Assessment of Rocky Intertidal habitats for the California Marine Protected Area Monitoring Program: Decadal report

A report to the Ocean Protection Council and UC Sea Grant

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Executive Summary

In this report we assessed the effects related to implementation of Marine Protected Areas (MPAs) for rocky intertidal habitats in California. The sampling methods use were those developed by MARINe, which have been used for nearly 30 years and thoroughly vetted by external review. The use of the MARINe approach allowed incorporation of MARINe data assets into the data collected during MPA evaluation leading to a database that spanned pre and post MPA implementation periods. A map depicting the survey sites used for the decadal analysis is shown in Figure ES1.

In general, there are two types of effects that could result from regulatory protection conferred by MPA's. First, there are likely to be effects related to removing harvest. These effects should result in a change in size structure (for species that had a size limit for harvest) and a potential change in density. In the rocky intertidal there are relatively few species (compared to other coastal marine ecosystems, such as kelp forests) that are harvested, but such effects were assessed. The other possible effect is more likely to be seen at the community level and is related to community structure. The effect could be manifest in multiple metrics such as species richness or diversity. However, the key metric is community stability, which may be affected by species richness or diversity, but which is an attribute that has been predicted to emerge from MPA protection. Hence, much of our effort has been directed at assessing stability and also at understanding possible mechanisms that could produce enhanced stability by means of MPA implementation.

We divided the report into sections that relate to physical, community, and species level effects. In addition, we considered structural and emergent effects (effects that manifested post-implementation). In the final sections of the report, we link results to both perturbations (e.g., the 2013-2015 marine heat wave) and putative mechanisms for observed effects such as network connectivity.

In the report we divided the state into three regions based on community structure: CA North (Oregon to San Francisco), CA Central (San Francisco to Point Conception), and CA South (Point Conception to Mexico).

Physical attributes

We compared physical attributes of sites (e.g., geomorphology, temperature, network connectivity) between MPA and reference sites. Geomorphological attributes were generally similar between MPA and reference sites, although the extent of sites varied (the width of the tide zone, which was generally wider in MPA's). The main regional difference was that Northern sites were generally wider and more rugose than either central or southern sites.

Temperatures varied as expected, generally increasing from south to north. Interestingly, there was considerable variability in mean annual temperature within regions and also variability among sites within regions in annual temperature standard deviation, which is likely due to two factors, geographic patterns of upwelling and shallow embayments.

Patterns of network connectivity were interesting and likely important to community function. Here network connectivity refers to contribution of propagules to from one site to others and also the settlement of propagules into a recipient site from donor sites. While our reporting is in the preliminary stages, in all three regions, connectivity in MPA's was higher than in reference sites. An expanded discussion of this finding is included with mechanisms for community stability patterns in the report.

Effects at the species level

We conducted an evaluation of potential effects of regulatory protection for single common and focal (those of species concern) species. These analyses were conducted both at an aggregate level (i.e., across all regions) and within individual regions (CA North, CA Central, CA South) to evaluate structural (pre-regulatory implementation) and emergent (post-regulatory implementation) effects. We used a combination of MARINe's Biodiversity and Long-Term Monitoring Surveys to analyze changes in the abundance and size structure (where possible) of single common and focal species pre and post implementation of regulatory protection.

Structural and emergent effects for single common and focal species

We compared the log-ratios of changes in the mean abundance of single common and focal species to evaluate whether an MPA effect is evidenced by post-regulatory changes. Other than a few species that are commonly harvested and/or poached (e.g., abalone and *Lottia*) there are no clear species specific predictions relating to regulatory protection. Given this and given that all populations are variable over time, there is one likely pattern of results – about half of the species should show an increase and about half a decrease, and the level of increase and decrease should be variable and more or less symmetrical around zero (the magnitude of effects are about as big positively and negatively). Overall, the results across all three regions indicate that more species responded positively to regulatory implementation relative to unprotected sites.

We evaluated changes in the size-frequency distributions of *Lottia gigantea, Haliotis rufescens, Haliotis cracherodii, Katharina spp.,* and *Pisaster ochraceous* between MPA and reference sites pre- and post-regulatory protection. For these analyses, the results are presented using Long Term Surveys. Results show that the mean size class of *Haliotis rufescens, Haliotis cracherodii,* and *Katharina spp.* all increased post-regulatory implementation both inside and outside of MPAs, while the mean size of *Lottia gigantea* and *Pisaster ochraceous* both decreased. For each of these five species, the magnitude of change (positive or negative) in the mean size was substantially greater in MPAs than in reference sites.

Results for changes in focal sessile invertebrate and algae species varied by region and level of regulatory protection. However, one interesting emergent pattern is that MPAs and reference sites generally responded synchronously within regions with either a positive or negative response. In other words, within any given region, if a response was a positive increase in the mean percent cover of a focal species within an MPA, the reference sites in that region also had a positive increase. Interestingly, the magnitude of change (positive or negative) for a given species was similar between MPA and reference sites within a given region.

Focal species responses to marine heatwave

We explored potential effects of regulatory protection for single common and focal species before and after an episodic marine heatwave effect. Here we used Biological Survey data for each region to evaluate species level responses pre (before 2014) and post (after 2014) marine heatwave. Overall, results indicate that a similar number of species responded positively inside of MPAs relative to reference sites following the marine heatwave event. However, we note that an important consideration for these analyses is the potentially confounding effect of the temporal onset of the marine heatwave relative to regulatory protection. Because the marine heatwave occurred post-regulatory protection, it is possible that some of the species' responses may in fact be due to regulatory implementation and not the marine heatwave.

Effects at the community level

There were a series of major effects that were found at the level of biological community. In general, MPA sites were more species rich and diverse than reference sites. In addition, these metrics indicated that MPAs were differentially benefited post-implementation of protection. Perhaps the key finding with respect to community attributes was that stability was enhanced in MPA's relative to reference sites, particularly in CA central and CA south (Figure ES2). This enhancement was mainly aligned temporally with the heat wave that occurred throughout the west coast during part of this MPA assessment period. The results suggested that resilience to the perturbation presented by the heat wave was greater in MPAs. We did not see the same effect in CA North. One possibility is that it was not present there. The other possibility and one that may have affected other results is that CA North was not as well characterized as the other regions. This is because of a number of factors. First, pre-MPA data from MARINe are less abundant than in other regions. Second, there are fewer MPA's that have sufficient rocky intertidal habitat in CA North than in other regions. Third, access to rocky intertidal habitat in the North is much more challenging: physically, logistically and politically than in the other regions.

As noted above, we addressed network connectivity in this report. We linked connectivity to patterns of site stability for MPA's in the central coast. This could be due to either density dependent effects or through buffering or poor years or both. We found that pre marine heatwave there was no relationship between stability and connectivity, but that during and after the heatwave increasing connectivity was associated with increasing community stability. This suggests that manifestation of effects of protection may be greatest in times of stress. Note also that the mechanism for this result is likely to be related to influx of propagules – the more the more stable. This early result may relate in part to the modeled result that MPAs receive disproportionately more propagules than reference sites. However, the mechanism should only strengthen over time as MPA function increases and leads also to enhanced production of propagules. This latter effect should benefit both MPA and reference sites

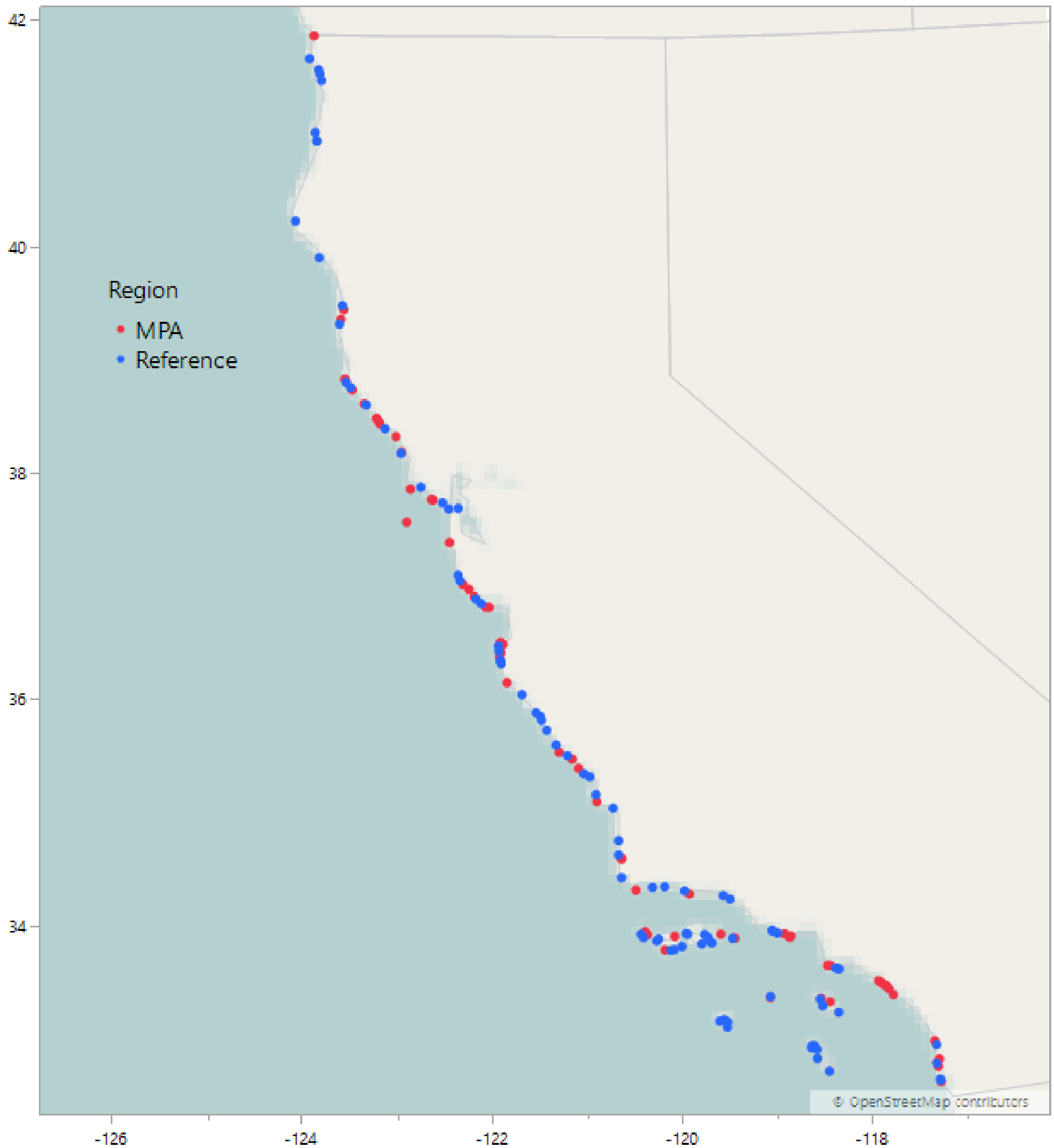

Figure ES1: Location of survey sites by level of protection (MPA in red, Reference in blue).

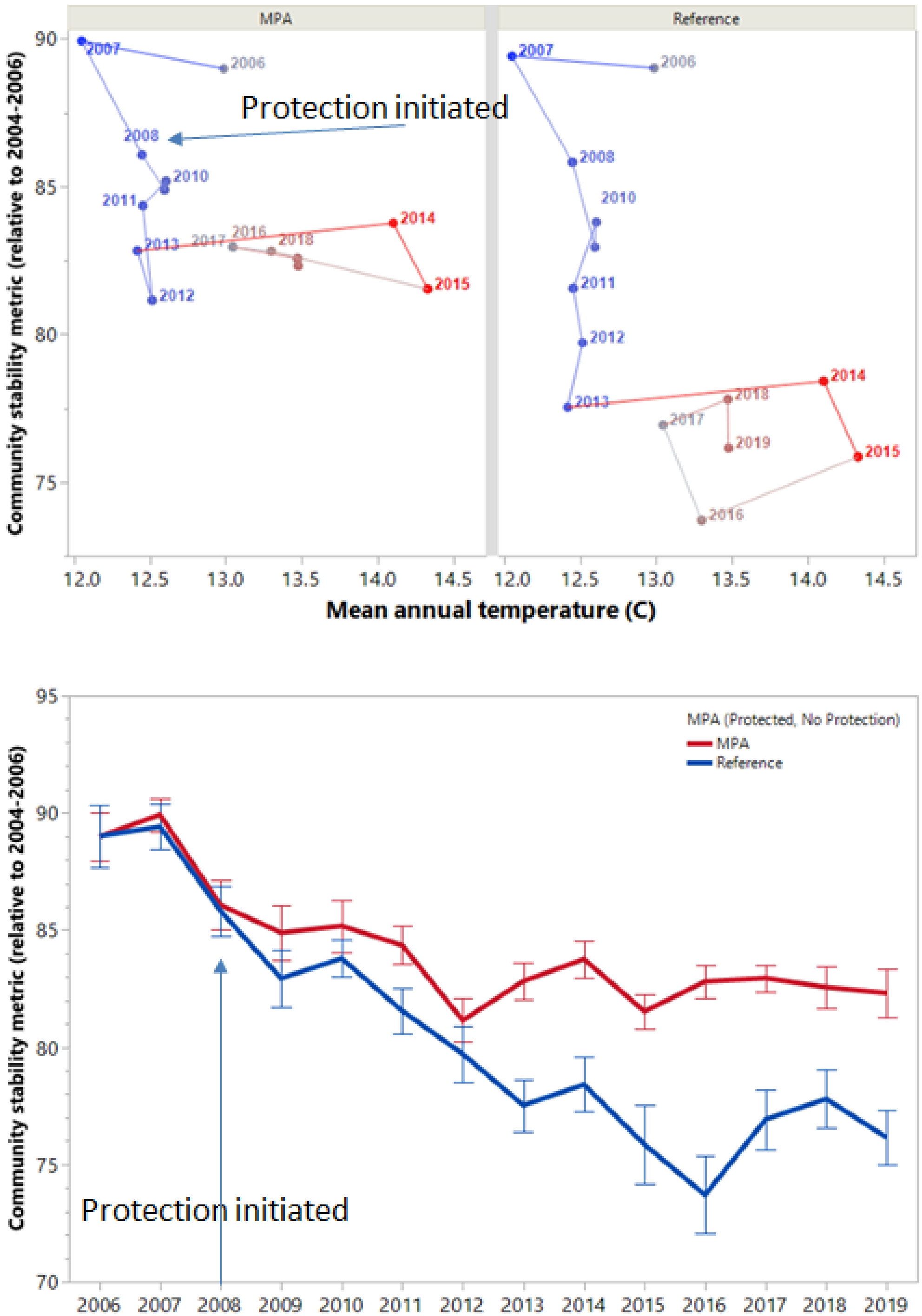

Figure ES2: **Bottom**, Pattern of community stability over time in the Central California Region**. Top**, Thermal Stability Profiles for MPA and reference sites in the Central California Region. Color of lines indicate temperature over time. Note that community stability is buffered from declines in stability with increasing temperature in MPA's but not in reference sites.

Management recommendations

1) *Complete high resolution coupled ROMS/habitat network connectivity modeling and assess the importance of connectivity to community stability and resilience*. In this report we introduced the ROMS / connectivity modeling we are doing as part of the MPA assessment. We used the draft results to address essential questions related to the linkage between community resilience and network connectivity. This linkage is a core but untested prediction of the benefit of MPA's either by selection (location) or protection or both selection and protection. It is also a benefit that could operate in all habitats; not simply those affected by extraction.
2) *Determine underlying drivers of increased intertidal community stability and resilience in MPA's relative to reference areas during stress (e.g., heat waves).* As an example, are communities stabilized during extreme events because of general increased network connectivity or as an alternative hypothesis, because of increased larval input (via network connectivity) of long lived foundation species, which act to stabilize the rest of the community. This has important implications for adaptive management of the MPA network. If the key stabilizing attribute is foundation species through network connectivity then priority locations would be those with high abundance of foundation species AND high donor connectivity to other locations.
3) *Continue field assessments and analyses to determine if other regions will also demonstrate MPA related protection or selection benefits to species and communities*. In this report we found most of the observed benefits of MPA selection/protection to be in the central coast region. This region was afforded protection earlier than the north coast and the mainland portion of the south coast. It is possible the manifestation of demonstrated benefit will manifest in these regions over the next 5 years. Decisions made in the absence of a longer period assessment are likely to be uninformed
4) *Based on 1-3 above, do a formal adaptive management assessment*. This would allow not only compliance with language of the MLPA and MLMA but also would allow optimized and informed tuning of the network, its regulatory provisions and enforcement policies.
5) *Conduct a comprehensive and synthetic assessment of the network properties across the assemblage of assessed habitats*. As noted in recommendation #1, network connectivity modeling can be done for all habitats assessed in the decadal review. This means that connectivity properties, including community resilience, could be assessed for the MPA network, rather than simply the intertidal habitats in the MPA network.

General overview

Here we provide an evaluation of the State of California network of marine protected areas (MPA's) with respect to rocky intertidal habitats. The field assessments that contribute to this evaluation, the data management, the analytical effort and report itself were carried out by the Multi Agency Rocky Intertidal Network (MARINe), led by UC Santa Cruz, with support from UC Santa Barbara, UCLA, UC Irvine, California State University Fullerton and California Polytechnic Pomona. The overreaching goal of this report was to assess the MPA's as a linked network of sites regulatory protection. Based on biogeographic analyses, the coastal region of the State was partitioned into three regions: (1) CA North, which extends from San Francisco to Oregon, (2) CA Central, which extends from San Francisco to Point Conception and, (3) CA South, which extends from Point Conception to Mexico and which includes both the mainland and Channel Islands. Our approach was to evaluate MPA effects at the scale of the whole network (statewide) and at the level of biogeographic regions (which are at least in part driven by changes in network connectivity at regional boundaries).

Introduction

Rocky intertidal ecosystems are incredibly diverse, exhibit spectacular patterns of zonation, house a suite of fascinating and ecologically/economically important plants and animals, accommodate extensive biological interactions, and are affected by numerous temporally and spatially variable abiotic conditions. Because of these attributes, rocky intertidal habitats are the locations of disproportionate scientific value based on the ecological theory that has arisen from investigations in this system. The ecological paradigms that have stemmed from rocky intertidal research include: Paine's (Paine 1966) work on keystone predation, Sousa's (Sousa 1979) work on the intermediate disturbance hypothesis, Connell's (Connell 1961) work on the importance of competition, Lubchenco's (Lubchenco 1978) work on alternate stable states, and Dayton's (Dayton 1971) work on the importance of abiotic conditions (e.g. wave action) to the structure of marine communities. Another important attribute of rocky intertidal ecosystems is their attractiveness to the public for the recreational, cultural, and economic services they provide. During low tides, rocky shores are easily accessible, allowing the public to interact with a natural ocean ecosystem without the need for expensive and technical equipment, such as a boat or SCUBA gear. An incredibly high number of local-residents and tourists flock to these locations for the opportunity to see marine life in its natural state. Furthermore, intertidal systems are utilized and valued both historically and presently for cultural significance by First Nations people. Additionally, a regular component of K-12 school programs in coastal cities is field trips to rocky intertidal ecosystems with buses bringing huge numbers of school kids to wander over the rocks in search of creatures so extraordinary that intellectual exploration is unavoidable. This combination of ease of access, diverse biological communities, massive increase of visitation especially by children coupled with the evolution of a culture of "tidepool etiquette" has led to a shift if the attitudes of the public with respect to marine conservation.

Despite an increasing public appreciation of rocky intertidal systems, these habitats remain gravely threatened and subject to massive local and regional anthropogenic perturbations, such as overexploitation, pollution, habitat alteration, species invasions, and climate change related impacts (sea level, ocean acidification, hypoxia, temperature increases, etc.), among other threats. Although seeming ubiquitous, rocky intertidal ecosystems exist as a narrow linear feature. Based on extensive mapping by our MARINe (Multi Agency Rocky Intertidal Network; https://marine.ucsc.edu/) surveys, the estimate of rocky intertidal habitat in our state is only ~5 square kilometers. This small overall footprint designates rocky intertidal habitats as the rarest of ecosystem types and makes them particularly sensitive and vulnerable to anthropogenic disturbances. Based on vulnerability and threats from numerous sources of anthropogenic stresses, the rocky intertidal ecosystem was targeted for protection in the MLPA Master Plan. To achieve the long-term monitoring required for evaluation of the efficacy of MPA's we have explicitly linked MPA monitoring to the MARINe collaborative network and its partners including, Bureau of Ocean Energy Management (BOEM), the National Park Service (NPS), National Marine Fisheries Service (NMFS), the National Marine Sanctuary Program (NMSP), the Department of Defense (Army, Navy and Air Force) and the Partnership for the Interdisciplinary Study of Coastal Oceans (PISCO). MARINe is unquestionably the primary rocky intertidal program along the west coast and perhaps the most important and expansive coastal biological monitoring program in the world. It is the program that has been used for all official rocky intertidal assessments to date in California (and Oregon) MPAs. The key attribute underlying the importance and utility of the MARINe program is the requirement for strict adherence to a common set of monitoring approaches, which are utilized from Mexico to Alaska. The benefits of MARINe and its participation in MPA assessment include: (1) the collection of data assets associated with MARINe (historic data along with ongoing collection of data funded by other sources); (2) the personnel assets – meaning the exceptional expertise and experience of MARINe members; (3) the standardized methodology approaches used consistently and vetted for statistical power and ongoing utility; (4) the data management system already in place (from data acquisition through database inclusion); (5) the web based data and data visualization portals; and (6) the historic and ongoing analytical products (e.g. assessment of the power of approaches to detect change, the development of community resilience metrics, detection of climate related impacts).

The core objectives of the MPA monitoring project were to:

1) Assess the efficacy of the State of California MPA network relative to a set of objectives (see detailed discussion below).
2) Link the data collected for the MPA funded work from 2005 to 2021 to data collected as part of the MARINe program under funding from different programs such as: BOEM, NPS, State Water Board, US Navy, US Air Force, NMFS, National Marine Sanctuaries.
3) Incorporate all MPA funded data into our MARINe database and provide the data to the State.
4) Port the entire MARINe database to our web based visualization portal (https://marine.ucsc.edu/) allowing users to explore all the data in the combined database. This allows user customized graphs.
5) To develop and use a set of metrics essential for the assessment of the MPA network. In addition to species (e.g., abundance, cover, size structure), physical (e.g., temperature, physical features, geomorphology, oceanographic connectivity) and community (stability, vulnerability, redundancy, connectivity) that can be visualized in our graphics portal (#4),

we also are presenting in this document a series of metrics that address ecosystem structure, function, and service. These latter metrics include biodiversity and community resilience.

6) Utilize the tremendous historical and data assets and ongoing monitoring (biological and environmental) to build a framework for collection of new data specifically designed to address questions of importance to the California MPA assessment.
7) Continue our ongoing practice of utilizing our web portal and visualization tools to provide an outreach platform for the public. Examples include (1) our citizen science web interface for collection of observations of seastar wasting, the dissemination of vetted results and a series of training and education documents (www.seastarwasting.org). (2) Our very recent effort to provide data collected by MARINe to educators for use in remote teaching and learning (https://marine.ucsc.edu/explore-the-data/distance.html)

Methods

Data Assets: In addition to the personnel assets of our sampling team, we have tremendous data assets associated with the MARINe program that guide our general assessment approach. The map of locations that MARINe has assessed and continues to monitor coast-wide is shown in Figure 1. With respect to the assessment of the California MPA network, the specific location and spatial arrangement of these data assets across multiple MARINe survey types are indicated in Figure 2 and Table 1. The spatial arrangement is impressive, both in terms of number of sites and geographic extent, and includes locations with a variety of habitat characteristics for robust assessment, such as inside and outside of the California MPA network, within multiple biogeographic regions, on islands and along the mainland, with different substrate composition, etc.

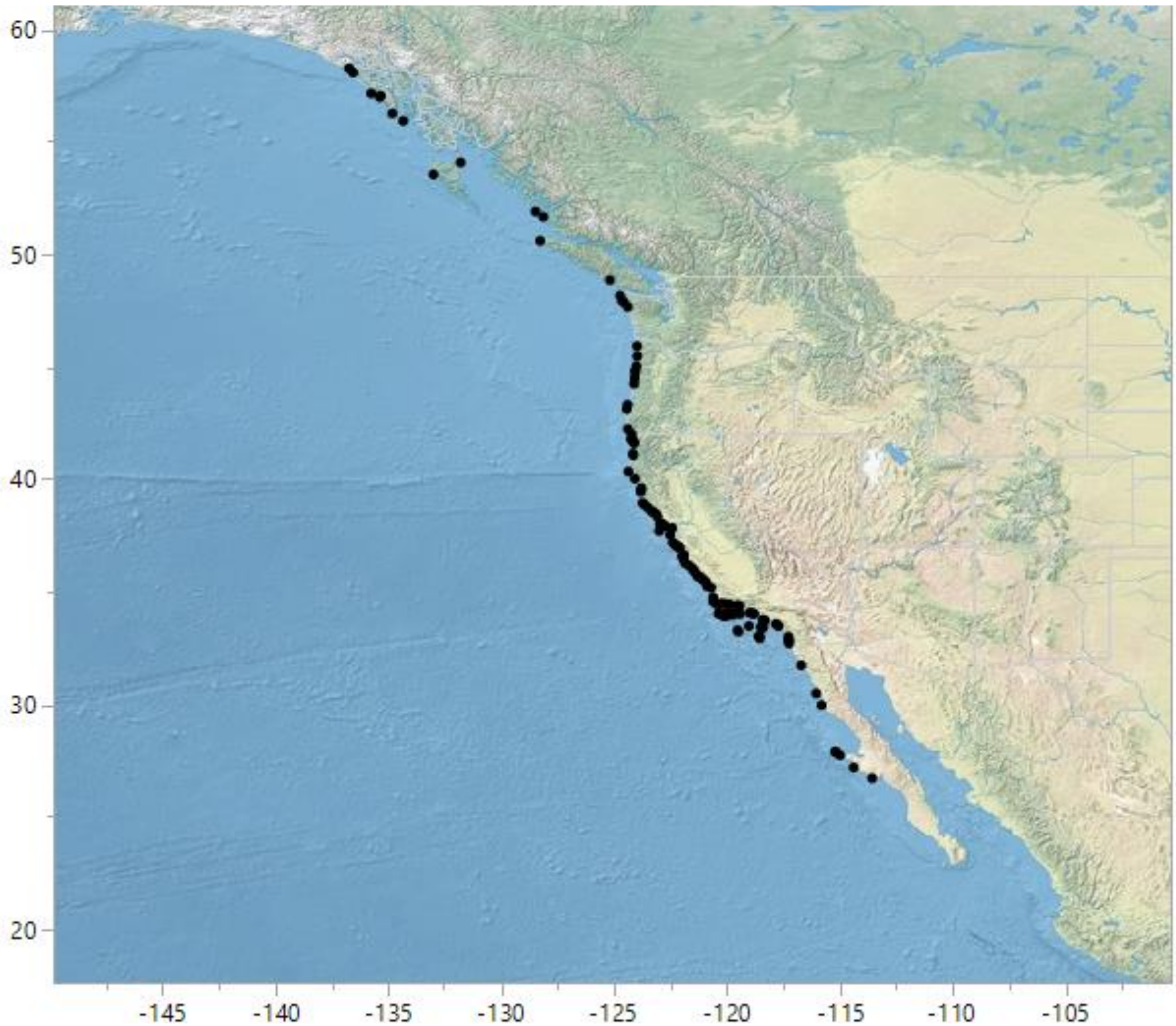

Figure 1: MARINe monitoring locations along the Pacific coast of North America

		Number of samples between 2004 and 2020		
Designation	**Total number of sites**	**Biodiversity surveys**	**Long term surveys**	**Abalone only surveys**
Reference	89	142	938	568
Special Closure	1	2	15	13
SMCA	26	61	232	196
SMR	45	90	377	289

Table 1: Distribution of sampling of the sites as a function of survey type and designation

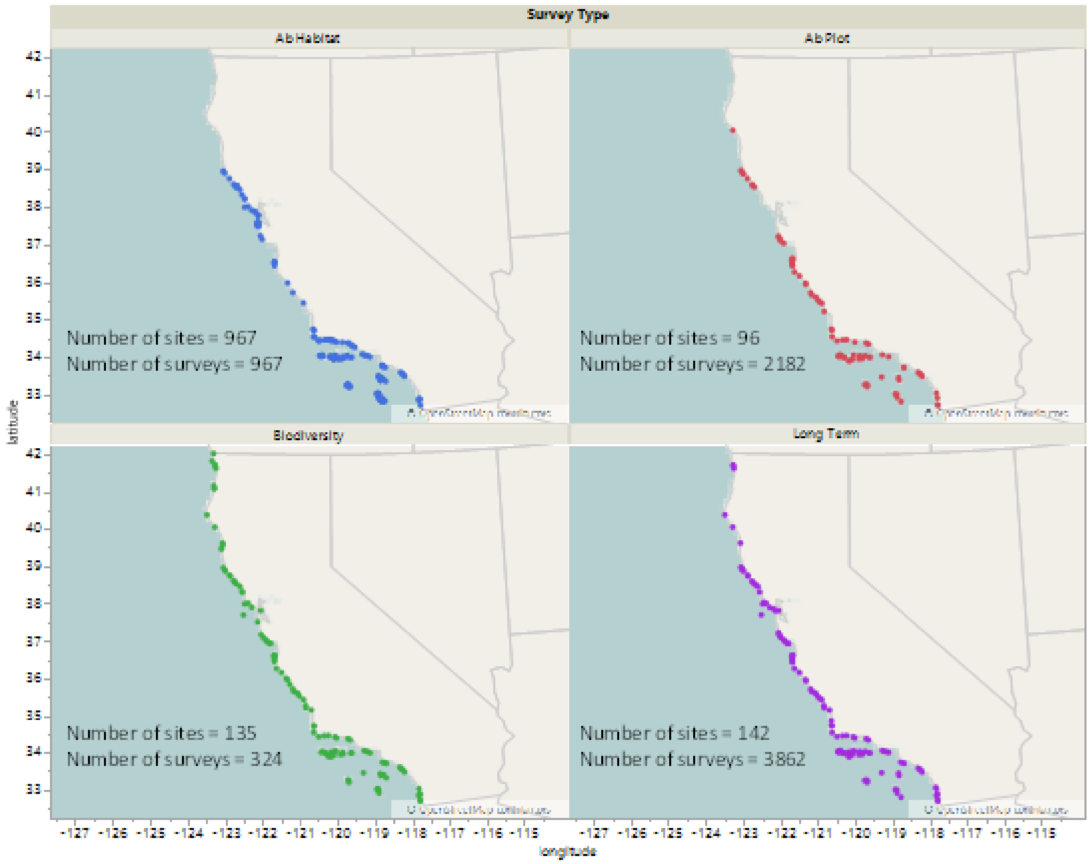

Figure 2: Historic and current data assets in MARINe databases by survey type (see Table 1 for more detail). Ab Habitat – assessment of abalone density and characterization of quality of habitat; Ab Plot – long term assessment of abalone density; Biodiversity – spatially explicit detailed assessment of the communities; Long Term – annual assessment of communities.

The MARINe survey methods and data assets (see https://marine.ucsc.edu/ for detailed descriptions of all survey types, also see appendices) include, in brief:

1) Long-Term Monitoring Surveys (LTMS, Appendix 1): LTMS are conducted annually and currently target 25 key species and species assemblages, including all MPA priority species.
    a. Photo Plots: Fixed photoplots are used to monitor percent cover of organisms within target species assemblages, scored either in the field or using photographs.
    b. Transects: Fixed point-intercept transects are used to monitor percent cover of surfgrass, kelps, and other algae.
    c. Species Counts and sizes: Surveys record the number and size of a specific organism found in a permanent plot. Species include abalone, sea stars, and owl limpets, among others.
2) Biodiversity Surveys (Appendix 2): Biodiversity surveys are periodically (every 3+ years) conducted to provide detailed information about the diversity and abundance of macrophytes and invertebrates and community structure on the west coast of temperate North America. These surveys are conducted at sites where LTMS are conducted, in

addition to numerous other locations along the coast, to provide a more comprehensive assessment of the community. The goals of the biodiversity surveys are to:

a. Determine the diversity and site-wide abundance of intertidal algae and invertebrate species.
b. Create a spatially explicit (x ,y, z) topographic map of species distributions for use in assessing the spatial distribution of species (and change to it) within each site (for an example see Figure 3).
c. Reveal long-term influences such as climate change and coastal development on intertidal communities and individual species.
d. Examine patterns of biogeography with a particular emphasis on locations where there may be large changes in species composition and diversity.

3) Abalone Plots: Abalone counts and size measurements are part of the LTMS. Additionally, because of the concern for abalone species, particularly the harvested red abalone and the listed (endangered) black abalone, numerous other sites have been added along the California coast.
4) Abalone Population and Habitat Assessments (Appendix 3): Surveys assessing black abalone population size and extent of appropriate abalone habitat availability were developed, in conjunction with NMFS, to respond to the need to: (1) understand current population size of black abalone in regions affected and not affected by withering disease, (2) determine the extent and quality of “essential habitat” for the species and (3) estimate the potential impact to black abalone from the repopulation of sea otters to southern California coastlines.
5) Environmental Monitoring: Temperature probes have been installed in most MARINe locations with data housed in a MARINe database. In addition to temperature measures across sites, during low and high tides, and over long temporal scales, we have used measured temperature patterns to estimate wave climate. Geology and geomorphology has also been assessed at each site.

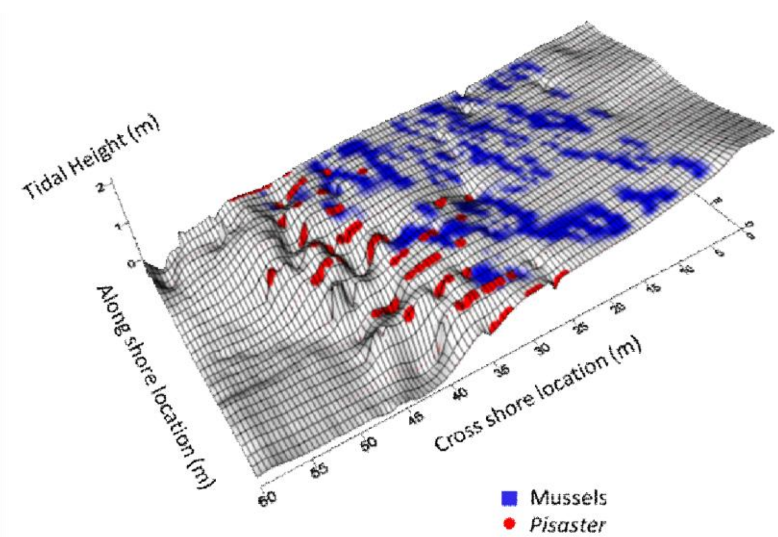

Figure 3: 3D topographic map of indicating spatial distribution of a mussel bed and sea stars (prior to sea star wasting).

The geographic distribution of MARINe assets for the period (2004-2020) in California (Figure 2) includes 132 long term monitoring sites and 134 biodiversity sites. Of these, 57 and 63 sites, respectively, are in MPAs thus the remaining 75 long term and 71 biodiversity sites will be able to serve as reference sites. Because MARINe has existed since 1992 and because our funders have required it, we have thoroughly examined, with external review, the analytic properties of the two core approaches (long term and biodiversity surveys). These have informed the evolution of our program and will provide important benefits to the MPA assessment.

The major results of MARINe systematic analyses are:

1) Methodical
    a. The main issues with most consortium monitoring that utilized large numbers of individuals and organizations relates to inconsistency in data collection and data management. We avoid these issues by: (i) Holding annual workshops to discuss methods and make sure there no subtle drifts in methods used among groups; (ii) Requiring all consortium members to use the same field approaches that are documented in sampling procedure guidelines; (iii) Utilizing standard forms for data uploading; and (iv) Having a single consortium database, administered at UCSC by our long-term data managers (Miner et al. 2015).
    b. Development of field data recorders. The development and use of electronic field data entry systems (iPads) greatly reduces error rates from simple omission and legibility errors to transcription errors. Error checking also involves a type of "smart" error checking that links sites to expected species, making the recorder consider the identity of a sample if it is unexpected.
2) Usefulness of data collection. We analyzed spatial and temporal MARINe data to determine the robustness of the monitoring program to address programmatic objectives. These include:
    a. Power analyses: We have evaluated numerous components of statistical power for MARINE, focusing on data from both BOEM and for the NPS, our key partner. The main results are:
        i. **Simple population changes**: Our long-term monitoring, coupled to a modified BACIP design (modified to account for trends), is capable of detecting changes to populations as small as 7 to 10% (Appendix 9, Figure S1) (Raimondi 2014, 2016). Similar estimates are associated with size structure.
        ii. **Community changes**: Our long-term monitoring again coupled to a modified BACIP design is capable of detecting a change to communities of 6-7% (Appendix 9, Figure S1). The community analysis is based on changes in Bray Curtis distance over time relative to that expected given natural variability. This suggests that community metrics may be more sensitive indicators of change than population metrics (Raimondi 2014).

iii. **Changes in vertical distribution of species**. As described above the biodiversity surveys provide x, y and z coordinates for all species observations at each site. Power analyses suggest (Raimondi et al. 2018) that we can detect a change in, for example, the upper vertical limit of a species as small as 10 centimeters. This means we have a powerful way to assess potential climate related effects (e.g., warming, sea level rise).

b. Broader assessment of change. We conducted additional analyses to determine use of MARINe data to inform network level attributes over broad spatial and temporal scales. Below we describe some examples of our derived metrics for assessment of current conditions that were facilitated by the large number of appropriate study sites and the spatial scale and the temporal breadth of the monitoring network along the coast. For example, a very recent analysis of the biodiversity data indicated that there has been a geographic shift in rocky intertidal communities along the coast of about 3 – 5 kilometers north per year since 2000. Communities that typically associated with more southern locations are shifting north at a surprising rate. We have subsequently evaluated this signal regionally to determine if the is a geographical signature to the rate of community change. We expressed this as measurement of resiliency (change from a state over time). These results (as an example of the use of derived metrics to be used in an MPA network assessment) are shown in Figure 4 (Miner et. al., 2021). Here southern sites exhibit much less resiliency than do those in the north.

   Decomposing these patterns shows that, even within a region, there are sites that have greater and lower resiliency (Miner et. al., 2021, Figure 5). This suggests that there may be attributes associated with resiliency that can be investigated and potentially used in management decisions. One such attribute may be level of network connectivity.

c. Coupled biological/physical assessments. As an example, some of the metric elements described above were utilized to depict the pattern of sea star wasting-disease-associated declines in sea star abundance, including spatial extent and temporal patterns (Figure 6 and see Miner et. al., 2018, Moritsch and Raimondi 2018). Our monitoring procedures and analytical capabilities were able to document the progression of wasting disease associated sea star declines along with local consequence to size patterns, recruitment and, potentially, community change.

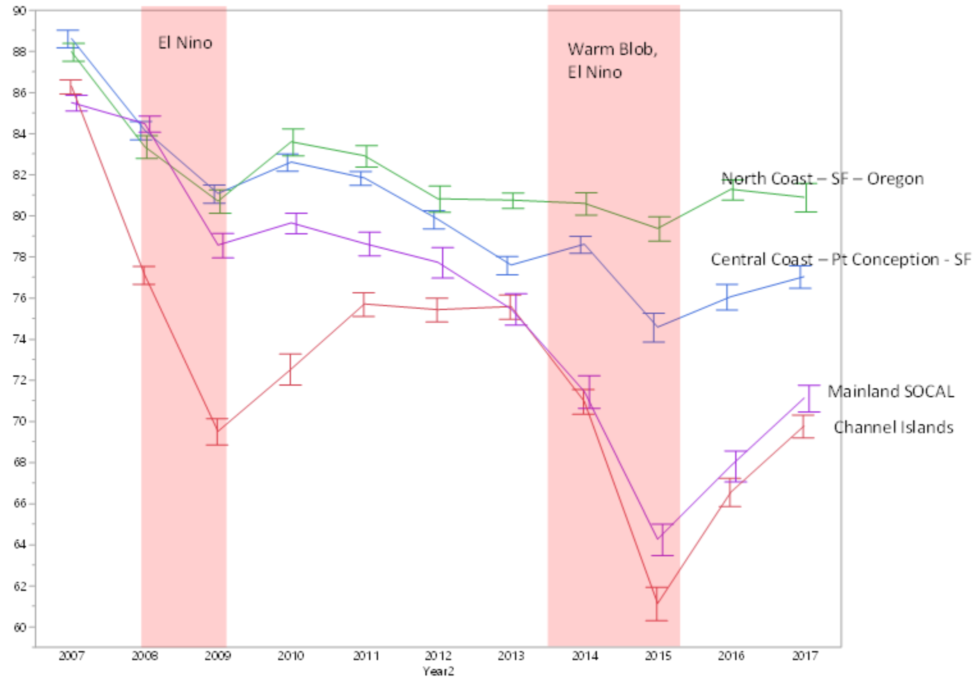

Figure 4: Regional patterns of resiliency (Miner et. al., 2021)

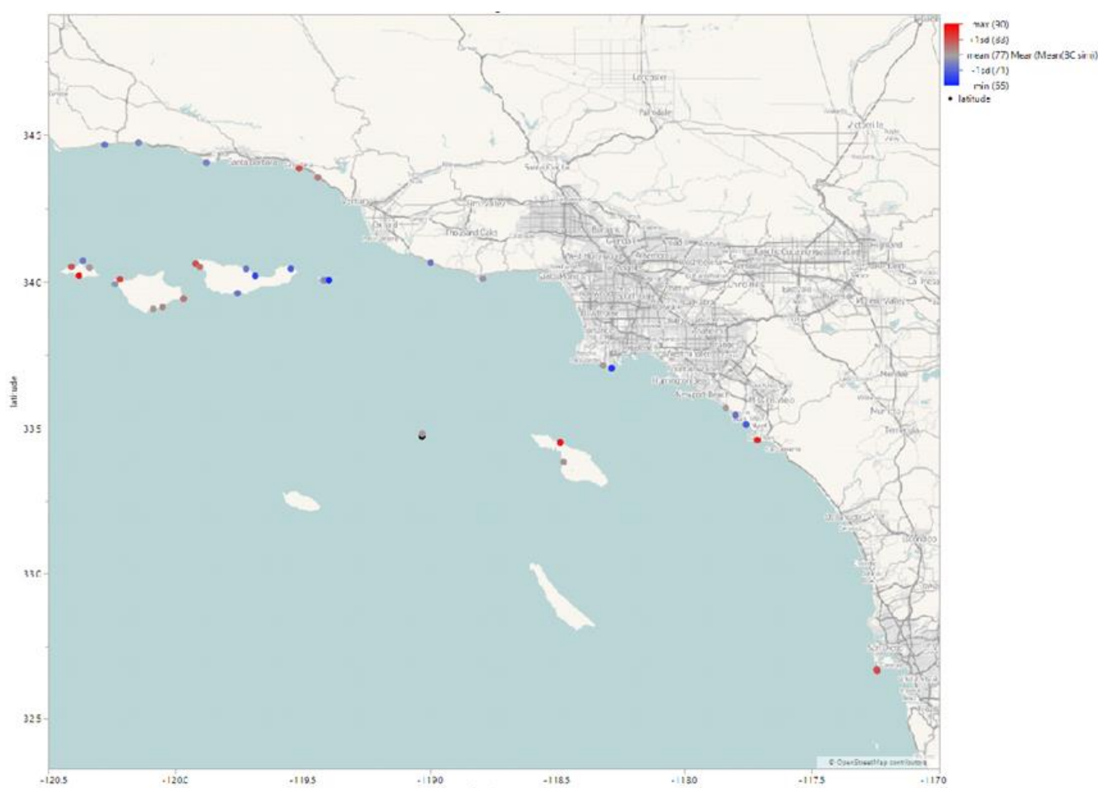

Figure 5: Patterns of resiliency for sites in southern California. Red = high resiliency, blue =low resiliency.

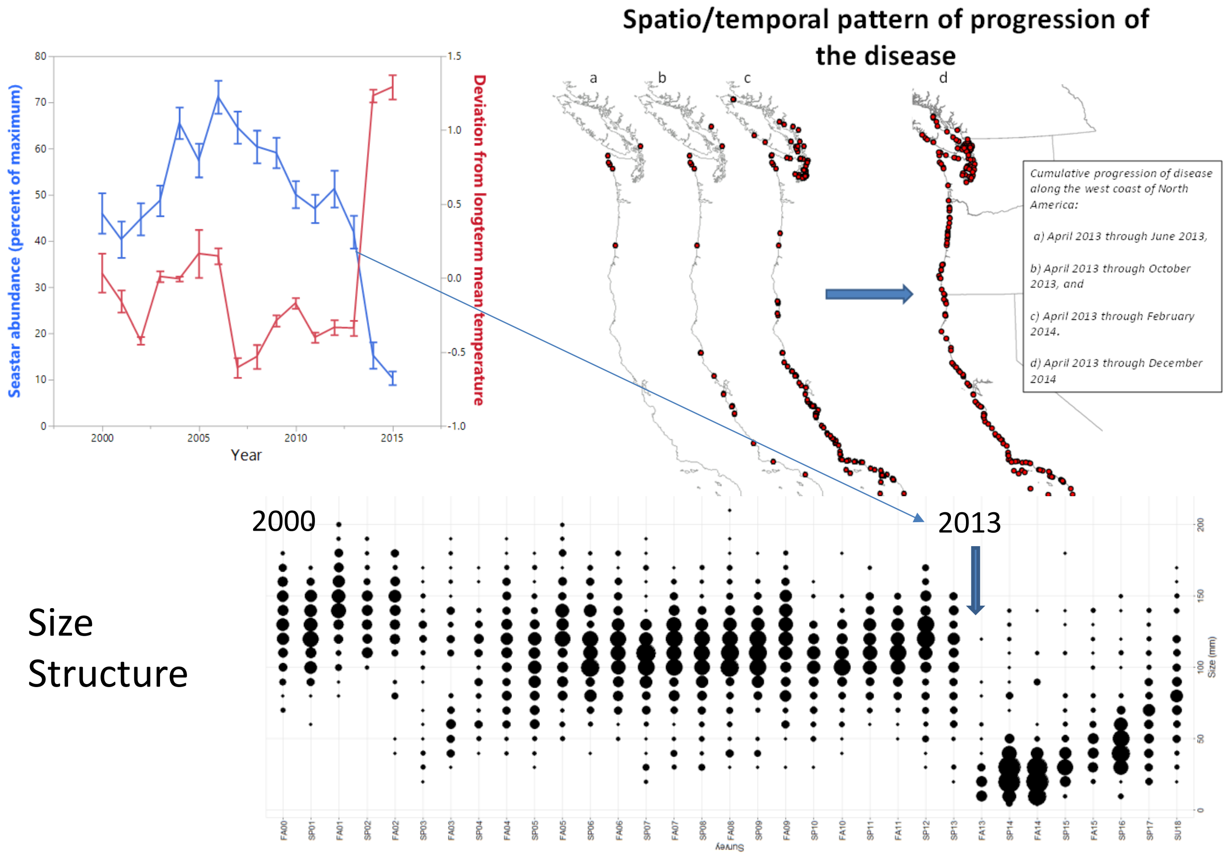

Figure 6: The spatial and temporal progression of sea star wasting-disease-associated changes to sea star population metrics, including the generalized relationship between temperature and sea star abundance and the sea star size frequency over time. Arrows indicate time of crash and the location of the site where size frequency information was collected. Note there was massive recruitment event soon after crash of population (2013).

Report Organization for assessment of MPA effects

The assessment of MPA effects that follows is divided into 6 sections:

1) *Our general approach for MPA network-based assessment in the rocky intertidal*. MPA network-based assessment means the comparison between regulatory protected areas and reference areas, not having regulatory protection.
2) *Biogeographical and oceanographic context for the MPA network in California.*
3) *Structural metrics of the MPA network* including geomorphology, ecological community metrics and species-based metrics. In this section we describe the current or static properties of the MPA network.
4) *Emergent metrics of the MPA network.* In this section we describe properties of the MPA network that have emerged over time, especially relative to time of implementation of the regulatory protection.
5) *Connectivity.* This section is at this point in a preliminary phase and is a description of patterns of connectivity among sites (MPA and reference) via propagule contribution from donor sites and propagule settlement in recipient sites.

6) *Linkages*. In this section link putative mechanisms with emergent patterns. As an example, assume that in the rocky intertidal we find emergent patterns suggesting MPA effects accruing over time. In order to understand such patterns, we need to understand the mechanism that produced the emergent pattern. Clearly, one such mechanism might be the reduction in harvest in MPA's after implementation relative to reference areas. One possibility would be to link harvest reduction to such effects. Because there is so little available information on harvest, temporally and geographically at the scale of sites, our linkage section will be primarily focused on other potential mechanisms such as network connectivity.

Each of these sections address performance objectives and questions outlined in the MPA Action Plan Appendix B. The specific performance objectives from Appendix B are parenthetically noted within each section.

General assessment approach for the rocky intertidal

The approach we used in the assessment of the California MPA network was developed based on understanding the effect of protection in a *designed network* of sites and our geographic level of reporting is based on two basic geographic strata: the whole state of California, and data supported biogeographic regions within the state (see next section). No site specific results will be discussed in this report, although such results are available in our web portal (https://marine.ucsc.edu). It is also important to note that our approach did not rely on geographic pairing of MPA and reference sites for two reasons. First, as described above, we are interested in the assessment of the efficacy of the MPA network and not site effects. Second, access to rocky intertidal sites differs from most other coastal habitats (e.g., kelp forests, deep rocky reefs, etc). In other habitats access to sites is restricted mainly by distance from ports and it is relatively simple to pair sites that are in and just outside any MPA location. Rocky intertidal sites are very rarely safely accessible by boat and instead must be accessed by roads, or trails. Moreover, access is often through private property, where access privileges are difficult and which must be obtained. This makes pairing of MPA and reference sites impossible.

One other difference between intertidal habitats and other habitats is that levels of protection do not differ between MPA designations (e.g., SMR and SMCA). Therefore, in our analyses we compare MPA to Reference sites where "MPA" represents all regulatorily protected areas and "Reference" represents all non-regulatorily protected areas.

Biogeographical and oceanographic context

We evaluated the biogeographical patterns of intertidal ecological communities along the west coast to determine bioregions that could be used in our regional network assessments. By far, the most common way to evaluate geographical patterns of communities is through clustering approaches that focus on building a hierarchical tree that links (usually) pairs of sites based on community similarity. The hierarchical pattern can then be projected on a map, which can be used to find geographical breaks. This approach then shifts from quantitative to qualitative and relies on subjective assessment of the breaks, which can be complicated by sites that mismatch their “region”. More importantly, this approach is not appropriate for determination of what we were interested in, which were the “most quantitatively supported” breaks. To illustrate the difference for assessment of most supported breaks and breaks by ordinary clustering “breaks, consider the following example. Ordinary clustering leads to groups of sites that are linked to similarity to each other and which may indicate biogeographic patterns if sites within groups arrange are also geographically aligned. Assessment of most supported breaks is essentially a type of k means clustering where the defined number of groups (e.g., k=2, groups A and B) is based on the most supported biogeographic break based on community attributes. This ensures that there will be group A sites in the region defined by group B sites. This means that Group A sites are all in Region A and Group B sites are all in Region B. The analytic approach that produces such k-clusters is called distance weighted clustering (DWC) and here we used Gabriel weighting for the assessment. Initially we used DWC to assess biogeographic patterns for the temperate west coast of North America, and produced solution for k=3 through k=7 (Figure 7). These maps are enlarged to show details in Figure 8. What is clear from the maps is that primary break along the west coast is near Point Conception. The next most supported break (see k=4-7) is near San Francisco. In addition, what is very clear is that biogeographic patterns along the coast of California south and east of Point Conception are more fractured and likely affected by the oceanographic circulation and human population patterns in this region. Figure 10 shows an enlargement of the map for k=5. Based on these maps and the complexity of the area south and east of Point Conception we assigned three regions to the intertidal community of the coast of California: CA North, which included sites north of San Francisco Bay; CA Central, which includes sites south of San Francisco Bay to Point Conception and CA South, which includes all sites south and east of Point Conception.

Biogeographic patterns are often linked to temperature regimes and Figure 9 shows the pattern of annual water temperature for the North, Central and South MPA regions over the period 2005 -2020. The data come from our on shore temperature loggers (Onset), which record temperature on (typically) 15 minute frequencies. While not shown, air temperatures are also available. Temperature can be plotted for all sites on our web portal (https://marine.ucsc.edu/). These patterns are presented as context for the coast and regions and also because they will be used in the last data section of this report, where we examine linkages between patterns and putative mechanism (e.g., temperature and community stability). As one would predict the average temperatures differ considerably by region and by year, with temperatures decreasing from south to north and annual patterns largely having similar patterns over time in each region. Two features of these general patterns are important to note. First, the south region is much warmer than the central or north regions. Second, the marine heat wave occurred in all three regions over the same general time period of 2014-2017, with temperature elevation continuing to 2020 in all three regions.

Figure 9 shows the general pattern of water temperature over time and space. In Figure 10, we show the site specific pattern of mean water temperature over time along with the standard deviation of this value. These maps show that even within regions temperatures are can vary site to site – but more informatively, that there are massive differences in within site temperature variability. This latter statistic is an estimate of the day to day variability in water temperature, which is primarily driven by meteorological and oceanographic forcing such as wind, upwelling and retention. Such forcing can greatly affect biological communities directly via effects on physiological responses (for example) and indirectly via connectivity via propagule dispersal.

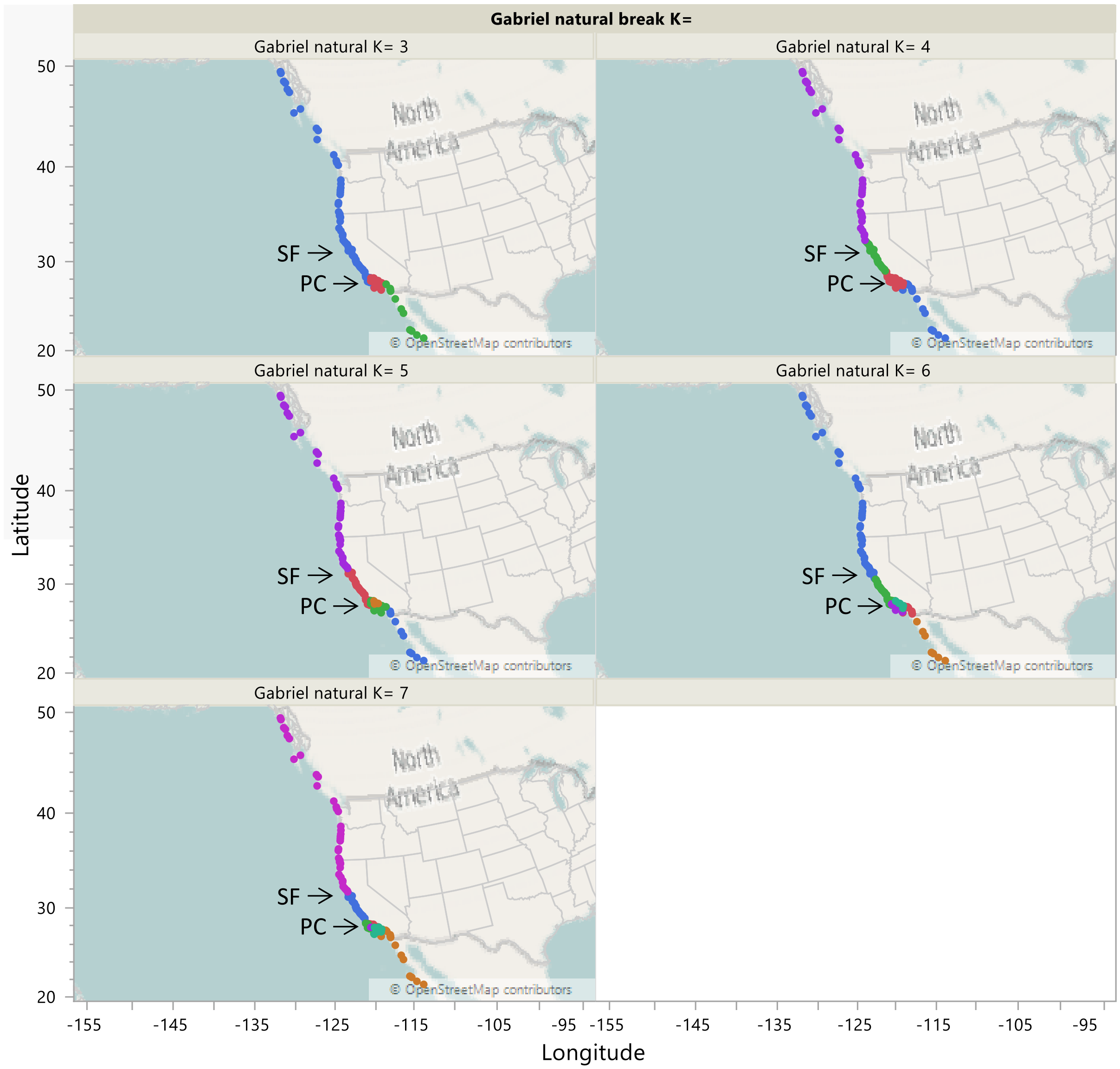

Figure 7: Distance based biogeographic regions for K (number of groups) = 3-7 along the temperate west coast of North America. SF = San Francisco, PC = Point Conception

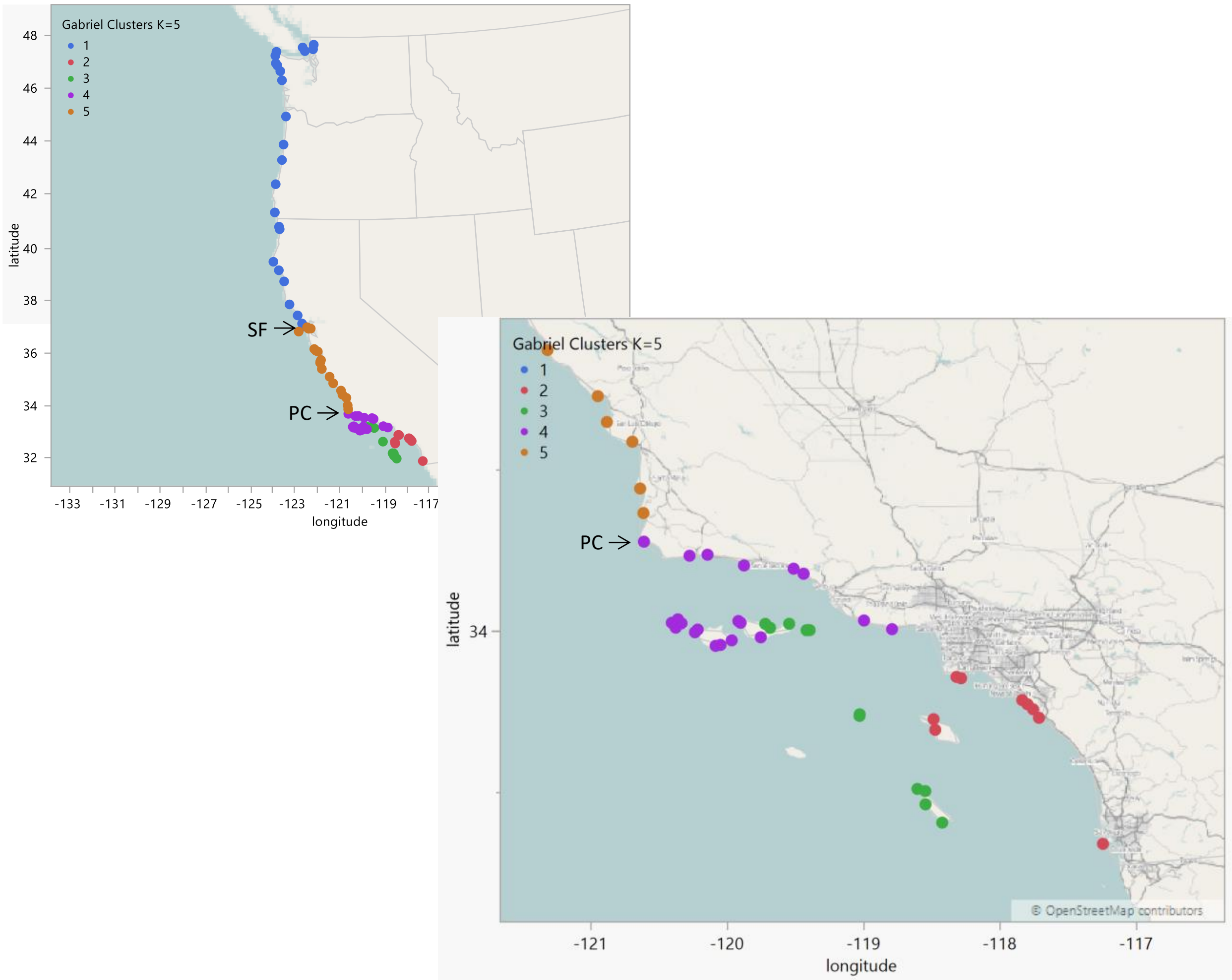

Figure 8: Distance based biogeographic regions for K (number of groups) = 3 along in California. SF = San Francisco, PC = Point Conception

Figure 9: Annual mean water temperature in the three MPA regions in California. Also shown are standard errors.

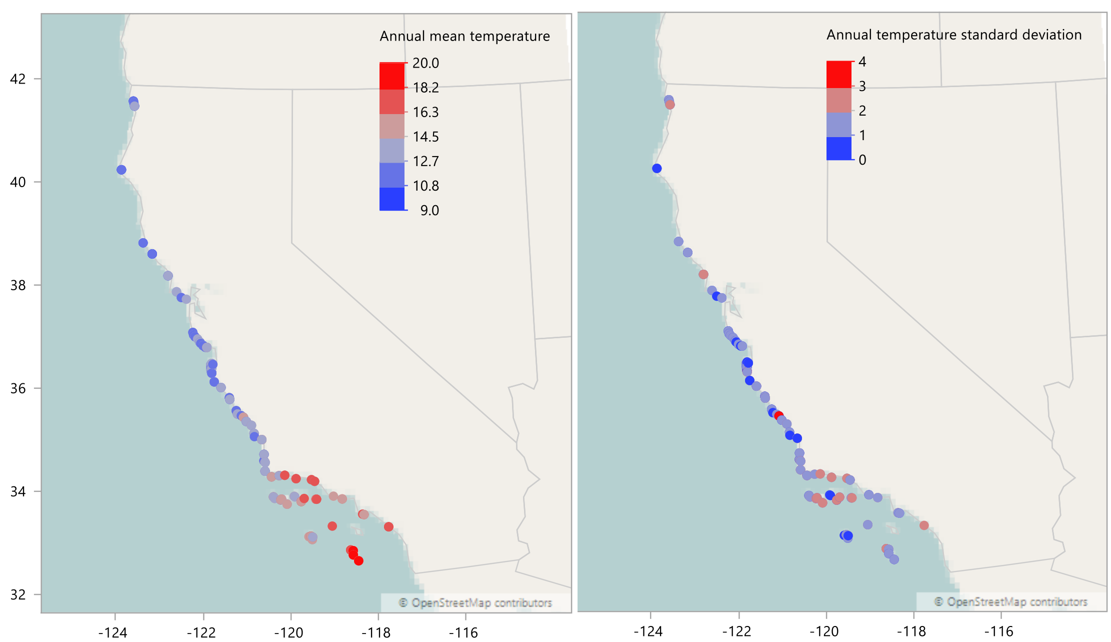

Figure 10: Site specific annual water temperature metrics: mean (left) and standard deviation (right) at intertidal sites in California.

Structural metrics of the MPA network

The results presented in this section are based primarily on the long term monitoring and biodiversity surveys (see methods above) that have been carried out by MARINe since 1992 (funded by a number of programs including those associated with MPA assessment). While the long term surveys are done every year, the biodiversity surveys are not, but are done episodically over time. This because these surveys are very labor and expertise intensive, but yield, what is unusual on monitoring – comprehensive estimation biodiversity and density as well as spatially explicit mapping of species distributions. This mapping is detailed geographically as well as micro-spatially (each species observation at each site is described in x, y, z space), allowing for evaluation of changes in species distributions and tidal range over time. These data are extraordinarily useful for physical and biological characterization of sites and with time become increasingly useful for temporal comparisons. Appendix 4 is a comprehensive table that provides metadata for all sites used in these analyses and figures. Appendix 7 provides a written description and image of all sites along with a description of the surveys that have been performed at each site. A map of all MPA and reference sites used in the analyses in this report is shown in Figure 11. We are describing the results shown in the tables and figures in this section of the report as structural metrics, which are meant to be in contrast to emergent metrics that are presented in the next section. Structural metrics values for variable assessed without regard to implementation of jurisdiction protection that may be dependent on structural or geographic attributes of the site. We consider emergent metrics to be those that may emerge because of jurisdiction protection.

First, we present the general physical and community metrics assessed for each site (see MLPA Appendix B, Goals 1 and 4). The description of these is found in table 2. Each site has a value for each characteristic and these can be visualized on our graphics portal.

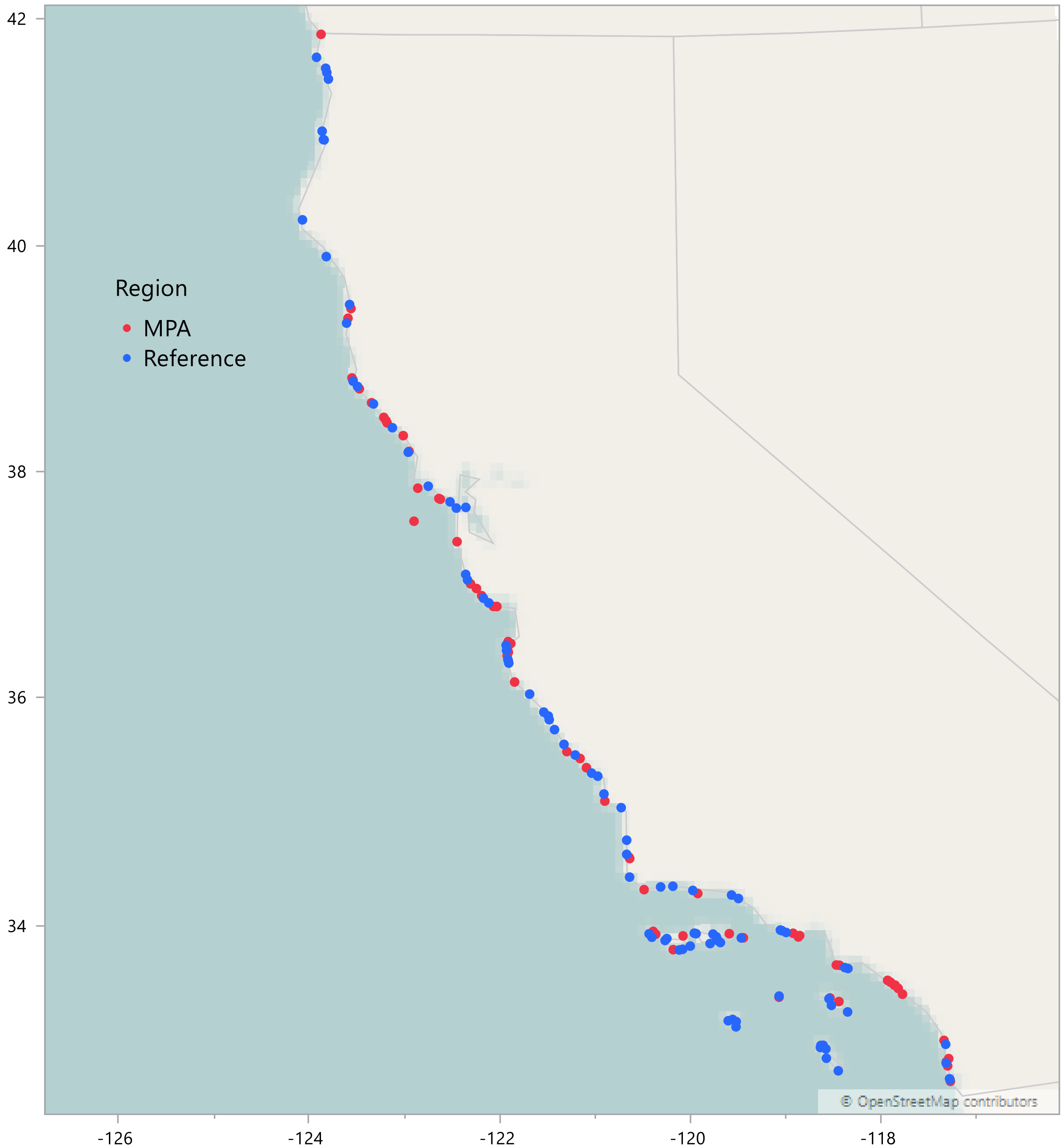

Figure 11: Location of survey sites by level of protection.

Attribute type	Metric	Calculation
Physical	Average maximum reef height (m) surveyed	Mean of the maximum reef heights (m) across all transects
Physical	Average minimum reef height (m) surveyed	Mean of the minimum reef heights (m) across all transects
Physical	Ratio cross - along shore elevation variation	Ratio of cross to along shore variance: indication of topographic complexity and bedding planes
Physical	Reef rugosity	Rugosity modeled from residuals of planer solution to z=x+y. Larger values indicate more rugosity
Physical	Reef slope	Mean rise over run for site
Physical	Reef tidal width	Average width of reef (m) from extreme high intertidal zone to low intertidal zone.
Physical	Tidal range (m) surveyed	Maximum - minimum reef height
Physical	Variance along shore elevation	Variance in along shore tidal hieghts (variance of the 11 transects mean tidal heights)
Physical	Variance cross shore elevation	Variance in cross shore tidal heights (mean across all transects)
Community	New species per observation	number of new species sampled per observation
Community	Species richness	number of species (biodiversity single point with layers)
Community	Margalef species richness (d)	species richness Margalef ((S-1)/ (log(N)
Community	Pielou species evenness (J')	Pielou evenness (H'/Log(S))
Community	Shannon Wiener diversity (H')	H'=∑pilnpi
Community	Brillouin species diversity	Log(N!/PROD(Ni!))/N
Community	Fisher's diversity (alpha)	S=αln(1+N/α)
Community	Community temporal stability	1/(V/mean V). Larger values indicate more stability. A value of 1 equals the mean for all all sites. Uses long term datasets to create resemblance matrix. V is the variance of the distance of each year to the site centroid
Community	Simpsons index (1 - λ)Mean community vulnerability	1 − λ equals the probability that the two entities represent different types. This measure is also known in ecology as the probability of interspecific encounter(pi/∑ pi) (1/Isi) where pi is the proportion of species i found at focal site, ∑ pi is sum of proportion of species i found at all sites, Isi = number of total sites that species i is found at , Mean is across all species at the site
Community	Community uniqueness	1-Community similarity
Community	Community Similarity	mean similarity of community to all others sites (simple matching)

Table 2: Physical and community attributes assessed at biodiversity sties

Physical attributes

Figures S2 and S3 in Appendix 9 show the results of our evaluation of some physical attributes of MPA and reference sites in California for the MPA regions (MLPA Appendix B, Goal 4). These physical attributes are primarily descriptive and are presented to give context for biological attributes discussed later. In addition, in future assessments that more completely include connectivity metrics, we will incorporate physical and network metrics as predictor factors. At the state level the physical factors presented are mainly similar between reference and MPA sites. The one factor that differs considerably is the width of the reefs assessed, which were much wider in MPA locations compared to reference locations (~ 8 meters wider).

At the regional level (Appendix 9, Figure S3), the main difference between MPA and reference sites was again width of the reefs, which are 3-8 meters wider, depending on region in the MPA sites than in reference sites. The other key result is that while CA North reefs are wider and more rugose in general site across the state are relatively similar in terms of physical characteristics.

Community attributes

Figure S4 in Appendix 9 shows the results of the assessment of community attributes in MPA and reference sites (MLPA Appendix B, Goal 1). At the state level, while the differences were sometimes small, MPA sites were generally more species rich, diverse, even and with more rare species than reference sites. This was across a variety of measures of the general metrics. At the regional level this pattern was generally true for the central and southern regions but not true for the northern region. As will be discussed later, this is potentially driven by the differences in sites and sampling in the regions. Sites, especially MPA's, were less common and less accessible in the north than in the rest of the state and this may have affected results.

Species attributes

Before describing the patterns of species abundance and size structure relative to MPA or reference status it is important to provide context for the system. The rocky intertidal is an immensely diverse ecosystem. In our surveys we make an attempt to describe each sampled individual at the species level. With one caveat, we also systematically sample sites from low to high tide to characterize the entire community. That caveat is that our sampling is non-destructive so many species that live in areas that cannot be sampled non-destructively are not well characterized. As an example, we do not tear up mussel beds so as to be able to characterize the infaunal communities that occur in the mussel bed matrix. Over the course of the surveys used in this report we found a total of 498 species intertidal sites in California. These sites were categorized as to their geographic extent (Figure 12). A comprehensive species list for all regions is presented in Appendix 5. In Appendix 6 we provide a list of invasive species and the regions that they have been found in. Most of our species-specific results will be described in the next section, Emergent Effects, however here we describe the primary geographic patterns of species we sampled (Figure 12). More species were found in CA South than in the other two MPA regions (North and Central). This was at least in part due the complexity of the region (see figures 7 and 8), which included the mainland and both the southern and northern Channel Islands. These three sub-regions are also shown. Separately shown are the attributes of the species themselves. Of the total, over 200 were cosmopolitan (found in all regions); around 80 were found only north of the major geographic break in California at Point Conception; around 150 were found only south of Pt. Conception and around 40 were found only on the islands.

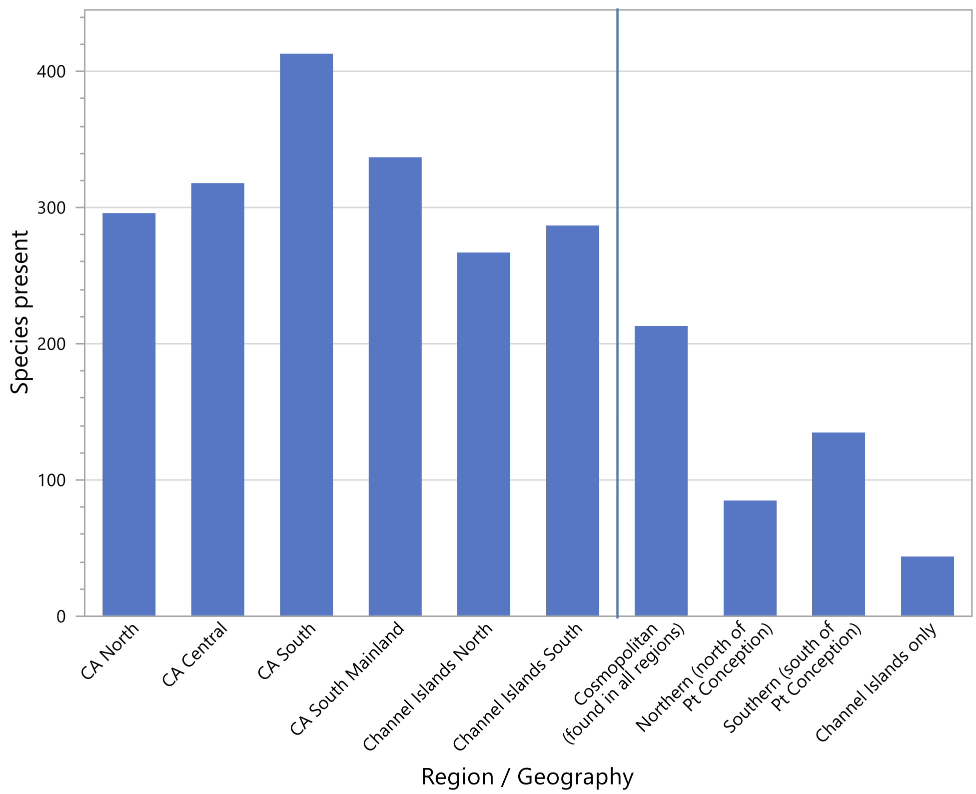

Figure 12: Geographic extent of species found in intertidal surveys. Numbers of species for geographic regions to the left of the vertical line are total number of species in each region. Note the same species could occur in more that one region. Numbers of species in regions to the right of the vertical line are the number of species that are only in that region or set of regions and not in the other regions. Cosmopolitan species are the set of species found in all regions.

Emergent metrics of the MPA network

Community Effects

The static community attributes examined above could have resulted from either differences in the physical characteristics of sites that were afforded MPA status relative to those that were not or the protection itself. In this section we examine the relationship between MPA and reference sites over time, with special attention being paid to determining if shifts in patterns generally co-occur with the implementation of regulatory protection (MLPA Appendix B, Goals 4 and 5). As above we will discuss community and species levels patterns.

There are two types of community attributes that, in theory, could benefit from regulatory protection: metrics of biodiversity and community resilience. Figure S6 in Appendix 9 is an example of the overall pattern of biodiversity in MPA and reference sites over time. Show are the conditional Shannon Wiener H' values over time for reference and MPA sites from 2001 to 2020. The conditional values are the output of a mixed model using site as a random effect. The pattern for the whole state is that biodiversity was unchanged over this period but declined in reference areas. We then assessed the specific prediction that differences in biodiversity metrics should be manifest in the post-MPA implementation period relative to the pre-implementation period.

Here we present graphics from our website as examples of the web graphics portal that is currently available and which can be used interactively to make custom output. Shown (Appendix 9, Figure S7) are a suite of community metrics (see table 2). In each panel there is information for MPA and reference sites pre and post implementation along with a derivative graph showing the difference Pre and Post for MPA and reference sites. Regional figures are available online (https://marine.ucsc.edu/).

While the magnitude of effects varies for all of these metrics, values increased more in the post-implementation period in MPA's than in reference sites.

The other attribute examined was community stability, which is considered a key indicator of resilience. Again, we evaluated this metric relative to MPA region and regulatory period. However, the data are presented over years because the time series is so interesting. Figure 13 shows community stability over time (years) for the three regions. Because of the way stability is calculated (similarity to a control community, which here is a period 2004-2006, prior to the years shown), there is expected decay in the values over time (i.e., communities are expected to naturally diverge in similarity over time). The key is the similarity or difference in pattern between MPA and Reference sites, particularly as the patterns relate to regulatory period.

The results are quite interesting. In the North, stability was slightly greater in MPA sites just prior to regulatory protection and post protection the pattern of stability started to converge for MPA and reference sites. In the Central region there was a clear pattern of increase community stability in MPA sites, relative to reference sites post regulatory protection. However, the separation in lines took a few years to truly manifest and the pattern in become stronger over time. Note also that protection in the Central region occurred many years prior to the other regions. In the south, two things a note-worthy. First, the clear signal of warm water (blob and ENSO) that arrived in 2013 and 2014 and, second the divergence in community stability between MPA and reference sites – MPA stability decreased more than reference sites during the peak warming. However, recovery occurred much more rapidly following in the MPA sites than in the reference sites. By 2019 sites in MPA locations had clearly higher values than reference sites.

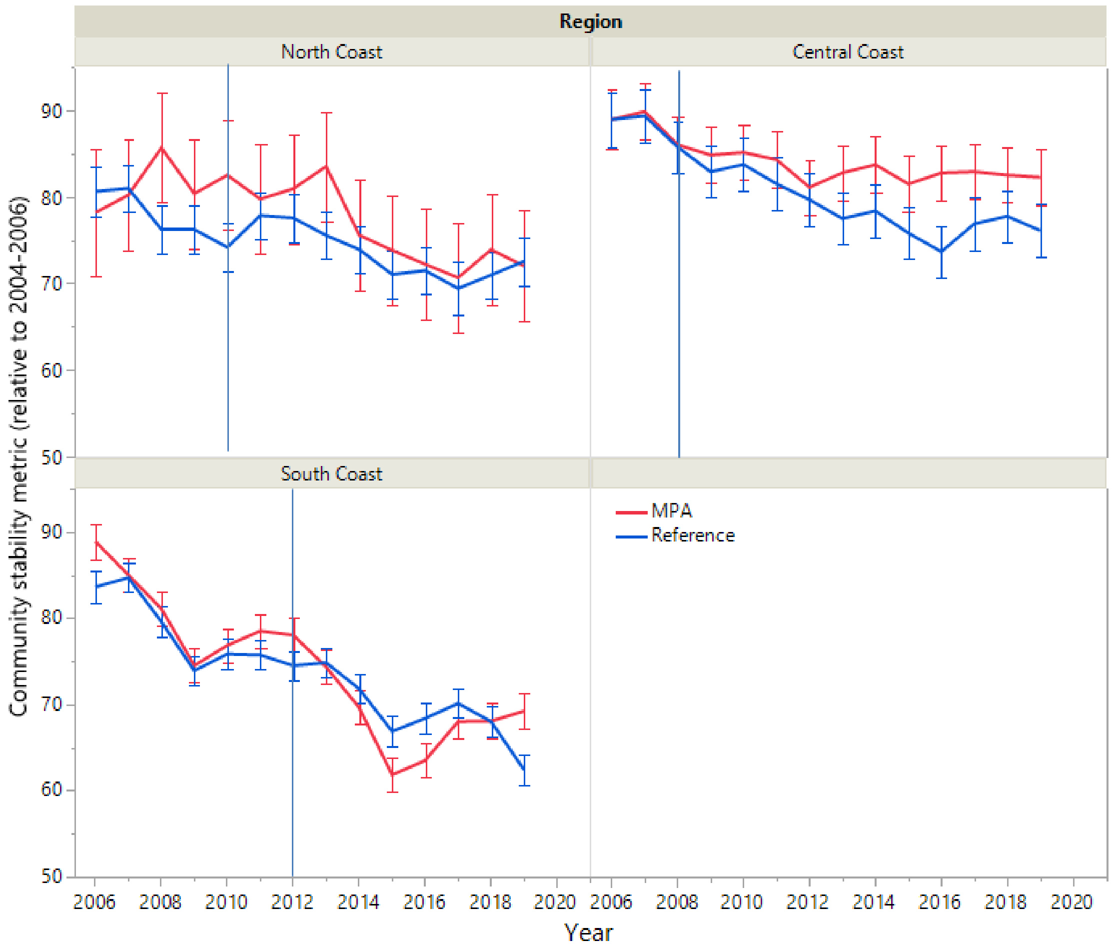

Figure 13: Relationship between community stability (resilience) and time as function of level of regulatory protection. Vertical line depicts the onset of protection. These results are based on Long-term Surveys. Results are from the interaction term (Level of Protection, Year, Region) in a Mixed Model (F=2.97, P<0.0001)

One problem with presentations of patterns of community stability / instability over time is that there is no way to link the change in the community to component species driving that change. In Appendix 9 Figure S8 we present an MDS plot overlaid with community trajectories for MPA and references sites for all three MPA regions. Years are indicated by the size of the symbol and linked sequentially by year. In addition, there is a vector plot showing the species that correlated >= 75% with the plot. A number of patterns are clear from plot: (1) Generally CA North is characterized by the foundation species *Mytilus californianus* (mussels) and the fucoid *Pelvetia*. The south is much more characterized by rock, articulated and crustose red algae and the southern barnacle species, *Tetraclita.* Central California communities are somewhat is between CA North and CA South. (2) The variability in the communities (how broad the pattern is) is highest in the north, and lowest in central California. (3) Reference communities differ from MPA communities generally in the North and over time in central and southern California. In central and southern California, divergence occurred in the years after implementation of protection and in both regions the reference community moved toward rock dominated areas. Reasons for these changes are discussed in the final section, *Linkages*.

Dynamical network attributes: species-based patterns over time

In this section, we summarize some of the results of our assessments of potential effects of regulatory protection for single common and focal species (MLPA Appendix B, Goals 4 and 6). For these analyses, the time series for each region was divided into two periods, Pre and Post implementation of regulatory protection. The mean value for each species was calculated for each period in each of the three MPA regions (North, Central, South). We then compared the log-ratios of common species within regions and overall (across all three regions) to assess whether an MPA effect is evidenced post-regulatory implementation. For this analysis, we first calculated the ratio of the means (MPA/Reference) for each period (Pre, Post) and region. For example, if the means for a species were the same in MPA and Reference sites, then the ratio would be 1. The next step is the calculation of the ratio of ratios. Here we take the ratio of the Post period and divide it by the ratio of the Pre period. Mathematically, this process can be described as:

$$MPA\ effect = E_{MPA} = \frac{\bar{y}_{MPA,Post} / \bar{y}_{Ref,Post}}{\bar{y}_{MPA,Pre} / \bar{y}_{Ref,Pre}}$$

The last step is to take the log of the E_{MPA} – this is done to make the scaling symmetrical around 0. As an example, E_{MPA} = 1 means that there is no MPA effect, positive or negative, a value of 2 means a doubling of the species mean in the MPA post-implementation and a value of .5 means a halving of the species mean in the MPA post-implementation. These are the same magnitude of change, but graphically they would not display as such. Logging the E_{MPA} corrects this. A value of 1 becomes 0 and values of 2 or ½ are (after logging) the same distance from 0 in opposite directions. All log transforms done in this document are based on log base 10.

The results for all common species are shown in Figures 14-17. It is important to describe the expectations for the rocky intertidal. Other that a few species that are commonly harvested and/or poached (e.g. abalone and *Lottia*) there are no clear species specific predictions relating to regulatory protection. Given this and given that all populations are variable over time, there is one likely pattern of results – about half of the species should show an increase and about half a decrease, and the level of increase and decrease should be variable and more or less symmetrical around zero (the magnitude of effects are about as big positively and negatively).

With respect to interpretation of results, a negative species effect does not necessarily imply that regulatory protection was a causative mechanism for the negative response, quite the opposite. The fundamental distinction is that all results presented for these analyses are relative to non-protected sites. Negative responses may be an artifact of natural variation between sites, biotic or environmental perturbations, or differences in recruitment. Finally, note that we also include bare rock and sand in these analyses because both of these metrics are important determinants of habitat suitability.

The overall results across all three regions are shown in Figure 14. Here the effects are relatively symmetrical around 0, but there are more positive than negative effects – meaning more species' increases in MPA than reference sites. This is evidenced by the disproportionate number of positive species above zero (n = 20) relative to those that are negative (n = 13). The results in the north coast region are not biased in number of species (i.e., equal number of species represented between positive and negative responses), but the net magnitude of MPA effect was substantially greater and had more positive than negative effects (Figure 15). Along the central coast (Figure 16), the results are positively biased both in magnitude and number of species (indicating an overall positive MPA effect). In other words, more species responded positively to regulatory implementation relative to unprotected areas. Finally, the results in the south coast (Figure 17) are slightly negatively biased both in magnitude and number of species.

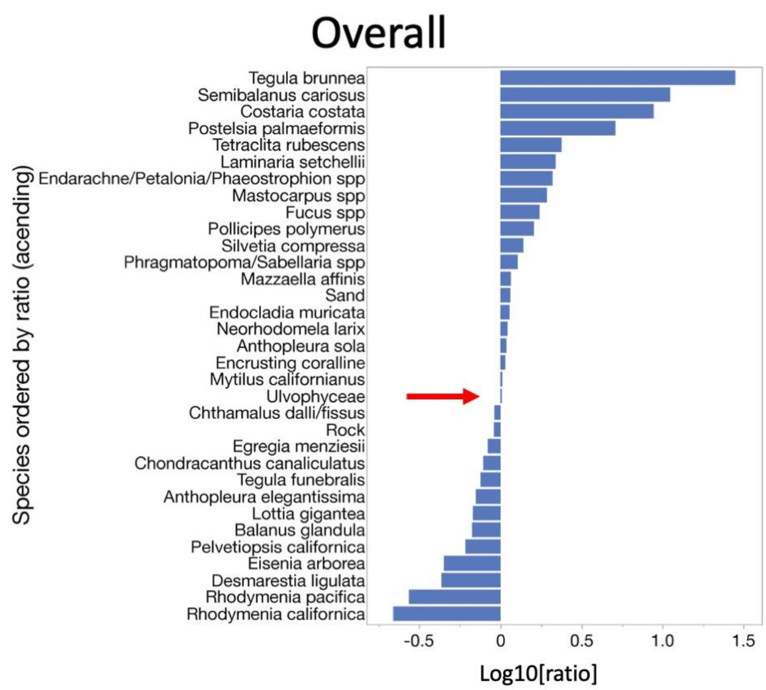

Figure 14: MPA effects for common species across all sampling regions. Positive values are associated with increased mean values for the species in MPA's relative to reference sites post-implementation of regulatory protection. Red arrow shows the point below which estimated MPA effects become negative. Results based on Biodiversity Surveys.

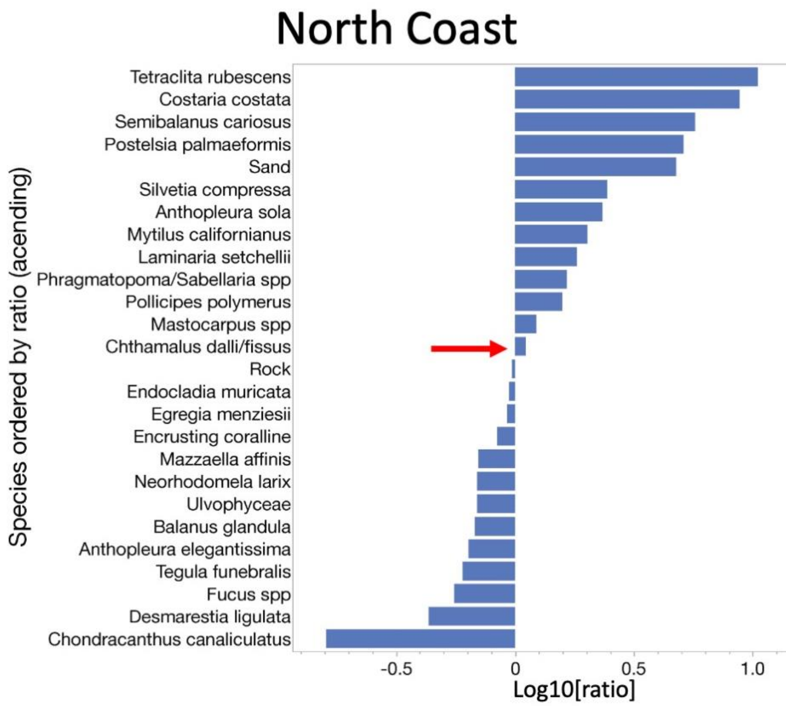

Figure 15: MPA effects across common species in the north coast. Positive values are associated with increased mean values for the species in MPA's relative to reference sites post-implementation of regulatory protection. Red arrow shows the point below which estimated MPA effects become negative. Results based on Biodiversity Surveys.

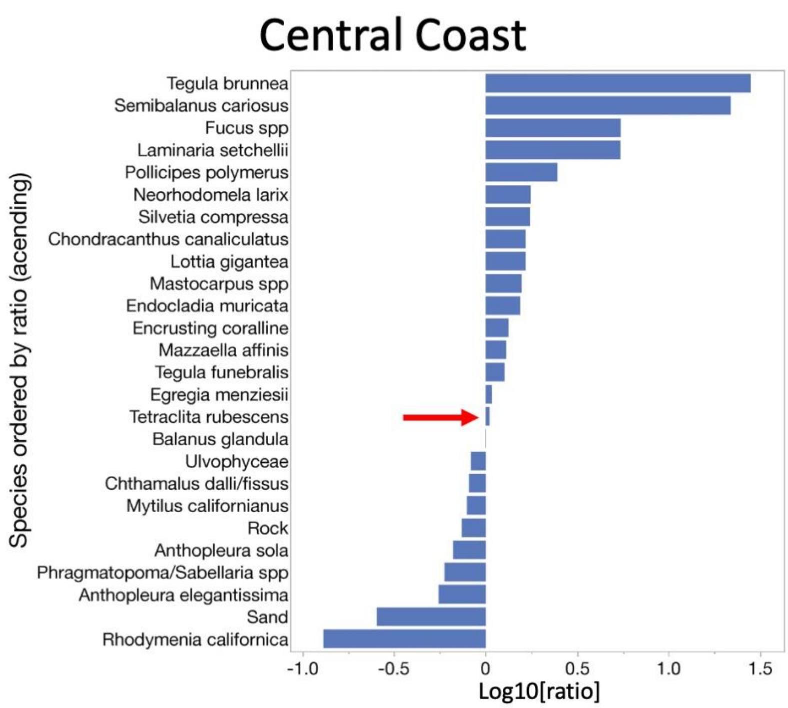

Figure 16: MPA effects across common species in the central coast. Positive values are associated with increased mean values for the species in MPA's relative to reference sites post-implementation of regulatory protection. Red arrow shows the point below which estimated MPA effects become negative. Results based on Biodiversity Surveys.

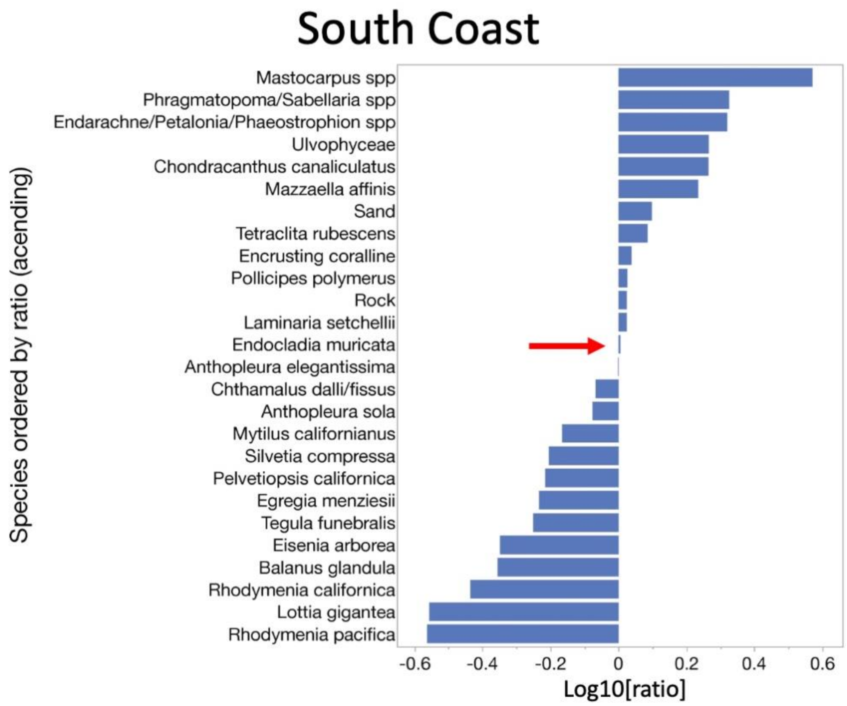

Figure 17: MPA effects across common species in the south coast. Positive values are associated with increased mean values for the species in MPA's relative to reference sites post-implementation of regulatory protection. Red arrow shows the point below which estimated MPA effects become negative. Results based on Biodiversity Surveys.

Size structure results for focal mobile invertebrates

Here we evaluate changes in the size-frequency distributions of *Lottia gigantea*, red (*Haliotis* rufescens) and black abalone (*Haliotis cracherodii*), *Katharina spp*, and *Pisaster ochraceous* between MPA and reference sites, and pre- and post-regulatory implementation (MLPA Appendix B, Goal 4). For these analyses, the results are presented using Long Term Surveys at an aggregate level (between MPA and reference sites across all regions) to evaluate broad emergent patterns potentially associated with a regulatory 'MPA effect.' However, neither *Lottia* nor black abalone are common enough to assess in the north, so results for these species are presented using only data from the central and south coast regions. Because focal plots for Long Term Surveys vary in size and frequency between sampling regions, all size-class results in this section are presented as the percent of total counts for a given species and regulatory protection type. This approach allows for the comparisons of relative changes in size structure irrespective of abundance. Finally, we used a Kolmogorov-Smirnov (KS) test on the size-frequency distribution of each species to evaluate statistical significance of observed changes pre- and post-regulatory protection for both MPAs and reference sites. All parenetical statistics (P = p-value, D = magnitude of difference) refer to the results of this test.

The detailed results for *Lottia* (giant owl limpet) are shown Appendix 9, Figure S9. In general, the mean size of *Lottia* was greater in references sites (37 mm) than in MPAs (35 mm) before regulatory protection (i.e., structural effect). However, the mean size of *Lottia* shifted towards a smaller size class (33 mm) in both reference sites ($P < 0.0001$) and MPAs ($P < 0.0001$). This shift in the mean size of *Lottia* is probably driven by an increase in the frequency of smaller individuals post regulatory implementation, rather than a decline in larger individuals.

For red abalone (Appendix 9, Figure S10), results indicate a positive shift towards a larger size class in both MPA (P < 0.0001) and reference (P < 0.01) sites. However, the magnitude of change was substantially greater in MPAs (positive shift by 9 mm; D = 0.14) than in reference sites (positive shift by 2 mm; D = 0.06). We also looked at the total change in red abalone of harvestable size (> 170mm) and found a substantial increase in MPAs relative to reference sites (Appendix 9, Figure S11).

Results for black abalone (Appendix 9, Figure S12) indicate a slight positive shift towards a larger mean size-class in both MPAs (P < 0.0001) and reference sites (P < 0.0001) post regulatory protection. However, this change was more pronounced in MPAs (increase in the mean size by 5 mm; D = 0.09) than in reference sites (increase in the mean size by 2 mm; D = 0.03).

The results for *Katharina* are presented in Appendix 9, Figure S13. Results indicate a positive shift towards a larger size class in both MPA (P < 0.0001) and reference (P < 0.0001) sites, but the magnitude of change was most pronounced in MPA sites. The mean size class of *Katharina* increased by 8 mm in MPAs (52 to 60 mm), whereas the magnitude of change was only 2 mm in reference sites (from 54 to 56 mm).

Results for *Pisaster ochraceus* (Appendix 9, Figure S14) show a shift towards a smaller mean size class for both MPAs and reference sites post-regulatory protection. This change was most pronounced in the MPAs (decrease in the mean size by 6 mm) relative to references sites (decrease by 1 mm). Although the change in the mean size class for reference sites was only 1 mm, results from the KS test showed that the pre and post distributions are not equivalent (P < 0.0001), and that both MPAs and reference sites had an overall shift towards a smaller size-frequency distribution.

Results for structural and emergent effects of focal sessile invertebrates

Results of focal sessile invertebrates pre and post regulatory management are presented (Appendix 9, Figure S15) as the mean percent cover of each focal species within a sampling region (North, Central, South). For *Mytilus californianus* (Appendix 9, Figure S15a), the mean precent was relatively similar between MPA and reference sites pre-implementation. In the post-implementation period, *Mytilus* percent cover increased both in MPA and reference sites in the northern region and there was a greater magnitude of increase inside MPAs than in reference sites. In the central and southern regions, the mean percent cover of *Mytilus* declined, although there was a slight but non-statistically significant increase inside MPAs in the central region.

For *Cthamalus spp.* (Appendix 9, Figure S15b), the mean percent cover was generally higher in reference sites both pre- and post-regulatory implementation across all three survey regions. Additionally, reference sites had the greatest magnitude of change (positive or negative) relative to MPAs.

The results for *Pollicipes polymerus* (Appendix 9, Figure S15c) are quite interesting in that the magnitude and direction of change was similar between both MPA and reference sites, but the three sampling regions were asynchronous in their response. The northern and central regions both had a slight increase in the mean percent cover of *Pollicipes*, while the southern sampling region had a decline. Finally, it is important to distinguish the frequency of observation between these three focal sessile invertebrate species. Both *Mytilus* and *Cthamalus* are quite common and the mean percent cover of these species was always greater than 10 percent, while *Pollicipes* was observed much less frequently (< 2.5 percent on average).

Results for structural and emergent effects of focal algae species

Results of focal algae species are presented in Appendix 9, Figures S16 -18 (MLPA Appendix B, Goal 4). Structurally, the mean percent cover of *Silvetia compressa* (Appendix 9, Figure S16b), *Postelsia polmaeformis* (Appendix 9, Figure S17c), and *Eisenia arborea* (Appendix 9, Figure S17d) was greater inside of MPAs than in reference sites pre-regulatory implementation. In addition to the percent cover of *Postelsia polmaeformis,* we also analyzed total counts of individuals and found that counts were greater inside of MPAs than in reference sites (Appendix 9, Figure S18). For these and all other focal algae species, the post-regulatory responses are similar between MPAs and reference sites across all three regions. MPAs and reference sites generally responded synchronously within regions with either a positive or negative response. In other words, within any given region, if a response was a positive increase in the mean percent cover of a focal species within an MPA, the reference sites in that region also had a positive increase. Interestingly, the magnitude of change (positive or negative) for a given species was similar between MPA and reference sites within a given region.

Results for invasive species

Here we present the results of four species identified as invasive recorded on Biodiversity Surveys (Appendix 9, Figure S19). First, it is important to note the scale (frequency) of observation for each of these species because they range from 0.05 percent (Figure S19C, *Sargassum horneri*) to 3 percent (Figure S19A, *Caulacanthus okamurae*) and therefore the frequency of observation is several orders of magnitude apart for each species. Structurally (i.e., pre-regulatory implementation), the mean percent cover was far greater for all invasive species inside of MPAs than in reference sites and limited almost exclusively to the southern region. Two of the four invasive species recorded had substantial changes post-regulatory implementation. The mean percent cover of *Caulacanthus okamurae* (Figure S19A) declined both in MPAs and reference sites, however the magnitude of change was substantially greater in MPAs than in reference sites. *Sargassum horneri* (Figure S19C) was not observed in the pre-regulatory implementation period, but it was observed both in MPAs and reference sites post-regulatory implementation.

Connectivity (see full report; Carr, Raimondi, Saarmann 2020, Appendix 8)

This section is in Draft Preliminary form. We are incorporating connectivity modeling results into the section and the linkage section because they are part of MPA APPENDIX B questions and also because they provide insight into other results in this section. A particular interest in understanding patterns of connectivity (contribution and settlement) is linked to the idea that community stability may be affected by degree of settlement into recipient locations through both density dependent and rescue processes.

A separate report for the connectivity modeling project will be delivered upon completion of that project.

The most distinctive attribute of California's system of marine protected areas (MPAs) established by the Marine Life Protection Act (MLPA) is its science-based design as an ecological network. One key feature of a geospatial ecological network is the degree to which locations are connected by the transport of propagules (animal larvae or algal spores) among the MPAs and interspersed populations that constitute the network. For most nearshore marine species, population connectivity is achieved primarily via propagule transport (i.e., dispersal), and such transport is often dictated by the interaction between oceanographic forcing and life history attributes (e.g., planktonic larval duration). Spatial variation in ocean currents and differences among species in propagule duration influence the direction and distance to which a species' propagules are dispersed. As such, the location of an MPA will greatly influence the number and location of MPAs to which propagules produced in that MPA will be transported to.

Over the last decade there have been remarkable advances in modeling oceanographic processes and propagule transport. Such models are typically developed using ROMS (Regional Ocean Modeling System) approaches. These are typically four-dimensional models (three spatial dimensions and time) that track propagules through spatial cells in a temporal series of incremental (time steps) spatial movements (through x, y, z vectors). Random movement via (random) turbulent vertical velocity can be incorporated to simulate small–scale effects not otherwise captured in the grid (cell)-based propagule movement forcing. Cells can be of differing size and shape, and these features affect computational requirements. Often, ROMS models have nested grids of cells of differing dimensions related to the complexity and spatial scaling of processes affecting particle motion (including the slope of the seafloor and complexity of the coastline). Usually this results in smaller cells close to shore with increasing size in offshore areas. For the application of ROMS to estimate spatial population connectivity via propagule dispersal, as we do here, mathematical propagules are "released" in cells and their dispersal is tracked over a period of time. At each time-step in the modeled period the location of the propagule can be assessed. By releasing a similar number of propagules from all of the cells across the spatial domain of the model (i.e., northern Baja California, Mexico to northern Washington state, including California state waters) and matching cell configuration with MPAs, the relative contribution of MPAs to the replenishment of other MPAs can be estimated.

By incorporating a metric or proxy (e.g., area of suitable habitat) for spatial variation in propagule production among cells, and applying a predetermined pelagic duration of a species' propagules (PLD), the relative contributions of populations (or MPAs) can be estimated. PLD categories representative of the diversity of marine species can be applied both to represent the spectrum of durations and dispersal of California marine species, and to assess how PLD influences the distribution of dispersing propagules. These relative contributions of propagule exchange among populations (or MPAs), often referred to as “connectivity”, are often characterized by “source” populations (or MPAs) that contribute more propagule replenishment to other populations (or MPAs) than they receive from other populations (or MPAs), and “sink” populations (or MPAs), that conversely receive more propagules than they contribute to other populations (or MPAs). While sink populations (or MPAs) can be more reliant on connectivity for replenishment and persistence, source populations (or MPAs) can contribute disproportionately to the replenishment of other populations (or MPAs) across the network. All of this suggests that ensuring that source MPAs support large populations and high levels of propagule production is key to the size and persistence of protected populations across the MPA network. In addition, those populations (or MPAs) that receive disproportionate numbers of propagules (relative to other locations) or that have disproportion number of links to donor populations (or MPAs) may in fact be more resilient than other populations (or MPAs).

Previously, we developed a population connectivity model for the purpose of identifying source populations and MPAs that was then incorporated into CDFW’s MPA prioritization scheme for the spatial design of the long-term MLPA monitoring program. The detailed methods employed in the development of that model and the resulting evaluation of population and MPA connectivity were summarized in the report to the Ocean Protection Council submitted in June 2020) and attached as Appendix 8. The results presented here are not subject to the previously identified - the biased connectivity metrics for MPAs at the northern and southern ends of the state because of the lack of information for habitat in Oregon and Mexico. The contributions of MPAs in northern California to the replenishment of other populations were underestimated because their contributions to populations in Oregon could not be calculated because of the inability to model the suitability of habitat for settlement in locations in Oregon. These estimates of population connectivity between California MPAs and ecosystems are now informed by information recently integrated in the Contribution modeling. In addition, information on the distribution and abundance of habitat (e.g., 0-30m depth rocky reef) across the network has been enhanced since the development of the original model. This includes updating the state’s seafloor database with data produced by more recent mapping studies, making it possible to separate mapped and predicted habitat where habitat types were interpolated across the unmapped nearshore “white zone”, use of high resolution data to attribute habitat depth zones, and new methods and data sources for calculating kelp cover.

Key model assumptions

To properly interpret model results, it is imperative to recognize and consider several key assumptions of the design and implementation of the model:

1) No effect of MPA or other protection has been included in the modeling. This will be rectified in future versions of the modeling.
2) Propagule production and subsequent settlement is assumed to be directly and linearly related to the amount of Habitat in the donor and recipient MPA or ROMS cell. Here

habitat means the general habitat types described above (e.g., rocky intertidal, Hard bottom subtidal from 0-30 m). This assumption has the following linked assumptions

a) No effect of protection (as noted above)
b) No effect of meso or micro habitat features on the abundance, the size structure or the size independent fecundity of species. These will be addressed in future versions of the modeling
c) No geographic patterns of abundance, the size structure or the size independent fecundity of species. These will be addressed in future versions of the modeling
d) No geographically independent environmental impacts on the abundance, the size structure or the size independent fecundity of species (e.g., local hypoxic events). However, note that projections of change in environmental conditions could be incorporated into modeling. Two examples will serve as examples. First, spatially explicit climate related change in temperature, OA or other attributes could be incorporated into connectivity and contribution modeling. Second, sea level rise could also be formally incorporated into connectivity modeling through projected spatially explicit predictions of habitat gain or loss.

We address a series of 5 questions below:

1) What are the geographic patterns of contribution of propagules from sites in California?

The modeled geographic patterns of contribution of propagules for all sites (MPA and reference) is shown in Figure 18. Each chart on in the graph represents model results from a particular range in planktonic larval duration (PLD). Note that the contribution decreases as PLD increases. This is due to larvae dying or being advected out of the system (off shore or out of the domain) before settlement can occur. Also note that for all PLD scenarios there are “hot spots” of greater than ordinary contribution

2) What are the geographic patterns of settlement of propagules from sites in California?

The modeled geographic patterns of settlement of propagules form all sites (MPA and reference) is shown in Figure 19. Description of the charts is as above. Note that the contribution decreases as PLD increases. Note that patterns of settlement into recipient locations differs by PLD and also that it differs from the patterns of contribution. Also note that for all PLD scenarios there are “hot spots” of greater than ordinary settlement

3) What are the geographic patterns of contribution of propagules from MPA’s to all sites (MPAs and reference) in California?

This is similar to #1 above except here contribution is only from MPA’s (to all locations). These results are shown in Figure 20.

4) What are the geographic patterns of settlement of propagules into MPAs from all sites (MPAs and reference) in California?

This is similar to #3 above except here settlement is from all locations to MPA’s). These results are shown in Figure 21.

A summary of results from figures 20 and 21 are presented in Figure 22.

5) *Are the observed (modeled) patterns of contribution from MPAs to MPAs and other locations greater than expected? and Are the observed (modeled) patterns of settlement into MPAs from MPAs and other locations greater than expected?*

These results are shown in Figure 23 and are the key results that come from summarizing 1-4 above. The modeled results indicate that contribution of propagules from MPA's to other MPA's is greater than expected. In addition, the results show that contribution from reference locations to MPA's as settlement is also higher than expected. The expected value is based on the area of the MPA's and reference locations. Hence, greater than expected means disproportionately more per unit area. Recall that the model does not yet incorporate an MPA effect (e.g., an increase in propagule production due to reduction of harvest in the MPA). This means the effects described above are due to the location of MPA's with respect to coastal circulation patterns. These results suggest that MPA placement enhances both contributions from and settlement into MPA's.

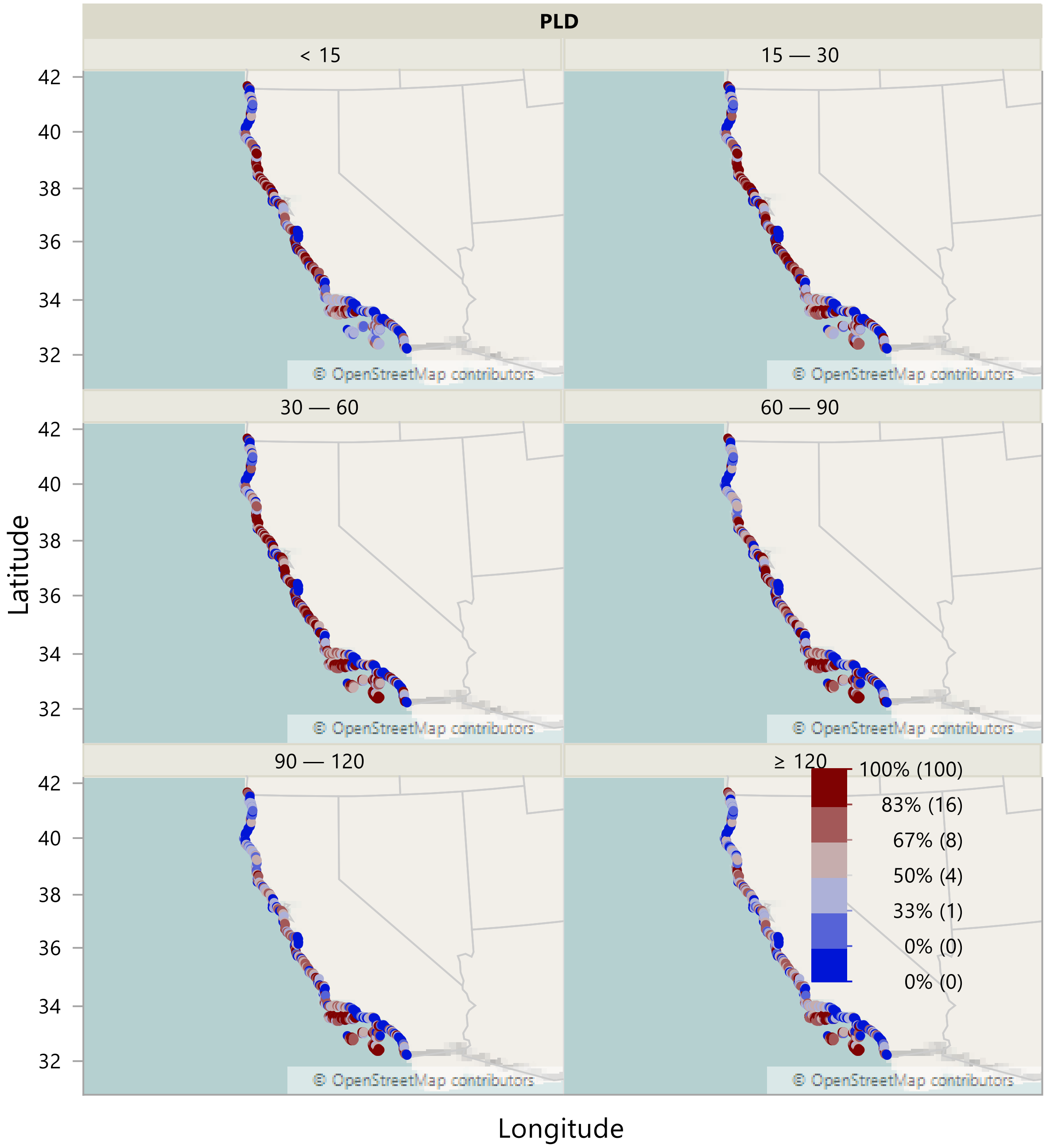

Figure 18: Geographic patterns of contribution of propagules from sites in California. Each chart represents a range of PLD's . Contribution is scaled to Maximum (100%) so that all PLDs have the same ranges.

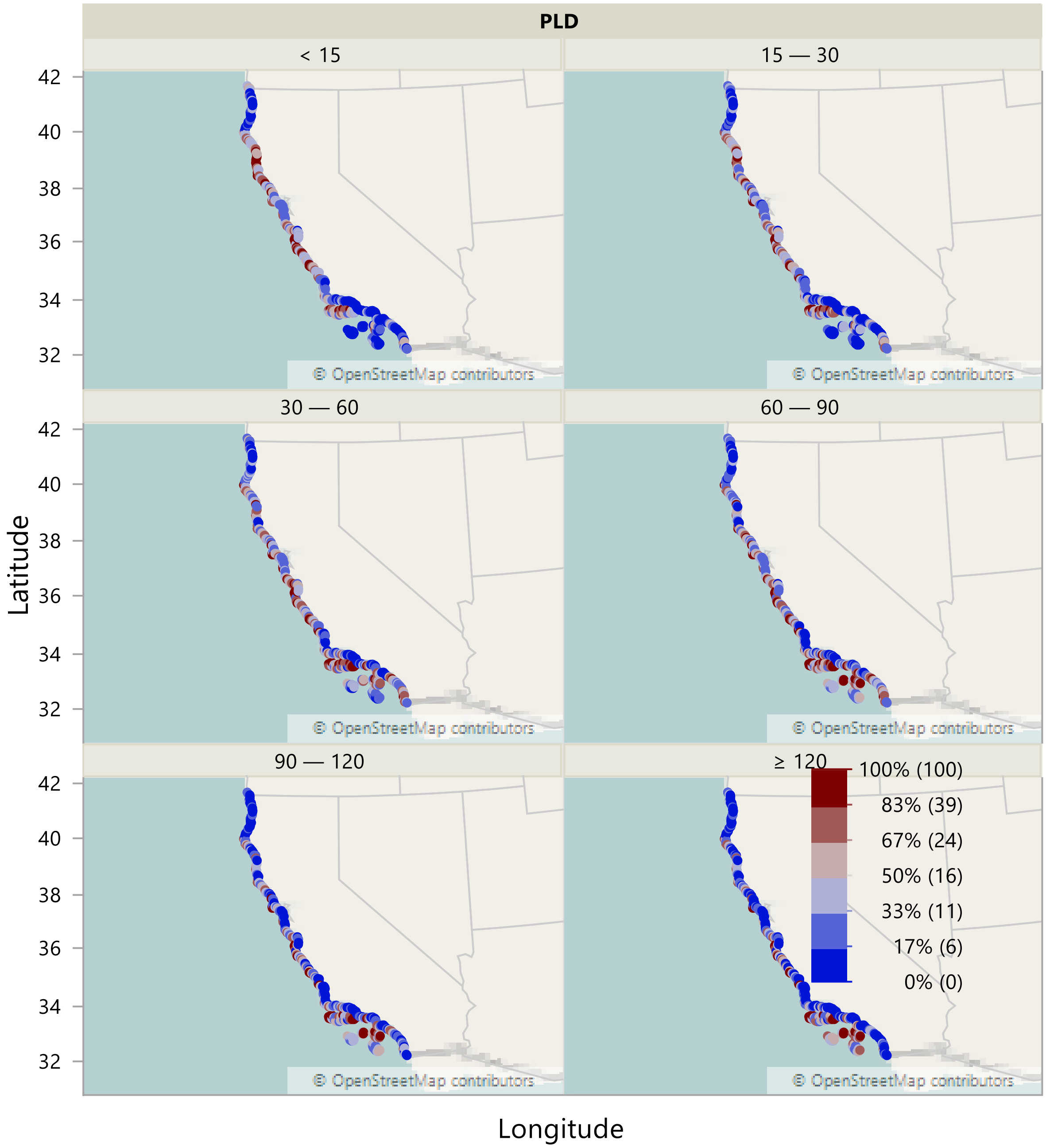

Figure 19: Geographic patterns of settlement of propagules into all sites in California. Each chart represents a range of PLD's . Settlement is scaled to Maximum (100%) so that all PLDs have the same ranges.

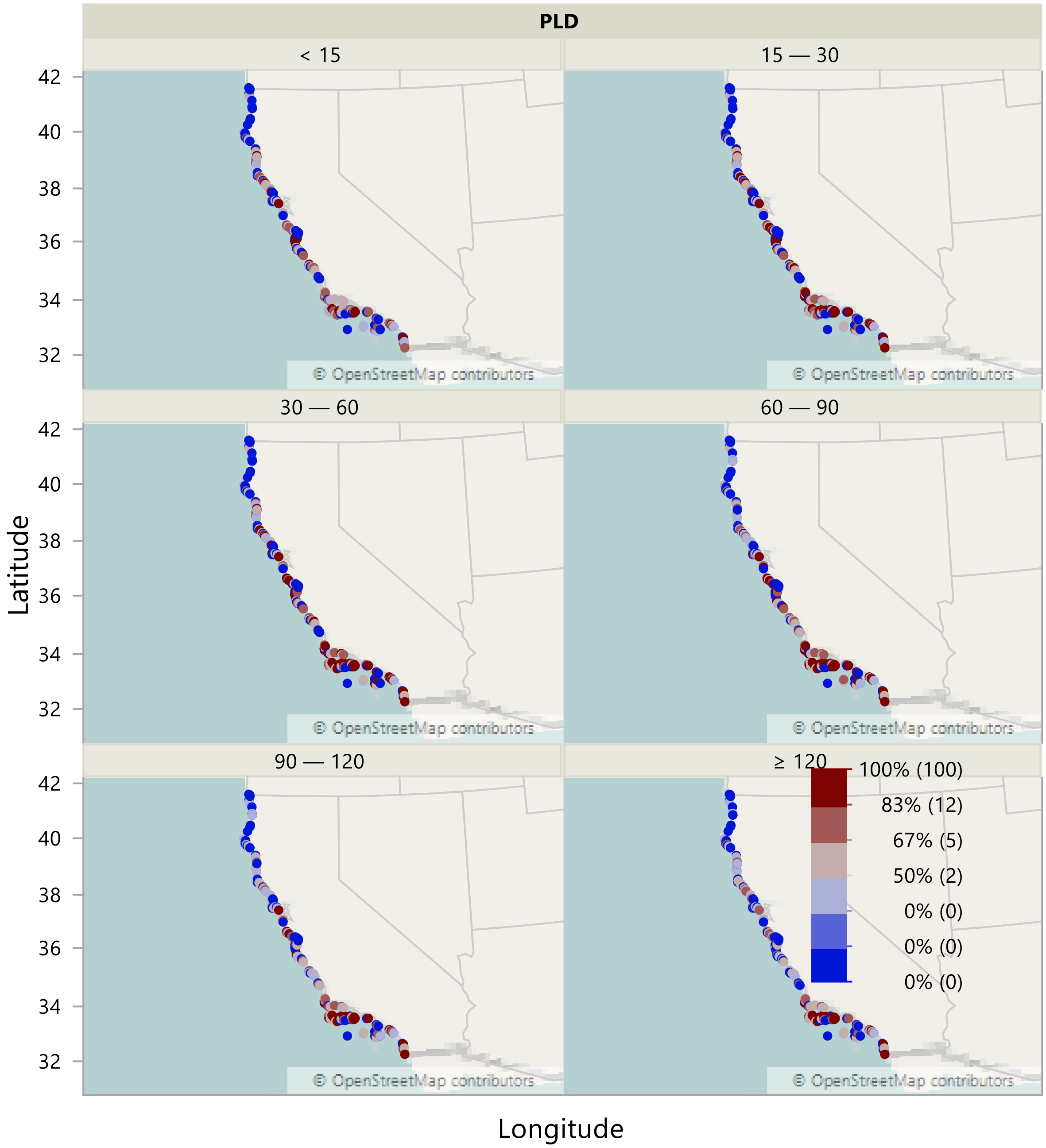

Figure 20: Geographic patterns of contribution of propagules from MPA's to all sites in California. Each chart represents a range of PLD's . Contribution is scaled to Maximum (100%) so that all PLDs have the same ranges.

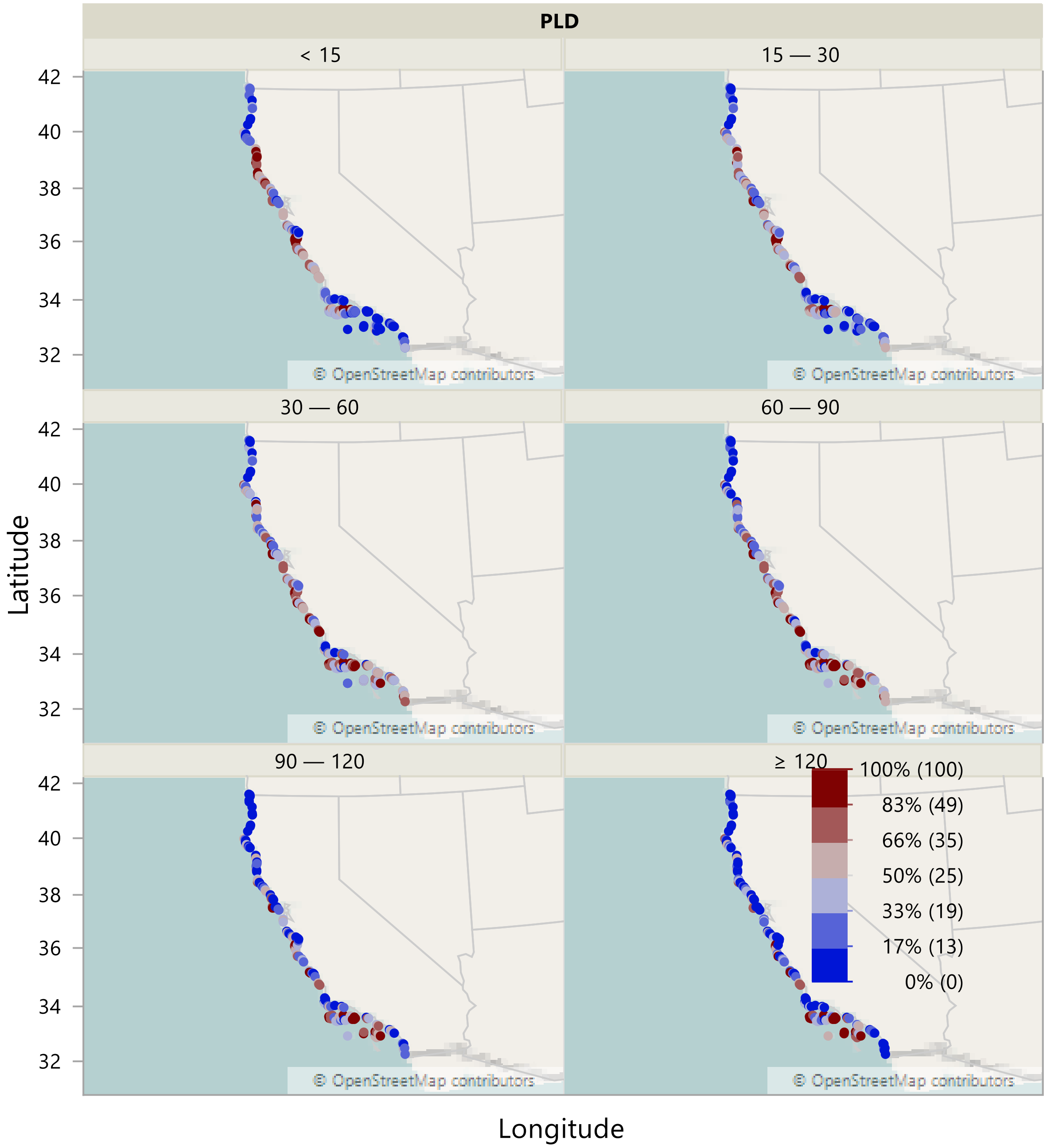

Figure 21: Geographic patterns of settlement of propagules from all sites in California to MPA's. Each chart represents a range of PLD's . Settlement is scaled to Maximum (100%) so that all PLDs have the same ranges.

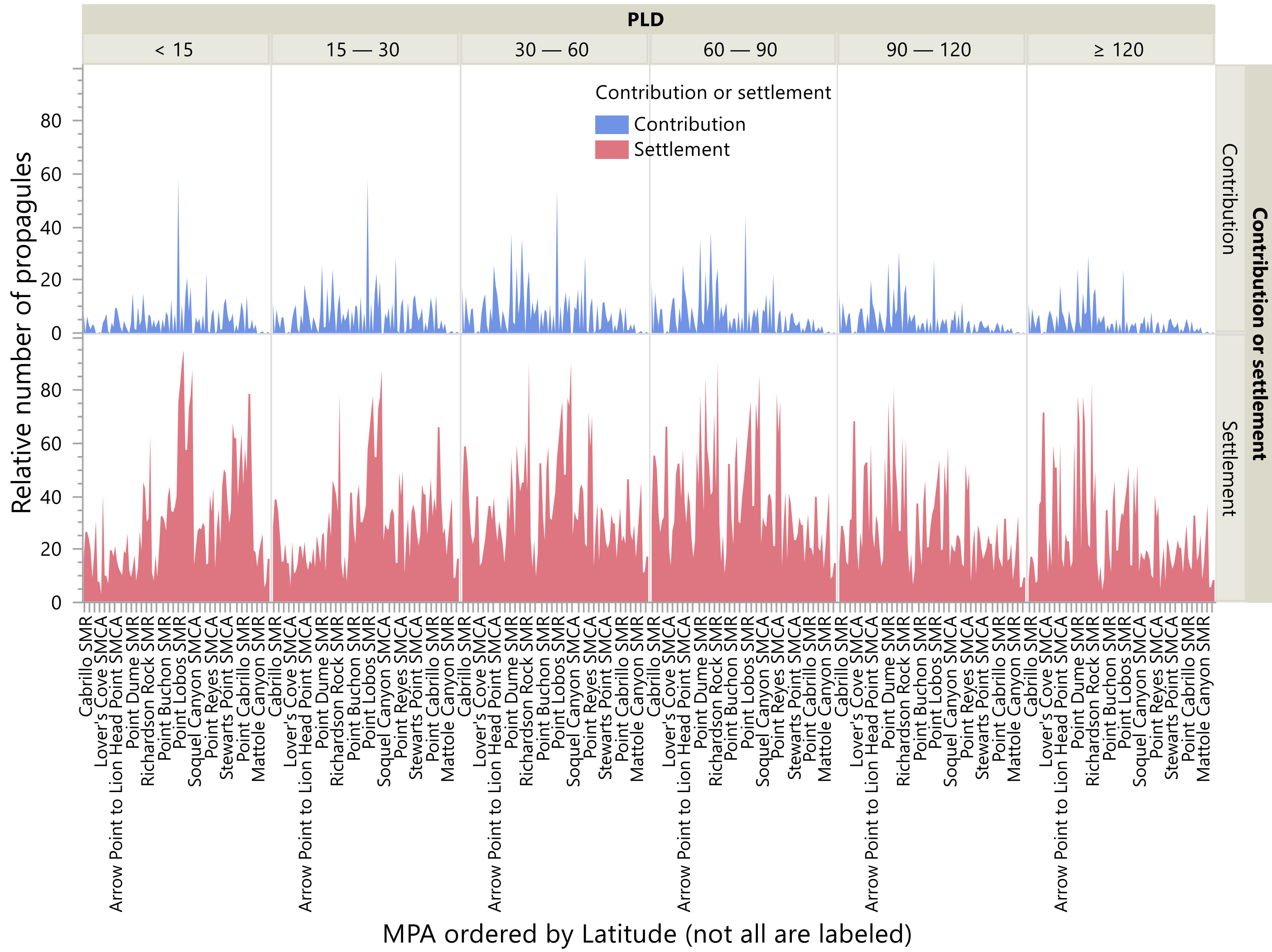

Figure 22: Patterns of contribution of propagules from all locations into all MPAs in California as settlement and patterns of contribution of propagules from all MPA's into all locations in sites in California as settlement. Shown are modeled results for a range of PLD's.

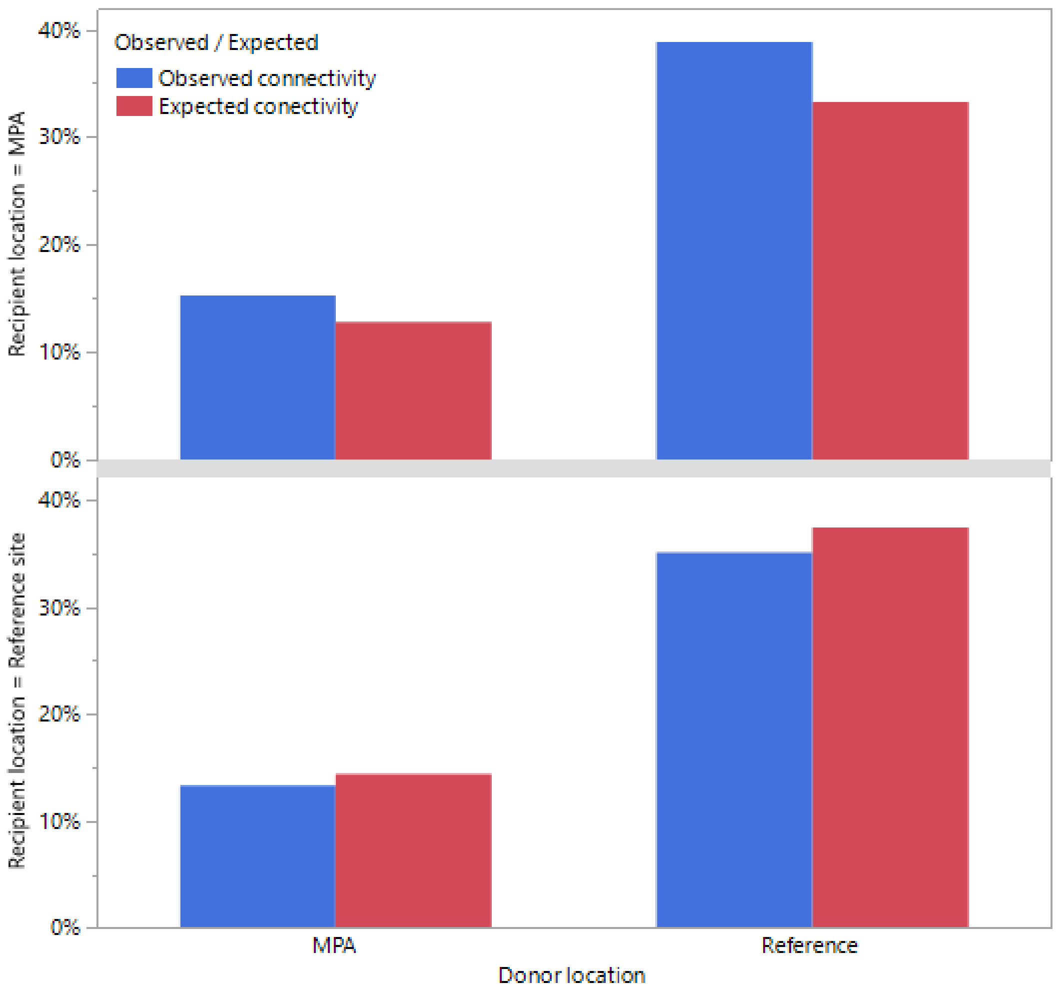

Figure 23: Summary results for models assessing patterns of contribution from reference and MPA locations into reference and MPA locations as settlement. Observed = modeled results from connectivity modeling. Expected results are based entirely on area of MPA or reference sites. Bars in each graph sum to 100%. Results are based on sums of values for all PLD's.

Linkages

In this section we link together patterns and processes to develop insight into the potential for regulatory protection in the form of MPAs to affect community attributes (MLPA Appendix B, Goals 2 and 6). We use the Marine Heat Wave (MHW) as a focal perturbation. The recent MHW initiated in 2013 (Figure 10) and led to very elevated temperatures for 2 years and higher than typical temperatures for another 2-4 years (depending on region). The MHW was associated with profound effects on biological communities and their dynamics (Figures 5, 7, 13). However, there was some evidence MPA sites were less affected or recovered more quickly than reference sites (Figure 13). Here we combine information already discussed in previous sections to assess mechanisms that may produce the apparent MPA effects.

The results of a PERMANOVA analysis, looking at community structure as a function of MHW (pre vs post), site status (MPA, Protected) and site (random effect nested within site status) is shown in Table 3 and the key result is shown in Figure 24, which shows that community structure was similar in reference and MPA sites prior to the MHW but diverged post MHW.

Source	df	SS	MS	Pseudo-F	P(perm
MHW	1	3570	3570	7.6973	0.001
Site Status (SS)	1	3384	3384	1.4312	0.148
Site {SS}	125	3.973E+05	3178.4	8.9828	0.001
MHW X SS	1	905.14	905.14	1.9516	0.027
MHW x Site{SS}	49	22885	467.04	1.32	0.006
Residual	100	35383	353.83		
Total	277	5.0514E+05			

Table 3: Results of a PERMANOVA analysis, looking at community structure as a function of MHW (pre vs post), site status (MPA, Protected) and site (random effect nested within site status).

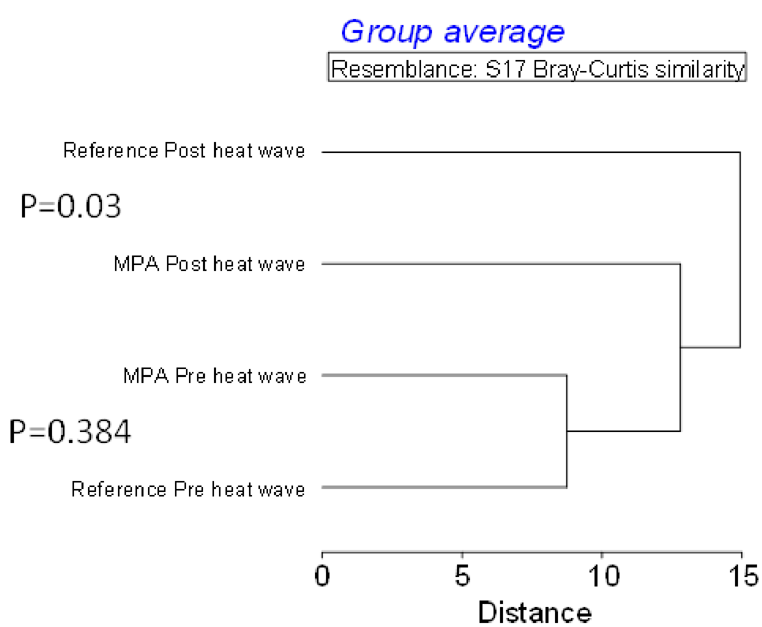

Figure 24: Results of a cluster analysis depicting the interaction between MHW and Site Status (see Table 3).

Important, common species (and substrate) that were important in driving the change in community pre and post MHW and also important in the difference in response for MPA and reference sites are shown in Appendix 9, Figure S20.

The most informative result is that bare rock (the absence of biological species) increased post MHW in reference sites (also see Appendix 9, Figure S8) but was unchanged in MPA sites. The foundation species *Mytilus* and *Phyllospadix(seagrass)* inceased post MHW in MPA's but decreased in reference sites, Fucales (*Fucus, Silvetia, Pelvetiopsis*), did the reverse. The seastar, *Pisaster ochreceus* decreased post MHW- this was a well reported phenomena. Our results show that the decrease was less in MPA sites than in reference sites.

An important question is what may have caused the responses to differ in MPA vs reference sites? This is really an essential question with respect to an environmental perturbation that was coast-wide and which did not differ (in terms of temperature elevation) between MPA and reference sites. Also, it is unlikely that difference in harvest of species between MPA and reference sites could explain these results as few species are harvested in intertidal systems; although mussels are, and the difference seen in mussel response (Appendix 9, Figure S20) may have been affected by harvest restrictions. After careful consideration we think the difference between MPA and reference sites may in fact be due to differences in the community stability of the two types of sites. The discussion below lays out this argument.

We linked the community stability metric shown in Figure S20 to site based temperature data shown in Figures 9 and 10 to create a thermal stability profile for MPA and reference sites over time for each region (Figure 25). The color of the line depicts the temperature of the region (also = x axis) and the trajectory documents the relationship between temperature and stability (stability = y axis). The polygon that contains the trajectory is the thermal / stability profile.

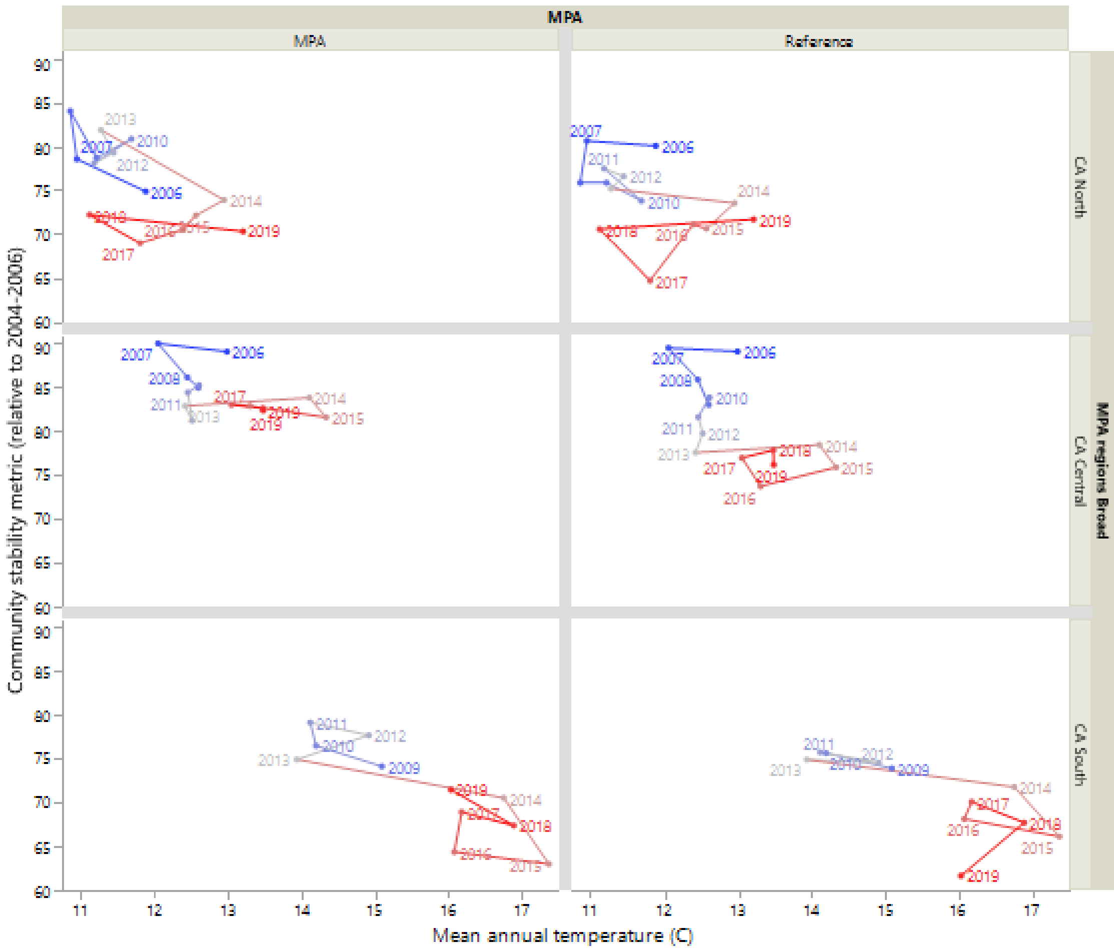

Figure 25: Regional Thermal / stability profiles for MPA and reference sites showing the relationship between community stability and mean annual water temperature over time. Color progression is by year.

There are a few important features of these profiles to note:

1) In general, as temperature rises, stability decreases.
2) For most scenarios (Site status x region) there are two states (pre and post MHW)
3) For all regions the profiles are higher in MPAs than in reference sites. This means that overall stability is generally higher in MPAs than reference sites
4) In the north, MPA and reference sites generally have similar profiles
5) In the south, MPA and reference site stability diverges during the recovery period from the MHW, with MPA sites recovering much more rapidly than reference sites.
6) In CA Central, MPA and reference sites have two very different thermal / stability profiles. The key distinguishing feature is that the impact of the MHW was much less severe in MPA sites than in reference sites. In the reference sites the MHW state was 10 points less than in the MPA sites indicating a buffering of community stability properties in MPA's.

These results and in particular the results for central California pushed us to explore mechanisms that could have led to the difference in stability properties for MPA's relative to reference sites. One possibility that has been proposed as a theoretical benefit is the effect of connectivity to the stability of a community. In theory, either because of density dependent feedbacks or through buffering of environmental stochasticity, connectivity can stabilize communities. In Figure 23, we showed that modeled connectivity into MPAs was higher per area than in reference areas. However, by itself this does not indicate that increased connectivity is associated with increased stability. To address this question, we linked stability to modeled connectivity, here considered as settlement into MPA sites. As noted in the connectivity section, the connectivity results are preliminary and are subject to many assumptions. Also, at the site-specific scale we only have results for MPA sites. Given these constraints was compared the relationship between connectivity stability using a mixed model ANCOVA with MHW period (pre , post) as a fixed categorical variable and connectivity (settlement into MPA site) as a covariate and the interaction between them as test for homogeneity of slopes. MPA site was the random effect. The results of the analysis showed that the interaction between MHW period and settlement into MPA was very significant ($F= 13.53$, $P<0.0001$), indicating the slopes differed for the two MHW periods (Figure 26). Examining Figure 26 reveals that there was no relationship between connectivity and stability in the pre MHW period, but there was a strong positive relationship in the post MHW period. The fit to the line is shown in the figure.

Following the logic laid out above, this result suggests that the MPA's may stabilize communities because they have greater connectivity than reference sites and that this effect is primarily manifest under periods of stress such as the marine heat wave of 2013-2015.

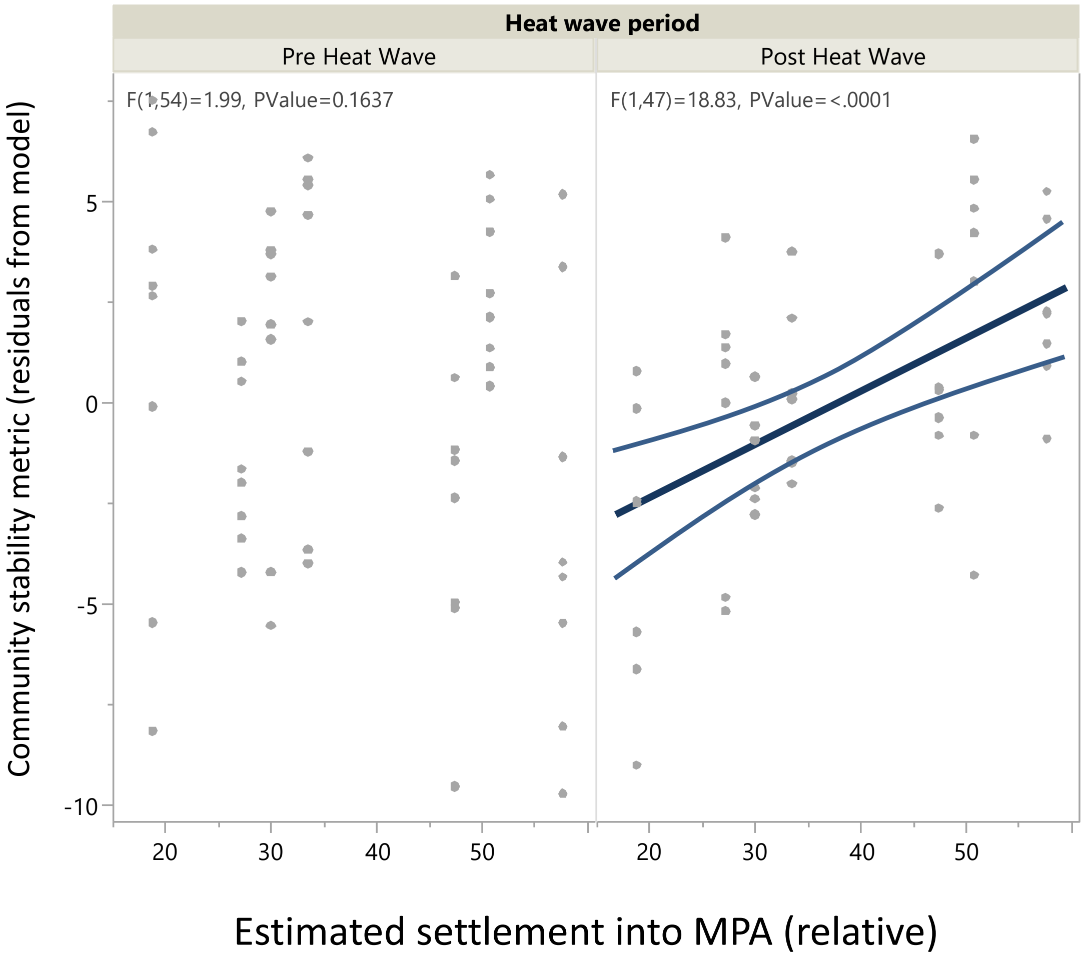

Figure 26: The relationship between modeled settlement in to MPA sites and community stability. Shown are two periods, pre heat wave and post heat wave.

Species based responses to the marine heatwave

In this section, we summarize some of the results of our assessments of potential effects of regulatory protection for single common and focal species before and after the punctuated marine heatwave event (MLPA Appendix B, Goal 2). For these analyses, we modified the approach described in Dynamical Network Attributes by incorporating the year of the onset of the marine heatwave (2014) as the temporal demarcation for evaluating change. Briefly, the time series of Biological Survey data for each region was divided into two periods, Pre and Post marine heatwave. The mean value for each species was calculated for each period in two of the three MPA regions (Central, South). We did not include the north coast region in these analyses because regulatory implementation did not occur until 2012 and Biodiversity Surveys were not conducted in 2013 (therefore, the pre-post regulatory implementation and pre-post marine heatwave periods were the same). After calculating the mean percent cover for species within each period and region, we then compared the log-ratios (see description of methods in Dynamical Network Attributes) of common species within regions and overall (across the central and southern regions) to assess whether MPAs differed in their response to the marine heatwave. Therefore, positive values indicate a positive increase in MPAs relative to reference sites.

The overall results across and within sampling regions are shown in Figures 27-29. These figures depict several important response metrics. First, as in section 5, the relative number of species that responded positively or negatively (above or below the arrow) provides one measure of the efficacy of regulatory-implementation in species' resistance to climate perturbations. Overall, the results are relatively symmetrical, with a similar number of species responding positively (above the arrows) inside of MPAs relative to reference sites following the marine heatwave event. This is evidenced by Figure 27, which shows the overall response across sampling regions. Second, we aligned the resulting marine heatwave responses (panel A in each figure) against the previously shown regulatory-implementation responses (panel B in each figure) to compare the relative changes of both the number of species' responses and the magnitude of change (to either the heatwave event or regulatory implementation). Both panels in these figures depict the same data, but panel A in each figure is sorted by ascending order in response to the marine heatwave, and panel B is sorted by ascending order in response to regulatory implementation (see Dynamical Network Attributes). These results show that overall, the response was relatively symmetrical, with an even number of species responding positively and negatively post-marine heatwave. Interestingly, for some individual species-level responses, the directionality of change was different for regulatory implementation vs marine heatwave. However, it is important to note that one confounding effect with these analyses is the temporal demarcation of regulatory implementation vs the marine heatwave. Because the marine heatwave occurred post-regulatory protection, it is possible that some of the species' responses may in fact be due to regulatory implementation and not the marine heatwave.

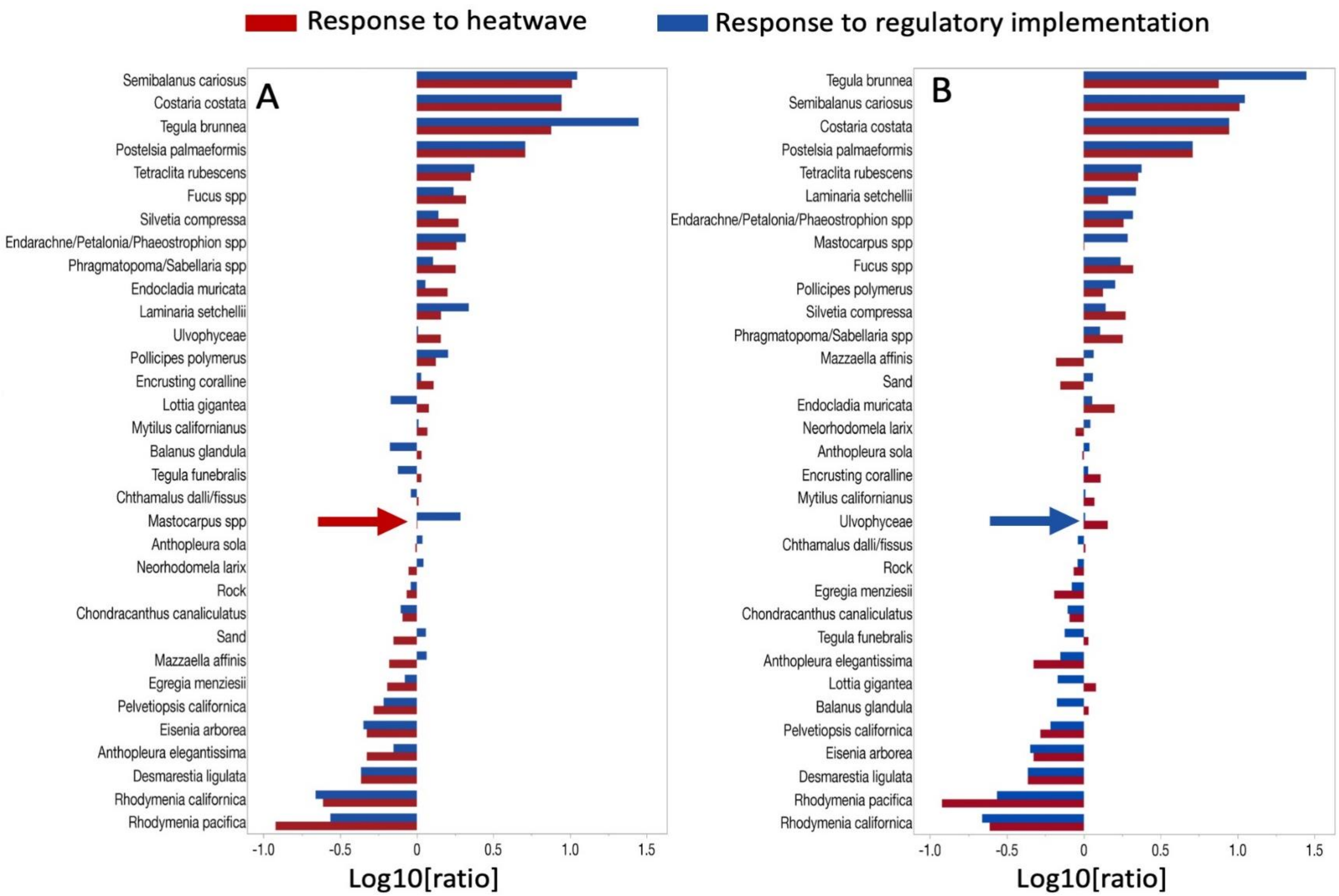

Figure 27. MPA and marine heatwave effects for common species across all sampling regions. Each bar depicts the log ratio for a given species in response to either the marine heatwave (red) or the year of regulatory implementation (blue). Positive values are associated with increased mean values for the species in MPA's relative to reference sites post-marine heatwave and arrows show the point below which estimated MPA effects become negative. Panel A is sorted by ascending log-ratios for the marine heatwave and panel B is sorted by regulatory implementation. Results based on Biodiversity Surveys.

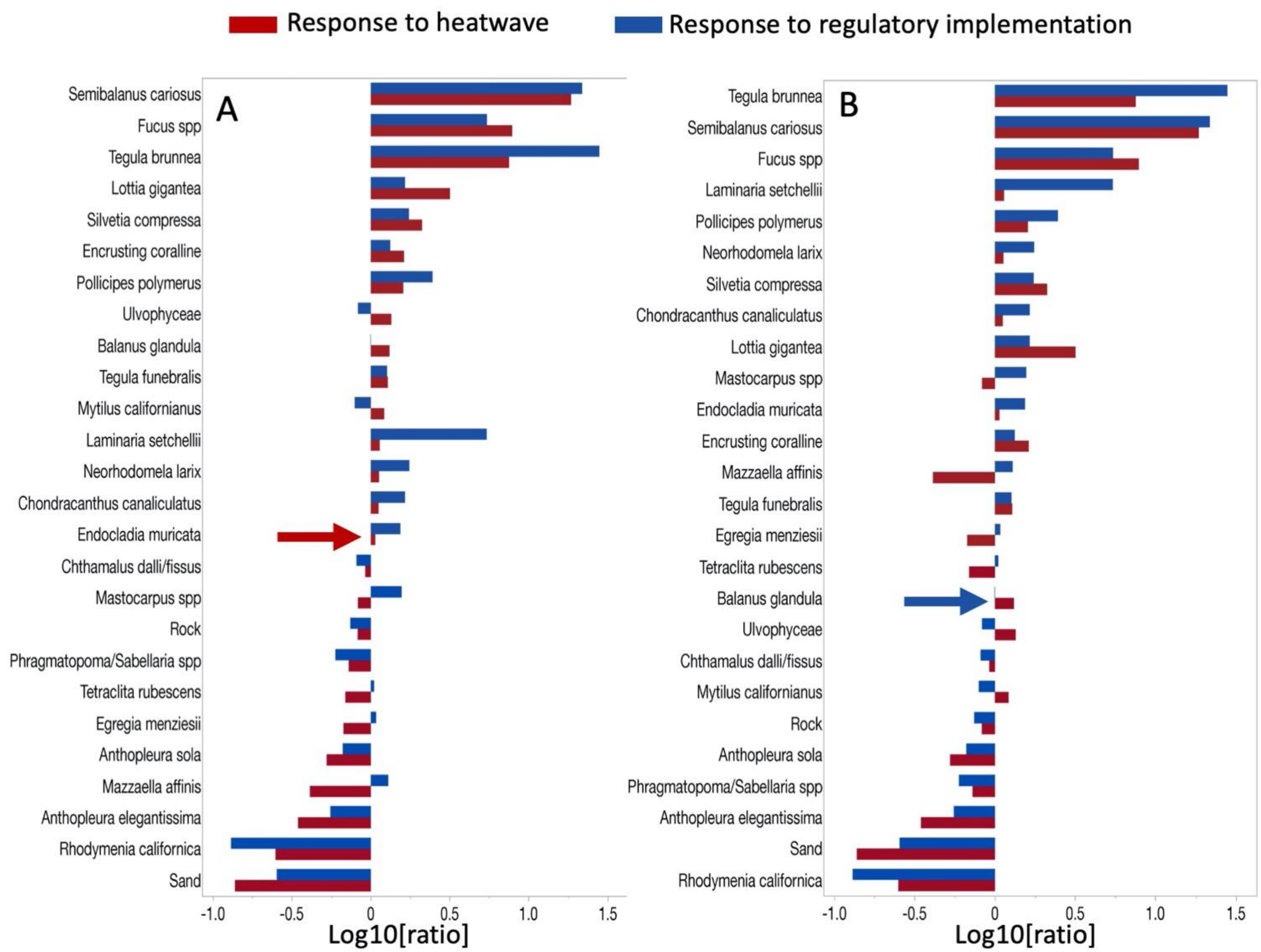

Figure 28. MPA and marine heatwave effects for common species in the central region. Each bar depicts the log ratio for a given species in response to either the marine heatwave (red) or the year of regulatory implementation (blue). Positive values are associated with increased mean values for the species in MPA's relative to reference sites post-marine heatwave and arrows show the point below which estimated MPA effects become negative. Panel A is sorted by ascending log-ratios for the marine heatwave and panel B is sorted by regulatory implementation. Results based on Biodiversity Surveys.

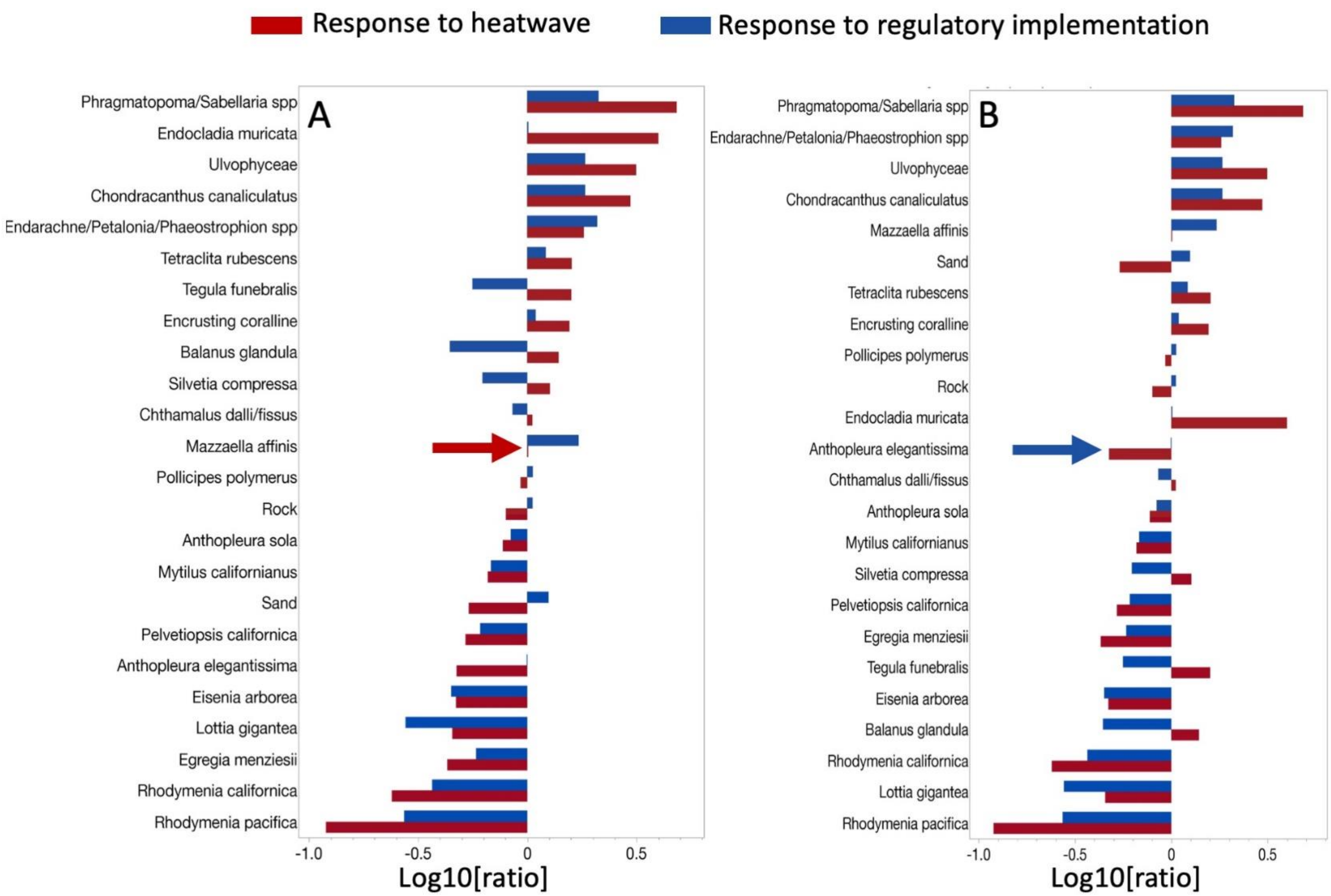

Figure 29. MPA and marine heatwave effects for common species in the southern region. Each bar depicts the log ratio for a given species in response to either the marine heatwave (red) or the year of regulatory implementation (blue). Positive values are associated with increased mean values for the species in MPA's relative to reference sites post-marine heatwave and arrows show the point below which estimated MPA effects become negative. Panel A is sorted by ascending log-ratios for the marine heatwave and panel B is sorted by regulatory implementation. Results based on Biodiversity Surveys

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Appendix 1: MARINe Long term monitoring protocols

Unified Monitoring Protocols for the Multi-Agency Rocky Intertidal Network

(November 2008)

John M. Engle

MMS U.S. Department of the Interior
Minerals Management Service
Pacific OCS Region

Unified Monitoring Protocols for the Multi-Agency Rocky Intertidal Network

(November 2008)

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Camarillo, California

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1. INTRODUCTION

1.1 Multi-Agency Rocky Intertidal Network Monitoring Program Background

Periodic monitoring of the condition and dynamics of rocky shore marine life is critical for detecting and understanding community dynamics in order to develop management measures to anticipate and reduce acute or chronic environmental impacts. **Goals of long-term rocky intertidal monitoring include the following:**

- Maintain an historical perspective of important resources.
- Document the effects of long-term climatic changes.
- Enhance understanding of the extent of temporal variation in natural systems.
- Determine compliance with standards or regulations.
- Provide an early warning of abnormal conditions.
- Help assess and reduce environmental impacts.
- Identify trends that may reflect cumulative impacts.
- Guide development and evaluation of impact mitigation measures.
- Provide information to assist in natural resource damage assessments.

The Bureau of Land Management (BLM) (now the Minerals Management Service (MMS)) funded detailed rocky intertidal monitoring at 22 sites in southern California over a 3-4 year period in the mid to late 1970’s (Littler 1977, 1978, 1979). However, costs for these intensive surveys precluded their long-term continuation. Channel Islands National Park (CINP) was created in 1980, with a mandate to inventory and monitor biological resources. As a result, they developed a permanent, cost-effective rocky shore monitoring program based on semi-annual surveys of target species assemblages in fixed plots or transects. This innovative program was expanded to the Cabrillo National Monument (Point Loma, San Diego) in 1990. In 1992, as a result of regulatory responsibilities and an increased public concern for oil spills after the EXXON VALDEZ spill in Alaska, MMS funded rocky intertidal monitoring sites in Santa Barbara County, with protocols modeled after the CINP methodology. The use of this core target-species/fixed-plot protocol was expanded to Ventura and Los Angeles Counties as well as Santa Cruz and Santa Catalina Islands (by the California Coastal Commission and Santa Barbara County) in 1994, to San Luis Obispo County (by MMS) and San Diego County (by the U.S. Navy) in 1995, and to Orange County (by MMS) in 1996.

With over 50 sites in central and southern California monitored by various institutions using similar, but slightly varying protocols, it became apparent that a more structured organization was needed for efficient, cooperative operation. The Multi-Agency Rocky Intertidal Network (MARINe) was created as a result of a workshop held at the University of California Santa Barbara (UCSB) in 1997 (Dunaway et al. 1997, Engle et al. 1997).

Objectives of MARINe include the following:

- Increase reliability, efficiency and cost-effectiveness of programs.
- Increase cooperation and communication among agencies and organizations.

- Enhance long-term support to ensure continuity of sampling.
- Provide opportunity for identification and rectification of data gaps.
- Allow more timely access to standardized data by all users.
- Integrate information for efficient analysis, synthesis and reporting.
- Permit evaluation of large-scale spatial and temporal patterns.
- Facilitate periodic review of ability of monitoring to achieve goals.
- Expedite linkages to other relevant programs.
- Enhance public outreach and interpretation programs.
- Assist in designing and critiquing restoration programs for impacted resources.
- Aid in framing research questions regarding cause and effect relationships.
- Increase public awareness of knowledge-based environmental management.
- Provide a cadre of trained biologists capable of rapid response to impacts.

The geographical area for MARINe ranged from San Luis Obispo County to San Diego County, including the Channel Islands. From 1999-2004, additional monitoring sites using the same core protocol were established north of San Luis Obispo County, primarily by the monitoring team from UC Santa Cruz, with funding from the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO), the Monterey Bay National Marine Sanctuary, and other organizations. MARINe was expanded to include northern California in 2005, Oregon in 2006 and Washington State in 2008. **Currently MARINe includes 98 core monitoring locations in California and Oregon, with 8 sites soon to be established in Washington State. (Table 1).**

MARINe is composed of partner organizations (Table 2) and monitoring groups (Table 3) that are directed by a Steering Committee, Science Panel, and Data Panel. The **MARINE Steering committee is made up of representatives of agencies and organizations committing resources to quantifying the health of rocky shore marine life and involved in joint assessment of intertidal monitoring data.** Major functions of the Steering Committee include ensuring long-term support of intertidal monitoring and providing oversight of the Science and Data Panels to make sure the goals of the Network are met. **Network goals include the following:**

- To support continuous long-term monitoring of rocky intertidal communities.
- To maximize coordination and communication among sponsoring groups.
- To increase access to the data collected for all users.
- To integrate intertidal surveys with other research efforts.
- To address questions that cannot be answered by individual projects.

1.2 Handbook Purpose

The purpose of this Handbook is to codify a standard set of core monitoring (target species/fixed plot) procedures for use at all MARINe monitoring sites. These standard

procedures should not be modified without network agreement. Agreed-upon changes will be incorporated into periodic updates of the Handbook and communicated to all monitoring groups.

Monitoring groups can opt to add procedures beyond the base monitoring. These optional procedures can be included in the Handbook for communication to other monitoring groups so that if they choose to carry out the optional surveys, they can conform to the same procedures. Data from optional procedures is not necessarily incorporated into the MARINe database, unless the effort to do so is deemed worthwhile and sufficient funding is available. Motile invertebrate counts are an example of an optional protocol.

The Handbook not only describes current protocols, but also documents variants of MARINe survey protocols previously used by particular monitoring groups or at certain sites. This provides historical perspective that is useful for data analysis. Additional information on protocols can be found in monitoring group study plans and handbooks (Ambrose et al. 1992, Engle & Davis 200b, Engle et al. 1994a,b, Richards & Davis 1988, Richards & Lerma 2003), as well as in data reports (Ambrose et al. 1995a,b, Davis & Engle 1991, Engle 2000, 2001, 2002, Engle & Adams 2003, Engle & Davis 2000a,c, Engle & Farrar 1999, Engle et al. 1998a,b, 2001, Miner et al. 2005, Raimondi et al. 1999, Richards 1986, 1988, 1998, Richards & Lerma 2000, 2002).

The Handbook provides a sole source for the standardized protocols that can be incorporated into each monitoring group's site-specific field manual. Field manuals should include such information as directions to the site; a site description that includes the site size, boundaries, and GPS coordinates; site maps showing prominent features and plot locations; print photos of plot locations; site safety considerations, and useful notes to efficiently locate and consistently sample the plots. **A supplement to this Handbook "Site Information for the Multi-Agency Rocky Intertidal Network" (Engle 2008) provides site and plot location information in case an oil spill or other circumstances require surveys by MARINe members who do not typically monitor the sites.** Information from the Supplement also is provided on the MARINe private website. Site-specific coordinates and sensitive species information should not be made available to the public to minimize collecting or other activities that may impact the sites.

The Unified Protocols Handbook also is designed to integrate with other MARINe information sources, including "Methods for Performing Monitoring, Impact, and Ecological Studies on Rocky Shores" (Murray et al. 2002), "MARINe Database User Guide" (Miner et al. 2007), and MARINe public and private websites.

2. TARGET SPECIES ASSEMBLAGE MONITORING SURVEYS

2.1 Monitoring Sites

Long-term MARINe monitoring sites have been established at representative rocky intertidal reefs along the U.S. West Coast and Channel Islands based on monitoring objectives and available funding. Criteria utilized for specific site selection include the following:

- Areas representing the geographic range of the California coastline.
- Areas representing major ecological communities along the California shoreline.

• *Biology*: emphasis on community differences north and south of major biogeographic change areas, such as Pt. Conception.

• *Geology*: with respect to rock type, size, slope, and topography (relief, rugosity, etc.).

• *Oceanography*: with respect to water temperature, wave exposure, currents, and nutrients (upwelling).

• *Meteorology*: with respect to air temperature, sun exposure, wind, and rain.

- Areas previously surveyed or monitored that provide historical data.
- Previously un-surveyed areas representing major data gaps.
- Areas of special human interest

• Areas of concern with regard to human impacts, especially those vulnerable and/or sensitive to oil spills.

• Areas with relatively pristine habitats.

• Areas containing unique habitats or species.

• Areas designated for protection by governmental agencies.

• Areas with concentrations of sport or commercial species.

• Areas visited for recreational, educational, or scientific purposes.

- Areas with optimum conditions for long-term monitoring.

• With sufficient abundances of the key species chosen for monitoring.

• With reasonable and safe access by road or by hiking.

• With moderate protection from waves so the intertidal zone can be worked safely at low tides.

• With adequate stable rock surfaces for establishing permanent plots.

• Without major sand or gravel scour, periodic sand burial, or other regular catastrophic disturbances.

Current MARINe sites are listed in Table 1, including County, year established, and protected are designation(s). Information about specific site locations (e.g., directions, GPS coordinates, site maps) can be found in the Supplement to this Handbook (Engle 2008) and on the MARINe Private Website. It is **MARINe policy not to provide site location details to the public to minimize possible interest in collecting species at these areas.**

2.2 Sampling Design: Target Species Assemblage/Fixed Plot Methodology

2.2.1 Target, Core, and Optional Species

Target Species: “Target” species (also called key or indicator species) are **species or species groups specifically chosen for long-term monitoring.** They dominate particular zones or biotic assemblages in rocky intertidal habitats. The **criteria for selecting target species include the following:**

- Species ecologically important in structuring intertidal communities.
  - Species that are competitive dominants or major predators.
  - Species that are abundant, conspicuous or large.
  - Species whose presence provides numerous microhabitats for other organisms.
  - Species that are slow growing and long-lived.
- Species that have interesting distributions along California coasts.
  - Species found throughout California shores.
  - Species characteristic of discrete intertidal heights.
  - Species that are rare, unique, or found only in a particular intertidal habitat.
  - Species approaching their biogeographic limits in California.
- Species that have been well studied, with extensive literature available.
- Species of special human interest.
  - Species vulnerable and/or sensitive to human impacts, especially from oil spills.
  - Species with special legal status.
  - Introduced or invasive species.
  - Species harvested by sport or commercial activities.
- Practical species for long-term monitoring.
  - Readily identifiable species.
  - Sessile or sedentary species of reasonable size.
  - Non-cryptic species.
  - Species located high enough in the intertidal to permit sufficient time to sample.

Currently, there are **18 designated target species**: *Egregia menziezii, Fucus gardneri, Hedophyllum sessile, Hesperophycus californicus, Pelvetiopsis limitata, Silvetia compressa, Endocladia muricata, Neorhodomela larix, Phyllospadix scouleri/torreyi, Anthopleura elegantissima/sola, Mytilus californianus, Lottia gigantea, Haliotis cracherodii, Chthamalus dalli/fissus/Balanus glandula, Semibalanus cariosus, Tetraclita rubescens, Pollicipes polymerus,* and *Pisaster ochraceus* (Table 4). Other species or species groups “targeted” by some monitoring groups include: *Mastocarpus papillatus*, *Mazzaella* spp (=*Iridaea* spp), *Postelsia palmaeformis,* Red Algae (includes plots targeting *Gelidium spp* and “red algae”, and transects targeting “turf”), *Balanus glandula* (separated from *Chthamalus fissus/dalli*), Tar, and Recovery. **Designated target species have the highest priority for monitoring. They are monitored at as many sites as possible**. If the species is present in sufficient numbers and it is logistically possible, plots or transects are established to monitor it every fall and spring in MARINe South or annually (in summer) above San Francisco in MARINe North. Anywhere from 1 to many target assemblages are monitored at a given site. More information on target species (e.g., photos and how to identify) can be found on the MARINe public website.

Core Species: "Core" species are those **species, species groups, or substrates that are scored using one or more survey methods by everyone in MARINe**. Core species must be reasonably and consistently identifiable using the designated scoring protocol (e.g., from lab-scored photos of fixed plots possibly supplemented by plot sketches/notes). They also must be important enough to warrant scoring for abundance trends. Some of these species only occur at northern sites, or conversely, southern sites, yet to ensure that we notice if they expand their range, we must score everywhere. Table 5 provides the official list of core species. All target species (shown in bold on the table) are core species. It is important that **scorers in all monitoring groups be able to identify and record all core species. Data sheets must include all core species**, though core species that are absent or rarely occur at a site can be de-emphasized. Entries for all core species will be required for data submission to the MARINe database. Definitions for core higher taxa and substrates are provided in Table 6.

Optional Species: "Optional" species are **non-core species or species groups that one or more monitoring groups choose to score at their sites; however, for various reasons, are not appropriate or feasible for all groups to score**. Since optional species will not be scored by everyone, regional comparisons of trends for these species will be limited or not possible. **Each monitoring group desiring to score optional species shall provide a list of these species to the MARINe data manager, along with mechanisms to translate optional species data to core species categories.** For example, if choosing to monitor *Codium fragile*, you would submit the optional species data which would be stored in the database as *Codium fragile*, but for standard regional comparisons of core species, would be lumped by the database to the next higher core species group "other green algae". **Choosing optional species requires a commitment to monitor the species consistently for a long period of time.** There is little value in scoring a species on an occasional basis (e.g., only when a particular person is available in the field to identify that species).

2.2.2 Fixed Plot Sampling Design

Background for Fixed Plot Sampling: Fixed plots are permanent areas of rocky intertidal habitat defined by epoxy or bolt markers. Fixed plots may be variable in size and shape, including square, rectangular (including band transects), circular, or even a one-dimensional transect line. The objective of MARINe core protocols is to monitor changes in abundances of target and core "species" within fixed plots over time (seasonal and annual). Fixed plots were chosen instead of randomly-located plots (in different locations for each sample) because intertidal assemblages are so heterogeneous that an impractically high number of replicate plots would be necessary to adequately detect temporal changes in species abundances in the midst of variability due to different plot placements for each sample season. Fixed plots reduce the high variability inherent in random plots and can be monitored easily and inexpensively; however, their dynamics cannot be extrapolated to larger areas without gathering additional larger-scale information. For in-depth discussion of the rationale and pros/cons of MARINe fixed plot sampling, see Ambrose et al. (1992, 1995b) and Murray et al. (2002).

MARINe Fixed Plot Types and Replicates: MARINe core fixed plot types include photoplots, point-intercept transects, circular plots, band transects, and irregular plots. The size and number of plots sampled with limited available effort is a compromise between gathering more detailed information about a limited segment of the resource versus sampling a wider range of resources (see Ambrose et al. (1992, 1995b), Drummond & Connell 2005, and Murray et al.

(2002). Tables 7-8 show the target species monitored (and # of replicate plots) at MARINe sites for each fixed plot methodology. Target species in these tables are listed as their 6-letter codes (see Table 4).

Photoplots: **Rectangular (50 x 75 cm; 0.375 m²)** photoplots are used to monitor the surface cover (top layer only) of relatively small, densely-spaced, sessile target and core species (Table 7). To minimize limited low-tide time in the field and provide a permanent visual record, these plots were designed to be photographed in the field, with photos scored in the lab. The plot size was designed to be the largest area that best utilized the rectangular 35 mm film frame, allowed a comfortable camera working height, and provided sufficient detail to identify target and core species. The MARINe standard is to monitor **5 replicate plots** per target species, placed in a stratified random manner throughout the target species zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent photoplots and sufficient (relatively high) cover of the target species. Variations from photoplot size and number standards are noted in Table 7.

Point-Intercept Transects: Ten meter long point transects are used to monitor the cover of **surfgrass** (also red algal turf and boa kelp at a few locations) and associated core species (Table 8). These transects were designed to sample a larger area, by field-scoring what occurs under **100 points spaced at 10 cm intervals along a 10 m tape** stretched out between marker bolts. The MARINe standard is to monitor **3 replicate plots** per target species, placed in a stratified random manner throughout the target species zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent transects and sufficient (relatively high) cover of the target species. Variations from point transect size and number standards are noted in Table 8.

Circular Plots: The number and size of **owl limpets** are monitored within permanent circular plots (**1 m radius, 3.14 m² area**), marked with a central bolt around which a 1 m long tape is circumscribed (Table 8). The size of the plot was designed to enclose enough owl limpets for size-frequency comparisons. The MARINe standard is to monitor **5 replicate plots** per site, placed in a stratified random manner throughout the owl limpet zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent circular plots and sufficient (relatively high) density of the target species. Variations from circular plot size and number standards are noted in Table 8.

Band Transects and Irregular Plots: The number and size of **ochre seastars and black abalone** are monitored within either band transects or irregular plots, the type and size of which is determined by what best encloses an area containing sufficient numbers of the target species for monitoring consistently (Table 8). The MARINe standard is to monitor **3 replicate plots** per site, placed in a stratified random manner throughout the target species zone of maximum abundance, within the limits set by stable substrate suitable for sampling permanent band transects or irregular plots and sufficient (relatively high) density of the target species. Black abalone and ochre seastars are monitored in the same set of transects/plots at some sites. Variations from transect/plot size and number standards are shown in Table 8.

Plot/Transect Establishment Procedures: Permanent plots or transects are established during the initial set-up of a new monitoring site (or may be added to expand the surveys at an existing site). For maximum comparability among sites, **all of the MARINe target species that occur in sufficient abundances for adequate sampling should be monitored at each site** (except for those sites established for a particular species, such as black abalone). New sites should be chosen according to the desired criteria (see above), including filling in geographic coverage gaps and evaluating what target species are suitable for monitoring at the location. Site reconnaissance is necessary to evaluate suitability for monitoring, to decide which target species should be surveyed, and to determine possible locations for plots and transects. Gear recommended for setting up a site include quadrat frames, meter tapes, compasses, scrapers, wire brushes, portable hammer drill and drill bits, stainless steel bolts, marine epoxy (e.g., Z•SPAR A-788 Splash Zone Compound), and cameras.

Specific **plot/transect establishment procedures** may vary depending on the nature of the site and preferences of the monitoring group. The following are **recommended guidelines for standard practices** that can increase efficiency, enhance compatibility among MARINe sites, and ease data entry into the MARINe Database:

- **For each target species assemblage, identify all good plot/transect locations within its optimal zone** (area of high abundance), stratify the area of possible plots by differing physical conditions/locations, then randomly choose the desired number of plots/transects from each of the strata. For example, if 2 surfgrass areas (one twice as large as the other) occur at the site, identify all good transect locations within the 2 areas, then choose 2 transects randomly from the large area and 1 transect from the small area to establish the MARINe standard of 3 replicate transects per site. Using numerous quadrat frames or meter tapes as a guide helps in looking at the overall layout.

- When identifying good plot/transect locations, be aware that if setting up on an exceptionally low tide (or during unusually calm conditions) that **plots/transects established in the low intertidal may not be as accessible during future surveys**. Photoplots need to be relatively flat (though not necessarily horizontal) so that the entire plot falls within a similar focal plane, with minimal shadowing from crevices or projections. Also, remember that the plots/transects you set up are permanent, so consider ease of relocation and re-sampling during the setup. Plot markers, especially the primary plot marker, should be placed in prominent locations whenever possible. This is especially important in mussel beds to minimize disruption during plot establishment and to maximize ease of relocating plots.

- **The best plot markers are stainless steel hex bolts** epoxied into holes drilled into the rock. Bolt length and diameter depend on ease of rock drilling as well as bolt conspicuousness versus public safety (tripping hazard) and aesthetic considerations. If bolts eventually become overgrown, large bolts (e.g., 4-6 inch long, 3/8 inch dia) will be more easily found using a metal detector. If the rock is soft, use large, long bolts for best anchorage so they are not easily lost if the rock erodes or flakes away. In remote areas (few visitors) or in mussel beds (where mussels can overgrow bolts) have bolts project out from the rock surface to aid relocation. However, on public access reefs, bolts may need to be small or inconspicuous (even flush with the substrate), or use epoxy blobs instead of bolts (but relocation and maintenance efforts will be greater).

- To **install a plot marker**, clear an area of about 5 cm by 5 cm to bare rock using scrapers and wire brushes. For bolts, drill a central hole and epoxy the bolt firmly in the hole. For plain epoxy markers, press a blob of well-mixed epoxy onto the rock and form it into a smooth mound approximately 4-cm in diameter. Clean rock is important for good adhesion, but it does not have to be dry.

- **Plots should be marked in numerical order starting with #1 for each target species (ideally from upcoast to downcoast).** Notches cut into the top of each primary plot bolt to indicate plot number work well (e.g., 1 to 5 notches for the 5 replicate photoplots). However, careful mapping may be necessary to distinguish similar-numbered plots for each target species (e.g., to distinguish Plot #1 of mussels from Plot #1 of goose barnacles). For photoplots, a good standard is to put a bolt in all 4 corners, with the notched bolt in the upper left corner as you typically stand to take the photo (often with your back to the ocean). If the rock is hard to drill, you can omit the lower right bolt or if necessary, use epoxy instead of bolts for all but the upper left primary bolt corner. Wherever epoxy blobs are used, it is helpful to inscribe code letters (or the plot # if the primary plot marker) in the partially-cured blob to indicate marker location (e.g., "LR" for "Lower Right" photoplot corner. For transects, install the primary bolt at the upcoast end and mark the mid bolt and end bolt with standard marks to distinguish them ("/" or "no mark" for mid and "X" for end (cut across the bolt top) work well).

- After all plots and transects are set up, locate several representative locations (on prominent spots) to install large hex bolts (e.g., 6 inch long by ½ inch dia) that will serve as **reference markers for relocating plots in the future** (if necessary) **and for fixed photopoint monitoring** (see below). These reference bolts should be placed centrally to groups of plots/transects to facilitate measurements and to allow overview photo pans to include nearby plots/transects. The number of reference/photopoint bolts will depend on site size and plot/transect distributions. An abalone-only site may need only 1 reference, while a large site with multiple target species assemblages may need 5 references.

- Ideally 1-3 **permanent benchmarks** can be established along the upper shore at each site, such as the Bureau of Land Management (BLM) accomplished in 2002-2004 at 19 of the MMS-sponsored mainland sites (from San Luis Obispo County to Orange County) (see Section 3 of Site Information Handbook (Engle 2008)). The monuments are bronze tablets, with 2 inch diameter caps and 2 inch stems, epoxied into a ¾ inch drill hole, with a magnet set in the hole bottom. The caps are marked "BLM", with the monument name (e.g., CAY1) and the surveyed point in the center of a small circle at the center of the cap. The precise coordinates (Datum NAD83 (1998)) include height measurements accurate to 0.2 ft vertical.

Site Mapping: It is important to **document the site location as well as the specific location of all plots and transects**. This can be done through a combination of directions to site, GPS coordinates, inter-plot measurements, sketch maps, plot overview photos, and aerial photos.

<u>Site Directions</u>: Briefly record **how to get to the site** (by car, boat, or on foot) from the monitoring team institution or city/base station closest to the site. Include waypoint mileages and estimated time to reach site.

<u>GPS Coordinates</u>: Record at minimum, **3 principal GPS coordinates** for each site: First, **a single latitude/longitude coordinate pair that defines the location** - preferably close to the physical center of the site. Permanent marker locations, such as the BLM markers or our Reference markers are preferred, or use the location of a specific target species plot. Then, the **two coastal boundaries of the site (north/south or east/west) should be documented**, ideally centered between high and low tide zones, but they could be the positions of the northern- or western-most plot and the southern- or eastern-most plot. Use the most accurate GPS unit available. Be sure to document who took the reading and when, the specific location (e.g., BLM Ref 1, MARINe Ref 2, MYT Plot 5, PHY Transect 3 Center Bolt), the type of unit used and its

accuracy, and the datum used (preferably NAD83 or WGS84). If possible, **record latitudes/longitudes as degrees with decimal minutes and seconds** (otherwise the coordinates must be converted to this decimal format for database entry).

Inter-plot Measurements: These measurements are valuable for site mapping and to aid relocation of plots on future samplings. **Record at least 3 pairs of distance** (to nearest 0.01 m) **and bearing** (to nearest 5°) **measurements from primary plot/transect bolt (# bolt) to closest 3 other plot/transect primary bolts**, preferably running in different directions. Also measure distance and bearing to nearest reference bolt. Be sure to properly record "from" and "to" bolt #'s. Additional measurements should be taken for other bolts of transects, between the bolts of irregular plots, between reference bolts, and between upcoast and downcoast boundaries of the site (defined as upcoast-most plot to downcoast-most plot).

Sketch Maps: From as much of an overhead perspective as possible, sketch the prominent features of the site (e.g., pinnacles, ridges, pools, boulders), with approximate **plot/transect locations shown relative to each other and to the physical features**. Scale relationships on sketch maps can be improved by incorporating the inter-plot measurements in a second draft of the maps. Indicate with a dot the primary marker location for quadrats and transects. For large sites, separate maps can be prepared for different sub-areas. Maps can be scanned into digital format for labeling and other enhancements.

Plot/Transect Overview Photos: Take lots of site overview photos (with digital camera) with plot quadrat frames and transect meter tapes in position. Put orange cones on reference markers. Photos can range from **broad views of large portions of the site to individual overviews of each plot and transect**. For the latter, include the area around each plot/transect to document location relative to nearby features. Plan to make prints of the best photos, label the plot/transect numbers on the prints, and organize in photo sheets in a binder to take on future surveys to aid relocation efforts.

Aerial Site Photos: If possible, take aerial photos of the site during low tide, with plot quadrat frames and transect meter tapes in position. Put orange cones on reference markers. This may be accomplished easily if the site abuts a high cliff. Another possibility being tested is use of a relatively small camera-mounted blimp tethered to a person who pulls it over the site and triggers snapshots. **A good aerial photo could greatly improve the site map** (see above).

Criteria for Adding or Dropping Plots/Transects: Target species abundances might decline dramatically in one or more plots or transects, due to changes in the biological community (e.g., ecological changes or zone shifts) or due to substrate disturbance from storm swells (including rock breakouts and boulder movements). Depending on the severity and persistence of the loss, we may no longer be monitoring the target species (except for its paucity in the plots), even though it could still be present elsewhere at the site. The following are recommendations for how to deal with these types of situations:

- **Greatly reduced or total loss of target species cover within one or more plots or transects should not trigger a decision to stop monitoring these plots** (and the plot should continue to be named after the originally-targeted species even if a different species now dominates). Continued monitoring is important to confirm this major loss over time or perhaps document later recovery. **If the target species remains low/absent in its targeted plot(s) for an extended period of time (perhaps 3 years), but shows reasonable cover elsewhere at the site, plan to add new plot(s) in areas with good cover.** For example, if Rockweed Plots #1, #2, and

#5 lose all rockweed for 3 years (apparently due to a zone shift) and Plots #3 and #4 still have good rockweed cover, in the 4th year establish 3 additional plots (#6, #7, and #8) in areas with similar cover to Plots #3 and #4. From this point on, all 8 plots will be monitored. It is **important to keep the plot numbers consistent** so that one can choose to follow the original plots (#1-#5) through all time or switch after 3 years to follow the good cover plots (#3-4 and #6-8).

If large countable target species such as abalone or seastars become low in the targeted plots and throughout the site, continue monitoring the plots, but also **institute site-wide timed search** (see below) during each survey (like having the entire site as one plot). This situation occurred for black abalone monitoring at Channel Islands sites when withering syndrome caused mass mortalities (Richards & Davis 1993), with practically no recovery to date.

- The above plan also is recommended for **situations where one or more plots have been subject to physical disturbance** such as breakout of the rock surface or movement of a previously stable rock. Typically this results in major reductions in key species cover that may or may not recover over time. Disturbed plots should continue to be monitored to document recovery or lack of recovery over time (replace any missing markers). If the disturbance has substantially changed the microhabitat or tidal height zone such that it is unlikely that recovery of the key species will occur, then add a replacement plot (or plots) with similar cover of the target species to what the original plot would have had if the disturbance had not occurred (based on the remaining undisturbed plots).

Plot Marker Maintenance: **Bolt and epoxy markers need to be cleaned of fowling growth during each survey to aid relocation during the subsequent sampling**. This is especially important for sites sampled only once per year. Stiff plastic or wire brushes and old table knives work well for cleaning markers, taking care not to disturb the rest of the plot. Loose markers should be repaired with fresh epoxy and missing markers replaced. An easy way to note photoplot marker condition is to record it directly on the plot corners of the Photoplot Sketch Data Sheet (Form 3).

3. SURVEY PROTOCOLS

3.1 Field Log and Site Reconnaissance Protocol

During each site monitoring survey, it is important to complete a field log (i.e., who, what, when, where) as well as to observe and record general physical and biological conditions at the site. Additional site-wide categorization of target and other core species abundance, appearance, and recruitment is useful whenever time permits. These observations, along with the habitat overview photographs, **provide valuable perspective on site dynamics that aid interpretation of data from the fixed, plots and transects**.

3.1.1 Completing the Field Log and Conducting Site-Wide Reconnaissance

Core Procedure: Field log information and site reconnaissance characterization are recorded on the two-page field log data form (Form 1a,b,c: Prototype MARINe Rocky Intertidal Field Log). Field log **data that must be recorded (required by database) include site, date, survey time, low tide time and height, and names of survey participants.** Core physical data that should be recorded include weather and sea conditions (swell/surge, wind, rain, recent rain, and water temperature), substratum changes (sediment level, scour, rock movement), and debris/

pollutants presence (plant wrack, driftwood, shells, dead animals, trash, and oil/tar). Relevant biological features that should be recorded include site-wide presence of birds, marine mammals, or humans; and abundance, appearance, and recruitment of target species (primary emphasis) and other core species (secondary consideration). To facilitate standardization and data management, many data entries are restricted to specific category codes (e.g., low, med, high). These codes and other terms are defined in Form 1c. Any additional information can be written as notes. All **data entry blanks on the field log should be filled in with a code, actual value, notes, or a dashed line indicating "no data".**

Physical Conditions: Emphasis is placed on **conditions that could affect quality of sampling**. Some physical conditions recorded in previous years (e.g., cloud cover) were deemed not relevant because the site is visited only 2 days a year. Water temperature can be useful to compare with satellite sea surface temperature records or buoy/thermister data.

Birds and Mammals: Core categories are listed and should be scored. Record maximum number seen at any one time during the sampling, preferably upon arrival at site prior to sampler disturbance. Other more specific categories or species may be added; however, this requires specifying a core taxon for "lumping" the more specific entry during database entry unless the species/higher taxon has officially been designated as an "optional species" (see above for optional species discussion). For example, a bird recorded as "crow" would be lumped with "other birds" during database entry unless the monitoring group designated "crow' as an optional species. Only score species within the defined site, either onshore or within 50 m of shore. Note relevant behaviors.

Humans: Record **maximum number of people seen at any one time during the sampling**. Especially check at low tide. Separate counts for people on the site reef and on nearby sand beach. Note relevant behaviors.

Species Conditions: Give **highest priority to scoring target species**, particularly those monitored at the site. Core species should be scored if possible or indicate "no data". Other species can be added for scoring if desired; however, they will not be entered in the MARINe database unless they have been designated as "optional species" (see above). To score, **consider the site-wide condition of the species within its optimum zone(s).** It is not practical to score for turf or other non-discrete algae and most small invertebrates where determination would be too time-consuming.

Guidelines:

- On a descending tide, it may be practical to start the field log and site reconnaissance upon first arrival at the site because many observations can be recorded before the tide is low enough for performing other tasks. Additional notes can be added later during the monitoring, or even afterwards, when more time is available to organize thoughts or confer with others. The **reconnaissance may take 30-60 min by 1 person** (less time if 2 or more persons participate), depending on site layout and complexity. If time is short, jot notes on blank paper, then transcribe to the data sheet shortly after the survey.

- Useful things to note include: general appearance of algae and encrusting animals, damaged patches of reef, signs of disease, **changes observed since last visit**, absence of animals or algae that might occur at the site, whether anything was done different from the standard methods, and problems encountered with equipment or locating plots.

Variations from and Additions to Core Procedures:

- Plot Marker Loss/Repair and Other Notes: These are **optional categories** that provide for additional information as desired. For example, under plot markers, note any problems with lost markers or difficult to find plots, record any repairs completed or newly installed bolts or plots. Identify problems that need to be fixed on the next visit. This section does not need to be entered in database, but can be checked when planning the next sampling trip. Notes on physical and biological conditions will contain useful information that should be entered in the database (as text entries) if possible.

- Survey Checklist: The **optional** survey checklist is used by some monitoring groups (e.g., UCSB) to mark off procedures done at a site to ensure that all tasks were completed.

- Visitor and Bird Census: **CABR separately monitors visitors and birds** as follows: Whenever possible, the number of people and birds (by species or by 3 ecological categories: wading birds, shore birds, and sea birds) are counted in the 3 CABR sites within 30 min of the low tide on those days throughout the year when the low tide falls between 1000-1600 hrs and is < 0.5 ft above MLLW.

3.1.2 Managing Field Log and Site Reconnaissance Data

Data are recorded on two data sheets (Form 1a,b: Prototype **MARINe Rocky Intertidal Field Log**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, most data were not entered in any computer file. Now, **data are entered into the MARINe Microsoft Access database via a standardized data entry template** (see Bealer & Cooper 2003). This template requires field log information to be entered first, before other survey data can be entered. Field log and site reconnaissance data should be entered into the database entry template as soon as possible after the survey, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived.

3.2 Habitat Overview Photograph Protocol

As an adjunct to the fixed plot/transect sampling, **whenever possible, a habitat-level photographic record of the monitoring site should be made** during the seasonal survey to document larger-scale site conditions including habitat views of survey plots and transects, sand influence (beach level, scour or smothering effects), health of organisms (bleached plants, dead barnacles, etc.), interesting concentrations of species, recruitment events, extent of ephemeral algae, oil/tar presence and extent, evidence of people use and/or pollution, and any unusual phenomena. Periodic overview photos taken from the same viewpoint are particularly useful for putting individual permanent plots or transects into perspective with surrounding assemblages.

3.2.1 Photographing Habitats and Other Site Features

Core Procedure:

Fixed Photopoint Monitoring: Whenever possible, **sequential, overlapping habitat photos (approximately 5-10 m away) are taken (using either film or digital camera) while rotating the view area in a circular fashion from a fixed point marked with a bolt or epoxy**. Often the point is a reference bolt centered among a cluster of plots/transects (reference bolt also facilitates relocation of plot/transect markers via distance/bearing measurements (see above)). **Delineate all possible plots/transects that will appear in the view with quadrat frames or meter tapes (if conditions permit).** To ensure repeatability of view areas, specific procedures must be written for each photopoint, including horizontal start view, vertical view, and extent of angular pan. Pans typically begin facing north or some major feature, then proceed clockwise or counter clockwise to **encompass a half circle (180°)or full circle (360°)**, depending on the extent of intertidal habitat surrounding the photopoint. Full circle pans can be printed as 2 separate 180° pans.

Other Photographic Documentation: **Whenever possible, photograph plots and transects that are not in view from the fixed photopoints**. It is especially useful to include photos of owl limpet and abalone/seastar plots, and point-intercept transects since these are not photographed for sampling. Each plot/transect should be photographed from a standard (generally unmarked) view point whenever possible (e.g., transect overview photographed from 3 m upcoast of transect start end; owl limpet plot photographed from 5 m away perpendicular to the plot). In addition, repeatable or one-time **photos can be taken to document particular site conditions** such as reef damage, sand levels or scouring, plant/invertebrate appearance (e.g., bleaching or epiphytes), recruitment events, ephemeral conditions, oil/tar presence, pollution, people activities, and any unusual phenomena.

Guidelines:

- Photopoints should be indicated on site maps.
- Salt water and sea spray can ruin cameras. Protective cases should be used or the monitoring group must plan to replace the camera if/when the camera gets wet.
- The same digital camera used for photoplots also can be used for overview photos. Digital cameras provide immediate feedback on image quality and simplify the organization, storage, and analysis of photos. Panoramic photos can be stitched together using available software programs.
- **Repeatability of image view areas is greatly enhanced if you carry print sheets in the field (that show the sequence of standard photo images) to guide aiming the camera**.
- Try to **take photographs during times of lowest tide and best light conditions** (e.g., closest to midday or when overcast). Avoid shooting into the sun, especially when low tides occur in the late afternoon. Avoid including sky, ocean, and tidepools in the view if possible because bright sky and highly reflective water can wash out portions of the image while under-exposing shaded reef areas (creating silhouette effects).
- If necessary, a monopod can be used to stabilize the camera for panoramic sequences.
- Quadrat frames can be split into 2-sided frames if many plots need to be delineated.

Variations from and Additions to Core Procedures:

- Overview Video: Prior to 2002, overview videotape records (including observational narration) often were made at monitoring sites during the seasonal surveys using an 8 mm camcorder. These video recordings provided much of the same visual documentation as the current photo overviews. They consisted of an overview of the entire site if possible from one or more high cliff vantage points, beach level overviews of plots and surrounding habitats from fixed vantage points, and closer views of interesting phenomena. Complete procedures are described in Engle et al. (1994) and Engle and Davis (2000). The usefulness of video records for detecting population changes at the monitoring sites was evaluated by Rivas et al. (1997) and others within MARINe. Video advantages over film photos included in situ feedback on image quality, ease of recording extensive habitat areas, zooming features, and ability to add narration. However, disadvantages of video included coarse-grained images, susceptibility to flaring, and inconvenience of reviewing and analyzing videotapes. After extensive evaluation of video vs. film photo for habitat overview documentation, a switch was made to film photos in 2001/2002, primarily based on image quality and the ability to zoom in on high quality digital copies scanned from the film photo and stitch the scanned digital images together for panoramic views.

- Digital Photos: As the quality and affordability of digital cameras improved, they became an attractive alternative to film cameras. Digital cameras were tested in 2002 and approved for use by 2003. **By 2004, all monitoring groups were using digital cameras for field photography**.

3.2.2 Managing Habitat Overview Photographs

The same photo log is used as for photoplots (Form 2a,b: Prototype MARINe Rocky Intertidal Photo Log). This information is used for labeling the photos, but not entered into the computer database.

Film Photographs: After the film is developed and mounted into slides, the slides are labeled individually with site name, date, and image information. They are then arranged by site and photopoint or target species habitat into high quality polyethylene slide pages organized into notebooks and archived. **If duplicate slides exist, they should be stored in a separate location to minimize data loss in the event of some catastrophe such as fire or theft**. Eventually, all photo slides should be scanned at a relatively high resolution and copied to CD or DVD for archiving. A backup copy (on a hard drive or another CD/DVD) is recommended. One of the CD's or DVD's can be placed in a folder with the original datasheets and the other in a separate storage location.

Digital Images: The **protocol for managing digital images is still being developed**. Typically images are downloaded from the camera memory chip to a computer for organization and labeling. The images are backed up to CD or DVD for archiving. Photo database software programs are currently being evaluated.

3.3 Photoplot Protocol

Permanent photoplots are employed to monitor the cover of target species assemblages representing different intertidal zones (Tables 10-12). Plots are established at sites with sufficient cover of the target species for monitoring. Plots are sampled each spring and fall at sites south of San Francisco Bay and annually (in summer) at sites north of San Francisco Bay.

3.3.1 Photographing Photoplots

Core Procedure: The cover of target species as well as core and optional species (including higher taxa and substrates) is sampled by photographing **5 permanent 50 x 75 cm (0.375 m²) plots per target species** (see Table 7 for exceptions to plot size and number of replicates), then **scoring point contact occurrences by superimposing a uniform grid of 100 dots on the photo image**.

Camera set-ups include 35 mm Nikonos waterproof camera, land cameras, or digital cameras with or without waterproof housings – all with added single or double strobe lighting. A **quadrapod apparatus is used to support the camera at a constant height (1 m with a 35 mm lens) and orientation to ensure consistent framing of each plot**. The quadrapod, constructed of PVC pipe, consists of a bottom photoplot-sized frame (50 x 75 cm internal dimensions) connected to a smaller camera frame by 4 poles. The lens of the camera is aligned to provide coverage of the entire plot. The quadrapod is placed over each plot in a consistent orientation, typically with the permanent plot number marker in the upper left corner. The plot number (also site, date, and target species) is written or otherwise set up on the quadrapod such that it will be recorded by the plot photo.

Specific photographic procedures vary depending on camera/strobe set-ups and **should be established by each monitoring team**. Resulting images must be of sufficient quality to consistently recognize target and core species when scoring. Unattached drift plants (e.g., giant kelp blades), large motile invertebrates that are not scored in photoplots (e.g., *Aplysia*; record count if doing motile invertebrate protocol), invertebrate debris (e.g., lobster exoskeleton or loose mollusk shell), or flotsam (e.g., driftwood) are removed prior to photographing plots (see Guidelines below). Otherwise, plot photos are taken “as is” without moving live organisms. For each consecutive photograph, record target species, plot number, and plot-specific notes (Form 2a,b: Prototype MARINe Rocky Intertidal Photo Log).

Guidelines:

- It is **important to properly locate and orient each photo so the same plot is sampled through time**. Over-view plot print photos (with plot frame in place) aid plot location and orientation of quadrapod if plot corner markers are obscured or missing.

- Cleaning plot corner markers aids in keeping overgrowth down so plots can more easily be located during the next survey.

- If algae such as rockweed must be moved to locate plot markers, be sure to return them to their original position for the photo.

- Waterproof camera/strobe set-ups protect sensitive equipment from salt spray and seawater, but can be bulky. Waterproof housings are subject to fogging if moist air is present between camera lens and housing. Place desiccant packs inside housing to minimize this problem.

- **Bracketing exposures helps ensure a good exposure for scoring and provides back-up photographs of each plot**.

- Strobes, preferably mounted laterally away from the camera, provide fill-in lighting to reduce shadows. A photographic umbrella will further reduce shadowing.

- Painting the white PVC gray or using gray Schedule 80 PVC for the bottom quadrapod frame reduces flaring (particularly evident with digital media) that may over-expose plot margins.

- The best quality photos are obtained by optimizing ASA (low requires more light while high becomes increasingly grainy), Aperture (small needs more light while large has poor depth of field), and Shutter Speed (slow increases likelihood of blurring while fast needs more light).

- **Remove large or abundant top-layer active motile invertebrates** (including *Aplysia*, *Lithopoma*, *Tegula*, predatory snails, hermit crabs) from photoplots prior to photo/scoring **if their presence significantly blocks scoring of topmost sessile cover** layer. Record appropriate data for removed individuals if plot is going to be sampled for motile invertebrates.

- **Do not remove sedentary motile invertebrates** (including chitons, limpets, black abalone, ochre seastars, purple urchins), particularly since they may be harmed by removal and displacement.

Variations from and Additions to Core Procedures:

- See footnotes in Table 7 for variations to core procedures (e.g., plot size and # replicates).

- CSUF does not use a quadrapod; they hand hold the camera while straddling the plot.

- CSUF uses a photographic umbrella to minimize shadows in the plot.

3.3.2 Sketching Plots and Taking Notes

Core Procedure: If time and resources permit, **rough field sketches and notes** are made of the distribution of organisms and substrates in each plot to **clarify species identifications when the photos are scored in the lab** (Form 3a,b: Prototype MARINe Rocky Intertidal Photoplot Sketch Data Sheet). For example, species that seem reddish in the field may look black in slides, and lighter-colored species like crustose corallines may not be obvious in photos. Code letters are used to indicate species in the plot sketch. Sketches and notes should take only a brief time for each quadrat (perhaps 1-2 min; thus a site with 25 plots might take 1 person up to 1 hr to complete (including time to move between plots)).

Guidelines:

- There is a temptation to get too detailed and spend too much time on sketching and noting. Keep in mind that this is just an aid to scoring. If too much effort is devoted to this task, then one might as well have scored the plot in the field, with more accurate results.

- It is not necessary to sketch obvious target or other distinct species.

- **It is preferable that the person who will score the data makes the sketches and notes**.

- Things to sketch/note include rock surfaces that may be confused with tar or crusts, tar spots, coralline and non-coralline crusts, sand depth (is it 5 cm or greater?), obviously dead invertebrate parts (e.g., shells, barnacle tests, *Phragmatopoma* tube fragments), un-removed drift algae fragments, bleached coralline algae, species recruits, closed anemones, motile invertebrates, uncommon species, unusual conditions, and obvious epibionts and layering – particularly as they affect the target and core species (e.g., algae atop mussels).

- Species scattered throughout the plot can be noted but not sketched.
- If possible, estimate extent of cover for sketched species or substrates.
- For barnacle plots where *Chthamalus* and *Balanus* are not distinguished in photo scoring, record quick visual estimate of % cover of each of these barnacle species (nearest 5%) whenever possible.
- The sketches are a good place to record plot corner marker conditions.

3.3.3 Scoring Cover in Photoplots – General Procedures

Core Procedure: Photoplots are scored from photographs or digital images in the laboratory, supplemented when possible by field plot sketches and notes. **Digital image scoring has become the standard since 2002/2003** because computer software provides a more convenient method of scoring images (e.g., ability to zoom and to enhance image quality). For film photographs, each slide is projected onto a white board that is marked with a grid of one hundred evenly-spaced points (10 x 10). Species, higher taxa, or substrates beneath the points are identified and recorded. When scoring digital images, a **grid of one hundred evenly-spaced points (10 x 10) is created on the computer monitor** (using Adobe Photoshop), and placed on a separate layer. This allows the scorer to easily remove the dot to see what lies beneath. The image can then be saved with the “grid layer”, clearly documenting the exact points scored. With either film or digital image scoring, grid size is manipulated to provide complete coverage of the plot within the quadrapod frame. Layering is not scored separately, so the total cover is 100%.

Film photographs of each photoplot have been scored in the lab by all groups from their initial survey dates until 2002/2003, except CINP has scored their photoplots in the field whenever practical since 1991, and UCSC began scoring acorn barnacle plots in the field in 2001 (see below). **If field scoring is done, the field protocol must be carefully specified to assure comparable results to photo scoring**. For example, discrepancies could arise because it is easier to identify species and to determine layering and epibiont conditions in the field versus lab. For consistency, it is preferable to use the same plan (either field or lab scoring) at given sites over time. If field scoring, plot photos should still be taken and “field scored” should be noted on the photoplot score sheet.

Variations from and Additions to Core Procedures:

- Switch to Digital Image Scoring: CSUF, UCSC, and UCLA began scoring digital photoplot images for all sites on a computer monitor in Fall 2002, except Bird Rock and Little Harbor photoplots were scored digitally beginning Spring 2003. UCSB began digital scoring in Spring 2003.
- Field Scoring: **CINP switched to field scoring whenever practical since 1991** for the following reasons: 1) Samplers sometimes had sufficient expertise and time in the field when sea conditions were mild enough to score in situ, 2) Field scoring is more accurate than scoring from photos, 3) Data are preserved if something happens to photos prior to lab scoring, and 4) Office demands made it difficult to find time for lab scoring. Plots are field scored using a collapsible 50 cm x 75 cm frame divided by 10 evenly-spaced string lines. With the frame over the plot, a narrow steel rod is placed across each string in sequence (using predetermined slots) to create 10 intersection points per string, making 100 points total under which organisms are

identified and recorded. Use of a multi-tally meter (tally-clicker) helps facilitate counting of multiple species.

- Acorn Barnacle Plot Field Scoring: **UCSC switched to field scoring of acorn barnacle plots in Spring 2001** in order to separately monitor live and dead (empty tests) *Chthamalus dalli/fissus*, *Balanus glandula*, and *Semibalanus cariosis*. They added the following categories to their optional species list for barnacle plots only: *S. cariosis* and dead *S. cariosis* (starting Fall 2000), live *C. dalli/fissus* and live *B. glandula* (starting Spring 2001), and dead *C. dalli/fissus* and dead *B. glandula* (starting Fall 2001). Acorn barnacle plots are scored in the field using a 50 cm X 75 cm frame with a 10 X 10 grid of evenly-spaced string lines. With the frame over the plot, a species, higher taxon, or substrate is identified below each of the 100 string intersection points.

3.3.4 Scoring Cover in Photoplots – Specific Procedures

Core Procedure: **Each of the 100 points within the photoplot is identified and scored as one of 46 categories of core species, higher taxa, or substrates** (Table 5 & Form 4: Prototype MARINe Rocky Intertidal Photoplot Slide-Scoring Data Sheet). Definitions for the lumped taxa and substrate categories are provided in Table 6. Monitoring groups can opt to score photos in greater taxonomic detail (e.g., some groups identify all organisms to the lowest level possible); however, finer-scaled data must be lumped to fit the core categories for database entry unless optional species have been formally registered with the database (requiring a commitment to consistently score the species in all surveys) (see above for optional species discussion). Prior to establishing core species, monitoring groups scored target species similarly, but secondary species categories varied somewhat among monitoring groups and through time (relational tables have been established in the MARINe database to document and standardize these lists, but the effort is not complete). An advantage of photos is that they can be rescored for standardization purposes or if a more thorough inventory becomes necessary (e.g., in the event of an oil spill). Layering is not scored separately, so the total percent cover is constrained to 100% (see below). **The following are core rules for photo scoring:**

- **Always score the top-most (visible) layer that is attached to the substrate (i.e., not an obvious epibiont) unless the top-most layer is a "weedy" species obviously overlaying a non-weedy species.** This rule applies regardless of the target or core species involved. The rule was formulated to work consistently for scoring from photos, supplemented when possible with rough plot sketches and brief notes. "Obvious" means that the layering can be discerned from the photograph or is clear from the brief field sketch/notes (e.g., a plot noted in the field to have 100% cover of mussels topped with weedy algae). Examples of epibionts include algae (e.g., crusts, articulated corallines, *Endocladia*) or invertebrates (e.g., barnacles or limpets) on live mussel shells or *Tetraclita* tests. Examples of "weedy" species include *Ulva*, *Enteromorpha*, *Endarachne*, *Porphyra*, and *Scytosiphon*. The top-most rule eliminates much of the uncertainty of trying to determine what lies below the upper layer, does not bias for or against target species, and generally keeps the photograph as the primary source of archival data (rather than some difficult to reconstruct combination of photo, plot sketch, and/or field scoring). This method will underestimate target species cover whenever the target species is covered by another species (e.g., by rockweeds or any plant whose attachment lies outside the plot). Such situations should be noted and considered when evaluating data trends. Though desirable, scoring cover of understory target species is too complex and time consuming to fall within the scope of this core laboratory-scored monitoring protocol. **Monitoring groups have the option to separately score epibionts or other layering; however, the current MARINe database is not capable of accepting the layered data**. Fortunately layering is not a major issue for most target species, except in plots where rockweeds occur.

- **Score sedentary motile invertebrates occurring under a photopoint as one of the following core categories: *Lottia gigantea*, limpet, chiton, *Pisaster ochraceus*, or other invertebrate.** Since black abalone and purple urchins are rarely encountered (if at all) in photoplots, they have not been designated as core species for this protocol. If encountered, they would be scored as "other invertebrate". **If an un-removed active motile invertebrate occurs under a photopoint, score what is likely underneath it if possible; otherwise, score the point as "unidentified"** (do not score the active motile invertebrate as "other invertebrate"). For example, the predatory snail *Mexacanthina* in CABR photoplots should be counted as an active motile invertebrate, not scored as sedentary invertebrate cover.

- **Score bleached crustose corallines (appearing white) as "crustose corallines", not "rock".** Bleached crustose corallines may still be alive, so assume they are live and score as such.

- **Score obviously dead barnacle tests, dead mollusk shells, and other non-living substrates that are not "rock", "sand" or "tar" as "other substrates".** This "other substrates" category was established in 2004. In prior years, dead shells and tests were scored primarily as "rock". UCSC scores each dead barnacle species separately in the field as an optional category. It is a more accurate determination that can be done with experienced samplers scoring in the field; however, these data must be lumped to the core category "other substrates" when comparing data with other MARINe sites scored from photos. When scoring from photos, if it is not obvious whether white acorn barnacles are live or dead, they must be assumed to be live and scored as "*Chthamalus dalli/fissus/Balanus glandula*". Larger, dead *Tetraclita* tests might be obvious in a photo, and if so, should be scored as "other substrates".

- **Epoxy corner markers and bolts should be scored as "rock".**

- **When sand is present under a point in the photo, if you can positively identify what is under the sand, then score the underlying core species or "rock"; otherwise score "sand".** This means that "sand" will be scored whenever sand thickness is greater than just a thin layer with patches of rock or some core species showing through.

Guidelines:

- If *Chthamalus* occurs as an epibiont on *Tetraclita*, score the point as "*Tetraclita*".

- If one species of rockweed overlays another species of rockweed, simply score the top layer as is, without moving either species. If a rockweed is obviously overlaying a mussel, score the rockweed because it is the top layer, is not an epibiont, and is not a "weedy" species.

- **If plant species are attached outside the plot but draping over target or core species in the plot, score the overlying species (if it is not a "weedy" species) without regard to place of attachment.** For example, in the rare case where *Egregia* drapes across a mussel plot, leave it in place and score it as the top-layer species (but note on the Sketch Data Sheet what it is covering). Ideally one would like to follow the target or core species despite over-draping, but in practice it would be too complex for field samplers to record and would likely lead to inconsistencies.

Variations from and Optional Additions to Core Procedures:

- Prior to establishing core species, non-target species categories varied among monitoring groups and through time. Relational tables have been established in the MARINe database to document and relate these species variations to core categories, but the effort is not complete (see Database User Guide: Bealer & Cooper 2003).

- CSUF scores all species layers evident in plot photos, but only transfers to the MARINe database those data that fit core rules.

3.3.5 Managing Photoplot Data and Photographs

Photoplot Data: The Photo Log and Photoplot Sketch Data Sheets are completed in the field (Forms 2 & 3), but not entered into the computer database. With either lab or field point scoring, data are recorded on data sheets (Form 4: Prototype **MARINe Rocky Intertidal Photoplot Slide Scoring Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see Database User Guide: Bealer & Cooper 2003). Photoplot data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived.

Photographs: After the film is developed and mounted into slides, the slides are labeled individually with site name, date, target species and plot number. They are then arranged by site and target species into high quality polyethylene slide pages organized into notebooks and archived. **If duplicate slides exist, they should be stored in a separate location to minimize data loss in the event of some catastrophe such as fire or theft.** Eventually, all photo slides should be scanned at a high resolution and copied to CD or DVD for archiving. A backup copy (on a hard drive or another CD/DVD) is recommended. One of the CD's or DVD's can be placed in a folder with the original datasheets and the other in a separate storage location.

Digital Images: The protocol for managing digital images is still being developed. Typically images are downloaded from the camera memory chip to a computer for organization and labeling. The images are superimposed with the dot grid in Adobe Photoshop for scoring. Original images and dot grid sets of images are backed up to CD or DVD for archiving. Photo database software programs are currently being evaluated.

Digital Photoplot Image File Naming Standard: The rationale for the photoplot file name standard includes the following:

- Photo file name must be easy to understand and implement and compatible with typical database style.

- Photo file names should not use spaces or special characters. Underscore is OK as a separator.

- For simplicity and reducing possibility of errors, photo file names should include only lower case letters.
- Even though a photo database can organize files based on key words, etc, it is best if file names are descriptive and display in a logical order. However, not all information needs to be included in the file name (directories can be used to separate some broad categories), and the file name should not be lengthy (<20 characters preferred).
- There are 6 main types of info that have been incorporated into MARINe photoplot file names. This hierarchy (in order from general to specific) is as follows:

1) **Site**: use our standardized 3-5 letter codes (lowercase) to conform with the database.

2) **Target Species**: Use the first 3 letters (lowercase) of the target species plot names in the database (see Table 7). Using fewer than 3 letters could lead to ambiguities, while more letters unnecessarily lengthens the file name.

3) **Plot Number**: Plot identifiers should conform to consecutive #'s starting with "1" if possible (e.g., 1, 2, 3, 4, 5 ...). Other unique and consistently applied plot #'s can be used (e.g., 212, 213,…); however, for simplicity in labeling, mapping, and database operations, we should strive to convert to the "1, 2, 3, 4, 5" format when feasible.

4) **Date (Season/Year)**: Most of core MARINe sampling takes place semi-annually, in fall and spring, though some northern sites are sampled annually, in summer. Due to the nature of our sampling schedules (including limited # of adequate low tide periods, site access limitations and weather delays), we have defined 3 sampling seasons (no winter), each 4 months long as follows: "Fall = October-January, Spring = February-May, and Summer = June-September (This does not quite match the calendar year; thus a sample in January 2005 would be listed as a Fall 2004 sample).

Seasons will be abbreviated as lowercase 2-letter codes (Fall = fa, Spring = sp, Summer = su) and years will be abbreviated as the final 2 digits (e.g., 1997 = 97, 2004 = 04). Using these codes means the file names as listed in alphanumeric order will group all Fall photos, followed by all Spring photos, and then all Summer photos. Also years in the new century (2000's) will sort out before the 1900's. This partial breakdown of chronological order was not considered significant enough to change to lengthier and less intuitive file names since the eventual implementation of a photo database will allow all kinds of sorts, including chronological.

5) **Photo Replicate:** For each photoplot sampling, there will be at least 2 photos to store: 1) the photo used for scoring and 2) that same photo overlain with the grid of 100 dots). In addition there may be 1-2 or more other photos, often representing different exposures (e.g., 1 more overexposed and 1 more underexposed) (Note: we should not label and organize photos that we are unlikely to use, such as duplicate exposure or poor quality extra photos). To differentiate the various photos for a given plot, we will add a single lowercase letter after the year in the file name as follows:

"a" = scored photo (no dot grid)

"b", "c", "d", "e", or "f" = additional photos taken (e.g., different exposures)

"g" = scored photo overlain with dot grid

6) **Photo Variants**: For some plots, there may be photos taken from different perspectives or of different subsections of the plot. For example, if plot lies over a ledge, 1 photo may be taken with the frame mostly horizontal and another photo taken more vertically. Another example: CSUF takes separate photo of each ¼ of the barnacle plots to get better resolution for scoring. To differentiate these types of photos in the relatively few circumstances when they occur, we will add an appropriate code at the end of the file name, such as (these example codes could be changed if other designations are found to be more appropriate):

"horiz" = horizontal or "vert" = vertical

"ul" = upper left, "ur" = upper right, "ll" = lower left, or "ul" = lower right quadrants

Based on the above criteria, the MARINe photoplot digital photo name standard is:

"site" "_" "target species" "plot #" "_" "season" "year" "replicate" "_" "variant"

Photoplot File Name Examples:

psn_maz2_fa04a.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "a" (scored photo)

psn_maz2_fa04b.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "b" (different exposure)

psn_maz2_fa04g.jpg = Pt Sierra Nevada, Mazzaella Plot #2, Fall 2004, Replicate "g" (dot grid photo)

shco_sil5_sp05a.jpg = Shaws Cove, Silvetia Plot #5, Spring 2005, Replicate "a" (scored photo)

shco_cht3_sp05a_ul.jpg = Shaws Cove, Chthamalus/Balanus Plot #3, Spring 2005, Replicate "a" (scored photo), upper left quadrant

care_pol4_fa03b_vert.jpg = Cardiff Reef, Pollicipes Plot #4, Fall 2003, Replicate "b", vertical emphasis

bml_myt1_su04g.jpg = Bodega, Mytilus Plot #1, Summer 2004, Replicate "g" (dot grid photo)

3.4 Point-Intercept Transect Protocol

Permanent point-intercept transects are employed to **monitor the cover of 3 target species: *Phyllospadix scouleri/torreyi* (33 sites), *Egregia menziezii* (3 sites), and Red Algae (turf algae, including articulated corallines and other red algae) (7 sites)** (Table 8). Transects are established at sites with sufficient cover of the target species for monitoring.

3.4.1 Scoring Cover on Point-Intercept Transects

Core Procedure: The cover of target species, as well as secondary core and optional species/taxa/substrates, is sampled each spring and fall by scoring point-intercepts along 3 permanent 10 m transects (see Table 8 and below for exceptions). Transects, which are marked at both ends (and often the center) with stainless steel bolts, usually are separate, but may run end to end depending on the shape and expanse of the target species habitat. Each transect is sampled by scoring occurrences under 100 points uniformly distributed at 10 cm intervals (10 cm, 20 cm, 30 cm …1000 cm) along a meter tape laid out along the transect. **Rules for scoring are as follows:**

Each of the 100 points along the transect meter tape is located and scored as one of 24 categories of core species, higher taxa, or substrates (Table 5 & Form 5). Only the topmost (visible) layer that is attached to the substrate (i.e., not an obvious epibiont) is scored, except that surfgrass is also scored separately when it is covered by another non-

epibiont species (see below). For example, if *Egregia* drapes across articulated corallines, leave it in place and score it as the top-layer species. Definitions for the lumped taxa and substrate categories are provided in Table 69. Monitoring groups can opt to score transects in greater taxonomic detail; however, finer-scaled data must be lumped to fit the core categories for database entry unless optional species have been formally registered with the database (requiring a commitment to consistently score the species (if present) in all surveys) (see above). Some monitoring groups previously recorded each point in order along the transect from start to end (generally north to south). This was deemed not necessary, so for efficiency the core method is to simply record the number of "hits" in each category without regard to position along the transect.

***Phyllospadix* is scored in either of 2 categories: "*Phyllospadix* Overstory" and "*Phyllospadix* Understory".** This procedure, initiated in Fall 2002, documents surfgrass even when it is covered by another species. Total transect cover will be greater than 100% whenever understory surfgrass is scored. Since any amount >100% cover represents understory surfgrass only, compatibility with previous "top-layer only" scoring is maintained. Scoring other understory species, though possible in the field, would be tedious and impractical (especially when transects are periodically awash) given personnel and time constraints. Except in San Diego County, all transects target surfgrass, so it is logical to deal with layering only when surfgrass is covered by another plant (e.g., *Egregia*). The categories "*Egregia* on *Phyllospadix*" or "*Phyllospadix* on *Egregia*" were scored by UCSC during 2002; thereafter, this practice was discontinued.

Score obviously dead barnacle tests, dead mollusk shells, and other non-living substrates that are not "rock", "sand" or "tar" as "other substrates". This "other substrates" category was established in 2004. In prior years, dead shells and tests were scored primarily as "rock".

Epoxy corner markers and bolts should be scored as "rock".

When sand is present under a point along the transect, score "sand" whenever the sand cover is 2 cm or greater; otherwise score "rock" or the underlying core species. This is determined by probing with the index finger, with 2 cm roughly being the distance from fingertip to the first joint. Note that the field-scored transect definition of "sand" is different than that for lab-scored photoplots (see above).

In addition to scoring point intercepts, abundance (none, low, med, high) of the following surfgrass epiphyte and appearance conditions are categorized for the transect areas: *Smithora* and *Melobesia* epiphyte cover, bleached and abraded appearance, and presence of flowers. Other notes may be recorded.

Guidelines:

- Minimize disturbance of surfgrass or algae along transects when laying out meter tapes. If vegetation must be moved to locate marker bolts, be sure to return it to its original position.

- Wave surge can rearrange surfgrass and other algae along the transect depending on the extent of low tide and sea conditions. Try to survey the entire transect during a period when the tape and grass are undisturbed. If this is not possible, get help to hold the tape in place and score during the calm periods.

- "Surfgrass" is scored under a point no matter what its appearance (bleached, abraded, etc.). Leaves, flowers, and rhizomes all are scored as "surfgrass".

- If possible, photograph each transect (lengthwise) during the seasonal monitoring to document the species assemblage and appearance.

Variations from and Additions to Core Procedures

- The footnotes in Table 8 describe variations to the core protocol with respect to transect length and number of replicates.

- Line-Intercept: The original method for scoring transects (developed at the CABR sites) used line-intercepts, where the sampler scored the core taxa and substrates lying under the entire edge of the 10 m transect tape. Line cover extents were rounded off to the nearest centimeter, thus 1000 separate segments were scored, then divided by 10 to get % cover. **UCSB and CABR scored line intercepts for all transects at their San Diego County sites until Fall 2000, when both groups switched to the point intercept method to standardize with other monitoring groups** (Pete Raimondi had compared the 2 methods and found that the point-intercept sub-sampling (100 versus 1000 data points) yielded similar cover results for surfgrass). Line-intercept data have been entered in the MARINe database, as percentage values just like the point-intercept values.

- Surfgrass Thickness: **As an optional procedure, UCSC collects information on thickness of the surfgrass layer.** Each transect is divided into ten 1 m long segments. If the entire segment is covered by surfgrass, surfgrass layer thickness is measured in the segment middle. If surfgrass covers only a portion of the segment, thickness is measured in the middle of the covered portion. To measure surfgrass thickness, lowermost through uppermost layers are compressed together (not bunched), then measured with calipers. These data have not been entered in the MARINe database.

- Surfgrass Species Separation: **As an optional procedure, UCSC records the percent cover of *Phyllospadix torreyi* vs. *Phyllospadix scouleri* along each transect** by estimating the proportion of each species for surfgrass covered areas. Overlapping morphological characters (e.g., leaf width 1-2 mm for *P. torreyi* vs. 2-4 mm for *P. scouleri*) and paucity of flower stalks (which can distinguish the 2 species) make species separation difficult. If transect sections contain surfgrass that is difficult to identify, the percentage of each species is based on the proportion of the transect that can be confidently identified. These data have not been entered in the MARINe database.

- **CSUF scores all species layers in point transects**, but only transfers to the MARINe database those data that fit core rules.

3.4.2 Managing Point-Intercept Transect Data

Data are recorded on data sheets (Form 5: Prototype **MARINe Rocky Intertidal Point-Intercept Transect Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see

Database User Guide: Bealer & Cooper 2003). Point-transect data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived. Any photographs are archived in notebooks, with digital images stored on CD's or DVD's.

3.5 Owl Limpet Plot Protocol

Permanent plots are employed at **43 MARINe sites** to monitor the density and size distribution of owl limpets (*Lottia gigantea*) (Table 8). Plots are established at sites with sufficient densities for monitoring.

3.5.1 Counting and Measuring Owl Limpets in Plots

Core Procedure: The density and size distribution of owl limpets are monitored each spring and fall to follow population dynamics within **5 permanent 1 m radius circular plots** per site (see Table 8 and below for exceptions). Plots were established in areas of high density to obtain as many counts and measurements for size-frequency as possible (preferably >20 individuals/plot for a total of >100 per site). Therefore, plot densities reflect maximum densities rather than average densities at each site. Plots are marked with one center bolt, notched to indicate the plot number. Limpets are measured within a circle (1 m radius, 3.14 m^2 area) projected around each bolt.

To survey a plot, a 1 m length of line or tape is attached to the center bolt and arced around to form a circle. The **maximum length of all owl limpets ≥15 mm** found within that circle (including those touched by the 1 m mark) are measured with calipers to the nearest millimeter, then temporarily marked with a yellow forestry crayon to avoid scoring duplication. If a limpet cannot be measured directly by the calipers (due to tight crevices or other irregularities), its size is estimated. **Limpets are never removed from the rock**. The measurement tape is either pulled taught along the topography of the substrate (i.e., if a limpet can be touched by the end of the line, it is included) or laid more loosely along the topographic contours (CINP & UCSC) to determine which limpets lie within the circle, with the method of choice employed consistently at each site. Some monitoring groups (e.g., UCSB) include limpets in narrow crevices within the circle even if the limpet cannot be touched by the line.

Guidelines:

- **It is important that each monitoring group documents its rules for delineating owl limpet plot boundaries so that plots are surveyed consistently.**
- To ease decisions about plot boundaries for plots on irregular rock surfaces, take a print photo (if possible) of each plot with a line or series of markers indicating the plot boundary, then use the prints in the field to confirm plot edges. Add notes about plot irregularities if necessary.
- Observers must refine their search image to locate owl limpets in narrow crevices and those covered with barnacles or algae. It helps to look through the plot from different angles of view. It is good practice to have a second scorer search the plot for limpets possibly missed by the first scorer. Also, *Lottia gigantea* may be confused with other large limpets (especially large *L. pelta* or *L. limatula*).

- Plot observations should be recorded on the data sheet, including obvious scars from missing limpets and any evidence of predation.
- If possible, photograph each owl limpet plot at least once a year to document the species assemblage and appearance.

Variations from and Additions to Core Procedures

- See footnotes in Table 8 for variations to core procedures (e.g., plot size, shape, and # replicates).
- Small owl limpets: The 15 mm minimum size for counting and measuring owl limpets was implemented during the initial design of this monitoring (at CABR) to reduce variability associated with increasing difficulty in locating and identifying smaller sizes of *Lottia gigantea*. Small owl limpets can be hidden in tiny crevices and may look similar to other limpet species, except to experienced samplers. **As an optional protocol, UCLA has recorded all owl limpets ≥ 10 mm since 1999, and UCSC records all limpets identified with no minimum size.** Data for owl limpets <15 mm shell length have been entered in the MARINe database; however, such data can result in incompatible comparisons of mean sizes and size-frequency histograms.
- **CINP samples annually in fall, unless the site is visited only in spring**.

3.5.2 Managing Owl Limpet Plot Data

Data are recorded on data sheets (Form 6: Prototype **MARINe Rocky Intertidal Owl Limpet Data Sheet**). Prototype data sheets can be used “as is” or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see Database User Guide: Bealer & Cooper 2003). Owl limpet data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived. Any photographs are archived in notebooks, with digital images stored on CD’s or DVD’s.

3.6 Black Abalone and Ochre Seastar Monitoring Protocol

Permanent plots or transects are employed to monitor the density and size distribution of black abalone (*Haliotis cracherodii*) and ochre seastars (*Pisaster ochraceus*) (Table 8). Plots/transects were established at sites with sufficient densities for monitoring. At most other sites, timed searches are used to document the absence or rarity of these species.

3.6.1 Counting and Measuring Black Abalone and Ochre Seastars

Core Procedure: The number and size of black abalone and ochre seastars are monitored each spring and fall within irregularly-shaped plots or along band transects, depending on site topography. **3-5 plots/transects generally were established in areas of high density to obtain as many counts and measurements for size-frequency as possible** (preferably >20 individuals/plot for a total of > 60-100 animals per site; primarily for black abalone). Irregular plots are marked by four or more "corner" bolts, one of which is notched as the plot number bolt.

These markers were placed on conspicuous (i.e., higher) rock features to ease relocation efforts, thus plot boundaries may include habitat unsuitable for abalone or seastars. For this reason, **irregular plots were not intended to provide densities for comparison between sites**. They were designed to provide temporal comparisons within a site. Seastar transects are 2 x 5 m; abalone transects are 1 x 10 m (see Table 8 and below for exceptions). Transects are marked at both ends (and often in the center) by bolts. At some sites, the same plots or transects are used to monitor both species.

To survey a plot or transect, once the tide is low enough, a meter tape (or line) is laid out along the transect length or around the irregular plot perimeter. Transects are surveyed by moving a 1 m wand down each side of the 2 x 5 m transects or down the center of the 1 x 10 m transects. All seastars or abalone present (wholly or in part) under the path of the wand are recorded and measured. For irregular plots, the entire area encompassed by the boundary tape (or line) is searched carefully. Seastars and abalone are included if any part of the animal is inside the plot.

Abalone shell lengths are measured with calipers or a ruler to the nearest 5 mm for animals <40 mm and the nearest 10 mm for larger abalone (CINP measures to the nearest mm). Each abalone is temporarily marked with a yellow forestry crayon to avoid duplication. Sometimes it is necessary to estimate lengths for abalone lodged deeply in cracks or otherwise inaccessible. Abalone are never removed from the rock. **Seastars are measured from the center of the disc to the tip of the longest ray with calipers to the nearest 5 mm for animals <10mm and the nearest 10 mm for larger seastars.** Often sizes must be estimated because seastars typically are wedged in tight spots with rays curved. Seastars should never be "straightened" or removed from the rock. CINP began measuring *P. ochraceus* in 2002 using estimated size classes (<50, 50-100, >100 mm). Starting Spring 2003, CINP switched to different size classes (<75, 75-150, >150 mm). UCLA and UCSC began recording seastar sizes in Fall 2000.

Guidelines:

- **Each monitoring group should document its rules for delineating abalone/seastar plots or transects so that areas are surveyed consistently**.

- Observers must refine their search image to locate abalone and seastars in deep or narrow crevices. Use a waterproof flashlight if necessary to see into dark areas. It helps to look through the plot from different angles of view. It is good practice to have a second scorer search the plot for abalone/seastars possibly missed by the first scorer.

- At some sites, seastar counts may be variable because these motile invertebrates move outside the plots/transects. If plot/transect boundaries are extended to reduce this variability, separate counts for old and new plots/transects are necessary to maintain compatibility with prior data.

- If possible, photograph each abalone/seastar plot or transect at least once a year to document the species assemblage and appearance.

Variations from and Additions to Core Procedures:

- The footnotes in Table 8 describe variations to the core protocol with respect to plot and transect sizes and shapes and number of replicates.

- In 2003 UCLA added large irregular plots for seastars at Arroyo Hondo, Carpinteria, and Old Stairs (3 replicates each). These plots are monitored in addition to the existing band transects (but scored separately) to provide larger search areas for seastars.

- Other abalone and seastar species: As an optional procedure, some monitoring groups also record number and sometimes size data for green abalone (*H. fulgens*), bat stars (*Patiria miniata*), sun stars (*Pycnopodia helianthoides)*, giant-spined stars (*Pisaster giganteus*), and fragile stars (*Astrometis sertulifera*).

- Ochre Seastar Color: As an optional procedure, UCSC has recorded color categories (orange or not orange (purple/brown)) of *Pisaster ochraceus* since Spring 1996. UCLA began recording these colors in Fall 1999.

3.6.2 Timed Search Protocol

Core Procedure: Site-wide timed searches have been **employed at locations where abalone and seastars have been absent or exist in too few numbers to monitor within replicated plots or transects**. The purpose of timed searches is to document absence/rarity or to recognize a population increase such that monitoring in replicated plots could be instituted. This method is primarily qualitative (indicating levels of abundance) because time limitations prevent a thorough search of the entire site and low tide/swell conditions affect the lower boundary accessible for searching. To survey (around the time of low tide), one person spends 30 min (or 2 persons 15 min each) searching appropriate abalone/seastar habitats (e.g., crevices and pools) along the low intertidal zone throughout the defined site (between upcoast and downcoast boundaries) for possible occurrences of ochre seastars or black abalone. Numbers encountered and sometimes size measurements are recorded.

Guidelines:

- **It is important that each monitoring group documents its rules for delineating timed search boundaries so that areas are surveyed consistently**.

- Observers must refine their search image to locate abalone and seastars in deep or narrow crevices. Use a waterproof flashlight if necessary to see into dark areas.

- If abalone or seastars show up in moderate numbers during timed searches over several sampling seasons, consider setting up fixed irregular plots (3 replicate plots) of sufficient size for adequate long-term quantitative monitoring.

Variations from and Additions to Core Procedures:

- Other abalone and seastar species: As an optional procedure for timed search sites, some monitoring groups also record number and sometimes size data for green abalone (*H. fulgens*), bat stars (*Patiria miniata*), sun stars (*Pycnopodia helianthoides)*, giant-spined stars (*Pisaster giganteus*), and fragile stars (*Astrometis sertulifera*).

- Ochre Seastar Color: As an optional procedure, some monitoring groups record color categories (orange or not orange (purple/brown)) of *Pisaster ochraceus*.

3.6.3 Managing Black Abalone and Ochre Seastar Plot Data

Data are recorded on data sheets (Form 7: Prototype **MARINe Rocky Intertidal Abalone and Seastar Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the core data and maintain an order consistent with database entry. Prior to Spring 2003, data were entered into various computer spreadsheets or databases by the different monitoring groups. Now, data are entered into the MARINe Microsoft Access database via standardized data entry templates (see Database User Guide: Bealer & Cooper 2003). Abalone/seastar data should be entered into the database entry template as soon as possible after scoring, while memories are fresh and questions can be resolved. All data sheets are organized into notebooks and archived. Any photographs are archived in notebooks, with digital images stored on CD's or DVD's.

3.7 Northern Sea Palm Monitoring Protocol

Northern Sea Palms (*Postelsia palmaeformis*) are counted within grid transects at some sites in central and northern California where there are sufficient abundances for monitoring (Table 8). At other sites, presence or relative abundance of northern sea palms is noted during site-wide species reconnaissance and recorded on the Field Log (Form 1b).

3.7.1 Counting Northern Sea Palms in Grid Transects

Core Procedure: The density of Northern Sea Palms are monitored each spring and fall (or annually) to follow population dynamics in permanent grid transects whose size and number vary by site. Meter tapes are laid out between permanent bolts to define the survey area. Each area is subdivided into a grid of 1m x 1m quadrats (except 1m x 1.5m at Mal Paso & 1m x "swath to water line" at Scott Creek & Sand Hill Bluff). Within each quadrat, all intact *Postelsia* stipes are counted and recorded. The relative abundances of recruits and adults are noted.

Site-specific grid arrangements are as follows:

Fogarty Creek: 1 area: a 9m transect line with 1m x 1m quadrats in each direction (18 quadrats total).

Shelter Cove: 3 areas: each made up of a 5m long transect line with 1m x 1m quadrats in each direction (30 quadrats total).

Sea Ranch: 2 areas: A 5m transect line and a 7m transect line, both with 1m x 1m quadrats in each direction (24 quadrats total).

Scott Creek: 2 areas: A 20m transect line with a swath quadrat to water line every 1m, and a 6x4 m grid with 1m x 1m squares, with the last row being swath quadrats to the water line (44 quadrats total).

Sand Hill: 1 area: a 7m x 20m grid with 1m x 1m squares, and the offshore row of quadrats being swaths to the water line (140 quadrats total).

Mal Paso: 1 area: a 12m transect line with 1m x 1.5m quadrats in each direction (24 quadrats total).

Bodega Bay: 2 areas: a 10m transect line and a 9m transect line, both with 1m x 1m quadrats in each direction 38 quadrats total).

Point Sierra Nevada: 1 area: a 6m transect line with 1m x 1m quadrats in each direction (12 quadrats total).

3.7.2 Managing Northern Sea Palm Data

Data are recorded on data sheets (Form 8: Prototype **MARINe Rocky Intertidal Northern Sea Palm Data Sheet**). Prototype data sheets can be used "as is" or may be slightly modified to meet specific needs of monitoring groups so long as they capture the standard data and maintain an order consistent with database entry. Northern Sea Palm data have not yet been incorporated into the MARINe Microsoft Access database; however, the database has been designed to facilitate the addition of these data. All data sheets are organized into notebooks and archived.

3.8 Motile Invertebrate Monitoring Protocol

The number and in some cases sizes of select motile invertebrates are monitored within the photoplots at sites where the monitoring group has sufficient experienced samplers and time to conduct this survey (Table 9). Though not a core procedure, the protocol has been tested and standardized for those monitoring groups choosing to use it. The **standard protocol was implemented in 2002/2003** (variations were tested in earlier years) by UCSC, CINP, UCLA, and CSUF. UCSB and CNM chose not to use this protocol due to sampling effort/expertise limitations. CINP conducts motile invertebrate surveys only once per year (in spring), alternating this protocol with owl limpet size/counts (in fall). The other **groups switched from semi-annual sampling to annual (in spring) in 2004** to reduce sampling effort and because analysis indicated motile invertebrates exhibited little seasonal variation in abundance.

3.8.1 Counting and Measuring Motile Invertebrates in Photoplots

Standard Procedure: The density of **16 motile invertebrates species or higher taxa** are monitored each spring and fall (or annually) to follow population dynamics in many of the permanent 50 x 75 cm photoplots at each site (Table 9). The **systematic plot searches are facilitated by subdividing the quadrat frames into 4 equal subsections with string**. Abundant species are sub-sampled.

Core motile invertebrate species/higher taxa by category include: gastropods (*Acanthina* sp., *Fissurella volcano*, limpets (excluding *Lottia gigantea*), *Littorina* spp., *Lottia gigantea*, *Nucella emarginata*, *N. canaliculata*, *Ocenebra circumtexta*, *Tegula brunnea*, *T. funebralis*, *T. gallina*), chitons (*Lepidochitona hartwegii*, *Mopalia* spp., *Nuttalina* spp.), and crabs (*Pachygrapsus crassipes*, *Pagurus* spp.) (see Table 5).

Limpets < 5 mm and limpets 5-15 mm are sub-sampled in three 20 x 20 cm quadrats, which are placed in upper left, middle, and lower right corner of each photoplot. Sub-sample counts are facilitated by subdividing the 20 x 20 cm quadrat frames into 4 equal subsections with string. If limpets are super-abundant, (as commonly occurs with the < 5 mm category), they can be sub-sampled in a 10 x 10 cm section of the 20 x 20 cm quadrat. If no limpets are counted in the 20 x 20 cm areas and limpets are present in the plot, then the entire photoplot is counted. Counts of limpets that are done in either the smaller 20 x 20 cm or 10 x 10 cm areas must be noted on the data sheet. Sub-sampled limpet counts will be extrapolated to the full 50 x 75 cm photoplot area (counts in 20 x 20 cm areas are summed and multiplied by 3.125, counts in 10 x 10 cm areas are summed and multiplied by 12.5).

Littorines are sub-sampled in a 10 x 10 cm section of the 20 x 20 cm sub-sampling quadrats. If no littorines are found in the 10 x 10 cm area, and littorines are present in the plot, then counts should be done in the entire 20 x 20 cm quadrats. As with limpets, counts from sub-sampled areas will be extrapolated to the full 50 x 75 cm photoplot area.

Sizes of the first 10 individuals encountered in each plot are measured to the nearest mm for the following 7 gastropod species: *Acanthina* spp., *Lottia gigantea*, *Nucella emarginata*, *N. canaliculata*, *Tegula brunnea*, *T. funebralis*, and *T. gallina*. Measured species will vary slightly among regions since only those that are abundant enough to get useful size data should be measured.

Guidelines:

- Sampling in plots with foliose algae that need to be rearranged to find motile invertebrates should be done after plot photos and photo notes have been taken.

- Motile invertebrates can be removed from plots and placed in a container for counting, but should be returned to the plot when sampling is completed. Forceps are useful for extracting whelks from crevices and from amongst mussels.

- It is not possible to locate all cryptic or tiny individuals in complex plots. Practical time limits should be placed on search efforts.

- A tally counter can be used to keep track of counts.

- Sampling often works best by conducting multiple searches through the plot, concentrating your search image on one or two species during each search.

Variations from and Additions to Core Procedures:

- Optional Species: The following optional species can also be counted in photoplots: gastropods (*Amphissa versicolor, Epitonium tinctum, Ceratostoma nuttalii, Haliotis cracherodii, H. fulgens,* Mexa*canthina lugubris)*, chitons (*Lepidochitona* spp., *Lepidozona* spp., *Stenoplax* spp., *Tonicella lineata*), seastars (*Patiria miniata*, *Leptasterias hexactis*, *Pisaster ochraceus*, and *P. giganteus*), and sea urchins (*Strongylocentrotus purpuratus* and *S. franciscanus*.

- The 1st 10 Pagurus spp. are identified to species by UCSC. This ratio is multiplied out for the total # counted.

- UCSC keeps separate counts of limpets occurring on rock vs. those occurring on *Mytilus* and *Pollicipes*.

- CINP samples annually in spring, except in fall only at Santa Barbara Island (to avoid disturbing nesting pelicans in spring) and semi-annually at Anacapa Island to evaluate rat removal effects (rats may have been foraging on small motile invertebrates. ANME is sampled only when there is enough time, since it is not expected to be much different from adjacent ANMW. When time is short at SCOC, may score 3 plot types in 1 season and 2 plot types in the other season.

3.8.2 Managing Motile Invertebrate Data

Data are recorded on data sheets (Form 9: Prototype **MARINe Rocky Intertidal Motile Invertebrate Data Sheet**). Prototype data sheets can be used “as is” or may be slightly modified to meet specific needs of monitoring groups so long as they capture the standard data and maintain an order consistent with database entry. Motile invertebrate data have not yet been incorporated into the MARINe Microsoft Access database; however, the database has been designed to facilitate the addition of these data. All data sheets are organized into notebooks and archived.

3.9 Invertebrate Recruitment Protocol

Though not a core procedure, white barnacle (*Chthamalus dalli/fissus/Balanus glandula*) and California mussel (*Mytilus californianus*) recruitment have been monitored at many MARINe sites (Table 10). Barnacle recruitment is monitored by scoring settlement on 5 10 x 10 cm PVC plates (covered in safety-walk) screwed into the substrate next to the white barnacle photoplots. The PVC plates are retrieved during each field survey (replaced with clean plates) and scored in the lab. White barnacle recruitment also is monitored in 10 x 10 cm clearings (wire-brushed to bare rock). Settlers are counted in the field during each survey, then the small plot is re-cleared. Mussel recruitment is monitored by scoring settlement into "Tuffy" mesh balls screwed into the substrate next to the mussel photoplots. The Tuffys are retrieved during each field survey (replaced with clean ones) and scored in the lab.

3.9.1 Field scoring barnacle clearings and collecting barnacle plates and mussel Tuffys

Clearings:

- Choose 5 random fields of view per clearing. Fields should represent entire clearing so try to pick one field per corner and one in center.
- In each field of view use scope or hand lens (magnifying glass) to count by species all barnacles and cyprids found.
- If the density of barnacles in the clearing is low and the field of view method does not accurately reflect actual density, count entire plot. A hand lens or magnifying glass is useful for this.
- Randomly measure 10 *Chthamalus* and 10 *Balanus* per clearing. Preferably, measure 2 from each field of view.
- Measure 1 cyprid of each species per clearing (if present).
- Use the metal brush and probe to clear the plot of all barnacles when done counting.

Plates:

- Remove each plate with nutdriver and store in "plate rack" (4" long bolt with 4 "spacer" nuts of larger diameter than bolt threading and 1 nut to secure plates on "rack").
- Replace each plate with clean plate using nutdriver.

Tuffys:

- Remove each Tuffy with nutdriver and store in labeled bag.
- Replace each Tuffy with clean Tuffy using nutdriver.

3.9.2 Lab scoring barnacle plates and mussel Tuffys

3.10 Intertidal Temperature Loggers

Though not a core procedure, intertidal temperature loggers have been deployed at many MARINe sites (Table 11). These small units ("Stowaways", "Tidbits", or "Pendants" from Onset Corporation) **record automated ambient temperatures (sea or air depending on**

tide height) at pre-set time intervals (usually every 15 min). Typically they are housed in capped PVC tubes bracketed to the rock, **in the mid-mussel zone or just below the mussel zone.** The units are changed out (or downloaded to an "Optic Shuttle") during the monitoring survey. After data are downloaded, the unit can be reset to use again. They may be triggered by a magnet to start sampling when deployed at a site. Battery life for the ~$100 Tidbits is about 5 years; once batteries fail, units are discarded. Battery life for the ~$50 Pendants is about 1 year; battery can be replaced by user. Start use dates should be noted and units (Tidbit) or batteries (Pendant) replaced after end of specified battery life span to prevent loss of data. Data managers can process the temperature records to separate submerged periods from times when the units are exposed to air.

4. MARINE DATA MANAGEMENT

Data sheets, maps, photographs, videotapes, and computer files are managed as described for each survey method (see above). Data entry, error checking and correction, and other data management procedures for the Microsoft Access database are described in the **MARINe Database User Guide** (Miner et al. 2007).

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Table 1: MARINe Core Monitoring and PISCO Biodiversity Survey Sites

SITE	County	PISCO Biodiversity			MARINe Core Survey				In or Near (<2mi) ASBS	In or Near (<2mi) CFG MPA	In or Near (<2mi) NOAA Mussel Watch Station	Other Designation #1	Other Designation #2
		Site Code	Initial Date	Re-Sample Date	Site Code	Region North	Region South	Initial Date					
ALASKA			_	_		_	_						
Graves Harbor	Skagway	3001	8/03	7/07		_	_	_					
Yakobi	"	3002	8/03	7/07		_	_	_					
Port Mary	Sitka	3003	8/03			_	_	_					
Puffin Bay		3009	7/07			_	_	_					
Coronation Island		3010	7/07			_	_	_					
BRITISH COLUMBIA						_	_	_					
Tow Hill		3008	6/05			_	_	_					
Hippa Island		3007	6/05			_	_	_					
Duck Island		3006	6/05			_	_	_					
Palmerston		3004	8/03	6/07		_	_	_					
Little Ohiat		3005	8/03	6/07		_	_	_					
WASHINGTON													
Cannonball Island	Clallam	1	7/02	6/06									
Chilean Memorial	Clallam	2	7/02	6/07									
Taylor Pt	Jefferson	3	7/02	7/03, 6/04									
Starfish Pt	Jefferson	4	7/02	6/06									
OREGON													
Ecola	Clatsop	5	6/01	6/05	**ESP**	**X**		6/01				Ecola State Park	
Fogarty Creek	Lincoln	6	6/01	7/03, 6/04	**FOG**	**X**		8/00					
Bob Creek	Lane	7	6/01	5/07	**BOB**	**X**		7/00					
Cape Arago	Coos	8	6/01	6/05	**ARG**	**X**		8/00				Cape Arago State Park	
Burnt Hill	Curry	9	5/02	5/06	**BRN**	**X**		6/02					
N. CALIFORNIA													
Enderts	Del Norte		None		**END**	**X**		6/04	Redwoods National Park			Redwoods National Park	Redwoods State Park
Damnation Creek	"	52	6/04		**DMN**	**X**		6/04	Redwoods National Park			Redwoods National Park	Redwoods State Park
False Klamath Cove	"		None		**FKC**	**X**		6/04	Redwoods National Park			Redwoods National Park	Redwoods State Park
Cape Mendocino	Humboldt	10	5/02	4/06	**MEN**	**X**		6/04					
Shelter Cove	"	11	7/01	4/06	**SHT**	**X**		6/04	King Range Nat Conser Area		Point Delgado Shelter Cove	King Range Nat Conser Area	
Kibisillah Hill	Mendocino	12	7/01	6/03, 5/07	**KIB**	**X**		6/04				Mendocino Headlands State Park	
Stornetta Ranch	"	53	5/04	5/07	**STO**	**Xa**		7/05			1.3mi SE Pt Arena Lighthouse		

Sea Ranch	"	13	8/01	6/05	**SEA**	**X**		su 04	1.1mi SE Del Mar Ldg ER		0.2mi NW Sea Ranch Fort Ross Cove*	Sea Ranch Preserve	
Bodega	Sonoma	14	7/01	7/03, 5/04	**BML**	**X**		4/01	Bodega Marine Life Refuge	Bodega State Marine Res	1.0mi N Bodega Bay Entrance		
Santa Maria Creek	Marin	15	5/02	5/05	**SMC**	**X**		5/06				Point Reyes National Seashore	
Bolinas Pt	"	16	5/02	5/05, 2/08	**BOL**	**X**		11/05	Duxbury Reef Res		1.4mi NW Duxbury Reef Point*	Point Reyes National Seashore	
Bolinas Pt Wreck	"	59	5/05	10/05					Duxbury Reef Res		1.2mi NW Duxbury Reef Point*	Point Reyes National Seashore	
Alder Creek	"	71	2/08						Duxbury Reef Res		0.5mi NW Duxbury Reef Point*	Point Reyes National Seashore	
Slide Ranch	"		None		**SLR**	**X**		6/06				Golden Gate Nat Recreation Area	
Pt Bonita	"		None		**PTB**	**X**		su 06				Golden Gate Nat Recreation Area	
Alcatraz Island	San Francisco	58	2/05										
Mussel Flat SE Farallon	"	57	2/05						Farallon Island	Farallon Is State Marine Cons Area	0.2mi W Farallon Is East Landing		
C. CALIFORNIA													
Fitzgerald	San Mateo	17	11/02	11/06					James Fitzgerald Marine Reserve				
Pebble Beach	"		None		**PEB**	**Xa**		su 04				Gulf of Farallones Nat Marine Sanctuary	Pescadero/Bean Hollow State Beach
Pigeon Pt	"	18	11/02	10/06	**PPT**	**Xa**		2002				Gulf of Farallones Nat Marine Sanctuary	Pigeon Pt Light State Historic Park
Franklin Pt	"		None		**FRA**	**Xa**		2004	1.6mi NW Ano Nuevo Pt/Is	Ano Nuevo State Mar Cons Area		Monterey Bay Nat Marine Sanctuary	
Año Nuevo	"	19	6/02	4/08					Ano Nuevo Point & Island	Ano Nuevo State Mar Cons Area	0.5mi NE Ano Nuevo Island	Monterey Bay Nat Marine Sanctuary	Ano Nuevo State Park
Scott Creek	Santa Cruz	20	1/00	1/03, 12/06	**SCT**	**X**		5/99		Greyhound Rk State Mar Cons. Area		Monterey Bay Nat Marine Sanctuary	
Davenport Landing	"	62	10/07		**DAV**	**X**		10/07		1.8miSE Greyhound Rock SMCA		Monterey Bay Nat Marine Sanctuary	
Sandhill Bluff	"	21	1/00	5/04	**SAD**	**X**		11/99		1.9mi NW NBSMR		Monterey Bay Nat Marine Sanctuary	
Wilder Ranch	"	63	10/07		**WIL**	**X**		10/07		Natural Bridges State Mar Res		Monterey Bay Nat Marine Sanctuary	Wilder Ranch State Park
Terrace Pt	"	22	1/00	1/03, 1/06	**TPT**	**X**		5/99		Natural Bridges State Mar Res		Monterey Bay Nat Marine Sanctuary	Natural Bridges State Park
Natural Bridges	"	64	10/07		**NAT**	**X**		10/07		Natural Bridges State Mar Res		Monterey Bay Nat Marine Sanctuary	Natural Bridges State Park
Hopkins	Monterey	23	2/00	1/03, 12/06	**HOP**	**X**		12/99	Pacific Grove Marine Gardens	Lovers Point State Mar Res	0.6mi SE Pacific Grove Lovers Point	Monterey Bay Nat Marine Sanctuary	
Pt Pinos	"	66	11/07		**PIN**	**X**		11/07	0.4mi W PacGrove Marine Gardens	Asilomar State Mar Res	1.55mi NW Pacific Grove Lovers Point	Monterey Bay Nat Marine Sanctuary	

China Rocks	"	67	11/07		**CHI**	**X**		11/07		0.3mi S Asilomar State Mar Res		Monterey Bay Nat Marine Sanctuary	
Stillwater Cove	"	24	2/01	4/05	**SWC**	**X**		4/00	Carmel Bay	Carmel Bay State Mar Cons Area	Carmel Bay Arrowhead Point*	Monterey Bay Nat Marine Sanctuary	
Carmel Pt	"		None		**CAR**	**Xa**		2004	Carmel Bay	Carmel Bay State Mar Cons Area	Carmel Bay Arrowhead Point*	Monterey Bay Nat Marine Sanctuary	
Point Lobos	"	25	2/01	3/05	**PTL**	**X**		5/99	Point Lobos Ecol Reserve	Point Lobos State Mar Res	0.3mi NW Pt Lobos Weston Beach*	Monterey Bay Nat Marine Sanctuary	Point Lobos State Park
Mal Paso	"		None		**MAL**	**Xa**		6/00		0.1mi S Pt Lobos State Mar Res		Monterey Bay Nat Marine Sanctuary	
Garrapata	"	65	11/07		**GAR**	**X**		11/07		0.9mi S Pt Lobos State Mar Res		Monterey Bay Nat Marine Sanctuary	Garrapata State Park
Soberanes	"		None		**SOB**	**Xa**		su 04				Monterey Bay Nat Marine Sanctuary	Garrapata State Park
Andrew Molera	"	26	2/01	3/03, 2/04	**MOL**	**X**		11/99		Point Sur State Mar Res		Monterey Bay Nat Marine Sanctuary	Andrew Molera State Park
Partington Pt	"	54	11/03	4/04	**PAR**	**Xa**		su 04	Julia Pfeiffer Burns Underwater Park		Partington Point Julia Burns ASBS*	Monterey Bay Nat Marine Sanctuary	Julia Pfeiffer State Park
Lucia	"	55	4/04									Monterey Bay Nat Marine Sanctuary	
Mill Creek	"	27	2/01	11/03, 4/04	**MCR**	**X**		5/99				Monterey Bay Nat Marine Sanctuary	
Pacific Valley	"		None		**PVA**	**Xa**		su 04				Monterey Bay Nat Marine Sanctuary	
Duck Ponds	"	56	11/03	2/08								Monterey Bay Nat Marine Sanctuary	
Pt Sierra Nevada	San Luis Obispo	28	4/01	4/03, 4/04	**PSN**		**X**	10/95		1.1mi N Piedras Blancas St Mar Res		Monterey Bay Nat Marine Sanctuary	Hearst Ranch State Park
Piedras Blancas	"	68	1/08		**PBL**		**X**	11/97 9/07		Piedras Blancas State Mar Res		Monterey Bay Nat Marine Sanctuary	BLM Field Station
San Simeon Point	"	61	9/07		**SSP**		**X**	9/07			San Simeon Point	Monterey Bay Nat Marine Sanctuary	access via Hearst Property White Rk State Beach
Vista del Mar (previously called "San Simeon" **SIM**)	"	69	12/07 1/08		**VDM**		**X**	su04 9/07		Cambria State Mar Cons Area		Monterey Bay Nat Marine Sanctuary	San Simeon State Park
Cambria (Rancho Marino)	"	29	6/01	7/05	**RMR**		**Xa**	2001		White Rk State Mar Cons Area		Rancho Marino Univ Calif Reserve	
Cayucos	"	30	5/01	2/08	**CAY**		**X**	10/95				Estero Bay State Park	
Hazards	"	31	4/01	3/05	**HAZ**		**X**	10/95				Montano de Oro State Park	
Diablo	"	70	12/07 1/08		**DIA**		**X**	11/07		Point Buchon State Mar Res			
Shell Beach	"	32	3/01	3/06	**SHB**		**X**	10/95					
Occulto	Santa Barbara		None		**OCC**		**X**	3/92				Vandenberg Ecological Reserve	

Purisima	"		None		**PUR**		**Xa**	11/93		1.0mi NW Vandenberg State Mar Res		Vandenberg Ecological Reserve	
Stairs	"	33	3/01	3/03, 2/04	**STA**		**X**	3/92		Vandenberg State Mar Res		Vandenberg Ecological Reserve	
Lompoc	"	60	3/07							Vandenberg State Mar Res		Vandenberg Ecological Reserve	
Boat House	"	36	3/01	3/07	**BOA**		**X**	3/92		0.6mi E Vandenberg State Mar Res		Vandenberg Ecological Reserve	
S. CALIFORNIA													
Government Pt	"	35	5/01	3/06	**GPT**		**X**	3/92			Point Conception		
Alegria	"	38	5/01	5/03, 5/04	**ALEG**		**X**	3/92					
Arroyo Hondo	"	37	5/01	4/05	**ARHO**		**X**	3/92			0.2 mi W Arroyo Hondo Canyon Mouth**		
Coal Oil Point	"	39	3/02	3/06	**COPT**		**X**	3/92				Coal Oil Point Univ Calif Reserve	
Carpinteria	"	40	6/01		**CARP**		**X**	3/92			Carpinteria State Beach**	Carpinteria State Beach	
Mussel Shoals	Ventura	41	5/01		**MUSH**		**X**	11/94					
Old Stairs	"	42	5/01	3/08	**OLDS**		**X**	11/94	Mugu Lagoon to Latigo Point		Old Stairs**		
Paradise Cove	Los Angeles	43	4/01	2/06	**PCOV**		**X**	11/94	Mugu Lagoon to Latigo Point		1.2 mi NE Point Dume Mussel Site		
Whites Pt	"	44	5/01	3/08	**WHPT**		**X**	11/94			0.2 mi SE Royal Palms Mussel Site		
Pt Fermin	"	45	6/01		**PTFM**		**X**	10/99		Point Fermin State Mar Park			
Crystal Cove	Orange	46	4/01	5/03, 5/04	**CRCO**		**X**	11/96	Irvine Coast Mar Life Refuge	Irvine Coast State Mar Cons Area	Crystal Cove State Park**	Crystal Cove State Park	
Shaws Cove	"	47	5/01	4/05	**SHCO**		**X**	10/96	1.5mi SE Irvine Coast MLR; 0.3mi W Heisler Park Ecol Reserve	Heisler Park State Mar Res			
Treasure Island	"		None		**TRIS**		**X**	10/96					
Dana Pt	"	48	5/01	2/06	**DAPT**		**X**	12/96		Dana Point State Mar Cons Area	Dana Point**		
Cardiff	San Diego		None		**CARE**		**X**	10/97		0.2mi S Cardiff-San Elijo State Mar Cons Area	Cardiff Reef**	Cardiff State Beach	
Scripps	"	49	3/02	2/06	**SCRE**		**X**	10/97	San Diego Marine Life Refuge	San Diego-Scripps State Mar Cons Area	Scripps Reef; 1.9mi NE Pt La Jolla Mussel**	Scripps Univ Calif Coastal Reserve	
Navy North	"		None		**NANO**		**X**	2/95				US Navy	
Navy South	"		None		**NASO**		**X**	3/95			0.2mi N Point Loma "Lighthouse" Mussel	US Navy	
Cabrillo Zone I	"	50	3/02	5/04	**CAB1**		**X**	2/90		Mia J Tegner State Mar Cons Area		Cabrillo National Monument	
Cabrillo Zone II	"		None		**CAB2**		**X**	2/90		Mia J Tegner State Mar Cons Area		Cabrillo National Monument	
Cabrillo Zone III	"	51	3/02		**CAB3**		**X**	2/90		Mia J Tegner State Mar Cons Area		Cabrillo National Monument	

SAN MIGUEL ISL													
Otter Harbor	Santa Barbara		None		**SMOH**		**X**	4/85	San Miguel Island		San Miguel Island Otter Harbor**	Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Harris Point	"		None		**SMHP**		**X**	4/85	San Miguel Island	Harris Point State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Cuyler Harbor	"	101	11/01	12/02	**SMCH**		**X**	4/85	San Miguel Island	Harris Point State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Crook Pt	"	100	11/01		**SMCP**		**X**	4/85	San Miguel Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
SANTA ROSA ISL													
NW Talcott	Santa Barbara	201	12/01	12/04	**SRNW**		**X**	11/86	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Fossil Reef	"	200	12/01	12/04	**SRFR**		**X**	3/88	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
East Pt	"	204	12/01	12/04	**SREP**		**X**	12/86	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Ford Pt	"	203	12/01		**SRFP**		**X**	12/85	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Johnsons Lee	"	202	12/01	12/02, 12/04	**SRJL**		**X**	12/85	Santa Rosa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
SANTA CRUZ ISL													
Fraser Pt	Santa Barbara	300	1/02	1/03, 1/04	**SCFC**		**X**	9/94	Santa Cruz Island		Santa Cruz Island Fraser Point	Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Orizaba	"		None		**SCOC**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Scorpion	"		None		**SCSR**		**X**	9/94	Santa Cruz Island	Scorpion State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Forney	"	301	1/02				**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Prisoners	"	305	4/02	4/03, 1/04	**SCPH**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Trailer	"	302	1/02	1/06	**SCTR**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Valley	"	304	1/02	1/06					Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Willows	"	303	1/02	1/06	**SCWA**		**X**	9/94	Santa Cruz Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
ANACAPA ISL													
Middle East	Ventura		None		**ANME**		**X**	3/82	Anacapa Island	Anacapa Island State Mar Res	Anacapa Island North Middle Island**	Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Middle West	"	402	10/01	12/05	**ANMW**		**X**	3/82	Anacapa Island	Anacapa Island State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park

Frenchys Cove	"	401	10/01	12/05	**ANFC**		**X**	3/82	Anacapa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Cat Rock	"	400	12/05		**ANCR**		**X**	3/82	Anacapa Island			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
SAN NICOLAS ISL													
Thousand Springs		700	2/03	2/07					San Nicolas Island			US Navy	
Marker Poles		701	2/03	2/07					San Nicolas Island			US Navy	
SANTA BARBARA ISL													
Landing Cove	Santa Barbara	500	11/01	11/06	**SBLC**		**X**	3/85	Santa Barbara Is			Channel Islands Nat Marine Sanctuary	Channel Islands National Park
Sea Lion Rookery	"	501	12/01	11/06	**SBSL**		**X**	3/85	Santa Barbara Is	Santa Barbara Island State Mar Res		Channel Islands Nat Marine Sanctuary	Channel Islands National Park
CATALINA ISL													
Bird Rock	Los Angeles	600	4/02	1/04, 4/07	**CTBR**		**X**	2/82	Santa Catalina Is		Bird Rock		
Little Harbor	"	601	4/02	4/07	**CTLH**		**X**	12/94	Santa Catalina Is				
BAJA CALIFORNIA													
La Buffadora		1001	2/03										
La Chorera		1002	2/03										
Punta Baja		1003	2/03										
El Tivo, Natividad I			3/07										
Punta Prieta, Natividad I			3/07										
Babencho Grande, Natividad			3/07										
El Nido, Natividad I			3/07										
La Cueva, Natividad I			3/07										
La Plana, Natividad I			3/07										
Punta Rompiente		1004	2/03										
Punta San Roque		1005	2/03										
Punta Abreojos		1006	2/03										
MAINLAND MEXICO													
Punta Borascosa		2001	3/03										
Pelican Pt		2002	3/03										
Punta Libertad		2003	3/03										
Punta Cerro Prieto II		2004	3/03										

Note: Biodiversity survey dates based on 4/15/08 Coastal Biodiversity website (http://cbsurveys.ucsc.edu/).
ASBS = Area of Special Biological Significance (California State Water Board)
CFG MPA = California Department of Fish and Game Marine Protected Area
xa = Abalone only monitoring site
*New Mussel Watch sites to be established 2008/09
**New Mussel Watch sites established 2007/08

Table 2. MARINe Partners

Primary Sponsors

- U.S. Minerals Management Service
- Channel Islands National Park
- Partnership for Interdisciplinary Studies of Coastal Oceans

Major Sponsors

- Cabrillo National Monument
- California Ocean Protection Council
- Golden Gate National Recreation Area
- Monterey Bay National Marine Sanctuary
- Point Reyes National Seashore
- Redwoods National and State Parks
- Southern California Coastal Water Research Project
- California Coastal Commission (past)
- County of Santa Barbara (past)
- San Diego Association of Governments (past)
- United States Navy (past)

Other Sponsors

- Cabrillo Marine Aquarium
- California Department of Fish and Game
- California State Water Quality Control Board
- National Center for Ecological Analysis and Synthesis
- National Park Service Northeast Temperate Network
- Tatman Foundation
- Tenera Environmental

MARINe Partners (continued)

Contributors

- California State University Fullerton
- Gulf of the Farallones National Marine Sanctuary
- Santa Barbara Channelkeeper
- University of California Berkeley
- University of California Los Angeles
- University of California Santa Barbara
- University of California Santa Cruz
- University of Southern California

Collaborators (past and presesent)

- Bodega Bay Marine Laboratories
- Bureau of Land Management California Coastal Monument
- California Coastal Commission
- California Coastal Conservancy
- California Polytechnic University, San Luis Obispo
- California State Parks and Recreation
- California State University Humboldt
- California State University Los Angeles
- Channel Islands National Marine Sanctuary
- County of San Luis Obispo
- County of Ventura
- Los Angeles County Natural History Museum
- Moss Landing Marine Labs
- NOAA National Status and Trends Program
- Santa Monica Bay Restoration Commission
- Scripps Institution of Oceanography
- Southern California Coastal Ocean Observing System
- Stanford University: Hopkins Marine Station
- University of California Natural Reserve System

Table 3. MARINe Monitoring Groups

Monitoring Group	Monitoring Regions
Olympic Coast National Marine Sanctuary (**OCNMS**)	Wahington State sites in OCNMS outside OLYM
Olympic National Park (**OLYM**)	Washington State sites in OLYM and San Juan Island National Historic Park
University of California Santa Cruz (**UCSC**)	Sites from Pt Conception north to Oregon & all biodiversity sites
Point Reyes National Seashore	Sites within Point Reyes National Seashore
Golden Gate National Recreation Area	Sites within Golden Gate National Recreation Area
University of California Santa Barbara (**UCSB**)	San Diego County & Santa Catalina Island
Channel Islands National Park (**CINP)**	Santa Barbara, Anacapa, Santa Cruz, Santa Rosa, & San Miguel Islands
MMS Intertidal Team (**MINT**)	San Luis Obispo, Santa Barbara, Ventura, & LA Counties
University of California Los Angeles (**UCLA**)	Southern Santa Barbara, Ventura, & LA Counties
California State University Fullerton **(CSUF)**	Orange County
Cabrillo National Monument (**CABR**)	Cabrillo National Monument sites (San Diego)

Table 4. Standardized Names for Target Species Plots

		Official Target Species for MARINe			
Plot Name	**Plot Type**	**Scientific Name**	**Common Name**	**6-Letter Code**	**3-LetterBrief**
Plants					
Egregia	Transect	*Egregia menziesii*	Boa Kelp	EGRMEN	EGR
Fucus	Photoplot	*Fucus gardneri*	Northern Rockweed	FUCGAR	FUC
Hedophyllum	Transect	*Hedophyllum sessile*	Sea Cabbage	HEDSES	HED
Hesperophycus	Photoplot	*Hesperophycus californicus*	Olive Rockweed	HESCAL	HES
Pelvetiopsis	Photoplot	*Pelvetiopsis limitata*	Dwarf Rockweed	PELLIM	PEL
Silvetia	Photoplot	*Silvetia compressa*	Golden Rockweed	SILCOM	SIL
Endocladia	Photoplot	*Endocladia muricata*	Turfweed	ENDMUR	END
Neorhodomela	Photoplot	*Neorhodomela larix*	Black Pine	NEOLAR	NEO
Phyllospadix	Transect	*Phyllospadix scouleri/torreyi*	Surfgrass	PHYOVR	PHY
Invertebrates					
Anthopleura	Photoplot	*Anthopleura elegantissima/sola*	Green Anemone	ANTELE	ANT
Mytilus	Photoplot	*Mytilus californianus*	California Mussel	MYTCAL	MYT
Lottia	Size/Count	*Lottia gigantea*	Owl Limpet	LOTGIG	LOT
Haliotis	Size/Count	*Haliotis cracherodii*	Black Abalone	HALCRA	HAL
Chthamalus/Balanus	Photoplot	*Chthamalus dalli/fissus/Balanus glandula*	White Barnacle	CHTBAL	CHT
Semibalanus	Photoplot	*Semibalanus cariosus*	Thatched Barnacle	SEMCAR	SEM
Tetraclita	Photoplot	*Tetraclita rubescens*	Pink Barnacle	TETRUB	TET
Pollicipes	Photoplot	*Pollicipes polymerus*	Goose Barnacle	POLPOL	POL
Pisaster	Size/Count	*Pisaster ochraceus*	Ochre Seastar	PISOCH	PIS
		Other Species "Targeted" by Some Monitoring Groups			
Plot Name		**Scientific Name**	**Common Name**	**6-Letter Code**	**3-LetterBrief**
Plants					
Mastocarpus	Photoplot	*Mastocarpus papillatus*	Turkish Washcloth	MASPAP	MAS
Mazzaella	Photoplot	*Mazzaella spp (=Iridaea spp)*	Iridescent Weed	MAZSPP	MAZ
Postelsia*	Size/Count	*Postelsia palmaeformis*	Northern Sea Palm	POSPAL	POS
Red Algae	Photoplot Transect	(includes plots targeting *Gelidium* & Red Algal & transects targeting Turf)	Red Algae	REDALG	RED
Invertebrates					
Balanus	Photoplot	*Balanus glandula*	Northern Barnacle	BALGLA	BAL
Other					
Tar	Photoplot		Tar	TAR	TAR
Recovery	Photoplot		Recovery	RECOV	REC
*note these data are not yet in database, and will likely be added to tblSpeciesCountSize (# of plants counted in 2 m swaths or in grids)					

Table 5. MARINe Core Species, Higher Taxa, and Substrates

(Target species are shown in bold.)	Photoplots	Transects	Size & Counts	Field Log Recon	Motile Inverts
GREEN ALGAE					
Cladophora columbiana	X			X	
Ulva/Enteromorpha	X			X	
Other Green Algae (any greens not listed above)*	X	X			
BROWN ALGAE					
***Egregia menziezii* (Boa Kelp)**	X	X		X	
Eisenia arborea	X	X		X	
Endarachne/Petalonia	X			X	
***Fucus gardneri* (= *F. distichus*)(Northern Rockweed)**	X			X	
Halidrys dioica/Cystoseira spp	X	X		X	
***Hedophyllum sessile* (Sea Cabbage)**	X	X		X	
***Hesperophycus californicus (= H. harveyanus)*(Olive Rockweed)**	X			X	
***Pelvetiopsis limitata* (Dwarf Rockweed)**	X			X	
***Postelsia palmaeformis* (Northern Sea Palm)**			X	X	
Sargassum muticum	X	X		X	
Scytosiphon spp	X			X	
***Silvetia compressa* (= *Pelvetia fastigiata*)(Golden Rockweed)**	X			X	
Other Brown Algae (any browns not listed above)*	X	X			
RED ALGAE					
Chondracanthus canaliculatus (= Gigartina canaliculata)	X			X	
***Endocladia muricata* (Turfweed)**	X			X	
***Mastocarpus papillatus* (blade)(Turkish Washcloth)**	X			X	
Mazzaella affinis (= Rhodoglossum affine)	X			X	
***Mazzaella* spp.(= *Iridaea* spp.)(Iridescent Weed)**	X			X	
***Neorhodomela larix)* (Black Pine)**	X			X	
Porphyra sp	X			X	
Articulated Corallines (Erect Corallines)	X	X			
Crustose Corallines (Encrusting Corallines)	X	X			
Other Red Algae (any reds not listed above)*	X	X			
ALGAE/PLANTS					
***Phyllospadix scouleri/torreyi* (Surfgrass)**	X	X		X	
Non-Coralline Crusts (reds and browns)	X	X			
Other Plant/Algae*	X	X			
ANEMONES					
***Anthopleura elegantissima/sola* (Green Anemone)**	X	X		X	
POLYCHAETE WORMS					
Phragmatopoma californica	X	X		X	
MOLLUSKS					
Acanthina spp					X
Fissurella volcano					X
***Haliotis cracherodii* (Black Abalone)**			X	X	
Katharina tunicata			X		
Lepidochitona hartwegii					X
Littorina spp				X	X
***Lottia gigantea* (Owl Limpet)**	X		X	X	X

Table 5. MARINe Core Species (cont.)

(Target species are shown in bold.)

	Photoplots	Transects	Size & Counts	Field Log Recon	Motile Inverts
MOLLUSKS (cont.)					
Mopalia spp					X
***Mytilus californianus* (California Mussel)**	X	X		X	
Nucella emarginata					X
Nucella canaliculata					X
Nuttalina spp					X
Ocenebra circumtexta					X
Tegula brunnea					X
Tegula funebralis					X
Tegula gallina					X
Tegula spp				X	
Limpets	X				
Large Limpets > 15mm (excluding *L. gigantea*)					X
Medium Limpets 5-15mm					X
Small Limpets < 5mm					X
Chitons	X				
BARNACLES					
***Balanus glandula* (Northern Barnacle)**	X**				
***Chthamalus dalli/fissus & Balanus glandula* (White Barnacle)**	X			X	
***Pollicipes polymerus* (Goose Barnacle)**	X			X	
***Semibalanus cariosus* (Thatched Barnacle)**	X			X	
***Tetraclita rubescens* (Pink Barnacle)**	X			X	
Barnacles		X			
Other Barnacles (any barnacles not listed above)*	X				
ECHINODERMS					
***Pisaster ochraceus* (Ochre Star)**	X	X	X	X	
Henricia spp			X		
Strongylocentrotus purpuratus				X	
CRUSTACEANS					
Ligia occidentalis				X	
Pachygrapsis crassipes					X
Pagurus spp					X
INVERTEBRATES					
Other Invertebrates (Other Animals) (any inverts not listed above)*	X	X			
SUBSTRATES					
Rock (Bare Rock)	X	X			
Sand	X	X			
Tar	X	X		X	
UNDETERMINED					
Other Substrate (e.g., dead mussel shells or barnacle tests)	X	X			
Unidentified (cannot tell if plant, invert or substrate)	X	X			

* The specific definitions of these categories are different for photoplots compared to transects.

** Core species for MARINe North only.

Table 6. Definitions for Core Higher Taxa and Substrates.

Articulated (Erect) Corallines: erect, jointed, calcified, red algae of the Family Corallinaceae, with flexible, articulate fronds arising from crustose bases.

Barnacles: adults or juveniles of any barnacle (Phylum Arthropoda, Class Crustacea, Subclass Cirripedia) species.

Chitons: adults or juveniles of any chiton (Phylum Mollusca, Class Polyplacophora) species.

Crustose (Encrusting) Corallines: thin, flattened, calcified, crust-like red algae of the Family Corallinaceae, having no erect, articulated fronds. Bleached crustose corallines (white) are scored as well because they may be alive.

Limpets: adults or juveniles of any limpet (Phylum Mollusca, Class Gastropoda, Family Acmaeidae) species, including *Lottia gigantea*.

Non-Coralline Crusts: any thin, flattened, crust-like red or brown algae that are not calcified species of the Family Corallinaceae.

Other Invertebrates (Other Animals): any invertebrates not listed or not identifiable in other more specific categories on the score sheet.

Other Barnacles: any barnacles not listed or not identifiable in other more specific categories on the score sheet.

Other Brown Algae: any brown algae not listed or not identifiable in other more specific categories on the score sheet (score “non-coralline crusts” separately).

Other Green Algae: any green algae not listed or not identifiable in other more specific categories on the score sheet.

Other Plant (Other Algae): any plants (algae) not listed or not identifiable in other more specific categories on the score sheet.

Other Red Algae: any red algae not listed or not identifiable in other more specific categories on the score sheet (score “non-coralline crusts” separately).

Rock (Bare Rock): bare, unconsolidated substrates larger than sand/gravel (including cobble, rocks, and boulders) and all consolidated substrates (i.e., bedrock) that contain no obvious living organisms or tar (epoxy corner markers and inconspicuous blue-green algal films are scored as “rock”).

Sand: granular, particulate (fine sand to gravel) substrate. Photoplots: score “sand” unless you can positively identify what lies under the sand in the photo. Transects: score “sand” whenever sand cover is 2cm or greater.

Tar: fresh or weathered oil or tar coating on the substrate.

Unidentified: cannot tell if plant, invertebrate, or substrate.

Table 7. Target Species Monitored in Photoplots at MARINe Core Sites.

MAINLAND	**Start**	**FUCGAR**	**HESCAL**	**PELLIM**	**SILCOM**	**ENDMUR**	**NEOLAR**	**MAZSPP**	**MASPAP**	**REDALG**	**ANTELE**	**MYTCAG**	**BALGLA**	**CHTBAL**	**SEMCAR**	**TETRUB**	**POLPOL**	**TAR**
Oregon	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Clatsop Co.																		
Ecola	2001			5			5					5	5					
Lincoln Co.																		
Fogarty Creek	2000	5		5			5					5	5					
Lane Co.																		
Bob Creek	2000	5		5		5						5	5					
Coos Co.																		
Cape Arago	2000	5		5		5						5	5					
Curry Co.																		
Burnt Hill	2002			5		5						5	5					
California																		
Del Norte Co.																		
Enderts	2004			5		5						5		5				
Damnation Creek	2004	5				5						10*		5				
*5 plots are surrounded by freshwater (upcoast) and 5 are regular marine (downcoast)																		
False Kalamath Cove	2004	5		5		5						5		5				
Humboldt Co.																		
Cape Mendocino	2004	5		5		5			5			5		5				
Shelter Cove	2004	5		5		5						5		5	5			
Mendocino Co.																		
Kibesillah Hill	2004	5		5		5			5			5		5				
Stornetta																		
Sea Ranch	2004	5		5		5	5					5		5				
Sonoma Co.																		
Bodega	2001			5		5						5		5				
Marin Co.																		
Santa Maria Creek	2006			5								5						
Bolinas Point	2005																	
Slide Ranch	2006																	
Point Bonita	2006																	
San Mateo Co.																		
Pebble Beach	2004																	
Pigeon Point	2002																	
Franklin Point	2004																	
Santa Cruz Co.																		
Scott Creek	1999	5			5	5						5		5				
Davenport Landing	2007																	
Sand Hill Bluff*	1999			5								5	5	5				
*UCSC PISCO monitors 2 "Recovery" plots at Sand Hill Bluff set up SP03																		
Wilder Ranch	2007																	
Terrace Point	1999				5				5			5	5	5				

	Start	FUCGAR	HESCAL	PELLIM	SILCOM	ENDMUR	NEOLAR	MAZSPP	MASPAP	REDALG	ANTELE	MYTCAG	BALGLA	CHTBAL	SEMCAR	TETRUB	POLPOL	TAR
Santa Cruz Co.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Natural Bridges	2007																	
Monterey Co.																		
Hopkins	1999				5	5			5			5	5	5				
Point Pinos	2007																	
China Rocks	2007																	
Stillwater	2000				5	5			5			5		5				
Carmel Point	2004																	
Point Lobos	1999				5	5			5			5		5				
Mal Paso	2000																	
Garrapata	2007																	
Soberanes	2004																	
Andrew Molera	1999	5			5	5						5		5				
Partington Cove	2004																	
Mill Creek	1999				5	5			5			5		5				
Pacific Valley	2004																	
San Luis Obispo Co																		
Pt Sierra Nevada	1995		5		5			5	5			5		5				
Piedras Blancas	1997																	
San Simeon Point	2007																	
Vista del Mar	2007																	
Rancho Marino	2001																	
Cayucos	1995		5		5	5						5		5				
Hazard's	1995				5	5		5				5		5				
Diablo	2007																	
Shell Beach	1995				5	5			5			5		5				
Santa Barbara Co																		
Occulto	1992					5						5		5				
Purisima	1993																	
Stairs*	1992				5	5						5		5				
*UCSC monitors 6 “Recovery” plots at Stairs																		
Boat House	1992				5	5					5	5		5				
Government Point	1992				5	5						5		5			5	
Alegria	1992										5	5		5			5	
Arroyo Hondo	1992											5		5				
Coal Oil Pt.	1992										5	5*						
*5 MYTCAL plots added SP03																		
Carpinteria	1992										5	5		5			5	
Ventura Co.																		
Mussel Shoals	1994										5	5		5				
Old Stairs	1994					5					5	5		5				
LA Co.																		
Paradise Cove	1994					5						5		5				
White's Point	1994					5						5		10*				
*5 plots emphasize *Chthamalus* spp. and 5 emphasize *Balanus glandula*, but both barnacle species are scored as *Chthamalus/Balanus*																		

	Start	FUCGAR	HESCAL	PELLIM	SILCOM	ENDMUR	NEOLAR	MAZSPP	MASPAP	REDALG	ANTELE	MYTCAG	BALGLA	CHTBAL	SEMCAR	TETRUB	POLPOL	TAR
LA Co.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Point Fermin	1999				5							5		5				
Orange Co.																		
Crystal Cove	1996				5							5		5				
Shaws Cove	1996				5	5						5		5				
Treasure Island	1996				5							5		5				
Orange Co.																		
Dana Point	1996				5							5		5				
San Diego Co.																		
Cardiff Reef	1997											10*		5			5	
*5 plots located on onshore reef and 5 on offshore reef																		
Scripps Reef	1997				5							5		5			5	
Navy North	1995				5							5		5		5	6[1]	
Navy South	1995				5							5		5		5	6[1]	
Cabrillo I	1990				5							5		5		5	6[1]	
Cabrillo II	1990				5							5		5		5	6[1]	
Cabrillo III	1990				5							5		5		5	6[1]	
ISLANDS																		
San Miguel I.																		
Otter Harbor	1985				5[2]	5[3]						5		5				
Harris Point	1985		5[2]			5[3]						5		2		3		
Cuyler Harbor	1985				5[2]	5[3]						5		5				
Crook Point	1985				5[2]	5[3]						5		5				
Santa Rosa I.																		
NW Talcott	1986				5[2]	5[3]						5		5				
Fossil Reef	1988				5[2]	5[3]						5		5				
Johnson's Lee	1985					5[3]						5		5				
Ford Point	1985					5[3]						5		5				
East Point	1986				5[2]	5[3]						5		5				
Santa Cruz I.																		
Fraser	1994		5		5	5						5		5			5	5
Trailer	1994		5		5							5		5				
Willows	1994		5		5	5						5						
Orizaba	1994		5		5							5		5		5		
Prisoner's	1994		5		5	5						5		5				
Scorpion	1994		5			5						5		5		5		
Anacapa I.																		
Middle West	1982				5[2,4]	5[3,4]						5[4]		5[4]				
Middle East	1982				3[2,4]	3[3,4]						3[4]		3[4]				
Frenchy's Cove	1982				5[2]	5[3]						5		5				
Cat Rock	1982				9[2,4]	9[3,4]						9[4]		9[4]				
Santa Barbara I.																		
Landing Cove	1985				5[2]					5*		5		5				
*In REDTUR plots, points scored as REDTUR are primarily *Gelidium* spp. and *Chondracanthus canaliculatus*.																		
Sea Lion Rookery	1985				5[2]	5[3]						5		5				

	Start	FUCGAR	HESCAL	PELLIM	SILCOM	ENDMUR	NEOLAR	MAZSPP	MASPAP	REDALG	ANTELE	MYTCAG	BALGLA	CHTBAL	SEMCAR	TETRUB	POLPOL	TAR
Santa Catalina I.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Bird Rock	1982				5*					5*		5*		5*		5	5	
*1 year trampling experiment followed by recovery monitoring from 1/82-F94 (21 SILCOM, 12 GELSPP, 12 CHTBAL, and 12 MYTCAL ¼ m2 plots (3 control, 3 light, 3 med, and 3 heavy trample (+ 3 Boots—SILCOM))). In F94, a subset of plots was converted to core MARINe monitoring.																		
Little Harbor	1982				5							5		5		5		

[1] 3 *Pollicipes* 1m X 10m transects at Cabrillo I, II, III converted to 6 photoplots starting S95; 6 plots established at Navy North & South to compare same number of replicates as Cabrillo.
[2] In some SILCOM plots and HESCAL plots, SILCOM and HESCAL were scored together as "rockweed."
[3] ENDMUR plots may include some *Gelidium* spp and *Chondracanthus canaliculatus* scored as ENDMUR.
[4] 8 or 9 plot replicates were initially established as part of a pre-monitoring experiment (3 Control, 3 Trample, 3 Scrape). Middle E & Middle W were originally one site.

Table 8. Target Species Monitored in Transects and Plots (not photoplots)

	Point-Intercept Transects			Circular Plots		Band Transects/Irregular Plots		
MAINLAND	**EGRMEN**	**REDALG**	**PHYOVE**	**Owl Limpets**		**Black Abalone**	**Ochre Seastars**	**Northern Sea Palm**
Oregon	**#Transects &Start Year**	**#Transects &Start Year**	**#Transects &Start Year**	**# Plots & Type**	**Start Year**	**# Plots, Type, & Start Year**	**# Plots, Type, & Start Year**	**# Plots, Type, & Start Year**
Clatsop Co.								
Ecola			1 2001			**Abalone**	3 IP 2001	**Sea Palm**
Lincoln Co.						**Monitoring**		**Monitoring**
Fogarty Creek			3 2000			**Sites**	3 IP 2000	**Sites**
Lane Co.						**Not**		**Not**
Bob Creek			3 2000			**Indicated**	3 IP 2000	**Indicated**
Coos Co.								
Cape Arago			3 2000					
Curry Co.								
Burnt Hill			3 2002				3 IP 2002	
California								
Del Norte Co.								
Enderts							2 IP 2004	
Damnation Creek			2 2004				3 IP 2004	
False Kalamath Cove							2 IP 2004	
Humboldt Co.								
Cape Mendocino							3 IP 2004	
Shelter Cove							3 IP 2004	
Mendocino Co.								
Kibesillah Hill			3 2004				3 IP 2004	
Stornetta								
Sea Ranch							3 IP 2004	
Sonoma Co.								
Bodega							3 IP 2001	
Marin Co.								
Santa Maria Creek							3 IP 2006	
Bolinas Point			3 2006				3 IP 2006	
Slide Ranch								
Point Bonita								
San Mateo Co.								
Pebble Beach								
Pigeon Point								
Franklin Point								
Santa Cruz Co.								
Scott Creek			3 1999				3 IP 1999	
Davenport Landing								
Sand Hill Bluff			2 1999	3 CP	1999			
Wilder Ranch								
Terrace Point				5 RP	1999		3 IP 1999	
Natural Bridges								
Monterey Co.								
Hopkins			3 1999	5 CP	1999		3 IP 1999	
Point Pinos								
China Rocks								
Stillwater			3 2000	5 CP	2000		3 IP 2000	
*Abalone sampled in 2 irregular plots established SP02 and in existing seastar plots.								
Carmel Point								
Point Lobos				5 CP	1999		3 IP 2003	
Mal Paso								
Garrapata								
Soberanes								
Andrew Molera			3 1999				3 IP 1999	
Partington Cove								
Mill Creek			3 1999	5 RP	1999		3 IP 1999	
Pacific Valley								
San Luis Obispo Co.								
Pt. Sierra Nevada			3 1995				3 IP 1995	
*Abalone sampled in 2 seastar plots in addition to 3 abalone plots.								
Piedras Blancas								
San Simeon Point								

	Point-Intercept Transects			Circular Plots		Band Transects/Irregular Plots		
	EGRMEN	REDALG	PHYOVE	Owl Limpets		Black Abalone	Ochre Seastars	Northern Sea Palm
San Luis Obispo Co.	#Transects &Start Year	#Transects &Start Year	#Transects &Start Year	# Plots & Type	Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year
Vista del Mar				5 CP	2004			
Rancho Marino				5 CP	2002	**Abalone**		**Sea Palm**
Cayucos			3 1995	5 CP	1995	**Monitoring**	3 IP[1] 1995	**Monitoring**
Hazard's			3 2001	5 RP	1995	**Sites**	3 IP[1] 1995	**Sites**
Diablo						**Not**		**Not**
Shell Beach			3 1999			**Indicated**	3 IP[1] 1995	**Indicated**
Santa Barbara Co.								
Occulto							1 IP 2000	
Purisima								
Stairs			3 1992	5 CP	1992		3 IP 1992	
Boat House				5 CP	1992		3 IP[1] 1992	
Government Pt.			3 1992	5 CP	1992		3 IP[1] 1992	
Alegria			3 2002	5 CP	1992		3 IP 2002	
Arroyo Hondo			3* 1992				3 BT[2] 1992	
*3rd PHYOVE transect added SP01.								
Coal Oil Pt.			3 1992					
Carpinteria			3 1992	5 CP	2001		3 BT[2] 1992	
Ventura Co.								
Mussel Shoals			3 1994	5 CP	2002		3 IP 1994	
Old Stairs				5 CP	1994		3 IP[2] 1994	
Los Angeles Co.								
Paradise Cove			3 1994	5 CP	1994		3 IP 2002	
White's Point				5 CP	2003			
Point Fermin			3 1999	5 CP	2003		3 IP 2003	
Orange Co.								
Crystal Cove			6* 1996	5 CP	1996		TS 1996	
*PHYOVE transects initially established as 3 20m transects; Transects divided into 6 10m transects in SP97.								
Shaws Cove				5 CP	1996		TS 1996	
Treasure Island							TS 1996	
Dana Point				5 CP	1996		TS 1996	
San Diego Co.								
Cardiff Reef		3[3] 1997	3[3] 1997	5 CP*	1997		TS 1997	
*Owl limpet plots are 3m diameter.								
Scripps Reef		3[3] 1997	3[3] 1997	5 CP	1997		TS 1997	
Navy North		3[3]* 1995	4[3]** 1995	6 CP[4]	1995		TS 1995	
Navy South		3[3]* 1995	4[3]** 1995	6 CP[4]	1995		TS 1995	
*3rd PHYOVE transect added SP02; **2 transects located on inshore reef and 2 transects located on offshore reef.								
Cabrillo I	2[3] 1990	2[3] 1990	2[3] 1990	6 CP[4]	1990		TS 1990	
Cabrillo II	2[3] 1990	2[3] 1990	2[3] 1990	6 CP[4]	1990		TS 1990	
Cabrillo III	2[3] 1990	2[3] 1990	2[3] 1990	6 CP[4]	1990		TS 1990	
ISLANDS								
San Miguel Island								
Otter Harbor				5 CP[5]	2001		5 IP[1] 1985	
Harris Point				5 CP	2001		5IP+1BT[1]	
Cuyler Harbor							TS 1994	
Crook Point				3 IP[5]	1987		5 IP[1] 1985	
Santa Rosa Island								
NW Talcott			3 2001	5 CP	1993		5 IP 1986	
Fossil Reef				5 CP	1999		1 BT 1988	
Johnson's Lee				5 CP*	1988		5IP+1BT[1]	
Ford Point				5 CP*	1988		5 IP[1] 1985	
East Point			3 2002				TS 1994	
Santa Cruz Island								
Fraser			3 1994	5 CP*	1994		TS 1994	
Trailer			3 1994	5 CP	1994		TS 1994	
Willows				5 CP	1994		TS 1994	
Orizaba							TS 1994	
Prisoner's							TS 1994	
Scorpion							TS 1994	
Anacapa Island								
Middle West							TS 1994	

	Point-Intercept Transects			Circular Plots		Band Transects/Irregular Plots		
	EGRMEN	REDALG	PHYOVE	Owl Limpets		Black Abalone	Ochre Seastars	Northern Sea Palm
Anacapa Island	#Transects &Start Year	#Transects &Start Year	#Transects &Start Year	# Plots & Type	Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year	# Plots, Type, & Start Year
Middle East								
Frenchy's Cove				3 CP	1999	**Abalone**	TS 1994	**Sea Palm**
Cat Rock				3 CP	1999	**Monitoring**	5 IP[1] 1982	**Monitoring**
Santa Barbara						**Sites**		**Sites**
Landing Cove						**Not**	1 BT 1985	**Not**
Sea Lion Rookery						**Indicated**	5 IP[1] 1985	**Indicated**
Santa Catalina								
Bird Rock				1 IP*	1998		TS 1994	
*Single owl limpet irregular plot = bedrock dike. No other suitable plot locations.								
Little Harbor							TS 1994	

CP = Circular Plot (2m diameter), **RP** = Rectangular Plot (1.5m X 1m plots), **IP** = Irregular Plot, **BT** = Band Transect (2m X ~8m band).
TS = Timed Search, **GT** = Grid Transect (w/ multiple 1m^2 or other size quadrats)

[2] 3rd IP added 2004.

[3] Transects scored using Line-Intercept method (1cm increments for 10m line thus 1,000 segments) from site establishment through SP00.

[4] 3 plots on inshore cliff & 3 on offshore rocks @ Cabrillo sites; 6 plots on cliff faces @ Navy sites for similar # replicates.

Table 9. Motile Invertebrate Monitoring at MARINe Sites.

See Table 4 for full target species plot name; sampling frequency semi-annual, except annual (spring) for island sites (starting 2002), Ventura/LA County (starting 2004), and annual (summer) for sites from Sonoma County north to Oregon; start Year represents 1st year using standard protocol. Sites may have protocol testing data for prior year(s).

MAINLAND	**Start**	**FUC**	**HES**	**PEL**	**SIL**	**END**	**NEO**	**MAZ**	**RED**	**ANT**	**MYT**	**MYTdn**	**BAL**	**CHT**	**SEM**	**TET**	**POL**	**TAR**
Oregon	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Clatsop Co.																		
Ecola																		
Lincoln Co.																		
Fogarty Creek																		
Lane Co.																		
Bob Creek																		
Coos Co.																		
Cape Arago																		
Curry Co.																		
Burnt Hill																		
California																		
Del Norte Co.																		
Enderts	2004			5		5					5			5				
Damnation Creek	2004	5				5					5	5		5				
False Kalamath Cove	2004	5		5		5					5			5				
Humboldt Co.																		
Cape Mendocino	2004	5		5		5		5			5			5				
Shelter Cove	2004	5		5		5					5			5	5			
Mendocino Co.																		
Kibesillah Hill	2004	5		5		5		5			5			5				
Stornetta																		
Sea Ranch	2004	5		5		5					5			5				
Sonoma Co.																		
Bodega	2002			5		5					5			5				
Marin Co.																		
Santa Maria Creek																		
Bolinas Point																		
Slide Ranch																		
Point Bonita																		
San Mateo Co.																		
Pebble Beach																		
Pigeon Point																		
Franklin Point																		
Santa Cruz Co.																		
Scott Creek	2002	5			5	5					5			5				
Davenport Landing																		
Sand Hill Bluff	2002			5							5		5	5				
Wilder Ranch																		
Terrace Point	2002				5			5			5		5	5				
Natural Bridges																		

	Start Year	FUC # Plots	HES # Plots	PEL # Plots	SIL # Plots	END # Plots	NEO # Plots	MAZ # Plots	RED # Plots	ANT # Plots	MYT # Plots	MYTdn # Plots	BAL # Plots	CHT # Plots	SEM # Plots	TET # Plots	POL # Plots	TAR # Plots
Monterey Co.					5	5		5			5		5	5				
Hopkins	2002																	
Point Pinos																		
China Rocks																		
Stillwater	2002				5	5		5			5			5				
Carmel Point																		
Point Lobos	2002				5	5		5			5			5				
Mal Paso																		
Garrapata																		
Soberanes																		
Andrew Molera	2002	5			5	5					5			5				
Partington Cove																		
Mill Creek	2002				5	5		5			5			5				
Pacific Valley																		
San Luis Obispo Co																		
Pt Sierra Nevada	2001		5		5						5			5				
Piedras Blancas																		
San Simeon Point																		
Vista del Mar																		
Rancho Marino																		
Cayucos	2001		5		5	5					5			5				
Hazard's	2001				5	5					5			5				
Diablo																		
Shell Beach	2001				5	5		5			5			5				
Santa Barbara Co																		
Occulto	2001					5					5			5				
Purisima																		
Stairs	2001				5	5			5		5			5				
Boat House	2001				5	5					5			5				
Government Point	2001				5	5					5			5				
Alegria	2001									5	5			5			5	
Arroyo Hondo	2001										5			5				
Coal Oil Pt.	2001									5	5							
Carpinteria	2001									5	5			5			5	
Ventura Co.																		
Mussel Shoals	2002									5	5			5				
Old Stairs	2002					5				5	5			5				
LA Co.																		
Paradise Cove	2002					5					5			5				
White's Point	2002					5					5		5	5				
Point Fermin	2002				5						5			5				
Orange Co.																		
Crystal Cove	2003				5						5			5				
Shaws Cove	2003				5	5					5			5				
Treasure Island	2003				5						5			5				

	Start	FUC	HES	PEL	SIL	END	NEO	MAZ	RED	ANT	MYT	MYTdn	BAL	CHT	SEM	TET	POL	TAR
Orange Co.	**Year**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**	**# Plots**
Dana Point	2003				5						5			5				
San Diego Co.																		
Cardiff Reef																		
Scripps Reef																		
Navy North																		
Navy South																		
Cabrillo I																		
Cabrillo II																		
Cabrillo III																		
ISLANDS																		
San Miguel I.																		
Otter Harbor	2002				5	5					5			5				
Harris Point	2002		5			5					5			5		5		
Cuyler Harbor	2002				5	5					5			5				
Crook Point	2002				5	5					5			5				
Santa Rosa I.																		
NW Talcott	2002				5	5					5			5				
Fossil Reef	2002				5	5					5			5				
Johnson's Lee	2002					5					5			5				
Ford Point	2002					5					5			5				
East Point	2002				5	5					5			5				
Santa Cruz I.																		
Fraser	2002		5		5	5					5			5			5	5
Trailer	2002		5		5						5			5				
Willows	2002		5		5	5					5							
Orizaba	2002		5		5						5			5		5		
Prisoner's	2002		5		5	5					5			5				
Scorpion	2002		5			5					5			5		5		
Anacapa I.																		
Middle West	2002				5	5					5			5				
Middle East	2002				5	5					5			5				
Frenchy's Cove	2002				5	5					5			5				
Cat Rock	2002				5	5					5			5				
Santa Barbara I.																		
Landing Cove	2002				5						5			5				
Sea Lion Rookery	2002				5	5					5			5				
Santa Catalina I.																		
Bird Rock																		
Little Harbor																		

Table 10. Barnacle and Mussel Recruitment Monitoring at MARINe Sites.

MAINLAND	*Chthamalus dalli/fissus/Balanus glandula*		*Mytilus californianus*	
Oregon	**# Plates/Clearings**	**Start Year**	**# Tuffys**	**Start Year**
Clatsop Co.				
Ecola				
Lincoln Co.				
Fogarty Creek				
Lane Co.				
Bob Creek				
Coos Co.				
Cape Arago				
Curry Co.				
Burnt Hill				
California				
Del Norte Co.				
Enderts				
Damnation Creek				
False Kalamath Cove				
Humboldt Co.				
Cape Mendocino	5[1]	2004		
Shelter Cove	5[1]	2004		
Mendocino Co.				
Kibesillah Hill	5[1]	2004		
Stornetta				
Sea Ranch	5[1]	2004		
Sonoma Co.				
Bodega	5	2004		
Marin Co.				
Santa Maria Creek				
Bolinas Point				
Slide Ranch				
Point Bonita				
San Mateo Co.				
Pebble Beach				
Pigeon Point				
Franklin Point				
Santa Cruz Co.				
Scott Creek	5	1999		
Davenport Landing				
Sand Hill Bluff	5	1999		
Wilder Ranch				
Terrace Point	5	1999		
Natural Bridges				
Monterey Co.				
Hopkins	5	1999		
Point Pinos				
China Rocks				
Stillwater	5	2000		
Carmel Point				
Point Lobos	5	1999		
Mal Paso				
Garrapata				
Soberanes				
Andrew Molera	5	1999		
Partington Cove				
Mill Creek	5	1999		
Pacific Valley				
San Luis Obispo Co.				
Pt. Sierra Nevada	5			
Piedra Blancas				
San Simeon Point				
Vista del Mar				
Rancho Marino				
Cayucos	5			
Hazard's	5			
Diablo				

	Chthamalus dalli/fissus/Balanus glandula		*Mytilus californianus*	
San Luis Obispo Co.	**# Plates/Clearings**	**Start Year**	**# Tuffys**	**Start Year**
Shell Beach	5			
Santa Barbara Co.				
Occulto	5			
Purisima				
Stairs	5			
Boat House	5			
Government Pt.	5			
Alegria	5		5	
Arroyo Hondo	5			
Coal Oil Pt.	5		5	
Carpinteria	5			
Ventura Co.				
Mussel Shoals	5			
Old Stairs	5			
Los Angeles Co.				
Paradise Cove	5			
White's Point	5			
Point Fermin				
Orange Co.				
Crystal Cove				
Shaws Cove				
Treasure Island				
Dana Point				
San Diego Co.				
Cardiff Reef				
Scripps Reef				
Navy North				
Navy South				
Cabrillo I				
Cabrillo II				
Cabrillo III				
ISLANDS				
San Miguel Island				
Otter Harbor				
Harris Point				
Cuyler Harbor				
Crook Point				
Santa Rosa Island				
NW Talcott				
Fossil Reef				
Johnson's Lee				
Ford Point				
East Point				
Santa Cruz Island				
Fraser	5	1994	5	1994
Trailer	5	1994	5	1994
Willows	5	1994	5	1994
Orizaba				
Prisoner's	5	1994	5	1994
Scorpion				
Anacapa Island				
Middle West				
Middle East				
Frenchy's Cove				
Cat Rock				
Santa Barbara Island				
Landing Cove				
Sea Lion Rookery				
Santa Catalina Island				
Bird Rock				
Little Harbor				

[1] Clearings only – no plates.

Table 11. Temperature Logger Deployment at MARINe Core Sites.

MAINLAND *Oregon*	Shore Zone Location	Sampling Interval (min)	Deployment Mo/Year	Logger Type (e.g. Tidbit)	Logger Housing (e.g. PVC tube, epoxy mussel)
Clatsop Co.					
Ecola					
Lincoln Co.					
Fogarty Creek					
Lane Co.					
Bob Creek					
Coos Co.					
Cape Arago					
Curry Co.					
Burnt Hill					
California					
Del Norte Co.					
Enderts	Below Mussel	15[1]	4/2004		
Damnation Creek	Below Mussel	15[1]	4/2004		
False Kalamath Cove	Below Mussel	15[1]	4/2004		
Humboldt Co.					
Cape Mendocino	Below Mussel	15	6/2005		
Shelter Cove	Below Mussel	15	6/2005		
Mendocino Co.					
Kibesillah Hill	Below Mussel	15	6/2005		
Stornetta					
Sea Ranch	Below Mussel	15	6/2005		
Sonoma Co.					
Bodega	Below Mussel	15	6/2005		
Marin Co.					
Santa Maria Creek					
Bolinas Point					
Slide Ranch					
Point Bonita					
San Mateo Co.					
Pebble Beach					
Pigeon Point (North)	Below Mussel	15	6/2000		
Pigeon Point (South)	Below Mussel	15	12/2003		
Franklin Point					
Santa Cruz Co.					
Scott Creek	Below Mussel	15	6/2001		
Davenport Landing					
Sand Hill Bluff	Below Mussel	15	12/1999		
Wilder Ranch					
Terrace Point	Below Mussel	15	12/1999		
Natural Bridges					
Monterey Co.					
Hopkins	Below Mussel	15	12/1999		
Point Pinos					
China Rocks					
Stillwater	Below Mussel	15	3/2000		
Carmel Point					
Point Lobos	Below Mussel	15	3/2004		
Mal Paso					
Garrapata					
Soberanes	Below Mussel	15	7/2003		
Andrew Molera	Below Mussel	15	12/1999		
Partington Cove					
Mill Creek	Below Mussel	15	4/2004		
Pacific Valley					
San Luis Obispo Co.					
Pt. Sierra Nevada	Below Mussel	15	2005		
Piedra Blancas	Below Mussel	15	2005		
San Simeon Point					
Vista del Mar					
Rancho Marino	Below Mussel	15	2005		
Cayucos	Below Mussel	15	2005		

Hazard's	Below Mussel	15	2005		
Diablo					
Shell Beach	Below Mussel	15	2005		
Santa Barbara Co.					
Occulto	Below Mussel	15	2005		
Purisima	Below Mussel	15	2005		
Stairs	Below Mussel	15	2005		
Boat House	Below Mussel	15	2005		
Government Pt.	Below Mussel	15	2005		
Alegria					
Arroyo Hondo					
Coal Oil Pt.					
Carpinteria					
Ventura Co.					
Mussel Shoals					
Old Stairs					
Los Angeles Co.					
Paradise Cove					
White's Point					
Point Fermin					
Orange Co.					
Crystal Cove	Above Mussel	5	10/2005		
Shaws Cove	Above Mussel	30	11/2005		
Treasure Island	Above Mussel	30	11/2005		
Dana Point	Above Mussel	5	9/2005		
San Diego Co.					
Cardiff Reef					
Scripps Reef					
Navy North					
Navy South					
Cabrillo I	Below Mussel	4	2000		
Cabrillo II	Below Mussel	4	2000		
Cabrillo III	Below Mussel	4	2000		
ISLANDS					
San Miguel Island					
Otter Harbor					
Harris Point	Mid Mussel	16*	1992		
*Housing lost winter 2000—no deployment since.					
Cuyler Harbor					
Crook Point	Mid Mussel	16[2]	1992		
Santa Rosa Island					
NW Talcott	Mid Mussel	16[2]	1992		
Fossil Reef					
Johnson's Lee	Mid Mussel	16[2]	1992		
Ford Point					
East Point	Mid Mussel	16*	1992		
*Housing lost winter 2004—no deployment since.					
Santa Cruz Island					
Fraser	Mid Mussel	16			
Trailer	Mid Mussel	16			
Willows	Mid Mussel	16			
Orizaba					
Prisoner's	Mid Mussel	16			
Scorpion					
Anacapa Island					
Middle West	Mid Mussel	16	1992		
Middle East					
Frenchy's Cove	Mid Mussel	16[2]	1992		
Cat Rock					
Santa Barbara Island					
Landing Cove	Mid Mussel	16	1992		
Sea Lion Rookery					
Santa Catalina Island					
Bird Rock					
Little Harbor					

[1] Switched to 20 min interval starting 8/05.
[2] Data gaps occurred since deployment date.

Form 1a: Prototype MARINe Rocky Intertidal Field Log

(Fill in all blanks.: **----**=No Data; **0**=None: **L**=Low; **M**=Med; **H**=High; or Actual Value)

Site:____________________ Date:___/___/___ Time:_____ to _____ Low Tide:_____(ft) at _____(hr)
Participants (Recorder 1st):____

____

Weather and Sea Conditions (affecting quality of sampling)(use codes listed above)
Swell/Surge:________ Wind:________ Rain:_______ Recent Rain:_______ Water Temp (°C):_______
Substratum Changes (sediment=sand, gravel, cobble) (magnitude at site)
Sediment Level:_______ Scour:_______ Rock Movement:_______
Debris and Pollutants (magnitude at site):
Plant Wrack:_____ Driftwood:_____ Shells:______ Dead Animals:______ Trash:______ Oil/Tar:_____
Notes on Physical Conditions:____

____
____
____
____
____

Birds and Mammals (maximum # seen at any one time during the sampling)(see bird/mammal list for other species)

Pelican	Great Egret			CA Sea Lion
Cormorant	Snowy Egret			Harbor Seal
Gull	Lg Shorebird			Elephant Seal
Tern	Sm Shorebird			Sea Otter
Oystercatcher	Other Birds			Dog
Blue Heron				

Bird/Mammal Notes:____

____

Humans (maximum # seen at any one time during the sampling; note behavior) Reef:________ Sand:________

____

Plot Marker Loss/Repair Notes:____

____
____

Other Notes:____

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Site:________________________________ Date:___/___/___ Recorder______________________________

Form 1b: Prototype MARINe Rocky Intertidal Site-Wide Species Conditions

Species	Abundance	Appearance	Recruitment	Notes
Target Species shown in bold. **Optimum Intertidal Zone** (may occur in 1, 2 or 3 zones) **H**=High **M**=Mid **L**=Low	----=No Data **0**=Absent **R**=Rare **U**=Uncommon **P**=Present **C**=Common **A**=Abundant	----=No Data √=Typical (healthy) **F**=Fertile/Flowers **B**=Bleached **D**=Damaged **L**=Low level **M**=Med level **H**=High level	----=No Data **0**=Absent **L**=Low level **M**=Med level **H**=High level	
Cladophora columbiana				
Ulva/Enteromorpha				
Egregia menziezii				
Eisenia arborea				
Endarachne/Petalonia				
Fucus gardneri				
Halidrys dioica/Cystoseira spp.				
Hesperophycus californicus				
Pelvetiopsis limitata				
Sargassum muticum				
Scytosiphon spp.				
Silvetia compressa				
Endocladia muricata				
Chondracanthus canaliculatus				
Mastocarpus papillatus				
Mazzaella affinis				
Mazzaella spp.(= Iridaea spp.)				
Porphyra sp.				
Phyllospadix scouleri/torreyi				
Anthopleura elegantissima/sola				
Phragmatopoma californica				
Mytilus californianus				
Littorina spp				
Lottia gigantea				
Haliotis cracherodii				
Tegula spp				
Chthamalus spp/B. glandula				
Tetraclita rubescens				
Pollicipes polymerus				
Ligia occidentalis				
Pisaster ochraceus				
Strongylocentrotus purpuratus				
Tar				

Form 1c: MARINe Rocky Intertidal Field Log Definitions

Codes

No Data (----): Draw a horizontal line through any blank area to indicate that this category was not evaluated or does not apply.

None (0): None were found within the defined site boundaries.

Low (L): Relatively few or low levels were found within the defined site boundaries.

Med (M): Medium numbers or moderate levels were found within the defined site boundaries.

High (H): High numbers or high levels were found within the defined site boundaries.

Weather and Sea Conditions

Swell/Surge: L/M/H relative levels of water movement over seaward portion of site.

Wind: L = ≤10 knots M = 11-20 knots H => 20 knots

Rain: L/M/H relative amounts of precipitation at the site during the survey.

Recent Rain: Evidence or knowledge of L/M/H amounts rain at the site within the past few days.

Water Temp: Actual seawater temperature (°C) or L: ≤14°C (57°F) M: 15-18°C H: >18°C (64°F).

Substratum Changes

Sediment Level: L/M/H relative levels of unconsolidated sand/gravel/cobble along reef/sediment interfaces.

Scour: L/M/H relative extent of scoured reef surfaces within the defined site boundaries.

Rock Movement: L/M/H relative extent of overturned boulders or bedrock breakouts.

Debris and Pollutants

Plant Wrack: L/M/H levels of unattached algae or other drift plants within the site.

Driftwood: L/M/H levels of sticks, branches, and logs within the site.

Shells: L/M/H levels of dead shells, especially mussel shells.

Dead Animals: L/M/H levels of dead invertebrates, fish, birds, or mammals.

Trash: L/M/H levels of human debris including cans, bottles, plastics, and metal items.

Oil/Tar: L/M/H relative extent of fresh or weathered oil/tar within the site.

Site-Wide Species Conditions

Abundance: Relative numbers of individuals or cover of species, in 5 levels, with “Present” representing the middle level.

Appearance: Checkmark indicates typical “healthy” non-reproductive appearance. If appearance is not typical, pair noted appearance codes with level codes (FL, FM, FH, BL, BM, BH, DL, DM, DH). Score L/M/H relative levels of reproductive appearance (F) (plants showing evidence of fertility), bleaching (B) (plants only: e.g., appearing pale or translucent or red algae appearing greenish), or damage (D) (plants & animals: e.g., abraded, torn, broken, withered, diseased, injured, or dead individuals). It is possible to record multiple entries (e.g., *Silvetia* = FL, BL, & DM).

Recruitment: For appropriate species when evident, score L/M/H relative levels of recruit abundances (settlers that have become obvious since the previous sampling).

Form 2a: Prototype MARINe Rocky Intertidal Photo Log

Site:____________________________________ Camera:______________________ Roll No.:_________ Date:______________
Photographer:____ Recorder:____

Photo #	Plot/Area Photographed (if area, indicate viewpoint)	Notes
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
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49		
50		

Form 2b: Prototype MARINe Rocky Intertidal Photo Log

Site:____________________________________ Camera:______________________ Roll No.:_________ Date:______________

Photographer:____ Recorder:____

Photo #	Plot/Area Photographed (if area, indicate viewpoint)	Notes
51		
52		
53		
54		
55		
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97		
98		
99		
100		

Form 3a: Prototype MARINe Rocky Intertidal Photoplot Sketch Data Sheet

Site:_____________________ Date:__________ Photographer:______________________ Roll #:_________

Target Species:_______________ Observer:__________________________________ Photo #s:____ - ____

Plot 1 (   ) Notes:______________________________

Plot 2 (   ) Notes:______________________________

Plot 3 (   ) Notes:______________________________

Green Algae: **CL**=Cladophora columbiana; **UE** = Ulva/Enteromorpha; **OG**=Other Green

Brown Algae: **EM**=Egregia; **EA**=Eisenia; **EP**=Endarachne/Petalonia; **FG**=Fucus; **HC**=Halidrys/Cystoseira; **HE**=Hesperophycus; **PL**=Pelvetiopsis; **SM**=Sargassum muticum; **SC**=Scytosiphon; **SI**=Silvetia: **OB**=Other Brown

Red Algae: **AC**=Articulated Corallines; **CC**=Crustose Corallines; **CO**=Chondracanthus can.; **EN**=Endocladia; **MP**=Mastocarpus pap.; **MZ**=Mazaella affinis; **MS**=Mazaella (Ididaea); **PS**=Porphyra spp;; **OR**=Other Reds

Algae/Plants: **PY**=Phyllospadix; **NC**=Non-Coralline Crusts; **OP**=Other Plants

Barnacles: **CB**=Chthamalus/Balanus; **TE**=Tetraclita; **PO**=Pollicipes; **BA**=Other Barnacles

Mollusks: **MY**=Mytilus; **LG**=Lottia gigantea; **LI**=Limpets; **CI**=Chitons

Invertebrates: **AE**=Anthopleura; **PH**=Phragmatopoma; **PI**=Pisaster ochraceus; **OI**=Other Invertebrates

Substrates: **R**=Rock, **S**=Sand, **T**=Tar

Form 3b: Prototype MARINe Rocky Intertidal Photoplot Sketch Data Sheet

Site:_____________________ Date:__________ Photographer:______________________ Roll #:_________

Target Species:________________ Observer:___________________________________ Photo #s:____ - ____

Plot 4 ( ) Notes:______________________________

Plot 5 ( ) Notes:______________________________

Plot ( ) Notes:______________________________

Green Algae: **CL**=Cladophora columbiana; **UE** = Ulva/Enteromorpha; **OG**=Other Green
Brown Algae: **EM**=Egregia; **EA**=Eisenia; **EP**=Endarachne/Petalonia; **FG**=Fucus; **HC**=Halidrys/Cystoseira; **HE**=Hesperophycus; **PL**=Pelvetiopsis; **SM**=Sargassum muticum; **SC**=Scytosiphon; **SI**=Silvetia: **OB**=Other Brown
Red Algae: **AC**=Articulated Corallines; **CC**=Crustose Corallines; **CO**=Chondracanthus can.; **EN**=Endocladia; **MP**=Mastocarpus pap.; **MZ**=Mazaella affinis; **MS**=Mazaella (Ididaea); **PS**=Porphyra spp;; **OR**=Other Reds
Algae/Plants: **PY**=Phyllospadix; **NC**=Non-Coralline Crusts; **OP**=Other Plants
Barnacles: **CB**=Chthamalus/Balanus; **TE**=Tetraclita; **PO**=Pollicipes; **BA**=Other Barnacles
Mollusks: **MY**=Mytilus; **LG**=Lottia gigantea; **LI**=Limpets; **CI**=Chitons
Invertebrates: **AE**=Anthopleura; **PH**=Phragmatopoma; **PI**=Pisaster ochraceus; **OI**=Other Invertebrates
Substrates: **R**=Rock, **S**=Sand, **T**=Tar

Form 4: Prototype MARINE Rocky Intertidal Photoplot Slide-Scoring Data Sheet

Site:______________________________ Sampling Season:____________ Date Sampled:____________

Assemblage:________________________ Recorder:__________________ Date Scored:_____________

Core Taxa		Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Cladophora columbiana	CLACOL						
Ulva/Enteromorpha	ULVENT						
Other Green Algae	OTHGRE						
•Egregia menziesii	**EGRMEN**						
Eisenia arborea	EISARB						
Endarachne/Petalonia	ENDPET						
Fucus gardneri	FUCGAR						
Halidrys/Cystoseira spp	HALCYS.						
Hedophyllum sessile	**HEDSES**						
•Hesperophycus californicus	**HESCAL**						
Pelvetiopsis limitata	PELLIM						
Sargassum muticum	SARMUT						
Scytosiphon spp	SCYSPP						
•Silvetia compressa	**SILCOM**						
Other Brown Algae	OTHBRO						
Chondracanthus canaliculatus	CHOCAN						
•Endocladia muricata	**ENDMUR**						
Mastocarpus papillatus	MASPAP						
Mazzaella affinis	MAZAFF						
Mazzaella spp.(= Iridaea spp.)	MAZSPP						
Neorhodomela larix	**NEOLAR**						
Porphyra spp	PORSPP						
Articulated Corallines	ARTCOR						
Crustose Corallines	CRUCOR						
Other Red Algae	OTHRED						
•Phyllospadix scouleri/torreyi	**PHYOVE**						
Non-Coralline Crusts	NONCRU						
Other Plant	OTHPLA						
•Anthopleura elegantissima/solis	**ANTELE**						
Phragmatopoma californica	PHRCAL						
•Lottia gigantea	**LOTGIG**						
•Mytilus californianus	**MYTCAL**						
Limpets	LIMPET						
Chitons	CHITON						
•Chthamalus spp/Bal glandula	**CHTBAL**						
•Pollicipes polymerus	**POLPOL**						
Semibalanus cariosus	**SEMCAR**						
•Tetraclita rubescens	**TETRUB**						
Other Barnacles	OTHBAR						
•Pisaster ochraceus	**PISOCH**						
Other Invertebrates	OTHINV						
Rock	ROCK						
Sand	SAND						
Tar	**TAR**						
Other Substrate	OTHSUB						
Unidentified	UNIDEN						

Form 5: Prototype MARINe Rocky Intertidal Point Intercept Transect Data Sheet

Site:__________________Date:_________Time:_______Sampler:________________Recorder:_______________

Directions: Record 100 point-intercepts (every 10 cm) along 10m transect lines. Target Species (circle): Boa Kelp Surfgrass Turf.

Species/Taxa/Substrate		Transect 1 ( )	Transect 2 ( )	Transect 3 ( )
Phyllospadix ***Overstory***				
Phyllospadix Understory				
Egregia menziesii				
Eisenia arborea				
Halidrys dioica/Cystoseira				
Hedophyllum sessile				
Sargassum muticum				
Crustose Algae	Coralline			
	Non-Coralline			
Articulated Corallines				
Other Algae	Red			
	Brown			
	Green			
Other Plant				
Anthopleura elegan/sola				
Phragmatopoma calif.				
Mytilus californianus				
Barnacles				
Pisaster ochraceus				
Other Invertebrates				
Rock				
Sand				
Tar				
Other Substrate				
Unidentified				
	Total:			

For each entry box, add the tick marks or counts, record the sum, and circle it.

Use the following classifications for epiphyte cover/appearance estimates: (0, L, M, H)=(none, low, med, high)

Cover of *Smithora:*______ *Melobsia:*________ bleached/brown grass:________ Abraded:_______ Flowers:________

Notes:____

Form 6a: Prototype MARINe Rocky Intertidal Owl Limpet Data Sheet

Site:______________________________ Date:__________ Time:_____________ Plot Size:______________

Measurers:__________________________________ Recorders:____________________________________

Plot 1 ( )				Plot 2 ( )				Plot 3 ( )			
Size mm	#	**Size mm**	#	**Size mm**	#	**Size mm**	#	**Size mm**	#	**Size mm**	#
<15				<15				<15			
15		60		15		60		15		60	
16		61		16		61		16		61	
17		62		17		62		17		62	
18		63		18		63		18		63	
19		64		19		64		19		64	
20		65		20		65		20		65	
21		66		21		66		21		66	
22		67		22		67		22		67	
23		68		23		68		23		68	
24		69		24		69		24		69	
25		70		25		70		25		70	
26		71		26		71		26		71	
27		72		27		72		27		72	
28		73		28		73		28		73	
29		74		29		74		29		74	
30		75		30		75		30		75	
31		76		31		76		31		76	
32		77		32		77		32		77	
33		78		33		78		33		78	
34		79		34		79		34		79	
35		80		35		80		35		80	
36		81		36		81		36		81	
37		82		37		82		37		82	
38		83		38		83		38		83	
39		84		39		84		39		84	
40		85		40		85		40		85	
41		86		41		86		41		86	
42		87		42		87		42		87	
43		88		43		88		43		88	
44		89		44		89		44		89	
45		90		45		90		45		90	
46		91		46		91		46		91	
47		92		47		92		47		92	
48		93		48		93		48		93	
49		94		49		94		49		94	
50		95		50		95		50		95	
51		96		51		96		51		96	
52		97		52		97		52		97	
53		98		53		98		53		98	
54		99		54		99		54		99	
55		100		55		100		55		100	
56				56				56			
57				57				57			
58				58				58			
59				59				59			

Notes:____

____

Form 6b: Prototype MARINe Rocky Intertidal Owl Limpet Data Sheet

Site:________________________________ Measurers:____

Date:_____________ Time:____________ Recorders:____

Plot 4 ( )				Plot 5 ( )				Plot 6 ( )			
Size mm	#	Size mm	#	Size mm	#	Size mm	#	Size mm	#	Size mm	#
<15				<15				<15			
15		60		15		60		15		60	
16		61		16		61		16		61	
17		62		17		62		17		62	
18		63		18		63		18		63	
19		64		19		64		19		64	
20		65		20		65		20		65	
21		66		21		66		21		66	
22		67		22		67		22		67	
23		68		23		68		23		68	
24		69		24		69		24		69	
25		70		25		70		25		70	
26		71		26		71		26		71	
27		72		27		72		27		72	
28		73		28		73		28		73	
29		74		29		74		29		74	
30		75		30		75		30		75	
31		76		31		76		31		76	
32		77		32		77		32		77	
33		78		33		78		33		78	
34		79		34		79		34		79	
35		80		35		80		35		80	
36		81		36		81		36		81	
37		82		37		82		37		82	
38		83		38		83		38		83	
39		84		39		84		39		84	
40		85		40		85		40		85	
41		86		41		86		41		86	
42		87		42		87		42		87	
43		88		43		88		43		88	
44		89		44		89		44		89	
45		90		45		90		45		90	
46		91		46		91		46		91	
47		92		47		92		47		92	
48		93		48		93		48		93	
49		94		49		94		49		94	
50		95		50		95		50		95	
51		96		51		96		51		96	
52		97		52		97		52		97	
53		98		53		98		53		98	
54		99		54		99		54		99	
55		100		55		100		55		100	
56				56				56			
57				57				57			
58				58				58			
59				59				59			

Notes:____

Form 7: Prototype MARINe Rocky Intertidal Abalone and Seastar Data Sheet

Site:________________________ Sampling Date:__________ Sampling Season___________
Recorder:________________________________ Sampler:________________________________
Is This a Time Search? (check if yes):____ Time Period for Search: From_______to_______

Black Abalone

Length (mm)	Plot/Transect 1 ( )	Plot/Transect 2 ( )	Plot/Transect 3 ( )
5			
10			
15			
20			
25			
30			
35			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
All			

Ochre Seastars

Radius (mm)	Plot/Transect 1 ( )	Plot/Transect 2 ( )	Plot/Transect 3 ( )
5			
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			
All			

Other Abalone (total # only – no sizes)

Species	Plot/Transect 1	Plot/Transect 2	Plot/Transect 3	Site

Other Seastars (total # only – no sizes)

Species	Plot/Transect 1	Plot/Transect 2	Plot/Transect 3	Site

Form 8: Prototype MARINe Rocky Intertidal Northern Sea Palm Data Sheet

Shelter Cove - *Postelsia*

Date________________

Plot 1 (blank bolt)- Upcoast to Downcoast 5m long

Name________________

Pp1

1 m onshore	0 m	offshore 1m
	0-1	
	1-2	
	2-3	
	3-4	
	4-5	

C

Plot 2 (2 notches)- Upcoast to Downcoast 5m long

Pp2

1 m onshore	0 m	offshore 1m
	0-1	
	1-2	
	2-3	
	3-4	
	4-5	

D

Plot 3 (3 notches)- Upcoast to Downcoast 5m long

Pp3

1 m onshore	0 m	offshore 1m
	0-1	
	1-2	
	2-3	
	3-4	
	4-5	

E

Form 9: Prototype MARINe Rocky Intertidal Motile Invertebrates Data Sheet

Plot Type:______________________ Site:________________________

Counter:_____________________ Date:_____________________

	Plot 1	Plot 2	Plot 3	Plot 4
Species counted in whole plot (can be sub-sampled if abundant)* For hermits, I.D. 1st 10 & multiply % by total.				
Lepidochitona hartwegii				
Nuttalina spp.				
Mopalia spp.				
Fissurella volcano				
Pachygrapsis crassipes				
Pagurus samuelis				
Pagurus hirsutiusculus				
Pagurus granosimanus				
Ocenebra circumtexta				
Large limpets (>15mm) (excluding L. gigantea)				

Species counted and measured (1st 10 encountered only) in whole plot (can be sub-sampled if abundant)*								
	#	sizes	#	sizes	#	sizes	#	sizes
Nucella emarginata								
Nucella canaliculata								
Acanthina spp.								
Tegula funebralis								
Lottia gigantea								

Species sub-sampled in 3 20x20cm quadrats placed in UL, middle & LR of plot** Count limpets on rock (R) and mus								
	R	M	R	M	R	M	R	M
limpet < 5mm								
limpet 5-15 mm								

Sample in 10x10 cm section of 20x20 cm quadrat**												
Littorina spp.												

Appendix 2: MARINe Biodiversity monitoring protocols

Coastal Biodiversity Survey Protocols

May, 2011

University of California
Santa Cruz
SWAT Team

Table of Contents

Coastal Biodiversity Survey Protocols

Selecting an appropriate location

The ideal location to establish a comprehensive survey is on a bedrock intertidal bench that 1) is at least 30m wide, 2) gently slopes from the high to low zone, and most importantly 3) contains a representative sample of the intertidal community of the entire site. If it is not possible to find a contiguous 30m stretch of coastline, the survey can either be split between two adjacent benches or setup along a contiguous 20m stretch of coastline. When split, the survey should be divided as evenly as possible between the two benches.

Set-Up

Once an appropriate area of shoreline has been selected, it is sampled using a series of parallel transect lines extending from the high zone to the low zone. To facilitate the setup of these lines, two permanent 30m horizontal baselines (parallel to the ocean) are first established. The upper baseline is placed in the high zone above the upper limit of the organisms, while the lower baseline, which should be parallel to the upper baseline, is established farther down the shore. Depending on the amount of beach traffic or site regulations, the ends of these lines are permanently marked with either hex or carriage bolts.

Once these two baselines have been established, parallel transect lines are run down the shore every three meters along the upper base line. To insure that these lines are parallel, they should intersect the appropriate meter mark on the lower baseline. In general the transect lines are allowed to follow the contours of the bench. When necessary, rocks are placed along the lines to prevent them from being shifted by heavy winds and a note is made of where each transect crosses the lower baseline.

To facilitate resurveys of the site, a map is drawn of the site showing the location of the bolts relative to notable landmarks or other, pre-existing permanent plots, GPS coordinates are recorded, and photographs are taken. The distance and bearing between the baseline end bolts are measured. When possible, measurements are also taken between the end bolts and any pre-existing permanent plots. Other information such as the compass heading of the vertical transects, coastal orientation and the sampling interval are also recorded. A rock sample is collected for determining geology of the bench.

Point-Contact Surveys

Each vertical transect is sampled using the point intercept method. Ideally 100 points are sampled on each transect line, so the interval between points should be 20cm for a 20m long transect, and 10cm for a 10m long transect. For each point two types of data are collected: data that are used to determine relative abundance (% cover), and data that are used to describe spatial distributions. The relative abundance data are collected by identifying all taxa that fall directly under each point, including rock, sand, and tar. If there is layering, the taxa occupying the different layers are identified and assigned a letter: A for the top layer, B for the second layer, and C for the third. (Note: For this survey, each layer must be a different taxa). If the point falls on an epibiont living on a recognized host species (Table 1), the epibiont is denoted by the letter E and the host by the letter H. [Note: Designating a species an epibiont/host does not preclude it from also being a layer. For example, if the point hits an epibiotic alga whose holdfast is not under the point, it is recorded as both a canopy (A) and as an epibiont (E). The host would be recorded as canopy (B) and host (H)]. Also recorded is whether the species under the point are found in pools, on cobble, or on boulders. A total of up to three taxa are identified under each point.

Table 1: List of recognized hosts.

Although many species are host to a few epibiotic species, for this survey only those species that offer substrate to a multitude of epibiotic species are considered hosts.

Balanus crenatus	*Jania crassa*
Balanus glandula	*Jania tenella*
Balanus nubilus	*Lithothrix aspergillum*
Bossiella spp	*Lottia gigantea*
Brachidontes/Septifer spp	*Megabalanus californicus*
Calliarthron spp	*Modiolus* spp
Chthamalus spp	*Mytilus californianus*
Corallina spp	*Mytilus galloprovincialis/trossulus*
Dendropoma lituella	*Petaloconchus montereyensis*
Dendropoma/Petaloconchus spp	*Pollicipes polymerus*
Dodecaceria fewkesi	*Pseudochama exogyra*
Dodecaceria spp	Sabellariidae
Encrusting coralline	*Semibalanus cariosus*
Haliptylon gracile	*Serpula vermicularis*

If fewer than three taxa are recorded under a point, then data are collected on the identity of the next one or two species closest to that point (Table 2). These data are used to describe the spatial distribution of species, and are not used when calculating relative abundances.

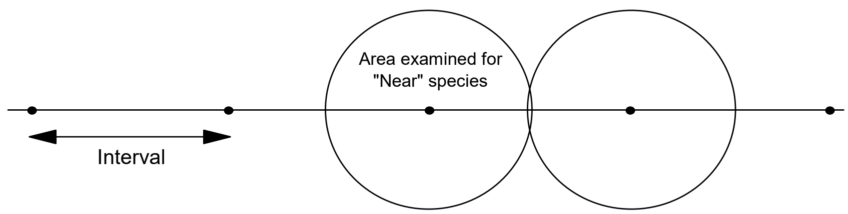
Table 2: Number of ‘nearby’ species recorded.

Taxa Recorded Under Point	Number of ‘Nearby’ Species
One taxa, (can be either an organism or bare space)	Two additional species
Two layers, with the bottom layer being bare space	Two additional species
Two layers, both of which are organisms	One additional species
Epibiont and Host	One additional species

Three layers, with the bottom layer being bare space	One additional species
Three layers, all of which are organisms	No additional species

These ‘nearby’ species must be different than those found under the point, and must fall within a circle centered over the point with a radius half the length of the sampling interval (Figure 1). Closeness is determined by location on the primary substrate. For example, if a frond of *Silvetia* is closer to the point than a barnacle, but its holdfast is farther away, the barnacle is considered the closer species. If all ‘nearby’ individuals are the same taxa as that found under the point, or there are no other ‘nearby’ species, ‘none’ is recorded. If the nearby species is an epibiont on a recognized host (Table 1), the host is denoted by the letter H and the epibiont the letter E. Again, note is made of whether these nearby species are found in pools, on cobble, or on boulders.

Figure 1: Diagram showing area examined for ‘near’ species.



Vouchers

When a species cannot be identified in the field, it is assigned an unknown number and a sample of it is collected. Samples are labeled with the date, site, name of sampler, transect line on which it is found, and the unknown number assigned to it. Samples are collected in seawater and are either immediately pressed (algae), and either desiccated or preserved in alcohol (invertebrates).

Mobile Invertebrate Quadrat Surveys

Although point-contact surveys are good at determining the abundance of spatially common species, they do not sample rare or spatially uncommon species very well. Because most mobile species are not spatially common, their abundances are determined in 50 x 50 cm quadrats placed at three locations along each transect. Each transect is first divided into three zones; the low zone is the area below the mussels, the mid-zone includes the mussels and the rockweeds (e.g. Silvetia, Pelvetiopsis), and the high zone is the area dominated by barnacles and littorines. Within each zone a quadrat is randomly placed on the transect, and all mobile species found within the quadrat are identified and counted. A random number table is used to select a number which represents the location (in meters) along a transect line where the quadrat should be placed. When a definitive high, mid, or low biological zone does not exist, one of the following protocols is followed: (in order of preference) 1) the quadrat may be offset from the transect line in order to capture the missing zone, 2) only two quadrats are sampled on the transect. For example, on a transect where no true high zone exists: 1) the quadrat may be placed just above the upper baseline in the high zone, and "offset" is noted as the location, 2) quadrats are sampled in only the mid and low zones. Sub-sampling may be used when there are more than one hundred individuals of one species in a quadrat. If the location of a quadrat is in a deep pool or in an area dominated by sand, a new location is selected. The only mobile species not counted are worms, *Neomolgus littoralis* (red mites), and amphipods.

Swath Counts

Sea stars play an important role in the intertidal community, but often they are also not spatially common. As such, their abundances are measured along a two-meter swath centered over each vertical transect. Sites utilizing a 20m baseline also measure along a two-meter swath. Within this swath, the abundance and location along the transect (to the nearest 0.5m) of the following sea stars is recorded: *Asterina miniata, Dermasterius imbricata, Echinaster* spp, *Evasterias troschelii, Heliaster kubinijii, Henricia leviuscula, Pharia pyramidata, Pisaster ochraceu*s, *Pisaster giganteus,* and *Pycnopodia helianthoides*. Sea stars measuring less than 5cm in total length are not counted. Species of *Leptasterias* are not counted in the swath counts, since these smaller stars are well represented in the quadrat surveys. Abundance and location are also recorded for individuals of *Cryptochiton stelleri, Haliotis cracherodii,* and *Haliotis rufescens*. The locations of any surge channels or pools that cannot be searched are also noted.

Topography

A three-dimensional map of the study area is created from topography measurements of each vertical transect line. A rotating laser leveler and a stadia rod are used to make the measurements. Ideally the laser leveler is positioned where the topography of all eleven transects can be measured. However, where this is not possible, and the laser leveler must be repositioned, it is important to make sure that several reference points are measured from both locations. This will ensure that the heights measured from the two locations will be compatible. Measurements are taken along each transect wherever there is a change in height. Thus, measurements are taken infrequently (every few meters) for gradual slopes, but more frequently (tens of centimeters) when necessary to capture the presence of smaller ridges and pools.

Modified Surveys

In some cases, biodiversity surveys will be completed using a modified set of protocols. Protocol modifications are typically made to the Point Contact Surveys only;

however a reduced number of transects may also be sampled for the other types of surveys. The type of survey completed is referenced in the data. Depending on what is desired for a specific project, there are 6 basic options for the types of modifications that can be made (Table 3).

Table 3: Survey Method Descriptions

Survey Method	Description
1) CBS standard (no modification)	CBS surveys are completed as described in the above survey protocols, with the full number of transects surveyed for all methods
2) CBS reduced	CBS surveys are completed as described in the survey protocols, with a reduced number of transects surveyed for one or more methods
3) CBS first point layering	CBS point contact surveys are modified. Only the first point is recorded at each location, but all layering and epi/host relationships on that point are also recorded. The full number of transects are surveyed for all methods.
4) CBS first point no layering	CBS point contact surveys are modified. Only the first point is recorded at each location, and layering and epi/host relationships are not recorded. If layering occurs, the top species is the organism recorded at this point, unless otherwise desired for a specific project. For example, if mussels are specifically of interest, layers over mussels may be ignored and mussels will be recorded at that point. In this case, the modification will be detailed in the project report and site notes. If epi/host relationships occur, the host species (the species attached to the substrate) is the organism recorded at this point. The full number of transects are surveyed for all methods.
5) CBS reduced first point layering	CBS point contact surveys are modified. Only the first point is recorded at each location, but all layering and epi/host relationships on that point are also recorded. A reduced number of transects are surveyed for one or more methods.
6) CBS reduced first point no layering	CBS point contact surveys are modified. Only the first point is recorded at each location, and layering and epi/host relationships are not recorded. If layering occurs, the top species is the organism recorded at this point (except if otherwise desired for a specific project as described in #4 above). If epi/host relationships occur, the host species (the species attached to the substrate) is the organism recorded at this point. A reduced number of transects are surveyed for one or more methods.

GPS Measurements

GPS measurements of latitude and longitude (WGS84) and height above mean sea level (meters above MSL GEOID03 Conus) are recorded at each permanent marker bolt. Trimble survey equipment is used, including a Zephyr antennae, ProXRT receiver, and Nomad computer running Terrasync software, all mounted upon a leveled bipod. The bipod is placed directly beside each bolt, and GPS measurements are recorded. Upon transferring the measurements to a personal computer, measurements are then post-processed using GPS Pathfinder Office software to increase precision. One bolt is selected as a "benchmark bolt," upon which all topography measurements are to be correlated.

Stillwater Measurement

Sites that do not have GPS measurements must use a "stillwater measurement" to correlate to topography measurements. The topography measurements are converted to tidal heights (meters above MLLW) by taking a stillwater measurement (measuring sea level at low tide). Three locations are selected that are covered and uncovered by waves for equal amounts of time. The orientation of these locations should be towards the incoming tide. The height of these locations and the time the measurement was taken are recorded and later converted to actual tidal height values using a tidal table.

Appendix 3: MARINe Black abalone habitat monitoring protocols

Black Abalone Population and Habitat Assessment

Developed by UC Santa Cruz Raimondi Lab

The purpose of this survey is to assess the abundance of black abalone as well as the abundance and spatial distribution of black abalone habitat. Compared to previous black abalone habitat surveys (central coast, north central coast), this method provides more extensive spatial coverage and is most appropriate for areas where black abalone are uncommon.

1. Abalone and habitat quality are surveyed within segments of rocky intertidal habitat. These are demarcated by natural obstacles (e.g. channels, cliffs), changes in the physical characteristics of the survey area (e.g. change of exposure, rock type), or areas of habitat not suitable for black abalone (e.g. sandy beaches). Note that segments will vary in length and may range from tens to hundreds of meters alongshore.

2. Photograph the start and end of each segment and mark each with a high and low GPS Waypoint (high start, low start, high end, low end. Segment waypoints will allow for an estimate of total linear distance sampled along the coastline and will be used to map polygons of the survey segment and calculate the total area sampled. Also have a GPS track running during the survey, this will help when mapping large survey segments.

3. Search for and record the number of abalone found within each segment. Record the size of each abalone (to the nearest cm) and the habitat quality of its immediate location (good, moderate, poor). Nearest neighbor distance information should also be recorded for each abalone (A = touching, B = <10cm, C = <1m, D = <5m, E = >5m). If abalone are rare it may be appropriate to photograph and mark the location of each abalone with GPS.

4. Subsampling abalone: if abalone are abundant, a subsample of the segment may be done by surveying a 10 meter swath of the segment for abalone.
    a. Upon initial inspection of the survey segment, determine if there are likely to be >50 abalone/10m of shoreline surveyed.
    b. If >50abs/10m of shoreline are present, use a random number generator (e.g. stopwatch, random number sheet) to select a distance from the segment start location to conduct the swath survey. Conduct one subsample for every 100m of survey segment.
    c. Conduct additional subsamples if there are drastic changes in habitat characteristics within the segment. Continue to survey the remainder of the segment for habitat quality.
    d. If a segment is not subsampled but 200+ abalone are counted, end the segment. Start a new adjacent segment or move onto the next natural segment.

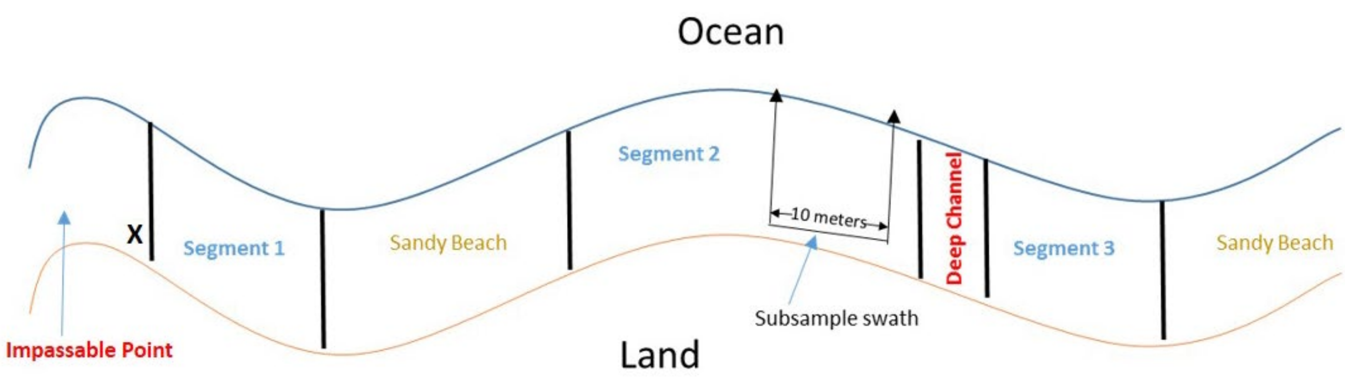


Figure 1. Survey setup example. X = predetermined starting point. Segments 1 & 3 had < 50 abs/10m of shoreline. Segment 2 had > 50 abs/10m of shoreline and was thus subsampled for abalone, but entire segment surveyed for habitat quality

5. At the completion of each segment, estimate the percent of the total area surveyed that is of good, moderate and poor habitat quality. The criteria used to distinguish these categories are:

   Good habitat –very suitable for abalone occupation/high refuge value. Any location where an abalone can live and receive protection from unsuitable environmental conditions and predation. These include cracks/crevices that are at least one hand length in depth (> 10-15cm), and are not too wide as to offer good protection to abalone. Note that such conditions may be found on the underside of boulders.

   Moderate habitat – moderately suitable for abalone occupation/moderate refuge value. Any location where an abalone can live and only receive moderate protection from unsuitable environmental conditions or predation. This includes cracks/crevices that are either not one hand length in depth or are too wide to offer the abalone good protection. May also include smaller pits or depressions in the rock (if big enough to support an abalone), and the undersides or sides of boulders.

   Poor habitat – minimally suitable for abalone occupation/low refuge value. Includes any location that offer little or no protection from unsuitable environmental conditions or predation (e.g. flat or bare surfaces), or areas outside the habitable zone for black abalone.

6. Also note and record additional segment characteristics:
   a. Substrate type (e.g. bedrock reef, boulders, mixed bedrock/boulders)
   b. Relief (high, moderate, low)
   c. Rock type
   d. Exposure (high, moderate, low)
   e. Sediment Influence (high, moderate, low)

Appendix 4: Comprehensive site information

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Pyramid Point	Del Norte	Mainland	41.989841	-124.2093	CA North	no	yes	SMCA	2012	Pyramid Point SMCA	NONE	NONE
Point Saint George	Del Norte	Mainland	41.784645	-124.2551	CA North	no	yes	NONE	2012	NONE	NONE	NONE
Enderts	Del Norte	Mainland	41.689999	-124.1426	CA North	yes	yes	NONE	2012	NONE	NONE	Redwood NP ASBS
Damnation Creek	Del Norte	Mainland	41.652489	-124.1278	CA North	yes	yes	NONE	2012	NONE	NONE	Redwood NP ASBS
False Klamath Cove	Del Norte	Mainland	41.594761	-124.1064	CA North	yes	yes	NONE	2012	NONE	NONE	Redwood NP ASBS
Palmers Point	Humboldt	Mainland	41.13121	-124.1633	CA North	no	yes	NONE	2012	NONE	NONE	NONE
Launcher Beach	Humboldt	Mainland	41.057156	-124.1453	CA North	no	yes	NONE	2012	NONE	NONE	Trinidad Head ASBS
Old Home Beach	Humboldt	Mainland	41.055275	-124.1368	CA North	no	yes	NONE	2012	NONE	NONE	NONE
Cape Mendocino	Humboldt	Mainland	40.341	-124.3632	CA North	yes	yes	NONE	2012	NONE	NONE	NONE
Shelter Cove	Humboldt	Mainland	40.022541	-124.0737	CA North	yes	yes	NONE	2012	NONE	NONE	King Range ASBS
Mal Coombs	Humboldt	Mainland	40.021698	-124.0683	CA North	no	yes	NONE	2012	NONE	NONE	King Range ASBS
Kibesillah Hill	Mendocino	Mainland	39.604118	-123.7889	CA North	yes	yes	NONE	2012	NONE	NONE	NONE
Abalobadiah Creek	Mendocino	Mainland	39.569065	-123.7718	CA North	no	yes	SMR	2012	Ten Mile SMR	NONE	NONE
MacKerricher	Mendocino	Mainland	39.482594	-123.8036	CA North	no	yes	SMCA	2012	MacKerricher SMCA	NONE	NONE
Fort Bragg	Mendocino	Mainland	39.439201	-123.8184	CA North	no	yes	NONE	2012	NONE	NONE	NONE
Point Arena	Mendocino	Mainland	38.955502	-123.7413	CA North	yes	yes	SMR	2010	Point Arena SMR	NONE	NONE
Stornetta	Mendocino	Mainland	38.93787	-123.7288	CA North	yes	yes	SMCA	2010	Sea Lion Cove SMCA	NONE	NONE

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Point Arena Field Station	Mendocino	Mainland	38.92704	-123.7279	CA North	yes	no	NONE	2010	NONE	NONE	NONE
Moat Creek	Mendocino	Mainland	38.880909	-123.6748	CA North	yes	yes	NONE	2010	NONE	NONE	NONE
Saunders Reef	Mendocino	Mainland	38.861382	-123.6536	CA North	yes	yes	SMCA	2010	Saunders Reef SMCA	NONE	Saunders Reef ASBS
Del Mar Landing	Sonoma	Mainland	38.740509	-123.5109	CA North	yes	yes	SMR	2010	Del Mar Landing SMR	NONE	Del Mar Landing Ecological Reserve ASBS
Sea Ranch	Sonoma	Mainland	38.730499	-123.4886	CA North	yes	yes	NONE	2010	NONE	NONE	NONE
Stewarts Point	Sonoma	Mainland	38.61364	-123.3675	CA North	no	yes	SMR	2010	Stewarts Point SMR	NONE	NONE
Phillips Gulch	Sonoma	Mainland	38.58585	-123.3415	CA North	yes	yes	SMCA	2010	Salt Point SMCA	NONE	NONE
Gerstle Cove	Sonoma	Mainland	38.566139	-123.3292	CA North	yes	yes	SMR	2010	Gerstle Cove SMR	NONE	Gerstle Cove ASBS
Windermere Point	Sonoma	Mainland	38.523941	-123.2675	CA North	yes	yes	NONE	2010	NONE	NONE	NONE
North Jenner Beach	Sonoma	Mainland	38.456181	-123.1424	CA North	yes	yes	SMCA	2010	Russian River SMCA	NONE	NONE
Bodega	Sonoma	Mainland	38.318199	-123.0737	CA North	yes	yes	SMR	2010	Bodega Head SMR	NONE	Bodega Marine Life Refuge ASBS
Horseshoe Cove	Sonoma	Mainland	38.316441	-123.0721	CA North	no	yes	SMR	2010	Bodega Head SMR	NONE	Bodega Marine Life Refuge ASBS
Bodega Head	Sonoma	Mainland	38.310398	-123.0824	CA North	yes	yes	NONE	2010	NONE	Gulf of the Farallones NMS	NONE
Santa Maria Creek	Marin	Mainland	38.012428	-122.8492	CA North	yes	yes	NONE	2010	NONE	Gulf of the Farallones NMS	NONE
Chimney Rock	Marin	Mainland	37.993832	-122.9673	CA North	yes	yes	SMR	2010	Point Reyes SMR	Gulf of the Farallones NMS	NONE
Bolinas Point	Marin	Mainland	37.903542	-122.7272	CA North	yes	yes	SMCA	2010	Duxbury Reef SMCA	Gulf of the Farallones NMS	Duxbury Reef Reserve and Extension ASBS
Alder Creek; Duxbury	Marin	Mainland	37.897579	-122.7107	CA North	no	yes	SMCA	2010	Duxbury Reef SMCA	Gulf of the Farallones NMS	Duxbury Reef Reserve and Extension ASBS
Slide Ranch	Marin	Mainland	37.874062	-122.6009	CA North	yes	no	NONE	2010	NONE	Monterey Bay NMS	NONE
Point Bonita	Marin	Mainland	37.819111	-122.5294	CA North	yes	no	NONE	2010	NONE	NONE	NONE

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Alcatraz	San Francisc	Alcatraz	37.825001	-122.4219	CA SF Bay	yes	yes	NONE	NONE	NONE	NONE	NONE
Blowhole	San Francisc	Southeast F	37.70118	-123.0038	CA Central	yes	no	SMR	2010	Southeast Farallon Island SMR	Gulf of the Farallones NMS	Farallon Islands ASBS
Dead Sea Lion Flat	San Francisc	Southeast F	37.698093	-122.9998	CA Central	yes	no	SMR	2010	Southeast Farallon Island SMR	Gulf of the Farallones NMS	Farallon Islands ASBS
Mussel Flat Farallones	San Francisc	Southeast F	37.6959	-123.0029	CA Central	yes	yes	SMR	2010	Southeast Farallon Island SMR	Gulf of the Farallones NMS	Farallon Islands ASBS
Fitzgerald Marine Reserve	San Mateo	Mainland	37.521671	-122.5167	CA Central	no	yes	SMR	2010	Montara SMR	Monterey Bay NMS	James V. Fitzgerald Marine Reserve ASBS
Pebble Beach	San Mateo	Mainland	37.232632	-122.4161	CA Central	yes	no	NONE	2010	NONE	Monterey Bay NMS	NONE
Pigeon Point	San Mateo	Mainland	37.183609	-122.3953	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Franklin Point	San Mateo	Mainland	37.149502	-122.361	CA Central	yes	no	SMR	2007	Ano Nuevo SMR	Monterey Bay NMS	NONE
Ano Nuevo	San Mateo	Mainland	37.10778	-122.2944	CA Central	no	yes	SMR	2007	Ano Nuevo SMR	Monterey Bay NMS	Ano Nuevo Point and Islands ASBS
Scott Creek	Santa Cruz	Mainland	37.04425	-122.2349	CA Central	yes	yes	SMCA	2007	Greyhound Rock SMCA	Monterey Bay NMS	NONE
Davenport Landing	Santa Cruz	Mainland	37.022079	-122.2154	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Sandhill Bluff	Santa Cruz	Mainland	36.980171	-122.155	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Wilder Ranch	Santa Cruz	Mainland	36.94915	-122.1038	CA Central	yes	yes	SMR	2007	Natural Bridges SMR	Monterey Bay NMS	NONE
Terrace Point	Santa Cruz	Mainland	36.94841	-122.0646	CA Central	yes	yes	SMR	2007	Natural Bridges SMR	Monterey Bay NMS	NONE
Natural Bridges	Santa Cruz	Mainland	36.94915	-122.0611	CA Central	yes	yes	SMR	2007	Natural Bridges SMR	Monterey Bay NMS	NONE

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Hopkins	Monterey	Mainland	36.621201	-121.9073	CA Central	yes	yes	SMR	2007	Lovers Point - Julia Platt SMR	Monterey Bay NMS	Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge ASBS
Point Pinos	Monterey	Mainland	36.637959	-121.9376	CA Central	yes	yes	SMR	2007	Asilomar SMR	Monterey Bay NMS	NONE
Asilomar	Monterey	Mainland	36.62225	-121.9416	CA Central	yes	yes	SMR	2007	Asilomar SMR	Monterey Bay NMS	NONE
China Rocks	Monterey	Mainland	36.606159	-121.9594	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Pescadero Point	Monterey	Mainland	36.561089	-121.9544	CA Central	yes	no	NONE	2007	NONE	Monterey Bay NMS	NONE
Stillwater	Monterey	Mainland	36.560871	-121.9405	CA Central	yes	yes	SMCA	2007	Carmel Bay SMCA	Monterey Bay NMS	Carmel Bay ASBS
Carmel Point	Monterey	Mainland	36.543758	-121.9341	CA Central	yes	no	SMCA	2007	Carmel Bay SMCA	Monterey Bay NMS	Carmel Bay ASBS
Point Lobos	Monterey	Mainland	36.51366	-121.9469	CA Central	yes	yes	SMR	2007	Point Lobos SMR	Monterey Bay NMS	Point Lobos Ecological Reserve ASBS
Mal Paso	Monterey	Mainland	36.479939	-121.9391	CA Central	yes	no	NONE	2007	NONE	Monterey Bay NMS	NONE
Garrapata	Monterey	Mainland	36.46904	-121.9344	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Soberanes	Monterey	Mainland	36.447868	-121.9287	CA Central	yes	no	NONE	2007	NONE	Monterey Bay NMS	NONE
Andrew Molera	Monterey	Mainland	36.280609	-121.8632	CA Central	yes	yes	SMR	2007	Point Sur SMR	Monterey Bay NMS	NONE
Partington Cove	Monterey	Mainland	36.173759	-121.6965	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	Julia Pfeiffer Burns Underwater Park ASBS
Lucia	Monterey	Mainland	36.014381	-121.5405	CA Central	no	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Mill Creek	Monterey	Mainland	35.979649	-121.4903	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Pacific Valley	Monterey	Mainland	35.947048	-121.4805	CA Central	yes	no	NONE	2007	NONE	Monterey Bay NMS	NONE
Duck Pond	Monterey	Mainland	35.859169	-121.4223	CA Central	no	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Point Sierra Nevada	San Luis Obi	Mainland	35.728828	-121.3187	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Piedras Blancas	San Luis Obi	Mainland	35.664928	-121.287	CA Central	yes	yes	SMR	2007	Piedras Blancas SMR	Monterey Bay NMS	NONE

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
San Simeon Point	San Luis Obi	Mainland	35.634548	-121.1956	CA Central	yes	yes	NONE	2007	NONE	Monterey Bay NMS	NONE
Vista del Mar	San Luis Obi	Mainland	35.604141	-121.1423	CA Central	yes	yes	SMCA	2007	Cambria SMCA	Monterey Bay NMS	NONE
Rancho Marino; Cambria	San Luis Obi	Mainland	35.522442	-121.073	CA Central	yes	yes	SMCA	2007	White Rock SMCA	NONE	NONE
Harmony Headlands	San Luis Obi	Mainland	35.47448	-121.0171	CA Central	yes	no	NONE	2007	NONE	NONE	NONE
Cayucos	San Luis Obi	Mainland	35.447392	-120.9498	CA Central	yes	yes	NONE	2007	NONE	NONE	NONE
Hazards	San Luis Obi	Mainland	35.289661	-120.8833	CA Central	yes	yes	NONE	2007	NONE	NONE	NONE
Diablo	San Luis Obi	Mainland	35.22691	-120.8743	CA Central	yes	yes	SMR	2007	Point Buchon SMR	NONE	NONE
Shell Beach	San Luis Obi	Mainland	35.168812	-120.6967	CA Central	yes	yes	NONE	2007	NONE	NONE	NONE
Occulto	Santa Barba	Mainland	34.881222	-120.6395	CA Central	yes	no	NONE	2007	NONE	NONE	NONE
Purisima	Santa Barba	Mainland	34.7556	-120.6408	CA Central	yes	no	NONE	2007	NONE	NONE	NONE
Stairs	Santa Barba	Mainland	34.730381	-120.6155	CA Central	yes	yes	SMR	2007	Vandenberg SMR	NONE	NONE
Lompoc Landing	Santa Barba	Mainland	34.7188	-120.6088	CA Central	yes	yes	SMR	2007	Vandenberg SMR	NONE	NONE
Boat House	Santa Barba	Mainland	34.553879	-120.6117	CA Central	yes	yes	NONE	2007	NONE	NONE	NONE
Government Point	Santa Barba	Mainland	34.44334	-120.4566	CA South	yes	yes	SMR	2012	Point Conception SMR	NONE	NONE
Alegria	Santa Barba	Mainland	34.46714	-120.2774	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Arroyo Hondo	Santa Barba	Mainland	34.473438	-120.1454	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Ellwood	Santa Barba	Mainland	34.435188	-119.9308	CA South	yes	yes	NONE	2012	NONE	NONE	NONE

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Coal Oil Point	Santa Barba	Mainland	34.406929	-119.878	CA South	yes	yes	SMCA	2012	Campus Point SMCA	NONE	NONE
Carpinteria	Santa Barba	Mainland	34.387032	-119.5141	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Mussel Shoals	Ventura	Mainland	34.35548	-119.4407	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Old Stairs	Ventura	Mainland	34.06612	-118.9978	CA South	yes	yes	NONE	2012	NONE	NONE	Mugu Lagoon to Latigo Point ASBS
Deer Creek	Ventura	Mainland	34.060692	-118.9822	CA South	no	yes	NONE	2012	NONE	NONE	Mugu Lagoon to Latigo Point ASBS
Sequit Point	Los Angeles	Mainland	34.043228	-118.937	CA South	yes	yes	NONE	2012	NONE	NONE	Mugu Lagoon to Latigo Point ASBS
Lechuza Point	Los Angeles	Mainland	34.034458	-118.8618	CA South	yes	yes	SMCA	2012	Point Dume SMCA	NONE	Mugu Lagoon to Latigo Point ASBS
Point Dume	Los Angeles	Mainland	34.000359	-118.807	CA South	no	yes	SMR	2012	Point Dume SMR	NONE	Mugu Lagoon to Latigo Point ASBS
Paradise Cove	Los Angeles	Mainland	34.012009	-118.7923	CA South	yes	yes	SMR	2012	Point Dume SMR	NONE	Mugu Lagoon to Latigo Point ASBS
Point Vicente	Los Angeles	Mainland	33.741009	-118.4095	CA South	yes	yes	SMCA	2012	Point Vicente SMCA	NONE	NONE
Abalone Cove	Los Angeles	Mainland	33.737782	-118.3761	CA South	yes	yes	SMCA	2012	Abalone Cove SMCA	NONE	NONE
White Point	Los Angeles	Mainland	33.715389	-118.3196	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Point Fermin	Los Angeles	Mainland	33.706791	-118.286	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Buck Gully South	Orange	Mainland	33.588242	-117.8674	CA South	no	yes	SMCA	2012	Crystal Cove SMCA	NONE	NONE
Crystal Cove	Orange	Mainland	33.570782	-117.8377	CA South	yes	yes	SMCA	2012	Crystal Cove SMCA	NONE	Irvine Coast Marine Life Refuge ASBS
Muddy Canyon	Orange	Mainland	33.565762	-117.8331	CA South	no	yes	SMCA	2012	Crystal Cove SMCA	NONE	Irvine Coast Marine Life Refuge ASBS
Shaws Cove	Orange	Mainland	33.544769	-117.7994	CA South	yes	yes	SMR	2012	Laguna Beach SMR	NONE	NONE
Heisler Park	Orange	Mainland	33.542591	-117.7893	CA South	no	yes	SMR	2012	Laguna Beach SMR	NONE	Heisler Park Ecological Reserve ASBS

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Treasure Island	Orange	Mainland	33.513351	-117.7579	CA South	yes	yes	SMCA	2012	Laguna Beach SMCA	NONE	NONE
Dana Point	Orange	Mainland	33.4599	-117.7148	CA South	yes	yes	SMCA	2012	Dana Point SMCA	NONE	NONE
Swamis Beach	San Diego	Mainland	33.035099	-117.2943	CA South	yes	no	SMCA	2012	Swamis SMCA	NONE	NONE
Cardiff Reef	San Diego	Mainland	32.99984	-117.2787	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Scripps Reef	San Diego	Mainland	32.871651	-117.2533	CA South	yes	yes	SMCA	2012	San Diego-Scripps Coastal SMCA	NONE	San Diego Marine Life Refuge ASBS
La Jolla Caves	San Diego	Mainland	32.843231	-117.2812	CA South	yes	yes	SMR	2012	Matlahuayl SMR	NONE	NONE
Wind and Sea	San Diego	Mainland	32.832851	-117.2823	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Sea Ridge	San Diego	Mainland	32.807991	-117.2679	CA South	yes	yes	SMR	2012	South La Jolla SMR	NONE	NONE
Navy North	San Diego	Mainland	32.6926	-117.2533	CA South	yes	yes	NONE	2012	NONE	NONE	NONE
Navy South	San Diego	Mainland	32.68288	-117.2496	CA South	yes	no	NONE	2012	NONE	NONE	NONE
Cabrillo I	San Diego	Mainland	32.669472	-117.2455	CA South	yes	yes	SMR	2012	Cabrillo SMR	NONE	NONE
Cabrillo II	San Diego	Mainland	32.66766	-117.2453	CA South	yes	no	SMR	2012	Cabrillo SMR	NONE	NONE
Cabrillo III	San Diego	Mainland	32.665829	-117.2442	CA South	yes	yes	SMR	2012	Cabrillo SMR	NONE	NONE
Otter Harbor	Santa Barba	San Miguel	34.052029	-120.4076	CA Channel Islands North	yes	no	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Harris Point	Santa Barba	San Miguel	34.073372	-120.3632	CA Channel Islands North	yes	no	SMR	2003	Harris Point SMR	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Cuyler Harbor	Santa Barba	San Miguel	34.04855	-120.3364	CA Channel Islands North	yes	yes	SMR	2003	Harris Point SMR	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Crook Point	Santa Barba	San Miguel	34.021591	-120.3789	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Fossil Reef	Santa Barba	Santa Rosa	33.993149	-120.2376	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
NW Talcott	Santa Barba	Santa Rosa	34.009571	-120.2176	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Carrington Point	Santa Barba	Santa Rosa	34.03352	-120.0439	CA Channel Islands North	yes	yes	SMR	2003	Carrington Point SMR	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
East Point	Santa Barba	Santa Rosa	33.942699	-119.968	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Ford Point	Santa Barba	Santa Rosa	33.914532	-120.0502	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Johnsons Lee	Santa Barba	Santa Rosa	33.908718	-120.0863	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
South Point	Santa Barba	Santa Rosa	33.911621	-120.151	CA Channel Islands North	no	yes	SMR	2003	South Point SMR	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Trailer	Santa Barba	Santa Cruz	34.051868	-119.9032	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Forney	Santa Barba	Santa Cruz	34.056389	-119.9222	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Fraser Cove	Santa Barba	Santa Cruz	34.062649	-119.9192	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Orizaba Cove	Santa Barba	Santa Cruz	34.045078	-119.7219	CA Channel Islands North	yes	no	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Prisoners Harbor	Santa Barba	Santa Cruz	34.020378	-119.6867	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Scorpion Rock	Santa Barba	Santa Cruz	34.045521	-119.5469	CA Channel Islands North	yes	no	SMR	2003	Scorpion SMR	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Valley	Santa Barba	Santa Cruz	33.983891	-119.6658	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Valley Anchorage	Santa Barba	Santa Cruz	33.969028	-119.6441	CA Channel Islands North	yes	no	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Willows Anchorage	Santa Barba	Santa Cruz	33.96183	-119.755	CA Channel Islands North	yes	yes	NONE	2003	NONE	Channel Islands NMS	San Miguel; Santa Rosa; and Santa Cruz Islands ASBS
Cat Rock	Ventura	Anacapa	34.005569	-119.4193	CA Channel Islands North	yes	yes	NONE	2003	Anacapa Island Special Closure	Channel Islands NMS	Santa Barbara Island and Anacapa Island ASBS
Middle West	Ventura	Anacapa	34.005901	-119.3965	CA Channel Islands North	yes	yes	SMR	2003	Anacapa Island SMR	Channel Islands NMS	Santa Barbara Island and Anacapa Island ASBS
Middle East	Ventura	Anacapa	34.005798	-119.3958	CA Channel Islands North	yes	no	SMR	2003	Anacapa Island SMR	Channel Islands NMS	Santa Barbara Island and Anacapa Island ASBS
S Frenchys Cove	Ventura	Anacapa	34.006599	-119.4108	CA Channel Islands North	yes	yes	SC	2003	Anacapa Island Special Closure	Channel Islands NMS	Santa Barbara Island and Anacapa Island ASBS
Landing Cove	Santa Barba	Santa Barba	33.481579	-119.0296	CA Channel Islands South	yes	yes	NONE	2003	NONE	Channel Islands NMS	Santa Barbara Island and Anacapa Island ASBS
Sea Lion Rookery	Santa Barba	Santa Barba	33.472012	-119.0307	CA Channel Islands South	yes	yes	SMR	2003	Santa Barbara Island SMR	Channel Islands NMS	Santa Barbara Island and Anacapa Island ASBS

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Thousand Springs	Ventura	San Nicolas	33.285049	-119.5298	CA Channel Islands South	yes	yes	NONE	NONE	NONE	NONE	NONE
Tranquility Beach	Ventura	San Nicolas	33.265671	-119.4921	CA Channel Islands South	no	yes	NONE	NONE	NONE	NONE	NONE
Anchor Point	Ventura	San Nicolas	33.267136	-119.4872	CA Channel Islands South	yes	no	NONE	NONE	NONE	NONE	NONE
Marker Poles	Ventura	San Nicolas	33.218681	-119.4956	CA Channel Islands South	yes	yes	NONE	NONE	NONE	NONE	NONE
Cosign	Ventura	San Nicolas	33.274464	-119.5768	CA Channel Islands South	yes	no	NONE	NONE	NONE	NONE	NONE
Two Harbors	Los Angeles	Catalina	33.444351	-118.4989	CA Channel Islands South	no	yes	NONE	2012	NONE	NONE	Santa Catalina Island - Subarea One; Isthmus Cove to Catalina Head ASBS
Bird Rock	Los Angeles	Catalina	33.45145	-118.4876	CA Channel Islands South	yes	yes	SMCA	2012	Blue Cavern Onshore SMCA	NONE	Santa Catalina Island - Subarea One; Isthmus Cove to Catalina Head ASBS
Big Fisherman Cove	Los Angeles	Catalina	33.446411	-118.4853	CA Channel Islands South	no	yes	SMCA	2012	Blue Cavern Onshore SMCA	NONE	Santa Catalina Island - Subarea One; Isthmus Cove to Catalina Head ASBS
Goat Harbor	Los Angeles	Catalina	33.416801	-118.3941	CA Channel Islands South	no	yes	SMR	2012	Long Point SMR	NONE	NONE
Avalon Quarry	Los Angeles	Catalina	33.321999	-118.3052	CA Channel Islands South	no	yes	NONE	2012	NONE	NONE	Santa Catalina Island - Subarea Four; Binnacle Rock to Jewfish Point ASBS

MARINe site name	county	island	latitude	longitude	georegion	long term site	biodiversity site	mpa designation	mpa baseline year	mpa_name	nms_name	asbs_name
Little Harbor	Los Angeles	Catalina	33.384991	-118.4752	CA Channel Islands South	yes	yes	NONE	2012	NONE	NONE	Santa Catalina Island - Subarea Two; North End of Little Harbor to Ben Weston Point ASBS
West Cove	Los Angeles	San Clemen	33.014771	-118.6061	CA Channel Islands South	yes	yes	NONE	NONE	NONE	NONE	NONE
North Head	Los Angeles	San Clemen	33.032867	-118.6006	CA Channel Islands South	no	yes	NONE	NONE	NONE	NONE	NONE
Graduation Point	Los Angeles	San Clemen	33.033276	-118.5756	CA Channel Islands South	no	yes	NONE	NONE	NONE	NONE	NONE
Boy Scout Camp	Los Angeles	San Clemen	33.001122	-118.5483	CA Channel Islands South	yes	yes	NONE	NONE	NONE	NONE	San Clemente Island ASBS
Horse Beach Cove	Los Angeles	San Clemen	32.803001	-118.4243	CA Channel Islands South	yes	no	NONE	NONE	NONE	NONE	NONE
Eel Point	Los Angeles	San Clemen	32.918011	-118.5467	CA Channel Islands South	yes	yes	NONE	NONE	NONE	NONE	San Clemente Island ASBS

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Pyramid Point	NONE	NONE	NONE	NONE	Smith River Rancheria	https://marine.ucsc.edu/sitepages/pyramid.html	2014	2016	2		
Point Saint George	NONE	NONE	NONE	NONE	Smith River Rancheria	https://marine.ucsc.edu/sitepages/saintgeorge.html	2014	2016	1		
Enderts	Redwood NP	KLMN	Del Norte Coast Redwoods SP	NONE	NONE	https://marine.ucsc.edu/sitepages/enderts.html	2014	2004	3	16	
Damnation Creek	Redwood NP	KLMN	Del Norte Coast Redwoods SP	NONE	NONE	https://marine.ucsc.edu/sitepages/damnation.html	2004	2004	5	17	
False Klamath Cove	Redwood NP	KLMN	Del Norte Coast Redwoods SP	NONE	Yurok Tribe	https://marine.ucsc.edu/sitepages/falseklamath.html	2014	2004	4	17	
Palmers Point	NONE	NONE	Patricks Point SP	NONE	NONE	https://marine.ucsc.edu/sitepages/palmerspoint.html	2015	2016	1		
Launcher Beach	NONE	NONE	NONE	NONE	Trinidad Rancheria; Yurok Tribe	https://marine.ucsc.edu/sitepages/launcher.html	2014	2016	2		
Old Home Beach	NONE	NONE	NONE	NONE	Yurok Tribe	https://marine.ucsc.edu/sitepages/oldhome.html	2014	2016	1		
Cape Mendocino	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/capemendocino.html	2002	2004	2	16	
Shelter Cove	King Range NCA	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/sheltercove.html	2001	2004	2	15	15
Mal Coombs	King Range NCA	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/malcoombs.html	2014	2016	2		
Kibesillah Hill	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/kibesillah.html	2001	2004	4	15	
Abalobadiah Creek	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/abalobadiah.html	2015	2016	2		
MacKerricher	NONE	NONE	MacKerricher SP	NONE	NONE	https://marine.ucsc.edu/sitepages/mackerricher.html	2015	2016	3		
Fort Bragg	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/fortbragg.html	2015	2016	1		
Point Arena	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/pointarena.html	2010	2010	2	3	3
Stornetta	California Coastal NM	NONE	NONE	NONE	Stornetta Ranch BLM Public Easement	https://marine.ucsc.edu/sitepages/stornetta.html	2004	2005	3	15	15

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Point Arena Field Station	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/ptarenafieldstation.html		2011		2	2
Moat Creek	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/moatcreek.html	2010	2010	2	3	3
Saunders Reef	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/saundersreef.html	2010	2010	3	3	2
Del Mar Landing	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/delmarlanding.html	2010	2010	3	4	4
Sea Ranch	NONE	NONE	NONE	NONE	Sea Ranch Preserve	https://marine.ucsc.edu/sitepages/searanch.html	2001	2004	4	17	2
Stewarts Point	NONE	NONE	Salt Point SP	NONE	NONE	https://marine.ucsc.edu/sitepages/stewarts.html	2017	2017	1		
Phillips Gulch	NONE	NONE	Salt Point SP	NONE	NONE	https://marine.ucsc.edu/sitepages/phillipsgulch.html	2010	2010	2	3	3
Gerstle Cove	NONE	NONE	Salt Point SP	NONE	NONE	https://marine.ucsc.edu/sitepages/gerstlecove.html	2010	2010	2	5	5
Windermere Point	NONE	NONE	Fort Ross SHP	NONE	NONE	https://marine.ucsc.edu/sitepages/windermerepoint.html	2010	2010	1	3	3
North Jenner Beach	NONE	NONE	Sonoma Coast SB	NONE	NONE	https://marine.ucsc.edu/sitepages/northjenner.html	2010	2011	1	1	
Bodega	NONE	NONE	NONE	NONE	Bodega UC Marine Reserve	https://marine.ucsc.edu/sitepages/bodega.html	2001	2001	5	17	
Horseshoe Cove	NONE	NONE	NONE	NONE	Bodega UC Marine Reserve	https://marine.ucsc.edu/sitepages/horseshoecove.html	2012	2016	2		
Bodega Head	NONE	NONE	Sonoma Coast SB	NONE	NONE	https://marine.ucsc.edu/sitepages/bodegahead.html	2010	2010	1	2	
Santa Maria Creek	Point Reyes NS	SFAN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/santamariacreek.html	2002	2006	4	15	3
Chimney Rock	Point Reyes NS	SFAN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/chimneyrock.html	2010	2011	2	2	
Bolinas Point	Point Reyes NS	SFAN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/bolinaspoint.html	2002	2006	5	15	3
Alder Creek; Duxbury	NONE	NONE	NONE	Agate Beach County Park	NONE	https://marine.ucsc.edu/sitepages/aldercreekduxbury.html	2008	2016	1		
Slide Ranch	Golden Gate Nat Rec Area	SFAN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/slideranch.html		1989		17	3
Point Bonita	Golden Gate Nat Rec Area	SFAN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/pointbonita.html		1998		16	2

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Alcatraz	Golden Gate NRA	SFAN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/alcatrazisland.html	2005	1989	1	16	3
Blowhole	NONE	NONE	NONE	NONE	Southeast Farallon Island Special Closure	https://marine.ucsc.edu/sitepages/blowhole.html		2017		2	
Dead Sea Lion Flat	NONE	NONE	NONE	NONE	Southeast Farallon Island Special Closure	https://marine.ucsc.edu/sitepages/deadsealion.html		2018		2	
Mussel Flat Farallones	NONE	NONE	NONE	NONE	Southeast Farallon Island Special Closure	https://marine.ucsc.edu/sitepages/musselflat.html	2005	2018	2	1	
Fitzgerald Marine Reserve	NONE	NONE	NONE	San Mateo County Park	NONE	https://marine.ucsc.edu/sitepages/fitzgerald.html	2002	2016	5		
Pebble Beach	NONE	NONE	Bean Hollow State Beach	NONE	NONE	https://marine.ucsc.edu/sitepages/pebblebeach.html		2004		17	17
Pigeon Point	NONE	NONE	Pigeon Pt Lightstation SHP	NONE	NONE	https://marine.ucsc.edu/sitepages/pigeonpoint.html	2002	2002	4	14	14
Franklin Point	NONE	NONE	Ano Nuevo SP	NONE	NONE	https://marine.ucsc.edu/sitepages/franklinpoint.html		2004		17	17
Ano Nuevo	NONE	NONE	Ano Nuevo SP	NONE	NONE	https://marine.ucsc.edu/sitepages/anonuevo.html	2002	2016	3		
Scott Creek	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/scottcreek.html	2000	1999	3	17	15
Davenport Landing	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/davenport.html	2007	2007	3	7	3
Sandhill Bluff	NONE	NONE	Coast Dairies SP	NONE	NONE	https://marine.ucsc.edu/sitepages/sandhillbluff.html	2000	1999	3	17	
Wilder Ranch	NONE	NONE	Wilder Ranch SP	NONE	NONE	https://marine.ucsc.edu/sitepages/wilderranch.html	2007	2007	1	4	
Terrace Point	NONE	NONE	Natural Bridges SP	NONE	NONE	https://marine.ucsc.edu/sitepages/terracepoint.html	2000	1999	2	17	1
Natural Bridges	NONE	NONE	Natural Bridges SP	NONE	NONE	https://marine.ucsc.edu/sitepages/naturalbridges.html	2007	2007	1	5	

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Hopkins	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/hopkins.html	2000	1999	3	17	16
Point Pinos	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/pointpinos.html	2007	2007	2	14	14
Asilomar	NONE	NONE	Asilomar SB	NONE	NONE	https://marine.ucsc.edu/sitepages/asilomar.html	2012	2012	1	9	9
China Rocks	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/chinarocks.html	2007	2007	3	14	13
Pescadero Point	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/pescadero.html		2008		13	13
Stillwater	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/stillwater.html	2001	2000	4	17	17
Carmel Point	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/carmelpoint.html		2004		17	17
Point Lobos	NONE	NONE	Point Lobos SP	NONE	NONE	https://marine.ucsc.edu/sitepages/pointlobos.html	2001	1999	4	17	17
Mal Paso	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/malpaso.html		2000		2	2
Garrapata	NONE	NONE	Garrapata SB	NONE	NONE	https://marine.ucsc.edu/sitepages/garrapata.html	2007	2007	3	14	14
Soberanes	NONE	NONE	Garrapata SB	NONE	NONE	https://marine.ucsc.edu/sitepages/soberanes.html		2004		17	17
Andrew Molera	NONE	NONE	Andrew Molera SP	NONE	NONE	https://marine.ucsc.edu/sitepages/andrewmolera.html	2001	1999	3	17	17
Partington Cove	NONE	NONE	Julia Pfeiffer SP	NONE	NONE	https://marine.ucsc.edu/sitepages/partington.html	2003	2004	1	16	16
Lucia	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/lucia.html	2004	2016	1		
Mill Creek	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/millcreek.html	2001	1999	3	17	17
Pacific Valley	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/pacificvalley.html		2004		17	17
Duck Pond	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/duckpond.html	2003	2016	1		
Point Sierra Nevada	NONE	NONE	Hearst Ranch SP	NONE	NONE	https://marine.ucsc.edu/sitepages/pointsierra.html	2001	1995	2	17	17
Piedras Blancas	Piedras Blancas Light Station; BLM	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/piedrasblancas.html	2008	1997	2	17	17

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
San Simeon Point	NONE	NONE	Hearst San Simeon SP	NONE	Hearst Property	https://marine.ucsc.edu/sitepages/sansimeonpoint.html	2007	2007	1	4	
Vista del Mar	NONE	NONE	San Simeon SP	NONE	NONE	https://marine.ucsc.edu/sitepages/vistadelmar.html	2008	2004	1	16	16
Rancho Marino; Cambria	NONE	NONE	NONE	NONE	Rancho Marino UC Reserve	https://marine.ucsc.edu/sitepages/cambria.html	2001	2001	1	17	17
Harmony Headlands	NONE	NONE	Harmony Headlands SP	NONE	NONE	https://marine.ucsc.edu/sitepages/harmony.html		2008		13	4
Cayucos	NONE	NONE	Estero Bluffs SP	NONE	NONE	https://marine.ucsc.edu/sitepages/cayucos.html	2001	1995	2	17	16
Hazards	NONE	NONE	Montana de Oro SP	NONE	NONE	https://marine.ucsc.edu/sitepages/hazards.html	2001	1995	2	17	
Diablo	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/diablo.html	2008	2007	2	5	3
Shell Beach	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/shellbeach.html	2001	1995	2	17	2
Occulto	Vandenberg AFB	NONE	NONE	NONE	Vandenberg Ecological Reserve	https://marine.ucsc.edu/sitepages/occulto.html		1992		17	
Purisima	Vandenberg AFB	NONE	NONE	NONE	Vandenberg Ecological Reserve	https://marine.ucsc.edu/sitepages/purisima.html		1993		17	17
Stairs	Vandenberg AFB	NONE	NONE	NONE	Vandenberg Ecological Reserve	https://marine.ucsc.edu/sitepages/stairs.html	2001	1992	2	17	17
Lompoc Landing	Vandenberg AFB	NONE	NONE	NONE	Vandenberg Ecological Reserve	https://marine.ucsc.edu/sitepages/lompoclanding.html	2007	2014	1	3	3
Boat House	Vandenberg AFB	NONE	NONE	NONE	Vandenberg Ecological Reserve	https://marine.ucsc.edu/sitepages/boathouse.html	2001	1992	3	17	17
Government Point	NONE	NONE	NONE	NONE	Bixby Ranch	https://marine.ucsc.edu/sitepages/government.html	2001	1992	3	10	9
Alegria	NONE	NONE	NONE	NONE	Hollister Ranch Conservancy	https://marine.ucsc.edu/sitepages/alegria.html	2001	1992	3	17	7
Arroyo Hondo	NONE	NONE	NONE	NONE	Arroyo Hondo Preserve	https://marine.ucsc.edu/sitepages/arroyohondo.html	2001	1992	2	17	4
Ellwood	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/ellwood.html	2012	2012	1	2	

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Coal Oil Point	NONE	NONE	NONE	NONE	Coal Oil Point UC Reserve	https://marine.ucsc.edu/sitepages/coaloilpoint.html	2002	1992	3	17	7
Carpinteria	NONE	NONE	Carpinteria SB	NONE	NONE	https://marine.ucsc.edu/sitepages/carpinteria.html	2001	1992	2	17	7
Mussel Shoals	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/musselshoals.html	2001	1994	1	17	4
Old Stairs	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/oldstairs.html	2001	1994	3	17	4
Deer Creek	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/deercreek.html	2013	2016	2		
Sequit Point	NONE	NONE	Leo Carillo SB	NONE	NONE	https://marine.ucsc.edu/sitepages/sequitpoint.html	2009	2012	3	3	
Lechuza Point	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/lechuzapoint.html	2009	2012	3	3	
Point Dume	NONE	NONE	Point Dume SB	NONE	NONE	https://marine.ucsc.edu/sitepages/pointdume.html	2013	2016	1		
Paradise Cove	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/paradisecove.html	2001	1994	4	17	4
Point Vicente	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/pointvicente.html	2012	2012	1	4	2
Abalone Cove	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/abalonecove.html	2012	2016	1		
White Point	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/whitepoint.html	2001	1994	2	17	4
Point Fermin	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/pointfermin.html	2001	1999	2	17	4
Buck Gully South	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/buckgullysouth.html	2009	2016	2		
Crystal Cove	NONE	NONE	Crystal Cove SP	NONE	NONE	https://marine.ucsc.edu/sitepages/crystalcove.html	2001	1996	3	17	17
Muddy Canyon	NONE	NONE	Crystal Cove SP	NONE	NONE	https://marine.ucsc.edu/sitepages/muddycanyon.html	2013	2016	1		
Shaws Cove	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/shawscove.html	2001	1996	3	17	17
Heisler Park	NONE	NONE	NONE	Orange County Marine Protected Areas	NONE	https://marine.ucsc.edu/sitepages/heislerpark.html	2009	2016	3		

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Treasure Island	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/treasureisland.html	2017	1996	1	17	17
Dana Point	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/danapoint.html	2001	1996	5	17	17
Swamis Beach	NONE	NONE	Cardiff SB	NONE	NONE	https://marine.ucsc.edu/sitepages/swamis.html		2017		4	4
Cardiff Reef	NONE	NONE	Cardiff SB	NONE	NONE	https://marine.ucsc.edu/sitepages/cardiffreef.html	2012	1997	1	16	15
Scripps Reef	NONE	NONE	NONE	NONE	Scripps UC Coastal Reserve	https://marine.ucsc.edu/sitepages/scripps.html	2002	1997	4	16	15
La Jolla Caves	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/lajollacaves.html	2009	2012	3	4	
Wind and Sea	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/windandsea.html	2012	2012	3	5	
Sea Ridge	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/searidge.html	2012	2012	2	4	
Navy North	NONE	NONE	NONE	NONE	US Navy	https://marine.ucsc.edu/sitepages/navynorth.html	2012	1995	1	15	7
Navy South	NONE	NONE	NONE	NONE	US Navy	https://marine.ucsc.edu/sitepages/navysouth.html		1995		15	7
Cabrillo I	Cabrillo NM	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/cabrillo1.html	2002	1990	4	17	16
Cabrillo II	Cabrillo NM	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/cabrillo2.html		1990		17	16
Cabrillo III	Cabrillo NM	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/cabrillo3.html	2002	1990	2	17	16
Otter Harbor	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/otterharbor.html		1985		14	14
Harris Point	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/harrispoint.html		1985		14	14
Cuyler Harbor	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/cuylerharbor.html	2001	1985	1	14	14
Crook Point	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/crookpoint.html	2001	1985	1	14	14

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Fossil Reef	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/fossilreef.html	2001	1988	1	13	13
NW Talcott	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/nwtalcott.html	2001	1986	1	13	12
Carrington Point	Channel Islands NP	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/carringtonpoint.html	2017	2016	1		
East Point	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/eastpoint.html	2001	1986	1	13	13
Ford Point	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/fordpoint.html	2001	1985	1	13	13
Johnsons Lee	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/johnsonslee.html	2001	1985	2	13	13
South Point	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/southpoint.html	2017	2017	1		
Trailer	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/trailer.html	2002	1994	1	15	14
Forney	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/forney.html	2002	2016			
Fraser Cove	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/frasercove.html	2002	1994	1	15	14
Orizaba Cove	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/orizabacove.html		1994		11	10

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Prisoners Harbor	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/prisonersharbor.html	2002	1994	1	15	14
Scorpion Rock	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/scorpionrock.html		1994		15	12
Valley	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/valley.html	2002	2016	1		
Valley Anchorage	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/valleyanchorage.html		2008		6	6
Willows Anchorage	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/willows.html	2002	1994	1	15	15
Cat Rock	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/catrock.html	2001	1981	1	15	15
Middle West	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/middlewest.html	2001	1982	3	15	15
Middle East	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/middleeast.html		1982		8	
S Frenchys Cove	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/sfrenchyscove.html	2001	1982	2	15	13
Landing Cove	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/landingcove.html	2001	1985	2	14	14
Sea Lion Rookery	Channel Islands NP	MEDN	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/sealionrookery.html	2001	1985	2	13	13

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Thousand Springs	NONE	NONE	NONE	NONE	San Nicholas Island Navy Outlying Field (NOLF)	https://marine.ucsc.edu/sitepages/thousandsprings.html	2003	2014	2	6	6
Tranquility Beach	NONE	NONE	NONE	NONE	San Nicholas Island Navy Outlying Field (NOLF)	https://marine.ucsc.edu/sitepages/tranquility.html	2009	2016	2		
Anchor Point	NONE	NONE	NONE	NONE	San Nicholas Island Navy Outlying Field (NOLF)	https://marine.ucsc.edu/sitepages/anchorpoint.html		2014		6	4
Marker Poles	NONE	NONE	NONE	NONE	San Nicholas Island Navy Outlying Field (NOLF)	https://marine.ucsc.edu/sitepages/markerpoles.html	2003	2014	2	6	6
Cosign	NONE	NONE	NONE	NONE	San Nicholas Island Navy Outlying Field (NOLF)	https://marine.ucsc.edu/sitepages/cosign.html		2014		6	6
Two Harbors	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/twoharbors.html	2010	2016	3		
Bird Rock	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/birdrock.html	2002	1994	4	16	12
Big Fisherman Cove	NONE	NONE	NONE	NONE	Wrigley Marine Reserve	https://marine.ucsc.edu/sitepages/bigfisherman.html	2010	2016	4		
Goat Harbor	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/goatharbor.html	2010	2016	4		
Avalon Quarry	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/avalonquarry.html	2010	2016	2		

MARINe site name	national designation	nps network code	state province designation	county designation	other designation	site link	Biodiversity year established	Longterm year established	Biodiversity number of years sampled	Longterm number of years sampled	Abalone only number of years sampled
Little Harbor	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/littleharbor.html	2002	1994	3	16	12
West Cove	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/westcove.html	2013	2011	2	9	8
North Head	NONE	NONE	NONE	NONE	Military Safety (Exclusion) Zone	https://marine.ucsc.edu/sitepages/northhead.html	2014	2016	2		
Graduation Point	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/graduationpoint.html	2014	2016	2		
Boy Scout Camp	NONE	NONE	NONE	NONE	Military Safety (Exclusion) Zone	https://marine.ucsc.edu/sitepages/boyscoutcamp.html	2009	2011	3	9	5
Horse Beach Cove	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/horsebeachcove.html		2011		9	4
Eel Point	NONE	NONE	NONE	NONE	NONE	https://marine.ucsc.edu/sitepages/eelpoint.html	2009	2011	3	9	8

Appendix 5: Species list

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Abietinaria/Amphisbetia spp	1	1	1	0	0	1	1	0	0	0
Acanthina paucilirata	0	0	1	1	0	0	0	0	1	0
Acanthinucella spp	1	1	1	1	1	1	1	0	0	0
Acmaea mitra	1	1	1	1	1	1	1	0	0	0
Acrosiphonia/Cladophora spp	1	1	1	1	1	1	1	0	0	0
Acrosorium ciliolatum	0	0	1	1	0	1	0	0	1	0
Adula/Lithophaga spp	0	0	1	1	0	0	0	0	1	0
Aeolidia papillosa	1	1	1	0	0	1	1	0	0	0
Agalophenia spp	1	1	1	1	1	0	1	0	0	0
Ahnfeltia fastigiata	1	1	1	1	1	0	1	0	0	0
Ahnfeltiopsis linearis	1	1	1	1	0	0	1	0	0	0
Alaria marginata	1	1	0	0	0	0	0	1	0	0
Alia spp	1	1	1	1	1	1	1	0	0	0
Amphiroa beauvoisii	0	0	1	1	0	1	0	0	1	0
Amphissa columbiana	1	1	1	1	0	0	1	0	0	0
Amphissa versicolor	1	1	1	1	1	1	1	0	0	0
Analipus japonicus	1	1	1	0	1	0	1	0	0	0
Anisocladella pacifica	0	1	1	1	0	1	0	0	0	0
Anisodoris nobilis	1	1	0	0	0	0	0	1	0	0
Anthithamnion spp	0	0	1	1	0	0	0	0	1	0
Anthopleura artemisia	1	1	1	1	0	1	1	0	0	0
Anthopleura elegantissima	1	1	1	1	1	1	1	0	0	0
Anthopleura elegantissima/sola	1	1	1	1	1	1	1	0	0	0
Anthopleura sola	1	1	1	1	1	1	1	0	0	0
Anthopleura xanthogrammica	1	1	1	1	1	1	1	0	0	0
Aplidium spp	1	1	1	1	1	1	1	0	0	0
Aplysia californica	0	0	1	1	1	1	0	0	1	0
Aplysia vaccaria	0	0	1	1	0	0	0	0	1	0
Aplysilla glacialis	1	0	0	0	0	0	0	1	0	0
Aplysilla rosea	1	0	0	0	0	0	0	1	0	0
Aplysina fistularis	0	1	0	0	0	0	0	1	0	0
Archidoris montereyensis	1	1	0	0	0	0	0	1	0	0
Asparagopsis taxiformis	0	0	1	1	0	1	0	0	1	0
Astrometis sertulifera	0	0	1	1	0	1	0	0	1	0
Atrimitra idae	0	0	1	0	1	0	0	0	1	1
Babelomurex oldroydi	0	0	1	0	0	1	0	0	1	1
Balanophyllia elegans	1	0	0	0	0	0	0	1	0	0
Balanus crenatus	1	0	0	0	0	0	0	1	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Balanus glandula	1	1	1	1	1	1	1	0	0	0
Balanus nubilus	1	1	0	0	0	0	0	1	0	0
Bangia spp	1	1	1	1	0	1	1	0	0	0
Besa leptophylla	1	1	1	1	1	1	1	0	0	0
Bittium eschrichtii	1	1	1	1	1	1	1	0	0	0
Blidingia spp	0	1	0	0	0	0	0	1	0	0
Blidingia subsalsa	0	1	0	0	0	0	0	1	0	0
Blue Green Algae	1	1	1	1	1	1	1	0	0	0
Boring clam	1	1	1	1	1	0	1	0	0	0
Bossiella spp	1	1	1	1	1	1	1	0	0	0
Botryllus spp	1	0	1	0	1	0	0	0	0	0
Bryopsis hypnoides	0	0	1	1	0	0	0	0	1	0
Bryopsis spp	1	1	1	1	1	1	1	0	0	0
Bugula neritina	1	1	1	1	0	1	1	0	0	0
Bulla gouldiana	0	0	1	1	0	0	0	0	1	0
Cadlina luteomarginata	0	1	0	0	0	0	0	1	0	0
Californiconus californicus	1	1	1	1	1	1	1	0	0	0
Calliarthron spp	1	1	1	1	1	1	1	0	0	0
Calliostoma annulatum	0	1	1	0	0	1	0	0	0	0
Calliostoma canaliculatum	1	1	1	0	0	1	1	0	0	0
Calliostoma ligatum	1	1	1	0	1	0	1	0	0	0
Calliostoma supragranosum	0	1	1	0	1	1	0	0	0	0
Callithamnion acutum	1	0	0	0	0	0	0	1	0	0
Callithamnion pikeanum	1	1	1	1	1	1	1	0	0	0
Callithamnion rupicola	0	1	1	1	1	1	0	0	0	0
Callophyllis pinnata	0	0	1	0	1	0	0	0	1	1
Callophyllis spp	1	1	1	1	1	1	1	0	0	0
Callophyllis violacea	0	1	1	0	1	0	0	0	0	0
Cancer antennarius	1	1	1	1	1	1	1	0	0	0
Cancer jordani	0	0	1	0	1	0	0	0	1	1
Cancer oregonensis	1	0	1	1	0	0	0	0	0	0
Cancer productus	1	0	1	0	1	0	0	0	0	0
Carpopeltis bushiae	0	0	1	1	0	1	0	0	1	0
Caulacanthus okamurae	1	1	1	1	1	1	1	0	0	0
Cauloramphus echinus	0	1	0	0	0	0	0	1	0	0
Ceramiales	1	1	1	1	1	1	1	0	0	0
Ceratostoma foliatum	1	1	1	1	1	1	1	0	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Ceratostoma nuttalli	1	1	1	1	1	1	1	0	0	0
Cerithiopsis spp	0	0	1	1	1	0	0	0	1	0
Chaetomorpha spp	1	1	1	1	1	1	1	0	0	0
Chondracanthus canaliculatus	1	1	1	1	1	1	1	0	0	0
Chondracanthus corymbiferus/e	1	1	1	1	1	0	1	0	0	0
Chondracanthus harveyanus	1	1	0	0	0	0	0	1	0	0
Chondracanthus spinosus	1	1	1	1	1	1	1	0	0	0
Chondria acrorhizophora	0	0	1	1	0	1	0	0	1	0
Chondria arcuata	0	0	1	1	1	1	0	0	1	0
Chondria dasyphylla	0	0	1	1	1	1	0	0	1	0
Chondria decipiens	0	1	1	1	1	1	0	0	0	0
Chondria nidifica	0	1	1	1	1	0	0	0	0	0
Chondria oppositiclada	0	0	1	1	0	1	0	0	1	0
Chone minuta	1	1	1	1	0	0	1	0	0	0
Chthamalus dalli/fissus	1	1	1	1	1	1	1	0	0	0
Chthamalus spp/Balanus glandul	1	1	1	1	1	1	1	0	0	0
Cirolana spp	1	1	1	1	1	1	1	0	0	0
Cladophora columbiana	1	1	1	1	1	1	1	0	0	0
Cladophora graminea	1	1	1	1	1	1	1	0	0	0
Cladophora microcladioides	0	0	1	1	0	0	0	0	1	0
Cladophora sericea	0	0	1	1	0	1	0	0	1	0
Cladophora stimpsonii	1	0	0	0	0	0	0	1	0	0
Clathromangelia interfossa	0	0	1	0	1	0	0	0	1	1
Clathurella canfieldi	0	0	1	0	1	0	0	0	1	1
Clavelina huntsmani	1	1	1	0	0	1	1	0	0	0
Cnemidocarpa finmarkiensis	0	1	0	0	0	0	0	1	0	0
Codium fragile	1	1	1	1	1	1	1	0	0	0
Codium setchellii	1	1	1	0	1	1	1	0	0	0
Collinsiella tuberculata	1	1	0	0	0	0	0	1	0	0
Colonial diatom	1	1	1	1	1	1	1	0	0	0
Colpomenia tuberculata	0	0	1	1	0	0	0	0	1	0
Colpomenia/Leathesia spp	1	1	1	1	1	1	1	0	0	0
Constantinea simplex	1	1	0	0	0	0	0	1	0	0
Corallina spp	1	1	1	1	1	1	1	0	0	0
Corynactis californica	0	1	1	0	0	1	0	0	0	0
Costaria costata	1	0	0	0	0	0	0	1	0	0
Crangon spp	0	1	1	1	0	0	0	0	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Crepipatella lingulata	1	0	1	1	1	1	0	0	0	0
Cryptochiton stelleri	1	1	0	0	0	0	0	1	0	0
Cryptolithodes sitchensis	1	1	0	0	0	0	0	1	0	0
Cryptonemia obovata	1	0	1	1	0	0	0	0	0	0
Cryptonemia spp	0	0	1	1	0	0	0	0	1	0
Cryptopleura/Hymenena spp	1	1	1	1	1	1	1	0	0	0
Cryptosiphonia woodii	1	1	1	1	1	0	1	0	0	0
Cucumaria miniata	0	0	1	0	1	0	0	0	1	1
Cucumaria/Pseudocnus spp	1	1	1	0	0	1	1	0	0	0
Cumagloia andersonii	1	1	1	1	1	1	1	0	0	0
Cyanoplax hartwegii	1	1	1	1	1	1	1	0	0	0
Cyanoplax spp	1	1	1	1	1	1	1	0	0	0
Cycloxanthops novemdentatus	0	0	1	1	0	0	0	0	1	0
Cypraea spadicea	0	0	1	1	0	0	0	0	1	0
Cystodytes lobatus	0	0	1	0	0	1	0	0	1	1
Dasya binghamiae	0	1	1	1	1	1	0	0	0	0
Dasya sinicola/californica	0	0	1	1	0	1	0	0	1	0
Dasysiphonia japonica	0	0	1	1	0	1	0	0	1	0
Delesseria decipiens	1	0	0	0	0	0	0	1	0	0
Dendrochiton flectens	1	0	0	0	0	0	0	1	0	0
Dendronotus subramosus	1	1	0	0	0	0	0	1	0	0
Dendropoma lituella	0	0	1	1	0	1	0	0	1	0
Derbesia marina	1	1	1	1	1	0	1	0	0	0
Dermasterias imbricata	1	1	1	0	0	1	1	0	0	0
Desmarestia ligulata	1	1	1	1	0	1	1	0	0	0
Desmarestia munda	1	0	0	0	0	0	0	1	0	0
Diaperoecia californica	1	0	0	0	0	0	0	1	0	0
Diaphoreolis lagunae	1	0	0	0	0	0	0	1	0	0
Diatom	1	1	1	1	1	1	1	0	0	0
Diaulula sandiegensis	1	1	1	1	1	1	1	0	0	0
Dictyoneurum californicum	1	1	0	0	0	0	0	1	0	0
Dictyopteris undulata	0	0	1	1	0	1	0	0	1	0
Dictyota binghamiae	0	0	1	1	0	1	0	0	1	0
Dictyota coriacea	0	0	1	1	1	1	0	0	1	0
Didemnum carnulentum	0	0	1	0	0	1	0	0	1	1
Dilsea californica	1	1	0	0	0	0	0	1	0	0
Diodora aspera	1	1	1	1	0	1	1	0	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Diopatra ornata	0	0	1	1	0	0	0	0	1	0
Dirona albolineata	1	0	0	0	0	0	0	1	0	0
Dirona picta	1	0	1	1	0	0	0	0	0	0
Discurria insessa	1	1	1	1	1	1	1	0	0	0
Distaplia occidentalis	1	1	1	1	1	0	1	0	0	0
Dodecaceria spp	1	1	1	1	1	1	1	0	0	0
Doriopsilla albopunctata	0	1	1	0	1	0	0	0	0	0
Doris odhneri	0	0	1	1	0	0	0	0	1	0
Echinaster spp	1	0	0	0	0	0	0	1	0	0
Ectocarpus spp	0	0	1	1	0	1	0	0	1	0
Egregia menziesii	1	1	1	1	1	1	1	0	0	0
Eisenia arborea	1	1	1	1	1	1	1	0	0	0
Encrusting coralline	1	1	1	1	1	1	1	0	0	0
Endarachne/Petalonia/Phaeostro	1	1	1	1	1	1	1	0	0	0
Endocladia muricata	1	1	1	1	1	1	1	0	0	0
Epiactis prolifera	1	1	1	1	1	0	1	0	0	0
Epialtoides hiltoni	0	0	1	0	0	1	0	0	1	1
Epitonium tinctum	1	1	1	1	1	1	1	0	0	0
Erythroglossum californicum	1	1	1	1	1	1	1	0	0	0
Erythrophyllum delesserioides	1	1	1	1	1	1	1	0	0	0
Eudendrium californicum	1	1	0	0	0	0	0	1	0	0
Eudistoma psammion	0	1	1	1	1	1	0	0	0	0
Eudistoma ritteri	1	1	1	1	1	1	1	0	0	0
Euherdmania claviformis	0	1	1	0	1	0	0	0	0	0
Eulithidium pulloides	0	1	0	0	0	0	0	1	0	0
Eupentacta spp	1	0	0	0	0	0	0	1	0	0
Eurystomella bilabiata	1	1	1	1	1	1	1	0	0	0
Evasterias troschelii	1	0	0	0	0	0	0	1	0	0
Farlowia compressa	1	1	0	0	0	0	0	1	0	0
Farlowia mollis	1	1	1	1	0	0	1	0	0	0
Farlowia/Pikea spp	1	1	1	1	1	1	1	0	0	0
Fauchea laciniata	0	0	1	0	1	0	0	0	1	1
Feldmannia cylindrica	1	0	0	0	0	0	0	1	0	0
Fissurella volcano	0	1	1	1	1	1	0	0	0	0
Fissurellidea bimaculata	0	1	1	1	0	1	0	0	0	0
Flabellinopsis iodinea	0	0	1	1	0	0	0	0	1	0
Flatworm	1	1	1	1	0	0	1	0	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Flustrellidra corniculata	1	1	0	0	0	0	0	1	0	0
Fredericqia chiton	0	1	1	1	0	0	0	0	0	0
Fucus gardneri	1	1	0	0	0	0	0	1	0	0
Fucus spp	1	1	1	0	1	1	1	0	0	0
Gastroclonium parvum	0	1	1	1	1	1	0	0	0	0
Gastroclonium subarticulatum	1	1	1	1	1	1	1	0	0	0
Gelidium purpurascens	0	1	1	1	1	1	0	0	0	0
Gelidium robustum	1	1	1	1	1	1	1	0	0	0
Gelidium spp	1	1	1	1	1	1	1	0	0	0
Glans carpenteri	0	0	1	0	1	0	0	0	1	1
Gloiopeltis furcata	1	0	1	1	0	1	0	0	0	0
Gloiosiphonia californica	1	0	0	0	0	0	0	1	0	0
Gloiosiphonia capillaris	0	0	1	1	0	0	0	0	1	0
Gloiosiphonia verticillaris	1	0	0	0	0	0	0	1	0	0
Gracilariopsis/Gracilaria spp	0	1	1	1	1	1	0	0	0	0
Grateloupia californica	1	1	1	1	1	1	1	0	0	0
Griffithsia pacifica	0	0	1	0	1	0	0	0	1	1
Halichondria panicea	1	1	1	1	0	0	1	0	0	0
Halichondria spp	1	1	1	1	1	1	1	0	0	0
Haliclona spp	1	1	1	1	1	1	1	0	0	0
Haliotis cracherodii	1	1	1	1	1	1	1	0	0	0
Haliotis fulgens	1	0	1	1	0	1	0	0	0	0
Haliotis rufescens	1	1	1	1	1	1	1	0	0	0
Halosaccion glandiforme	1	1	1	1	0	0	1	0	0	0
Halymenia/Schizymenia spp	1	1	1	1	1	1	1	0	0	0
Haminoea vesicula	0	0	1	1	0	1	0	0	1	0
Haminoea virescens	0	0	1	1	1	0	0	0	1	0
Hapalospongidion gelatinosum	0	0	1	0	0	1	0	0	1	1
Haplogloia andersonii	1	1	1	1	0	0	1	0	0	0
Hapterophycus canaliculatus	1	0	1	1	1	1	0	0	0	0
Hedophyllum sessile	1	1	0	0	0	0	0	1	0	0
Hemigrapsus nudus	1	1	1	1	0	1	1	0	0	0
Hemigrapsus oregonensis	1	0	0	0	0	0	0	1	0	0
Henricia spp	1	1	1	1	1	1	1	0	0	0
Heptacarpus pictus	0	1	0	0	0	0	0	1	0	0
Hermissenda crassicornis	1	1	1	1	1	1	1	0	0	0
Herposiphonia littoralis	0	0	1	1	1	1	0	0	1	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Herposiphonia plumula	1	1	1	0	1	1	1	0	0	0
Herposiphonia verticillata	0	1	1	1	1	1	0	0	0	0
Hesperaptyxis luteopictus	0	1	1	0	1	0	0	0	0	0
Hesprerato vitellina	0	0	1	1	0	0	0	0	1	0
Heterosiphonia erecta	0	0	1	1	1	1	0	0	1	0
Heterosiphonia spp	0	0	1	1	0	0	0	0	1	0
Hinnites giganteus	0	0	1	0	0	1	0	0	1	1
Hipponix cranioides	0	0	1	1	0	0	0	0	1	0
Homalopoma spp	1	1	1	1	1	1	1	0	0	0
Hymeniacidon ungodon	0	0	1	0	1	0	0	0	1	1
Hypnea johnstonii	0	0	1	1	0	1	0	0	1	0
Hypnea valentiae	0	0	1	1	0	1	0	0	1	0
Hypnea variabilis	0	0	1	1	0	0	0	0	1	0
Idotea spp	1	1	1	1	1	1	1	0	0	0
Jania rosea	0	1	1	1	1	1	0	0	0	0
Jania tenella	0	0	1	1	0	1	0	0	1	0
Jania verrucosa	0	0	1	1	1	1	0	0	1	0
Johansenia macmillanii	1	1	0	0	0	0	0	1	0	0
Katharina tunicata	1	1	0	0	0	0	0	1	0	0
Kelletia kelletii	0	0	1	1	0	0	0	0	1	0
Lacuna spp	1	1	1	1	1	1	1	0	0	0
Laminaria ephemera	1	0	0	0	0	0	0	1	0	0
Laminaria farlowii	0	0	1	1	1	1	0	0	1	0
Laminaria setchellii	1	1	1	0	1	0	1	0	0	0
Laminaria sinclairii	1	1	1	1	1	0	1	0	0	0
Lasaea spp	0	0	1	1	0	1	0	0	1	0
Laurencia pacifica/masonii	0	1	1	1	1	1	0	0	0	0
Laurencia spp	0	0	1	1	0	1	0	0	1	0
Leiosolenus plumula	0	0	1	0	1	0	0	0	1	1
Lepidozona spp	1	1	1	1	1	1	1	0	0	0
Leptasterias spp	1	1	1	1	1	1	1	0	0	0
Leptocladia binghamiae	0	0	1	0	0	1	0	0	1	1
Leptopecten spp	0	1	0	0	0	0	0	1	0	0
Lessoniopsis littoralis	1	1	0	0	0	0	0	1	0	0
Leucetta losangelensis	0	0	1	1	0	0	0	0	1	0
Leucilla nuttingi	0	0	1	0	1	1	0	0	1	1
Leucosolenia eleanor	0	1	0	0	0	0	0	1	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Ligia spp	1	1	1	1	1	1	1	0	0	0
Limacia cockerelli	0	0	1	1	0	0	0	0	1	0
Linckia columbiae	0	0	1	0	0	1	0	0	1	1
Lirabuccinum dirum	1	1	0	0	0	0	0	1	0	0
Lirularia/Margarites spp	1	1	1	1	1	1	1	0	0	0
Lithophyllum/Lithothamnion spp	1	1	1	1	1	1	1	0	0	0
Lithopoma gibberosum	0	0	1	1	0	0	0	0	1	0
Lithothrix aspergillum	1	1	1	1	1	1	1	0	0	0
Littorina spp.	1	1	1	1	1	1	1	0	0	0
Lomentaria hakodatensis	0	1	1	1	1	1	0	0	0	0
Lophogorgia chilensis	0	0	1	0	0	1	0	0	1	1
Lophopanopeus bellus	0	1	0	0	0	0	0	1	0	0
Lottia asmi	1	1	1	1	1	0	1	0	0	0
Lottia austrodigitalis/digitalis	1	1	1	1	1	1	1	0	0	0
Lottia fenestrata	1	1	1	1	1	0	1	0	0	0
Lottia gigantea	1	1	1	1	1	1	1	0	0	0
Lottia limatula	1	1	1	1	1	1	1	0	0	0
Lottia ochracea	1	1	1	1	1	1	1	0	0	0
Lottia paradigitalis/strigatella	1	1	1	1	1	1	1	0	0	0
Lottia pelta	1	1	1	1	1	1	1	0	0	0
Lottia persona	1	0	1	1	1	1	0	0	0	0
Lottia polyfacies	0	0	1	1	0	0	0	0	1	0
Lottia scabra/conus	1	1	1	1	1	1	1	0	0	0
Lottia scutum	1	1	1	1	1	1	1	0	0	0
Loxorhynchus crispatus	0	1	0	0	0	0	0	1	0	0
Macrocystis pyrifera	0	1	1	1	1	1	0	0	0	0
Macron lividus	0	0	1	1	1	1	0	0	1	0
Mastocarpus spp	1	1	1	1	1	1	1	0	0	0
Maxwellia gemma	0	0	1	1	1	1	0	0	1	0
Mazzaella affinis	1	1	1	1	1	1	1	0	0	0
Mazzaella californica	0	1	1	1	0	0	0	0	0	0
Mazzaella cordata/oregona/sple	1	1	1	1	1	1	1	0	0	0
Mazzaella leptorhynchos	0	1	1	1	1	1	0	0	0	0
Mazzaella linearis	1	1	1	0	1	1	1	0	0	0
Mazzaella parksii	1	1	0	0	0	0	0	1	0	0
Mazzaella parva	0	0	1	0	1	0	0	0	1	1
Mazzaella volans	1	1	1	1	1	0	1	0	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Megabalanus californicus	1	1	1	1	1	1	1	0	0	0
Megastraea undosa	0	0	1	1	0	1	0	0	1	0
Megathura crenulata	0	0	1	1	0	0	0	0	1	0
Melanosiphon/Scytosiphon spp	1	1	1	1	1	1	1	0	0	0
Membranipora spp	1	1	1	1	1	1	1	0	0	0
Mesophyllum/Clathromorphum	1	1	0	0	0	0	0	1	0	0
Metandrocarpa taylori	0	1	0	0	0	0	0	1	0	0
Mexacanthina lugubris	0	0	1	1	0	1	0	0	1	0
Microcladia borealis	1	1	1	1	1	0	1	0	0	0
Microcladia coulteri	1	1	1	1	1	1	1	0	0	0
Modiolus spp	0	1	1	1	1	1	0	0	0	0
Mopalia spp	1	1	1	1	1	1	1	0	0	0
Musculus spp	1	0	0	0	0	0	0	1	0	0
Mytilisepta/Brachidontes spp	0	1	1	1	1	1	0	0	0	0
Mytilus californianus	1	1	1	1	1	1	1	0	0	0
Mytilus spp	1	1	1	1	1	1	1	0	0	0
Mytilus trossulus	1	1	1	1	0	0	1	0	0	0
Navanax inermis	0	0	1	1	1	1	0	0	1	0
Nemalion elminthoides	0	1	1	1	1	1	0	0	0	0
Neoptilota/Ptilota spp	1	1	1	1	1	0	1	0	0	0
Neorhodomela larix	1	1	1	1	0	0	1	0	0	0
Neorhodomela oregona	1	1	0	0	0	0	0	1	0	0
Nereocystis luetkeana	1	1	0	0	0	0	0	1	0	0
Nienburgia andersoniana	0	1	1	1	1	1	0	0	0	0
Non Coralline crust	1	1	1	1	1	1	1	0	0	0
Norrisia norrisi	0	1	1	1	1	1	0	0	0	0
Nucella canaliculata	1	1	1	1	1	1	1	0	0	0
Nucella emarginata/ostrina	1	1	1	1	1	1	1	0	0	0
Nucella lamellosa	1	0	1	0	1	0	0	0	0	0
Nuttallina spp	1	1	1	1	1	1	1	0	0	0
Nymphopsis spinosissima	0	0	1	0	1	0	0	0	1	1
Obelia spp	0	0	1	1	1	0	0	0	1	0
Ocenebra circumtexta	1	1	1	1	1	1	1	0	0	0
Ocenebra interfossa	1	1	1	1	1	1	1	0	0	0
Ocenebra subangulata	0	1	1	0	1	0	0	0	0	0
Ocinebrellus inornatus	0	0	1	0	0	1	0	0	1	1
Ocinebrina lurida	1	1	1	1	1	1	1	0	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Octopus spp	0	0	1	0	1	0	0	0	1	1
Odonthalia floccosa	1	1	1	1	0	0	1	0	0	0
Odonthalia washingtoniensis	1	1	0	0	0	0	0	1	0	0
Oedignathus inermis	1	0	0	0	0	0	0	1	0	0
Okenia rosacea	0	0	1	1	0	0	0	0	1	0
Olivella biplicata	0	1	1	1	0	0	0	0	0	0
Onchidella borealis	1	1	0	0	0	0	0	1	0	0
Opalia borealis	0	1	0	0	0	0	0	1	0	0
Opalia funiculata	0	1	1	1	1	1	0	0	0	0
Opalia montereyensis	1	0	1	1	0	0	0	0	0	0
Ophionereis annulata	0	0	1	0	0	1	0	0	1	1
Ophiothrix spiculata	0	0	1	1	0	0	0	0	1	0
Ophiuroid	1	1	1	1	1	1	1	0	0	0
Ophlitaspongia pennata	1	1	1	1	1	1	1	0	0	0
Orienthella trilineata	1	1	0	0	0	0	0	1	0	0
Osmundea sinicola	1	1	1	1	1	1	1	0	0	0
Osmundea spectabilis	1	1	1	1	1	1	1	0	0	0
Osmundea splendens	0	1	1	1	1	1	0	0	0	0
Ostrea lurida	0	0	1	1	0	0	0	0	1	0
Pachycheles spp	1	1	1	1	1	1	1	0	0	0
Pachygrapsus crassipes	1	1	1	1	1	1	1	0	0	0
Pachythyone rubra	0	0	1	0	1	0	0	0	1	1
Pagurus beringanus	1	1	0	0	0	0	0	1	0	0
Pagurus caurinus	1	1	0	0	0	0	0	1	0	0
Pagurus granosimanus	1	1	1	1	1	1	1	0	0	0
Pagurus hemphilli	1	0	1	1	0	0	0	0	0	0
Pagurus hirsutiusculus	1	1	1	1	1	1	1	0	0	0
Pagurus samuelis	1	1	1	1	1	1	1	0	0	0
Palmaria mollis	1	1	0	0	0	0	0	1	0	0
Panulirus interruptus	0	0	1	1	0	1	0	0	1	0
Parastichopus californicus	0	0	1	1	0	0	0	0	1	0
Paraxanthias taylori	0	1	1	1	1	0	0	0	0	0
Patiria miniata	1	1	1	1	1	1	1	0	0	0
Pelia tumida	0	0	1	0	0	1	0	0	1	1
Pelvetiopsis arborescens/hybrida	1	1	1	1	0	1	1	0	0	0
Pelvetiopsis californica	1	1	1	1	1	1	1	0	0	0
Penitella spp	0	0	1	0	0	1	0	0	1	1

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Petaloconchus montereyensis	1	0	1	0	1	1	0	0	0	0
Petroglossum parvum	0	0	1	1	0	0	0	0	1	0
Petrolisthes spp	1	1	1	1	1	1	1	0	0	0
Petrospongium rugosum	1	1	1	1	1	1	1	0	0	0
Phidiana hiltoni	0	1	0	0	0	0	0	1	0	0
Phimochirus californiensis	0	0	1	0	1	0	0	0	1	1
Phragmatopoma/Sabellaria spp	1	1	1	1	1	1	1	0	0	0
Phycodrys setchellii	1	1	1	1	0	1	1	0	0	0
Phyllochaetopterus prolifica	0	1	0	0	0	0	0	1	0	0
Phyllospadix scouleri	1	1	1	1	1	1	1	0	0	0
Phyllospadix spp	1	1	1	1	1	1	1	0	0	0
Phyllospadix torreyi	1	1	1	1	1	1	1	0	0	0
Pilayella littoralis	0	0	1	0	0	1	0	0	1	1
Pilumnus spinohirsutus	0	0	1	1	0	0	0	0	1	0
Pisaster brevispinus	1	1	1	1	0	1	1	0	0	0
Pisaster giganteus	1	1	1	1	1	1	1	0	0	0
Pisaster ochraceus	1	1	1	1	1	1	1	0	0	0
Pista spp	1	1	1	1	1	1	1	0	0	0
Placiphorella velata	1	1	0	0	0	0	0	1	0	0
Pleonosporium spp	0	0	1	0	0	1	0	0	1	1
Plocamium oregonum	1	0	0	0	0	0	0	1	0	0
Plocamium pacificum	1	1	1	1	1	1	1	0	0	0
Plocamium violaceum	1	1	1	1	1	1	1	0	0	0
Pollicipes polymerus	1	1	1	1	1	1	1	0	0	0
Polycera atra	0	0	1	1	0	0	0	0	1	0
Polyneura latissima	1	1	1	1	0	0	1	0	0	0
Polysiphonia spp	1	1	1	1	1	1	1	0	0	0
Postelsia palmaeformis	1	1	0	0	0	0	0	1	0	0
Potamilla occelata	0	0	1	1	0	0	0	0	1	0
Prasiola spp	1	1	0	0	0	0	0	1	0	0
Prionitis angusta	0	0	1	1	1	1	0	0	1	0
Prionitis australis	0	1	1	0	0	1	0	0	0	0
Prionitis cornea	0	0	1	1	1	0	0	0	1	0
Prionitis filiformis	1	0	1	1	0	0	0	0	0	0
Prionitis lanceolata	1	1	1	1	1	1	1	0	0	0
Prionitis linearis	1	1	1	1	0	0	1	0	0	0
Prionitis sternbergii	1	1	1	1	1	0	1	0	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Pseudochama exogyra	0	1	1	1	1	1	0	0	0	0
Pseudolithoderma nigra	1	1	1	1	1	1	1	0	0	0
Pseudomelatoma penicillata	0	1	1	1	0	0	0	0	0	0
Pseudomelatoma torosa	1	1	1	1	0	0	1	0	0	0
Pseudopusula californiana	0	0	1	1	0	1	0	0	1	0
Pterocladiella caloglossoides	0	0	1	0	0	1	0	0	1	1
Pterocladiella capillacea	0	1	1	1	1	1	0	0	0	0
Pterocladiella media	0	1	1	1	0	1	0	0	0	0
Pteropurpura trialata	0	0	1	1	0	1	0	0	1	0
Pterosiphonia baileyi	1	1	1	1	1	1	1	0	0	0
Pterosiphonia bipinnata	1	1	1	1	1	0	1	0	0	0
Pterosiphonia dendroidea/penna	1	1	1	1	1	1	1	0	0	0
Pterothamnion spp	0	0	1	0	0	1	0	0	1	1
Pterygophora californica	1	1	0	0	0	0	0	1	0	0
Pugettia foliata	0	0	1	0	0	1	0	0	1	1
Pugettia gracilis/richii	1	1	1	1	1	1	1	0	0	0
Pugettia producta	1	1	1	1	1	1	1	0	0	0
Pycnogonida	1	1	1	1	1	1	1	0	0	0
Pycnopodia helianthoides	1	1	1	1	1	1	1	0	0	0
Pyropia spp	1	1	1	1	1	1	1	0	0	0
Red Crust	1	1	1	1	1	1	1	0	0	0
Rhizoclonium spp	1	0	1	0	0	1	0	0	0	0
Rhodochorton purpureum	0	0	1	1	0	1	0	0	1	0
Rhodymenia californica	1	1	1	1	1	1	1	0	0	0
Rhodymenia pacifica	1	1	1	1	1	1	1	0	0	0
Rictaxis punctocaelatus	0	0	1	1	0	0	0	0	1	0
Ritterella rubra	0	1	1	0	1	0	0	0	0	0
Ritterella spp	1	1	1	1	1	1	1	0	0	0
Roperia poulsoni	0	0	1	1	0	1	0	0	1	0
Rostanga pulchra	1	0	0	0	0	0	0	1	0	0
Salmacina tribranchiata	0	0	1	1	0	0	0	0	1	0
Sarcodiotheca gaudichaudii	1	1	1	1	1	1	1	0	0	0
Sargassum agardhianum	0	1	1	1	1	1	0	0	0	0
Sargassum horneri	0	0	1	1	1	1	0	0	1	0
Sargassum muticum	1	1	1	1	1	1	1	0	0	0
Sargassum palmeri	0	0	1	0	1	1	0	0	1	1
Schizoporella unicornis	1	1	0	0	0	0	0	1	0	0

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Scinaia confusa	0	0	1	1	0	0	0	0	1	0
Scinaia spp	0	0	1	1	0	0	0	0	1	0
Seila montereyensis	0	0	1	0	1	1	0	0	1	1
Semibalanus cariosus	1	1	1	1	1	1	1	0	0	0
Serpula vermicularis	1	1	1	1	1	1	1	0	0	0
Sertularella/Sertularia spp	1	1	1	1	0	1	1	0	0	0
Silvetia compressa	1	1	1	1	1	1	1	0	0	0
Siphonaria brannii	0	0	1	0	0	1	0	0	1	1
Sorella delicatula	0	0	1	0	0	1	0	0	1	1
Sphacelaria californica	0	0	1	1	0	0	0	0	1	0
Spirobranchus spinosus	0	1	1	1	1	1	0	0	0	0
Spirorbis spp	1	1	1	1	1	1	1	0	0	0
Spyridia filamentosa	0	0	1	1	0	1	0	0	1	0
Stenogramme interrupta	1	1	1	0	1	0	1	0	0	0
Stenoplax conspicua	0	0	1	1	0	0	0	0	1	0
Stephanocystis dioica	1	1	1	1	1	1	1	0	0	0
Stephanocystis osmundacea	1	1	1	1	1	1	1	0	0	0
Stephanocystis setchellii	0	0	1	1	0	0	0	0	1	0
Strongylocentrotus franciscanus	1	1	1	1	1	1	1	0	0	0
Strongylocentrotus purpuratus	1	1	1	1	1	1	1	0	0	0
Styela montereyensis	1	1	1	1	1	0	1	0	0	0
Stylantheca spp	1	0	0	0	0	0	0	1	0	0
Suberites ficus	1	0	0	0	0	0	0	1	0	0
Taonia lennebackerae	0	0	1	1	0	0	0	0	1	0
Tectura paleacea	1	1	1	1	1	0	1	0	0	0
Tegula aureotincta	0	0	1	1	1	1	0	0	1	0
Tegula brunnea	1	1	0	0	0	0	0	1	0	0
Tegula eiseni	0	0	1	1	0	1	0	0	1	0
Tegula funebralis	1	1	1	1	1	1	1	0	0	0
Tegula gallina/funebralis	0	1	1	1	1	1	0	0	0	0
Tetraclita rubescens	1	1	1	1	1	1	1	0	0	0
Thalamoporella spp	0	0	1	1	1	0	0	0	1	0
Thelepus crispus	0	0	1	0	1	0	0	0	1	1
Thylacodes squamigerus	1	1	1	1	1	1	1	0	0	0
Tiffaniella snyderiae	1	1	1	1	1	1	1	0	0	0
Tonicella spp	1	1	1	1	1	0	1	0	0	0
Tricellaria occidentalis	0	0	1	0	0	1	0	0	1	1

Species	CA North	CA Central	CA South	CA South Mainland	Channel Islands North	Channel Islands South	Cosmopolitan (found in all regions)	Northern (north of Pt Conception)	Southern (south of Pt Conception)	Channel Islands only
Trimusculus reticulatus	0	1	1	0	0	1	0	0	0	0
Trimusculus spp	0	1	0	0	0	0	0	1	0	0
Triopha catalinae	0	1	1	0	1	0	0	0	0	0
Trivia spp	0	1	0	0	0	0	0	1	0	0
Tubularia marina	0	0	1	0	1	0	0	0	1	1
Ulothrix spp	1	0	1	1	0	1	0	0	0	0
Ulvophyceae	1	1	1	1	1	1	1	0	0	0
Urosalpinx cinerea	0	0	1	0	0	1	0	0	1	1
Urospora spp	1	1	1	1	0	0	1	0	0	0
Urticina coriacea	1	1	0	0	0	0	0	1	0	0
Urticina crassicornis	1	0	0	0	0	0	0	1	0	0
Volvarina taeniolata	0	0	1	0	1	0	0	0	1	1
Watersipora spp	0	0	1	1	0	1	0	0	1	0
Williamia peltoides	0	1	0	0	0	0	0	1	0	0
Xingyurella turgida	1	1	1	0	1	1	1	0	0	0
Zonaria farlowii	0	0	1	1	1	1	0	0	1	0

Appendix 6: Invasive species list

List of Invasive species by region that were encountered during surveys

Region	Species
CA North	*Caulacanthus okamurae*
CA North	*Sargassum muticum*
CA Central	*Caulacanthus okamurae*
CA Central	*Lomentaria hakodatensis*
CA Central	*Sargassum muticum*
CA South Mainland	*Caulacanthus okamurae*
CA South Mainland	*Lomentaria hakodatensis*
CA South Mainland	*Sargassum horneri*
CA South Mainland	*Sargassum muticum*
Channel Islands North	*Caulacanthus okamurae*
Channel Islands North	*Lomentaria hakodatensis*
Channel Islands North	*Sargassum horneri*
Channel Islands North	*Sargassum muticum*
Channel Islands South	*Caulacanthus okamurae*
Channel Islands South	*Lomentaria hakodatensis*
Channel Islands South	*Sargassum horneri*
Channel Islands South	*Sargassum muticum*

Appendix 7: Site descriptions

Pyramid Point

Pyramid Point is located in the North Coast region of California within the Pyramid Point State Marine Conservation Area (SMCA) and is part of the Smith River Rancheria. The site is highly sand influenced with sand levels varying greatly throughout the year. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Pyramid Point is dominated by a mixture of boulder fields (Franciscan mélange/Soapstone/serpentinite), cobble, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west/southwest.

Biodiversity Surveys at Pyramid Point were done in 2014 and 2018. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 33 meters (seaward).

Point Saint George

Point Saint George is located in the North Coast region of California and is part of the Smith River Rancheria. This site is near the Point Saint George Mussel Watch site. This site is located on the northern end of Crescent City and is easily accessible from the parking lot at Point St. George. It receives moderate visitation from school groups and tide poolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Point Saint George is dominated by a mixture of consolidated bedrock, boulder fields, and cobble and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west.

Biodiversity Surveys at Point Saint George were done in 2014. The Biodiversity Survey grid encompasses one section that is approximately 29 meters (along shore) x 50 meters (seaward).

Enderts

Enderts is located in the North Coast region of California, within Redwood National and State Parks. This site is located in an Area of Special Biological Significance (Redwood National Park ASBS). Visitation is relatively low due to obstructed access through a cave. This steep site consists of moderately uneven terrain, containing few cracks and folds.

Enderts is dominated by consolidated bedrock (greywacke mudstone/sandstone with calcite intrusions), and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The coastal orientation of this site is both north and south.

Long-Term Monitoring Surveys at Enderts were established in 2004 and Biodiversity Surveys were done in 2014, 2018, 2019. The Biodiversity Survey grid encompasses two sections that are approximately 10 meters (along shore) x 10 meters (seaward), and 8 meters (along shore) x 15 meters (seaward).

Damnation Creek

Damnation Creek is located in the North Coast region of California, within Redwood National and State Parks. This site is located in an Area of Special Biological Significance (Redwood National Park ASBS). To access this site, a 45 min steep hike is required and then Damnation Creek must be crossed. This site receives very low visitation by hikers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds

Damnation Creek is dominated by a mixture of consolidated bedrock, boulders, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Damnation Creek were established in 2004, and Biodiversity Surveys were done in 2004, 2015, 2017, 2019, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

False Klamath Cove

False Klamath Cove is located in the North Coast region of California, within Redwood National and State Parks. This site is located in an Area of Special Biological Significance (Redwood National Park ASBS) and is part of the Yurok Tribal Territory. This site is easily accessible from Highway 101 and receives moderate visitation from tide poolers and fishers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

False Klamath Cove is dominated by a mixture of consolidated bedrock, boulder fields, and cobble and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. This site is a peninsula and consists of a boulder field with some bedrock. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at False Klamath Cove were established in 2004, and Biodiversity Surveys were done in 2014, 2017, 2018, 2020, and 2021. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 10 meters (seaward), and 15 meters (along shore) x 20 meters (seaward).

Palmers Point

Palmers Point is located in the North Coast region of California, within Patrick's Point State Park. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Palmers Point is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west/northwest.

Biodiversity Surveys at Palmers Point were done in 2015. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 100 meters (seaward).

Launcher Beach

Launcher Beach is located in the North Coast region of California. This site is located in an Area of Special Biological Significance (Trinidad Head ASBS) and is near the Flint Rock Head Mussel Watch site. This site is part of the Trinidad Rancheria and Yurok Tribal Territory and receives relatively high visitation due to easy access and being near the Trinidad boat launch. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Launcher Beach is dominated by a mixture of boulder fields, cobble, and sandy beach, and the area surrounding the site is comprised of a mixture of boulder fields, cobble beach, and sandy beach. The primary coastal orientation of this site is southwest.

Biodiversity Surveys at Launcher Beach were done in 2014 and 2018. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 15 meters (seaward).

Old Home Beach

Old Home Beach is located in the North Coast region of California and is part of the Yurok Tribal Territory. This site is located at the southern end of Old Home Beach and receives moderate visitation by tide poolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Old Home Beach is dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of boulder fields, cobble beach, and sandy beach. The primary coastal orientation of this site is south/southwest/southeast.

Biodiversity Surveys at Old Home Beach were done in 2014. The Biodiversity Survey grid encompasses two sections that are approximately 8 meters (along shore) x 20 meters (seaward), and 10 meters (along shore) x 20 meters (seaward).

Cape Mendocino

Cape Mendocino is located in the North Coast region of California. This site receives low visitation by fishermen and tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Cape Mendocino is dominated by consolidated bedrock, and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is west/northwest.

Long-Term Monitoring Surveys at Cape Mendocino were established in 2004, and Biodiversity Surveys were done in 2002, 2006, 2015. The Biodiversity Survey grid encompasses two sections that are approximately 15 meters (along shore) x 60 meters (seaward), and 12 meters (along shore) x 60 meters (seaward).

Shelter Cove

Shelter Cove is located in the North Coast region of California. This site is located in an Area of Special Biological Significance (King Range NCA ASBS) and is near the Point Delgada/Shelter Cove Mussel Watch site. This site receives moderate visitation by abalone divers, fishermen, and tide poolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Shelter Cove is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulders. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Shelter Cove were established in 2004, and Biodiversity Surveys were done in 2001, 2006, and 2014. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

Mal Coombs

Mal Coombs is located in the North Coast region of California, within the King Range National Conservation Area. This site is located in an Area of Special Biological Significance (King Range NCA ASBS) and is near the Point Delgada/Shelter Cove Mussel Watch site. This site receives relatively high visitation by tide poolers due to nearby parking and steps leading down to the intertidal. It is also about a quarter mile upcoast of the Shelter Cove boat launch. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Mal Coombs is dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southeast.

Biodiversity Surveys were done in 2014 and 2018. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 50 meters (seaward).

Kibesillah Hill

Kibesillah Hill is located in the North Coast region of California. Kibesillah Hill is one of 6 sites where Kinnetic Laboratories did experimental clearings (1m x 2m) in 1985 in the *Endocladia*, *Mastocarpus* and *Mytilus* zones to look at recovery rates within these assemblages. This site receives low visitation by fisherman and tide poolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Kibesillah Hill is dominated by consolidated bedrock, and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is north/northwest.

Long-Term Monitoring Surveys at Kibesillah Hill were established in 2004 and Biodiversity Surveys were done by in 2001, 2003, 2007, 2014, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 80 meters (seaward).

Abalobadiah Creek

Abalobadiah Creek is located in the North Coast region of California, within Ten Mile State Marine Reserve (SMR). This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Abalobadiah Creek is dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is west.

Biodiversity Surveys were done in 2015 and 2018. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 25 meters (seaward).

MacKerricher

MacKerricher is located in the North Coast region of California, within MacKerricher State Marine Conservation Area (SMCA) and MacKerricher State Park. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

MacKerricher is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is west.

Biodiversity Surveys were done in 2015, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 40 meters (seaward).

Fort Bragg

Fort Bragg is located in the North Coast region of California. This steep site consists of moderately uneven terrain, containing few cracks and folds.

Fort Bragg is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is east.

Biodiversity Surveys were done in 2015. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 5 meters (seaward).

Point Arena

Point Arena is located in the North Central Coast region of California, within the Point Arena State Marine Reserve (SMR). This site is near the Point Arena Lighthouse Mussel Watch site. This site receives low visitation. Harbor seals are often hauled out near this site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Point Arena is dominated by consolidated bedrock (mudstone), and the area surrounding the site is comprised of a mixture of consolidated bedrock (mudstone), boulder fields, and cobble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Point Arena were established in 2010 and Biodiversity Surveys were done in 2010 and 2017. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 100 meters (seaward).

Stornetta

Stornetta is located in the North Central Coast region of California, within the Sea Lion Cove State Marine Conservation Area (SMCA). This site is 1.3 mi southeast of the Point Arena Lighthouse Mussel Watch site. This site currently receives low visitation by tidepoolers. While open between 2005 and 2010, the site received moderate to high visitation during low tides by abalone divers, fishermen, and tidepoolers. Portions of this site are only accessible during low tides. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Stornetta is dominated by consolidated bedrock (mudstone), and the area surrounding the site is comprised of a mixture of consolidated bedrock (mudstone) and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Stornetta were established in 2005 and Biodiversity Surveys were done in 2004, 2007, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward).

Point Arena Field Station

Point Arena Field Station is located in the North Central Coast region of California. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Point Arena Field Station is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and cobble beach. The primary coastal orientation of this site is northeast.

Long-Term Monitoring Surveys at Point Arena Field Station were established in 2011.

Moat Creek

Moat Creek is located in the North Central Coast region of California. This site is near the Saunders Landing/Saunders Reef Mussel Watch site. This site receives high visitation during low tides by abalone divers, fishermen, surfers, and tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Moat Creek is dominated by a mixture of consolidated bedrock (mudstone) and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock (mudstone), boulder fields, and cobble beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Moat Creek were established in 2010 and Biodiversity Surveys were done in 2010 and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 100 meters (seaward).

Saunders Reef

Saunders Reef is located in the North Central Coast region of California, within the Saunders Reef State Marine Conservation Area (SMCA). This site is near the Saunders Landing/Saunders Reef Mussel Watch site. This site receives low visitation by abalone divers, fisherman, and tide poolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Saunders Reef is dominated by a mixture of consolidated bedrock (mudstone) and boulders, and the area surrounding the site is comprised of a mixture of consolidated bedrock (mudstone), boulder fields, and sandy beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Saunders Reef were established in 2010 and Biodiversity Surveys were done in 2010, 2014, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 80 meters (seaward).

Del Mar Landing

Del Mar Landing is located in the North Central Coast region of California, within the Del Mar Landing State Marine Reserve (SMR). This site is located in an Area of Special Biological Significance (Del Mar Landing Ecological Reserve ASBS) and is near the Sea Ranch Del Mar Mussel Watch site. This site receives low visitation by tidepoolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Del Mar Landing is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Del Mar Landing were established in 2010 and Biodiversity Surveys were done in 2010, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 20 meters (seaward).

Sea Ranch

Sea Ranch is located in the North Central Coast region of California. This site is 0.4 mi southeast of the Sea Ranch Del Mar Mussel Watch site. Sea Ranch is one of 6 sites where Kinnetic Laboratories did experimental clearings (1m x 2m) in 1985 in the Endocladia/Mastocarpus and Mytilus zones to look at recovery rates within these species assemblages. This site receives low visitation by tidepoolers and abalone divers and is accessed through The Sea Ranch community (private property). This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Sea Ranch is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Sea Ranch were established in 2004 and Biodiversity Surveys were done in 2001, 2005, 2010, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

Stewarts Point

Stewarts Point is located in the North Central Coast region of California, within the Stewarts Point State Marine Reserve (SMR). This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds. This site receives low visitation due to tricky access through Salt Point State Park.

Stewarts Point is dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is south.

Biodiversity Surveys were done in 2017 and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 60 meters (seaward).

Phillips Gulch

Phillips Gulch is located in the North Central Coast region of California, within the Salt Point State Marine Conservation Area (SMCA). This site receives moderate visitation during low tides by abalone divers and tidepoolers. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Phillips Gulch is dominated by consolidated bedrock (conglomerate), and the area surrounding the site is comprised of a mixture of consolidated bedrock (conglomerate), boulder fields, and cobble beach. The primary coastal orientation of this site is southwest

Long-Term Monitoring Surveys at Phillips Gulch were established in 2010 and Biodiversity Surveys were done in 2010 and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 15 meters (seaward).

Gerstle Cove

Gerstle Cove is located in the North Central Coast region of California, within the Gerstle Cove State Marine Reserve (SMR). This site is located in an Area of Special Biological Significance (Gerstle Cove ASBS) and is near the Gerstle Cove Mussel Watch site. This site receives high visitation during low tides by tidepoolers and high visitation by abalone divers and fisherman just outside the reserve. This steeply sloping site consists of moderately uneven terrain, containing few cracks and folds.

Gerstle Cove is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Gerstle Cove were established in 2010 and Biodiversity Surveys were done in 2010, 2017, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 5 meters (seaward).

Windermere Point

Windermere Point is located in the North Central Coast region of California. This site is near the Gerstle Cove Mussel Watch site. This site receives moderate visitation during low tides by abalone divers and tidepoolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Windermere Point is dominated by a mixture of consolidated bedrock (sandstone) and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock (sandstone), boulder fields, and cobble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Windermere Point were established in 2010 and Biodiversity Surveys were done in 2010. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 33 meters (seaward).

North Jenner Beach

North Jenner Beach is located in the North Central Coast region of California, within the Russian River State Marine Conservation Area (SMCA). This site is near the Gerstle Cove Mussel Watch site. This site receives low visitation by fisherman and tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

North Jenner Beach is dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at North Jenner Beach were established in 2010 and Biodiversity Surveys were done in 2010. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 80 meters (seaward).

Bodega

Bodega is located in the North Central Coast region of California. This site is located in an Area of Special Biological Significance (Bodega Marine Life Refuge ASBS), within the Bodega Head State Marine Reserve (SMR) and is 0.9 mi northwest of the Bodega Bay Head Mussel Watch site. This site is within the University of California Bodega Marine Reserve, and there is an abundance of historical and ongoing research surrounding and throughout the site. This site is accessed through Bodega Marine Lab and receives high visitation by researchers. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Bodega is dominated by a mixture of consolidated granite (Salinian Block), boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, cobble beach, and sandy beach. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Bodega were established in 2001 and Biodiversity Surveys were done in 2001, 2003, 2004, 2010, 2012, 2017, and 2020. The Biodiversity Survey grid encompasses two sections that are approximately 14 meters (along shore) x 20 meters (seaward), and 12 meters (along shore) x 40 meters (seaward).

Horseshoe Cove

Horseshoe Cove is located in the North Central Coast region of California, within the Bodega Head State Marine Reserve (SMR). This site is also located in an Area of Special Biological Significance (Bodega Bay Head ASBS). This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Horseshoe Cove is dominated by consolidated granite (Salinian Block), and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, cobble beach, and sandy beach. The primary coastal orientation of this site is south.

Biodiversity Surveys were done in 2012 and 2018. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 25 meters (seaward).

Bodega Head

Bodega Head is located in the North Central Coast region of California, within the Gulf of the Farallones National Marine Sanctuary. This site is near the Bodega Bay Head Mussel Watch site. This site receives low visitation. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Bodega Head is dominated by a mixture of consolidated bedrock, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is northeast.

Long-Term Monitoring Surveys at Bodega Head were established in 2010 and Biodiversity Surveys were done in 2010. The Biodiversity Survey grid encompasses one section that is approximately 18 meters (along shore) x 15 meters (seaward).

Santa Maria Creek

Santa Maria Creek is located in the North Central Coast region of California, within the Gulf of the Farallones National Marine Sanctuary and Point Reyes National Seashore.

The site is located along the shores of Drake's Bay approximately ¼ mile southeast of the mouth of Santa Maria Creek. Point Reyes Peninsula offers this site some protection from the predominantly northwesterly winds and seas. This gently sloping site consists of moderately uneven terrain and is on a sedimentary rock platform which has numerous crevices and gullies. This site receives low visitation by tidepoolers

Long-Term Monitoring Surveys at Santa Maria Creek were established in 2006 and Biodiversity Surveys were done in 2002, 2005, 2010, 2013, 2018 and 2021. The Biodiversity Survey grid encompasses two sections that are approximately 4 meters (along shore) x 40 meters (seaward), and 21 meters (along shore) x 33 meters (seaward).

Chimney Rock

Chimney Rock is located in the North Central Coast region of California, within the Gulf of the Farallones National Marine Sanctuary. This site is located within the Point Reyes State Marine Reserve (SMR) and is near the Point Reyes Mussel Watch site. This site receives low visitation and has limited access due to bird and mammal restrictions. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Chimney Rock is dominated by a mixture of consolidated bedrock, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is north.

Long-Term Monitoring Surveys at Chimney Rock were established in 2010 and Biodiversity Surveys were done in 2010 and 2017. The Biodiversity Survey grid encompasses one section that is approximately 12 meters (along shore) x 10 meters (seaward).

Bolinas Point

Bolinas Point is located in the North Central Coast region of California, within the Gulf of the Farallones National Marine Sanctuary and Point Reyes National Seashore. This site is located in an Area of Special Biological Significance (Duxbury Reef Reserve and Extension ASBS), within the Duxbury Reef State Marine Conservation Area (SMCA) established by the State of California and is 1.4 mi northwest of the Duxbury Reef Point Mussel Watch site.

The site is northwest of the town of Bolinas. This gently sloping site consists of relatively flat terrain. The survey plots are located on the outermost intertidal bench and consist primarily of sedimentary rock outcrops with folded layers oriented in a NW-SE direction. This site receives low visitation by tidepoolers.

Long-Term Monitoring Surveys at Bolinas Point were established in 2005 and Biodiversity Surveys were done in 2002, 2005, 2008, 2013, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 150 meters (seaward).

Alder Creek/Duxbury

Alder Creek/Duxbury is located in the North Central Coast region of California, within the Gulf of the Farallones National Marine Sanctuary. This site is located within the Duxbury Reef State Marine Conservation Area (SMCA) and Agate Beach County Park. This site is also located in an Area of Special Biological Significance (Duxbury Reef Point ASBS). This gently sloping site consists of relatively flat terrain.

Biodiversity Surveys at Alder Creek/Duxbury were done in 2008. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 80 meters (seaward).

Slide Ranch

Slide Ranch is located in the North Central Coast region of California, within the Gulf of the Farallones National Marine Sanctuary and Golden Gate National Recreation Area.

The site is located at the base of a steeply sloped cliff that opens onto a cobble beach. Large boulders are scattered throughout the intertidal zone and into the deep water. Transects and plots are arrayed along the boulder beach. The site receives high wave action but there are many semi-protected areas among the large serpentine and greywacke boulders in the area.

Long-Term Monitoring Surveys at Slide Ranch were established in 2006

Point Bonita

Point Bonita is located in the North Central Coast region of California, near the Golden Gate and within the Gulf of the Farallones National Marine Sanctuary and Golden Gate National Recreation Area.

The site is located at the base of a moderately sloped cliff that opens onto a large cobble beach. A few large boulders are scattered throughout the intertidal zone and into the deep water. The bedrock bench at this site has been artificially modified for use as a boat ramp. The seastar transects are located along the northern edge of the cobble beach with the northernmost transect ending at the base of a horizontal cliff face. The plots are arrayed throughout the cobble beach. The northernmost plot is located adjacent to the remnant rails of the former Coast Guard lifeboat station. This site receives considerable visitation by guided youth groups.

Long-Term Monitoring Surveys at Point Bonita were established in 2006.

Alcatraz

Alcatraz is located in California, in San Francisco Bay, approximately three miles east of the Golden Gate Bridge within the Golden Gate National Recreation Area.

The site consists of a rock terrace (approximately 3-4 m wide) at the base of a 10 m cliff on the SW end of the island. Plots are located along the terrace and transects remain submerged until peak low tide.

Long-Term Monitoring Surveys at Alcatraz were established in 1989 and Biodiversity Surveys were done in 2005 and 2009. The Biodiversity Survey grid encompasses one section that is approximately 32 meters (along shore) x 15 meters (seaward).

Blowhole

Blow Hole is located in the North Central Coast region of California on Southeast Farallon Island, within the Greater Farallones National Marine Sanctuary. This site is located within the Southeast Farallon Island State Marine Reserve (SMR) and Special Closure. This site is also located in an Area of Special Biological Significance (Farallon Islands ASBS) and is contiguous with Farallon Islands National Wildlife Refuge, which is closed to the public. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Blow Hole is dominated by consolidated bedrock, and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is east.

Long-Term Monitoring Surveys at Blow Hole were established in 2017.

Dead Sea Lion Flat

Dead Sea Lion Flat is located in the North Central Coast region of California on Southeast Farallon Island, within the Gulf of the Farallones National Marine Sanctuary. This site is located within the Southeast Farallon Island State Marine Reserve (SMR) and Special Closure. This site is also located in an Area of Special Biological Significance (Farallon Islands ASBS). This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Dead Sea Lion Flat is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is north-northwest.

Long-Term Monitoring Surveys at Dead Sea Lion Flat were established in 2018.

Mussel Flat SE Farallon

Mussel Flat SE Farallon is located in the North Central Coast region of California on Southeast Farallon Island, within the Greater Farallones National Marine Sanctuary. This site is located within the Southeast Farallon Island State Marine Reserve (SMR) and Special Closure. This site is also located in an Area of Special Biological Significance (Farallon Islands ASBS) and is contiguous with Farallon Islands National Wildlife Refuge, which is closed to the public. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds. This area is an established harbor seal rookery and pinniped haul-out.

Mussel Flat SE Farallon is dominated by bedrock and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Mussel Flat SE Farallon were established in 2018 and Biodiversity Surveys were done in 2005 and 2017. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 15 meters (seaward).

Fitzgerald Marine Reserve

Fitzgerald Marine Reserve is located in the North Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Montara State Marine Reserve (SMR) and San Mateo County Park. This site is also located in an Area of Special Biological Significance (James V. Fitzgerald Marine Reserve ASBS). This gently sloping site consists of relatively flat terrain.

Fitzgerald Marine Reserve is dominated by a mixture of consolidated bedrock and sandy beach and the area surrounding the site is sandy beach. The primary coastal orientation of this site is west/southwest.

Biodiversity Surveys were done in 2002, 2006, 2011, 2014, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 40 meters (seaward).

Pebble Beach

Pebble Beach is located in the North Central Coast region of California within the Monterey Bay National Marine Sanctuary. This site is located within Bean Hollow State Beach. This site receives moderate visitation by tidepoolers and is often visited by school groups. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Pebble Beach is dominated by a mixture of consolidated bedrock, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Pebble Beach were established in 2004

Pigeon Point

Pigeon Point is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within Pigeon Point Lightstation State Historic Park. This site receives high visitation by tidepoolers and is often visited by school groups. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Pigeon Point is dominated by a mixture of consolidated conglomerate rock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated conglomerate rock, boulder fields, and sandy beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Pigeon Point were established in 2002 and Biodiversity Surveys were done in 2002, 2006, 2013, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 33 meters (along shore) x 33 meters (seaward).

Franklin Point

Franklin Point is located in the Central Coast region of California within the Monterey Bay National Marine Sanctuary. This site is located within the Año Nuevo State Marine Conservation Area (SMCA). This site receives low visitation by tidepoolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Franklin Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Franklin Point were established in 2004.

Año Nuevo

Año Nuevo is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Año Nuevo State Marine Reserve (SMR) and Año Nuevo State Park. This site is also located in an Area of Special Biological Significance (Año Nuevo Point and Islands ASBS) and is near the Año Nuevo Island Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Año Nuevo is dominated by a mixture of consolidated sedimentary rock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is west.

Biodiversity Surveys were done in 2002, 2008, 2013, 2017, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 40 meters (seaward).

Scott Creek

Scott Creek is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Greyhound Rock State Marine Conservation Area (SMCA). This site receives moderate visitation by fisherman, kite surfers, and tidepoolers. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Scott Creek is dominated by a mixture of consolidated mudstone and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated mudstone and sandy beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Scott Creek were established in 1999 and Biodiversity Surveys were done in 2000, 2003, 2006, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Davenport Landing

Davenport Landing is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site receives moderate visitation by surfers and tidepoolers. This gently sloping site consists of relatively flat terrain.

Davenport Landing is dominated by a mixture of consolidated mudstone and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated mudstone and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Davenport Landing were established in 2007 and Biodiversity Surveys were done in 2007, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

Sandhill Bluff

Sandhill Bluff is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is often not accessible during winter months due to drastic flux in sand accumulation. This site receives low visitation by fisherman, surfers, and tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Sandhill Bluff is dominated by consolidated mudstone, and the area surrounding the site is comprised of a mixture of consolidated mudstone and sandy beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Sandhill Bluff were established in 1999 and Biodiversity Surveys were done in 2000, 2004, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Wilder Ranch

Wilder Ranch is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Natural Bridges State Marine Reserve (SMR) and Wilder Ranch State Park. This site receives low visitation by tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Wilder Ranch is dominated by consolidated mudstone, and the area surrounding the site is comprised of a mixture of consolidated mudstone and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Wilder Ranch were established in 2007 and Biodiversity Surveys were done in 2007. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 20 meters (seaward).

Terrace Point

Terrace Point is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Natural Bridges State Marine Reserve (SMR) and Natural Bridges State Park. This site is near the Monterey Bay/Point Santa Cruz Mussel Watch site. This site is located directly below UCSC's Long Marine Laboratory, and there is an abundance of historical and ongoing research taking place at this site. This site receives low visitation by researchers and tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Terrace Point is dominated by consolidated mudstone, and the area surrounding the site is comprised of a mixture of consolidated mudstone and sandy beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Terrace Point were established in 1999 and Biodiversity Surveys were done in 2000, 2003, 2006, 2017, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Natural Bridges

Natural Bridges is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Natural Bridges State Marine Reserve (SMR) and Natural Bridges State Park. This site is near the Monterey Bay/Point Santa Cruz Mussel Watch site. This site receives high visitation by tidepoolers and is often visited by school groups. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Natural Bridges is dominated by consolidated mudstone, and the area surrounding the site is comprised of a mixture of consolidated mudstone and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Natural Bridges were established in 2007 and Biodiversity Surveys were done in 2007. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Hopkins

Hopkins is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Lovers Point – Julia Platt State Marine Reserve (SMR). This site is also located in an Area of Special Biological Significance (Pacific Grove Marine Gardens Fish Refuge and Hopkins Marine Life Refuge ASBS) and is 0.6 miles southeast of the Pacific Grove/Lovers Point Mussel Watch site. This site is part of Hopkins Marine Reserve. There is an abundance of historical and ongoing research at this site, and this site has moderate visitation by researchers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Hopkins is dominated by a mixture of consolidated granite and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated granite, boulder fields, and cobble beach. The primary coastal orientation of this site is north/northwest.

Long-Term Monitoring Surveys at Hopkins were established in 1999 and Biodiversity Surveys were done in 2000, 2003, 2006, 2013, 2017, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Point Piños

Point Piños is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Asilomar State Marine Reserve (SMR). This site is 1.55 miles southeast of the Pacific Gove/Lovers Pt Mussel Watch site. This site receives high visitation by tidepoolers and is often visited by school groups. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Point Piños is dominated by a mixture of consolidated granite, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated granite, boulder fields, and cobble beach. The primary coastal orientation of this site is west/northwest.

Long-Term Monitoring Surveys at Point Piños were established in 2007 and Biodiversity Surveys were done in 2007, 2017, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 15 meters (seaward).

Asilomar

Asilomar is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Asilomar State Marine Reserve (SMR) and Asilomar State Beach. The site is located 1.05 miles southeast of the Point Piños site. This site has been actively managed by California State Parks since 1956 and is subject to regular patrols by Park Rangers. Prior to the acquisition by State Parks the area around Asilomar served as a Young Women's Christian Association (YWCA) retreat and camp. This site receives a low amount of visitation from tidepoolers due to the high level of rugosity present at the site.

The site is steeply sloped in most areas and consists of extremely uneven terrain. The site has several large and deep fractures running parallel to the shoreline that separate areas of raised continuous outcroppings. Overall, the site has many cracks and folds throughout the area.

Asilomar is dominated by consolidated granite outcroppings. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Asilomar were established in 2012 and Biodiversity Surveys were done in 2012. The Biodiversity Survey grid encompasses one section that is approximately 40 meters (along shore) x 20 meters (seaward).

China Rocks

China Rocks is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is accessed through the 17 Mile Drive toll road. This site receives moderate visitation by tidepoolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

China Rocks is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at China Rocks were established in 2007 and Biodiversity Surveys were done in 2007, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 33 meters (seaward).

Pescadero Point

Pescadero Point is located in the Central Coast region of California within the Monterey Bay National Marine Sanctuary. This site is accessed through the 17 Mile Drive toll road. This site receives low visitation by surfers and tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Pescadero Point is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Pescadero Point were established in 2008.

Stillwater

Stillwater is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Carmel Bay State Marine Conservation Area (SMCA). This site is also located in an Area of Special Biological Significance (Carmel Bay ASBS) and is near the Carmel Bay/Arrowhead Point Mussel Watch site. This site is accessed through the 17 Mile Drive toll road. This site is directly below Pebble Beach Golf Course and receives low visitation by tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Stillwater is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Stillwater were established in 2000 and Biodiversity Surveys were done in 2001, 2005, 2014, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 10 meters (seaward).

Carmel Point

Carmel Point is located in the Central Coast region of California within the Monterey Bay National Marine Sanctuary. This site is located within the Carmel Bay State Marine Conservation Area (SMCA). This site is 1.2 miles southeast of the Carmel Bay/Arrowhead Point Mussel Watch site. This site receives low visitation by tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Carmel Point is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Carmel Point were established in 2004.

Point Lobos

Point Lobos is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Point Lobos State Marine Reserve (SMR) and Point Lobos State Park. This site is also located in an Area of Special Biological Significance (Point Lobos Ecological Reserve ASBS) and is 0.3 mi northwest of the Point Lobos/Weston Beach Mussel Watch site. This site receives high visitation by tidepoolers and is often visited by school groups. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Point Lobos is dominated by consolidated conglomerate rock and sandstone, and the area surrounding the site is comprised of a mixture of consolidated conglomerate rock and sandstone, boulder fields, and cobble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Point Lobos were established in 1999 and Biodiversity Surveys were done in 2001, 2005, 2014, 2017, and 2020. The Biodiversity Survey grid encompasses two sections that are approximately 8.4 meters (along shore) x 20 meters (seaward), and 12 meters (along shore) x 20 meters (seaward).

Mal Paso

Mal Paso is located in the Central Coast region of California within the Monterey Bay National Marine Sanctuary. This site is often inaccessible due to a shift in sand accumulation at rocky bench access point. This site receives low visitation. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Mal Paso is dominated by consolidated igneous rock (granodiorite), and the area surrounding the site is comprised of a mixture of consolidated igneous rock (granodiorite) and sandy beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Mal Paso were established in 2000

Garrapata

Garrapata is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within Garrapata State Beach. This site receives low visitation by fisherman and tidepoolers. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Garrapata is dominated by consolidated igneous rock (granodiorite), and the area surrounding the site is comprised of consolidated igneous rock (granodiorite). The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Garrapata were established in 2007 and Biodiversity Surveys were done in 2007, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 25 meters (seaward).

Soberanes

Soberanes is located in the Central Coast region of California within the Monterey Bay National Marine Sanctuary. This site receives moderate visitation by fisherman, researchers, and tidepoolers. This site is used commonly by researchers at Moss Landing Marine Labs and UC Santa Cruz. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Soberanes is dominated by consolidated igneous rock (granodiorite), and the area surrounding the site is comprised of a mixture of boulder fields and sandy beach at this site. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Soberanes were established in 2004

Andrew Molera

Andrew Molera is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Point Sur State Marine Reserve (SMR) and Andrew Molera State Park. The site is directly below private property and access is restricted. This site receives low visitation by fisherman and tidepoolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Andrew Molera is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west/northwest.

Long-Term Monitoring Surveys at Andrew Molera were established in 1999 and Biodiversity Surveys were done in 2001, 2003, 2004, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward).

Partington Cove

Partington Cove is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within Julia Pfeiffer State Park. This site is also located in an Area of Special Biological Significance (Julia Pfeiffer Burns Underwater Park) and is near the Partington Point/Julia P. Burns ASBS Mussel Watch site. This site receives low visitation by fisherman and tidepoolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Partington Cove is dominated by consolidated bedrock, and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is west/northwest.

Long-Term Monitoring Surveys at Partington Cove were established in 2004 and Biodiversity Surveys were done in 2003 and 2004. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 5 meters (seaward).

Lucia

Lucia is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. The bench slope ranges from 10-60 degrees, and an active slide exists to the north of the site. This steep site consists of moderately uneven terrain, containing few cracks and folds.

Lucia is located on a rocky headland dominated by consolidated sedimentary rock, and the area surrounding the site is comprised of a mixture of boulder fields, and cobble and sandy beach. The primary coastal orientation of this site is south/southwest.

Biodiversity Surveys were done in 2004. The Biodiversity Survey grid encompasses two sections that are approximately 4 meters (along shore) x 5 meters (seaward), and 10 meters (along shore) x 5 meters (seaward).

Mill Creek

Mill Creek is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is only accessible by boat or from land at low tides in order to get around a couple of points. This site receives low visitation by fisherman and tidepoolers. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Mill Creek is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Mill Creek were established in 1999 and Biodiversity Surveys were done in 2001, 2003, 2004, 2017, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Pacific Valley

Pacific Valley is located in the Central Coast region of California within the Monterey Bay National Marine Sanctuary. This site receives low visitation by fisherman and tidepoolers. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Pacific Valley is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Pacific Valley were established in 2004.

Duck Pond

Duck Pond is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. Downcoast of the survey site the slope is partially retained with wire caged rock blocks. Upcoast of the survey site two drainage pipes run down the length of the slope. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Duck Pond is dominated by natural and rip rap boulder fields, and the area surrounding the site is comprised of natural and rip rap boulder fields. The primary coastal orientation of this site is southwest.

Biodiversity Surveys were done in 2003 and 2008. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 10 meters (seaward). Click here to view Biodiversity Survey findings at this site.

Point Sierra Nevada

Point Sierra Nevada is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. When the site was established in 1995, it was accessible only by crossing private property (Hearst Corporation) and received very little visitation (occasional trespassers). Then in 2005 the land was transferred to CA State Parks (now part of Hearst San Simeon State Park) and human visitation, particularly by fishermen, increased substantially. The site is fairly remote, which affords it protection from large numbers of visitors, but fishermen are now seen nearly every time the site is sampled. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Point Sierra Nevada is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and pebble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Point Sierra Nevada were established in 1995 and Biodiversity Surveys were done in 2001, 2003, 2004, 2017, and 2021. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 20 meters (seaward), and 15 meters (along shore) x 20 meters (seaward).

Piedras Blancas

Piedras Blancas is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Piedras Blancas State Marine Reserve (SMR). The property adjacent to Piedras Blancas is an old lighthouse station and public access to the area is restricted. The land is managed by the Bureau of Land Management, and docent-led public tours are occasionally done, but access to the intertidal has been limited to researchers. The area to the south is an important elephant seal rookery, and an offshore island is heavily used by shorebirds and pinnipeds, so localized nutrient levels are likely quite high. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Piedras Blancas is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Piedras Blancas were established in 1997 (with expanded monitoring implemented in 2007 as part of the MLPA) and Biodiversity Surveys were done in 2008, 2017, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

San Simeon Point

San Simeon Point is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is near the San Simeon Point Mussel Watch site. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

San Simeon Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at San Simeon Point were established in 2007 and Biodiversity Surveys were done in 2007. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 25 meters (seaward).

Vista del Mar

Vista del Mar is located in the Central Coast region of California, within the Monterey Bay National Marine Sanctuary. This site is located within the Cambria State Marine Conservation Area (SMCA) and Hearst San Simeon State Park. The site is relatively accessible, via a trail along the bluff or a beach walk, and thus receives a moderate amount of human visitation. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Vista del Mar is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Vista del Mar were established in 2004 (with expanded monitoring implemented in 2007 as part of the MLPA) and Biodiversity Surveys were done in 2008 and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 40 meters (seaward).

Rancho Marino/Cambria

Rancho Marino/Cambria is located in the Central Coast region of California, in the Kenneth S. Norris Rancho Marino Reserve (part of the University of California Research Reserve Network). The site is located within the White Rock State Marine Conservation Area (SMCA). Access to the site is restricted due to its location on the UC Reserve. This moderately sloping site consists of consolidated bedrock benches and large boulders separated by surge channels.

Rancho Marino/Cambria is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Rancho Marino; Cambria were established in 2001 and Biodiversity Surveys were done in 2001, 2005, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 29.6 meters (along shore) x 33 meters (seaward).

Harmony Headlands

Harmony Headlands is located in the Central Coast region of California. Historically, the region of coastline where the site is located could only be accessed via private property, but the land was converted to CA State Parks in 2008, and thus human visitation has increased in recent years. This moderately sloping, site consists of extremely uneven terrain, containing many deep cracks and folds.

Harmony Headlands is dominated by consolidated bedrock separated by numerous surge channels, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach.

Long-Term Monitoring Surveys at Harmony Headlands were established in 2008.

Cayucos

Cayucos is located in the Central Coast region of California. Prior to 1998, the coastal land adjacent to the site was privately owned, although public use of the property was common. The property was then purchased by the state, and in 2002, the area was converted to CA State Park land (Estero Bluffs State Park), further opening up access to the general public. This site is near the Morro Bay/Virg's Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Cayucos is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, and boulder fields. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Cayucos were established in 1995 and Biodiversity Surveys were done in 2001, 2008, and 2017. The Biodiversity Survey grid encompasses two sections that are approximately 9 meters (along shore) x 25 meters (seaward), and 18 meters (along shore) x 25 meters (seaward).

Hazards

Hazards is located in the Central Coast region of California, within Montaña de Oro State Park. This site is near the Morro Bay/Virg's Mussel Watch site. Visitation by tidepoolers and surfers at this park is fairly high. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Hazards is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is northwest.

Long-Term Monitoring Surveys at Hazards were established in 1995 and Biodiversity Surveys were done in 2001, 2005, and 2017. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 50 meters (seaward), and 14.5 meters (along shore) x 50 meters (seaward).

Diablo

Diablo is located in the Central Coast region of California, within the Point Buchon State Marine Reserve (SMR). This site is located on the property surrounding Diablo Canyon Power Plant, managed by PG&E, and access is extremely restricted. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Diablo is dominated by a mixture of consolidated bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Diablo were established in 2007 and Biodiversity Surveys were done in 2008 and 2017. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 66.6 meters (seaward).

Shell Beach

Shell Beach is located in the Central Coast region of California. This site is near the San Luis Obispo Bay/Point San Luis Mussel Watch site. The site is located within a developed stretch of coastline, with stairs leading to the beach downcoast of the site, and human use is fairly high. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Shell Beach is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Shell Beach were established in 1995 and Biodiversity Surveys were done in 2001, 2006, and 2019. The Biodiversity Survey grid encompasses two sections that are approximately 9 meters (along shore) x 33 meters (seaward), and 18 meters (along shore) x 33 meters (seaward).

Occulto

Occulto is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). The site's location on VAFB largely restricts human use, although the reef is used by military personnel for fishing. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds, which are separated by large sandy surge channels.

Occulto is dominated by consolidated bedrock, which is bordered upcoast and downcoast by sandy beaches. The primary coastal orientation of this site is west/northwest.

Long-Term Monitoring Surveys at Occulto were established in 1992

Purisima

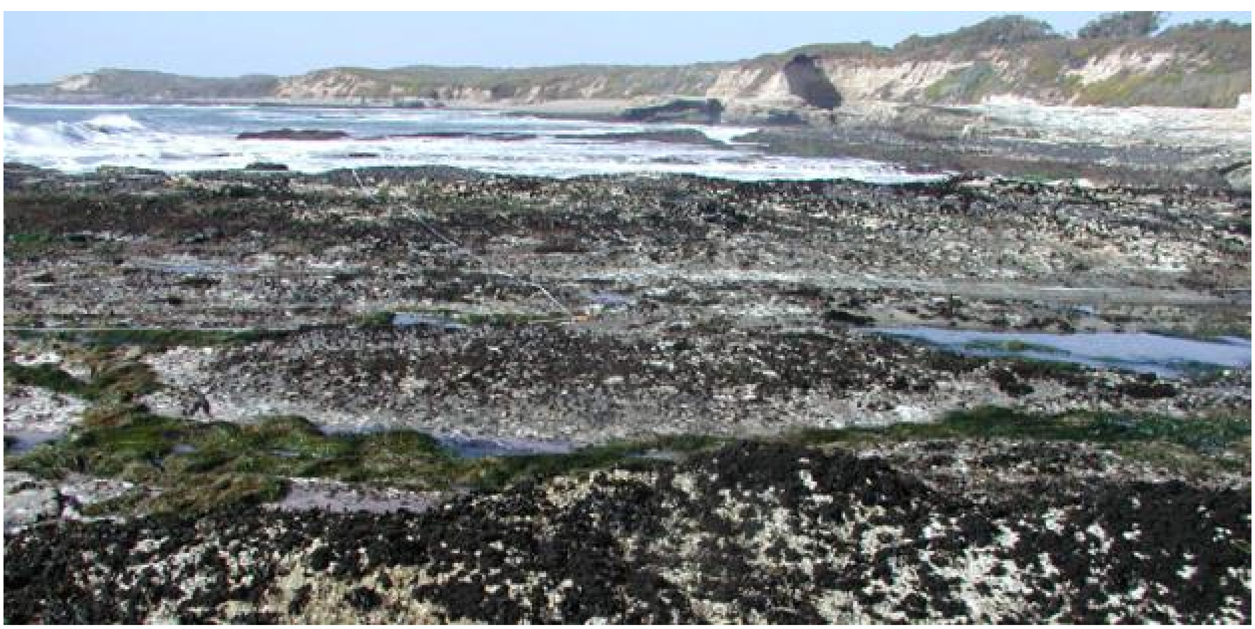
Purisima is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). Purisima is accessed via a trail through sand dunes and along a beach and this remote location on VAFB severely limits human visitation. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Purisima is on a long, rocky point dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, cobble and sandy beach.

Long-Term Monitoring Surveys at Purisima were established in 1993.

Stairs

Stairs is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). This site is located within the Vandenberg State Marine Reserve (SMR). The site's location on VAFB largely restricts human use, although the reef is occasionally used by military personnel for fishing. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.



Stairs is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Stairs were established in 1992 and Biodiversity Surveys were done in 2001, 2003, 2004, and 2017. The Biodiversity Survey grid encompasses two sections that are approximately 9 meters (along shore) x 50 meters (seaward), and 18 meters (along shore) x 50 meters (seaward).

Lompoc Landing

Lompoc Landing is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). This site is located within the Vandenberg State Marine Reserve (SMR). The site's location on VAFB largely restricts human use. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Lompoc Landing is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Biodiversity Surveys at Lompoc Landing were done in 2007. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Boat House

Boat House is located in the Central Coast region of California, on Vandenberg Air Force Base (VAFB). Boat House's location on VAFB limits human visitation, but it is a popular destination for military personnel, and the area is used by surfers, scuba divers and fishermen. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Boat House is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Boat House were established in 1992 and Biodiversity Surveys were done in 2001, 2007, 2017, and 2020. The Biodiversity Survey grid encompasses two sections that are approximately 21 meters (along shore) x 20 meters (seaward), and 6 meters (along shore) x 10 meters (seaward).

Government Point

Government Point is located in the South Coast region of California, within the Point Conception State Marine Reserve (SMR). This site is approximately 1.5 km downcoast from Point Conception, an important biogeographical barrier, and is near the Point Conception Mussel Watch site.

Government Point is arguably one of the most important sites monitored by the MARINe group because it is located at the junction of two major biogeographic provinces (cold-temperate Oregonian and warm-temperate Californian), where the ranges of many marine species begin or end. Thus, it gives us the unique opportunity to study species that might be living at their maximum tolerance level to certain environmental stressors, such as temperature or wave exposure. Monitoring community change in the marine environment at this unique location provides important insight to understanding the impacts of global climate change.

Government Point is accessed via private property, and there is almost no human visitation. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Government Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. Some unique features of the site include deep water directly offshore and numerous natural hydrocarbon seeps in the surrounding offshore benthos. Naturally occurring tar is common at this site, particularly in the high zone. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Government Point were established in 1992 and Biodiversity Surveys were done in 2001, 2006, 2016, and 2019. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 25 meters (seaward), and 15 meters (along shore) x 25 meters (seaward).

Alegria

Alegria is located in the South Coast region of California, within Hollister Ranch, which requires special access approval to visit and sample. Alegria is very sand influenced, and portions of the site may be inundated with sand. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Alegria is dominated by a mixture of consolidated sandstone and mudstone bedrock, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Alegria were established in 1992 and Biodiversity Surveys were done in 2001, 2003, 2004, 2012, 2016, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward).

Arroyo Hondo

Arroyo Hondo is located in the South Coast region of California. This site is 0.2 miles west of the Arroyo Hondo Canyon Mouth Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Arroyo Hondo is dominated by a mixture of consolidated sandstone and mudstone bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Arroyo Hondo were established in 1992 and Biodiversity Surveys were done in 2001, 2005, and 2016. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Ellwood

Ellwood is located in the South Coast region of California. This site is located upcoast of the Ellwood Pier, and there is a popular surfing location near the site. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Ellwood is dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble and sandy beach. The primary coastal orientation of this site is south.

Biodiversity Surveys at Ellwood were done in 2012. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Coal Oil Point

Coal Oil Point is located in the South Coast region of California, in the University of California Coal Oil Point Natural Reserve. The site is located within the Campus Point State Marine Conservation Area (SMCA) and is near the Santa Barbara Point Mussel Watch site. This gently sloping site consists of relatively flat terrain.

Coal Oil Point is dominated by a mixture of consolidated sandstone and mudstone bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. Sand inundation of the plots (sometimes 100% cover in the *Anthopleura* plots) is common at this site. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Coal Oil Point were established in 1992 and Biodiversity Surveys were done in 2002, 2006, 2012, 2016, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

Carpinteria

Carpinteria is located in the South Coast region of California, on Carpinteria State Beach, and is near the Carpinteria State Beach Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Carpinteria is dominated by a mixture of consolidated sandstone and mudstone bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Carpinteria were established in 1992 and Biodiversity Surveys were done in 2001, 2012, and 2019. The Biodiversity Survey grid encompasses one section that is approximately 27 meters (along shore) x 50 meters (seaward).

Mussel Shoals

Mussel Shoals is located in the South Coast region of California. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Mussel Shoals is dominated by a mixture of consolidated sandstone bedrock, riprap, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of boulder fields and sandy beach at this site. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Mussel Shoals were established in 1994 and Biodiversity Surveys were done by in 2001 and 2016. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Old Stairs

Old Stairs is located in the South Coast region of California. This site is located in an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS). This site is near the Point Mugu Old Stairs Mussel Watch site. This moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Old Stairs is dominated by a mixture of consolidated sandstone bedrock, riprap, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of boulder fields and sandy beach at this site. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Old Stairs were established in 1994 and Biodiversity Surveys were done in 2001, 2008, 2013, and 2019. The Biodiversity Survey grid encompasses two sections that are approximately 6 meters (along shore) x 20 meters (seaward), and 21 meters (along shore) x 20 meters (seaward).

Deer Creek

Deer Creek is located in the South Coast region of California. This site is located in an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS). This site is near the Point Mugu Old Stairs Mussel Watch site. This gently sloping site is greatly sand influenced with a steep drop-off into a channel, and consists of moderately uneven terrain, containing few cracks and folds.

Deer Creek is dominated by a mixture of consolidated basalt and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southeast.

Biodiversity Surveys were done in 2013 and 2018. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 5 meters (seaward).

Sequit Point

Sequit Point is located in the South Coast region of California, within an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS). This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Sequit Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south.

Biodiversity Surveys at Sequit Point were done in 2009, 2013, 2018, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 25 meters (seaward).

Lechuza Point

Lechuza Point is located in the South Coast region of California, within the Point Dume State Marine Conservation Area (SMCA) and is located in an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS). This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Lechuza Point is dominated by a mixture of consolidated bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is south.

Biodiversity Surveys were done in 2009, 2013, and 2018. The Biodiversity Survey grid encompasses two sections that are approximately 14 meters (along shore) x 40 meters (seaward), and 4 meters (along shore) x 25 meters (seaward).

Point Dume

Point Dume is located in the South Coast region of California, within the Point Dume State Marine Reserve (SMR). This site is located in an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS). This site is near the Point Dume Mussel Watch site. This site is accessed through Point Dume State Beach. This gently sloping site has a steep drop-off at the end of the reef, and consists of moderately uneven terrain, containing few cracks and folds.

There are tidepools downcoast of this site that are easily accessed by a stairway, however the site itself is likely infrequently visited due to tide dependent access around the rocky point. The Native Californian Chumash tribe inhabited this coastline for thousands of years and used this area as a sacred space. In 1542, the point was an important navigational marker for Spanish explorer Juan Rodriguez Cabrillo, but only received its name in 1793 when British sea captain George Vancouver named the craggy headlands Point Dume after Father Francisco Dumetz from the Mission San Buenaventura. During World War II, the U.S. Army used this site as an anti-aircraft artillery training area. It is believed that the top of the headlands was flattened after the war for commercial construction purposes. In 1979, Point Dume was acquired by the State of California and is being carefully and gradually restored to its pristine state.

Point Dume is dominated by a mixture of consolidated basalt, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south.

Biodiversity Surveys were done in 2013. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 10 meters (seaward).

Paradise Cove

Paradise Cove is located in the South Coast region of California. The site is located in an Area of Special Biological Significance (Mugu Lagoon to Latigo Point ASBS), within the Point Dume State Marine Conservation Area (SMCA). There is at least one storm water discharge in the vicinity of this site, and this site is 1.2 miles northeast of the Point Dume Mussel Watch site. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Paradise Cove is dominated by a mixture of consolidated sandstone bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southeast.

Long-Term Monitoring Surveys at Paradise Cove were established in 1994 and Biodiversity Surveys were done in 2001, 2006, 2010, 2013, 2018, and 2021. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 10 meters (seaward), and 15 meters (along shore) x 10 meters (seaward).

Point Vicente

Point Vicente is located in the South Coast region of California, within the Point Vicente State Marine Conservation Area (SMCA). This site is accessed through Pelican Cove Park, which has been owned by the city of Rancho Palos Verdes since May 2004. There is a parking lot with an access trail down to the beach. Almost directly up the steep cliff from the site (though not accessible directly from the site) is Point Vicente Lighthouse. This gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Point Vicente is dominated by a mixture of consolidated sandstone and mudstone, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is south/southwest.

Biodiversity Surveys were done in 2012. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Abalone Cove

Abalone Cove is located in the South Coast region of California, in Palos Verdes Open Space District, within the Abalone Cove State Marine Conservation Area (SMCA). This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Abalone Cove is dominated by a mixture of consolidated basalt bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Abalone Cove were established in 2009 and Biodiversity Surveys were done in 2012. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 10 meters (seaward).

White Point

White Point is located in the South Coast region of California and is 0.2 miles southeast of the Palos Verdes Royal Palms Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

White Point is dominated by a mixture of consolidated basalt bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at White Point were established in 1994 and Biodiversity Surveys were done in 2001, 2008, and 2018. The Biodiversity Survey grid encompasses two sections that are approximately 6 meters (along shore) x 25 meters (seaward), and 21 meters (along shore) x 25 meters (seaward).

Point Fermin

Point Fermin is located in the South Coast region of California. This site is near the San Pedro Fishing Pier Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Point Fermin is dominated by a mixture of consolidated sandstone and basalt bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southeast.

Long-Term Monitoring Surveys at Point Fermin were established in 1999 and Biodiversity Surveys were done in 2001, 2012, and 2019. The Biodiversity Survey grid encompasses two sections that are approximately 18 meters (along shore) x 50 meters (seaward), and 9 meters (along shore) x 50 meters (seaward).

Buck Gully South

Buck Gully South is located in the South Coast region of California, within the Crystal Cove State Marine Conservation Area (SMCA). This site is near the West Jetty Mussel Watch site. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Buck Gully South is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Biodiversity Surveys were done in 2009 and 2013. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward).

Crystal Cove

Crystal Cove is located in the South Coast region of California, in Crystal Cove State Park. The site is located in an Area of Special Biological Significance (Irvine Coast Marine Life Refuge ASBS) within the Crystal Cove State Marine Conservation Area (SMCA) and is near the Crystal Cove State Beach Mussel Watch site. This site is one of many rocky reefs located on the Crystal Cove State Park grounds, which receives a high number of visitors, including tidepoolers. Reef Point, where the site is located, has a flattened and angled bench separated by crevices resulting from uplifted bedding planes.

Crystal Cove is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. Sand levels in the splash and upper intertidal zone vary greatly within a year, sometimes covering the upper limits of barnacles. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Crystal Cove were established in 1996 and Biodiversity Surveys were done by in 2001, 2003, 2004, 2012, and 2018. The Biodiversity survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward).

Muddy Canyon

Muddy Canyon is located in the South Coast region of California, within the Crystal Cove State Marine Conservation Area (SMCA). This site is located in an Area of Special Biological Significance (Irvine Coast Marine Life Refuge ASBS). This site is near the Crystal Cove State Park Mussel Watch site. This site is accessed through Crystal Cove State Park, and has very high visitation by tidepoolers, surfers, SCUBA divers, and swimmers. The offshore waters are designated as an underwater park. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Muddy Canyon is dominated by a mixture of consolidated mudstone and sandstone, boulder fields, cobble, and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, cobble beach, and sandy beach. The primary coastal orientation of this site is southwest.

Biodiversity Surveys were done in 2013. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 33 meters (seaward).

Shaws Cove

Shaws Cove is located in the South Coast region of California, within the Laguna Beach State Marine Reserve (SMR). This site is popular for fishing, diving, recreational visitors, and educational field trips resulting in multiple anthropogenic disturbances. Docent educators are frequently on site. The site is characterized by flattened and gently sloping bedrock benches separated by crevices and channels.

Shaws Cove is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Shaws Cove were established in 1996 and Biodiversity Surveys were done in 2001, 2005, 2012, 2017, and 2021. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 10 meters (seaward).

Heisler Park

Heisler Park is located in the South Coast region of California, within the Laguna Beach State Marine Reserve (SMR). This site is located in an Area of Special Biological Significance (Heisler Park Ecological Reserve ASBS). This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Heisler Park is dominated by a mixture of consolidated bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southwest.

Biodiversity Surveys were done in 2009, 2013, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 33.3 meters (seaward).

Treasure Island

Treasure Island is located in the South Coast region of California, within the Laguna Beach State Marine Conservation Area (SMCA). This site is located just below a luxury resort and is heavily impacted by high levels of human visitors. Docent educators are frequently on site. The site is a gently sloping bedrock bench separated by large pools and channels.

Long-Term Monitoring Surveys at Treasure Island were established in 1996 and Biodiversity Surveys were done in 2017. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 25 meters (seaward).

Dana Point

Dana Point is located in the South Coast region of California, within the Dana Point State Marine Conservation Area (SMCA) and is near the Dana Point Mussel Watch site. The Ocean Institute is located at the entrance of the long reef and provides educational materials to the numerous schools that visit this site, some that make the hike to the monitoring location at the end of the reef. The site is located at the upcoast portion of this reef and is characterized by granitic boulders mixed with flattened benches.

Dana Point is dominated by a mixture of consolidated bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Dana Point were established in 1996 and Biodiversity Surveys were done in 2001, 2006, 2010, 2013, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 25 meters (seaward).

Swamis Beach

Swami's Beach is located in the South Coast region of California, within Cardiff State Beach and the Swamis State Marine Conservation Area (SMCA). This gently sloping site consists of flat terrain.

Long-Term Monitoring Surveys at Swami's Beach were established in 2017.

Cardiff Reef

Cardiff Reef is located in the South Coast region of California, at the south end of Cardiff State Beach. This site is on the border of the Swami's State Marine Conservation Area (SMCA) and is near the Cardiff Reef Mussel Watch site. This site is roughly 1.7 km south of the entrance to San Elijo Lagoon and is about 100 meters south of a large beach parking lot. This site receives a high number of visitors, including tidepoolers. This gently sloping site consists of moderately uneven terrain, containing relatively few large crevices and folds.

Cardiff Reef is dominated by a mixture of consolidated sedimentary bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of cobble/gravel fields and sandy beach at this site. Sand can fluctuate by more than one meter in less than a year at this site, resulting in a heavily scoured site. The primary coastal orientation of this site is west.

Long-Term MARINe surveys at Cardiff Reef were established in 1997 and Biodiversity Surveys were done in 2012. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 10 meters (seaward).

Scripps Reef

Scripps Reef is located in the South Coast region of California, midway between the Scripps Institution of Oceanography Pier and Black's Canyon in La Jolla, in the Scripps UC Coastal Reserve. The site is located in an Area of Special Biological Significance (San Diego Marine Life Refuge ASBS), within the San Diego-Scripps Coastal State Marine Conservation Area (SMCA) and is near the Scripps Reef Mussel Watch site. This site receives a high number of visitors, including tidepoolers, students, and scientists. Various class projects and research studies have been conducted here by UC San Diego and Scripps personnel, with authorization and documentation by the Scripps Coastal Reserve. This gently sloping site consists of moderately uneven terrain, containing many boulders and crevices.

Scripps Reef is dominated by a mixture of consolidated sedimentary and metamorphic bedrock, boulder fields, and sandy beach, and the area surrounding the site is comprised of sandy beach with upper intertidal boulders and rock outcrops. Sand can fluctuate over one meter within a single year at this site and may play a dominant role in structuring the community. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Scripps Reef were established in 1997 and Biodiversity Surveys were done in 2002, 2006, 2010, 2013, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 29.6 meters (along shore) x 40 meters (seaward).

La Jolla Caves

La Jolla Caves is located in the South Coast region of California, within the Matlahuayl State Marine Reserve (SMR). and is near the Point La Jolla Mussel Watch site. This gently sloping site consists of relatively flat terrain.

La Jolla Caves is dominated by a mixture of consolidated bedrock, boulder fields, and sandy beach, and the area surrounding the site is comprised of a mixture of boulder fields and cobble and sandy beach. The primary coastal orientation of this site is north.

Biodiversity Surveys were done in 2009, 2013, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

Wind and Sea

Wind and Sea is located in the South Coast region of California. This site is part of Windansea Beach, located in La Jolla. In addition to being known for surf breaks created by underwater reefs, this site has high visitation due to easy access and nearby neighborhoods. This site is highly sand influenced. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Wind and Sea is dominated by a mixture of consolidated sandstone and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is west/northwest.

Biodiversity Surveys at Wind and Sea were done in 2012, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 40 meters (seaward).

Sea Ridge

Sea Ridge is located in the South Coast region of California, within the South La Jolla State Marine Reserve (SMR). This site is accessible by stairway, then walking across a boulder field. The site has high visitation due to easy access and nearby neighborhoods. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Sea Ridge is dominated by a mixture of consolidated conglomerate bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble and sandy beach. The primary coastal orientation of this site is southwest.

Biodiversity Surveys at Sea Ridge were done in 2012 and 2017. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 60 meters (seaward).

Navy North

Navy North is located in the South Coast region of California, on the outer Point Loma Peninsula in San Diego. This site is located on a Navy base and receives few visitors due to access restrictions and high coastal bluffs. This gently sloping site consists of moderately uneven terrain, containing relatively few large crevices and folds.

Navy North is dominated by a mixture of consolidated sedimentary bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is west.

Long-Term MARINe surveys at Navy North were established in 1995 and Biodiversity Surveys were done by in 2012. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 25 meters (seaward).

Navy South

Navy South is located in the South Coast region of California, on the outer Point Loma Peninsula in San Diego, and is 0.2 miles north of the Point Loma Lighthouse Mussel Watch site. This site is located on a Navy base and receives few visitors due to access restrictions and high coastal bluffs. This moderately sloping site consists of moderately uneven terrain, containing relatively few large crevices and folds.

Navy South is dominated by a mixture of consolidated sedimentary bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Navy South were established in 1995.

Cabrillo I

Cabrillo I is located in the South Coast region of California, in Cabrillo National Monument. The site is located within the Cabrillo State Marine Reserve (SMR). This site receives approximately 150,000 visitors per year and is patrolled by volunteers of the National Park Service who educate visitors and enforce no-take regulations. The Point Loma Wastewater Treatment Plant is a short distance to the north, though the outfall is more than three miles offshore and is not thought to be a regular source of pollution for this site. Cabrillo I forms the upper end of a steep visitation gradient with Cabrillo III. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Cabrillo I is dominated by a mixture of consolidated sandstone, mudstone, and granite bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. There is a small sandy beach at the southern end of the site. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Cabrillo I were established in 1990 and Biodiversity Surveys were done in 2002, 2004, 2009, 2013, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 40 meters (seaward).

Cabrillo II

Cabrillo II is located in the South Coast region of California, in Cabrillo National Monument. The site is located within the Cabrillo State Marine Reserve (SMR). This site is adjacent to and south of Cabrillo I and receives approximately 10,000 visitors per year. It is patrolled by volunteers of the National Park service who educate visitors and enforce no-take regulations. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Cabrillo II is dominated by a mixture of consolidated sandstone, mudstone, and granite bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Cabrillo II were established in 1990.

Cabrillo III

Cabrillo III is located in the South Coast region of California, in Cabrillo National Monument. The site is located within the Cabrillo State Marine Reserve (SMR). This site is off limits to human visitors and receives very low visitation. As such it forms a steep visitation gradient with Cabrillo 1. This site may occasionally be exposed to San Diego Bay water which is a potential source of pollution. There is heavy boat traffic offshore coming and going from San Diego Bay. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Cabrillo III is dominated by a mixture of consolidated sandstone, mudstone, and granite bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is south, since Cabrillo III is at the southern tip of Point Loma but weather often comes from the west and southwest. Cabrillo III is exposed to sun and wind from the east.

Long-Term Monitoring Surveys Cabrillo III were established in 1990 and Biodiversity Surveys were done in 2002, 2012, and 2017. The Biodiversity Survey grid encompasses two sections that are approximately 21 meters (along shore) x 60 meters (seaward), and 4 meters (along shore) x 60 meters (seaward).

Otter Harbor

Otter Harbor is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on San Miguel Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park and is near the San Miguel Island Otter Harbor Mussel Watch site. The gently sloping site consists of moderately uneven terrain, with long channels almost parallel to shore.

Otter Harbor is dominated by consolidated sandstone bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. Offshore from the site is a detached reef rising 1-2 m serving as a breakwater for the site. A channel about 5 m wide and 1-2 m deep separates the reef from the main island. The primary coastal orientation of this site is north.

Long-Term Monitoring Surveys at Otter Harbor were established in 1985.

Harris Point

Harris Point is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on San Miguel Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) within the Harris Point State Marine Reserve (SMR) in Channel Islands National Park. The moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Harris Point is dominated by consolidated angular metamorphic bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. There is a small islet offshore from the site that rises 6-8 m high that affords the site some protection, however waves have been observed breaking over the islet. High rocks on the outer edge of the site give further protection from the prevailing NW swell.

Long-Term Monitoring Surveys at Harris Point were established in 1985

Cuyler Harbor

Cuyler Harbor is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on San Miguel Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) within the Harris Point State Marine Reserve (SMR) in Channel Islands National Park. This site was established in the same location as one of the historic study sites used for a baseline study of the Southern California Bight (conducted by the Bureau of Land Management in 1978-79). This site may receive a small number of visitors camping in the summer. The gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Cuyler Harbor is dominated by consolidated basalt bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The high ridge on the northern, exposed side protects the monitoring site from swells and some weather. A small surge channel on the north side of the site provides a nice example of zonation and holds a broad diversity of algae. Lower reaches are heavily influenced by sand.

Long-Term Monitoring Surveys at Cuyler Harbor were established in 1985 and Biodiversity Surveys were done in 2001, 2002, and 2012. The Biodiversity Survey grid encompasses one section that is approximately 29 meters (along shore) x 15 meters (seaward).

Crook Point

Crook Point is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on San Miguel Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. This site was established in the same location as one of the historic study sites used for a baseline study of the Southern California Bight (conducted by the Bureau of Land Management in 1978-79). The gently sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Crook Point is dominated by consolidated sandstone bedrock, (some of which is quite soft in areas and easily eroded), and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The site is at the two western most outcrops of the series along the Crook Point area. All the outcrop peninsulas point southeast. The outer reef absorbs most of the impacts from the heavy south westerly swells that pound this area. While the inner reef is quite smooth, the outer reef is very pock marked with many pools and areas of very rough surface.

Long-Term Monitoring Surveys at Crook Point were established in 1985 and Biodiversity Surveys were done in 2001 and 2012. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 20 meters (seaward).

Fossil Reef

Fossil Reef is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Rosa Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. Hard sedimentary rocks form jetty-like reefs with flat rock and sand between. The shale rocks are often eroded into irregular shapes. Crumbly rock forms a steep bluff behind the reef. The reef itself extends from the bluff over 100 m. There are wide flat areas of reef between finger ridges that slope down to the west.

Fossil Reef is dominated by consolidated sandstone bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Fossil Reef were established in 1988 and Biodiversity Surveys were done in 2001 and 2004. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 10 meters (seaward).

NW Talcott

NW Talcott is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Rosa Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. The surf break here is popular with commercial divers who surf, and good conditions will attract several boats. The rocks here are gray Monterey shale forming very flat reefs and rocky outcrops. Even in rough seas, most of this site is protected because of its extensive reef flat. A narrow sand beach above the reef flat is backed by a vertical cliff. Surfaces tend to be close to horizontal or vertical here.

NW Talcott is dominated by a mixture of consolidated monterey shale bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is north.

Long-Term Monitoring Surveys at NW Talcott were established in 1986 and Biodiversity Surveys were done in 2001 and 2004. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 15 meters (seaward).

Carrington Point

Carrington Point is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Rosa Island, California. This site is located in Carrington Point State Marine Reserve (SMR) in Channel Islands National Park. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Carrington Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of a mixture of consolidated bedrock, boulder fields, cobble, and sandy beach. The primary coastal orientation of this site is southeast.

Biodiversity Surveys at Carrington Point were done in 2017. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 20 meters (seaward).

East Point

East Point is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Rosa Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. This site receives roughly 200-300 visitors per year. Hard, coarse, volcanic rock forms the reef at the eastern tip of the island. A low, sloping, rocky bluff backs the reef. At the point, the reef flat extends about 60 m from the bluff, stepping down with abrupt changes in biota from barnacles to rockweed, to mussels, to surfgrass. Because of the low slope though, the zones tend to be wide. The lower reef has many channels and small pools.

East Point is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southeast.

Long-Term Monitoring Surveys at East Point were established in 1986 and Biodiversity Surveys were done in 2001 and 2004. The Biodiversity Survey grid encompasses one section that is approximately 35 meters (along shore) x 20 meters (seaward).

Ford Point

Ford Point is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Rosa Island. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. A narrow reef of sandstone, backed by a sandstone cliff, runs east-west on the south side of Ford Point. The sandstone forms smooth steps to the water, each gently slope away from the water. The entire reef is tilted down to the east where the different zones grade into the next

Ford Point is dominated by consolidated sandstone bedrock, and the area surrounding the site is comprised of consolidated bedrock. The sandstone at this site is soft and erodes quickly. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Ford Point were established in 1985 and Biodiversity Surveys were done in 2001 and 2017. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 15 meters (seaward).

Johnsons Lee

Johnsons Lee is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Rosa Island. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. The gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Johnsons Lee is dominated by consolidated sandstone bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The sandstone at this site is soft and erodes quickly, and parts of the reef are occasionally subject to inundation by deep sand. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Johnsons Lee were established in 1985 and Biodiversity Surveys were done in 2001, 2002, 2004, and 2017. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 15 meters (seaward).

South Point

South Point is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Rosa Island, California. This site is located within South Point State Marine Reserve (SMR) in Channel Islands National Park. This gently sloping site consists of flat terrain, such as a sandy beach.

South Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, cobble, and sandy beach. The primary coastal orientation of this site is southwest.

Biodiversity Surveys were done in 2017. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 40 meters (seaward).

Trailer

Trailer is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. This site was used as a research site for graduate work (abalone studies) by Brian Tissot and Bill Douros. The west facing reef is rough volcanic rock with a rugose topography. Large cobbles are present between the two rocky benches that form the site. Each bench is about 40 m long with a steep rock cliff behind the site.

Trailer is dominated by a mixture of consolidated volcanic bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. High tide goes to the base of the cliff. A small sandy beach at the base of a small canyon marks the north end of the site. To the south there are some large boulders on the reef. The primary coastal orientation of this site is west.

Long-Term Monitoring Surveys at Trailer were established in 1994 and Biodiversity Surveys were done in 2002 and 2006. The Biodiversity Survey grid encompasses two sections that are approximately 15 meters (along shore) x 15 meters (seaward), and 12 meters (along shore) x 15 meters (seaward).

Forney

Forney is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) and is near the Santa Cruz Island Fraser Point Mussel Watch site. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Forney is dominated by consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sand. The primary coastal orientation of this site is east/southeast.

Biodiversity Surveys were done in 2002. The Biodiversity Survey grid encompasses one section that is approximately 29.3 meters (along shore) x 25 meters (seaward).

Fraser Cove

Fraser Cove is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. This site was used as a research site for graduate work (abalone studies) by Brian Tissot and Bill Douros. Fraser Cove is a flat wave cut bench about 40 m wide on average, and the entire site is quite broad. The gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Fraser Cove is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is north.

Long-Term Monitoring Surveys at Fraser Cove were established in 1994 and Biodiversity Surveys were done in 2002, 2003, and 2004. The Biodiversity Survey grid encompasses two sections that are approximately 15 meters (along shore) x 15 meters (seaward), and 12 meters (along shore) x 20 meters (seaward).

Orizaba Cove

Orizaba Cove is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. The slope at this site is fairly high, making a narrow intertidal zone which consists of moderately uneven terrain, containing few cracks and folds.

Orizaba Cove is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of consolidated bedrock. The site receives some protection from Orizaba Rock but large swells commonly roll over the site and can be quite impressive. The primary coastal orientation of this site is northwest.

Long-Term Monitoring Surveys at Orizaba Cove were established in 1994.

Prisoners Harbor

Prisoners Harbor is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological

Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. The reef is only a few hundred meters from the Prisoners Pier. This site was established in the same location as one of the historic study sites used for a baseline study of the Southern California Bight (conducted by the Bureau of Land Management in 1978-79). This site receives roughly 200-300 visitors per year. The reef is difficult to access though due to an almost 2 m vertical rock at the beach intersection that is washed by waves on all but lowest tides. Access is easier when the sand accumulates but that is rare. The moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Prisoners Harbor is dominated by consolidated sedimentary bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is northeast and is protected within the Prisoners Bay.

Long-Term Monitoring Surveys at Prisoners Harbor were established in 1994 and Biodiversity Surveys were done in 2002, 2003, and 2004. The Biodiversity Survey grid encompasses two sections that are approximately 18 meters (along shore) x 5 meters (seaward), and 9 meters (along shore) x 5 meters (seaward).

Scorpion Rock

Scorpion Rock is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) within the Scorpion State Marine Reserve (SMR) in Channel Islands National Park. This site consists of two areas: the main site and the *Hesperophycus* plots, on rocks separated from the main island. The moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Scorpion Rock is dominated by a mixture of consolidated volcanic bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation varies at this site, and it is well protected from direct northwest swells by Scorpion Rock (for which the site is named).

Long-Term Monitoring Surveys at Scorpion Rock were established in 1994.

Valley

Valley is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS). This steep site consists of moderately uneven terrain, containing few cracks and folds.

Valley is dominated by consolidated bedrock, and the area surrounding the site is comprised consolidated bedrock. The primary coastal orientation of this site is southeast.

Biodiversity Surveys were done in 2002 and 2006. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 10 meters (seaward).

Valley Anchorage

Valley Anchorage is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. The moderately sloping site consists of extremely uneven terrain, containing many deep cracks and folds.

Valley Anchorage is dominated by a mixture of consolidated volcanic bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The site has a hard rocky point that is often subjected to the southerly swell making it a difficult place to work.

Long-Term Monitoring Surveys at Valley Anchorage were established in 2008

Willows Anchorage

Willows Anchorage is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Cruz Island, California. This site is located in an Area of Special Biological

Significance (San Miguel, Santa Rosa, and Santa Cruz Islands ASBS) in Channel Islands National Park. This site was established in the same location as one of the historic study sites used for a baseline study of the Southern California Bight (conducted by the Bureau of Land Management in 1978-79). The moderately sloping site consists of moderately uneven terrain, containing few cracks and folds. The reef is narrow and is backed by very tall rocky cliffs.

Willows Anchorage is dominated by a mixture of consolidated metamorphic bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The high tide washes up to the base of the cliff. The reef faces southeast and is subject to powerful long period swells that wash-up over the reef rather than crash onto it.

Long-Term Monitoring Surveys at Willows Anchorage were established in 1994 and Biodiversity Surveys were done in 2002 and 2006. The Biodiversity Survey grid encompasses two sections that are approximately 18 meters (along shore) x 15 meters (seaward), and 13.5 meters (along shore) x 20 meters (seaward).

Cat Rock

Cat Rock is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Anacapa Island. This site is located in an Area of Special Biological Significance (Santa Barbara Island and Anacapa Island ASBS) within the Anacapa Island Special Closure in Channel Islands National Park. The site is actually the second reef to the east of Cat Rock. This site was used in a visitor impact study (Littler), and the monitoring plots were part of an experiment to measure impacts of trampling and scraping (VTN Oregon). The rocky point has extensive rocky intertidal with small sandy beaches on both sides. The reef is actually a series of raised reef with surge channels separating the rocks. There is a great deal of relief, and different heights are present on each reef.

Cat Rock is dominated by a mixture of consolidated volcanic bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The volcanic rock rises one to two meters above the zero-tide level, and the outer most reef breaks nearly all the wave energy at low tide. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at Cat Rock were established in 1982 and Biodiversity Surveys were done in 2001 and 2005. The Biodiversity Survey grid encompasses two sections that are approximately 12 meters (along shore) x 20 meters (seaward), and 15 meters (along shore) x 15 meters (seaward).

Middle West

Middle West is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Anacapa Island. This site is located in an Area of Special Biological Significance (Santa Barbara Island and Anacapa Island ASBS) within the Anacapa Island State Marine Reserve (SMR) in Channel Islands National Park and is near the Anacapa Island Mussel Watch site. Deep surge channels separate this site from Middle East, and what little landing occurs at Middle Island occurs at Middle West. The site is typically lower and has more relief than Middle East.

Middle West is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is north.

Long-Term Monitoring Surveys at Middle West were established in 1982 and Biodiversity Surveys were done in 2001, 2005, 2012, and 2018. The Biodiversity Survey grid encompasses one section that is approximately 29 meters (along shore) x 10 meters (seaward).

Middle East

Middle East is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Anacapa Island. This site is located in an Area of Special Biological Significance (Santa Barbara Island and Anacapa Island ASBS) within the Anacapa Island State Marine Reserve (SMR) in Channel Islands National Park and is near the Anacapa Island Mussel Watch site. This site was established as a control site for visitation at Middle West (from which it is separated by a surge channel), as access is difficult here. This site is a flat-topped reef between one and two meters above the zero tide and has a steep slope to the water.

Middle East is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is north.

Long-Term Monitoring Surveys at Middle East were established in 1982

S Frenchys Cove

S Frenchys Cove is located in the Northern Channel Islands, within the Channel Islands National Marine Sanctuary, on Anacapa Island. This site is located in an Area of Special Biological Significance (Santa Barbara Island and Anacapa Island ASBS) within the Anacapa Island Special Closure in Channel Islands National Park. The site is the first reef from the access point, or gap, near the east end of West Anacapa Island. The second reef (first major point) includes one of the historic study sites used for a baseline study of the Southern California Bight (conducted by the Bureau of Land Management in 1978-79). This second reef is also referred to as the "blowhole" and is where the majority of visitors go. This site receives 1500-3000 visitors per year, primarily tidepoolers. The site consists of a number of solid rocky reefs one to almost two meters above zero tide level. The reef is quite level with little change in elevation from the cliff out to the end of the mussel plots.

S Frenchys Cove is dominated by a mixture of consolidated volcanic bedrock and sandy beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The outer reef has a fairly dense mussel bed and even at low tide is washed by large swells. The primary coastal orientation of this site is south.

Long-Term Monitoring Surveys at S Frenchys Cove were established in 1982 and Biodiversity Surveys were done in 2001, 2005, and 2012. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 33 meters (seaward).

Landing Cove

Landing Cove is located in the Southern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Barbara Island, California. This site is located in an Area of Special Biological Significance (Santa Barbara Island and Anacapa Island ASBS) in Channel Islands National Park. This site was established a few hundred meters north of one of the historic study sites (Cave Canyon) used for a baseline study of the Southern California Bight (conducted by the Bureau of Land Management in 1978-79). This site may receive a small number of visitors camping in the summer; however sea lions outnumber people. The intertidal is a narrow, sloping bench flanked by high cliffs and an abrupt drop-off into the subtidal.

Landing Cove is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of consolidated bedrock. The east facing exposure and high cliffs result in the intertidal being shaded in the late afternoon.

Long-Term Monitoring Surveys at Landing Cove were established in 1985 and Biodiversity Surveys were done in 2001, 2006, and 2020. The Biodiversity Survey grid encompasses two sections that are approximately 11 meters (along shore) x 10 meters (seaward), and 14 meters (along shore) x 10 meters (seaward).

Sea Lion Rookery

Sea Lion Rookery is located in California in the Southern Channel Islands, within the Channel Islands National Marine Sanctuary, on Santa Barbara Island, California. This site is located in an Area of Special Biological Significance (Santa Barbara Island and Anacapa Island ASBS) in Channel Islands National Park, within the Santa Barbara Island State Marine Reserve (SMR). This site is adjacent to a sea lion rookery, and the intertidal receives a lot of trampling from the sea lions. The east facing intertidal shelf is an extensive flat reef 10-40 m in width, with irregularities in the rock leaving pools which never drain and high spots that may be exposed for hours during a low tide. Surge channels cut into the reef and the edges drop abruptly into deeper water.

Sea Lion Rookery is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of consolidated bedrock. The primary coastal orientation of this site is east.

Long-Term Monitoring Surveys at Sea Lion Rookery were established in 1985 and Biodiversity Surveys were done in 2001, 2006, and 2020

Thousand Springs

Thousand Springs is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Nicolas Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Thousand Springs is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is north/northeast.

Long-Term Monitoring Surveys at Thousand Springs were established in 2015 and Biodiversity Surveys were done in 2003, 2007, and 2013. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 10 meters (seaward).

Tranquility Beach

Tranquility Beach is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Nicolas Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Tranquility Beach is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is north/northwest.

Biodiversity Surveys were done in 2009 and 2013. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 40 meters (seaward).

Anchor Point

Anchor Point is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Nicolas Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Anchor Point is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is north.

Long-Term Monitoring Surveys at Anchor Point were established in 2015.

Marker Poles

Marker Poles is located in the Southern Channel Islands. This site is near the San Nicolas Island/Freighter dock Mussel Watch site and is not accessible by the public, as it is on navy-owned San Nicolas Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Marker Poles is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and sandy beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at Marker Poles were established in 2015 and Biodiversity Surveys were done in 2003, 2007, and 2013. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward).

Cosign

Cosign is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Nicolas Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping, site consists of extremely uneven terrain, containing many deep cracks and folds.

Cosign is predominantly a mixture of consolidated bedrock and boulder fields, and the surrounding area is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is west/southwest.

Long-Term Monitoring Surveys at Cosign were established in 2015

Two Harbors

Two Harbors is located in the Southern Channel Islands, on Santa Catalina Island, California. This site is located in an Area of Special Biological Significance (Santa Catalina Island - Subarea One, Isthmus Cove to Catalina Head ASBS). This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Two Harbors is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is southeast.

Biodiversity Surveys were done in 2010, 2013, and 2018. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 10 meters (seaward).

Bird Rock

Bird Rock is located in the Southern Channel Islands, on the northeast side of Santa Catalina Island, California. This site is located in an Area of Special Biological Significance (Santa Catalina Island - Subarea One, Isthmus Cove to Catalina Head ASBS) within the Blue Cavern Onshore State Marine Conservation Area (SMCA) and is near the Bird Rock Mussel Watch site. This site lies approximately 500 meters offshore of the University of Southern California Wrigley Marine Science Center. This site receives moderately low visitation due to its offshore location; however, USC Marine Lab classes and scientists focus studies there because of its excellent intertidal habitat. California State University Los Angeles researchers have conducted experimental studies here since the 1980’s. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Bird Rock is dominated by consolidated volcanic breccia bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulders. The primary coastal orientation of this site is west/northwest.

Long-Term Monitoring Surveys at Bird Rock were established in 1982 and Biodiversity Surveys were done in 2002, 2004, 2007, 2013, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 10 meters (seaward).

Big Fisherman Cove

Big Fisherman Cove is located in the Southern Channel Islands, on Santa Catalina Island, California, within the Blue Cavern Onshore State Marine Conservation Area (SMCA). This site is near the USC Wrigley Marine Science Center and is located in an Area of Special Biological Significance (Santa Catalina Island - Subarea One, Isthmus Cove to Catalina Head ASBS). This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Big Fisherman Cove is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is west/northwest.

Biodiversity Surveys were done in 2010, 2013, 2018, and 2020. The Biodiversity Survey grid encompasses two sections that are approximately 8 meters (along shore) x 10 meters (seaward), and 10 meters (along shore) x 10 meters (seaward).

Goat Harbor

Goat Harbor is located in the Southern Channel Islands, on Santa Catalina Island, California, within the Long Point State Marine Reserve (SMR). This steep site consists of extremely uneven terrain, containing many deep cracks and folds.

Goat Harbor is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of boulder fields. The primary coastal orientation of this site is north/northwest.

Biodiversity Surveys were done in 2010, 2013, 2018, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 10 meters (seaward).

Avalon Quarry

Avalon Quarry is located in the Southern Channel Islands, on Santa Catalina Island, California. This site is located in an Area of Special Biological Significance (Santa Catalina Island - Subarea Four, Binnacle Rock to Jewfish Point ASBS). This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Avalon Quarry is dominated by natural boulder fields, and the area surrounding the site is comprised of boulder fields. The primary coastal orientation of this site is east/northeast.

Biodiversity Surveys were done in 2010 and 2013. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 10 meters (seaward).

Little Harbor

Little Harbor is located in the Southern Channel Islands, on the southwest side of Santa Catalina Island, California. This site is located in an Area of Special Biological Significance (Subarea Two, North End of Little Harbor to Ben Weston Point ASBS). This site is situated between the Little Harbor campground and Shark Cove surfing beach. This site receives moderately low visitation due to its remote location and steep bluffs; however, campers and boaters explore the area. This moderately sloping site consists of moderately uneven terrain, containing crevices and folds.

Little Harbor is dominated by a mixture of consolidated metamorphic bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Little Harbor were established in 1995 and Biodiversity Surveys were done in 2002, 2007, 2018, and 2020. The Biodiversity Survey grid encompasses two sections that are approximately 10 meters (along shore) x 10 meters (seaward), and 12 meters (along shore) x 10 meters (seaward).

West Cove

West Cove is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Clemente Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

West Cove is dominated by a mixture of consolidated granite bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is southwest.

Long-Term Monitoring Surveys at West Cove were established in 2011 and Biodiversity Surveys were done in 2013 and 2019. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 50 meters (seaward).

North Head

North Head is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Clemente Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

North Head is dominated by a mixture of consolidated conglomerate bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is north.

Biodiversity Surveys were done in 2014 and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 40 meters (seaward).

Graduation Point

Graduation Point is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Clemente Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Graduation Point is dominated by a mixture of consolidated bedrock, boulder fields, and cobble beach, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble and sandy beach. The primary coastal orientation of this site is northwest.

Biodiversity Surveys were done by in 2014 and 2020. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 25 meters (seaward).

Boy Scout Camp

Boy Scout Camp is located in the Southern Channel Islands, within an Area of Special Biological Significance (San Clemente Island ASBS). This site is not accessible by the public, as it is on navy-owned San Clemente Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Boy Scout Camp is dominated by a mixture of consolidated volcanic bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock and boulder fields. The primary coastal orientation of this site is northeast.

Long-Term Monitoring Surveys at Boy Scout Camp were established in 2011 and Biodiversity Surveys were done in 2009, 2013, and 2019. The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 15 meters (seaward).

Horse Beach Cove

Horse Beach Cove is located in the Southern Channel Islands. This site is not accessible by the public, as it is on navy-owned San Clemente Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This gently sloping site consists of moderately uneven terrain, containing a few cracks and folds.

Horse Beach Cove is dominated by consolidated bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock and cobble beach. The primary coastal orientation of this site is east.

Long-Term Monitoring Surveys at Horse Beach Cove were established in 2011.

Eel Point

Eel Point is located in the Southern Channel Islands. This site is within an Area of Special Biological Significance (San Clemente Island ASBS) and is near the San Clemente Island/Darter ASBS Mussel Watch site. This site is not accessible by the public, as it is on navy-owned San Clemente Island. Visitation to this site is limited to fishing and tidepooling navy personnel and a handful of researchers. This moderately sloping site consists of moderately uneven terrain, containing few cracks and folds.

Eel Point is dominated by consolidated volcanic bedrock, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and cobble beach. The primary coastal orientation of this site is south/southwest.

Long-Term Monitoring Surveys at Eel Point were established in 2011 and Biodiversity Surveys were done by in 2009, 2013, and 2020. The Biodiversity Survey grid encompasses one section that is approximately 20 meters (along shore) x 25 meters (seaward).

Appendix 8: Connectivity report to CDFW

Further development of the California Connectivity Population Model (CCPM)

A report submitted to the California Department of Fish and Wildlife

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Background

The most distinctive attribute of California's system of marine protected areas (MPAs) established by the Marine Life Protection Act (MLPA) is its science-based design as an ecological network. One key feature of a geospatial ecological network is the degree to which locations are connected by the transport of propagules (animal larvae or algal spores) among the MPAs and interspersed populations that constitute the network. For most nearshore marine species, population connectivity is achieved primarily via propagule transport (i.e. dispersal), and such transport is often dictated by the interaction between oceanographic forcing and life history attributes (e.g. planktonic larval duration). Spatial variation in ocean currents and differences among species in propagule duration influence the direction and distance to which a species' propagules are dispersed. As such, the location of an MPA will greatly influence the number and location of MPAs to which propagules produced in that MPA will be transported to.

Over the last decade there have been remarkable advances in modeling oceanographic processes and propagule transport. Such models are typically developed using ROMS (Regional Ocean Modeling System) approaches. These are typically four-dimensional models (three spatial dimensions and time) that track propagules through spatial cells in a temporal series of incremental (time steps) spatial movements (through x,y,z vectors). Random movement via (random) turbulent vertical velocity can be incorporated to simulate small–scale effects not otherwise captured in the grid (cell)-based propagule movement forcing. Cells can be of differing size and shape, and these features affect computational requirements. Often, ROMS models have nested grids of cells of differing dimensions related to the complexity and spatial scaling of processes affecting particle motion (including the slope of the seafloor and complexity of the coastline). Usually this results in smaller cells close to shore with increasing size in offshore areas. For the application of ROMS to estimate spatial population connectivity via propagule dispersal, as we do here, mathematical propagules are "released" in cells and their dispersal is tracked over a period of time. At each time-step in the modeled period the location of the propagule can be assessed. By releasing a similar number of propagules from all of the cells across the spatial domain of the model (i.e. northern Baja California, Mexico to northern Washington state, including California state waters) and matching cell configuration with MPAs, the relative contribution of MPAs to the replenishment of other MPAs can be estimated.

By incorporating a metric or proxy (e.g., area of suitable habitat) for spatial variation in propagule production among cells, and applying a predetermined pelagic duration of a species' propagules (PLD), the relative contributions of populations (or MPAs) can be estimated. PLD categories representative of the diversity of marine species can be applied both to represent the spectrum of durations and dispersal of California marine species, and to assess how PLD influences the distribution of dispersing propagules. These relative contributions of propagule exchange among populations (or MPAs), often referred to as "connectivity", are often characterized by "source" populations (or MPAs) that contribute more propagule replenishment to other populations (or MPAs) than they receive from other populations (or MPAs), and "sink" populations (or MPAs), that conversely receive more propagules than they contribute to other populations (or MPAs). While sink populations (or MPAs) can be more reliant on connectivity for replenishment and persistence, source populations (or MPAs) can contribute disproportionately to the replenishment of other populations (or MPAs) across the network. All of this suggests that ensuring that source MPAs support large populations and high levels of propagule production is key to the size and persistence of protected populations across the MPA network. In addition, those populations (or MPAs) that receive disproportionate numbers of propagules (relative to other locations) or that have disproportion number of links to donor populations (or MPAs) may in fact be more resilient than other populations (or MPAs).

Previously, we developed a population connectivity model for the purpose of identifying source populations and MPAs that was then incorporated into CDFW's MPA prioritization scheme for the spatial design of the long-term MLPA monitoring program. The detailed methods employed in the development of that model and the resulting evaluation of population and MPA connectivity were summarized in the report to the Ocean Protection Council submitted this past month (June 2020) and attached as **Appendix I**. One key shortcoming identified by those results was the biased connectivity metrics for MPAs at the northern and southern ends of the state because of the lack of information for habitat in Oregon and Mexico. The contributions of MPAs in northern California to the replenishment of other populations were underestimated because their contributions to populations in Oregon could not be calculated because of the inability to model the the suitability of habitat for settlement in locations in Oregon. These estimates of population connectivity between California MPAs and ecosystems in Oregon are important for understanding the integration of the California and Oregon systems of MPAs. Similarly, the replenishment of populations in MPAs in southern California by populations in Mexican waters could not be estimated because of the lack of information about habitat in Mexican locations. Connectivity with populations in Mexico informs our understanding of how the condition of species populations and ecosystems in northern Baja California influence the performance and conservation value of California MPAs, and how the design of future MPA networks in northern Baja California, Mexico might best integrate with California's network of MPAs. In addition, information on the distribution and abundance of habitat (e.g., 0-30m depth rocky reef) across the network has been enhanced since the development of the original model. This includes updating the state's seafloor database with data produced by more recent mapping studies, making it possible to separate mapped and predicted habitat where habitat types were interpolated across the unmapped nearshore "white zone", use of high resolution data to attribute habitat depth zones, and new methods and data sources for calculating kelp cover. As such, connectivity metrics were likely to change to varying degrees across the entire state network.

Therefore, this project had four overarching objectives. First, we acquire and process seafloor data from Oregon state agencies and from various sources in Mexico to provide the area or linear extent of the same targeted habitats previously incorporated into the California connectivity model. We then assimilate those data into the ROMS-based contribution model (linking the ROMS model to habitat in donor and recipient locations), extending it throughout coastal Oregon and northern Baja California (south to Punta Baja/ El Rosario). We updated the state's database with new and refined seafloor information and updated the existing California contribution model from that database. We run this model to re-evaluate the metrics associated with the MPAs that constitute the network. In addition, this updated version of the contribution model forms the foundation that we build upon for our current application for evaluating the ecological performance of the network in preparation for the 2022 network evaluation.

Approach

Habitat attributes targeted for collection

We targeted open coast (non-estuarine) habitats and used simple rock/sediment binary classifications of geologic habitats. Our final habitat list included kelp forests, rocky shores, beaches/ sedimentary shores, and rock vs. sediment across 4 depth categories (0-30m, 30-100m, 100-200m, and >200m depth). We were able to collect some information on all of these habitat categories from the three model regions (Baja California, Mexico; California; Oregon), but the quality of the information varied by region.

Collection of information on habitat distribution in Mexico

We worked with a group of academics interested in the application of marine protected areas to Baja California to acquire the best available habitat data from a variety of sources. PhD candidate Nur Arafeh-Dalmau (of the University of Queensland, Australia) used satellite imagery to map kelp, nearshore rock, emergent rocks, and shoreline habitats. Kyle Cavanaugh of UCLA applied the same techniques used in California to map kelp canopy from Landsat satellite imagery to northern Baja and generated maps of both the maximum extent of kelp canopy and the persistence of that canopy. Cira Gabriela Montaó Moctezuma and her student Beatriz Ibarra of Universidad Autónoma de Baja California (UABC) used satellite imagery and ground-truthing to map shoreline habitats. We processed bathymetric data from GEBCO and NOAA's online bathymetric data viewer, removed artifacts, and used these sources to generate a depth zone file for habitat classification. A number of other researchers contributed biological and habitat data toward writing a paper on the potential for MPA development in Baja California, but these data were not ultimately used in the connectivity modelling effort.

Collection of information on habitat distribution in OR

We worked with staff from the Oregon Department of Fish and Wildlife and Oregon Department of Land Conservation and Development to acquire the best available habitat data for Oregon waters. These agency staff, including Andy Lanier and Dave Fox used their familiarity with the datasets to crosswalk the substrate data from its existing Coastal and Marine Ecological Classification Standard (CMECS) habitat classification system to a binary rock/sediment system to be compatible with that used in California. Bathymetry data was acquired from a 100m bathymetric DEM from the Active Tectonic & Seafloor Mapping Lab at Oregon State University, and the NOAA/NGDC coastal relief model (v4.1), which is consistent with the bathymetry data used during California's MPA planning process and processed by Andy Lanier to generate depth zones. We processed shoreline data from NOAA's Environmental Sensitivity Index (ESI) maps to convert from the complex ESI classification system to the simpler classifications used in California. This ESI data is the same source used for California's shoreline mapping, and Emily Saarman used her experience classifying shoreline habitats in California to inform the work in Oregon.

Updating habitat information in California

In this effort to ensure the most robust habitat availability estimates for California, we made several key updates to the California habitat databases that had substantial impacts on the total areas of habitat estimated in each ROMS cell or MPA.

- We included high resolution habitat mapping in several areas where it had either been accidentally omitted in the previous version, or where new habitat data had been collected.
- We used the depth information collected from the high resolution mapping to attribute depth zones. In the previous version, depth zones were attributed using much lower resolution bathymetry data, which was an artifact of data limitations during the MPA planning process. This change resulted in large differences in areas of habitats attributed to different depth zones in some locations.
- We estimated habitat availability in the nearshore “white zone” using similar methods to those used in the previous habitat calculations, but we maintained the ability to separate mapped from predicted habitat, which was not possible in previous versions.
- For consistency with data availability from OR and Baja, we calculated kelp canopy from the CDFW overflight data as a maximum extent of kelp across all years. Kelp area had previously been calculated for individual survey years, but these individual survey years had not been collapsed to create a single maximum kelp estimate.
- To allow comparison between high resolution (~2m) CDFW kelp overflights and lower resolution (30m) Landsat kelp data (the only data available in Baja), we calculated maximum kelp extent from both types of kelp data in the region of overlap (Pigeon Pt. to San Diego, California). We then compared the two different kelp measures by ROMS cell and found that measures were very similar. In general Landsat estimated slightly less maximum kelp area than CDFW data, and this was especially true where patches of kelp were smaller than the 30m Landsat pixels. Overall, we concluded that the two data types were compatible.
- To create a single measure of shallow (0-30m) reef for input into the population models, we generated a file that was a union of mapped rock (0-30m), predicted rock (0-30m), and maximum kelp. This enabled us to calculate the total area with any of these three habitats without double-counting areas with both rock and kelp. The union file will also enable us to explore the relationship between the habitat types (i.e. answer questions like “what proportion of mapped 0-30m rock also has kelp cover?”) in the future.

ROMS model (cells) in OR and MX

ROMS cells in all three model regions were originally drawn using coarse shoreline data and needed to be refined to ensure that they: 1) effectively captured all intended subtidal and intertidal habitats, 2) were consistent with respect to capturing estuarine habitats, especially shoreline habitats within estuaries, 3) didn’t contain duplicate or overlapping sections that would result in double-counting habitats in the final habitat availability analyses, and 4) incorporated relevant marine protected areas. In Oregon, Andy Lanier took the first crack at cell refinement, including identifying a number of offshore areas that fall within state waters, but were currently not included in any cells. These areas were created as potential cell extensions. These cells were further refined to ensure consistent application to estuarine areas. In California, a number of inconsistencies were found in how the ROMS cells last used for habitat calculations (previous model versions) treated estuarine habitats, as well as several areas where overlapping cells would have resulted in double-counting habitats. These inconsistencies were fixed to match the work done in OR and Baja. The ROMS cells in Baja were refined using rules consistent with the work done in the other regions.

Habitat data processing and archiving

All habitat data used to calculate habitat availability has been organized and stored in the form of ESRI geodatabases at UCSC. These geodatabases will enable revisiting the habitat calculations if need be and also serve as a resource for others interested in habitat availability in the three model regions.

- For California, high resolution habitat and bathymetry geodatabases that include the best available habitat data for all of California are stored locally at UCSC and will be shared more broadly via CDFW's FTP site so that a variety of scientists and others interested in ocean habitats can access them.
- For Oregon, final habitat data layers used in calculations will be shared back with OR state agency personnel, as well as archived at UCSC.
- For Baja, final habitat layers will be shared back with the group of academics lead by Nur Arafeh Dalmau to ensure that work by this group to inform potential establishment of MPAs is consistent with the ROMS modelling effort. These data will also be archived at UCSC.

Ongoing constraints in the California ROMs and habitat data

Despite the incorporation of more recent habitat data across California waters, the ROMS model still cannot resolve oceanographic processes in the vicinity of the Farallon Islands, because no ROMS cells were created for the Farallons during the initial oceanographic modeling. In addition, as identified below, there are still gaps in seafloor mapping in the Northern Channel Islands that are currently being filled, but these data are not yet publicly available. Finally, detailed substrate mapping is somewhat limited in Oregon, and extremely limited in Baja, resulting in limited available information for deeper (>30m) habitats in Baja. This lack of information will reduce the accuracy of estimated contributions from and to Mexico and Oregon, respectively.

Key model assumptions

To properly interpret model results, it is imperative to recognize and consider several key assumptions of the design and implementation of the model:

1) No effect of MPA or other protection has been included in the modeling. This will be rectified in future versions of the modeling.
2) Propagule production and subsequent settlement is assumed to be directly and linearly related to the amount of Habitat in the donor and recipient MPA or ROMS cell. Here habitat means the general habitat types described above (e.g. rocky intertidal, Hard bottom subtidal from 0-30 m). This assumption has the following linked assumptions
    a) No effect of protection (as noted above)
    b) No effect of meso or micro habitat features on the abundance, the size structure or the size independent fecundity of species. These will be addressed in future versions of the modeling

c) No geographic patterns of abundance, the size structure or the size independent fecundity of species, These will be addressed in future versions of the modeling
d) No geographically independent environmental impacts on the abundance, the size structure or the size independent fecundity of species (e.g. local hypoxic events). However note that projections of change in environmental conditions could be incorporated into modeling. Two examples will serve as examples. First, spatially explicit climate related change in temperature, OA or other attributes could be incorporated into connectivity and contribution modeling. Second, sea level rise could also be formally incorporated into connectivity modeling through projected spatially explicit predictions of habitat gain or loss.

Results

Results of contribution modeling (i.e. relative magnitude of propagule contribution and receipt or "settlement" among MPAs) are presented for three ecosystems (rocky intertidal, 0-30m depth rocky reef, and 30-100m depth rocky reef). For each ecosystem, we present the connectivity results by the four categories of propagule duration: 5-20 days, 20-45 days, 45-90 days, and 90-150 days. We first present both the contribution of each MPA to replenishment of all other MPAs (i.e. "donor" MPA) and the extent to which each MPA received propagules from all other MPAs (i.e. "recipient" MPA) also referred to as "settlement". Although the model runs incorporated propagule production and receipt in Mexico and Oregon ROMs cells, the graphs only display the transfer of propagules in California MPAs. As such, the added contribution of northern California MPAs to Oregon cells and the additional receipt of propagules in Southern California MPAs from Mexican populations are not reflected in these figures. The magnitude of contribution and receipt of propagules among MPAs is reflected in the scale of the vertical axis of these graphs. For example, note how the vertical scale decreases from one figure to the next with increasing PLD (e.g., Figure 1 vs. 3 vs. 5), indicating the lower magnitudes of contribution and receipt as propagules with greater PLDs experience higher mortality in the plankton and advection from the study region. The relative contributions and receipt of propagules is reflected across MPAs within each graph. Note that not all MPAs can be listed on these figures because of spacing on the axes and caution has to be made when ascribing depicted levels of contribution or receipt (settlement) to a specific MPA. Where we have attributed propagule contributions to specific MPAs, we have scrutinized the habitat areas and modelled propagule production in those MPAs and concluded that they are the likely contributors of propagules.

We then present the spatial pattern over which each MPA contributes to the replenishment of other MPAs and, conversely, the distribution of MPAs receiving propagules from a donor MPA. Here, connectivity matrices match the donor and recipient MPAs. As with the donor-recipient graphs described above, not all MPAs can be listed on the orthogonal axes of the connectivity matrices, but they illustrate broad geographic patterns of the magnitude and spatial scales of connectivity. Note that the shade of grey represents the contribution of propagules from one MPA to another and that the units are standard deviations (for defined PLD's). This has two effects. First the scaling is the same for all PLD ranges (-3 to +3 sd) and, second that because of the use of standard deviations even very low values (e.g. -3 sd ~ 1st percentile of values that occurred) are shown in the figures (i.e. light grey).

Note that this report only includes analyses of contribution out of and into MPAs. Other quesitons and combinations of donor and recipient locations may be very useful and interesting for assessment and management of marine resources. These combinations include but are not limited to the following:

1) Contribution of MPAs to non-MPA locations. Results of these analyses would provide insight into the effect of MPA's in subsidizing providing resilience to area not under regulatory protection. These analyses could be tailored to include many ancillary questions such as level of MPA benefit, geographic differences in effect size and relative importance of MPA effects to differing habitats
2) Contribution of non-MPA locations to MPA's. Results of these analyses would provide insight into the effect of non-MPA location to MPA's, relative to the contribution of MPAs, thus allowing understanding of the importance of "ordinary" management to the success of the individual MPAs as well as the MPA network. As above, these analyses could be tailored to include many ancillary questions such geographic differences in effect size and relative importance of non-MPA effects to differing habitats
3) Network analyses – such as estimation of the inclusion and exclusion importance of specific MPAs or non-MPA locations to network performance.

Overarching patterns and results

1) Across all three ecosystems assessed, the magnitude of both MPA contributions and receipt ("settlement") of propagules declines with increasing propagule duration (PLD) because of higher net mortality during dispersal and advection of propagules from the study region.
2) Across all three ecosystems, there are strong regional (southern, central, northern California) differences in the relative contribution and receipt of propagules among MPAs. These regional patterns are similar among ecosystems: lowest, highest, intermediate for southern, central, and northern California, respectively. However, the magnitude of these regional differences vary among the three ecosystems; least for the rocky intertidal, intermediate for 0-30m deep hard bottom and kelp forest, greatest for 30-100m deep hard bottom.
3) In each of the southern, central and northern regions, some MPAs stand out as disproportionately contributing to both propagule contribution and receipt.
4) Across all three ecosystems, the spatial extent to which MPAs contributed to replenishment of other MPAs increased with increasing PLD (see connectivity matrices).
5) Within central California, MPAs contributed to the replenishment of MPAs primarily to the north, whereas within southern and northern California, MPAs contributed to replenishment of MPAs both to the north and south.

Detailed summaries by ecosystem and propagule duration (PLD)

Summaries for model outputs for each ecosystem and propagule duration (PLD) are repetitive in case readers restrict their attention to a particular ecosystem.

Estimates of the relative contribution of each MPA to the replenishment of other MPAs for **rocky intertidal species with PLDs of 5-20 days** varied substantially among MPAs across the study region (Figure 1 lower graph). The overall magnitude of propagule contribution among MPAs is high relative to longer PLDs as reflected in the higher values of the vertical axis scale. Most notably, the estimated contribution from the Point Sur SMR was markedly higher than other MPAs. Although recipient populations in Oregon were incorporated into this new model, the contribution of the northernmost California MPAs remained at zero for rocky intertidal species because contributions are shown only to MPAs in California. There is also a paucity of rocky intertidal habitat in those MPAs. The receipt of propagules is more broadly distributed across MPAs and the relative variation among MPAs in their receipt of propagules of species with short PLDs was not as great a s the variation in contributions (Figure 1, upper graph). However some MPAs stood out as receiving substantially more propagules from other MPAs, especially in central California around Carmel Bay and the Monterey peninsula (Point Lobos SMR to Pacific Grove SMCA). This high level of connectivity likely reflects the close proximity of the MPAs to one another in that region.

The general pattern of high connectivity restricted to nearby MPAs is reflected in the connectivity matrix for rocky intertidal species with PLDs of 5-20 days across the state (Figure 2). One notable exception is the Judith Rock SMR that was a donor to a large number of other MPAs in part because of its large size and oceanographic connectivity throughout the Northern Channel Islands. The connectivity matrix illustrates the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California. The increased receipt of propagules from Mexico by MPAs in southern California is not depicted because the graphs only show receipt from other MPAs in California.

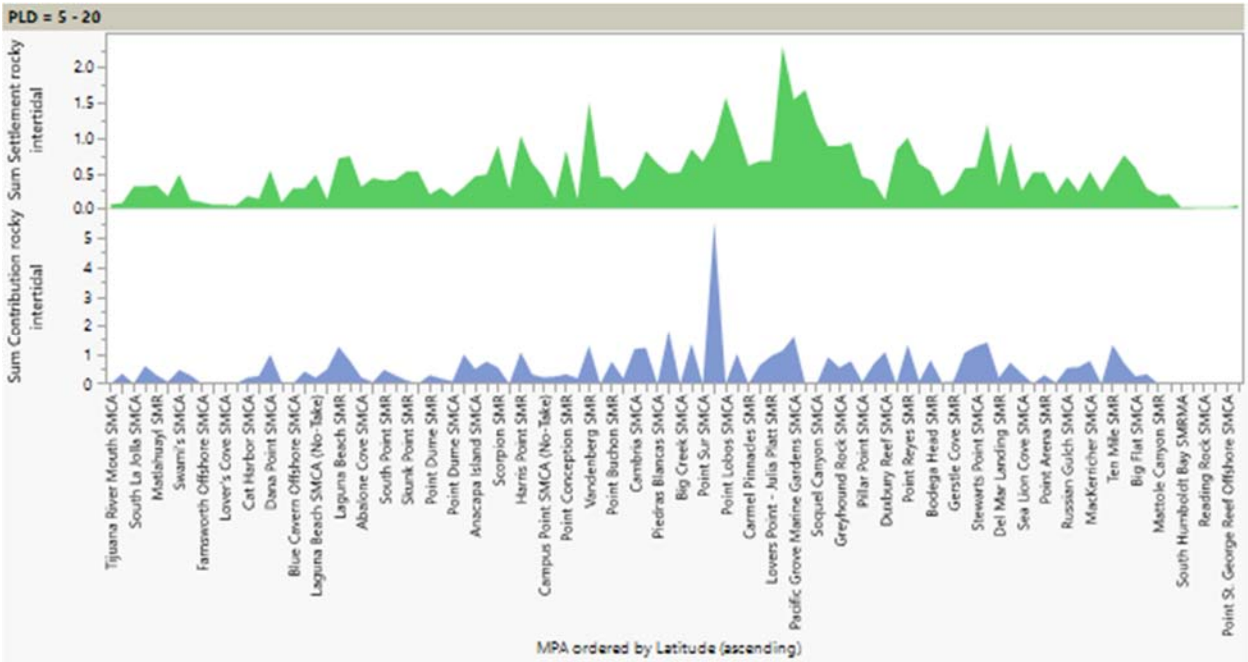

Figure 1. Rocky intertidal: comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. “recipient”) referred to as “settlement” (upper graph in green) for propagule durations **(PLD) of 5-20 days**. MPAs are ordered from south to north, left to right, respectively.

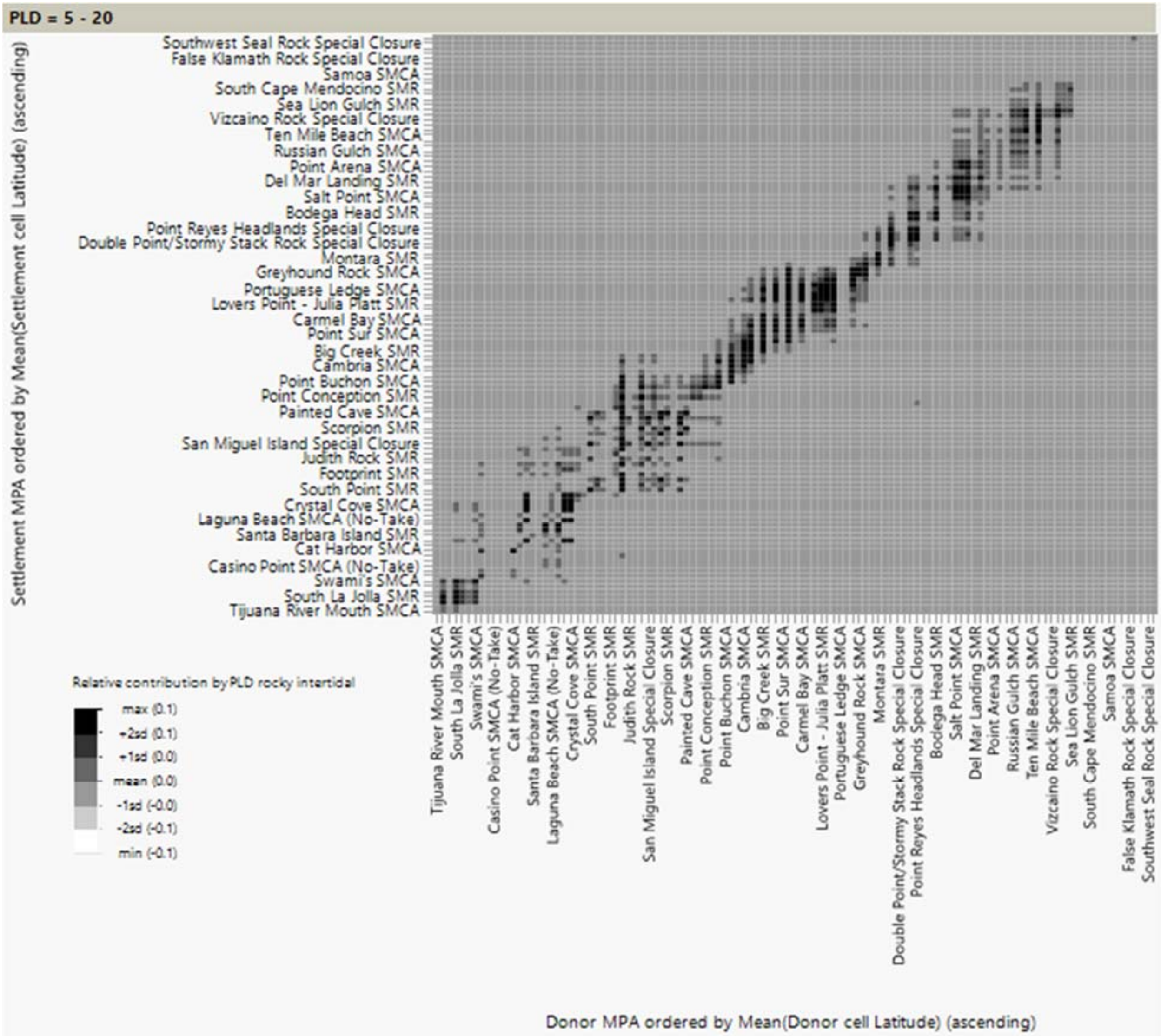

Figure 2. Rocky intertidal: spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 5-20 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

As the **PLD of rocky intertidal species** increases to **20-45 days**, the magnitude of contribution from MPAs to other MPAs decreases (note reduced vertical scale), though the geographic patterns among MPAs are very similar (Figure 3). Again, the Point Sur SMR contributed notably to other MPAs in the network and MPAs around the Monterey peninsula were notable recipients. Variation in the relative receipt of propagules among MPAs is also reduced as propagules are delivered more broadly among MPAs, though the geographic pattern is similar to the shorter PLD. The connectivity matrix exhibits a broadening of recipient MPAs from each donor MPA and this occurs across the state as PLD is increased (Figure 4). The connectivity matrix illustrates again the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California.

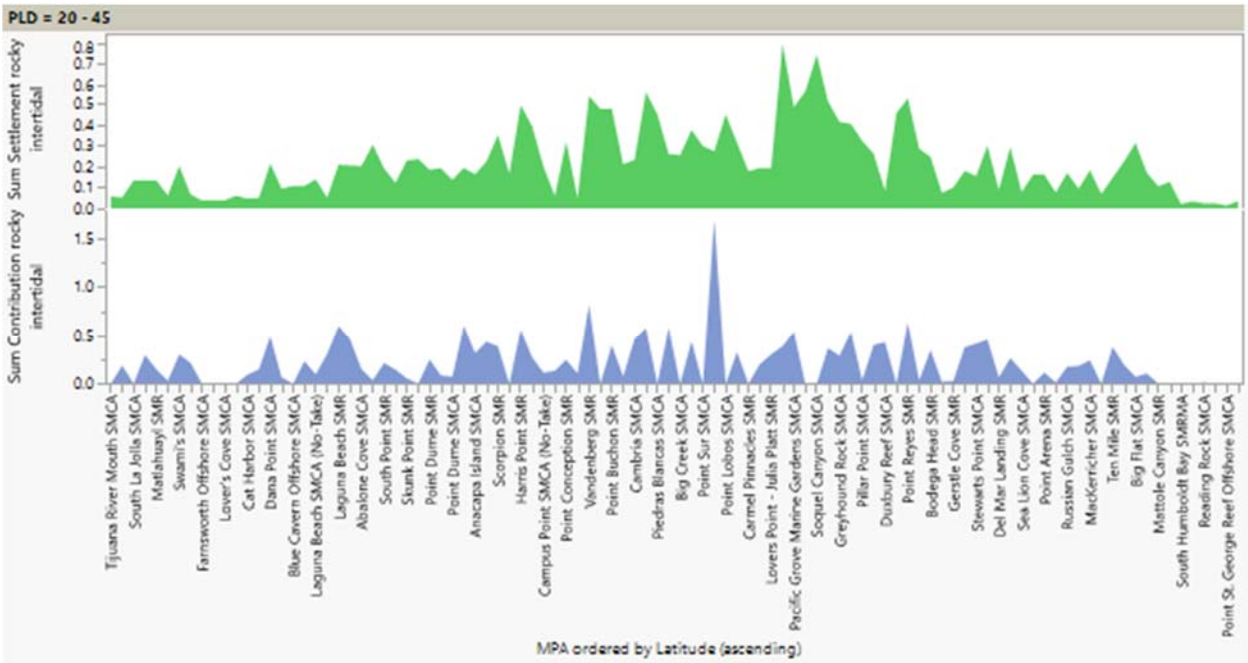

Figure 3. Rocky intertidal: comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. “recipient”) referred to as “settlement” (upper graph in green) for propagule durations **(PLD) of 20-45 days**. MPAs are ordered from south to north, left to right, respectively.

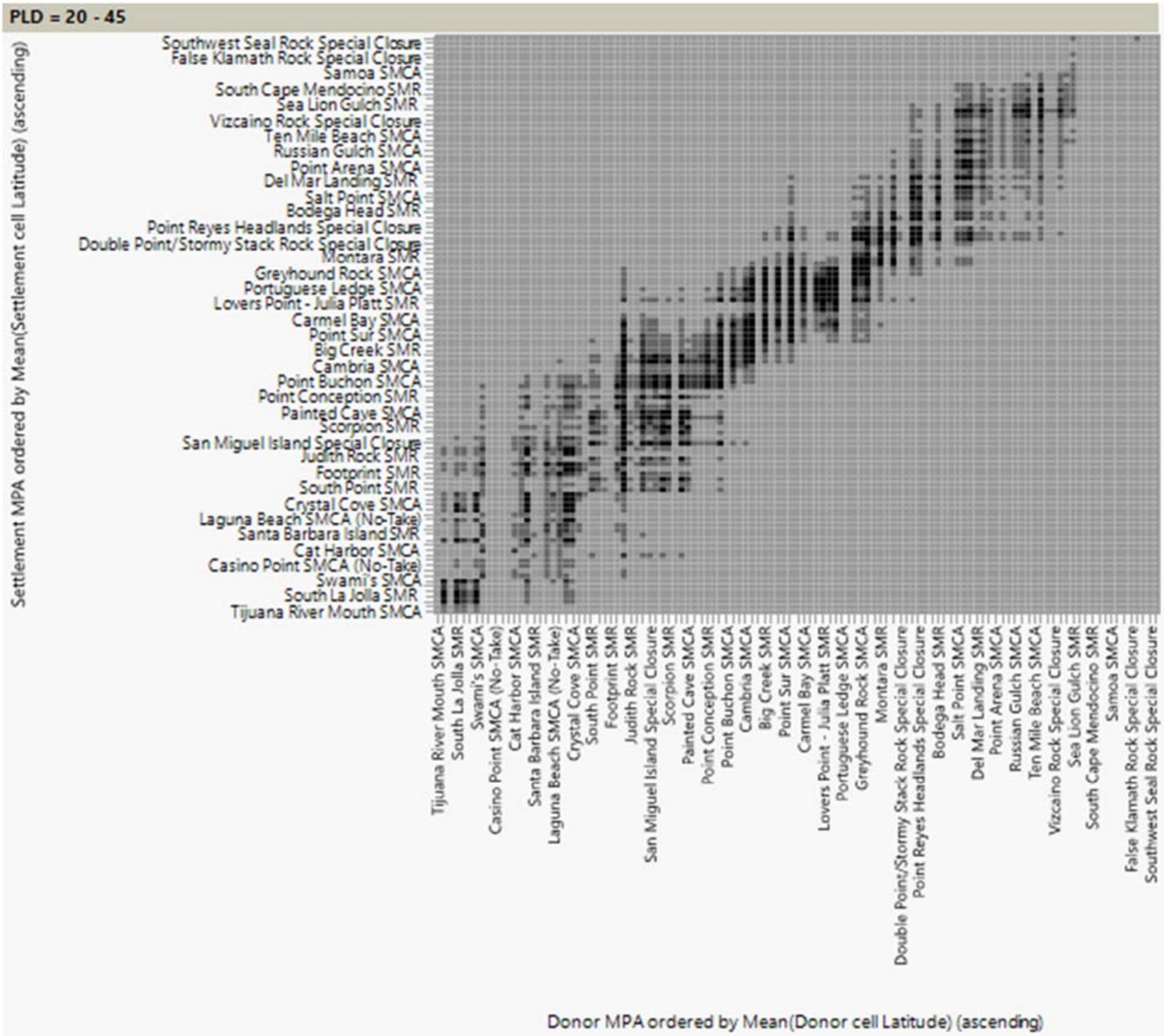

Figure 4. Rocky intertidal: spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 20-45 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

As the PLD of **rocky intertidal species** increases to **45-90 days**, the magnitude of contributions and recipients among MPAs declines further due to increasing propagule loss (mortality and advection), however the geographic pattern remains largely the same as the shorter PLDs, with less variation in the magnitude of propagule receipt among MPAs (Figure 5). The number and spread of MPAs receiving propagules from each MPA continues to increase with increasing propagule duration (Figure 6).

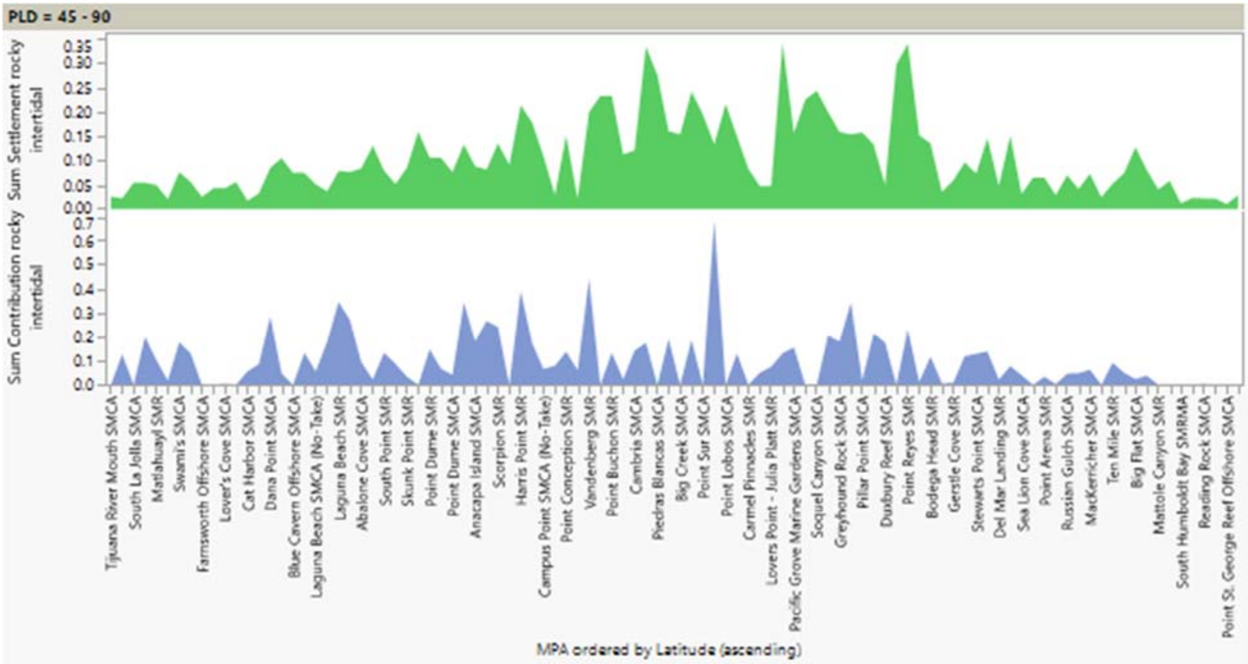

Figure 5. Rocky intertidal: comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. "recipient") referred to as "settlement" (upper graph in green) for propagule durations **(PLD) of 45-90 days**. MPAs are ordered from south to north, left to right, respectively.

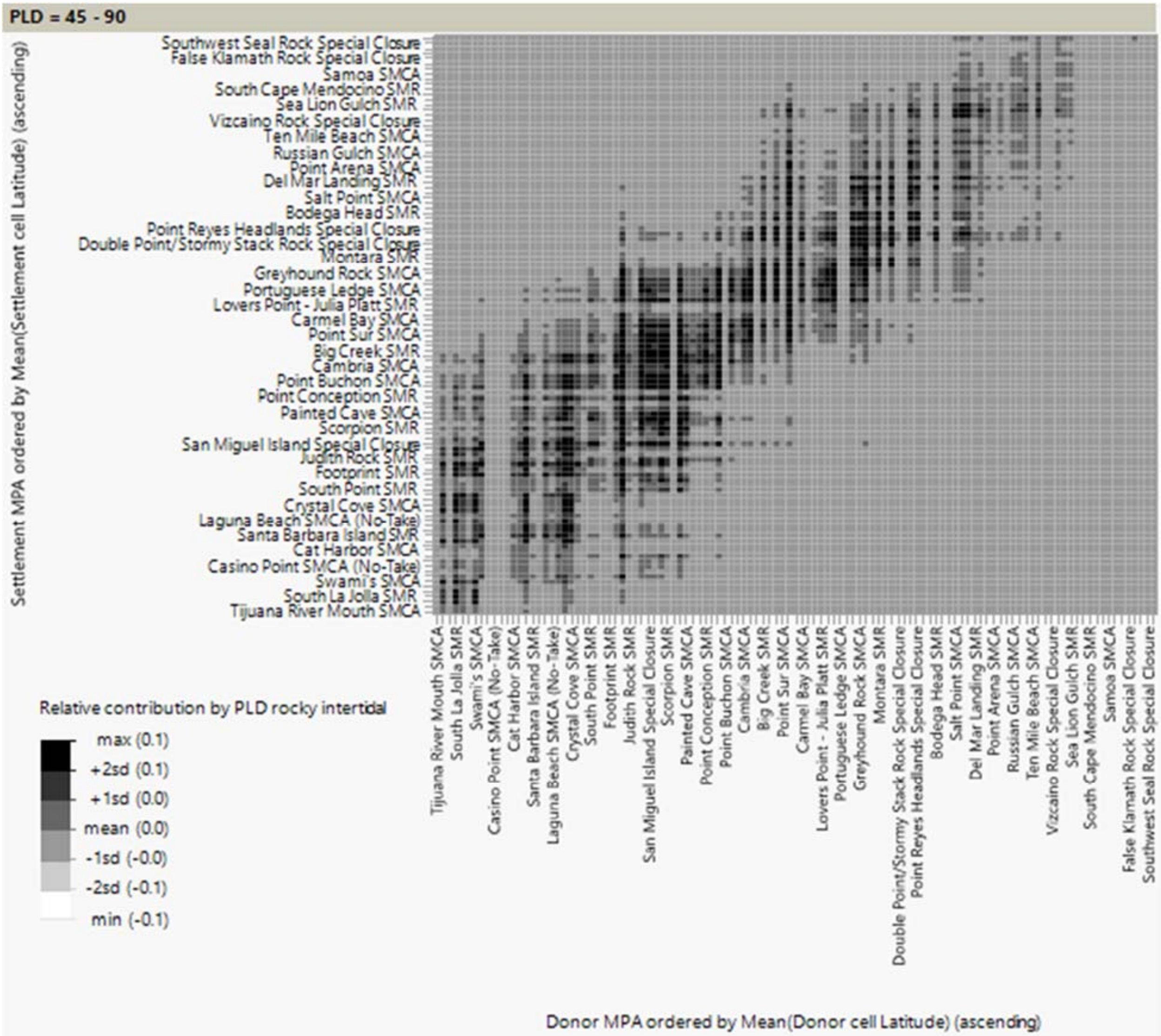

Figure 6. Rocky intertidal: spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 45-90 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

As the PLD of **rocky intertidal species** increases to **90-150 days**, the magnitude of contributions and recipients among MPAs declines further due to increasing propagule loss (mortality and advection), however the geographic pattern remains largely the same as the shorter PLDs (Figure 7). Point Sur MPA continues to be a major donor, whereas Harris Point SMR also becomes a major donor in the Northern Channel Islands region. The number and spread of MPAs receiving propagules from each MPA continues to increase over broad sections of the coast with increasing propagule duration (Figure 8). This spatial expansion of MPAs receiving substantial replenishment from individual MPAs is especially evident in southern California and the Northern Channel Islands (e.g. Judith Rock SMR).

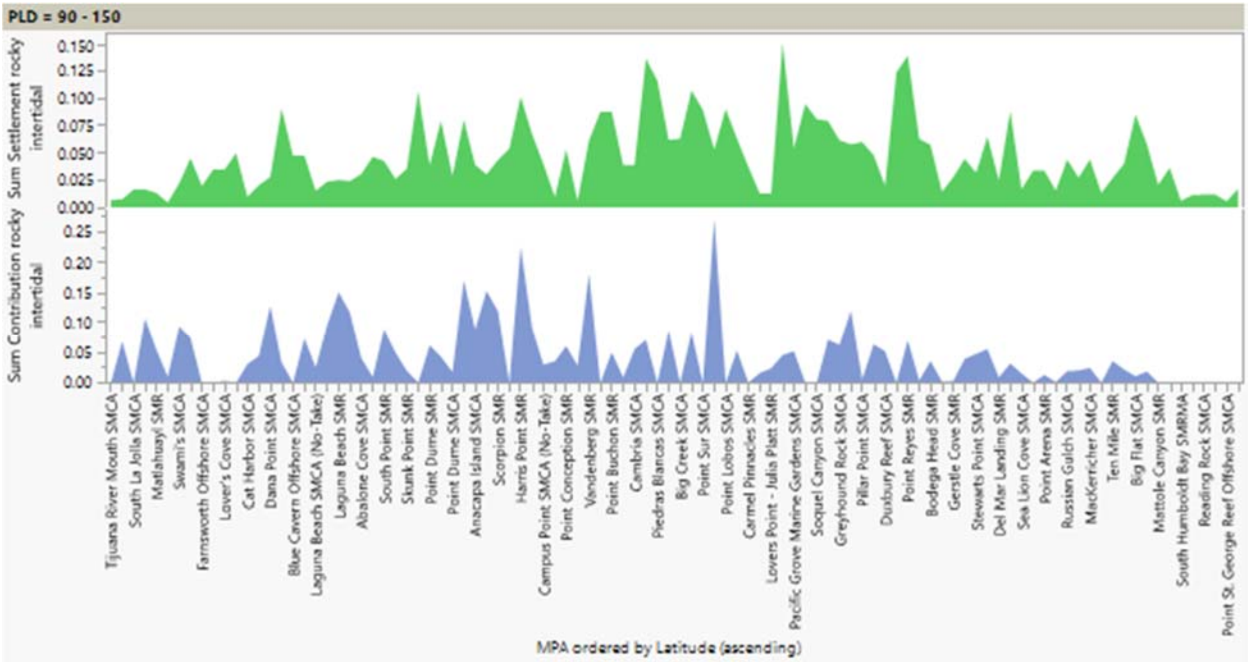

Figure 7. Rocky intertidal: comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. "recipient") referred to as "settlement" (upper graph in green) for propagule durations **(PLD) of 90-150 days**. MPAs are ordered from south to north, left to right, respectively.

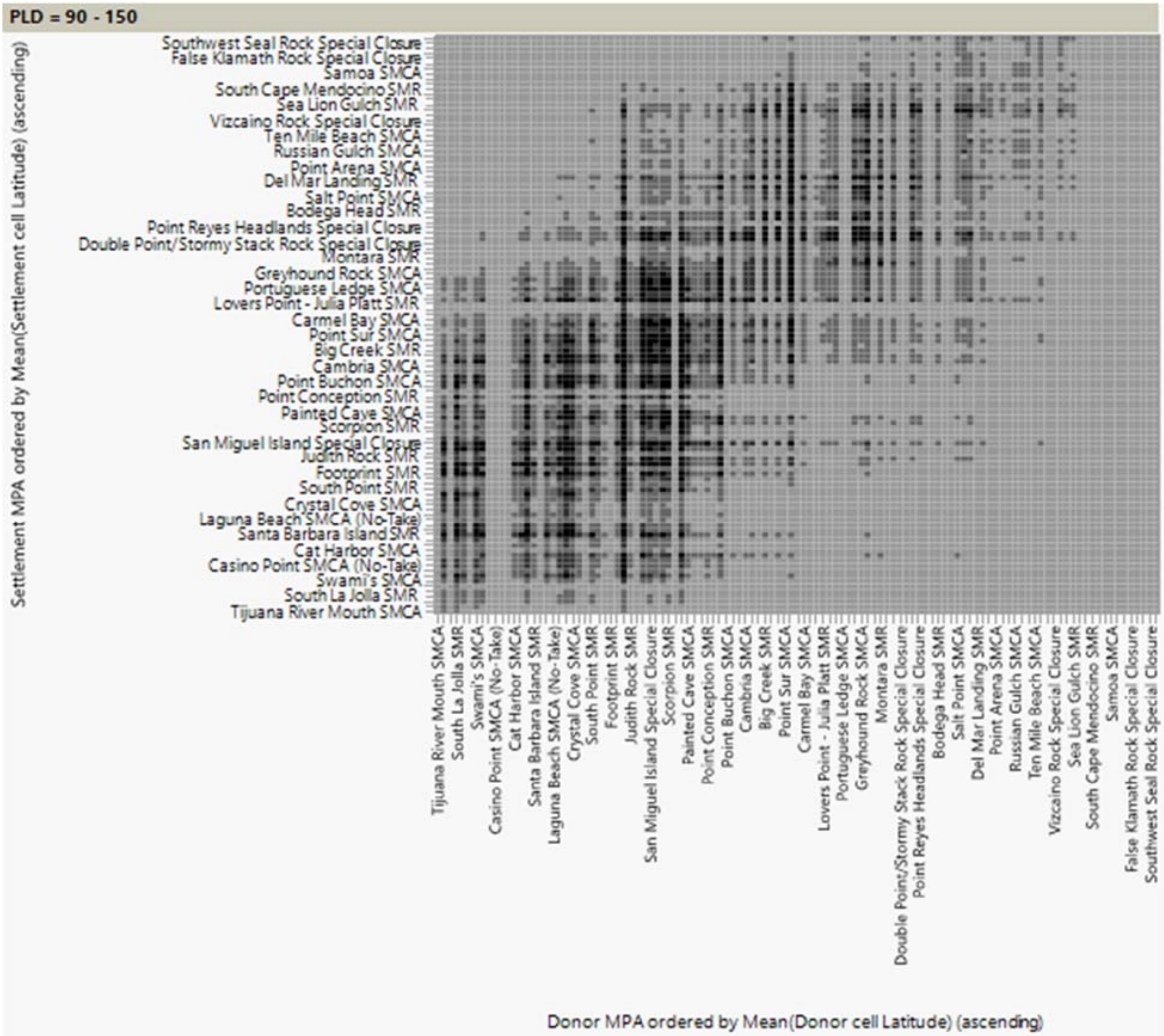

Figure 8. Rocky intertidal: spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 90-150 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

Estimates of the relative contribution of each MPA to the replenishment of other MPAs for **0-30m depth rocky reef and kelp forest species with PLDs of 5-20 days** exhibit dramatic regional differences (Figure 9, lower graph). Most notably, is the high contribution of MPAs in south central California (Point Buchon to Cambria) and the very low contributions of MPAs throughout mainland southern California and the Northern Channel Islands. The one key exception to that pattern is the high contribution by the South La Jolla SMCA. This paucity of contribution in southern California likely reflects the patchy and low abundance of shallow rocky reef across the region. In contrast, the paucity of contribution and reception of propagules in the Northern Channel Islands likely reflects the lack of mapping around the islands and a resulting low abundance of rock at the 0-30m depths. As with the rocky intertidal species, the overall magnitude of propagule contribution among MPAs for these short PLD species is high relative to longer PLDs as reflected in the higher values of the vertical axis scale. This again reflects the higher mortality and advection of propagules from the study region with increasing PLD. Again, although recipient populations in Oregon were incorporated into this new model, the contribution of the northernmost California MPAs remained low for shallow (0-30m) rocky bottom species because contributions are shown only to MPAs in California. The receipt of propagules is more broadly distributed across MPAs and the relative variation among MPAs in their receipt of propagules of species with short PLDs was not as great as the variation in contributions (Figure 9, upper graph). However some MPAs stood out as receiving substantially more propagules from other MPAs, especially in south central and central California from Cambria SMR/SMCA to Pillar Point SMCA. This high level of connectivity likely reflects, in part, the many MPAs in close proximity to one another in central California.

The general pattern of high connectivity restricted to nearby MPAs is reflected in the connectivity matrix for 0-30m rocky bottom species with PLDs of 5-20 days across the state (Figure 2). The matrix illustrates the prevalence of recipient MPAs across the south central and central region. The connectivity matrix illustrates the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California. The increased receipt of propagules from Mexico by MPAs in southern California is not depicted because the graphs only show receipt from other MPAs in California.

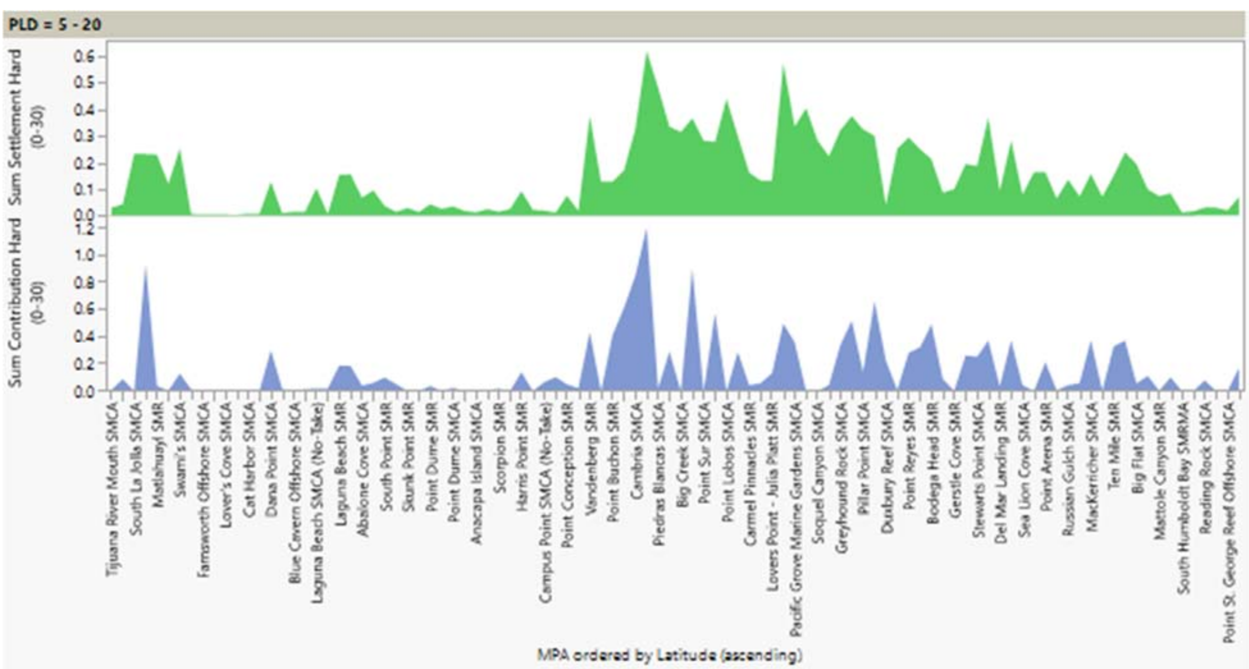

Figure 9. Rocky reef (0-30m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. "recipient") referred to as "settlement" (upper graph in

green) for propagule durations **(PLD) of 5-20 days**. MPAs are ordered from south to north, left to right, respectively.

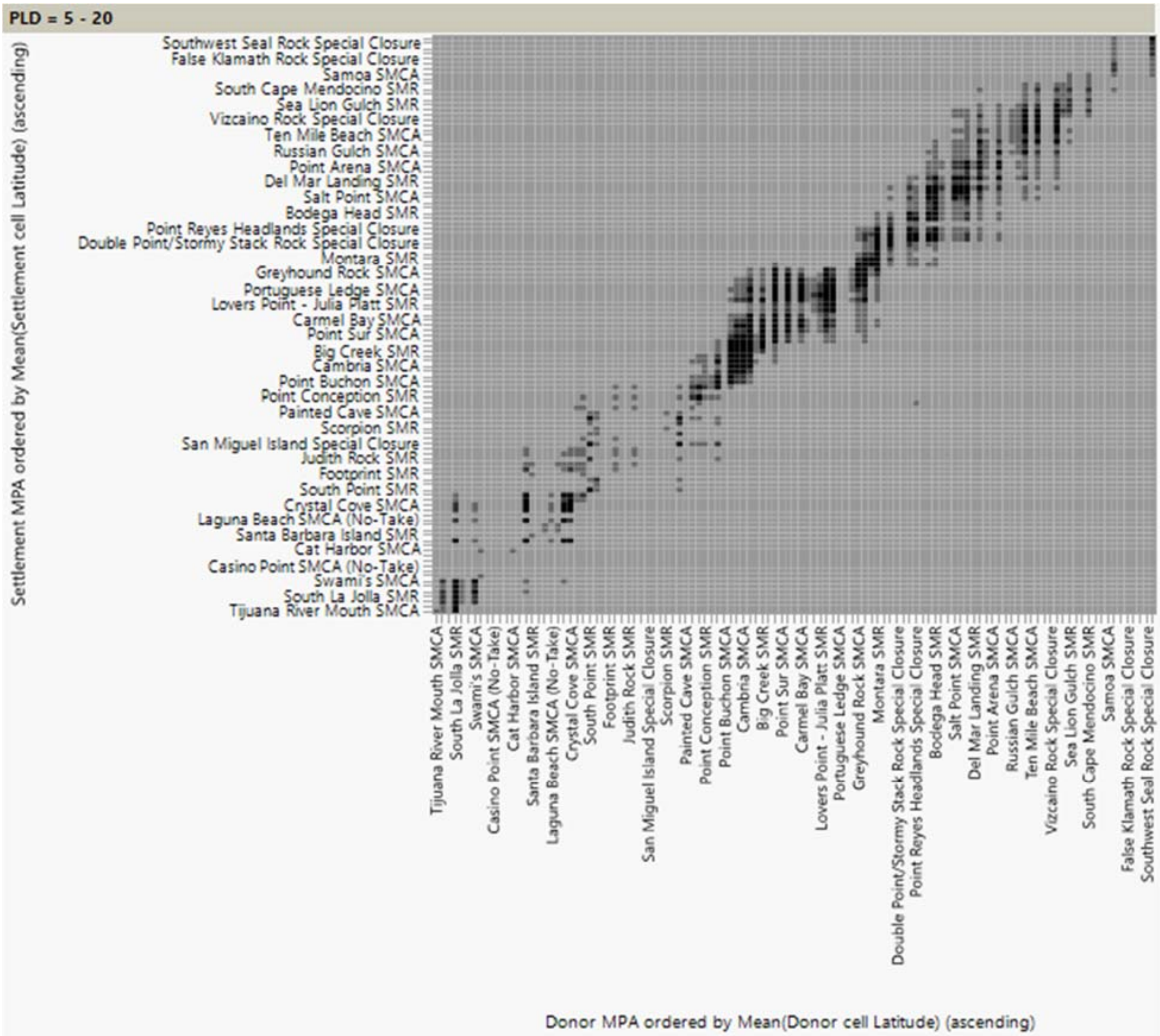

Figure 10. Rocky reef (0-30m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 5-20 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

Estimates of the relative contribution of each MPA to the replenishment of other MPAs for **0-30m depth rocky reef and kelp forest species with PLDs of 20-45 days** exhibit the same dramatic regional differences as for the shorter PLD species (Figure 11, lower graph). Most notably again is the high contribution of MPAs in south central California (Point Buchon to Cambria) and the very low contributions of MPAs throughout mainland southern California and the Northern

Channel Islands. The one key exception to that pattern is the high contribution by the South La Jolla SMCA. As with the rocky intertidal species, the overall magnitude of propagule contribution and receipt among MPAs for these intermediate PLDs is in between the shorter and longer PLD species as reflected by the scale of the vertical axis scale. This again reflects the mortality and advection of propagules from the study region with increasing PLD. The receipt of propagules is more broadly distributed across MPAs and the relative variation among MPAs in their receipt of propagules is not as great as the variation in contributions (Figure 11, upper graph). However some MPAs stood out as receiving substantially more propagules from other MPAs, especially in south central and central California from Cambria SMR/SMCA to Pillar Point SMCA. This high level of connectivity likely reflects, in part, the many MPAs in close proximity to one another in central California.

The general pattern of high connectivity restricted to nearby MPAs is reflected in the connectivity matrix for 0-30m rocky bottom species with PLDs of 20-45 days across the state (Figure 12). The matrix illustrates the prevalence of recipient MPAs across the south central and central region. The connectivity matrix illustrates the greater number and spatial range to which MPAs contribute to recipient MPAs relative to the shorter (5-20 day) PLDs. The connectivity matrix again illustrates the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California. The increased receipt of propagules from Mexico by MPAs in southern California is not depicted because the graphs only show receipt from other MPAs in California.

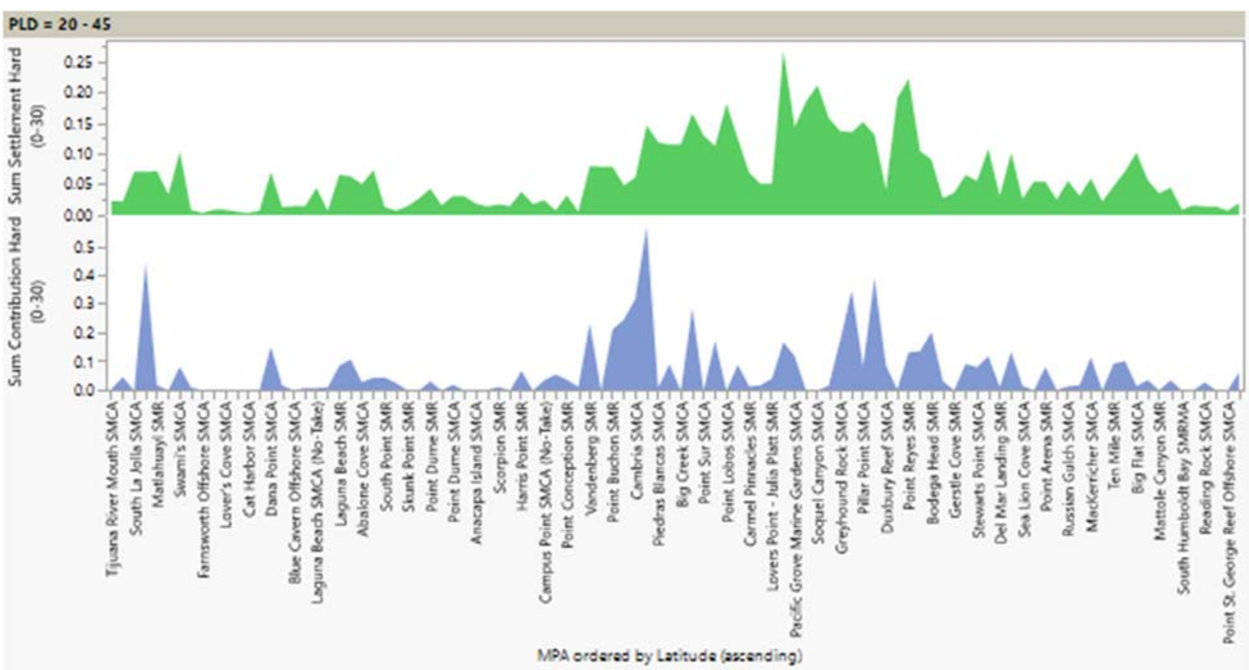

Figure 11. Rocky reef (0-30m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. “recipient”) referred to as “settlement” (upper graph in

green) for propagule durations **(PLD) of 20-45 days**. MPAs are ordered from south to north, left to right, respectively.

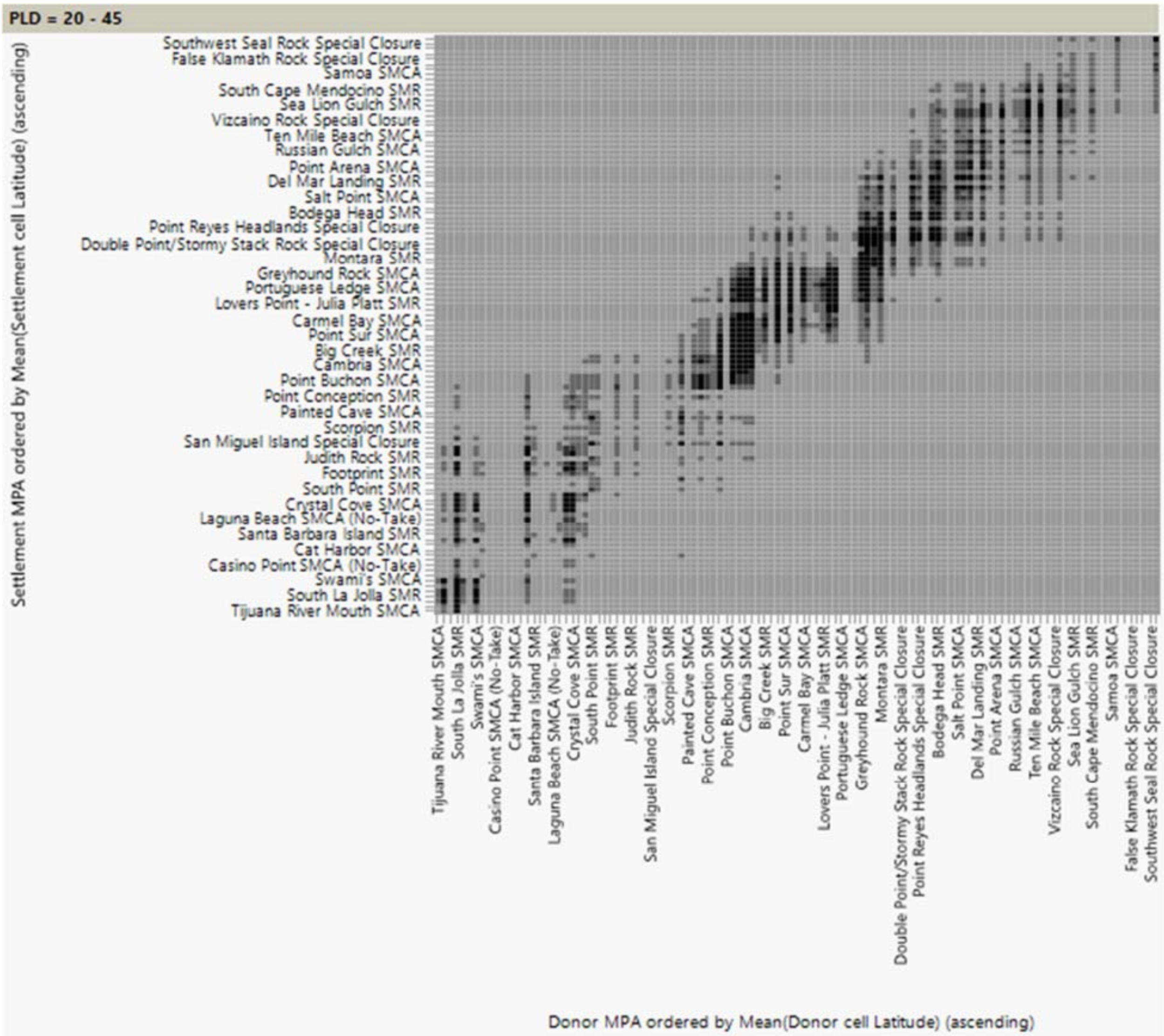

Figure 12. Rocky reef (0-30m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 20-45 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

Estimates of the relative contribution of each MPA to the replenishment of other MPAs for **0-30m depth rocky reef and kelp forest species with PLDs of 45-90 days** exhibit similar dramatic regional differences as for the shorter PLD species (Figure 13, lower graph). Most notably again is the high contribution of MPAs in south central California (Point Buchon to Cambria) as well as a more prominent contribution from MPAs between Monterey Bay and Point Reyes. These are in contrast to the much lower contributions of MPAs throughout mainland southern California and the Northern Channel Islands. Again, the one key exception to that pattern is the high contribution by the South La Jolla SMCA. The lower overall magnitude of propagule contribution and receipt among MPAs relative to the shorter PLD species is reflected by the scale of the vertical axis scale. As with the other PLDs, receipt of propagules is more broadly distributed across MPAs and the relative variation among MPAs in their receipt of propagules is not as great as the variation in contributions (Figure 13, upper graph). Again, some MPAs stood out as receiving substantially more propagules from other MPAs, especially in south central and central California from Cambria SMR/SMCA to Pillar Point SMCA. This high level of connectivity likely reflects, in part, the many MPAs in close proximity to one another in central California.

The connectivity matrix illustrates the prevalence of recipient MPAs across the south central and central region (Figure 14). It also illustrates the greater number and spatial range to which MPAs contribute to recipient MPAs relative to the shorter PLDs. The matrix also illustrates the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California. The increased receipt of propagules from Mexico by MPAs in southern California is not depicted because the graphs only show receipt from other MPAs in California.

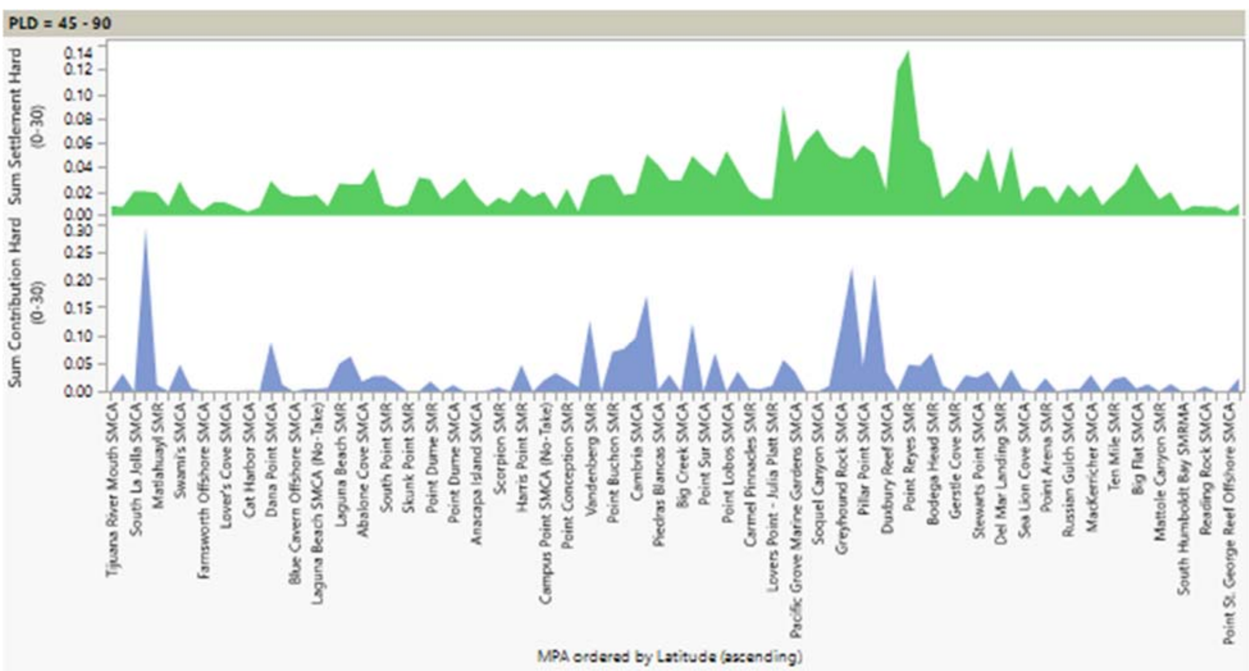

Figure 13. Rocky reef (0-30m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. “recipient”) referred to as “settlement” (upper graph in green) for propagule durations **(PLD) of 45-90 days**. MPAs are ordered from south to north, left to right, respectively.

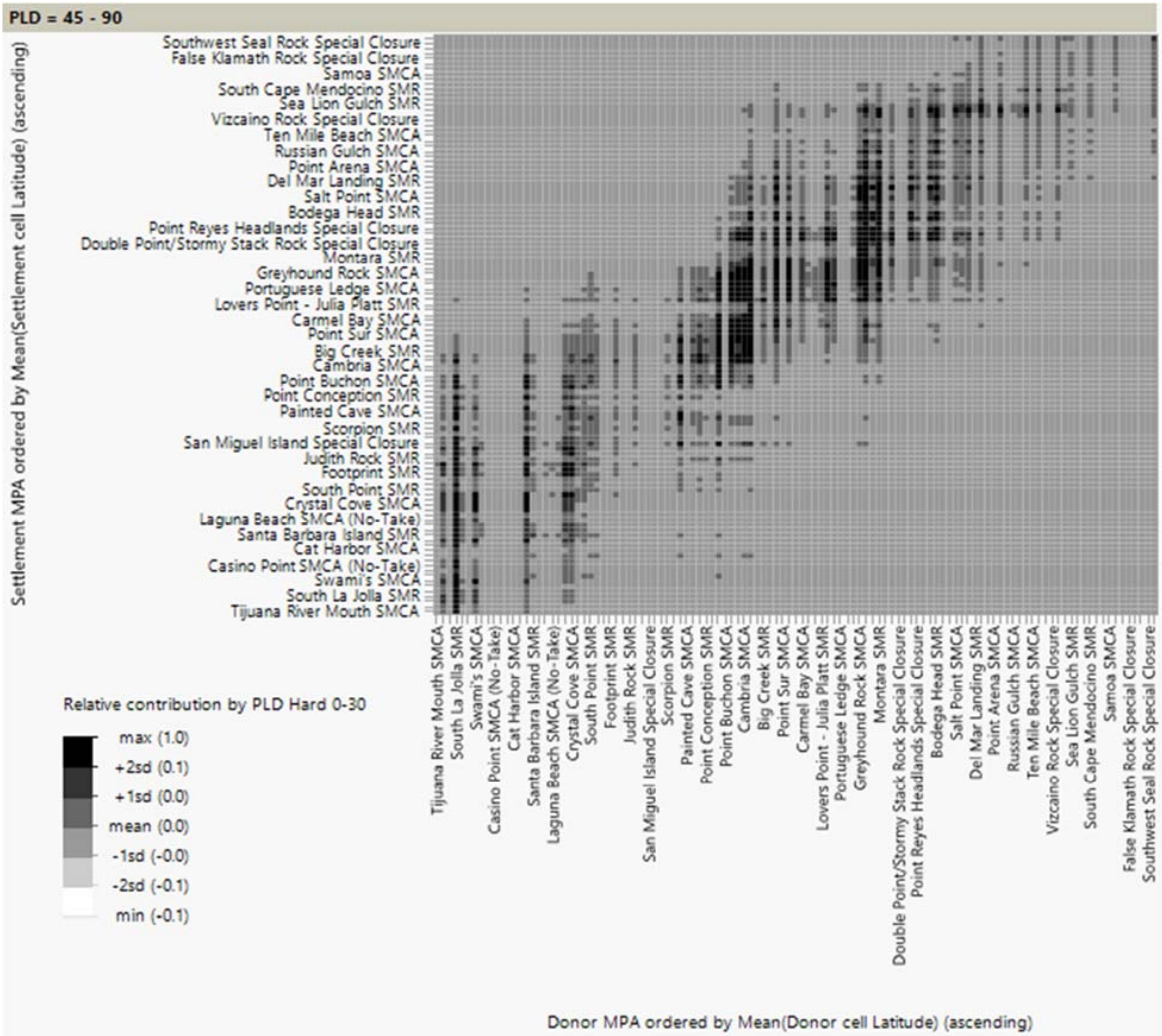

Figure 14 Rocky reef (0-30m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 45-90 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

Estimates of the relative contribution of each MPA to the replenishment of other MPAs for **0-30m depth rocky reef and kelp forest species with PLDs of 90-150 days** exhibit the same marked regional differences as for the shorter PLD species (Figure 15, lower graph). Most notably again is the high contribution of MPAs in south central California (Point Buchon to Cambria) as well as a more prominent contribution from MPAs between Monterey Bay and Point Reyes. These are in contrast to the much lower contributions of MPAs throughout mainland southern California and the Northern Channel Islands. Again, the one key exception to that pattern is the high contribution by the South La Jolla SMCA. The lower overall magnitude of propagule contribution and receipt among MPAs relative to the shorter PLD species is reflected by the scale of the vertical axis scale. As with the other PLDs, receipt of propagules is more broadly distributed across MPAs and the relative variation among MPAs in their receipt of propagules is not as great as the variation in contributions (Figure 15, upper graph). Again, some MPAs stood out as receiving substantially more propagules from other MPAs, especially in south central and central California from Cambria SMR/SMCA to Pillar Point SMCA. This high level of connectivity likely reflects, in part, the many MPAs in close proximity to one another in central California.

The connectivity matrix illustrates the prevalence of recipient MPAs across the south central and central region (Figure 16). It also illustrates the even greater number and spatial range to which MPAs contribute to recipient MPAs relative to the shorter PLDs. The matrix illustrates the general northward dispersal of propagules along the central coast, however, with increased PLD, these MPAs also contribute much more to replenishment of MPAs to the south. Similarly, the range to which southern and northern California MPAs replenish others extends much more northward and southward, respectively.

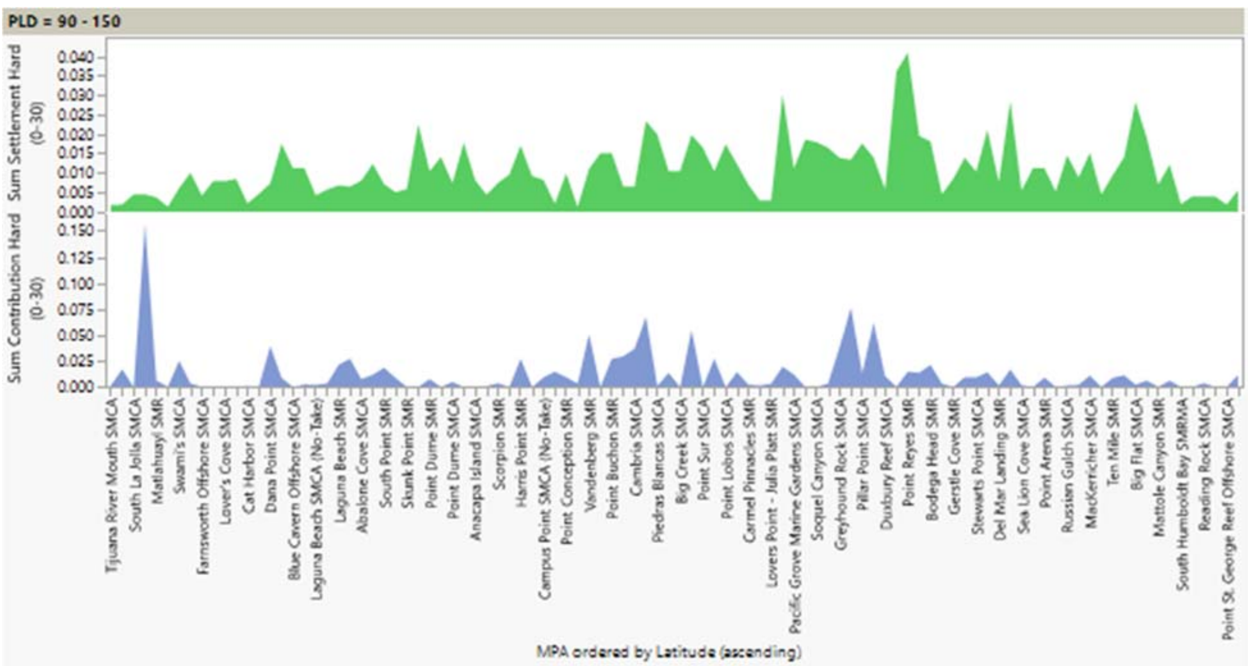

Figure 15. Rocky reef (0-30m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. "recipient") referred to as "settlement" (upper graph in green) for propagule durations **(PLD) of 90-150 days**. MPAs are ordered from south to north, left to right, respectively.

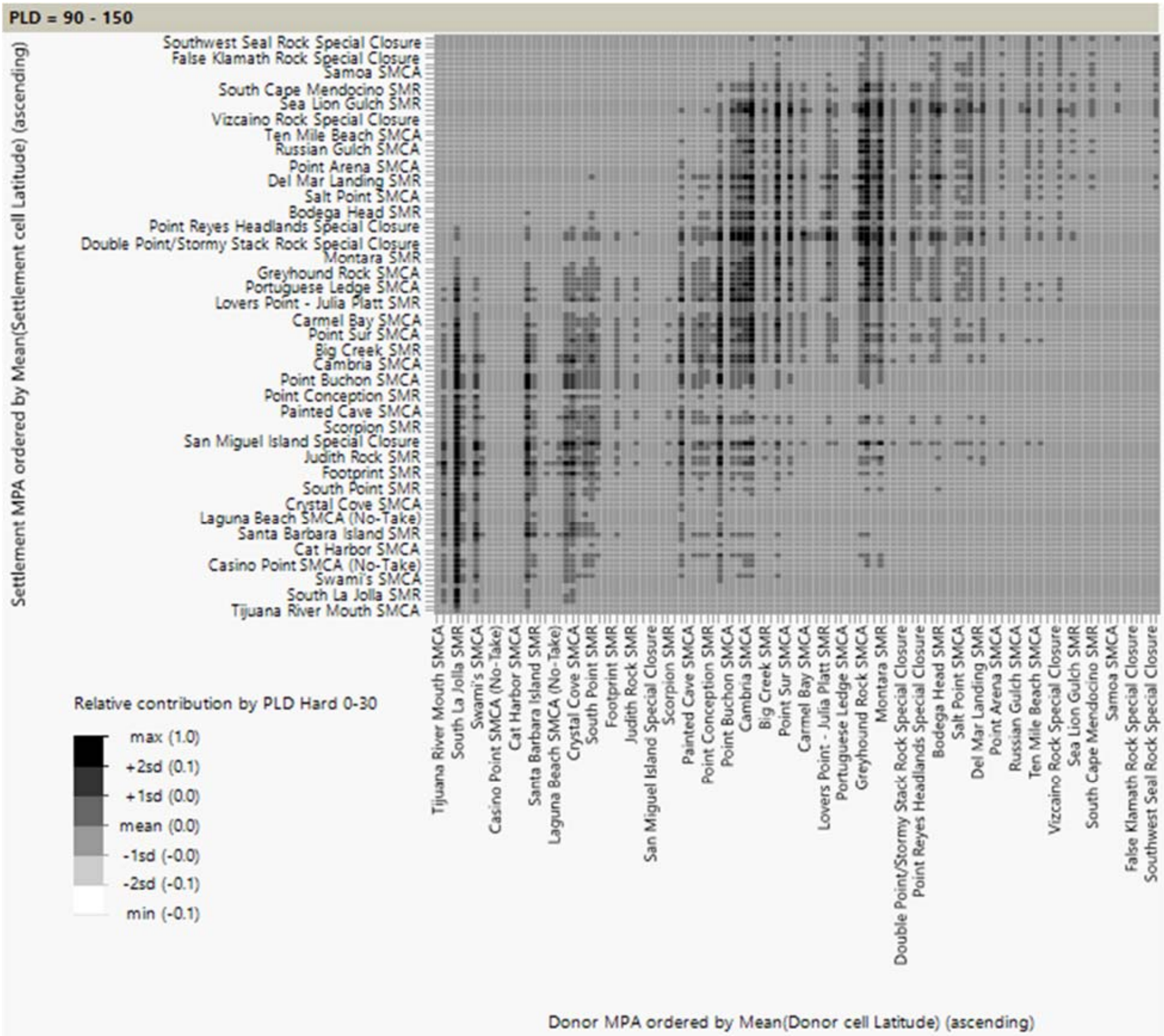

Figure 16. Rocky reef (0-30m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 90-150 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

Estimates of the relative contribution of each MPA to the replenishment of other MPAs for **30-100m depth rocky reef species with PLDs of 5-20 days** exhibit the greatest regional differences of the three ecosystems (Figure 17, lower graph), reflecting the relative abundance of this habitat among regions and some gaps in mapping. Most notably, is the high contribution of MPAs in south central California (Point Buchon to Cambria) and the very low contributions of MPAs throughout mainland southern California and the Northern Channel Islands. The low contribution throughout southern California reflects the paucity of this habitat in that region, whereas this habitat is still not well mapped in areas of the Northern Channel Islands. The two key exceptions to that pattern in southern California is the high contribution by the South La Jolla SMCA and Farnsworth Offshore SMCA (near Lover's Cove SMCA on the graph) because of the large areas of deep rocky reef in those MPAs. Major contributors occur in south central (Piedras Blancas to Point Lobos) and central California (Portuegese Ledge SMCA and Soquel Canyon in Monterey Bay). Further north, two pronounced contributors are Bodega Head SMR and SMCA. Another peak of contribution and reception occurs at two MPAs near Cape Mendocino (Sea Lion Gulch SMR and South Cape Mendocino SMR). As with the rocky intertidal and 0-30m depth hard bottom species, the overall magnitude of propagule contribution among MPAs for these short PLD species is high relative to longer PLDs as reflected in the higher values of the vertical axis scale. This again reflects the higher mortality and advection of propagules from the study region with increasing PLD.

The receipt of propagules of species with short PLDs generally reflects regional patterns of contribution, but is more broadly distributed across MPAs than that of contributing MPAs (Figure 17, upper graph). However some MPAs stood out as receiving substantially more propagules from other MPAs, especially in south central and central California from Cambria SMR/SMCA to Pillar Point SMCA. This high level of connectivity likely reflects, in part, the many MPAs in close proximity to one another in central California. Of note however, is the relative high levels of settlement to MPAs in Monterey Bay and north-central California compared to their relative contribution. Again, although recipient populations in Oregon were incorporated into this new model, the contribution of the northernmost California MPAs remained low for deep (30-100m) rocky bottom species because contributions are shown only to MPAs in California.

The state-wide pattern of high connectivity restricted to nearby MPAs is reflected in the connectivity matrix for these species on deep (30-100m) rocky reefs with short propagule durations (Figure 18). The matrix illustrates the prevalence of recipient MPAs across the south central and central region. The connectivity matrix illustrates the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California. The increased receipt of propagules from Mexico by MPAs in southern California is not depicted because the graphs only show receipt from other MPAs in California.

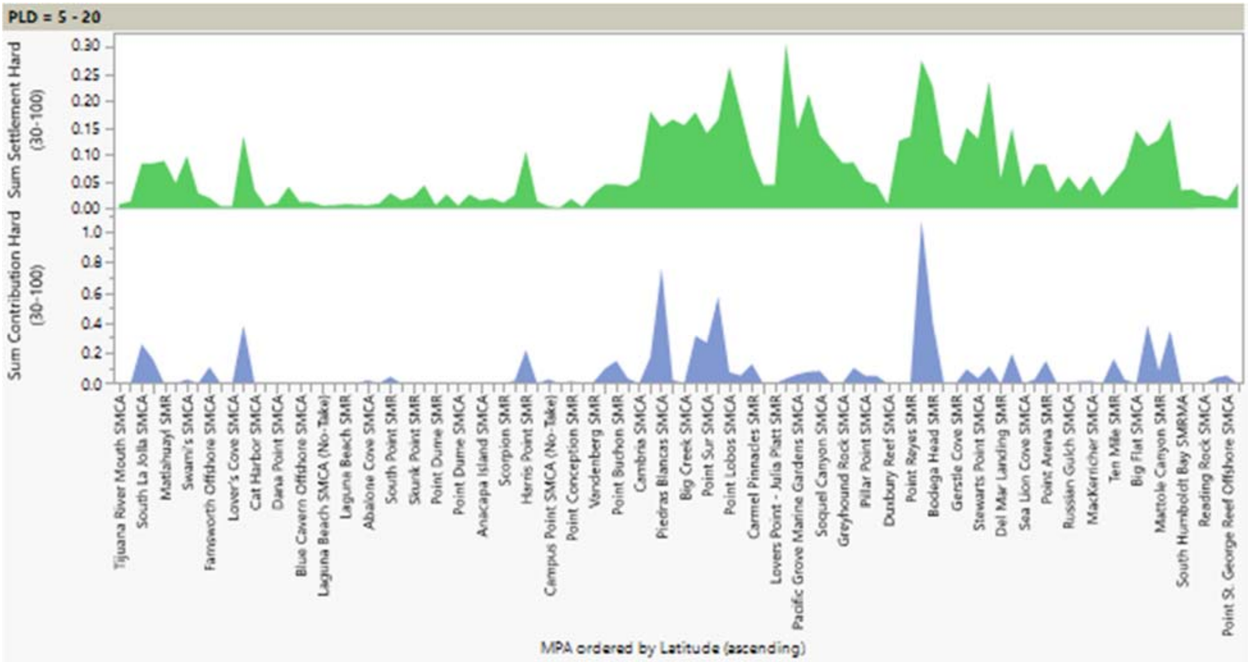

Figure 17. Rocky reef (30-100m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. "recipient") referred to as "settlement" (upper graph in green) for propagule durations **(PLD) of 5-20 days**. MPAs are ordered from south to north, left to right, respectively.

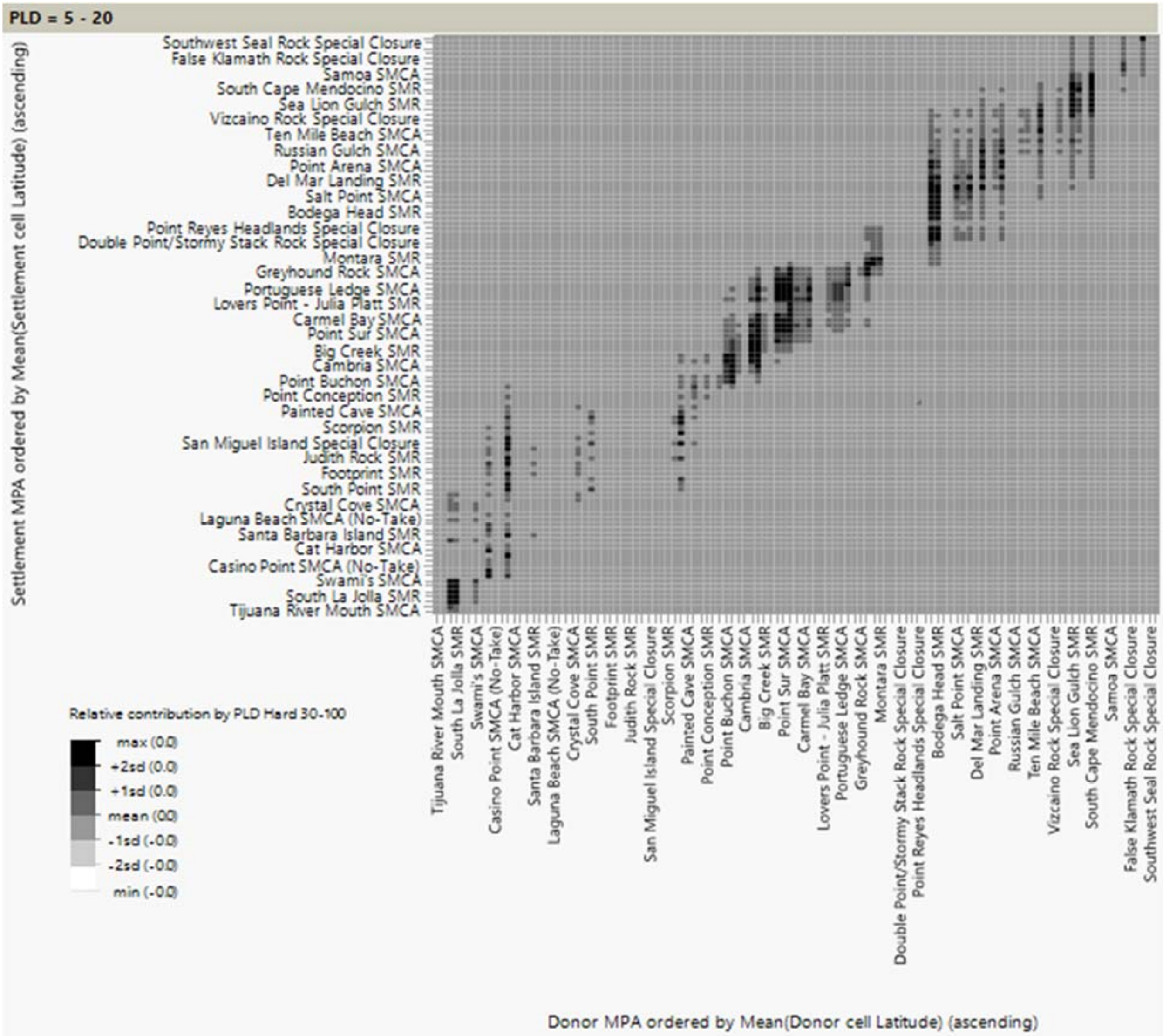

Figure 18. Rocky reef (30-100m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 5-20 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

Similar to trends in the other two ecosystems, as the **PLD of deep (30-100m) hard bottom species** increases to **20-45 days**, the magnitude of contribution from MPAs to other MPAs decreases (note reduced vertical scale), though the geographic patterns among MPAs are very similar (Figure 19 lower graph). Those regions and MPAs that stand out as substantial contributors for the short PLD species also stand out for these PLDs. Variation in the relative receipt of propagules among MPAs is also reduced as propagules are delivered more broadly among MPAs, though the geographic pattern is similar to the shorter PLD (Figure 19 upper graph). The connectivity matrix exhibits a broadening of recipient MPAs from each donor MPA and this occurs across the state as PLD is increased (Figure 20). The connectivity matrix illustrates again the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California.

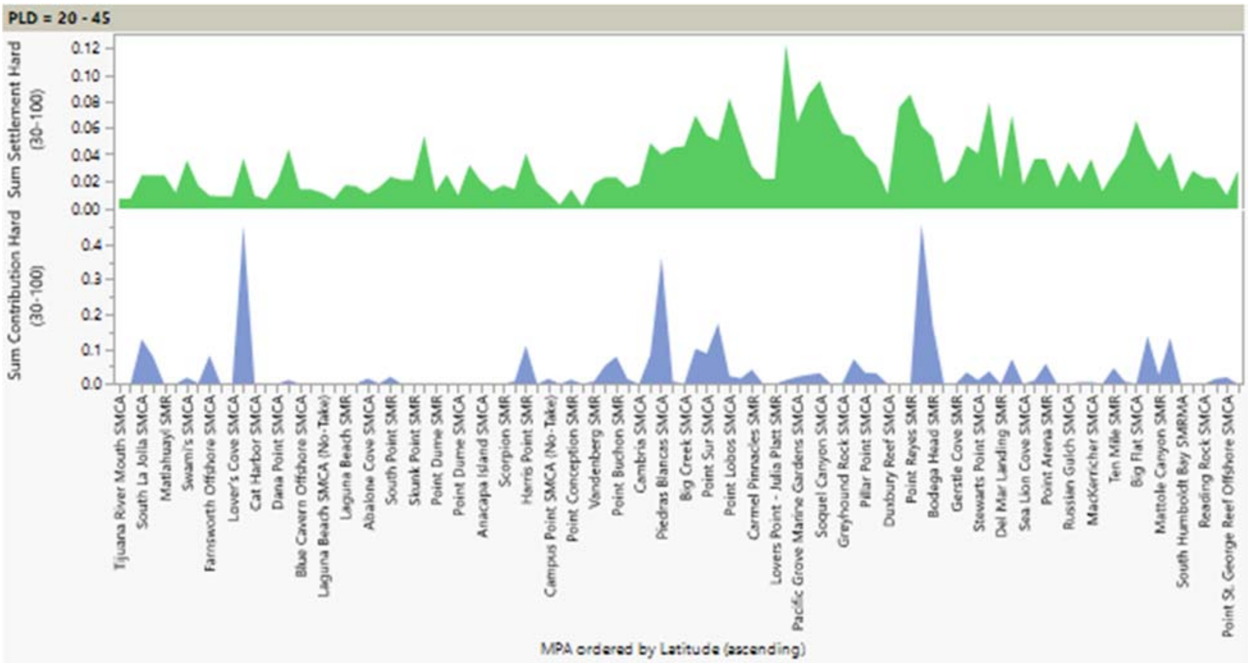

Figure 19. Rocky reef (30-100m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. “recipient”) referred to as “settlement” (upper graph in green) for propagule durations **(PLD) of 20-45 days**. MPAs are ordered from south to north, left to right, respectively.

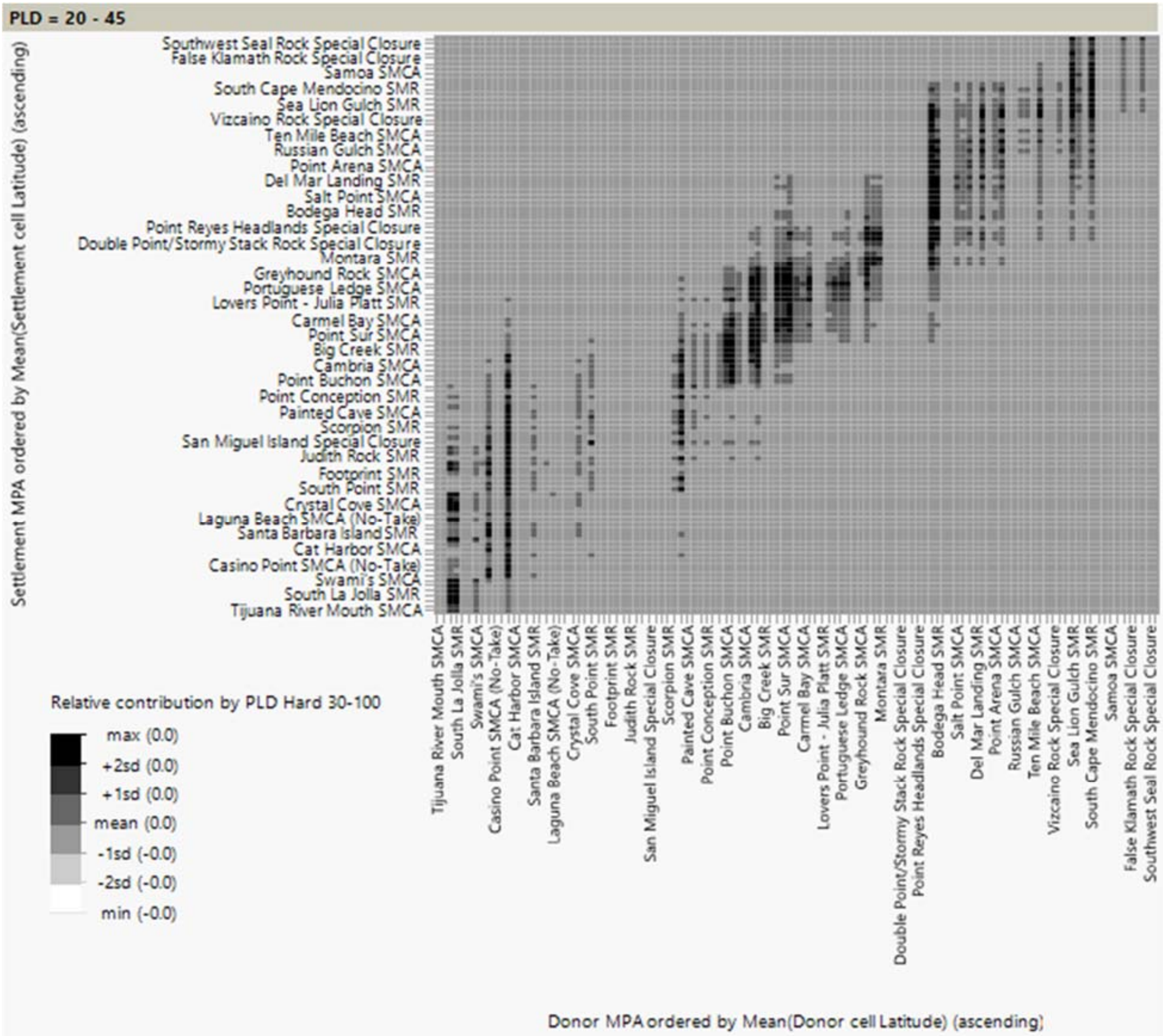

Figure 20. Rocky reef (30-100m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 20-45 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

As the **PLD of deep (30-100m) hard bottom species** increases to **45-90 days**, the magnitude of contribution from MPAs to other MPAs further declines (note reduced vertical scale), though the geographic patterns among MPAs are very similar (Figure 21 lower graph). Those regions and MPAs that stand out as substantial contributors for the shorter PLD species also stand out for these PLDs. However, the relative contribution of particular MPAs begin to shift. The substantial contribution of the Farnsworth Offshore SMCA (near Lover's Cove SMCA on the graph) becomes proportionally greater relative to all other MPAs along the study region. Variation in the relative receipt of propagules among MPAs is also reduced as propagules are delivered more broadly among MPAs, and this pattern is particularly evident in the southern California and Northern Channel Island regions (Figure 21, upper graph). Otherwise, the geographic pattern is generally similar to the shorter PLDs. However, the discrepancies between contribution and receipt noted for the shorter PLDs is accentuated, with relatively higher levels of propagule receipt (relative to other MPAs) in regions of relatively low contribution (e.g., southern California and Northern Channel Islands, Monterey Bay). The connectivity matrix exhibits a broadening of recipient MPAs from each donor MPA and this occurs across the state as PLD is increased (Figure 22). The connectivity matrix illustrates again the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California.

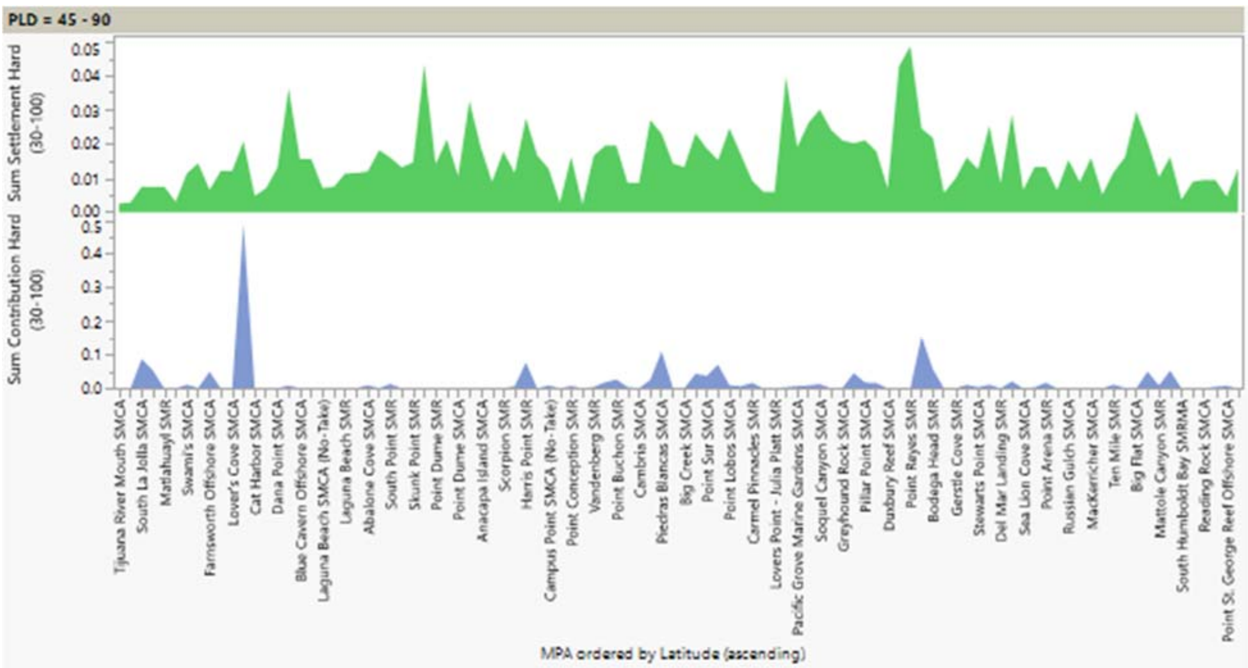

Figure 21. Rocky reef (30-100m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. “recipient”) referred to as “settlement” (upper graph in green) for propagule durations **(PLD) of 45-90 days**. MPAs are ordered from south to north, left to right, respectively.

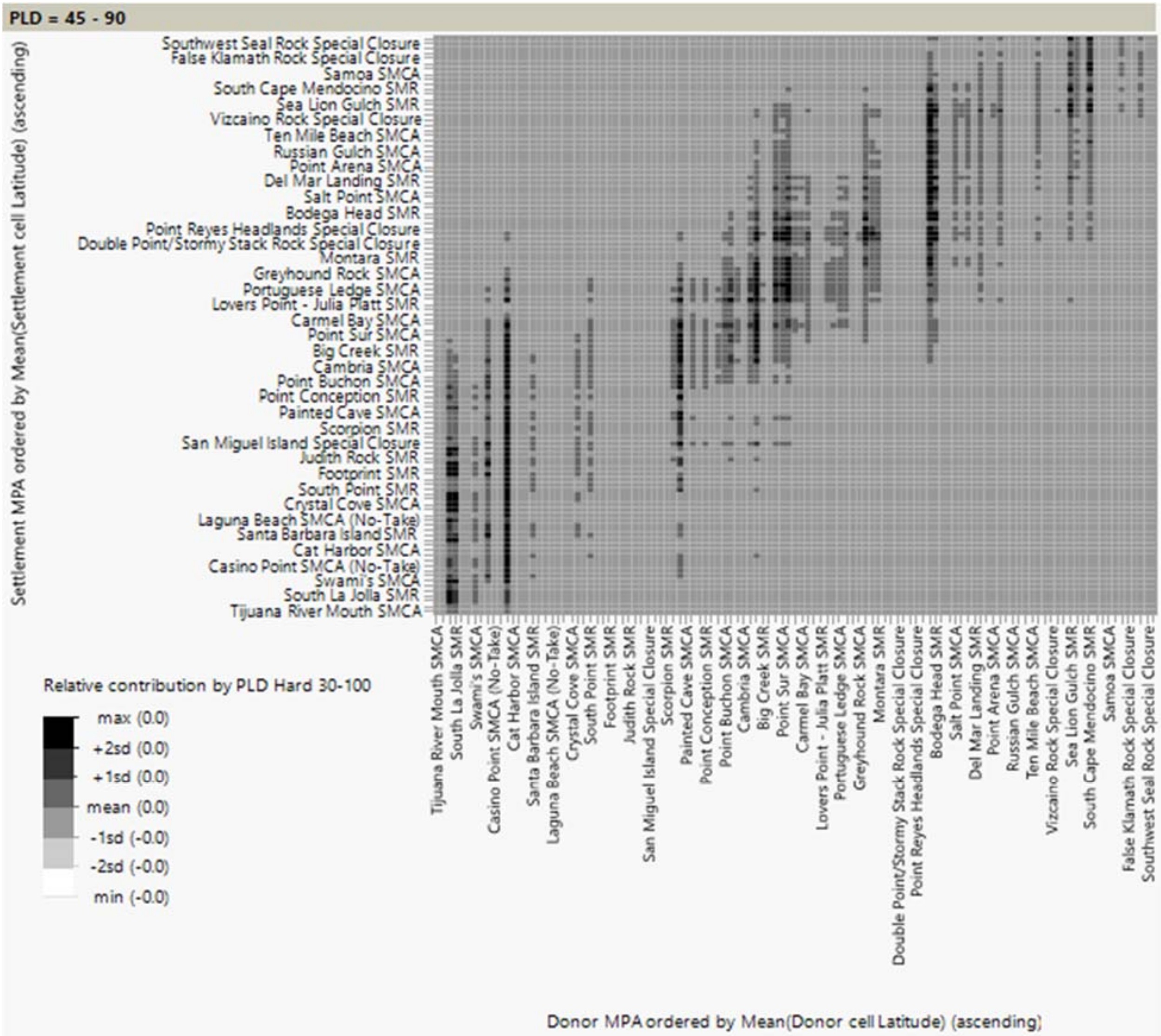

Figure 22. Rocky reef (30-100m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 45-90 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

As the **PLD of deep (30-100m) hard bottom species** increases to **90-150 days**, the magnitude of contribution from MPAs to other MPAs further declines (note reduced vertical scale), though the geographic patterns among MPAs are very similar to the 54-90 day PLD (Figure 23 lower graph). Those regions and MPAs that stand out as substantial contributors for the shorter PLD species also stand out for these PLDs. In particular, the disproportionate contribution of the Farnsworth Offshore SMCA (near Lover's Cove SMCA on the graph) remains pronounced relative to all other MPAs along the study region. Variation in the relative receipt of propagules among MPAs is also reduced as propagules are delivered more broadly among MPAs (Figure 23, upper graph). The geographic pattern is similar to the 45-90 day PLD and the discrepancies between contribution and receipt noted for the shorter PLDs is accentuated, with relatively higher levels of propagule receipt (relative to other MPAs) in regions of relatively low contribution (e.g., southern California and Northern Channel Islands, Monterey Bay). The connectivity matrix exhibits a broadening of recipient MPAs from each donor MPA and this occurs across the state as PLD is increased (Figure 24). The connectivity matrix illustrates again the general northward dispersal of propagules along the central coast, whereas propagules are distributed both to the north and south of donor MPAs in southern and northern California. The spatial range of MPAs replenished by donor MPAs increases with increasing PLD.

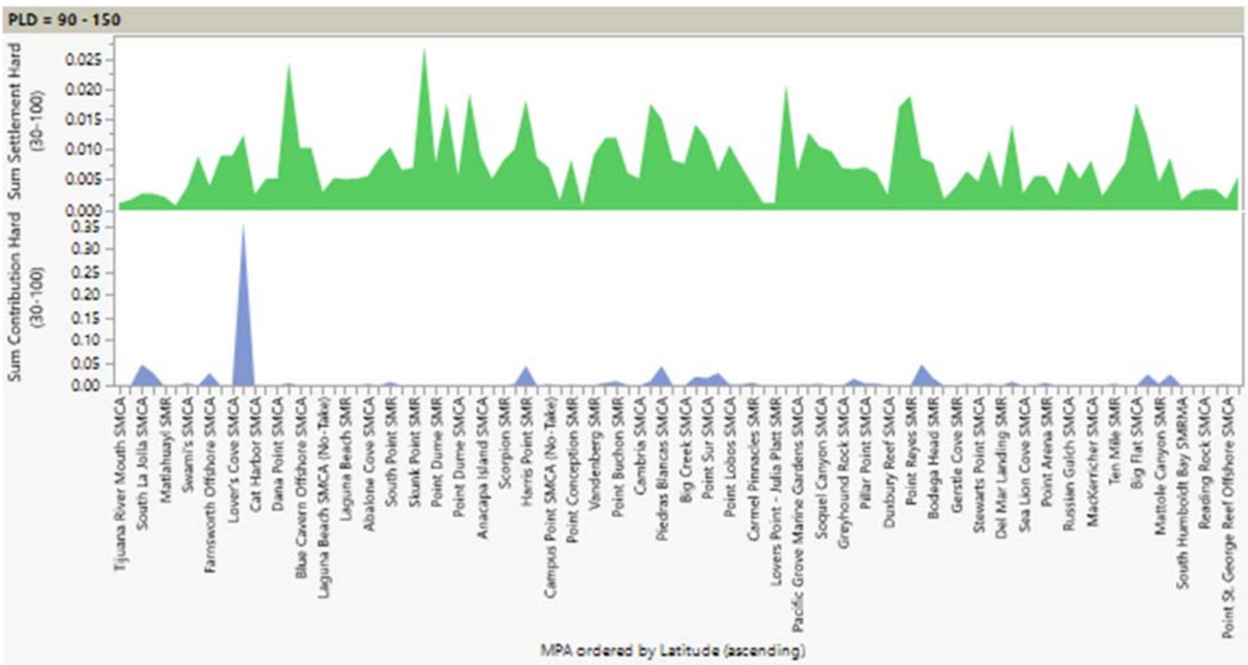

Figure 23. Rocky reef (30-100m depth): comparison of the **contribution** of each MPA to the replenishment of other MPAs (lower graph in blue), and the the extent to which each MPA **received** propagules from other MPAs (i.e. “recipient”) referred to as “settlement” (upper graph in green) for propagule durations **(PLD) of 90-150 days**. MPAs are ordered from south to north, left to right, respectively.

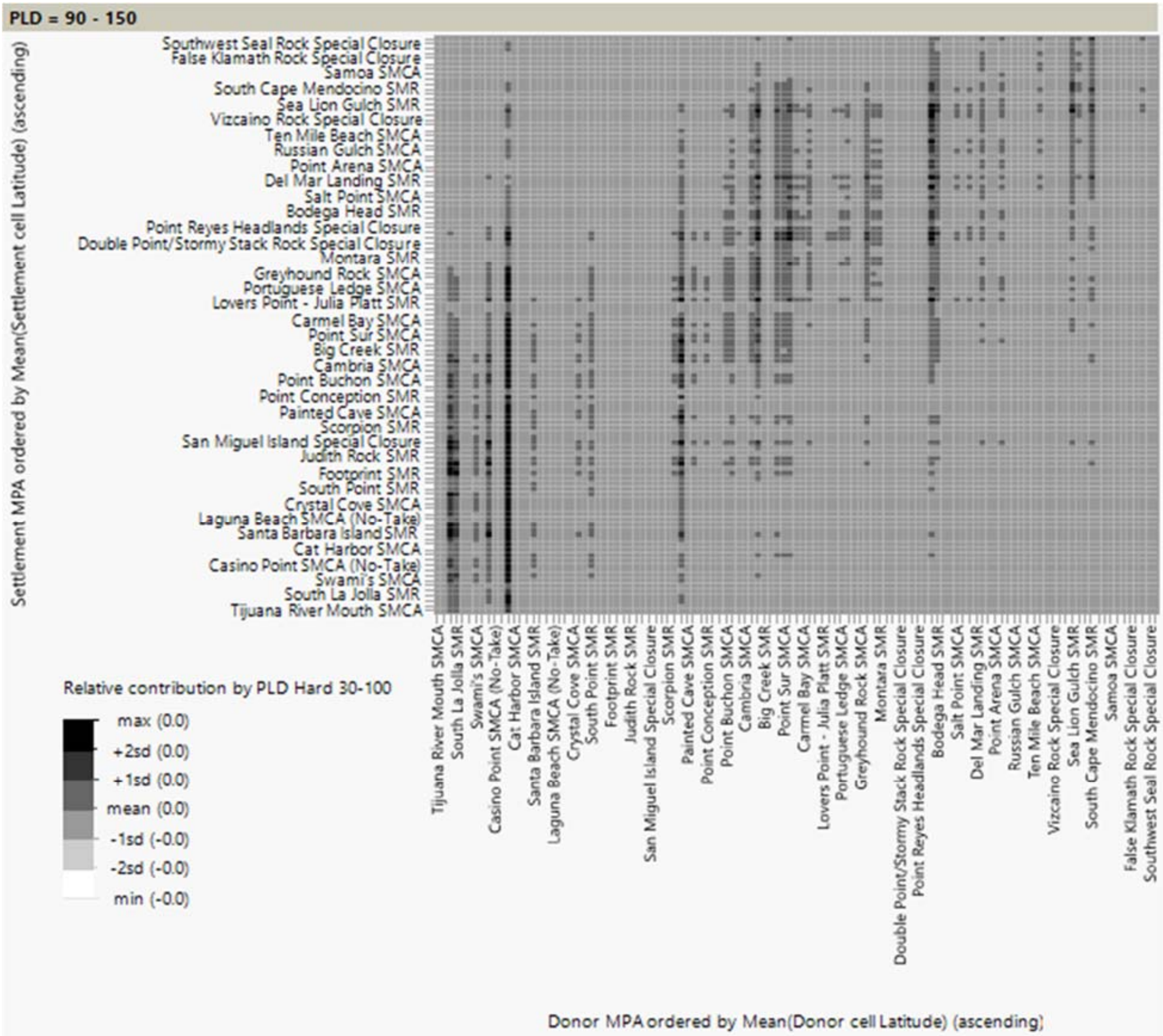

Figure 24. Rocky reef (30-100m depth): spatial pattern of recipient MPAs of propagules generated within each MPA for propagule durations **(PLD) of 90-150 days**. The relative magnitude of contribution among the recipient MPAs is color coded from highest (darkest cells) to lowest (lightest cells) in units of standard deviations from the mean contribution by that MPA. MPAs are ordered from south to north, left to right, respectively.

Other data products developed as a result of this project

As a result of this effort, habitat geodatabases and analysis methods were revisited for California and a number of changes were made to ensure that habitat availability calculations were conducted in a robust and consistent way that took the best advantage of the available data. This work naturally led to several data products that will be made available to the long term MPA monitoring PIs and other researchers interested in California's coastal marine habitats and MPAs. Those products include:

- High resolution habitat and bathymetry geodatabases that include the best available habitat data for all of California. These will be shared broadly via CDFW's FTP site. Previously most of this data was available only in small chunks that required months of compilation work before they were amenable to regional-scale analyses.
- Updated habitat calculations have been conducted for all of California's MPAs and the habitat availability totals will be made available to the long-term MPA monitoring PIs in support of analyses for the upcoming decadal MPA review
- High resolution bathymetry data can provide the basis for a variety of other more complex analyses of habitat characteristics. As part of an earlier (SeaGrant funded) project, a number of such habitat characteristics were calculated and used along with kelp forest monitoring information to generate species distribution models for several kelp forest species. This type of species distribution model is likely to play a role in future refinement of the connectivity modeling. The results of the habitat characteristic calculations are stored in a (very large) geodatabase at UCSC, and have already been shared with one long term monitoring PI (Dr. Richard Starr) to support similar species-habitat analyses.

Discussion

The further development of the contribution model achieved in this study continues to increase the value and applications of the model. Inclusion of ecosystems in Mexican and Oregon waters not only are creating better estimates of connectivity among California MPAs, but can eventually inform our understanding of connectivity between the California network and existing and future MPAs along those coasts. Similarly, the enhanced seafloor information within California waters is increasing the accuracy of contribution estimates with more refined propagule production and settlement metrics. These enhanced estimates of the relative contribution of MPAs to the replenishment of others across the network identify MPAs for which monitoring to evaluate the condition of species populations (and larval production) should be prioritized. This improved model provides us with a more robust foundation on which to create the coupled demographic-connectivity population model that we are currently funded to produce. The goal of that model is to create a tool to evaluate the performance of the MLPA network as required in the MLPA. With the impending integration of natural and fishing mortality rates, including levels of protection afforded by the MPAs and the broader geographic patterns in fishing mortality, the model will also inform how MPAs and fisheries management interact to determine the size and persistence of fishery yields as well as their influence on the conservation efficacy of the network.

Appendix 1. Excerpted description of the design of the connectivity model from Task 1 of "Collecting Data: Assessing Ecosystem Conditions and Trends", submitted to the California Ocean Protection Council on June 3, 2020 by Peter Raimondi and Mark Carr.

To determine the spatial patterns of oceanographic forcing across the study region, we applied a ROMS simulation based on an average solution (i.e. average spatial pattern of transport) over a 15-year period (1999-2013). The spatial domain of the model included California waters from Mexico to Canada. Approximately 88,000 propagules were released from each of the 557 cells that constitute the ROMS (when all releases through the years were added up), with a total of 49 million propagules released. These cells included all coastal areas of the model domain with one important exception, the Farallon Islands, because of the complexity of modeling those small offshore islands. Propagules moved hourly, but with daily averaged currents. So, every hour we interpolated the daily average currents from the ROMS model in space and time to find the current at each propagule location. Then we moved each propagule with its appropriate current velocity. Landward of a certain depth isobath, 500 m, the propagules are also given a random kick simulating tidal currents of 5 cm/s. This kick was also given every hour in addition to the daily-averaged motion.

As mentioned above, the distance that propagules are transported and likelihood of being delivered to distant MPAs is influenced by the planktonic duration (PLD). Therefore, across the network, the total number of propagules delivered (referred to as "settlement") among the MPAs depends on the PLD. To determine how PLD influenced patterns of connectivity, and the relative contribution of MPAs to replenishment of others, we ran model solutions for 11 PLD's: 5, 10, 15, 20, 30, 45, 60, 90, 120, 150, and 180 days. To account for variation around each of these PLD categories, we allowed for successful delivery of propagules to occur only within 10% of each PLD category (e.g. for PLD of 30 days: 27-33 days).

However, propagules (larvae and spores) die in the plankton at a constant rate such that fewer propagules are delivered with increasing distance between MPAs. To mimic this effect of propagule mortality, propagules are removed as a function of time in the plankton.

The ROMS output itself can be considered a measure of connectivity among cells (locations) but should not be considered an estimate of one cell's contribution of larvae (propagules) to other cells. This is because cells in ROMS grids are only characterized by oceanographic forcing and spatial dimensions (and vertical layers). In order to estimate the relative contribution of a cell or MPA to the replenishment of other cells or MPAs, propagule production and settlement must be estimated for the donor and recipient cells, respectively. This is done using the area of a species' suitable habitat (e.g., kelp, rocky reef) in donor cells and recipient cells as proxies for propagule production and settlement, respectively. This must be incorporated as a sub-model.

Habitat sub-model: The area or linear extent of key habitats (e.g. rocky intertidal, shallow rock and kelp forest) was estimated for each ROMS cell in California using a suite of data sources (e.g. sea floor mapping, existing GIS data layers). Separately, areas or linear extents were estimated for all MPA's in California. Linear extent was used for Sandy Beaches and Rocky

Intertidal habitats and area was used for all other habitats. To date we have not incorporated locations outside of California because spatially explicit habitat information is lacking.

Coupling sub-model: Habitat and ROMS sub-models were coupled using a coupling sub-model. Here raw connectivity between locations (i.e. cells, MPA's) was calibrated based on suitable habitat in the donor and recipient location. The following steps were used.

1) Each donor/recipient location pair in the connectivity matrix was converted to contribution using the equation $C_{hdr} = (N_{hdr} \times A_{hd} \times A_{hr})$, where C_{hdr} = Contribution for habitat h from donor location d to recipient location r; N_{hdr} = Connectivity for habitat h from donor location d to recipient location r; A_{hd} = Area (or linear extent) of habitat h in donor location d and; A_{hr} = Area (or linear extent) of habitat h in recipient location r. This equation ensures that donor locations without certain types of habitat cannot contribute propagules from those habitats. It also ensures that propagules associated with habitats not found in a location cannot settle in recipient locations lacking those habitats. In essence we are equating habitat area in a potential donor location with relative reproduction of species found in those habitats. We are also equating habitat area in a recipient location with a target for settlement. There is no density dependence in the contribution equation in this iteration of the model.

2) For a given PLD or set of PLD's the sum of contributions is calculated for all location pairs by habitat. For most locations this is the same as the actual value (no summation required). However, some MPA's are found in multiple ROMS cells so the separate values for each portion of the cells represented by the MPA is summed to produce an MPA value.

3) The master file (step 2) can then be queried to produce contribution or connectivity (or both) estimates for all habitats. In addition, we calculated to other contribution/connectivity attributes

4) To date there has been no incorporation of MPA enhancement in the model. This will be changed in the next round of modeling efforts to reflect the effect of protection and other services on the network metrics.

Appendix 9: Additional Figures

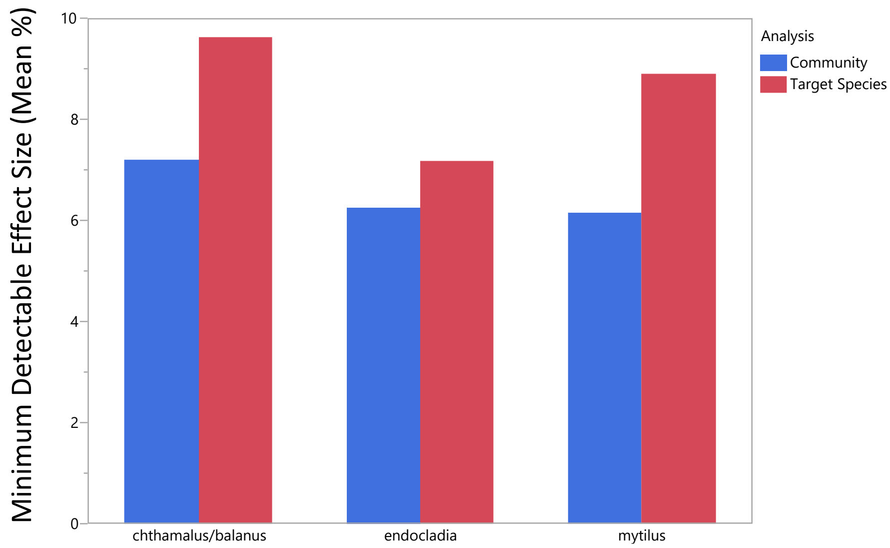

Figure S1: Minimum detectable effect sizes (MDES) for populations and communities. Target species values are based on cover of species. Community values are based on the community of organisms living in the habitat of the target species (e.g., low, mid, high intertidal).

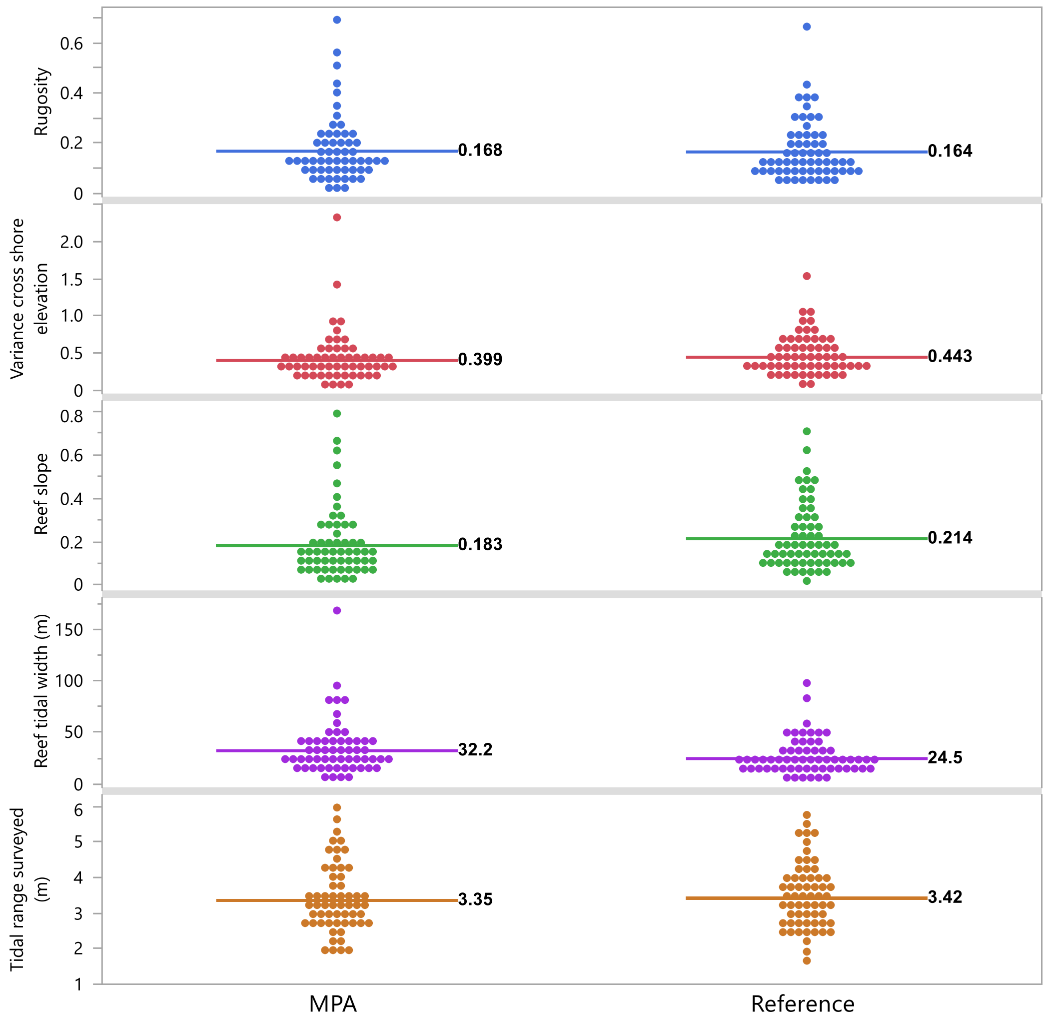

Figure S2: Physical attributes of site as a function of level of protection across California. Points represent individual sites. Horizontal lines are the mean for all observations. Labels are means for each attribute Site Type combination. shown are means across all represented sites in California. Results are based on Biodiversity Surveys.

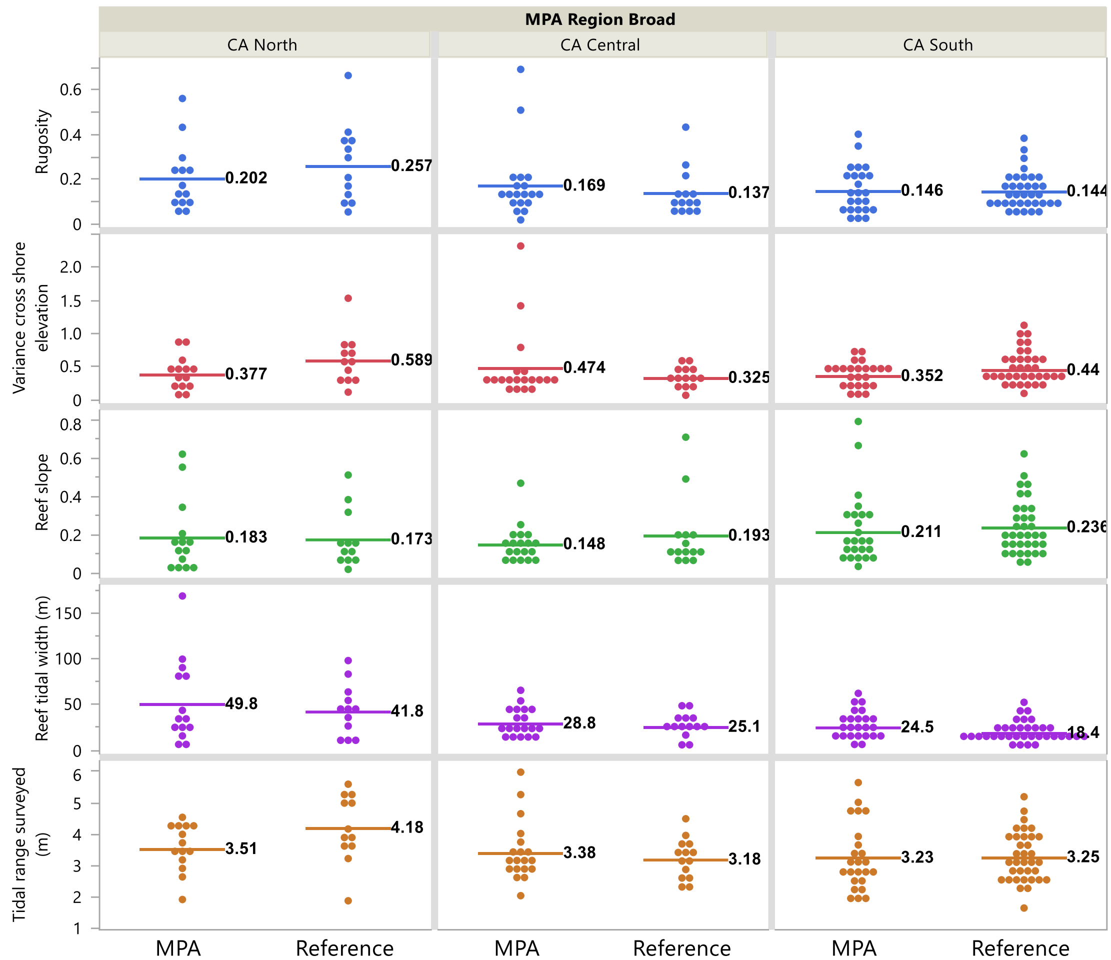

Figure S3: Physical attributes of sites as a function of level of protection for regions in California. Points represent individual sites. Horizontal lines are the mean for all observations. Labels are means for each attribute Site Type combination. Shown are means across all represented sites in California. Results based on Biodiversity Surveys.

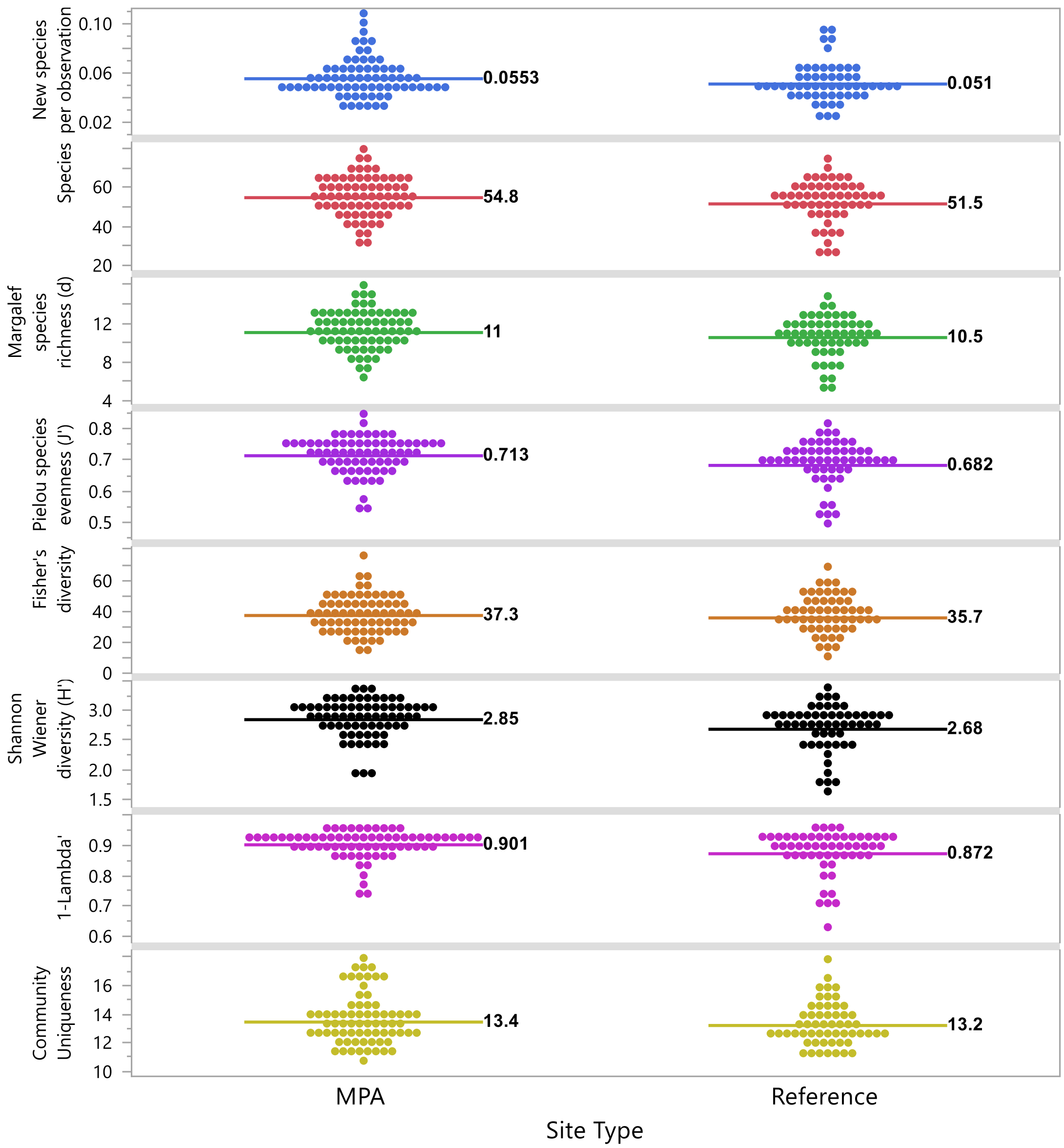

Figure S4: Community attributes of sites as a function of level of protection across California. Points represent individual sites. Horizontal lines are the mean for all observations. Labels are means for each attribute Site Type combination. Shown are means across all represented sites in California. Results based on Biodiversity Surveys.

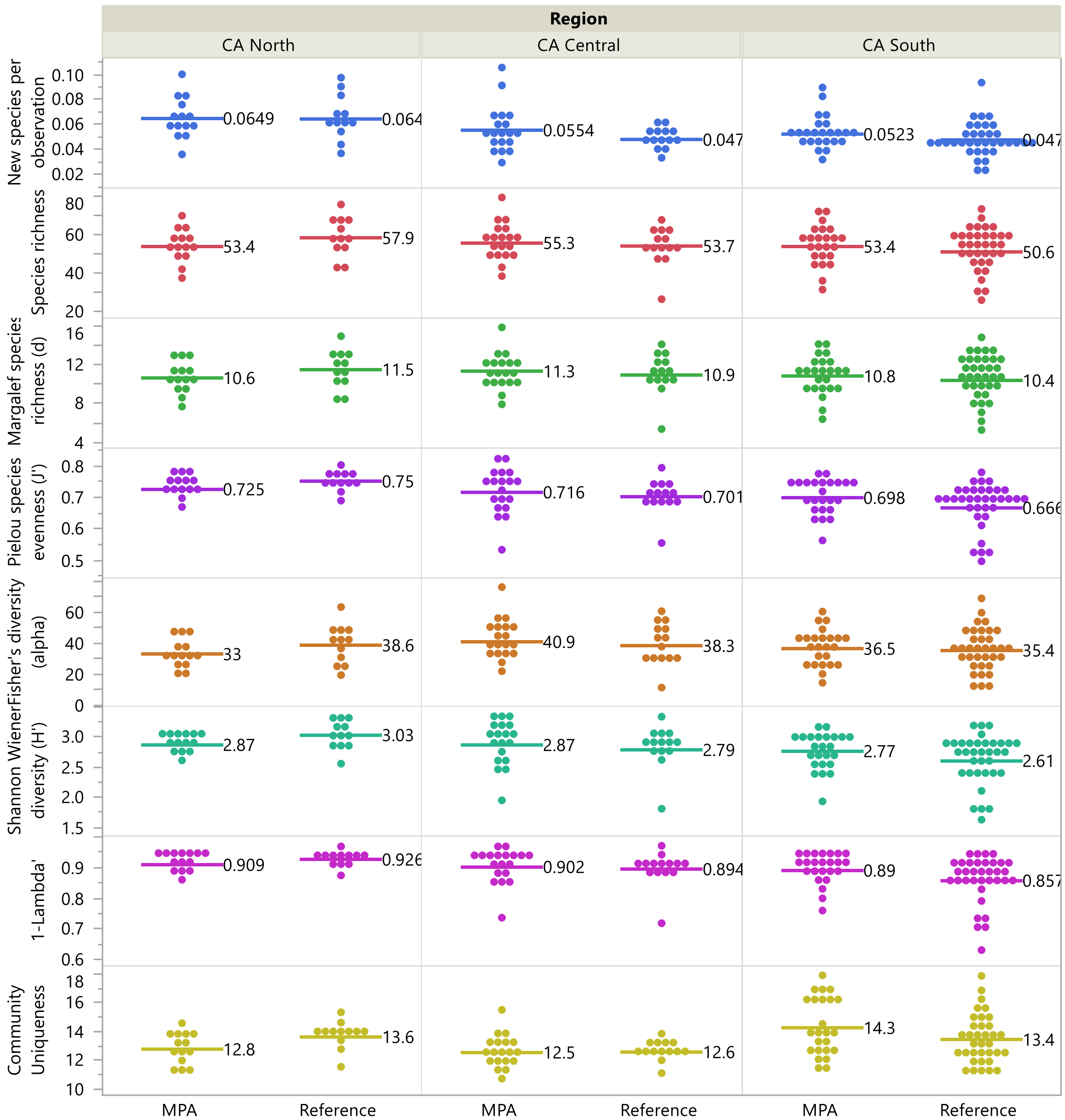

Figure S5: Community attributes of sites as a function of level of protection for regions in California. Points represent individual sites. Horizontal lines are the mean for all observations. Labels are means for each attribute Site Type combination. Shown are means across all represented sites in California. Results based on Biodiversity Surveys.

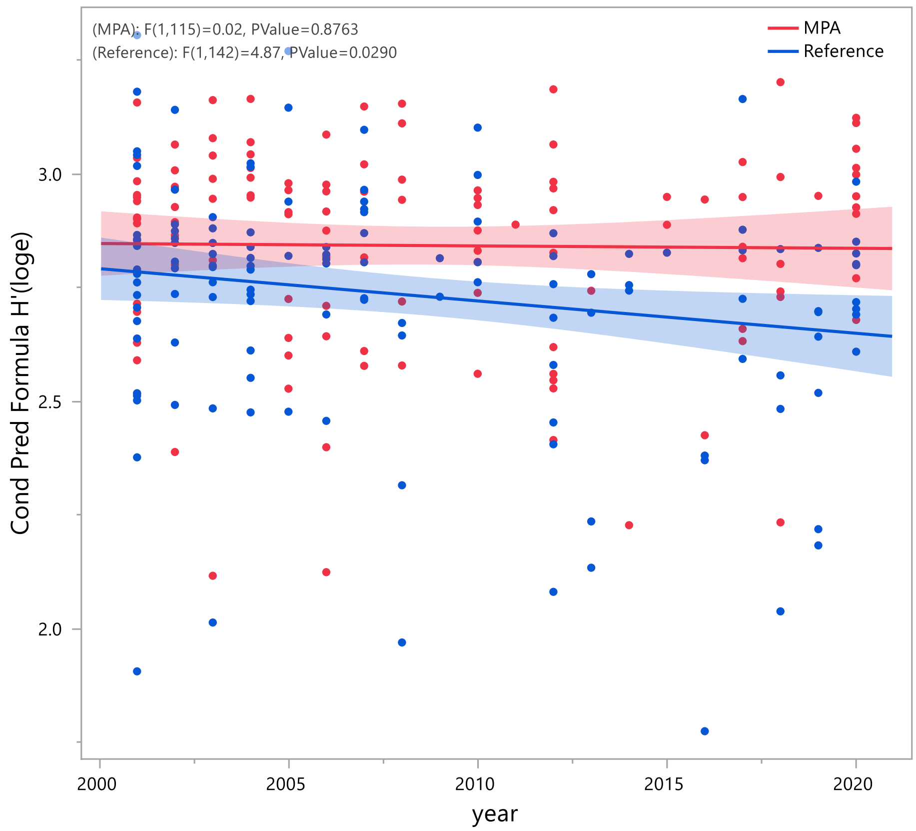

Figure S6: Shannon Weiner diversity index (log e transformed) over time for MPA sites and reference sites. These results are based on Biodiversity Surveys.

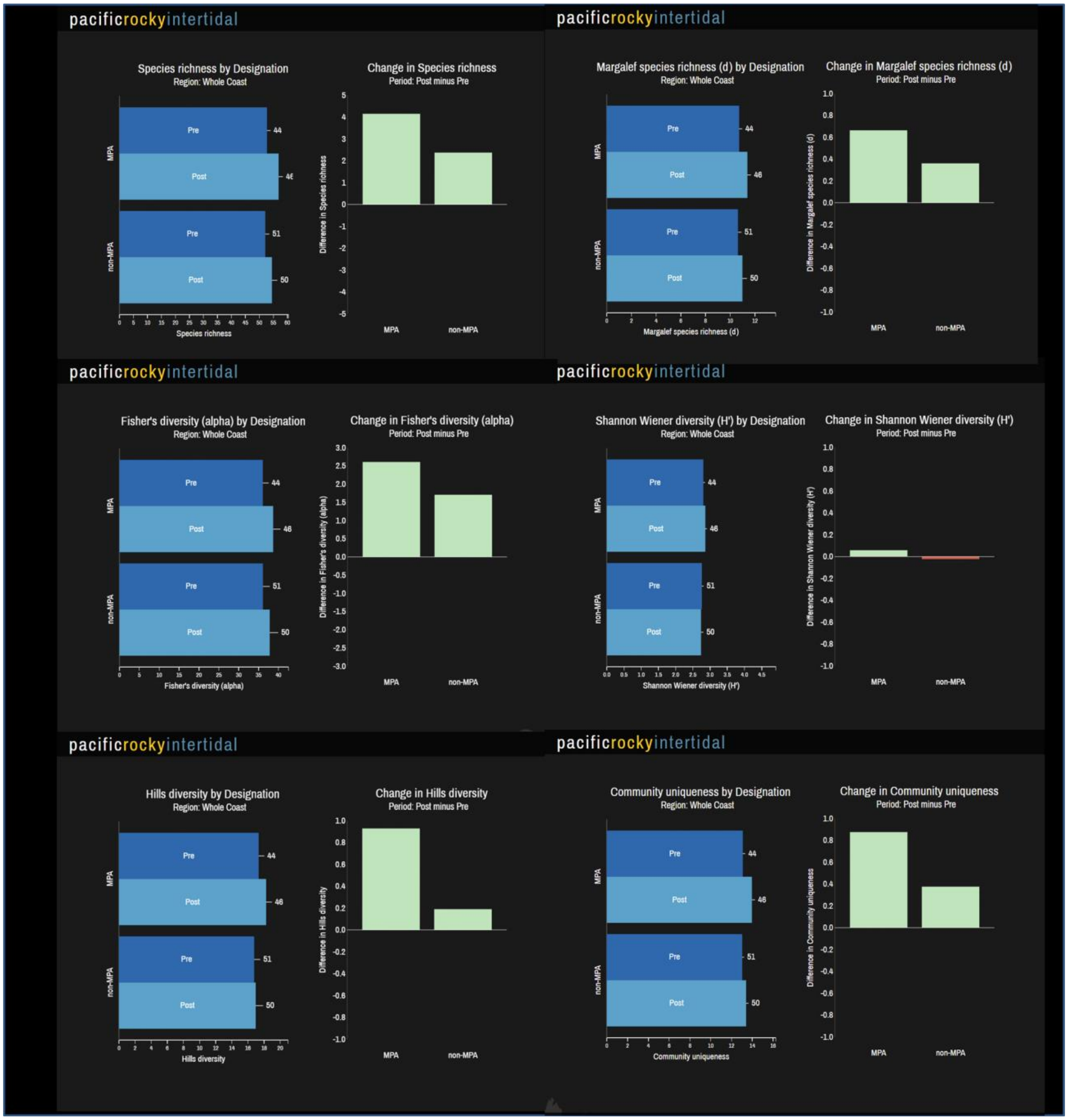

Figure S7: Community diversity by level of protection and period (pre, post MPA Implementation).

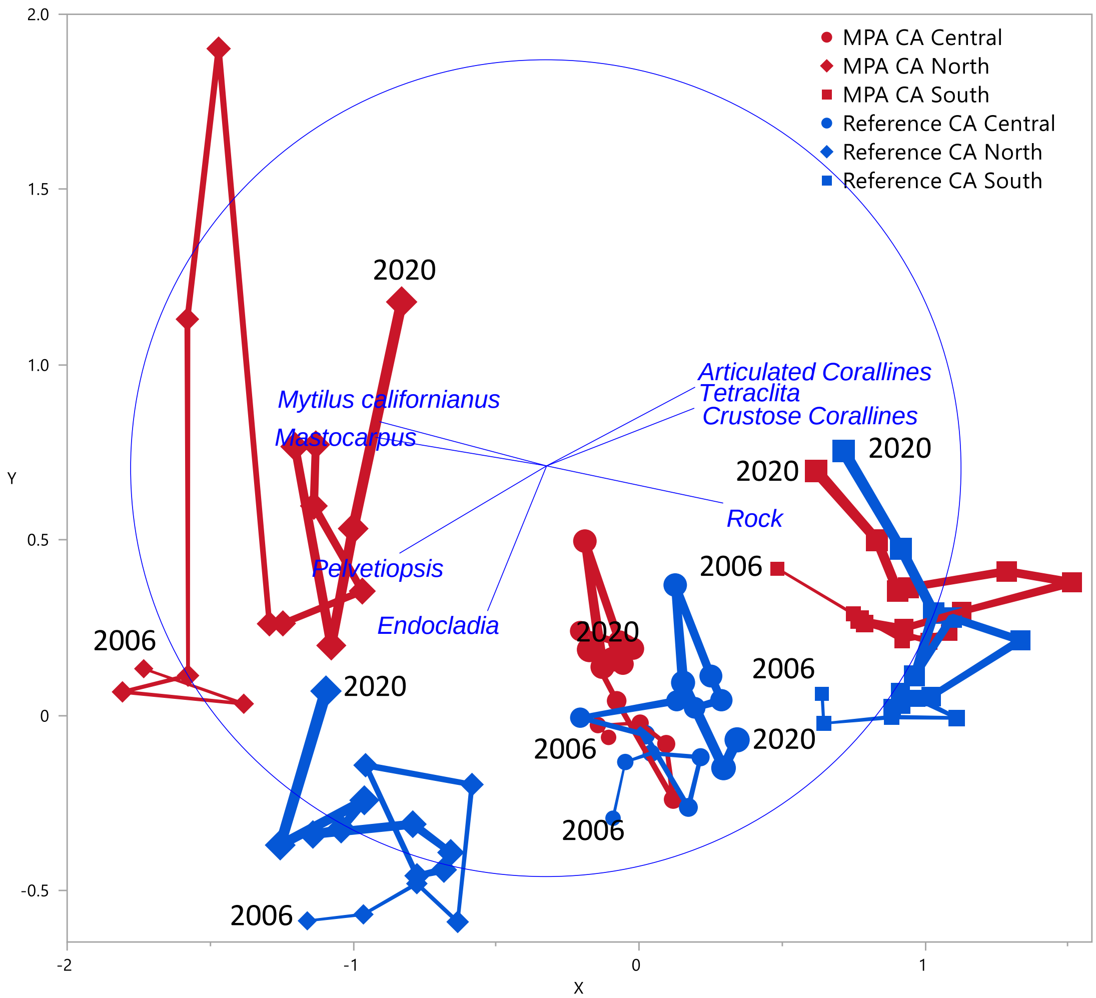

Figure S8: MDS plot of MPA and reference communities over time in CA North, CA Central and CA South regions. Start (2006) and end (2020) years are indicated. Intervening years are scaled by size of marker. Vector plots is shown for species correlated at 75% or greater with the plot.

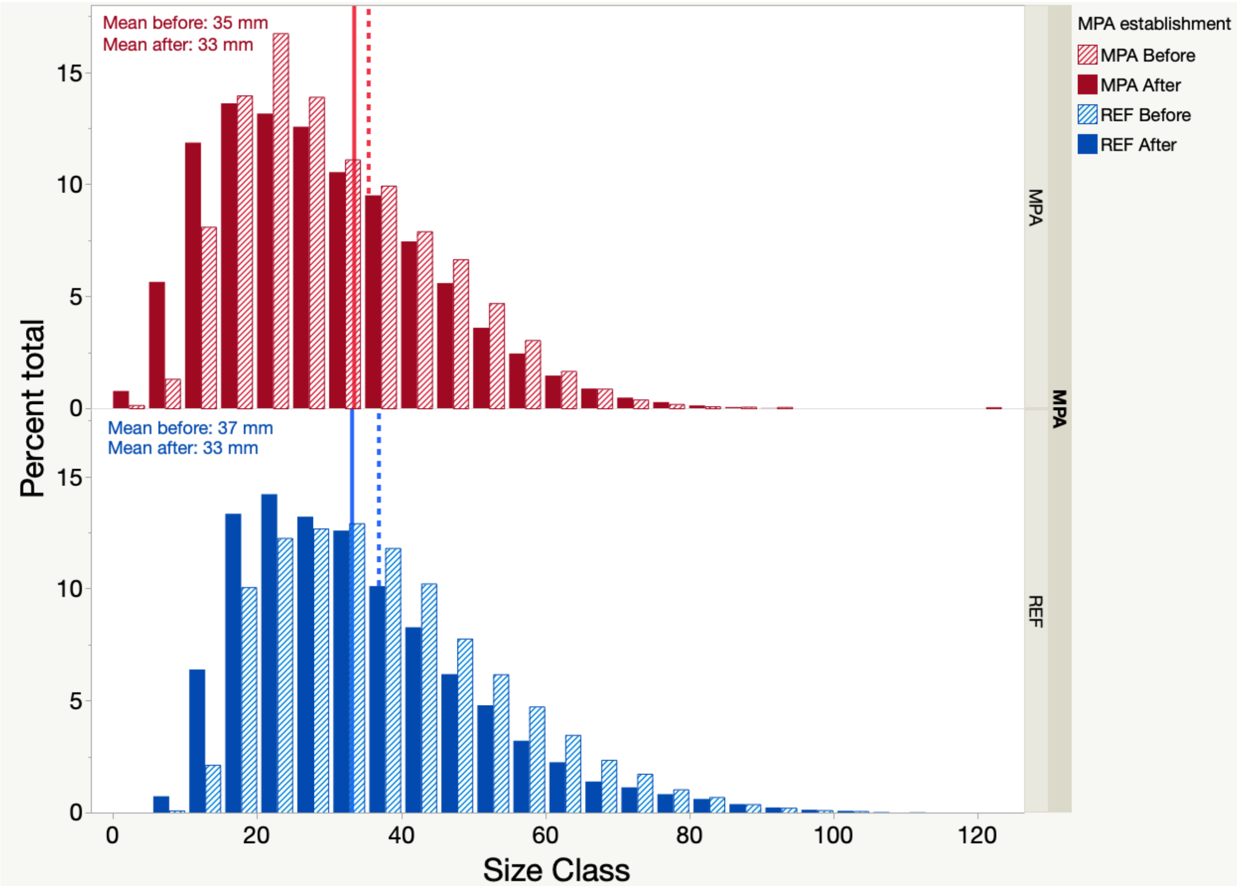

Figure S9: *Lottia* size distributions in the central and south coast regions for both MPA (red) and reference (blue) sites in pre (striped bars) and post (solid bars) MPA implementation periods. Results based on Long Term Surveys.

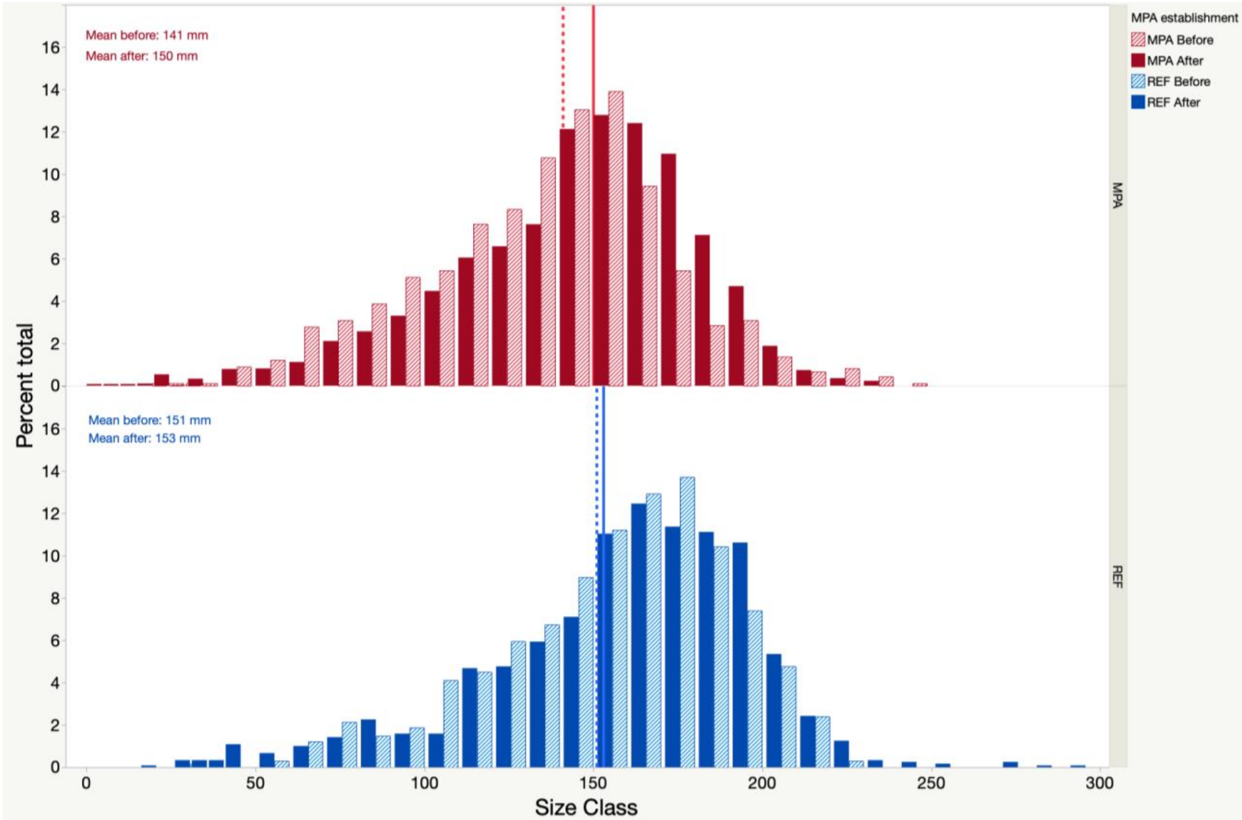

Figure S10: Red abalone (*Haliotis rufescens*) size distributions for both MPA (red) and reference (blue) sites in pre (striped bars) and post (solid bars) MPA implementation periods. Results based on Long Term Surveys.

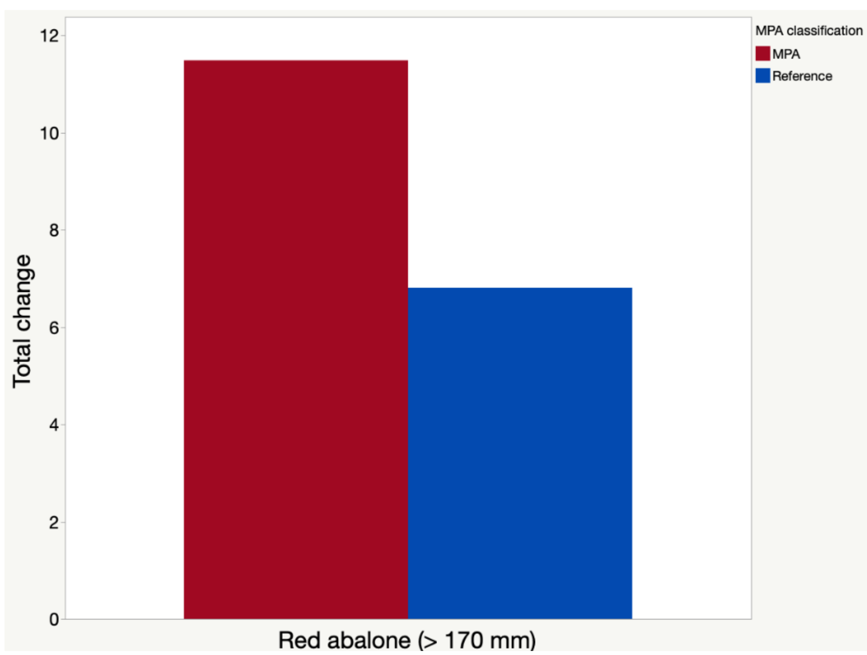

Figure S11: Total change in the size-frequency distribution of red abalone > 170 mm between MPA and reference sites. Results based on Long Term Surveys.

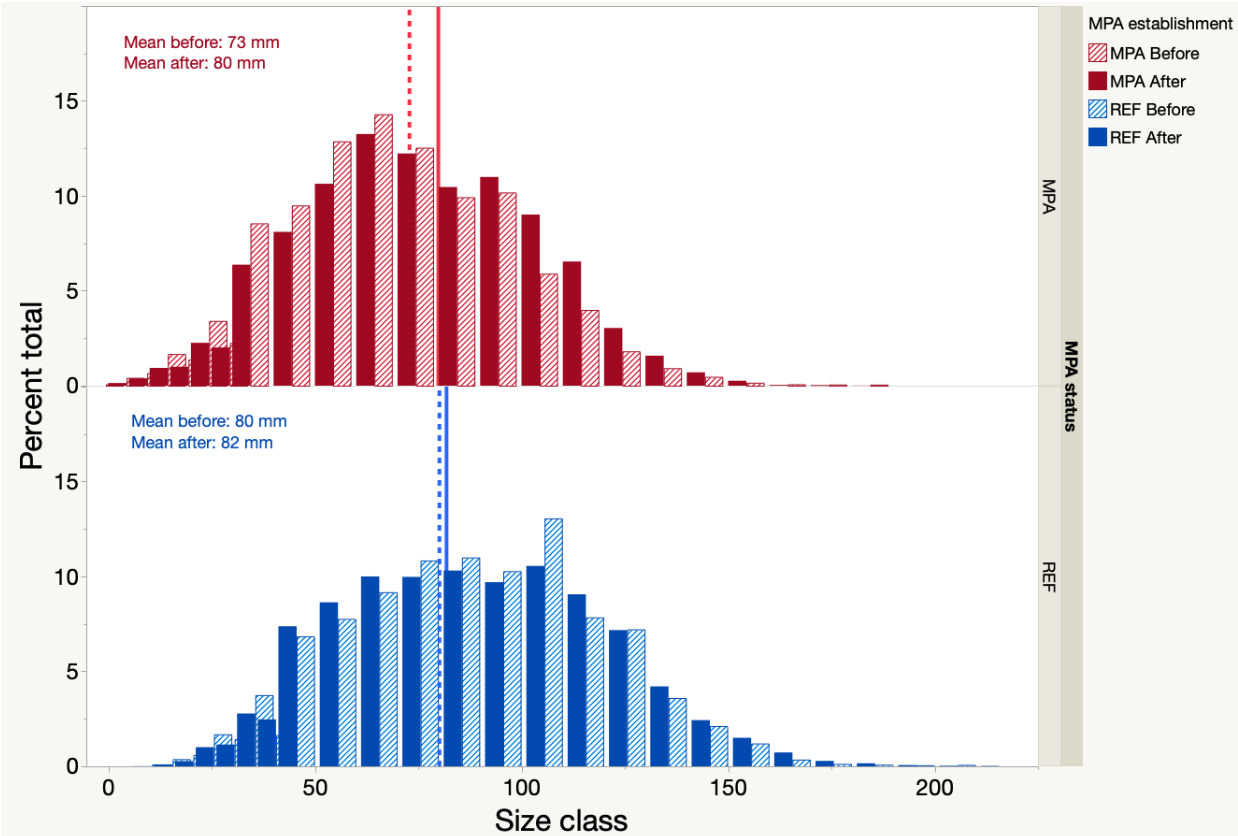

Figure S12: Black abalone (*Haliotis cracherodii*) size distributions for both MPA (red) and reference (blue) sites in pre (striped bars) and post (solid bars) MPA implementation periods. Results based on Long Term Surveys.

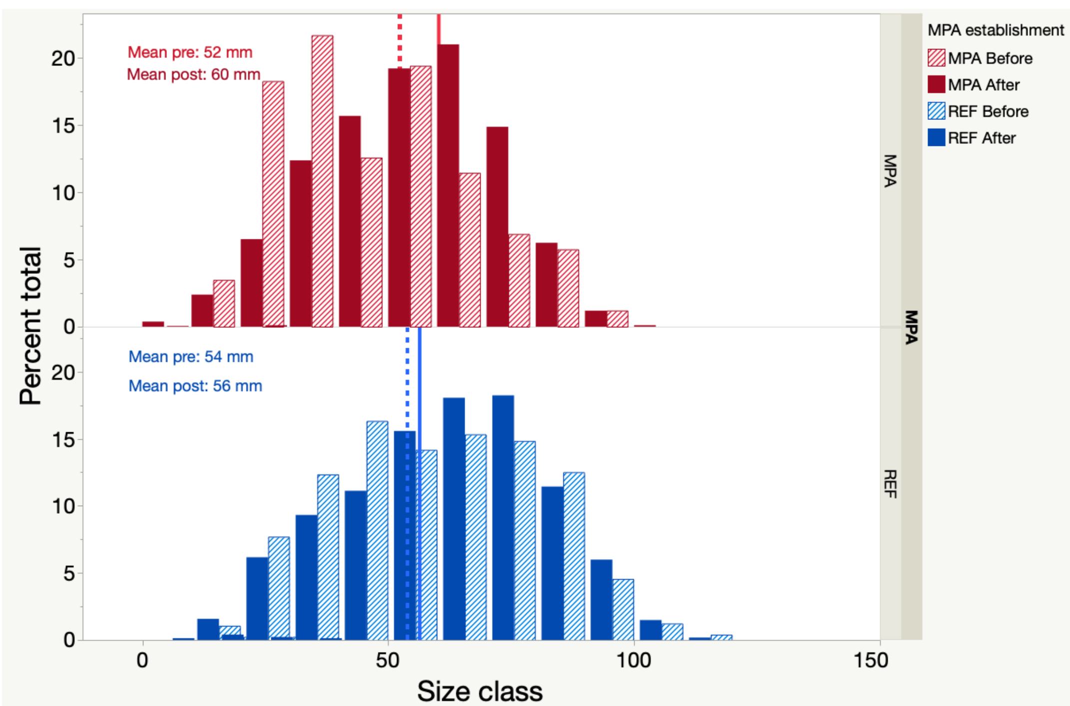

Figure S13: *Katharina spp* size distributions for both MPA (red) and reference (blue) sites in pre (striped bars) and post (solid bars) MPA implementation periods. Results based on Long Term Surveys.

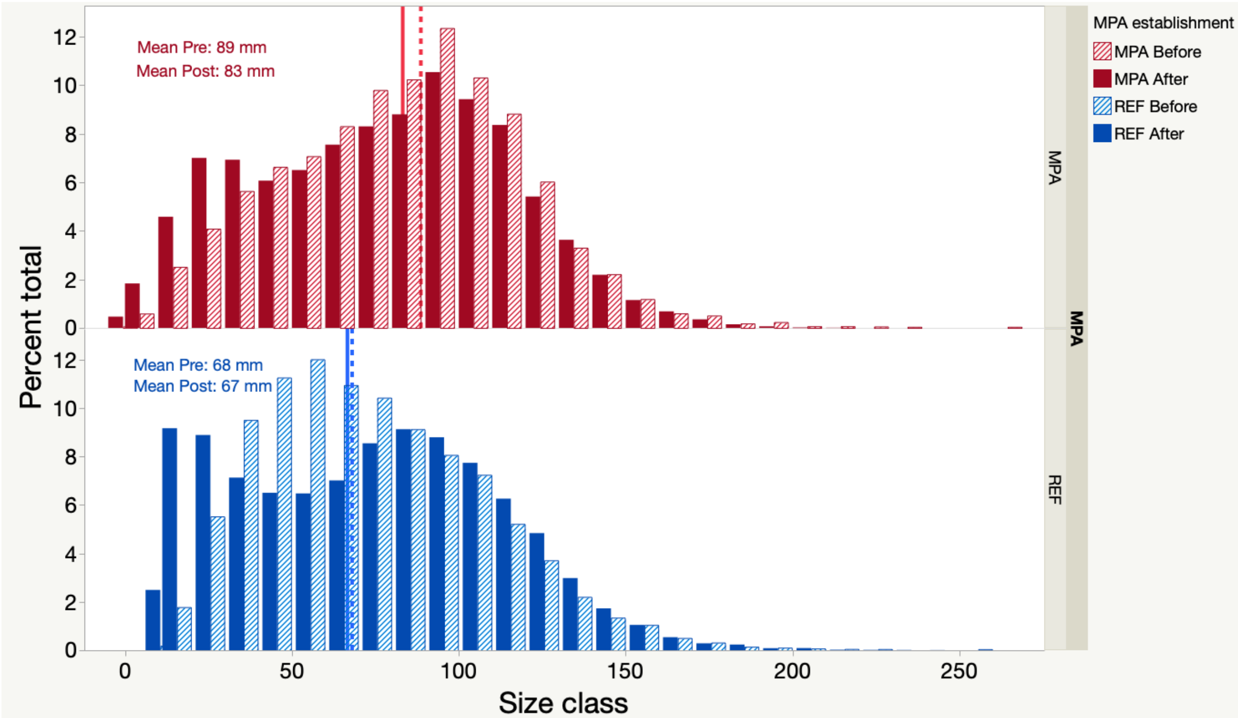

Figure S14: *Pisaster ochraceus* size distributions for both MPA (red) and reference (blue) sites in pre (striped bars) and post (solid bars) MPA implementation periods. Results based on Long Term Surveys.

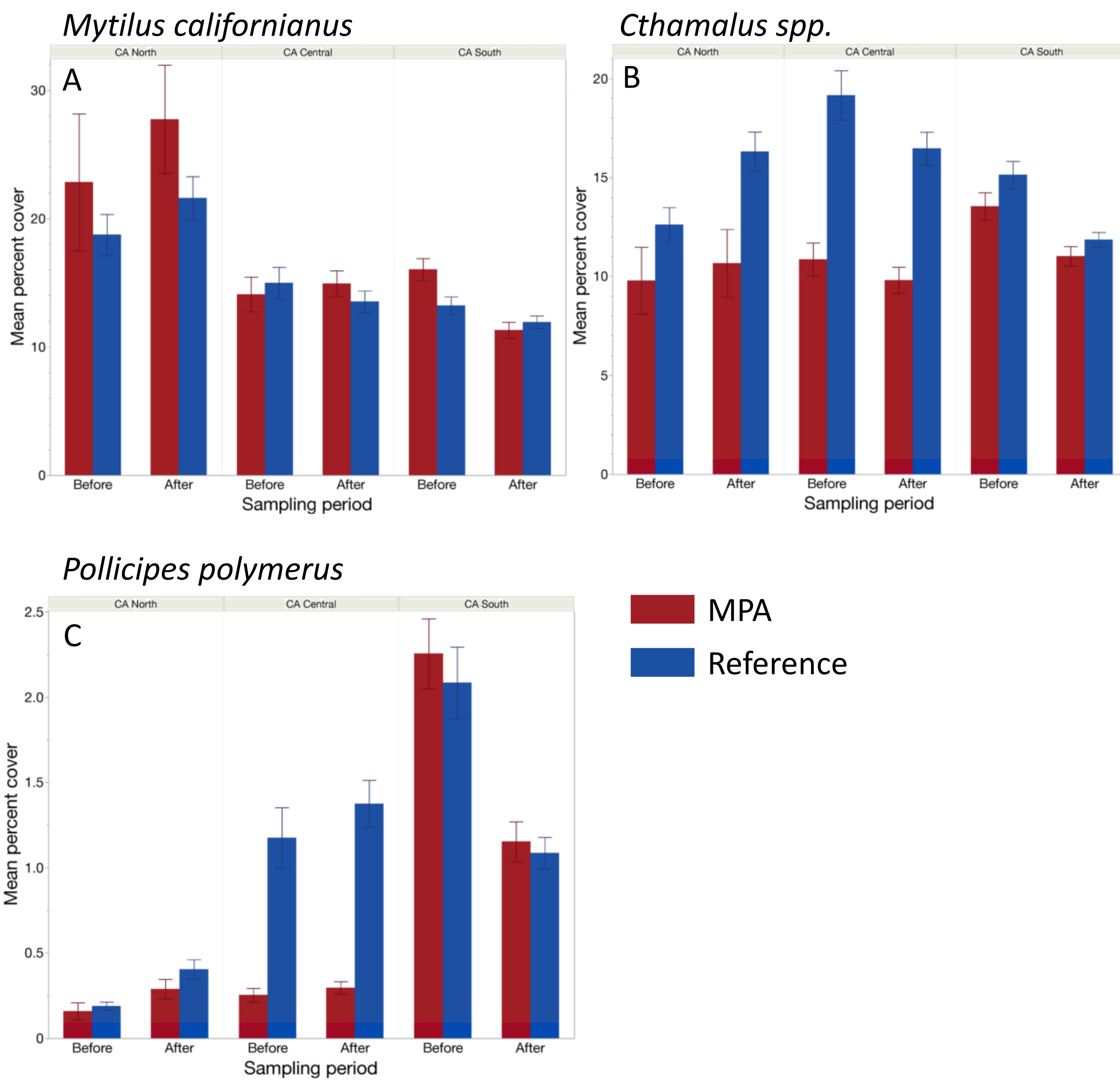

Figure S15. Mean percent cover of focal sessile invertebrates before and after regulatory implementation for MPAs (red) and reference sites (blue) with standard error bars.

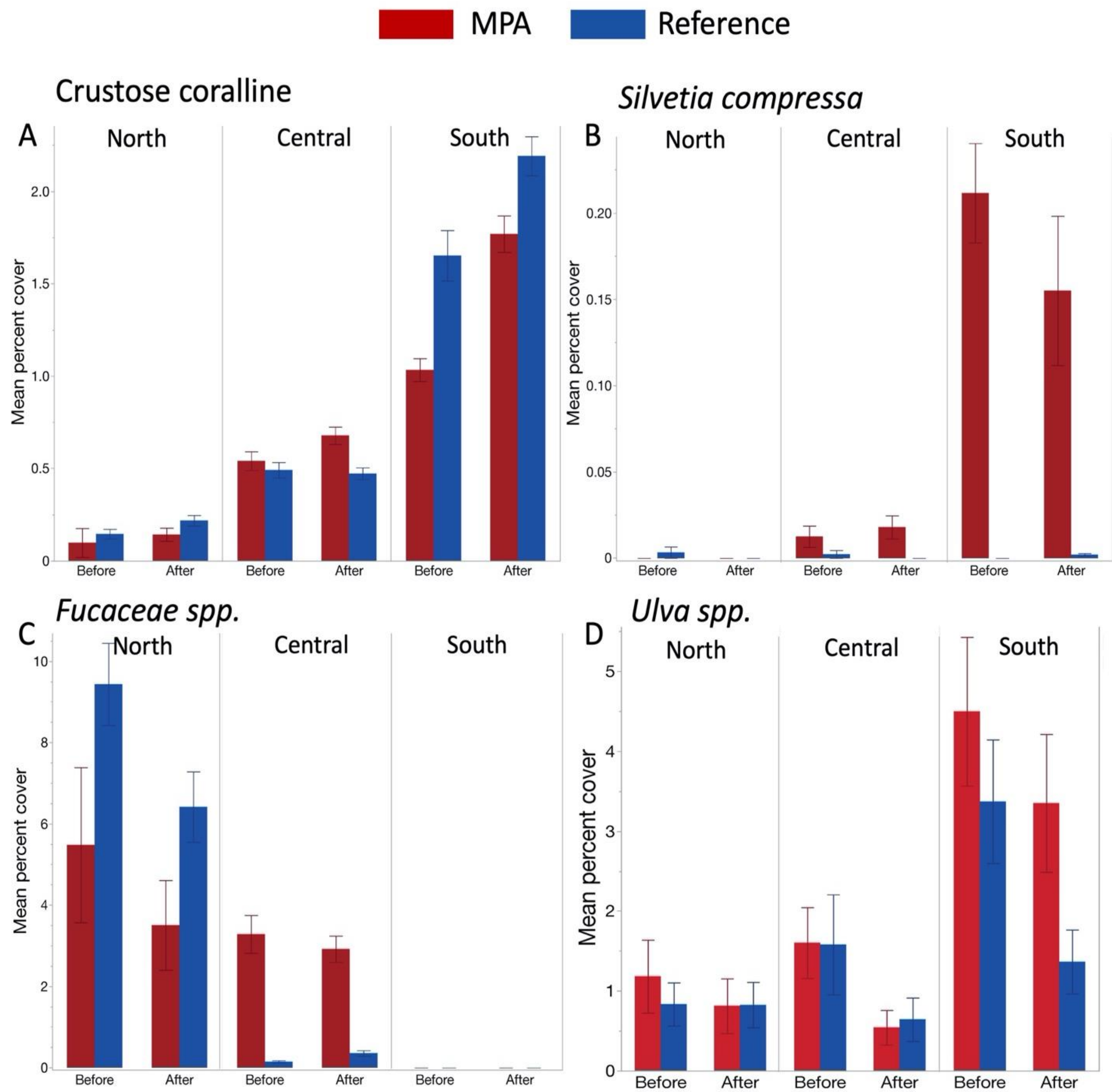

Figure S16. Mean percent cover of crustose coralline algae (A), *Silvetia compressa* (B), *Fucaceae spp.* (C), and *Ulva spp.* (D) before and after regulatory implementation across three sampling regions (North, Central, South). Error bars depict standard error. Results are presented using Biodiversity Surveys.

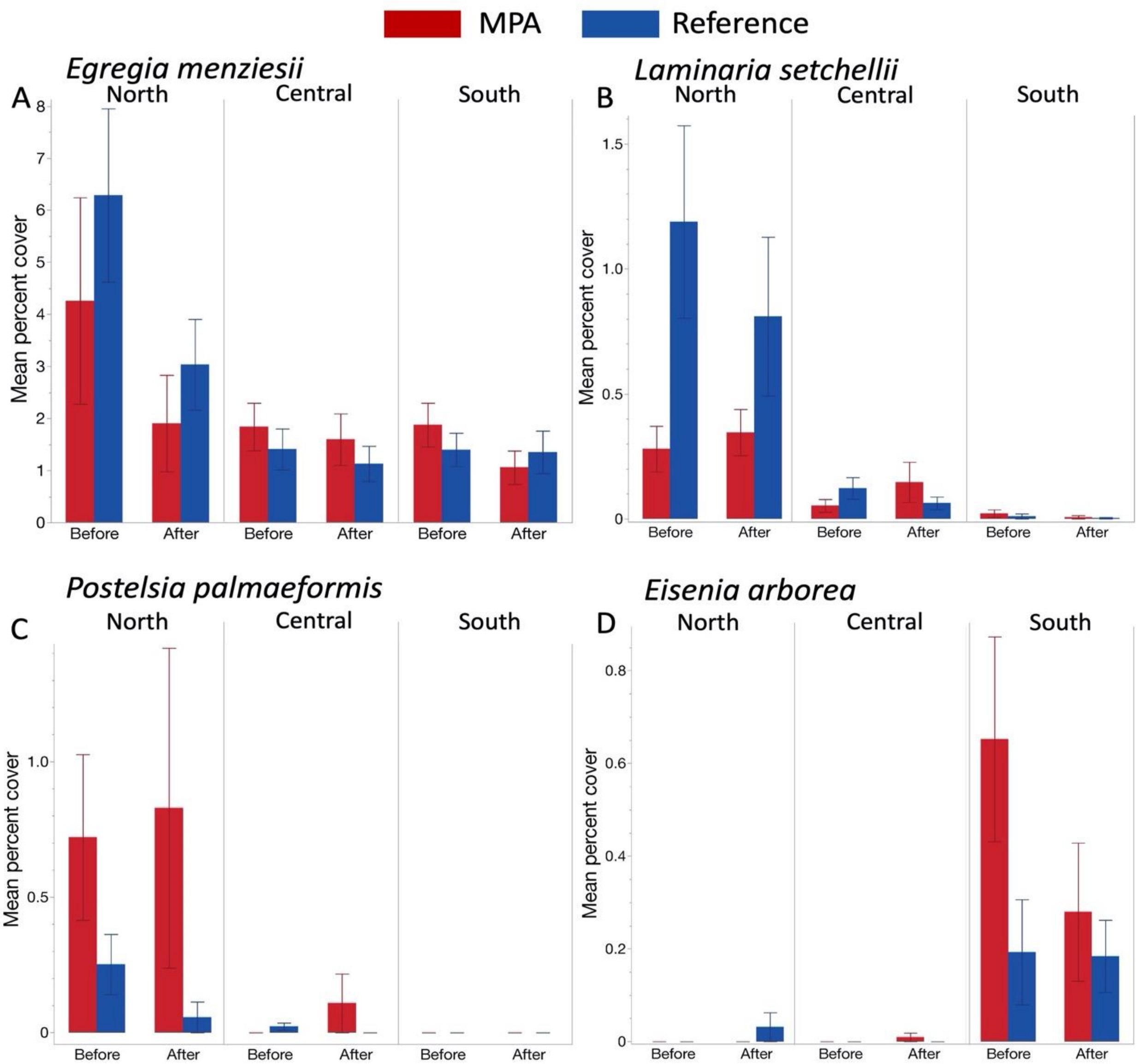

Figure S17. Mean percent cover of focal stipitate brown algae including *Engregia menziesii* (A), *Laminaria setchellii* (B), *Postelsia palmaeformis* (C), and *Eisenia arborea* (D) before and after regulatory implementation across three sampling regions (North, Central, South). Error bars depict standard error. Results are presented using Biodiversity Surveys.

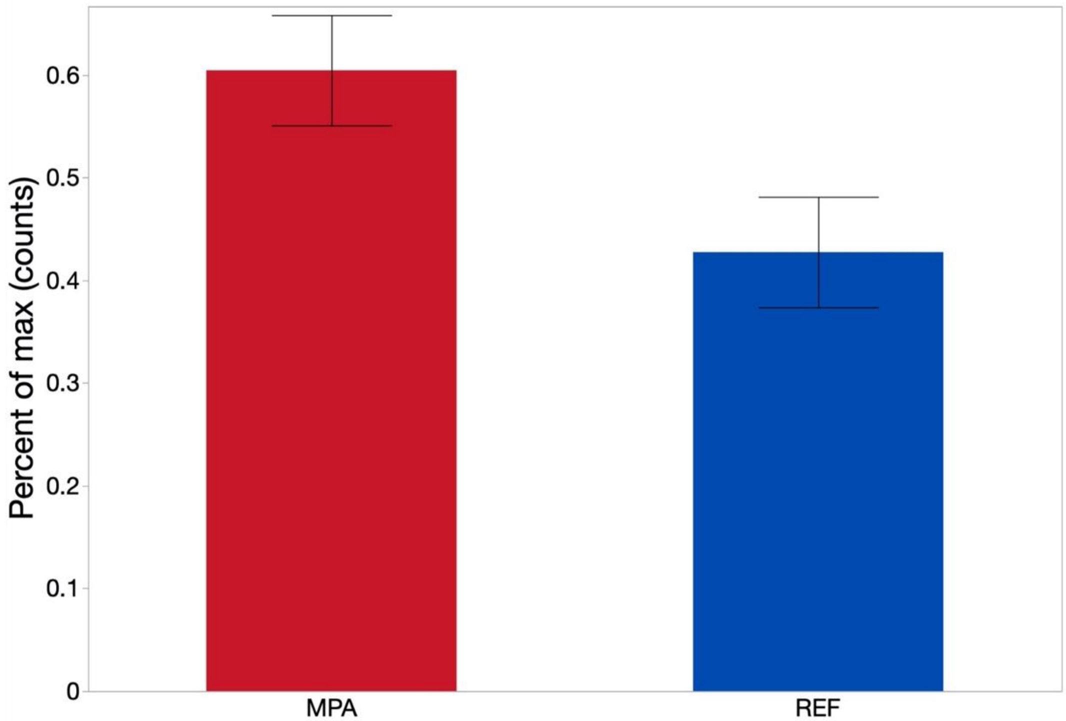

Figure S18. Mean counts of *Postelsia polmaeformis* with standard error bars for MPA (red) and reference (blue) sites. These count data are reported from long term biodiversity surveys. Because these sampling plots vary in size, we standardized counts relative to the maximum number recorded within a given site.

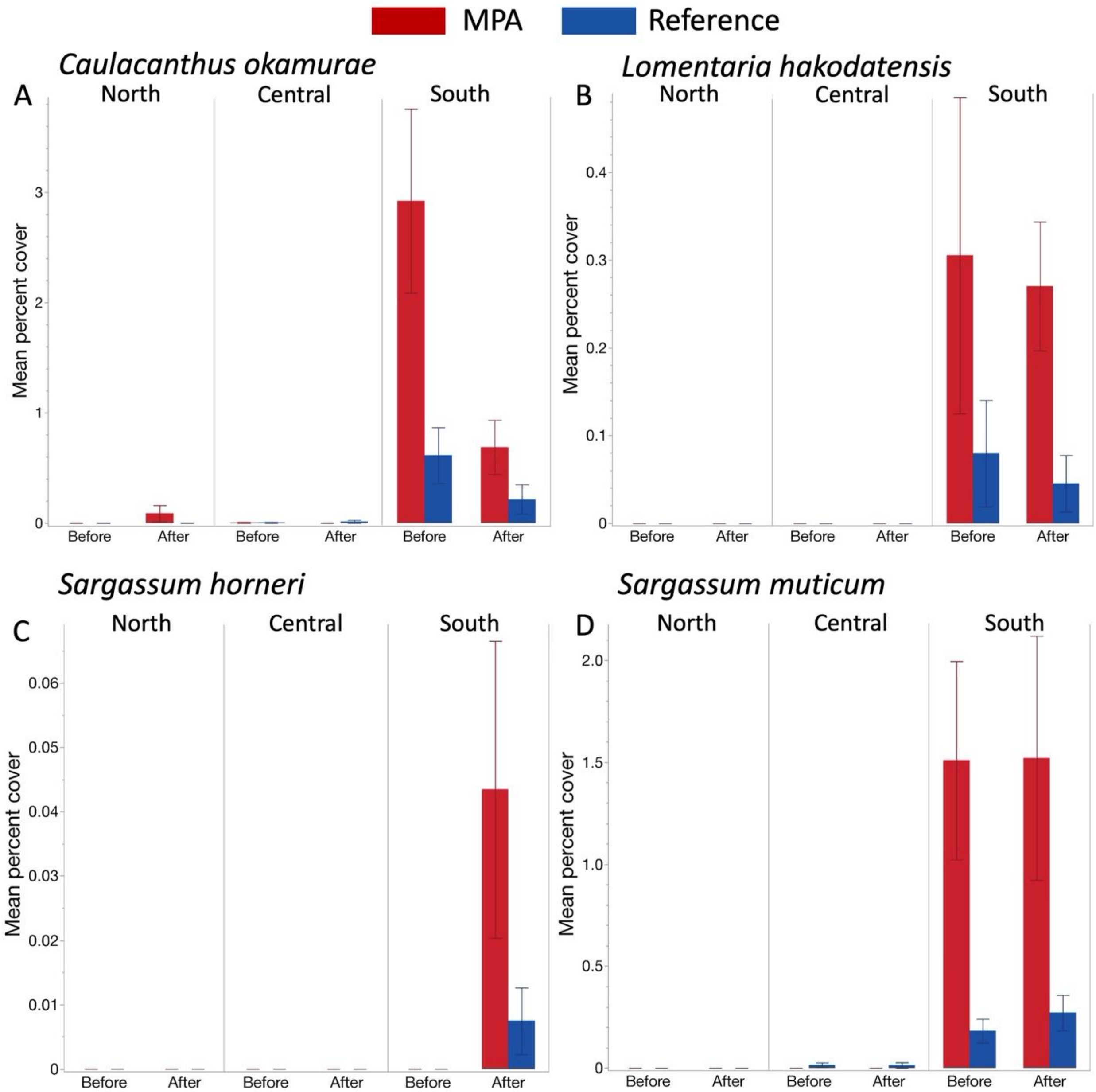

Figure S19. Mean percent cover of invasive algae species including *Caulacanthus oamurae* (A), *Lomentaria hakodatensis* (B), *Sargassum horneri* (C), and *Sargassum muticum* (D) before and after regulatory implementation across three sampling regions (North, Central, South). Error bars depict standard error. Results are presented using Biodiversity Surveys.

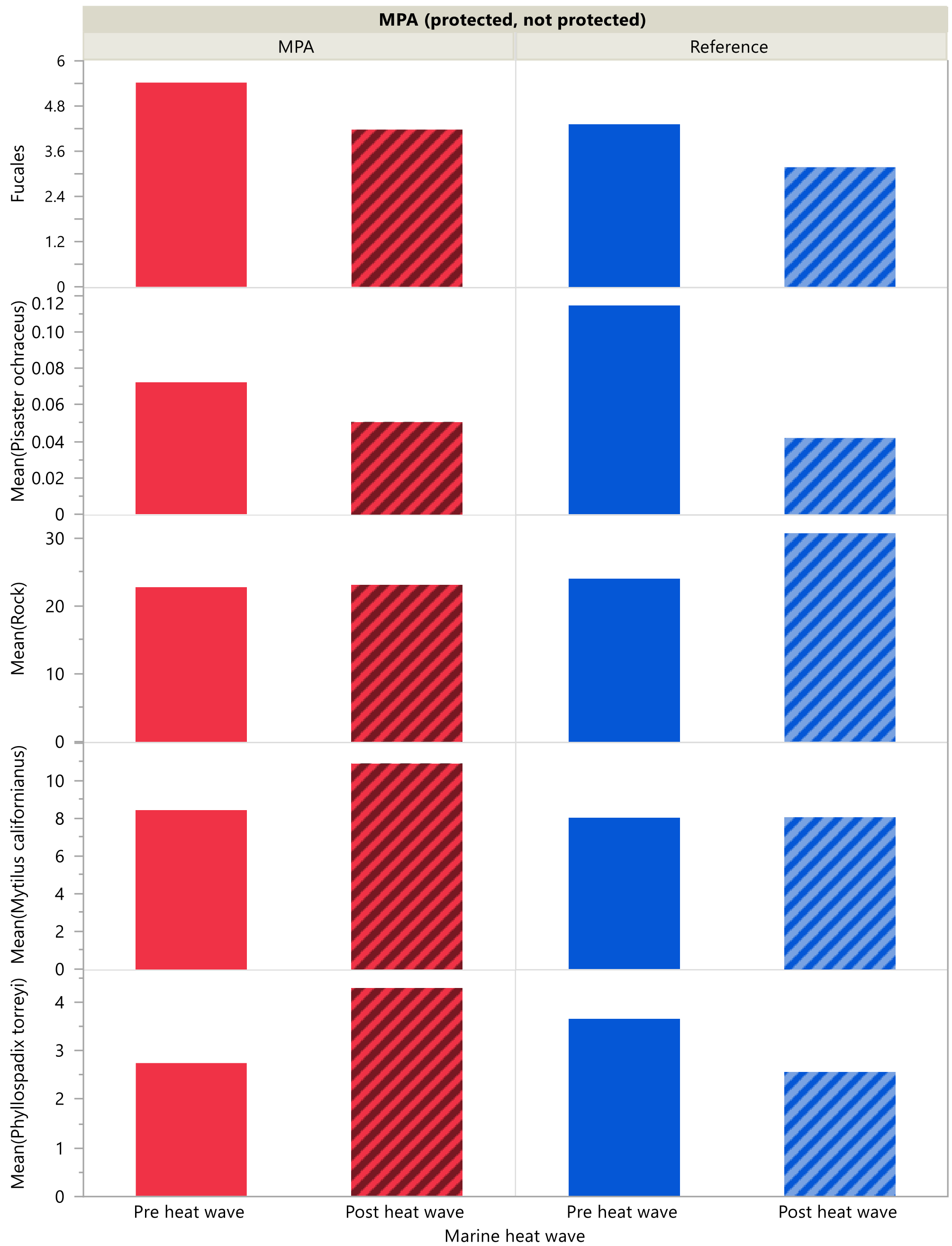

Figure S20: Mean abundance or cover per site for common species or substrate as a function of Site Status (MPA, Reference) and MHW period (pre, post).