North Coast Baseline Surveys of Rocky Intertidal Ecosystems

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Final Report: Baseline Characterization of Rocky Intertidal Ecosystems along the North Coast of California

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Rocky Intertidal Ecosystems: Baseline Characterization of MPAs along the North Coast of California

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Executive Summary

The objectives of this baseline study of rocky intertidal habitats along the North Coast Study Region (NCSR) are to (1) produce a quantitative baseline characterization of the structure of rocky intertidal ecosystems in Marine Protected Areas (MPAs) established by the Marine Life Protection Act (MLPA), (2) provide an initial comparison between rocky intertidal ecosystems inside MPAs and nearby associated (unprotected) reference areas, (3) analytically explore baseline characterizations for potential indicators of the state of rocky intertidal ecosystems, (4) generate a fish biodiversity baseline within rocky tide pools at a few sites inside and outside of MPAs (for the first time) as well as (5) examine rockfish recruitment into these tide pools, and (6) integrate these assessments with other components of the baseline survey, including (7) high resolution topographic geological surveys, to inform the role and design of these programs for future monitoring and evaluation of MPAs.

Results indicate very clear patterns of species biogeography along the west coast of North America, with the NCSR specifically divided into two regions, with a break near Cape Mendocino. High-resolution topographic surveys showed sites in the northern region of the NCSR tended to have higher surface roughness than those along the southern (Mendocino) region. For both mobile and sessile invertebrates as well as algal species, we found that species richness, if anything, was higher for sites outside of MPAs. We compared the sessile and mobile biological communities of sites within MPAs to those at unprotected sites using PERMANOVA. We found no differences between MPA and reference sites in either community. This was not surprising as this project provides baseline characterization of the region only shortly after MPAs were enacted in this region, long before any biological response from MPA protection might be expected. Species richness of tide pool fishes was higher outside of MPAs (although fishes were sampled at only 2 MPAs). Rockfish recruits, seen in the hundreds to thousands at several sites (e.g. Palmers Point) in the northern region of the NCSR in prior years (Studebaker & Mulligan, 2008), were noticeably absent during this study (2014-2015). This could be related to the anomalous ocean conditions during the 2014-2016 period including the strong El Niño and "The Blob" of warm water (and associated "Ridiculously Resilient Ridge" of high atmospheric pressure) in the eastern Pacific; these resulted in warmer water temperatures and reduced coastal upwelling, and may have affected larval rockfish survival, movement patterns, and/or habitat usage. In addition, we observed dramatic declines in sea star abundance at northern sites decline dramatically and approach very low densities similar to those found at southern sites. This was the result of Sea Star Wasting Disease (SSWD) that may also have been connected to the unusual climatic conditions during this period (Figure 1). Interestingly, despite the marked decrease in sea stars that are believed to be a keystone predator of the California mussel (*Mytilus californianus*), the mussel exhibited little change in abundance or size (as measured by percent cover, bed depth, and mean length of individuals) during the study (Figure 2).

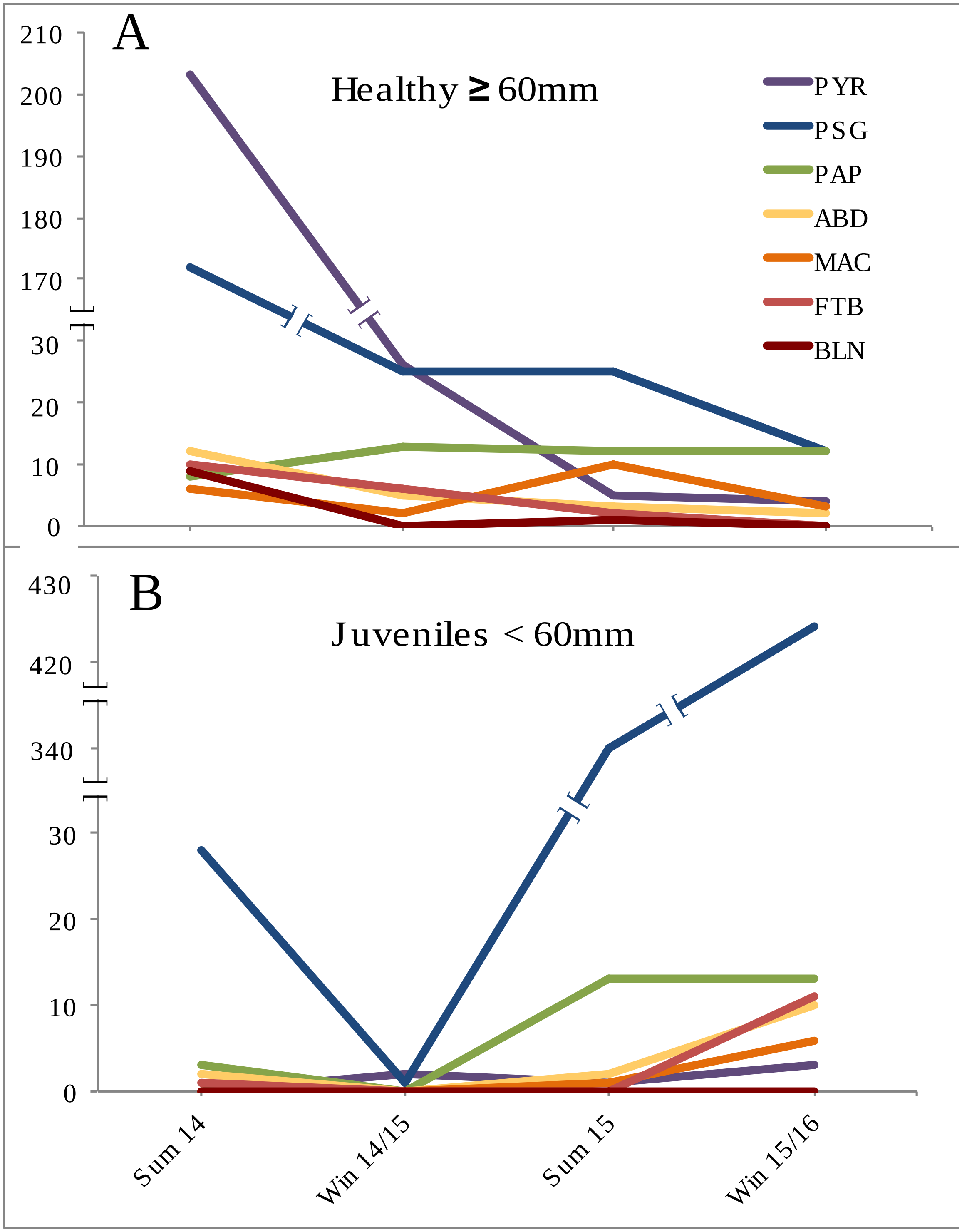


Figure 1. Abundance *of Pisaster ochraceus* at all seven sites for all four sampling seasons; (A) numbers of healthy (asymptomatic) large (rays ≥ 60mm) individuals, and (B) numbers of juveniles (rays < 60mm) in an all three *Pisaster* plots at each site.

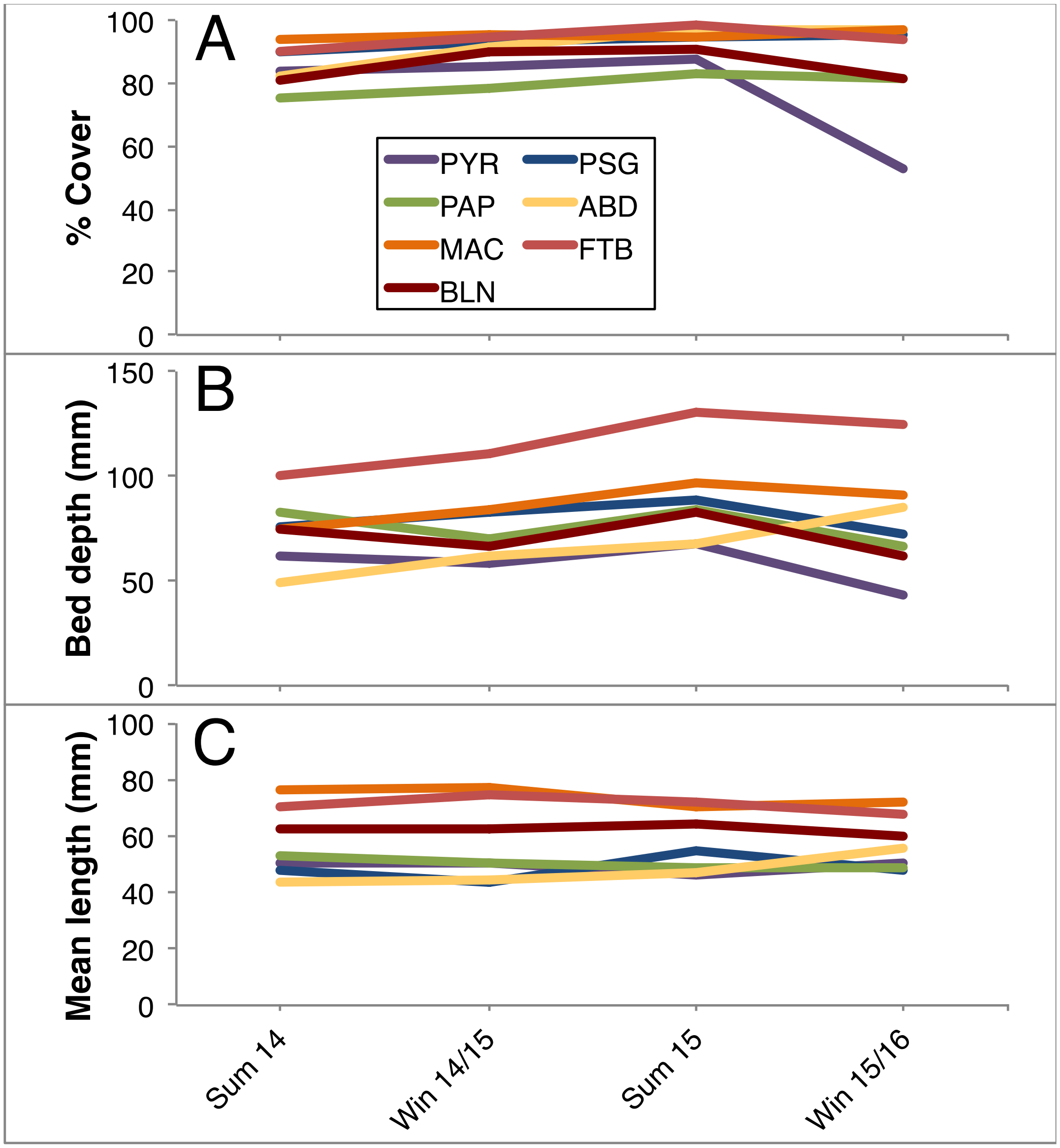


Figure 2. Mussel measurements based on five permanent plots per site; (A) percent cover of mussels within plots, (B) mussel bed depth within plots, and (C) mean length of individual mussels.

Finally, we found a single non-MPA site in Fort Bragg at the site of a former pulp mill that had been protected by fences and guards for many years and appears to have served as a *de facto* marine reserve. This site had abundant red abalone within it, though their numbers declined rapidly (especially in easily accessible areas) during the course of this study. This decline is almost certainly the result of people accessing the site to pick abalone in anticipation of the site being opened to the public as open space in June 2016; this scenario very closely parallels a similar on that played out when Stornetta Ranch was opened to the public (Rogers-Bennett et al. 2013). Despite declines in sea stars and abalone, the baseline data collected by this project can be used to measure changes in the future. Hence, the effect of protection should be relatively easy to interpret in future surveys, although there is scope for the development of a set of simplified protocols to facilitate participation by citizen science groups in monitoring efforts.

Introduction

North Coast Rocky Intertidal Ecosystems

The North Coast region of California ranges from Point Arena to the Oregon Border. Highway 1/101 hugs the coast along much of this stretch of coastline, and spectacular views and abundant recreational activities bring visitors from around the world. Coastal habitat within this region includes estuaries, bays, mudflats, rocky headlands/reefs, and boulder/cobble/sandy beaches.

Historically, commercial fishing has been an important part of the economy in this region. Sport fishing, including harvesting of red abalone, is a major attractor of visitors to the region and continues to be an important source of income for coastal communities.

Threats to the rocky intertidal in North Coast California include overuse and overharvesting as well as land use issues that can impact water quality and sedimentation levels. Increasing coastal development in this region could lead to concerns about elevated levels of sediment and urban runoff. This region also contains agricultural and some industrial areas, and the impact of runoff on marine communities is a concern.

The region includes 6 State Marine Reserves (SMR), in which all fishing is prohibited, 13 State Marine Conservation Areas (SMCA), in which limited commercial or recreational take is allowed, 7 areas of special closure (for particular species) and a single State Marine Recreational Management Area (Figure 3). These North Coast Study Region (NCSR) MPAs cover approximately 13% of the state's coastal waters in this region. Some of these (including 3 SMR's) are offshore and many others do not contain consolidated reef/rocky intertidal or do not have access from land. Hence, the total number of suitable coastal sampling locations is somewhat limited. Biodiversity and Long-Term Monitoring Surveys have been done in this region since 2001 by UCSC-PISCO (Raimondi, lead PI). Baseline monitoring for the newly established Marine Protected Areas began in 2014 for this MPA study.

Project Goals and Objectives

The objectives of our rocky intertidal surveys and analyses for the North Coast Baseline Surveys are to (1) produce a quantitative baseline characterization of the structure of rocky intertidal ecosystems in all of the Marine Protected Areas (MPAs) that have rocky intertidal habitats established by the Marine Life Protection Act (MLPA) Initiative along the North Coast Study Region (NCSR), (2) provide a quantitative comparison between the rocky intertidal ecosystems in these MPAs and associated reference areas in the NCSR, (3) analytically explore baseline characterizations for potential indicators of the state of rocky intertidal ecosystems, using newly collected data along with existing PISCO datasets from the region (from 6 sites where UCSC-PISCO monitoring is ongoing), (4) generate a fish biodiversity baseline within rocky tide-

Figure 3. California Department of Fish & Wildlife map of MPAs in the NCSR.

pool habitats both inside and outside MPA sites, (5) monitor and characterize rockfish recruitment into these tide pool habitats, and (6) integrate these assessments with other components of the baseline survey, including (7) high resolution topographic geological surveys, to inform the role and design of these programs for future monitoring and evaluation of MPAs.

The goal of this report and the associated survey data (uploaded to Oceanspaces.org) is to provide a baseline characterization summary of the Rocky Intertidal Ecosystems in the NCSR (1 and 2 above). These data can then be used for future synthesis and integration efforts across the other projects associated with the North Coast Baseline Program (3 -6 above). Though we intended to integrate the results of our project with that of other North Coast MPA baseline projects, we found that there was insufficient time to accomplish this. The PIs are committed to participating in and contributing to the North Coast Science Integration project, led by Eve Robinson, which should accomplish similar objectives.

Methods

Overall Approach

Our rocky intertidal monitoring program is a product of over three decades of research at more than 200 monitoring sites ranging from Southeast Alaska to Mexico. Our approach for the NCSR involved replicating this ongoing intertidal sampling program, coordinated with Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) and the Multi-Agency Rocky Intertidal Network (MARINe). For the NCSR, the team from UC Santa Cruz (UCSC) lead by Raimondi (PI) focused on baseline characterization of community structure and biodiversity using Biodiversity Surveys. Other groups, led by Craig (PI) from Humboldt State University (HSU), Tyburczy (CA Sea Grant) and Laucci (Tolowa Dee-ni' Nation) were responsible for surveys of Focal Species. Examinations of fish diversity and rockfish recruitment in tide pools were led by Kinziger (PI-HSU) and Hinterman (Trainee-HSU). Finally, Aiello (PI) at Moss Landing Marine Lab (MLML), lead surveys to produce high resolution topographic maps of the geological foundations at several of the surveyed sites. This overall approach is the same one that was used to generate baseline characterizations of rocky intertidal ecosystems in the North Central, Central Coast and South Coast Study Regions and the network of marine reserves in the Northern Channel Islands. It is also the same approach we used to characterize MPAs in Oregon, run off in Areas of Special Biological Significance (ASBS) in California and biodiversity along the temperate North American West Coast. This provides comprehensive ecological context for our work in the NCSR.

The Biodiversity Surveys provide detailed information about biodiversity and community structure. These surveys were designed to measure diversity and abundance of algae and invertebrates found within rocky intertidal communities on the western coast of temperate North America.

Our selected rocky reefs are usually broad (typical width between 30-50 m) and long (typical length between 50-500 m). Contiguous rocky reefs are the most stable of rocky intertidal habitats, and targeting a specific habitat type results in higher consistency among sites, which allows for better comparisons among sites and regions. This basic level of consistency in site selection is important, because targeted reefs vary immensely by rock type, shape, rugosity, exposure, surrounding habitat, human visitation levels and other factors, which all contribute to explaining patterns of community structure and biodiversity.

We note that many of the Biodiversity Survey sites are located in the same areas as Long-Term PISCO Monitoring sites, overseen by UCSC, but which are not part of this MPA sampling effort. In combination, the long-term, focal species approach and biodiversity surveys along with tidepool fish diversity surveys and high resolution topographic maps provide a wealth of information about the structure and dynamics of rocky intertidal communities along the Pacific Coast of North America.

For the purposes of this baseline characterization report, only Biodiversity Survey data were used for the biological summaries of each study site in Appendix A (see Figures 37-55). Detailed information on our intertidal surveys, including full survey protocols, trend graphs, and an interactive map and graphing tool, can be found at the UCSC website at http://www.eeb.ucsc.edu/pacificrockyintertidal/index.html . These methods are briefly summarized below.

Description and Location of Sites

We established a total of 16 rocky intertidal sites within the NCSR (Figure 4, Table 1: note sites in table 1 are listed from north to south). Four of these sites are located within MPAs [(1) Pyramid Point SMCA, (2) False Klamath Rock Special Closure, (3) Ten-Mile SMR = Abalobadiah Creek, and (4) Mackerricher SMCA], and 11 were located outside of MPAs.

It should be noted that the original proposal for baseline characterization using Biodiversity sampling was for 25 sites in the NCSR. Because that budget was cut by 56%, this led to a reduction in sampling effort and hence number of sites sampled.

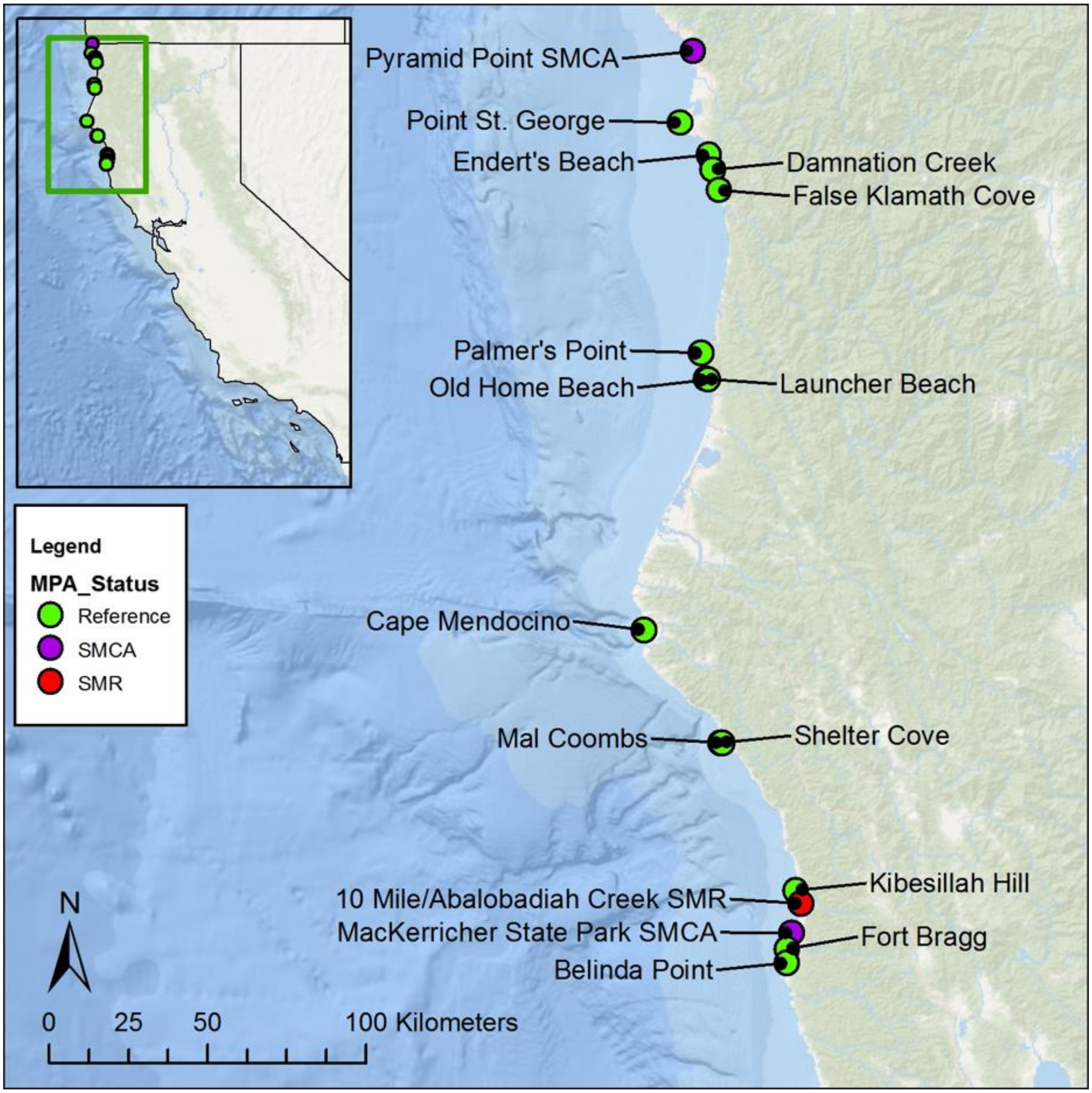


Figure 4. Map of NCSR study region including 16 sites used in this study, of which were in MPAs (SMCA & SMR locations are shown in purple and red, respectively).Table 1. Rocky Intertidal biodiversity sites in the NCSR. Also shown are some sites from the northern portion of the NCCSR (shaded gray), used for

reference.

Intertidal Site Name	MPA Region	MPA Name	primary bench type	slope	relief	extent	surrounding coast
Pyramid Point	North	Pyramid Point SMCA	boulders/cobble/sand	0-5 degrees	high	long	bedrock/boulders/cobble/sand
Point Saint George	North	Reference	bedrock/boulders/cobble/sand	0-5 degrees	moderate	long	bedrock/boulders/cobble/sand
Enderts	North	Reference	bedrock	greater than 15 degrees	moderate	intermediate	bedrock/boulders/cobble/sand
Damnation Creek	North	Reference	bedrock/boulders/cobble	0-5 degrees	moderate	long	bedrock/boulders/cobble
False Klamath Cove	North	False Klamath Rock Special Closure	bedrock/boulders/cobble/sand	5-15 degrees	high	intermediate	bedrock/boulders/cobble/sand
Palmers Point	North	Reference	bedrock/boulders	0-5 degrees	moderate	long	bedrock/boulders/sand
Launcher Beach	North	Reference	boulders/cobble/sand	5-15 degrees	high	intermediate	boulders/cobble/sand
Old Home Beach	North	Reference	bedrock/boulders/cobble/sand	5-15 degrees	high	long	boulders/cobble/sand
Cape Mendocino	North	Reference	bedrock	0-5 degrees	moderate	long	bedrock
Shelter Cove	North	Reference	bedrock	5-15 degrees	high	long	bedrock/boulders
Mal Coombs	North	Reference	bedrock/boulders/cobble/sand	0-5 degrees	moderate	long	bedrock/boulders/cobble/sand
Kibesillah Hill	North	Reference	bedrock	0-5 degrees	moderate	long	bedrock
Abalobadiah Creek	North	Ten Mile SMR	bedrock/boulders/cobble	0-5 degrees	moderate	long	bedrock/boulders/cobble
MacKerricher	North	MacKerricher SMCA	bedrock	0-5 degrees	moderate	long	bedrock/boulders/cobble
Fort Bragg	North	Reference	bedrock	greater than 15 degrees	moderate	long	bedrock/sand
Point Arena	North Central	Point Arena SMR	bedrock	0-5 degrees	moderate	long	bedrock/boulders/cobble
Stornetta	North Central	Sea Lion Cove SMCA	bedrock	0-5 degrees	moderate	long	bedrock/sand
Moat Creek	North Central	Reference	bedrock/boulders	0-5 degrees	moderate	long	bedrock/boulders/cobble
Saunders Reef	North Central	Saunders Reef SMCA	bedrock/boulders	0-5 degrees	moderate	long	bedrock/boulders/sand

Table 2. Sites of biodiversity, focal species, tide pool fish, and 3-D topographic surveys.

Study Sites	Protected Area	Biodiversity (invertebrate & algae)	High-res 3-D Topography	Focal Species (invertebrate & algae)	Fish Diversity
Pyramid Point	SMCA	X	X	X	
Point Saint George		X	X	X	X
Endert's Beach		X		X*	
Damnation Creek		X		X*	
False Klamath Cove		X	X	X*	X
Palmer's Point (Patrick's Point SP)		X	X	X	X
Launcher Beach (Trinidad)		X			
Old Home Beach (Trinidad)		X			
Cape Mendocino (Petrolia)		X		X*	
Shelter Cove		X	X	X*	
Mal Coombs		X			
Kibesillah Hill		X	X	X*	
Abalobadiah Creek (Ten Mile)	SMR	X	X	X	X
MacKerricher	SMCA	X	X	X	X
Fort Bragg		X	X	X	X
Belinda Point				X	X

* Sampled by PISCO/MARINe (Raimondi) at lower frequency (once/year)

Physical Site Attributes

The physical characteristics of the rocky intertidal habitat in the NCSR are highly variable, from the dominant geology type to the slope and rugosity of the coastline. The physical attributes of each of our intertidal sites are summarized in Table 1 (see also Appendix B). The associated metadata descriptions for these attributes are below:

1. **Primary Bench Type:** describes the dominant geology of the site
    a. **bedrock:** the primary bench type is consolidated bedrock at this site
    b. **bedrock/boulders:** the primary bench type is a mixture of consolidated bedrock and boulder fields at this site
    c. **bedrock/boulders/cobble:** the primary bench type is a mixture of consolidated bedrock, boulder fields, and cobble beach at this site
    d. **bedrock/boulders/sand:** the primary bench type is a mixture of consolidated bedrock, boulder fields, and sandy beach at this site
    e. **bedrock/sand:** the primary bench type is a mixture of consolidated bedrock and sandy beach at this site
    f. **boulders:** the primary bench type is boulder fields at this site
2. **Slope:** describes the slope of the coastline at the site
    a. **gentle:** the slope of this site is between 0-5 degrees
    b. **moderate:** the slope of this site is between 5-15 degrees
3. **Relief:** describes the rugosity of the site
    a. **high:** the relief of the site consists of extremely uneven terrain, containing many deep cracks and folds, such as in some mixed consolidated bedrock and boulder fields
    b. **moderate:** the relief of the site consists of moderately uneven terrain, containing few cracks and folds, such as in boulder or cobble fields and some consolidated

bedrock
   c. **low:** the relief of the site consists of flat terrain, such as a sandy beach
4. **Extent:** describe the cross shore width of the rocky bench in qualitative terms
5. **Surrounding Coast:** describes the geology of the area surrounding the site
   a. **bedrock:** the surrounding coast is consolidated bedrock at this site
   b. **bedrock/boulders/cobble:** the surrounding coast is a mixture of consolidated bedrock, boulder fields, and cobble beach at this site
   c. **bedrock/boulders/cobble/sand:** the surrounding coast is a mixture of consolidated bedrock, boulder fields, and cobble and sandy beach at this site
   d. **bedrock/boulders/sand:** the surrounding coast is a mixture of consolidated bedrock, boulder fields, and sandy beach at this site
   e. **bedrock/sand:** the surrounding coast is a mixture of consolidated bedrock and sandy beach at this site
   f. **boulders/sand:** the surrounding coast is a mixture of boulder fields and sandy beach at this site
   g. **sand:** the surrounding coast is sandy beach at this site

Invertebrate & Algal Diversity Surveys

Our methods to characterize the biodiversity of intertidal invertebrate and algal species are identical to the approach and protocols of the Coastal Biodiversity Surveys (http://www.eeb.ucsc.edu/pacificrockyintertidal/index.html), which were used in all other MPA regions. This protocol was done at 15 sites listed in Table 1 (above). Below we briefly describe this sampling approach.

Once an appropriate area of rocky shoreline was selected, the grid of the sampling area was defined by 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 shoreline) were first established. The upper baseline was placed in the high zone above the upper limit of marine biota, such as barnacles, while the lower baseline was established farther down the shore within the low zone of biota at that site. The ends of these lines were permanently marked with either hex or carriage bolts. Once these two baselines were established, parallel transect lines were run perpendicular to the shoreline at 3-meter intervals crossing both the upper and lower baselines. In general these transect lines followed the contours of the site topography. When necessary, rocks were placed along the lines to prevent them from being shifted by heavy winds, and a note was made of where each transect crosses the lower baseline.

Intertidal Biodiversity Monitoring: Point-Contact Surveys

Each vertical transect was sampled using the point intercept method. Ideally 100 points were sampled at uniform intervals on each transect line. For each point two types of data were collected: data that were used to determine relative abundance (% cover), and data that were used to describe spatial distributions. The relative abundance data were collected by identifying all taxa that fall directly under each point, including rock, sand, and tar. If there was layering, the taxa occupying these different layers were identified and assigned a letter defining their vertical position within the canopy. Also recorded was whether the species under the point were found in pools, on cobble, or on boulders. A total of up to three taxa were identified under each point. If fewer than three taxa were recorded under a point, then data were collected on the identity of the next one or two species closest to that point. These data were used to describe the spatial distribution of species, and were not used when calculating relative abundances. The '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. When a species could not be identified in the field, it was assigned an unknown number and a sample of it was collected.

Biodiversity Monitoring: Mobile Invertebrate Surveys, Sea Star and Abalone Swaths

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 was first divided into three zones; the low zone is the area below the mussels, the mid-zone included the mussels and the rock weeds (e.g. Silvetia, Pelvetiopsis), and the high zone was the area dominated by barnacles and littorine snails. Within each zone a quadrat was randomly placed on the transect, and all mobile species found within the quadrat were identified and counted. Sub-sampling was used when there were more than one hundred individuals of a given species in a quadrat. If a quadrat landed in a deep pool or in an area dominated by sand, a new location was selected. The only mobile species not counted were worms, mites (*Neomolgus littoralis*), and amphipods. Sea stars and abalone play an important role in the intertidal community, but often they are also not spatially common. As such, their abundances were measured along a two-meter swath centered over each vertical transect. Within this swath, the abundance and location along the transect (to the nearest 0.5m) of the following seastars and abalone were recorded: *Haliotis rufescens*, *Asterina miniata, Dermasterius imbricata, Pisaster ochraceus, Pisaster giganteus,* and *Pycnopodia helianthoides*.

Focal Species Surveys

To address issues of changes in community structure over time, we set up permanent monitoring plots at 16 sites (all 15 sites in Table 1 above, plus Belinda Point) using MARINe protocols. As noted above our past studies and review led to the unified MARINe protocols. We (HSU) monitored existing and new plots associated with target species at a total of 16 rocky intertidal sites along the coast of Northern California. Target species included all species indicated to be important to the MPA process, which were consistent with MARINe species guidelines. These target species included: mussels (*Mytilus californianus*), algal species including surfgrass (*Phyllospadix scouleri & torreyi*), and sea palms (*Postelsia palmaeformis*), abalone (*Haliotis rufescens*) and sea stars (*Pisaster ochraceus*, *Henricia spp., Leptasterias spp*., *Dermasterias imbricata*, and *Asterina miniata*). Analysis following the "Torch spill", an OCS pipeline spill from Platform Irene in Santa Barbara County (CA), showed that it was possible to detect change in percent cover as small as 8-15% using this fixed plot sampling protocol. Importantly, it was also possible to differentiate between natural changes, such as El Niño storms, and the effects of the oil spill (Raimondi et. al, 1999). It is vital that this monitoring protocol is sufficient in detail to address low-level changes that may accompany MPA protection.

Mussels and associated algae and inverts (on the mussel bed surface) were photographed in fixed 0.5 x 0.75 m rectangular plots and scored in the field by recording species under 100 points projected onto each plot. Five replicate plots per assemblage were photographed at each site. The dominant motile invertebrates within these permanent plots (*Nucella canaliculata*, *Nucella ostrina*, *Tegula funebralis*, and limpets and littorines) were counted and the first 10 *Nucella* and *Tegula* encountered were measured to obtain their total length. Within the mussel bed, data on mussel sizes (10 per plot) and mussel bed depth (5 per plot) were recorded.

Surfgrass cover was estimated using a point contact method along 10 m transects. Surfgrass mat thickness was also measured by using calipers to measure the width of all surfgrass leaves at the center of the transect. *Postelsia palmaeformis* were counted within 2 x 5 m belt transects.

Additional abalone surveys were completed with 2 x 10 m band transects at the Fort Bragg site after we discovered an unexpected number of these animals in the intertidal zone at this “reference” site. This site is located behind a series of fences with stationed guards at the old wood mill, and hence is essentially a “de-facto” marine reserve. Hence the site is clearly not a good “reference” site, but served to show what the rocky intertidal community looks like if protected over a long period of time.

Sea stars were counted, measured and classed by their disease state (see PISCO website for 4 categories) in either 2 meter wide, 10 m long band transects or within irregular plots, depending on the habitat, at each of the 16 sites (see MARINe protocols).

Monitoring of these species occurred in long-term, permanent plots twice each year in Winter and Spring of 2014-15 and 2015-16. There can be considerable seasonal changes in the rocky intertidal community, especially after stormy winters or sunny summers. Two samples per year should adequately track these communities (Raimondi et al. 1999). May or June was usually the first period in summer with negative low tides during the daytime when (which greatly improved efficiency and safety of sampling) when sampling was done, and this was appropriate for determining the spring community. December to February was the “best” time to determine the winter community, and while there were once again low tides (although most were not during the daytime, necessitating headlamps) the weather was often rough. These protocols used to collect the data were standardized, coordinated with other members of MARINe, and not altered without prior approval of all parties.

Tide Pool Fish diversity & Rockfish Settlement Surveys

Tide Pool Fish Diversity Monitoring

Baseline monitoring of intertidal fishes was conducted at 7 rocky intertidal field sites twice per year in two different seasons (Summer = April through August, and Winter = November through February) during 2014-2015 and 2015-2016. A bi-annual monitoring program for fish biodiversity inventory was selected because rocky intertidal fish assemblages tend to be stable on an inter-annual basis. However, it should be noted that species that recruit into the rocky intertidal may be overlooked using this approach (Almada and Faria 2004; but see rockfish settlement surveys described below). Fish sampling was led by graduate student trainee Kevin Hinterman at HSU (in collaboration with other trainees). Travel costs associated with these efforts were already accounted for in the budget for studies of invertebrate and algal focal species (the HSU fish diversity & focal species teams traveled together).

At each of 7 field sites with appropriate tide pools, a total of three tide pools distributed across the site, one each at the (1) high, (2) mid and (3) low intertidal zones [see methods below], were selected, geo-referenced for archiving purposes, and permanently marked using bolts for identification to facilitate returning to the same tide pool through time. Field sites were divided into two categories based on separation by the Cape Mendocino and the Lost Coast region: the (1) Point St. George, (2) False Klamath, and (3) Palmers Point sites were called “north” sites, while the remaining four sites [(1) Abalobadiah Creek, (2) Mackerricher, (3) Fort Bragg, and (4) Belinda Point] were called “south” sites. Cape Mendocino, which lies roughly between Ferndale and Rockport, may provide a biogeographical break between these regions that exceeds the typical larval drift distance of less than 120 km for many intertidal fishes (Miller and Shanks 2004). This region is also the site of convergent shelf flow that results in either cyclonic coastal eddies or strong offshore transport that forms a barrier for larval transport between these two geographic regions (Hayward and Mantyla 1990, Magnell et al. 1990).

Intertidal zones can be categorized based on the measured height of a tide pool relative to mean lower low water (MLLW). This can be determined using measuring devices and comparing to the shoreline (Yoshiyama 1981), or it can be estimated based on when the pool becomes fully isolated as the tide recedes, which was sufficient for this study. Pools that are isolated one and a half hours or more before the lowest point of the summer and winter spring tide series were considered “high intertidal” pools, those that became isolated between half an hour and 1.5 hours before the low were considered “mid intertidal” pools, and those that were only isolated in the last half hour before the low were considered “low intertidal” pools.

Three different rocky intertidal habitat types were sampled: (1) boulder fields, (2) benches, and (3) sites with a combination of boulders and bench. Boulder fields typically cover a large region and consist of many boulders emerging from a sandy shoreline. Pools form in the divots between the boulders and are protected during low tide by emerging rocks along the edges of the zone, which typically lie near a sandy beach. Benches are large pieces of bedrock that drop off sharply into the ocean. At high tide the bench is completely covered in water, but as the tide goes out it becomes exposed. Pools are formed in the cracks and crevices of the rocky bench.

Sites that are a combination usually have a sharp drop off into the subtidal, similar to a bench, but contain many boulders and divots that form pools more similar to those among boulder fields.

In contrast to traditional destructive sampling approaches that kill all fish in pools (using ichthyocides), we followed the recommendations of Almada and Faria (2004) and employed non-destructive sampling methods. Tidepools were only sampled on extreme low spring tides when the predicted low tide level was -0.5 feet below MLLW or lower to allow low intertidal pools to become fully isolated. These very low tide cycles occur in the early morning during the summer (typically 0300 to 0900) and at night during the winter (1600-1900). Consequently, much of the sampling occurred in the dark.

All fish within each tidepool were captured using dipnets, identified to species, and returned. This process was expedited by draining and subsequently refilling tidepools with a portable, gas-powered pump (Honda WX-15 with 240L/min capacity). Tidepools were refilled using the pump immediately after sampling to minimize environmental disturbance. Captured fish were temporarily kept in holding tanks (plastic totes) before being identified, measured, and returned to their refilled tide pool. Small, portable, viewing aquaria aided in examination and photography of individual fish when necessary for identification. Headlamps and dive lights were used to search crevices when it was dark. Rockfish were searched for by walking around the mid and low intertidal zone at extreme low tide and searching for rockfish in larger, isolated pools. Since juvenile black rockfish are mostly pelagic, they are easily spotted without having to move boulders or drain pools. If a rockfish was spotted, it was captured with handheld dip-nets. Rockfish found in large channels that remained connected to the ocean were not captured as they were considered subtidal recruits. Pool volume was measured by counting the number of 5 gallon buckets filled with water as the pool was being drained. The remaining amount of water left was estimated to the nearest gallon (typically less than 2 gallons) and added to the total. A small fin clip was taken from the second dorsal fin of all rockfish and preserved in 95% ethanol (non-denatured; Dauble et al. 2012). This served two purposes: it marked all individuals so that total seasonal settlement can be accurately determined, and made it possible for genetic work including species identifications and phylogenetic analysis (Not part of this project-but See thesis of kevin Hinterman, HSU library, for more information and confirmation of all species identities).

Because the distribution and abundance of tide pool fishes may be correlated with various biotic and abiotic factors (Nakamura 1976, Davis 2000), several basic tide pool characteristics were also measured. At each tide pool during every sampling period we measured: (1) tide pool water temperature, (2) ocean temperature, (3) air temperature, (4) lowest tide height time, (5) pool dimensions and (6) pool volume.

Rockfish Settlement Surveys

Settlement of juvenile black rockfish and their use of intertidal habitats was examined at two sites monthly from May-August in the summer of 2015: (1) Palmer's Point and (2) False

Klamath Cove. Palmer's Point was sampled three times that summer, and False Klamath was sampled twice in an effort to locate juvenile rockfish recruits.

High Resolution Topographic Surveys

In past characterizations, we sampled topography using standard surveying equipment (a rotating laser leveler mounted on a tripod and a stadia rod). For the NCSR, PI Aiello (MLML) used state of the art laser scanning technology to produce high-resolution digital elevation models (DEMs) and maps of nine of our biodiversity sites (listed from North to South): (1) Pyramid Point, (2) Point St. George, (3) False Klamath Cove, (4) Palmer's Point, (5) Shelter Cove, (6) Kibesillah Hill, (7) Abalobadiah Creek, (8) MacKerricher, and (9) Fort Bragg (see Appendix B for site descriptions) . The goal of this work is to assess the relationship between geology of the rocky substratum and distribution and abundance of intertidal species. The primary product of the work will be layered GIS based 3-dimensional map of species and habitat for each of these sampled sites. The ability to use direct laser-based mapping rather than laser-based elevation assessment will make a profound difference in both the resolution in the maps and the ease in producing them. Such linked geospatial/biodiversity maps and datasets will allow broader understanding of the ecology of different species, and serve as a basis for assessment of change resulting from (as examples) sea level rise, temperature variation and change in wave climate (due to climate change or the potential installment of wave energy arrays), and MPA designation. The approach was to use Terrestrial Laser Scanning (TLS), a new mapping technology that allows multi-scale geospatial surveys over spatial scales ranging between centimeters to hundreds of meters. Because of its high resolution (0.01 m) and accuracy (<0.005m), along with repeated survey feasibility, we were able to collect thousands of high-resolution topographic data points. Each point consisted of X,Y and Z (height) coordinates and will be explicitly linked to data collected during the simultaneous assessment of biodiversity (as described above). High-resolution laser-based maps were created for 9 sites in total. Specifically, the proposed work for each survey site included:

1) Use of Global Navigation Satellite System (GNSS) receivers to establish project controls relative to the existing National Geodetic Survey (NGS) monuments and Continuously Operating Reference Stations (CORS). We used static differential GPS (DGPS) technology which yielded horizontal and vertical accuracies of about 1". Vertical controls were based upon the North American Vertical Datum of 1988 and for the elevations we used the Geoid 12A model. Permanent benchmarks were established for each project control.
2) Assessment of the lithologies exposed at the site and characterization of the main sedimentary (e.g. bedding) and tectonic (e.g. faults, joints) structures driving the geomorphology.
3) Field surveys were carried out with a Trimble VX, a state-of-the-art Spatial Station equipped with Infrared (IR) Direct Reflex (DR) technology. Surveys were done at ~5cm resolution and from at least two separate fore-sights for a total of ~400,000 points per site (roughly 12 hours of point collection) using direct reflex.
4) Survey data post-processing was done using Trimble's Realworks Advanced 6.5

software. Post-processing operations included point cloud “cleaning” and survey registrations (for surveys collected from multiple fore-sights).

An example of the imagery produced by this technology is shown below in Figure 5 (note the image is backed by spatially explicit digital datasets). An example of the overlay between geomorphology and biodiversity is shown on the next page, in Figure 6.

Using this laser scanning technology we will be able to assess the relationship between community structure and substrate rugosity, slope and surface roughness. With additional data we may be able to examine the relationship between community structure and water temperature and/or wave splash. We have done this type of analysis in other MLPA regions and the results have shown the importance of physical factors (such as wave splash) in structuring biological communities (see Figure 7).

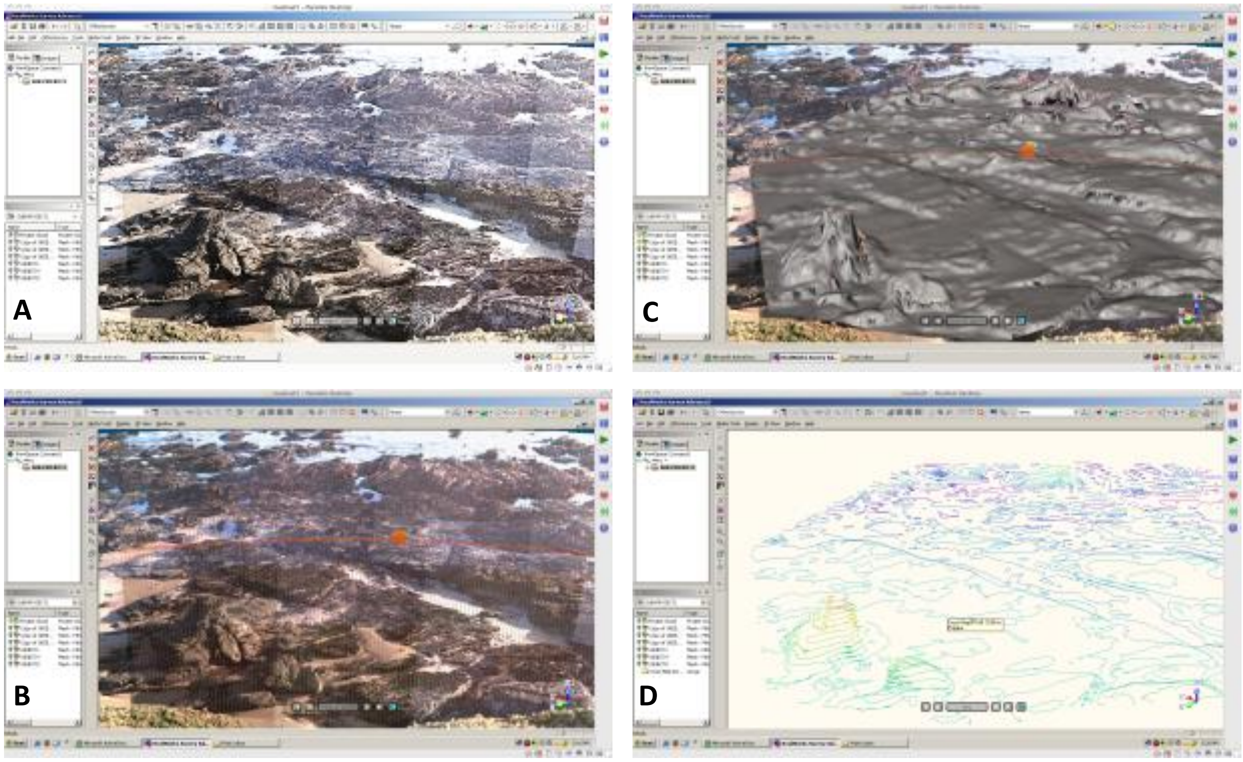


Figure 5. Digital series of production of geospatial maps. (A) raw photo. (B) grid of points sampled using the laser. (C) Smoothed surface resulting from sampling. (D) High resolution contour map of site.

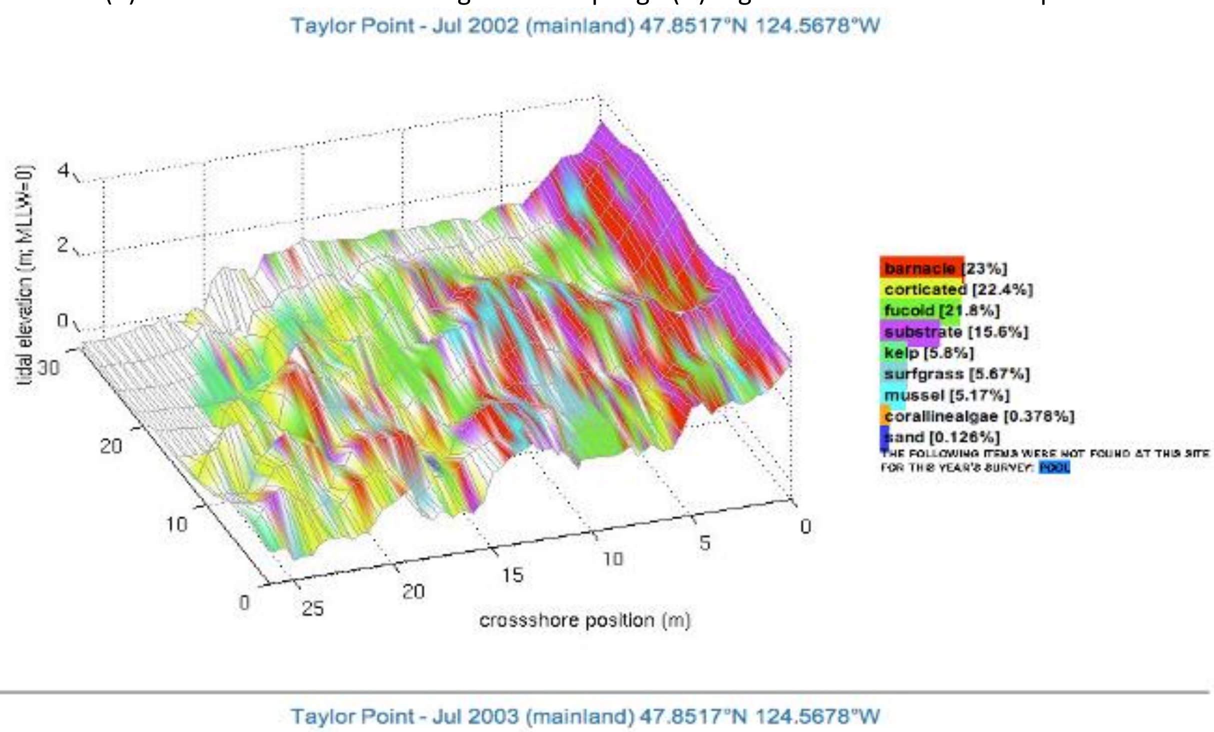


Figure 6. Overlay of biodiversity and geomorphology for Taylor Point, Washington. Note that the geomorphological data was attained using traditional approaches, which are much cruder than those proposed for this project. Map was created using our interactive mapping application.

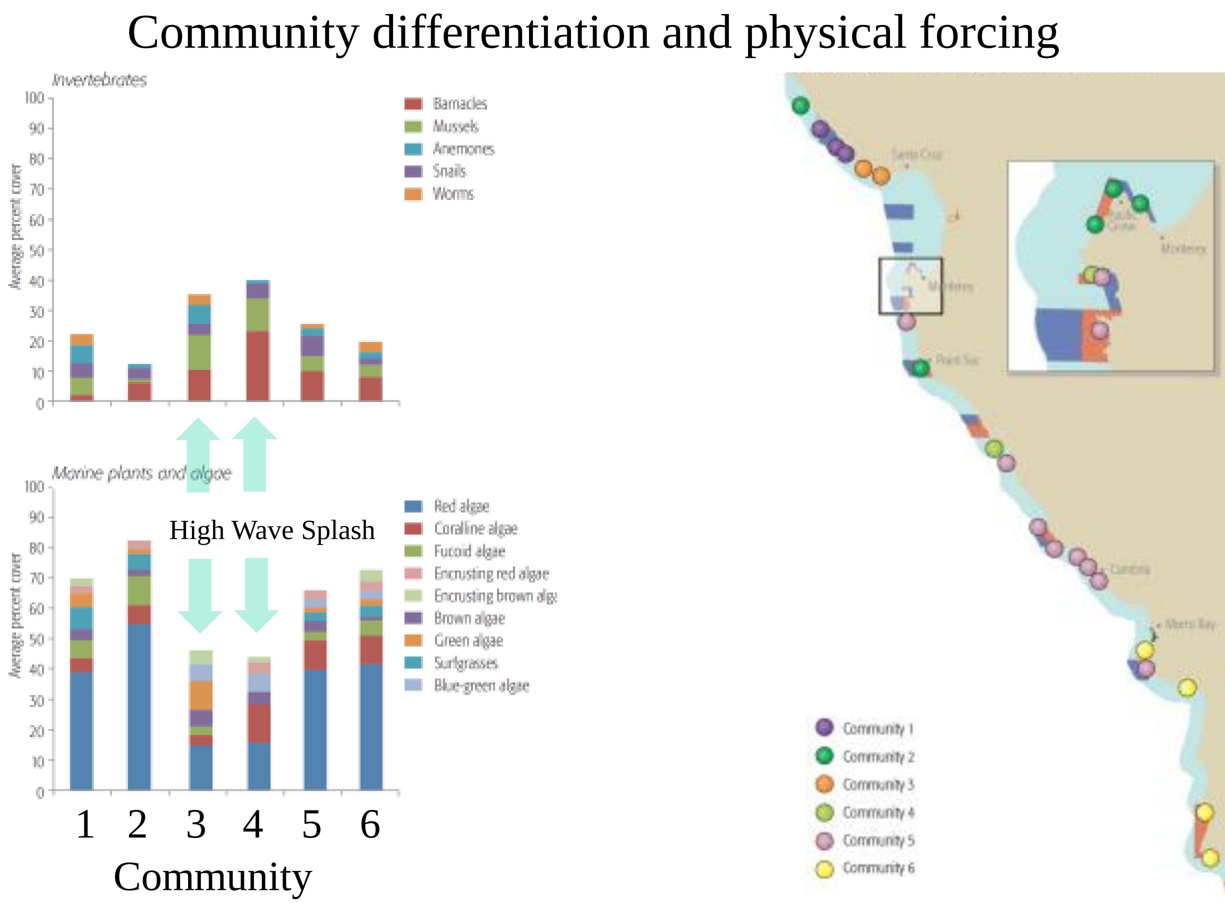


Figure 7. Results from the Central Coast MPA rocky intertidal baseline characterization. Shown are the geographic patterns of communities, the species that characterize each community, and where wave splash has the greatest impact on these biological communities.

Results & Discussion

Description of the North Coast Rocky Intertidal Community

Pattern of biogeography

As noted above, one key benefit of the Biodiversity Surveys is that the results can be integrated into the West-Coast Biodiversity database and results can be given spatial context. Figure 8 (below) shows the modeled biogeography for the temperate West Coast based on K-Means clustering with Bray-Curtis similarity using a latitudinal smoother. The smoother is essentially a prior probability that leads to more discrete clusters. Shown is a k=10 cluster solution for the West Coast. The general patterns are very similar to what we have previously published (earlier studies had fewer sites). There are clear and predicted boundaries north of Vancouver Island, at the southern edge of the Olympic peninsula, near Cape Arago, near Cape Mendocino, at San Francisco Bay, near Pt. Conception, separating mainland southern California (two clusters) from northern and southern Channel Islands (which are separated), and Baja California. In the NCSR there are two regions, which essentially break north and south of Cape Mendocino (actually at the southern boundary of the Lost Coast).

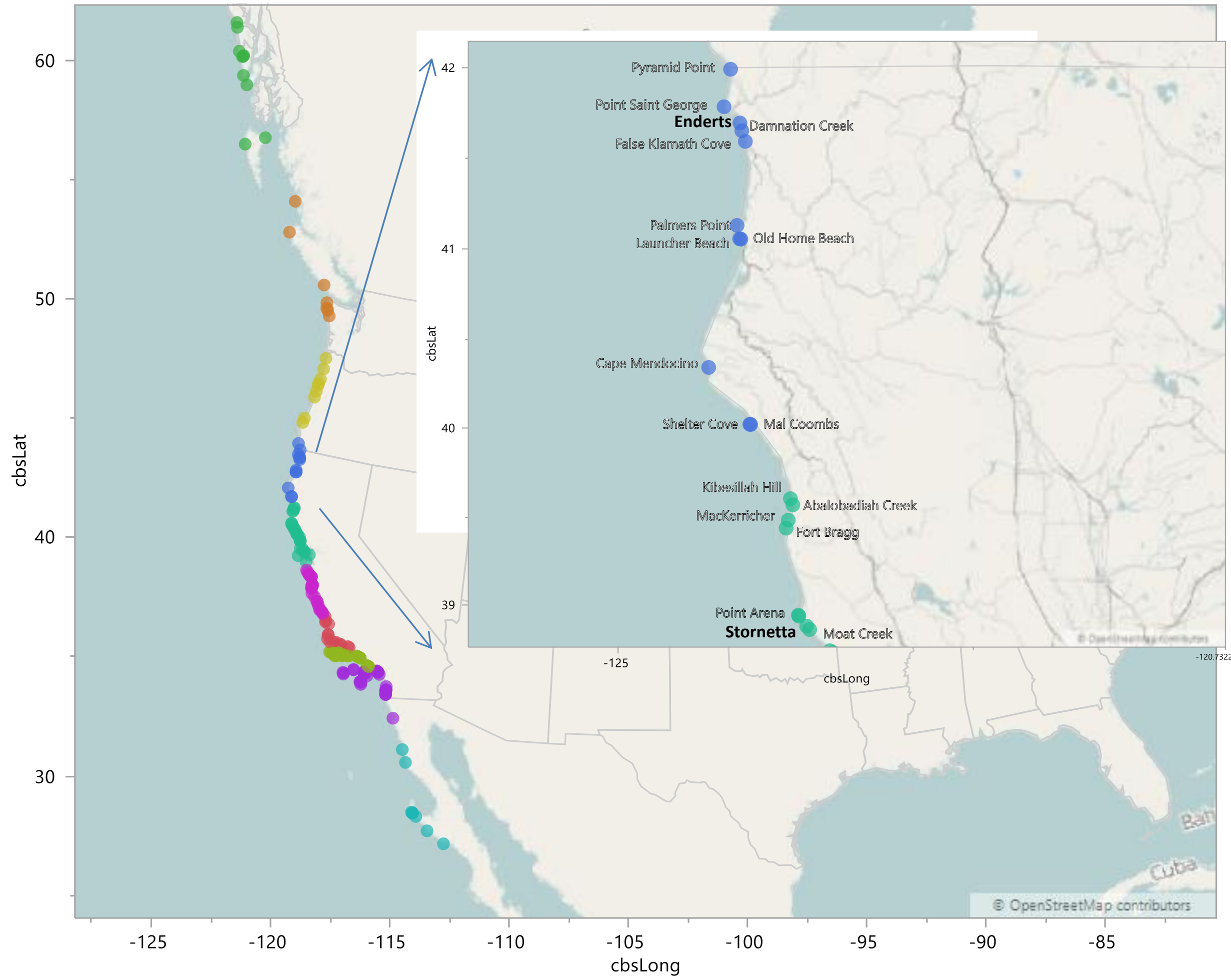


Figure 8. Biogeography of the rocky intertidal community based on K-Mean clustering here with k=10. Shown in inset is the NCSR study region.

General patterns of species richness and diversity inside and outside of MPAs

Across our NCSR monitoring program, we sampled 241 species (153 sessile species and 88 mobile species). Using the data collected, we compared species richness and diversity (Shannon Wiener index, base e) for both sessile (Figure 9) and mobile species (Figure 11) between sites inside and outside MPAs. The overall patterns were similar for both types of species. Species richness was generally lower (P<010) in sites in MPAs than in sites outside them. However, there was little evidence that diversity differed inside vs outside of MPAs. Also shown is the cover or density of the 25 most common sessile (Figure 10) and mobile (Figure 12) species based on whether sites were inside or outside of MPAs.

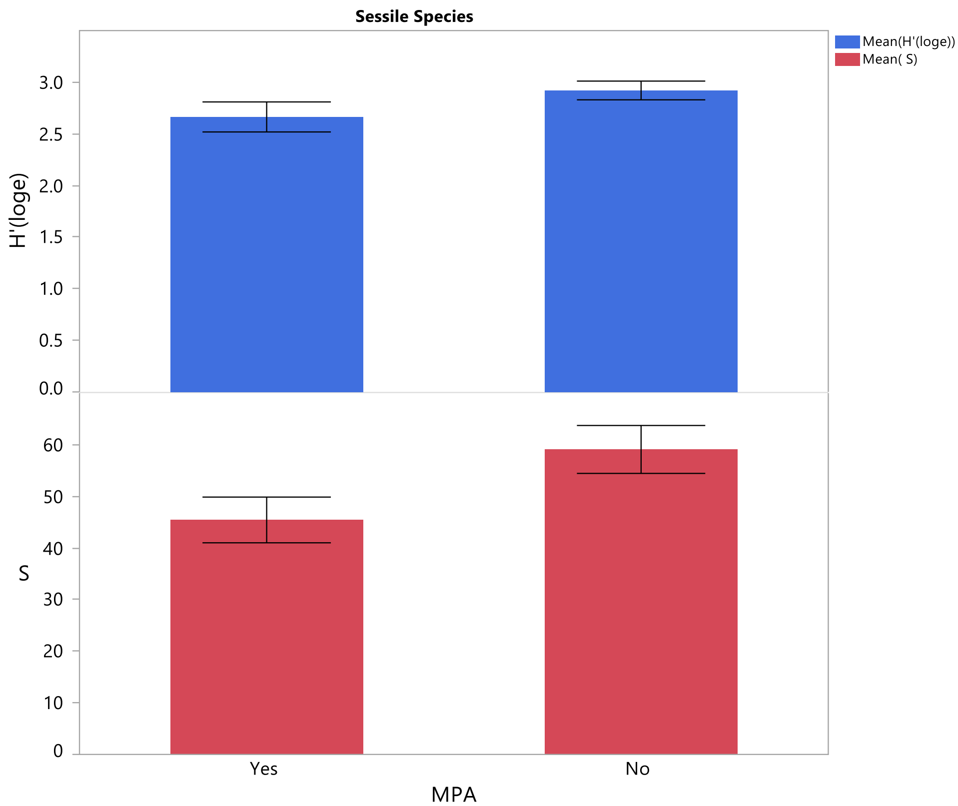


Figure 9. Sessile Species Richness (S) and Diversity (H') for sites inside and outside MPAs. P=0.067, F = 3.82, df=1,17 and P=0.13, F = 2.50, df=1,17, respectively.

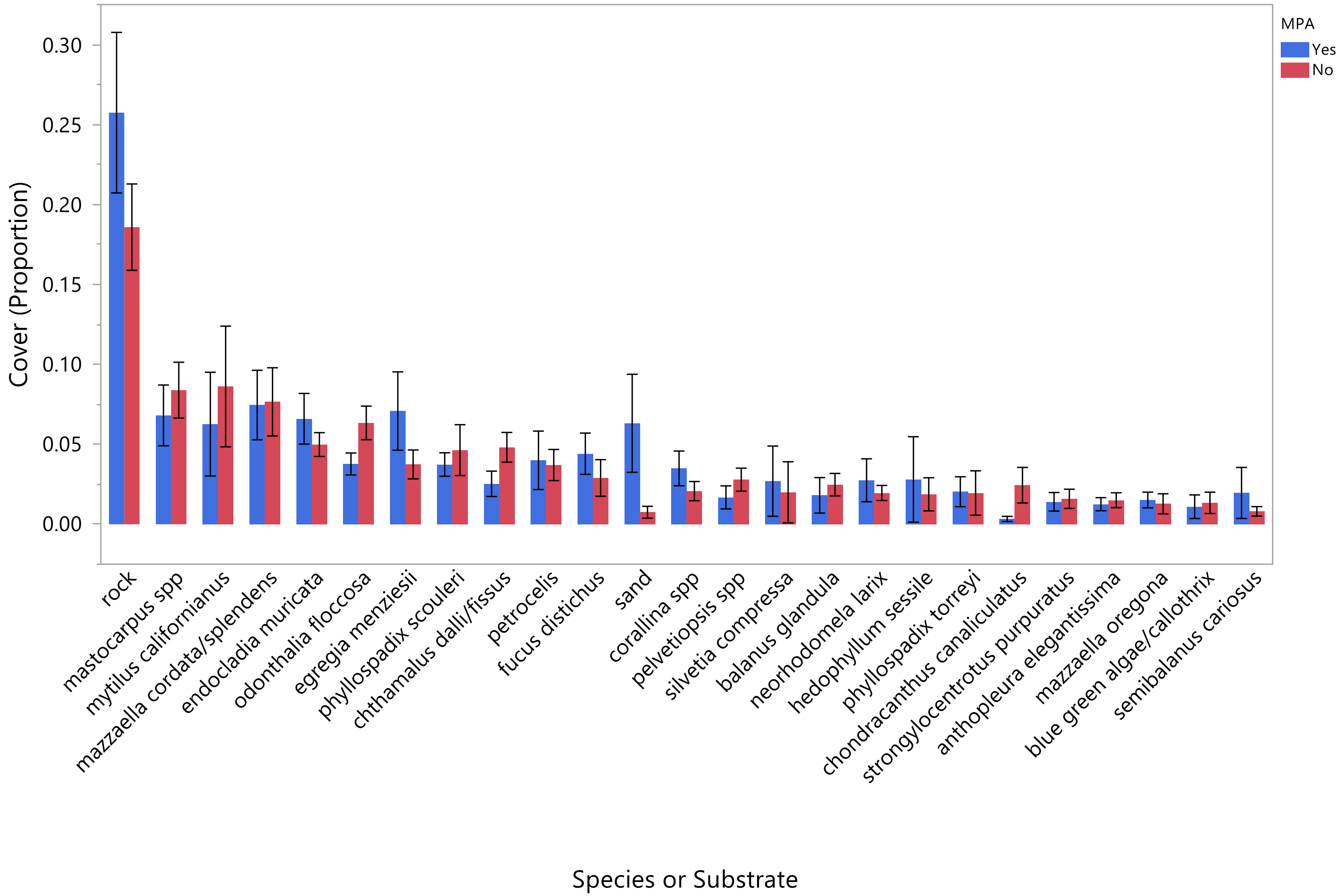


Figure 10. Proportion Cover for the 25 most common species and substrate types sampled in the sessile community, inside and outside of MPAs.

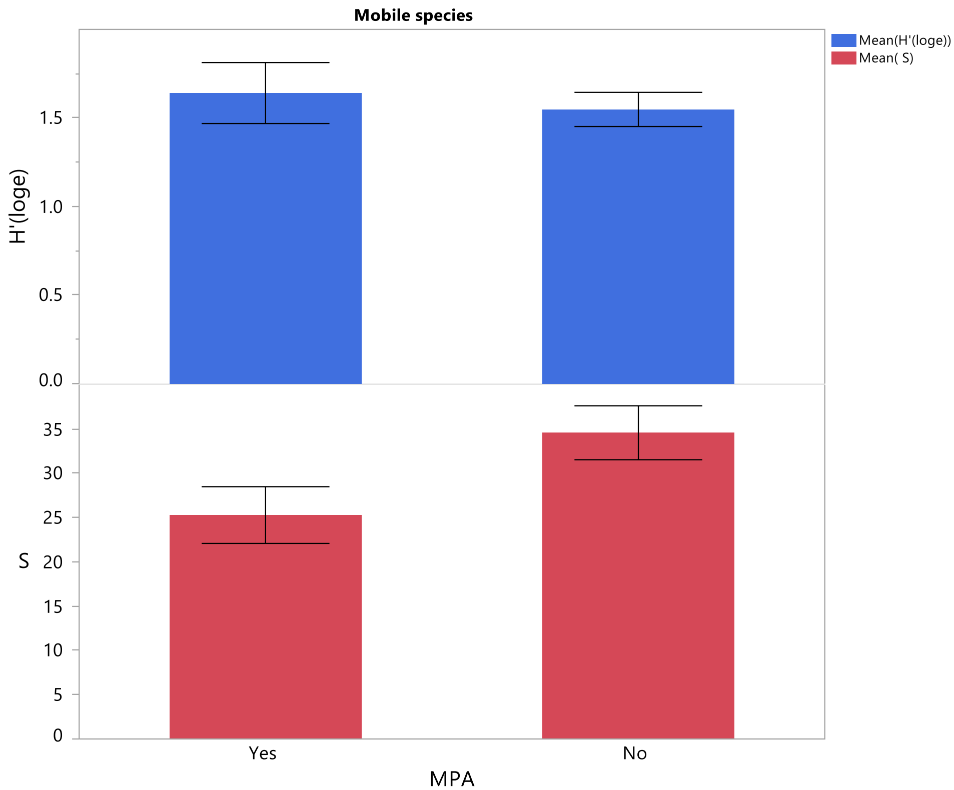


Figure 11. Mobile Species Richness (S) and Diversity (H') for sites inside and outside MPAs. P=0.064, F = 3.92, df=1,17 and P=0.62, F = 0.26, df=1,17, respectively.

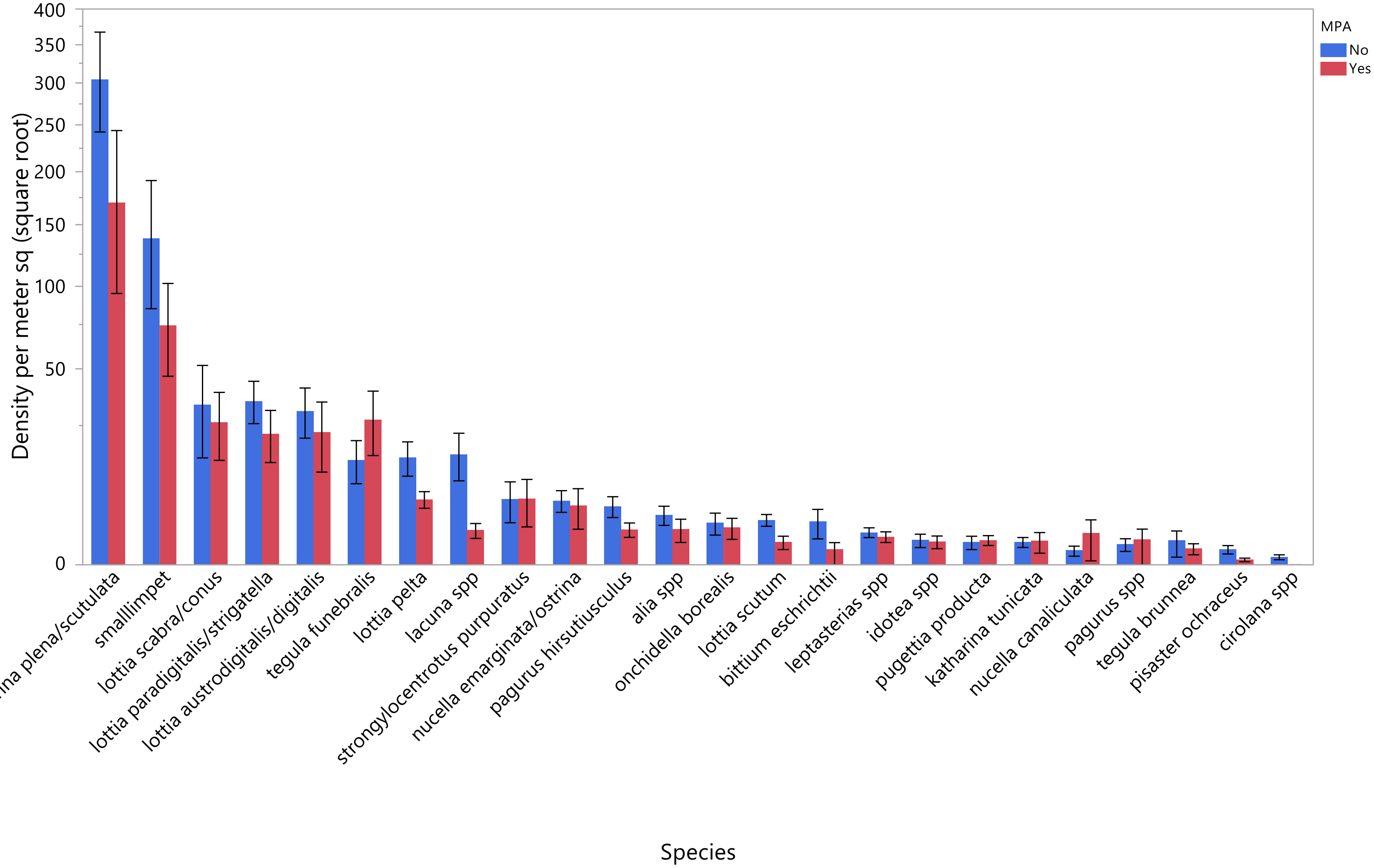
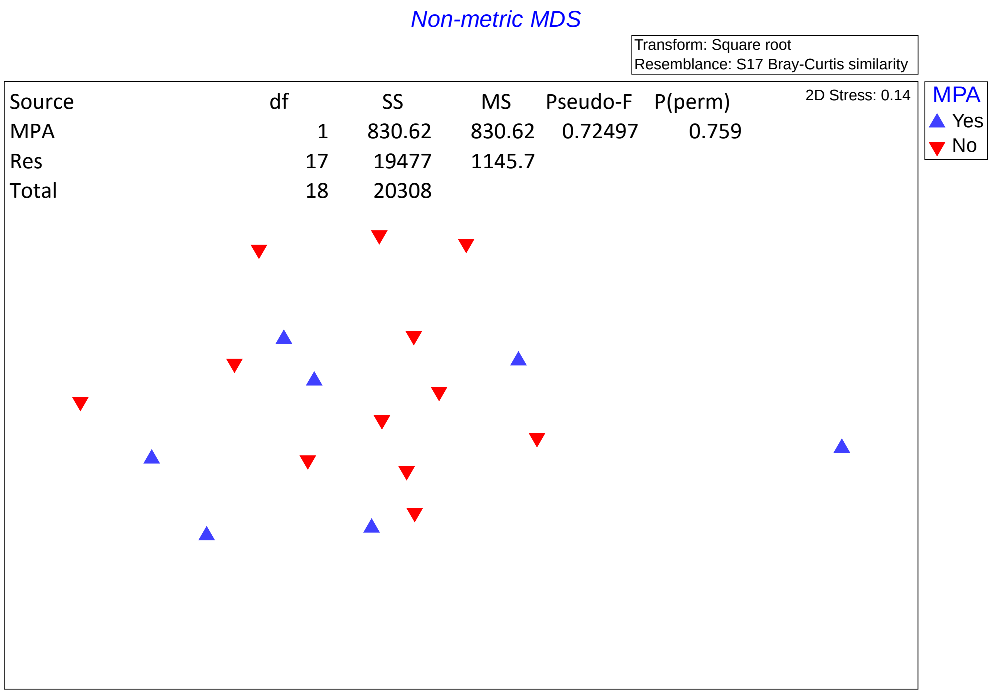


Figure 12. Density of the 25 most common species in the mobile community inside and outside MPAs.**General patterns of community composition for the sessile and mobile communities as a function of MPA status and habitat attributes (bench type, slope, relief and extent)**

We were also interested in exploring the relationships between community composition, where the cover or abundance of species along with their identity is important, relative to their MPA status as well as a set of habitat attributes. These were the attributes we used to describe each sample site (see above under "Physical Site Attributes"). For some attributes (bench type and slope) we simplified the levels to make statistical comparisons possible. The basic approach was to construct similarity matrices for sessile and mobile species using the Bray-Curtis similarity function (sites = samples and species = variable) then partition the variance of the matrices using a PERMANOVA model to assess the contribution of potential predictors of composition. Those predictors are the MPA status and habitat attributes. Below are the results for sessile and mobile community composition presented in a MDS graphical element along with PERMANOVA results (Figures 13-17).



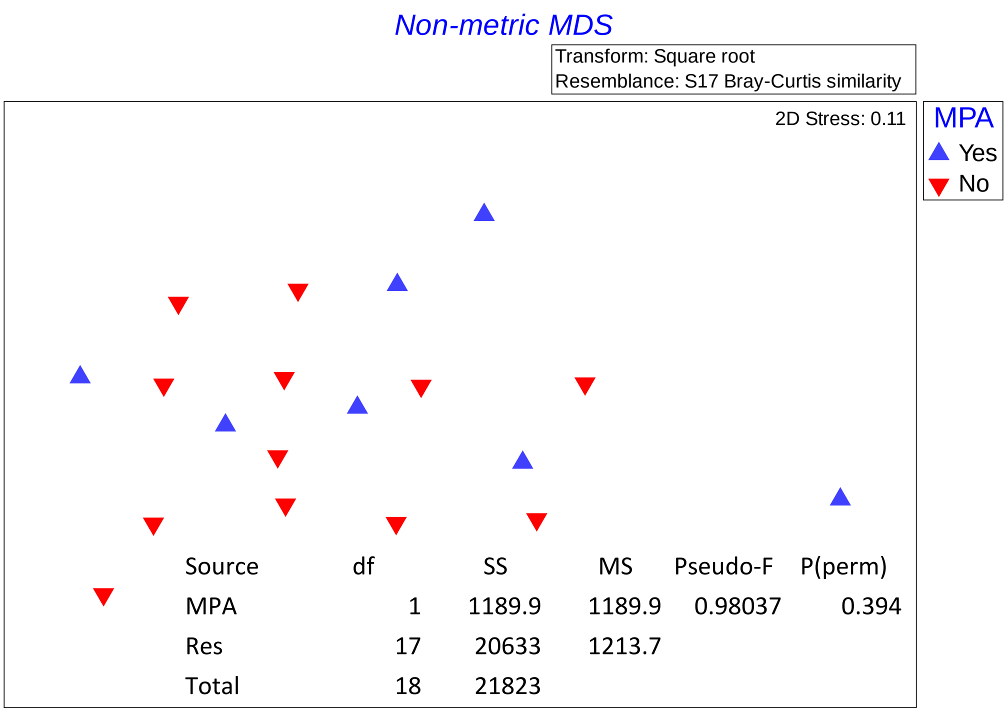
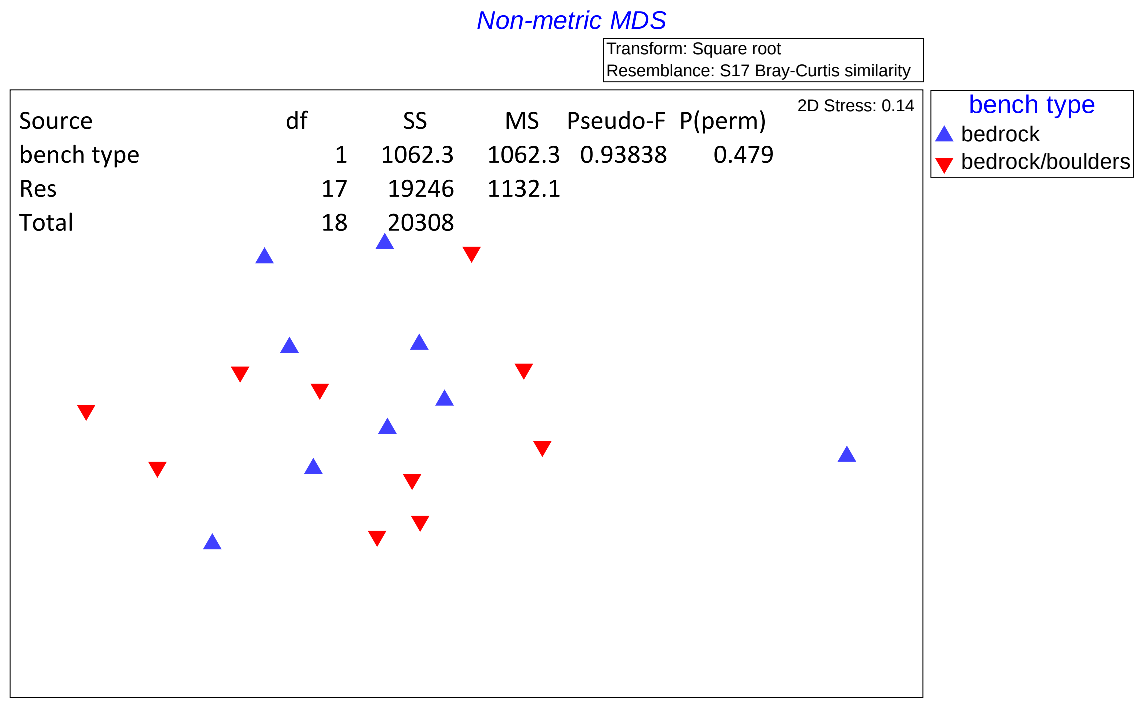


Figure 13. MDS plots and PERMANOVA of community composition for sites inside versus outside of MPAs. Top: sessile community; bottom: mobile community.



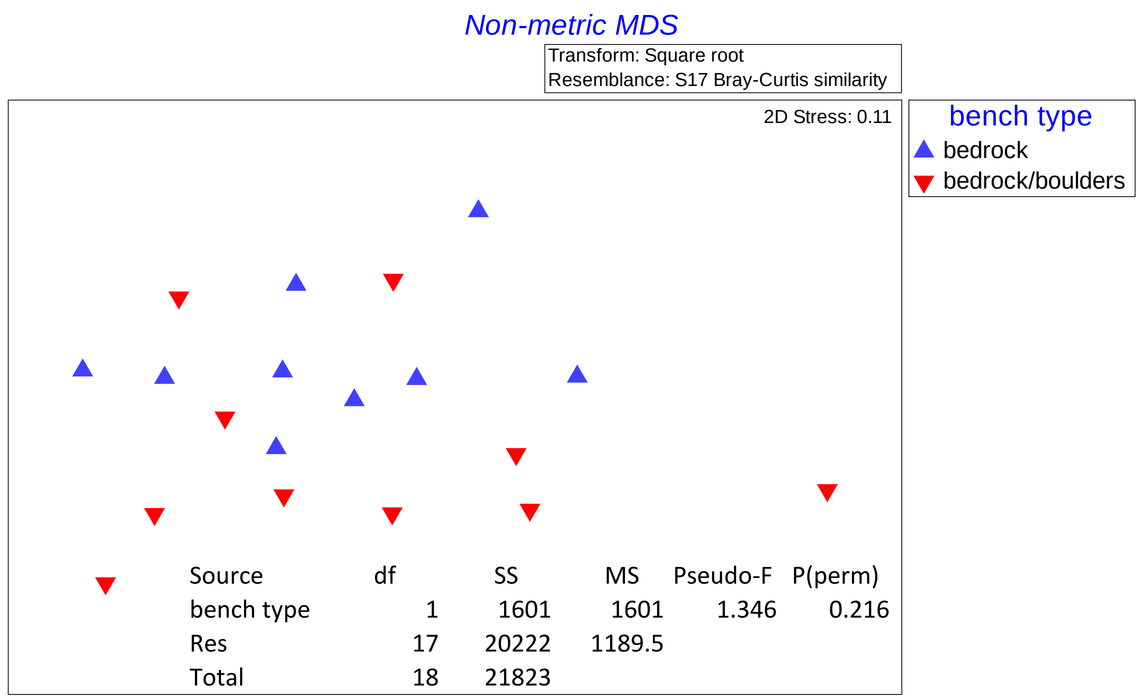
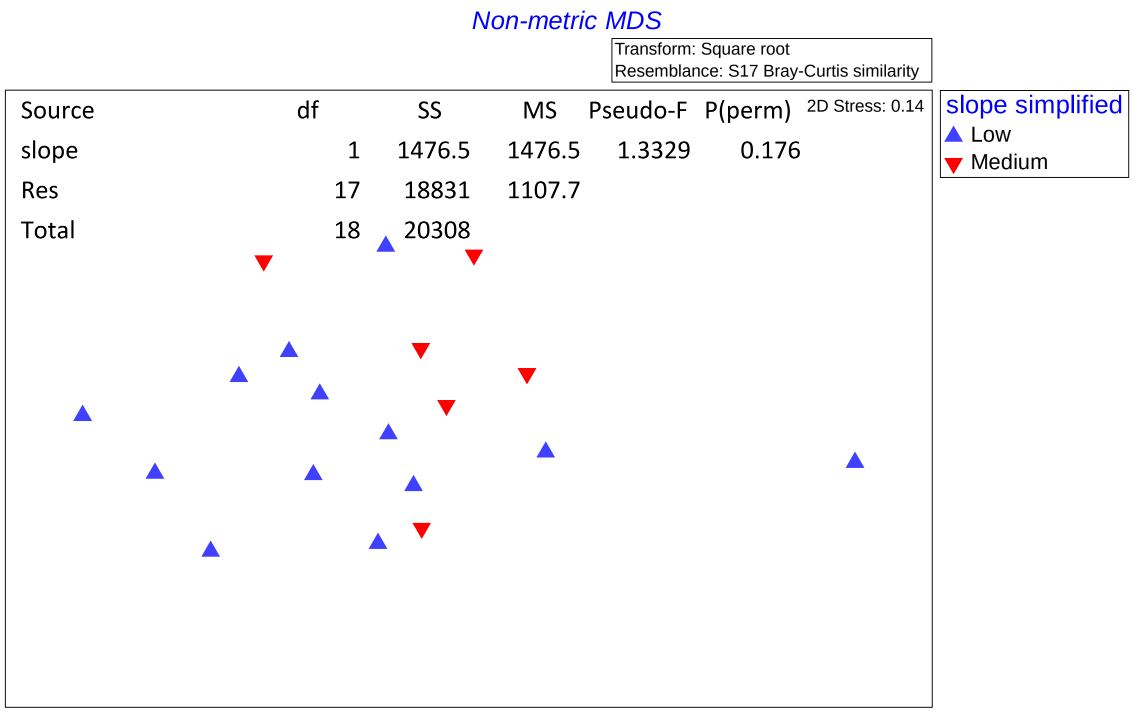


Figure 14. MDS plots and PERMANOVA of community composition based on bench type at each site. Top: sessile community; bottom: mobile community.



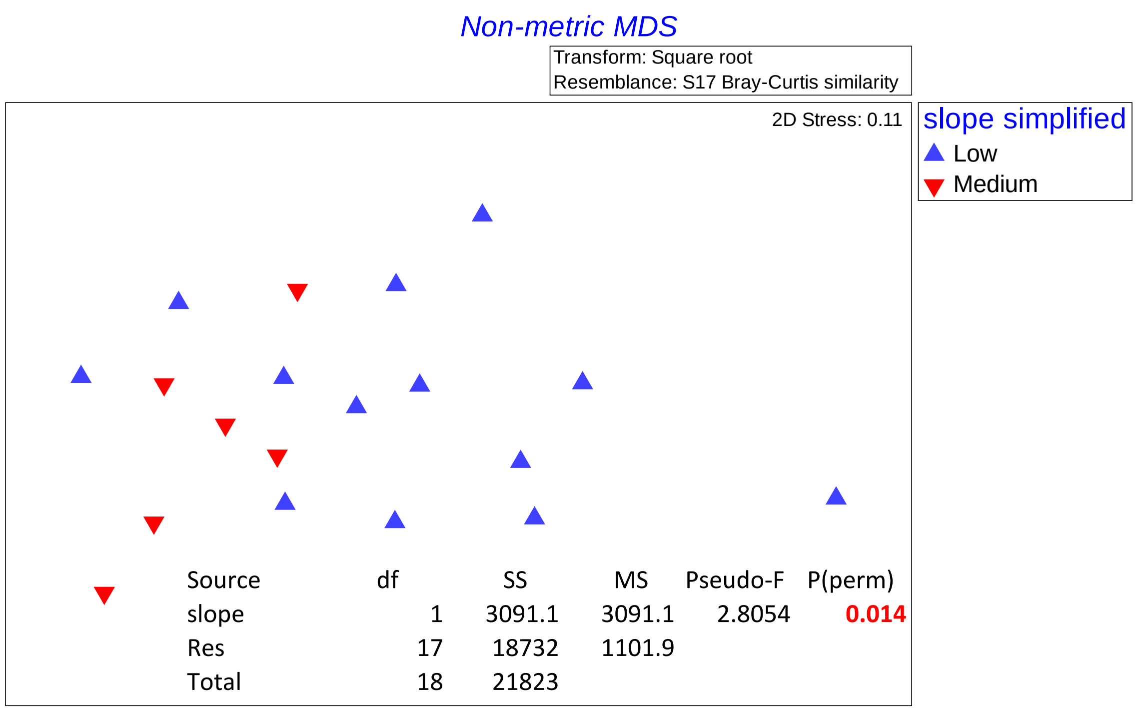
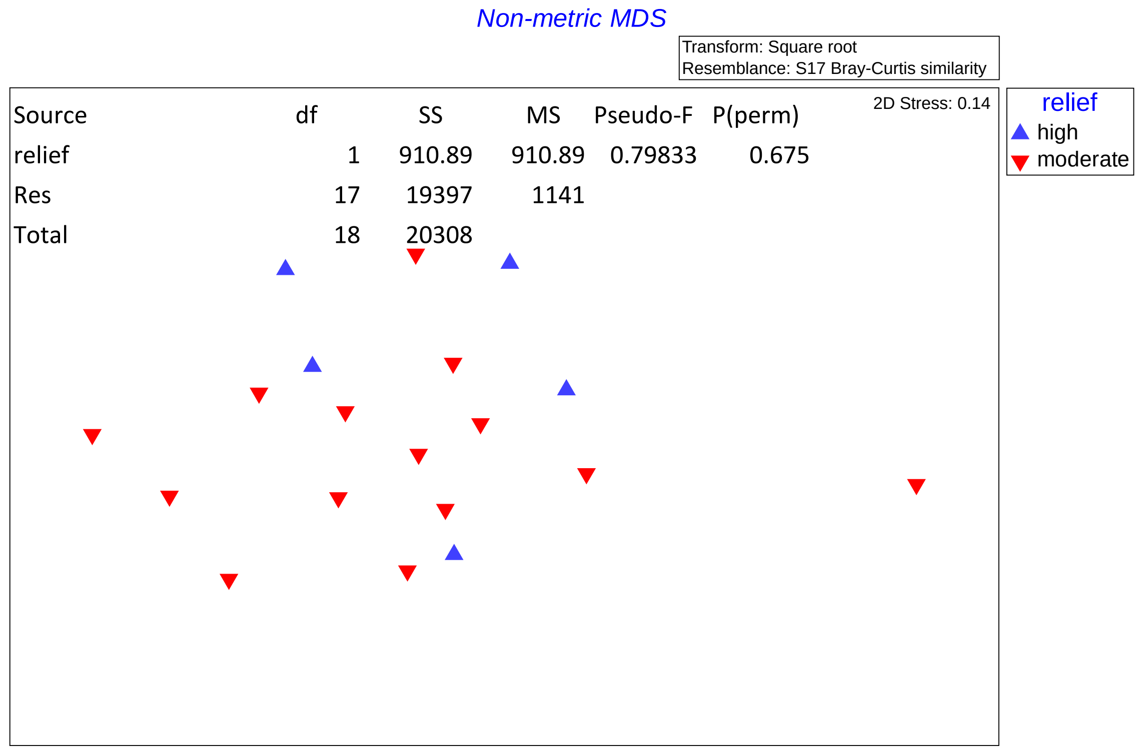


Figure 15. MDS plots and PERMANOVA of community composition for sites with differing slopes. Top: sessile community; bottom: mobile community. Note significant difference for the mobile community.



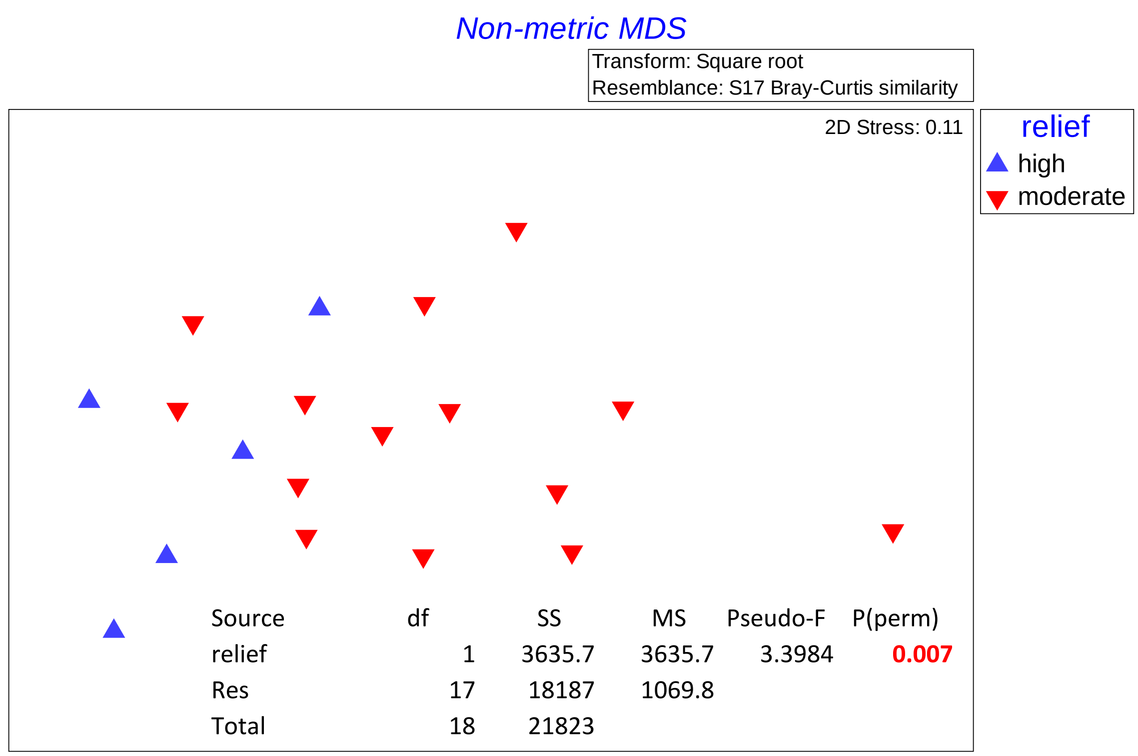
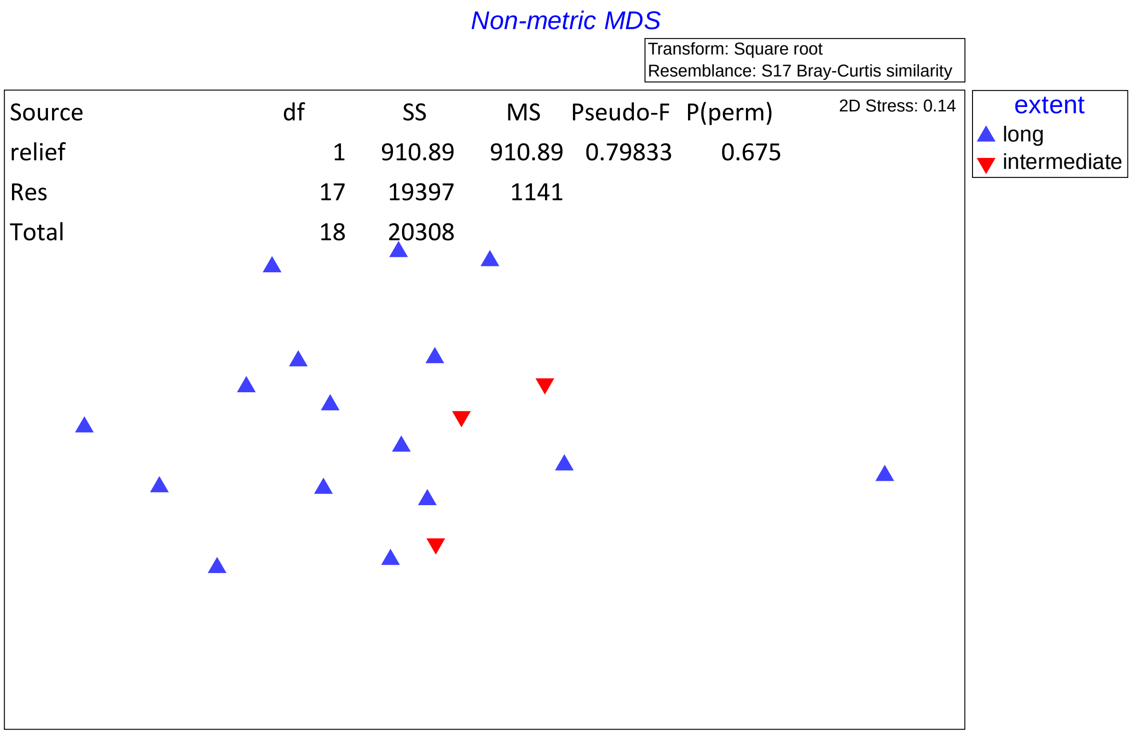


Figure 16. MDS plots and PERMANOVA of community composition for sites with differing relief. Top: sessile community; bottom: mobile community. Note significant difference for the mobile community.



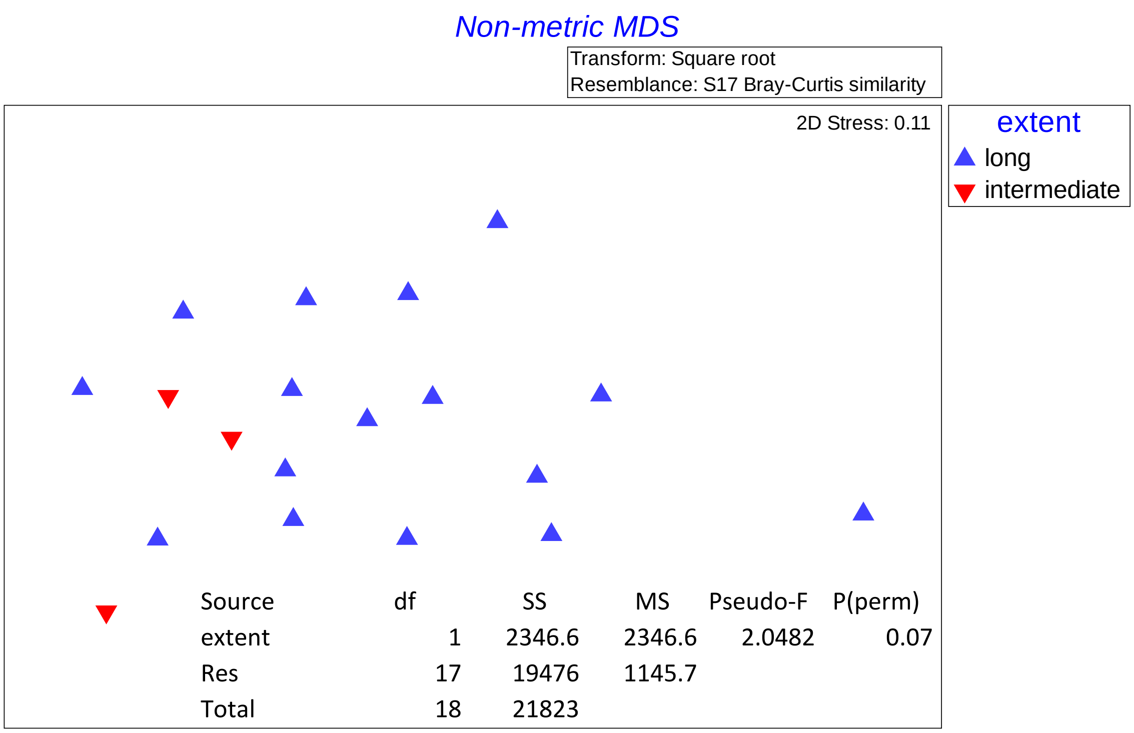


Figure 17. MDS plots and PERMANOVA of community composition for sites with differing reef extent. Top: sessile community; bottom: mobile community.

Focal Species Surveys

Among the most striking changes in focal species through time was the decline in sea stars at numerous sites due to Sea Star Wasting Disease (SSWD). Although large *Pisaster ochraceus* (ray length > 60mm) were still found in some abundance at the two northern-most sites (Pyramid Point and Point Saint George) as this study began in summer 2014 (Figures 18, 19), their numbers at other sites were already very low at the start of this baseline characterization (Figures 1, 10-24). By the subsequent sampling period, winter 2014/2015, the numbers of *Pisaster* at even these two most northern sites had crashed also (Figures 1, 18, & 19).

However, some recovery was evident. Starting in summer of 2015, and extending into winter 2015/2016, there was marked recruitment of small (ray length < 60mm), young *Pisaster*, most notably at Point Saint George, but also at Palmers Point, Abalobadiah (10-mile), MacKerricher, and Fort Bragg (Figures 1, 19-23). Two sites, Pyramid Point and Belinda Point, however, showed little to no recruitment of small *Pisaster* (Figures 1, 18, & 24). After the initial sampling period at Belinda Point, there was only one observation of a single *Pisaster* in the marked plots (Figures 1 & 24); this may be related to the isolated nature of this site which consists of a rocky outcropping that projects from the middle of a small pocket beach.

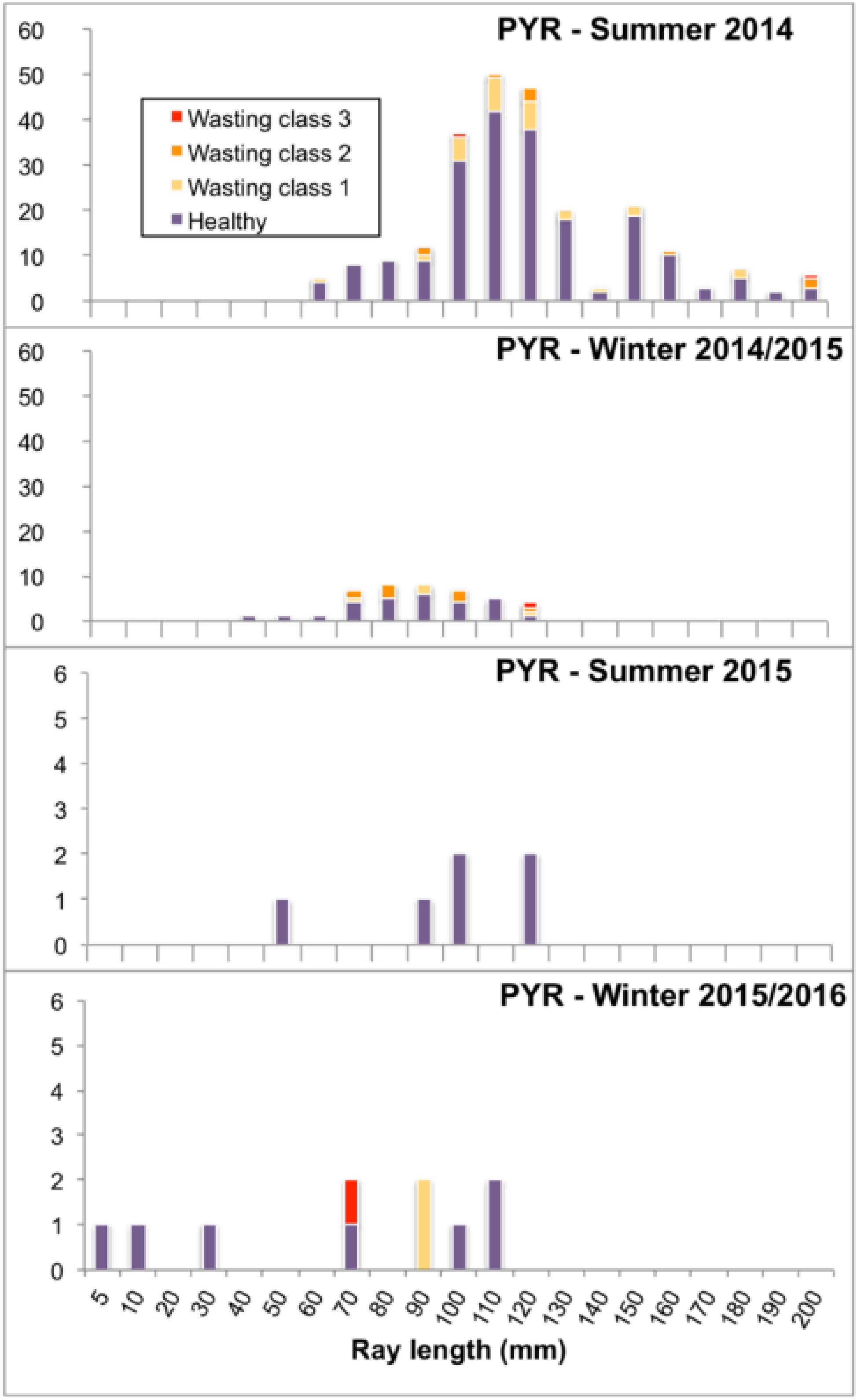


Figure 18. Histogram of total *Pisaster ochraceus* abundance for Pyramid Point (PYR) in all three plots by ray (arm) length and wasting disease class (disease severity).

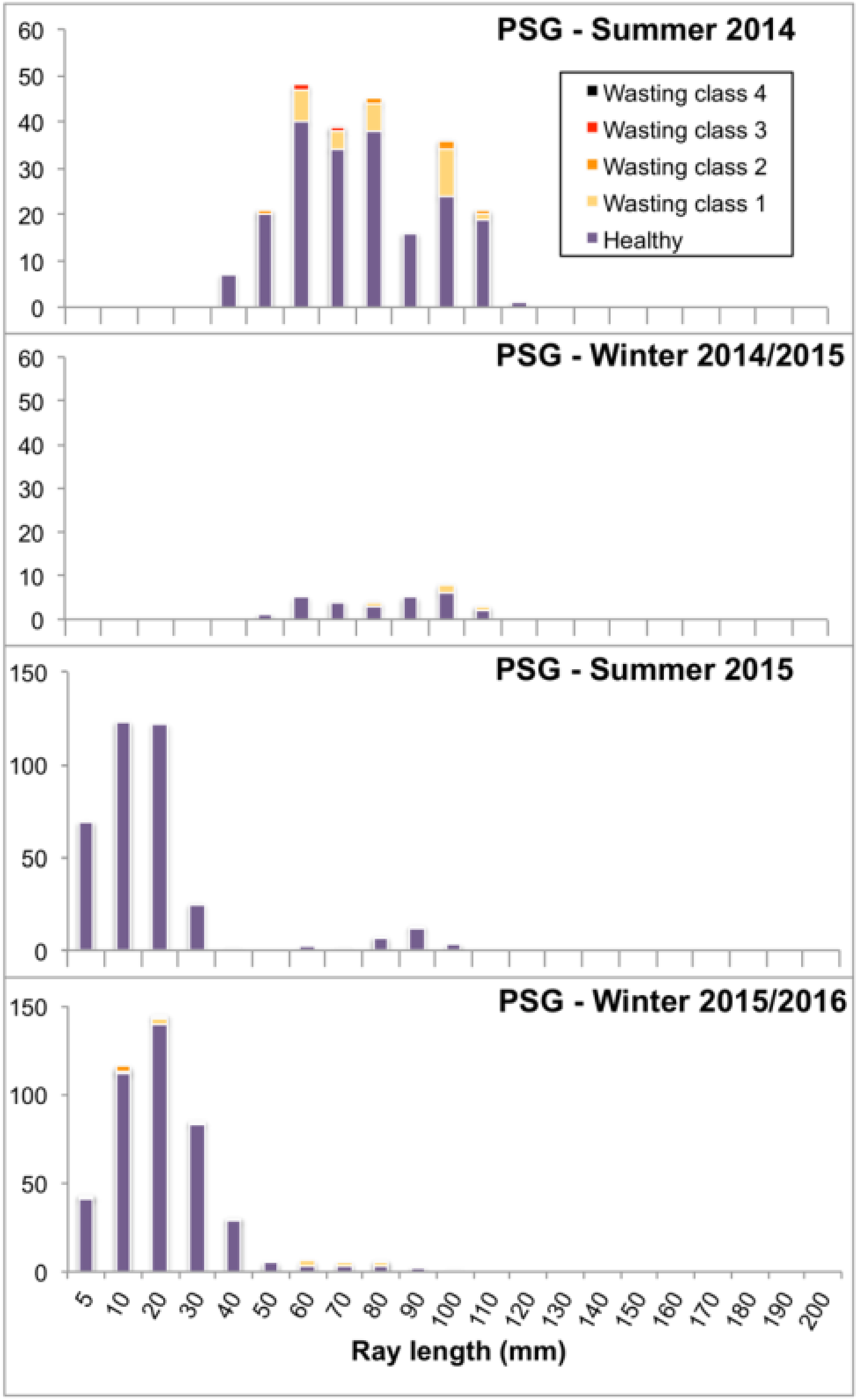


Figure 19. Histogram of total *Pisaster ochraceus* abundance for Point Saint George (PSG) in all three plots by ray (arm) length and wasting disease class (disease severity).

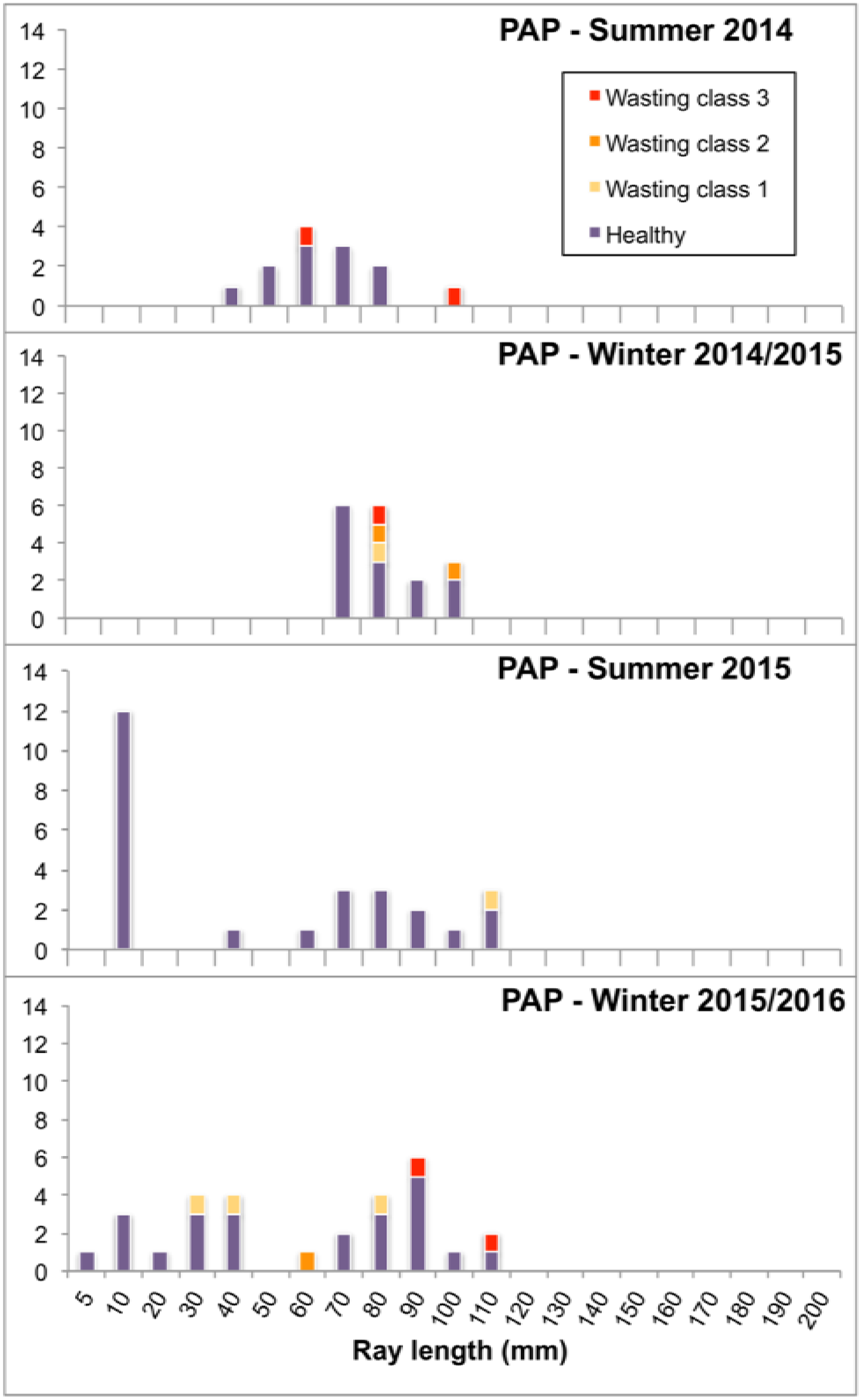


Figure 20. Histogram of total *Pisaster ochraceus* abundance for Palmer's Point (PAP) in three plots by ray (arm) length and wasting disease class (disease severity).

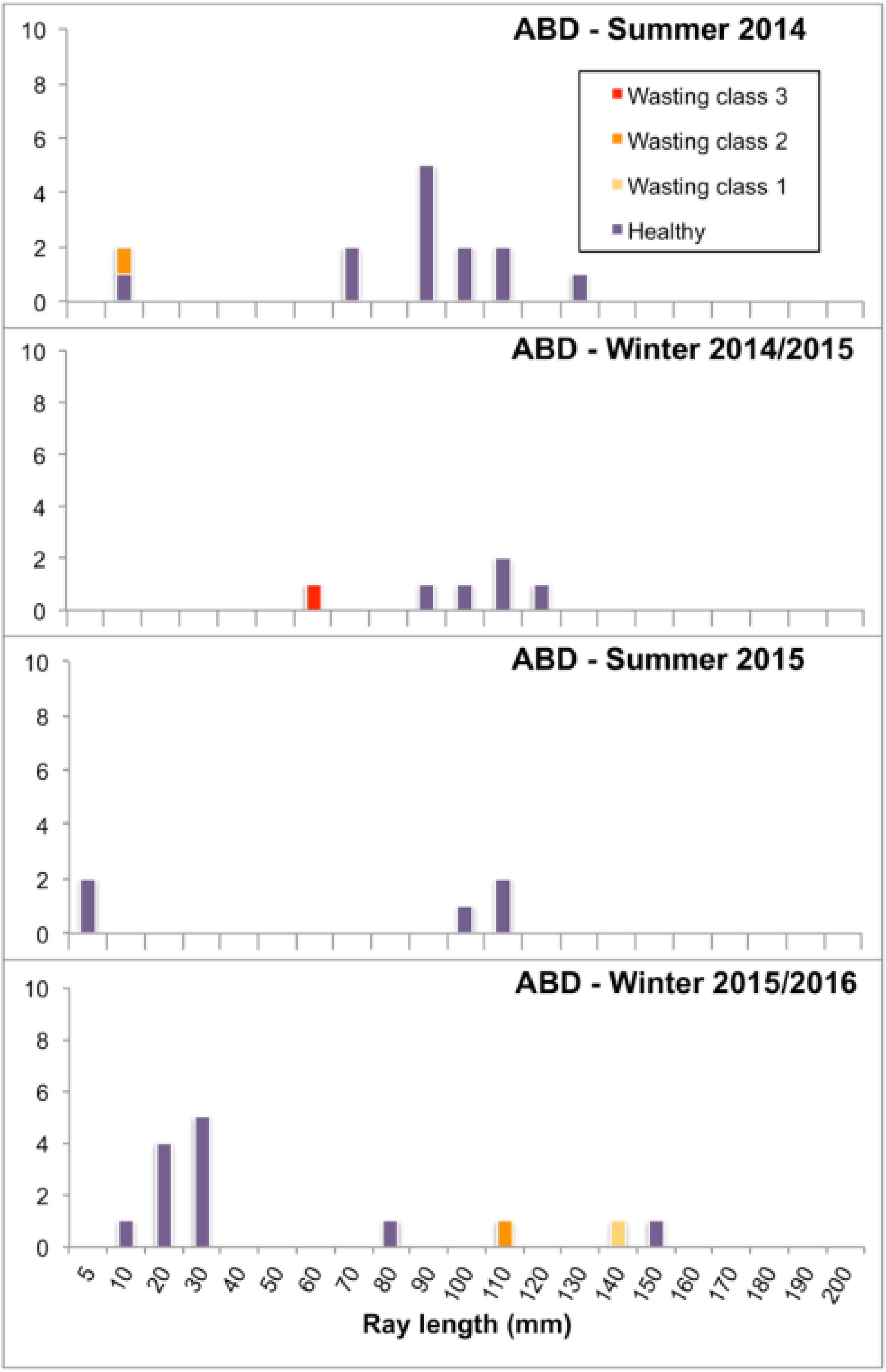


Figure 21. Histogram of total *Pisaster ochraceus* abundance for Abalobadiah Creek (ABD) in all three plots by ray (arm) length and wasting disease class (disease severity).

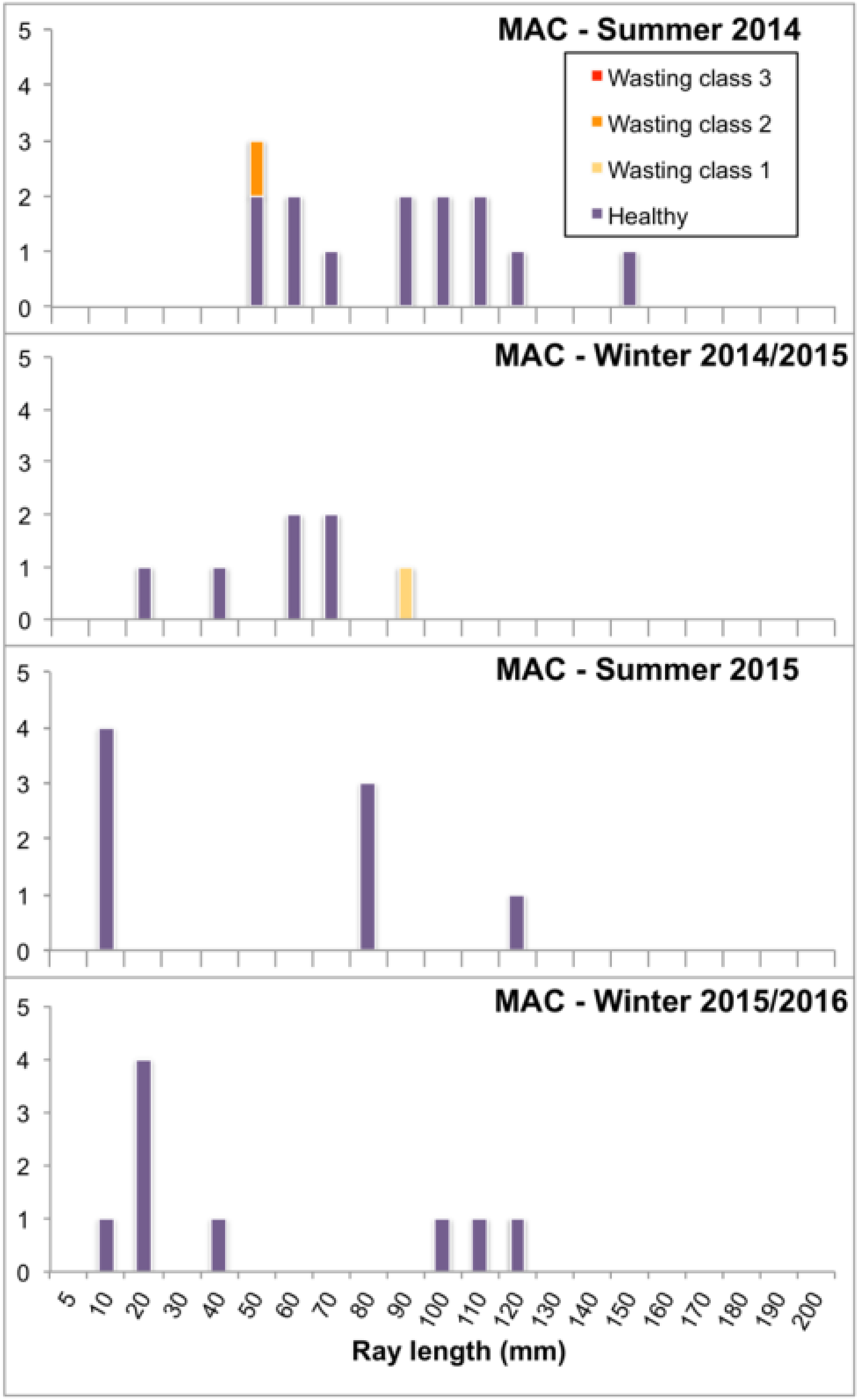


Figure 22. Histogram of total *Pisaster ochraceus* abundance for MacKerricher SMCA (MAC) in all three plots by ray (arm) length and wasting disease class (disease severity).

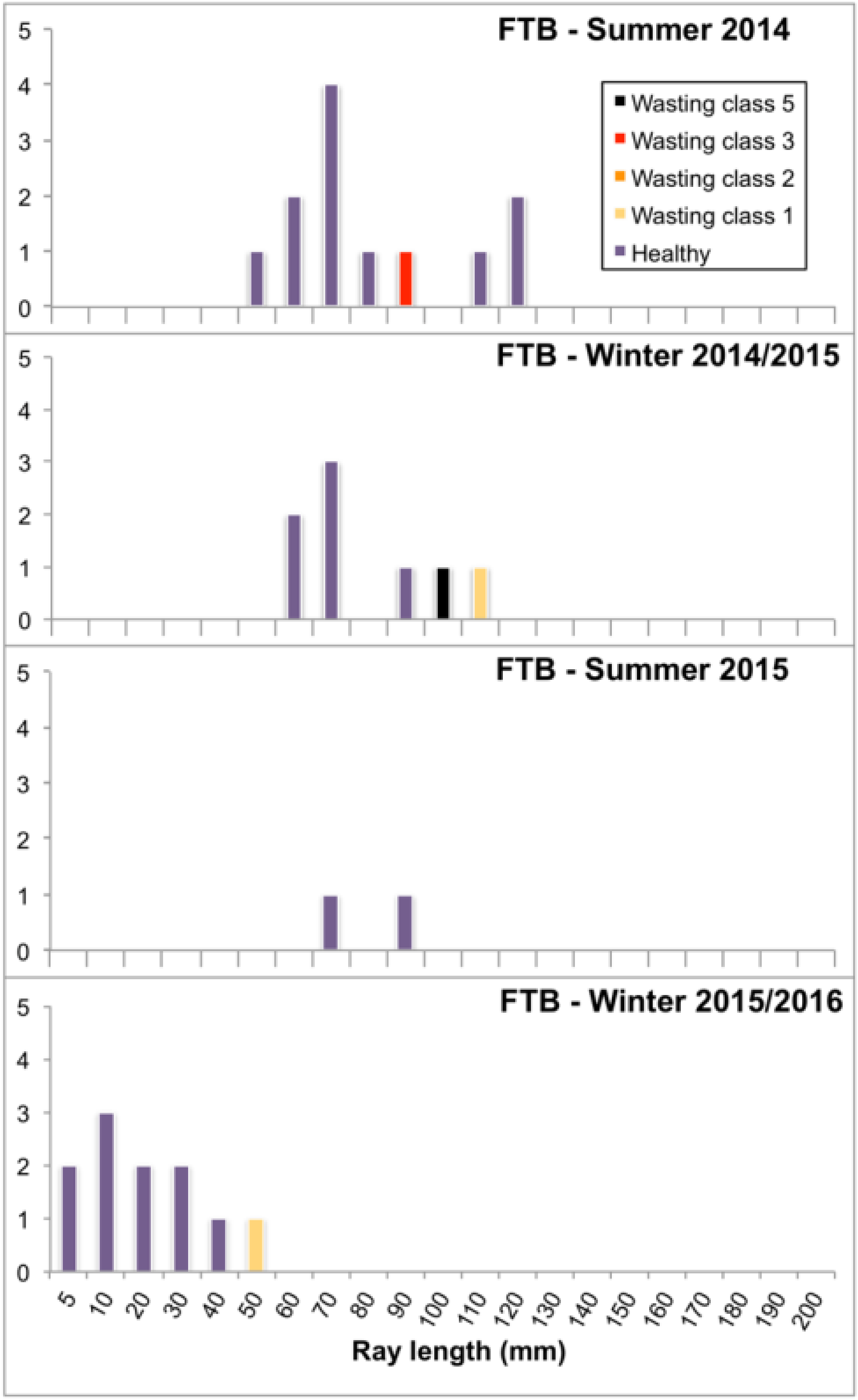


Figure 23. Histogram of total *Pisaster ochraceus* abundance for Fort Bragg (FTB) in all three plots by ray (arm) length and wasting disease class (disease severity).

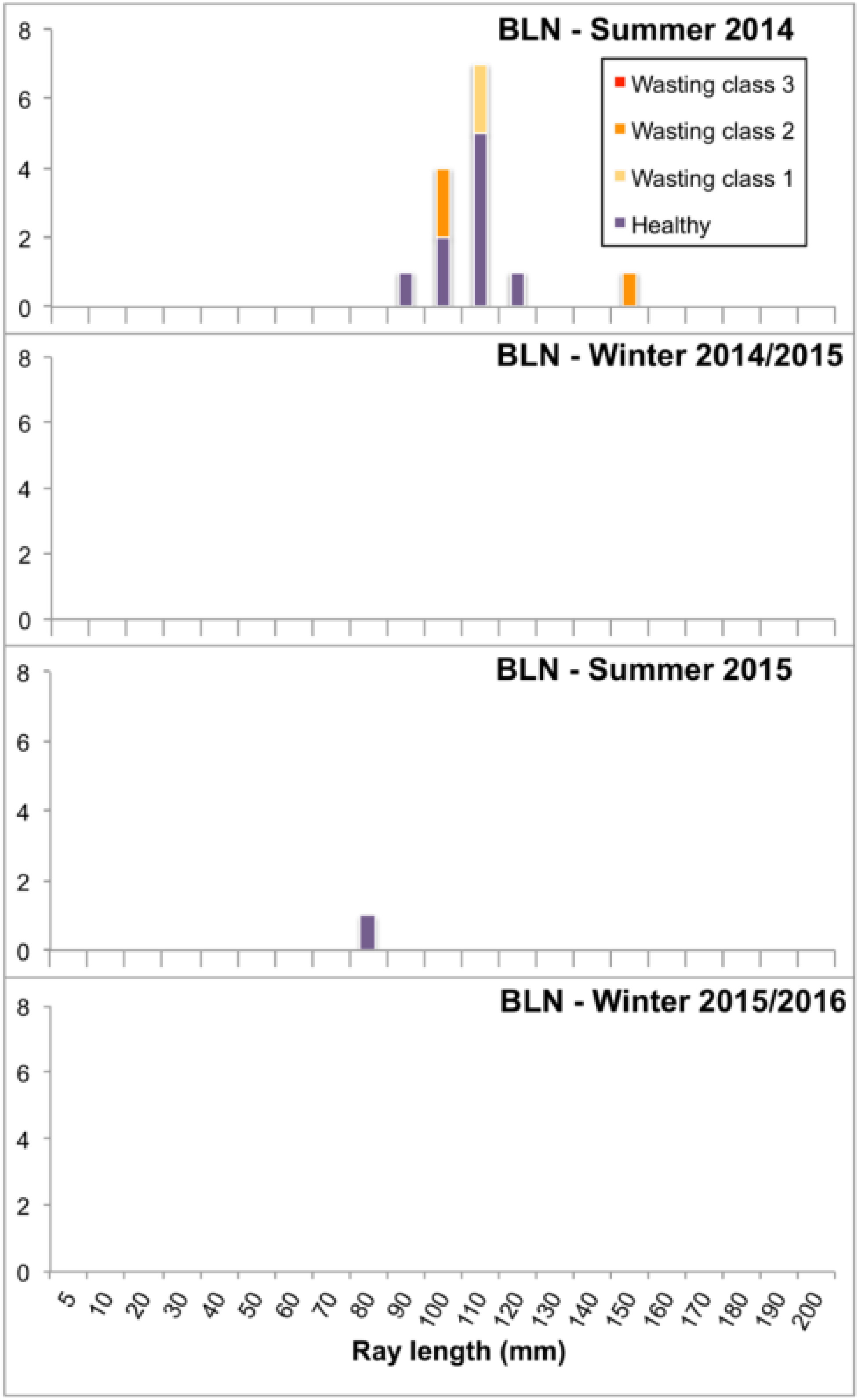


Figure 24. Histogram of total *Pisaster ochraceus* abundance for Belinda Point (BLN) in all three plots by ray (arm) length and wasting disease class (disease severity).

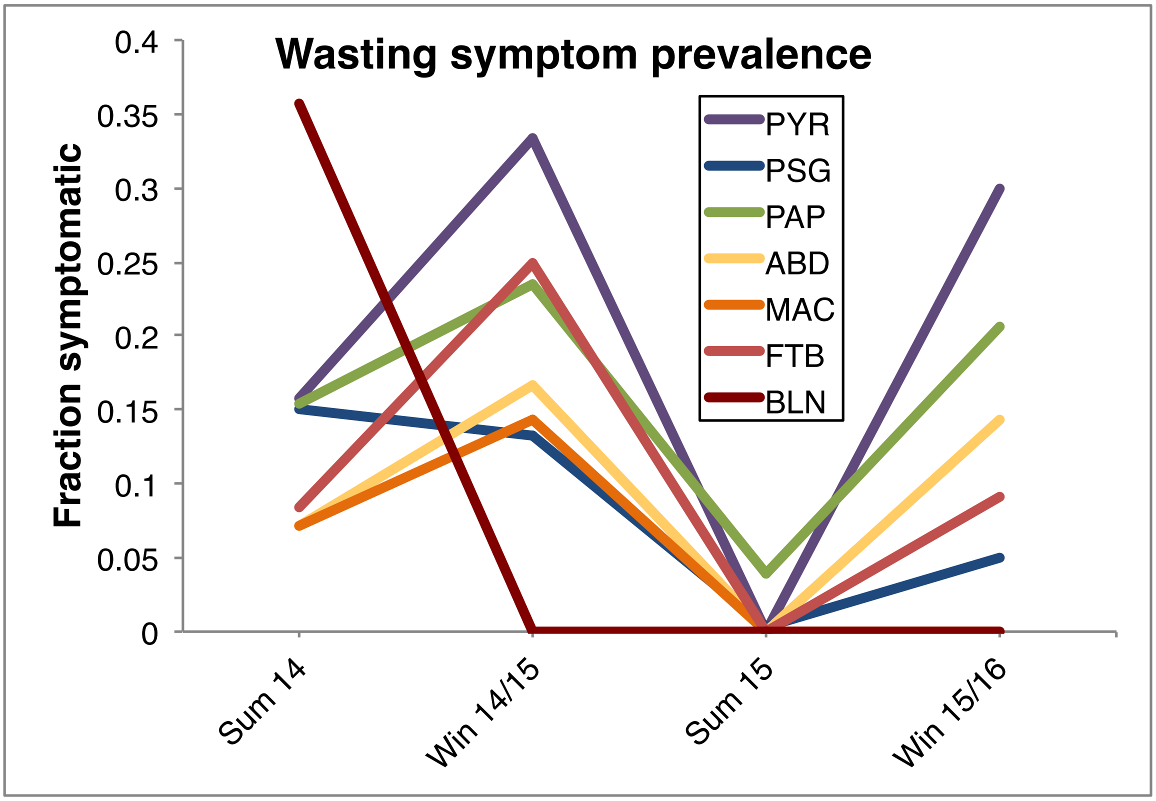


Figure 25. Prevalence of wasting syndrome symptoms among *Pisaster* across all three plots at each of the seven sites.

At most sites the frequency of Sea Star Wasting Disease (SSWD) symptoms among *Pisaster* was higher in the winter than the summer (Figure 25). Belinda Point, however, was an outlier in this: the frequency of SSWD dropped to zero at that site, but this was because sampling yielded only a single observation of one individual sea star during the final three sampling seasons.

Few trends were noted in data from mussel plots (Figure 2). What appeared to be gradual increases in mussel bed depth and percent cover through summer 2015 reversed in winter 2015/2016. It is interesting that the apparent release from predation by *Pisaster* did not result in substantial increases in percent cover, bed depth, or in the mean length of mussels. The reversal in winter 2015/2016 of the slight increasing trends noted in bed depth and percent cover appears unrelated to *Pisaster* abundance, since those beds that declined the most that winter, especially at Pyramid Pont and Belinda Point, have seen little recovery of sea stars. One plausible explanation is that the increase in percent cover and bed depth through time were at least partially the result of the very mild 2014/2015 winter – and that the substantially rougher winter of 2015/2016 helped drive the observed decline in both measures. This project did not collect data that could detect hypothesized expansion of mussel beds into the low intertidal and subtidal. However, a large collaborative effort by S. Gravem et al. (pers. comm.) has been conducting sampling to detect this and other trends in mussel abundance, and like this project, they have seen substantial variation among sites but few clear relationships between the degree of mussel expansion and potential drivers (including declines in *Pisaster* mortality). It may be that there has not yet been sufficient time for mussel populations and the rest of the community to respond to SSWD and the decline in sea star abundance.

Abalone Abundance at Fort Bragg (FTB) Site:

To our surprise, the site within Fort Bragg that we chose as a non-MPA reference site turned out to have a large number of abalone within it in the intertidal zone. Intense fishing pressure has removed nearly all large red abalone (*Haliotis rufescens*) from publicly accessible intertidal sites along the entire coast of California. However, during our baseline sampling of marine protected areas (MPAs) along Mendocino County in the summer of 2014, we discovered an intertidal site with abundant *H. rufescens* that had functioned as a *de facto* marine reserve due to its long history of private ownership. The lumber mill at that site was in operation for over 100 years, and was last operated by Georgia Pacific which shut down the mill in 2002. Trespassing was not allowed on the site during its operation nor after its closure, until the site was opened to the public as open space in late 2015. Though access to the site from the ocean was possible, because of a rocky reef and wash rocks just offshore, doing so would be difficult and dangerous except on very calm days. Using three 2 x 10 m belt transects (60 m2) and count data from three irregular plots we found a density of 2.1 abalone m^{-2}, including 0.5 individuals m^{-2} above legal harvest size (≥178 mm- see Figure 26).

This site has recently experienced a marked increase in accessibility as the surrounding beaches were opened to the public in late 2015, after we had completed a second survey of abalone at the site. Though the site had not been opened to the public at the time of our second survey, increasing numbers of people began trespassing at the site (and likely to harvest abalone) in early 2015 when it became known that the site would soon be opened to the public (pers. comm. Marie Jones, Fort Bragg Community Development Director). Resampling in 2015 found minimal abalone recruitment and mortality rates ranging from 18-100% for larger size classes and a 24% decline in overall abundance (Figure 26). The greatest reductions in densities were found in the most accessible transects (close to shore, gentle slope), while those requiring more effort to reach (farther from shore, steep or vertical slope, isolated by wide tidal channels) remained largely unperturbed (see Figures 27-28). These patterns along with observations from City of Fort Bragg staff of extensive trespassing on the site in anticipation of its opening to the public provide convincing evidence that abalone picking by people is responsible for the observed decline in abundance. We expect to see further reductions in abalone abundance as the entire site was opened to the public by the City of Fort Bragg in June 2016. This circumstance is very similar to what transpired when Stornetta Ranch was opened to the public and intertidal abalone abundance decreased by 78% in just 3 years (Rogers-Bennett et al. 2013).

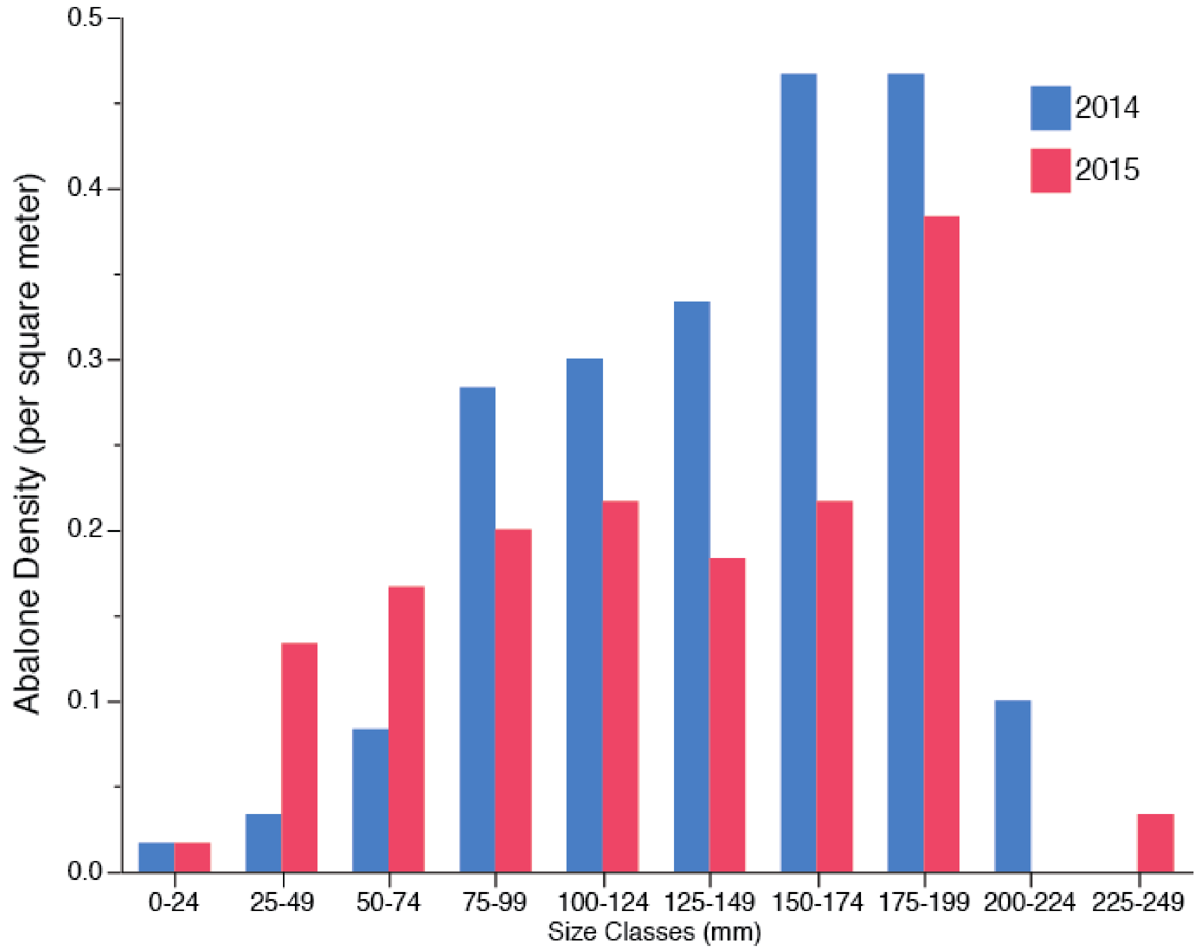


Figure 3. Red abalone density by size classes from belt transects at the Fort Bragg (old GP mill) site in 2014 (blue) and 2015 (red).

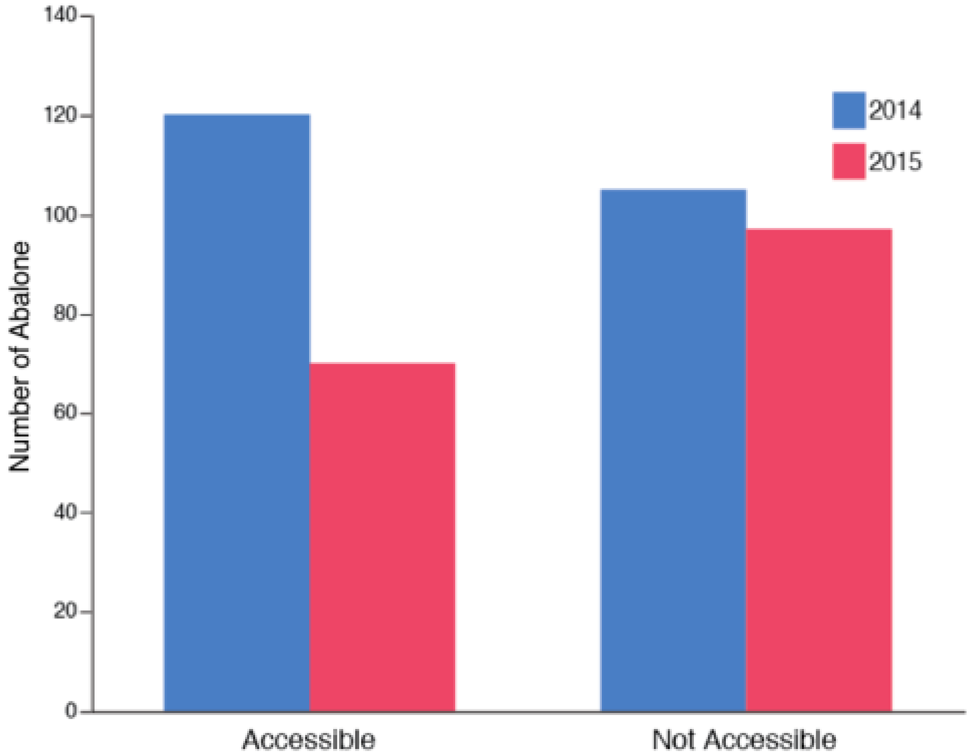

140
120
100
80
60
40
20
0
Number of Abalone
2014
2015
Accessible
Not Accessible

Figure 4. Total number of abalone found in high versus low accessibility plots/transects (3 in each category) in 2014 (blue) and 2015 (red).

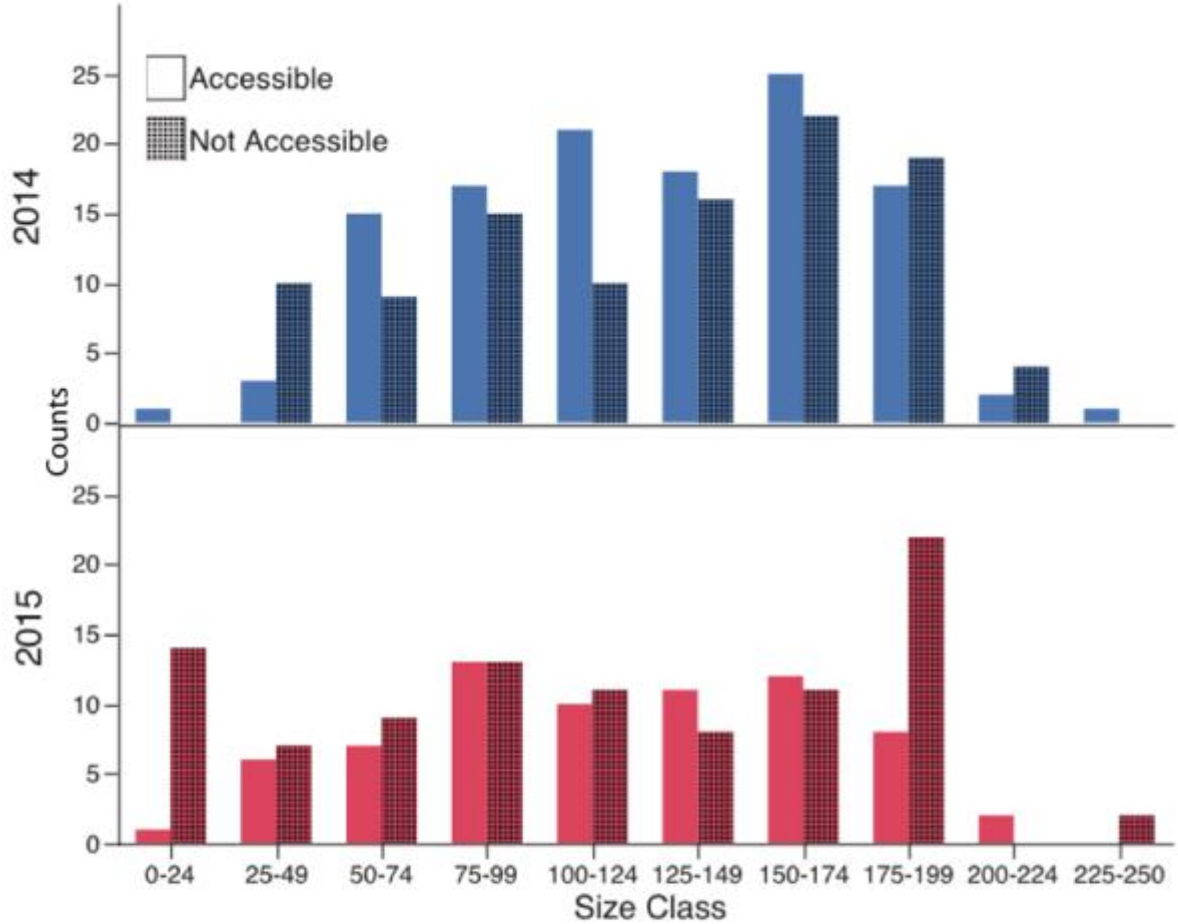


Figure 5. Abundance of abalone by size class and accessibility (low and high) for 2014 (blue) and 2015 (red). Cross hatched bars represent individuals in locations that were more difficult to access, whereas solid bars represent individuals that were easily accessible.

Tide Pool Fish diversity & Rockfish Settlement Surveys

Physical Characteristics of Tide Pools

Pool water temperatures averaged 13.5 °C and fluctuated between 10 °C and 19.2 °C. Pool temperature tended to be warmer during the winter (average 14.37 °C) from being exposed to daytime heating by the sun, since the extreme low tides were in the evening. Since summer low tides were in the early morning, before sunrise, the pools were cooler (averaged 12.74 °C). Pools averaged 2.78 m^2 (0.97 to 6.6 m^2) in surface area and had an average volume of 434.16 L (Range of 54.42 to 1715.3 L). Pools in boulder fields were, on average, larger in surface area but much smaller in volume than those in benches (table 2). This is due to the nature of how the pools are formed; in boulder fields, they fill large, shallow spaces in between rocks and divots in sand, whereas on benches they fill deep cracks and crevices in the solid bedrock.

Linear regressions showed that temperature had no significant impact on the number of fish found in the pools ($p=0.25$). There was a significant difference between bench and boulder fields in the number of fish per pool ($p<0.01$) where boulder fields had more fish (17.5 $\text{fish} \bullet \text{pool}^{-1}$) than benches (7.0 $\text{fish} \bullet \text{pool}^{-1}$), but no difference between bench and combination intertidal types ($p=0.26$). There was also no significant effect of surface area ($p=0.71$) or volume ($p=0.79$) on the abundance of fish in tidepools. Volume and surface area also did not show any effect on richness ($p=0.09$ and 0.28, respectively).

Table 3. Site and tide pool physical characteristics for each location surveyed.

Location	Site type	Average pool surface area (m^2)	Average pool volume (L)	Latitude	Longitude
Point St. George	Boulder field	2.7	105.2	41.784	-124.255
False Klamath	Boulder field	4.0	208.6	41.595	-124.105
Palmers Point	Boulder field	3.7	449.8	41.131	-124.163
Ten Mile/Abalobadiah	Combination	2.1	380.9	39.568	-123.772
MacKerricher State Park	Bench	1.5	232.2	39.483	-123.804
Fort Bragg Cove	Combination	2.9	669.4	39.437	-123.819
Belinda Point	Bench	2.6	853.3	39.398	-123.820

Fish diversity and abundance

A total of 1756 fish were caught in the 84 surveyed pools (3 pools at each of 7 sites across 4 survey periods). Collections included 34 species representing eight families, based on taxonomy from the Catalog of Fishes (Eschmeyer et al 2016): Clinidae (kelpfishes), Cottidae (sculpins), Gobiesocidae (clingfishes), Hexagrammidae (greenlings), Liparidae (snailfishes), Pholidae (gunnels), Scorpaenidae (rockfishes), and Stichaeidae (pricklebacks) (Table 4). Cottidae was the most common and had the highest abundance at 1270 individuals (72% of total catch) from 18 different species. The most common species were the fluffy sculpin, *Oligocottus snyderi*, with 546 individuals and the tidepool sculpin, *Oligocottus maculosus,* with 390 individuals. All families included multiple species with the exceptions of Gobiesocidae and Liparidae, where the northern clingfish, *Gobiesox maeandricus,* and the tidepool snailfish, *Liparis florae,* were the sole representatives, respectively.

Species richness across sites ranged from 13 to 22 species (Figure 29). At all sites, Cottidae made up most of the catch with Stichaeidae and Gobiesocidae also consistently making up a large proportion of the catches (Figure 30). Clinidae was caught in fairly high abundance at MacKerricher State Park and Belinda Point, the two bench sites, but was either very rare or nonexistent at the other 6 sites. Kelpfishes were only caught at the three southernmost sites. Species richness at protected sites was lower than at the other two southern sites, but was higher than at the two northernmost sites (Figure 29). The mid and high intertidal zones had greater abundance than the low intertidal zone. Richness was similar in the low and high intertidal zones but greater in the mid zone (Figure 31).

Diversity, as measured by Simpson's Index of Diversity, did not differ very much across the sites (Figure 32). There was generally no difference in diversity between sites, except for the northern three sites during the winter where False Klamath was more diverse than Point St. George and Palmers Point. MacKerricher State Park was less diverse than Fort Bragg and Belinda Point during the summer, but did not differ during the winter. False Klamath was the only site that showed a difference in diversity between the seasons, with winter having a higher diversity than summer. The three boulder field sites generally had lower diversities than the other habitat types, but these differences have overlapping confidence intervals. Diversity was lower in the high intertidal zone during both the summer and winter (Figure 32). Diversity was very similar between seasons for all three intertidal zones.

Abundance varied greatly by site with the most fish being caught at Palmers Point and the fewest caught at Ten Mile (Table 4). Since there was uneven sampling effort at some of the sites due to ocean conditions occasionally making it impossible to drain pools, catch per unit effort was calculated as the average number of fish caught per pool among three pools surveyed during each sampling effort (Figure 34). Palmers Point had the highest number of fish caught and the highest catch per unit effort, although Point St. George and Fort Bragg had similar numbers of fish per pool.

Table 4. Total numbers of each fish species caught in tide pools during the entire study period at each site: Point St. George (PSG), False Klamath Cove (FKC), Palmers Point (PP), 10 Mile (10M), MacKerricher State Park (MSP), Fort Bragg (FB), and Belinda Point (BP). The dashed line indicates the division between northern sites (left) and southern sites (right).

Species	**PSG**	**FKC**	**PP**	**10M**	**MSP**	**FB**	**BP**
Anoplarchus purpurescens	4	19	2	10	12	20	3
Apodichthys flavidus	13	8	6	3	1	8	3
Apodichthys fucorum	1		1	1	10	2	3
Artedius corallinus		4	1	4	1		
Artedius fenestralis		1					
Artedius harringtoni			1				
Artedius lateralis		7	6	10	6	56	13
Ascelichthys rhodorus	1	2	7	1			1
Cebidichthys violaceus	4	6	26	1	3	5	2
Clinocottus acuticeps	12						
Clinocottus analis				2	1	8	
Clinocottus embryum	1						
Clinocottus globiceps	59	6	41	11		18	5
Clinocottus recalvus	7		2			2	1
Enophrys bison	6		1	4			
Gibbonsia metzi					2		2
Gibbonsia montereyensis					10	2	25
Gobiesox maeandricus	28	48	5	8		25	22
Hemilepidotus hemilepidotus			3				
Hemilepidotus spinosus			5				
Hexagrammos decagrammus				1			1
Hexagrammos lagocephalus						1	
Liparis florae						6	3
Oligocottus maculosus	8	84	211	4	6	76	1
Oligocottus rimensis							5
Oligocottus rubellio					1	1	11
Oligocottus snyderi	129	85	124	41	50	79	38
Phytichthys chirus							1
Scorpaenichthys marmoratus		6	1			1	2
Sebastes carnatus							1
Sebastes melanops				3			
Sebastes miniatus						1	
Xiphister atropurpureus		3	10		1	5	24
Xiphister mucosus		4	8	2	3	10	2
Total	**273**	**283**	**461**	**106**	**107**	**326**	**169**

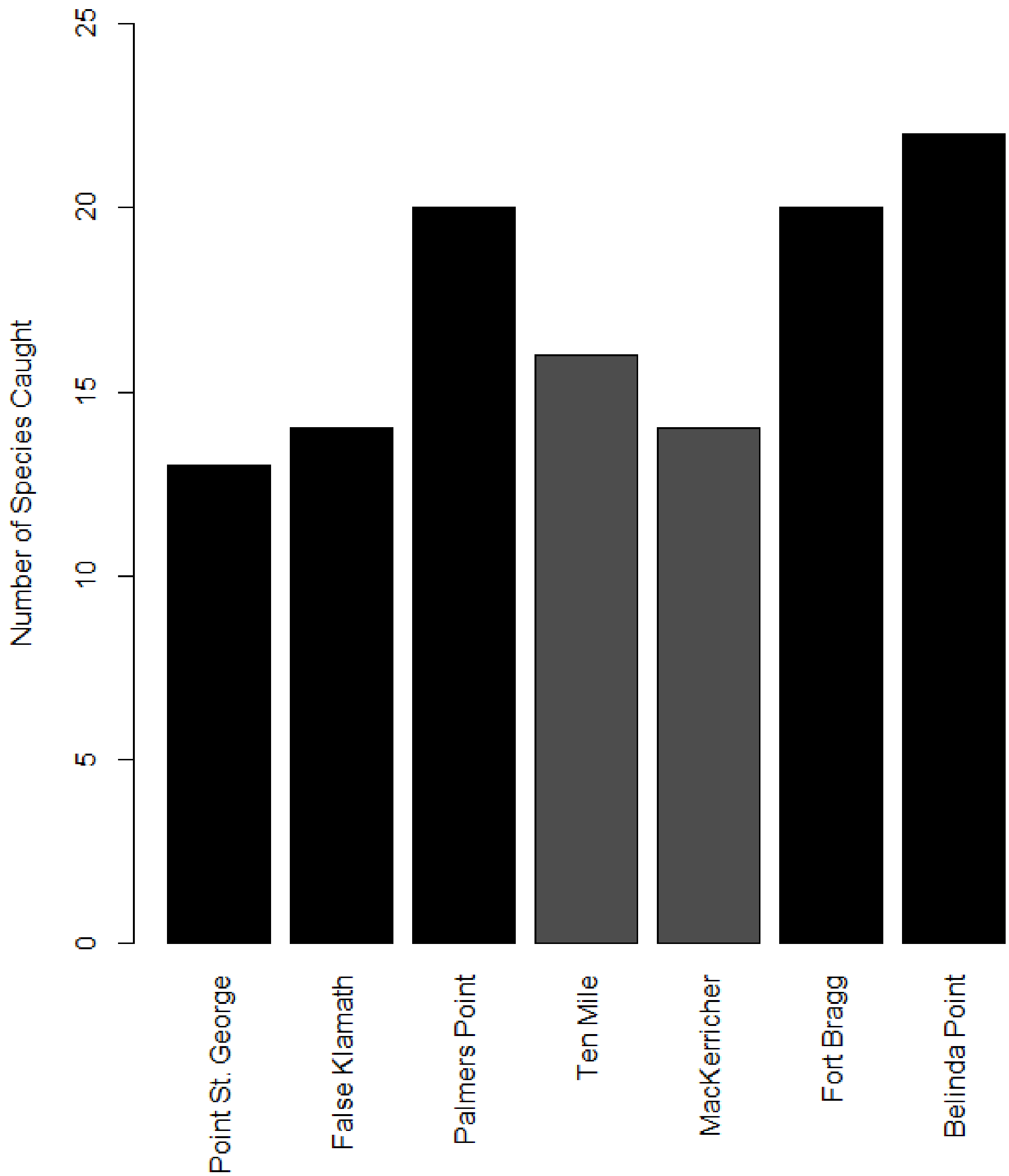


Figure 6. Species richness for each of 7 sites sampled for tide pool fishes, represented as the total number of species caught throughout all four sampling seasons. Lighter bars indicate sites that are MPAs.

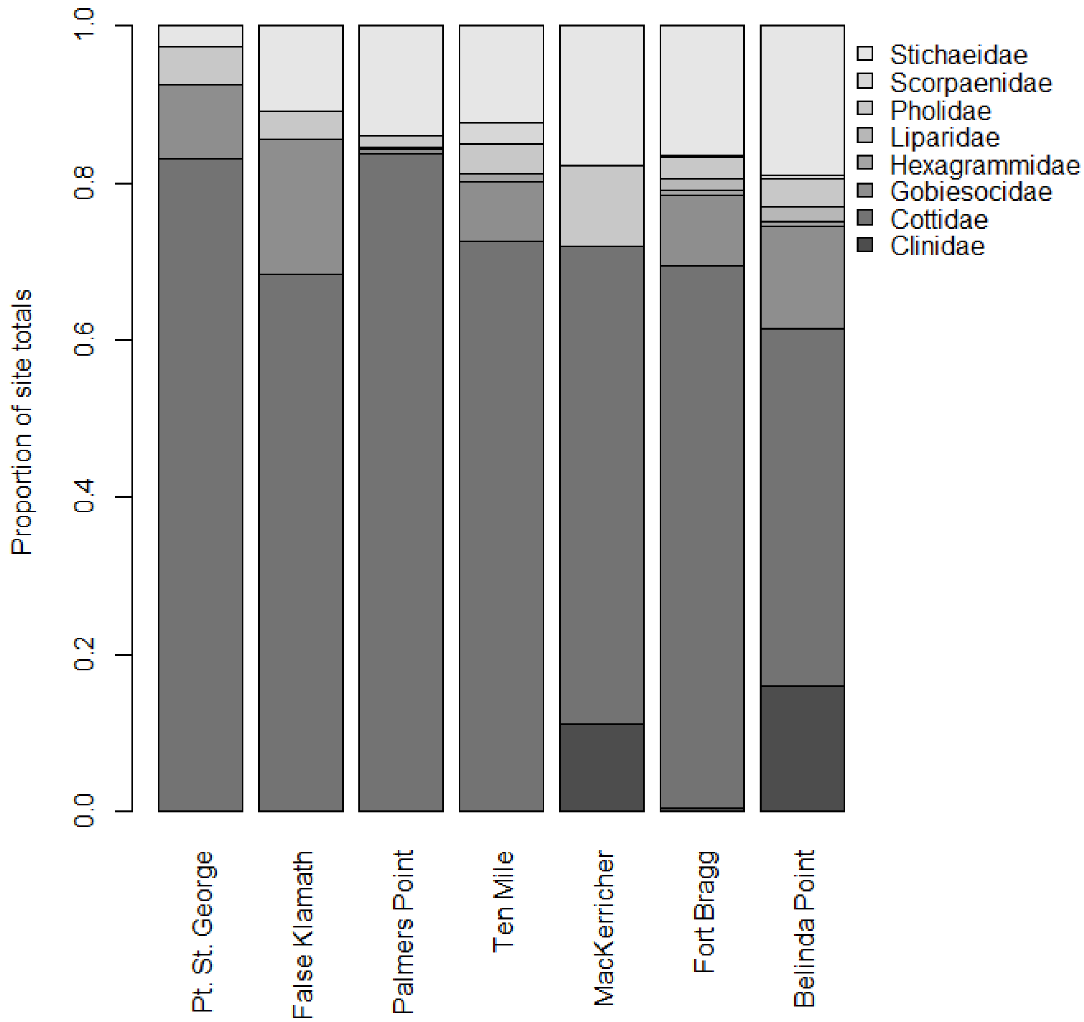


Figure 7. Proportion of fishes caught by family at each sampling site. MacKerricher and Ten Mile are the two MPAs.

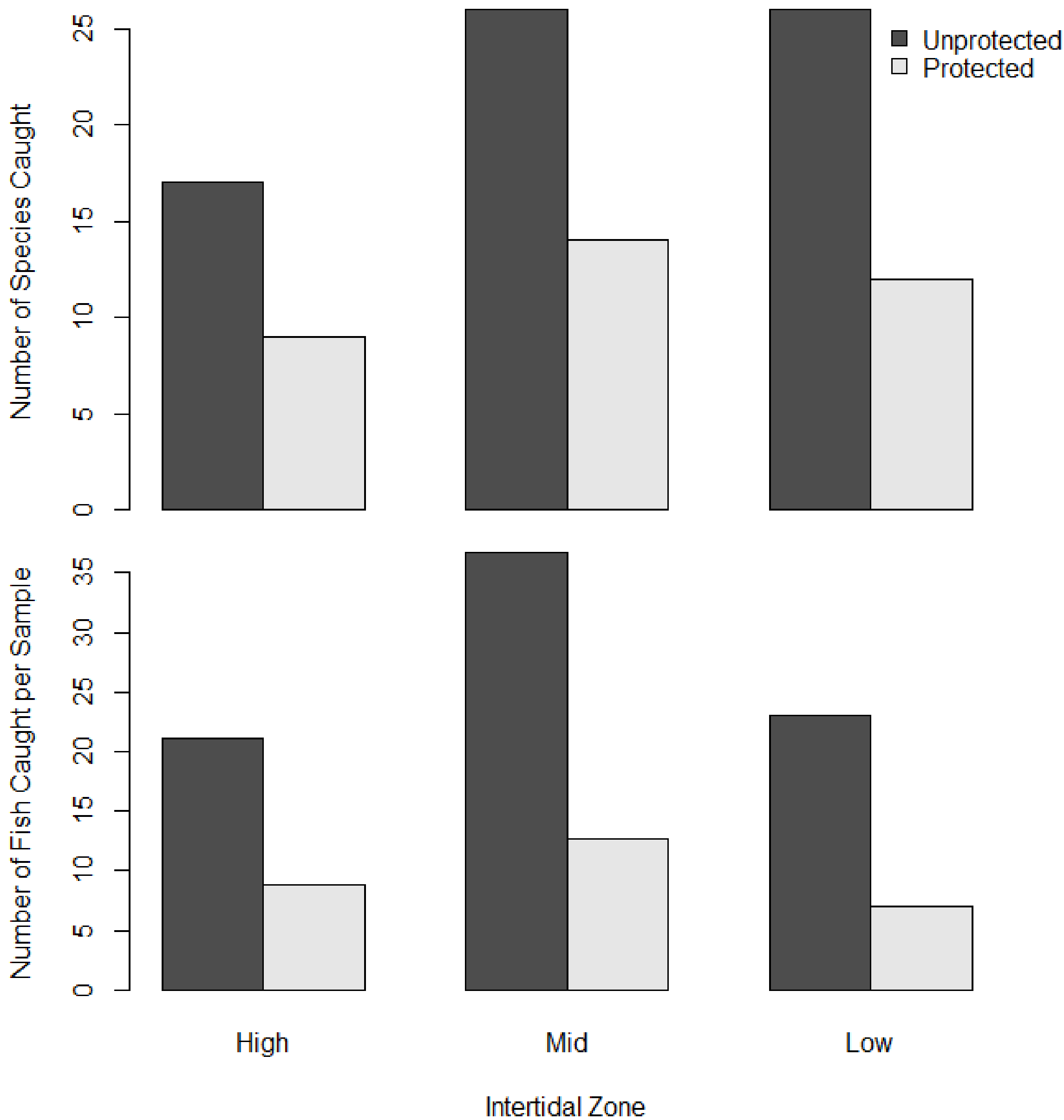


Figure 8. Species richness (top) and CPUE (bottom) by intertidal zone and MPA versus reference site. Darker bars indicate unprotected sites while lighter bars represent sites located within MPAs. CPUE is measured as the number of fish caught per pool in each zone.

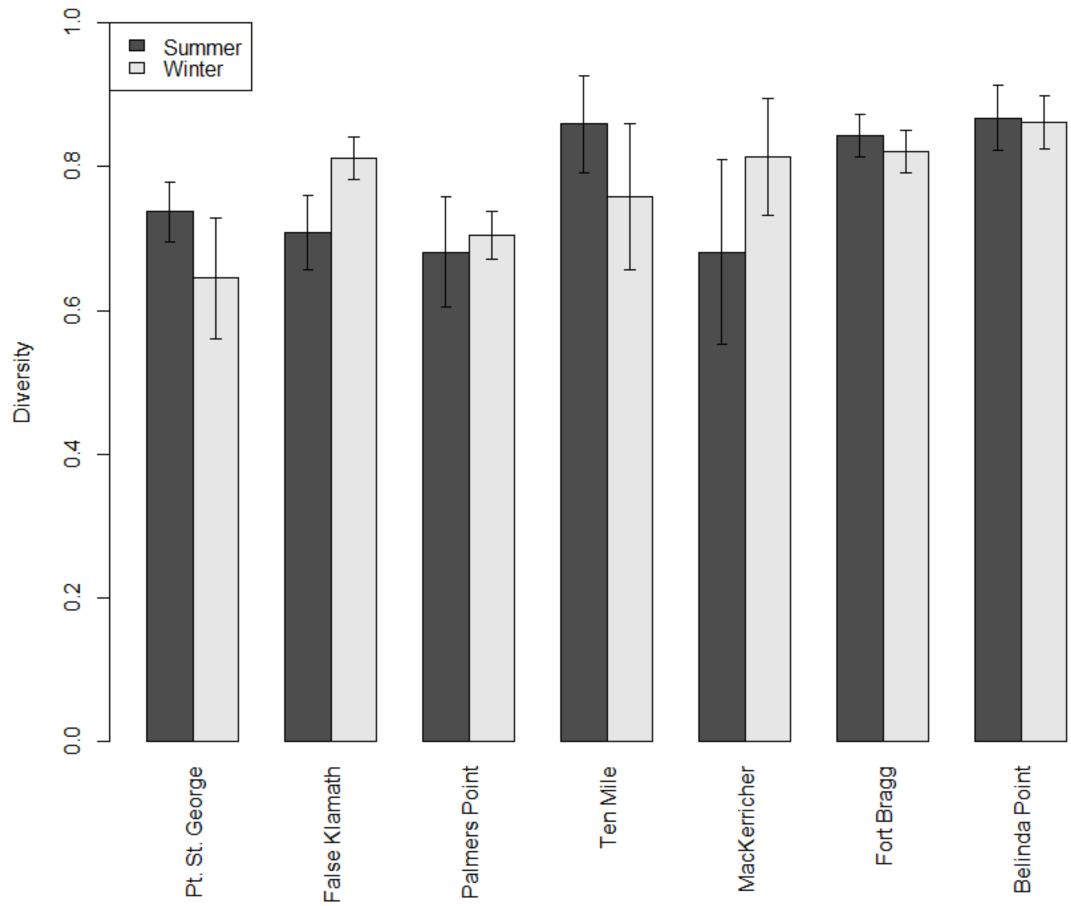

Summer
Winter
Diversity
0.0
0.2
0.4
0.6
0.8
1.0
Pt. St. George
False Klamath
Palmers Point
Ten Mile
MacKerricher
Fort Bragg
Belinda Point

Figure 9. Simpson Diversity Index for intertidal fishes by site during summer and winter. Error bars are 95% confidence intervals.

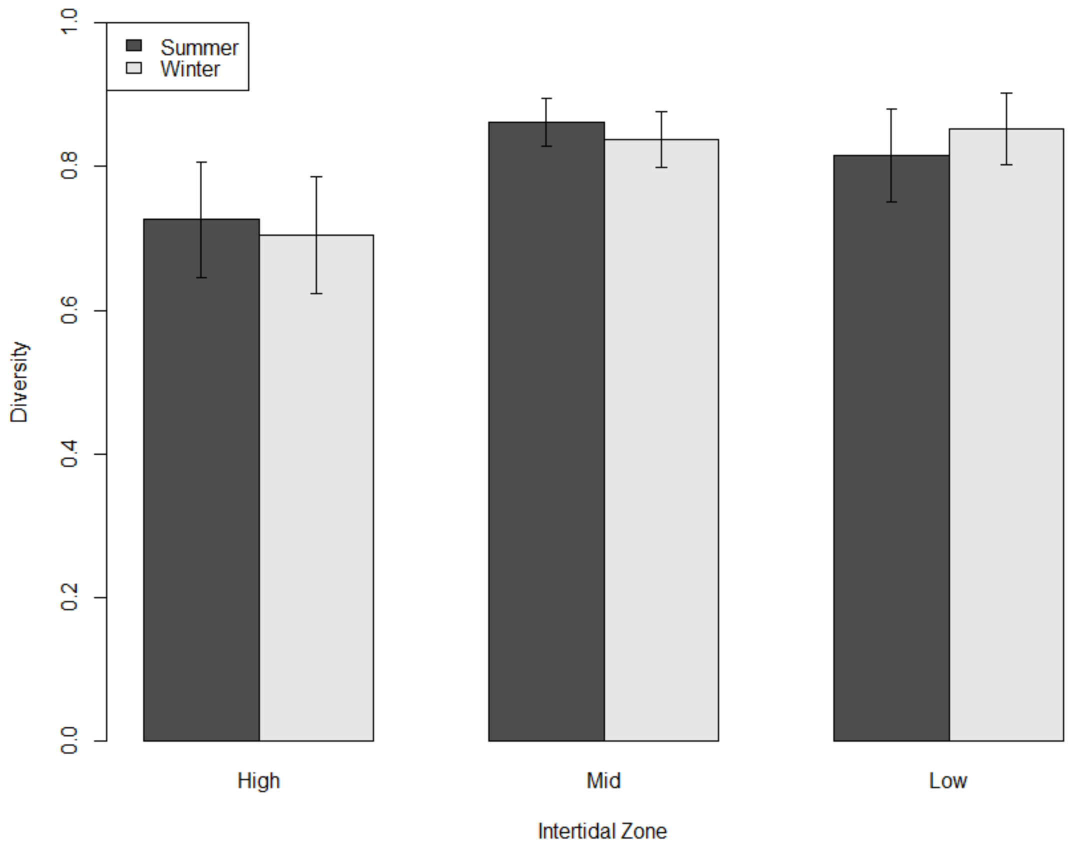


Figure 10. Simpson Diversity Index of fishes by intertidal zone and season (summer versus winter). Error bars are 95% confidence intervals.

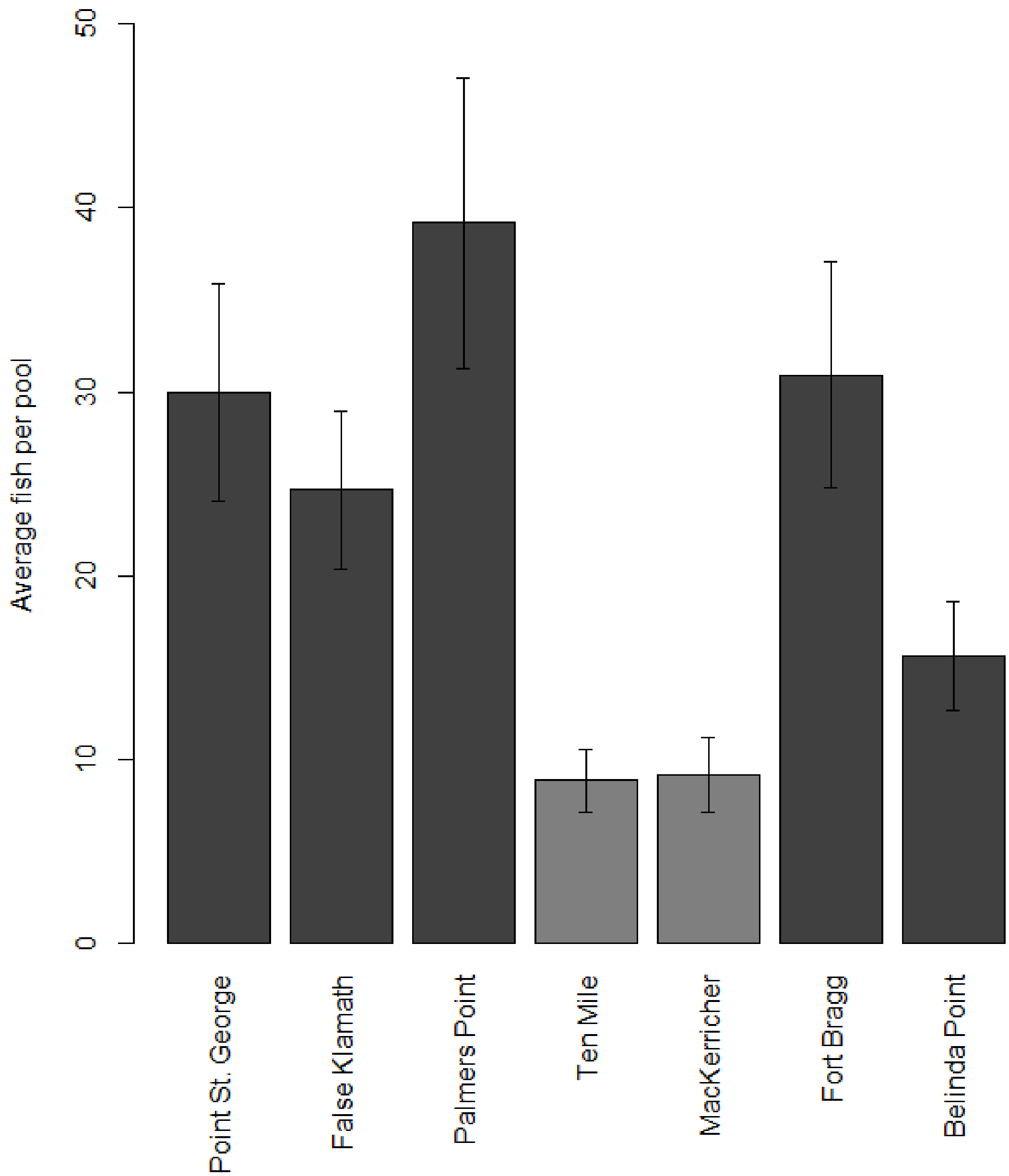


Figure 11. Mean catch per unit effort at each site (measured as the number of fish caught in each pool) with standard error. Light gray indicates sites that are within MPAs.

False Klamath and Point St. George had similar abundances and CPUEs. Apart from Fort Bragg, northern sites had higher abundances and catches per unit effort than southern sites. The two sites located within MPAs had the lowest abundances and the fewest fish per pool, and were both substantially lower than the site with the next fewest fish (Belinda Point).

Size (total length) frequency distributions were generated for the two most abundant fish species, *Oligocottus snyderi* and *O. maculosus*, collected at all sites during all summer and winter sampling events (Figure 8). Size ranges were very similar for the two species, ranging from 13-85 mm for *O. maculosus*, and 13-86 mm for *O. snyderi*. Both species had the most individuals in the 25 to 35 mm range during the summer, but during the winter most *O. maculosus* were between 35 and 40 mm while most *O. snyderi* were between 40 and 55 mm. For both species, two peaks can be seen during the summer, centered around 25-35 mm and 50-55 mm for *O. maculosus*, and 25-35 mm and 60-65 mm for *O. snyderi*. These indicate at least two year classes, with a potential very small third age class in *O. maculosus,* centered around 80 mm. Two peaks can be observed in *O. maculosus* during the winter, centered around 35 mm and 70-75 mm. Only one major peak is observed in *O. snyderi* during the winter, centered around 40-55 mm, suggesting that this species likely only survives one winter and very rarely lives through two.

Rockfish Settlement Surveys

Rockfish surveys included twenty-eight sampling periods (seven sites sampled across four seasons) and six additional surveys spent solely looking for rockfish at False Klamath (one extra survey) and Palmers Point (five extra surveys). Only five total rockfish were caught in southern sites, and none were observed or captured in tidepools in northern sites. Of those five individuals, three were black rockfish *Sebastes melanops* and one was a vermilion rockfish, *Sebastes miniatus*, and one was likely a gopher rockfish *Sebastes carnatus* although due to its very small size it could have been a black-and-yellow rockfish *Sebastes chrysomelas*. At Palmers Point, one juvenile black rockfish was caught in a large channel that was connected to the ocean. At Fort Bragg Cove, four juvenile blue rockfish *Sebastes mystinus* were caught in a very large pool that was connected to the ocean, and small schools of black rockfish and pelagic gopher rockfishes were observed in the shallow subtidal and could be sampled with handheld dipnets. Since these were not isolated in pools, however, they were not included in the data collection.

These results are in stark contrast of previous studies done by Lomeli (2009), and Studebaker and Mulligan (2008), where hundreds to thousands of rockfish were being collected from isolated tidepools in the same areas surveyed in this study. One hypothesis about why there were no rockfish in the northern areas during this study is that the water temperature was warmer so the rockfish may have settled immediately into the subtidal rather than the intertidal. Upwelling patterns and water temperature can have strong influences on recruitment and intertidal fish assemblages (Ritter 2009, Shanks and Pfister 2009). During 2014 and 2015, California experienced a very strong positive El Niño event, causing warmer water temperatures and less upwelling. This can be seen when looking at changes in sea surface temperature (SST) using 2007 as a baseline and plotting the years this study was conducted (2014-2016) as differences from 2007. Sea surface temperature data was not available for the region in 2003-2005 during the Studebaker and Mulligan (2008) study. From the middle of January through March, water temperatures were typically several degrees warmer during this study than in previous years. This is the period when larval rockfish are in their pelagic stage and starting to settle out in central and northern California (Stein and Hassler 1989). Two possibilities arise from this information: either the pelagic larvae grew more quickly as a result of the warmer water and settled out much earlier in the intertidal and then moved to the subtidal much earlier as well, or survival of planktonic larvae was much lower due to inadequate ocean conditions resulting from the El Niño event, so there were very few recruits overall. The former is less likely because the search for rockfish in this study started at the end of March, well before the larvae would start to settle out. The settling (recruitment) stage where black rockfish are typically observed in the intertidal occurs from May to August (Moring 1986, Cox 2007, Studebaker and Mulligan 2008).

High Resolution Topographic Surveys

The goal of this portion of the project was to collect geological and geomorphological survey data at multiple rocky intertidal sites within the North California MPAs. Geospatial surveys allow quantitative methods to assess the relationships between geology of the rocky substratum and biodiversity of intertidal species. Linked, geospatial/biodiversity maps and datasets allow broader understanding of the ecology of different species, and serve as a basis for assessment of change resulting from (as examples) sea level rise, temperature variation and change in wave climate due to both climate change and potential changes in the wave regime.

This geospatial information was collected from a total of nine sites surveyed in the NCSR. These sites, including the main rocky shore lithology, geologic formation, and, when available, the age of the unit are:

1) Point S. George - Sandstones and mudstones, St. George Formation, late Miocene.
2) Kibesillah Hill - Metasandstones, Franciscan Complex, Cretaceous.
3) Shelter Cove - Metasandstones, Franciscan Complex, Cretaceous.
4) False Klamath Cove Rock Special Closure – Metasandstones, Franciscan Mélange.
5) Pyramid Point – Greenstones, Franciscan Mélange.
6) Abalobadiah Creek/10-Mile SMR – Greenstones, Franciscan Mélange.
7) Fort Bragg - Metasandstones, Franciscan Complex, Cretaceous.
8) MacKerricher SMCA - Metasandstones, Franciscan Complex, Cretaceous.
9) Patrick’s Point State Park - Metasandstones, Franciscan Mélange.

For each survey site we created high-resolution, Digital Elevation Models/baselines (DEMs) that can be used as the basis to interpret the relationships between geomorphology and geology at the outcrop scale. These DEM models can be also interpreted for surface parameters that are relevant to rocky intertidal ecology (e.g. roughness).

To produce high-resolution, 3D models of rock surfaces in rocky intertidal habitats using Terrestrial Laser Scanning (TLS), field surveys were carried out using a Trimble VX terrestrial laser scanner which uses Infrared laser and robotic technology in order to measure rock surface morphology at scales ranging between centimeter to meter scales to produce DEMs of the terrain.

Further details concerning the geology of each site, the location of the benchmarks and the number of surveys carried out can be found in the attached Appendix B.

We also tested different analytical approaches to parameterize the geospatial data and to quantify the ecologically significant geomorphologic parameter rugosity at scales that range from cm to tens of meters.

For the surveyed sites listed above, we created topographic maps over spatial scales ranging between cm to tens of meters, having higher resolution than traditional maps (minimum 0.01 m), and accuracies (<0.005m). We also combined the TLS surveys with more traditional field reconnaissance methods to identify structural and lithologic discontinuities that might affect the rock's geomorphology.

At each of the surveyed sites we established a geodetic framework of benchmarks using a differential GPS. Based on the overall geomorphological characteristics of the outcrop, we established one or two fore-sights from which the surveys were conducted plus one or two back-sights to orient the instrument and 4 or more ground controls to match surveys done from different fore-sights. Each site survey required approximately 2 to 3 days of fieldwork. During day one we established the benchmarks, collected georeferenced digital photomosaics of the outcrops and collected single point measurements of the transect tapes used for the ecological surveys done in parallel with the UCSC crew. Day 2 was devoted to high-resolution scanning and the collection of approximately 70,000 survey points per site. Day 3 was used to finish any work not done on previous days.

The survey data collected with the Trimble VX were then post-processed using Trimble's RealWorks, a proprietary 3D software that allows cleaning and registration of the topographic data points and, ultimately, the creation of high-resolution (cm) DEMs of each of the survey sites.

The DEMs were further analyzed to ascertain two main geomorphological parameters that were selected to model the surface characteristics of the rocky intertidal outcrops: 1) "Surface roughness" or root mean squared error (RMSE) of points from an interpolated surface defined by a linear polynomial function, and 2) "Relief" or Surface to Planar ratio based on the ration between the Surface and the 3 X, Y and Z components of each point, using Principle Component Analysis (PCA), see Figures 35-36.

The parameterization of rock surfaces was done with two different approaches:

1) Using ArcGIS - RMSE was measured for virtual quadrates created at 5 scales ($0.1m^2$, $0.5m^2$, $1m^2$, $5m^2$, $10m^2$). The ArcGIS procedure included: 1) random point generation to locate the center of virtual quadrats and dissect the DEMs in smaller plots; 2) selection of only those virtual quadrats that passed quality standards (e.g. enough points in the quadrats, homogenous distribution of points and lack of clustering); 3) calculation of the surface parameter RMSE for the quadrats that passed this quality control standard (Wheeler and Aiello, 2014; Wheeler, 2015).

2) Using Matlab - We developed a Matlab script that uses Delaunay triangulations to produce a Triangular Irregular Network (TIN) of the original survey data. For the triangles included in a window of variable size-range (between 0.1 and 10m) the Delauney triangles that are fully included are identified and the area of each triangle calculated. The script also calculates the area of an interpolated plane to the Delauney triangles included in the moving window using PCA. Finally, roughness is calculated as the ratio between the area of the triangles and the area of the interpolated plane (Aiello et al., 2016).

The large amount of geospatial data collected for this project and the results of the parameterization of the surface geomorphology (i.e. roughness) are still being analyzed and interpreted.

The presence of permanent benchmarks will also allow future surveys of the same sites to assess changes in the shoreline position and medium- to long-term shore stability to both wave action and sea level rise.

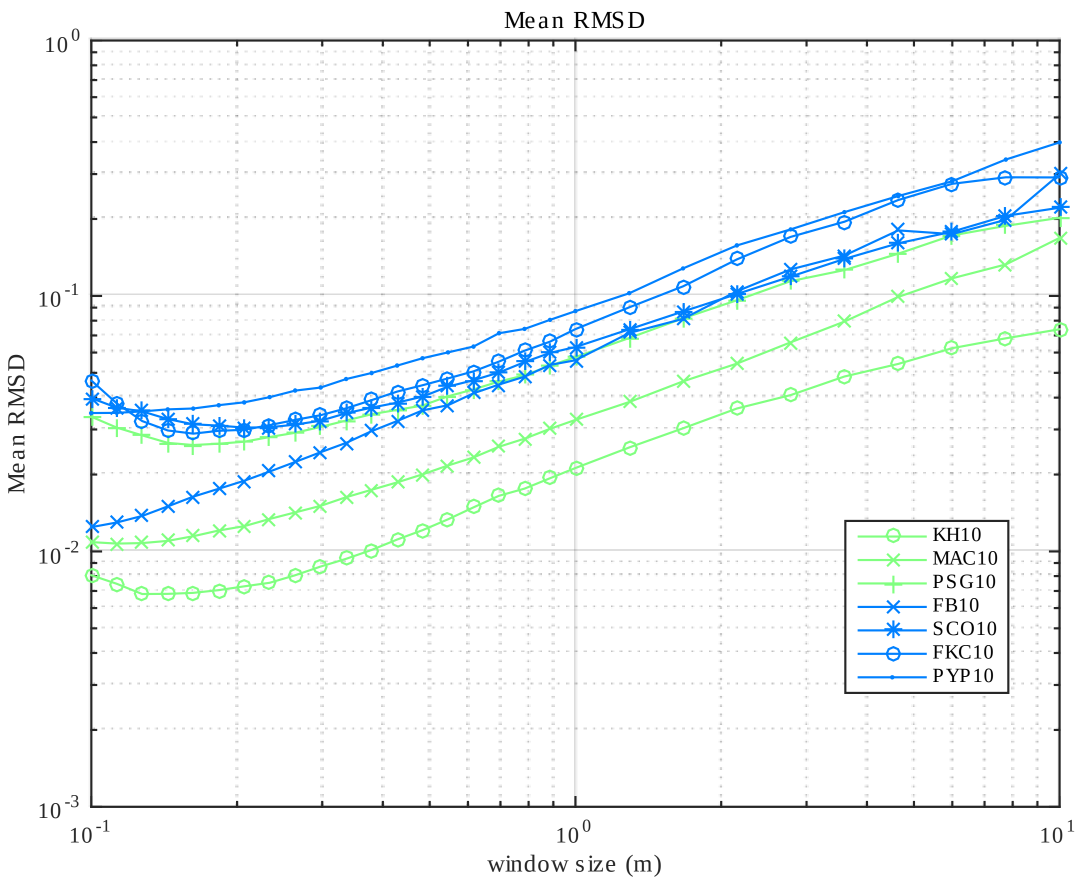


Figure 12. Semi-logarithmic plots of Surface Roughness expressed as mean RMSE vs. window size. RMSE shows a clear grouping of the rocky shore sites: the low rugosity shore platforms (KH=Kibesilla Hill, MAC=MacKerricher and PSG= Point St. George) show lower RMSE values for each window size than the higher rugosity rocky shore sites characterized by tilted beds and boulder fields (FB = Fort Bragg, SCO = Shelter Cove, FKC = False Klamath Cove and PYP = Pyramid Point).

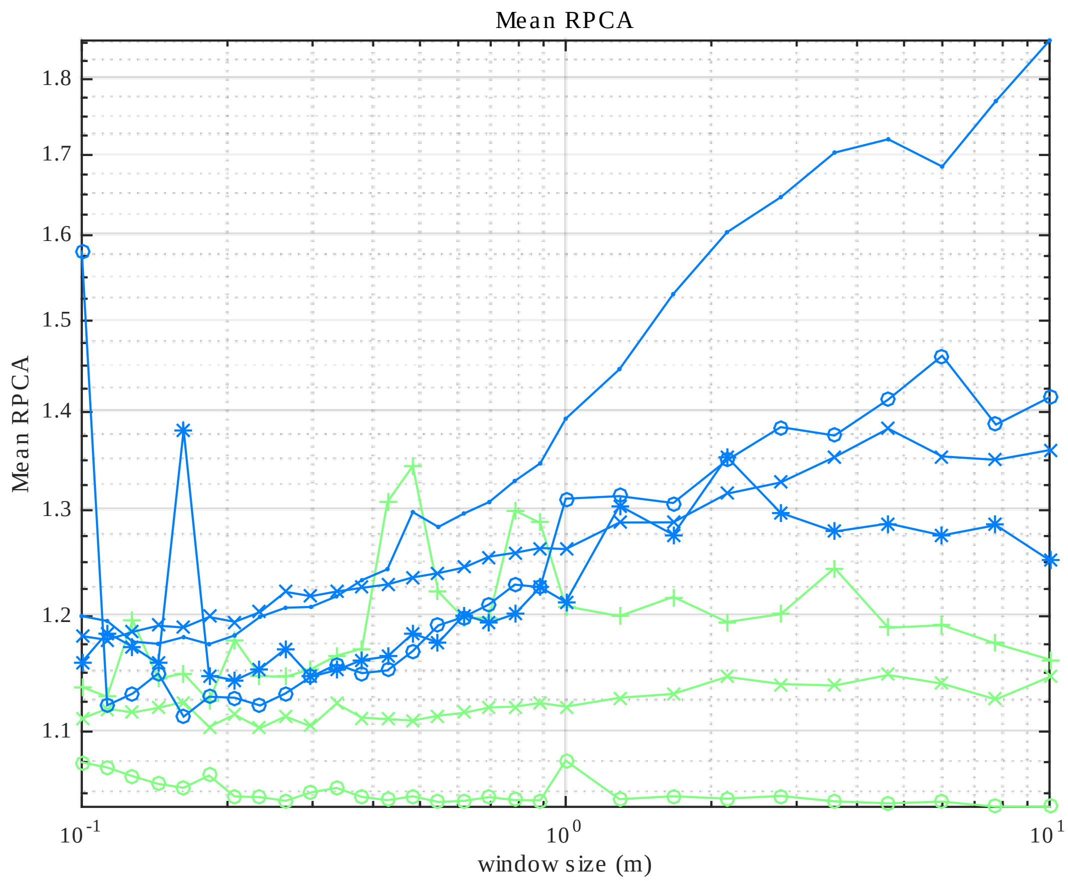


Figure 13. Semi-logarithmic plots of Roughness vs. window size, where roughness is calculated as the ration between surface and interpolated surface area, using Principal Component Analysis (RPCA). Note the key for this figure is the same as for Figure Z1 above. RPCA shows a clear grouping of the rocky shore sites: the low rugosity shore platforms (KH=Kibesilla Hill, MAC=MacKerricher and PSG= Point St. George) show lower RPCA values than the higher rugosity rocky shore sites characterized by tilted beds and boulder fields (FB = Fort Bragg, SCO = Shelter Cove, FKC = False Klamath Cove and PYP = Pyramid Point). Similar differences are also visible in the RPCA plot where the shore platform sites have generally low (<~1.2) roughness across all window sizes. Conversely, the high rugosity rock sites show an increase in roughness at window scales >~0.2m, which reflects the presence of tilted beds and boulders.

Summary of Findings from High Resolution Topographic Surveys

1) We found very clear patterns of species biogeography along the west coast of North America. We used this pattern to provide context for the NCSR. The NCSR is divided into two regions with a break near Cape Mendocino. The northern region extends from Cape Mendocino north to near Cape Arago, and the southern region extends from Cape Mendocino south to San Francisco. The biogeography of the intertidal community must be accounted for in any longer term assessment of community change and the effects of MPA protection.
2) For both mobile and sessile species, we found that Species Richness, if anything, was higher for sites not in MPAs. There was no pattern with respect to species diversity.

Importantly, these initial data can be used to gauge change in the future. Hence, the effect of protection should be relatively easy to interpret.

3) We compared the sessile and mobile biological communities associated with MPAs to those sites without protection using a PERMANOVA approach. We found that MPA status made no difference to either community. This is expected as this report is for the baseline characterization of the region during a period considered to be in the absence of MPA beneficial protection.
4) No measured habitat attribute (bench type, slope, relief or extent) was found to be an important predictor for the sessile community. By contrast, both bench slope and relief were important community predictors for the mobile community.

Long-Term Monitoring Recommendations

The methods used herein to assess the baseline conditions for Rocky Intertidal sites within the NCSR are identical to those developed by MARINe, and are used extensively by PISCO, MARINe, the State of California (for use in oil spill Natural Resource Damage Assessments = NRDA's), as well as in the Channel Islands and the South and Central Coast MPA baseline characterizations. These may be the most standardized, spatially and temporally expansive protocols used in any marine ecosystem in the world. Based on the vast data sets that have been collected thus far (which can be used for spatial and temporal analyses across the entire state of California), continued use of these protocols is likely the most powerful long-term approach to assess the efficacy of the MPA network for coastal, rocky intertidal ecosystems.

We believe that long-term monitoring should achieve the following four goals. (1) Sampling should provide an ability to assess species-specific change that is directly related to protection. This effort should focus on species subject to take (e.g. abalone, sea palms, mussels, sea stars). Here sampling should continue to use our focal species approach, which is consistent with targeted species monitoring. We recommend continued use of this focal species approach (also used in all other MPA studies of rocky intertidal regions), with continued focus on abalone, sea stars, mussels and sea palms. Both red abalone and sea palm have a history of harvest and have declined recently, so monitoring changes in abundance and possible recovery inside and outside MPAs is important. Abundance of the ochre sea star (*Pisaster ochraceus*), a conspicuous intertidal predator has declined dramatically along the North Coast (and the rest of the U.S. West Coast) as a result of Sea Star Wasting Disease. Despite this decline in the ochre star, supposedly a keystone predator, measures of abundance of a key prey species and dominant intertidal space competitor, the California mussel (*Mytilus californianus*), did not increase in bed depth, percent cover, or the size of individuals during the 2 years of this baseline study. Tracking the possible recovery of ochre star abundance, as well as the consequences for its California mussel prey will provide insight into this predator-prey system – upon which a great deal of marine ecological theory is based. One additional metric to document possible vertical expansion of mussel beds into the low intertidal would be to monitor the same metrics of mussel abundance (bed depth, percent cover, individual size) along vertical transects using methods established by S. Gravem et al. (unpub. data). (2) Sampling should provide an ability to assess the effect of protection on ecological function, as well as the diversity and integrity of communities. Our Biodiversity sampling protocols should be continue to be used here to allow detection of changes across as many taxa as possible, since all play some role in community and ecosystem function. (3) Sampling should be able to detect long-term change, such as that expected under climate change, or the success of the implementation of the MPA network. Since the effects of local fishing, large-scale environmental changes (e.g. global warming, ocean acidification), and their interactions are likely to be complex and difficult to predict *a priori*, the broad taxonomic coverage of the Biodiversity surveys is essential; if continued both inside and outside of MPAs, these surveys should provide valuable insight about whether observed changes are the result of local pressures (e.g. fishing) or large-scale processes. (4) Continued data collection should facilitate integration with existing datasets all along the Pacific coast, and this is true of the current sampling protocols used in this study, which match those of all other MPAs along the California coast.

We believe goals 1 and 2 (above) are met through the use of methodologies used in this North Coast baseline assessment, and therefore goal three can also be met in the future with continued use of these protocols. Finally, goal 4 (above) can be met because the target species and biodiversity approaches used in this study have also been used for all other statewide MPA regions, and are also core approaches for the Multi-Agency-Rocky-Intertidal Network (www.pacificrockyintertidal.org). Hence these data, all collected using the same protocols, will clearly allow goal 4 to be achieved.

It is possible that a less expert-intensive approach may be developed to complement these MARINe protocols which might possibly be completed by volunteer citizen science groups. PI Raimondi and colleagues have spent a considerable amount of time and effort assessing this question and have concluded that citizen science is unlikely to be useful for biodiversity and community level assessment, but could and should contribute to targeted species assessment. Citizen science has been somewhat controversial, and increasing cost-effectiveness may come at the possible expense of scientific accuracy. However, it is likely feasible to get at trends in MPA performance with the help of citizen scientists to monitor plots of a limited number of focal species.

For example, the North Central Coast (NCC) baseline study (Raimondi, PI) developed a reduced set of 9 species, incuding 6 sessile species (*Fucus* sp., *Mazzaella cordata/splendens*, *Mytilus californianus*, *Petrocelis* spp., *Phyllospadix scouleri/torreyi*) and 3 mobile species (*Littorina plena/scutulata*, small limpets, *Tegula funebralis*) which could be analyzed to examine community structure. When they completed such an analysis, they were able to show an 80% correlation between their matrices and the full set of all species matrices within their NCC final report. However, an analysis to examine the subset of focal species that are effective in providing results similar to the full data set used here has not been performed for the north coast. It has been done for certain other regions (e.g. Channel Islands) and is currently being assessed across a much wider region. Now that this final region of the California MPA baseline study for rocky intertidal sites has been completed, an analysis of community structure to develop a smaller set of more easily assayed invertebrates and algae should include all MPA/Reference sites along the coast of California.

While rocky intertidal fishes are highly diverse and abundant in many tide pools along the North Coast Study Region (NCSR), this report, which includes data from Kevin Hinterman's master's thesis at HSU, shows these fishes are highly variable in both time and space across the NCSR region. Nevertheless, the observed lower species richness within MPAs versus non-protected sites indicate that these tide pool fishes deserve more study, as they *may* respond to offshore fishing pressure. Given that this is the very first study of its kind done on tide pool fishes inside versus outside of MPA sites, it is too soon to tell.

We recommend continued sampling of tidepool fishes yearly (each summer) as a part of rocky intertidal monitoring at MPA sites (and reference sites) within the Northern California region. Juvenile black rockfish have been shown to heavily utilize tide pools on rocky shores along our coast in the past, and we suspect that the lack of juvenile black rockfish in tidepools during the period of study included in this work (2014-2015) may have more to do with the unusual oceanographic conditions (e..g the "warm blob"), present during this study, than anything else.

It is unclear whether differences in tidepool fish species richness found in this study reflect a lack of sufficient sampling through time, or is indicative of early changes within MPA sites relative to nearby reference sites (which seems doubtful). Therefore we also recommend using the methods included herein to study "focal tidepools" in order to continue monitoring tidepool fishes to assess the effects of MPA designation on rocky intertidal fish community structure, integrity and ecosystem function. Many of these fishes have a strong effect on recruitment dynamics of invertebrates within these habitats, and a few (e.g. rockfish) may depend on tidepool habitats as nursery areas for juveniles-indicating their importance for recovery of rockfish populations.

The Terrestrial laser scanning (TLS) used in this project provides higher resolutions (cm), higher accuracies (mm), increased portability and more rapid data collection (tens of points per second), all characteristics which are superior compared to traditional survey methods using total stations or rotating construction-lasers. The survey system used for this project is a Trimble Spatial station which, compared to other TLS systems, also has the option of combining IR laser scanning with single point measurements using a survey rod equipped with a laser target, and can also take georeferenced digital photographs. These characteristics are particularly important when working in highly rugged rocky intertidal terrain, where survey times are constrained by the narrow temporal window of the negative tides and the equipment sometimes has to be carried over long distances from the nearest access road.

The survey data collected with this method provide an essential geomorphologic baseline needed for long-term monitoring studies in order to understand coastal change and the effects of this change on local biodiversity, as well as to investigate how the surface characteristics of rocky shores influence/control intertidal ecological patterns. In addition, the TLS system used here can ultimately create a high-resolution coastal baseline to monitor the effects of sea level rise.

The frequency at which these surveys should be collected depends upon several factors, including the type of rocky shore. According to historic classification of rocky shores, two main types can be recognized: (1) rock platforms and (2) bouldery rocky shores. The latter are formed by a mix of bedrock and boulders ranging in size from pebbles to rock fragments that, while relatively stable during fair conditions, can be broken and re-mobilized during storms. Most of the sites included in this baseline assessment of the Northern California coast are dominated by boulder fields, and thus are more prone to geomorphologic change at seasonal and longer (e.g. El Niño) scales of variability. Rocky shore sites that are periodically affected by the accumulation and erosion of sediments, carried by longshore drift, can also change at seasonal scales. Hence these sites should be sampled frequently-preferably every year before and after the winter season, during the same months. For longer term monitoring on relatively stable rocky shore sites, we believe surveys every 5 years should be sufficient. Finally, it is worth mentioning that certain indicator species in this study (e.g. red abalone) seem to be good choices for future metrics concerning the performance of MPAs. We found red abalone in abundance at only 1 of our 16 rocky intertidal sites: at the Fort Bragg Noyo Headlands (former GP mill) site behind the fences and guards that essentially made this location a very effective *de facto* marine reserve. While it may not be surprising that this species has disappeared from almost all rocky intertidal habitats along the North Coast Study Region (NCSR), much as they have from other rocky intertidal sites all along the coast of California, their presence at the Fort Bragg site certainly serves to remind us of what at least some undisturbed rocky intertidal sites might look like if they were truly protected. Clearly, harvesting of these marine animals has been extensive and intense over time in California.

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Appendix A: Site Descriptions (North to South)

Pyramid Point

Pyramid Point is located in the North Coast region of California within the Pyramid Point State Marine Conservation Area and is within Tolowa Dee-ni' Nation ancestral territory. 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.

Figure 14. 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.

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 within Tolowa Dee-ni' Nation ancestral territory. 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.

Figure 15. 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.

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, and also within Tolowa Dee-ni' Nation ancestral territory. 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.

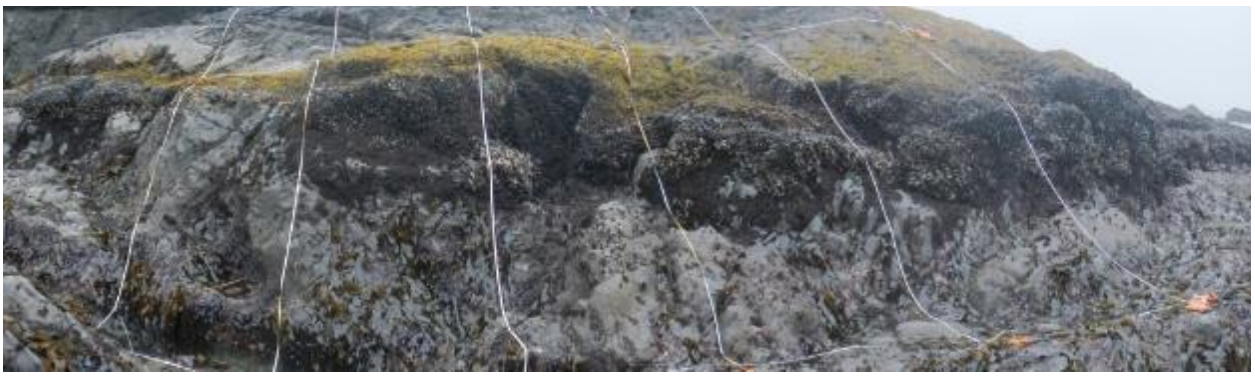

Figure 16. Endert's Beach is dominated by consolidated bedrock (greywacke mudstone/sandstone with calcite intrusions), and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The coastal orientation of this site is both north and south.

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, and also within Tolowa Dee-ni' Nation ancestral territory. 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.

Figure 17. 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.

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.

Figure 18. 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.

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).

Palmer’s Point

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

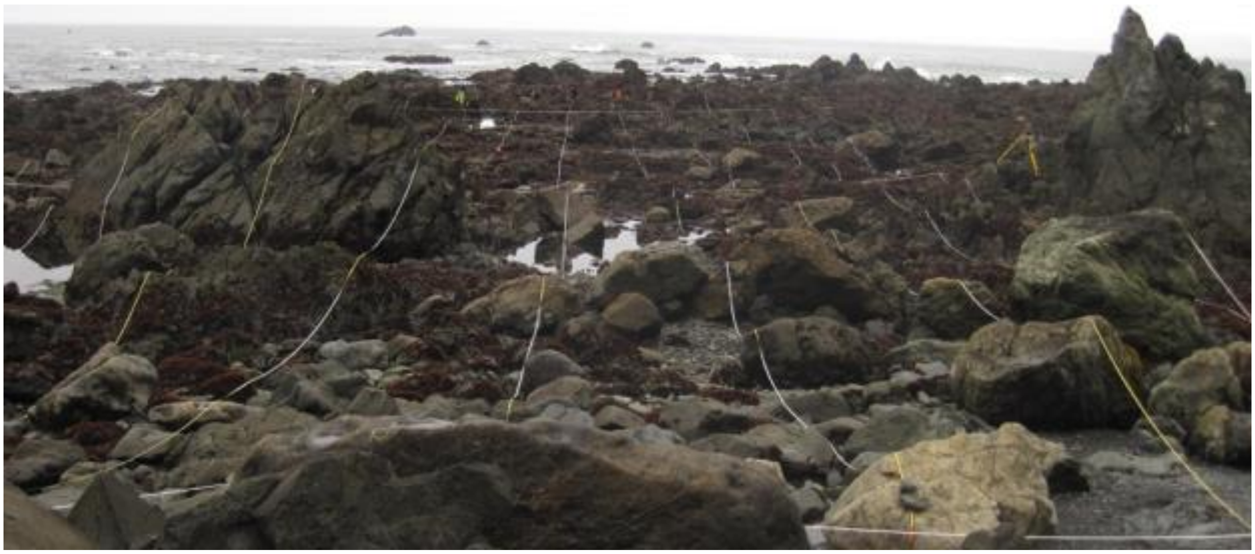

Figure 19. Palmer’s Point is dominated by a mixture of consolidated bedrock and boulder fields, and the area surrounding the site is comprised of a mixture of consolidated bedrock, boulder fields, and sandy beach. The primary coastal orientation of this site is west/northwest.

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.

Figure 20. 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.

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.

Figure 21. 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.

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 tide poolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Figure 22. 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.

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.

Figure 23. 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.

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.

Figure 24. 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.

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 fishermen and tide poolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Figure 25. 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.

The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 80 meters (seaward).

Abalobadiah Creek

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

Figure 26. 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.

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 Conservation Area and MacKerricher State Park. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Figure 27. 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.

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.

Figure 28. 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.

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. 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.

Figure 29. 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.

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. This site is 1.3 mi southeast of the Point Arena Lighthouse Mussel Watch site. This site currently receives low visitation by tide poolers. While open between 2005 and 2010, the site received moderate to high visitation during low tides by abalone divers, fishermen, and tide poolers. Portions of this site are only accessible during low tides. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Figure 30. 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.

The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 33 meters (seaward).

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 tide poolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Figure 31. 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.

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. This site is near the Saunders Landing/Saunders Reef Mussel Watch site. This site receives low visitation by abalone divers, fishermen, and tide poolers. This gently sloping site consists of moderately uneven terrain, containing few cracks and folds.

Figure 32. 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.

The Biodiversity Survey grid encompasses one section that is approximately 30 meters (along shore) x 80 meters (seaward).

Appendix B: Topographic Descriptions

Topographic Survey, Site = Point Saint George

Point St. George, Crescent City, Del Norte County, Northern California
Survey Dates: 5/19-20/2014
WGS 1984 UTM Zone 10N, Geoid 2003

Main Coordinates

Measured using Trimble Differential GPS, 100 point count and averaged
Foresight (FS1): 4626622.89 N 395705.97 E 5.14m Elevation
Backsight (FS2): 4626597.63 N 395679.96 E 1.349m Elevation

Controls

Each control was a bolt in the intertidal from the NCMPA sampling grid. Each bolt measured is listed along with the foresight each bolt was measured from with the difference in position for each bolt measured multiple times.

Table 5. Coordinates of survey bolts at Point Saint George (PSG).

Name	Measured From	Northing	Easting	Elevation (m)	N Diff (m)	E Diff (m)	El Diff (m)	Comments
FS1	FS2	4626622.867	395705.947	5.132				
FS2	FS1	4626597.664	395679.995	1.349	-0.009	-0.009	-0.009	
FS2	FS1(1)	4626597.673	395680.004	1.358				
OT1	FS2	4626627.285	395702.726	1.882				
OT3	FS1	4626600.298	395693.038	1.341	0.03	-0.003	0.004	FS1-FS1(1)
OT3-1	FS1(1)	4626600.268	395693.041	1.337	0.02	0.031	0.012	FS1(1)-FS2
OT3-2	FS2	4626600.248	395693.01	1.325	0.05	0.028	0.016	FS2-FS1
OT4	FS1	4626631.162	395693.84	0.603	0.059	0.058	-0.004	
OT4-2	FS2	4626631.103	395693.782	0.607				
OT5	FS1	4626603.961	395683.908	1.363	0.042	0.002	-0.021	
OT5-2	FS2	4626603.919	395683.906	1.384				

* OT3-1 and OT4-1 measured from FS1(1) were taken, however, station measured FS2 target instead of prism on rod

Figure 33. Stitched photomosaic of Point Saint George (PSG). Locations of survey station and bolts are marked.

Table 6. Differences in coordinates from TLS versus GPS at Point Saint George (PSG). Northing, Easting, and Elevation coordinates from 100 GPS counts compared with TLS coordinates relative to coordinates of station FS2 because all main bolts could be measured from this location.

Bolt	Latitude	Longitude	Elevation (m)	UTM N	UTM E	TLS N	TLS E	TLS El (m)	N Diff (m)	E Diff (m)	El Diff (m)
OT1	41.784643828	-124.255127074	2.32	4626627.19	395702.66	4626627.285	395702.726	1.882	-0.09	-0.07	0.438
OT3	41.784399054	-124.255239910	1.84	4626600.15	395692.89	4626600.248	395693.010	1.325	-0.1	-0.12	0.515
OT4	41.784678062	-124.255235221	0.99	4626631.12	395693.73	4626631.103	395693.782	0.607	0.02	-0.05	0.383
OT5	41.784431426	-124.255349996	1.84	4626603.88	395683.80	4626603.919	395683.906	1.384	-0.04	-0.11	0.456
FS1	41.784605482	-124.255086596	5.14	4626622.89	395705.97	4626622.867	395705.947	5.132	0.02	0.02	0.008
FS2	41.784374673	-124.255395007	1.42	4626597.63	395679.96	4626597.664	395679.995	1.349	-0.03	-0.03	0.071

<u>Scans</u>
Scan0214 – from FS1 @ 0.5m x 0.25m with 25m distance
Scan0215 – from FS1(1) @ 0.2m x 0.1m with 20m distance
Scan0216 – from FS1(1) @ 0.2m x 0.1m with 20m distance
Scan0217 – from FS1(1) @ 0.05m x 0.025m with 10m distance
Scan0218 – from FS1(1) @ 0.2m x 0.1m with 15m distance
Scan0219 – from FS1(1) @ 0.2m x 0.1m with 40m distance
Scan0220 – from FS1(1) @ 0.1m x 0.05m with 35m distance
Scan0221 – from FS2 @ 0.1m x 0.05m with 18m distance
Scan0222 – from FS2 @ 0.1m x 0.05m with 35m distance
Scan0223 – from FS2 @ 0.1m x 0.05m with 17m distance
Scan0224 – from FS2 @ 0.1m x 0.05m with 16m distance
Scan0225 – from FS2 @ 0.1m x 0.05m with 45m distance
Scan0226 – from FS2 @ 0.1m x 0.05m with 10m distance
Scan0227 – from FS2 @ 0.1m x 0.05m with 15m distance
Scan0228 – from FS2 @ 0.1m x 0.05m with 20m distance

<u>Topo Points</u>
Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 3 meters (0,3,6,9,12…).
UT-Upper Transect
LT-Lower Transect
Labeled as:
T#-#: Transect Number Line-Meter along transect

<u>Site Geology</u>
Rocky intertidal consisted of fine sand/mudstone sedimentary boulders and bedrock, however no clear bedding of sedimentary layers were observed. However, bedrock had obviously been uplifted and tilted, giving the majority of bedrock a dip between 50-55° to the northeast.

Kjfmc –KJfmc Mélange unit of Crescent City area (Cretaceous and Jurassic) – Tectonically disrupted blocks of greywacke, shale, conglomerate, chert, limestone, phyllite, greenstone, and serpentinite, in a shaley matrix; contact with KJfbf to the east is gradational, marked by the disappearance of chert and greenstone blocks (Aalto and Harper, 1982). Unlike mélange of the Central Belt (KJfm), exotic blocks of blueschist are absent. Where exposed along the shoreline west of Crescent City, some disruption of strata interpreted as due to olistostromal deposition and soft-sediment deformation of turbidite beds (Aalto, 1989a). Individual blocks large enough to be shown at this Greenstone; Metagraywacke Red and green, thin bedded, radiolarian chert Undifferentiated rock mass mapped from a distance or aerial photos, but lithology not confirmed in the field. map scale are as follows: mostly agglomerate, felsic tuff, and pillow basalt.

<u>Topographic Survey: Site = Kibesillah Hill</u>

Site: Kibesillah Hill, Menacino County, Northern California
Survey Dates: 6/14-15/2014
WGS 1984 UTM Zone 10N, Geoid 2003

<u>Main Coordinates</u>

Foresight 1 (FS1): Measured using Trimble Differential GPS, 100 points measured and averaged, used as backsight for FS2
Foresight 2 (FS2): Measured using Trimble Differential GPS, 100 points measured and averaged, used as backsight for FS2

Control Points

Each control was a bolt in the intertidal from the NCMPA sapling grid. Each bolt measured is listed along with the foresight each bolt was measured fro with the difference in position for each bolt measured multiple times.

Table 7. Coordinates of survey bolts at Kibesillah Hill (KIB).

Name	Measured From	Northing	Easting	Elevation	N Diff	E Diff	El Diff
FS1	GPS	4384091.280	432299.390	4.580			
FS1	FS2	4384091.273	432299.387	4.379	0.007	0.003	0.201
FS2	GPS	4384042.520	432281.160	5.600			
FS2	FS1	4384042.461	432281.138	5.531	0.059	0.022	0.069
OT1	FS1	4384118.355	432276.240	1.910	0.013	0.009	-0.009
OT1-1	FS2-Day 1	4384118.342	432276.231	1.919	-0.014	0.013	0.010
OT1-2	FS2-Day 2	4384118.356	432276.218	1.909	-0.001	0.022	0.001
OT2	FS1	4384089.504	432284.143	2.467	0.029	-0.012	0.036
OT2-1	FS2-Day 1	4384089.475	432284.155	2.431	-0.014	0.019	-0.035
OT2-2	FS2-Day 2	4384089.489	432284.136	2.466	0.015	0.007	0.001
OT3	FS1	4384134.415	432229.000	0.744	-0.002	0.006	0.001
OT3-2	FS2-Day 2	4384134.417	432228.994	0.743			
OT4	FS1	4384105.639	432235.308	1.307	0.030	0.021	0.014
OT4-1	FS2-Day 1	4384105.609	432235.287	1.293	-0.022	0.026	-0.013
OT4-2	FS2-Day 2	4384105.631	432235.261	1.306	0.008	0.047	0.001

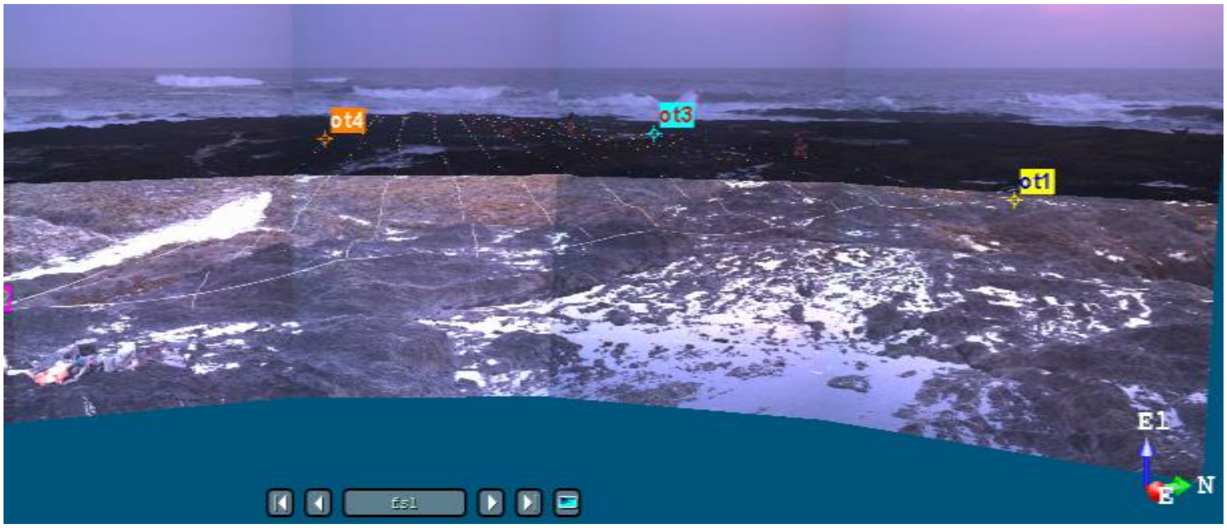

Figure 34. Stitched photomosaic of Kibesillah Hill (KIB). Locations of bolts are marked.

Table 8. Differences in coordinates from TLS versus GPS at Kibesillah Hill (KIB). Northing, Easting, and Elevation coordinates from 100 GPS counts are compared with TLS coordinates relative to station FS1.

Bolt	Latitude	Longitude	Elevation (m)	UTM N	UTM E	TLS UTM N	TLS UTM E	TLS Elevation (m)	N Diff	E Diff	El Diff
OT1	39.60413211	-123.788848	1.57	4384118.470	432276.540	4384118.355	432276.240	1.910	0.115	0.300	-0.340
OT2	39.60387305	-123.7887536	2.09	4384089.640	432284.390	4384089.504	432284.143	2.467	0.136	0.247	-0.377
OT2	39.60387281	-123.7887538	2.01	4384089.620	432284.380	4384089.504	432284.143	2.467	0.116	0.237	-0.457
FS2	39.60344824	-123.7887865	5.6	4384042.520	432281.160	4384042.461	432281.138	5.531	0.059	0.022	0.069

<u>Surveys</u>

Scans

Scan0243	0.5m x 0.5m	80m
Scan0244	0.5m x 0.5m	110m
Scan 0245	0.5m x 0.5m	30m
Scan0246	0.5m x 0.5m	15m
Scan0247	0.1m x 0.05m	40m
Scan0248	0.1m x 0.05m	35m
Scan0249	0.1m x 0.05m	92m
Scan0250	0.1m x 0.05m	70m
Scan0251	0.1m x 0.05m	50m
Scan0252	0.1m x 0.05m	50m
Scan0253	0.1m x 0.05m	40m
Scan0254	0.1m x 0.05m	50m
Scan0255	0.05m x 0.025m	25m
Scan0256	0.01m x 0.01m	30m
Scan0257	0.01m x 0.025m	70m
Scan0258	0.01m x 0.025m	55m
Scan0259	0.5m x 0.25m	90m
Scan0260	0.1m x 0.05m	100m
Scan0261	0.1m x 0.05m	100m
Scan0262	0.1m x 0.05m	130m
Scan0263	0.1m x 0.05m	140m

Scan0264	0.1m x 0.05m	125m
Scan0265	0.1m x 0.05m	130m
Scan0266	0.1m x 0.05m	90m
Scan0267	0.1m x 0.05m	85m
Scan0268	0.1m x 0.05m	120m
Scan0269	0.1m x 0.05m	65m
Scan0270	0.1m x 0.05m	50m
Scan0271	0.1m x 0.05m	80m
Scan0272	0.1m x 0.05m	130m
Scan0273	0.1m x 0.05m	80m

Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 3 meters (0,3,6,9,12…).
UT-Upper Transect
LT-Lower Transect
Labeled as:
T#-#: Transect Number Line-Meter along transect

Site Geology

This area consists of brittle cretaceous marine sandstone with many fine calcite veins with consistent flat bedded features. Survey site consists of a long wave cut bench, with micro-fault to the east and south of the site, and a pocket beach to the north.

<u>Topographic Survey: Site = Shelter Cove</u>
Site: Shelter Cove, Humboldt County, California
Survey Dates: 5/16-17/2014
WGS 1984 UTM Zone 10N, Geoid 2003

<u>Main Coordinates</u>
Foresight 1 (FS1): Measured using Trimble Differential GPS, 100 points measured and averaged
Foresight 2 (FS2): Measured using TLS from FS1
Backsight (BS): Measured using Trimble Differential GPS, 100 points measured and averaged

Control Points
Each control was a bolt in the intertidal from the NCMPA sampling grid. Each bolt measured is listed along with the foresight each bolt was measured from with the difference in position for each bolt measured twice.

Table 9. Coordinates of survey bolts at Shelter Cove.

Point	Surveyed From	El	Northing	Easting	El Diff	N Diff	E Diff
FS1	GPS	2.210	4430818.460	408377.620	0.1	0.008	-0.004
FS1	FS2	2.110	4430818.452	408377.624			
BS	GPS	3.080	4430852.850	408411.080	0.008	0	0
BS	FS1-Day1	3.072	4430852.850	408411.080	0.003	-0.004	-0.004
BS	FS1-Day2	3.069	4430852.854	408411.084	-0.003	0.019	0.045
BS	FS2	3.072	4430852.835	408411.039	0	0.015	0.041
FS2	FS1-Day1	0.754	4430830.589	408348.987			
O1	FS1-Day1	0.662	4430833.610	408363.757	0.005	-0.047	0.038
OT1-1	FS1-Day2	0.657	4430833.657	408363.719	-0.006	0.062	0.01
OT1-2	FS2	0.663	4430833.595	408363.709	-0.001	-0.047	0.048
O2	FS1-Day1	1.636	4430809.939	408381.772	0.006	-0.016	0.039
OT2-1	FS1-Day2	1.630	4430809.955	408381.733	-0.007	0.039	0.01
OT2-2	FS2	1.637	4430809.916	408381.723	-0.001	0.023	0.049
OT3	FS1-Day1	0.851	4430814.537	408331.589	0.006	-0.007	0.057
OT3-1	FS1-Day2	0.845	4430814.544	408331.532	-0.006	0.027	-0.029
OT3-2	FS2	0.851	4430814.517	408331.561	0	0.02	0.028
OT4	FS1-Day1	-0.022	4430790.340	408348.901	0.007	-0.005	0.048
OT4-1	FS1-Day2	-0.029	4430790.345	408348.853	-0.007	0.051	-0.011
OT4-2	FS2	-0.022	4430790.294	408348.864	0	0.046	0.037
OT5	FS1-Day1	0.615	4430826.487	408351.457	-0.023	0.089	-0.033
OT5-1	FS1-Day2	0.638	4430826.398	408351.490	-0.027	-0.007	0.044
OT5-2	FS2	0.665	4430826.405	408351.446	-0.05	0.082	0.011
OT6	FS1-Day1	0.977	4430802.677	408369.546	0.004	0.02	-0.057
OT6-1	FS1-Day2	0.973	4430802.657	408369.603	-0.01	-0.002	0.094
OT6-2	FS2	0.983	4430802.659	408369.509	-0.006	0.018	0.037

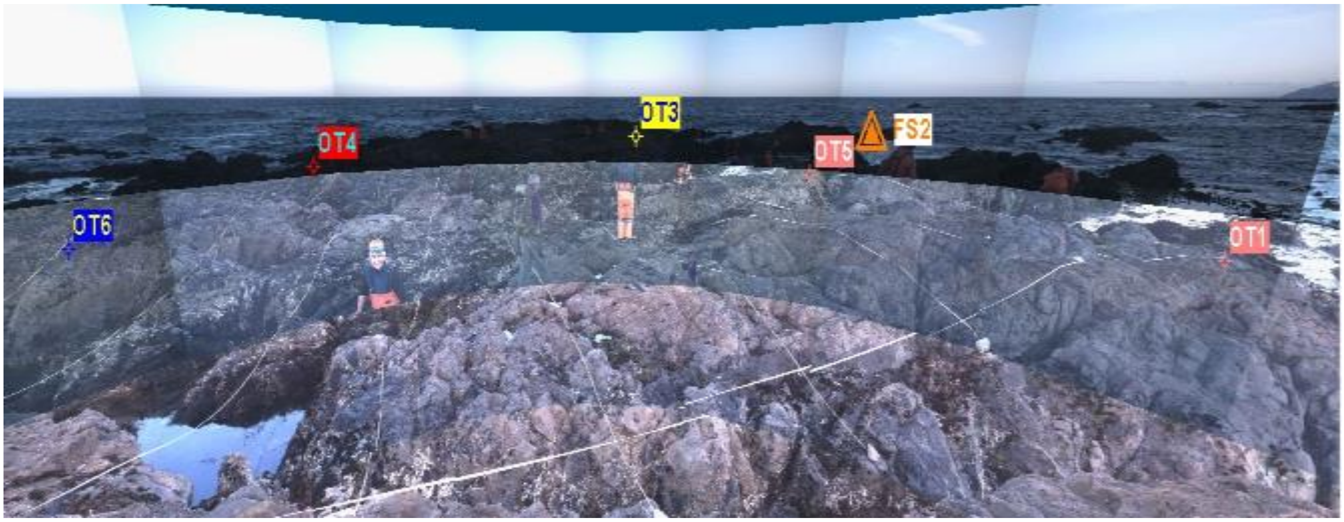

Figure 35. Stitched photomosaic of Shelter Cove. Locations of survey station and bolts are marked.

Table 10. Differences in coordinates from TLS versus GPS at Shelter Cove. Northing, Easting, and Elevation coordinates from 100 GPS counts are compared with TLS coordinates relative to station FS1.

Bolt	Latitude	Longitude	GPS Elevation	UTM N	UTM E	TLS UTM N	TLS UTM E	TLS Elevation	N Diff	E Diff	El Diff
OT1	40.02274142	-124.073876	0.82	4430833.37	408362.07	4430833.61	408363.757	0.662	-0.24	-1.687	0.158
OT2	40.02252983	-124.0736612	1.86	4430809.89	408381.79	4430809.94	408381.772	1.636	-0.05	0.018	0.224
OT2-2	40.0225304	-124.073661	1.66	4430809.95	408381.81	4430809.94	408381.772	1.636	0.01	0.038	0.024
BS	40.02292002	-124.0733241	3.08	4430852.85	408411.08	4430852.84	408411.039	3.072	0.01	0.041	0.008
FS1	40.02260663	-124.0737113	2.10	4430818.46	408377.62	4430818.45	408377.624	2.110	0.01	-0.004	-0.010

Scans

Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 3 meters (0,3,6,9,12…).
UT-Upper Transect
LT-Lower Transect
Labeled as:
T#-#: Transect Number Line-Meter along transect

Site Geology: Site lithology is of the Fransciscan Formation of complex metamorphosed marine clastic sedimentary and mafic igneous rocks which are highly sheared, dated to be from the Mezozoic or Upper Jurassic. The outcrop is composed of many fractures from meter to sub-meter scale with many calcite veins, forming deep channels within the study site.

<u>Topographic Survey: Site = False Klamath Cove</u>
Site: False Klamath Cove, Del Norte County, Northern California
Survey Dates: 5/15-16/2014
WGS 1984 UTM Zone 10N, Geoid 2003

<u>Main Coordinates</u>
Foresight 1 (FS1): Measured using Trimble Differential GPS, 100 points measured and averaged
Backsight for FS1 (FS2): FS2 is also known as OT1, a bolt installed in intertidal for NCMPA sampling grid

Foresight 3 (fs3-1): Measured from Foresight (FS1)-Bolt in intertidal outside of gridded sample area
Backsight for fs3-1: FS1 measured from fs3-1: 4605334.351 N 407964.018 E 11.803 Elevation

Control Points
Each control was a bolt in the intertidal from the NCMPA sampling grid. Each bolt measured is listed along with the foresight each bolt was measured from with the difference in position for each bolt measured twice.

Table 11. Coordinates of survey bolts at False Klamath Cove.

Name	Measured From	Northing	Easting	Elevation	N Diff	E Diff	El Diff
FS1	GPS/FS3	4605334.351	407964.081	11.820			
FS2 (OT1)	FS1	4605316.965	407879.833	3.343			
FS3	FS1	4605286.084	407910.749	0.735			
OT2	FS1	4605305.819	407883.788	2.904	0	0.013	0
OT2-1	FS3	4605305.819	407883.775	2.904			
OT3	FS1	4605315.696	407875.465	1.426	0	-0.033	0.001
OT3-1	FS3	4605315.696	407875.498	1.425			
OT4	FS1	4605304.493	407879.477	1.015	0.036	-0.008	0.004
OT4-1	FS3	4605304.457	407879.485	1.011			
OT5	FS1	4605312.181	407896.027	3.212	0.016	-0.015	0.001
OT5-1	FS3	4605312.165	407896.042	3.211			
OT7	FS1	4605302.480	407906.857	2.243	-0.002	0.022	-0.017
OT7-1	FS3	4605302.482	407906.835	2.260			
OT8	FS1	4605302.353	407888.559	1.231	-0.003	-0.001	0.006
OT8-1	FS3	4605302.356	407888.560	1.225			
OT9-1	FS1	4605292.37	407899.701	1.194			

Figure 36. Stitched photomosaic of False Klamath Cove. Locations of survey station and bolts are marked.

Table 12. Differences in coordinates from TLS versus GPS at False Klamath Cove. Northing, Easting, and Elevation coordinates from 100 GPS counts are compared with TLS coordinates relative to station FS1.

Bolt	Latitude	Longitude	Elevation (m)	UTM N	UTM E	TLS UTM N	TLS UTM E	TLS Elevation	N Diff	E Diff	El Diff
OT1	41.59426408	-124.1053283	2.94	4605319.35	407879.45	4605316.965	407879.833	3.343	2.385	-0.383	-0.403
OT3	41.59425371	-124.1053808	1.05	4605318.25	407875.06	4605315.696	407875.465	1.426	2.554	-0.405	-0.376
OT2	41.5941634	-124.1052829	2.52	4605308.12	407883.09	4605305.819	407883.788	2.904	2.301	-0.698	-0.384
OT4	41.59415145	-124.1053346	0.62	4605306.85	407878.77	4605304.493	407879.477	1.015	2.357	-0.707	-0.395
OT8	41.59413154	-124.1052261	0.82	4605304.53	407887.78	4605302.353	407888.559	1.231	2.177	-0.779	-0.411
OT9	41.59403991	-124.1050942	0.87	4605294.21	407898.64	4605292.370	407899.701	1.194	1.84	-1.061	-0.324
OT7	41.5941308	-124.1050067	1.94	4605304.21	407906.06	4605302.480	407906.857	2.243	1.73	-0.797	-0.303
OT6	41.59420012	-124.1051281	3.07	4605312.04	407896.05	N/A	N/A	N/A	N/A	N/A	N/A
OT5	41.59421943	-124.1051348	2.8	4605314.19	407895.51	4605312.181	407896.027	3.212	2.009	-0.517	-0.412
FS1	41.59440893	-124.1043161	11.82	4605334.35	407964.02	4605334.350	407964.020	11.82	0	0	0

Scans
Scan0185: from FS1 @ 0.5m x 0.25m, distance 60m
Scan0186: from FS1 @ 0.05m x 0.1m, distance 60m
Scan0187: from FS1 @ 0.05m x 0.1m, distance 60m
Scan0188: from FS3 @ 0.05m x 0.025m, distance 20m
Scan0189: from FS3 @ 0.05m x 0.025m, distance 20m
Scan0190: from FS3 @ 0.05m x 0.025m, distance 20m
Scan0191: from FS3 @ 0.05m x 0.025m, distance 20m
Scan0192: from FS3 @ 0.05m x 0.025m, distance 20m
Scan0193: from FS3 @ 0.05m x 0.025m, distance 20m
Scan0194: from FS3 @ 0.05m x 0.025m, distance 13m
Scan0195: from FS3 @ 0.05m x 0.025m, distance 13m
Scan0196: from FS3 @ 0.05m x 0.025m, distance 13m

Scan0197: from FS3 @ 0.05m x 0.025m, distance 13m

Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 3 meters (0,3,6,9,12…).
UT-Upper Transect
LT-Lower Transect
Labeled as:
T#-#: Transect Number Line-Meter along transect

Site Geology
Mainly consisted of large boulders and bedrock composed of a metamorphic greywacke mélange which remains after softer material which once surrounded it has been weathered away. The main control of feature formation is most likely fractures which range from about 1m to cm spacing and where these fractures intersect to form joints creating a weaker area where more erosion persists.

Kjfmc –KJfmc Mélange unit of Crescent City area (Cretaceous and Jurassic) – Tectonically disrupted blocks of greywacke, shale, conglomerate, chert, limestone, phyllite, greenstone, and serpentinite, in a shaley matrix; contact with KJfbf to the east is gradational, marked by the disappearance of chert and greenstone blocks (Aalto and Harper, 1982). Unlike mélange of the Central Belt (KJfm), exotic blocks of blueschist are absent. Where exposed along the shoreline west of Crescent City, some disruption of strata interpreted as due to olistostromal deposition and soft-sediment deformation of turbidite beds (Aalto, 1989a). Individual blocks large enough to be shown at this Greenstone; Metagraywacke Red and green, thin bedded, radiolarian chert Undifferentiated rock mass mapped from a distance or aerial photos, but lithology not confirmed in the field. map scale are as follows: mostly agglomerate, felsic tuff, and pillow basalt.

Topographic Survey: Site = Pyramid Point

Pyramid Point SMCA, Del Norte County, Northern California
Survey Dates: 5/17-18/2014
WGS 1984 UTM Zone 10N, Geoid 2003

Main Coordinate

Measured using Trimble Differential GPS, 100 points measured and averaged
Foresight (FS1): 4649359.6 N 399843.35 E 4.84m Elevation

Controls

Each control was a bolt in the intertidal from the NCMPA sampling grid. Each bolt measured is listed along with the foresight each bolt was measured from with the difference in position for each bolt measured twice

Table 13. Coordinates of survey bolts at Pyramid Point (PYR)

Name	Measured From	Northing	Easting	Elevation (m)	N Diff (m)	E Diff (m)	El Diff (m)
FS1	GPS	4649359.6	399843.35	4.84			
OT1	FS1	4649355.608	399831.621	2.418	-0.015	0.018	-0.008
OT1-1	FS1-Day 2	4649355.623	399831.603	2.426			
OT2	FS1	4649336.501	399837.691	2.556	-0.076	0.028	0
OT2-1	FS1-Day 2	4649336.577	399837.663	2.556			
OT3	FS1	4649351.27	399819.992	1.754	-0.027	0.01	-0.001
OT3-1	FS1-Day 2	4649351.297	399819.982	1.755			
OT4	FS1	4649332.279	399825.901	1.354	0.001	0.001	0.009
OT4-1	FS1-Day 2	4649332.278	399825.9	1.345			

Figure 37. Stitched photomosaic of Pyramid Point (PYR). Locations of survey bolts are marked.

Table 14. Differences in coordinates from TLS versus GPS at Pyramid Point (PYR). Northing, Easting, and Elevation coordinates from 100 GPS counts are compared with TLS coordinates relative to station FS1.

Bolt	Latitude	Longitude	Elevation (m)	UTM N	UTM E	TLS N	TLS E	TLS El (m)	N Diff (m)	E Diff (m)	El Diff (m)
OT1	41.989841119	-124.209303819	2.37	4649355.55	399831.61	4649355.608	399831.621	2.418	-0.058	-0.011	-0.048
OT2	41.989671010	-124.209226281	2.57	4649336.57	399837.77	4649336.501	399837.691	2.556	0.069	0.079	0.014
OT3	41.989801246	-124.209443667	1.61	4649351.28	399819.96	4649351.27	399819.992	1.754	0.01	-0.032	-0.144
OT4	41.989630607	-124.209367491	1.33	4649332.25	399826.01	4649332.279	399825.901	1.354	-0.029	0.109	-0.024

Scans

All scans of site conducted from foresight FS1
Scan0199 @ 0.5m x 0.25m 20m distance
Scan0200 @ 0.5m x 0.25m 30m distance
Scan0201 @ 0.05m x 0.025m 25m distance
Scan0202 @ 0.05m x 0.025m 25m distance
Scan0203 @ 0.05m x 0.025m 25m distance
Scan0204 @ 0.05m x 0.025m 20m distance
Scan0205 @ 0.05m x 0.025m 18m distance
Scan0206 @ 0.05m x 0.025m 18m distance
Scan0207 @ 0.05m x 0.025m 18m distance
Scan0208 @ 0.05m x 0.025m 45m distance
Scan0209 @ 0.05m x 0.025m 45m distance
Scan0210 @ 0.05m x 0.025m 25m distance
Scan0211 @ 0.05m x 0.025m 15m distance
Scan0212 @ 0.01m x 0.01m 30m distance

Topo Points

Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 3 meters (0,3,6,9,12…).
UT-Upper Transect
LT-Lower Transect
Labeled as:
T#-#: Transect Number Line-Meter along transect

Site Geology

This site contains large boulders throughout the intertidal, with bedrock outcrops in the higher intertidal, each made of the same metamorphosed rock most likely a form of serpentinite. The most obvious geological structure controlling the outcrops weathering was from multiple systems of fractures and joints ranging from tens of centimeters to centimeter scale.

Topographic Survey: Site = Abalobadiah Creek (10-Mile)

Abalobadiah Creek, Mendocino County, Northern California
Survey Date(s): 6/2 – 3/2015
WGS 1984 UTM Zone 10N, Geoid 2003

Site Description: Survey area over a boulder field/possible olistolith deposit with large seastacks in the survey area with pebble and cobble in fill made of mostly greywacke sandstone, some with calcite veins, and others of conglomerate pebbles and boulders. Pebbles and cobbles fill in from nearby Abalobadiah Creek.

Main Coordinates:
Foresight 1 (FS1): 433702.98 m E, 4380238.25 m N, 5.03 m El
Foresight 2 (FS2): 433701.43 m E, 4380213.64 m N, 3.47 m El

Controls:
OT1: 433698.271 m E, 4380242.55 m N 1.766 m El
OT2: 433704.984 m E, 4380213.48 m N, 2.369 m El
OT3: 433676.030 m E, 4380244.998 m N, 0.312 m El
OT4: 433684.636 m E, 4380215.600 m N, 1.830 m El

Table 15. Coordinates of survey bolts at Abalobadiah Creek (ABD).

Benchmark	Surveyed From	Easting (m)	Northing (m)	Elevation (m)	Elevation Change to FS1
FS1	GPS	433702.98	4380238.25	5.03	
FS2	GPS	433701.43	4380213.64	3.47	
FS2	FS1	433701.432	4380213.67	3.358	
OT1	FS1	433698.2714	4380242.55	1.766341	
OT2	FS1	433704.9841	4380213.48	2.368884	
OT3	FS1	433676.0302	4380245	0.311879	
OT4	FS1	433684.636	4380215.6	1.830053	
FS1	FS2	433702.9801	4380238.25	4.886481	
OT1-1	FS2	433698.2804	4380242.59	1.704148	-0.062193
OT2-1	FS2	433705.0301	4380213.51	2.222848	0.456507
FS2	FS1(2)	433701.432	4380213.67	3.354364	-0.003636
OT1-2	FS1(2)	433698.2692	4380242.58	1.81333	0.046989
OT2-2	FS1(2)	433705.0428	4380213.51	2.287754	-0.08113
OT3-2	FS1(2)	433677.582	4380244.71	0.621053	0.309174
OT4-2	FS1(2)	433684.6739	4380215.55	1.778603	-0.05145
FS1	FS2(2)	433702.9802	4380238.25	4.966302	0.079821
OT2-3	FS2(2)	433705.0481	4380213.57	2.264031	-0.104853

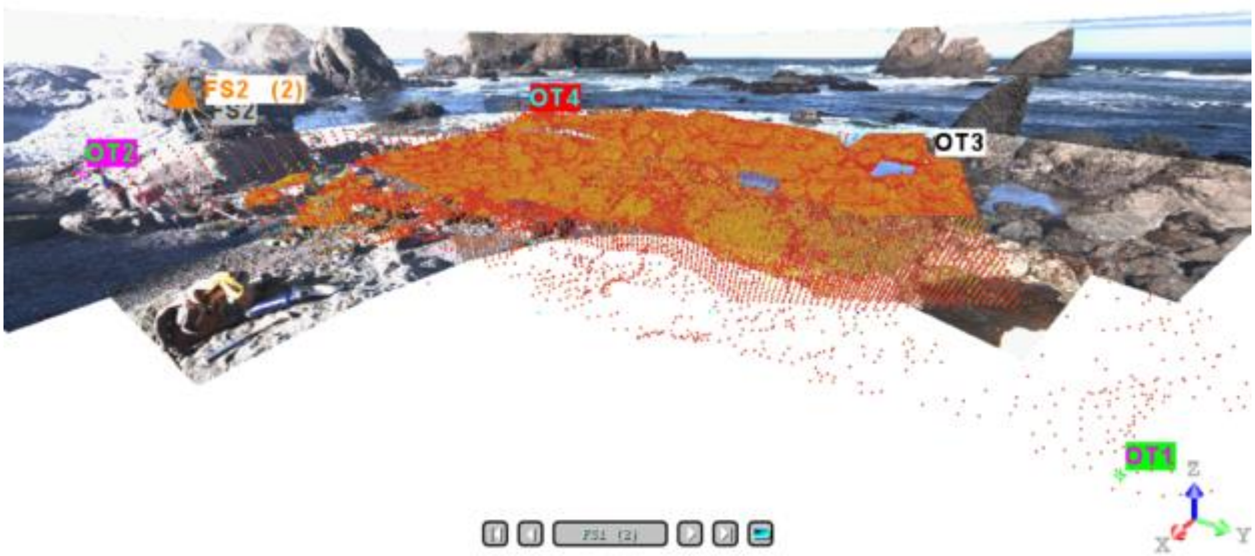

Figure 38. Panoramic photo of survey area at Abalobadiah Creek with location of scan area designated by 4 intertidal bolts used as controls, listed as OT1-OT4.

Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 3 meters (0,3,6,9,12…). Each point taken with survey rod and 360º prism.
T#-#: Transect Number Line-Meter along transect

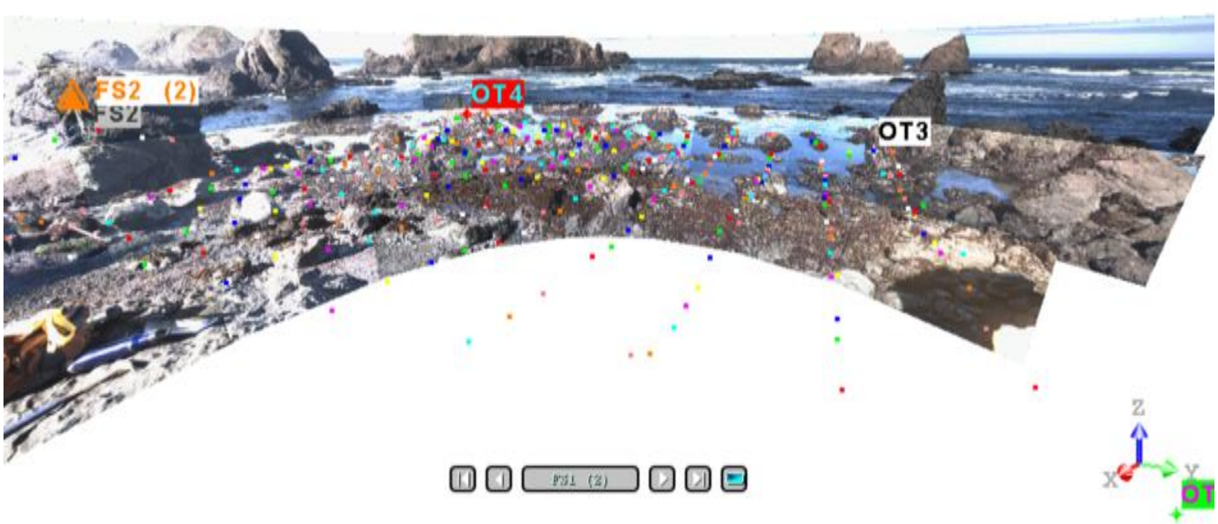

Figure 39. Panoramic picture of transect lines with topo points at Abalobadiah Creek.
Scans
SCAN0016 – FS1(2)
SCAN0017 – FS1(2)
SCAN0018 – FS1(2)
SCAN0019 – FS1(2)
SCAN0020 – FS1(2)
SCAN0021 – FS1(2)

SCAN0022 – FS2(2)
SCAN0023 – FS2(2)
SCAN0024 – FS2(2)

Topographic Survey: Site = Fort Bragg
Fort Bragg, Mendocino County, Northern California
Survey Date(s): 6/4 – 5/2015
WGS 1984 TUM Zone 10N, Geoid 2003

Site Description: Survey area over a narrow side of a sea stack composed of silty/sandstone with faulting and micro-faulting highly protected from protrusions offshore. Near survey area is a compressed and deeply folded Franciscan Formation with serpentine and possible red cherts.

Main Coordinates:
Foreshight 1 (FS1): 429518.89 4365637.93 6.34
Foresight 2 (FS2): 429526.65 4365608.8 3.66

Controls:
OT1: 429511.4351 4365614.265 1.889169
OT2: 429508.4412 4365623.191 1.609815
OT3: 429503.0081 4365631.341 1.308646
OT4: 429513.9198 4365614.439 1.2446
OT5: 429510.7502 4365623.909 1.299355
OT6: 429505.165 4365631.973 -0.034811

Table 16. Coordinates of survey bolts at Fort Bragg (FTB).

Benchmark	Surveyed From	Easting (m)	Northing (m)	Elevation (m)	Elevation Change to FS1
FS1	GPS	429518.89	4365637.93	6.34	
FS2	GPS	429526.65	4365608.8	3.66	
FS2	FS1	429527.209	4365609.28	3.572	
FS2-1	FS1	429527.209	4365609.28	3.571796	
OT1	FS1	429511.4351	4365614.265	1.889169	
OT1-1	FS1(2)	429511.419	4365614.273	1.919357	0.030188
OT1-2	FS2	429511.4217	4365614.294	1.910266	0.021097
OT2	FS1	429508.4412	4365623.191	1.609815	
OT2-2	FS1(2)	429508.413	4365623.174	1.604203	-0.005612
OT3	FS1	429503.0081	4365631.341	1.308646	
OT4	FS1	429513.9198	4365614.439	1.2446	
OT4-1	FS1(2)	429513.8972	4365614.457	1.243612	-0.000988
OT4-2	FS2	429513.9216	4365614.47	1.261132	0.016532
OT5	FS1	429510.7502	4365623.909	1.299355	
OT5-1	FS1(2)	429510.7654	4365623.887	1.29439	-0.004965
OT5-2	FS2	429510.7902	4365623.907	1.288359	-0.010996
OT6	FS1	429505.165	4365631.973	-0.034811	
OT6-1	FS1(2)	429505.1571	4365631.983	-0.053647	-0.018836
OT6-2	FS2	429505.1362	4365631.987	-0.060846	-0.026035

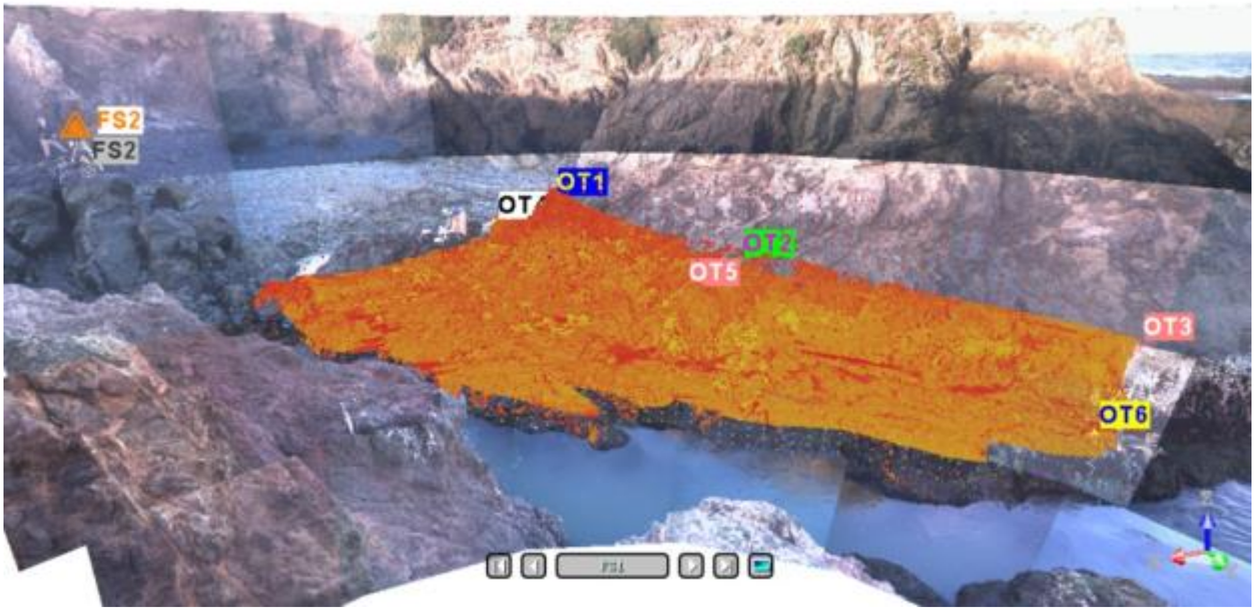

Figure 40. Panoramic photo of Fort Bragg survey area with total area scanned and location of control points (OT1-OT6).

Figure 41. View of main survey area from station FS2 at Fort Bragg; colored dots indicate transect tape topo points.

Transects: Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 2 meters (0,2,4,6,8…). Each point taken with survey rod and 360º prism.
Transect Meter Line # - Meter Mark on Line

T0-3: Baseline Meter 0 – Meter 3

Figure 42. Panoramic picture of survey points and transect lines at Fort Bragg.

Scans
SCAN0025 – FS1
SCAN0026 – FS1
SCAN0027 – FS1
SCAN0028 – FS1
SCAN0029 – FS1
SCAN0030 – FS1
SCAN0031 – FS1
SCAN0032 – FS1
SCAN0033– FS1
SCAN0034 – FS1
SCAN0035 – FS1
SCAN0036 – FS1
SCAN0037 – FS1
SCAN0038 – FS1
SCAN0039 – FS1(2)
SCAN0040 – FS1(2)
SCAN0041 – FS1(2)
SCAN0042 – FS1(2)
SCAN0043 – FS2
SCAN0044 – FS2
SCAN0045 – FS2
SCAN0046 – FS2
SCAN0047 – FS2
SCAN0048 – FS2
SCAN0049 – FS2

SCAN0050 – FS2
SCAN0051 – FS2

Topographic Survey: Site = MacKerricher

MacKerricher State Park, Mendocino County, Northern California
Survey Date(s): 6/6 – 7/2015
WGS 1984 UTM Zone 10N, Geoid 2003

Site Description: Survey area over a moderate size bench of fine-grained sandstone with thin calcite veins dating to the Cretaceous. Possible layers point to being a gravity/turbidity current with patches of silty/mudstone with/without ripples, indicating layers of the Bouma sequence, however specific layers could not be distinguished from one another due to the massive shearing caused by multiple faults running through the site.

Main Coordinates:
Foreshight 1 (FS1): 430888.23 4370631.09 4.04
Foresight 2 (FS2): 430874.341 4370651.942 2.433

Controls:

OT1	430890.8482	4370640.92	2.263341
OT2	430882.353	4370622.954	2.309347
OT3	430878.2622	4370648.685	1.681628
OT4	430869.723	4370630.618	1.977514

Table 17. Coordinates of survey bolts at MacKerricher (MAC).

Benchmark	Surveyed From	Easting (m)	Northing (m)	Elevation (m)	Elevation Change to FS1
FS1	GPS	430888.23	4370631.09	4.04	
FS2	FS1	430874.335	4370651.951	2.433214	
FS2	GPS	430874.341	4370651.942	2.433	
OT1	FS1	430890.8482	4370640.92	2.263341	
OT2	FS1	430882.353	4370622.954	2.309347	
OT3	FS1	430878.2622	4370648.685	1.681628	
OT4	FS1	430869.723	4370630.618	1.977514	
OT1-1	FS2(2)	430890.8405	4370640.919	2.293	0.029659
OT2-1	FS2(2)	430882.3745	4370622.959	2.308	-0.001347
OT3-1	FS2(2)	430878.2556	4370648.684	1.673	-0.008628
OT4-1	FS2(2)	430869.7619	4370630.635	1.961	-0.016514
OT1-2	FS2(3)	430890.8507	4370640.916	2.261	-0.002341
OT2-3	FS2(3)	430882.3686	4370622.951	2.31	0.000653
OT3-2	FS2(3)	430878.2507	4370648.674	1.687	0.005372
OT4-2	FS2(3)	430869.7496	4370630.608	1.974	-0.003514

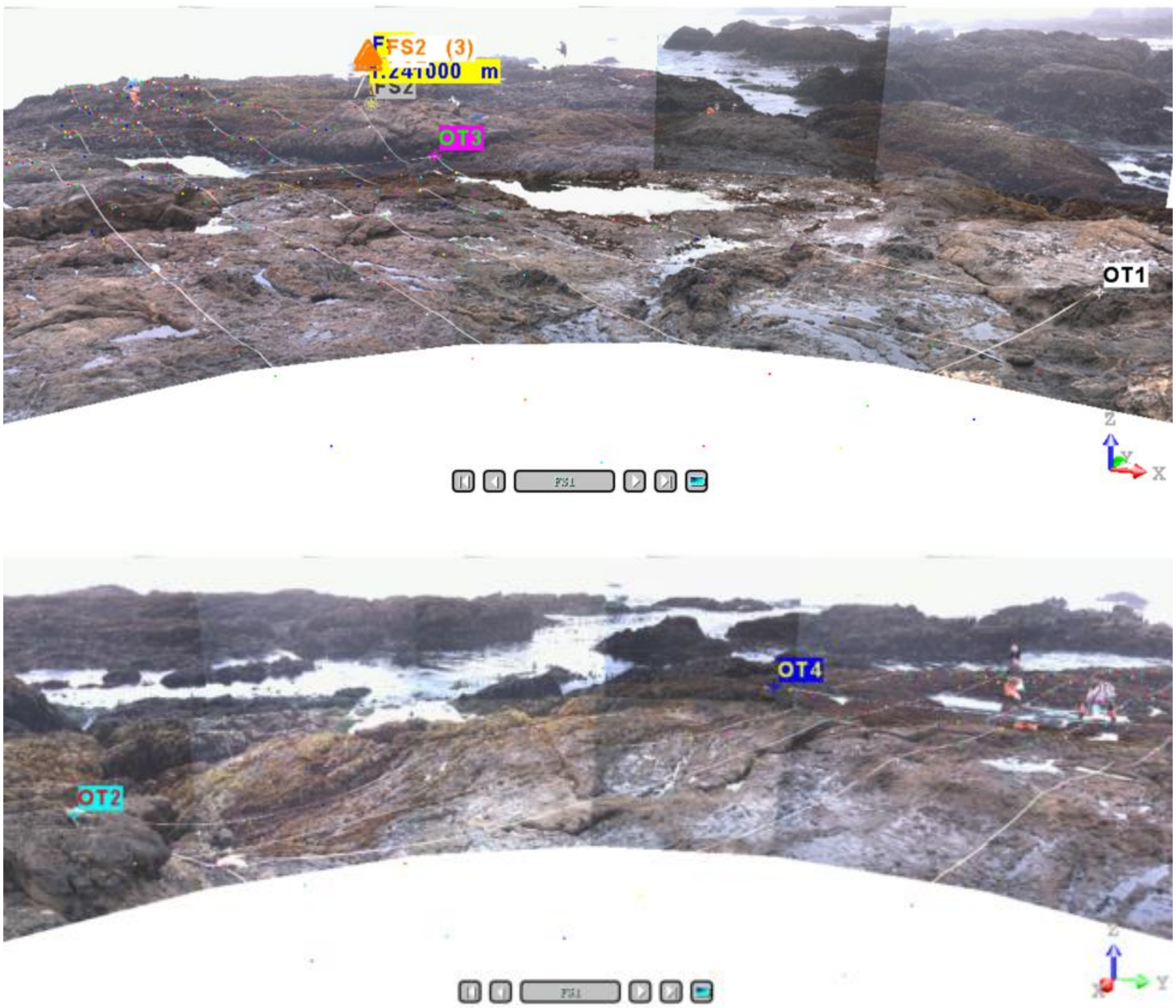

Figure 43. Panoramic photos of MacKerricher survey area with locations of station and control points (OT1-OT4).

Transects: Continuous topo points taken acros transect lines at every meter mark along transect lines spaced out every 2 meters along baseline (0,2,4,6,8…). Each point taken with survey rod and 360 deg prism.
Transect#-Meter#
T0 – T20, every 2 meters along the baseline

Scans
SCAN0052 – FS1
SCAN0053 – FS1
SCAN0054 – FS1
SCAN0055 – FS1
SCAN0056 – FS1
SCAN0057 – FS1

SCAN0058 – FS1
SCAN0059 – FS2(2)
SCAN0060 – FS2(2)
SCAN0061 – FS2(3)
SCAN0062 – FS2(3)
SCAN0063 – FS2(3)
SCAN0064 – FS2(3)
SCAN0065 – FS2(3)
SCAN0066 – FS2(3)
SCAN0067 – FS2(3)
SCAN0068 – FS2(3)
SCAN0069 – FS2(3)
SCAN0070 – FS2(3)
SCAN0071 – FS2(3)
SCAN0072 – FS2(3)

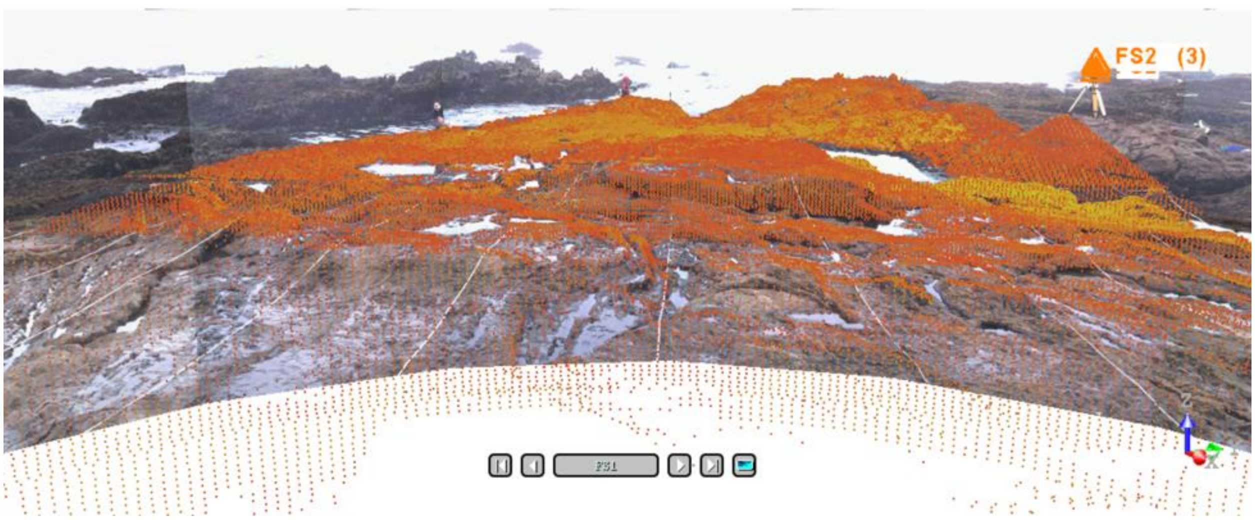

Figure 44. Display of all scans at MacKerricher taken from both stations.

Topographic Survey: Site = Palmer's Point

Palmers Point, Patrick's Point State Park, Humboldt County, Northern California
Survey Dates: 5/20 – 21/2015
WGS 1984 UTM Zone 10N, Geoid 2003

Site Description: Survey area over boulder field/ possible olistolith deposit, with large sea stacks in and around the survey area composed of the Franciscan Complex, mostly metagraywacke.

Main Coordinates:
Foresight 1 (FS1): 41.13110584, -124.1632532, 5.7m → 402361.820 4553963.23 5.7
Foresight 2 (FS2): 41.13134728, -124.1635492, 1.78m → 402337.291 4553990.413 1.814

Controls:
OT1: 402358.4472 4553974.697 2.188601
OT2: 402346.0527 4553947.51 2.067657
OT3: 402333.1644 4553991.569 1.280517
OT4: 402320.7411 4553964.275 1.082476
OT5: 402302.6477 4554011.455 0.966925

Table 18. Coordinates of survey bolts at Palmer's Point (PAP).

Benchmark	Surveyed From	Easting (m)	Northing (m)	Elevation (m)	Elevation Change to FS1
FS1	GPS	402361.820	4553963.23	5.7	
FS2	GPS	402337.330	4553990.37	1.78	
FS2	FS1	402337.291	4553990.413	1.814	
FS2	FS1(2)	402337.291	4553990.413	1.810519	-0.003481
OT4	FS1(2)	402320.741	4553964.275	1.082476	
OT5	FS1(2)	402302.648	4554011.455	0.966925	
FS2	FS1(3)	402337.286	4553990.419	1.81	-0.000519
OT1	FS1(3)	402358.447	4553974.697	2.188601	
OT2	FS1(3)	402346.053	4553947.51	2.067657	
OT3	FS1(3)	402333.164	4553991.569	1.280517	
OT4-REAL	FS1(3)	402321.32	4553963.983	1.541448	0.458972
FS1	FS2	402361.823	4553963.227	5.557659	-0.142341

Figure 45. Panoramic Photo of Survey Area at Palmer's Point with location of control points established as NCMPA biodiversity survey, listed as OT1-OT6.

Figure 46 Display of main deposit in the main survey area at Palmer's Point and more focused area of FS2, near control point OT3. Primarily boulder field as seen in picture above (Figure 68).

Continuous topo points taken across transect lines at every meter mark along transect lines spaced out every 3 meters (0,3,6,9,12…). Each point taken with survey rod and 360º prism.
T#-#: Transect Number Line-Meter along transect
Scans
SCAN0003 – FS1(3)
SCAN0004 – FS1(3)
SCAN0005 – FS1(3)
SCAN0006 – FS1(3)

SCAN0007 – FS1(3)
SCAN0008 – FS1(3)
SCAN0009 – FS2
SCAN0010 – FS2
SCAN0011 – FS2
SCAN0012 – FS2
SCAN0013 – FS2
SCAN0014 – FS2
SCAN0015 – FS2

Figure 47. Display of all scans taken from both perspectives at Palmer's Point.

Financial Reports

From HSU:

	Budget		**Actual**		**Variance**		
	SEA GRANT FUNDS	**GRANTEE SHARE**	**SEA GRANT FUNDS**	**GRANTEE SHARE**	**SEA GRANT FUNDS**	**GRANTEE SHARE**	
Total salaries & wages	$68,051	$29,479	**$ 63,733**	**$21,778**	-6%	-26%	Difference will be match for March
Fringe	$11,870		**$8,410**		-29%		And pay for final report help
Total permanent equip							
Expendable supplies and equip	$2,500		**$1,601**		-36%		Will reimburse craig for supplies
Total (domestic) travel	$15,788		**$15,950**		1%		
Pubs & Comms							
Total Other	$37,100		**$37,282**		0%		
TOTAL DIRECT	$135,309		**$126,976**		-6%		
IDC	$24,552		**$21,550**		-12%		
IDC (foregone) waived as match		$18,154		**$17,066**		-6%	
TOTAL COSTS	$159,861	$47,633	**$148,526**	**$38,844**	-7%	-18%	(see above)

Please note that these amounts are only through 2/27/17. The final financials will be provided after 3/31/17 (the final day to post expenses). There were no positive or negative variances >10%

Financial Report

From Tolowa Dee-Ni' Nation (PI Rosa Laucci):

MPA REQUEST FOR REIMBURSEMENT

Grant Number: 50645587	**Project Number: R/MPA-**			**33E**
Name of Grantee: Smith River Rancheria	**Purchase Order Number:**		**Invoice Number:** 2017-	
PROJECT TITLE: Baseline Characterization of Rocky Intertidal Ecosystems for MPAs	**CA Sea Grant accounting #: SEA_______ (include 4 di**			
Address (include zip code):	**Project Leader:**			
140 Rowdy Creek Road	**ROSA LAUCCI**			
Smith River, CA 95567	**Billing Period Covered:**			
	From: February 1, 2014		To: January 31, 2017	
Category Reimbursement *(insert rows as needed for additional budget categories)*	**Category Budget**	**Costs Incurred this Period**	**Total Cost to Date**	**Remaining Balance**
Salaries - Senior Personnel	$ 6,723.00	$ 1,878.95	$ 1,878.95	$ 4,844.05
Salaries - Other Personnel	$ 2,658.00	$ 4,108.56	$ 4,108.56	$ (1,450.56)
Benefits	$ 2,908.00	$ 2,097.69	$ 2,097.69	$ 810.31
Supplies	$ -	**$ -**	$ -	$ -
Travel	$ -	**$ -**	$ -	$ -
Tuition Fee Remission	$ -	**$ -**	$ -	$ -
Other Costs	$ -	**$ -**	$ -	$ -
				$ -
				$ -
				$ -
Indirect	$ 3,073.00	$ 1,758.54	$ 1,758.54	$ 1,314.46
TOTAL	$ 15,362.00	$ 9,843.74	$ 9,843.74	$ 5,518.26
TOTAL AMOUNT REQUESTED		**$ 9,843.74**	**NOTE:** All receipts for expenditures over $250 and all travel/mileagel	

*NOTE: Equipment/supplies over $250 require supporting documentation. Hotel, airfare and travel expense form required for all travel.