.0111 | 0.0111 | 0.53 | 0.4702 |
| | protection*size | 1 | 0.0002 | 0.0002 | 0.01 | 0.9244 |
| **Distance to Nearest Port** | | | | | | |
| | protection level | 1 | 0.0294 | 0.0294 | 1.40 | 0.2449 |
| | port distance | 1 | 0.0024 | 0.0024 | 0.11 | 0.7394 |
| | protection*distance | 1 | 0.0013 | 0.0013 | 0.06 | 0.8015 |
| **Latitude (Centroid)** | | | | | | |
| | protection level | 1 | 0.0489 | 0.0489 | 2.55 | 0.1197 |
| | latitude | 1 | 0.0252 | 0.0252 | 1.31 | 0.2595 |
| | protection*latitude | 1 | 0.0402 | 0.0402 | 2.10 | 0.1569 |
| **Rocky Reef at the Depth of 0 – 30 m** | | | | | | |
| | protection level | 1 | 0.0347 | 0.0347 | 1.70 | 0.2015 |
| | rocky reef | 1 | 0.0087 | 0.0087 | 0.43 | 0.5179 |
| | protection*rocky reef | 1 | 0.0135 | 0.0135 | 0.66 | 0.4218 |
| **Habitat Richness** | | | | | | |
| | protection level | 1 | 0.0351 | 0.0351 | 1.69 | 0.2025 |
| | habitat richness | 1 | 0.0067 | 0.0067 | 0.32 | 0.5737 |
| | protection*habitat richness | 1 | 0.0046 | 0.0046 | 0.22 | 0.6422 |
| **Habitat Diversity (Shannon)** | | | | | | |
| | protection level | 1 | 0.0255 | 0.0255 | 1.26 | 0.2699 |
| | habitat diversity | 1 | 0.0257 | 0.0257 | 1.27 | 0.2683 |
| | protection*habitat diversity | 1 | 0.0015 | 0.0015 | 0.08 | 0.7844 |

**Table 15.**
Slope estimates for change in targeted fish biomass over time and MPA attributes**.** The linear regression models include targeted biomass x protection level (MPA/REF) as an interaction term.

| MPA Attribute | Label | Estimate | StdErr | DF | tValue | Probt |
|---|---|---|---|---|---|---|
| **MPA Size** | | | | | | |
| | size*MPA slope | 0.0008 | 0.0018 | 34 | 0.45 | 0.6564 |
| | size*REF slope | 0.0011 | 0.0018 | 34 | 0.58 | 0.5630 |
| **Distance to Nearest Port** | | | | | | |
| | port distance*MPA slope | -0.00009 | 0.0016 | 34 | -0.06 | 0.9541 |
| | port distance*REF slope | -0.00065 | 0.0016 | 34 | -0.42 | 0.6798 |
| **Latitude (Centroid)** | | | | | | |
| | latitude*MPA slope | -0.0036 | 0.0171 | 34 | -0.21 | 0.8327 |
| | latitude*MPA slope | 0.0314 | 0.0171 | 34 | 1.83 | 0.0754 |
| **Rocky Reef at the Depth of 0 – 30 m** | | | | | | |
| | rocky reef*MPA slope | 0.0191 | 0.0184 | 34 | 1.04 | 0.3070 |
| | rocky reef*MPA slope | -0.0021 | 0.0184 | 34 | -0.11 | 0.9107 |
| **Habitat Richness** | | | | | | |
| | habitat richness*MPA slope | -0.0075 | 0.0102 | 34 | -0.73 | 0.4684 |
| | habitat richness*MPA slope | -0.0007 | 0.0102 | 34 | -0.07 | 0.9445 |
| **Habitat Diversity (Shannon)** | | | | | | |
| | habitat diversity*MPA slope | -0.0766 | 0.0773 | 34 | -0.99 | 0.3288 |
| | habitat diversity*MPA slope | -0.0464 | 0.0773 | 34 | -0.60 | 0.5519 |

**Table 16.** Least squares means estimates for targeted fish biomass slope by nearest port and protection level. The ANOVA model includes nearest port x protection level (MPA/REF) as an interaction term.

| **Label** | **Estimate** | **StdErr** | **DF** | **tValue** | **Probt** | **Alpha** | **Lower** | **Upper** |
|---|---|---|---|---|---|---|---|---|
| Bodega Bay **MPA** x Bodega Bay **REF** | 0.2462 | 0.1881 | 24 | 1.31 | 0.2030 | 0.05 | -0.1420 | 0.6345 |
| Channel Islands **MPA** x Channel Islands **REF** | 0.02764 | 0.1330 | 24 | 0.21 | 0.8371 | 0.05 | -0.2469 | 0.3022 |
| Fort Bragg **MPA** x Fort Bragg **REF** | -0.08345 | 0.1330 | 24 | -0.63 | 0.5364 | 0.05 | -0.3580 | 0.1911 |
| Monterey **MPA** x Monterey **REF** | 0.06315 | 0.09406 | 24 | 0.67 | 0.5084 | 0.05 | -0.1310 | 0.2573 |
| Morro Bay **MPA** x Morro Bay **REF** | 0.4131 | 0.1881 | 24 | 2.20 | 0.0380 | 0.05 | 0.02488 | 0.8014 |
| San Pedro **MPA** x San Pedro **REF** | 0.3611 | 0.1330 | 24 | 2.71 | 0.0121 | 0.05 | 0.08658 | 0.6357 |
| Santa Barbara **MPA** x Santa Barbara **REF** | 0.1328 | 0.07110 | 24 | 1.87 | 0.0741 | 0.05 | -0.01396 | 0.2795 |

**Table 17. Linear regression between targeted fish biomass log response ratio averaged across years and MPA attributes.**

| MPA Attributes | Label | Estimate | Std.Err. | t-Value | Prob-t |
|---|---|---|---|---|---|
| **MPA Size** | | | | | |
| | Intercept | 0.0807 | 0.0765 | 1.06 | 0.3069 |
| | MPA Size | 0.0013 | 0.0022 | 0.59 | 0.5633 |
| **Distance to Nearest Port** | | | | | |
| | Intercept | 0.1248 | 0.0870 | 1.44 | 0.1683 |
| | Distance to Nearest Port | 0.00008 | 0.0021 | 0.04 | 0.9717 |
| **Latitude (Centroid)** | | | | | |
| | Intercept | 2.1177 | 0.6675 | 3.17 | 0.0053 |
| | Latitude (Centroid) | -0.0559 | 0.0187 | -2.99 | **0.0079** |
| **Rocky Reef at the Depth of 0 – 30 m** | | | | | |
| | Intercept | 0.1860 | 0.0638 | 2.92 | 0.0092 |
| | Rocky Reef (0-30 m) | -0.0316 | 0.0249 | -1.27 | 0.2209 |
| **Habitat Richness** | | | | | |
| | Intercept | 0.3235 | 0.1413 | 2.29 | 0.0343 |
| | Habitat Richness | -0.0199 | 0.0136 | -1.46 | 0.1621 |
| **Habitat Diversity (Shannon)** | | | | | |
| | Intercept | 0.3180 | 0.1434 | 2.22 | 0.0398 |
| | Habitat Diversity (Shannon) | -0.1430 | 0.1026 | -1.39 | 0.1804 |

**Table 18. Two-sample test results for targeted fish biomass by proximity to other MPAs.** Table highlighted in **orange (A)** uses Wilcoxon test to compare <u>targeted fish biomass slope</u> between MPA and REF for solitary and cluster MPAs. Table highlighted in **blue (B)** uses t-test to compare <u>targeted fish biomass log response ratio averaged across years</u> between solitary and cluster MPAs.

A.

| Proximity to other MPAs | Site Status | Site Status | P Value |
|---|---|---|---|
| Solitary | MPA | Reference | 0.049 |
| Cluster | MPA | Reference | 0.026 |

B.

| Proximity to other MPAs | Proximity to other MPAs | P Value |
|---|---|---|
| Solitary | Cluster | 0.029 |

**Table 19. Slope estimates for focal fish biomass log response ratio by species and MPA group.** The linear regression model includes year as a fixed effect.

| Species | MPA Group | Parameter | Estimate | StdErr | tValue | Probt |
|---|---|---|---:|---:|---:|---:|
| **Black Rockfish** | | | | | | |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | 2.990074 | 27.239572 | 0.11 | 0.9140 |
| | Carmel Bay SMCA | year | -0.001592 | 0.013542 | -0.12 | 0.9080 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | -1.288586 | 21.053756 | -0.06 | 0.9518 |
| | Lovers Point - Julia Platt SMR | year | 0.000589 | 0.010477 | 0.06 | 0.9558 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -64.226028 | 35.995247 | -1.78 | 0.1122 |
| | Point Buchon SMR | year | 0.031887 | 0.017877 | 1.78 | 0.1123 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | 539.149098 | 94.545721 | 5.70 | 0.0107 |
| | Point Cabrillo SMR | year | -0.267361 | 0.046884 | -5.70 | 0.0107 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | 3.859812 | 27.259974 | 0.14 | 0.8896 |
| | Point Lobos SMR | year | -0.001913 | 0.013542 | -0.14 | 0.8899 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | -59.919747 | 43.420543 | -1.38 | 0.2101 |
| | Point Sur SMR | year | 0.029855 | 0.021587 | 1.38 | 0.2092 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -144.472192 | 91.775137 | -1.57 | 0.1763 |
| | Saunders Reef SMCA | year | 0.071758 | 0.045527 | 1.58 | 0.1758 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | -12.588241 | 47.781898 | -0.26 | 0.8093 |
| | Stewarts Point SMR | year | 0.006186 | 0.023713 | 0.26 | 0.8111 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | -77.055156 | 128.210213 | -0.60 | 0.5902 |
| | Ten Mile SMR | year | 0.038067 | 0.063558 | 0.60 | 0.5914 |
| **Blacksmith** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -214.023283 | 130.498713 | -1.64 | 0.1396 |
| | Abalone Cove SMCA | year | 0.106500 | 0.064747 | 1.64 | 0.1386 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | -15.928296 | 43.566409 | -0.37 | 0.7201 |
| | Anacapa Island SMCA | year | 0.007892 | 0.021654 | 0.36 | 0.7210 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 35.727281 | 33.118662 | 1.08 | 0.2989 |
| | Anacapa Island SMR | year | -0.017813 | 0.016461 | -1.08 | 0.2975 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 21.399526 | 21.911202 | 0.98 | 0.3518 |
| | Campus Point SMCA | year | -0.010649 | 0.010877 | -0.98 | 0.3506 |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 0.309911 | 36.290679 | 0.01 | 0.9933 |
| | Gull Island SMR | year | 0.000020995 | 0.018042 | 0.00 | 0.9991 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | 74.675874 | 51.616905 | 1.45 | 0.1736 |
| | Harris Point SMR | year | -0.036802 | 0.025663 | -1.43 | 0.1771 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -49.091297 | 34.714064 | -1.41 | 0.1877 |
| | Naples SMCA | year | 0.024551 | 0.017232 | 1.42 | 0.1847 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -5.498771 | 26.358566 | -0.21 | 0.8376 |
| | Painted Cave SMCA | year | 0.002743 | 0.013104 | 0.21 | 0.8370 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -94.926353 | 48.634638 | -1.95 | 0.0795 |
| | Point Vicente SMCA | year | 0.047474 | 0.024142 | 1.97 | 0.0776 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | 52.415240 | 24.307826 | 2.16 | 0.0477 |
| | Scorpion SMR | year | -0.026111 | 0.012081 | -2.16 | 0.0473 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -31.599501 | 36.147817 | -0.87 | 0.3968 |
| | South Point SMR | year | 0.015771 | 0.017962 | 0.88 | 0.3947 |
| **Blue Rockfish** | | | | | | |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | -29.570178 | 23.174015 | -1.28 | 0.2214 |
| | Carmel Bay SMCA | year | 0.014438 | 0.011521 | 1.25 | 0.2293 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 30.457209 | 20.295149 | 1.50 | 0.1499 |
| | Lovers Point - Julia Platt SMR | year | -0.015135 | 0.010100 | -1.50 | 0.1504 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -95.189034 | 36.890283 | -2.58 | 0.0326 |
| | Point Buchon SMR | year | 0.047465 | 0.018321 | 2.59 | 0.0321 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | 496.413117 | 146.416242 | 3.39 | 0.0428 |
| | Point Cabrillo SMR | year | -0.246015 | 0.072605 | -3.39 | 0.0428 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | 43.937133 | 30.274725 | 1.45 | 0.1704 |
| | Point Lobos SMR | year | -0.021823 | 0.015040 | -1.45 | 0.1705 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | -88.977093 | 58.497256 | -1.52 | 0.1721 |
| | Point Sur SMR | year | 0.044296 | 0.029082 | 1.52 | 0.1715 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -56.941276 | 124.407996 | -0.46 | 0.6664 |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Saunders Reef SMCA | year | 0.028015 | 0.061715 | 0.45 | 0.6689 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | -68.131838 | 32.074676 | -2.12 | 0.1237 |
| | Stewarts Point SMR | year | 0.033811 | 0.015918 | 2.12 | 0.1237 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | 62.643723 | 73.738806 | 0.85 | 0.4580 |
| | Ten Mile SMR | year | -0.031246 | 0.036555 | -0.85 | 0.4555 |
| **Cabezon** | | | | | | |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | -20.281422 | 26.237842 | -0.77 | 0.4515 |
| | Carmel Bay SMCA | year | 0.010058 | 0.013044 | 0.77 | 0.4526 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 21.686565 | 16.680480 | 1.30 | 0.2091 |
| | Lovers Point - Julia Platt SMR | year | -0.010732 | 0.008301 | -1.29 | 0.2115 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -11.480830 | 48.453147 | -0.24 | 0.8187 |
| | Point Buchon SMR | year | 0.005753 | 0.024064 | 0.24 | 0.8171 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | 3.565561 | 24.408783 | 0.15 | 0.8861 |
| | Point Lobos SMR | year | -0.001695 | 0.012126 | -0.14 | 0.8910 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 16.067116 | 54.143765 | 0.30 | 0.7753 |
| | Point Sur SMR | year | -0.007959 | 0.026918 | -0.30 | 0.7761 |
| **California Sheephead** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -248.308213 | 103.471878 | -2.40 | 0.0432 |
| | Abalone Cove SMCA | year | 0.123002 | 0.051338 | 2.40 | 0.0435 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | 17.815317 | 25.966734 | 0.69 | 0.5039 |
| | Anacapa Island SMCA | year | -0.008643 | 0.012906 | -0.67 | 0.5140 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 41.714236 | 22.404589 | 1.86 | 0.0837 |
| | Anacapa Island SMR | year | -0.020559 | 0.011136 | -1.85 | 0.0861 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 29.359914 | 58.831359 | 0.50 | 0.6285 |
| | Campus Point SMCA | year | -0.014585 | 0.029204 | -0.50 | 0.6283 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | -50.409120 | 18.514316 | -2.72 | 0.0157 |
| | Gull Island SMR | year | 0.025286 | 0.009205 | 2.75 | 0.0150 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | 29.729521 | 44.228408 | 0.67 | 0.5142 |
| | Harris Point SMR | year | -0.014519 | 0.021989 | -0.66 | 0.5216 |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -16.420216 | 54.720676 | -0.30 | 0.7703 |
| | Naples SMCA | year | 0.008532 | 0.027163 | 0.31 | 0.7599 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -22.117800 | 13.502161 | -1.64 | 0.1222 |
| | Painted Cave SMCA | year | 0.011256 | 0.006713 | 1.68 | 0.1143 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -73.417614 | 41.978555 | -1.75 | 0.1109 |
| | Point Vicente SMCA | year | 0.036622 | 0.020838 | 1.76 | 0.1094 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | 3.175197 | 12.920466 | 0.25 | 0.8092 |
| | Scorpion SMR | year | -0.001445 | 0.006422 | -0.23 | 0.8250 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | 1.627771 | 30.683921 | 0.05 | 0.9584 |
| | South Point SMR | year | -0.000650 | 0.015247 | -0.04 | 0.9666 |
| **Garibaldi** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -15.057538 | 73.363758 | -0.21 | 0.8425 |
| | Abalone Cove SMCA | year | 0.007421 | 0.036400 | 0.20 | 0.8435 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | -13.660935 | 18.511860 | -0.74 | 0.4727 |
| | Anacapa Island SMCA | year | 0.006826 | 0.009201 | 0.74 | 0.4705 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 0.784789 | 16.322948 | 0.05 | 0.9623 |
| | Anacapa Island SMR | year | -0.000424 | 0.008113 | -0.05 | 0.9591 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 13.318637 | 6.655604 | 2.00 | 0.0733 |
| | Campus Point SMCA | year | -0.006623 | 0.003304 | -2.00 | 0.0728 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 9.717952 | 17.232364 | 0.56 | 0.5811 |
| | Gull Island SMR | year | -0.004562 | 0.008567 | -0.53 | 0.6022 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -17.564690 | 13.637333 | -1.29 | 0.2268 |
| | Naples SMCA | year | 0.008753 | 0.006770 | 1.29 | 0.2251 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -38.148568 | 17.853216 | -2.14 | 0.0495 |
| | Painted Cave SMCA | year | 0.018860 | 0.008876 | 2.12 | 0.0506 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -32.077194 | 46.021958 | -0.70 | 0.5017 |
| | Point Vicente SMCA | year | 0.016216 | 0.022845 | 0.71 | 0.4940 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | 0.954003 | 16.140769 | 0.06 | 0.9536 |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Scorpion SMR | year | -0.000636 | 0.008022 | -0.08 | 0.9379 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -7.196351 | 16.797197 | -0.43 | 0.6749 |
| | South Point SMR | year | 0.003590 | 0.008346 | 0.43 | 0.6737 |
| **Gopher Rockfish** | | | | | | |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | 17.205862 | 19.032970 | 0.90 | 0.3803 |
| | Carmel Bay SMCA | year | -0.008508 | 0.009462 | -0.90 | 0.3828 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 1.676324 | 12.041957 | 0.14 | 0.8908 |
| | Lovers Point - Julia Platt SMR | year | -0.000833 | 0.005993 | -0.14 | 0.8909 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -9.810444 | 38.810421 | -0.25 | 0.8068 |
| | Point Buchon SMR | year | 0.005032 | 0.019275 | 0.26 | 0.8006 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | 116.158151 | 66.539494 | 1.75 | 0.1792 |
| | Point Cabrillo SMR | year | -0.057520 | 0.032996 | -1.74 | 0.1796 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | -27.972672 | 24.824035 | -1.13 | 0.2802 |
| | Point Lobos SMR | year | 0.013973 | 0.012332 | 1.13 | 0.2776 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | -66.980456 | 22.922556 | -2.92 | 0.0223 |
| | Point Sur SMR | year | 0.033195 | 0.011396 | 2.91 | 0.0226 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | 78.848003 | 37.138152 | 2.12 | 0.0872 |
| | Saunders Reef SMCA | year | -0.039235 | 0.018423 | -2.13 | 0.0864 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | 29.743082 | 30.978619 | 0.96 | 0.4078 |
| | Stewarts Point SMR | year | -0.014721 | 0.015374 | -0.96 | 0.4089 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | 21.484889 | 91.991698 | 0.23 | 0.8304 |
| | Ten Mile SMR | year | -0.010764 | 0.045604 | -0.24 | 0.8286 |
| **Kelp Bass** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -358.916659 | 78.602028 | -4.57 | 0.0018 |
| | Abalone Cove SMCA | year | 0.178050 | 0.038999 | 4.57 | 0.0018 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | 7.169345 | 21.887663 | 0.33 | 0.7481 |
| | Anacapa Island SMCA | year | -0.003403 | 0.010879 | -0.31 | 0.7590 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 41.483472 | 23.018119 | 1.80 | 0.0931 |
| | Anacapa Island SMR | year | -0.020498 | 0.011441 | -1.79 | 0.0948 |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 37.372933 | 64.025938 | 0.58 | 0.5723 |
| | Campus Point SMCA | year | -0.018459 | 0.031782 | -0.58 | 0.5742 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | -123.840479 | 21.411871 | -5.78 | <.0001 |
| | Gull Island SMR | year | 0.061600 | 0.010645 | 5.79 | <.0001 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | -75.576479 | 31.787961 | -2.38 | 0.0349 |
| | Harris Point SMR | year | 0.037839 | 0.015804 | 2.39 | 0.0339 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -93.178861 | 34.281001 | -2.72 | 0.0216 |
| | Naples SMCA | year | 0.046425 | 0.017017 | 2.73 | 0.0213 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -61.932826 | 20.151683 | -3.07 | 0.0077 |
| | Painted Cave SMCA | year | 0.030855 | 0.010019 | 3.08 | 0.0076 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -182.934586 | 45.502000 | -4.02 | 0.0024 |
| | Point Vicente SMCA | year | 0.090907 | 0.022587 | 4.02 | 0.0024 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | 23.519903 | 20.283891 | 1.16 | 0.2644 |
| | Scorpion SMR | year | -0.011612 | 0.010081 | -1.15 | 0.2674 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | 0.903225 | 28.357331 | 0.03 | 0.9750 |
| | South Point SMR | year | -0.000367 | 0.014091 | -0.03 | 0.9796 |
| **Kelp Greenling** | | | | | | |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | -24.735610 | 18.012518 | -1.37 | 0.1899 |
| | Carmel Bay SMCA | year | 0.012268 | 0.008955 | 1.37 | 0.1908 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 25.073713 | 10.731580 | 2.34 | 0.0306 |
| | Lovers Point - Julia Platt SMR | year | -0.012400 | 0.005340 | -2.32 | 0.0315 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -18.737160 | 20.217194 | -0.93 | 0.3811 |
| | Point Buchon SMR | year | 0.009268 | 0.010041 | 0.92 | 0.3830 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | -90.745257 | 85.992401 | -1.06 | 0.3688 |
| | Point Cabrillo SMR | year | 0.045049 | 0.042642 | 1.06 | 0.3683 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | 9.115848 | 26.386083 | 0.35 | 0.7353 |
| | Point Lobos SMR | year | -0.004597 | 0.013108 | -0.35 | 0.7314 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 9.276774 | 22.808095 | 0.41 | 0.6964 |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Point Sur SMR | year | -0.004776 | 0.011339 | -0.42 | 0.6862 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -27.232047 | 32.560432 | -0.84 | 0.4411 |
| | Saunders Reef SMCA | year | 0.013571 | 0.016152 | 0.84 | 0.4391 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | 47.051339 | 25.226939 | 1.87 | 0.1590 |
| | Stewarts Point SMR | year | -0.023362 | 0.012520 | -1.87 | 0.1589 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | -16.262137 | 31.729512 | -0.51 | 0.6436 |
| | Ten Mile SMR | year | 0.007993 | 0.015729 | 0.51 | 0.6463 |
| **Kelp Rockfish** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | 16.952435 | 44.392224 | 0.38 | 0.7125 |
| | Abalone Cove SMCA | year | -0.008322 | 0.022025 | -0.38 | 0.7154 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | -27.355882 | 17.722025 | -1.54 | 0.1450 |
| | Anacapa Island SMCA | year | 0.013644 | 0.008808 | 1.55 | 0.1437 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 6.088930 | 11.392990 | 0.53 | 0.6014 |
| | Anacapa Island SMR | year | -0.002992 | 0.005663 | -0.53 | 0.6055 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 16.555419 | 54.611274 | 0.30 | 0.7680 |
| | Campus Point SMCA | year | -0.008369 | 0.027109 | -0.31 | 0.7639 |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | -0.206474 | 15.805308 | -0.01 | 0.9897 |
| | Carmel Bay SMCA | year | 0.000064553 | 0.007858 | 0.01 | 0.9936 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 20.379092 | 22.070676 | 0.92 | 0.3704 |
| | Gull Island SMR | year | -0.010152 | 0.010973 | -0.93 | 0.3695 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | 49.103721 | 18.895287 | 2.60 | 0.0233 |
| | Harris Point SMR | year | -0.024426 | 0.009394 | -2.60 | 0.0232 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | -11.217613 | 15.206835 | -0.74 | 0.4697 |
| | Lovers Point - Julia Platt SMR | year | 0.005648 | 0.007568 | 0.75 | 0.4646 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -146.786448 | 54.383679 | -2.70 | 0.0223 |
| | Naples SMCA | year | 0.072911 | 0.026996 | 2.70 | 0.0223 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -98.195010 | 21.288540 | -4.61 | 0.0003 |
| | Painted Cave SMCA | year | 0.048681 | 0.010584 | 4.60 | 0.0003 |
| | **Point Buchon SMR** | | | | | |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Point Buchon SMR | Intercept | 27.880225 | 27.203410 | 1.02 | 0.3354 |
| | Point Buchon SMR | year | -0.013804 | 0.013510 | -1.02 | 0.3368 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | -26.069294 | 19.637201 | -1.33 | 0.2072 |
| | Point Lobos SMR | year | 0.013063 | 0.009755 | 1.34 | 0.2035 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 28.361959 | 23.993030 | 1.18 | 0.2758 |
| | Point Sur SMR | year | -0.013958 | 0.011928 | -1.17 | 0.2802 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -74.551502 | 24.930918 | -2.99 | 0.0136 |
| | Point Vicente SMCA | year | 0.037102 | 0.012376 | 3.00 | 0.0134 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -60.259123 | 25.135118 | -2.40 | 0.0300 |
| | Scorpion SMR | year | 0.029873 | 0.012493 | 2.39 | 0.0303 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -18.381179 | 23.535462 | -0.78 | 0.4478 |
| | South Point SMR | year | 0.009183 | 0.011695 | 0.79 | 0.4454 |
| **Lingcod** | | | | | | |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | 23.899148 | 28.082171 | 0.85 | 0.4081 |
| | Carmel Bay SMCA | year | -0.012068 | 0.013961 | -0.86 | 0.4010 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 16.214393 | 22.407558 | 0.72 | 0.4781 |
| | Lovers Point - Julia Platt SMR | year | -0.008006 | 0.011151 | -0.72 | 0.4815 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | 48.923776 | 70.605220 | 0.69 | 0.5080 |
| | Point Buchon SMR | year | -0.024187 | 0.035066 | -0.69 | 0.5099 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | -169.668457 | 191.719669 | -0.88 | 0.4413 |
| | Point Cabrillo SMR | year | 0.084140 | 0.095071 | 0.89 | 0.4413 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | -102.084826 | 47.310903 | -2.16 | 0.0502 |
| | Point Lobos SMR | year | 0.050898 | 0.023503 | 2.17 | 0.0495 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 19.823530 | 76.421553 | 0.26 | 0.8028 |
| | Point Sur SMR | year | -0.009886 | 0.037993 | -0.26 | 0.8022 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | 54.279000 | 122.301488 | 0.44 | 0.6757 |
| | Saunders Reef SMCA | year | -0.027054 | 0.060670 | -0.45 | 0.6743 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | 2.338180 | 74.793719 | 0.03 | 0.9770 |
| | Stewarts Point SMR | year | -0.000980 | 0.037118 | -0.03 | 0.9806 |

## Table 19. continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | -25.460586 | 13.260896 | -1.92 | 0.1506 |
| | Ten Mile SMR | year | 0.012667 | 0.006574 | 1.93 | 0.1496 |
| **Opaleye** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -189.428847 | 126.239850 | -1.50 | 0.1719 |
| | Abalone Cove SMCA | year | 0.093742 | 0.062634 | 1.50 | 0.1729 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | -1.321279 | 31.533055 | -0.04 | 0.9672 |
| | Anacapa Island SMCA | year | 0.000558 | 0.015673 | 0.04 | 0.9721 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | -11.084593 | 30.457372 | -0.36 | 0.7213 |
| | Anacapa Island SMR | year | 0.005400 | 0.015138 | 0.36 | 0.7266 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 92.963084 | 76.228901 | 1.22 | 0.2506 |
| | Campus Point SMCA | year | -0.046184 | 0.037840 | -1.22 | 0.2503 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 2.077159 | 38.194890 | 0.05 | 0.9573 |
| | Gull Island SMR | year | -0.000826 | 0.018989 | -0.04 | 0.9659 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -45.489219 | 82.457210 | -0.55 | 0.5933 |
| | Naples SMCA | year | 0.022644 | 0.040932 | 0.55 | 0.5923 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -120.737786 | 33.821280 | -3.57 | 0.0028 |
| | Painted Cave SMCA | year | 0.060239 | 0.016815 | 3.58 | 0.0027 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -19.889632 | 77.473917 | -0.26 | 0.8026 |
| | Point Vicente SMCA | year | 0.010106 | 0.038458 | 0.26 | 0.7980 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | 17.941783 | 42.382075 | 0.42 | 0.6781 |
| | Scorpion SMR | year | -0.008822 | 0.021065 | -0.42 | 0.6813 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | 18.205814 | 47.324954 | 0.38 | 0.7062 |
| | South Point SMR | year | -0.008996 | 0.023515 | -0.38 | 0.7078 |

**Table 20.** Slope estimates for focal invertebrate and algal density log response ratio by species and MPA group. The linear regression model includes year as a fixed effect.

| Species | MPA Group | Parameter | Estimate | StdErr | tValue | Probt |
|---|---|---|---|---|---|---|
| **All Abalone Spp.** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -2.119646 | 2.475967 | -0.86 | 0.4169 |
| | Abalone Cove SMCA | year | 0.001053 | 0.001228 | 0.86 | 0.4161 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | -4.432615 | 1.247849 | -3.55 | 0.0045 |
| | Anacapa Island SMCA | year | 0.002204 | 0.000620 | 3.56 | 0.0045 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | -6.928514 | 2.219340 | -3.12 | 0.0097 |
| | Anacapa Island SMR | year | 0.003448 | 0.001102 | 3.13 | 0.0096 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 4.169749 | 2.315152 | 1.80 | 0.1052 |
| | Campus Point SMCA | year | -0.002073 | 0.001149 | -1.80 | 0.1048 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 0.521084 | 1.997179 | 0.26 | 0.7982 |
| | Gull Island SMR | year | -0.000261 | 0.000993 | -0.26 | 0.7965 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | -0.289507 | 0.699643 | -0.41 | 0.6863 |
| | Harris Point SMR | year | 0.000142 | 0.000348 | 0.41 | 0.6898 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | 1.583088 | 2.974003 | 0.53 | 0.6074 |
| | Naples SMCA | year | -0.000783 | 0.001476 | -0.53 | 0.6086 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | 1.798460 | 1.922306 | 0.94 | 0.3654 |
| | Painted Cave SMCA | year | -0.000902 | 0.000956 | -0.94 | 0.3616 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | -129.182339 | 41.625381 | -3.10 | 0.0532 |
| | Point Cabrillo SMR | year | 0.064037 | 0.020641 | 3.10 | 0.0532 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | 1.831922 | 1.389202 | 1.32 | 0.2167 |
| | Point Vicente SMCA | year | -0.000913 | 0.000690 | -1.32 | 0.2151 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -57.467201 | 20.405094 | -2.82 | 0.0480 |
| | Saunders Reef SMCA | year | 0.028556 | 0.010126 | 2.82 | 0.0478 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -1.351551 | 0.576555 | -2.34 | 0.0333 |
| | Scorpion SMR | year | 0.000672 | 0.000287 | 2.35 | 0.0332 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -0.259909 | 3.457154 | -0.08 | 0.9413 |
| | South Point SMR | year | 0.000157 | 0.001718 | 0.09 | 0.9287 |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | -18.289451 | 11.444545 | -1.60 | 0.2083 |
| | Stewarts Point SMR | year | 0.009063 | 0.005680 | 1.60 | 0.2088 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | -24.136709 | 9.436930 | -2.56 | 0.0834 |
| | Ten Mile SMR | year | 0.011959 | 0.004678 | 2.56 | 0.0835 |
| **All Gorgonian Spp.** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -126.872792 | 48.666581 | -2.61 | 0.0313 |
| | Abalone Cove SMCA | year | 0.063054 | 0.024146 | 2.61 | 0.0311 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | 11.625476 | 25.951123 | 0.45 | 0.6629 |
| | Anacapa Island SMCA | year | -0.005632 | 0.012888 | -0.44 | 0.6706 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 16.852704 | 12.128246 | 1.39 | 0.1922 |
| | Anacapa Island SMR | year | -0.008439 | 0.006023 | -1.40 | 0.1888 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 6.243494 | 21.858622 | 0.29 | 0.7816 |
| | Campus Point SMCA | year | -0.003090 | 0.010848 | -0.28 | 0.7822 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | -13.196198 | 9.809279 | -1.35 | 0.2015 |
| | Gull Island SMR | year | 0.006533 | 0.004876 | 1.34 | 0.2033 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | 0.615469 | 0.281698 | 2.18 | 0.0495 |
| | Harris Point SMR | year | -0.000305 | 0.000140 | -2.18 | 0.0499 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | 30.601370 | 16.944462 | 1.81 | 0.1044 |
| | Naples SMCA | year | -0.015182 | 0.008409 | -1.81 | 0.1045 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -4.841202 | 5.826520 | -0.83 | 0.4200 |
| | Painted Cave SMCA | year | 0.002323 | 0.002897 | 0.80 | 0.4360 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -6.862563 | 16.813894 | -0.41 | 0.6918 |
| | Point Vicente SMCA | year | 0.003561 | 0.008346 | 0.43 | 0.6787 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -15.957150 | 10.624310 | -1.50 | 0.1539 |
| | Scorpion SMR | year | 0.007818 | 0.005280 | 1.48 | 0.1594 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | 2.735309 | 2.730534 | 1.00 | 0.3362 |
| | South Point SMR | year | -0.001375 | 0.001357 | -1.01 | 0.3310 |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| **All Sea Cucumber Spp.** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -41.835779 | 25.512737 | -1.64 | 0.1397 |
| | Abalone Cove SMCA | year | 0.020767 | 0.012658 | 1.64 | 0.1395 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | -55.474909 | 13.890883 | -3.99 | 0.0021 |
| | Anacapa Island SMCA | year | 0.027721 | 0.006899 | 4.02 | 0.0020 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | -57.358083 | 13.193236 | -4.35 | 0.0012 |
| | Anacapa Island SMR | year | 0.028729 | 0.006552 | 4.38 | 0.0011 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | -30.071150 | 6.250252 | -4.81 | 0.0010 |
| | Campus Point SMCA | year | 0.014893 | 0.003102 | 4.80 | 0.0010 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 10.654491 | 11.760107 | 0.91 | 0.3814 |
| | Gull Island SMR | year | -0.005225 | 0.005846 | -0.89 | 0.3877 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | -12.748774 | 6.299634 | -2.02 | 0.0659 |
| | Harris Point SMR | year | 0.006382 | 0.003132 | 2.04 | 0.0643 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -14.826161 | 9.649672 | -1.54 | 0.1588 |
| | Naples SMCA | year | 0.007368 | 0.004789 | 1.54 | 0.1583 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | 9.606998 | 9.158638 | 1.05 | 0.3120 |
| | Painted Cave SMCA | year | -0.004762 | 0.004554 | -1.05 | 0.3134 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -9.340636 | 10.079633 | -0.93 | 0.3759 |
| | Point Vicente SMCA | year | 0.004649 | 0.005004 | 0.93 | 0.3747 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -70.193205 | 17.006976 | -4.13 | 0.0009 |
| | Scorpion SMR | year | 0.035142 | 0.008453 | 4.16 | 0.0008 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -1.528931 | 4.848542 | -0.32 | 0.7579 |
| | South Point SMR | year | 0.000780 | 0.002409 | 0.32 | 0.7517 |
| **Bull Kelp** | | | | | | |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | -19.033253 | 20.723162 | -0.92 | 0.3729 |
| | Carmel Bay SMCA | year | 0.009370 | 0.010302 | 0.91 | 0.3775 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 20.973317 | 12.809996 | 1.64 | 0.1172 |
| | Lovers Point - Julia Platt SMR | year | -0.010468 | 0.006375 | -1.64 | 0.1162 |
| | **Point Buchon SMR** | | | | | |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Point Buchon SMR | Intercept | -6.036561 | 50.057227 | -0.12 | 0.9070 |
| | Point Buchon SMR | year | 0.002885 | 0.024861 | 0.12 | 0.9105 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | 5.115880 | 6.390699 | 0.80 | 0.4819 |
| | Point Cabrillo SMR | year | -0.002532 | 0.003169 | -0.80 | 0.4827 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | -39.151606 | 32.127015 | -1.22 | 0.2446 |
| | Point Lobos SMR | year | 0.019363 | 0.015960 | 1.21 | 0.2466 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 78.720303 | 17.851226 | 4.41 | 0.0045 |
| | Point Sur SMR | year | -0.038865 | 0.008878 | -4.38 | 0.0047 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -195.254807 | 90.607524 | -2.15 | 0.0974 |
| | Saunders Reef SMCA | year | 0.097099 | 0.044963 | 2.16 | 0.0969 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | 20.120377 | 18.403981 | 1.09 | 0.3542 |
| | Stewarts Point SMR | year | -0.009983 | 0.009133 | -1.09 | 0.3543 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | 30.784852 | 67.185667 | 0.46 | 0.6780 |
| | Ten Mile SMR | year | -0.015332 | 0.033306 | -0.46 | 0.6766 |
| **Giant Kelp** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | -100.112597 | 62.241555 | -1.61 | 0.1464 |
| | Abalone Cove SMCA | year | 0.049735 | 0.030881 | 1.61 | 0.1459 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | -213.970974 | 40.321372 | -5.31 | 0.0002 |
| | Anacapa Island SMCA | year | 0.106356 | 0.020025 | 5.31 | 0.0002 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | -6.220306 | 30.502774 | -0.20 | 0.8421 |
| | Anacapa Island SMR | year | 0.003330 | 0.015149 | 0.22 | 0.8300 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 9.510430 | 50.410881 | 0.19 | 0.8545 |
| | Campus Point SMCA | year | -0.004680 | 0.025018 | -0.19 | 0.8558 |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | -35.211529 | 15.547780 | -2.26 | 0.0388 |
| | Carmel Bay SMCA | year | 0.017521 | 0.007730 | 2.27 | 0.0386 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | -69.432058 | 24.742460 | -2.81 | 0.0149 |
| | Gull Island SMR | year | 0.034617 | 0.012299 | 2.81 | 0.0146 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | -3.391571 | 24.786401 | -0.14 | 0.8934 |
| | Harris Point SMR | year | 0.001599 | 0.012323 | 0.13 | 0.8989 |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | -8.613096 | 5.287236 | -1.63 | 0.1190 |
| | Lovers Point - Julia Platt SMR | year | 0.004267 | 0.002631 | 1.62 | 0.1205 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -49.778112 | 32.574754 | -1.53 | 0.1608 |
| | Naples SMCA | year | 0.024685 | 0.016166 | 1.53 | 0.1611 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -64.574406 | 22.985153 | -2.81 | 0.0139 |
| | Painted Cave SMCA | year | 0.031905 | 0.011429 | 2.79 | 0.0144 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | 5.800091 | 7.520979 | 0.77 | 0.4628 |
| | Point Buchon SMR | year | -0.002836 | 0.003735 | -0.76 | 0.4695 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | 6.760494 | 10.649528 | 0.63 | 0.5366 |
| | Point Lobos SMR | year | -0.003365 | 0.005290 | -0.64 | 0.5357 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | -32.403202 | 16.751942 | -1.93 | 0.1012 |
| | Point Sur SMR | year | 0.016044 | 0.008331 | 1.93 | 0.1024 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | 11.498603 | 40.076285 | 0.29 | 0.7800 |
| | Point Vicente SMCA | year | -0.005725 | 0.019894 | -0.29 | 0.7794 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -112.193182 | 33.043370 | -3.40 | 0.0040 |
| | Scorpion SMR | year | 0.056037 | 0.016423 | 3.41 | 0.0039 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -47.011073 | 18.916604 | -2.49 | 0.0287 |
| | South Point SMR | year | 0.023406 | 0.009398 | 2.49 | 0.0284 |
| **Purple Urchin Adult** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | 207.005265 | 109.201845 | 1.90 | 0.0946 |
| | Abalone Cove SMCA | year | -0.102484 | 0.054181 | -1.89 | 0.0952 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | 71.706344 | 29.195594 | 2.46 | 0.0319 |
| | Anacapa Island SMCA | year | -0.035838 | 0.014500 | -2.47 | 0.0310 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 216.944722 | 32.854814 | 6.60 | <.0001 |
| | Anacapa Island SMR | year | -0.108204 | 0.016317 | -6.63 | <.0001 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 134.680911 | 64.141762 | 2.10 | 0.0651 |
| | Campus Point SMCA | year | -0.066784 | 0.031832 | -2.10 | 0.0653 |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | 29.284362 | 16.902768 | 1.73 | 0.1037 |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Carmel Bay SMCA | year | -0.014652 | 0.008403 | -1.74 | 0.1017 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 150.801469 | 44.569470 | 3.38 | 0.0049 |
| | Gull Island SMR | year | -0.075099 | 0.022155 | -3.39 | 0.0048 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | -7.480077 | 29.353258 | -0.25 | 0.8032 |
| | Harris Point SMR | year | 0.003651 | 0.014594 | 0.25 | 0.8067 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | -28.231198 | 10.232522 | -2.76 | 0.0121 |
| | Lovers Point - Julia Platt SMR | year | 0.014055 | 0.005092 | 2.76 | 0.0121 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -92.469219 | 47.208687 | -1.96 | 0.0818 |
| | Naples SMCA | year | 0.045767 | 0.023429 | 1.95 | 0.0825 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | 45.176453 | 24.988672 | 1.81 | 0.0922 |
| | Painted Cave SMCA | year | -0.022366 | 0.012425 | -1.80 | 0.0934 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -67.614844 | 48.719272 | -1.39 | 0.2026 |
| | Point Buchon SMR | year | 0.033701 | 0.024196 | 1.39 | 0.2012 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | 108.577382 | 101.407560 | 1.07 | 0.3628 |
| | Point Cabrillo SMR | year | -0.053737 | 0.050286 | -1.07 | 0.3636 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | 30.340922 | 23.080752 | 1.31 | 0.2114 |
| | Point Lobos SMR | year | -0.015101 | 0.011466 | -1.32 | 0.2106 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 57.608650 | 9.585095 | 6.01 | 0.0010 |
| | Point Sur SMR | year | -0.028706 | 0.004767 | -6.02 | 0.0009 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | 104.903429 | 22.381760 | 4.69 | 0.0009 |
| | Point Vicente SMCA | year | -0.051798 | 0.011110 | -4.66 | 0.0009 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -27.851215 | 77.574205 | -0.36 | 0.7377 |
| | Saunders Reef SMCA | year | 0.013818 | 0.038495 | 0.36 | 0.7378 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | 120.308419 | 36.474866 | 3.30 | 0.0049 |
| | Scorpion SMR | year | -0.060000 | 0.018129 | -3.31 | 0.0048 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | 140.084764 | 35.548604 | 3.94 | 0.0020 |
| | South Point SMR | year | -0.069499 | 0.017661 | -3.94 | 0.0020 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | 50.000375 | 35.993345 | 1.39 | 0.2589 |

**Table 20. Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| | Stewarts Point SMR | year | -0.024790 | 0.017863 | -1.39 | 0.2593 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | -247.201582 | 31.504377 | -7.85 | 0.0043 |
| | Ten Mile SMR | year | 0.122661 | 0.015618 | 7.85 | 0.0043 |
| **Red Abalone** | | | | | | |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | -0.012061 | 0.116238 | -0.10 | 0.9192 |
| | Anacapa Island SMR | year | 0.000006105 | 0.000057728 | 0.11 | 0.9177 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 3.737328 | 2.367097 | 1.58 | 0.1488 |
| | Campus Point SMCA | year | -0.001858 | 0.001175 | -1.58 | 0.1483 |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | -7.982049 | 6.474727 | -1.23 | 0.2366 |
| | Carmel Bay SMCA | year | 0.003958 | 0.003219 | 1.23 | 0.2378 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 3.367126 | 1.385300 | 2.43 | 0.0303 |
| | Gull Island SMR | year | -0.001679 | 0.000689 | -2.44 | 0.0299 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | 0.057183 | 0.652537 | 0.09 | 0.9316 |
| | Harris Point SMR | year | -0.000030333 | 0.000324 | -0.09 | 0.9271 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | -3.872408 | 1.766822 | -2.19 | 0.0404 |
| | Lovers Point - Julia Platt SMR | year | 0.001932 | 0.000879 | 2.20 | 0.0399 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | 1.150667 | 2.974084 | 0.39 | 0.7078 |
| | Naples SMCA | year | -0.000568 | 0.001476 | -0.38 | 0.7092 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | 2.217726 | 1.878564 | 1.18 | 0.2575 |
| | Painted Cave SMCA | year | -0.001110 | 0.000934 | -1.19 | 0.2545 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -10.460704 | 4.647376 | -2.25 | 0.0545 |
| | Point Buchon SMR | year | 0.005217 | 0.002308 | 2.26 | 0.0537 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | -111.973212 | 43.246947 | -2.59 | 0.0811 |
| | Point Cabrillo SMR | year | 0.055503 | 0.021445 | 2.59 | 0.0812 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | -9.203875 | 8.936685 | -1.03 | 0.3218 |
| | Point Lobos SMR | year | 0.004593 | 0.004439 | 1.03 | 0.3197 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 0.367755 | 3.436785 | 0.11 | 0.9183 |
| | Point Sur SMR | year | -0.000175 | 0.001709 | -0.10 | 0.9219 |
| | **Saunders Reef SMCA** | | | | | |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Saunders Reef SMCA | Intercept | -58.650400 | 22.285663 | -2.63 | 0.0581 |
| | Saunders Reef SMCA | year | 0.029146 | 0.011059 | 2.64 | 0.0579 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -0.181941 | 0.139576 | -1.30 | 0.2120 |
| | Scorpion SMR | year | 0.000090334 | 0.000069371 | 1.30 | 0.2125 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -0.247078 | 3.455615 | -0.07 | 0.9442 |
| | South Point SMR | year | 0.000151 | 0.001717 | 0.09 | 0.9315 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | -16.855735 | 9.457276 | -1.78 | 0.1727 |
| | Stewarts Point SMR | year | 0.008350 | 0.004693 | 1.78 | 0.1733 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | 27.755205 | 22.305805 | 1.24 | 0.3017 |
| | Ten Mile SMR | year | -0.013759 | 0.011058 | -1.24 | 0.3018 |
| **Red Urchin Adult** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | 184.158814 | 30.020278 | 6.13 | 0.0003 |
| | Abalone Cove SMCA | year | -0.091158 | 0.014895 | -6.12 | 0.0003 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | 92.263579 | 26.732574 | 3.45 | 0.0054 |
| | Anacapa Island SMCA | year | -0.046020 | 0.013276 | -3.47 | 0.0053 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | 100.396331 | 18.158736 | 5.53 | 0.0002 |
| | Anacapa Island SMR | year | -0.050135 | 0.009018 | -5.56 | 0.0002 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | 105.066500 | 36.326090 | 2.89 | 0.0178 |
| | Campus Point SMCA | year | -0.052098 | 0.018028 | -2.89 | 0.0179 |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | 6.076556 | 15.029278 | 0.40 | 0.6917 |
| | Carmel Bay SMCA | year | -0.003033 | 0.007472 | -0.41 | 0.6905 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 69.161175 | 21.391714 | 3.23 | 0.0065 |
| | Gull Island SMR | year | -0.034515 | 0.010634 | -3.25 | 0.0064 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | 22.678847 | 24.692958 | 0.92 | 0.3765 |
| | Harris Point SMR | year | -0.011133 | 0.012277 | -0.91 | 0.3823 |
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 2.318059 | 7.424970 | 0.31 | 0.7581 |
| | Lovers Point - Julia Platt SMR | year | -0.001171 | 0.003695 | -0.32 | 0.7546 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -7.881677 | 57.942115 | -0.14 | 0.8948 |
| | Naples SMCA | year | 0.004154 | 0.028755 | 0.14 | 0.8883 |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | 33.804436 | 27.547507 | 1.23 | 0.2400 |
| | Painted Cave SMCA | year | -0.016609 | 0.013698 | -1.21 | 0.2454 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | 3.506761 | 9.360072 | 0.37 | 0.7177 |
| | Point Buchon SMR | year | -0.001741 | 0.004649 | -0.37 | 0.7177 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | 52.583313 | 121.403394 | 0.43 | 0.6942 |
| | Point Cabrillo SMR | year | -0.025925 | 0.060202 | -0.43 | 0.6958 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | -4.564367 | 15.453894 | -0.30 | 0.7724 |
| | Point Lobos SMR | year | 0.002259 | 0.007677 | 0.29 | 0.7732 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | 73.274550 | 10.150009 | 7.22 | 0.0004 |
| | Point Sur SMR | year | -0.036506 | 0.005048 | -7.23 | 0.0004 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -53.218433 | 23.079991 | -2.31 | 0.0438 |
| | Point Vicente SMCA | year | 0.026545 | 0.011457 | 2.32 | 0.0430 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -38.588289 | 31.617470 | -1.22 | 0.2893 |
| | Saunders Reef SMCA | year | 0.019116 | 0.015690 | 1.22 | 0.2900 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | 46.633552 | 16.414870 | 2.84 | 0.0124 |
| | Scorpion SMR | year | -0.023213 | 0.008158 | -2.85 | 0.0123 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | 3.684407 | 16.902948 | 0.22 | 0.8311 |
| | South Point SMR | year | -0.001730 | 0.008398 | -0.21 | 0.8402 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | 122.348637 | 48.963856 | 2.50 | 0.0878 |
| | Stewarts Point SMR | year | -0.060725 | 0.024300 | -2.50 | 0.0878 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | -147.702236 | 46.538357 | -3.17 | 0.0503 |
| | Ten Mile SMR | year | 0.073192 | 0.023071 | 3.17 | 0.0504 |
| **Spiny Lobster** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | 14.984371 | 16.677116 | 0.90 | 0.3952 |
| | Abalone Cove SMCA | year | -0.007459 | 0.008274 | -0.90 | 0.3937 |
| | **Anacapa Island SMCA** | | | | | |
| | Anacapa Island SMCA | Intercept | 4.199240 | 2.186159 | 1.92 | 0.0810 |
| | Anacapa Island SMCA | year | -0.002090 | 0.001086 | -1.93 | 0.0805 |
| | **Anacapa Island SMR** | | | | | |
| | Anacapa Island SMR | Intercept | -13.614760 | 5.843197 | -2.33 | 0.0399 |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | Anacapa Island SMR | year | 0.006823 | 0.002902 | 2.35 | 0.0384 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | -31.317412 | 12.966070 | -2.42 | 0.0389 |
| | Campus Point SMCA | year | 0.015576 | 0.006435 | 2.42 | 0.0386 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | -10.044097 | 5.068919 | -1.98 | 0.0691 |
| | Gull Island SMR | year | 0.005020 | 0.002520 | 1.99 | 0.0678 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | -1.194109 | 0.498969 | -2.39 | 0.0339 |
| | Harris Point SMR | year | 0.000595 | 0.000248 | 2.40 | 0.0336 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | -0.503452 | 10.938043 | -0.05 | 0.9643 |
| | Naples SMCA | year | 0.000260 | 0.005428 | 0.05 | 0.9629 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | -0.551769 | 0.817068 | -0.68 | 0.5105 |
| | Painted Cave SMCA | year | 0.000276 | 0.000406 | 0.68 | 0.5080 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | -23.600538 | 17.611066 | -1.34 | 0.2099 |
| | Point Vicente SMCA | year | 0.011737 | 0.008742 | 1.34 | 0.2091 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -18.841254 | 4.555890 | -4.14 | 0.0009 |
| | Scorpion SMR | year | 0.009409 | 0.002264 | 4.16 | 0.0008 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -4.220181 | 1.020515 | -4.14 | 0.0014 |
| | South Point SMR | year | 0.002103 | 0.000507 | 4.15 | 0.0014 |
| **Sunflower Star** | | | | | | |
| | **Abalone Cove SMCA** | | | | | |
| | Abalone Cove SMCA | Intercept | 2.159152 | 1.104829 | 1.95 | 0.0864 |
| | Abalone Cove SMCA | year | -0.001070 | 0.000548 | -1.95 | 0.0867 |
| | **Campus Point SMCA** | | | | | |
| | Campus Point SMCA | Intercept | -1.634843 | 1.815700 | -0.90 | 0.3914 |
| | Campus Point SMCA | year | 0.000810 | 0.000901 | 0.90 | 0.3922 |
| | **Carmel Bay SMCA** | | | | | |
| | Carmel Bay SMCA | Intercept | 1.029750 | 1.972939 | 0.52 | 0.6093 |
| | Carmel Bay SMCA | year | -0.000508 | 0.000981 | -0.52 | 0.6122 |
| | **Gull Island SMR** | | | | | |
| | Gull Island SMR | Intercept | 2.225265 | 7.336345 | 0.30 | 0.7664 |
| | Gull Island SMR | year | -0.001109 | 0.003647 | -0.30 | 0.7659 |
| | **Harris Point SMR** | | | | | |
| | Harris Point SMR | Intercept | 21.825474 | 11.132978 | 1.96 | 0.0736 |
| | Harris Point SMR | year | -0.010805 | 0.005535 | -1.95 | 0.0747 |

**Table 20.** continued

| | | | | | | |
|---|---|---|---|---|---|---|
| | **Lovers Point – Julia Platt SMR** | | | | | |
| | Lovers Point - Julia Platt SMR | Intercept | 1.177572 | 1.799045 | 0.65 | 0.5202 |
| | Lovers Point - Julia Platt SMR | year | -0.000584 | 0.000895 | -0.65 | 0.5216 |
| | **Naples SMCA** | | | | | |
| | Naples SMCA | Intercept | 25.939245 | 8.102917 | 3.20 | 0.0108 |
| | Naples SMCA | year | -0.012859 | 0.004021 | -3.20 | 0.0109 |
| | **Painted Cave SMCA** | | | | | |
| | Painted Cave SMCA | Intercept | 2.428598 | 9.203694 | 0.26 | 0.7957 |
| | Painted Cave SMCA | year | -0.001228 | 0.004576 | -0.27 | 0.7924 |
| | **Point Buchon SMR** | | | | | |
| | Point Buchon SMR | Intercept | -3.662292 | 5.351168 | -0.68 | 0.5131 |
| | Point Buchon SMR | year | 0.001814 | 0.002658 | 0.68 | 0.5141 |
| | **Point Cabrillo SMR** | | | | | |
| | Point Cabrillo SMR | Intercept | -1.220976 | 0.716865 | -1.70 | 0.1871 |
| | Point Cabrillo SMR | year | 0.000605 | 0.000355 | 1.70 | 0.1873 |
| | **Point Lobos SMR** | | | | | |
| | Point Lobos SMR | Intercept | -4.290019 | 2.790551 | -1.54 | 0.1482 |
| | Point Lobos SMR | year | 0.002125 | 0.001386 | 1.53 | 0.1493 |
| | **Point Sur SMR** | | | | | |
| | Point Sur SMR | Intercept | -2.076620 | 4.983631 | -0.42 | 0.6914 |
| | Point Sur SMR | year | 0.001036 | 0.002478 | 0.42 | 0.6906 |
| | **Point Vicente SMCA** | | | | | |
| | Point Vicente SMCA | Intercept | 7.227300 | 2.969231 | 2.43 | 0.0352 |
| | Point Vicente SMCA | year | -0.003581 | 0.001474 | -2.43 | 0.0355 |
| | **Saunders Reef SMCA** | | | | | |
| | Saunders Reef SMCA | Intercept | -2.089792 | 1.769836 | -1.18 | 0.3031 |
| | Saunders Reef SMCA | year | 0.001035 | 0.000878 | 1.18 | 0.3039 |
| | **Scorpion SMR** | | | | | |
| | Scorpion SMR | Intercept | -3.056405 | 1.566275 | -1.95 | 0.0699 |
| | Scorpion SMR | year | 0.001512 | 0.000778 | 1.94 | 0.0712 |
| | **South Point SMR** | | | | | |
| | South Point SMR | Intercept | -11.795509 | 8.168379 | -1.44 | 0.1743 |
| | South Point SMR | year | 0.005835 | 0.004058 | 1.44 | 0.1761 |
| | **Stewarts Point SMR** | | | | | |
| | Stewarts Point SMR | Intercept | 6.828544 | 1.746404 | 3.91 | 0.0297 |
| | Stewarts Point SMR | year | -0.003384 | 0.000867 | -3.90 | 0.0298 |
| | **Ten Mile SMR** | | | | | |
| | Ten Mile SMR | Intercept | -3.061282 | 2.518120 | -1.22 | 0.3110 |
| | Ten Mile SMR | year | 0.001516 | 0.001248 | 1.21 | 0.3115 |

**Table 21.** A. Kolmogorov-Smirnov results comparing shape and location of the total length distributions between MPA and reference by focal fish species and region for recent years (2016 to 2020). B. Kruskal-Wallis ANOVA results comparing medians of the total length distributions between MPA and reference by focal fish species and region for recent years (2016 to 2020).

## A.

| Species | Region | D | P Value |
|---|---|---|---|
| **Black Rockfish** | | | |
| | North Coast | 0.1312 | < 0.0001 |
| | Central Coast | 0.0936 | 0.1952 |
| **Blacksmith** | | | |
| | South Coast | 0.1884 | < 0.0001 |
| | Northern Channel Islands | 0.1289 | < 0.0001 |
| | Southern Channel Islands | 0.2445 | < 0.0001 |
| **Blue Rockfish** | | | |
| | North Coast | 0.0548 | < 0.0001 |
| | Central Coast | 0.0220 | 0.0011 |
| **Cabezon** | | | |
| | Central Coast | 0.4833 | 0.0018 |
| **California Sheephead** | | | |
| | South Coast | 0.2394 | < 0.0001 |
| | Northern Channel Islands | 0.1209 | < 0.0001 |
| | Southern Channel Islands | 0.1469 | 0.009 |
| **Garibaldi** | | | |
| | South Coast | 0.1534 | < 0.0001 |
| | Northern Channel Islands | 0.0298 | 0.3947 |
| | Southern Channel Islands | 0.1545 | < 0.0001 |
| **Gopher Rockfish** | | | |
| | North Coast | 0.1108 | 0.1315 |
| | Central Coast | 0.0466 | 0.7060 |
| **Kelp Bass** | | | |
| | South Coast | 0.1934 | < 0.0001 |
| | Northern Channel Islands | 0.0657 | < 0.0001 |

**Table 21** continued

| | | | |
|---|---|---|---|
| | Southern Channel Islands | 0.0827 | 0.0380 |
| **Kelp Greenling** | | | |
| | North Coast | 0.0625 | 0.2769 |
| | Central Coast | 0.0956 | 0.4464 |
| **Kelp Rockfish** | | | |
| | Central Coast | 0.0467 | 0.3777 |
| | South Coast | 0.4011 | < 0.0001 |
| | Northern Channel Islands | 0.1263 | 0.0130 |
| **Lingcod** | | | |
| | North Coast | 0.2008 | 0.0823 |
| | Central Coast | 0.1895 | 0.0769 |
| **Opaleye** | | | |
| | South Coast | 0.1424 | < 0.0001 |
| | Northern Channel Islands | 0.1564 | < 0.0001 |
| | Southern Channel Islands | 0.2024 | 0.0047 |

B.

| Species | Region | Chi-Squared | DF | P value |
|---|---|---:|---:|---:|
| **Black Rockfish** | | | | |
| | North Coast | 67.2612 | 1 | < 0.0001 |
| | Central Coast | 0.4709 | 1 | 0.4925 |
| **Blacksmith** | | | | |
| | South Coast | 111.0170 | 1 | < 0.0001 |
| | Northern Channel Islands | 490.9462 | 1 | < 0.0001 |
| | Southern Channel Islands | 1132.380 | 1 | < 0.0001 |
| **Blue Rockfish** | | | | |
| | North Coast | 15.6998 | 1 | < 0.0001 |
| | Central Coast | 4.0548 | 1 | 0.0440 |
| **Cabezon** | | | | |
| | Central Coast | 13.5386 | 1 | < 0.0001 |
| **California Sheephead** | | | | |
| | South Coast | 138.6212 | 1 | < 0.0001 |
| | Northern Channel Islands | 135.9460 | 1 | < 0.0001 |
| | Southern Channel Islands | 0.6823 | 1 | 0.4088 |
| **Garibaldi** | | | | |
| | South Coast | 29.2113 | 1 | < 0.0001 |
| | Northern Channel Islands | 2.8984 | 1 | 0.0887 |

**Table 21** continued

| Species | Region | Chi-Squared | DF | P value |
|---|---|---|---|---|
| | Southern Channel Islands | 4.3099 | 1 | 0.0379 |
| **Gopher Rockfish** | | | | |
| | North Coast | 3.3974 | 1 | 0.0653 |
| | Central Coast | 0.0191 | 1 | 0.8900 |
| **Kelp Bass** | | | | |
| | South Coast | 295.3667 | 1 | < 0.0001 |
| | Northern Channel Islands | 1.7841 | 1 | 0.1817 |
| | Southern Channel Islands | 1.0981 | 1 | 0.2947 |
| **Kelp Greenling** | | | | |
| | North Coast | 3.4208 | 1 | 0.0644 |
| | Central Coast | 1.3427 | 1 | 0.2466 |
| **Kelp Rockfish** | | | | |
| | Central Coast | 2.2317 | 1 | 0.1352 |
| | South Coast | 70.5225 | 1 | < 0.0001 |
| | Northern Channel Islands | 12.48110 | 1 | 0.0004 |
| **Lingcod** | | | | |
| | North Coast | 4.1688 | 1 | 0.0412 |
| | Central Coast | 1.9828 | 1 | 0.1591 |
| **Opaleye** | | | | |
| | South Coast | 10.5904 | 1 | 0.0011 |
| | Northern Channel Islands | 112.5311 | 1 | < 0.0001 |
| | Southern Channel Islands | 8.7325 | 1 | 0.0031 |

**Table 22. A.** Kolmogorov-Smirnov results comparing shape and location of the size distributions between MPA and reference by focal invertebrate species and region for recent years (2016 to 2020). **B.** Kruskal-Wallis ANOVA results comparing medians of the size distributions between MPA and reference by focal invertebrate species and region for recent years (2016 to 2020).

## A.

| Species | Region | D | P Value |
|---|---|---|---|
| **All Abalone Spp.** | | | |
| | North Coast | 0.167 | **<0.0001** |
| | Northern Channel Islands | 0.089 | 0.93 |
| **Purple Urchin** | | | |
| | North Coast | 0.048 | **<0.0001** |
| | Central Coast | 0.033 | **<0.0001** |
| | South Coast | 0.179 | **<0.0001** |
| | Northern Channel Islands | 0.231 | **<0.0001** |
| **Red Abalone** | | | |
| | North Coast | 0.158 | **<0.0001** |
| | Central Coast | 0.155 | **<0.0001** |
| | Northern Channel Islands | 0.227 | 0.47 |
| **Red Urchin** | | | |
| | North Coast | 0.082 | **<0.0001** |
| | Central Coast | 0.113 | **<0.0001** |
| | South Coast | 0.247 | **<0.0001** |
| | Northern Channel Islands | 0.102 | **<0.0001** |
| **Spiny Lobster** | | | |
| | South Coast | 0.107 | 0.38 |
| | Northern Channel Islands | 0.288 | **<0.0001** |

## B.

| Species | Region | Chi-Squared | DF | P value |
|---|---|---|---|---|
| **All Abalone Spp.** | | | | |
| | North Coast | 29.209 | 1 | **<0.0001** |
| | Northern Channel Islands | 0.016 | 1 | 0.900 |
| **Purple Urchin** | | | | |
| | North Coast | 174.463 | 1 | **<0.0001** |

**Table 22.** continued

| | | | | |
|---|---|---|---|---|
| | Central Coast | 275.549 | 1 | **<0.0001** |
| | South Coast | 34.622 | 1 | **<0.0001** |
| | Northern Channel Islands | 107.918 | 1 | **<0.0001** |
| **Red Abalone** | | | | |
| | North Coast | 25.156 | 1 | **<0.0001** |
| | Central Coast | 17.282 | 1 | **<0.0001** |
| | Northern Channel Islands | 2.992 | 1 | 0.084 |
| **Red Urchin** | | | | |
| | North Coast | 295.760 | 1 | <0.0001 |
| | Central Coast | 704.252 | 1 | <0.0001 |
| | South Coast | 45.160 | 1 | <0.0001 |
| | Northern Channel Islands | 20.839 | 1 | <0.0001 |
| **Spiny Lobster** | | | | |
| | South Coast | 0.606 | 1 | 0.436 |
| | Northern Channel Islands | 38.018 | 1 | <0.0001 |

**Table 23.** Slope estimates for focal fish larval production log response ratio by species and region. The linear regression model includes year as a fixed effect.

| Species | Region | Parameter | Estimate | StdErr | tValue | Probt |
|---|---|---|---:|---:|---:|---:|
| **California Sheephead** | | | | | | |
| | **Central Coast** | | | | | |
| | Central Coast | Intercept | -90.124292 | 54.526437 | -1.65 | 0.1328 |
| | Central Coast | year | 0.044889 | 0.027097 | 1.66 | 0.1320 |
| | **South Coast** | | | | | |
| | South Coast | Intercept | -134.561738 | 42.316327 | -3.18 | 0.0098 |
| | South Coast | year | 0.066894 | 0.021006 | 3.18 | **0.0097** |
| | **Northern Channel Islands** | | | | | |
| | Northern Channel Islands | Intercept | -107.983650 | 19.001610 | -5.68 | <.0001 |
| | Northern Channel Islands | year | 0.053774 | 0.009446 | 5.69 | **<.0001** |
| **Kelp Bass** | | | | | | |
| | **South Coast** | | | | | |
| | South Coast | Intercept | -45.184485 | 31.171089 | -1.45 | 0.1778 |
| | South Coast | year | 0.022507 | 0.015473 | 1.45 | 0.1765 |
| | **Northern Channel Islands** | | | | | |
| | Northern Channel Islands | Intercept | -25.314810 | 9.933242 | -2.55 | 0.0215 |
| | Northern Channel Islands | year | 0.012634 | 0.004938 | 2.56 | **0.0210** |
| **Kelp Rockfish** | | | | | | |
| | **Central Coast** | | | | | |
| | Central Coast | Intercept | 16.024348 | 7.356086 | 2.18 | 0.0415 |
| | Central Coast | year | -0.007931 | 0.003661 | -2.17 | **0.0425** |
| | **South Coast** | | | | | |
| | South Coast | Intercept | -118.216052 | 39.995332 | -2.96 | 0.0144 |
| | South Coast | year | 0.058716 | 0.019854 | 2.96 | **0.0144** |
| | **Northern Channel Islands** | | | | | |
| | Northern Channel Islands | Intercept | 7.738516 | 10.295712 | 0.75 | 0.4632 |
| | Northern Channel Islands | year | -0.003868 | 0.005118 | -0.76 | 0.4608 |
| **Lingcod** | | | | | | |
| | **North Coast** | | | | | |
| | North Coast | Intercept | -3.678913 | 37.542146 | -0.10 | 0.9251 |
| | North Coast | year | 0.001909 | 0.018627 | 0.10 | 0.9217 |
| | **Central Coast** | | | | | |
| | Central Coast | Intercept | -57.905916 | 18.166084 | -3.19 | 0.0054 |
| | Central Coast | year | 0.028764 | 0.009038 | 3.18 | **0.0054** |

**Table 24.** Mixed model ANCOVA resu4lts for fish diversity by analysis region. Models were run first with year, site status, and year by site status interaction. For regions without year by site status interaction, a second model was run with just year and site status.

| Region | Response | Effect | Num DF | Den DF | F Value | Prob |
|---|---|---|---|---|---|---|
| **North Coast** | | | | | | |
| | Shannon Index | site status | 1 | 26 | 0.52 | 0.4762 |
| | Shannon Index | year | 1 | 111 | 5.76 | 0.0181 |
| | Species Richness | site status | 1 | 26 | 6.73 | 0.0154 |
| | Species Richness | year | 1 | 111 | 1.19 | 0.2785 |
| **Central Coast** | | | | | | |
| | Shannon Index | site status | 1 | 42 | 0.25 | 0.6204 |
| | Shannon Index | year | 1 | 538 | 58.46 | <.0001 |
| | Species Richness | site status | 1 | 42 | 14.24 | 0.0005 |
| | Species Richness | year | 1 | 538 | 1.64 | 0.2015 |
| **South Coast** | | | | | | |
| | Shannon Index | site status | 1 | 13 | 5.55 | 0.0349 |
| | Shannon Index | year | 1 | 174 | 1.36 | 0.2454 |
| | Species Richness | site status | 1 | 13 | 1.16 | 0.3014 |
| | Species Richness | year | 1 | 174 | 2.55 | 0.1121 |
| **Northern Channel Islands** | | | | | | |
| | Shannon Index | site status | 1 | 40 | 11.55 | 0.0015 |
| | Shannon Index | year | 1 | 697 | 3.58 | 0.0588 |
| | Shannon Index | year*site status | 1 | 697 | 11.54 | 0.0007 |
| | Species Richness | site status | 1 | 40 | 0.74 | 0.3940 |
| | Species Richness | year | 1 | 698 | 11.56 | 0.0007 |

**Table 25.** Mixed model ANCOVA results for benthic diversity by survey and analysis region. Models were run first with year, site status, and year by site status interaction. For regions without year by site status interaction, a second model was run with just year and site status.

| Survey | Region | Response | Effect | Num DF | Den DF | F value | Prob |
|---|---|---|---|---|---|---|---|
| **Algae (stipitate kelps)** | | | | | | | |
| | **North Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 25 | 2.09 | 0.1609 |
| | | Shannon Index | year | 1 | 71 | 15.76 | 0.0002 |
| | | Species Richness | site status | 1 | 26 | 3.96 | 0.0573 |
| | | Species Richness | year | 1 | 106 | 34.64 | <.0001 |
| | **Central Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 42 | 0.19 | 0.6669 |
| | | Shannon Index | year | 1 | 434 | 56.08 | <.0001 |
| | | Species Richness | site status | 1 | 42 | 1.01 | 0.3211 |
| | | Species Richness | year | 1 | 450 | 63.99 | <.0001 |
| | **South Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 13 | 2.26 | 0.1566 |
| | | Shannon Index | year | 1 | 143 | 52.16 | <.0001 |
| | | Species Richness | site status | 1 | 13 | 6.22 | 0.0269 |
| | | Species Richness | year | 1 | 144 | 26.75 | <.0001 |
| | | Species Richness | year*site status | 1 | 144 | 6.2 | 0.0139 |
| | **Northern Channel Islands** | | | | | | |
| | | Shannon Index | site status | 1 | 39 | 23.78 | <.0001 |
| | | Shannon Index | year | 1 | 421 | 22.9 | <.0001 |
| | | Shannon Index | year*site status | 1 | 421 | 23.89 | <.0001 |
| | | Species Richness | site status | 1 | 39 | 26.48 | <.0001 |
| | | Species Richness | year | 1 | 533 | 69.1 | <.0001 |
| | | Species Richness | year*site status | 1 | 533 | 26.71 | <.0001 |
| **Invertebrates (mobile or conspicuous)** | | | | | | | |
| | **North Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 26 | 0.98 | 0.332 |
| | | Shannon Index | year | 1 | 106 | 432.76 | <.0001 |
| | | Species Richness | site status | 1 | 26 | 6.35 | 0.0182 |
| | | Species Richness | year | 1 | 106 | 52.47 | <.0001 |
| | **Central Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 42 | 0.06 | 0.8001 |
| | | Shannon Index | year | 1 | 450 | 149.8 | <.0001 |
| | | Species Richness | site status | 1 | 42 | 2.29 | 0.1375 |
| | | Species Richness | year | 1 | 450 | 2.33 | 0.1273 |
| | **South Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 13 | 9.38 | 0.0091 |

**Table 25.** continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | Shannon Index | year | 1 | 144 | 4.73 | 0.0313 |
| | | Shannon Index | year*site status | 1 | 144 | 9.44 | 0.0025 |
| | | Species Richness | site status | 1 | 13 | 18.88 | 0.0008 |
| | | Species Richness | year | 1 | 145 | 11.68 | 0.0008 |
| | **Northern Channel Islands** | | | | | | |
| | | Shannon Index | site status | 1 | 39 | 35.94 | <.0001 |
| | | Shannon Index | year | 1 | 533 | 7.68 | 0.0058 |
| | | Shannon Index | year*site status | 1 | 533 | 36.06 | <.0001 |
| | | Species Richness | site status | 1 | 39 | 15.8 | 0.0003 |
| | | Species Richness | year | 1 | 533 | 43.62 | <.0001 |
| | | Species Richness | year*site status | 1 | 533 | 15.89 | <.0001 |
| **UPC** | | | | | | | |
| | **North Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 26 | 6.38 | 0.0179 |
| | | Shannon Index | year | 1 | 106 | 78.39 | <.0001 |
| | | Species Richness | site status | 1 | 26 | 6.02 | 0.0212 |
| | | Species Richness | year | 1 | 106 | 37.18 | <.0001 |
| | **Central Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 42 | 7.01 | 0.0114 |
| | | Shannon Index | year | 1 | 449 | 0.35 | 0.5562 |
| | | Shannon Index | year*site status | 1 | 449 | 7.07 | 0.0081 |
| | | Species Richness | site status | 1 | 42 | 6.35 | 0.0156 |
| | | Species Richness | year | 1 | 449 | 0.12 | 0.7332 |
| | | Species Richness | year*site status | 1 | 449 | 6.4 | 0.0118 |
| | **South Coast** | | | | | | |
| | | Shannon Index | site status | 1 | 13 | 0.09 | 0.767 |
| | | Shannon Index | year | 1 | 145 | 2.19 | 0.1408 |
| | | Species Richness | site status | 1 | 13 | 3.87 | 0.0708 |
| | | Species Richness | year | 1 | 145 | 2.16 | 0.1441 |
| | **Northern Channel Islands** | | | | | | |
| | | Shannon Index | site status | 1 | 39 | 32.27 | <.0001 |
| | | Shannon Index | year | 1 | 533 | 94.86 | <.0001 |
| | | Shannon Index | year*site status | 1 | 533 | 32.41 | <.0001 |
| | | Species Richness | site status | 1 | 39 | 4.09 | 0.05 |
| | | Species Richness | year | 1 | 533 | 103.48 | <.0001 |
| | | Species Richness | year*site status | 1 | 533 | 4.13 | 0.0427 |

**Table 26.** Ocean acidification and hypoxia (OAH) measurements at sites along the California coast.

| Measurement | Van Damme | Point Arena | Big Creek | Point Buchon | Catalina Island | Laguna Beach |
|---|---|---|---|---|---|---|
| pH | 7.81 ± 0.15 | 7.78 ± 0.15 | 7.84 ± 0.14 | 7.90 ± 0.12 | 8.01 ± 0.05 | 7.98 ± 0.13 |
| pH$_{min}$ | 7.30 | 7.44 | 7.43 | 7.30 | 7.81 | 7.39 |
| pH$_{max}$ | 8.28 | 8.22 | 8.28 | 8.35 | 8.48 | 8.28 |
| pH$_{UQ}$ | 7.71 | 7.67 | 7.72 | 7.84 | 7.97 | 7.95 |
| pH$_{LQ}$ | 7.82 | 7.90 | 7.95 | 7.98 | 8.04 | 8.04 |
| pH Temp (°C) | 10.11 ± 1.28 | 10.12 ± 1.32 | 11.60 ± 1.24 | 11.76 ± 1.55 | 17.40 ± 2.33 | 15.87 ± 1.60 |
| pH temp$_{min}$ (°C) | 6.84 | 7.18 | 8.44 | 8.57 | 11.59 | 11.52 |
| pH temp$_{max}$ (°C) | 13.40 | 14.18 | 15.33 | 17.34 | 23.99 | 24.52 |
| pH temp$_{UQ}$ (°C) | 9.15 | 9.09 | 10.60 | 10.45 | 15.49 | 14.91 |
| pH temp$_{LQ}$ (°C) | 10.94 | 10.98 | 12.51 | 12.95 | 19.22 | 16.55 |
| DO (mgL$^{-1}$) | 6.24 ± 1.81 | 5.43 ± 1.86 | 6.63 ± 1.18 | 6.46 ± 1.26 | 7.75 ± 0.48 | 7.50 ± 0.64 |
| DO$_{min}$ (mgL-1) | 0.24 | 1.78 | 2.29 | 2.41 | 4.05 | 3.70 |
| DO$_{max}$ (mgL-1) | 10.53 | 12.29 | 11.52 | 9.82 | 10.61 | 11.05 |
| DO$_{UQ}$ (mgL-1) | 5.04 | 3.93 | 5.90 | 5.58 | 7.46 | 7.31 |
| DO$_{LQ}$ (mgL-1) | 7.93 | 6.84 | 7.48 | 7.45 | 7.97 | 7.83 |
| DO Temp (°C) | 11.14 ± 0.94 | 10.32 ± 1.19 | 12.12 ± 1.22 | 12.29 ± 1.57 | 17.86 ± 2.32 | 16.03 ± 1.75 |
| DO Temp$_{min}$ (°C) | 9.12 | 7.83 | 8.81 | 8.82 | 12.22 | 11.40 |
| DO Temp$_{max}$ (°C) | 13.54 | 17.19 | 15.96 | 17.95 | 24.68 | 24.82 |
| DO Temp$_{UQ}$ (°C) | 10.48 | 9.44 | 11.27 | 11.13 | 15.81 | 14.89 |
| DO Temp$_{LQ}$ (°C) | 11.85 | 11.03 | 12.98 | 13.3 | 19.68 | 16.87 |