NGEMELIS ISLAND COMPLEX

BASELINE ASSESSMENT

Evelyn Otto, Marine Gouezo, Shirley Koshiba, Dawnette Olsudong,

Randa Jonathan, Geory Mereb

Palau International Coral Reef Center

Palau International Coral Reef Center

PICRC Technical Report No. 16-04

January 2016

ABSTRACT

With the increasing demand of marine resources throughout the world, it is important to establish a foundation to determine how the use of resources is affecting the health of marine habitats. An initial assessment of Koror's Ngemelis Island Complex was conducted to establish a baseline database to support long-term adaptive management of the protected areas in Palau. A total of 39 sites within Ngemelis Island Complex were randomly selected and surveyed over five days between October 26 and November 3, 2015. The survey was specifically geared to assessing the benthic community, coral recruits, commercially important invertebrates, and the abundance and biomass of commercially important fish. The sample design was habitat-stratified with the number of sites being proportional to the size of each habitat. These habitats include the back reef, channel, fore reef, lagoon, reef crest, vertical wall, and an unknown habitat. This assessment shows that fish abundance and biomass are the most dominant on the vertical wall where turf and crustose coralline algae were the predominant benthic substrates. Coral recruit density was observed to be the most dominant on the fore reef where carbonate was the most dominant benthic substrate and invertebrate density was observed to be the most dominant in the channel where *Acropora sp.* and sand were the predominant substrate.

1. INTRODUCTION

Marine Protected Areas (MPAs) are conservation tools that aim to protect biodiversity and ensure sustainable resource practices. This conservation tool is increasingly used in Palau, as well as throughout Micronesia and the rest of the world. Palau has over 44 protected areas nation-wide, 33 of which are marine habitats. In 2003, Palau enacted the Protected Areas Network (PAN) Act, which establishes a framework for and provides technical and financial resources to a nation-wide system of protected areas (RPPL No. 6-39). In 2007, Palau further strengthened its national commitment to conservation by joining forces with other Micronesian jurisdictions in declaring the Micronesia Challenge (MC), a collective pledge to effectively conserve at least 30% of near shore marine resources and 20% of terrestrial resources by 2020 (RPPL No. 7-42).

Coral reefs provide ecosystem goods and services to people around the world in terms of livelihood resources as well as recreational resources (Mascia, M. B. 2003). Therefore, biological monitoring is an essential component of adaptive management and enables managers to measure the effectiveness of management interventions. In order to effectively manage protected areas, resource managers and relevant stakeholders need information on trends in the condition of resources and the effectiveness of management actions. MPA monitoring data provide the resource managers key information that will assist in prioritizing management strategies and allocating resources (Wilkinson *et al 2003)*.

Ngemelis Island Complex (from here on referred to as “Ngemelis”) was established in 1995 by Koror State legislature (K4-68-95) and later amended its regulations and boundaries in 2010 (K9-229-10). This 40.28 km^2 conservation area, located on the southern end of Koror’s boundaries within the Rock Island Southern Lagoon (RISL) is a host habitat to hundreds of marine flora and fauna species. In 2012, the Koror State RISL became a World Heritage site through the United Nations Educational, Scientific, and Cultural Organization (UNESCO). The RISL is 100,200 ha of designated conservation zone which includes most of Palau's popular beaches, dive sites, and snorkeling sites. Ngemelis alone has at least eight of the most popular diving and snorkeling spots in Palau. By restricting any type of collection within Ngemelis, it provides a sanctuary for marine life which in turn provides an ideal destination for snorkelers and/or divers to experience the unique wildlife Palau has to offer. Since the fishing closure in 1995, Ngemelis offers an array of threatened species such as sharks, sea turtles, and Napoleon wrasses.

Ngemelis baseline assessment was conducted by the Palau International Coral Reef Center (PICRC). The main objective of this survey was to collect baseline data on the main marine ecological indicators within the different habitats of the protected area. Baseline data will be used to assess the effectiveness of protective management in the future.

METHODS

This study was conducted between October 26-29, 2015 and one day on November 3, 2015. The survey targeted the vertical wall, fore reef, back reef, reef crest, channel and an unknown habitat at depths between 1-5 m. The unknown habitat previously mention was classified as back reef due to benthic similarities. A total of 42 randomly selected sites were first targeted but 39 of them were surveyed because three sites fell outside of the boundaries of the MPA (Fig 1). The monitoring protocol followed an established method from determining location to analyzing the data in order to ensure uniformity among all MPA assessments conducted in Palau. Random sites locations were allocated within each habitat present in the MPA depending on their size using QGIS (QGIS Development Team 2015) (Fig. 1). According to protocol, 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.

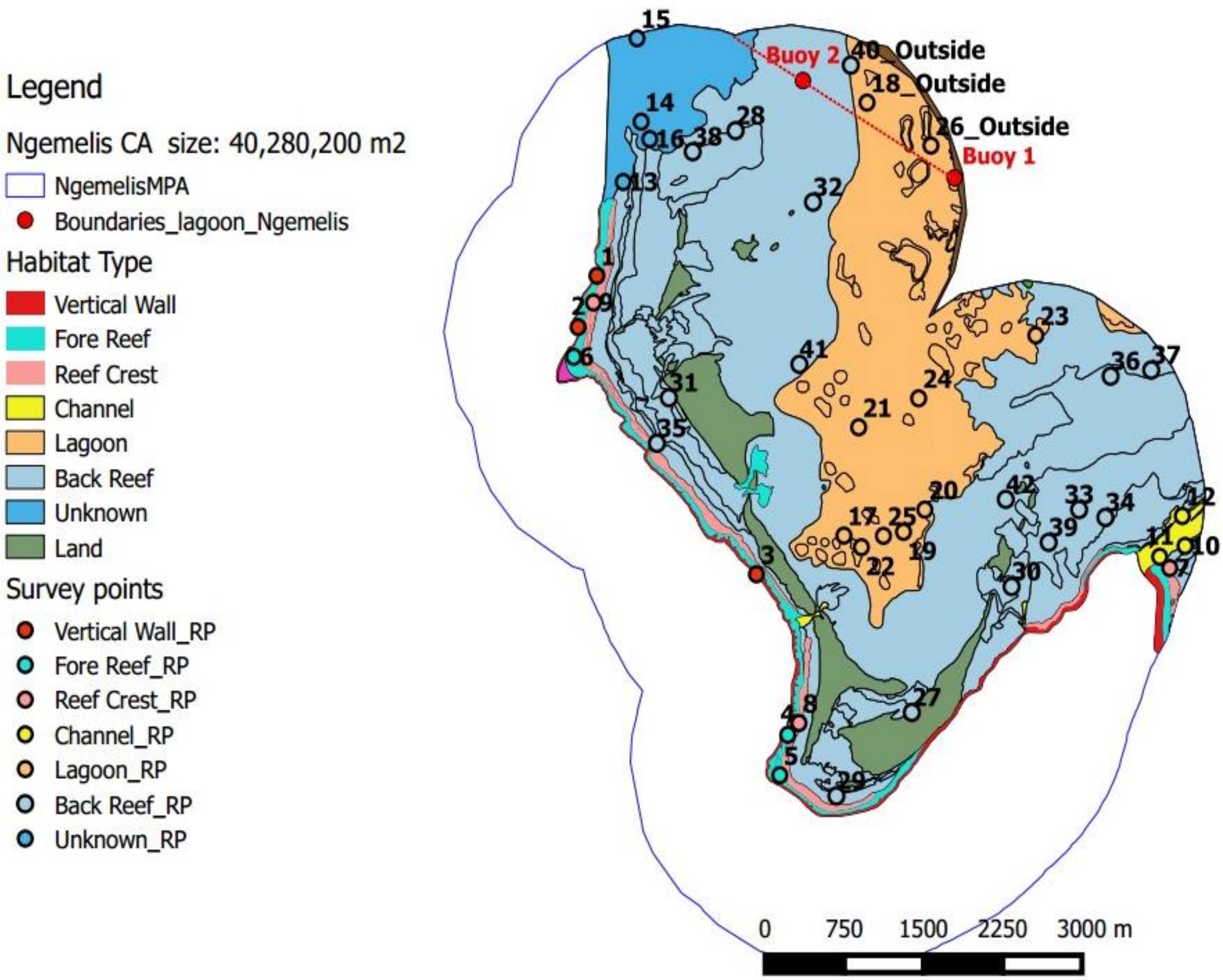


Figure 1: Map of Koror's Ngemelis Island Complex, showing the 39 randomly selected sites and the three sites that fell outside of the conservation markers on site.

Fish surveys targeted those that are commercially important and were conducted on 30 m x 5 m belt transects (150 m^2 total area per transect) where the abundance as well as the estimated length of each fish (in centimeters) was recorded. Commercially targeted invertebrates were identified and recorded along a reduced width of 30 m x 2 m (60 m^2 total area per transect). Coral recruits were measured on a further reduced width of 0.3 m x 10 m (3 m^2 total area per transect). Benthic coverage which includes coral cover in depths greater than 1 m was recorded by taking pictures at every meter using a wide angle lens camera (*Canon G16 with attachable fish eye*) and a 1 m^2 photo-quadrat alongside the right side of each 30 m transect. Benthic coverage in depths 1 m or less was recorded by taking pictures at every meter using a wide angle lens camera and a 0.5 m^2 photo-quadrat alongside the right side of each 30 m transect.

Back in the laboratory, the photographs of benthic and coral coverage were analyzed using the program Coral Point Count with excel extensions (CPCe) (Kohler and Gill 2006). Using CPCe, five random points from each frame was used to determine benthic cover classified into categories (Appendix 3).

Fish surveys were conducted to estimate density and biomass, where size was recorded in centimeters and biomass was calculated using the length-weight relationship, a(L^b), where *L*= length in centimeters, and *a* and *b* as constants values published biomass-length relationships from Kulbicki et al. (*2005*) and from Fish Base (www.fishbase.org). Back at PICRC, all data was entered into Microsoft (MS) excel spread sheets and later analyzed.

2. RESULTS

3.1 Fish Abundance

Fish abundance were reported as the average number of fish per 150 m^2 area. Mean abundance for all commercially important fish (see Appendix 1) observed for all habitats in Ngemelis was 19 fish (± 3.7 SE). For all commercially important fish observed at each habitat, the vertical wall had the highest density observed at 36.9 fish (± 11.6 SE) per 150 m^2. The lowest density observed among the six habitats was the back reef with a mean of 9.4 fish (± 1.7 SE). The remaining four habitats had the following mean density of fish observed per 150 m^2: 26.3 (± 10.1 SE) (reef crest), 20.4 (± 5.2 SE) (lagoon), 15.6 (± 5 SE) (channel), and 14.4 (± 3.2 SE) (fore reef) (Fig 2).

A total of 34 species in 10 families were observed over the six habitats of Ngemelis. The six most abundant families were the Emperor fish, Parrot fish, Rabbit fish, Snapper, Unicorn fish, and Wrasse (Fig 3).

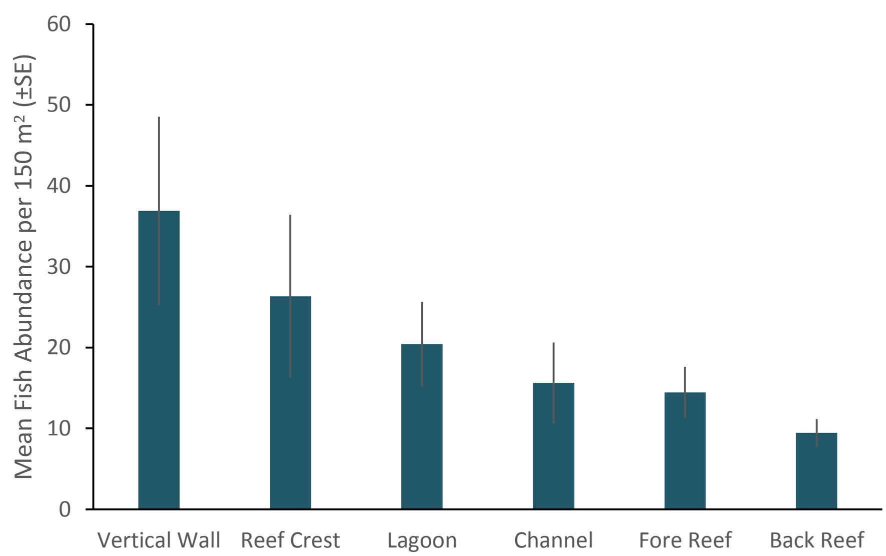


Figure 2: Abundance of commercially important fish species observed in Ngemelis

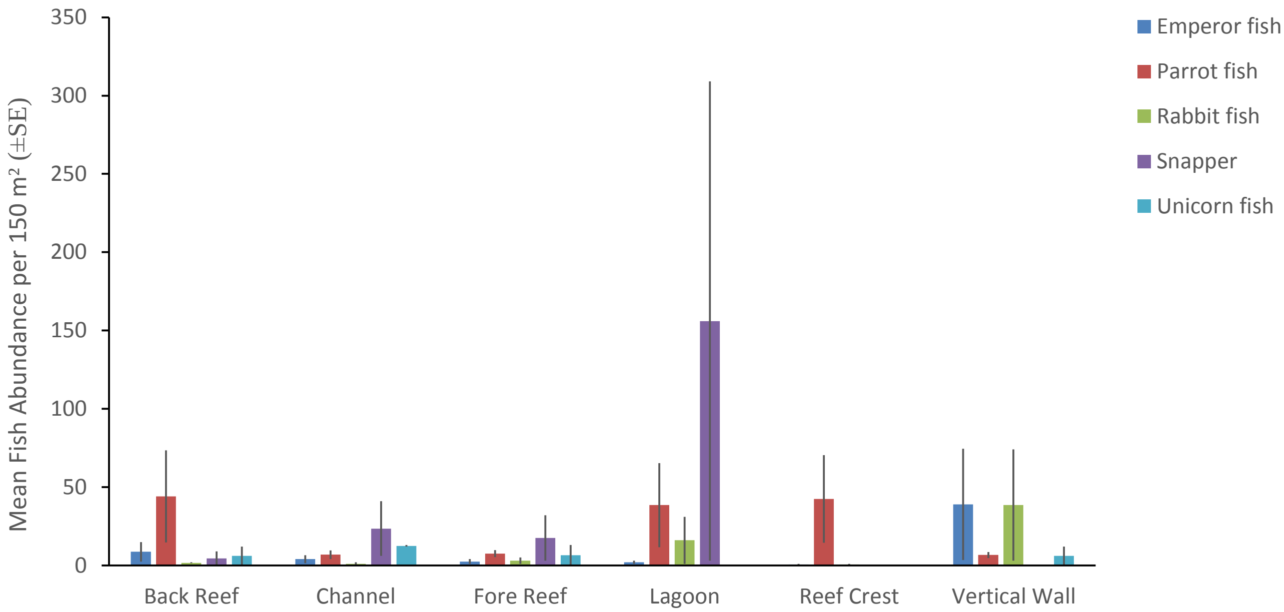


Figure 3: Abundance of top six fish families observed in Ngemelis

3.2 Fish Biomass

The mean biomass for all the commercially important fish observed within Ngemelis was 2190.9 g (± 850.3 SE) per 150 m². For all commercially important fish observed at each habitat, the vertical wall had the largest recorded biomass of all fish within the habitat at 5463 g (± 1110.6 SE) and the reef crest had the least recorded mean biomass of all fish at 135.7 g (± 61.4 SE). The mean biomass for all fish within each of the remaining habitats was at 4546.6 g (± 535.3 SE) (fore reef), 3500.9 g (± 787.2 SE) (channel), 790.9 g (± 337.8 SE) (lagoon), and 563.5 g (± 175.1 SE) (back reef) (Fig 3). Figure 4 illustrates the total biomass for each of the six most abundant fish families within each habitat (Fig 4).

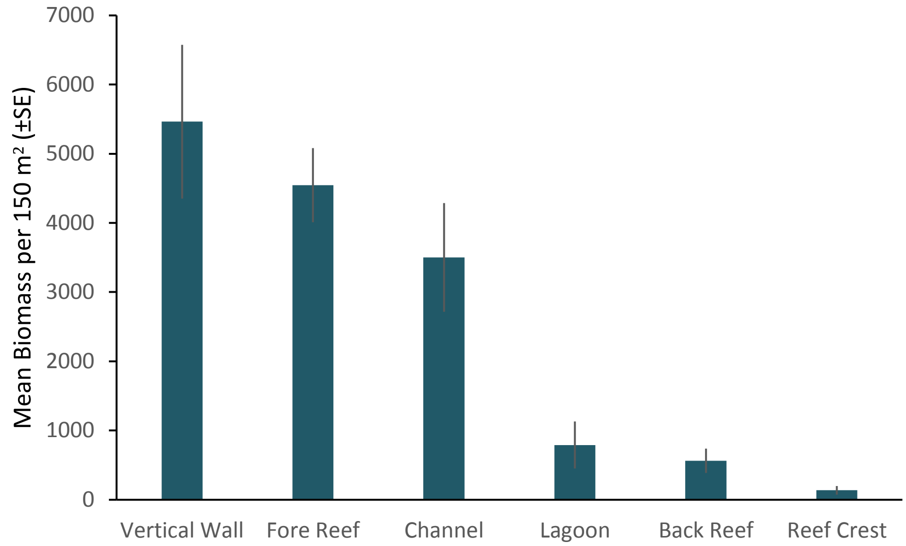


Figure 4: Mean biomass of all commercially important fish observed within the six habitats

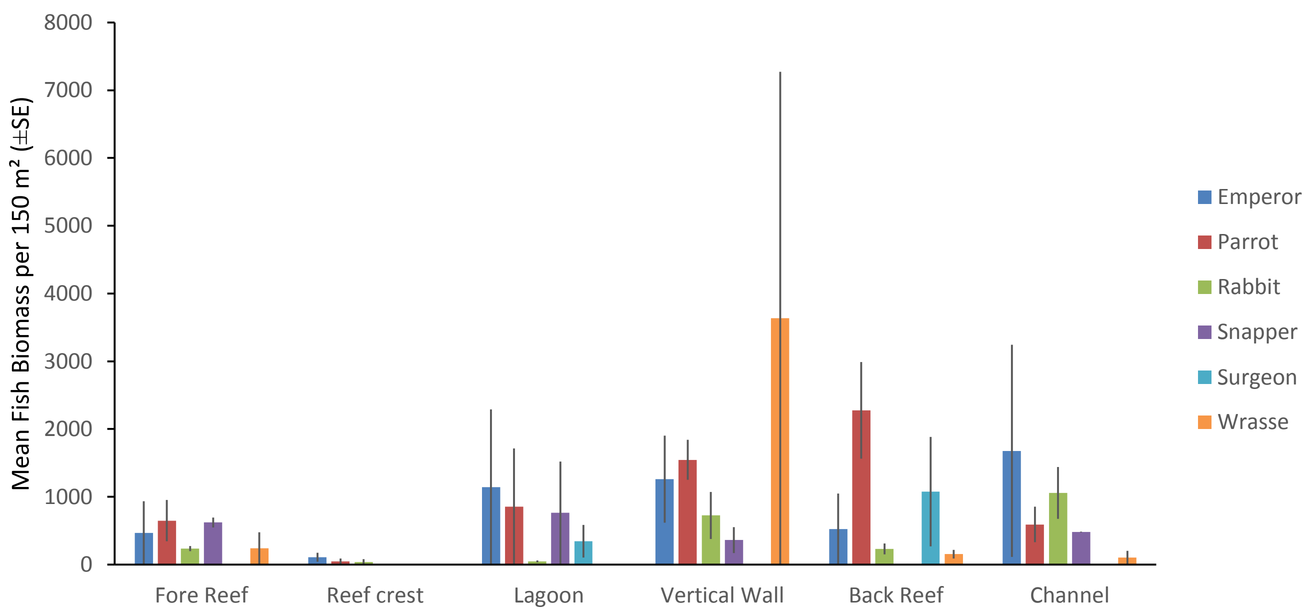


Figure 5: Mean biomass of all commercially important fish categorized within common family names

3.3 Invertebrates

Mean density of all commercially important invertebrates (Appendix 2) in Ngemelis was 1.7 (± 0.1 SE) per 60 m². The channel had a mean density of 2.3 (± 0.4 SE), the highest of the six habitats.

The lowest count of invertebrates was in the lagoon with a mean density of 0.3 (± 0.3 SE). The mean density of observed invertebrates within the remaining four habitats follow: 1.9 (± 0.3 SE) (vertical wall), 1.8 (± 0.4 SE) (reef crest), 1.8 (± 0.4 SE) (fore reef), and 1.7 (± 0.1 SE) (back reef) (Fig 6). The most abundant invertebrates within Ngemelis was clams, being observed at least once in each habitat whereas sea cucumbers were observed only in the back reef and channel.

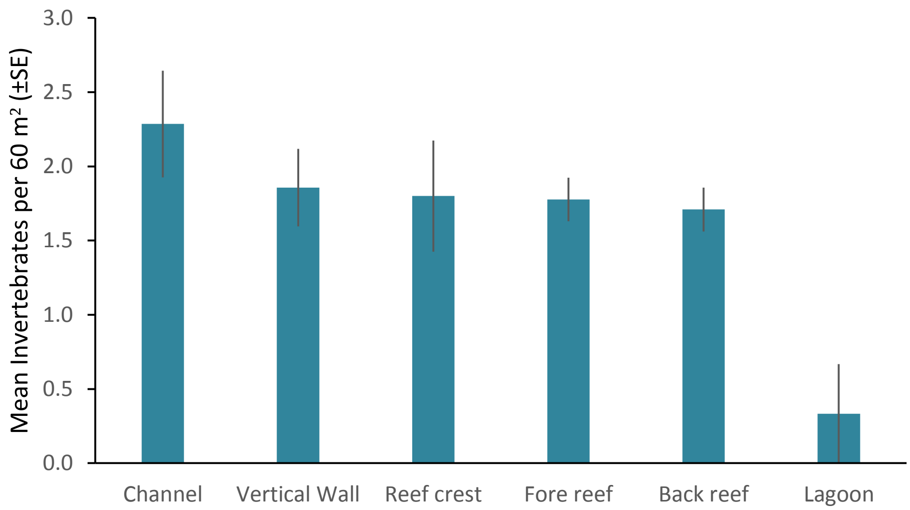


Figure 6: Mean density of invertebrates in Ngemelis at each habitat

3.4 Coral Recruit

Mean density of coral recruits for Ngemelis on the fore reef was 29.2 recruits (± 3.7 SE) per 3 m^2, recorded as the most abundant of the six habitats. The lagoon had the least density of recruits observed at 2.8 (± 0.7 SE). The vertical wall had the second highest mean of 21.1 (± 3.3 SE) coral recruits per 3 m^2, followed by the channel having 7.3 (± 1.5 SE), back reef had 6.7 (± 0.6 SE), and the reef crest had 3.4 (± 0.9 SE) per 3 m^2 (Fig. 7). Figure 8 shows the six most abundant coral genus species observed within the six habitats.

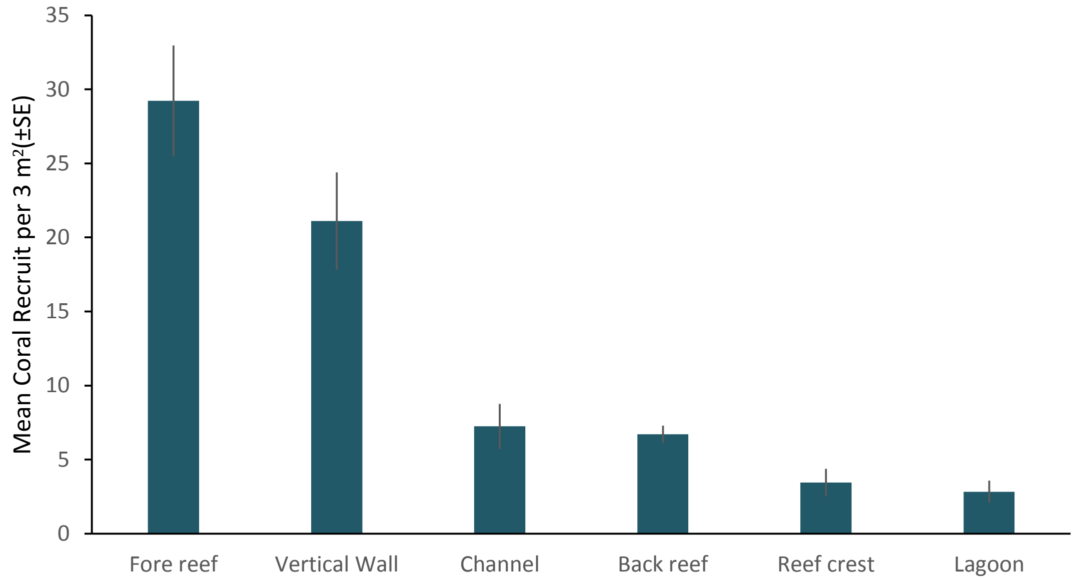


Figure 7: Mean density of coral recruits at Ngemelis

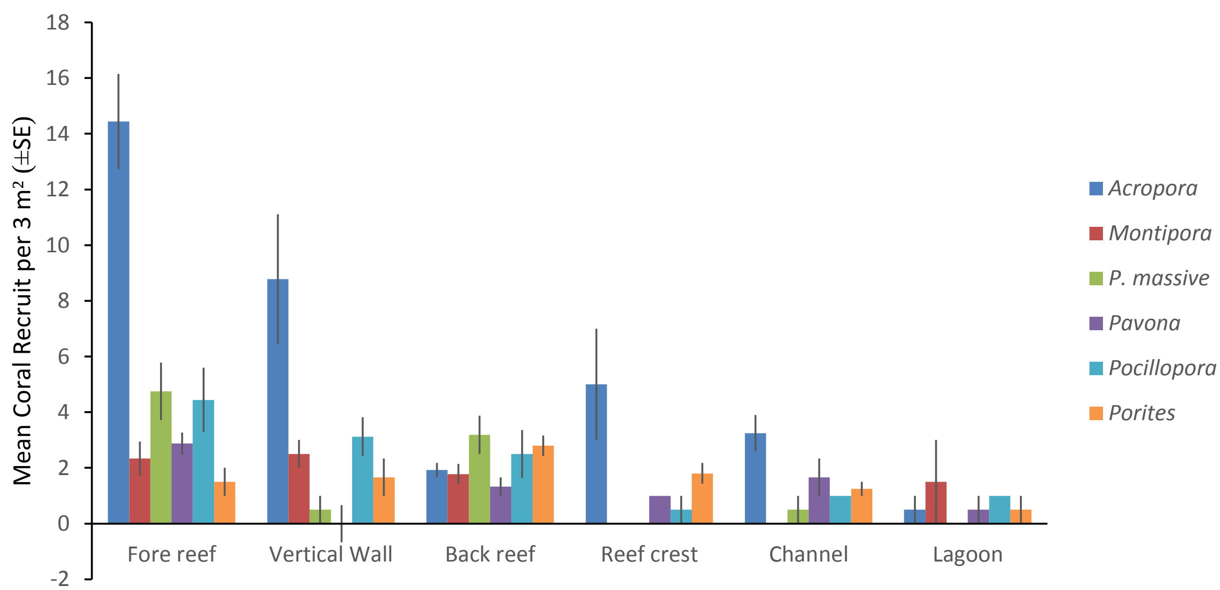
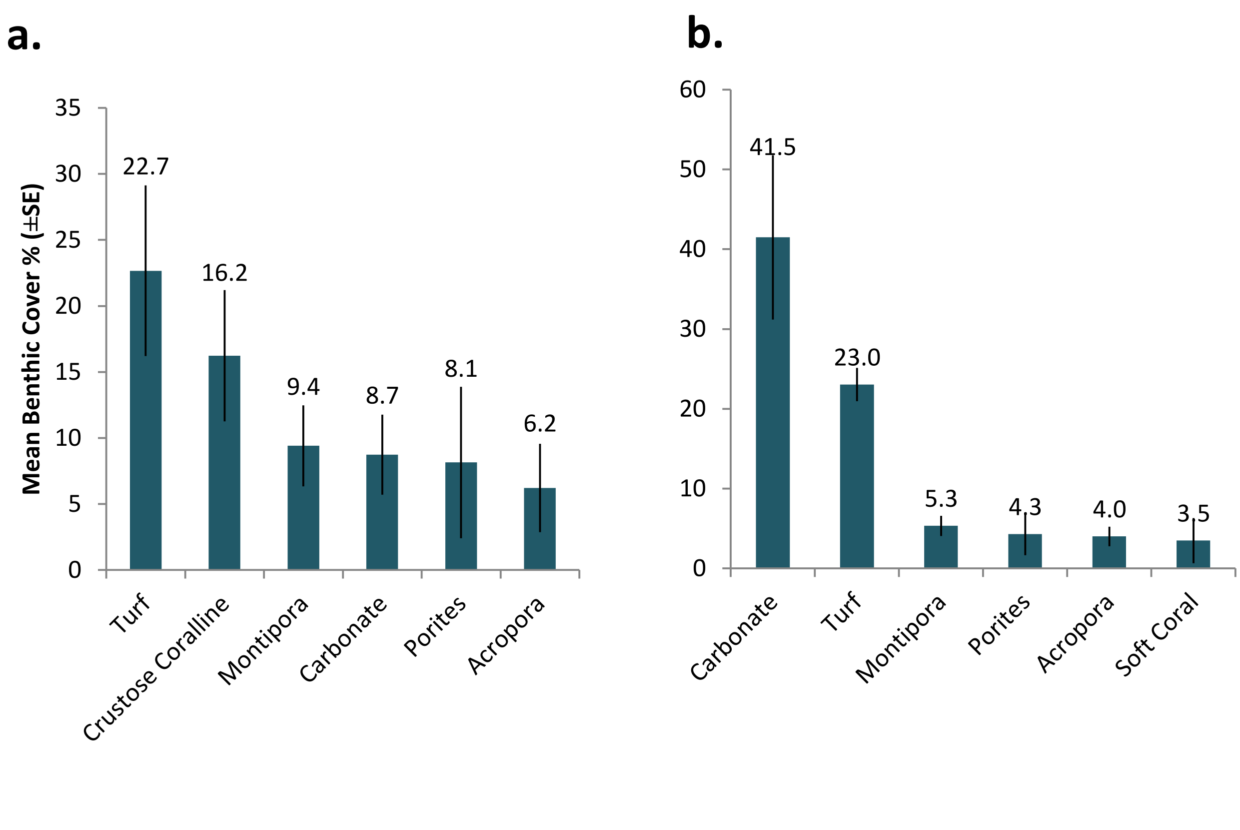


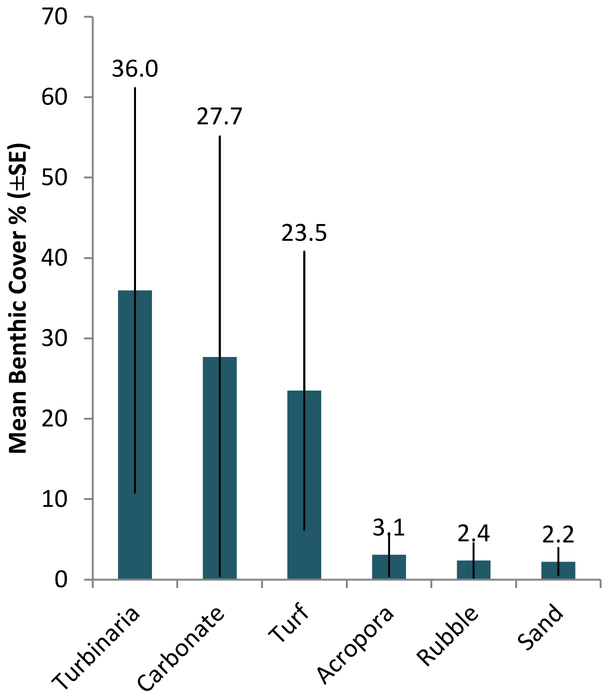
Figure 8: Six most abundant coral recruits observed within Ngemelis

3.5 Benthic cover

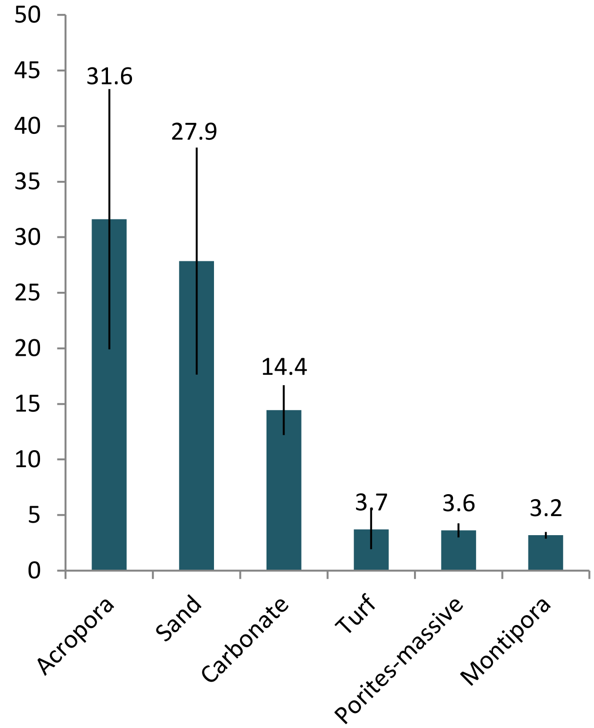
Figure 9 shows the most abundant six benthic categories observed within each of the seven habitats of Ngemelis. The most abundant benthic cover within the vertical wall was turf (22.7% [± 6.5 SE]) (Fig. 9a), the fore reef was predominately made up on carbonate (41.5% [± 10.3% SE]) (Fig. 9b), the reef crest was made up of *Turbinaria* (36% [± 25.3% SE]) (Fig. 9c), the channel was predominantly *Acropora* (31.6% [± 11.7% SE]) (Fig. 9d), and the unknown habitat was predominantly Carbonate (51.1% [± 11.5% SE]) (Fig. 9e). The lagoon and the back reef were both predominantly Sand with 71% (± 2.6% SE) and 69.6% (± 7.3% SE), respectively (Fig. 9f-g).



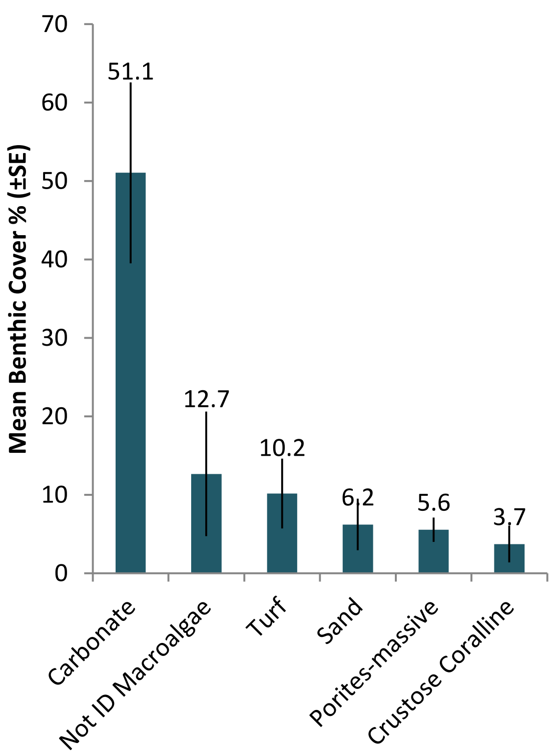
c.


Mean Benthic Cover % (±SE)
70
60
50
40
30
20
10
0
36.0
27.7
23.5
3.1
2.4
2.2
Turbinaria
Carbonate
Turf
Acropora
Rubble
Sand

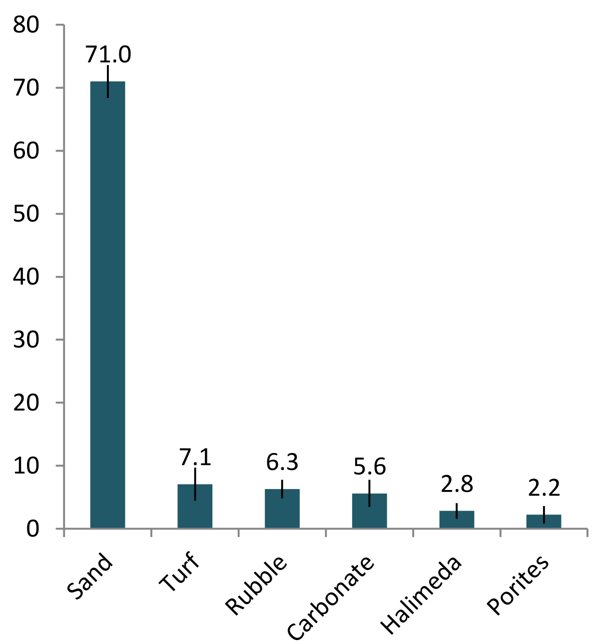
d.


50
45
40
35
30
25
20
15
10
5
0
31.6
27.9
14.4
3.7
3.6
3.2
Acropora
Sand
Carbonate
Turf
Porites-massive
Montipora

e.


Mean Benthic Cover % (±SE)
70
60
50
40
30
20
10
0
51.1
12.7
10.2
6.2
5.6
3.7
Carbonate
Not ID Macroalgae
Turf
Sand
Porites-massive
Crustose Coralline

f.


80
70
60
50
40
30
20
10
0
71.0
7.1
6.3
5.6
2.8
2.2
Sand
Turf
Rubble
Carbonate
Halimeda
Porites

g.

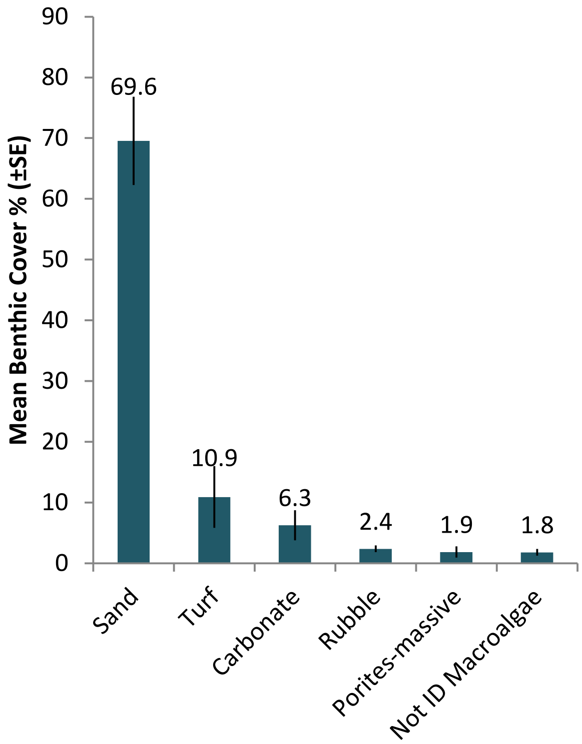


Figure 9: Mean benthic cover in percentage per habitat, categorized in order of abundance (a: Vertical Wall; b: Fore Reef; c: Reef Crest; d: Channel; e: Unknown; f: Lagoon; g: Back Reef)

3. Discussion

The overall objective of this study was to collect environmental baseline information within Koror's Ngemelis Island Complex. Since 1995 and amended in 2010, Ngemelis has been restricted as a "no take" zone and has restricted any time of fishing or collecting within a 1 mile radius of the area. This is the first survey that has studied all habitats within Ngemelis Island Complex, whereas other studies have focused on the fore reef and the vertical wall habitats.

Over time, no-take marine protected areas have the ability to increase targeted fish abundance and biomass, as well as invertebrate density, given that enforcement and compliance is strictly regulated. The fishing and collection restriction within Ngemelis is highly favorable because it contains many popular dive sites within the boundaries. Though strict enforcement is not enough, MPAs only function well when the local users accept and support the effort (Wilkinson *et al 2003)*. Local guides are most likely to abide by the conservation laws in order to ensure their customers unique experience that is being expected.

This assessment showed that fish abundance and biomass were high on the vertical wall where turf and crustose coralline algae were the predominant benthic substrates. The reef crest had the second most abundant in fish density but recorded the lowest fish biomass of all six sites. This means the reef crest had smaller fish in size. Recruits were observed to be most abundant on the fore reef where carbonate are the predominant benthic substrate and invertebrates were observed to be most abundant in the channel where *Acropora sp.* and sand are the predominant substrates.

Future assessments in this area will help determine whether or not the management practices are effectively working. It is essential for policy makers and managers adjust their management to field observations to ensure the increase of marine resources over time and meet their conservation goals. This information provided a baseline but will require regular monitoring of ecological indicators that have been surveyed in order to provide long term trends that can enable management to adapt and ensure the effectiveness of the MPA.

ACKNOWLEDGMENT

We would like to thank Koror State and Koror State rangers for their continuous support and assistance. This project is made possible with the support of PEW charitable trust, Micronesia Conservation Trust, NOAA’s Coral Reef Conservation Program, and GEF small grant program for their generosity and support.

REFERENCE

Kohler KE, Gill SM (2006) Coral Point Count with Excel extensions (CPCe): A Visual Basic program for the determination of coral and substrate coverage using random point count methodology. Comput.Geosci. 32:1259–1269

Kulbicki M, Guillemot N, Amand M (2005) A general approach to length-weight relationships for New Caledonian lagoon fishes. Cybium 29:235–252

Mascia, M. B. (2003). The Human Dimension of Coral Reef Marine Protected Areas: Recent Social Science Research and Its Policy Implications. Conservation Biology, 17(2), 630-632.

Ninth Koror State Legislature (2010) *KSPL No. K9-229-2010: An act to establish a "no fishing" zone for all areas within one (1) mile of the Ngemelis Islands complex, to prohibit the taking of flora and fauna from, and introduction of flora and fauna into, the Ngemelis Islands complex, to provide penalties for violations of this Act, and for related purposes.* Available at: http://www.kororstategov.com/pdf/9th%20laws/K9-229-2010%20No%20Fishing%20Zone%20Ngemelis%20Area.pdf (Accessed: 4 January 2016).

Rock Islands Southern Lagoon Management Area Fact Sheet. http://www.kororstategov.com/pdf/Fact%20Sheet_2.15.13.pdf (Accessed: 4 January 2016).

QGIS Development Team (2015) QGIS Geographic Information System. Open Source Geospatial Foundation Project.

White, A. T., Courtney, C. A., & Salamanca, A. (2002). Experience with Marine Protected Area Planning and Management in the Philippines. *Coastal Management, 30*(1), 1-26.

Wilkinson, C., Green, A., Almany, J., & Dionne, S. (2003). Monitoring coral reef marine protected areas: A practical guide on how monitoring can support effective management of MPAs (Version 1. ed., p. 2). Townsville, Qld., Australia: Australian Institute of Marine Science.

Appendix 1: Commercially important fish species in Palau

Commercially important fish species in Palau			
	Common name	**Palauan name**	**Scientific name**
1	Bluefin trevally	Erobk	*Caranxignobilis*
2	Giant trevally	Oruidel	*Caranxmelampygus*
3	Bicolor parrotfish	Beyadel/Ngesngis	*Cetoscarus bicolor*
4	Parrotfish species	Melemau	*Cetoscarus/Chlorurus/Scarus*spp
5	Yellow cheek tuskfish	Budech	*Choerodonanchorago*
6	Indian ocean longnose parrotfish	Bekism	*Hiposcarusharid*
7	Pacific longnose parrotfish	Ngeaoch	*Hipposcaruslongiceps*
8	Rudderfish	Komud, Teboteb	*Kyphosusspp (vaigiensis)*
9	Orangestripe emperor	Udech	*Lethrinusobsoletus*
10	Longface emperor	Melangmud	*Lethrinusolivaceus*
11	Red gill emperor	Rekruk	*Lethrinusrubrioperculatus*
12	Yellowlip emperor	Mechur	*Lethrinusxanthochilis*
13	Squaretail mullet	Uluu	*Liza vaigiensis*
14	River snapper	Kedesau'liengel	*Lutjanusargentimaculatus*
15	Red snapper	Kedesau	*Lutjanusbohar*
16	Humpback snapper	Keremlal	*Lutjanusgibbus*
17	Orangespineunicornfish	Cherangel	*Nasolituartus*
18	Bluespineunicornfish	Chum	*Nasounicornis*
19	Giant sweetlips	Melimralm,Kosond/Bikl	*Plectorhinchusalbovittatus*
20	Yellowstripe sweetlips	Merar	*Plectorhinchuscrysotaenia*
21	Pacific steephead parrotfish	Otord	*Scarusmicorhinos*
22	Greenthroat parrotfish	Udouungelel	*Scarusprasiognathus*
23	Forketailrabbitfish	Beduut	*Siganusargenteus*
24	Lined rabbitfish	Kelsebuul	*Siganuslineatus*
25	Masked rabbitfish	Reked	*Siganuspuellus*
26	Goldspottedrabbitfish	Bebael	*Siganuspunctatus*
27	Bluespot mullet	Kelat	*Valamugilseheli*
Protected Fish Species (yearly and seasonal fishing closure)			
28	Bumphead parrotfish	Kemedukl	*Bolbometoponmuricatum*
29	Humpheadwrasse	Ngimer, Maml	*Cheilinusundulatus*
30	Brown-marbled grouper	Meteungerel'temekai)	*Epinephelusfuscoguttatus*
31	Marbled grouper	Ksau'temekai	*Epinepheluspolyphekadion*
32	Squaretail grouper	Tiau	*Plectropomusareolatus*
33	Saddleback grouper	Katuu'tiau, Mokas	*Plectropomuslaevis*
34	Leopard grouper	Tiau (red)	*Plectropomusleopardus*
35	Dusky rabbitfish	Meyas	*Siganusfuscescens*

Appendix 2: Macro-invertebrates targeted by the local fisheries

Common names	**Palauan name**	**Scientific name**
Black teatfish	Bakelungal-chedelkelek	*Holothurianobilis*
White teatfish,	Bakelungal-cherou	*Holothuriafuscogilva*
Golden sandfish	Delalamolech	*Holothurialessoni*
Hairy blackfish	Eremrum, cheremrumedelekelk	*Actinopygamiliaris*
Hairy greyfish	Eremrum, cheremrum	*Actinopyga sp.*
Deepwater red fish	Eremrum, cheremrum	*Actinopygaechinites*
Deepwater blackfish	Eremrum, cheremrum	*Actinopygapalauensis*
Stonefish	Ngelau	*Actinopygalecanora*
Dragonfish	Irimd	*Stichopushorrens*
Brown sandfish	Meremarech	*Bohadschiavitiensis*
Chalk fish	Meremarech	*Bohadschiasimilis*
Leopardfish /tigerfish	Meremarech, esobel	*Bohadschiaargus*
Sandfish	Molech	*Holothuria scabra*
Curryfish	Delal a ngimes/ngimesratmolech	*Stichopushermanni*
Brown curryfish	Ngimes	*Stichopusvastus*
Slender sea cucumber	Sekesaker	*Holothuria impatiens*
Prickly redfish	Temetamel	*Thelenotaananas*
Amberfish	Belaol	*Thelenotaanax*
Elephant trunkfish	Delal a molech	*Holothuriafuscopunctata*
Flowerfish	Meremarech	*Pearsonothuriagraeffei*
Surf red fish	Badelchelid	*Actinopygamauritiana*
Crocus giant clam	Oruer	*Tridacnacrocea*
Elongate giant clam	Melibes	*Tridacna maxima*
Smooth giant clam	Kism	*Tridacnaderasa*
Fluted giant clam	Ribkungel	*Tridacnasquamosa*
Bear paw giant clam	Duadeb	*Hippopushippopus*
True giant clam	Otkang	*Tridacnagigas*
Sea urchin	Ibuchel	*Tripneustesgratilla*
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 (in UTM)

Vertical Wall

ID	lat	long
1	789502.076	414253.611
2	789049.07	414074.377
3	786861.013	415759.752

Fore Reef

4	785442.004	416054.198
5	785085.253	415977.739
6	788786.403	414032.923

Reef Crest

7	786909.782	419672.972
8	785545.629	416160.179
9	789265.31	414220.176

Channel

10	787105.376	419818.714
11	787009.765	419577.826
12	787369.726	419792.925

Unknown

13	790329.77	414504.397
14	790862.562	414674.757
15	791599.362	414637.013
16	790709.283	414756.279

Lagoon

ID	lat	long
17	787201.849	416588.735
18	791027.812	416813.548
19	787233.781	417152.824
20	787430.01	417354.92
21	788158.74	416729.826
22	787099.169	416753.84
23	788968.564	418408.604
24	788413.72	417298.217
25	787198.702	416962.695
26	790646.937	417417.783

Back Reef

ID	lat	long
27	785638.012	417229.082
28	790781.877	415568.645
29	784901.034	416513.761
30	786748.782	418175.506
31	788422.26	414933.07
32	790148.713	416301.014
33	787427.985	418815.545
34	787357.962	419064.623
35	788020.324	414819.227
36	788606.343	419115.95
37	788659.872	419500.561
38	790596.371	415162.843
39	787138.644	418526.75
40	791359.007	416660.387
41	788715.989	416169.597
42	787519.403	418121.762