**Majuro atoll FY 2010 Coral Reef Monitoring Final Report**

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G. Summary of Progress

## Final Project Outcomes:

1. Majuro Monitoring Guide, with coral identification guide
2. Databases for 2010 fish, coral, benthic and invertebrate surveys
3. Established new rubbish monitoring program, with baseline database
4. Continued database for Majuro coral disease occurences

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## Executive Summary:

**Majuro Atoll reefs were surveyed using a comprehensive quantitative method that targeted fishes, hard corals, benthos, and macroinvertebrates at 14 sites that represented environmental and human gradients. This survey serves as the start of the Majuro Atoll Long-term Monitoring Program. In addition, a comprehensive survey of rubbish in the lagoon and around the atoll was conducted, and serves as a baseline to monitor trends of rubbish breakdown and additional disposal in the future.**

**Fish communities were surveyed as density and biomass of all non-cryptic species on short 50m transects, and as density and biomass of large fishes and sharks on longer 250m transects. The species richness of fishes was found to be similar across all sites, with deeper habitats supporting more species. The biomass showed differences between depth and position of site relative to human population centres – higher biomass was recorded at more remote sites. Both for all fishes and large fishes surveys, there was a significant difference between lagoonal and outer habitats, as well as between depths in species assemblages. Multivariate analysis showed that gradients in biomass of species assemblages also corresponded to the distance of sites to human population centres.**

**Coral communities were found to be relatively depauperate in terms of biodiversity, compared to other atolls in RMI. However, many sites had high coral cover, which was often a largely mono-specific coral community of *Porites* spp. (*rus* and massive). The benthic communitites were characterized by a high proportion of sand in the lagoon, where coral bommies were often sparsely distributed on sandy substrate. Some sites had a high proportion of non-scleractinian corals (*Millepora, Heliopora*). Very low cover of soft corals and sponges was recorded throughout.**

**The survey found several types of coral disease. Continuing the ongoing disease monitoring in Majuro, many lesions that continued to expand were monitored, and a new type of disease was recorded.**

**Invertebrate diversity was relatively rich in molluscs overall, but site-specific diversity was low. With X species, the diversity of Holothurians was extremely low.**

**Rubbish surveyed discovered a high diversity and cover of rubbish items in the lagoon near the population centres, and fewer items on more distant dive sites. In the shallow populated eastern part of the lagoon we recorded a total of 773 items of rubbish in 3,300m$^2$ surveyed, which corresponds to 4.308 items of rubbish/1m$^2$**

## Introduction:

Majuro Atoll (7°4′N 171°16′E) is a large coral atoll of 64 islands in the Pacific Ocean, and forms part of the Ratak Chain of the Marshall Islands (Figure 1). As with other atolls in the Marshall Islands, Majuro consists of extremely narrow land masses. The highest point of elevation on the island is 3m. Majuro Atoll is the most densely populated atoll in the Marshall Islands, and houses over 25,000 residents on 9.7 $km^2$ but encloses a lagoon of 295 $km^2$. This has resulted in reef management challenges unique to the country, as there are increased levels of threat from the wild disposal of solid waste, eutrophication from point (i.e., a shallow sewage outfall in Delap) and non-point sources, over-fishing and over-collection of aquarium fishes. In addition to human and pig sewage and carelessly managed solid waste, a fleet of tuna boats and their tenders are sources of pollution.

A survey of reefs around Majuro lagoon was conducted in 2004, with sites distributed mostly in the lagoon [1]. This survey showed that the health of Majuros reefs was relatively good at the surveyed sites, however these sites were predominantly further away from areas with highest human population densities. The baseline survey data were unsuitable as a basis for quantitative monitoring, as the methodology did not allow robust statistical analysis, and site choice was limited by adverse weather conditions. Other survey efforts were conducted by SPC in 2006, and a small number of sites were surveyed by the Marshall Island Marine Resource Authority in 2009. In addition to this there have been ongoing coral disease, bleaching and crown of thorn surveys conducted by the College of the Marshall Islands.

## Methods:

Marine surveys were completed at **14 scuba sites** (Figure 1a), using the methodologies detailed in Figure 2 (see also the Majuro Monitoring Guide). Two depth zones were surveyed at every dive site 3-5m and 8-10m. At every dive site the following organisms were surveyed:

1. **Large reef fish and sharks**
2. **Macro-invertebrates**
3. **Reef fish biodiversity**
4. **Coral biodiversity (including rubbish abundance and diversity)**
5. **Benthic Cover (including rubbish cover)**
6. **Photo transects**

1. **Large reef fish and sharks** and were surveyed along 3x 250m x 5m wide belt transects in the two depth zones. Large fishes targeted with this methodology include – Serranids (Groupers), Scarids (Parrotfishes), Acanthurids (Surgeonfishes), Carangids (Jacks), and Humphead wrasse.
2. **Macroinvertebrates** surveyed along 3x 250m x 5m wide belt transects in the two depth zones. Targeted macroinvertebrates were identified to species where possible and the basal shell width of *Trochus* spp. was measured.
3. **Fish biodiversity** surveys record all non-cryptic species along three replicate 50m transects in each depth zone. All individuals of the larger mobile species are identified and their size estimated within 5m wide belts, whereas for small more sedentary fishes, identifications and size estimates are made within 2m wide belts.
4. **Coral biodiversity** was surveyed on three replicate 50m long x 2m wide belts conducted in two depth zones. Within each belt, all individual corals were identified to species level, counted and qualitative notes were made about coral health in terms of disease, bleaching, predation. If items of rubbish were present within the biodiversity belts, they were also counted and identified where possible.
5. **Benthic cover** was documented on point-intercept transects (the same transects as coral and fish biodiversity - 3 x 50m transects in two depth zones). To determine the percent cover of benthic organisms, the benthos underlying 100 points was documented. Common benthic categories include hard corals (identified to genus), abiotic (sand or rubble), turf algae, coralline algae, fleshy green macroalgae, *Halimeda* spp., sponge, soft coral, macro-invertebrates, rubbish and other (includes anemones, tubeworms).
6. **Photo Transects** were conducted to obtain a permanent photographic record of the substrate was photographed every 10m along 3 replicate 250m transects. The photo-transect surveyor towed a GPS/depth sonar which enabled the photos to be geo-referenced. These transects were completed at about half of our dive sites.

In addition to the scuba sites, **11 snorkel sites** were surveyed in shallow (<3m) habitat on the edge of the most populated parts of the eastern lagoon (Figure 1b). At these sites coral and rubbish biodiversity were surveyed on 3 x 50 m x 2m wide belt transects. Further benthic cover estimates were also obtained using the point-intercept technique described above on the return pass of each transect.

*Practical notes about conducting the surveys*

It is important to mention that deep sites were always surveyed first to ensure safe dive profiles. **Four weighted marker buoys** were deployed every 250 m using a GPS to measure the distance to be swum by large reef fish and macro-invertebrate surveyors. The coral and fish surveyors began surveying first starting at the second marker buoy and the large fish and invertebrate surveyor then began their surveys at the first marker buoy. This strategy minimizes the disturbance of sharks and large reef fish to ensure non-biased estimates of large mobile fish at each site.

For reef fish and coral biodiversity surveys, the fish surveyor swam first while deploying the 50 m transect tapes and was followed by the coral biodiversity surveyor. After 3 transects, the coral surveyor swam back along each transect conducting point-intercept transects with the fish surveyor following winding up the transect tape. With this method, matching fish, coral and benthic data is obtained on all transects at every site.

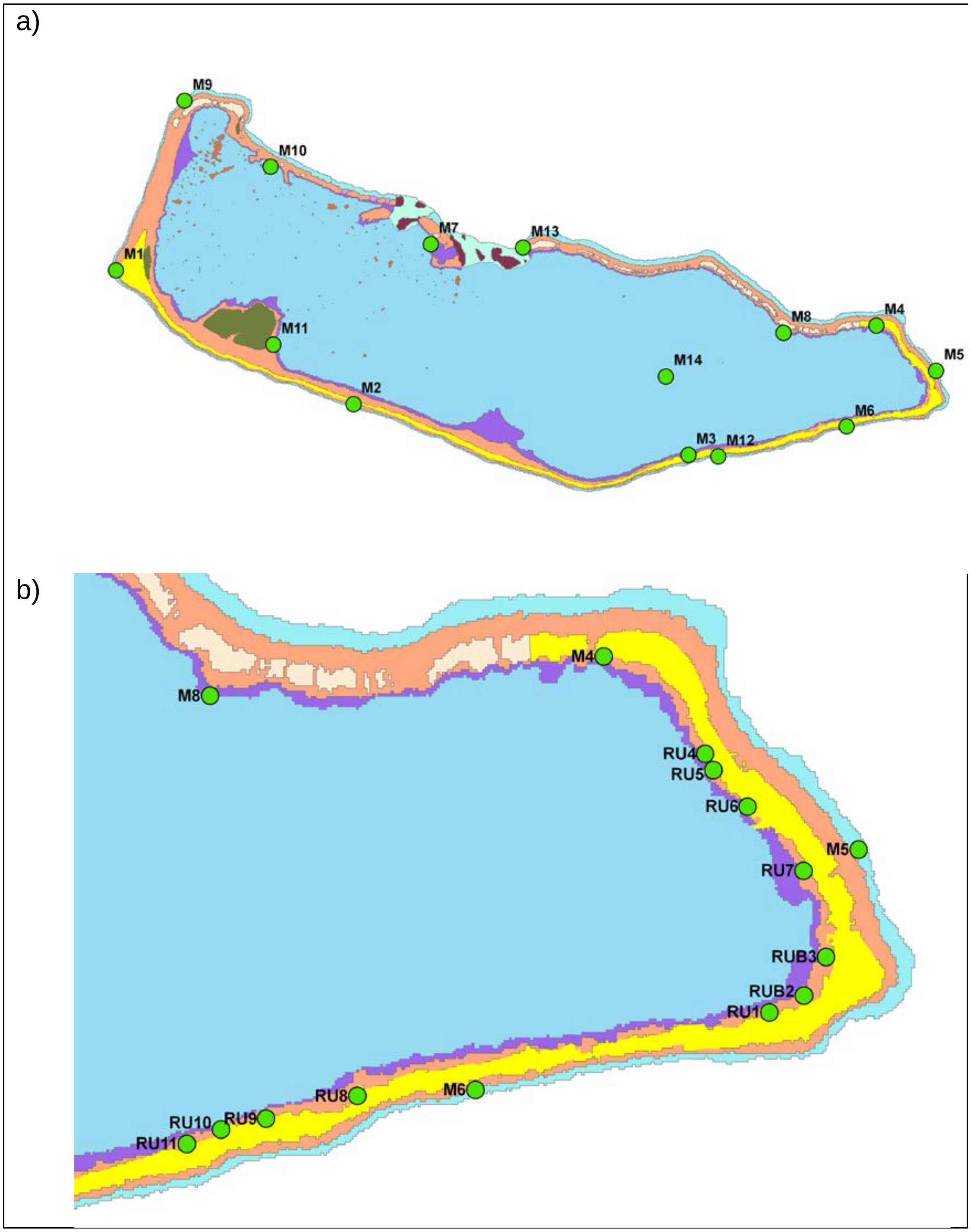



**Figure 1. Sampling sites in Majuro Atoll. a) SCUBA sites with data from reef slope and reef slope habitat, b) shallow lagoon reef slope sites.**

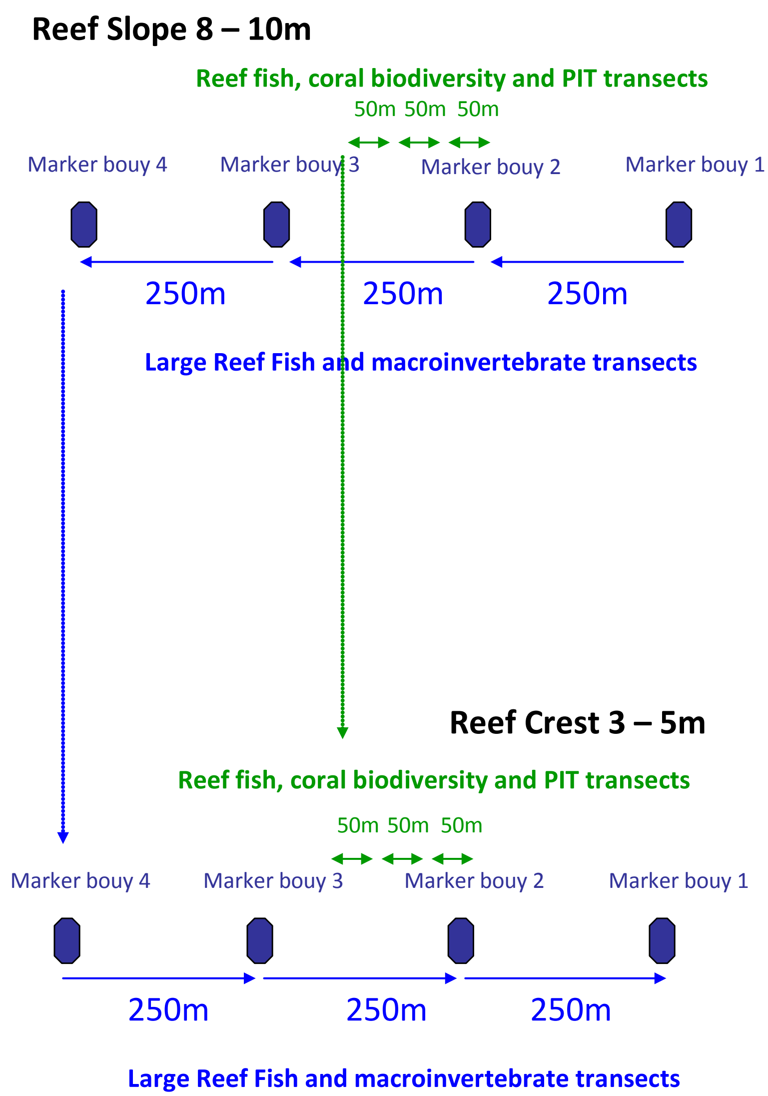



**Figure 2. Sampling design.**

## Results:

*Habitat descriptions*

Coral reef habitats at Majuro Atoll were typical for Micronesian atolls. The southern outer reefs exhibit steep dropoffs, with intact coral and fish communities. The eastern outer reefs are relatively gently sloping and had very low coral cover from a storm a few years back. The northern and western outer reefs had drop offs with intact reef structure. The lagoonal reefs were generally more damaged the closer they were to population centres. Most patchreefs and bommies in the lagoon were characterized by large colonies of *Porites rus*. The status, diversity and health of reef communities was generally lower than that of outer atolls, as expected for the Marshallese population centre.

***Porites rus* dominates in Majuro Lagoon.**

*Fish communities*

A total number of 268 species were recorded during Majuro Atoll surveys. Site species richness was relatively uniform across all sites, with no apparent differences in richness between lagoon and outer sites (Figure 3). At most sites, species richness in the shallow habitat was lower than in the deeper reef slope (Figure 3). The lagoon sites M3 and M8 had higher species richness in the shallows as there were more complex and denser reef matrix structures. Species richness was lowest at Site 4, which was a lagoon site with extremely high rubbish prevalence with few species.

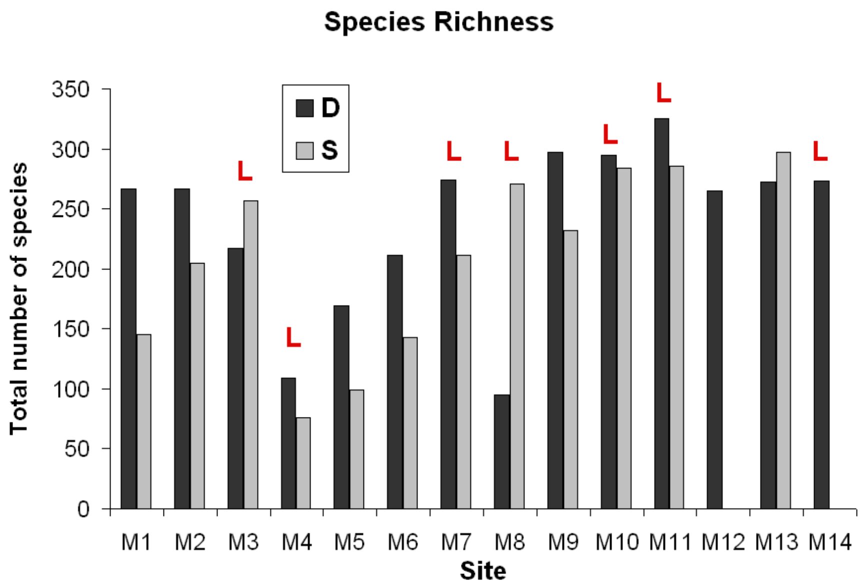



**Figure 3. Species richness recorded on sites by depth. Lagoon sites marked with "L".**

The biomass of fishes varied substantially with depth, with higher biomass on deep transects for most sites (Figure 4). Lagoon sites generally had a lower biomass than outer reef sites (Figure 4).

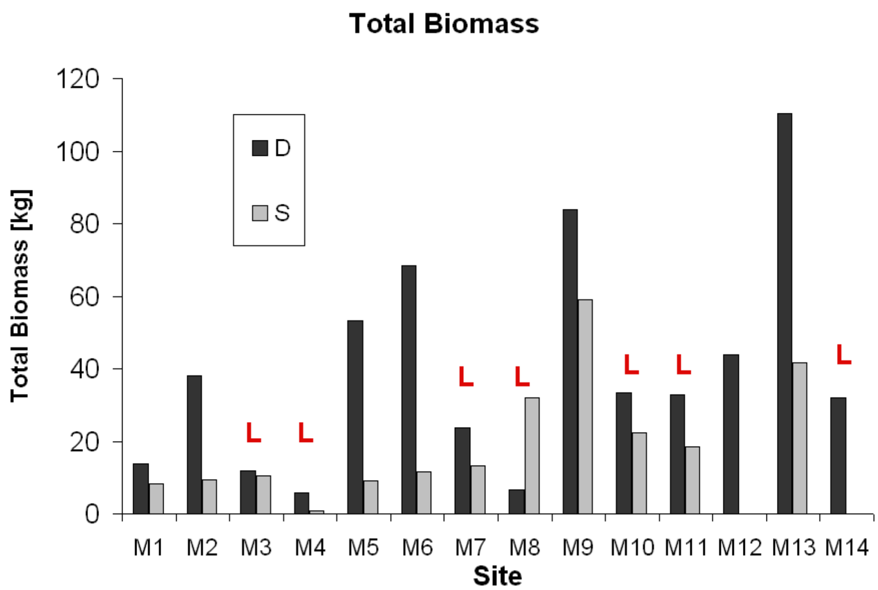



**Figure 4. Total biomass recorded on sites by depth. Lagoon sites marked with "L".**

In a multi-dimensional scaling analysis which compares the similarity of fish communities by their fish abundances, a clear partition of habitat types by lagoon/ outer reef and depth is evident (Figure 5). In contrast to the simple count of species (see Figure 3), the fish assemblages show a differentiation with distance to human settlement. In the MDS plot, sites near the top of the plot (e.g. M4, M1) signify depauperate sites with generally lower abundances and species richness, whereas the "good" sites are placed towards the base of the plot, representing rich fish communities (Figure 5).

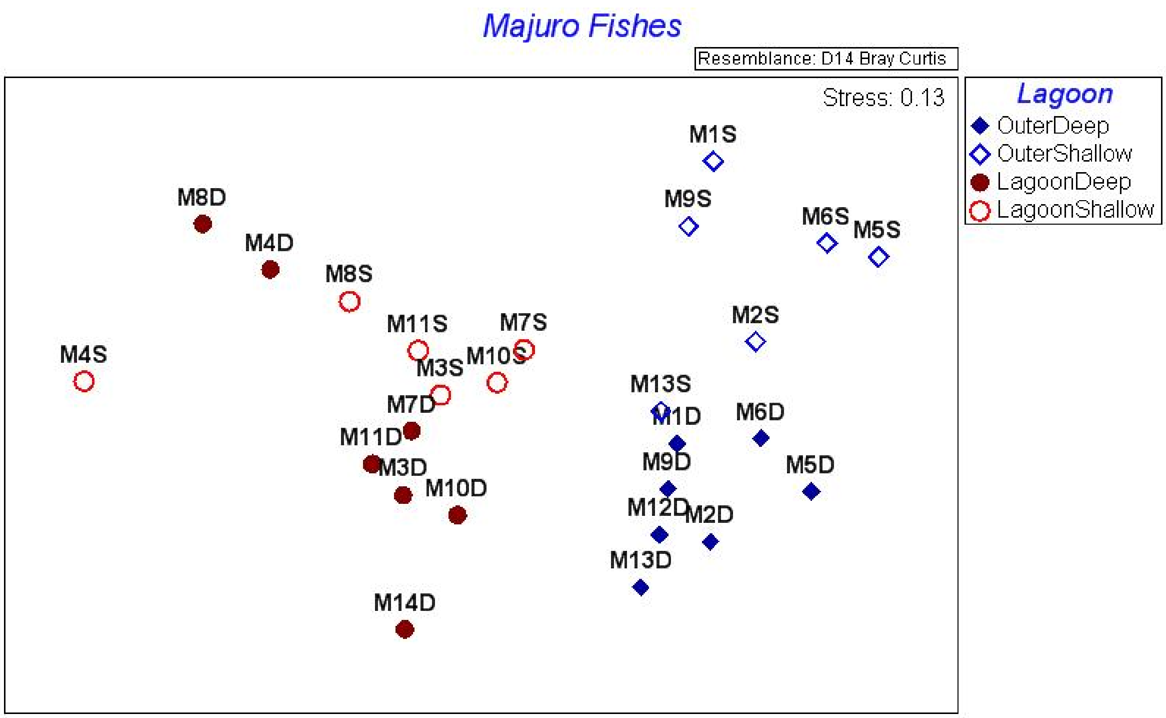



**Figure 5. Multi-dimensional scaling multivariate analysis of species richness per depth.**

Multi-variate analysis of biomass data shows a similar result, with lagoon and outer reef habitats clustering in different parts of the plot, signifying very different assemblages and their biomasses (Figure 6). There is less clustering between depths, as some sites had high biomass in the shallow areas. Similarly, differences in site positions between the two MDS plots represent sites where fewer large individuals of fewer species result in high biomass. For example, Site 6 had relatively low species richness (Figure 3), and high biomass (Figure 4) despite a low abundance (Figure 5). Sites near the human population centre in the SE of Majuro (M4, 5, 6) all range in the upper part of the plot, signifying low biomass and diversity (Figure 6).

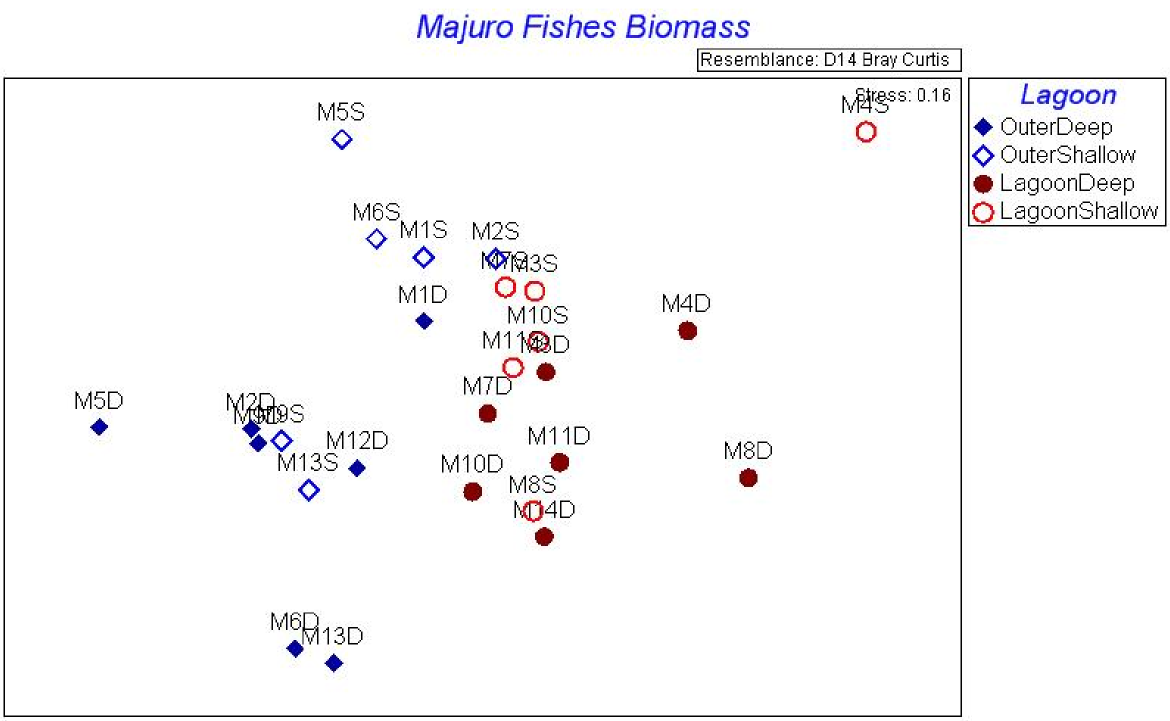



**Figure 6. Multi-dimensional scaling multivariate analysis of biomass per depth.**

**Black morph of endemic 3-stripe anemonefish *Amphiprion tricinctus***

Similar to the fish diversity data, preliminary analysis of the **big fish** counts shows that big fish communities differ considerably between the eastern (populated) and western (remote) side of the lagoon, as demonstrated by Multidimensional scaling (MDS) analysis (Figure 7).

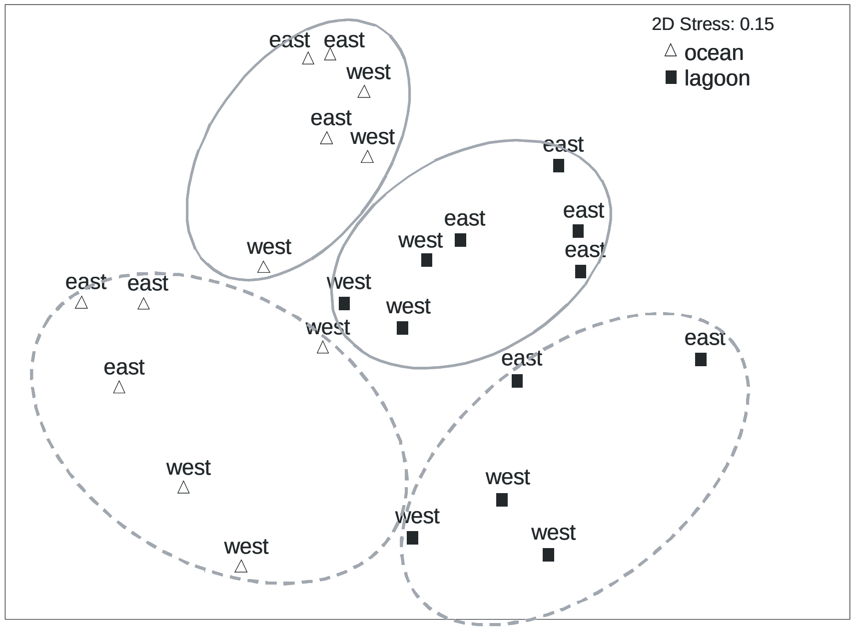



**Figure 7. MDS plot of fish communities for large fishes: dotted lines represent deep communities and solid lines represent shallow communities.**

*Coral/benthic communities*

Preliminary analysis of benthic cover data shows a high degree of variability in the amount of hard coral cover (ranging from 10% - 74%) (Figure 8). The sites with the highest level of hard coral cover were Site 14 (86%), Site 13 (74%) and Site (3 65%). At all three of these sites, the high coral cover was driven by a high abundance of Porites (namely *Porites rus* and *Porites cylindrica*) especially at Sites 3 and 14 where only 20 and 12 species of coral were recorded in total (respectively). The high coral cover at Site 13 in the lagoon was however more closely related to coral biodiversity with a total of 54 species recorded at this site making this the 3rd most species rich site surveyed.

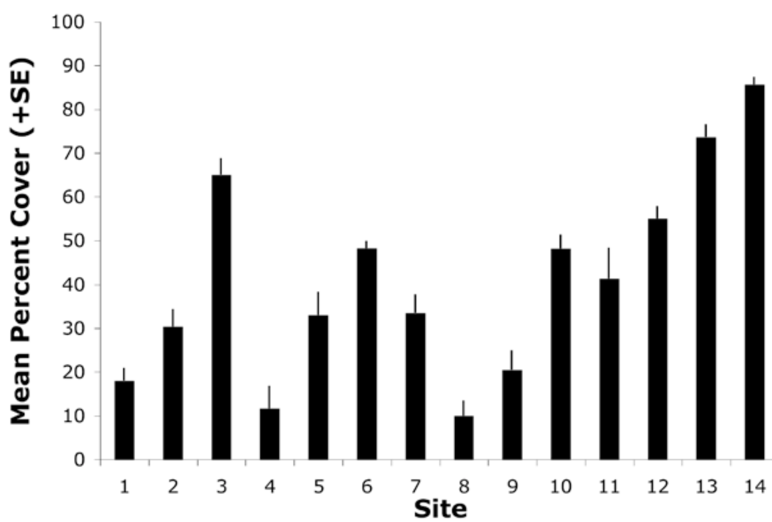



**Figure 8. Mean percent cover (+SE) of hard coral cover at 14 sites at Majuro Atoll.**

Sites with the lowest level of hard coral cover were dominated by abiotic material (sand or rubble) (Figure 9). Site 4 (Rita) was the only dive site where rubbish formed large proportion of the benthic cover. On deep transects, a mean of 46% rubbish cover was recorded whilst at shallower sties 10% cover of rubbish was recorded (Figure 10). Rubbish cover peaked at 52% on two of the three transects conducted at 10m depth. Aluminium cans, metal, glass and plastic were the predominant types of rubbish recorded at Rita however fishing line, types, shoes, iron and other construction materials, wood, material, cardboard, rope and 44 gallon drums were documented among the 159 items of rubbish counted within the $600m^2$ surveyed at this site. At Rita, coral cover was conspicuously low at 12% and this is taken to relate directly to the high amount of rubbish at this site.

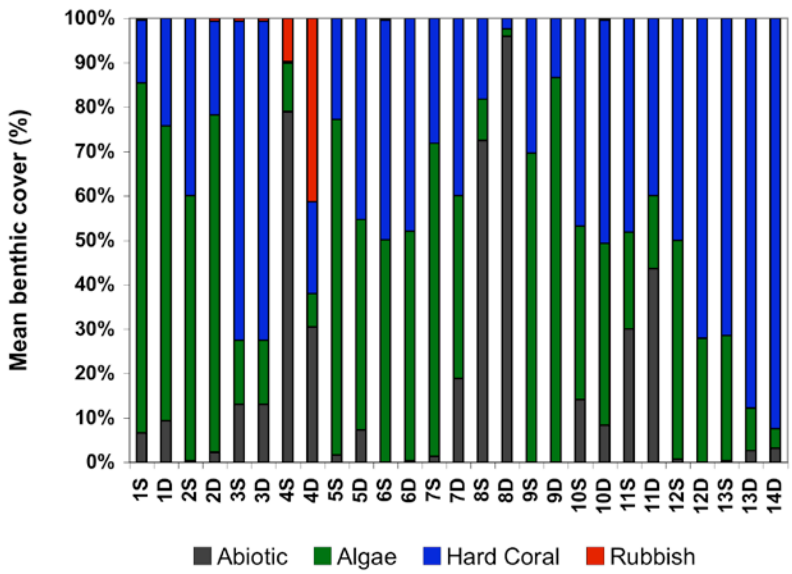



**Figure 9. Percent cover of 4 major benthic categories at Majuro Atoll.** The algae category includes all algal types – turf algae, *Halimeda* spp., various green macroalgae, coralline algae, filamentous and red algae.

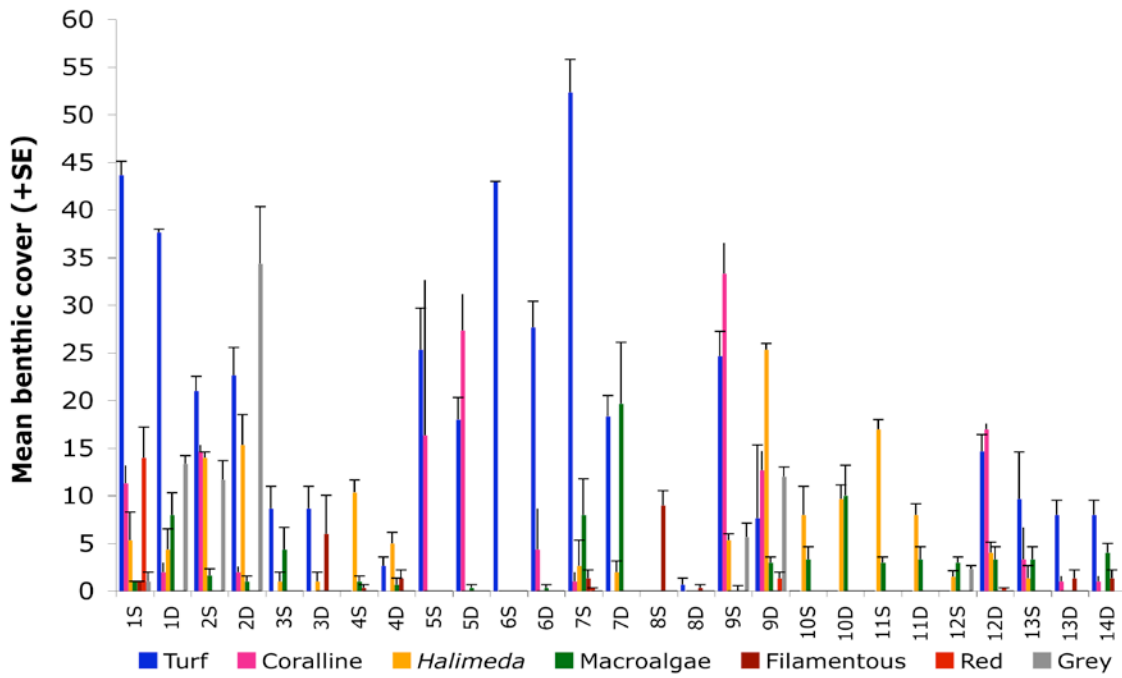



**Figure 10. Mean percent cover of major categories of algae at Majuro Atoll.**

Turf algae dominated at sites 1, 2, 6 & 7. Coralline algae were dominant at sites 5 & 9. Curious on the deep transects at site 2 was an encrusting grey alga. Fleshy green macroalgae was relatively sparse at all sites. *Halimeda spp*. was present in high numbers at sites 2, 4, 10 and 11 (Figure 9). It is important to note that non-scleractinian corals (such as *Heliopora coercula*, blue coral and *Millepora* spp. fire coral) contribute significant levels of cover to the hard coral estimates shown above, particularly at exposed sites 1 & 2 (Figure 10). Notable is the lack of soft coral and sponge at all sites with the maximum cover either of these groups obtained was 2% (Figure 11). Freshly dead coral was detected at sites 2, 9, 10, 12. There was a large biomass of corallimorphs at site 13 and this explains the large proportion of cover of the ‘other’ category in Figure 11.

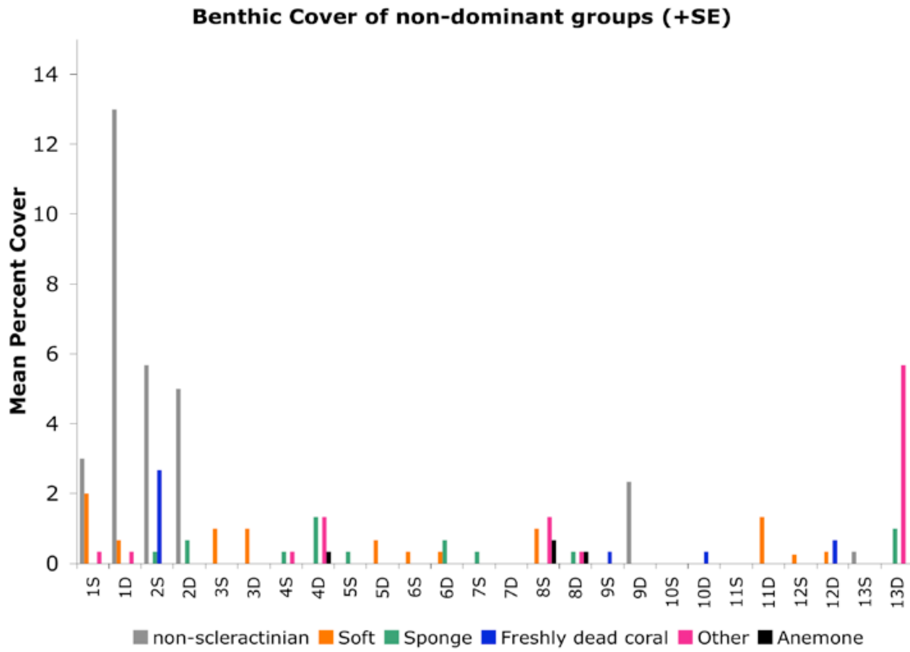



**Figure 11. Percent cover of other groups including sponge, soft coral, dead coral, anemone. The category 'other' includes corallimorphs, urchins, gastropods and fish.**

15 Families, 43 Genera, 136 species of hard coral were recorded from Majuro Atoll, compared to 183 species recorded from Bikini Atoll in 2002 [2], 179 Species from Mili and 198 species from Rongelap Atoll. Hence, the species diversity at Majuro is relatively low in a regional context, as also found in previous assessments [1,3]. The highest coral species richness was recorded at sites on the northern side of the atoll away from the populated areas (e.g. site 10, 13) (Figure 12). Generally, species diversity was higher within the 8-10 m habitat zone (Figure 13).

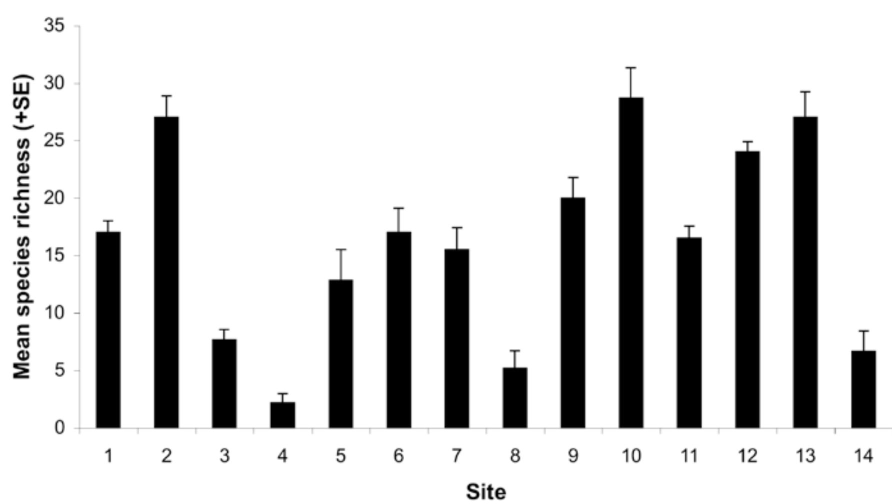



**Figure 12. Mean species richness across 6 replicated transects (3 deep/3 shallow) at 14 sites. NB. Only deep sites were surveyed at sites 12 and 14. A total of 9125 colonies were examined.**

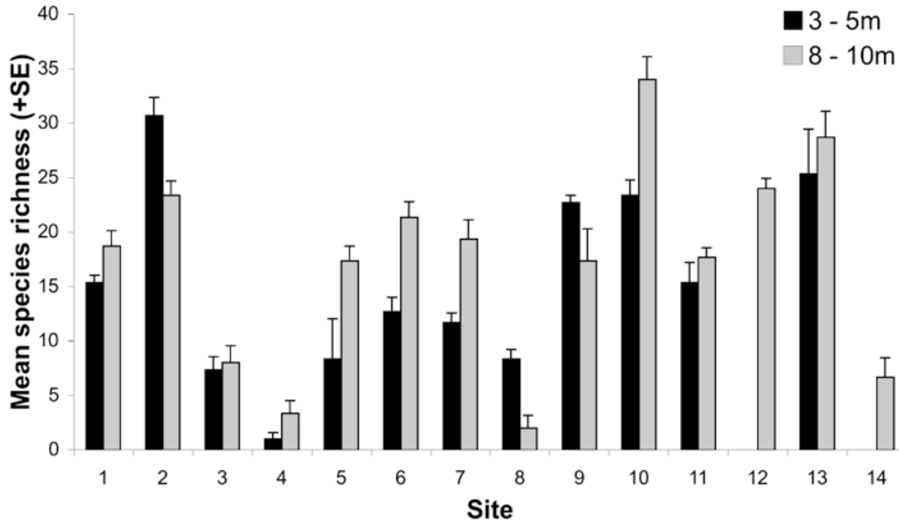



**Figure 13. Mean species richness at 14 sites in deep/shallow habitat zones.**

Generally our data shows at Majuro, species richness increases in correlation with coral cover (Figure 14). However, there are several notable exceptions whereby a site has extraordinarily high coral cover (e.g. site 14 – approx 85% cover) however the community is dominated by a single species, *Porites rus* and only a handful of other species are present at this site.

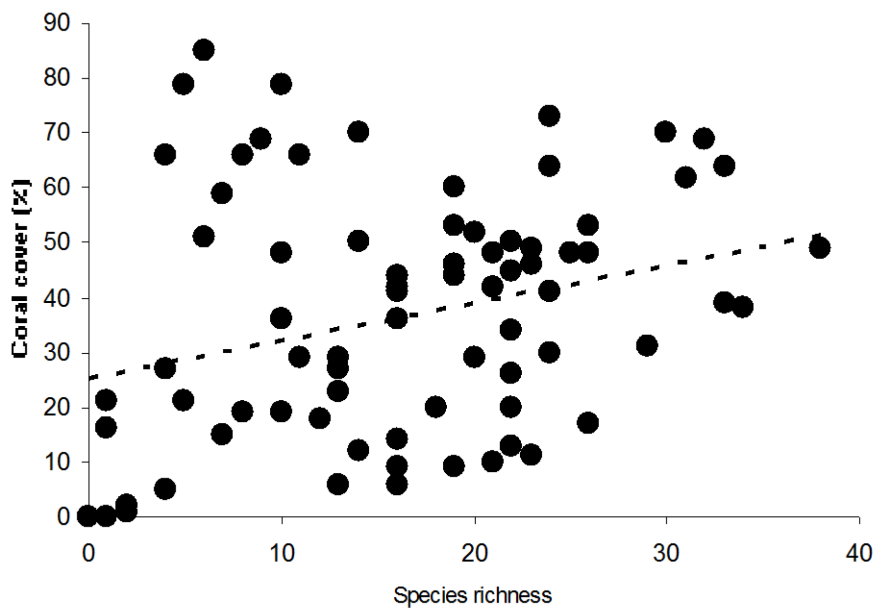



**Figure 14. Regression of hard coral cover against species richness of scleractinian corals on each individual transect at dive sites (n=79). A significant relationship exists between these two variables (Regression analysis $r^2$ = 0.0796, df = 78, p = 0.012).**

*Rubbish surveys*

A multitude of discarded household items, building materials, plastics, aluminium cans, tyres and nappies was recorded on rubbish surveys (Tables 1 & 2). Aluminium cans, soft plastics, glass bottles and metal were the most common items recorded. In the shallow populated eastern part of the lagoon we recorded a total of 773 items of rubbish in 3,300m$^2$ surveyed, which corresponds to 4.308 items of rubbish/1m$^2$ (Table 3).

**Table 1. Itemized list of rubbish items recorded on snorkel surveys.**

| **Rubbish Item along populated lagoon edge** | **Total count in 3300m2** |
|---|---|
| Aluminium can | 139 |
| Plastic bottle/foodwrap/other soft | 109 |
| Glass bottle/jar | 96 |
| Construction material (Roofing iron/plastic pipe) | 68 |
| Tin | 57 |
| Metal misc/chair/pipe/gate | 54 |
| Bricks/blocks | 44 |
| Other Aluminium | 42 |
| Tyre/Wheel | 28 |
| Nappy | 21 |
| Wire/cable/metal cage | 19 |
| Material/hessian/string bag | 16 |
| Cooking (pots/pans/cup/fork/plate/ | 14 |
| Rope | 13 |
| Metal tin/Paint tin/44 gallon | 12 |
| Plastic bag | 11 |
| Household items (cardboard/fan/lampshade/lightbulb/bucket/ suitcase/lino/TV) | 9 |
| Fishing line | 7 |
| Plastic chair | 5 |
| Pram/shopping trolley | 4 |
| Rubber Mat | 2 |
| Turtle shell | 2 |
| Car | 1 |

**Table 2. Itemized list of rubbish items recorded at dive sites.**

| Rubbish Item at Dive Sites | Total count in 7900m2 |
|---|---|
| Aluminium can | 355 |
| Plastic (bottle/wrapper) | 125 |
| Glass bottle | 116 |
| Metal | 64 |
| Material (clothing/hessian) | 37 |
| Shoe | 19 |
| Construction materials incl. fibreglass | 17 |
| Tyre | 12 |
| Fishing line | 10 |
| Roofing iron | 7 |
| Paint tin/20L drum /44L drum | 12 |
| Cooking pot | 7 |
| Nappy | 5 |
| Flooring (lino/carpet) | 4 |
| Rope | 3 |
| Anchor | 2 |
| Wire/cable | 2 |
| Machinery/car parts | 2 |
| TV | 1 |

**Table 3. Summary results from marine debris surveys.**

| | TOTAL ITEMS OF RUBBISH | Total number of transects | Total area surveyed | Total items of rubbish/1m$^2$ |
|---|---|---|---|---|
| Lagoon snorkel sites | 773 | 33 | 7900m$^2$ | **4.308** |
| Lagoon dive sites | 776 | 43 | 4300m$^2$ | **0.1805** |
| Exposed dive sites | 26 | 36 | 3600m$^2$ | **0.0072** |
| Overall total | 1575 | 112 | 15800m$^2$ | **0.0996** |

Results from our snorkel surveys confirm that as rubbish cover increases the cover of coral decreases (Figure 15). Our survey of the populated lagoon areas confirms that there are three clusters of community types, communities that have a small amount of rubbish and a small amount of coral, those that have a large amount of coral and small amount of rubbish and those that have a high amount of rubbish and low coverage of coral.

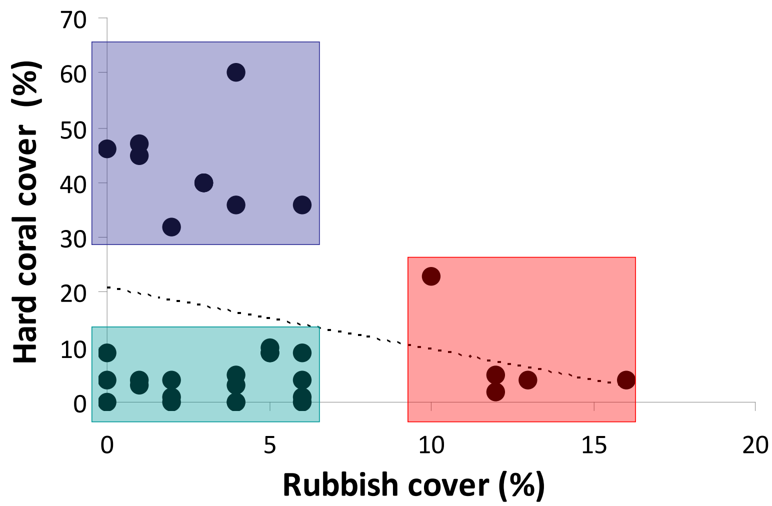



**Figure 15. Regression of rubbish cover against mean coral cover recorded on shallow populated lagoon edge snorkel transects. A non-significant relationship exists between these two variables (Regression analysis $r^2 = 0.059$, df = 33, p = 0.163).**

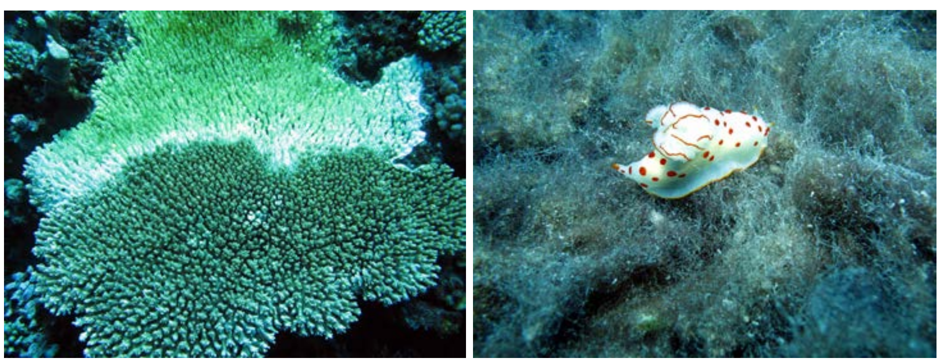
**Rubbish in Majuro lagoon.**

*Coral disease*

While much coral on Majuro appears healthy, with high coverage compared to the Carribean and other regions, many of these coral reefs are significantly degraded compared to nearby unpolluted atolls. The June surveys confirmed geographic patterns seen previously (Jacobson, unpubl.): white syndrome (WS) persists along the entire southern shore, recently becoming established throughout the lagoon, while two other coral-killing processes are more localized. The first is a slow disease infecting massive corals, particularly *Hydnophora* and *Platygyra*, having a patchy distribution documented earlier [4]. The second is the dramatic overgrowth of coral by a brown encrusting algae, widely distributed between Laura and Rita.

In addition to microbial and algal mortality of coral, *Acanthaster* predation continues in some sites, including the first survey site in Laura. As shown below, nearly all coral have been killed after decades of chronic COTS impact, with coral still persisting in the shallows.

High rates of *Acanthaster* predation (on-going since 2004) was also seen in the NW lagoon (at Eniue Island, see below) which was formerly hosted the most diverse coral community on Majuro, and on the outer shore of Jelta Island, north of Laura. Numerous fresh feeding scars on massive colonies were also seen at Enemonit (Figure 16). However, near Irooj Island, site of a massive COTS infestation that killed over 90 of coral, no recent feeding activity was found; *Acropora* colonies that recruited several years ago are growing rapidly.



**White syndrome on an *Acropora* plate and a nudibranch feeds upon cyanobacteria in Majuro lagoon.**

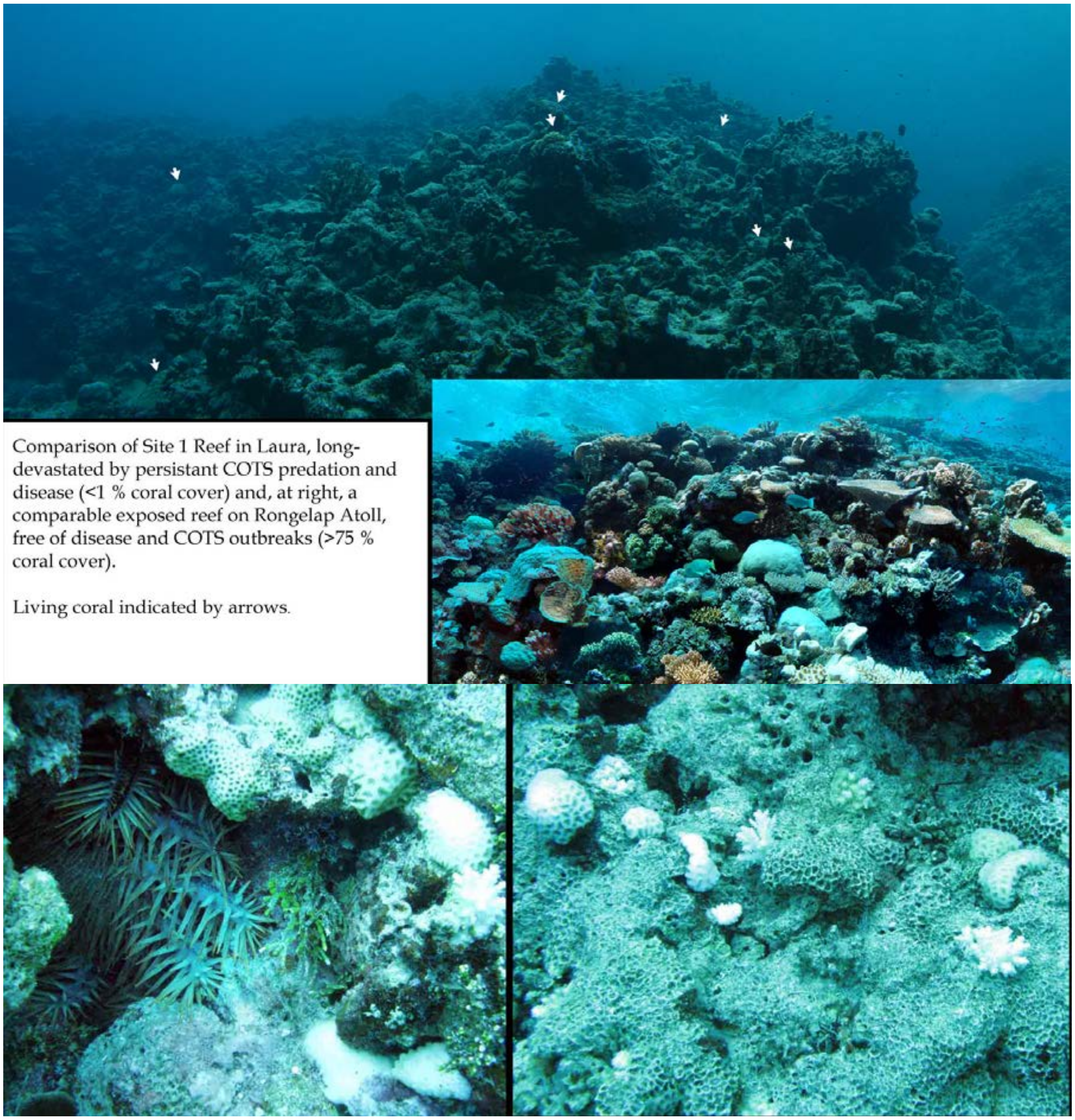



**Figure 16. COTS predation on small recruits at Eniue Island, NW lagoon.**

The restricted distribution of the “brain coral disease” infecting *Hydnophora*, *Platygyra* and other genera is intriguing (Figure 17). The Woja survey site was located immediately west of the disease patch, which extends eastward through Ajeltake, ending west of Peace Park (near the mid-southern “corner” of the atoll). This distribution correlates with density of human settlement, suggesting chronic exposure to human sewage may be to blame. The disease is also found in eastern Majuro, but susceptible colonies are now quite rare, probably having been reduced by disease over many years. Time series analysis of dozens of colonies shows the disease spreads roughly 1 cm each month; nearly all lesions expanded between May and August, 2010. Prior to 2005 this disease, which can take 5 or more years to entirely kill a colony, was not noticed.

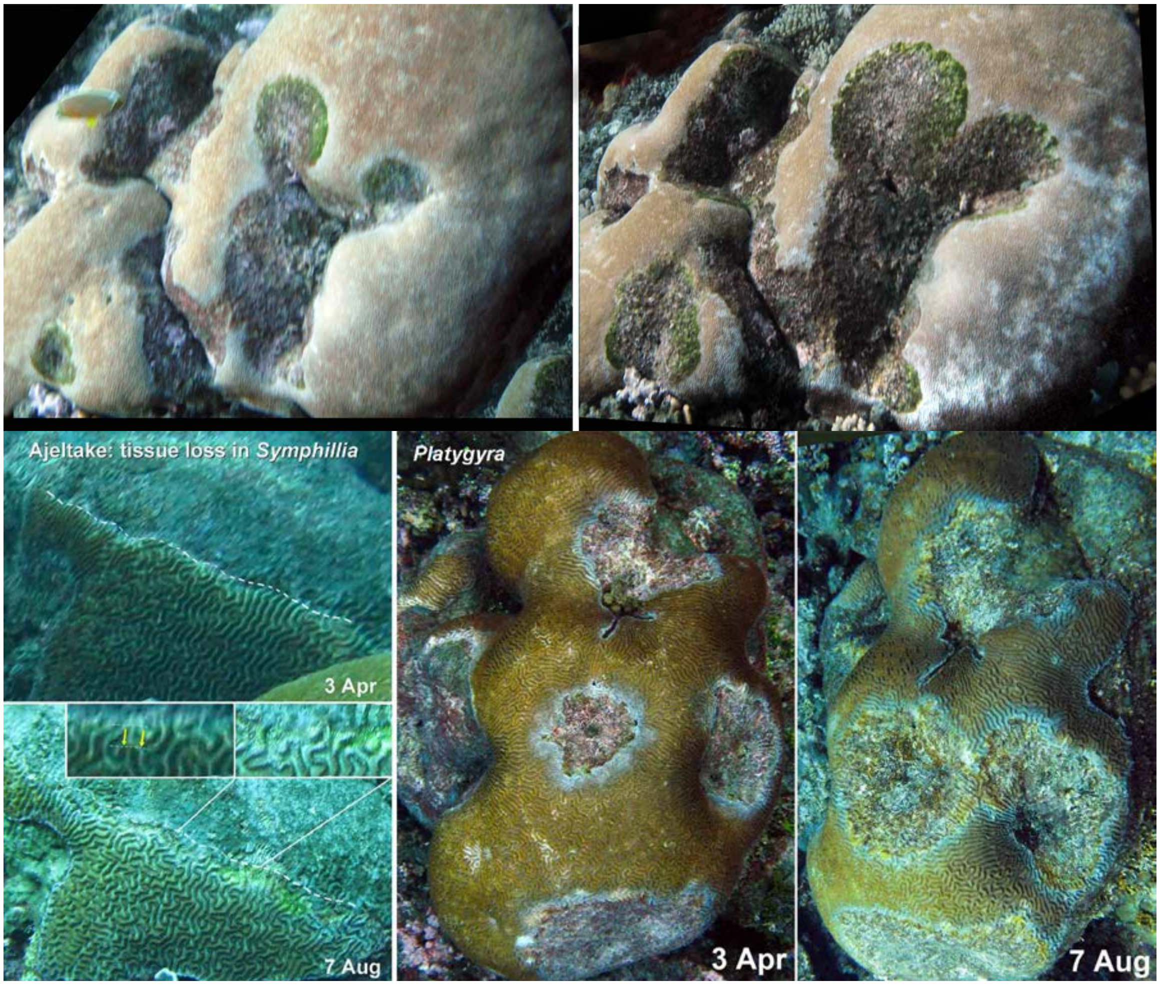


**Figure 17. Spreading disease lesions, 3 April and 7 August.**

Finally, an algal overgrowth syndrome seen in much of Majuro's south shore is causing significant coral mortality (Figure 18). As seen below, this strongly adhering encrusting phaeophyte affects *Montipora*, *Astreopora*, *Porites*, faviids and many other corals. One *Hydnophora* colony experienced algal overgrowth at a rate of 6 mm/month (determined by establishing "survey points" from the subtle patterns on the coral surface, Figure 19). The normal process of pattern change as a result of coral growth was also documented, at right. This encrusting algae grows well on disease lesions, but also overgrows disease-free colonies.

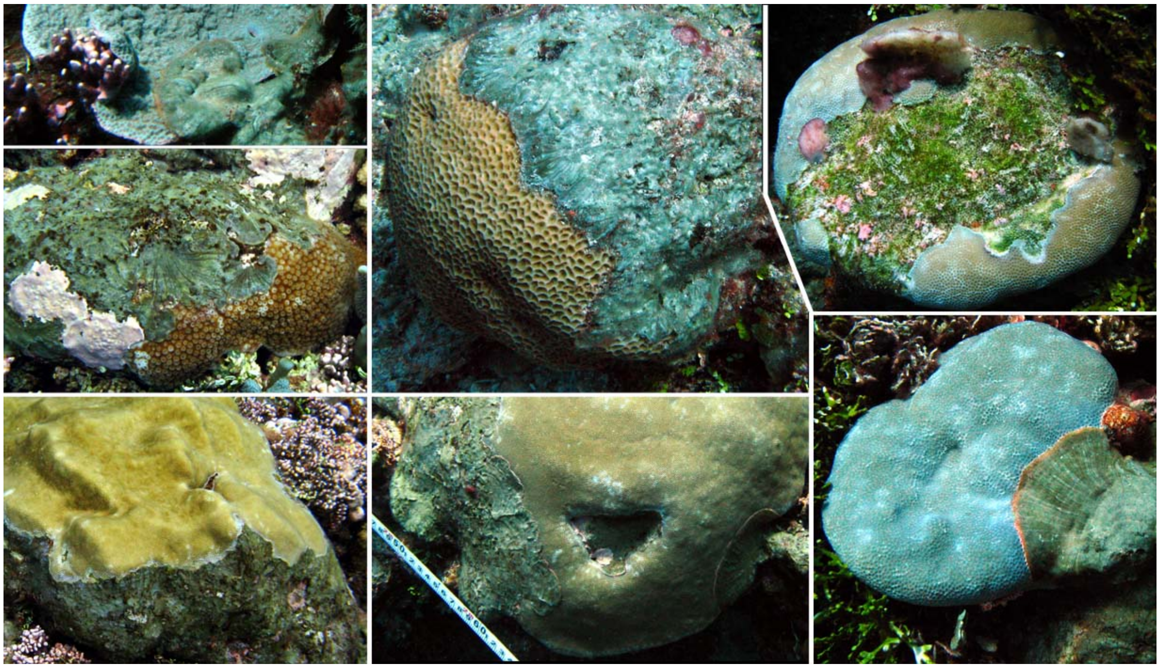


**Figure 18. Encrusting brown algae over-growing a variety of coral in Woja.**

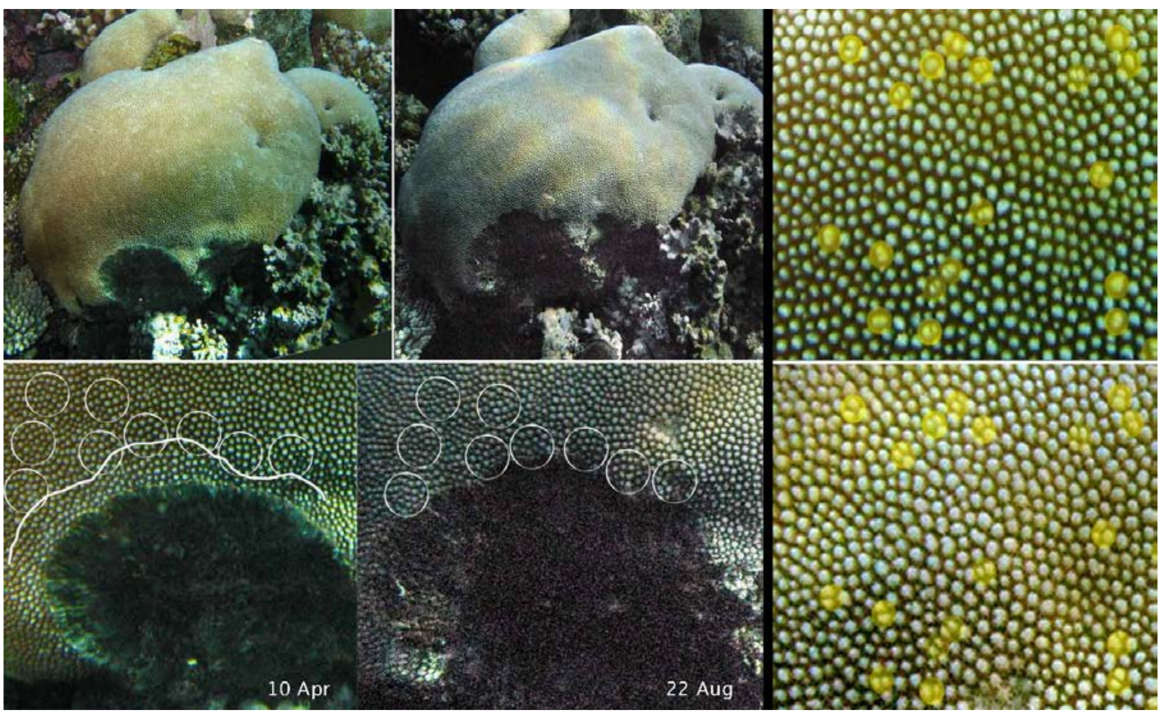



**Figure 19. Rate of algal growth determined on *Hydnophora* in Ajeltake.**

A new type of coral lesion was much in evidence on Enemonit (Figure 20), found on 30% of colonies. Identical lesions were discovered immediately following the severe bleaching event in 2009 on a nearby reef, so it is probable that this blotchy mortality is a result of thermal stress.

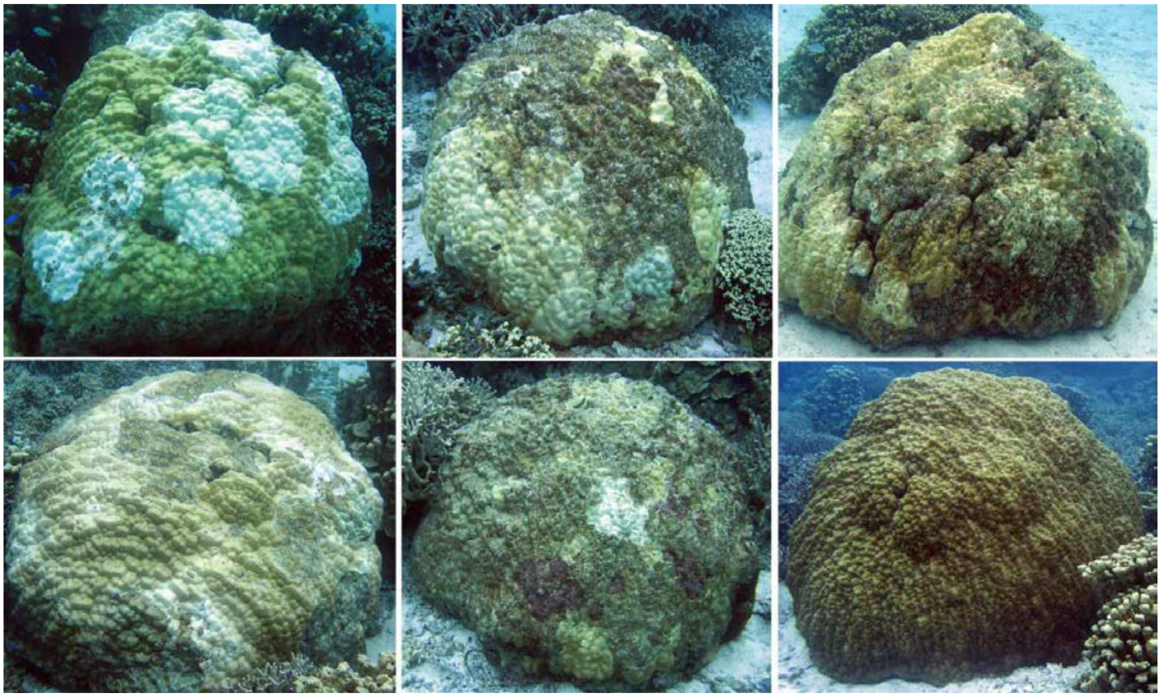


**Figure 20. Blotchy lesions on *Porites* of the Enemonit lagoon reef, with COTS feeding scars at upper left and a lesion-free colony at lower right.**

Returning to the long-established WS outbreak, it should be noted that there is a high incidence of infection on *Isopora* in Ajeltake and Woja. This is a dominant species, but between 50-80% has already been killed (some of this mortality may have been from *Acanthaster* predation). WS is probably also causing high levels of *Pocillopora* mortality. WS disease incidence on tabulate *Acropora* persists, but appears to be lower than during the outbreak peak in 2004.

*Macroinvertebrates*

Macro-invertebrates were relatively low in abundance and were not often encountered. Sea cucumbers are collected for export throughout the region, and it is unknown if there are exports from Majuro, or if they are consumed locally. However, numbers of sea cucumbers were generally low (Figure 21).

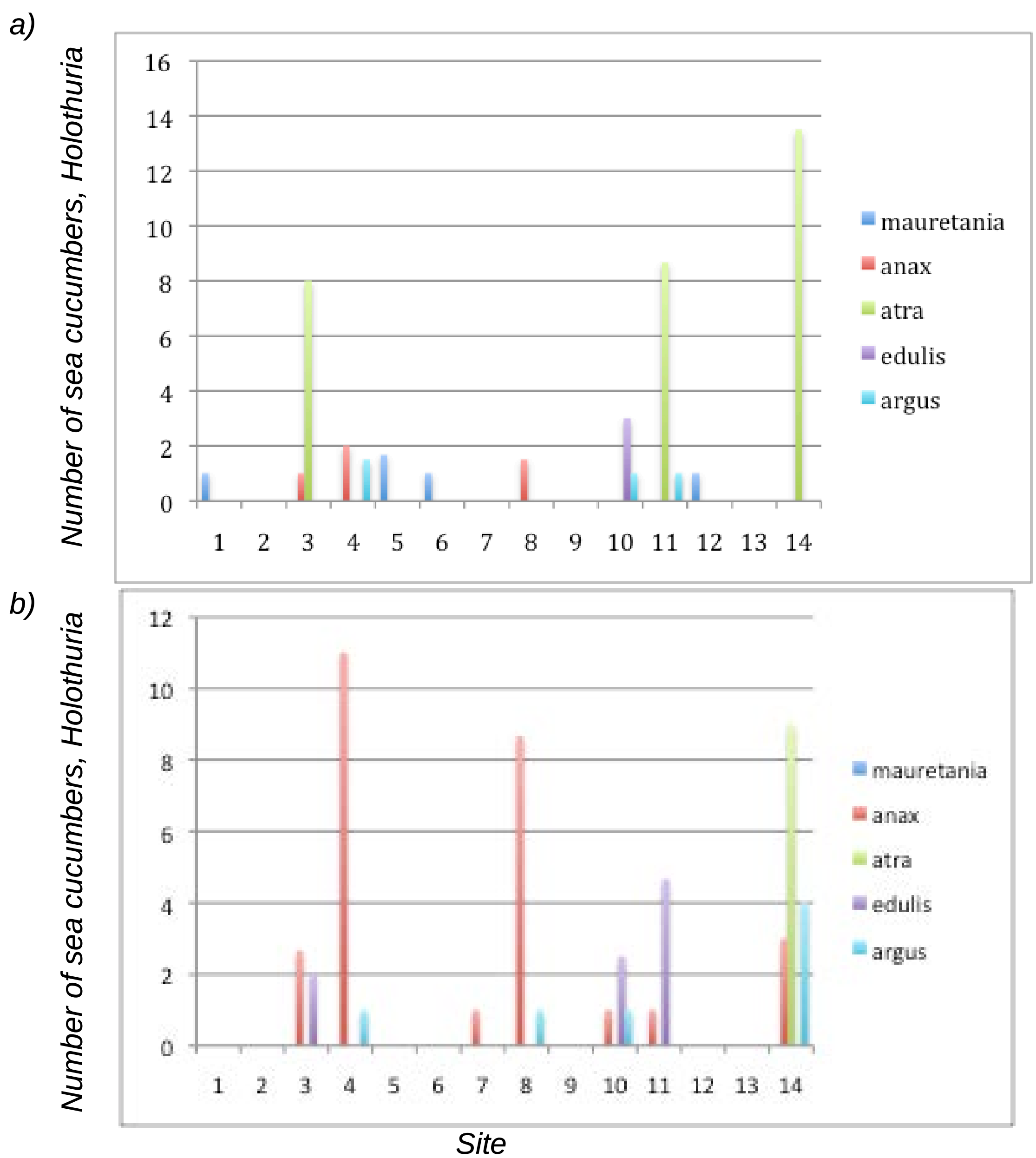



**Figure 21. Sea cucumber mean numbers per 1250 m2.**

Giant clams are consumed locally, and correspondingly, their densities were extremely low (Figure 22). Very few *Tridacna gigas* were encountered, and only remote sites (away from the SE corner of the atoll) had any clams.

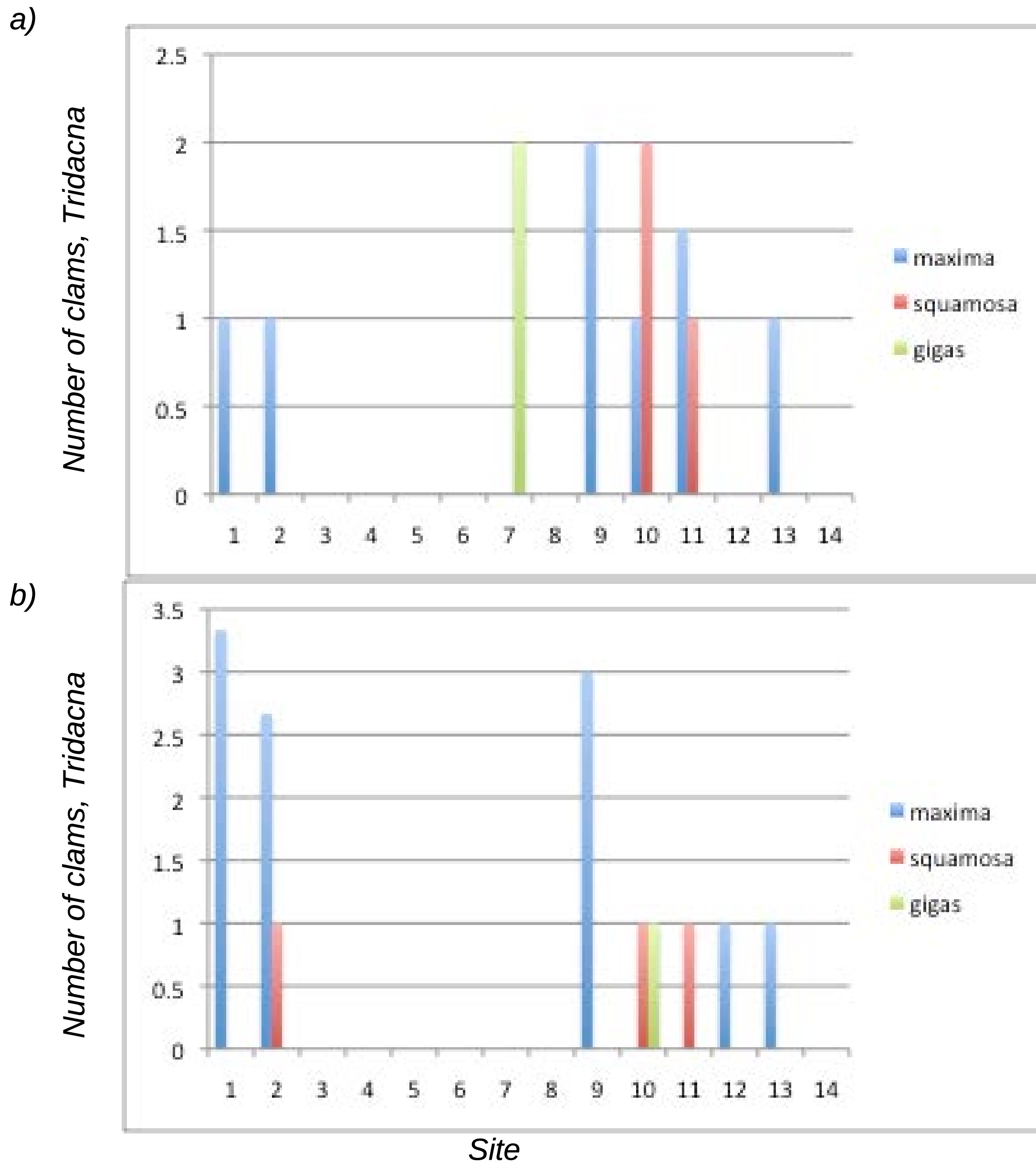



**Figure 22. Giant clam mean numbers per 1250 m2.**

## Discussion:

Coral reefs are vulnerable to chronic stress from pollution. Data on benthic marine ecosystems show directional changes in the structure of these ecosystems, which are related to the increasing occurrence, diversity, and scale of anthropogenic disturbance (Jackson, et al., 2001; Hughes et al., 2003). The results of our survey of Majuro Atoll show that for corals in particular, pollution of the lagoon is having a detrimental impact. We detect a clear link between the amount of marine debris and the level of coral cover.

The relatively low level of coral species richness was recorded at Majuro. Only approximately have of the corals species known to occur in the Republic of the Marshall Islands are present at Majuro. This is most likely reflection of the disturbed status of this populated atoll. A predominant feature of the Majuro coral community is the domination of *Porites rus* in lagoonal habitat. *Porites rus* appears to be exceptionally hardy and was observed to overgrow marine debris and thrive in particularly degraded habitat conditions. We found no evidence of *Acanthaster plancii* feeding on *P. rus* and no evidence of *P. rus* being susceptible to bleaching or disease. These features make *P. rus* and exceedingly resilient species.

Fish communities in Majuro Atoll were found to be relatively intact and diverse, but with reduced biomass nearer human centres. This is difficult to assert, because most parts of the lagoon are easily accessible by boat for fishing, and the degraded habitats near high population numbers do not represent the original reef structure. The bridging and filling in of small island throughflows around SE-Majuro have altered the lagoonal flow regime [5], and land-reclamation on the reef flat has significantly altered the shallow reef habitats, and the dissipation of incoming wave energy. Human impacts on fish communities are long-standing [6], but Majuro still holds large food fishes. Most species considered high-value aquarium species (e.g. the flame angelfish *Centropyge loricula*, and the endemic anemonefish *Amphiprion tricinctus*) were rarely seen, and had extremely low abundances, which is probably a result of relentless overfishing by aquarium trade operators. Conversations in the bar with one particular operator indicated that they intensively fish a site until economic extinction of the target species occurs, then the operation moves to new sites. Aquarium fishery appears to operate largely unregulated and unchecked to the detriment of both the target species and local divers, whose health is jeopardized.

In offshore areas of the pacific, the seasonal flow of wind-driven surface currents leads to marine debris concentrating in certain areas such as the North Pacific Subtropical Convergence Zone (STCZ) (Pichel et al., 2007). The Marshall Islands is also prone to being the final resting place for rubbish with remote origins however the rubbish we survey in Majuro lagoon does not appear to be derived from elsewhere. The marine debris appears to be the result of local dumping and/or ineffective waste disposal schemes.

Of particular concern is that the majority of rubbish items recorded in Majuro lagoon have long degrading times (Table 4). For example, aluminium cans, which were found to be the most common item in Majuro lagoon have been estimated to take 200 years to degrade in the marine environment. While the Marshall Island Conservation Society has acted to conduct various coastal clean-up initiatives it will be virtually impossible to remove the huge quantity of rubbish in Majuro lagoon. This study serves to illustrate that the lagoon appears to serve as a convenient rubbish disposal option for many residents along the coast and targeted efforts must be enabled to stop this practice immediately. Monitoring the quantity and type of rubbish in the lagoon over time will help to determine the effectiveness of the new (2008) solid waste disposal scheme on Majuro.

**Table 4. Estimated time for marine debris to degrade in the ocean. (Mote Marine Laboratory, 1993) http://cmore.soest.hawaii.edu/cruises/super/biodegradation.htm.**

| ***Item*** | ***Time to degrade*** |
|---|---|
| Newspaper | 6 weeks |
| Cardboard box | 2 months |
| Plywood | 1-3 years |
| Plastic beverage holder | 400 years |
| Plastic bags | 10-20 years |
| Plastic bottle | 100 years |
| Glass bottle and jars | undetermined |
| Disposable diapers | 50-100 years |
| Tin can | 50 years |
| Aluminium can | 200 years |
| Monofilament fishing line | 600 years |

Marine debris is hugely diverse, ranging from plastic bottles to fishing lines to fridges. The effect of this debris depends on the rubbish type. For example, the effects of ghost fishing gear can be detrimental to fish populations, hard corals, and megafauna through continued capturing of animals, and entanglement and physical breakage of corals. Iron materials and building materials shade the reef, and damage corals in storms. However, these solid materials may in some cases provide an albeit short-lived substrate for coral and algal growth. Dynamic interactions between iron metal and reefal growth include the initial enhancement of calcification through beneficial chemical conditions (low acidicty) followed by the stripping of heavy growth with the flaking of corroded metals [7].

Majuro Atoll now has a number of small locally administered marine reserves (e.g. Wotje), but more reserves and larger protected reef tracts are required to achieve the targets detailed in the Micronesian Challenge and the National Conservation plan, which are 30% of the marine resources protected [8,9]. Our data show that higher biomass and higher shallow species richness are found at Wotje (M2) compared to similar nearby sites (M1), which could be a result of the reserve. Continued monitoring will show trends in the future, however this encouraging result could be indicative of what Majuro needs. Improved resource management in the sea, and better and continued solid waste management on land are crucial future management needs in Majuro. This may also include a clean-up effort of underwater rubbish. Aquarium fisheries should be tightly regulated, and the environmental impact of building projects on the reef flat should be thoroughly assessed.

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**Appendix 1:**
**MAJURO ATOLL SURVEY SITES, 2010**

### *2010 Dive Sites*

| ID | LAT: N | LON: E |
|---|---|---|
| M1 | 7.147326 | 171.026506 |
| M2 | 7.089044 | 171.129486 |
| M3 | 7.066964 | 171.274774 |
| M4 | 7.123253 | 171.35631 |
| M5 | 7.103624 | 171.38224 |
| M6 | 7.079354 | 171.343472 |
| M7 | 7.158668 | 171.163085 |
| M8 | 7.123253 | 171.35629 |
| M9 | 7.221025 | 171.056227 |
| M10 | 7.192273 | 171.093613 |
| M11 | 7.114926 | 171.094738 |
| M12 | 7.066318 | 171.28767 |
| M13 | 7.157113 | 171.203093 |
| M14 | 7.101144 | 171.265011 |

### *2010 Lagoon Snorkel Sites (rubbish counts)*

| ID | LAT: N | LON: E |
|---|---|---|
| RU1 | 7.086766 | 171.373531 |
| RU2 | 7.088113 | 171.378002 |
| RU3 | 7.092751 | 171.379386 |
| RU4 | 7.113357 | 171.366963 |
| RU5 | 7.111748 | 171.367668 |
| RU6 | 7.10811 | 171.371193 |
| RU7 | 7.101758 | 171.377096 |
| RU8 | 7.078722 | 171.33149 |
| RU9 | 7.076408 | 171.322287 |
| RU10 | 7.074649 | 171.318014 |
| RU11 | 7.074649 | 171.318 |

**Appendix 2:**
**MAJURO ATOLL FISH SPECIES LIST**

| |
|---|
| Abudefduf vaigenensis |
| Acanthuridae spp. |
| Acanthurus achilles |
| Acanthurus bariene |
| Acanthurus blochii |
| Acanthurus guttatus |
| Acanthurus leucocheilus |
| Acanthurus lineatus |
| Acanthurus maculiceps |
| Acanthurus mata |
| Acanthurus nigricans |
| Acanthurus nigricansxachilles |
| Acanthurus nigricauda |
| Acanthurus nigrofuscus |
| Acanthurus nigroris |
| Acanthurus olivaceus |
| Acanthurus pyroferus |
| Acanthurus thompsoni |
| Acanthurus triostegus |
| Acanthurus xanthopterus |
| Aetobatus narinari |
| Amanses scopas |
| Amblyeleotris spp. |
| Amblyglyphidodon aureus |
| Amblyglyphidodon chrysopterus |
| Amblyglyphidodon curacao |
| Amblyglyphidodon leucogaster |
| Amblygobius phalaena |
| Amblygobius rainfordi |
| Amphiprion melannotus |
| Amphiprion melanopus |
| Amphiprion tricinctus |
| Anampses caeruleopunctatus |
| Anampses melanurus |
| Anampses meleagrides |
| Anampses twisti |
| Anyperodon leucogrammicus |
| Aphareus furca |
| Apogon bandanensis |
| Apogon compressa |
| Apogon exostigma |
| Apogon fraenatus |
| Apogon fragilis |
| Apogon kallopterus |
| Apogon lateralis |
| Apogon lutescens |
| Apogon luteus |
| Apogon sangiensis |

Apogon selai
Aprion virescens
Archamia fucata
Arothon stellatus
Arothron nigrifuscus
Arothron nigropunctatus
Arothron stellatus
Asterropteryx striatus
Atrosalarias fuscus
Atule mate
Aulostomus chinensis
Balistapus undulatus
Balistoides conspicillum
Balistoides viridescens
Belonoperca chabanaudi
Blenniella chrysospilos
Bodianus axillaris
Bothus mancus
Caesio caerulaurea
Caesio lunaris
Caesio teres
Calotomus carolinus
Calotomus spinidens
Canthigaster benetti
Canthigaster solandri
Canthigaster spp.
Caracanthus maculatus
Carangoides ferdau
Carangoides orthogrammus
Carangoides plagiotaenia
Carangoides sexmaculatus
Caranx melampygus
Carcharhinus amblyrhynchos
Carcharhinus melanopterus
Centropyge bicolor
Centropyge bispinosus
Centropyge flavissimus
Centropyge flavxvrol
Centropyge heraldi
Centropyge loricula
Centropyge loriculus
Centropyge vroliki
Centropyge vroxflav
Cephalopholis argus
Cephalopholis leopardus
Cephalopholis miniata
Cephalopholis sonnerati
Cephalopholis spilotoceps
Cephalopholis urodeta
Cetoscarus bicolor
Chaetodon auriga
Chaetodon benetti

Chaetodon citrinellus
Chaetodon ephippium
Chaetodon fasciatus
Chaetodon kleinii
Chaetodon lineolatus
Chaetodon lunula
Chaetodon lunulatus
Chaetodon melanotus
Chaetodon mertensi
Chaetodon meyeri
Chaetodon ornatissimus
Chaetodon punctatofasciatus
Chaetodon quadrimaculatus
Chaetodon rafflesi
Chaetodon reticulatus
Chaetodon semeion
Chaetodon trifascialis
Chaetodon trifasciatus
Chaetodon ulietensis
Chaetodon unimaculatus
Chaetodon vagabundus
Cheilinus chlorosus
Cheilinus fasciatus
Cheilinus oxycephalus
Cheilinus trilobatus
Cheilinus undulatus
Cheilinus unifasciatus
Cheilodipterus macrodon
Cheilodipterus quinquelineatus
Chlorurus frontalis
Chlorurus japonicus
Chlorurus microrhinus
Chlorurus sordidus
Chromis acares
Chromis alpha
Chromis amboinensis
Chromis atripectoralis
Chromis atripes
Chromis lepidolepis
Chromis lineata
Chromis margaritifer
Chromis ternatensis
Chromis viridis
Chromis weberi
Chromis xanthura
Chrysiptera biocellata
Chrysiptera traceyi
Chrysiptera unimaculata
Cirrhilabrus balteatus
Cirrhilabrus johnstoni
Cirrhilabrus katherini
Cirrhilabrus luteovittatus

Coris aygula
Coris batuensis
Coris gaimard
Corythoichthys sp.
Cryptocentrus strigilliceps
Ctenochaetus binotatus
Ctenochaetus cyanocheilus
Ctenochaetus hawaiiensis
Ctenochaetus striatus
Ctenogobiops spp.
Dascyllus aruanus
Dascyllus reticulatus
Dascyllus trimaculatus
Decapterus macarellus
Diodon hystrix
Echeneis naucrates
Ecsenius bicolor
Elagatis bipinnulata
Epibulus insidiator
Epinephelus fasciatus
Epinephelus fuscoguttatus
Epinephelus hexagonatus
Epinephelus macrospilos
Epinephelus maculatus
Epinephelus melanostigma
Epinephelus merra
Epinephelus ongus
Epinephelus polyphekadion
Epinephelus spilotoceps
Exallias brevis
Fistularia commersoni
Forcipiger flavissimus
Forcipiger longirostris
Gnathodentex aurolineatus
Gnatholepis cauerensis
Gobiodon okinawae
Gomphosus varius
Gracilia albimarginatus
Gunnelichthys monostigma
Gymnocranius sp.
Gymnosarda unicolor
Gymnothorax eurostus
Gymnothorax flavimarginatus
Halichoeres biocellatus
Halichoeres chrysus
Halichoeres hortulanus
Halichoeres leucurus
Halichoeres margaritaceus
Halichoeres marginatus
Halichoeres melanurus
Halichoeres nebulosus
Halichoeres richmondi

Halichoeres scapularis
Halichoeres trimaculatus
Hemigymnus fasciatus
Hemigymnus melapterus
Hemitaurichthys polylepis
Heniochus acuminatus
Heniochus chrysostomus
Heniochus monoceros
Heniochus singularis
Heniochus varius
Heteroconger hassi
Hipposcarus longiceps
Iniistius aneitensis
Kyphosus vaigenensis
Labrichthys unilineatus
Labroides bicolor
Labroides dimidiatus
Labroides pectoralis
Labropsis micronesia
Labropsis unilineata
Labropsis xanthonota
Leiuranus semicinctus
Lepidozygus tapeinosoma
Lethrinus erytheropterus
Lethrinus erythracanthus
Lethrinus harak
Lethrinus lentjan
Lethrinus obsoletus
Lethrinus olivaceus
Lethrinus semicinctus
Lethrinus xanthocheilus
Lotilia graciliosa
Lutjanus bohar
Lutjanus fulvus
Lutjanus gibbus
Lutjanus kashmira
Lutjanus kasmira
Lutjanus monostigma
Lutjanus rubrioperculatus
Lutjanus semicinctus
Macolor macularis
Macolor niger
Macropharyngodon meleagris
Macropharyngodon ornatus
Malacanthus brevirostris
Malacanthus latovittatus
Melichthys niger
Melichthys vidua
Monotaxis grandoculis
Mulloidichthys flavolineatus
Mulloidichthys vanicolensis
Myripristis adusta

Myripristis berndti
Myripristis kuntee
Myripristis murdjan
Myripristis vittata
Naso annulatus
Naso brevirostris
Naso caesius
Naso hexacanthus
Naso literatus
Naso unicornis
Naso vlamingi
Neoniphon argenteus
Neoniphon opercularis
Neoniphon sammara
Novaculichthys taeniourus
Ostracion cubicus
Ostracion meleagris
Oxycheilinus arenatus
Oxycheilinus bimaculatus
Oxycheilinus digramma
Oxycheilinus johnstoni
Oxycheilinus orientalis
Oxycheilinus rhodochrous
Oxycheilinus unifasciatus
Oxymonacanthus longirostris
Paracirrhites arcatus
Paracirrhites forsteri
Paracirrhites hemistictus
Parapeneus pleurostigma
Parapercis clathrata
Parapriacanthus ransonneti
Parupeneus barbarinoides
Parupeneus barbarinus
Parupeneus bifasciatus
Parupeneus cyclostomus
Parupeneus multifasciatus
Parupeneus pleurostigma
Parupeneus trifasciatus
Pentapodus caninus
Pentapodus emeryii
Plagiotremus laudanus
Plagiotremus rhinohynchus
Plagiotremus tapeinosoma
Platax orbicularis
Plectorhinchus picus
Plectroglyphidodon dickii
Plectroglyphidodon johnstonianus
Plectroglyphidodon lacrymatus
Plectroglyphidodon leucozonus
Plectropomus aerolatus
Plectropomus laevis
Plectropomus leopardus

Plectropomus maculatus
Plectropomus oligacanthus
Pomacanthus imperator
Pomacentrus amboinensis
Pomacentrus brachialis
Pomacentrus coelestis
Pomacentrus grammorhynchus
Pomacentrus nagasakiensis
Pomacentrus pavo
Pomacentrus simsiang
Pomacentrus vaiuli
Pomacentrus yoshii
Pomachromis vanderbilti
Pseudanthias dispar
Pseudanthias pascalus
Pseudanthias tuka
Pseudobalistes flavimarginatus
Pseudobalistes fuscus
Pseudocheilinus evanidus
Pseudocheilinus hexataenia
Pseudocheilinus tetrataenia
Pseudochromis marshallensis
Pseudochromis pascalus
Pseudocoris yamashiroi
Pseudodax moluccensis
Pseudojulioides cerasinus
Pteragogus cryptus
Ptereleotris evides
Ptereleotris microlepis
Pterocaesio lativittata
Pterocaesio tile
Pterocaesio trilineata
Pteroeleotris evides
Pterois antennata
Pygoplites diacanthus
Rhabdamia gracilis
Rhinecanthus aculeatus
Rhinecanthus rectangulus
Salarias segmentatus
Sargocentron caudimaculatus
Sargocentron melanospilos
Sargocentron spiniferum
Sargocentron tiere
Sargocentron violaceum
Saurida gracilis
Scaridae spp.
Scarus altipinnis
Scarus Black IP
Scarus bleekeri
Scarus chamaeleon
Scarus dimidiatus
Scarus festivus

Scarus flavipectoralis
Scarus forsteni
Scarus frenatus
Scarus frontalis
Scarus fuscocaudalis
Scarus ghobban
Scarus globiceps
Scarus niger
Scarus oviceps
Scarus psittacus
Scarus pyrrhurus
Scarus quoyi
Scarus rivulatus
Scarus rubroviolaceus
Scarus schlegeli
Scarus sordidus
Scarus sp.
Scarus spinus
Scarus tricolor
Scolopsis affinis
Scolopsis lineatus
Scomberoides lysan
Siganus argenteus
Siganus guttatus
Siganus puellus
Siganus punctatus
Siganus spinus
Siganus vulpinus
Stegastes fasciolatus
Stegastes lividus
Stegastes nigricans
Stethojulis bandanensis
Stethojulis interruptus
Stethojulis strigiventer
Stethojulis trilineata
Sufflamen bursa
Sufflamen chrysopterus
Synodontidae spp.
Synodus dermatogenys
Synodus variegatus
Thalassoma amblycephalum
Thalassoma hardwicke
Thalassoma lunare
Thalassoma lutescens
Thalassoma purpureum
Thalassoma quinquevittatum
Thalassoma trilobatum
Trachinotus bailloni
Trachinotus blochii
Trachyrhamphus bicoarctatus
Triaenodon obesus
Trimma tevagaen

| |
|---|
| Urogymnus africanus |
| Valenciennea puellaris |
| Valenciennea sexguttata |
| Variola albimarginatus |
| Variola louti |
| Zanclus cornutus |
| Zebrasoma flav x scop |
| Zebrasoma flavescens |
| Zebrasoma scopas |
| Zebrasoma veliferum |

**Appendix 3:**
**MAJURO ATOLL HARD CORAL SPECIES LIST**

Family Astrocoeniidae Koby, 1890
Genus *Stylocoeniella* Yabe and Sugiyama, 1935
*Stylocoeniella guentheri* Bassett-Smith, 1890
Family Pocilloporidae Gray, 1842
Genus *Pocillopora* Lamarck, 1816
*Pocillopora damicornis* (Linnaeus, 1758)
*Pocillopora eydouxi* (Milne Edwards and Haime, 1860)
*Pocillopora meandrina* (Dana, 1846)
*Pocillopora verrucosa* (Ellis and Solander, 1786)
Genus *Seriatopora* Lamarck, 1816
*Seriatopora aculeata* (Quelch, 1886)
*Seriatopora dendritica* (Veron, 2000)
*Seriatopora hystrix* (Dana, 1846)
Genus *Stylophora* Schweigger, 1819
*Stylophora pistillata* (Esper, 1797)
Family Acroporidae Verrill, 1902
Genus *Montipora* Blainville, 1830
*Montipora danae* (Milne Edwards and Haime, 1851)
*Montipora digitata* (Dana, 1846)
*Montipora foveolata* (Dana, 1846)
*Montipora incrassata* (Dana, 1846)
*Montipora peltiformis* (Bernard, 1897)
*Montipora tuberculosa* (Lamarck, 1816)
*Montipora turgescens* (Bernard, 1897)
*Montipora verrucosa* (Lamarck, 1816)
Genus *Acropora* Oken, 1815
*Acropora abrotanoides* (Lamarck, 1816)
*Acropora aculeus* (Dana, 1846)
*Acropora acuminata* (Verrill, 1864)
*Acropora anthocercis* (Brook, 1893)
*Acropora austera* (Dana, 1846)
*Acropora cerealis* (Dana, 1846)
*Acropora digitifera* (Dana, 1846)
*Acropora divaricata* (Dana, 1846)
*Acropora elseyi* (Brook, 1892)
*Acropora florida* (Dana, 1846)
*Acropora gemmifera* (Brook, 1892)
*Acropora granulosa* (Milne Edwards and Haime, 1860)
*Acropora horrida* (Dana, 1846)
*Acropora humilis* (Dana, 1846)
*Acropora hyacinthus* (Dana, 1846)
*Acropora intermedia* (Brook, 1891)
*Acropora kimbeensis* Wallace, 1999
*Acropora latistella* (Brook, 1891)
*Acropora longicyathus* (Milne Edwards and Haime, 1860)
*Acropora loripes* (Brook, 1892)

*Acropora lovelli* (Veron and Wallace, 1984)
*Acropora lutkeni* (Crossland, 1952)
*Acropora monticulosa* (Brüggemann, 1879)
*Acropora muricata* (Linneaus, 1758)
*Acropora nasuta* (Dana, 1846)
*Acropora paniculata* (Verrill, 1902)
*Acropora robusta* (Dana, 1846)
*Acropora rongelapensis* (Richards and Wallace, 2004)
*Acropora samoensis* (Brook, 1891)
*Acropora sarmentosa* (Brook, 1892)
*Acropora secale* (Studer, 1878)
*Acropora selago* (Studer, 1878)
*Acropora striata* (Verrill, 1866)
*Acropora subulata* (Dana, 1846)
*Acropora tenuis* (Dana, 1846)
*Acropora valida* (Dana, 1846)
*Acropora vaughani* (Wells, 1954)
Genus *Astreopora* Blainville, 1830
*Astreopora listeri* (Bernard, 1896)
*Astreopora myriophthalma* (Lamarck, 1816)
Genus *Isopora* Studer, 1878
*Isopora palifera* (Lamarck, 1816)
*Isopora crateriformis* (Gardiner, 1898)
Family Oculinidae Gray, 1847
Genus *Galaxea* Oken, 1815
*Galaxea horrescens* (Dana, 1846)
Family Siderasteridae Vaughan and Wells, 1943
Genus *Psammocora* Dana, 1846
*Psammocora explanulata* (Horst, 1922)
*Psammocora haimeana* (Milne Edwards and Haime, 1851)
*Psammocora nierstraszi* (Horst, 1921)
*Psammocora profundacella* (Gardiner, 1898)
Genus Coscinaraea Milne Edwards and Haime, 1848
*Coscinaraea columna* (Dana, 1846)
Family Agariciidae Gray, 1847
Genus *Pavona* Lamarck, 1801
*Pavona cactus* (Forskål, 1775)
*Pavona decussata* (Dana, 1846)
*Pavona frondifera* (Lamarck, 1816)
*Pavona maldivensis* (Gardiner, 1905)
*Pavona varians* (Verrill, 1864)
*Pavona venosa* (Ehrenberg, 1834)
Genus *Leptoseris* Milne Edwards and Haime, 1849
*Leptoseris mycetoseroides* (Wells, 1954)
Genus *Coeloseris* Vaughan, 1918
*Coeloseris mayeri* (Vaughan, 1918)
Genus *Gardineroseris* (Scheer and Pillai, 1974)
*Gardineroseris planulata* (Dana, 1846)
Genus *Pachyseris* (Milne Edwards and Haime, 1849)

*Pachyseris speciosa* (Dana, 1846)
Family Fungiidae Dana, 1846
Genus *Fungia* Lamarck, 1801
*Fungia danai* (Milne Edwards and Haime, 1851)
*Fungia klunzingeri* (Döderlein, 1901)
*Fungia paumotensis* (Stutchbury, 1833)
*Fungia repanda* (Dana, 1846)
*Fungia scutaria* (Lamarck, 1801)
Genus *Ctenactis* Verrill, 1864
*Ctenactis echinata* (Pallas, 1766)
Genus *Herpolitha* Eschscholtz, 1825
*Herpolitha limax* (Houttuyn, 1772)
Genus *Halomitra* Dana, 1846
*Halomitra pileus* (Linnaeus, 1758)
Family Pectiniidae Vaughan and Wells, 1943
Genus *Echinophyllia* Klunzinger, 1879
*Echinophyllia aspera* (Ellis and Solander, 1788)
Genus *Oxypora* Saville-Kent, 1871
*Oxypora lacera* (Verrill, 1864)
Family Merulinidae Verrill, 1866
Genus Hydnophora Fischer de Waldheim, 1807
*Hydnophora pilosa* (Veron, 1985)
Genus *Merulina* Ehrenberg, 1834
*Merulina ampliata* (Ellis and Solander, 1786)
Family Dendrophylliidae Gray, 1847
Genus *Turbinaria* Oken, 1815
*Turbinaria mesenterina* (Lamarck, 1816)
*Turbinaria reniformis* (Bernard, 1896)
Family Mussidae Ortmann, 1890
Genus *Acanthastrea* Milne Edwards and Haime, 1848
*Acanthastrea brevis* (Milne Edwards and Haime, 1849)
*Acanthastrea echinata* (Dana, 1846)
*Acanthastrea hemprichii* (Ehrenberg, 1834)
Genus *Lobophyllia* Blainville, 1830
*Lobophyllia corymbosa* (Forskål, 1775)
*Lobophyllia hemprichii* (Ehrenberg, 1834)
Genus *Symphyllia* Milne Edwards and Haime, 1848
*Symphyllia recta* (Dana, 1846)
Genus *Scolymia* Haime, 1852
*Scolymia vitiensis* (Brüggemann, 1878)
Family Faviidae Gregory, 1900
Genus *Favia* Oken, 1815
*Favia matthaii* (Vaughan, 1918)
*Favia pallida* (Dana, 1846)
*Favia rotundata* (Veron, Pichon & Wijsman-Best, 1972)
*Favia speciosa* Dana, 1846
*Favia stelligera* (Dana, 1846)
Genus *Favites* Link, 1807
*Favites abdita* (Ellis and Solander, 1786)

*Favites complanata* (Ehrenberg, 1834)
*Favites halicora* (Ehrenberg, 1834)
Genus *Goniastrea* Milne Edwards and Haime, 1848
*Goniastrea aspera* (Verrill, 1905)
*Goniastrea australensis* (Milne Edwards and Haime, 1857)
*Goniastrea edwardsi* (Chevalier, 1971)
*Goniastrea pectinata* (Ehrenberg, 1834)
*Goniastrea retiformis* (Lamarck, 1816)
Genus *Platygyra* Ehrenberg, 1834
*Platygyra lamellina* (Ehrenberg, 1834)
*Platygyra pini* (Chevalier, 1975)
*Platygyra ryukyuensis* (Yabe and Sugiyama, 1936)
*Platygyra sinensis* (Milne Edwards and Haime, 1849)
Genus *Oulophylli*a Milne Edwards and Haime, 1848
*Oulophyllia crispa* (Lamarck, 1816)
Genus *Montastrea* Blainville, 1830
*Montastrea curta* (Dana, 1846)
Genus *Leptastrea* Milne Edwards and Haime, 1848
*Leptastrea pruinosa* (Crossland, 1952)
*Leptastrea transversa* (Klunzinger, 1879)
Genus *Cyphastrea* Milne Edwards and Haime, 1848
*Cyphastrea microphthalma* (Lamarck, 1816)
Genus *Echinopora* Lamarck, 1816
*Echinopora lamellosa* (Esper, 1795)
Family Poritidae Gray, 1842
Genus *Porites* Link, 1807
*Porites australiensis* (Vaughan, 19itygsgff**-free colony at lower right.**