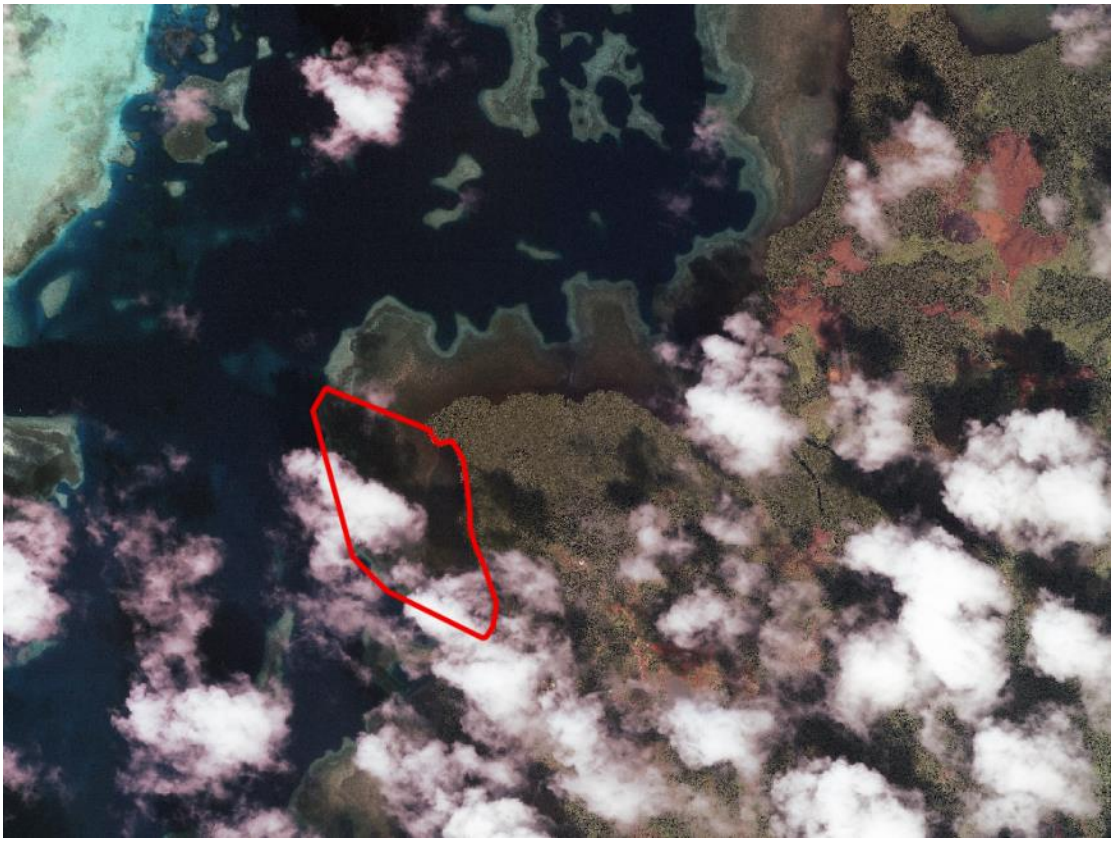
Baseline Assessment of Bkullengriil Conservation Area



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

Geory Mereb, Randa Jonathan

Palau International Coral Reef Center

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Abstract

Marine Protected Areas (MPAs) have become a widely used tool worldwide, including Palau and Micronesia. In 2003, the Palau Protected Areas Network (PAN) was created to protect and conserve Palau's biodiversity. Today, the PAN is Palau's mechanism to achieving the goals of the Micronesia Challenge (MC), a regional initiative to conserve at least 30% of near-shore marine resources and 20% of terrestrial resources by the year 2020. Although the PAN is a network of numerous MPAs within Palau, little information has been collected on the baseline status of existing and new MPAs in Palau. To determine the baseline status of marine resources in Palau, the Palau International Coral Reef Center conducted baseline ecological surveys of all MPAs in Palau. This report presents the baseline monitoring results of Bkullengriil Conservation Area (CA), a legislated protected area in Ngeremlengui State in Palau. Although the protected area is relatively small in size and was recently created in 2012, coral coverage was high in the lagoon habitat with an average coral cover of 44%. Fish densities and biomass appeared in lower numbers including invertebrate densities and coral recruitment. Further monitoring of the biological indicators presented in this report, is needed in order to track changes and trends to the marine resources of Bkullengriil CA over time.

Introduction

The use of Marine Protected Areas (MPAs) as a conservation measure has become widely used not only in Palau, but as well as Micronesia and the rest of the world. Studies have indicated the positive benefits of MPAs, including the spillover effect to adjacent non-protected areas (McClanahan and Mangi 2000) as well as providing a significant source of recruitment in fished and protected areas on a regional scale (Harrison et al. 2012). MPAs, when properly managed and monitored over time, can generate many biological and social benefits to coastal communities, including the protection of coral reef ecosystems, which provide a wide range of ecosystem services such as protection from storms or surges, economic gains from tourism activities, and sources of food or protein for human consumption (Costanza et al. 2014).

In 2003, the government of the Republic of Palau enacted a legislation to create a network of protected areas in Palau with the overall aim to conserve and protect Palau's biodiversity. Known as the Palau Protected Areas Network (PAN), the PAN has become Palau's mechanism to achieving the goals of the Micronesia Challenge (MC). In 2006, the governments of the Federated States of Micronesia, the Republic of the Marshall Islands, the Republic of Palau, the Commonwealth of the Northern Marianas, and Guam launched the MC with the goals of each MC jurisdiction to effectively conserve at least 30% of near-shore marine resources and 20% of terrestrial resources by the year 2020 (Micronesia Challenge Report 2011).

Although such advancements for marine and terrestrial conservation have been made in Palau and the region, little information is known on the baseline status of all MPAs across Palau. With the aim of supporting coral reef stewardship and marine conservation through research and its application for Palau, the Palau International Coral Reef Center (PICRC) made a commitment to conduct baseline

surveys of all MPAs within Palau. This report is based on baseline data collected in Bkullengriil Conservation Area (CA), a legislated protected area in Ngeremlengui State in Palau.

Bkullengriil CA is located at 7˚31.8828'N, 134˚29.8482'E in Ngeremlengui State and includes lagoon, reef flat and mangroves habitats. It is a no take, no entry zone, with entry only allowable once a permit is approved and issued from the Ngeremlengui State Government. It was designated in November 2012 as a protected area under the Ngeremlengui State government as a mean to sustain and protect the marine resources for the people of Ngeremlengui State. It has not been legislated as a PAN site yet.

Methods

Study site

This study was conducted in Bkullengriil CA in August 2015. The size of the CA is 665,899 m^2. The monitoring protocol followed a stratified sampling design. Random stations' locations were allocated within each habitat present in the MPA depending on their size using QGIS (QGIS Development Team 2015). Areas smaller than 900,000 m^2 were allocated three random points. Six randomly selected sites were surveyed in the lagoon and reef-flat habitats which represent the main habitats in Bkullengriil CA (Figure 1). At each site, three 30-m belt transects were laid following the reef contour at 3 – 5 m and several ecological indicators were measured and recorded.

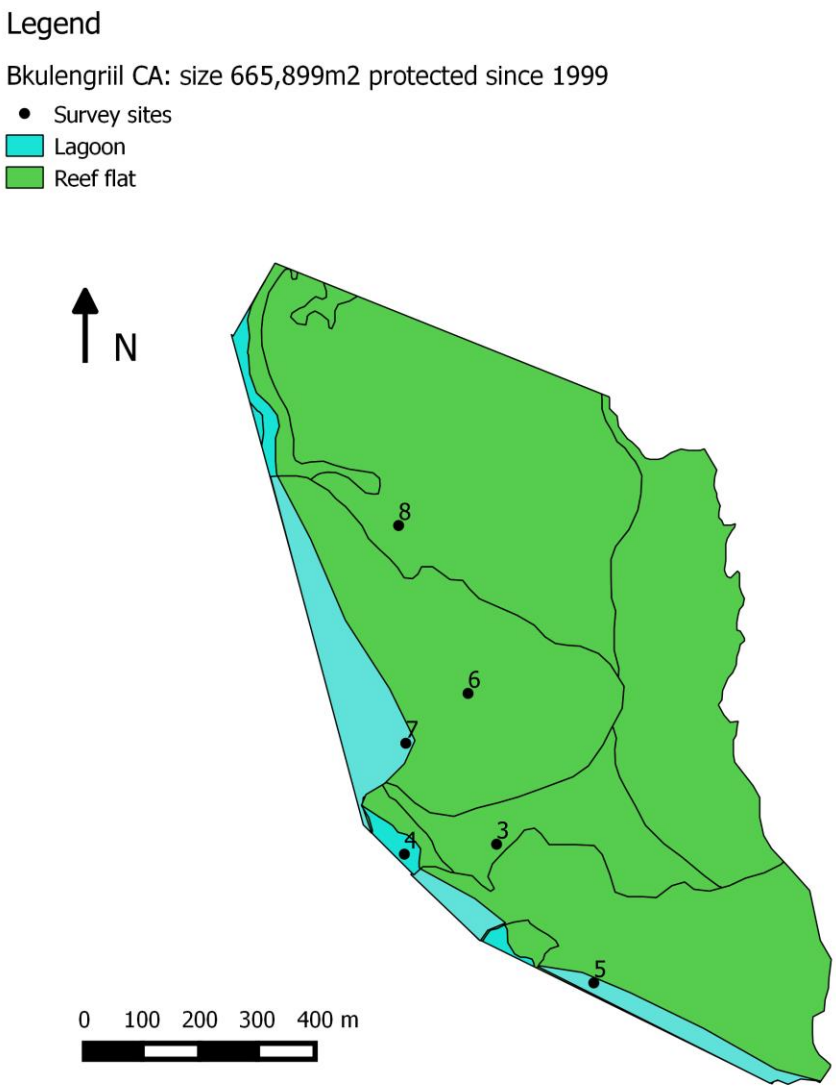

Figure 1. Map of CA showing the two different habitat types (green = reef flat, blue = lagoon), and the locations of sampling stations within each habitat (see GPS coordinates in Appendix 4)

Fish Surveys

Commercially-valuable fish species were surveyed for density and biomass along each 30 x 5m transect (total area per transect = 150 m^2), where the length of each fish species was estimated to the nearest centimeter. Fish density and biomass calculations, were calculated using the length-weight

relationship, $a(L^{b})$, where L= length in centimeters, and a and b as constants obtained from published papers (Kulbicki et al. 2005) and fish base (www.fishbase.org).

Benthic, Invertebrate, and Coral Recruits Surveys

The benthic community was surveyed using 1 m^2 photo-quadrats recorded with a wide-angle camera lens, in which photos of the entire 30 m transect were taken (30 quadrats per transect which equals to 90 photos per site). Benthic composition was analyzed using CPCe (Coral Point Count with excel extensions); a visual basic program for the determination of coral and substrate coverage in which five random points from each quadrat were used to generate estimates of coral cover, with corals being identified to the genus level (Kohler and Gill 2006). 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). The abundance of coral recruits (< 5cm in diameter) was recorded to the genus level within a 30 cm width of the first 10-m of each transect. All data were collated and analyzed in Microsoft (MS) excel.

Results

Fish abundance and biomass

Mean fish biomass was the highest in the lagoon habitat with 2,287.1 (± 674.7) g per 150 m^2 while the reef-flat had a mean fish biomass of 72 (± 60.2) g per 150 m^2 (Figure 2). Similarly, fish density was also higher in the lagoon with mean fish densities of 10 (± 0.3) fish per 150 m^2, while the reef-flat had mean fish densities of 4.7 (± 3.4) fish per 150 m^2 (Figure 2).

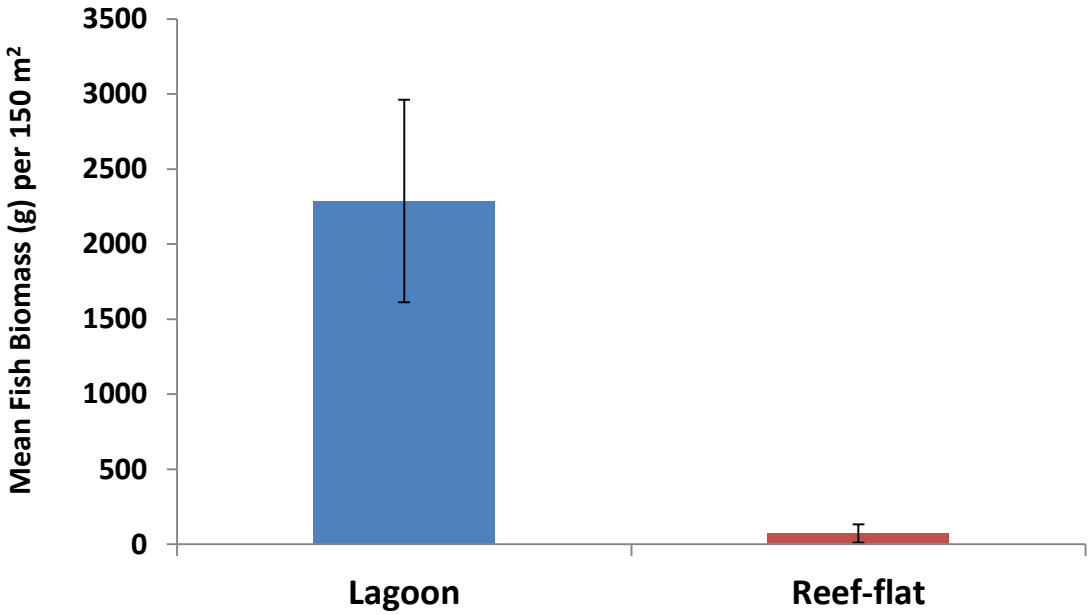

Figure 2. Mean fish biomass in the lagoon and reef-flat habitats within Bkullengriil conservation area.

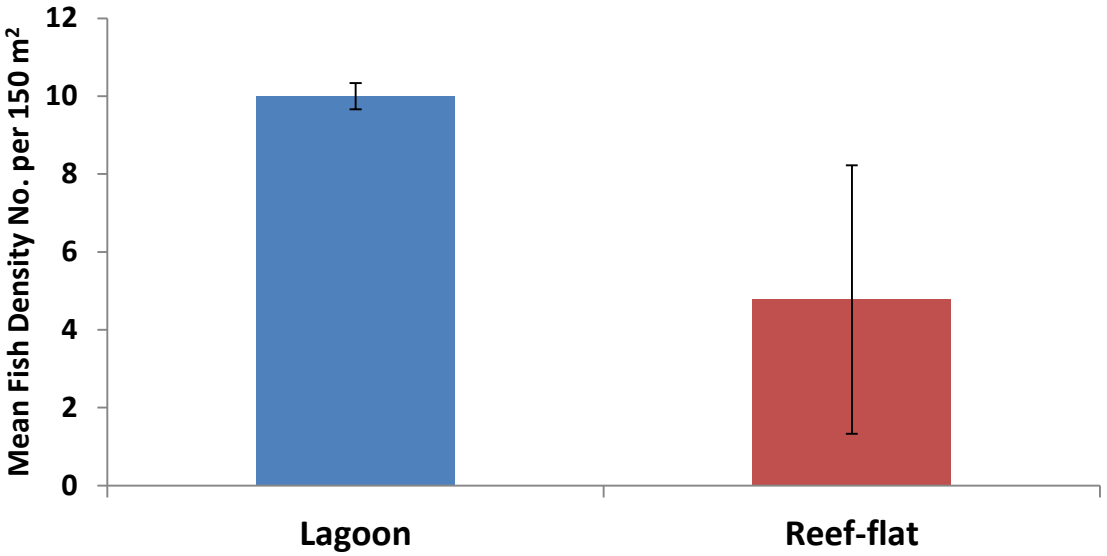

Figure 3. Mean fish density in the lagoon and reef-flat habitats within Bkullengriil conservation area.

From the 35 commercially-important fish species (Appendix 1), only 5 species were recorded inside Bkullengriil CA: Budech (*Choredon anchorago),* Udech *(Lethrinus obsoletus),* Keremlal *(Lutjanus gibbus),* Erangel *(Nasa lituartus)*, Melemau (*Scarus* spp.), and one protected species, Meyas (*Siganus fuscensens)*.

Benthic cover

Mean coral cover in the lagoon habitat in Bkullengriil CA was 44% (± 8.2), while coral cover in the reef-flat was 2.9 % (± 2.3). The lagoon habitat also had a higher percentage of carbonate cover (21.7% ± 8.3) than the reef-flat which had a mean carbonate cover of 8.9 % (± 5.8) (Figure 4). The reef flat was dominated by seagrass with a mean cover of 39.4% (± 6.6). The seagrass community within the reef flat consisted of three different species: *Enhalus acroides*, *Syringodium isoetifolium*, and *Thalassia hemprichi*. The remaining main benthic cover in the lagoon and reef-flat habitats within Bkullengriil CA consisted of sand, rubble and turf (Figure 4).

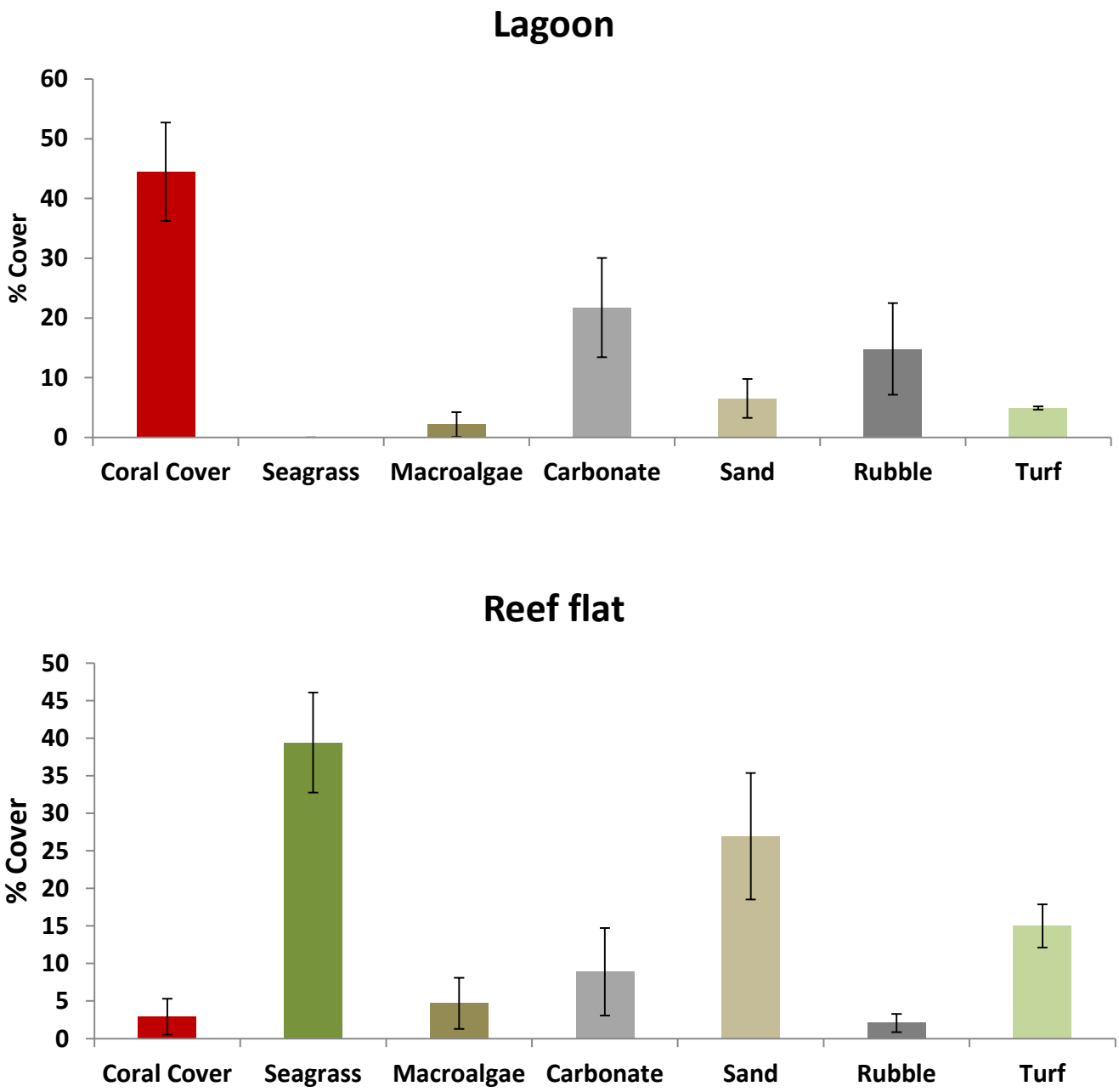

Figure 4. Mean percentage cover of main benthic categories in the lagoon and reef-flat habitats within Bkullengriil conservation area.

The coral community within the lagoon habitat was dominated by *Acropora* spp., followed by *Porites* spp., *Seriatopora* spp., and *Anacropora* spp., (Fig. 5). A total of 23 coral genera were recorded within this habitat of which 16 appeared in coverage lower than 1%. The coral community within the reef flat was composed of *Porites* spp., *Acropora* spp, and *Montipora* spp. in low coverage (Fig. 5).

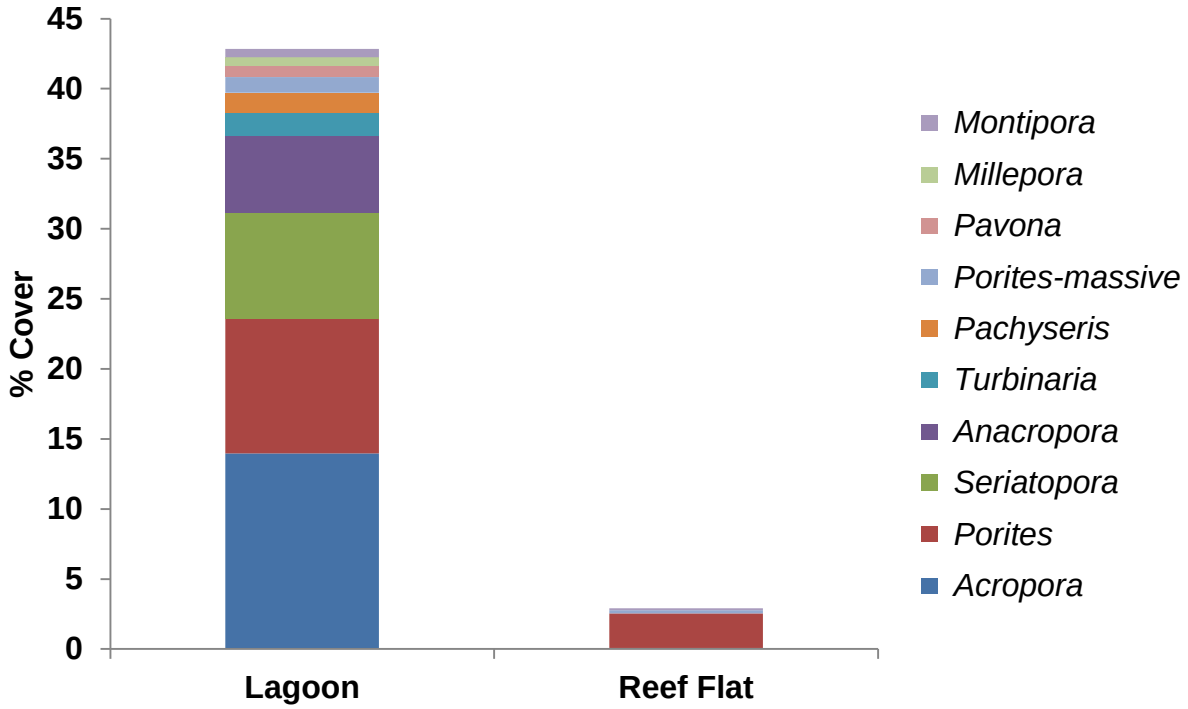

Figure 5. The percentage cover of the most dominant coral genera observed within each habitat of the CA

Coral Recruitment

Mean coral recruitment in the lagoon habitat was 12.4 (± 2.1) juvenile corals per $3m^2$, whereas the reef-flat habitat had average coral recruitment of 2.1 (± 0.6) juvenile corals per $3m^2$ (Figure 6). The lagoon harbored 17 genera of juveniles corals dominated by *Seriatopora* spp., *Acropora* spp., *Fungia* spp. and *Pavona* spp. The juvenile coral community on the reef flat consisted in only two genera: *Porites* and *Montipora*.

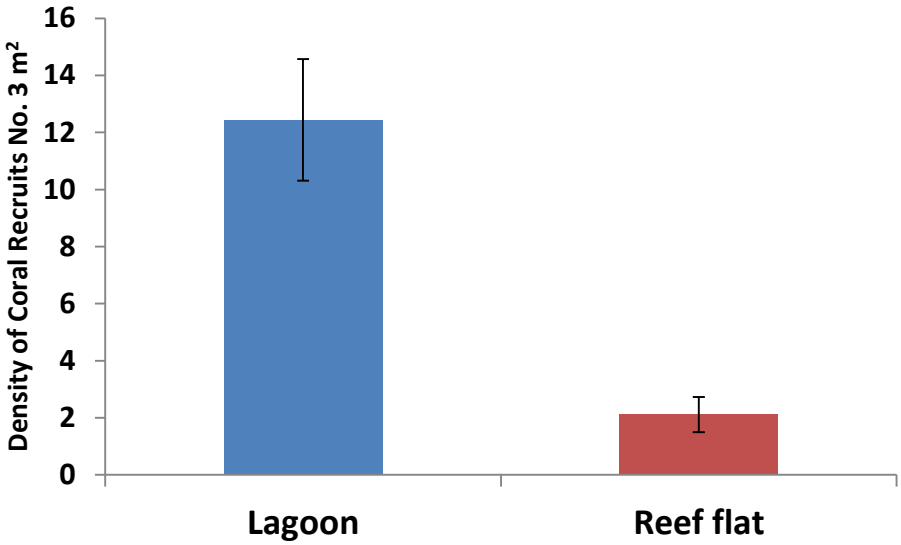

Figure 6. Mean density of coral recruits in the lagoon and reef-flat habitats within Bkullengriil conservation area.

Macro-Invertebrates

Both the lagoon and reef-flat habitats showed average invertebrate densities of less than 2 individuals per 60 m^2 (Figure 7). The lagoon hosted clams (*Tridacna* spp.) and one sea cucumber, Bakelungal (*Holothuria nobilis*) was observed in the reef flat.

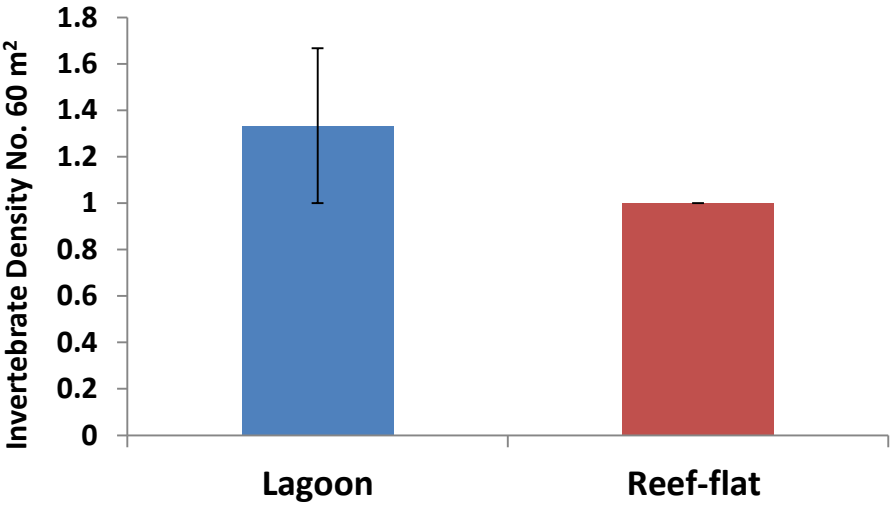

Figure 7. Mean densities of macro-invertebrates within the lagoon and reef-flat habitats of Bkullengriil conservation area.

Discussion

The purpose of baseline assessment of Bkullengriil CA is to provide a baseline status of the marine resources currently within the protected area. Because monitoring is an essential component for management of natural resources, results of this survey will allow for site managers and relevant stakeholders to make informed management decisions regarding Bkullengriil CA.

Bkullengriil CA includes three habitats, namely the mangrove area, the lagoon and reef-flat which are essential for ecological connectivity. This baseline assessment focused on lagoon and reef flat habitats. The results of this baseline survey indicate a higher fish biomass in the lagoon habitat than in the reef flat. Similarly, coral cover was higher in the lagoon habitat with an average cover of 44% than in the reef flat. Additionally, the reef flat was dominated by seagrass and sand, making it an important habitat for juvenile fish. Invertebrate densities appeared in low numbers with less than two individuals per 60 m^2 in both habitats.

Despite the good status of the coral community in the lagoon habitat, the biomass and abundance of commercially-targeted species within the CA was low compared to other CAs in Palau. If enforcement is maintained, there are two possibilities explaining this observation. First, the CA was established late 2012 and more time is needed for marine resources to increase. Second, Bkullengriil CA is too small to protect effectively marine species.

Further biological monitoring of the marine resources in Bkullengriil CA is needed in order to assess the changes and trends of the marine resources overtime. Standard biological monitoring procedures applied by trained individuals must be carried out overtime to provide resource managers the necessary information for adaptive management of Bkullengriil CA.

Acknowledgment

The Palau International Coral Reef Center would like to thank the Ngeremlengui State government for assistance with this baseline survey. This publication was made possible with support from NOAA's Coral Reef Conservation Program, PEW charitable trusts, and the GEF Small Grant Programme.

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Appendix 1:

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 list

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*
Greenfish	Cheuas	*Stichopuschloronotus*
Slender sea cucumber	Sekesaker	*Holothuria impatiens*
Prickly redfish	Temetamel	*Thelenotaananas*
Amberfish	Belaol	*Thelenotaanax*
Elephant trunkfish	Delal a molech	*Holothuriafuscopunctata*
Flowerfish	Meremarech	*Pearsonothuriagraeffei*
Lolly fish	Cheuas	*Holothuriaatra*
Pinkfish	Cheuas	*Holothuriaedulis*
White snakefish	Cheuas	*Holothurialeucospilota*
Snakefish	Cheuas	*Holothuriacoluber*
Red snakefish	Cheuas	*Holothurisfalvomaculata*
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 of survey sites

Site	Latitude	Longitude
3	832209.57	444482.191
4	832192.49	444322.31
5	831968.71	444650.4
6	832471.41	444433
7	832385	444325
8	832763	444313