Baseline Assessment of Ongiil Conservation Area

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Abstract

Marine Protected Areas (MPAs) have been used worldwide to protect biodiversity and increase marine resources' yields. In 2003, the Republic of Palau established the Protected Areas Network (PAN) to help improve the management and effectiveness of Palau's MPA. In 2006, Palau made a commitment to effectively conserve 30% of its near shore habitat through the Micronesia Challenge. Yet, very few data on the baseline status of MPAs that are part of this network have been collected. This present study was conducted to collect baseline ecological data within the different habitats of Ongiil Conservation Area located in Ngaraard State of Palau, to assess the effectiveness of the MPA over time. The conservation area is not classified as a PAN site yet but has been closed to fishing since 4 years. The baseline ecological data showed a system that has suffered from past fishing pressure and typhoon disturbances with low fish density and biomass, low coral cover and low invertebrates densities. Over time, further surveys will help assessing the recovery rate of a system that underwent several stressors and its effectiveness at protecting biodiversity.

Introduction

Marine Protected Areas have been widely used as an effective conservation tool against anthropogenic threats such as overfishing (Halpern et al. 2009; Lester et al. 2009; Edgar et al. 2014). MPAs have demonstrated to increase fish biomass, abundance, mean size and species biodiversity (Friedlander and DeMartini 2002; Abesamis et al. 2006; Hamilton et al. 2011). In addition, it has been shown that they also benefit adjacent non-protected areas (McClanahan and Mangi 2000; Agardy et al. 2003).

The Republic of Palau, located in western Micronesia, has made great advances in its marine protective management. In 1994, the marine protection act implemented fishing restrictions on several commercially-important species, and in 2003 the Palauan government established the Protected Areas Network (PAN). This network aims to effectively protect both terrestrial and marine habitats of Palau. In 2006, an international initiative called the Micronesia Challenge (MC), required Micronesian nations (The Federated States of Micronesia, The Republic of Marshall Islands, Guam, The Commonwealth of the Northern Marianas Islands, and The Republic of Palau) to commit to effectively protect at least 20% of their terrestrial habitats and 30% of their marine habitats by 2020(Micronesia Challenge Steering Committee 2011). This initiative far exceeds the current request for countries to protect 10% of their marine and terrestrial habitats through international conventions and treaties(United Nations 1992). The Palauan government is using its PAN to meet the goals of the MC and to effectively expand its protected areas.

Despite these great advances since 2006, very little information has been gathered on the baseline status of MPAs. As an organization that is committed to guide efforts supporting coral reef stewardship through research and its applications for the people of Palau, Palau International Coral Reef Center (PICRC) collects baseline ecological data at MPAs sites.

Ongiil CA is located in Ngaraard State at 07°34'30'' N, 134°38'24'' E. The conservation area includes fore reef, channel, and reef flat habitats. The total area is 1.1 km^2 (Fig. 1). Ongiil CA is not a PAN site and still under the State legislature. This conservation area was enacted by the Olbetibel Era Ngaraard (NSPL 8-5) The legislature and the current management plan of the State (Kerradel Conservation network management plan) includes Ongiil CA as a site to be strictly enforced as a no-take protected area since December 2010.

Figure 1: Satellite image showing Ongiil CA (red boundaries)

The main objective of this survey was to collect baseline ecological data within the different habitats of Ongiil CA. Over the coming years, as it will probably become a PAN site, subsequent sampling at the same sites will allow us to assess the effectiveness of the MPA at protecting biodiversity and increasing commercially-important species' biomass over time.

Methods

1. Study Site

Baseline ecological surveys were conducted within Ongiil CA that has been protected from fishing for a little over 4 years. The monitoring protocol followed a stratified sampling design. Random stations' locations were allocated within each habitat present in the MPA depending on their size using QGIS (QGIS Development Team 2015)(Fig. 2). Areas smaller than 900,000 m^2 were allocated three random points; areas from 1 km^2 to 5 km^2 in size were allocated one random point per 300,000 m^2. This baseline monitoring protocol excludes mangrove forests because the methodology differs too much from other marine habitats; therefore, the mangrove area of Ongiil CA was excluded from our sampling. There were a total of three sites in the outer reef habitat (n = 9 transects), a total of three sites in the channel habitat (n = 9 transects), and a total of three sites in the reef flat/lagoon habitat (n = 9 transects) (Fig. 2). The survey was conducted in July 2015 over two days at high tide.

Figure 2: A map of Ongiil Conservation Area showing the three different habitat types (green= channel, red = outer reef, blue = reef flat) found there, and the locations of sampling sites within each habitat (see GPS coordinates in Appendix 4).

2. Measurements of ecological variables

At each site, three 30-m transects were laid at a maximum depth of 5-m, following the same direction as the current, and consecutively with a few meters separating each transect. Along each 30-m transect, four surveyors recorded data on fish, invertebrates, benthic cover and coral recruitment. The first surveyor recorded the abundance and size estimates of the most common commercially important and protected fish species within a 5-m wide belt (see fish list in Appendix 1). The second surveyor recorded the abundance of invertebrates targeted by local fisheries within a 2-m wide belt (see invertebrates list in Appendix 2). For the estimation of benthic cover, the third surveyor took a photo every meter along the 30-m transect using an underwater camera mounted on a 1-m x 1-m photo-quadrat PVC frame, for a total of 30 photos per transect. The fourth surveyor recorded the abundance of coral recruits smaller than 5-cm diameter (to genera) within a 30-cm wide belt of the first 10-m of each transect.

3. Data extraction and analysis

To estimate benthic cover, photo-quadrats were analyzed using CPCe software (Kohler and Gill 2006). Five random points were allocated to each photo and the substrate below each point was classified into benthic categories (see the benthic categories list in Appendix 3). The mean percentage benthic cover of each category was calculated for each transect (n = 30 photos per transect, n = 3 transects per site).

The biomass of fish was calculated using the total length-based equation: $W = aTL^b$, where W is the weight of the fish in grams, TL the total length of the fish in centimeters (cm), and a and b are constant values from published biomass-length relationships (Kulbicki et al. 2005) and from Fishbase (http://fishbase.org).

The data collected at Ongiil CA were baseline data, therefore neither comparison through time nor with a reference site were possible for this study. Mean values with standard errors of each of the measured ecological variables were calculated and plotted into bar charts using R and excel.

Results

<u>Fish abundance and biomass</u>

The abundance of commercially-important species (Appendix 1) was the highest in the reef flat with 11.2 (± 5.8) individuals per 150 m^2 while the biomass was the highest in the outer reef with 1,582.3 (± 1366.9) grams per 150 m^2 (Fig. 2). The lowest fish abundance was found in the outer reef with 4.1 (± 3.3) fish per and the lowest biomass was found in the reef flat habitat (<1,000 grams per 150 m^2) (Fig. 2).

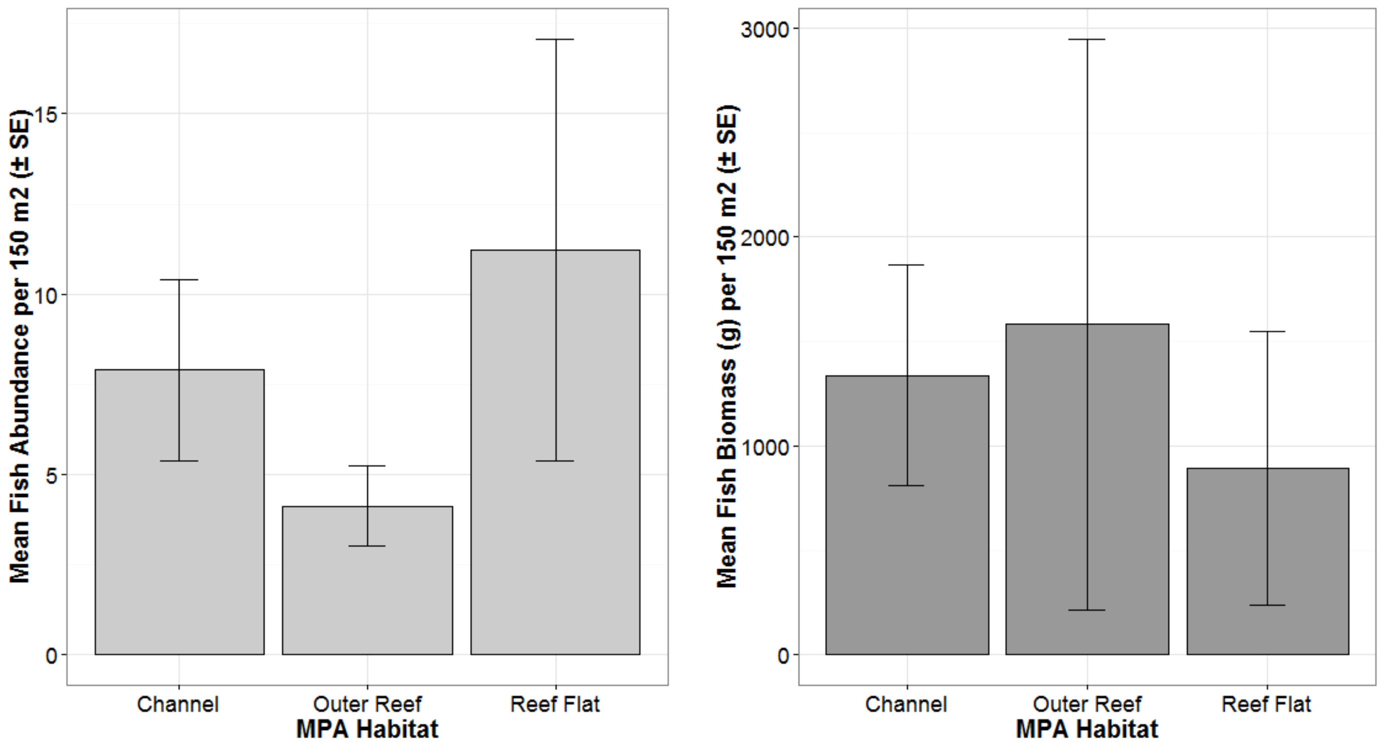

Figure 3: Mean fish abundance (left) and biomass(right) of commercially-important species within the three main habitats of MPA

From all the surveyed fish species, the dominant fish family was parrotfish (Scaridae). A total of 12 commercially-important species were recorded.

Benthic cover

Coral cover was lower than 8% in the three habitats. The channel had the highest coral cover (7.5%). There were 18 recorded coral genera. *Porites* spp. were the most dominant genus followed by *Montipora* and *Millepora* spp. The reef flat, due to soft-sediment substrates (sand, 28.3%), was covered with seagrass (29%). *T. hemprichii* was the dominant seagrass species in this habitat. All habitats had a high cover of turf algae (>20%), and carbonate (>17%)(Fig. 4).

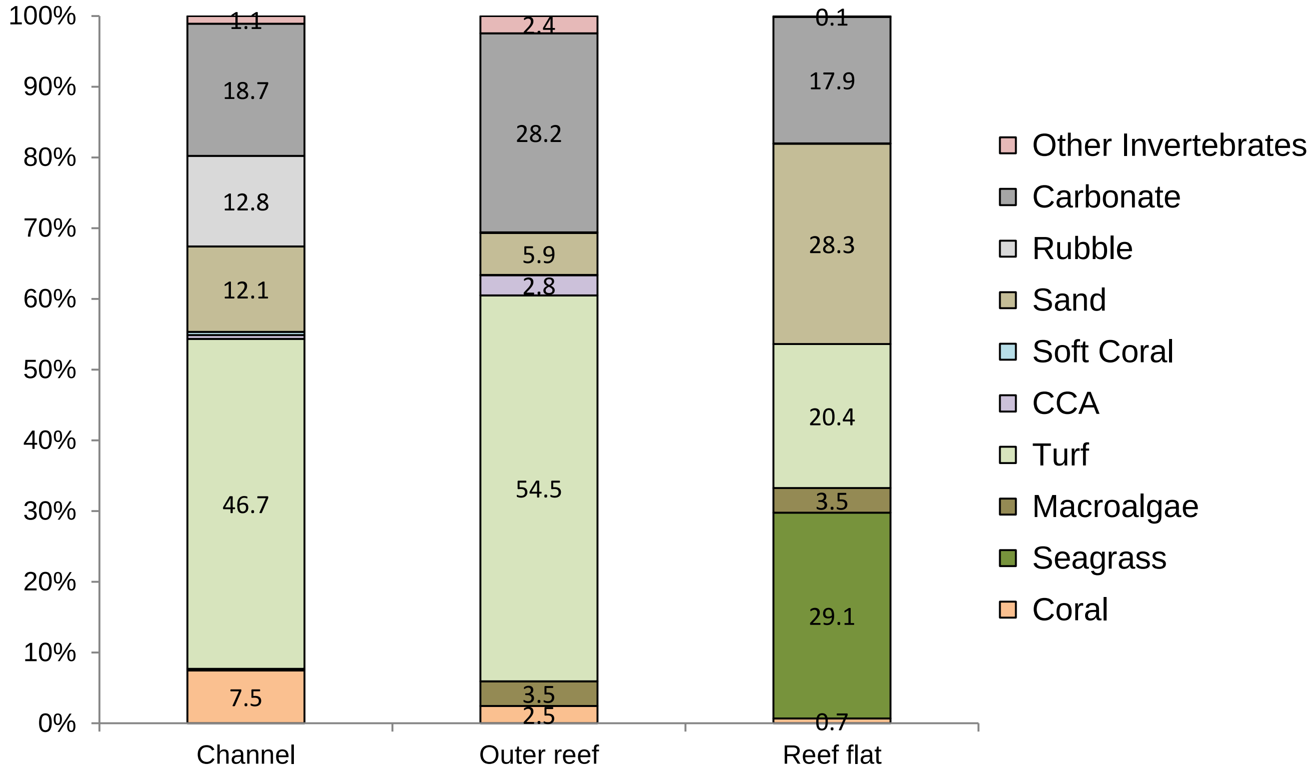

Figure 4: Mean percentage cover of main benthic cover present in the three habitats of Ongiil CA

Coral recruitment

Coral recruitment was the highest in the outer reef habitat with 9.6 (± 1) juvenile corals per 3 m^2 (Fig. 6). Other habitats displayed very low recruitment (< 2 juvenile corals per 3 m^2). There were 15 recorded juvenile corals genera. The outer reef was dominated by *Porites* spp.

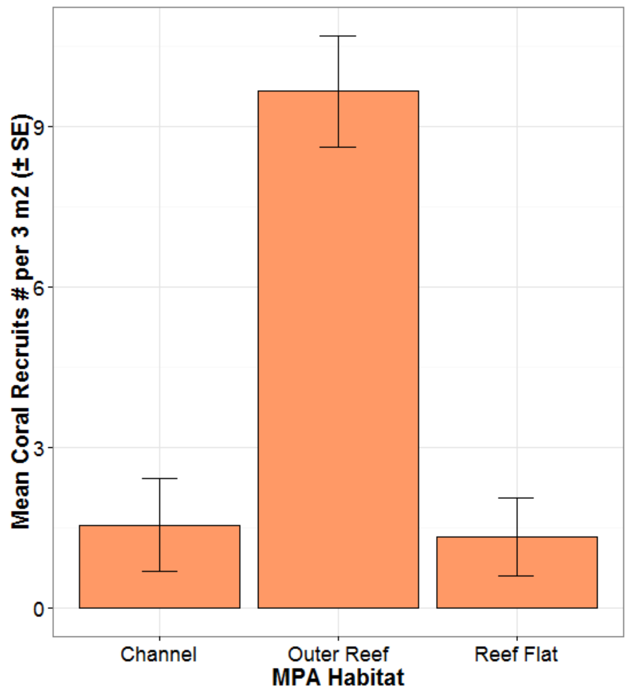

Figure 6: Mean coral recruits density in the three habitats of Ongiil CA

Invertebrates' density

The abundance of macro-invertebrates was low (<1 individuals per 60 m^2) in all habitats. The low abundance consisted of clam species (*Tridacna crocea* and *Hippopus hippopus*)

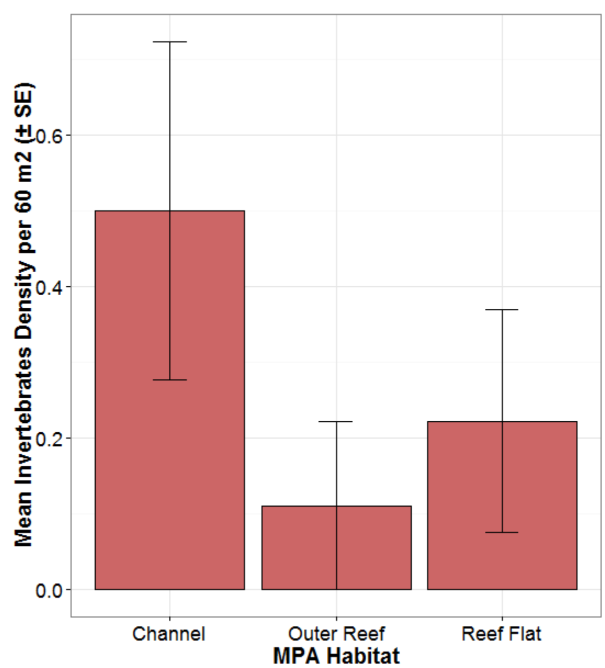

Figure 7: Mean abundance of commercially-targeted invertebrates' species in the three habitats of Ongiil CA

Discussion

The overall goal of this study was to collect baseline ecological information within Ongiil CA. This site has been closed to fishing since December 2010. Ongiil CA is a protected area under the Ngaraard State Legislature (NSPL 8-5) and it is not classified as a PAN site.

The fish abundance and biomass of targeted species was relatively low in all habitats but especially on the outer reef. The reef flat had higher fish abundance than other habitats but fish were smaller in size, hence a lower biomass than in other habitats. Overall, the fish community was dominated by parrotfish (Scaridae) but appeared in low densities in all habitats. No carnivorous species such as species belonging to Lutjanidae, Lethrinidae, Serranidae families, and few individuals from Carangidae family were observed. This may indicate sings of past fishing pressure and/or a loss of habitat complexity. Coral-associated fish need a three-dimensional habitat to hide from predators and sleep. Extensive changes of the benthic structure have been shown to affect fish assemblages (Wilson et al. 2006; Pratchett et al. 2008), often reducing fish densities (Lassig 1983; Bouchon et al. 1994) . The recent occurrence of two typhoons on the east coast of Palau have intensively damaged the reef framework and may have impacted their habitats and assemblages.

Live coral cover was low in all habitats (< 8 %) and especially on the outer reef (2.5 %). The east coast of Palau has been damaged by the two typhoons in 2012 and 2013 and PICRC long term monitoring data showed that live coral cover decreased by 80 % on the exposed coast (Gouezo et al. in review). Despite the low coral cover, the coral community was diverse with 18 recorded coral genera within the CA. Turf algae dominated the channel and outer reef habitats (> 45 %) because of the low live coral cover and high cover of carbonate substrate. The reef flat had soft-sediments substrates covered by seagrass.

Coral recruitment was low. Juvenile corals density appeared in lower densities than 2 individuals per 3 m^2 in the reef flat and in the channel habitats. The reef flat was dominated by soft sediments and seagrass. The absence of hard substrate on the reef flat explained the low abundance of juvenile corals. However, the channel had a high cover of carbonate substrate but its location close to the river mouth exposes it to sediment loads which may interfere with coral recruitment. For the outer reef habitat, coral recruitment was lower than other MPAs in Palau on the West coast (Gouezo et al. 2015a, 2015b). As mentioned previously, the loss of live coral after the two typhoons all along the east coast indirectly affected the supply of coral larvae. The density of juvenile corals at Ongiil CA is similar to other sites on the east coast (Gouezo et al. in review). Further research is needed to assess the recovery potential of the impacted reefs by the typhoons in Palau.

The macro-invertebrates community appeared in very low abundance (< 1 individuals per 60 m^2). The quasi-absence of clams and edible sea cucumbers showed signs of past fishing pressure and invertebrates populations which have not recovered.

Ongiil CA is small in size, but encompasses 3 habitats: reef flat, channel and outer reef. It has been closed to fishing very recently and populations have not shown signs of recovery yet. In addition, the area was highly damaged by two typhoons in 2012 and 2013 respectively. It will take time for the system to recover from these multiple stressors.

Acknowledgment

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Appendix 1:

Commercially important fish species in Palau			
	Common name	**Palauan name**	**Scientific name**
1	Bluefin trevally	Erobk	*Caranx ignobilis*
2	Giant trevally	Oruidel	*Caranx melampygus*
3	Bicolor parrotfish	Beyadel/Ngesngis	*Cetoscarus bicolor*
4	Parrotfish species	Melemau	*Cetoscarus/Chlorurus/Scarus* spp
5	Yellow cheek tuskfish	Budech	*Choerodon anchorago*
6	Indian ocean longnose parrotfish	Bekism	*Hiposcarus harid*
7	Pacific longnose parrotfish	Ngeaoch	*Hipposcarus longiceps*
8	Rudderfish	Komud, Teboteb	*Kyphosusspp (vaigiensis)*
9	Orangestripe emperor	Udech	*Lethrinus obsoletus*
10	Longface emperor	Melangmud	*Lethrinus olivaceus*
11	Red gill emperor	Rekruk	*Lethrinus rubrioperculatus*
12	Yellowlip emperor	Mechur	*Lethrinus xanthochilis*
13	Squaretail mullet	Uluu	*Liza vaigiensis*
14	River snapper	Kedesau'liengel	*Lutjanus argentimaculatus*
15	Red snapper	Kedesau	*Lutjanus bohar*
16	Humpback snapper	Keremlal	*Lutjanus gibbus*
17	Orangespineunicornfish	Cherangel	*Naso lituartus*
18	Bluespineunicornfish	Chum	*Naso unicornis*
19	Giant sweetlips	Melimralm,Kosond/Bikl	*Plectorhinchus albovittatus*
20	Yellowstripe sweetlips	Merar	*Plectorhinchus crysotaenia*
21	Pacific steephead parrotfish	Otord	*Scarus micorhinos*
22	Greenthroat parrotfish	Udouungelel	*Scarus prasiognathus*
23	Forketailrabbitfish	Beduut	*Siganus argenteus*
24	Lined rabbitfish	Kelsebuul	*Siganus lineatus*
25	Masked rabbitfish	Reked	*Siganus puellus*
26	Goldspottedrabbitfish	Bebael	*Siganus punctatus*
27	Bluespot mullet	Kelat	*Valamugil seheli*
Protected Fish Species (yearly and seasonal fishing closure)			
28	Bumphead parrotfish	Kemedukl	*Bolbometopon muricatum*
29	Humpheadwrasse	Ngimer, Maml	*Cheilinus undulatus*
30	Brown-marbled grouper	Meteungerel'temekai	*Epinephelus fuscoguttatus*
31	Marbled grouper	Ksau'temekai	*Epinephelus polyphekadion*
32	Squaretail grouper	Tiau	*Plectropomus areolatus*
33	Saddleback grouper	Katuu'tiau, Mokas	*Plectropomus laevis*
34	Leopard grouper	Tiau (red)	*Plectropomus leopardus*
35	Dusky rabbitfish	Meyas	*Siganus fuscescens*

Appendix 2: Macro-invertebrates list

Common names	Palauan name	Scientific name
Black teatfish	Bakelungal-chedelkelek	*Holothuria nobilis*
White teatfish,	Bakelungal-cherou	*Holothuria fuscogilva*
Golden sandfish	Delalamolech	*Holothuria lessoni*
Hairy blackfish	Eremrum, cheremrumedelekelk	*Actinopyga miliaris*
Hairy greyfish	Eremrum, cheremrum	*Actinopyga sp.*
Deepwater red fish	Eremrum, cheremrum	*Actinopyga echinites*
Deepwater blackfish	Eremrum, cheremrum	*Actinopyga palauensis*
Stonefish	Ngelau	*Actinopyga lecanora*
Dragonfish	Irimd	*Stichopus horrens*
Brown sandfish	Meremarech	*Bohadschia vitiensis*
Chalk fish	Meremarech	*Bohadschia similis*
Leopardfish /tigerfish	Meremarech, esobel	*Bohadschia argus*
Sandfish	Molech	*Holothuria scabra*
Curryfish	Delal a ngimes/ngimesratmolech	*Stichopus hermanni*
Brown curryfish	Ngimes	*Stichopus vastus*
Greenfish	Cheuas	*Stichopus chloronotus*
Slender sea cucumber	Sekesaker	*Holothuria impatiens*
Prickly redfish	Temetamel	*Thelenota ananas*
Amberfish	Belaol	*Thelenota anax*
Elephant trunkfish	Delal a molech	*Holothuria fuscopunctata*
Flowerfish	Meremarech	*Pearsonothuria graeffei*
Lolly fish	Cheuas	*Holothuria atra*
Pinkfish	Cheuas	*Holothuria edulis*
White snakefish	Cheuas	*Holothuria leucospilota*
Snakefish	Cheuas	*Holothuria coluber*
Red snakefish	Cheuas	*Holothuris falvomaculata*
Surf red fish	Badelchelid	*Actinopyga mauritiana*
Crocus giant clam /	Oruer	*Tridacna crocea*
Elongate giant clam	Melibes	*Tridacna maxima*
Smooth giant clam	Kism	*Tridacna derasa*
Fluted giant clam	Ribkungel	*Tridacna squamosa*
Bear paw giant clam	Duadeb	*Hippopus hippopus*
True giant clam	Otkang	*Tridacna gigas*
Sea urchin	Ibuchel	*Tripneustes gratilla*
Trochus	Semum	*Trochus niloticus*

Appendix 3: Benthic categories

CPCe Code	Benthic Categories
"C"	"Coral"
"SC"	"Soft Coral"
"OI"	"Other Invertebrates"
"MA"	"Macroalgae"
"SG"	"Seagrass"
"BCA"	"Branching Coralline Algae"
"CCA"	"Crustose Coralline Algae"
"CAR"	"Carbonate"
"S"	"Sand"
"R"	"Rubble"
"FCA"	"Fleshy Coralline algae"
"CHRYS"	"Chrysophyte"
"T"	"Turf Algae"
"TWS"	"Tape
"G"	"Gorgonians"
"SP"	"Sponges"
"ANEM"	"Anenome"
"DISCO"	"Discosoma"
"DYS"	"Dysidea Sponge"
"OLV"	"Olive Sponge"
"CUPS"	"Cup Sponge"
"TERPS"	"Terpios Sponge"
"Z"	"Zoanthids"
"NoIDINV"	"Not Identified Invertebrate"
"AMP"	"Amphiroa"
"ASC"	"Ascidian"
"TURB"	"Turbinaria"
"DICT"	"Dictyota"
"LIAG"	"Liagora"
"LOBO"	"Lobophora"
"SCHIZ"	"Schizothrix"
"HALI"	"Halimeda"
"SARG"	"Sargassum"
"BG"	"Bluegreen"
"Bood"	"Boodlea"
"GLXU"	"Galaxura"
"CHLDES"	"Chlorodesmis"
"JAN"	"Jania"
"CLP"	"Caulerpa"
"MICDTY"	"Microdictyton"
"BRYP"	"Bryopsis"

"NEOM"	"Neomeris"
"TYDM"	"Tydemania"
"ASP"	"Asparagopsis"
"MAST"	"Mastophora"
"DYCTY"	"Dictosphyrea"
"PAD"	"Padina"
"NOIDMAC"	"Not ID Macroalgae"
"CR"	"C.rotundata"
"CS"	"C.serrulata"
"EA"	"E. acroides"
"HP"	"H. pinifolia"
"HU"	"H. univervis"
"HM"	"H. minor"
"HO"	"H. ovalis"
"SI"	"S. isoetifolium"
"TH"	"T.hemprichii"
"TC"	"T. ciliatum"
"SG"	"Seagrass"
"ACAN"	"Acanthastrea"
"ACROP"	"Acropora"
"ANAC"	"Anacropora"
"ALVEO"	"Alveopora"
"ASTRP"	"Astreopora"
"CAUL"	"Caulastrea"
"CRUNK"	"Coral Unknown"
"COSC"	"Coscinaraea"
"CYPH"	"Cyphastrea"
"CTEN"	"Ctenactis"
"DIPLO"	"Diploastrea"
"ECHPHY"	"Echinophyllia"
"ECHPO"	"Echinopora"
"EUPH"	"Euphyllia"
"FAV"	"Favia"
"FAVT"	"Favites"
"FAVD"	"Faviid"
"FUNG"	"Fungia"
"GAL"	"Galaxea"
"GARD"	"Gardininoseris"
"GON"	"Goniastrea"
"GONIO"	"Goniopora"
"HELIO"	"Heliopora"
"HERP"	"Herpolitha"
"HYD"	"Hydnophora"
"ISOP"	"Isopora"
"LEPT"	"Leptastrea"
"LEPTOR"	"Leptoria"

"LEPTOS"	"Leptoseris"
"LOBOPH"	"Lobophyllia"
"MILL"	"Millepora"
"MONT"	"Montastrea"
"MONTI"	"Montipora"
"MERU"	"Merulina"
"MYCED"	"Mycedium"
"OULO"	"Oulophyllia"
"OXYP"	"Oxypora"
"PACHY"	"Pachyseris"
"PAV"	"Pavona"
"PLAT"	"Platygyra"
"PLERO"	"Plerogyra"
"PLSIA"	"Plesiastrea"
"PECT"	"Pectinia"
"PHYSO"	"Physogyra"
"POC"	"Pocillopora"
"POR"	"Porites"
"PORRUS"	"Porites-rus"
"PORMAS"	"Porites-massive"
"PSAM"	"Psammocora"
"SANDO"	"Sandalolitha"
"SCAP"	"Scapophyllia"
"SERIA"	"Seriatopora"
"STYLC"	"Stylocoeniella"
"STYLO"	"Stylophora"
"SYMP"	"Symphyllia"
"TURBIN"	"Turbinaria"
"CCA"	"Crustose Coralline"
"CAR"	"Carbonate"
"SC"	"Soft Coral"
"Sand"	"Sand"
"Rubble"	"Rubble"
"Tape"	"Tape"
"Wand"	"Wand"
"Shadow"	"Shadow"
"FCA"	"Fleshy-Coralline"
"CHRYOBRN"	"Brown Chysophyte"
"TURF"	"Turf"
"BCA"	"Branching Coralline general"
"BC"	"Bleached Coral"

Appendix 4: GPS coordinates of survey sites (UTM)

ID	Lat	long
3	837682.076	460137.749
4	837530.898	460832.581
5	837426.481	460912.752
6	837119.804	460970.6
7	837518.238	460694.487
9	836957.572	460172.442
10	460135	837303
11	460339	837724
12	460517	837740