NGELUKES CONSERVATION AREA

BASELINE ASSESSMENT

Evelyn Otto, Marine Gouezo, Dawnette Olsudong, Jay Oruetamor

Randa Jonathan, Geory Mereb

Palau International Coral Reef Center

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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 Ngchesar's Ngelukes Conservation Area (CA) was conducted to determine baseline data for long term adaptive management of the protected areas in Palau. Nine randomly selected sites were chosen and surveyed on September 23, 2015. The assessment is specifically geared to establishing an initial database for the benthic community, coral recruit, commercially important invertebrates, and the abundance and biomass of commercially important fish. Of the nine sites, three were located on the fore reef, three on the reef crest, and three on the reef flat. This assessment shows that the fore reef had the highest observation of commercially important fish abundance and biomass, coral cover, and coral recruit density of the three habitats. The fish census show that Ngelukes CA has a high abundance of parrot fish such as Melemau (*Scarus spp.*) and Bikism (*Chlorurus sordidus*) to name a few. The reef crest showed low coral cover and fish abundance and biomass, but high carbonate substrate and high density of clams. Whereas the reef flat had low fish abundance and biomass, invertebrate density, and coral recruit, but had high sand and sea grass cover (*T. hemprichii* and *E. acroides*).

1. INTRODUCTION

Marine Protected Areas (MPAs) are conservation tools that protect biodiversity and assist in 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 nationwide, 33 of which cover marine habitats. In 2003, Palau established by legislation, the Protected Areas Network (PAN), which serves as a nation-wide system of protected areas (RPPL No. 6-39). In 2007, Palau strengthened its national conservation campaign by joining forces with the Micronesia Challenge (MC). This collaboration commits Palau to effectively conserving at least 30% of near-shore marine resources and 20% of terrestrial resources by 2020.

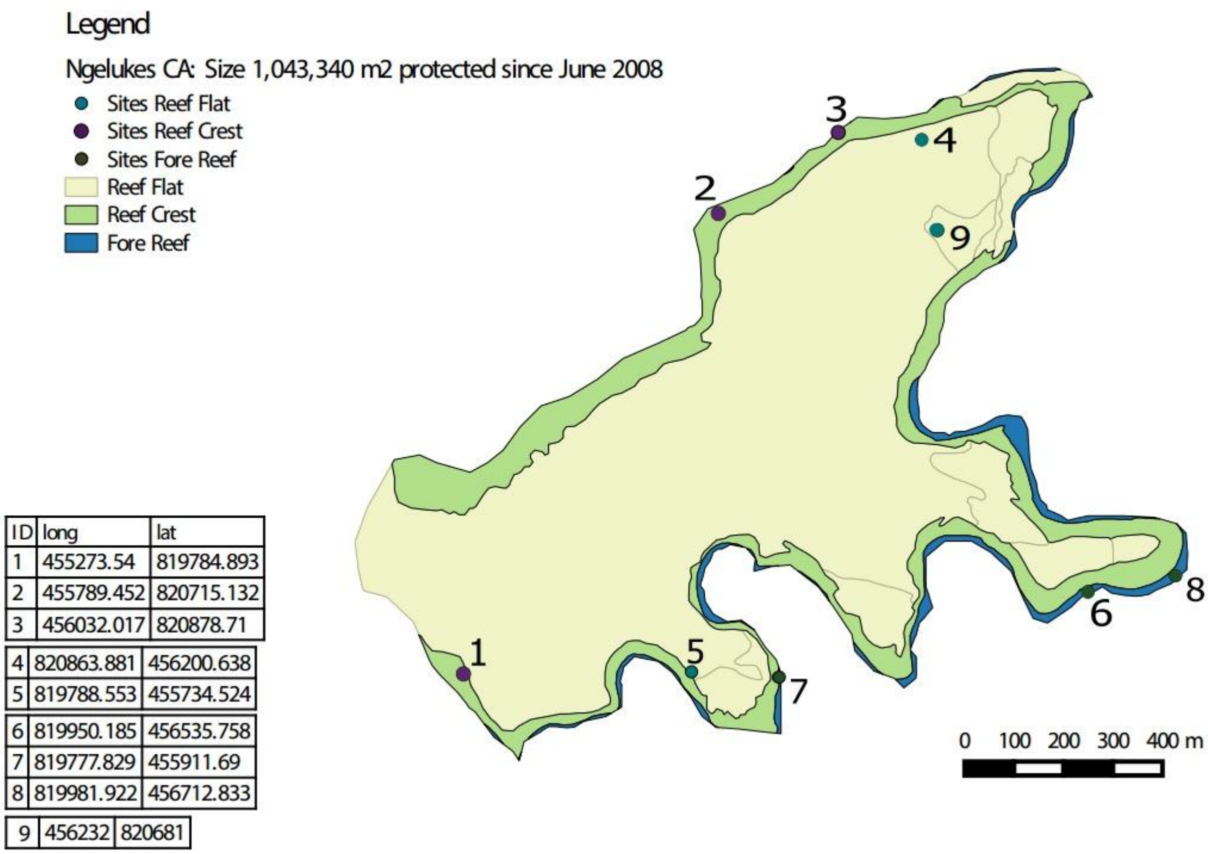
Biological monitoring is an essential component of adaptive management to measure the effectiveness and progress of MPAs. In order to effectively manage protected areas, resource managers and relevant stakeholders need information on the changes and trends in the condition of resources. MPA monitoring data provide the resource managers key information that will assist in decision-making (Wilkinson *et al 2003)*.

Established in 2002, the state of Ngchesar passed their legislation to close off a section of the states marine habitat for conservation purposes, known as Ngelukes Conservation Area (Ngirkelau *et al* 2010). In March of 2011, Ngelukes CA became a PAN site, which is the second CA in Ngchesar. The first being Mesekelat CA, a watershed and forest area. Ngelukes is approximately 1.04 km^2 of patch reef and consist of three different habitats - fore reef, reef crest, and reef flat.

This survey is a baseline assessment that was conducted by the Palau International Coral Reef Center (PICRC) during one day in September of 2015. The objective of assessing Ngelukes CA was to collect baseline data on commercially important fish abundance and biomass, commercially important invertebrate densities, benthic cover, and coral recruitment. This information will act as the original data that will be used for comparison with future assessments.

2. METHODS

This study was conducted on September 23, 2015 and targeted the fore reef, reef flat, and reef crest habitats at a depth between 1-5 m. A total of nine randomly selected sites were surveyed within Ngelukes CA. The monitoring protocol followed an established method from determining location and analyzing the data, in order to ensure uniformity among all MPA assessments. Random site 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.



ID	long	lat
1	455273.54	819784.893
2	455789.452	820715.132
3	456032.017	820878.71
4	820863.881	456200.638
5	819788.553	455734.524
6	819950.185	456535.758
7	819777.829	455911.69
8	819981.922	456712.833
9	456232	820681

Figure 1: A map of Ngchesar's Ngelukes Conservation Area, showing the nine randomly selected locations of the surveyed sites.

Fish surveys targeted fishes that are commercially important and were conducted on 30 m x 5 m belt transects (150 m² total area per transect) where the abundance as well as the estimated length of each fish (in centimeters) were recorded. Commercially targeted invertebrates were identified and recorded along a reduced width of 30 m x 2 m (60 m² total area per transect). Benthic coverage which includes coral cover was recorded by taking pictures using a wide angle lens camera (Canon G16 with attachable fish eye) and a 1 m² photo-quadrat alongside the right side of each 30 m transect. Coral recruits were measured on a further reduced width of 0.3 m x 10 m (3 m^2 total area per transect).

Back in the laboratory, the photographs of benthic and coral coverage were analyzed using the program called Coral Point Count with excel extensions, otherwise known as 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 for biomass-length relationships taken 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.

3. RESULTS

3.1 Fish Abundance

Mean abundance for all commercially important fish (see Appendix 1) observed in Ngelukes CA was 16.9 fish (± 9.3 SE). For all commercially important fish observed at each habitat, the fore reef had the highest density observed at 32.4 fish (± 3.4 SE) per 150 m^2. The reef crest had mean abundance of 18 fish (± 4.2 SE) per 150 m^2 and the reef flat had a mean of 0.2 fish (± 0.2 SE) (Fig 2). Of the 20 species observed, 11 were different types of parrot fish found in the following genus: *Scarus* (Melemau), *Hipposcarus* (Bekism), *Chlorurus* (Otord), *Cetoscarus* (Ngesngis), *Bolbometopon* (Kamedukl). Figure 2 shows that most of the fish observed in each habitat were parrot fish. The fore reef recorded an average of 24.9 parrot fish (± 2.6 SE), the reef crest recorded 14.2 parrot fish (± 4.6 SE), and the reef flat recorded 0.2 parrot fish (± 0.2 SE) (Fig 2).

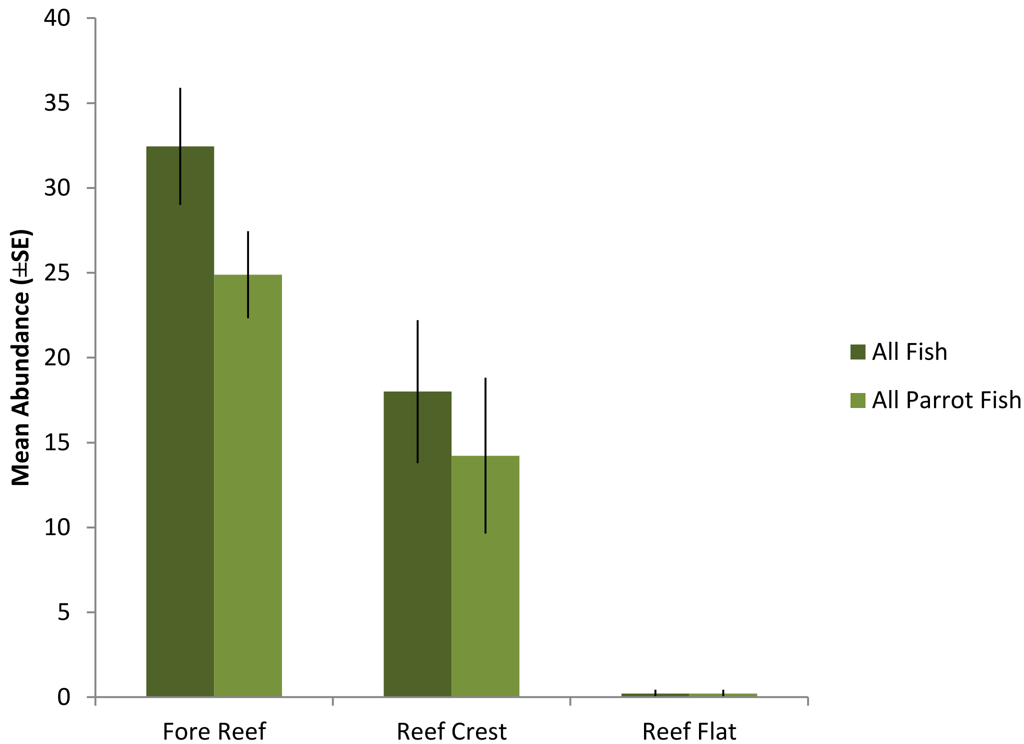


Figure 2: Abundance of the commercially important fish and all parrot fish observed in Ngelukes CA.

3.2 Fish Biomass

The mean biomass for all the commercially important fish observed within Ngelukes CA was 3056 g (± 2507.2 SE) per 150 m². For all commercially important fish observed at each habitat, the fore reef had an mean biomass of 8027.3 g (± 1473.3 SE), the reef crest recorded 1138.1 g (± 256.6 SE) and the reef flat had an average biomass of 2.4 g (± 2.4 SE)(Fig 3). For all the parrot fish recorded within each habitat, the fore reef had a mean of 6371.2 g (± 1512.8 SE), the reef crest had 804.9 g (± 258 SE), and the Reef Flat recorded a mean of 2.4 g (± 2.4 SE) (Fig 3).

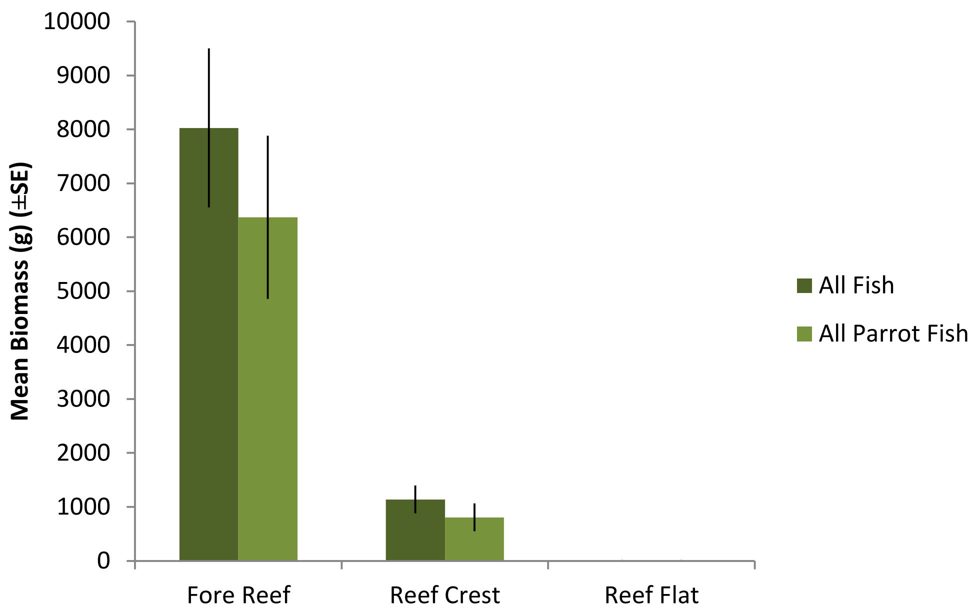


Figure 3: Mean biomass of all commercially important fish and all parrot fish observed within the three habitats – fore reef, reef crest, and reef flat

3.3 Invertebrates

Mean density of the commercially important invertebrates (Appendix 2) in the Ngelukes CA on the fore reef was 0.3 (± 0.2 SE) per 60 m^2. The reef crest had a mean density of 32.4 (± 10.8 SE), the highest of the three habitats. And the reef flat had a mean count of 0.4 (± 0.2 SE) (Fig 4).

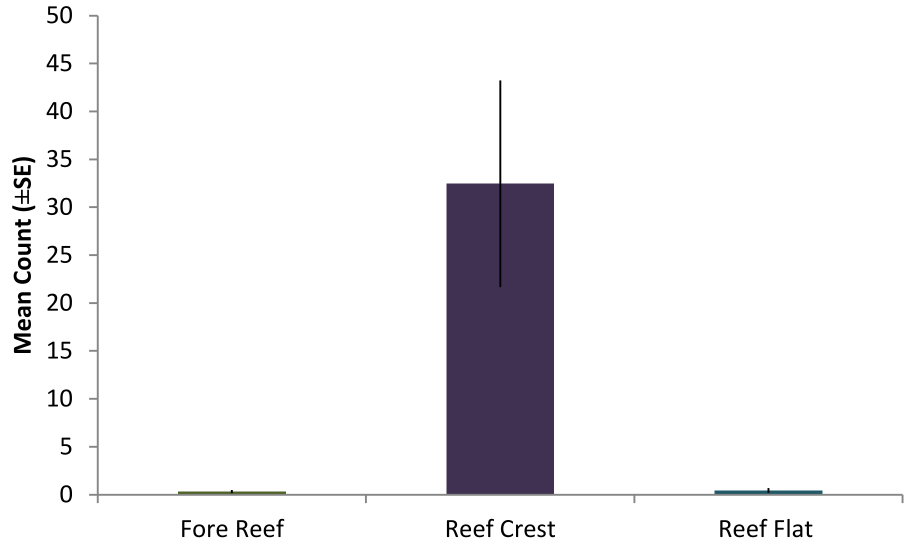


Figure 4: Mean density of invertebrates at Ngelukes Conservation Area

Of the 299 individual invertebrates recorded in Ngelukes, *Tridacna crocea* (Oruer) was the most abundant with a total count of 290 individuals, 289 observed on the reef crest and one on the reef flat (Fig 5). Of the 6 different species of invertebrates observed, *Bohadschia argus* (Mermarch) was the only species observed across each habitat - twice on the fore reef, once on the reef crest, and once on the reef flat.

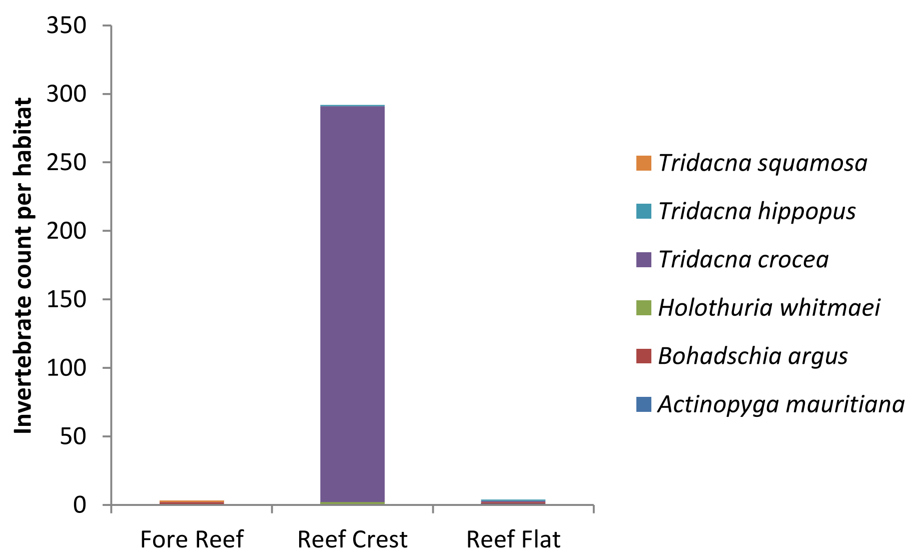


Figure 5: Invertebrates observed at Ngelukes Conservation Area

3.4 Coral Recruit

Mean density of coral recruits for Ngelukes CA on the fore reef was 3.2 (± 0.9 SE) per 3 m^2. The reef crest had a mean recruit count of 1.1 (± 0.5 SE) and the reef flat had the lowest of the three habitats with a recruit count of 0.8 (± 0.5 SE) (Fig. 6).

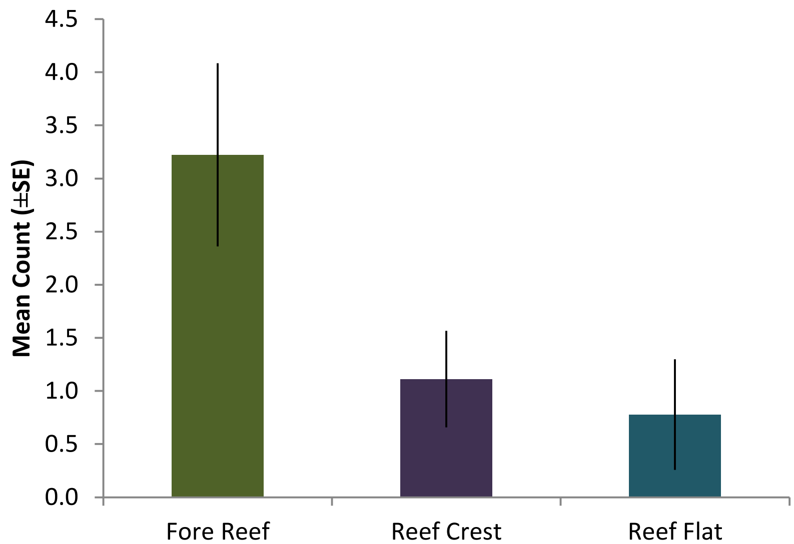


Figure 6: Mean density of coral recruits at Ngelukes Conservation Area

The most abundant recruit observed was *Montipora* with a total count of 16 and observed in the reef crest (1) and fore reef (15). For the lowest recruits, *Pachyseris* and *Pocillopora damicornis* were each observed once throughout the three habitats (Fig 7).

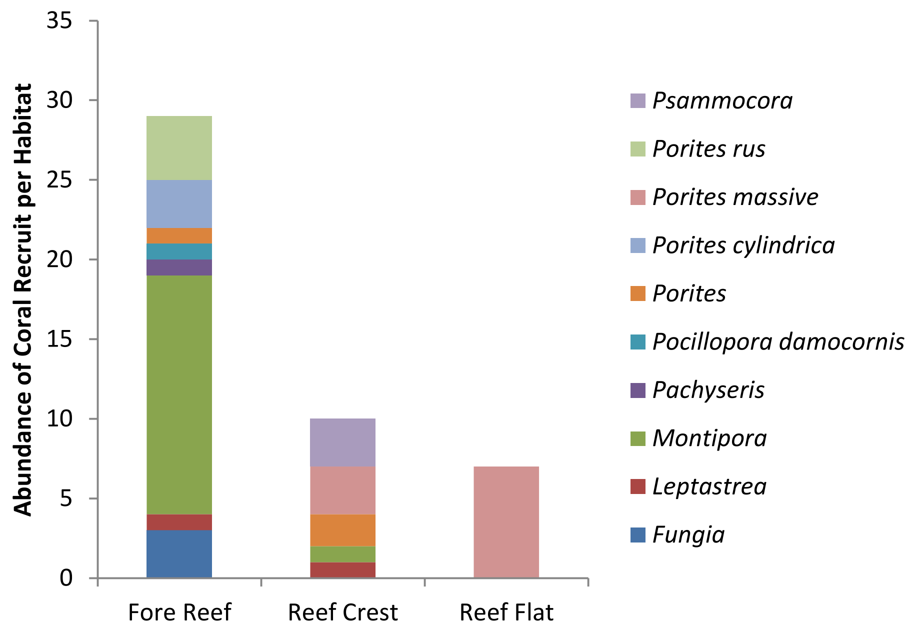


Figure 7: Total count of coral recruits observed per habitat within Ngelukes Conservation Area

3.5 Benthic cover

The fore reef was predominately made up on *Acropora* (29.9% [± 5.1% SE]), Carbonate (27.8% [± 4.8% SE]), and Turf (21.3% [± 3% SE]). The reef crest was predominately made of Carbonate (39 % [± 5.8% SE]), Turf (27.7% [± 3.2% SE]), and *Porities-massive* (12.9% [± 1.4% SE]). The reef flat predominately consisted of Sand (54.1% [± 4% SE]), *Thalassia hemprichii* (sea grass) (23.4% [± 3.6% SE]), and *Enhalus acroides* (sea grass) (10.4% [± 2.5% SE]) (Fig 8).

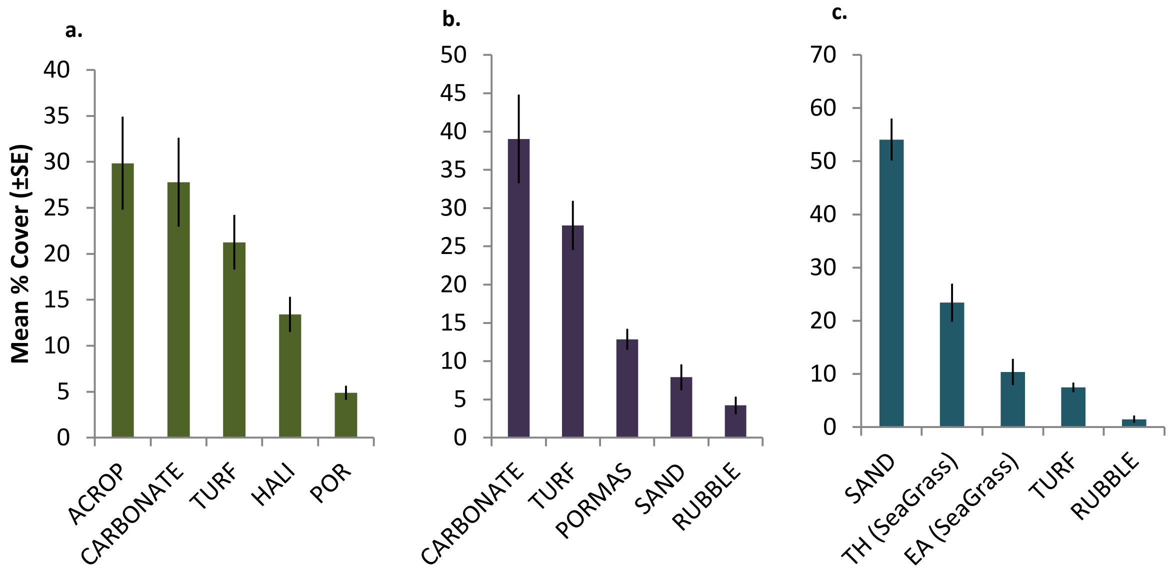


Figure 8: Mean benthic cover in percentage per habitat, benthic category in order of abundance

4. Discussion

The overall objective of this study was to collect environmental baseline information within Ngchesar's conservation area. Since 2002 when it became part of Ngchesar State Protected Area System (NSPAS) and further strengthened in 2011 when it became part of Palau's Protected Areas Network (PAN), this conservation area has been restricted as a "no entry-no take" area, intended to remove the pressure of overfishing (Ngirkelau *et al* 2010). The only activities allowed within this conservation area are for the purpose of research, monitoring and enforcement, and education. Access to this restricted area is only granted by Ngchesar State and State Governor. This study illustrates an interesting picture of the marine life within the conservation area and the difference among the three habitats. As the first assessment of the protected area, it is not required within the protocol to cross-reference a similar, non-conservation site. Over time, no-take marine protected areas have the ability to increase targeted fish and invertebrate density and biomass, given that enforcement and compliance is strictly regulated. Though strict enforcement is not enough, MPAs only function well when the local users accept and support the effort (Wilkinson *et al 2003)*.

This assessment shows that fish abundance and biomass, and coral recruits are notably higher on the fore reef and reef crest than those observed on the reef flat. The reef crest showed high abundance of invertebrates where both the fore reef and the reef flat recorded approximately the same density (3 and 4, respectively). The data shows that there is a correlation with the benthic make up of each habitat and the habitat communities. The fore reef has the highest coral community of the three habitats and had the highest fish abundance, biomass, and diversity. Eighteen different species of fish were observed on the fore reef compared with the reef crest which only had eight different species, and the reef flat that had observed one. With carbonate being the predominating benthic substrate on the reef crest, there is a notably higher count of invertebrates (289) than that of the fore reef (3) and the reef flat (4). The reef flat mainly consisted of sand followed by seagrass (*T. hemprichii* and *E. acroides*) and did not demonstrate high fish, invertebrate, or recruit count.

Future assessments in these areas would be able to project a progression and determine whether or not the management practices are working. If the management practices are found not to be working, this assessment compared with future ones will indicate how to adapt and where it is needed. Without an over abundance of the commercially targeted fish, the threat of poaching will apply to the invertebrates.

This data will be used by management to track the progress of the Ngelukes Conservation area. It is essential for policy makers and managers to keep an adaptive management style to ensure maximum growth over time. This is a present day assessment and results are subject to change over time. This information will indicate trends in each of the ecological indicators surveyed and will help management make necessary adjustments to ensure the effectiveness of the MPA.

ACKNOWLEDGMENT

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Seventh Olbiil Era Kelulau (2007) *RPPL NO. 7-42: An act to amend Title 24 of the Palau National Code, Chapter 34 to clarify the intent of the "Protected Areas Network Act"; to endorse the "Micronesia Challenge"; to provide financing provisions for the Protected Areas Network; and to implement an Environmental Protection Arrival Fee ("Green Fee") for the financial sustainability of the Protected Areas Network; and for other related purposes.* Available at: http://www.palauconservation.org/cms/images/stories/resources/pdfs/2007_PAN_Leg_GreenFee_MicronesiaChallenge.pdf (Accessed: 25 September 2015).

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: Macroinvertebrates 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)

Site	Long	Lat
1	455273.54	819784.893
2	455789.452	820715.132
3	456032.017	820878.71
4	820863.881	456200.638
5	819788.553	455734.524
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