Relationship between intertidal habitat complexity and Ochre sea star (*Pisaster ochraceus)* abundance

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Abstract

The Ochre sea star (*Pisaster ochraceus*) is a well-studied invertebrate of the rocky intertidal due to its direct influence on the zonation of benthic invertebrates in this community. Predation by *Pisaster* regulates the distributional boundaries of the competitively dominant mussel, *Mytilus californianus*, which can in turn help provide space, a critical resource in the intertidal, for other organisms. In this study we examined whether regional variation in the complexity of intertidal habitat and availability of *M. californianus* around the Monterey Peninsula could be used to explain variation in the abundance and distribution of *Pisaster*. A Topcon total station laser surveyor was used to record the position of *Pisaster* within the intertidal, the lower boundary of the mussel beds, and the habitat complexity, a measurement incorporating the complexity of geological and biological habitat, at each site. Percent cover of the mussel beds was also measured in the corresponding photo surveys taken at three shore levels: 0.61, 1.22, and 1.83 m above Mean Lower Low Water (MLLW). The local variation in intertidal complexity and abundance of *Pisaster* at each site suggests that there are environmental factors contributing to the difference in distribution of mussel beds and sea stars. In addition to the large scale marine factors influencing *Pisaster* abundance, local variation in the complexity and mussel bed cover could influence *Pisaster* foraging in the rocky intertidal, resulting in change in its current structure and function.

Introduction

Along the Western coast of the United States, the rocky intertidal is one of the most expansive and recognizable ecosystems **(Figure 1)**. Not only does it provide habitat for endangered and economically important species, but it is also a critical system that is used to monitor changes in the marine environment (Menge 1995, Smith 2008). For instance, environmental changes that alter the composition of the intertidal can affect interactions between species and serve as an indicator for changes in local marine environments and other relatable ecosystems. One of the most noteworthy interactions studied within the intertidal is the predation of *Pisaster ochraceus* **(Figure 2)** on the dominant mussel, *Mytilus californianus*. *Pisaster* are an important keystone predator within the intertidal because without their regulation of the mussel boundaries, the mussel beds would extend well beyond their current limits to cover more of the intertidal and occupy space needed by other benthic invertebrate and algal species (Robles et al. 1995). Thus, any decrease in *Pisaster* may alter the structure of intertidal habitats, resulting in dramatic shifts to predominately mussel covered habitats with low species diversity (Robles et al. 1995).

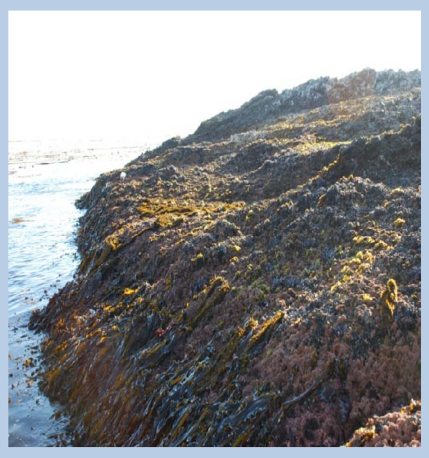

Figure 1: Intertidal zone at Sea Lion Point.

Figure 2: *Pisaster ochraceus*.

Research Question: Does the complexity of intertidal habitat and availability of *Mytilus californianus* around the Monterey Peninsula influence the abundance and distribution of *Pisaster ochraceus*?

Hypothesis: A greater abundance of *Pisaster* is expected in areas of lower complexity with high mussel bed cover.

Methods

Data Collection: Three sites were chosen around the Monterey Peninsula with varying habitat complexity **(Figure 3)**. Sea Lion Point (SLP) in Point Lobos State Natural Reserve contains a mussel beds 10.0m in length and was chosen as the site with moderate habitat complexity. During low tide, photo surveys of transects set out at 0.61 m, 1.22m, and 1.83 m above MLLW were recorded at SLP. A Topcon total station laser surveyor **(Figure 4)** was used to record the N, E, and Z coordinates for the control points associated with the photo transects and the location of *Pisaster* that were found in the 1.0 m band of each transect.

GIS Analysis: A base map of photo transects was georeferenced to its corresponding control points from the Topcon total station in the GIS software ArcMap to create a map for SLP, which contained all three transects **(Figure 5)**. Habitat complexity was then modeled using raster interpolation function in ArcMap from the coordinates associated with the control points. Complexity is represented as the standard deviation of the slope of shore and incorporates both biological (e.g. mussel beds) and geological structures within a site. To measure mussel bed cover within ArcMap, a grid was laid over each photo and the presence / absence of mussels was manually identified. Finally, the *Pisaster* locations, as measured with the Topcon Total Station, were inserted as points over the map containing the transects and percent mussel bed cover.

Figure 3: Location of three sites (Sea Lion Point, Point Pinos, Hopkins Marine Station) around Monterey Peninsula.

Figure 4: TOPCON total station laser surveyor.

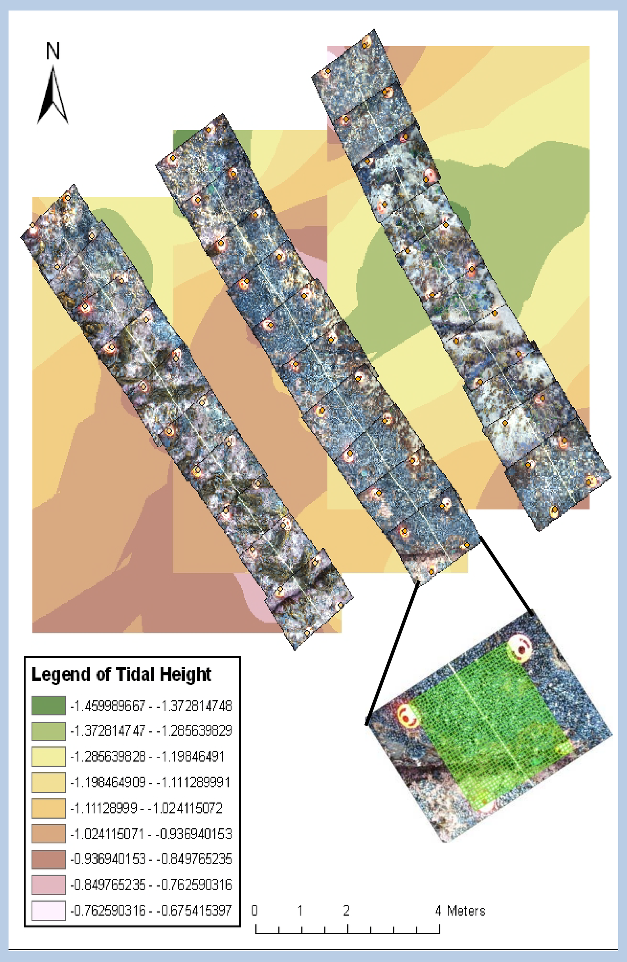

Figure 5: Georeferenced map of the three transects from Sea Lion Point with corresponding tidal height layers and grid overlay.

Results

Map Layers of Sea Lion Point Transect

Figure 6 shows the corresponding photo mosaic, percent mussel cover, complexity, and *Pisaster* location layers that were compiled in ArcMap for the 1.22m transect at SLP.

Abundance and Distribution of *Pisaster* at Sea Lion Point

1) There is no significant relationship between number of *Pisaster* and habitat complexity (Regression; $F_{1,18}$=1.244, p=0.279, R^2=0.065) **(Figure 7)**.

2) There is a significant negative relationship between *Pisaster* abundance and percent mussel bed cover (Regression; $F_{1,18}$=5.035, p=0.038, R^2=0.175) **(Figure 8)**. Percent mussel bed cover explained 17.5% of the variation in the observed number of *Pisaster*.

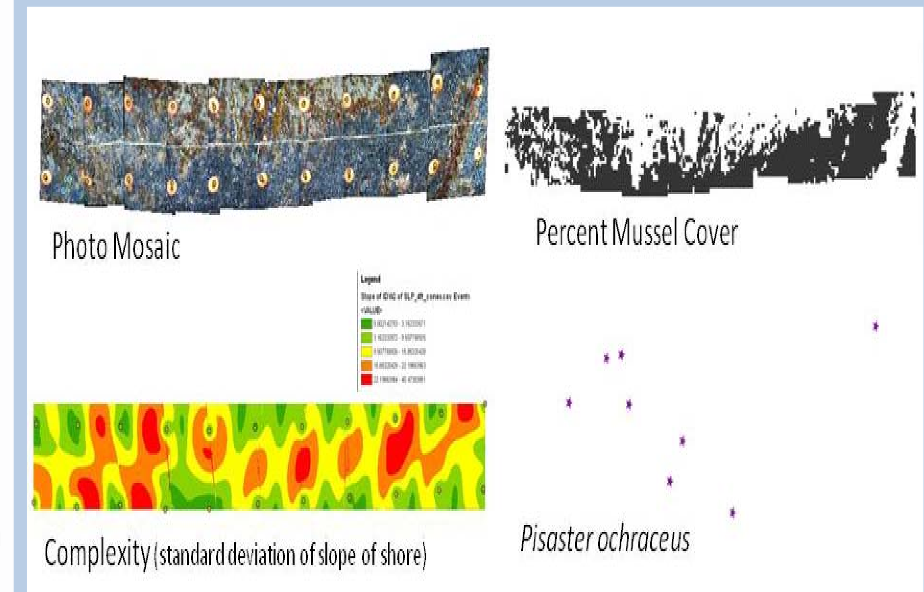

Figure 6: Deconstructed ArcMap layers of the 1.22m transect at Sea Lion Point.

Mussel Bed Cover and Complexity

There is a significant negative relationship between percent mussel bed cover and habitat complexity (Regression; $F_{1,18}$=5.787, p=0.027, R^2=0.243) **(Figure 9)**. Percent mussel bed cover explained 24.3% of the variation in habitat complexity.

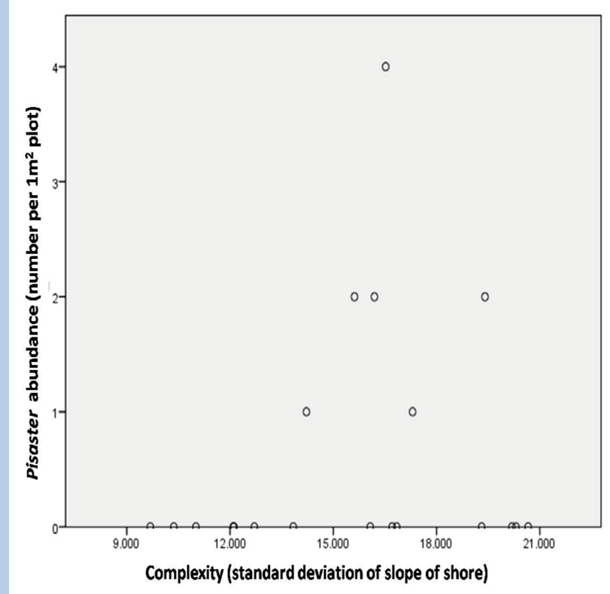

Figure 7: Scatterplot that shows no relationship between number of *Pisaster* and habitat complexity.

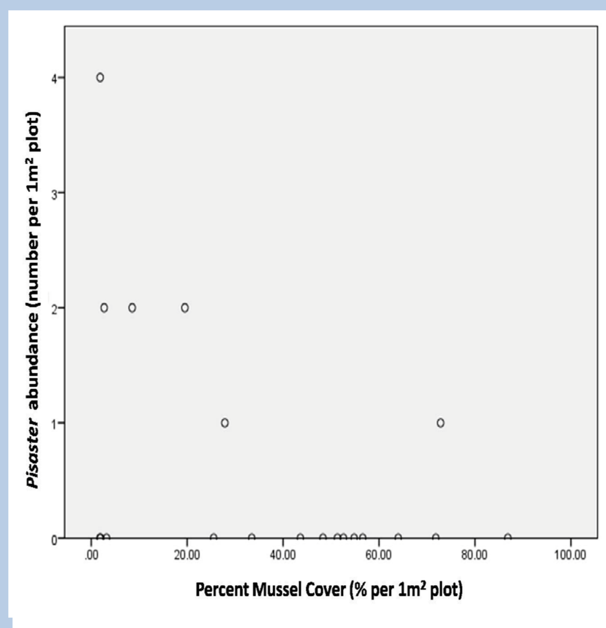

Figure 8: Scatterplot that shows a negative relationship between number of *Pisaster* and percent mussel bed cover.

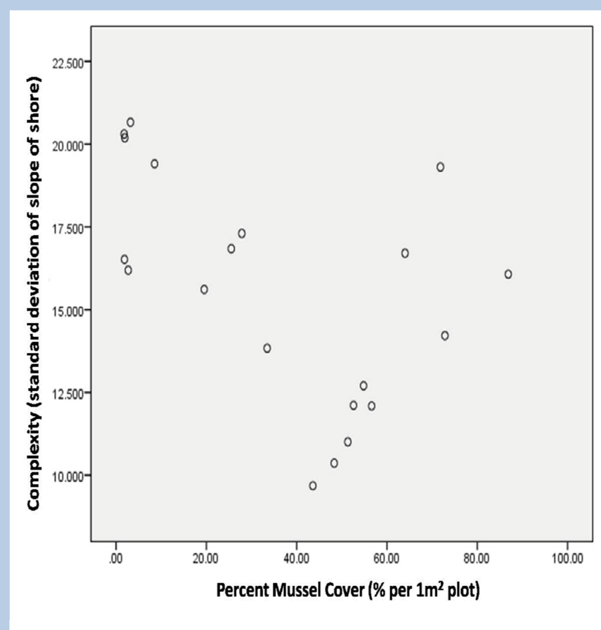

Figure 9: Scatterplot showing a positive relationship between habitat complexity and percent mussel bed cover.

Summary, Conclusions, and Future Work

Summary:

- The lack of a significant relationship between the number of *Pisaster* and habitat complexity **(Figure 7)** could be attributed to the movement of *Pisaster* to lower intertidal zones during low tide. Therefore, not as many *Pisaster* were recorded in the transect bands near the mussel beds because the sea stars were at lower areas of the intertidal closer to the ocean trying to avoid desiccation.
- Mussel bed cover was a good predictor for the number of *Pisaster,* as 17.5% of the variation in number of *Pisaster* could be explained by variation in mussel bed cover **(Figure 8)**. Mussels are the main source of prey for *Pisaster*, so a significant relationship between the number of *Pisaster* and the cover of their food source is expected. Contrary to the hypothesis, the negative relationship is indicative of the predator-prey interaction between *Pisaster* and mussels because high mussel cover would occur where there are few *Pisaster*.
- The significant relationship between mussel bed cover and habitat complexity demonstrates that the mussel beds are an important component of intertidal habitat because they contribute to the biological complexity **(Figure 9)**. Percent mussel bed cover was also a good predictor of habitat complexity at Sea Lion Point (SLP) with 24.3% of the variation in habitat complexity able to be explained by percent mussel bed cover. The negative relationship between mussel bed cover and complexity suggests that with higher mussel bed cover, a decrease in habitat complexity occurs presumably due to mussels becoming the predominant structural feature within a community.

Future Work: Within the significant relationship between low mussel cover and high *Pisaster* abundance there is a potential indirect interaction between habitat complexity and variation in *Pisaster* abundance. Thus, the current lack of among site replication may be masking a significant relationship between high habitat complexity and increased *Pisaster* abundance. Adding additional sites, such as Point Pinos and Hopkins Marine Station, may help in detecting statistical relationships between habitat complexity and *Pisaster* abundance around Monterey Peninsula. In addition to percent mussel bed cover, we also plan to set out wave force dynamometers at all three sites to collect estimates of wave force along each transect. Wave force can have a positive relationship to mussel growth since higher wave force provides a more consistent flow of water and food particles for these filter feeders.

Acknowledgments

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Literature Cited:

Menge BA. 1995. Indirect effects in marine rocky intertidal interaction webs: patterns and importance. Ecological Monographs 65(1): 21-74.

Robles C, Sherwood-Stephens R, Alvarado M. 1995. Responses of a key intertidal predators to varying recruitment of its prey. Ecology 76(2): 565-579.

Smith JR, Fong P, Ambrose RF. 2008. The impacts of human visitation on mussel bed communities along the California coast: are regulatory marine reserves effective in protecting these communities? Environmental Management 41: 599-612.