Title
SEEKING SPONGES: DISTRIBUTION OF EXPOSED PORIFERA IN MO'OREA, FRENCH POLYNESIA

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SEEKING SPONGES: DISTRIBUTION OF EXPOSED PORIFERA IN MO'OREA, FRENCH POLYNESIA

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Abstract. Sponges constitute an important part of marine and aquatic ecosystems, however compared to other benthic groups little is known about sponges. Knowledge of sponge species and distribution is extremely limited on Mo'orea, French Polynesia. The purpose of this research was to describe the distribution of sponges using Rapid Habitat Assessment surveys at different locations around the island and to investigate distributional influences that cause zonation via a transplant experiment. Sponge species were given arbitrary species names and identified based on basic morphological characteristics. RHA's were conducted at fives sites around Mo'orea sampling the sub habitats present on the reef in terms of % cover of substrate types and ecological benthic attributes as well as taxon abundance for coral, fish and, sponges. To examine influences on distribution one sponge species was transplanted from the fringing to the barrier reef and caged against various factors then evaluated based on weight change. A one way ANOVA revealed certain species have significant differences in distribution with respect to location on the reef. Experimental results did not show a significant difference between weight loss based on the cage treatments, but overall every treatment lost weight. Based on the factors examined by the RHA no habitat types or distributional information specific to any one species could be attained. Analysis of the experiment data indicated that predation may limit some species to specific habitats.

Key words: porifera; distribution; *habitat type; predation;, French Polynesia*

INTRODUCTION

The first and oldest phylum branching from the Kingdom Animalia on the tree of life is the Phylum Porifera which is made up of sponges as they were the first true multi cellular organisms to evolve (Wörheide et Al. 2005). Although thousands of species are distributed world wide, sponges are simple sessile benthic filter feeders. A sponge individual is essentially a mass of transiently specialized, but relatively independent cells supported by a skeletal frame coordinating their action to draw in water (Wulff 2006). As these cells are able to change form and function as needed, sponges endure mutilation better than any known animal (Wulff 2006).

Through their long evolutionary history sponges have come to play key roles in numerous ecological processes including space competition, predation, primary production, nutrient cycling and, food chains (Wulff 2006). Sponges are important components of coral reef systems but few quantitative surveys have looked at their importance in reef systems (Wulff 2006). Their ecological importance has barely been studied compared to other benthic groups such as corals and algae. From a conservation stand point, the lack of knowledge about sponges is concerning as, of the estimated 15000 species world wide only about 30% have been described (Hooper and Levi).

While basic, distributional information provides the foundation for future research. Although many sponge species are broadly distributed across the reef, some are limited to a few specific habitats and can be used to characterize those habitats (Wilkinson and Cheshire 1989).

To date knowledge of sponge distribution is minimal at best compared to other benthic groups (Hooper et Al. 2002). French Polynesia

is no different. French Polynesia is no different. Information regarding sponges of Mo'orea and French Polynesia in general is extremely limited at best. It is the purpose of this paper to examine the relationship between habitat type and the species of exposed sponges found there.

The dual goals of this research were to (1) investigate the distribution of sponges using broad habitat surveys of different locations around the island and (2) investigate the reasons for and influences on distribution of sponges in the barrier reef, fringing reef and the bay using transplant experiments to explore causality in zonation. My hypotheses about the distribution of sponges on Moorea are:

- There are differences in sponge distribution at different locations around the islands.
- Locations with the same sponges present will have very similar abiotic and biotic factors.
- Sponges transplanted to a location with no naturally occurring sponges of the same species will not survive.

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METHODS

Site Selection

To examine sponge distribution, rapid habitat assessments (RHA) were conducted at various locations around Mo'orea, on both the fringing and barrier reefs during October and November, 2009. The finging and barrier reefs surveyed were Opunohu Public Beach, Ma'atea, PGEM buoy at the pharmacy, East

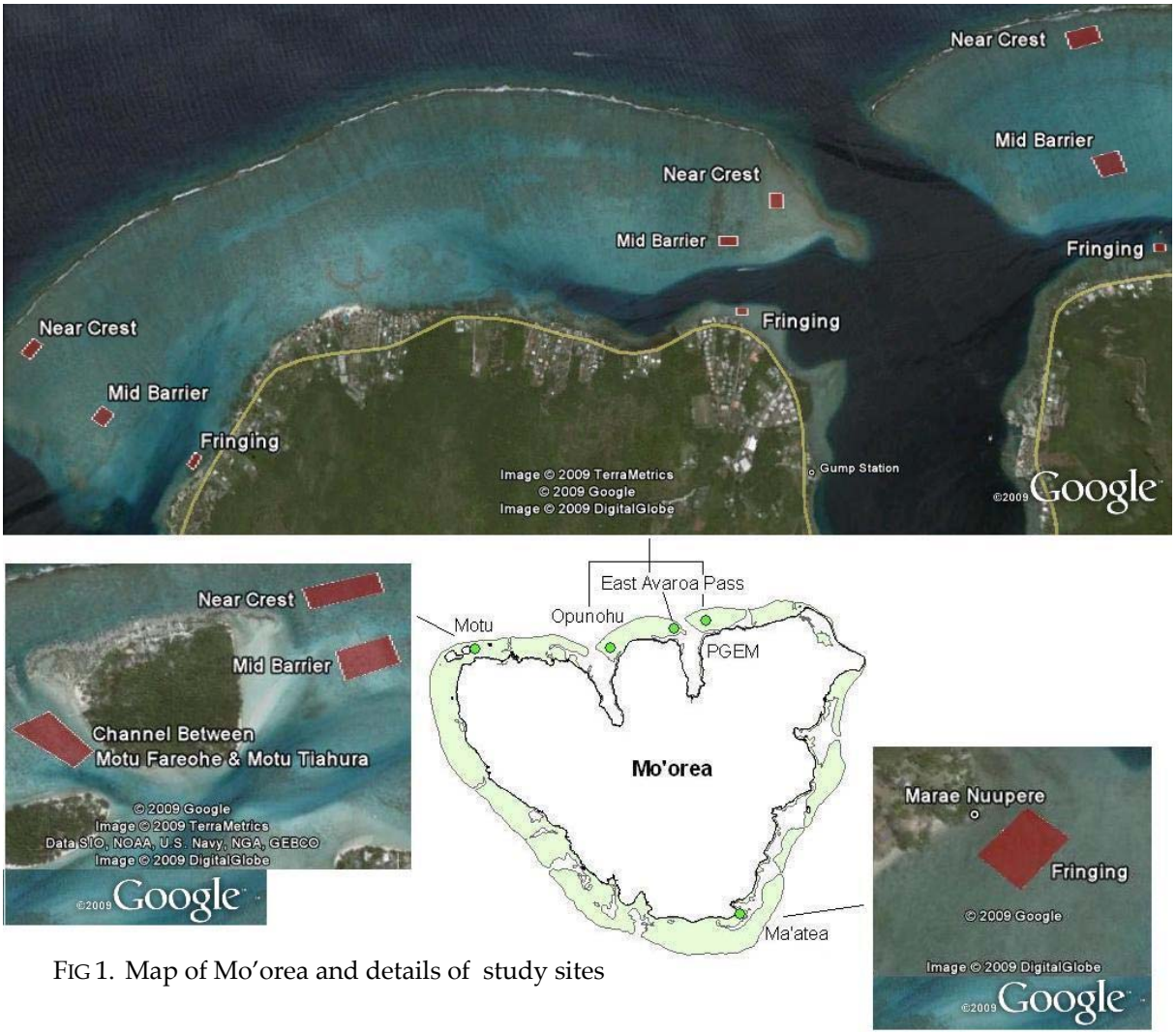

FIG 1. Map of Mo'orea and details of study sites

Avaroa Pass and Motu Tiahura (Fig. 1). The barrier reef at the motu and the fringing reef at the Opunohu public beach were used as study sites, because the preliminary surveys I conducted revealed that sponges were present at these sites. Additional sites were chosen based on accessibility and their comparative value. PGEM and East Avaroa Pass are on opposite sides of Avaroa Pass and easily accessible. Ma'atea provided data for a different side of the island than all the other sights. The location of the transplant experiment was chosen after field work revealed it was a habitat with no naturally occurring sponges of the species used for the experiment and easily accessible.

TABLE 1. Categories used in Rapid Habitat Assessment: (a) abundance ranking for taxonomic groups (b) Benthic attributes and (c) ranking of percent cover.

a) Abundance

Rank	Abundance
0	Absent
1	Rare
2	Uncommon
3	Common
4	Abundant
5	Dominant

b) Benthic Attributes

Ecological	Substrate
Hard Coral	Continuous Pavement
Dead Stading Coral	Large Block >1M diameter
Turbenaria	Small Block <1M diameter
Halameda	Rubble
Other Macro Alga	Sand
	Silt

c) Percent Cover

Rank	Percentage
0	None Recorded
1	1-10
2	11-30
3	31-50
4	51-75
5	76-100

Sampling Method

The rapid habitat assessment was conducted with stratified random sampling to provide a comparison of the different habitats present on the reef. The site was divided into 3 bands in order to sample the sub habitats. The sub habitats or "bands" examined were: (1) the fringing reef (f); (2) the mid barrier reef (m): between the channel or sand flat where large block substrate and coral heads are dispersed in a matrix of mainly sand and/or rubble; and, (3) near reef crest (c): large block substrate and coral heads become densely packed close to the reef crest, pavement and rubble are bake up the benthic cover between blocks. The channel (chan) between Motu Fareohe and Motu Tiahura was also sampled and treated as a band, as it was a unique habitat. As a narrow channel between two motu, it is subject to conditions unlike that of the other three habitats. In the field RHA delineation was carried out by laying a 25 meter transect and swimming with a 2 meter pole to measure 1 meter on each side of the tape. Three RHA's were conducted in each band. Each sub habitat sampling was completed on the same day. Upon finishing the first RHA, I swam for 30 seconds either towards or away from the reef crest within the sub habitat aiming to go farther into the sub habitat and away from its edges. I then laid a new transect and repeated the sampling. Upon finishing the second sample the process was repeated again, 30 second swim in the same direction as before, lay transect, sample. Within the band I sampled from either the shore towards the crest or crest to shore to prevent sampling the same area twice. RHAs were conducted at each site a total of 9 times and all transects were run parallel to the reef crest.

I swam along the transect recording taxon abundance using the definitions stated in Table 1a for organisms including corals, fish, invertebrates and sponges (DeVantier et Al. 1998). Then repeated the swim recording percent cover of benthic attributes using the categories defined in Table 1b which was later given a rank defined in Table 1c (DeVantier et Al 1998). For each band, the following

conditions were also recorded: visibility, benthic sedimentation, surge, current strength and, wave action. Except for the sponges, all organisms were identified to the family or genus level. Due to the lack of information available about sponges on Mo'orea, sponges were identified based on color and morphological characteristics: osculate size, density, structural characteristics and, exterior texture. Sponges were then given arbitrary species names Species A, Species B etc. Spicule identification was not conducted, but specimens found in the field were photographed and morphological features were taken note of see Appendix C for study species and species catalog.

TABLE 2. Sites Description

Site	Location on Reef	GPS	Benthic Cover
PGEM Buoy	Fringing	17°28'47.73"S 149°48'51.09"W	90% live coral mainly Acroporidae Sand, rubble and, large blocks
	Mid Barrier	17°28'48.01"S 149°48'43.95"W	Mainly sand with loosely dispersed large blocks and Large Porites coral heads
	Near Crest	17°28'27.36"S 149°48'54.65"W	Mainly live coral, rubble, pavement, small blocks, large blocks Diverse coral species
Opunohu Public Beach	Fringing	17°29'27.44"S 149°51'1.79"W	>50% live Acroporidae coral, Also sand, and sediment laden brown carpet alga covering dead coral and rock
	Mid Barrier	17°29'19.08"S 149°51'12.76"W	Dominated by large blocks and massive Porites coral heads in a sand matrix
	Near Crest	17°29'10.44"S 149°51'23.26"W	coral, large blocks, small blocks, pavement
East Avaroa Pass	Fringing	17°29'5.25"S 149°49'43.31"W	Mix of fine sediment, sand, a fine carpeting brown algae, some coral, Padina *boryana* (Pig's Ear algae)
	Mid Barrier	17°28'55.77"S 149°49'45.37"W	Large blocks, large Porites coral heads, sand and, alga
	Near Crest	17°28'49.06"S 149°49'38.36"W	Live coral, sand, rubble, pavement
Motu	Channel *between Motu Fareohe and Motu Tiahura	17°29'19.70"S 149°54'46.80"W	Large and small blocks, large Porites coral heads in a sand matrix *highest density of fleshy exposed sponges
	Mid Barrier	17°29'13.10"S 149°54'28.08"W	Low density of small blocks, pavement covered in thin sand layer *sponges common
	Near Crest	17°29'8.53"S 149°54'29.01"W	Densely packed Porites coral heads and large blocks Pocilloporidae & Acroporidae corals very abundant
Ma'atea	Fringing *unsafe to sample Mid Barrier or Near Crest	17°35'27.09"S 149°48'15.82"W	Homogenized mix of mud, silt and, sand Over 85% cover of Padina *boryana* (Pig's Ear algae) Sea Cucumbers (*Holothuria atra)* dominant
Transplant	Barrier	17°28'58.81"S 149°49'49.76"W	Sand, large blocks, and massive Porites and Acroporidae corals heads

Experimental Design

Forty individuals of Species G were used for the transplant experiment, because they only occurred in specific fringing habitat types and were never seen anywhere on the barrier reef. Sp. G was taken from its native habitat which is characterized by a silty algae covered benthos in shallow (<50cm) water on the fringing reef. Specifically, sponges were collected from Gump reef south of the boat dock. They were then placed on the East Avaroa barrier reef (see Table 2) in a non-native coral reef habitat and observed for weight changes. Using the forty individuals, a preliminary transplant was conducted within the same location to ensure sponges can survive a transplant. They were moved within the habitat and left for 96 hours. There were no color or size changes on any individual; indicating they survived the transplant. To minimize stress weight was not taken for the preliminary transplant. Exposure to air is dangerous as it can kill a sponge (Osinga et Al 1999). Therefore, all preparation, transfer and, transportation of sponges took place underwater. The forty sponges were selected and carefully removed from the substrate using a dive knife to minimize tissue damage. Then placed in buckets, transferred underwater to a tank with flowing unfiltered seawater and held overnight. The following day all sponges were tagged and weighed in the laboratory. Each sponge was skewered underwater with a length of fishing line on which an identification number was attached (Pawlik 1998) and a loop was tied. The sponge was removed from the holding tank water for 2 seconds and placed in the pretared container of sea water with a constant volume and weighed on an electronic scale (Pawlik 1998). The sponges were then immediately returned to a large bucket of fresh seawater for transport to the study site. Sponges were tagged weighed and placed at the study site with in 4 hours (Pawlik 1998).

At the site sponges were placed at a depth of 1.4 meters in one of the four cage treatments and anchored individually by a nail threaded through the pre-tied loop. Ten sponges were placed in each treatment: 1) caged from predators and current 2) caged from current but exposed to predators 3) caged against predators but exposed to current 4) exposed to both predators and current. Predator cages were 10cmX 30cmX 40cm open sided boxes covered in plastic mesh with 1mm² openings. Current cages consisted of two 60cm X 40cm plexiglass sheets placed on the long side of the cage or mat and the cinderblocks were placed on the short ends to support the plexiglass. The top was open to allow potential predation and adequate water flow but blocked current from every direction. Sponges exposed to predators, were placed on 50cmX 30cm mesh mats with 5cm² openings. The nails were threaded through the hole and left under the mat to anchor the sponge. Caged and uncaged treatments were less than 2 meters apart. After 72 hours the sponges were removed from the nail with the fishing line intact, collected, placed in labeled treatment specific zip-lock bags, transported back and, weighed as before (Pawlik, 1998).

Data Analysis

To examine distributional differences between species, the differences between sites and differences between location on the reef were determined for each species of sponge. A one way analysis of variance (ANOVA) was used to analyze each sponge species in respect to the location on the reef: fringing, mid barrier, and near crest. One-way ANOVA was also used to analyze each sponge species in respect to the five study sites. Significance was adjusted for the number of comparisons made via the Bonferroni correction. Seven comparisons were made so p was divided by seven.

Histograms were used to examine the similarities between locations with the same sponges present. A nonparametric Wilcoxon/ Kruskal-Wallis test was used to examine these locations in respect to substrate cover and ecological cover. A one way ANOVA was used to compare fish abundance between two sites.

To test if Species G could survive in a non native habitat, changes in wet weight were analyzed using a one way ANOVA of the percent wet weight change for each treatment.

RESULTS

General Observations

In the presence of a thin fuzzy looking green brown carpet like algae that covered exposed rock substrate on blocks and dead coral, dense small oscula, DSO, sponges (Species A,B,C and, D) were not present. The fringing location for Ma'atea, East Avaroa Pass and Opunohu had this type of algae in abundance.

In the Motu channel DSO species were most densely clustered along the 0.5-1 meter depth gradient. Several species would cluster together in a small area often growing up onto one another (See Appendix B Fig. 1B). These sponges were most abundant on exposed rock and pavement with no visible biofilm or algae. Bite marks were not seen on any of the DSO species, Species E or Species F. Bite marks were seen on Species G after being transplanted to the barrier reef.

Experiment Results

In the transplant experiment each cage treatment resulted in a loss of wet weight (Figure 2). However, the differences among treatments were not statistically different (df=3, F=0.395 p=0.75).

Rapid Habitat Assessment Results

Sponge species were not distributed randomly with respect to their location on the reef (Table 3). Separate one way analyses of variance showed that the abundances of Sp. A, B, C, D and, G were each significantly different across reef locations. Abundance of Species E and Species F were not significantly different among reef locations. Significance was adjusted for the number of comparisons made via the Bonferroni correction.

A one way analysis was used to test whether differences existed in the abundance of each species across study sites (Table 4). Significant differences in abundance across sites were found revealed a significant difference for Sp. A, B, C and, G, while abundances of Sp. D, E and, F were not significantly different across sites. Significance was adjusted for the number of comparisons made via the Bonferroni correction.

The Motu channel and the Motu mid barrier both had the same sponges present, Species A, B and, C. Histograms were used to compare their benthic similarities based on substrate cover and ecological cover (Fig. 3 and 4). A nonparametric Wilcoxon/ Kruskal-Wallis test revealed a significant difference between the Motu channel and the Motu mid barrier in respect to the percent substrate cover (df=5, p=0.02). A nonparametric Wilcoxon/ Kruskal-Wallis test revealed a significant difference between the Motu channel and the Motu mid barrier in respect to the percent ecological cover (df =4, p=0.0008).

Species G was present at 2 locations Ma'atea fringing and East Avaroa fringing. Histograms were used to compare their benthic similarities based on substrate cover and ecological cover (Fig. 5 and 6).

A nonparametric Wilcoxon/ Kruskal-Wallis test revealed a significant difference between the Ma'atea fringing and East Avaroa fringing in respect to the percent substrate cover (df =5, p=0.0006). A nonparametric Wilcoxon/ Kruskal-Wallis test revealed a significant difference between the Ma'atea fringing and East Avaroa fringing in respect to the percent ecological cover (df =4, p=0.0056). Spongivorous fish presence at Ma'atea fringing and East Avaroa fringing is shown in Appendix A. A one way ANOVA for wrasse abundance between sites was not statistically significant (df =1, F=0.25 p=0.64)

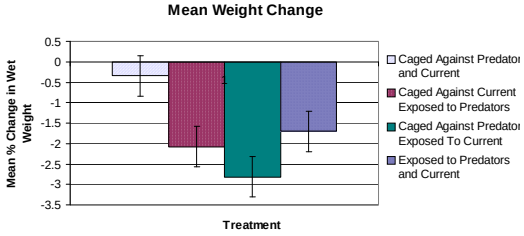

FIG 2. Mean change in wet weight change after 72 hours *Error Bars shown are Standard Error

TABLE 3. One way analysis of variance for each sponge species to test whether the abundance of each was the same across reef locations.

Species	Original P value	Adjusted P value	Deg of Freedom	Location Recoreded on Reef
A	0.0008	0.000114286	7.0644	mid barrier, motu channel, near crest
B	0.0005	7.14286E-05	7.4933	motu channel, mid barrier
C	0.0004	5.71429E-05	7.8796	fringing, mid barrier, near crest
D	0.0091	0.0013	4.4872	motu channel, mid barrier
E	0.0965	0.013785714	2.5616	mid barrier
F	0.3212	0.045885714	1.1868	fringing, near crest
G	0.0056	0.0008	4.9636	fringing

Note: Adjusted p = 0.00714285, values < adjusted p are significant

TABLE 4. One way analysis of variance for each sponge species to test whether the abundance of each was the same across sites.

Species	P value	Adjusted P value	Deg of Freedom	Recorded Presence at Study Site
A	<.0001	1.43E-05	10.7373	Motu, Opunohu
B	0.0043	0.000614	4.6272	Motu, Opunohu
C	0.0169	0.002414	3.5	Motu, Opunohu
D	0.1387	0.019814	1.8681	Motu
E	0.205	0.029286	1.642	East Avaroa
F	0.2371	0.033871	1.5069	Motu, Opunohu, East Avaroa
G	<.0001	1.43E-05	25.2703	East Avaroa, Ma'atea

Note: Adjusted p = 0.00714285, values < adjusted p are significant

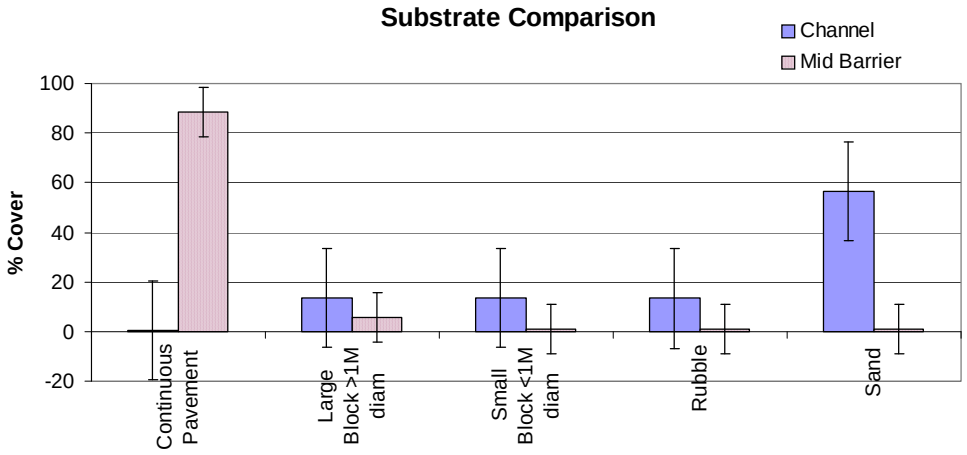

FIG 3. Average substrate cover between Motu channel and Motu mid Barrier. *Error Bars shown are Standard Error

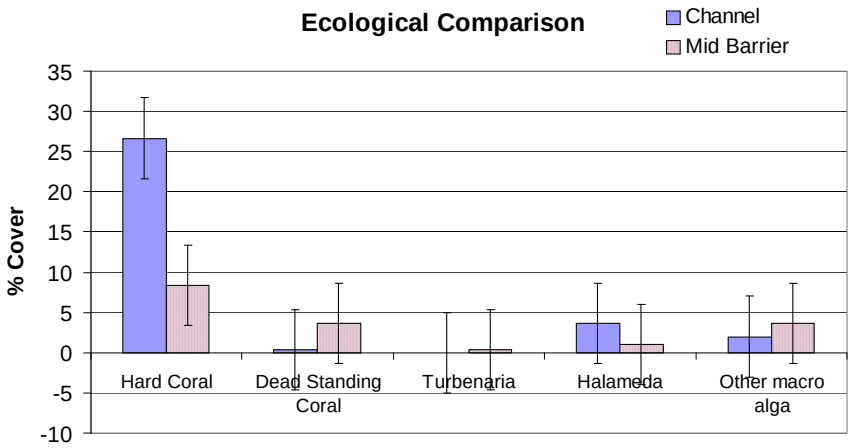

FIG 4. Average ecological cover between Motu channel and Motu mid Barrier. *Error Bars shown are Standard Error

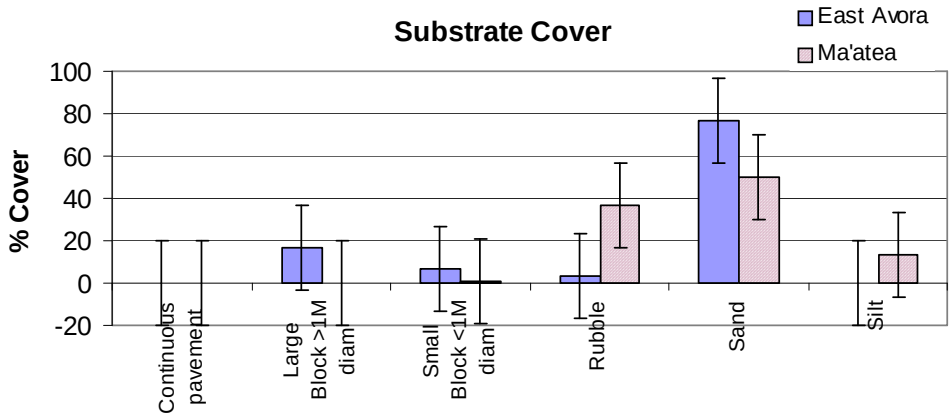

FIG 5. Average substrate cover between fringing East Avaroa and Ma'atea. *Error Bars shown are Standard Error

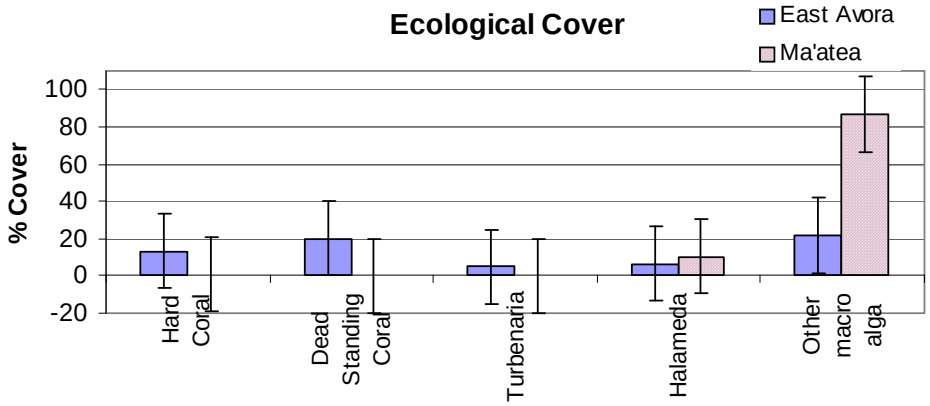

FIG 6. Average ecological cover between fringing East Avaroa and Ma'atea. *Error Bars shown are Standard Error

DISCUSSION

Observations

Competition between DSO sponges and algae may account for the absence of these species at locations with an abundance of algae. A study examining competition between sponges and algae would be illustrative in determining their relationship. The depth related clustering and competition of sponges in the Motu channel suggests some species have depth specific habitats restrictions. Photosynthetic symbionts could account for shallow depths some species appeared to require. As some coral reef sponge species include animals which are either predominantly phototrophic, mixed phototrophic and heterotrophic or totally heterotrophic, variations in the amount of light transmittance is a physical factor that is likely to influence the distribution of sponges (Wilkinson and Cheshire1989). Further studies examining the phototrophic characteristics for each species and the depth related requirements of each species would be useful in determining the distribution of each species in relation to depth and sunlight requirements.

Experiment Discussion

The transplant experiment revealed that Sp. G cannot survive on the barrier reef. While the factors caged for did not make a statistical difference in the weight loss observed between treatments, all treatments experienced a negative weight change. Sponge death occurred regardless of the cage treatments, indicating another factor is responsible for limiting the distribution of Sp.G. Due to experimental flaws, the data does not give strong support to the assertion that predation was an obvious factor limiting the distribution of Sp. G. However, multiple bite marks were evident on sponges exposed to predation. Both treatments exposed to predation lost the most weight. A design flaw resulted in sponge death for the treatment caged against predation but exposed to current, which actually lost the most weight. The cage water grew stagnant because the mesh barrier became clogged with sediment blocking flow into the cage. Regardless, the presence of bite marks on both predator exposed treatments indicates predation is a considerable factor limiting Sp. G's distribution. As the RHA data indicated, in Sp. G's native habitat spongivorous fish, namely angelfish (family Pomacanthidae) and wrasse (family Labridae) (Randall and Hartman 1968) are exceedingly rare; while on the barrier angelfish and wrasse are more abundant (Appendix A Table A3 and A4). Similarly in mangrove habitats where spongivorous fish are rare or absent certain Caribbean sponges grow conspicuous and large, while out on the reef these same sponges remain small and cryptic often growing under coral rubble (Pawlik 1998).

Consideration should also be given to the influence of current and wave action. The amount of wave action and hydraulic stress is minimal in the shallow silty waters where Sp. G is found. On the barrier reef increased turbulence and strong current would compromise its porous structure. The hydrodynamic stresses of the barrier reef are too intense for some, more delicate, sponges (Pawlik 1998) to withstand. Calm conditions prevailed during the 72 hour experiment; thus, weight change cannot be attributed to the effects of current or wave action. To test the effects of hydraulic action the experiment should be run for a longer period of time (Pawlik 1998) and placed nearer the reef crest where more turbulent conditions can be consistently guaranteed. Repeating this experiment, with more replicates and treatments and at more locations would help clarify the results of this experiment and give a better understanding of what factors are keeping Sp. G resigned to calm shallow and silty habitats on the fringing reef.

Result Interpretation Rapid Habitat Analysis

There were significant distributional differences in abundance among locations on the reef for Sp. A, B, C, D and, G as shown in Table 5. Each of these species showed habitat preference, as they were not randomly distributed across locations on the reef. For Sp. E and, F no significant distributional

differences in abundance among locations on the reef were attained. Indicating Sp. E and Sp. F were either randomly distributed over all the three reef locations or there was not enough data to give reliable results. It is likely there was not enough data for Sp. E and, F as these two species were seen only four times out of 39 transects in very low abundance.

Differences in distribution between sites were analyzed to illustrate that abundance of each species varied between sites. For Sp. A, B, C and, G there were significant distributional differences in abundance between each site, indicating their distribution was not random. For Sp. D, E and, F distributional differences in abundance between sites were not significant. This is most likely due to the low sample size of these more rare species

Coupling the location and site analysis suggests that analogous location on the reef between sites may not be predictive of species presence. Using the data from Appendix A Table A5 presence and absence can be examined in relation to location on the reef across sites. Sp. A, B and, C were abundant at mid barrier Motu but all species were absent from the mid barrier PGEM On the near crest Sp. A and, C were present at Opunohu while on the near crest at East Avaroa no sponges were present. Sp. G was present on the fringing reef for Ma'atea and East Avaroa but absent from the fringing reef at both Opunohu and PGEM. Unlike the others, this difference was apparent as Sp. G appears to prefer silty shallow habitats present at Ma'atea and East Avaroa fringing, while Opunohu and PGEM fringing are more stereotypical coral reef habitats with abundant coral. However, while not backed by data, field observations showed Sp. A and B were present at the Opunohu fringing but not at the PGEM fringing. While a study in the Caribbean noted sponges have marked habitat preferences but their within-habitat distribution is patchy (Zea 2001), it appears this is not true for Mo'orea based on the presence absence characteristics. Further exploration into this occurrence would be illustrative in determining causation for the differences in terms of sponge presence between comparable locations at different sites.

Based on ecological cover and substrate cover, locations with similar biotic and abiotic factors will not necessarily have the same sponges present . Although Sp. A, B and, C were present at both locations, comparison of the histograms and p-values generated for Motu channel and Motu mid barrier in relation to the substrate cover and ecological cover indicate the two locations are very different (Fig. 3 and 4). Ma'atea fringing and East Avaroa fringing were compared in the same fashion and using the same criteria because both locations had Sp. G present. Again both substrate cover and ecological cover were significantly different between these sites (Fig. 5 and 6). Thus, locations with the same sponges present would not have similar biotic and abiotic factors in respect to substrate type and benthic ecological composition. However, this explanation is based solely on the variables tested. Sponge distribution can also be influenced by factors such as turbidity, depth, hydraulic action, predation, biochemical elements, nutrients, and competition (Wilkinson and Evans 1988).

Sp. G proved to be a prey item during the transplant experiment. Two important commonalities shared by the Ma'atea fringing and East Avaroa fringing were the presence of Sp. G and the absence of angelfish and rarity of wrasse, two well known spongivorous fish (Randall and Hartman 1968). In terms of predator abundance, these two fringing sites were not statistically different. Thus my second hypothesis that locations with the same sponges present will have very similar abiotic and biotic factors, is not completely disproved by the data.

Although the RHA data collected was imperfect for ultimately defining habitat types and thereby the habitat preferences of the species evaluated, it raised a point that may have otherwise been missed. Sponge abundance for Sp. A, B and, C was very high in the Motu channel and mid barrier (Appendix A Table 1A). No other locations had such high occurrences of these three species. Further studies investigating factors such as depth, current, turbidity, and chemical the conditions around Motu Fareohe and Motu Tiahura would be informative in

determining habitat preferences for this group of sponges.

Intensive sampling and data collection at locations with abundant sponges would better define the habitat requirements of sponges on Mo'orea. It would also be valuable to describe different sponges based on their ecological roles and to define and quantify habitat types in order to provide a comprehensive distributional overview of the sponges present in Mo'orea. Although this paper was unsuccessful in defining and describing sponge distribution in Mo'orea, it did raise many new questions about sponge distribution. My data strongly supported the hypothesis that there are differences in sponge distribution at different locations around the islands. Based on the benthic biotic and abiotic variables considered it was determined that locations with the same sponges present will not necessarily have very similar abiotic and biotic factors. However looking at predator abundance this may not be the case for Sp. G and would be worth investigating further. The hypothesis that sponges transplanted to a location with no naturally occurring sponges of the same species will not survive was supported by the transplant data for Sp. G. Additional inquiry is warranted as predation was not the only factor limiting the distribution of Sp. G.

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LITERATURE CITED

DeVantier, LM, De'ath G., Done TJ, Turak, E (1998) Ecological Assessment of a Complex Natural System: A Case Study From the Great Barrier Reef. *Ecological Applications.* 8: 480–496

Hooper, JNA, Kennedy, JA, Quinn, RJ (2002) Biodiversity 'Hotspots', Patterns of Richness and Endemism, and Taxonomic Affinities of Tropical Australian Sponges (Porifera). *Biodiversity and Conservation.* 11**:** 851–885

Hooper JNA, Le´vi, C (1994) Biogeography of Indo-west Pacific sponges: Microcionidae, Raspailiidae, Axinellidae. *Sponges in Time and Space*. Balkema, Rotterdam, pp. 191–212.

Osinga, R, Tramper, J, Wijffels, RH (1999) Cultivation of Marine Sponges. *Marine Biology.* 1:509-532

Pawlik, JR. (1998) Coral Reef Sponges: Do Predatory Fishes Affect TheirDistribution? *Limnology and Oceanography*. 43:1396-1399

Randall, JE, Hartman, WD (1968) Sponge-feeding fishes of the West Indies. *Marine Biology*. 1: 216-225

Wilkinson, CR, Cheshire, AC (1988) Cross-Shelf Variations in Coral Reef Structure and Function - Influences of Land and Ocean. *Proc 6th Int. Coral Reef Symp* 1:227-233

Wilkinson, CR, Evans, EA (1989) Sponge distribution across Davies Reef, Great Barrier Reef, relative to location, depth, and water movement. *Coral Reefs.* 8:1-7

Wilkinson, CR, Cheshire AC, (1989) Patterns in the distribution of sponge populations across the central Great Barrier Reef. *Coral Reefs*. 8:127-134

Wulff, LJ (2006) Ecological interactions of marine sponges. *Canadian Journal of Zoology*. 84(2): 146–166

Zea, S (2001) Patterns of Sponge (Porifera, Demospongae) Distribution in Remote Oceanic Reef Complexes of the South West Carribean. Zoology 25: 579-592

Appendix A

Select Raw RAH Data

Table A1. Motu Abundance

	Channel between Motu Fareohe and Motu Tiahura			Mid Barrier		
Angel Fish	0	0	0	0	0	0
Wrasse	3	4	4	3	2	3
Species A	2	1	4	3	3	3
Species B	0	3	2	1	2	2
Species C	0	2	4	2	1	1

Table A2.
East Avaroa Barrier Reef Abundance Data

	Replicate 1	Replicate 2	Replicate 3
Angel Fish	1	2	2
Wrasse	3	3	3
Species G	0	0	0

Table A3. East Avaroa Fringing Reef Abundance Data

	Replicate 1	Replicate 2	Replicate 3
Angel Fish	0	0	0
Wrasse	1	2	1
Species G	0	1	3

Table A4. Ma'atea Fringing Reef Abundance Data

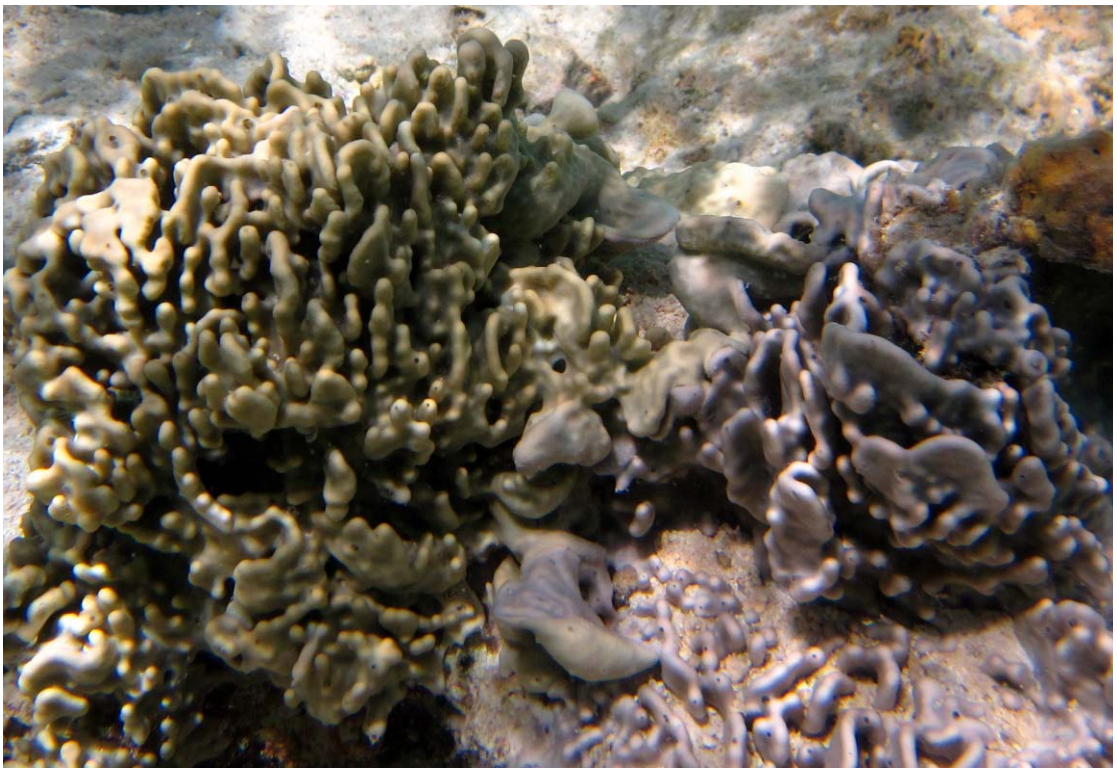
	Replicate 1	Replicate 2	Replicate 3
Angel Fish	0	0	0
Wrasse	1	2	0
Species G	3	3	3

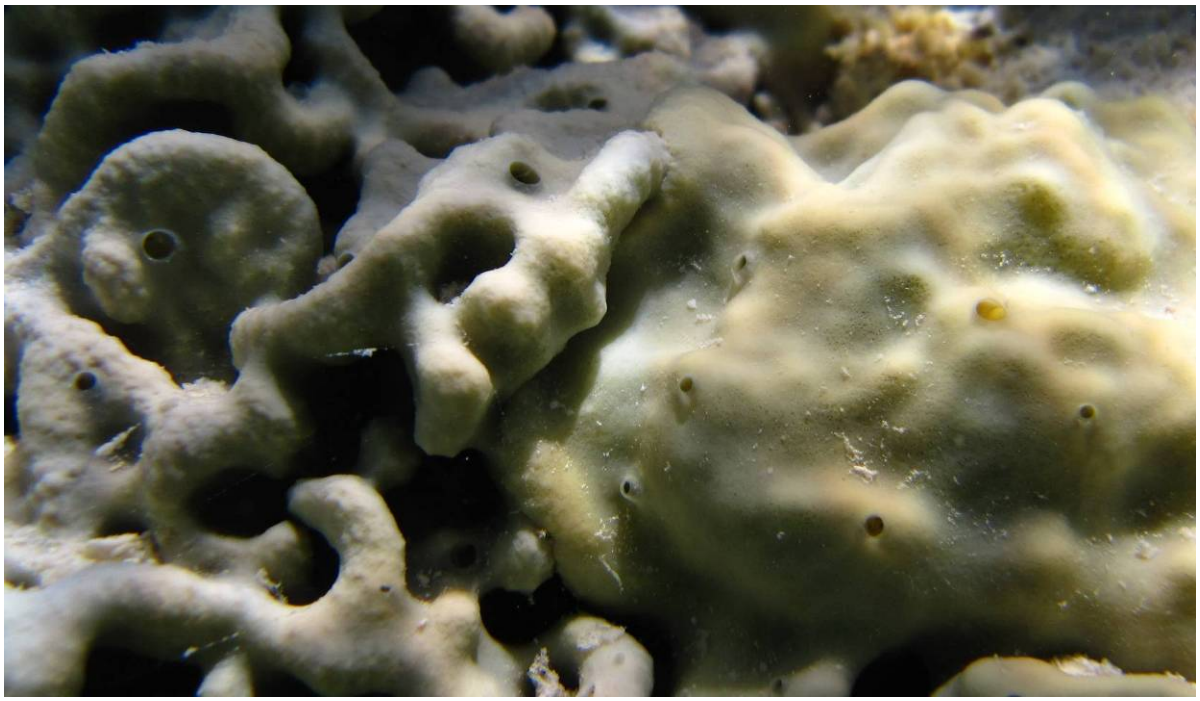
Table A5. Species presence (P) absence (A) across location at each site

	PGEM			E.Arova			Opunohu			Motu			Ma'atea
Species	Fringing	Mid Barrier	Near Crest	Fringing	Mid Barrier	Near Crest	Fringing	Mid Barrier	Near Crest	Channel	Mid Barrier	Near Crest	Fringing
A	A	A	A	A	A	A	A	P	P	P	P	P	A
B	A	A	A	A	A	A	A	P	A	P	P	A	A
C	A	A	A	A	A	A	A	P	P	P	P	A	A
D	A	A	A	A	A	A	A	A	A	P	P	A	A
E	A	A	A	A	A	A	A	A	A	A	A	P	A
F	A	A	A	P	P	A	P	A	A	A	A	A	A
G	A	A	A	P	A	A	A	A	A	A	A	A	P

Appendix B

Fig. 1B. Competition at the Motu





Appendix C

Photographic species identification guide for study species

Species A

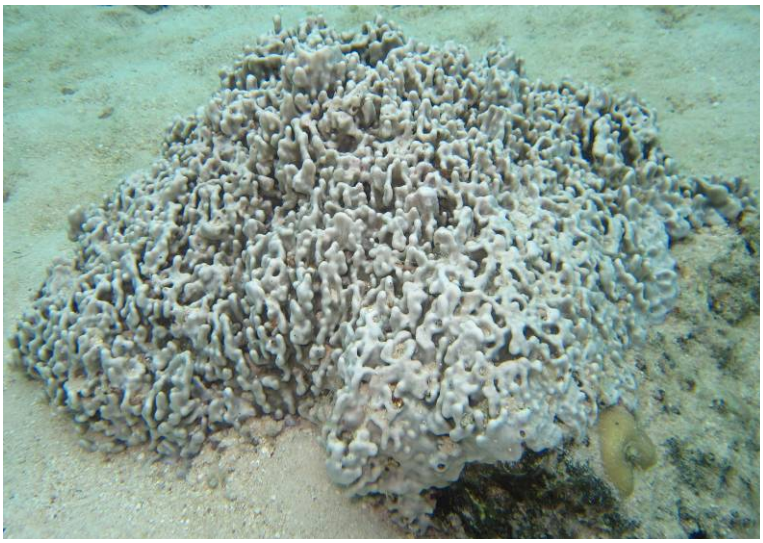
- Green
- Smooth surface
- Dense
- Wall and fingerlike projections
- Small osculate roughly 1mm in diameter

Species B

- Grey Green
- Purple interior (below)
- Dense
- Wall and fingerlike projections
- Small osculae roughly 1mm in diameter

Species C

- Grey
- Smooth surface
- Dense
- Globy finger like projections (below)
- Small osculae <1mm in diameter



Species D

- Orange
- Dense
- Rough exterior
- Wall and fingerlike projections
- Small osculate < 1mm in diameter

Species E

Family Thorectidae
- Black (often covered in sediment)
- Slippery surface
- Rough geometric surface
- Pattern less defined around edges
- Crunchy and Hard Dense
- Pronounced oscula >1mm in diameter

Species F

Family Ircinia
- Black (white sediment covering sponge,)
- Rough Spikey surface
- Cut away shows tan inside
- Crunchy and Hard
- Pronounced oscula
  >1mm in diameter

Species G

- Purple
- Often covered in sediment
- Very soft and spongy
- Pronounced osculae
  >1mm in diameter