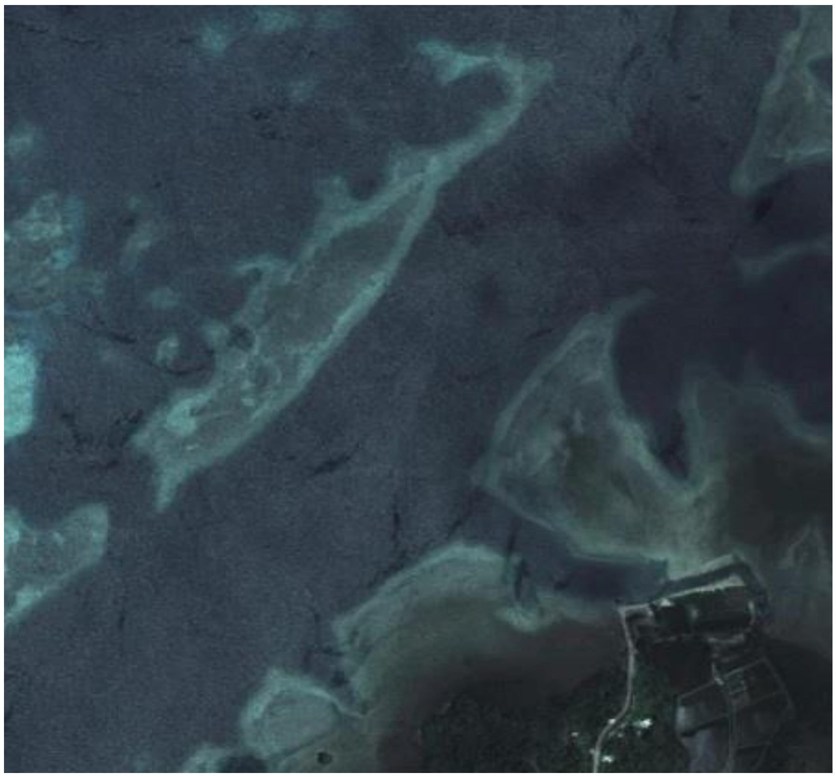
ORUAOL LIBUCHEL MARINE PROTECTED AREA BASELINE ASSESSMENT



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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 Ngatpang's Oruaol Libuchel protected area was conducted to determine baseline data for long term adaptive management of the protected areas in Palau. Six randomly selected sites were chosen and surveyed over a span of two days. The assessment is specifically geared to establish initial data for the benthic community, coral recruit, commercially important invertebrates, and the abundance and biomass of commercially important fish. Of the six sites, three were located in the lagoon and three on the reef flat. The lagoon had the highest fish density observed at 8.3 fish (± 1 SE) per 150 m^2 with respectively a higher biomass of 1202.6 fish (± 398.9 SE). The lagoon had an average invert density of 1 (± 0.5 SE), coral recruit density of 8 (± 2.1 SE), and coral density of 2.4% (± 0.8% SE). The reef flat had mean abundance of 1.7 fish (± 1 SE) per 150 m^2 and a mean biomass of 195.33 g (± 184.2 g SE). The reef flat had an average invert density of 2.9 (± 2.4 SE), coral recruit density of 12.4 (± 3.3 SE), and coral density of 1.5% (± 0.8% SE).

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.

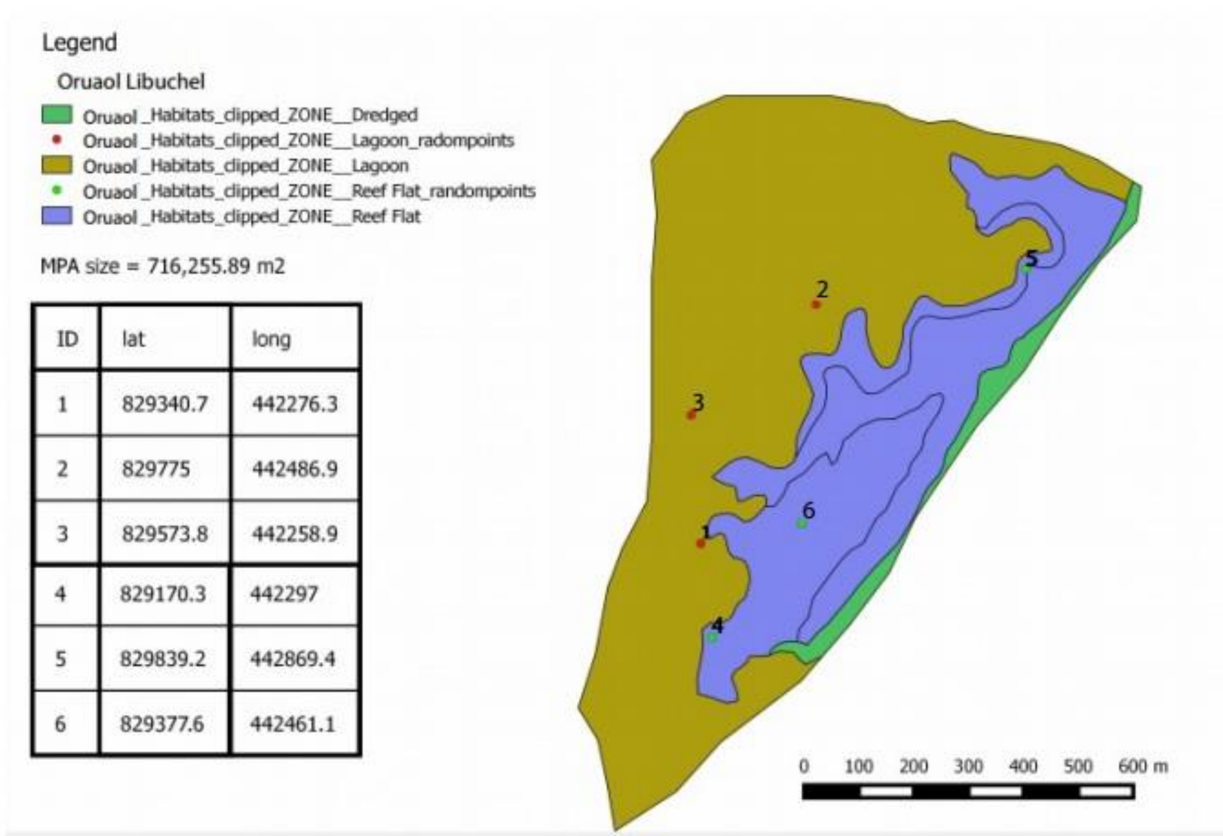
Biological monitoring is an essential component of adaptive management to measure the effectiveness and progress of MPAs. In order to effectively manage protected areas, resource managers and relevant stakeholders need information on the changes and trends in the condition of resources. MPA monitoring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

In 2000, the states of Aimeliik, Ngatpang, and Ngeremlengui joined together to establish Palau's primary marine nursery grounds and the largest marine estuary in all of Micronesia. Ngermeduu Bay, with the size of 129.6 k^2 includes 3 rivers, mangrove forests, sea-grass beds, lagoon and reefs, is one of the most biologically diverse marine areas in Palau (Sengebau *et al 2007*). Since the establishment of the Ngermeduu Bay Conservation area, these three states went on to established separate conservation areas within their boundaries and apply directly to their sustainable needs. The Ngatpang Conservation Act of 1999 established the Ngatpang Reserve which includes three areas and Ngatpang's portion of Ngermeduu Bay (Birkeland *et al (n.d)*). This assessment is focused on the fish conservation area of Ngatpang State.

This study is a baseline assessment that was conducted by the Palau International Coral Reef Center over two days in April of 2015. The objective of this assessment of the Ngatpang conservation area was to collect baseline data on commercially important fish abundance and biomass, 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 over two days in April (April 7^{th}, 8^{th}) and targeted the lagoon and the reef-flat habitats at a depth between 1-5 m. A total of six randomly selected sites were surveyed. The monitoring protocol follows an established method from determining location to analyzing the data in order to ensure uniformity among all MPA assessments. 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.



ID	lat	long
1	829340.7	442276.3
2	829775	442486.9
3	829573.8	442258.9
4	829170.3	442297
5	829839.2	442869.4
6	829377.6	442461.1

Figure 1: A map of Ngatpang's Oruaol Libuchel, showing the six randomly selected locations of the surveyed sites.

Fish surveys targeted those 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) was 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 each of the 30 m transect. Coral recruits were measured on a further reduced width of 0.3 m x 10 m (3 m² 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 published biomass-length relationships from Kulbicki et al. (2005) and from Fishbase (www.fishbase.org). At the Palau International Coral Reef Center, 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 fish in Oruaol Libuchel was 5 fish (± 1.6 SE) per 150 m^2. The Lagoon had the highest fish density observed at 8.3 fish (± 1 SE) per 150 m^2. The Reef Flat had mean density of 1.7 fish (± 1 SE) per 150 m^2 (Fig 2).

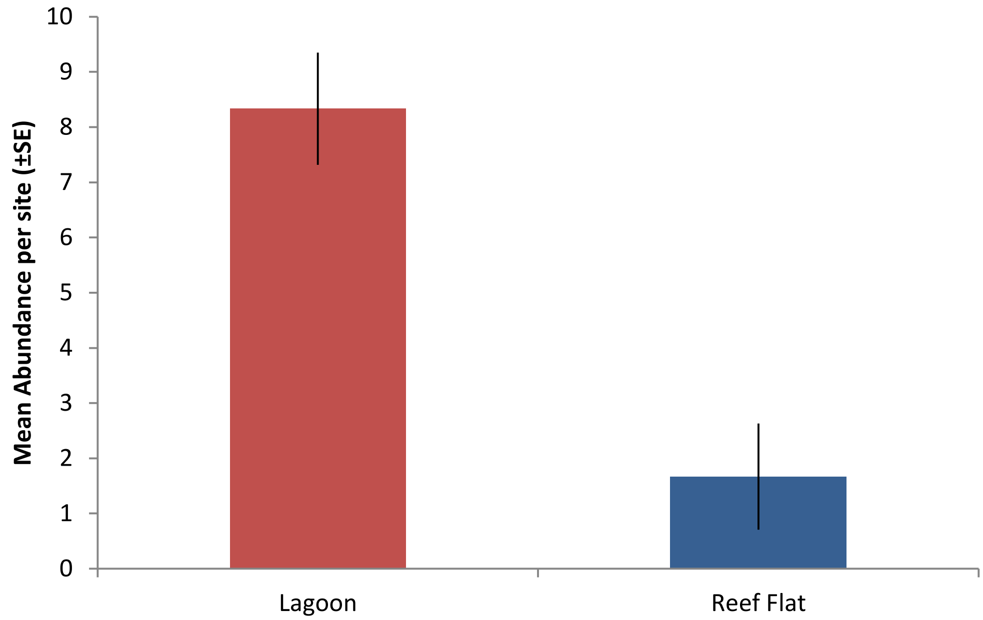


Figure 2: Abundance of the commercially important fish for at Ngatpang fish conservation area.

As seen in figure 3, the lagoon had a higher diversity of fish with 34 *Scarus Sp.* (Mellemau), 23 *Siganus puellus* (Reked), 4 *Plectropomus leopardus* (Tiau), and *1 Cheilinus undulatus* (Maml). Of the reef flat habitat, 6 *Siganus puellus* (Reked) and 4 *Cheilinus undulatus* (Maml) were recorded (Fig 3).

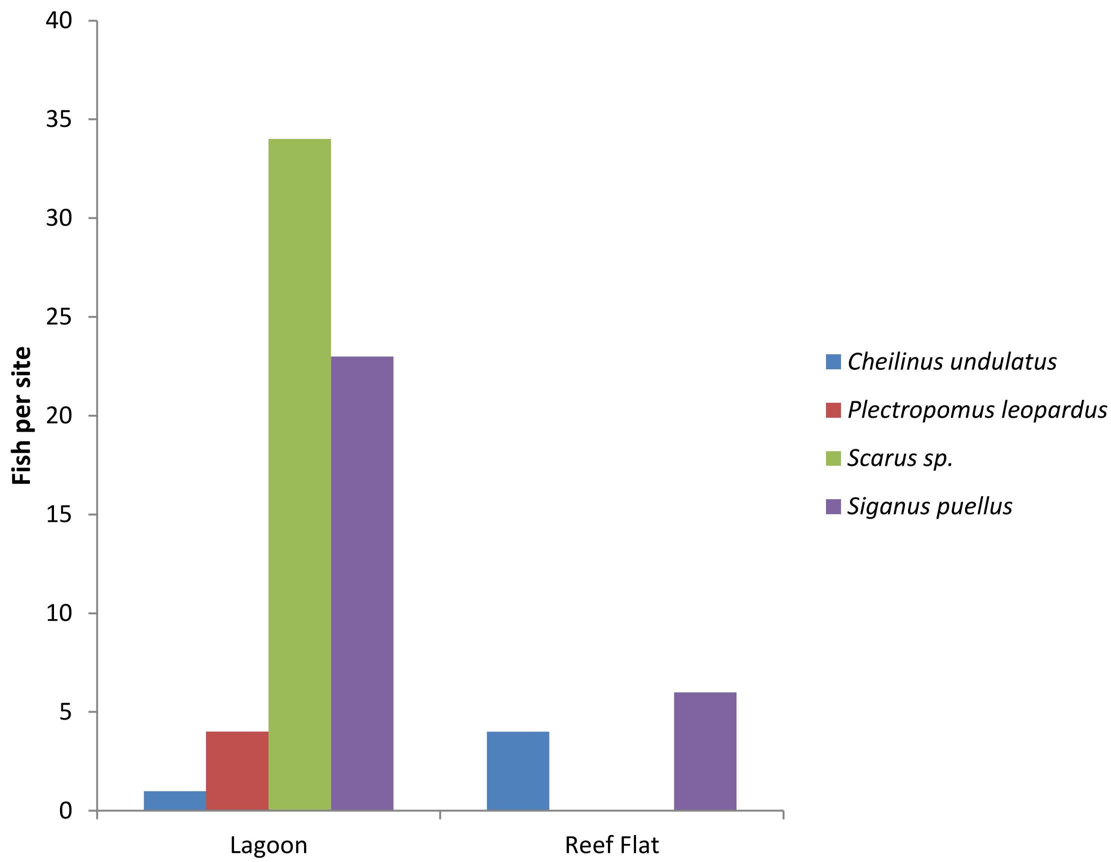


Figure 3: Commercially important fishes observed within each of the two habitats surveyed.

3.2 Fish Biomass

The mean biomass for all the commercially important fish observed fish within Oruaol Libuchel was 698.9 g (± 298.8 SE) per 150 m². The lagoon had the highest biomass of 1202.6 g (± 398.9 SE), the Reef Flat had an average biomass of 195.33 g (± 184.2 SE) (Fig 4).

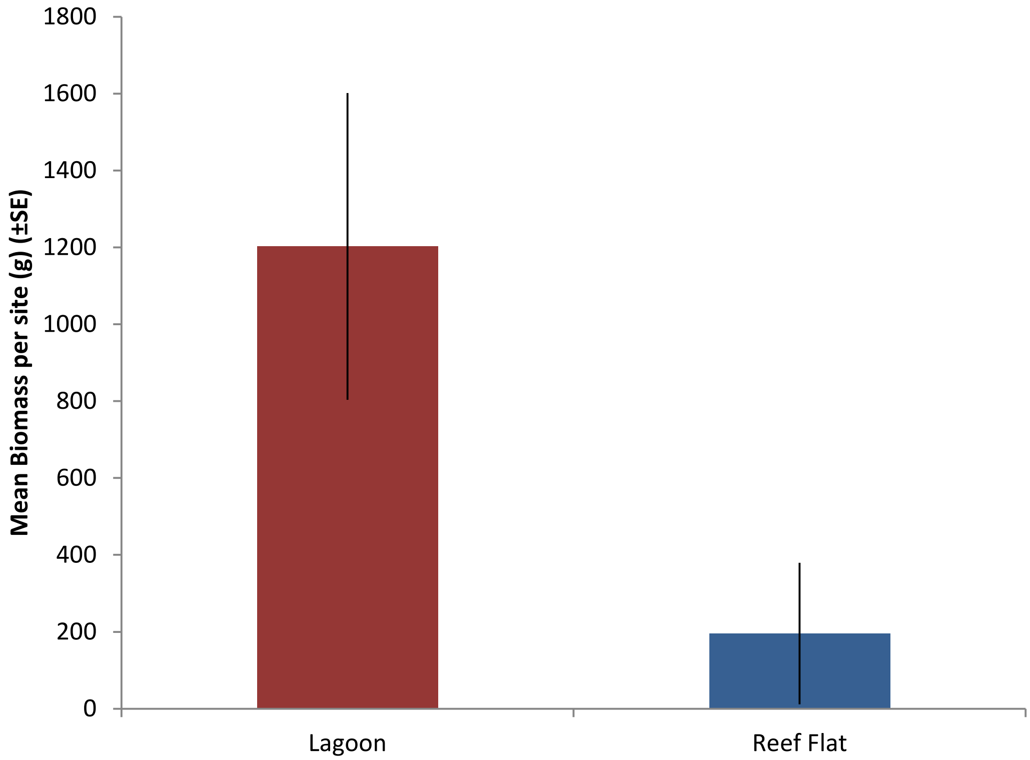


Figure 4: Mean biomass of all commercially important fish observed within the two habitats – Lagoon and Reef Flat

3.3 Invertebrates

Mean density of invertebrates at Oruaol Libuchel was 0.5 (± 0.2 SE) per 60 m². The Lagoon had an average density of 1 (± 0.5 SE) invertebrate with the Reef Flat had a higher average density of 2.9 (± 2.4 SE) (Fig 5). Of the 35 commercially important invertebrates (Appendix 2) observed, *Tridacna crocea* (Oruer) was the most abundant with a total count of 32 individuals. Others observed were (2) *Tridacna maxima* (Melibes), and (1) *Bohadschia spp.* (Mermarch).

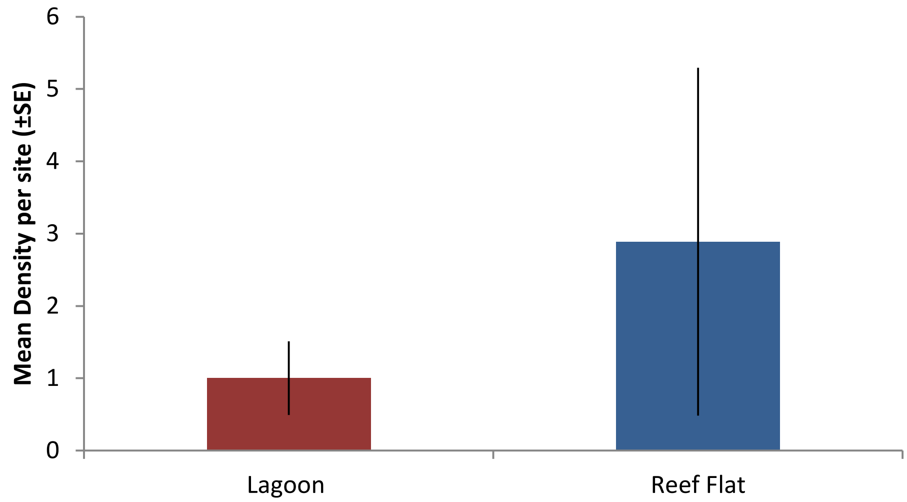


Figure 5: Mean density of invertebrates at Ngatpang Conservation Area

3.4 Coral Recruit

Mean density of coral recruits for Oruaol Libuchel was 10.2 (± 2.0 SE) per 3 m^2. The Lagoon had a mean recruit count of 8 (± 2.1 SE). The Reef Flat had the higher recruit count of 12.4 (± 3.3 SE) (Fig. 6).

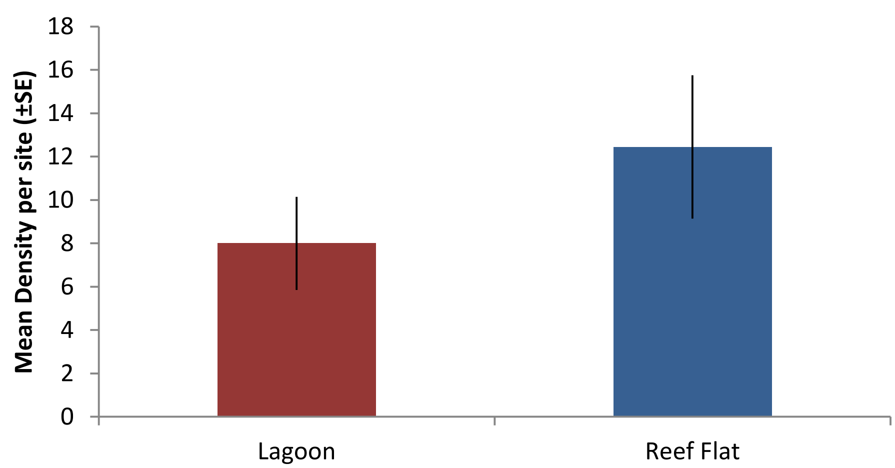


Figure 6: Mean density of coral recruits at Ngatpang fish conservation area

3.5 Benthic cover

The lagoon showed the highest diversity of benthic coverage with coral cover at 2.4% (± 0.8% SE); *Padina*, a brown fleshy algae, percent cover was of 6.4% (± 3.4% SE); sand was 12.3% (± 8.8% SE); and rubble was 19.7% (± 10.6% SE). The reef flat showed the highest coverage of turf with 27.3% (± 9.3% SE), carbonate with 10% (± 6.4% SE), and Soft corals with 3.1% (± 3.1% SE), (Fig 7).

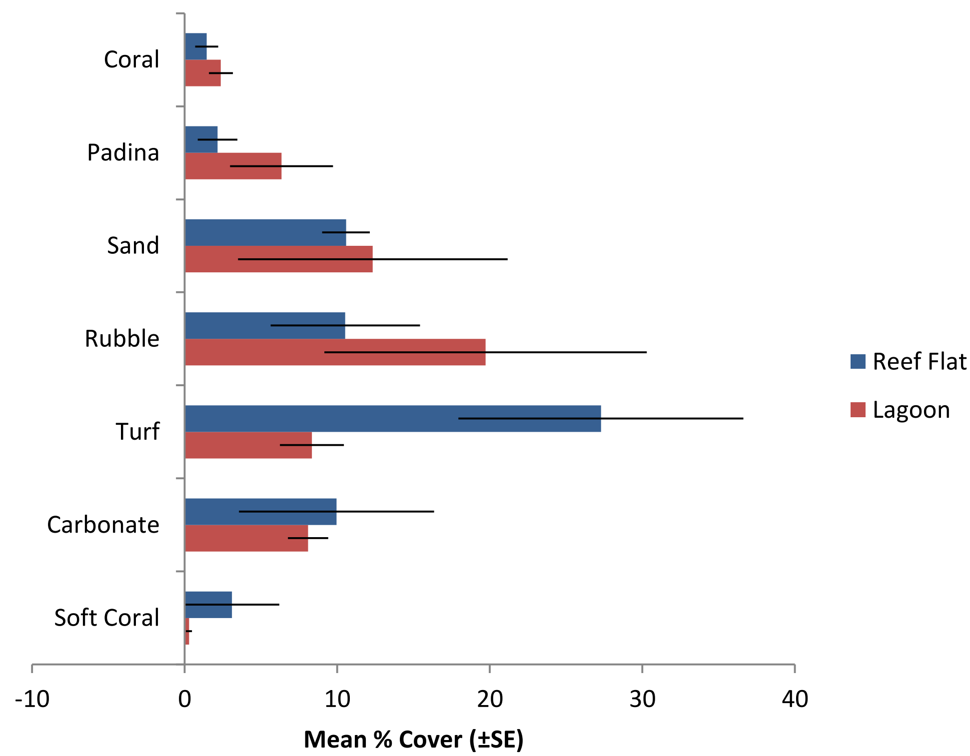


Figure 7: Mean benthic cover in percentage between the two habitats – Lagoon and Reef Flat

The reef flat shows the highest coral cover of *Seriatopora* with 3.6% (± 3.3% SE) and *Porites*-massive with 5.3% (± 4.9% SE). The lagoon sites showed the mean of *Anacropora* with 26.1% (± 12% SE), *Porites* with 8.4% (± 4.3% SE), and *Acropora* with 4.8% (± 1.6% SE) (Fig 8).

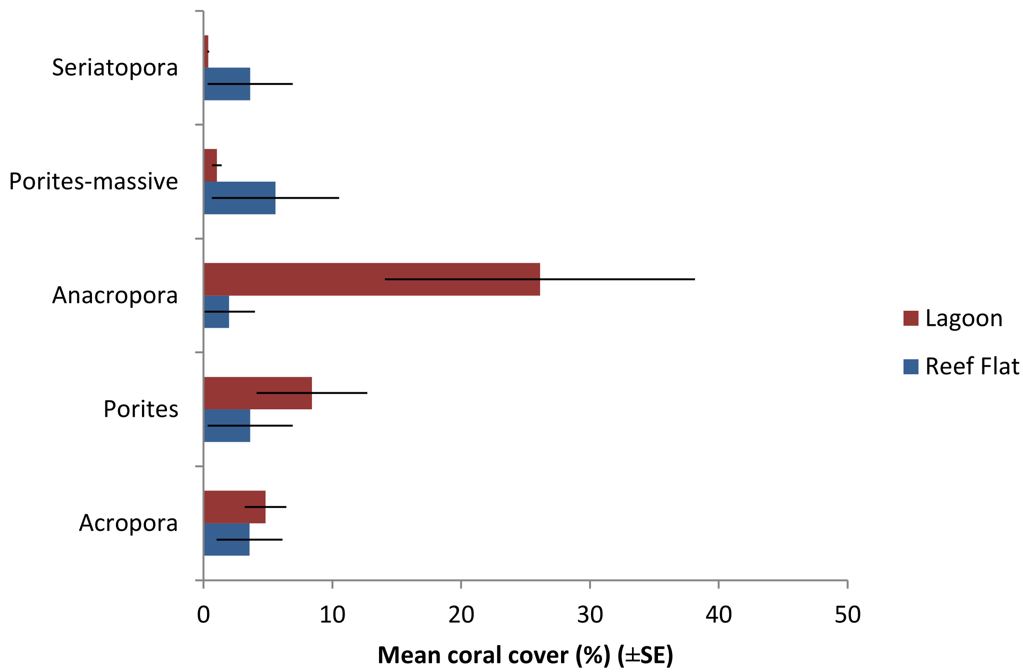


Figure 8: Mean cover in percentage across the two habitats of the six most abundant coral species to the genus level.

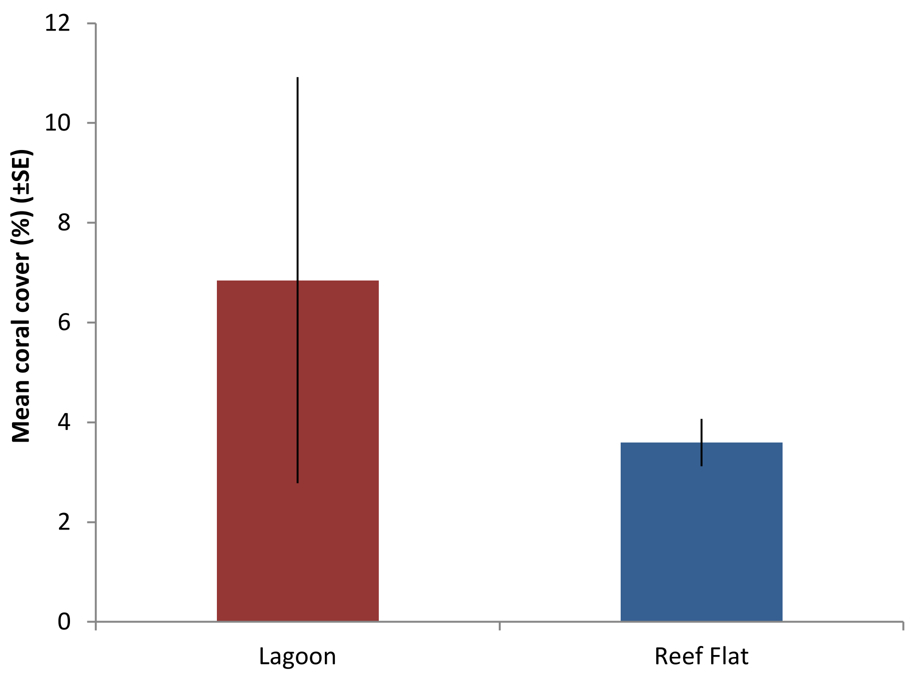


Figure 9: Mean coral cover in percentage between the two habitats of the six most abundant coral species (Fig 8).

4. Discussion

The overall objective of this study was to collect environmental baseline information within the Ngatpang fish conservation zone. Since 1999, this conservation area has been restricted to a no-take zone, preventing the possibility of overfishing from occurring. This study illustrates an interesting picture of the marine life within the conservation area and the difference between the two 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)*.

Based on the results from the invertebrates and coral recruits, there is a notably higher abundance of each in the reef flat than that of the lagoon. Looking at the big picture, in the deeper depths of the lagoon, it shows that with higher benthic community composition and coral cover, there is a higher abundance of fish, larger fish biomass, and a greater density of the commercially important fish. 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 overabundance 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 Ngatpang's Oruaol Libuchel protected 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 with 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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Appendix 1: Commercially important fish species in Palau

Commercially important fish species in Palau			
	Common name	**Palauan name**	**Scientific name**
1	Lined rabbitfish	Kelsebuul	*Siganus lineatus*
2	Forketail rabbitfish	Beduut	*Siganus argenteus*
3	Bluespine unicornfish	Chum	*Naso unicornis*
4	Orangspine unicornfish	Cherngel	*Naso lituratus*
5	Longface enperor	Melangmud	*Lethrinus olivaceus*
6	Orangestripe emperor	udech	*Lethrinus obsoletus*
7	Yellowlip emperor	Mechur	*Lethrinus xanthochilis*
8	Red snapper	Kedesau	*Lutjanus bohar*
9	Humpback snapper	Keremlal	*Lutjanus gibbus*
10	Bluefin trevally	Erobk	*Caranx ignobilis*
11	Giant trevally	Oruidel	*Caranx melampygus*
12	Parrotfish species	Melemau	*Cetoscarus/Scarus Spp.*
13	Pacific longnose parrotfish	Ngeaoch	*Hipposcarus longiceps*
14	Bluespot mullet	Kelat	*Valamugil seheli*
15	Squaretail mullet	Uluu	*Liza vaigiensis*
16	Rudderfish (lowfin)	Komud, Teboteb	*Kyphosus spp (vaigiensis)*
17	Giant sweetlips	Melim ralm, Kosond/Bikl	*Plectorhinchus albovittatus*
18	Yellowstripe sweetlips	Merar	*Plectorhinchus crysotaenia*
19	River snapper	Kedesau'l iengel	*Lutjanus argentimaculatus*
20	Yellow cheek tuskfish	Budech	*Choerodon anchorago*
21	Masked rabbitfish	Reked	*Siganus puellus*
22	Goldspotted rabbitfish	Bebael	*Siganus punctatus*
23	Bicolor parrotfish	Beyadel/ngesngis	*Cetoscarus bicolor*
24	Indian Ocean Longnose parrotfish	Bekism	*Hiposcarus harid*
25	Red gill emperor	Rekruk	*Lethrinus rubrioperculatus*
26	Pacific steephead parrotfish	Otord	*Scarus micorhinos*
Protected Fish Species (yearly and seasonal fishing closure)			
27	Dusky rabbitfish	*Meyas*	*Siganus fuscescens*
28	Bumpead parrotfish	*Kamedukl*	*Bolbometopon muricatum*
29	Humphead parrotfish	*Maml*	*Cheilinus undulatus*
30	Squaretail grouper	*Tiau*	*Plectropomus areolatus*
31	Leopard grouper	*Tiau*	*Plectropomus leopardus*

32	Saddleback grouper	*Tiau, Katuu'tiau, Mokas*	*Plectropomus laevis*
33	Brown-marbled grouper	*Meteungerel'temekai)*	*Epinephelus fuscoguttatus*
34	Marbled grouper	*Kesau'temekai*	*Epinephelus polyphekadion*

Appendix 2: Macroinvertebrates targeted by the local fisheries

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, cheremrum edelekelk	*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/ngimes ra tmolech	*Stichopus hermanni*
Brown curryfish	Ngimes	*Stichopus vastus*
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*
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 (in UTM)

Site	Lat	Long
1	829340.7	442276.3
2	829775	442486.9
3	829573.8	442258.9
4	829170.3	442297
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