The effects of habitat structure on algal associated invertebrates

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Introduction

With current declines in biodiversity, understanding how plant community richness and composition influence ecosystem processes has received great deal of attention. Though this subject has been well explored in the context of system primary productivity, not as much information exists regarding the effects of plant diversity on the provision of habitat for associated epifauna.

Kelp forests contain heterogeneous communities of algae that enhance local diversity through the provision of food and habitat to a wide variety of invertebrates. These invertebrates, in turn, provide an important link between primary producers and higher trophic levels. Numerous observational and experimental studies suggest that invertebrates associate with algal habitat is based on physical features. The effects of algal diversity on associated community structure, however, are poorly understood.

Research Questions

1. How do patch size, algal richness, and algal identity/composition influence associated invertebrates? Do the effects of richness and composition change at different spatial scales?
2. Do invertebrates respond more strongly to algal richness or composition?
3. Are invertebrate communities found on monospecific algal patches characteristic of those found on patches with multiple component species?

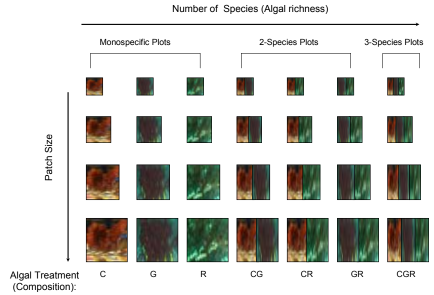
Materials and Methods

Using three species of red algae, I manipulated algal patch size and composition in an orthogonal design to determine the effects of algal patch size, richness, and composition on associated invertebrate communities. Algae of varying physical complexity were chosen to observe if potential patterns of invertebrate association were consistent with expectations based on the generally strong influence of thallus structure. The experimental design employed both additive and substitutive designs to observe if increasing algal richness enhances/reduces invertebrate response to each type of algal habitat.

Structural Complex ity	Algal Speci es Richn ess 1	2	3
Low	Chon droc anthus (C)	Chon droc anthus + Gymn ogo ngrus (CG)	
Inte rmediat e	Gymn ogo ngrus (G)	Chon droc anthus + Gelidium (CR)	Chon droc anthus + Gelidium + Gymn ogo ngrus (CGR)
High	Gelidium (R)	Gymn ogo ngrus + Gelidium (GR)	

Table 1. Description of the seven algal treatments arranged according to algal richness, and structural complexity within each richness treatment. All treatments were created at four patch sizes, with the three-species combination treatment (CGR) created at a fifth size to extend the additive experimental design. Species are labeled throughout the experiment as follows: *Chondrocanthus corymbiferus* (C), *Gymnogongrus chiton* (G), and *Gelidium robustum* (R). For each algal treatment, N = 10 replicates/patch size.

Experimental Design



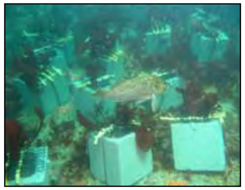


Figure 1. Experimental Design

Treatments were grouped into five distinct blocks on rocky reef at approximately 30 feet, and left out for 17-21 days to allow for invertebrate colonization. The experiment was conducted twice (July and August) to increase replication.

Algal transplants placed directly into sealable plastic bags to retain all associated invertebrates. Invertebrates were collected by rinsing each transplant repeatedly in fresh water, and were enumerated and identified to broad taxonomic groupings (Order level).

Analysis

Patch Size, Algal Richness, Algal Composition

I used a series of univariate general linear models (GLM) with pre-planned comparisons to analyze the effect of patch size, and the effects of algal richness and composition at varying spatial scales, on associated invertebrate abundance, richness, and diversity (Shannon-Weiner Index). The relative effects of algal richness and composition were tested by comparing each monospecific treatment to the three-species treatment.

Differences between habitat types based on the distribution and abundance of associated invertebrate taxon were analyzed using two-way crossed ANOSIM (treatment and size as factors). SIMPER analyses were conducted to determine which taxon most contributed to observed differences between invertebrate assemblages associated with each algal habitat type.

Additive and Substitutive Experimental Designs

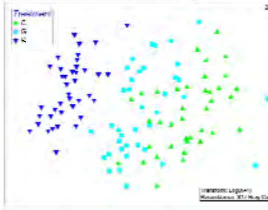
I determined if increasing algal species richness effects invertebrate association with algal habitat using both additive and substitutive designs by comparing observed invertebrate abundance when multiple habitat types were present to expected values based on the summed observations from monospecific habitat patches.

Results

Patch Size, Algal Richness, and Composition:

- Invertebrate abundance (p=0.000) and richness increased and invertebrate density decreased (p=0.000) with increasing patch size (p=0.000).
- Patch size did not influence invertebrate diversity (p=0.607).

Figure 3. MDS ordination of differences between 1-species treatments based on associated invertebrate community composition. Pairwise ANOSIM comparisons showed significant differences (*R*=0.568, *P*=0.1%) between all three treatments



- Algal richness significantly influenced invertebrate richness (p=0.008) and diversity (p=0.000) , but not abundance (p=0.275) (**Fig. 4**).
- Algal composition significantly influenced invertebrate community structure; Invertebrate abundance, richness, and diversity were significantly higher on monospecific patches of *G. robustum* than any other algal treatment, and decreased with the proportion of *G. robustum* present (**Fig. 5**).
- There were no interactions between patch size and either algal richness or algal composition for any of the invertebrate response variables.

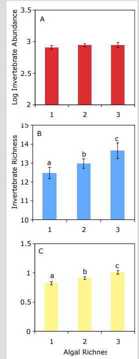


Figure 4. Richness effects

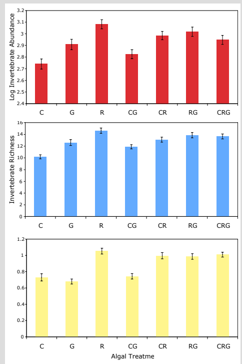
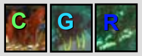


Figure 5. Composition effects (mean ± SE).

General test of algal Richness effects versus Composition effects:



versus

Each Monospecific Treatment

3-Species Treatment

Results

Comparison of Additive and Substitutive Experimental Designs:

Additive Design: Total amount of each alga kept constant (confounds algal richness with patch size).

- Additive design significantly overestimated invertebrate abundance
- Perimeter corrected invertebrate abundance as well as invertebrate richness and diversity showed no deviation from additive expectations.

Substitutive Design: Total amount of algal habitat kelp constant (different relative amounts of each alga in monospecific and combination plots).

- Accurately predicted invertebrate abundance and diversity, but overestimated richness.

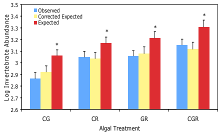


Figure 7. Expected and observed invertebrate abundances using the Additive Design. Both initial expected abundances and abundances values after perimeter corrections are included. Error Bars are mean +1SE. Significant differences marked by an asterisk.

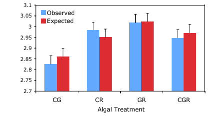


Figure 8. Expected and observed invertebrate abundances using the Substitutive Design. Error Bars are mean +1SE.

Conclusions

This experiment showed evidence for habitat composition effects; no multi-species plot supported an invertebrate community with higher abundance, diversity, or richness than monospecific plots of *G. robustum*. Though I detected significant effects of algal richness on invertebrate richness and diversity, these effects were likely the result of sampling effects, where combination treatments were more likely to contain *G. robustum.*

Increasing algal richness did not impact invertebrate response to each algal species; all measures of invertebrate community structure were additive. Analysis of expected abundance based on the additive experimental design yielded insight into the importance of edge effects to algal associated epifauna. Expected abundances were significantly higher than those observed for all treatments before corrections were made to account for the discrepancy in perimeter between summed monospecific component patches and observed multi-species patches. The same overestimation was not made using the substitutive design. These results, in addition to the significant decrease in invertebrate density with patch size, suggest that perimeter availability has a positive influence on associated invertebrate communities.

Understanding how structural attributes of algal patches influence patterns of invertebrate diversity is important for understanding of how algal-associated invertebrates (and the many species that forage on these invertebrates) will respond to factors that alter the diversity and abundance of benthic marine algae. This information is necessary for informing decisions regarding resource management and conservation in near shore marine systems where algae are a major source of habitat.

Literature cited

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For further information

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More information on this and related projects can be obtained at http://bio.research.ucsc.edu/people/carr/