Invasive reefs as structural habitat for introduced species

Kimberly W. Heiman, Nicholas Vidargas, and Fiorenza Micheli
Stanford University's Hopkins Marine Station, Pacific Grove, California

OVERVIEW

The vectors of transport and introduction of marine invasives, such as oyster culture and boat fouling, often select for organisms that are dependent on hard substrate during some life-stage. In many highly invaded estuaries, hard substrates are added through human activities and through the introduction of reef-building invasives. Concurrently, many native biogenic habitats (structured environments created by the bodies of animals and plants) are on the decline. Do invasive biogenic habitats, which are becoming increasingly common and in some cases replacing declining native biogenic species, provide ecosystems with the same services and functions as the natives? Do the invasive biogenic habitats increase the likelihood of hard-substrate-dependent invasive species surviving and reaching high abundances in invaded systems?

Study site and species

Elkhorn Slough, a small central California estuary, historically had large populations of the native oyster *Ostrea conchaphila*, but today this species is rare. In the 1990s, the reef-building tubeworm *Ficopomatus enigmaticus* invaded Elkhorn Slough from San Francisco Bay and spread throughout the system. In this research we explore the impacts of the invasive *F. enigmaticus* reefs on local communities.

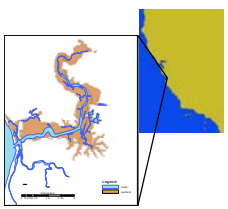


Figure 1: Elkhorn Slough is a central California estuary 150km south of San Francisco Bay

Funding sources
National Estuarine Research Reserve Graduate Research Fellowship
Myers Oceanographic Trust
Environmental Protection Agency-STAR Graduate Fellowship

Reef removal experiment

Do habitat-forming invasives facilitate other invaders through the provision of structural resources?

METHODS
- 12 reefs divided into 3 treatment groups (control, disturbance control, removal)
- Community sampled
  - Where: reef, under, 5cm, and 100cm outside reef's edge
  - When: before, 6, and 12 months after treatment
- Statistics (MDS, ANOSIM, SIMPER, ANOVA)

Invasive species dominate communities both in and near invasive *F. enigmaticus* reefs. The average percent abundance before treatments were applied is displayed by sample location in Fig. 2. Within the reefs, 96% of the animals found were invasive due to the high densities of three non-native amphipods. In the mudflat samples, regardless of proximity to the reef, ~65% of the animals were invasive. 10 of the 26 species identified in this experiment were invasive. The highly invaded communities around the *F. enigmaticus* reefs may indicate possible facilitation by the reefs on other invasive species. For example, many of the invasive species in high abundance within the reefs are species that were introduced through oyster culture and prefer to utilize complex structures such as the reef's biogenic matrix.

Figure 2: Percent abundance of invasive and native species in samples before removal.

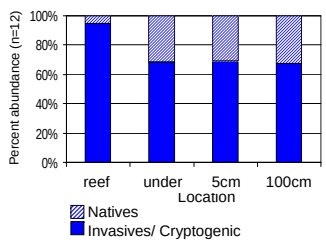
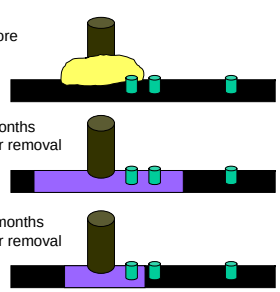


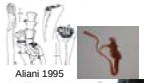
Figure 3: Spatial extent of significant community differences between removal and control reefs shown as purple bars (MDS, ANOSIM).

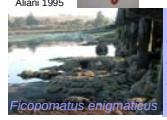


Mudflat communities showed a significant but highly localized response to the removal of reefs. Changes in the abundance of invasives such as the amphipod *Monocorophium insidiosum*, and the oligochaete *Tubificoides brownae* drive the community differences. The difference is limited to the samples taken from under and near (5cm away) where the reef used to be (Fig. 3). The community differences persist through time and are driven by changes in the abundance of 6 species, 4 of which are invasive. This experiment indicates that the presence of *F. enigmaticus* reefs has an effect on nearby mudflat community composition.

Biogenic habitat comparison

Do invasive and native biogenic habitats host different communities?





METHODS
- 4 oyster sites and 4 *F. enigmaticus* sites (3-6 samples/site)
- All associated species identified and counted
- Samples standardized by weight
- Statistics (MDS, ANOSIM, SIMPER)

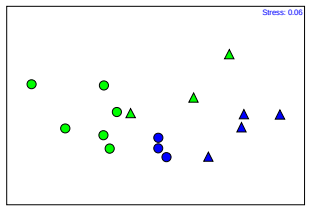
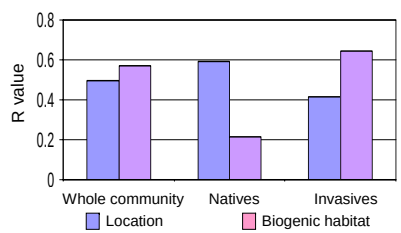


Figure 4: Ordination of rank similarity between sites with both *F. enigmaticus* and *O. conchaphila*. Symbols that clump together represent samples that are similar in species composition and abundance. (MDS)

Communities using biogenic habitats differ between location and between invasive tubeworm and native oyster clumps. The green site B symbols are on the top of the ordination plane and the blue site F symbols are on the bottom (Fig. 4). Additionally, most of the *F. enigmaticus* samples (triangles) fall to the right of the *O. conchaphila* samples (circles). *F. enigmaticus* reefs are not serving the same function as native oysters in terms of habitat provision. Invasive reefs house significantly different communities of animals than native oysters.

Invasive species prefer the invasive reefs to the native oysters regardless of location, whereas native communities depend more on location within Elkhorn Slough than on a specific biogenic habitat. When the entire community is analyzed as a whole, location and biogenic habitat have a similar predictive power (Fig. 5). High R values indicate a high explanatory value (e.g. more dissimilarity between locations than within a location).

Figure 5: Average dissimilarity between location and habitat for community components (ANOSIM)



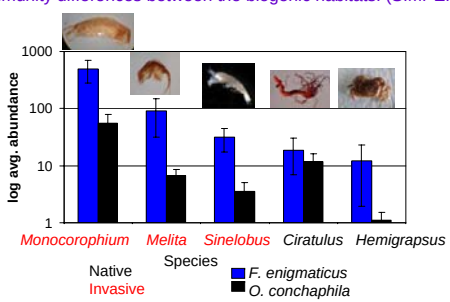
CONCLUSIONS

The presence of *F. enigmaticus* reefs enhances the local abundance of invasive species.

F. enigmaticus reefs support a unique community, making the reefs functionally different from other biogenic habitats in Elkhorn Slough.

Managers can target control efforts on habitat-forming invasives as a means of reducing abundances of associated invasives.

Figure 6: The average abundance of six species that drive community differences between the biogenic habitats. (SIMPER)



F. enigmaticus reefs are better habitat than *O. conchaphila* clumps for many species, especially invasives. The differences between communities found in invasive tubeworm clumps and native oyster clumps are driven by the high abundance of 6 species in the tubeworm clumps, 3 of which are invasive (Fig. 6).