BASELINE ASSESSMENT FOR NGERKEBESANG MARINE PROTECTED AREA

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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 the marine habitats. An initial assessment of the Ngerkebesang marine protected area was conducted to determine this foundation for long term adaptive management of the protected area. Three sites were randomly selected within the conservation zone and surveyed. Our findings show that among the three sites, there is a high abundance of fish in the conservation area. Of what was surveyed, the average overall fish abundance is 39.2 where if compared to just the commercially important fish, there is only an average of 8.6. When you compare this finding with that of the biomass, it is notable that the commercially targeted fish average biomass makes up a large portion of the overall calculated biomass.

1. INTRODUCTION

Marine Protected Areas (MPA) are conservation tools that protect biodiversity and assists in sustainable resource practices. Though it may seem as a new conservation tool, MPAs have been in existence for several decades (Bjorklund 1974). This conservation tool is being increasingly used in Palau, as well as throughout Micronesia and the rest of the world. Palau has over 33 MPAs nationwide. Biological monitoring is an essential component of adaptive management to measure the effectiveness and progress of MPAs. Resource managers and relevant stakeholders need information on the changes and trends in the condition of resources overtime in order to effectively manage protected areas. MPA monitoring data provides the resource managers key information that will assist in decision-making.

In 2002, Koror State legislature passed an act to make Ngerkebesang waters in front of Palau Pacific Resort (PPR) an MPA. This act came by request from the Palau Pacific Resort when they asked to make the waters in or around the resort a “No Fishing” zone to preserve the marine fauna and flora for the guest of the resort. Prior to the act, there was already an existing *bul* by the traditional leaders of Ngerkebesang that prohibited fishing around the resort. A *bul* is a traditional restriction regarding harvesting or hunting within a specific area that is implemented by the traditional leaders and chiefs of the area. Koror State legislature passed the act in November 2002 to preserve and protect the area of Ngerkebesang in front of PPR.

This study is a baseline assessment that was conducted by the Palau International Coral Reef Center on March 04, 2015. The objective of this assessment of the Ngerkebesang conservation area was to collect baseline data on commercially important fish abundance and biomass, invertebrate densities, benthic cover, and coral recruitment. This information will serve as baseline data that will be used for comparison with future assessments.

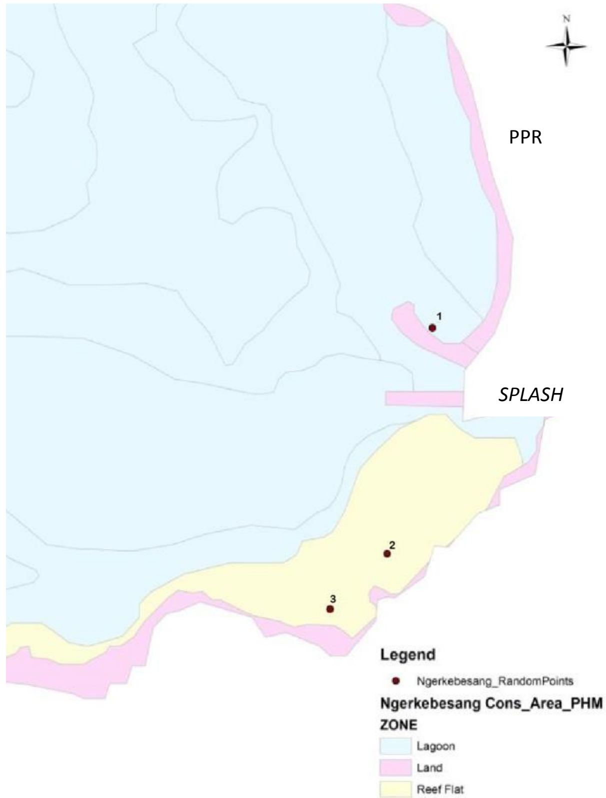

Figure 1: A map of Ngerkebesang Conservation Zone, showing the 3 randomly selected locations of the surveyed sites (see GPS coordinates in Appendix 4). The white area is land.

2. METHODS

This study was conducted on March 04, 2015 and targeted the shallow lagoon and the reef-flats at a depth between 1-5 m. A total of 3 randomly selected sites were surveyed with three 30 m belt transects at each site. The monitoring protocol follows an established method from determining location to analyzing the data in order to ensure uniformity among all MPA assessments. Random station 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.

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 identified and recorded on the tape with a further reduced width of 10 m x 1 m (10 m^2 total area per transect). Benthic coverage which includes coral cover was recorded by taking pictures using a wide angle lens camera and a 1 m^2 photo-quadrat alongside each of the 30 m 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 (see 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 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 observed fish in Ngerkebesang Marine Protected Area was 39.2 fish (± 12.0 SE) per 150 m^2. The site showing the highest fish density was site 2, which had a mean fish abundance of 63 fish (± 37.5 SE) per 150 m^2, with the lowest fish density occurring in site 1 which had an average density of 24 fish (± 9.0 SE) per 150 m^2 (Fig 2).

Mean abundance for all commercially important fish (see Appendix 1) observed in Ngerkebesang Marine Protected Area was 8.6 fish (± 2.1 SE) per 150 m². The site showing the highest fish density was site 2, which had a mean fish abundance of 11.3 fish (± 5.6 SE) per 150 m², with the lowest fish density occurring in site 3 which had an average density of 4.3 fish (± 0.8 SE) per 150 m² (Fig 2).

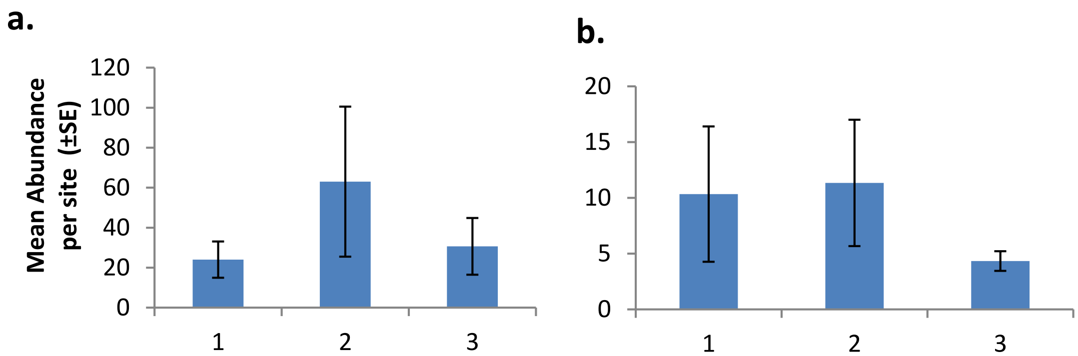

Figure 2: (A) Mean abundance of all observed fish among the three sites surveyed; (B) Mean abundance of observed commercially important fish (Appendix 1).

As seen in figure 3, of the three sites, it was found that *Siganus lineatus* (Kelsebuul) was the highest recorded commercially targeted fish. *Siganus lineatus* (Kelsebuul) was recorded in site 1 and 2 with a total count of 17 individuals observed. The lowest observed were *Caranx melampyus* (Oruidel), *Naso lituratus* (Erangel), and *Siganus punctatus* (Bebael) where each was observed once through the three sites (Fig 3).

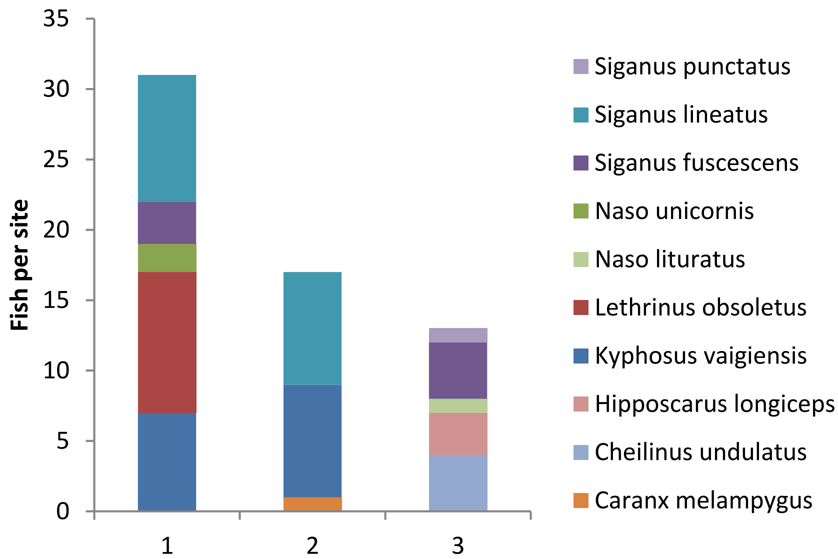

Figure 3: Commercially important fish observed within each of the three sites surveyed (Appendix 1)

3.2 Fish Biomass

The mean biomass for all observed fish within Ngerkebesang Marine Protected Area was 357.7 g (± 78.9 SE) per 150 m². The site showing the highest fish biomass was site 2, with a mean fish biomass of 488.8 g (± 181.8 SE) per 150 m², while the site showing the lowest fish biomass was site 1, which had a mean value of 215.9 g (± 83.0 SE) per 150 m² (Fig. 4).

The mean biomass for the commercially important fish (see Appendix 1) within Ngerkebesang Marine Protected Area was 261.4 g (± 39.5 SE) per 150 m². The site showing the highest fish biomass was site 1, with a mean fish biomass of 309.5 g (± 155.0 SE) per 150 m², while the site showing the lowest biomass was site 2, which had a mean value of 182.9 g (± 182.9 SE) per 150 m² (Fig. 4).

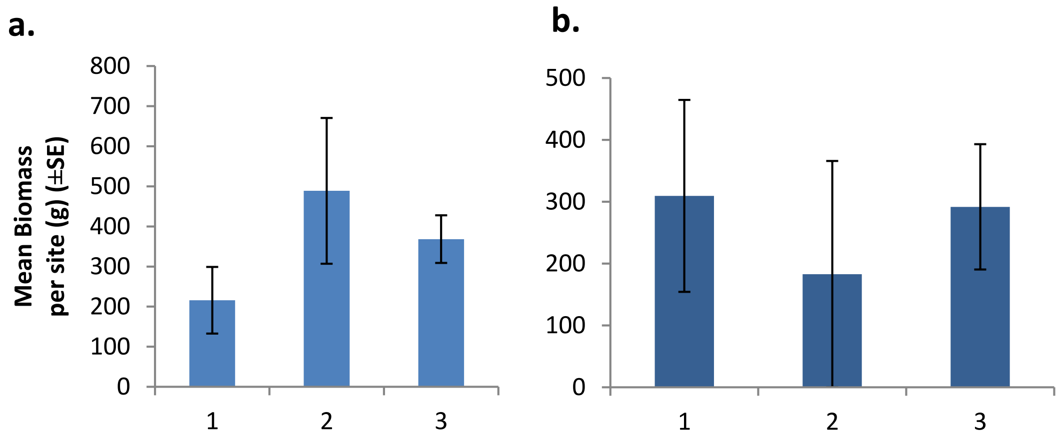

Figure 4: (A) Mean biomass of all observed fish among the three sites surveyed; (B) Mean biomass of observed commercially important fish (Appendix 1).

3.3 Invertebrates

Mean density of invertebrates for Ngerkebesang Marine Protected Area was 23.8 (± 2.2 SE) per 150 m^2. The site showing the highest invertebrate count was site 3, with a mean density of 28.3(± 2.4 SE) per 150 m^2, while site 1 and 2 show just about the same individual count of 21.5 (± 10.8 SE) and 21.6 (± 10.72 SE) per 150 m^2 respectively (Fig. 5). Of the 244 commercially important invertebrates (Appendix 2) observed, *Tridacna crocea* (Oruer) was the most abundant with a total count of 237 individuals. Other observed were (4) *Tridacna derasa* (Kism), (2) *Tridacna gigas* (Otkang), and (1) *Thelonatta ananas* (Temetaml).

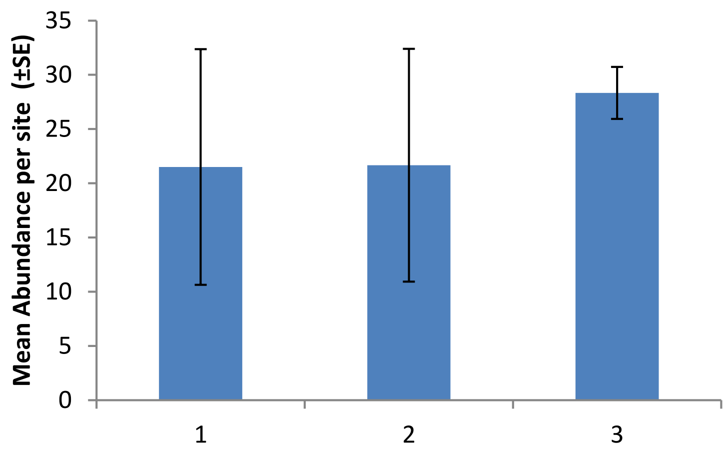

Figure 5: Mean density of invertebrates among the three sites surveyed

3.4 Coral Recruit

Mean density of coral recruit for Ngerkebesang Marine Protected Area was 1.58(± 0.04 SE) per 150 m^2. The site showing the highest recruit count was site 3, with a mean of 1.63 (± 0.36 SE) per 150 m^2, while site 2 show the lowest count of the three at 1.5 recruits (± 0.28 SE) per 150 m^2 (Fig. 6).

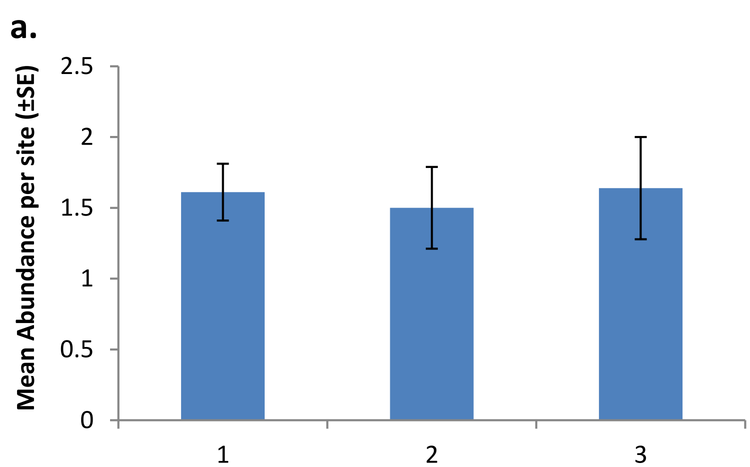

Figure 6: Mean density of coral recruits among the three sites surveyed

3.5 Benthic cover

Using the CPCe results, six of the most abundant categories are displayed for comparison. Site 1 showed the highest percent in coverage for coral with 32.2% (± 4.1% SE) and carbonate cover with 29.3% (± 4.2%

SE) (Fig 7; Table 1, 3). Site 2 had the highest coverage of crustose coralline algae with 1.1% (±0.8% SE), sand with 1.1% (± 0.8% SE), rubble with 30.8% (± 10.5% SE), and turf algae with 34% (± 14.2 SE) (Fig 7; Table2, 4-6). Site 3 showed no dominating cover over the three sites (Fig 7).

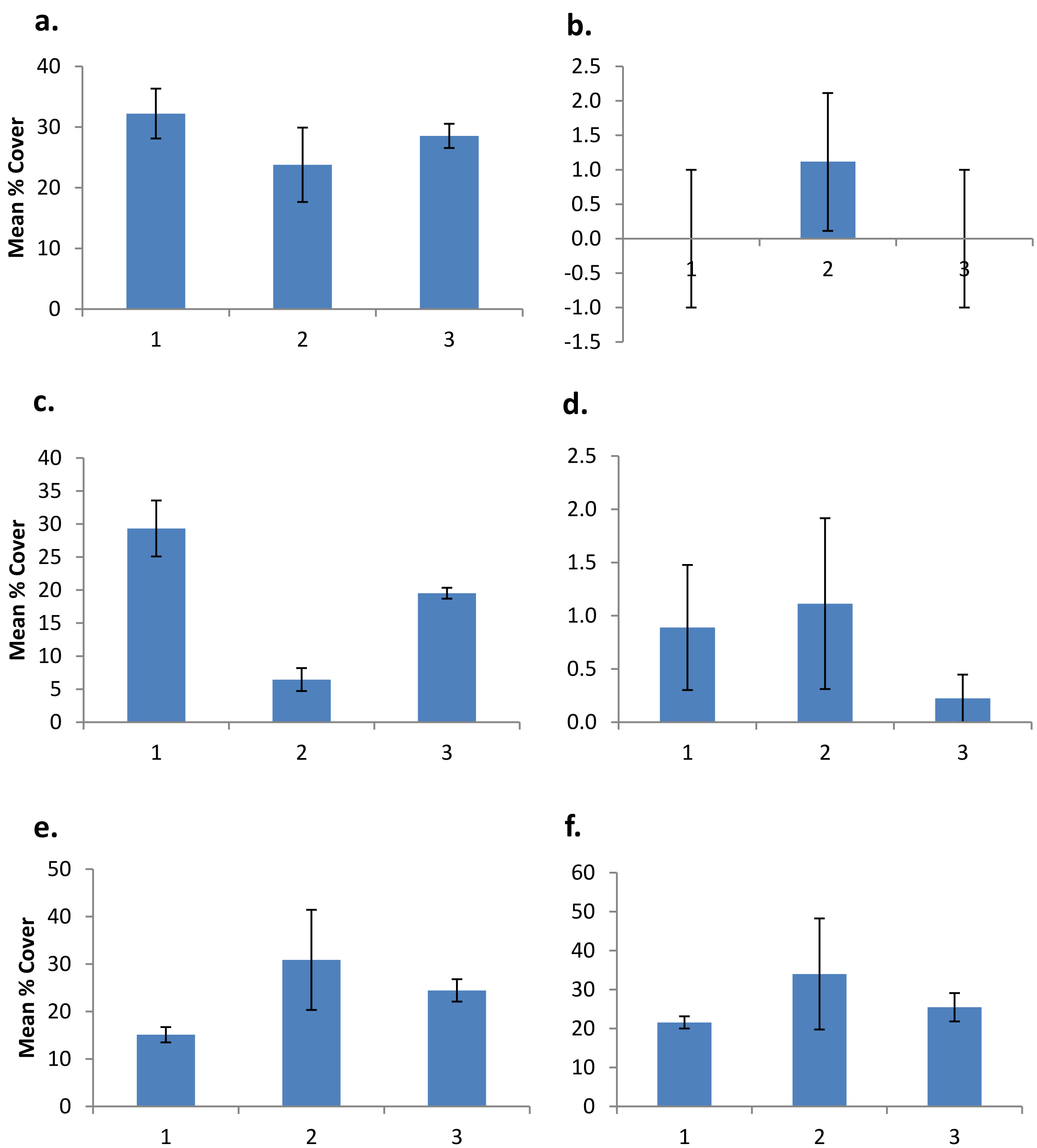

Figure 7: Mean benthic cover in percentage across the 3 sites. (Table A: Coral (C), B: Crustos Coralline Algae (CCA), C: Carbonate (CAR); D: Sand (S); E: Rubble (R); F: Turf Algae (T))

4. Discussion

The overall objective of this study was to collect environmental baseline information within the Ngerkebesang conservation zone. This site has been a no-take area since legislation was passed in 2002 and has allowed for the ecosystem to be preserved for patrons that use the area. Though there is not much of a habitat change among the surveyed sites, this study illustrates an interesting picture of the marine life within the conservation area. Because this is an initial baseline, prior data is not available on the marine make-up for the past 13 years.

Secondly, as the first assessment of the protected area, it is not required within the protocol to cross-reference a similar, non-conservation site. With that though, it is recommended that a baseline assessment is also established for a reference site which is not within a protected area in order to compare changes and effects over time.

Previous studies have shown that the only sites that had significant difference were those that have strict enforcement. Other sites indicated no statistical significance with that of its control. Over time, no-take marine protected areas, no matter how small the area is, has the possibility to grow in benthic and marine life given that enforcement and compliance is strictly regulated. Accordingly, small reserves are potentially easier to establish and enforce (Samoilys et al. 2007). In addition, PPR is currently constructing water bungalows that sit just outside of the MPA. Studying the impact of this construction could illustrate on a small scale how coastal developments could affect marine habitats.

Our findings show that among the three sites, there is a high abundance of fish in the conservation area. Of what was surveyed, the average overall fish abundance is 39.2 where if compared to just the commercially important fish, there is only an average of 8.6. When you compare this finding with that of the biomass, it is notable that the commercially targeted fish average biomass makes up a large portion of the overall calculated biomass. This means that even though there was not a huge observation of commercially targeted fish species, they were bigger in size.

Abundance and density are two factors that help with the spillover effect for the area. This is where a non-conservation reference site would be able to illustrate the effects. Based on the results from the invertebrates and coral recruits, there is no difference among the sites. For example, site 0 which is located within the snorkeling section of the beach front, has a higher carbonate and higher coral cover compared to the other two sites. Site 1 and 2 had similar recruit and invert density where site 3 had noticeably more in numbers. Whereas Site 2, which is located near the boat path for *SPLASH,* has higher sand, rubble, and turf algae. 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 Ngerkebesang Marine Protected Area. It is essential for policy makers and managements 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: Invertebrates 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*
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	
Trochus	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"

Appendix 4

Site	x	y
1	134.4433	7.353747
2	134.4431	7.352498
3	134.4428	7.352191