**Title**
The Effect of Rock Type on Intertidal Community Structure



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Abstract

Altering the coastline in the U.S. in order to prevent erosion is a common practice. Armoring, the addition of hard substrate to the intertidal where soft rocks and sand once existed, covers up native rocks and associated organisms and is a significant disturbance to the intertidal flora and fauna. Since a significant El Niño event in 1983, Santa Cruz County, in central California, has spent several tens of millions of dollars to prevent the erosion of the coastline by armoring (G. Griggs, personal comm., 2002). About 20% of Monterey Bay is armored with concrete seawalls, rip-rap and concrete blocks. Without this human intervention, the coast along Santa Cruz would, on average, retreat about one foot per year (Griggs et al., 1985). Most armoring occurs where the native substrates are soft and easily eroded so houses built too close to the shore run the risk of falling into the sea. In San Diego Bay, to the south, 74% of the total shoreline is now armored with artificial hard substrate. Armoring is a big, expanding business and with global climate changes and a potential sea level rise, armoring may continue to be a prevalent practice. As this alteration of the rock type/substrate is occurring along our coastlines, little consideration is being paid to any ecological consequences of these disturbances. I am interested in how armoring influences the native invertebrate and plant communities in the intertidal zone.

## Activities and Accomplishments

During my one year UCMC funding I was able to get my experiments started. There are several going on simultaneously. Along the central California coast in Monterey Bay, two sites were chosen – Terrace Point (UC Santa Cruz), an intertidal bench with mudstone as bedrock in the north, and Hopkins Marine Station (Stanford University), a granitic boulder field in the south. Both sites have restricted access to the public so field experiments will not be altered. Through a series of transplantation experiments set up in a randomized block design, I am examining how variation in rock type affects the community structure on plates of different rock types with natural rugosity in the field. I installed plates of cut basalt, granite, sandstone and shale 10x10x2cm to the native substrate by a stainless-steel screw drilled in the bedrock in March 2002. I am assessing settlement by counting animals and plants monthly in the field with a 25-power field microscope and recording abundance data for all species that settle on the plates. Settlement plates are cleared of life quarterly in order to see what new species will arrive on new surfaces. Post-settlement plates will be undisturbed in the field for 2 years. I am using a species diversity index as a measure of community structure because it is sensitive to both the number of species in the sample and the relative abundances of the species. These experiments allow for comparisons between shores and between shores with different rocks.

Intertidal communities can be affected by chemical cues, temperature cues, substrate rugosity (surface texture), erosion rates, or interactions between these forces. For example, sandstone retains more water than shale and remains cooler. Some algae have been shown to prefer roughened surfaces, while others are more abundant on smooth surfaces. Rough surfaces provide more water retention preventing desiccation, enhancing evaporative cooling, and can protect spores from being swept away by currents (Fletcher and Callow, 1992). I am in the preliminary stages of setting up my tertiary experiments which include testing the temperature, water retention, and rugosity of different rocks. So, numerous separate experiments will tease apart the effects of different physical attributes of each rock type. To examine temperature, I have temperature loggers secured to the bedrock and on sunny vs. overcast days; I measure the temperature of the different rock plates with a thermistor. It could be that one rock type gets too hot on sunny days and an animal cannot survive the extreme temperature. I am also measuring water retention by submerging rocks in sea water for 5 days and then weighing the rocks as they dry out over time to determine the water capacity and heating/cooling properties. To examine rugosity or roughness of the different rocks, I am cutting plates of basalt, granite and sandstone with surface textures ranging from smooth to medium to rough (normal) and determining which texture is preferred for settlement. It could be that one rock type is preferred over the others simply because of the surface texture not the temperature or evaporative cooling properties, which this experiment will address. I am also working on replicate casts of the different rock types made from molds of z-spar (an epoxy shown to not influence larvae or spores) with characteristic rugosities of the 4 different substrates. This will allow me to discern again if the texture is important and rule out any chemicals that the separate rocks could be exuding. The settlement plates will be in the field for 2 years, until March 2004, and these temperature and surface texture experiments will be completed in April 2004, giving me 2 months to finish writing my thesis.

## Principal Findings

In my preliminary experiment, invertebrate species found in the mid zone at two sites with armoring were similar. A canonical discriminant analysis (CDA), a multivariate technique, was used to evaluate which species were driving the differences in community structure. CDA led to a high degree of classification and the ability to correctly identify the substrate from the community structure was highly significant at Rockview and Merced (MANOVA, Rockview $p<0.001$, Merced $p<0.01$). Both studies showed that on basalt, *Chthamalus* (barnacle) and *Lottia digitalis* (limpet) are more abundant and on sandstone, *Lottia scabra* (rough limpet) and *Porphyra* (green alga) are more abundant. A pattern of substrate type affecting intertidal communities was confirmed in this initial study, and my experimental plates will hopefully tease apart the mechanisms that could contribute to this pattern.

In my secondary experiment, the transplanted plates have been collecting spores and larvae for 8 months. So far, a few patterns are emerging, although these variations are not significant. At Terrace Point, many *Chthamalu*s, small acorn barnacles, settled and grew on the plates. Averaging the settlement on each type of rock for the 6 blocks and 12 replicates, *Chthamalus* prefers to settle on the sandstone plates, and then mudstone bedrock, granite, basalt and the least amount of recruitment occurred on shale plates (Fig. 1). At Hopkins Marine Station interestingly, the substrate preference is the same – most settlement has occurred on sandstone, then the granite bedrock, granite, basalt and shale plates (Fig. 2). It is interesting that the relationship is the same for this animal at 2 sites on either side of the bay and holds for several other species of animals and plants. Also interesting, is that the settlement at Terrace is about 10 times greater than at Hopkins. I believe this relationship is not significant because of the difference between the blocks. That is why my tertiary experiments are so important and in addition, I will address the temperature difference between the plates and the tidal heights. *Balanus* (white barnacle) at Terrace settled preferentially on the bedrock, then sandstone, then basalt, granite and shale. At Hopkins, the preference for settlement was on the bedrock, sandstone, granite, basalt and shale, a little different. Green algae at Terrace settled preferentially on sandstone, then granite, basalt, shale and the bedrock. Green algae at Hopkins settled only on the bedrock. The intertidal is a patchy habitat and indeed, my results may change during the duration of these experiments.

Figure 1. The average number of barnacles alive on the plates at Terrace Point with the standard deviation.

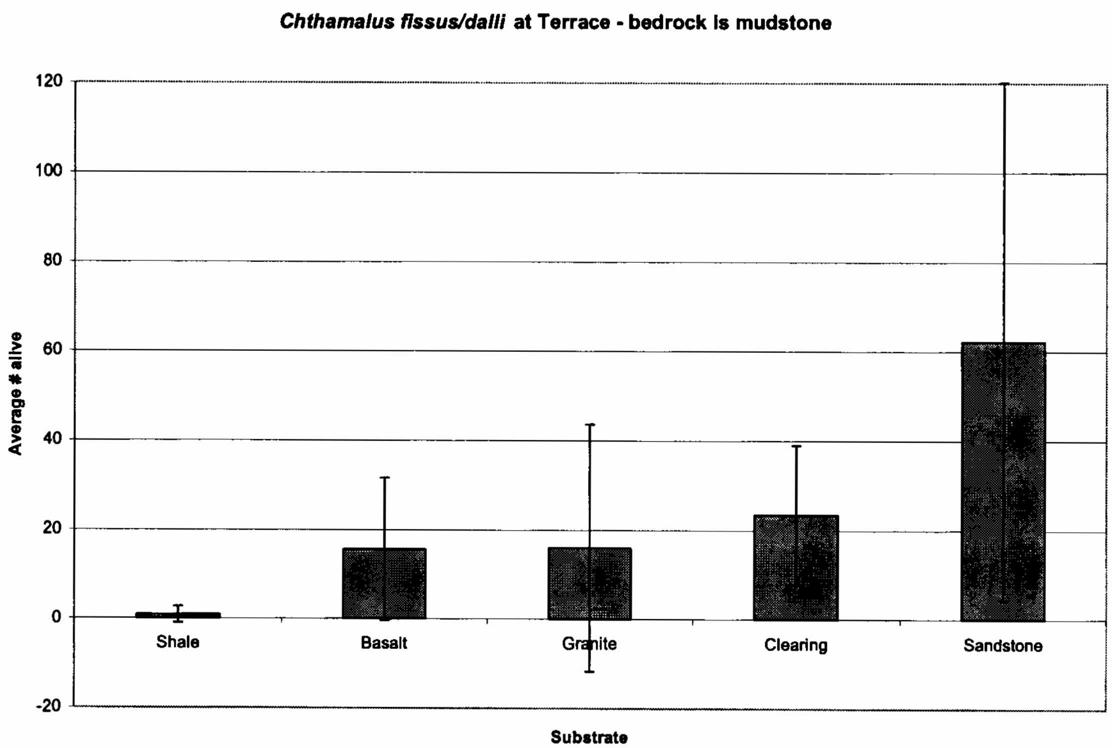
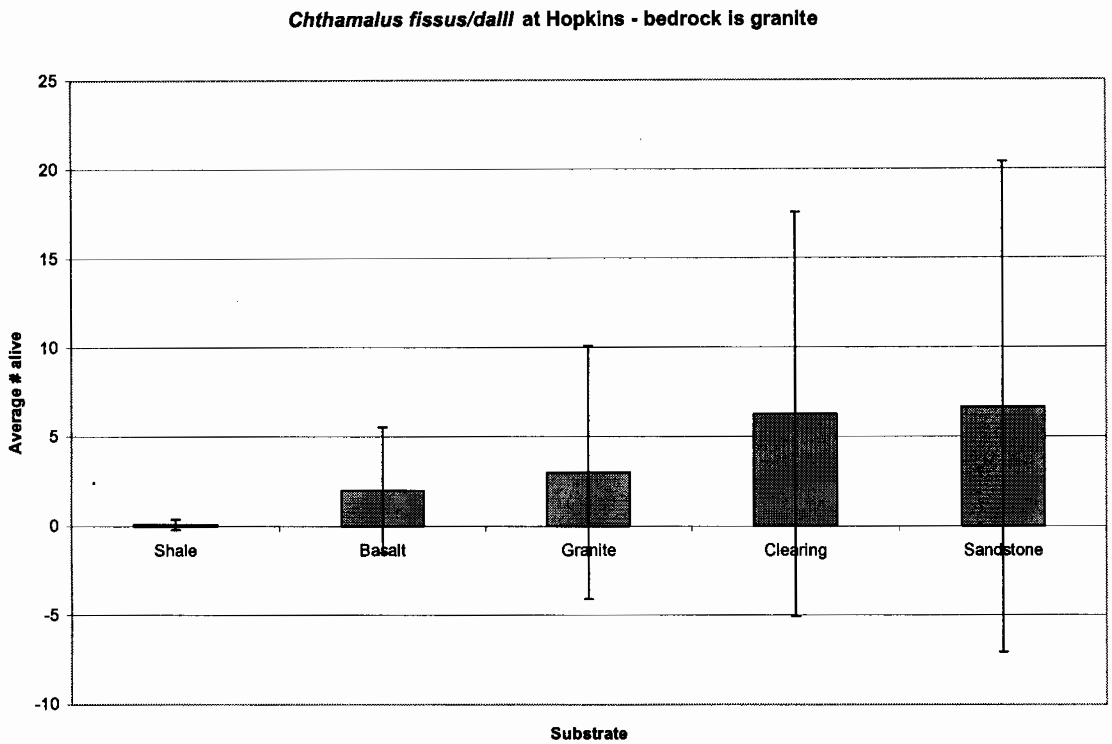


Figure 2. The average number of barnacles alive on the plates at Hopkins with the standard deviation





## Summary

I detected a pattern of distinct communities on different rock types in my preliminary study. Communities were collected on the different substrates at one point in time however, and not over time. The secondary study suggests that different rock types have an effect on community composition, but as I continue with my experiments I hope to demonstrate the mechanisms responsible for these patterns. My experiments now are necessary to determine causes of variations in community structure on different rock types. The pattern could be due to chemical cues, temperature cues, facilitation cues from adult conspecifics, substrate rugosity, boundary layer flows, erosion rates, or interactions between these forces.


## References


Fletcher, R. L. & Callow, M. E. (1992). The settlement, attachment and establishment of marine algal spores. *British Phycol. J.* **27,** 303-329.

Griggs, G.B. & Savoy, L.E. (1985). Living with the California Coast. Duke University Press, Durham, N.C., 394 pp.