Baseline Assessment of Ngeruangel Marine Reserve

Shirley Koshiba, Marine Gouezo, Lincoln Rehm, Dawnette Olsudong,

Geory Mereb, Randa Jonathan

Palau International Coral Reef Center

PICRC Technical Report No. 15-03

September 2014

Abstract

Marine Protected Areas (MPAs) have become an effective tool in managing coastal marine resources not only in Palau but worldwide. In 2006, Palau established the Palau Protected Areas Network (PAN), as a national conservation strategy to conserve and protect Palau's marine and terrestrial resources. As part of Palau's national goal for conserving marine resources, the Palau International Coral Reef Center conducted baseline assessments of all PAN MPAs in Palau. This study is a baseline assessment of the marine resources in Ngeruangel Marine Reserve. The study focused on the density and biomass of commercially important fish species, coral cover, coral recruits density and the density of commercially valuable and edible invertebrates. Our results show that there was a relatively higher fish biomass in the back-reef and fore-reef compared to the lagoon, however the differences in mean fish biomass across all habitats were not significant. In addition, coral cover was considerably low in all habitats compared to carbonate, rubble and sand which appeared in higher percentages across all habitats. Densities of commercially valuable invertebrates also appeared in relatively low numbers. The results presented in this report suggest that the impact of recent natural disturbances such as typhoons had an influence on the biomass and densities of the marine resources in Ngeruangel Marine Reserve. Thus, further ecological monitoring of the MPA overtime is required in order to evaluate the effectiveness and progress of Ngeruangel Marine Reserve.

1. Introduction

Marine Protected Areas (MPAs) have become a widely used tool in managing and conserving marine resources. In addition to the usefulness of MPAs, studies have demonstrated that the spillover effect of MPAs to surrounding reefs (of both adults and larvae) is one of the many benefits of MPAs. Thus, reserve networks have the ability to provide a considerably large source of recruitment to populations in both protected and unprotected areas on a regional scale (Harrison et al, 2012). In the Republic of Palau, a network of protected areas was created in 2006 to help conserve and protect Palau's biodiversity. Known as the Palau Protected Areas Network (PAN), the PAN is now being used to achieve the goals of the Micronesia Challenge (MC). As a regional conservation initiative, the MC is a commitment by the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, the Commonwealth of the Northern Marianas, and Guam to effectively conserve 30% of near-shore marine resources and 20% of terrestrial resources by the year 2020 (Micronesia Challenge Report, 2011).

In addition to Palau's current national and regional efforts in conserving and protecting biodiversity, the Palau International Coral Reef Center (PICRC) made a commitment to conduct baseline surveys of all MPAs within the PAN network. This report presents baseline data collected in Ngeruangel Marine Reserve, a locally managed marine reserve that is part of the PAN. The data presented in this report will be used with subsequent monitoring of the various ecological indicators to assess the long-term trends and effectiveness of the MPA.

Ngeruangel Marine Reserve (Fig. 1) is located in Kayangel State, the northern most island of the Palau archipelago. The reserve is 10 km^2 and consists of a small islet. The small islet on Ngeruangel is a breeding area for the Great Nested Tern and a known nesting site for the Green Turtle and Hawksbill Turtle. In 1996, Ngeruangel was designated as a marine reserve through a traditional closure, or *bul*, by the chiefs of Kayangel State and later became a legislated marine reserve through the Ngeruangel Reserve Act of 1996 that was passed by the Kayangel State Government.

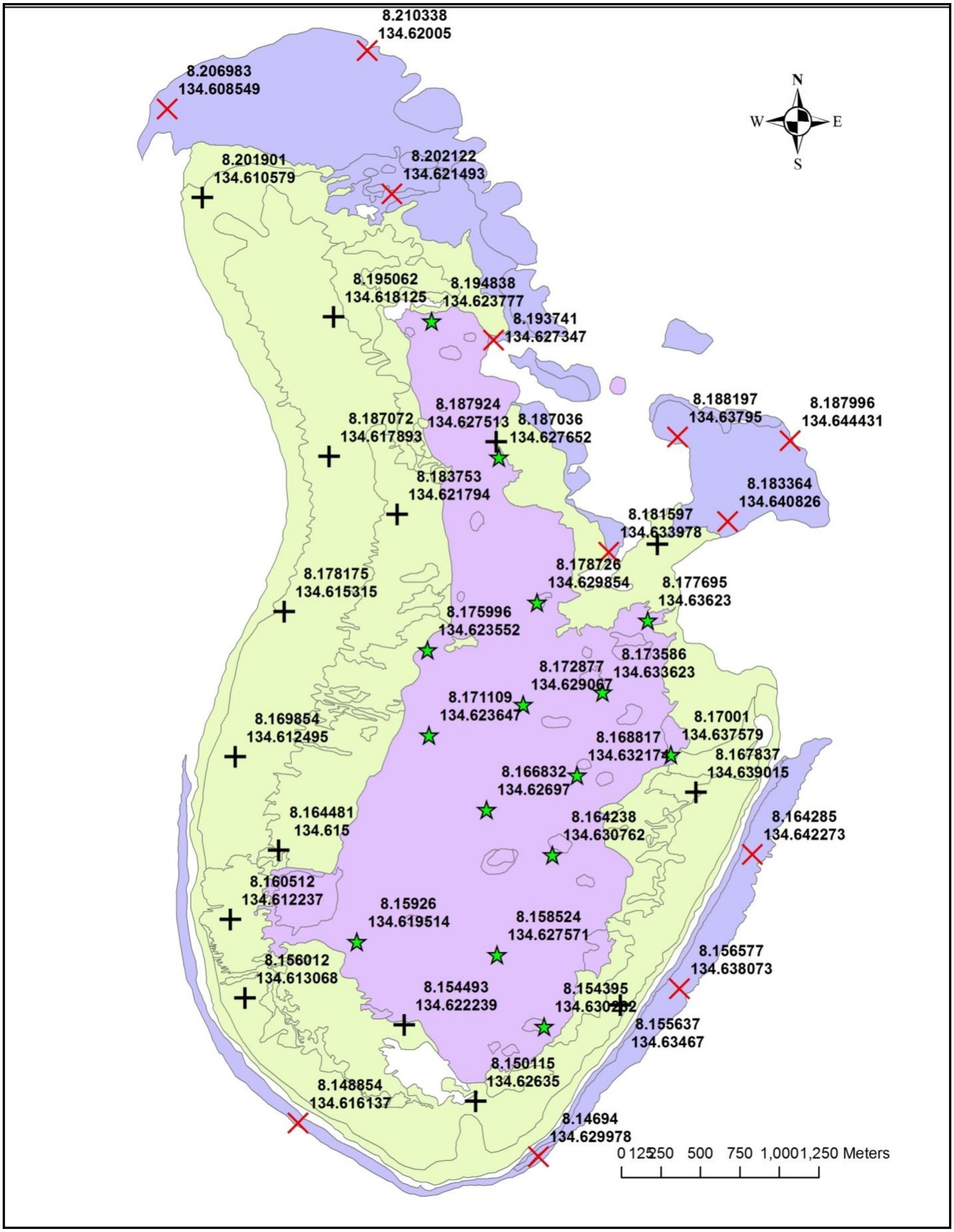

Figure 1. Map of Ngeruangel Marine Reserve and randomly selected survey sites within each habitat: fore-reef (green), back-reef (light blue), and lagoon (purple).

2. Methods

Study site

This study was conducted in Ngeruangel Marine Reserve in May 2014 (Fig.1). A total of forty-two randomly selected sites were surveyed within each habitat with 15 sites in the back-reef, 12 sites in the fore-reef, and 15 sites in the lagoon. The numbers of survey sites within Ngeruangel Marine Reserve were distributed according to the size of each major habitat with larger habitats having more sites compared to smaller habitats. At each site, three 30 m belt transects were laid following the reef contour at 3 – 5 m and a number of biological metrics were recorded.

Fish Surveys

The abundance and density of commercially-valuable fish species (Appendix 1) was surveyed along each 30 x 5m transect (total area per transect = 150 m^2), and the length of each fish species was estimated to the nearest cm. For fish surveys, the size, density and biomass were estimated, 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 obtained from fish base (www.fishbase.org).

Benthic, Invertebrate, and Coral Recruits Surveys

Edible and commercially targeted macro-invertebrates were identified and measured in centimeters along a reduced belt width of 30 x 2m transect (total area per transect = 60 m^2).

Coral recruits surveys were conducted on the first 10 m of each transect. The species and size (i.e. < 5cm maximum diameter) of coral recruits were recorded along a 0.30 x 10 m transect (total area per transect = 3 m^2). One meter square photoquadrats were recorded along the length of each transect of each 30 m transect to survey the benthic community. Benthic composition was analyzed using CPCe (Coral Point Count with excel extensions); in which five random points from each quadrat were used to generate estimates of coral cover, with corals identified to the genus level. All data were collated in Microsoft Excel and analyzed using a One-way ANOVA and Kruskal-Wallis test when ANOVA assumptions weren't met.

3. Results

3.1 Fish density and biomass

The mean fish density did not vary greatly among the three major habitats in Ngeruangel Marine Reserve (ANOVA; F=0.4208, p= 0.65). Mean fish density for the back-reef habitat was 17 fish per 150 m^2, while the fore-reef and lagoon had average fish densities of 13 fish per 150 m^2 (Fig.2). Similarly, fish biomass was not significantly different amongst the three habitats in Ngeruangel Marine Reserve (ANOVA ; F=0.4606, p=0.6343). Mean fish biomass in the back-reef was 15, 409.967 g per 150 m^2, while the fore-reef had a mean biomass of 15,049.460 g per 150m^2 with the lowest fish biomass occurring in the lagoon with an average fish biomass of 9,917.370 g per 150 m^2 (Fig. 3).

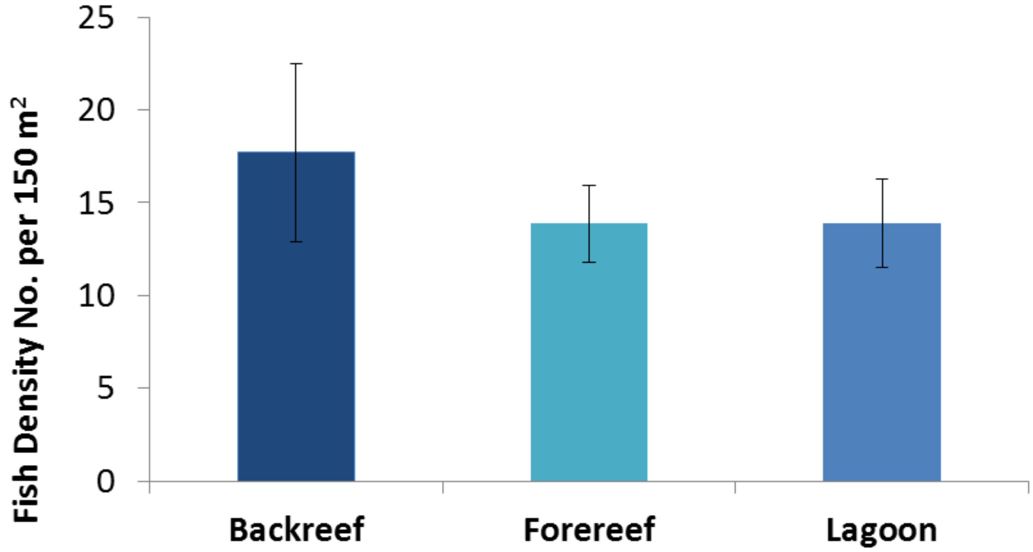

Figure 2. Mean fish density for each habitat in Ngeruangel Marine Reserve. Error bars indicate standard errors.

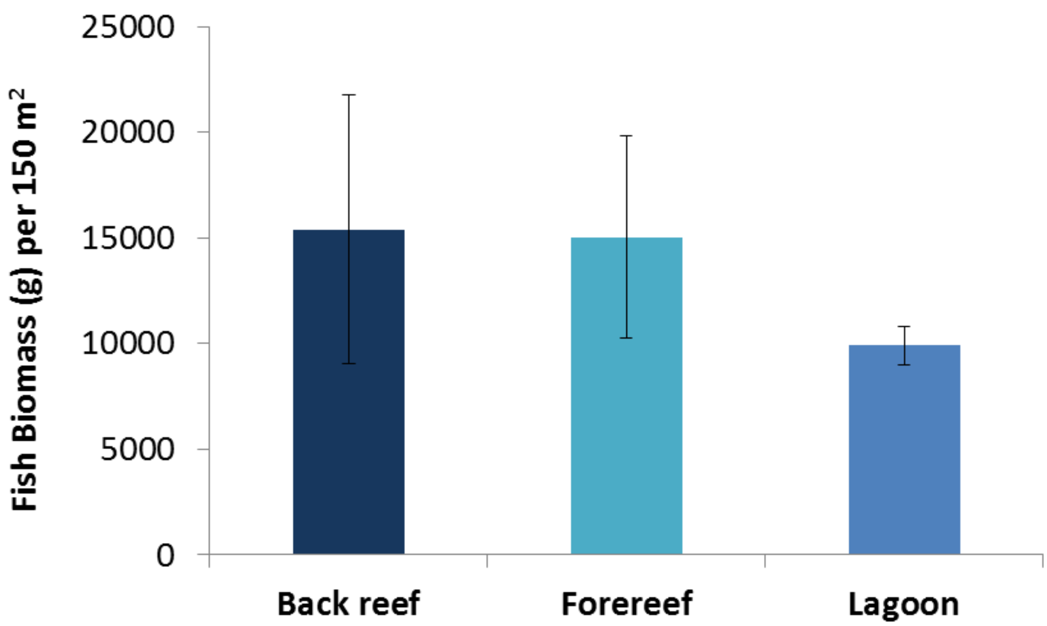

Figure 3. Mean biomass of fish for each habitat in Ngeruangel Marine Reserve. Error bars indicate standard errors.

3.2 Invertebrate Density

Densities of commercially targeted and edible invertebrates (Appendix 2) did not vary significantly between the three habitats in Ngeruangel Marine Reserve (ANOVA; F=0.8991, p=0.4152). The habitat showing the highest invertebrate densities was the lagoon, which had an average density of 3.3 individuals per 60 m^2, compared to the fore-reef and back-reef habitats which had average densities of less than 3 individuals per 60 m^2 (Fig. 4).

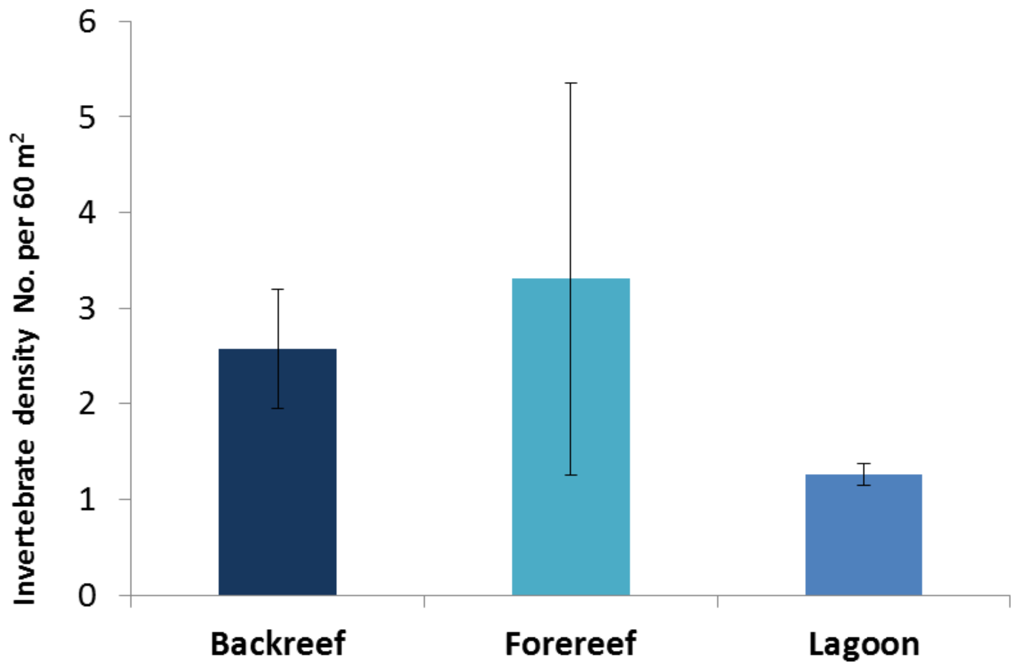

Figure 4. Mean Invertebrate density for each habitat in Ngeruangel Marine Reserve. Error bars indicate standard errors.

3.3 Coral Recruits Density

Coral recruits (i.e. < 5cm maximum diameter) densities were also not significantly different amongst the three habitats within Ngeruangel Marine Reserve (ANOVA; F=2.191, p=0.1254). The highest average density of coral recruits was in the back-reef with 6.7 individuals per $3m^2$, while the fore-reef and lagoon had average coral recruit densities of less than 6 individuals per $3m^2$ (Fig. 5).

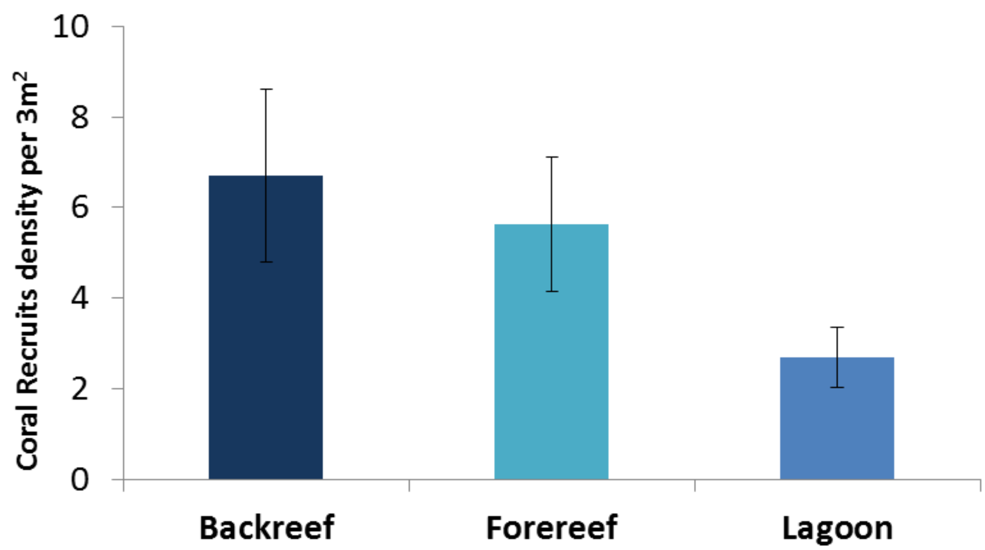

Figure 5. Mean Coral Recruits density for each habitat in Ngeruangel Marine Reserve. Error bars indicate standard errors.

3.4 Benthic composition

Coral cover was significantly higher in the fore-reef (6.8%) compared to the lagoon (1.7%) (p=0.0295) (Fig.6). Similarly, coral cover in the back-reef (6%) was also significantly higher compared to the coral cover in the lagoon (p=0.0422). The fore-reef had a significantly higher carbonate cover compared to the lagoon (p=0.0001), similar to the back-reef having a significantly higher carbonate cover compared to the lagoon (p=0.0039). In terms of sand cover, the back-reef and lagoon had an average sand cover of 27% and 35% respectively, while the fore-reef had an average sand cover of 6%. The lagoon had the highest rubble cover of 40% with the back-reef and fore-reef having an average rubble cover of 23% and 11%, respectively (Fig.6).

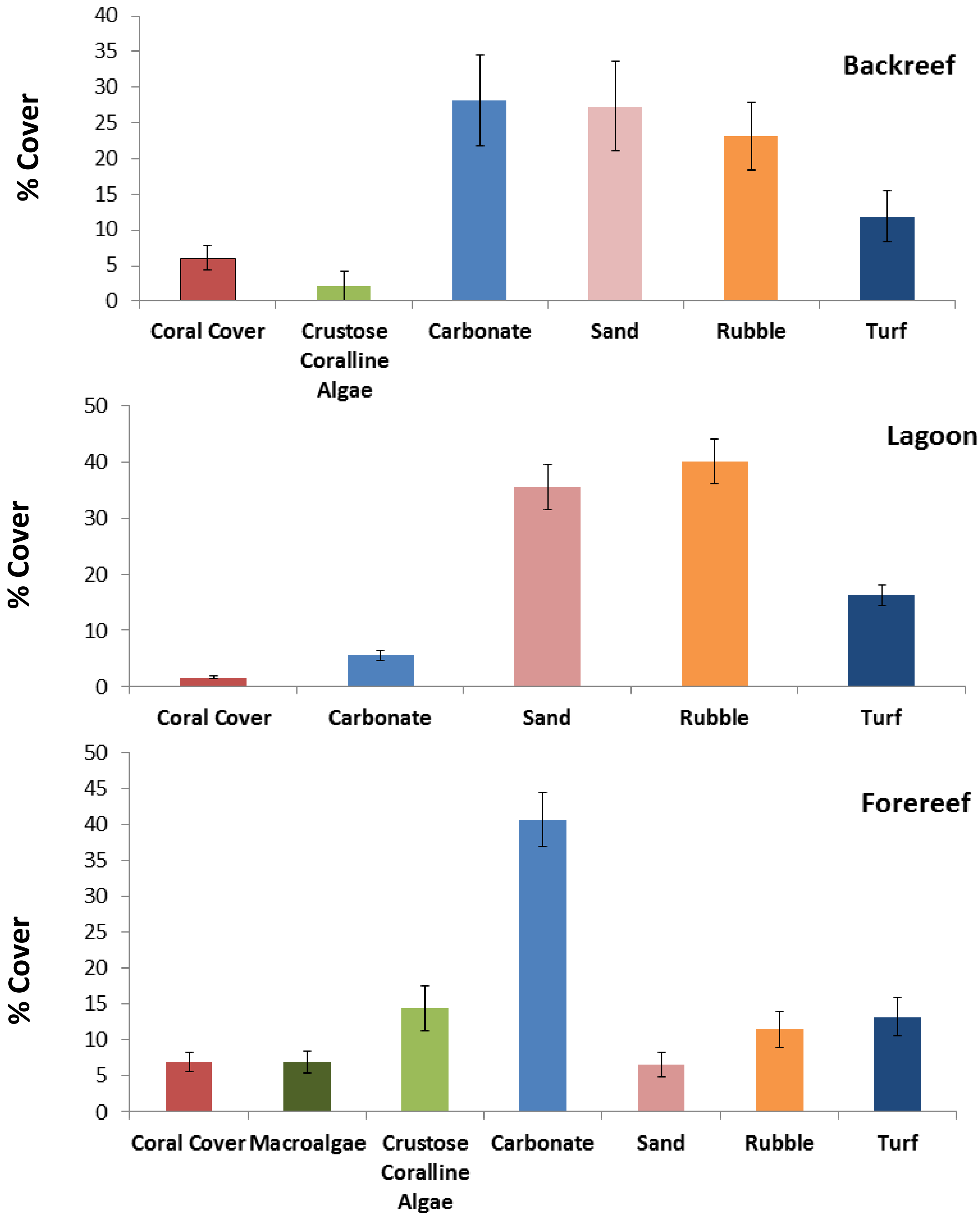

Figure 6. Benthic coverage in the back-reef, lagoon and fore-reef habitats within Ngeruangel Marine Reserve. Error bars indicate standard errors.

4. Discussion

The overall focus of this study in Ngeruangel Marine Reserve was to collect baseline data on specific ecological indicators that will provide resource managers and relevant stakeholders the necessary information for evaluating the effectiveness and progress of MPAs. In 2012, Ngeruangel Marine Reserve experienced Super-typhoon Bopha, and again in 2013, Super-Typhoon Haiyan heavily impacted Kayangel Island and its surrounding reefs, including Ngeruangel Marine Reserve. Having experienced such frequent natural disturbances the results presented in this report could be highly influenced by the impacts of both typhoons.

There were no major differences in the biomass and densities of fish amongst all habitats within Ngeruangel Marine Reserve (Fig. 2 & 3). Similarly invertebrate densities did not significantly differ amongst all three habitats, with relatively low coral cover across habitats as well (Fig. 6). Coral cover was the lowest in the lagoon with an average of 1.7%, and relatively low in the back reef (5.9%) and fore reef (6.8%) (Fig.6). Coral recruits densities were also not significantly different between all three habitats in Ngeruangel Marine Reserve (Fig. 5). High coral cover and low algal cover are associated with the rapid recovery of coral reef communities as demonstrated by Golbuu et al. 2005 and Golbuu et al. 2007 in examining the recovery of coral reef communities after a major bleaching event in Palau in 1998.

Given the results from this baseline assessment, these results could be highly influenced by the impacts of recent natural disturbances such as typhoons. Thus, further studies are needed in order to assess the changes and trends of the marine resources in Ngeruangel Marine Reserve. As a baseline assessment, the results presented in this report will be used for future monitoring purposes to assess the effectiveness and progress of Ngeruangel Marine Reserve, and to provide resource managers and relevant stakeholders the information needed to effectively conserve the marine resources in Ngeruangel Marine Reserve.

Acknowledgements

The Palau International Coral Reef Center would like to thank the Kayangel State Government and the Kayangel State Conservation Officers for their assistance throughout this study as well as Mark Priest for his assistance in reviewing this report.

References

H Harrison, D Williamson, R Evans, G Almany, S Thorrold, G Russ, K Feldheim, L Herwerden, S Planes, M Srinivasan, M Berumen, G Jones (2012). "Larval export from marine reserves and the recruitment benefit for fish and fisheries."Current Biology. doi:10.1016/j.cub.2012.04.008

Micronesia Challenge Steering Committee (2011). A Report on Progress to Implement the Micronesia Challenge 2006-2011, Micronesia Chief Executives Summit**:** 1-33.

Ngedebuul Conservation and Resource Planning Team (2012). "The people of Kayangel and the Kayangel Protected Areas Network Five Year Management Plan 2013 to 2018". 1-75.

Y Golbuu, S Victor, L Penland, D Idip Jr, C Emaurois, K Okaji, H Yukihira, A Iwase and R Van Woesik (2007). "Palau's coral reefs show differential habitat recovery following the 1998-bleaching event." Coral reefs 26(2): 319-332.

Y Golbuu, A Bauman, J Kuartei and S Victor (2005). "The state of coral reef ecosystems of Palau." The state of coral reef ecosystems of the United States and Pacific freely associated states: 488-507.

Appendix 1: Commercially important fish species in Palau

	Scientific name	Palauan name
1	*Caranxignobilis*	Erobk
2	*Caranxmelampygus*	Oruidel
3	*Cetoscarus bicolor*	Beadel/Ngesngis
4	*Cetoscarus/Scarus Spp.*	Mellemau
5	*Choerodonanchorago*	Budech
6	*Hipposcaruslongiceps*	Ngiaoch
7	*Hiposcarusharid*	Bekism
8	*Kyphosusspp (vaigiensis)*	Komud, Teboteb
9	*Lethrinusobsoletus*	Udech
10	*Lethrinusolivaceus*	Melangmud
11	*Lethrinusrubrioperculatus*	Rekruk
12	*Lethrinusxanthochilis*	Mechur
13	*Liza vaigiensis*	Uluu
14	*Lutjanusargentimaculatus*	Kedesau'liengel
15	*Lutjanusbohar*	Kedesau
16	*Lutjanusgibbus*	Keremlal
17	*Nasolituratus*	Cherangel
18	*Nasounicornis*	Chum
19	*Plectorhinchusalbovittatus*	Melimralm, Kosond/Bikl
20	*Plectorhinchuscrysotaenia*	Merar
21	*Scarusmicorhinos*	Otord
22	*Siganusargenteus*	Beduut
23	*Siganuslineatus*	Kelsebuul
24	*Siganuspuellus*	Reked
25	*Siganuspunctatus*	Bebael
26	*Valamugilseheli*	Kelat
Protected Fish Species (yearly and seasonal fishing closure)		
27	*Bolbometoponmuricatum*	Kemedukl
28	*Cheilinusundulatus*	Maml
29	*Epinephelusfuscoguttatus*	Meteungerel'temekai)
30	*Epinepheluspolyphekadion*	Ksau'temekai
31	*Plectropomusareolatus*	Tiau
32	*Plectropomuslaevis*	Tiau, Katuu'tiau, Mokas
33	*Plectropomusleopardus*	Tiau
34	*Siganusfuscescens*	Meyas

Appendix 2: Edible and commercially valuable Invertebrates in Palau

	Scientific name	Palauan name
1	*Actinopygaechinites*	Eremrum, cheremrum
2	*Actinopygalecanora*	Ngelau
3	*Actinopygamauritiana*	Badelchelid
4	*Actinopygamiliaris*	Eremrum, cheremrumedelekelk
5	*Actinopygapalauensis*	Eremrum, cheremrum
6	*Actinopyga sp.*	Eremrum, cheremrum
7	*Bohadschiaargus*	Meremarech, esobel
8	*Bohadschiasimilis*	Meremarech
9	*Bohadschiavitiensis*	Meremarech
10	*Hippopushippopus*	Duadeb
11	*Holothuriaatra*	Cheuas
12	*Holothuriacoluber*	Cheuas
13	*Holothuriaedulis*	Cheuas
14	*Holothuriafuscogilva*	Bakelungal-cherou
15	*Holothuriafuscopunctata*	Delal a molech
16	*Holothuria impatiens*	Sekesaker
17	*Holothurialessoni*	Delalamolech
18	*Holothurialeucospilota*	Cheuas
19	*Holothurianobilis*	Bakelungal-chedelkelek
20	*Holothuria scabra*	Molech
21	*Holothurisfalvomaculata*	Cheuas
22	*Pearsonothuriagraeffei*	Meremarech
23	*Stichopuschloronotus*	cheuas
24	*Stichopushermanni*	Delal a ngimes/ngimesratmolech
25	*Stichopushorrens*	Irimd
26	*Stichopusvastus*	Ngimes
27	*Thelenotaananas*	Temetamel
28	*Thelenotaanax*	Belaol
29	*Tridacnacrocea*	Oruer
30	*Tridacnaderasa*	Kism
31	*Tridacnagigas*	Otkang
32	*Tridacna maxima*	Melibes
33	*Tridacnasquamosa*	Ribkungel
34		Ibuchel
35		Semum

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"