

Algal Community Dynamics at Fitzgerald Marine Reserve

An Annual Report for Permit # SP-2021-08-FMR-PPB
Prepared for San Mateo County Parks

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Summary

During 2021-2022, surveys were conducted at Fitzgerald Marine Protected Area, Bluffs Marine Protected Area, and Pillar Point to better characterize the algal communities in intertidal habitats. Overall, the sites had similar algal diversity within each tidal height; low, middle, and high. However, some specific species showed differences among these three sites. The percent cover of surf grass was the same at all three sites. There were more rockweeds at Fitzgerald MPA, but higher abundance of sea palm at Pillar Point. Overall, the herbivore communities were similar with more purple sea urchins observed at Fitzgerald MPA and the most owl limpets observed at the Bluffs MPA. Bluffs MPA also had the highest abundance of *Pisaster ochraceus*, and both Bluffs MPA and Pillar Point had higher percent cover of mussels compared to Fitzgerald MPA. These trends suggest that there are important differences among these sites, and these data provide a baseline to assess the impact of future stressors on local community diversity.

Introduction

The rocky intertidal habitat is an important center of biodiversity along the Californian Coast. The intertidal habitat hosts a diverse algal community that is made up of red algae, brown algae, green algae, and surf grass (a flowering plant). The abundance and diversity of algae can be influenced by abiotic parameters including wave energy, nutrients, and water temperature, as well as ecological interactions including herbivory and competition. Extensive literature has shown that the communities in these intertidal habitats are stratified into three different tidal heights; the low intertidal that is rarely exposed to air, the middle intertidal that is only exposed during some low tides, and the high intertidal where the organisms are adapted to frequent and long exposure to the air. While tidal height is an important abiotic factor that structures algal communities, local harvesting and climate change can also impact the community structure of intertidal habitats.

Critical to managing local marine resources is establishing a baseline understanding of the diversity and abundance of organisms that inhabit these diverse habitats. There are many variations in environmental and biological drivers of intertidal community diversity across the Californian intertidal heights, making it important to survey sites at a fine spatial resolution. One critical factor that can influence the health of the intertidal habitat is the site's protection status. Sites that restrict harvesting can conserve the abundance of some species. In 2010 California established a series of 124 marine preserves, including the Montara State Marine Reserve, to protect specific intertidal habitats along the Pacific coast.

Along the San Mateo coast there are multiple intertidal sites that have protected status considered marine protected areas (MPA). Fitzgerald Marine Reserve is in the Montara State Marine Reserve a full no-take preserve that has a relatively high level of enforcement but also a relatively high visitation rate. The Pillar Point Bluffs site is also a no-take preserve (although off shore there are some finfish, squid, and crab exceptions), that is south of the Montara State Marine Reserve inside of the Pillar Point State Marine Conservation Area. Directly south of the

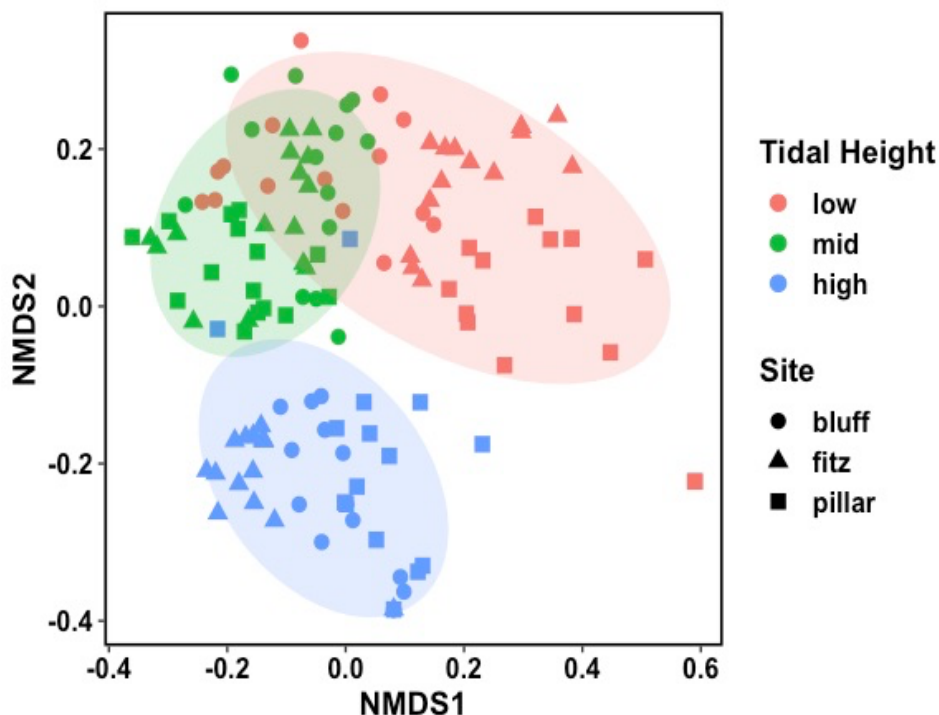
Timed counts were conducted to better characterize the abundance of a few ecologically important species (*Pisaster ochraceus*, the owl limpet, rockweeds and sea palm) in May 2022. While timed counts do not survey a consistent area, they are an important technique to quantify rare or patchy organisms outside of transects and quadrats. Timed counts were 2 minute haphazard walks within each tidal height (n=9-10) at each site.

Data were analyzed in R 3.6.0. If the data did not have a normal distribution or the variances were unequal, non-parametric statistical tests were used to compare among tidal heights and sites. For ordination analysis the percent cover data was square root transformed and a Bray Curtis matrix was used.

Results and Discussion

Algal Diversity and Distribution

There was a high diversity of red algae in the low tidal height at all three of these sites (10-20 different species). The middle tidal height was often dominated by surf grass (*Phyllopadix scouleri*) and *Neorhodomela larix*, although there are quite a few other species of algae that were patchy. The high zone was dominated by mussels, bare space, and a few species of algae. In an ordination analysis of the algal communities using the percent cover data, the tidal height was a major factor controlling algal community (Fig. 2). There was some overlap of algal communities between the mid and low tidal height, but the community in the highest zone was



distinct from the other zones (Fig. 2). Spatially, there is not a large area of the “high” zone at Pillar Point and in this analysis the % cover data show that Pillar is separated (along NMDS 1) from Fitzgerald MPA, which could be explained by the patterns of species distributions discussed below.

Figure 2. A comparison of algal communities % cover across tidal heights and sites in May 2022.

Surf grass (*Phyllospadix scouleri*) is an important community member of Californian intertidal habitats. Critically, it has the potential to mitigate the impacts of ocean acidification and should be considered an ecosystem engineer. There was no difference in the percent cover of

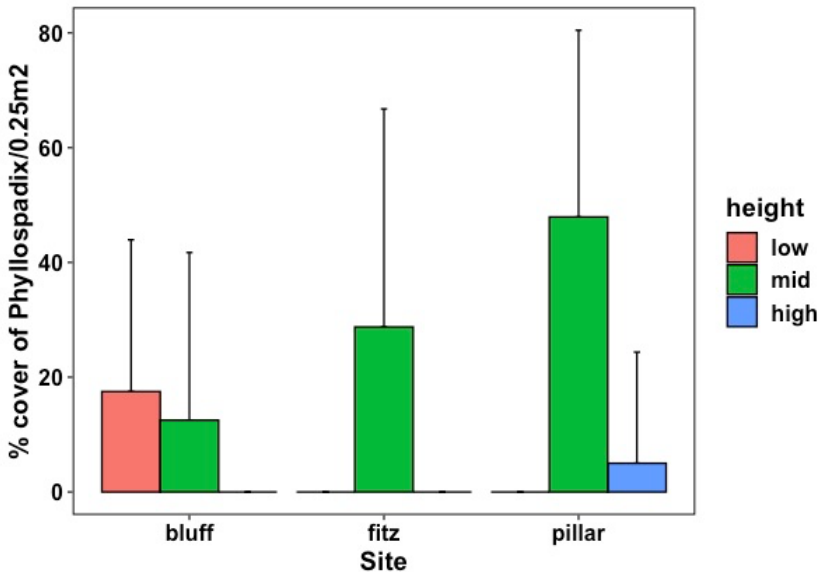


Figure 3. The % cover of surf grass in May 2022. Bars represent the mean (n=15) and error bars are +1 standard deviation.

Phyllospadix scouleri among the three sites (Fig. 3).

There was a significant difference among tidal heights (Kruskal wallis, $p < 0.001$), with the highest percent cover at the middle tidal height (Fig. 3).

However, *Phyllospadix scouleri* have extensive cover at these sites and quadrats are an unreliable method for estimating the true area of surf grass at a site. Surf grass area would be better characterized with arial (drone) surveys to measure the total area. This

should be a priority as the role of surf grass as an ecosystem engineer has been shown, and the abundance of surf grass is probably impacted by natural and anthropogenic disturbances.

Coralline algae can have multiple ecological roles in marine habitats but they remain poorly

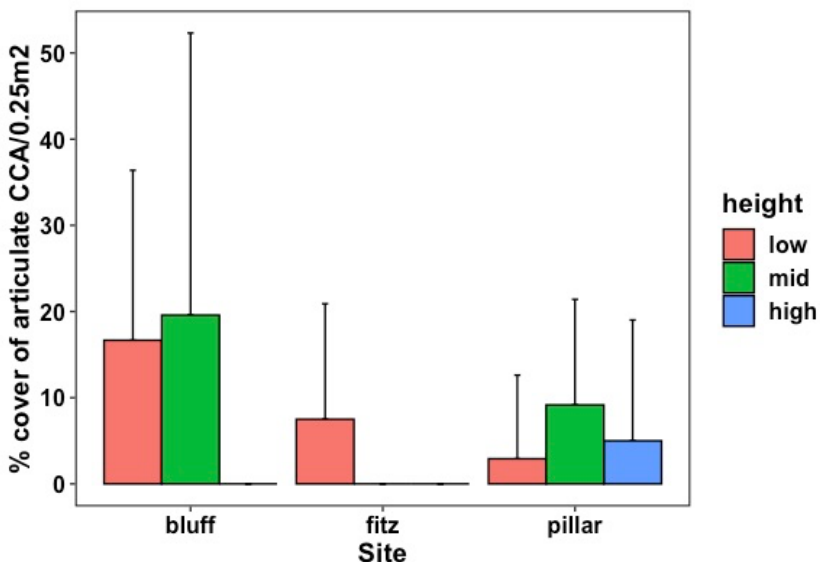


Figure 4. The % cover of crustose coralline algae in May 2022. Bars represent the mean (n=15) and error bars are +1 standard deviation.

studied in intertidal habitats. From the quadrats, the percent cover of articulate coralline algae was different among the sites (Bluff MPA had a higher percent cover than Fitzgerald MPA, but Pillar Point is not different from the other sites) and had a higher percent cover at the middle tidal height (Fig. 4, Kruskal Wallis, $p = 0.001$). There was low % cover recorded at Fitzgerald MPA, but it is not clear what process might drive that observation. Crustose

coralline algae are known to be susceptible to ocean acidification so the population trajectory of these species will be important to monitor into the future.

There are a few different species of rockweed that can be found along the San Mateo open coast. During the timed counts in the high tidal zone the distribution of rockweed species across sites was compared. The wide bladed *Fucus distichus* was more abundant at Fitzgerald MPA, compared to Bluff MPA and Pillar Point (Fig. 5: Kruskal Wallis, $p < 0.01$). The abundance of *Pelvetiopsis limitata* was higher at Fitzgerald MPA compared to Bluff MPA, but the abundance at Pillar Point was not different from either site (Figure 5: Kruskal Wallis, $p = 0.003$). These rockweeds can have low/short dispersal (Whitaker et al., 2017), possibly explaining their patchy distribution. The large populations that do exist, such as those at Fitzgerald MPA, should continue to be protected.

Sea palm (*Postelsia palmaeformis*) is a high intertidal species that thrives in wave exposed habitats. This species is sometimes harvested so its abundance was compared within the high tidal height across all the sites. From the timed counts, the total number of *P. palmaeformis* was highest at Pillar Point (824), but some were observed at Bluff MPA (190), and none were

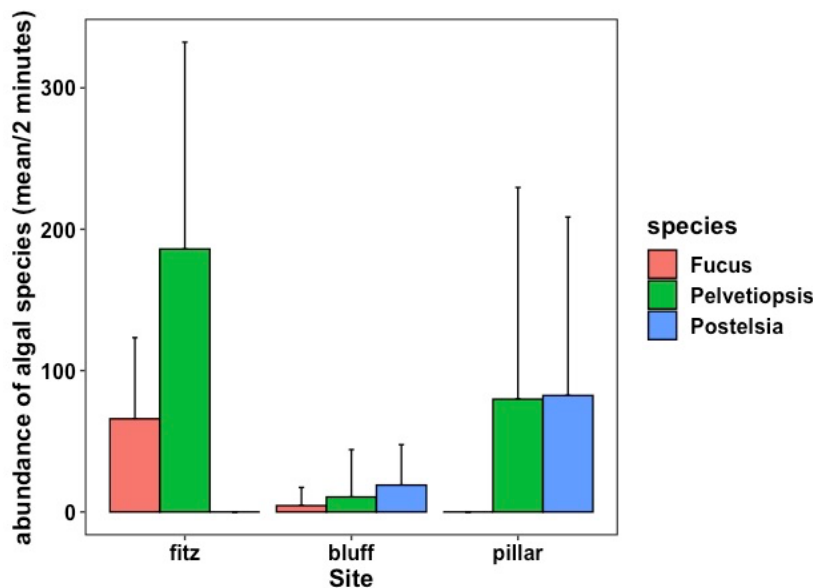


Figure 5. The abundance of rockweed and sea palm in the high intertidal in May 2022. Bars represent the mean ($n=9-10$) and error bars are +1 standard deviation.

found at Fitzgerald MPA (Fig. 5). Since this alga was very patchy there was no significant difference in its abundance among these sites ($p > 0.05$). Interestingly, the highest abundance of sea palms was at Pillar Point where harvesting is allowed. This is probably due to the exposure of this site with high wave action at the southern most part of Pillar Point, where this species was observed. Without repeated long term surveys it would be difficult to assess the impact of harvesting on this species since the population at each site was very different.

Herbivore Diversity and Distribution

Herbivore abundance can be a major factor that can structure algal communities (Williams et al., 2013). The abundance of the black turban snail (*Tegula funebris*), and the purple sea urchin (*Strongylocentrotus purpuratus*), were quantified by counting the total number of individuals in each of the 0.25m^2 quadrats. The abundance of turban snails ranged from 0-45/ 0.25m^2 , but did not significantly differ among the sites ($p > 0.05$). The highest mean abundance was in the middle intertidal height and the lowest in the low tidal height. It is difficult to know

whether the population size at Pillar Point has changed, a study over multiple years should be designed to quantify the impact of harvesting on the population size of turban snails.

The abundance of purple sea urchins was consistently highest in the low intertidal height. Within this tidal height there was a difference in urchin abundance among the sites, with the highest urchin abundance at Fitzgerald MPA and the lowest at Pillar Point. Again, long term repeated surveys are necessary to determine the trajectory of the population size at sites open to harvesting.

Owl limpets (*Lottia gigantea*) are important herbivores that can be impacted by human collecting (Sagarin et al., 2006). During the timed counts *L. gigantea* was only observed during one two minute survey in the high zone at Bluff MPA where 24 individuals were counted. This species was never observed at Fitzgerald MPA or Pillar Point (there is a large population on the sea wall at Princeton Harbor). This species appears very patchy, but is noticeably absent from appropriate habitat at Pillar Point. It may be that this species has been harvested at Pillar Point but more long-term data should be collected to understand the population trajectory of this species at these sites.

Sea Star Abundance

During the 2 minute timed counts there were different numbers of *P. ochraceus* among the sites (Fig. 6: Kruskal Wallis, $p < 0.01$). Bluff MPA had higher abundance of *P. ochraceus* compared to both Pillar Point and Fitzgerald MPA, which were not different from each other (TukeyHSD). However, the number of *P. ochraceus* was not different among the tidal heights (Fig. 6: Kruskal Wallis, $p = 0.97$).

Sea stars are keystone species that can determine the abundance of mussels and their

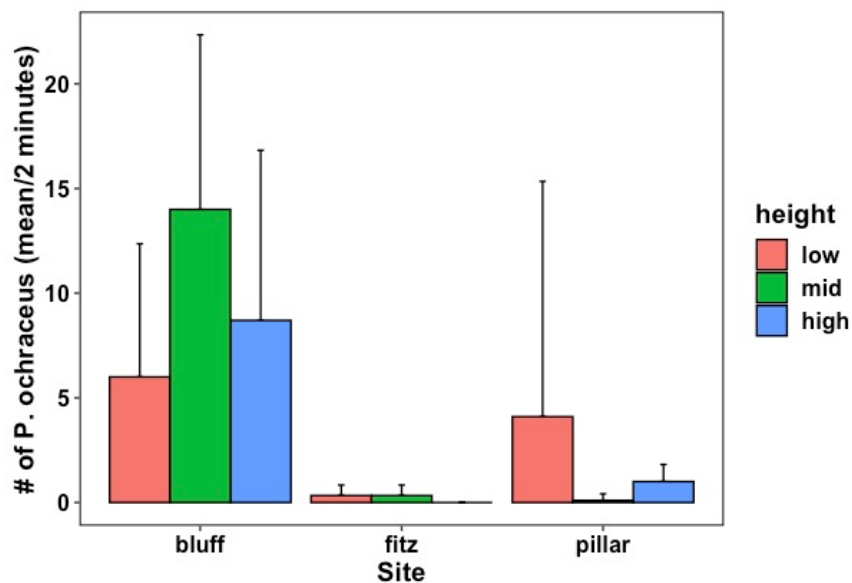


Figure 6. The abundance of sea stars (*P. ochraceus*) in May 2022. Bars represent the mean (n=9-10) and error bars are +1 standard deviation.

associated communities. Many echinoderm species including *Pisaster ochraceus* had extensive population declines in 2014 and 2015 due to sea star wasting disease (Menge et al., 2016; Miner et al., 2018). Many populations along the central Californian coast have shown only low levels of population recovery (Moritsch and Raimondi, 2018). Unfortunately, it is difficult to know if the measured abundances are typical for these San Mateo

sites. Regardless of historical abundances, currently the Bluff MPA had the largest population of *P. ochraceus* (Fig. 6). Possibly this is due to physical characteristics of the Bluff site as it has a northerly exposure and high rugosity through the mid tidal height. It is surprising that the population sizes of *P. ochraceus* are so low at Fitzgerald MPA and Pillar Point. Further studies could tease out the drivers of these patterns for this keystone species.

Mussel Abundance

The mussel, *Mytilus californianus*, is an ecosystem engineer in the rocky intertidal. Mussel abundance was quantified using the percent cover data from the photo quadrats, and there were consistently more mussels in the high tidal height (Fig. 7). Among the sites Fitzgerald had

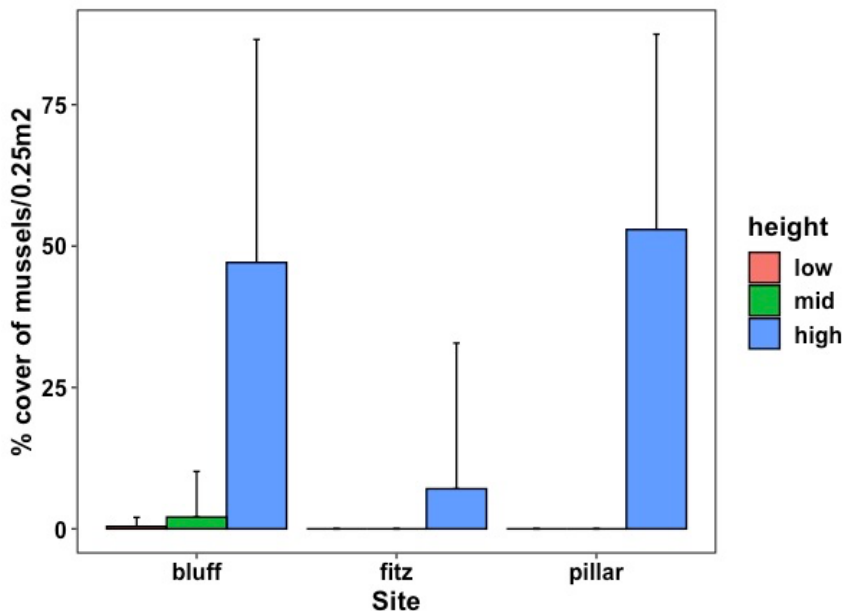


Figure 7. The % cover of mussels in May 2022. Bars represent the mean (n=15) and error bars are +1 standard deviation.

less mussel percent cover than the other two sites which were not different from each other (Kruskal Wallis, $p=0.002$). Unfortunately, quadrat percent cover data is not the best way to assess the total cover of mussels. Drone arial surveys would be a better method to quantify the actual area of mussel cover among these sites. This could provide extensive photographic data that would be an excellent community science project.

Random Observations

During the surveys there was a very rare occurrence of a few species of interest/concern:

- Live red abalone (*Haliotis rufescens*) were only observed at Fitzgerald MPA. One morning two different large individuals were observed in the lowest tidal zone. However, typically no live abalone (red or black) were observed at these three sites.
- One live red sea urchin (*Mesocentrotus franciscanus*) was observed at Bluff MPA in the mid tidal height. This species has not been observed at any of the other sites surveyed during this study.
- A few (1-4) gumboot chitons (*Cryptochiton stelleri*) have been observed occasionally at all three sites.

Conclusions

Overall, the communities of algae are quite diverse and health at these three sites. Each site has unique characteristics that are probably driving differences in distribution and abundance among some of these algal species. Critically, there are other time points (May 2021, January 2020) that still need to be quantified, to better quantify population trajectories over time. There are still a few outstanding questions that could be followed up using modified methods to improve the accuracy of data being collected.

- It is difficult to estimate the total area of seagrass and mussels using these random quadrats. Instead, a drone could be flown over these sites to get a more accurate estimate of the percent cover of these species. These images would provide a terrific community science activity that would help to engage the public and would provide a great baseline of data for these sites.
- The high abundance of *Pisaster ochraceus* at Bluff MPA is curious. Further research could help to elucidate the physical and biological factors that might be limiting *P. ochraceus* population size at the other sites.
- Sea urchin and black turban snails are harvested from Pillar Point and preliminary data in this report suggest these populations are relatively small at this site. Specific surveys in the field should target these species (they can be obscured in the photographs) to get a more accurate estimate of their abundance.
- Future surveys should be conducted to better assess the change in these communities over time. As climate change progresses and harvesting at Pillar Point continues it is important to have current data to assess any changes in these intertidal habitats.

Acknowledgements

Special thanks to San Mateo County Parks Department for providing a permit for this research. Thanks to the Santa Clara University Biology 160 class in Spring 2022 for helping me to survey these sites and test some alternative hypotheses.

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