

Cleaning up Oahu's Coastal Waters, the Role of Tube-Building Polychaetes in Sediment Dynamics

Problem and Research Objectives

The natural dynamics of marine sediments and their associated biota are affected by human disturbance in coastal waters. These areas receive drainage from land, groundwater incursion, periodic stream runoff, and may be influenced by sewage injection wells, cesspools and seasonal high surf. Reefs and adjacent beaches are heavily used for recreation, boat traffic and fishing along the south shore of Oahu, Hawaii and on the other Hawaiian Islands. Changes to these reefs over the last three decades include increased terrigenous inputs due to development in the watershed, the accidental introduction of non-native algae and benthic invertebrates to the reef fauna and the reduced abundances of corals, fish and octopus due to overfishing and habitat loss or changes in the habitat.

Since the early 1980's, *Avrainvillea amadelpha*, an introduced alga, was reported on the southeast shore of Oahu. It is now considered one of the most widespread invasive nonindigenous species in Maunalua Bay, Oahu (Coles et al. 2002). This species inhabits soft bottom habitats co-occurring with the endemic Hawaiian sea grass *Halophila hawaiiiana* (Smith et al. 2002) and is a serious environmental threat to local marine communities.

Efforts to remove introduced algae from reefs in Kaneohe Bay and off Waikiki have been ongoing with some success (Smith et al. 2004). However, the assemblage of invertebrate taxa associated with these algae has not been thoroughly investigated to ascertain if native and/or introduced species are a part of the community. These benthic invertebrate assemblages may be affected by the presence of invasive algae, which may enhance (Argyrou et al. 1999) or decrease (Streftaris and Zenetos 2006) local diversity.

Avrainvillea amadelpha mats typically serve as a substrate for many native epiphytic algae (Smith et al. 2002). This association is known to increase the diversity of associated faunal assemblages by providing food and shelter (Duffy 1990), increasing the physical complexity of the habitat and providing a refuge from fish predation (Dean and Connell 1987), providing greater availability of surface area (McGuinness and Underwood 1986) and by reducing the impact from wave exposure (Dommasnes 1968).

The principal objectives of this proposal are to:

1. Characterize the macrobenthic communities associated with the invasive alga *Avrainvillea amadelpha* in a reef flat on Oahu's south shore.
2. Characterize the macrobenthic communities of the surrounding sediments.
3. Verify if there are differences between the macrobenthic communities associated with the invasive alga and those living in bare sediments using analysis of similarity.
4. Understand the distribution of some endemic and more widely distributed species that characterize these communities prior to invasive algal removal efforts.

Methodology

Study Area

This study was carried out on the south shore of Oahu on the nearshore reef flats in Maunalua Bay (Figure 1). The area is predominantly composed of consolidated limestone reef flats covered by a shallow substratum of fine to coarse sand.

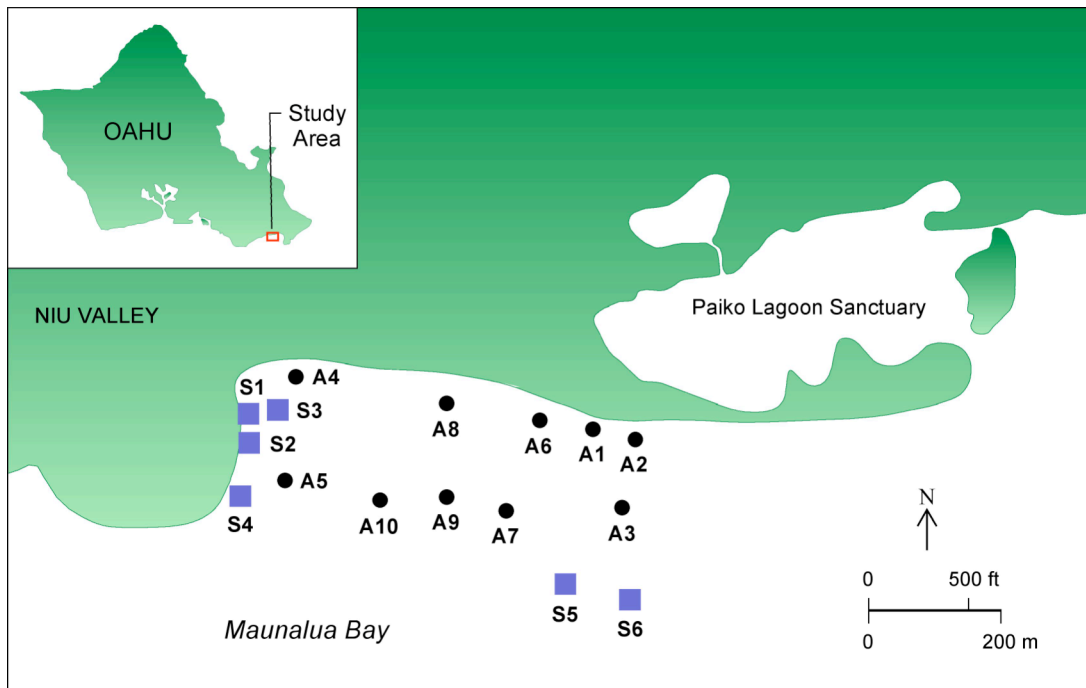


Figure 1. Map of the study area showing the algae (circles) and sediment (squares) stations.

Sampling Design and Macrobenthic Assemblages Survey

Sixteen sampling stations were selected for this study; ten stations (A1–A10) were distributed in areas where *Avrainvillea amadelpha* occurs abundantly and six stations (S1–S6) were placed on sand patches without any algal growth. Three replicates of approximately 475 cm³ each were collected in March 2010 at each station by hand using a Nalgene corer (11 cm in diameter × 5 cm deep). The *Avrainvillea amadelpha* samples (A stations) were composed of sediment to a depth of 5 cm and the overlying algae within the corer. The sediment samples (S stations) were collected with the same Nalgene corer and comprised the top 5 cm of sediment.

All samples were fixed in buffered 10% formalin in water and in a Rose Bengal mixture immediately after sampling for a minimum of 48 hours. Organisms were carefully removed from the crevices and blades of the algae, and placed in 70% ethanol. The algal and sediments were then elutriated with tap water over a 0.5 mm sieve. The organisms retained on the sieve were placed in 70% ethanol. Using compound and dissecting microscopes, the organisms were sorted by major taxa, counted and identified to the lowest taxonomic level possible.

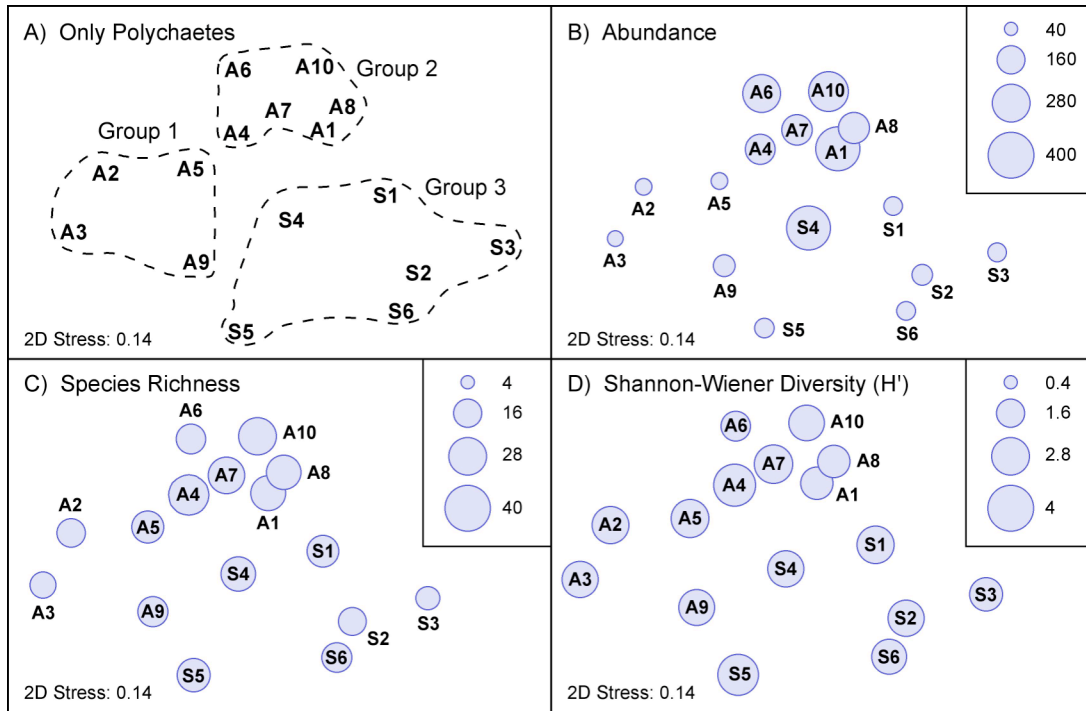
Data Analyses

The replicates within each station were pooled and the abundance (N), species richness (S), and Shannon-Wiener diversity index (H') were calculated for each station. Non-metric Multidimensional Scaling (nMDS) was constructed to produce two-dimensional ordination plots and show relationships among assemblages of all invertebrates and polychaetes, excluding the other taxa. Since the general pattern using both matrices was very similar, we used only the polychaete species structure in the multivariate analysis due to its better taxonomic resolution.

An analysis of similarity (ANOSIM) was performed to verify if the patterns observed in the nMDS ordinations were statistically significant. Similarity percentage analysis (SIMPER) was used to determine the taxa contributing the most to the dissimilarity between groups. All multivariate analyses dealing with biological data were done using the Bray-Curtis similarity coefficient with non-standardized and fourth root transformed data in the PRIMER 6.0 software.

Principal Findings and Significance

1. The macrobenthic assemblages associated with the green invasive alga *Avrainvillea amadelpha* and surrounding sediment patches were very diverse and abundant with a total of 13,607 macrobenthic organisms collected representing 106 taxa.
2. Two new species of polychaete worms were discovered from samples taken from this project, *Raphidrilus hawaiiensis* and *Protocirrinieris* sp. nov.
3. *Avrainvillea amadelpha* mats are a suitable habitat for macrobenthic organisms at this location, especially those detritus feeders favored by the fine sediment coating accumulated on the branches and in crevices of the alga. This green alga housed a large diversity of organisms and seemed to serve as a permanent habitat for several crustaceans, nematodes, and polychaetes.
4. The sampling stations were separated into three groups that were significantly distinct in terms of composition of organisms (Figure 2, Table 1). Group 1 comprised of stations on *Avrainvillea amadelpha* mats with low abundance of polychaetes and characterized by the presence of the syllids *Sphaerosyllis densopapillata* and *Branchiosyllis exilis*, and the eunicid *Nematonereis unicornis*. Group 2 was characterized by stations on *A. amadelpha* mats with higher abundance of polychaetes and the presence of the syllids *S. densopapillata*, *Exogone verugera* and *Exogone longicornis*. Group 3 was characterized by stations on surrounding sediments without *A. amadelpha* and by the presence of the syllids *S. densopapillata* and *E. longicornis* and the endemic lumbrinerid *Lumbrineris dentata*.



Note: Station samples (circle) for plots: B represents the abundance of polychaetes in number of individuals (ranging from 40 to 400), C represents the richness of polychaetes in number of species (ranging from 4 to 40), and D represents the diversity of polychaetes (ranging from 0.4 to 4).

Figure 2. Comparison of nMDS ordinations for polychaete species by: A) Sampling groups, B) Abundance, C) Species richness, and D) Shannon-Wiener diversity (H').

Table 1. Top five polychaete species typical of each group, based on SIMPER.

	Group 1	Group 2	Group 3
	<i>S. densopapillata</i> (Syllidae) (16.82%, 16.98)	<i>S. densopapillata</i> (Syllidae) (13.75%, 3.58)	<i>S. densopapillata</i> (Syllidae) (16.89%, 4.33)
	<i>B. exilis</i> (Syllidae) (12.40%, 6.46)	<i>E. verugera</i> (Syllidae) (7.93%, 7.78)	<i>L. dentata</i> (Lumbrineridae) (10.12%, 3.60)
	<i>N. unicornis</i> (Eunicidae) (12.32%, 6.27)	<i>E. longicornis</i> (Syllidae) (7.57%, 5.80)	<i>E. longicornis</i> (Syllidae) (9.01%, 6.50)
	<i>E. verugera</i> (Syllidae) (12.20%, 4.63)	<i>A. intermedia</i> (Opheliidae) (7.14%, 9.62)	<i>T. cornuta</i> (Syllidae) (8.86%, 1.23)
	<i>Scyphoproctus</i> sp. (Capitellidae) (16.43%, 0.91)	<i>T. cornuta</i> (Syllidae) (6.89%, 8.02)	<i>Paraonella</i> sp. (Paraonidae) (8.65%, 5.05)
Mean No. of Species/Group	48.73 %	55%	47.96%

Note: Percentage of species and ratio (n) of average similarity to standard deviation of similarities indicated in parenthesis.

5. Several polychaete worms, including the tube builder *Mesochaetopterus minutus*, were predominantly collected in the sediment patches without algal growth. *M. minutus* is a gregarious worm that forms tufts of sand-covered tubes and is mainly found on shallow water reef flats along Oahu's south shore (Bailey-Brock 1979, Bailey-Brock 1987). This species might play an important role in these assemblages by binding the sediments loosened by the algal removal efforts in and around their tubes.
6. Current efforts to remove the attached *A. amadelpha* in the study area might destabilize the existing assemblages and recruitment to the cleared area of the reef, but further collections after the removal efforts are necessary to reach any conclusion. This study was conducted right before the first clearing of invasive alga from the area and represents important baseline information to understand the resilience of this ecosystem.

Publications Cited in Synopsis

- Argyrou, M., A. Demetropoulos, and M. Hadjichristophorou, 1999, "Expansion of the macroalga *Caulerpa racemosa* and changes in soft bottom macrofaunal assemblages in Moni Bay, Cyprus." *Oceanologica Acta*, 22, 517–528.
- Bailey-Brock, J.H., 1979, "Sediment trapping by chaetopterid polychaetes on a Hawaiian fringing reef." *Journal of Marine Research*, 37(4), 643–656.
- , 1987, "Phylum Annelida," in D.M. Devaney and L.G. Eldredge (eds.), *Reef and Shore Fauna of Hawaii*, Honolulu, Hawaii, Bishop Museum Press, pp. 213–454.
- Brostoff, W.N. 1989. *Avrainvillea amadelpha* (Codiales, Chlorophyta) from O'ahu, Hawai'i. *Pacific Science* 43(2): 166–169.
- Coles, S.L., R.D. DeFelice, and L.G. Eldredge, 2002, "Nonindigenous marine species at Waikiki and Hawai'i Kai, O'ahu, Hawai'i," Bishop Museum Technical Report 25, 245 p.
- Dean, R.L., and J.H. Connell, 1987, "Marine invertebrates in algal succession. II. Tests of hypothesis to explain diversity with succession," *Journal of Experimental Marine Biology and Ecology*, 109, 217–247.
- Dommasnes, A., 1968, "Variations in the meiofauna of *Corallina officinalis* L. with wave exposure," *Sarsia*, 34, 117–124.
- Duffy, J.E., 1990, "Amphipods on seaweeds: Partners of pests?" *Oecologia*, 83, 267–276.
- McGuinness, K.A., and A.J. Underwood, 1986, "Habitat structure and the nature of communities on intertidal boulders," *Journal of Experimental Marine Biology and Ecology*, 104, 97–123.
- Smith, J.E., C.L. Hunter, and C.M. Smith, 2002, "Distribution and reproductive characteristics of nonindigenous and invasive marine algae in the Hawaiian Islands," *Pacific Science* 56(3), 299–315.
- Smith, J.E., C.L. Hunter, E.F. Conklin, R. Most, T. Sauvage, C. Squair, and C.M. Smith, 2004, "Ecology of the invasive red alga *Gracilaria salicornia* (Rhodophyta) on O'ahu, Hawai'i," *Pacific Science*, 58(2), 325–343.
- Streftaris, N., and A. Zenetos, 2006, "Alien marine species in the Mediterranean – the 100 'Worst Invasives' and their impact," *Mediterranean Marine Science*, 7(1), 87–118.