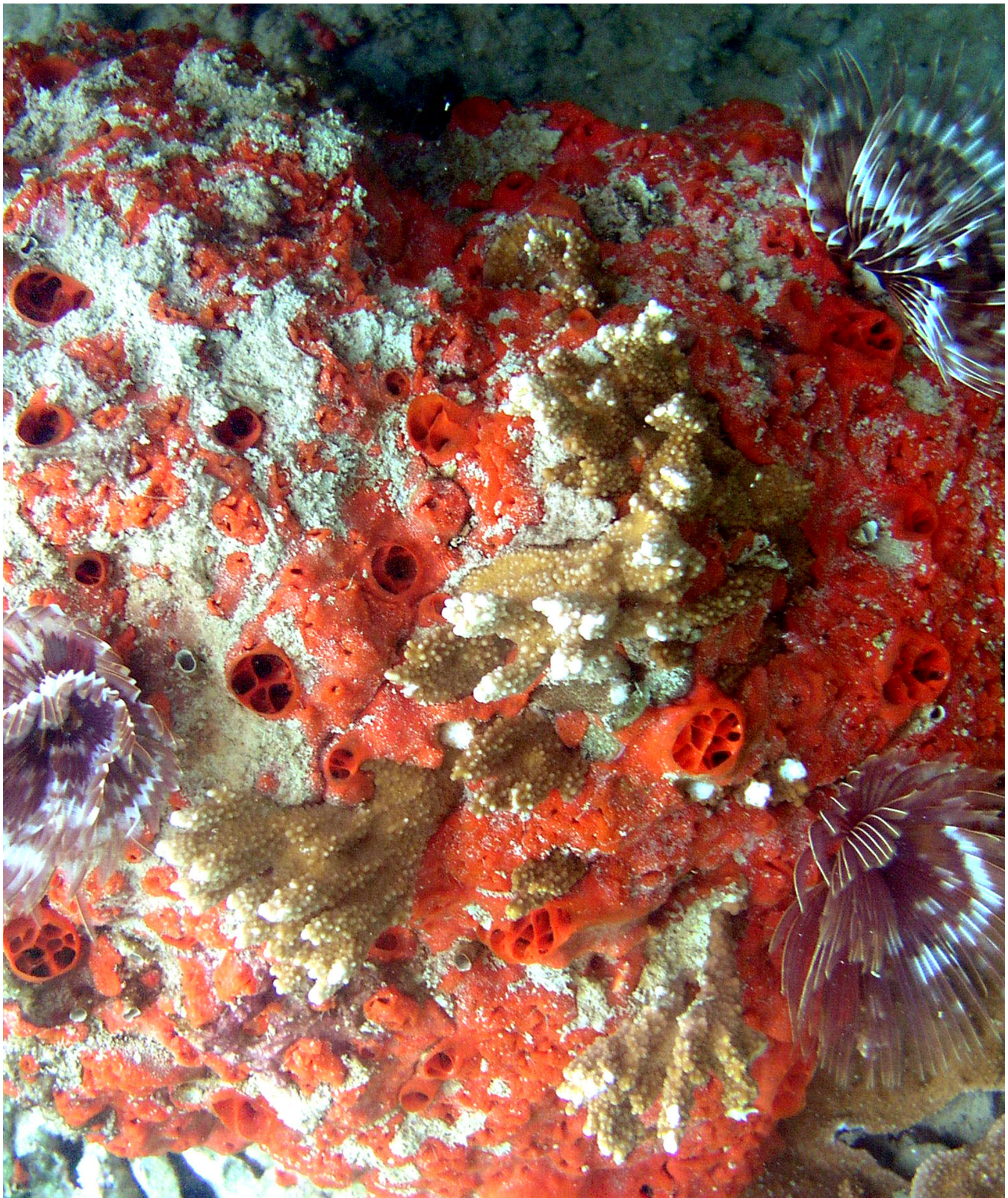

Assessment of Invasiveness of the Orange Keyhole Sponge *Mycale armata* in Kāneʻohe Bay, Oʻahu, Hawaiʻi

Hawaii Biological Survey

Final Report, Year 1

Assessment of Invasiveness of the Orange Keyhole Sponge *Mycale armata*

in Kāne‘ohe Bay, O‘ahu, Hawai‘i.

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January 2006

Contribution No. 2006–02 to the Hawai‘i Biological Survey

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Executive Summary

The Orange Keyhole Sponge, *Mycale armata* Thiele, was unknown in Hawai‘i prior to 1996. First reported in Pearl Harbor, it now occurs in virtually every commercial harbor in the main Hawaiian islands, where it can be a major component of the fouling community on harbor piers and jetties. It has been reported from a few coral reef locations near harbors, but in Kāne‘ohe Bay it has become a major component of the benthic biota in the south bay in the last 5-10 years. A study was conducted in 2004-2005 to determine *Mycale armata's* distribution, abundance throughout the bay, its growth rates on permanent quadrats, and whether mechanical removal would be an effective management technique for its control. Results from 190 manta board surveys on 28 reefs and paired 25 m belt transects using photo quadrats on 19 reefs indicated that the sponge had maximal coverage in the south-central part of the bay, in the vicinity of Coconut Island. Despite the visual dominance of this conspicuous sponge on many reefs, its maximum coverage on any transect was 9.2% of available area, with a mean of two transects at this site of 6.5%. Sponge coverage on reefs decreased to less than 1% on reefs at 1-3 km from this zone of maximum abundance, and mean coverage for all 19 reef sites was 1.7%. Quarterly measurements of changes on sponge coverage on permanent photo quadrats indicated a mean increase of 13.1% in the area covered by sponge during one year on undisturbed control quadrats, with a mean decrease in coral cover of 16.3% on the same quadrats. By comparison, sponge coverage on quadrats where all feasible sponge had been mechanically removed at the beginning of the year showed a similar sponge mean increase of 10.2% and a mean decreased coral cover of 6.3%. These results indicate that mechanical removal would not be an effective method of controlling the sponge over the long term, especially considering that removal required an equivalent of 11-22 hours per sq. m. Studies are continuing in 2006 to determine if the distribution and coverage of the sponge is expanding in the bay and if the rates of increase on both control and removal quadrats continues to occur.

Introduction

Mycale armata Thiele is an introduced sponge that is considered invasive and a potential threat to corals and reefs in Hawaiian waters (Coles et al. 2004). This species was originally described in 1903 (Thiele 1903) from a specimen collected in the Moluccas islands in Indonesia. According to Burton (1934) this is a junior synonym for *Mycale grandis*, described by Gray (1867) from a specimen of unknown origin. However, this synonymy is considered suspect (see Hooper, et al. 1999) and, lacking further taxonomic information, *Mycala armata* is presently accepted as a valid identification for this species (J.N.A Hooper, pers. comm.)

Whatever its correct species name and type locality, it is evident that this sponge did not occur in Hawai‘i until at least the mid 20th century. Given its conspicuous characteristics and bright color, it is highly unlikely that it would have been missed by de Laubenfels (1950, 1951) on his surveys of sponges in Kāne‘ohe Bay and elsewhere in Hawai‘i. The sponge was first reported in Hawai‘i from Pearl Harbor in 1996 (Coles et al. 1997, 1999) where it was especially prominent in the vicinity of the Hawaiian Electric thermal discharge in Pearl Harbor's East Loch. It was one of the more frequently occurring introduced invertebrates on the 2003 HCRI rapid assessments of introduced species on coral reefs in the main Hawaiian islands, where it was reported at 5 of the 41 sites (Coles et al. 2004, in press). Most of these locations were relatively close to harbors or in Kāne‘ohe Bay, where the sponge occurred at both of two sites sampled. In a more extensive Kāne‘ohe Bay study conducted in 1999-2000 (Coles et al 2002), it occurred at 4 of the 24 sites sampled in the bay, and these were all in the south basin. The Guidebook of Introduced Species in Hawai‘i (Eldredge and Smith 2001) reports that the sponge appears to be overgrowing corals in Kāne‘ohe Bay, especially the finger coral *Porites compressa* Dana and *Montipora capita* (Dana), the two dominant reef-forming coral species in Kāne‘ohe Bay.

In order to more explicitly determine the spatial distribution, abundance, growth rates and competitive impacts of *Mycale armata* in Kāne‘ohe Bay, a proposed study "Assessment of Invasiveness of the Orange Keyhole Sponge *Mycale armata* in Kāne‘ohe Bay, O‘ahu, Hawai‘i" was funded by the Hawai‘i Coral Reef Initiative (HCRI) during FY2004-2005. Specific tasks to be accomplished in the project were 1) using manta board rapid assessments, determine the spatial distribution of the sponge throughout Kāne‘ohe Bay with semi-quantitative estimates of its abundance where it occurs; 2) at selected sites based on the manta board survey results, quantitatively determine the coverage of the sponge as a percentage of the total available substrate and of the live coral present; 3) using permanently marked quadrats and digital photographs, measure the coverage of both the sponge and corals quarterly to determine the degree of competition by the sponge for available habitat and if it is actively overgrowing the corals; 4) on an equal number of quadrats, determine rates of re-growth where sponge was removed in 2004 to determine whether the sponge could be effectively managed by mechanical removal; 5) measure quarterly, using buoyant weighing and areal estimates from digital photographs, the growth rates of samples of sponge collected and redeployed to the reef.

Methods

1. Manta Board Surveys

Manta board surveys were conducted in Kāne‘ohe Bay in September 2004 to determine the extent of occurrence and relative coverage of *Mycale armata*. The Global Coral Reef Monitoring Network's (GCRMN) manta board procedure described in the Methods for Ecological Monitoring of Coral Reefs, (http://www.icran.org/pdf/Methods_Ecological_Monitoring.pdf**),** in which a trained observer is towed for two minutes behind a small boat, was modified to a snorkeling observer swimming with the manta board for four minutes along the reef edge. This modification was found to be more feasible in Kāne‘ohe Bay because of the difficulty in towing behind a boat under the prevailing wind conditions and the general murkiness of the water in the bay. The manta board swims were a satisfactory and time-efficient method for rapidly acquiring a substantial quantity of semi-quantitative distribution data for dominant benthic organisms. The observer estimated and recorded the coverage of *Mycale armata*, the two dominant corals *Porites compressa* and *Montipora capitata*, the introduced feather duster worm *Sabellastarte spectabilis* and the invasive algae *Dictyosphaeria cavernosa*, *Gracilaria salicornia*, and *Kappaphycus* sp. on reef crests and slopes along the edges of reefs in the south and middle sectors of Kāne‘ohe Bay. The relative abundance of each these species was estimated and recorded using the GCRMN scale ranging from 1 (1-10% cover) to 5 (75-100% cover). The location of the beginning and end of each swim was recorded using a Garmin 76 WAAF Global Positioning System (GPS) unit accurate to ± 8 m carried by the manta board observer in a waterproof bag. Using this technique the 190 manta board transects shown in Figure 1 were completed on 28 reefs by three observers in 13 days.

Data from the manta observations and the GPS locations were merged and entered into a Global Information System using ArcGIS9 software (http://www.esri.com/software/arcgis/**)** and plotted on map layers which showed the distribution and relative abundance of *Mycale armata* in Kāne‘ohe Bay, along with relative abundance of other major plant and animal benthic components.

2. Quantitative Photo Quadrat Transects

Having established the extent of the sponge in the bay using manta board swims, linear photo transects were used to establish quantitatively the areal coverage of *Mycale armata* and other dominant benthic biota along transects at 19 sites on 18 reefs throughout Kāne‘ohe Bay (Figure 1). Digital photographs of bottom cover were taken along belt transects using an Olympus 5060 digital camera contained within an underwater housing and held on a fixed height camera stand (Figure 2), producing an image area of ca. 0.66 m^2. Twenty-five photographs were taken on each of two transects per site for a total of 33 m^2 reef surface measured per site. The start and end of each set of transects was recorded using GPS and mapped using ArcGIS.

Images obtained were enhanced and cropped to a consistent size of 0.66 m^2 and processed using the Coral Point Count with Excel extension (CPCe) program available from the National Coral Reef Initiative (http://www.nova.edu/ncri/research/a10.html). Each quadrat was assigned 50 random points (Figure 3)

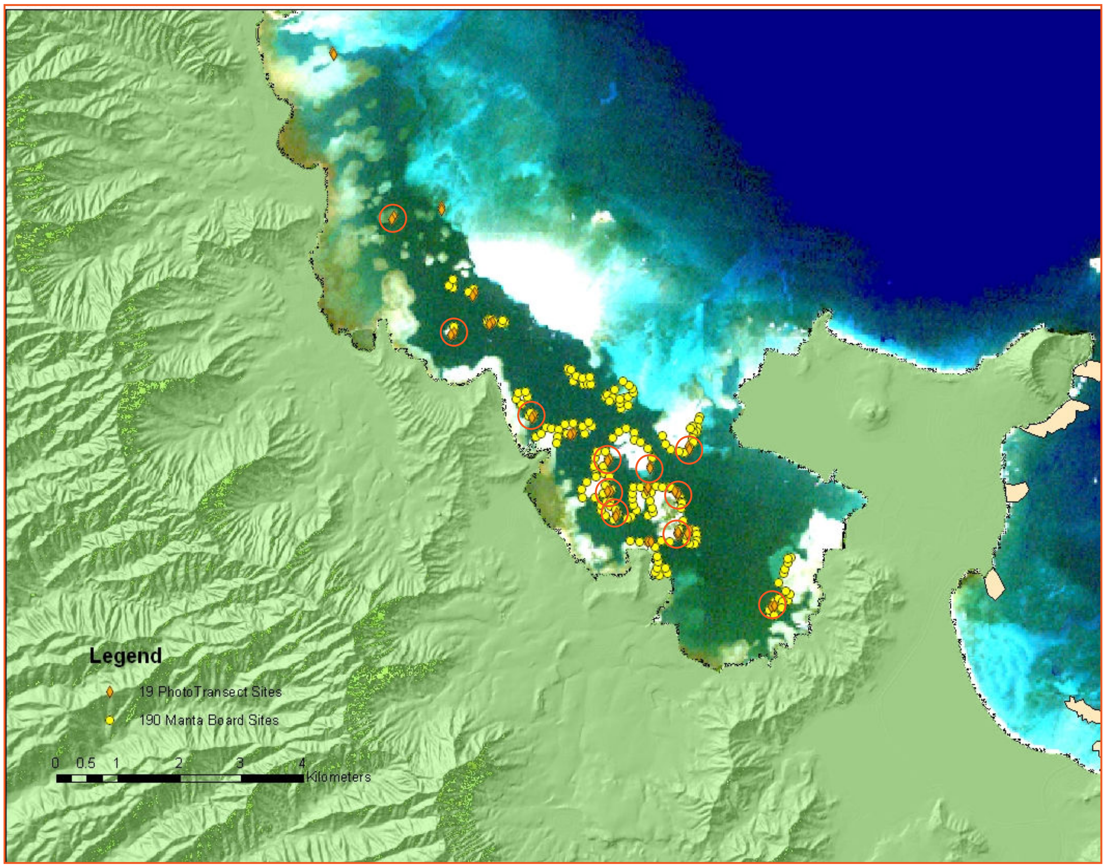

Figure 1. Locations of manta board surveys (yellow dots) and photo quadrat transects (orange diamonds). Red circled transect sites to be resurveyed in 2006.

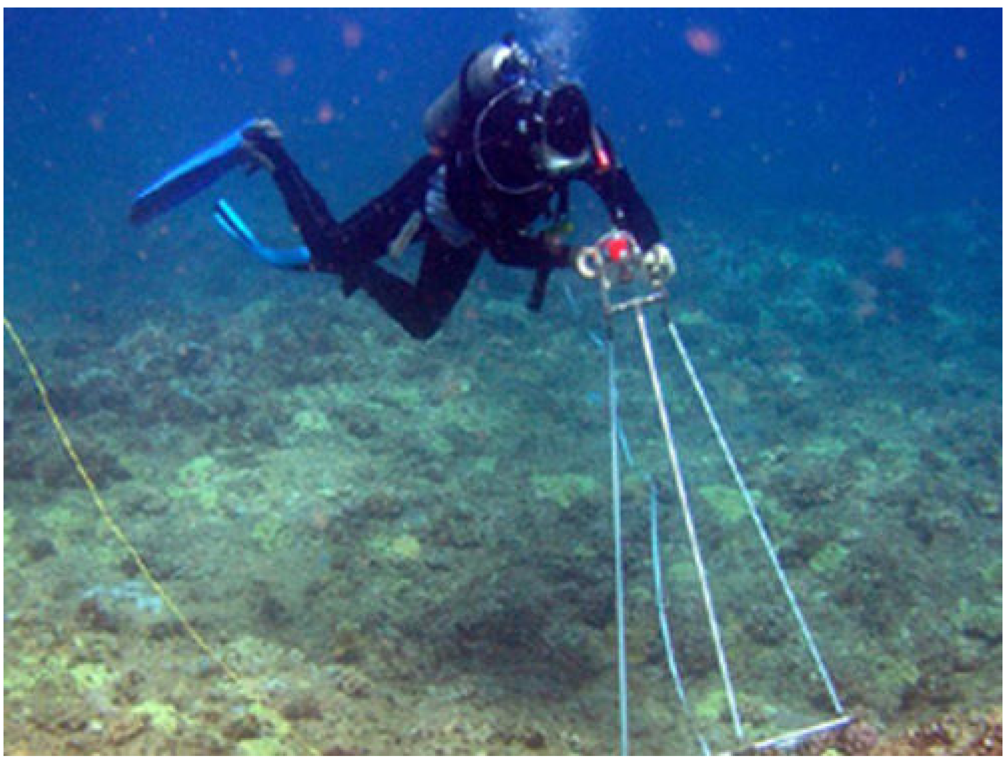

Figure 2. Diver photographing benthic cover along photo quadrat transect.

and the composition under each point was recorded, for a total of 1250 points analyzed per transect or 2500 points per site. These data were used to determine the percent cover of *Mycale armata*, macroalgae, corals and other invertebrates, and substratum types within the photoquadrats, which were averaged at each site.

3. Measurement of changes in sponge cover on control and removal quadrats

Twenty permanently marked photo quadrats were established in October 2004 on the reef slope along the southeast perimeter of Coconut Island to monitor sponge growth and competition with reef corals within the marked areas. The corners of each 0.165 m^2 quadrat were marked with iron rebar or cable ties, enabling quarterly measurements of the same reef area for each quadrat throughout the year. No sponge was removed from 10 of the quadrats (Controls), while all the sponge that could be mechanically extracted from the remaining 10 quadrats (Removals) was removed (Figure 4). The amount of sponge removed averaged an equivalent of 1.85 kg dry wt per m^2 for the ten quadrats. This was time-consuming and impacted corals within some of the quadrats, requiring an equivalent of 12.6-22.7 hr m^{-2} for removal from a single quadrat and removing an equivalent 0.18-1.72 kg m^{-2} of live coral skeleton as by-catch from six of the ten removal quadrats. Both sets of quadrats were photographed soon after sponge removal and quarterly thereafter in February, May, August, and November 2005 using a digital camera on a stand with a fixed photographic area of ca. 0.165 m^2.

After cropping to a consistent image area of 0.165 m^2, the CPCe program was used to analyze the coverage of all components within the permanent photo quadats for each quarter's determinations in a similar manner as was done for transect photo quadrats, except that 100 points evenly spaced in a grid were used for analysis of each permanent photo quadrat. This stratified approach provided greater sensitivity and probability that the same specific areas on a quadrat were being sampled each quarter, resulting in more replicability for time-series analyses of changes within the permanent photo quadrats.

4. Measurement of changes in weight and volume of sponge fragments

Twenty fragments of sponge were collected from near the HIMB pier on 3 December 2004, transferred to the laboratory, and held in flowing seawater under screen shade until 6 December. They were then photographed underwater with the digital camera held on a small quadrapod frame that provided a consistent image frame size of 412 cm^2. The sponges were then weighed underwater in a basket suspended from the bottom hook of an Ohaus Scout-Pro digital balance read to 0.001 g (Figure 5). Each sponge fragment was weighed twice and the results averaged. After weighing and photographing, each sponge was placed on a piece of underwater paper and both sponge and paper were attached to galvanized wire mesh platforms and deployed to the reef where they were held in place by cable ties attached to quadrat marker stakes or coral branches. The sponges were photographed and weighed quarterly thereafter in March, June, September, and December 2005. The projected areas of sponge images were determined using CPCe analysis software for determining the area of a irregular object (Figure 6). Duplicate area determinations were made and averaged for each sponge at each quarterly measurement.

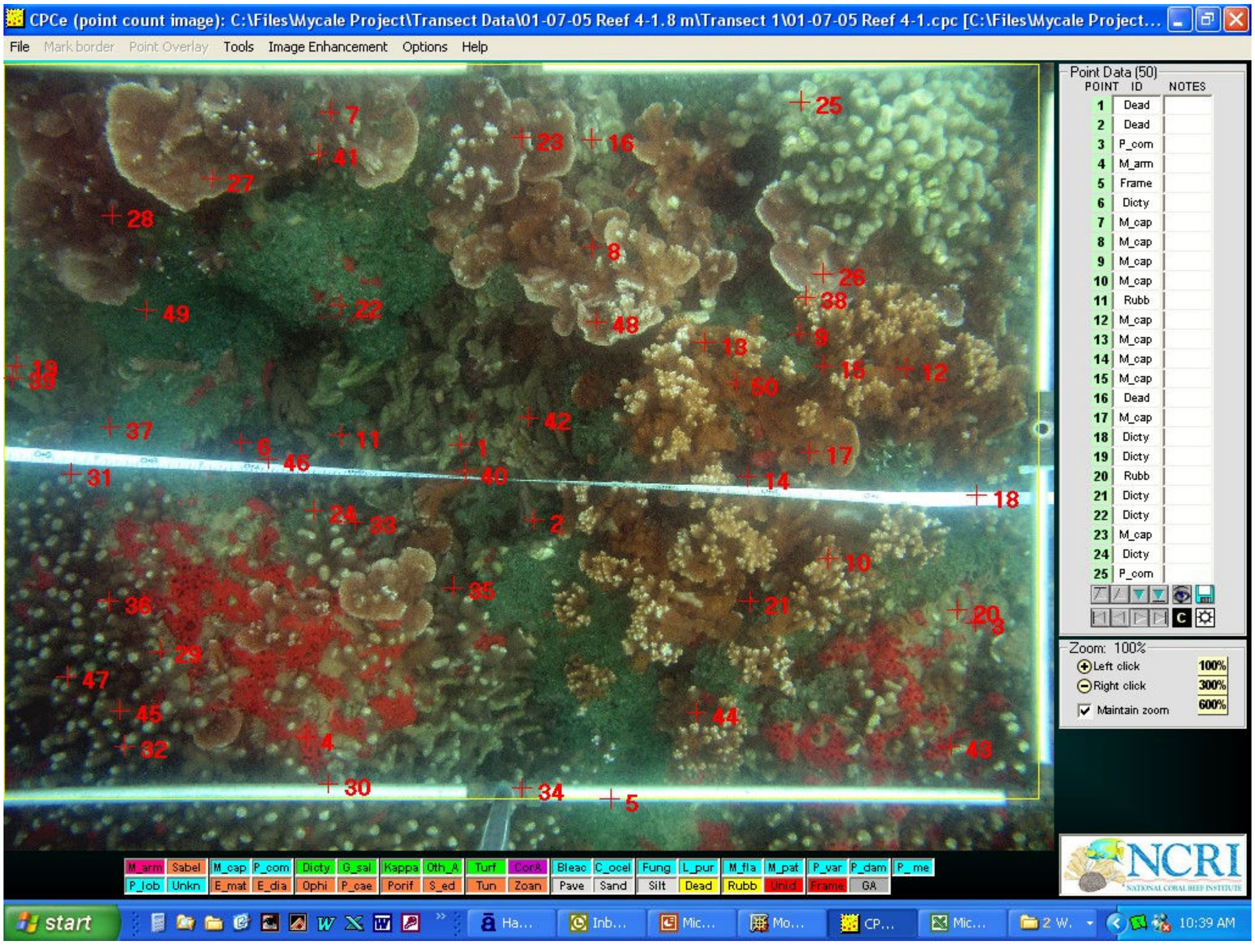

Figure 3. CPCe analysis view of a photo transect quadrat showing *Mycale armata*, *Montipora capitata*, *Porites compressa*, and *Dictyosphaeria cavernosa*.

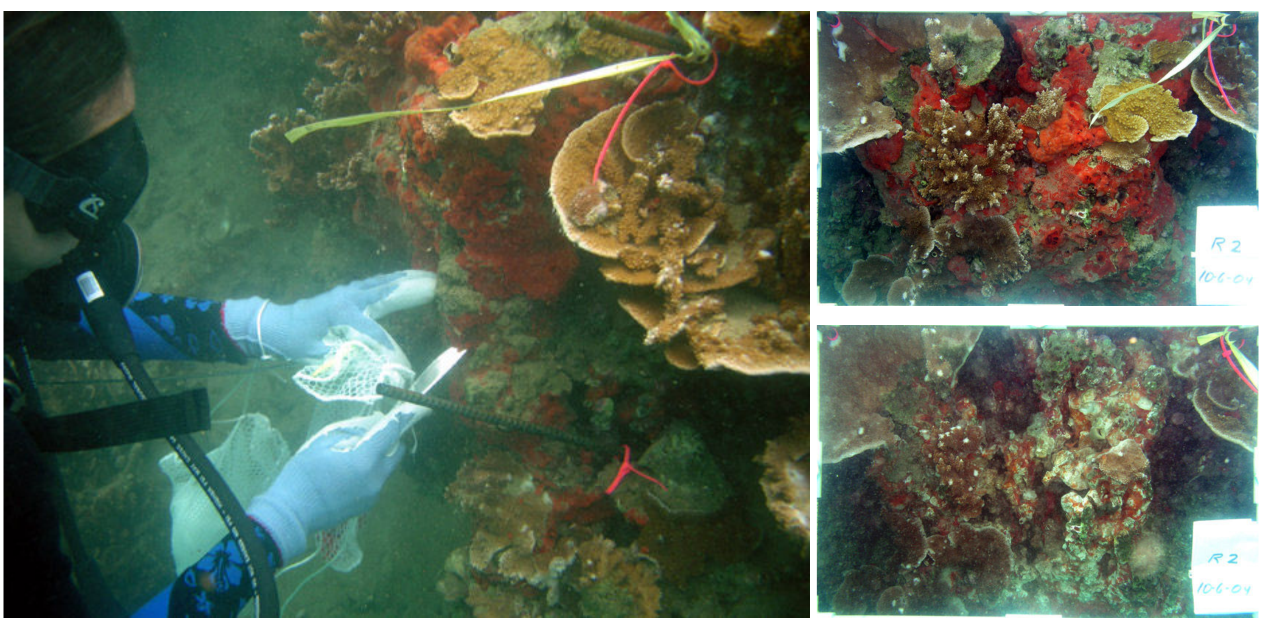

Figure 4. Sponge removal and photoquadrat showing sponge present before and immediately after removal.

Figure 5. Photographing and weighing sponge fragment for growth determination.

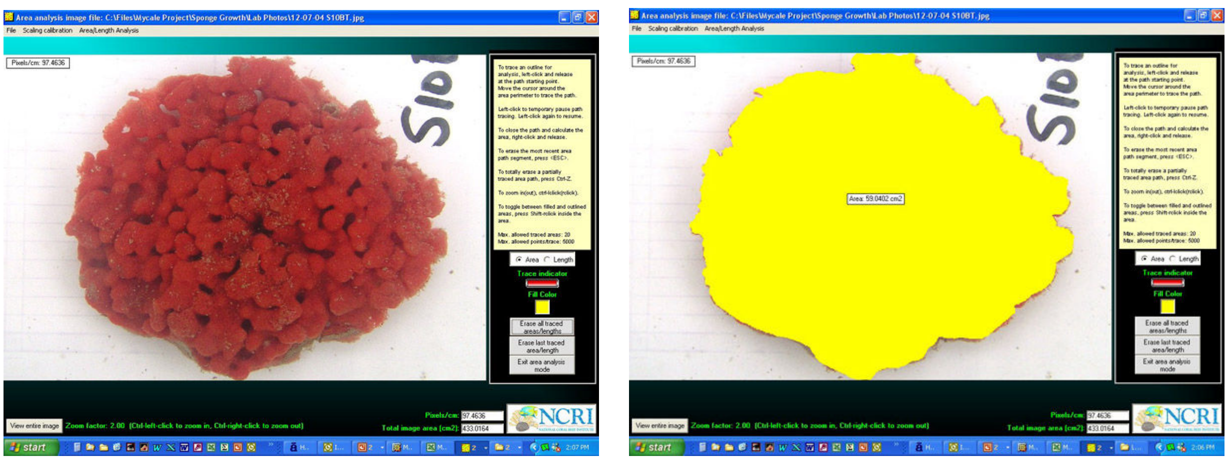

Figure 6. CPCe analysis of projected area of sponge fragment.

Results

1. Manta board observations of *Mycale armata* occurrence in Kāneʻohe Bay

Manta board swim estimates for coverage of *Mycale armata* ranged from GCMN Category 0 to 2.5 (1-10% to 25-30%), and these results are summarized in Figure 6. By comparison, estimates for coral and algal coverage ranged up to Category 5 (75-100%) on the same transects. Complete data for manta board swim results and GPS coordinates are available on spreadsheets provided with this report. The manta board surveys summarized in Figure 7 indicate that *Mycale armata* had its greatest abundance in the vicinity of Coconut Island and decreased substantially in all directions from that area. The greatest mean abundance for a given reef (Figure 8) determined by this method occurred along the reef adjacent to the HIMB Pier, closely followed by Coconut Island reef and nearby Reef 4, which were the only areas where GCRMN manta board coverage values exceeded 2 (10-25%). No *Mycale* was observed north of Kahaluʻu and very little along the northeast side of the main ship channel north of Coconut Island.

2. Sponge abundance on selected reefs

Quantitative measurements using photoquadrat transects on 19 selected reefs (Figure 9) confirmed the pattern of *Mycale armata* distribution previously determined from manta board surveys. Complete data for photo transect results and GPS coordinates are available on spreadsheets provided with this report. The highest value for *Mycale armata* determined for one transect was 9.2% at Reef 4, with a mean of 6.5% for the two transects at that reef. Mean values for the Coconut Island and HIMB dock reefs nearby ranged 4.5-5%, and *Mycale* cover decreased substantially with distance from this area to less than 1% at 1-3 km from Reef 4. Overall, *Mycale* coverage averaged only 1.7% on the 19 sites surveyed. By comparison, reef coral and macroalgae showed substantially higher coverages at all sites, ranging up to 30% for total macroalgae and 89% for total coral with respective means of 7.8% and 35.3% (Figure 10). Coral was the dominant live bottom cover at all sites except at four reefs along the northeast side of the main ship channel in the central bay where macroalgae, with a large component of introduced and invasive species, made up the major portion of the benthic biota.

Comparison of the manta board relative abundance and photo transect survey percent cover results indicates a high correlation of between the two methods for estimating *Mycale armata* coverage (Figures 11 and 12). Although the manta board results clearly overestimated percent coverages of *Mycale* on the reefs, both methods showed a consistent distribution pattern of the sponge, with the highest abundance occurring in the vicinity of Coconut Island and coverage decreasing with distance from this area.

3. Changes in sponge cover on permanent control and removal quadrats

Nine of the 10 control and eight of the 10 removal permanent photoquadrats remained by the time of fourth quarter coverage measurements in November 2005. Examples of the changes that occurred on control and removal quadrats are shown in Figures 13 and 14. Although there was substantial variability in changes in cover between quarters for individual quadrats, the overall trends (Figure 15) showed consistent increases in *Mycale armata* + silt for most control and removal quadrats and decreases in total

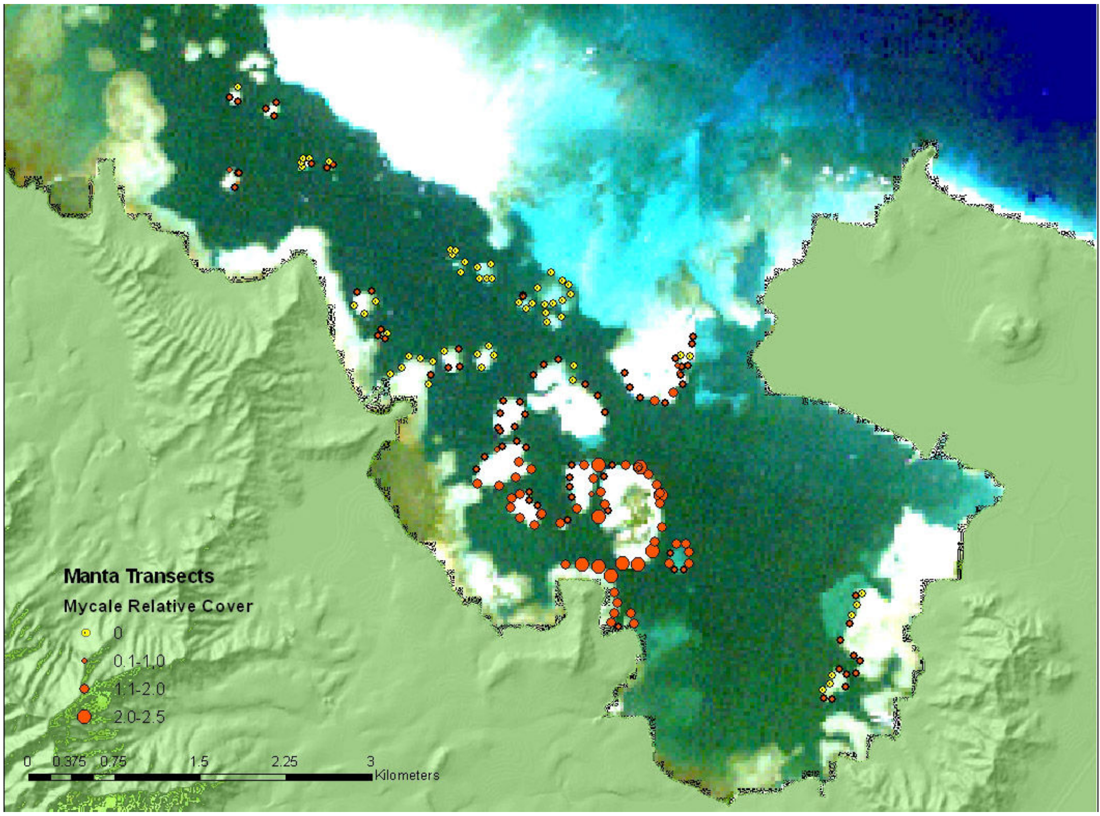

Figure 7. Distribution and relative abundance of *Mycale armata* recorded on manta board surveys.

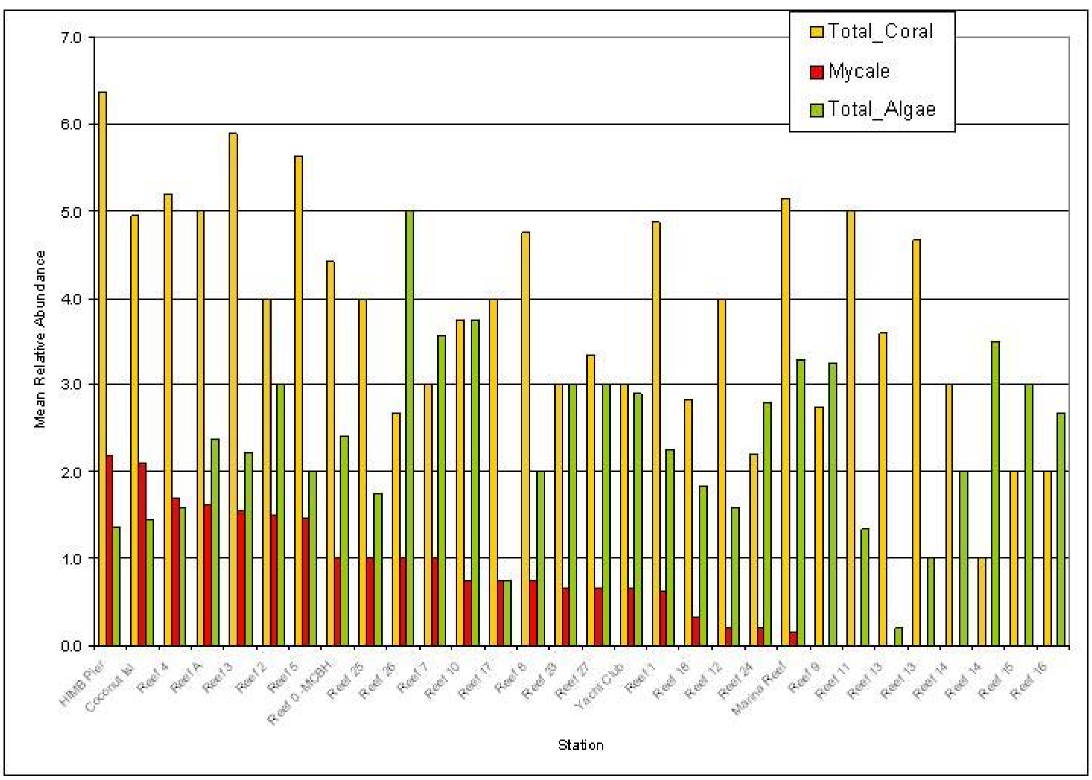

Figure 8. Mean coverage by reef for *Mycale armata* determined from manta board surveys.

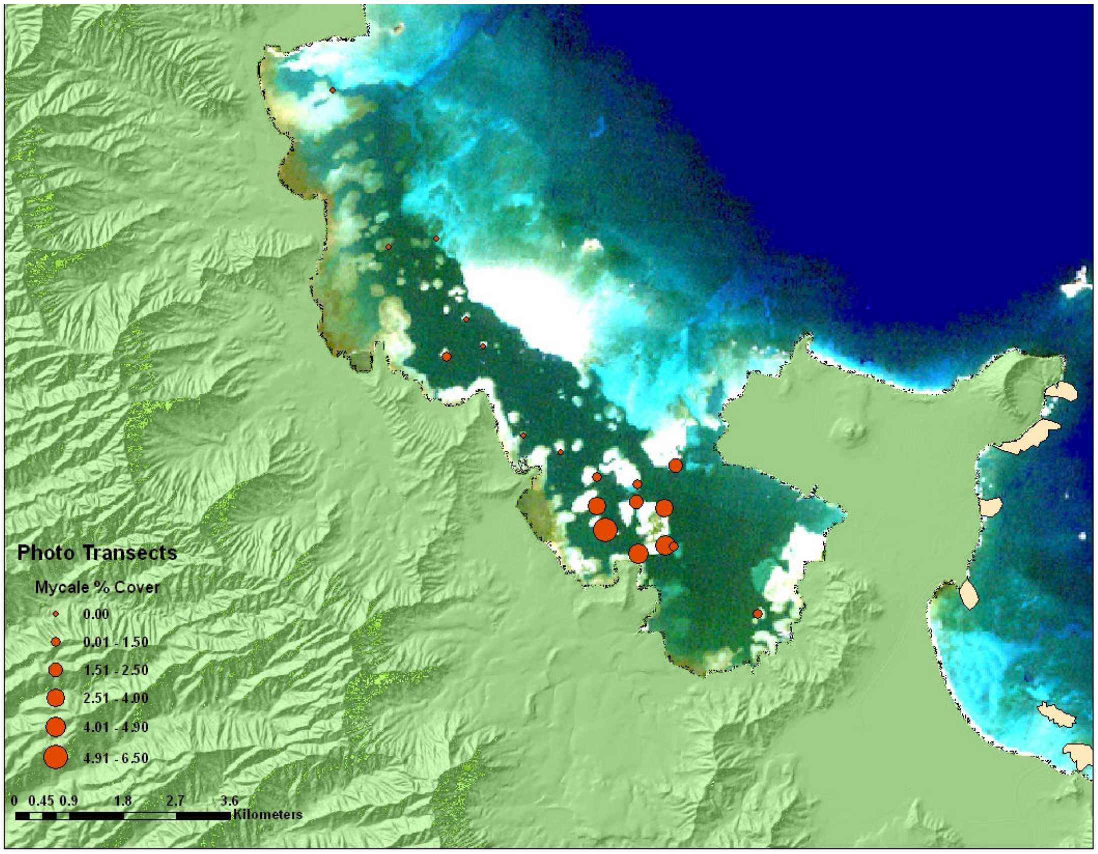

Figure 9. Mean abundance of *Mycale armata* on 18 Kāneʻohe Bay reefs determined by photo transects.

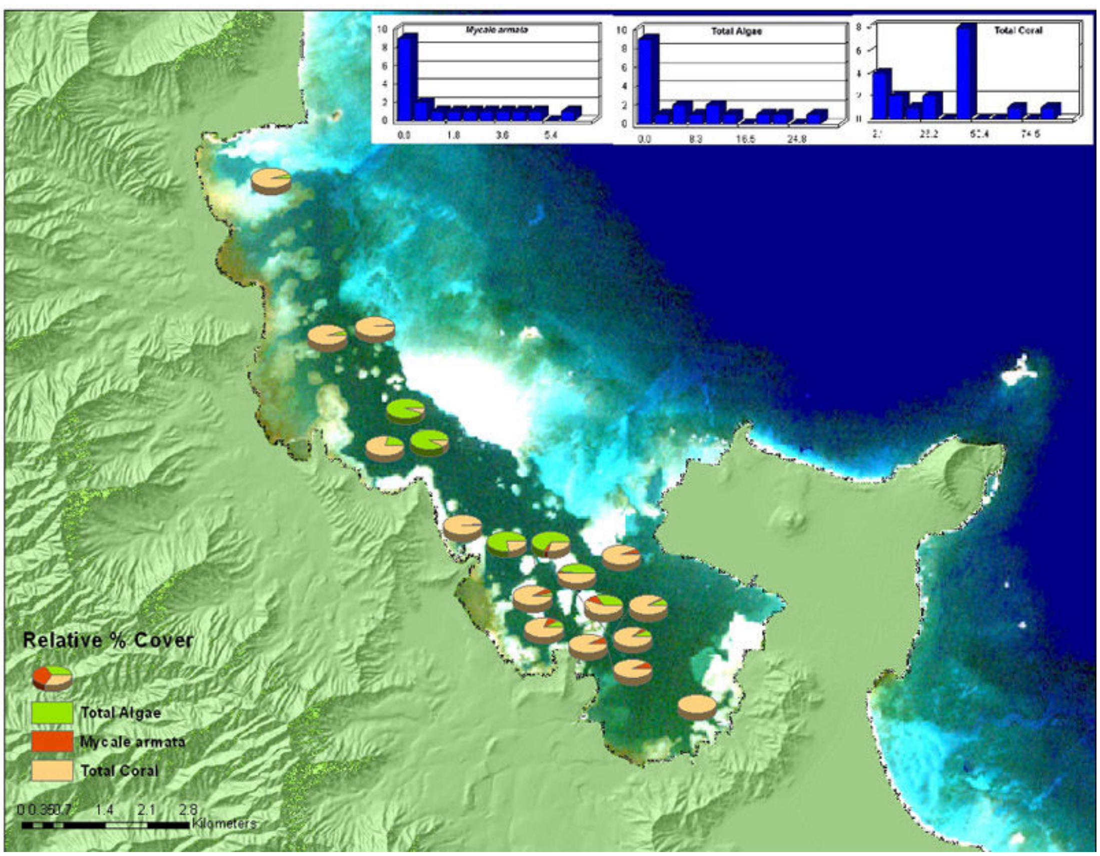

Figure 10. Mean *Mycale armata*, coral, and algal coverage determine on 18 reefs by photo transects.

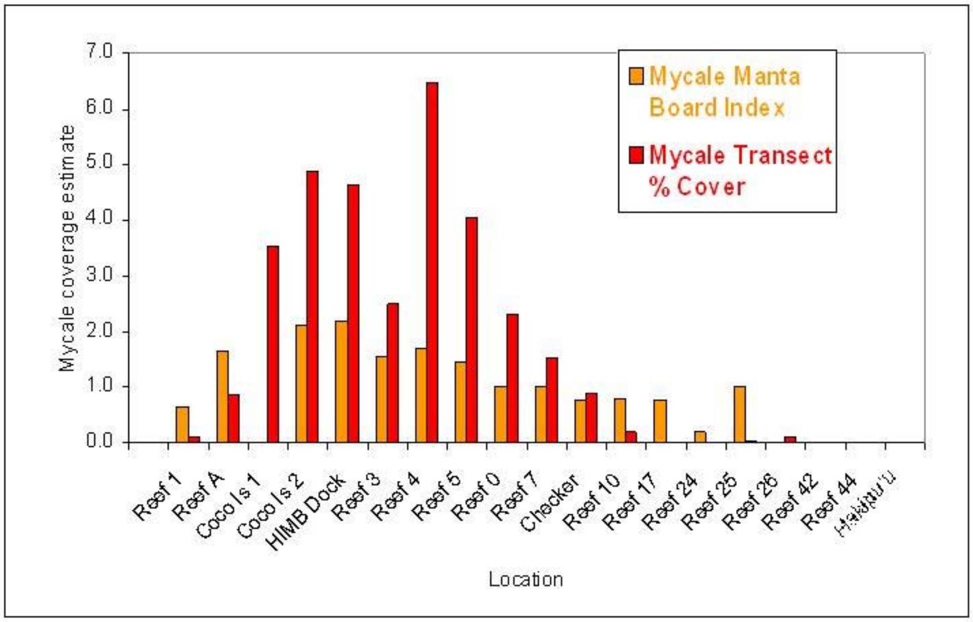

Figure 11. Comparison of mean manta board survey index values with mean photo transect % coverage for 16 Kāne‘ohe Bay reefs where *Mycale armata* occurred.

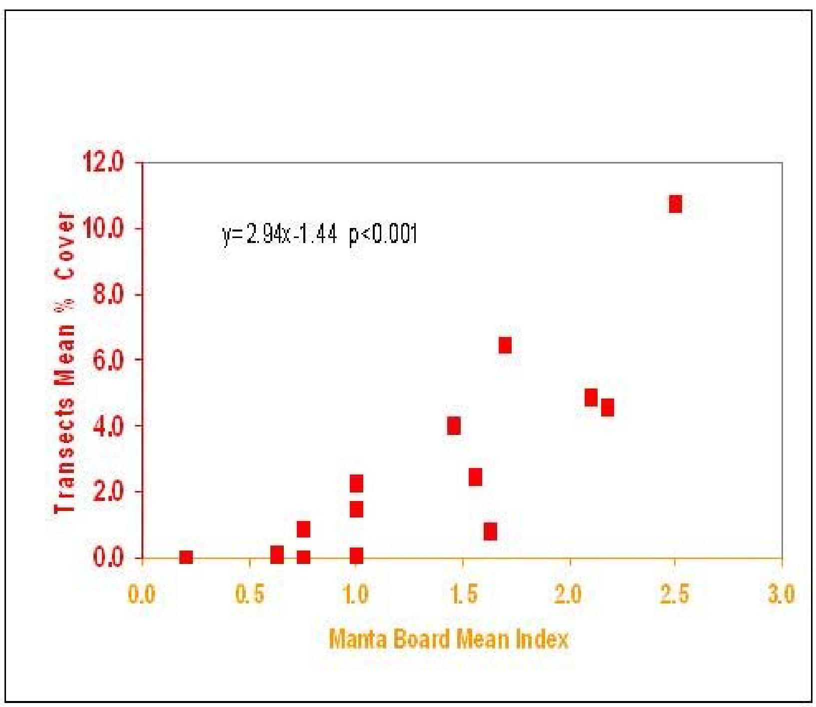

Figure 12. Regression between manta board index and photo transect % cover results for *Mycale armata*.

coral compared to their initial values. (Silt coverage was lumped with *Mycale* coverage because large portions of the sponge were periodically covered with silt). All nine of the control quadrats remaining by the fourth quarter (Figure 16) showed increases in *Mycale* coverage while eight of the nine quadrats showed decreased total coral cover. Average *Mycale*+silt coverage for the nine control quadrats increased a highly significant 13.1% ($p<0.001$, paired t-test), and total coral decreased a highly significant 16.3% ($p<0.001$). Sponge+silt cover increase on the control quadrats was highly significantly related ($p<0.001$) with decreased coral on the same quadrats, indicating displacement of the coral by sponge growth during the year.

For the removal quadrats (Figure 17), sponge removal in October-November 2004 reduced *Mycale* cover on quadrats by as much ca. 65% of the total quadrat surface area. Seven of the eight quadrats remaining in November 2005 quadrats showed regrowth, with one quadrat having recovered to virtually its pre-removal value. In most cases removal of sponge from the quadrats was followed by some degree of continuous decline in coral cover, with six of the eight quadrats remaining by the fourth quarter showing reduced coral cover compared to pre-removal levels. Average *Mycale*+silt coverage for the eight remaining removal quadrats increased a significant 10.2% ($p<0.05$, paired t-test), and total coral on the quadrats decreased an average 6.3%, but the decrease was not significant by a paired t-test ($p=0.09$).

4. Changes in weight and volume of isolated sponge fragments

Quarterly changes in sizes of sponge fragments (Figure 18) determined by buoyant weight and projected surface area were highly variable, both by quadrat and by quarter (Figure 19), and only 12 of the 20 original fragments remained at the end of the year. Of these (Figure 20), six fragments showed annual increases of up to 84% from their original buoyant weight or 150% of their original surface area, and the other six showed buoyant weight decreases of up to 90% or projected area decreases up to 59%. Overall, buoyant weight for the 12 fragments decreased 8.1% and projected area increased 18.5% for the year. Despite this substantial difference between mean results for the buoyant weight and projected area methods, there was highly significant regression ($p<0.001$) and high correlation ($r^2=0,88$) between the two methods for individual sponge fragments for the year's results. The high variation of results by fragment and by quarter was attributed to a number of possible factors, including differing initial recovery of the sponges after their first deployment, variability in stress imposed when sponges were transferred to tanks for weighing and photographing, and seasonal changes in available food sources.

Discussion and Management Considerations

The only previous published information on interaction and competition between sponges and corals on reefs is provided by the classic paper by Goreau and Hartmann (1966) who described *Mycale laevis* (Carter) growing on the underside of corals on fore-reef slopes in Jamaica. Contrary to the present situation in Kāneʻohe Bay, the interaction between the Jamaican *Mycale* and the coral *Montastrea annularis* was described as mutually beneficial, with the sponge receiving the advantage of substratum availability free of competitors and the coral receiving increased feeding efficiency from sponge-generated water currents and protection from boring organisms. This association was manifested in a

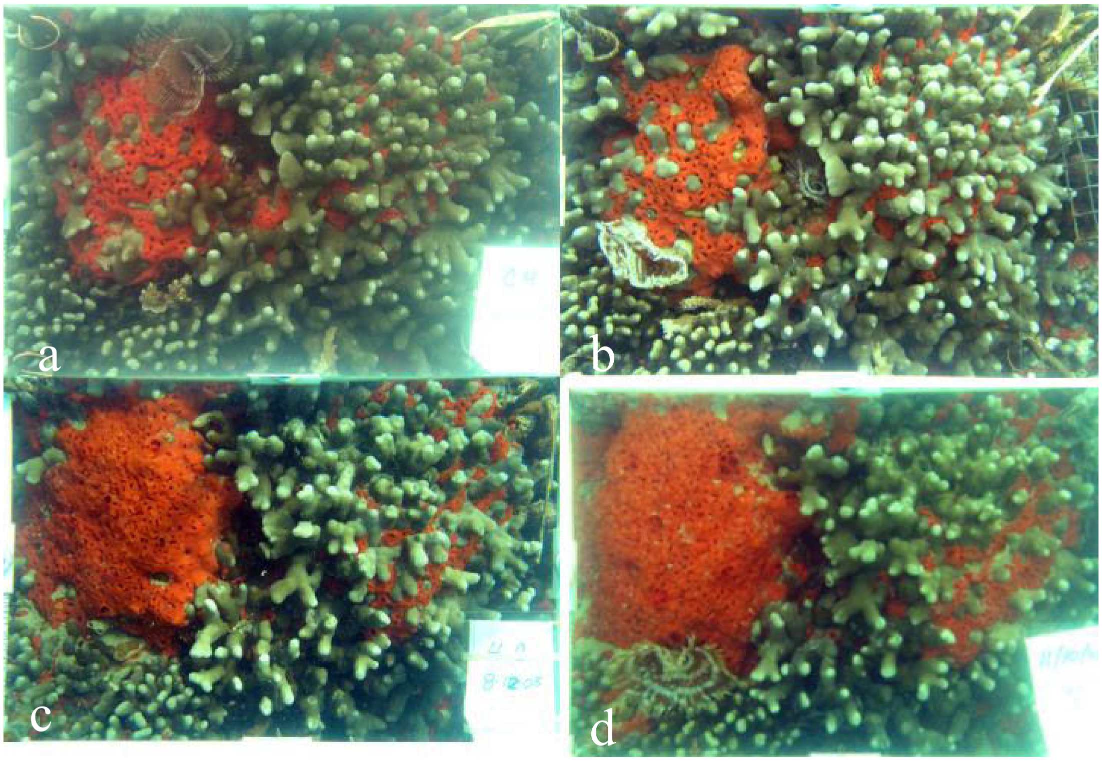

Figure 13. Quarterly photos of *Mycale armata* on a control quadrat. a: 17Nov04; b: 7Feb05; c: 12Aug05; d: 10Nov05.

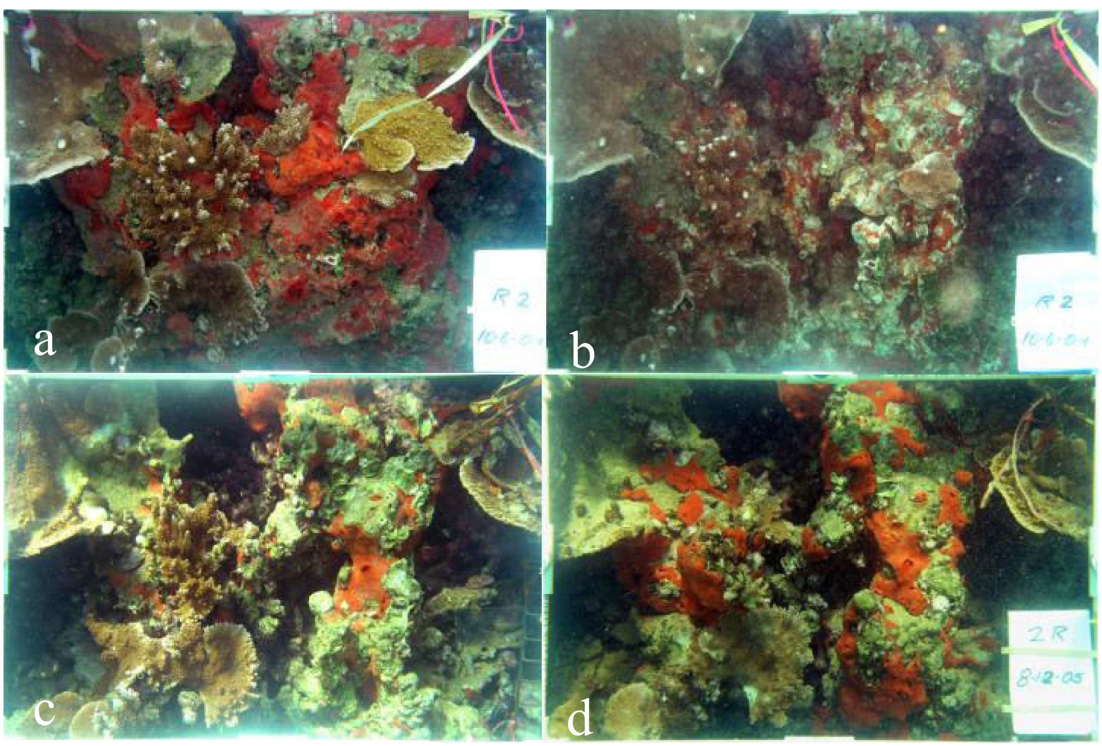

Figure 14. Quarterly photos of *Mycale armata* on a removal quadrat. a: 10Oct04; b:10Oct04 after sponge removal; c: 10Feb05; d: 12Aug05

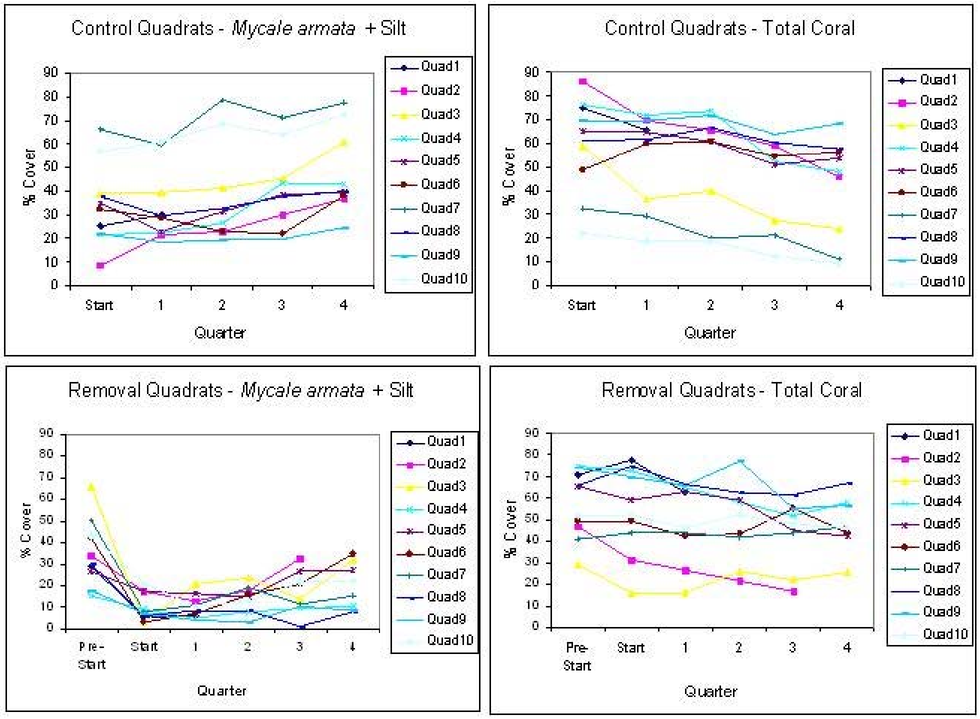

Figure 15. Time series of *Mycale armata* and coral on control and removal quadrats Nov. 2004-2005.

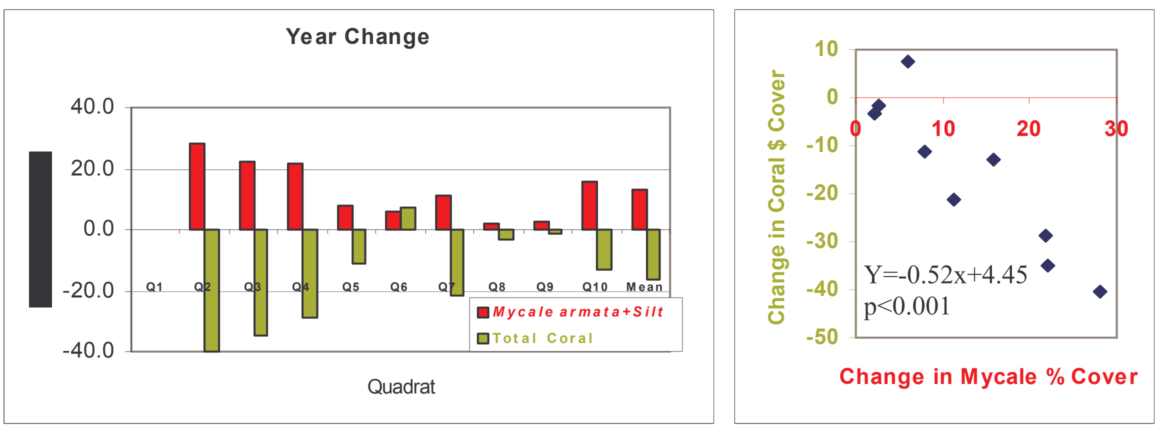

Figure. 16. Year's change of *Mycale armata* and total coral control on control quadrats, Nov. 2004-2005.

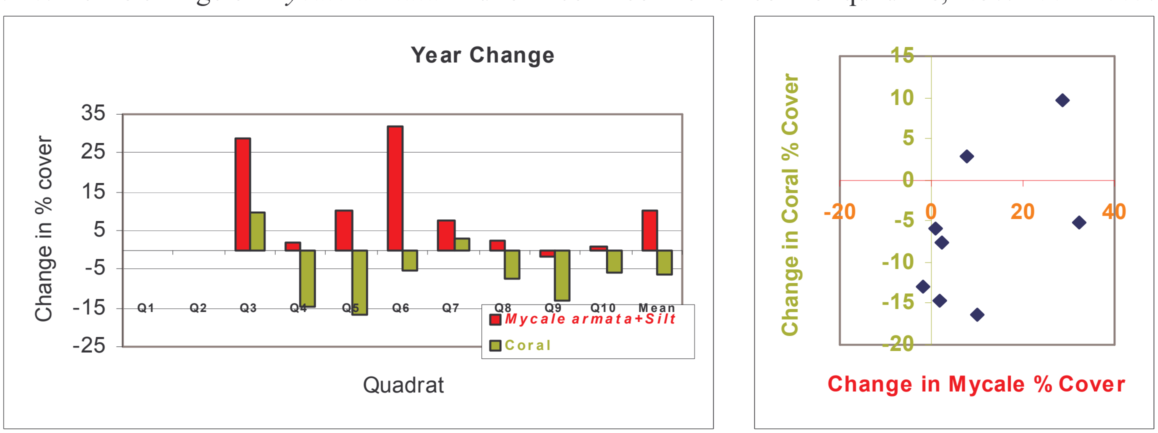

Figure 17. Year's change of *Mycale armata* and total coral control on removal quadrats, Nov. 2004-2005.

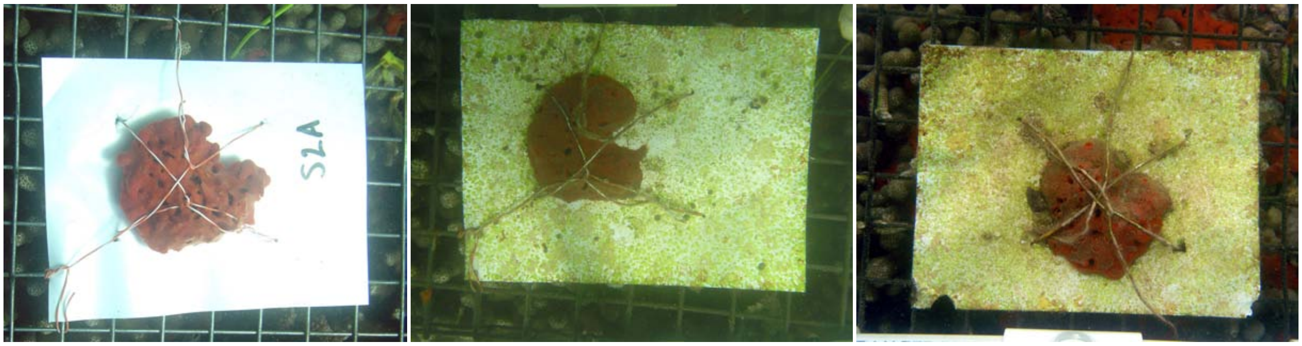

Figure 18. Appearance of sponge fragment at start, first and second quarter of measurements.

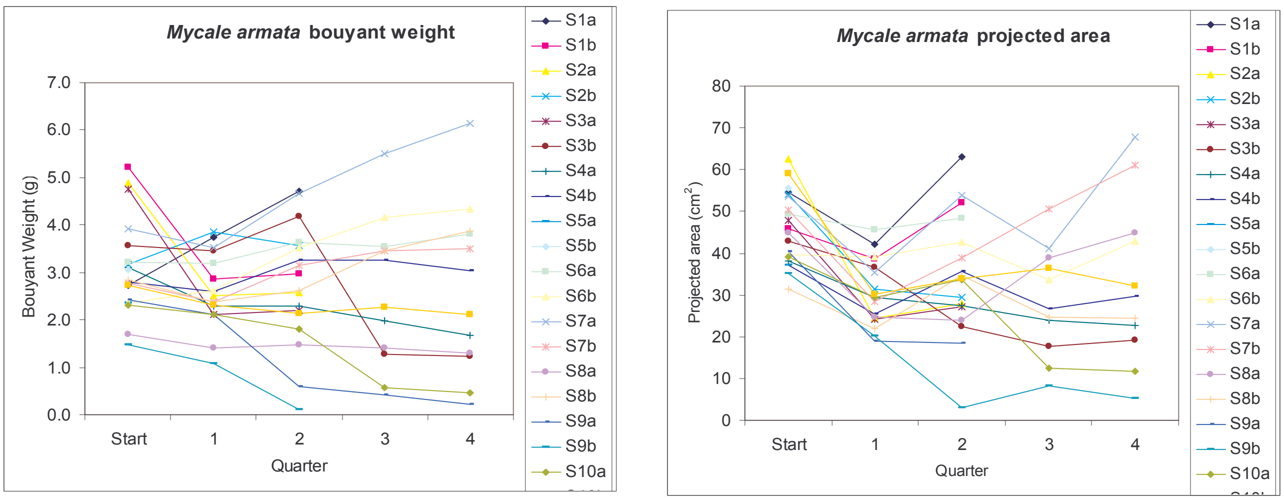

Figure 19. Bouyant weights and projected area of sponge fragments for quarterly measurements.

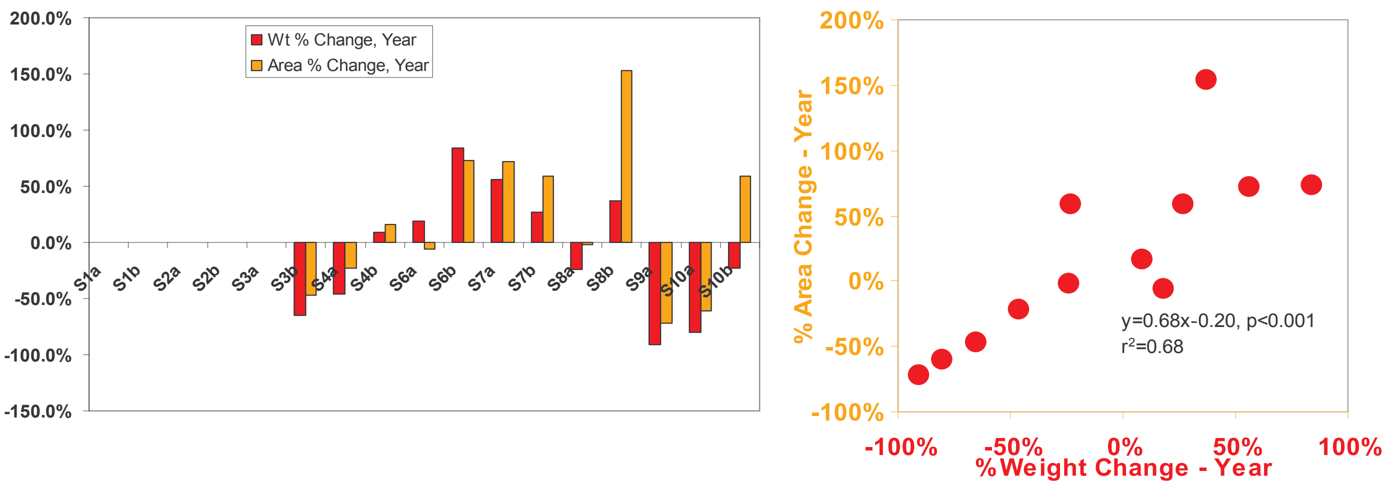

Figure 20. Percent changes in mean buoyant weights (red) and projected areas (orange) for sponge fragments remaining in December 2005.

characteristic laminar form of the corals that showed prominent, regularly spaced peripheral folds at depths greater than 25 m.

In contrast, *Mycale armata* growth in Kāneʻohe Bay is clearly not beneficial to corals that co-occur with the sponge on back slopes and fore slopes of fringing and patch reefs. Our results indicate that, although the sponge is still relatively restricted in the bay and occupies a relatively low percent of the available area in locations where it does occur, it is increasing at a rate of around 10-15% per year of available area where the sponge is most abundant. Not only is *Mycale armata* able to overgrow live coral in this area of highest abundance, but it also weakens coral skeletal structure where the sponge has reached partial coverage, especially of finger coral *Porites compressa*. This rate of sponge regrowth appears to apply even when all sponge feasible has been mechanically removed.

The sponge shows its principal distribution and maximal abundance in South Kāneʻohe Bay near Coconut Island and decreases in coverage substantially in all directions, comprising less than 1% of the available substratum at locations more than 3 km from its epicenter in the bay. Given the nutrition requirements and ecological role of sponges as filter feeders on microscopic organic particles in Kāneʻohe Bay (Ribes et al. 2005) and the relatively higher concentrations of nutrients and particulate organic matter in south Kāneʻohe Bay compared to the mid or north bay (Smith et al. 1981, Coles and Ruddy 1995) it would be expected that high abundances of *Mycale armata* would occur in the vicinity of Coconut Island in the south bay. However, it is surprising that the sponge occurs in such low abundance at Reef 1 and on the fringing reef near the Kāneʻohe Bay Yacht Club (Figures 7-10), in the southernmost sector of the bay. These reefs are also relatively close to the Kāneʻohe Marine Base main pier and docks and boat ramps of the Marine Base, Kāneʻohe Bay Yacht Club, and Makani Kai Marinas, all of which would be likely locations from which the sponge could have been introduced to the bay. Although the there is no direct evidence to confirm a firm conclusion, the distribution of the sponge's occurrence and abundance suggests that it could have been introduced to Kāneʻohe Bay in the vicinity of Coconut Island or HIMB Dock.

The sponge appears to have no direct predators that would provide a natural control to its proliferation in Kāneʻohe Bay. No fishes or macroinvertebrates have been observed to feed on it, and the Hawksbill Turtle *Eretmochelys imbricata*, the only known predator of sponges (Leon and Bjorndal 2002) has not been reported in Kāneʻohe Bay and is rarely found in Hawaiian waters. However, we have found two sponges with large gouges in them that appear to have resulted from recent feeding (Figure 21) near the south end of the permanent quadrats on the southeast side of Coconut Island reef. This location also appears to be the residential area of a green turtle (*Chelonias mydas*) with shell diameter of about 0.75 m that we have seen frequently on quarterly visits to this area, suggesting that this turtle may have at least sampled the sponge. If the turtle has consumed any of the sponge it has had little controlling effect, since this site (Coconut Island 2 Photo transect) had the second highest sponge coverage (5%) determined on the photo transects.

Mechanical removal appears to have been highly ineffective as a control of the sponge and is unfeasible in a practical sense. Divers required an equivalent of ca. 13-23 hours/m^{-2} to remove as much sponge as

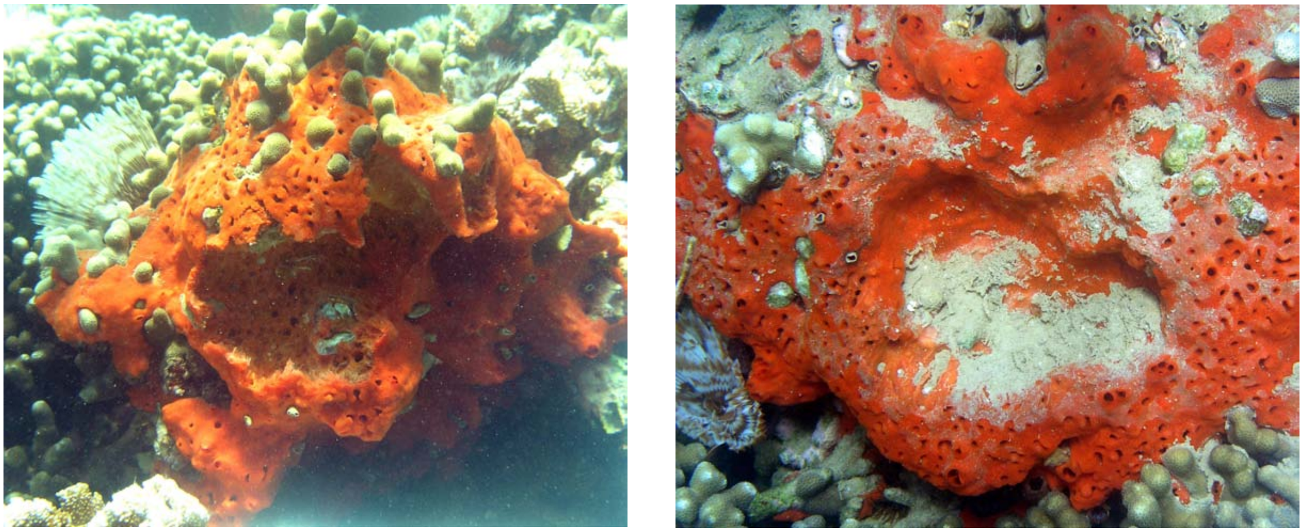

Figure 21. Cavities in sponges photographed 11May05 near permanent quadrat 10.

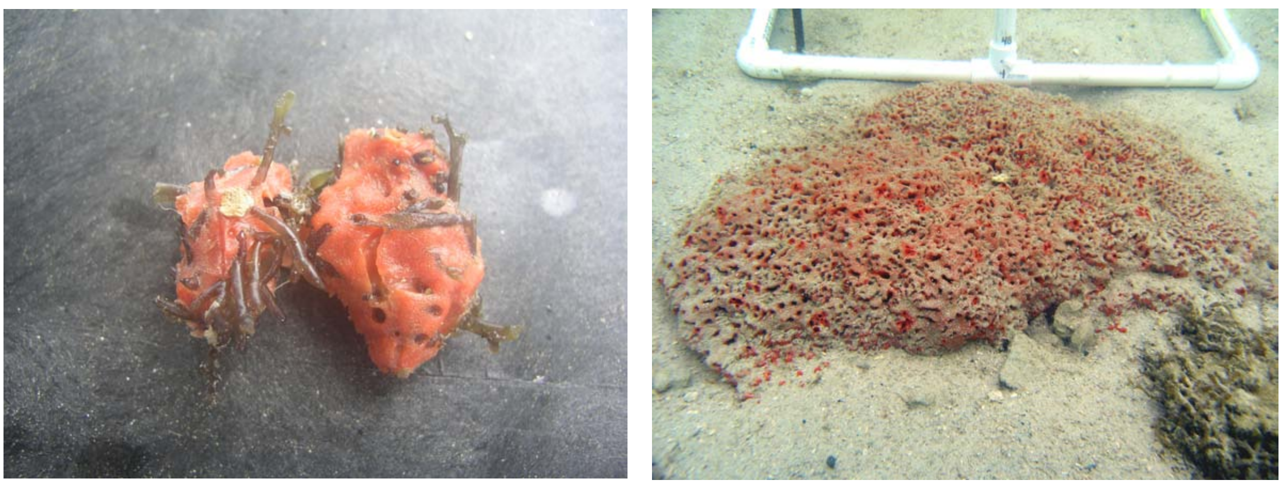

Figure 22. *Mycale armata* caught as bycatch with *Gracilaria salicornia* by the “Supersucker” (left), and *Mycale* growth on reef flat near HIMB dock ca. 50 m from the reef edge (right).

possible from the 0.165 m^2 quadrats. This removed an equivalent of 0.6 to 5.1 kg dry wt of sponge/m^{-2}, but also removed an equivalent of 0.2 to 3.5 kg dry skeletal wt. of live coral/m^{-2} from 4 of the 10 quadrats as by-catch. Moreover, sponge grew back on the removal quadrats at an average rate of about 10% yr^{-1}, while coral cover on the same quadrats continued to decline at a average rate of about 6% yr^{-1}, suggesting that mechanical removal sponge imparted both initial and long-term negative impacts to corals.

The operators of the "Supersucker" being tested for its feasibility for mass removal of the invasive macroalga *Gracilaria salicornia* in Kāneʻohe Bay have noted that the principal by-catch with the algae is *Mycale armata* sponge (Eric Conklin, pers. comm., Figure 22). We have also noted that some growth areas of this alga on reef flats often contain substantial quantities of the sponge, and that the areas of sponge sometimes remain after the algae dies or is moved on by waves or currents. Proliferation of fragments of rapidly growing *G. salicornia* that are easily moved by waves may therefore provide a mechanism by which *Mycale armata* is spread to new areas in the bay and may have produced new areas of sponge in shallow water on the reef flat along the HIMB dock causeway, over 50 m from the reef edge (Figure 22).

This project will be continued through 2006, with a final report of the results to be completed in January 2007. Due to funding limitations, work will focus on resurveys of photo transects and quarterly measurements on permanent photo quadrats. Photo transects will be completed on 11 of the 19 2005 photo-transects that were selected to coincide with both the locations of highest sponge coverage and limits of distribution in 2005 (Figure 1). Results will be compared statistically between study years to determine whether the sponge has changed significantly in either its coverage or the distribution of its occurrence. The eight control and removal permanent photo quadrats that remained in November 2005 will be re-photographed quarterly to determine if the past year's trends in sponge and coral coverage change continue. Also, two more control and removal quadrats are planned for deployment in February 2006 to replace those that were lost in 2005. For these removal quadrats, a new method for sponge removal will utilize a newly designed, more portable "Supersucker" apparatus that has a higher suction capacity to evaluate whether sponge removal by a more mechanized technique can be more time efficient and have longer lasting results. Isolated sponge fragments measured in 2005 will not be reweighed quarterly, but those remaining at the end of 2005 will be reweighed for a final time in December 2006 to determine whether the erratic results determined by this method continue or if leaving the sponges undisturbed produces more consistent changes in sponge buoyant weight and projected area.

Acknowledgments

This project was supported by funding provided by the Hawaiʻi Coral Reef Initiative and the National Oceanic and Atmospheric Administration Project Number NA04NOS426017. We thank the staff and management of those organizations and of Bishop Museum for their continued support. Boats, scuba tanks and access to the Kāneʻohe Bay sites were made available by the Hawaiʻi Institute of Marine Biology. We wish to specially thank HIMB Director Jo-ann Leong and Paul Jokiel, Fenny Cox, Kuulei Rogers and Fred Farrell for their tolerance of our periodic use of facilities at the HIMB "Point Lab". We greatly benefited from the assistance of Adrienne Romanski, graduate intern from the Dept. of Ecology, Evolution & Environmental Biology, Columbia University, in the conducting and GIS analysis of the manta board and photo quadrat surveys. This internship was partially supported by the U.S. Department

of Education. The program is an initiative under the Office of Innovation and Improvement of the U.S. Department of Education. Education through Cultural & Historical Organizations (ECHO) provides educational enrichment to Native and non-Native children and lifelong learners.

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