Population Dynamics of Hermatypic Corals on Artificial Reef Modules at Waiʻanae, Hawaiʻi

Julia Rose

University of Hawaiʻi at Hilo Marine Option Program

Advisor: Dr. Megan Ross

Faculty Mentor: Lisa Parr

Abstract

Artificial reefs are a controversial method of increasing fish biomass by creating new habitat on the ocean substrate. In this study, cement artificial reef modules were examined to assess their efficacy as a suitable substrate for coral recruitment and growth. The artificial reefs off of Waiʻanae on the island of Oʻahu were sampled for coral distribution as well as taxa and size demographics. These artificial reefs are comprised of two different sites with slightly differing environmental characteristics. Coral distribution and demographics were compared at either site and also on both horizontal and vertical surfaces of the cement modules. Overall percent cover of live coral was found to be much higher on the artificial reef modules than averages from across the same coast and island, according to data from NOAA PIFSC. Size frequency distributions showed that colonies on vertical surfaces were larger on average than those on horizontal surfaces, indicating that sediment may be a controlling factor in the mortality of coral colonies at this site. Recommendations were made to account for this in the placement and design of future artificial reefs.

Introduction

Artificial reefs have been implemented in Hawaiʻi since 1961 and have been popular management and mitigation strategies to create habitat for commercially important ocean

resources. The majority of artificial reefs in Hawai‘i have been placed with the intention of increasing fish biomass by providing new structurally complex habitat (Division of Aquatic Resources), but other ecologically significant organisms such as corals, other invertebrates and algae also utilize the space at most artificial reefs (Fitzhardinge and Bailey-Brock 1989).

Corals, algae, and invertebrates provide food and shelter for a more diverse population of fishes and also serve to cement the reef structure together (Carter et al. 1985). This could further fortify the reef against large storm events and other damaging elements, in turn protecting the shoreline and other coastal resources. Coral growth on artificial reefs could also ultimately allow the habitat to attain a more natural equilibrium and provide further habitat complexity and shelter for fishes and invertebrates. Further, recent concern about mass coral bleaching and mortality events has made coral habitat mitigation and restoration more relevant and important than ever.

The Division of Aquatic Resources has conducted surveys at two sites in Waianae just offshore of Ma‘ili Beach to assess the fish population and conduct a brief benthic assessment of the artificial reef. The objective of this study was to augment their existing data and describe the species composition, spatial distribution, size and growth forms of coral colonies found on the artificial reef modules at these two sites in Waianae.

Methods

Two sites of artificial reefs in Waianae on the western coast of O‘ahu are made of prefabricated cement structures called Z modules. Z modules are commonly used structures in artificial reef building in that they are relatively inexpensive and easy to deploy. These modules measure 4’x8’ on their largest flat surface, with two 12” surfaces in opposite directions perpendicular to the flat surface on either end (Fig 1). These modules were dropped haphazardly

from a barge to create maximum three-dimensional surface area in the most cost-effective manner. The modules were placed in Waianae in 1993.

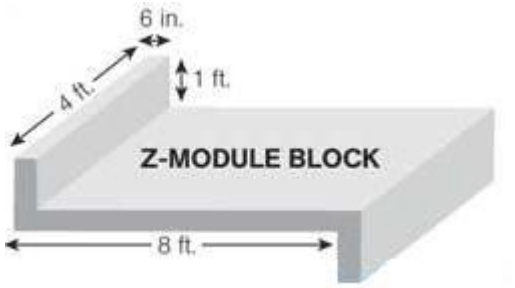

Figure 1: Illustration of the standard dimensions and shape of the artificial reef Z modules used at the Waianae Artificial Reefs

Coral Surveys

A 30m transect was rolled out over maximum target habitat (Z modules). The uppermost modules found every five meters on the transect beginning at meter 5 were sampled. A 0.4ft^2 quadrat was placed as close to center on the horizontal side of the module and all coral colonies were counted, sized and identified within the quadrat. This procedure was repeated on the inner facing vertical face of the Z module. Size was recorded as the maximum length and perpendicular width of an individual colony. Photo-quadrats were taken of the sampled areas, as well as four other locations of the quadrat on the Z module.

Statistical Analyses

Data was assessed using Minitab 16 software to compare colony sizes, numbers, and species between the vertical and horizontal portions of the Z modules. Size frequency distributions were generated for each North, South, Horizontal, and Vertical variable combination. Photo-quadrat images were analyzed using Coral Point Count with Excel Extention 4.1 (CPCE 4.1) to describe 50 random points for each photoquad area.

Results & Discussion

In total, 57 modules were surveyed across both sites, with a total of 303 photoquadrats analyzed. Species distribution was found to differ greatly between individual observers, and was therefore excluded from final data analysis. Instead, genus was used to define the taxanomic distribution, with *Porites* comprising the largest portion of the coral community.

Varying environmental conditions were observed at either site. At the North Site, a steep drop-off from 60 – 80fsw ended in a large sand patch, covering many Z-modules. These modules were mostly beyond the allotted depth range for this study and were not sampled for coral cover. However, it was observed and noted that there were few to no coral colonies growing on the heavily sediment-impacted modules (fig 2). The proximity of this sand patch and the sediment flow of the area may be influencing coral growth and mortality at this site, particularly on the horizontal surfaces of the modules. Dominant water currents during the time of survey were noted to be flowing generally parallel to the coast, north to south. Directly to the south of the largest group of modules at this site was an aggregation of coral colonies adhering to the natural substrate and making a small reef (fig 3). Genetic sampling of these colonies in future studies could illuminate relationships between the corals on the modules and those found on the small natural reef. It would be interesting to investigate whether the corals on the modules are spawning and supporting further growth on the natural reef.

Figure 2. Showing heavily sediment-impacted modules at the North Site. The noted absence of coral on these modules is highly indicative that sediment is a controlling factor of coral recruitment and growth at these sites.

Figure 3. Showing the small natural reef directly adjacent and down-current of the North Site.

Size frequency distributions were generated for each site and each variable (horizontal and vertical surfaces) (fig 4). These distributions and their corresponding statistics indicate that the horizontal surfaces at both sites had on average a greater number of smaller colonies than vertical surfaces. In other words, the average size of coral colonies on vertical surfaces was larger than those on horizontal surfaces. This is also reflected in the percent cover data (fig_) where a higher average percent cover of live coral is found on vertical surfaces. This may indicate a higher mortality rate of coral colonies on horizontal surfaces. Contributing factors to this difference may be rooted in the sedimentation that these sites experience. Future placement

of artificial reefs may want to take sediment loads into account while choosing potential locations to install Z modules. The module design could also integrate more vertical surfaces to promote coral growth, if this is a priority of artificial reefs in the future.

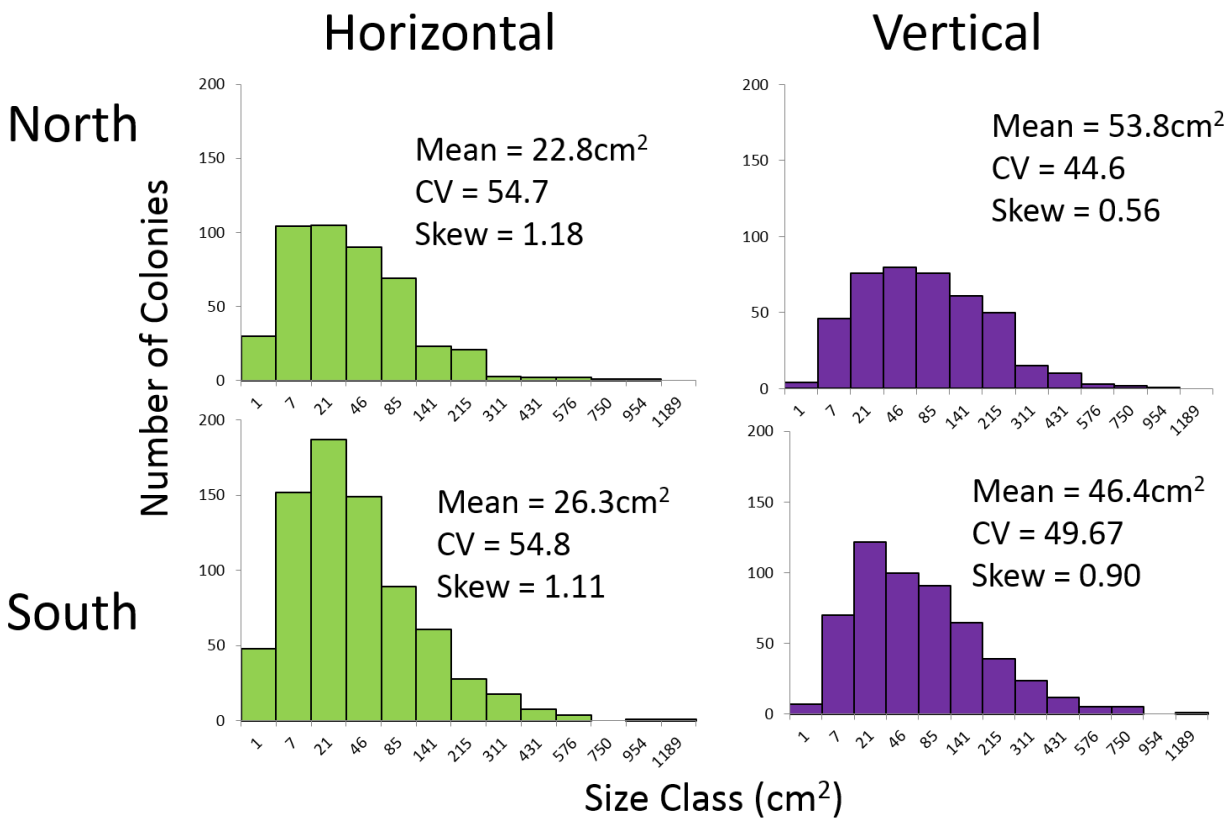

Figure 4. Size frequency distributions of coral colonies at both sites and across both horizontal and vertical surfaces of Z modules.

The average percent cover of live coral found across the two sites at Waianae was much greater than the average found in West O‘ahu and all of O‘ahu at the same depth range (NOAA PIFSC) (Table 1). This may be a good indicator that the Z modules serve as a better recruitment surface for coral than the natural substrate surrounding most of the island. Further comparisons with the adjacent natural substrate would be beneficial in illuminating the efficacy of the Z

modules as a substrate for coral recruitment. Coral reefs are characteristically patchy, and this patchy distribution may influence the island or coast-wide average, making this an imbalanced comparison because the two datasets are at drastically different scales. Comparison of other reefs of roughly the same age may also be useful in determining how effective the Z modules are as a coral recruitment substrate.

Table 1. Average values of percent live coral cover for each variable including site, horizontal/vertical, and pooled data. *Data from NOAA PIFSC is also shown for comparison.

VARIABLE	AVG. % LIVE CORAL COVER	STD. DEVIATION	STD. ERROR
NORTH SITE	31.0	16.0	1.2
SOUTH SITE	38.3	16.1	1.5
VERTICAL	44.8	15.7	2.2
HORIZONTAL	29.5	15.4	1.0
POOLED	32.0	16.4	0.9
WEST O‘AHU*	5.6*		
O‘AHU*	12.0*		

The artificial reefs off of Waiʻanae boast a surprising amount of coral. Several environmental factors may be contributing to the distribution of colonies, including sediment, currents, and depth. The coral cover on the modules is much higher than local averages on the coast and island-wide scale, indicating that they may serve a second purpose as coral recruitment surfaces that could boost the coral cover at locations with otherwise unsuitable substrate. To maximize this effect at future artificial reefs, locations should be selected with minimal sedimentation, and modules should maximize vertical recruitment habitat in their design.

References

Carter, J. W.; Jessee, W. N.; Foster, M. S.; Carpenter, A. L. **1985. "**Management of Artificial Reefs Designed to Support Natural Communities**."** *Bulletin of Marine Science*, Volume 37, Number 1, July 1985, pp. 114-128(15)

Division of Aquatic Resources: Artificial Reefs and FADs. http://dlnr.hawaii.gov/dar/fishing/artificial-reefs-and-fads/

Fitzhardinge, R.C., and J.H. Bailey-Brock. 1989. "Colonization of Artificial Reef Materials by Corals and Other Sessile Organisms." *Bulletin of Marine Science* 44: 567-579.

NOAA PIFSC: National Oceanic and Atmospheric Administration, Pacific Islands Fisheries Science Center. Coral Reef Ecosystem Division: Reef Assessment and Monitoring. 2012.