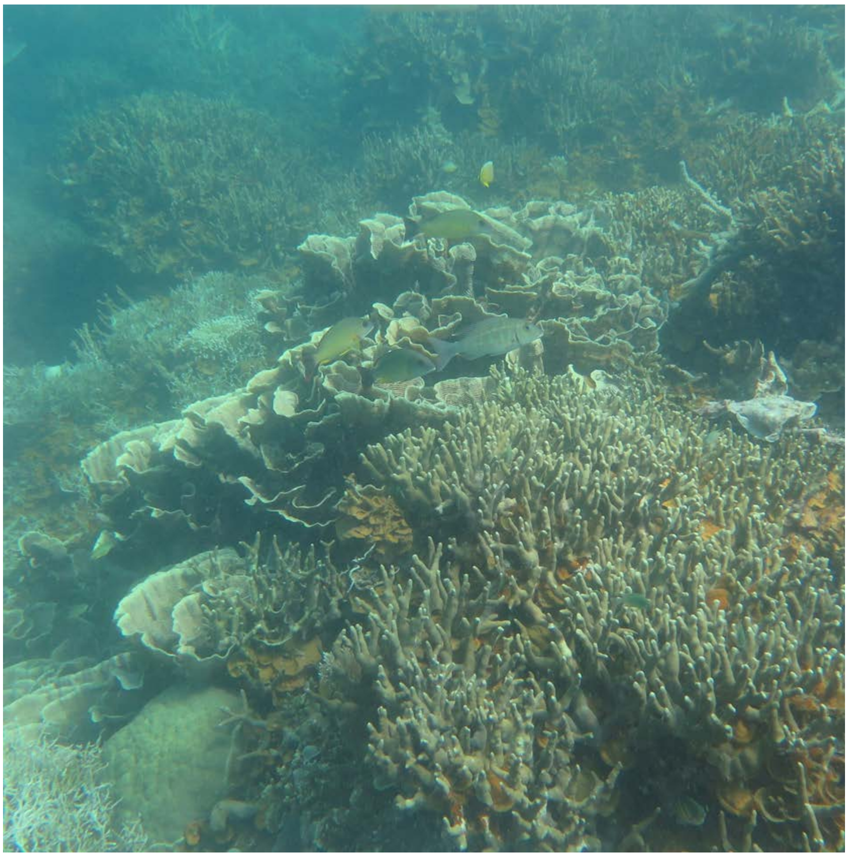
Ngermasech Conservation Area appear to be more resilient than the nearby unprotected reefs



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Palau International Coral Reef Center

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Abstract

Since 2014, the Palau International Coral Reef Center (PICRC) has been monitoring the 14 coral-reef and seagrass marine protected areas (MPA) within the Palau Protected Areas Network (PAN). Baseline assessments were conducted between 2014 and 2015 with subsequent assessments conducted two years later between 2017 and 2018. This study was conducted at the Ngermasech Conservation Area (CA) located within the state of Ngardmau. This assessment focused on recording abundance and biomass of commercially important fish, abundance of edible macro-invertebrates (within the lagoon), benthic community, and coral recruitment on two main habitats of Ngermasech CA – reef flat and lagoon. On the reef flat, results show that there was no significant difference between the CA and the reference site in terms of the commercially important fish abundance or biomass and seagrass percent coverage. Due to the survey design of the reef flat, results do not capture the special distribution of the sea cucumber population and therefore is not examined in depth within this study. In the lagoon, there was no significant difference between the CA and the reference site in terms of commercially important fish abundance or biomass, macro-invertebrates or the recruitment of juvenile corals. The benthic data within the lagoon indicated that the CA had significantly lower substrate (i.e. carbonate, rubble, sand, and turf), macroalgae cover, and other invertebrates (ascidians, sponges) cover compared to the reference site in 2017. Low substrate and macroalgae within the CA is a good indicator of a healthy herbivorous fish community. While the Ngermasech CA has been protected for the past 19 years, continuous monitoring only began in 2015. Therefore, monitoring should continue in order to help illustrate a better projection and assessment of the CA's effectiveness.

Introduction

Marine Protected Areas (MPAs) is a management tool used to protect marine biodiversity. This tool is increasingly being utilized in Palau, as well as throughout Micronesia. Nationwide, Palau has over 44 protected areas, 33 of which cover marine habitats (Alan M. Friedlander et al., 2017). The Protected Areas Network (PAN) was established in 2003 by the Palau National Government, and serves as a nation-wide system of protected areas (RPPL No. 7-42). In 2007, Palau strengthened its national conservation goals by participating in the regional initiative of the Micronesia Challenge (MC). This collaboration encourages Palau to effectively conserve at least 30% of near-shore marine resources and 20% of terrestrial resources by 2020.

Since 2015, the Palau International Coral Reef Center (PICRC) has been conducting ecological surveys to assess the effectiveness of the PAN MPAs. Biological monitoring is an essential component of adaptive management to measure the effectiveness and progress of MPAs. Baseline assessments were conducted at all PAN MPAs between 2014 and 2015 (Gouezo et al., 2016). To assess their effectiveness, PICRC has subsequently re-surveyed each of the PAN MPAs between 2017 and 2018. In order to effectively manage protected areas, resource managers and relevant stakeholders need information on the changes and trends in the condition of resources.

Ngermasech Conservation Area (CA) formally became a state conservation area in 1998 (NPL 4-20) and became a PAN site in 2009 (Ngardmau Conservation Board 2011), being completely protected from fishing for the past 19 years. Ngermasech CA is located in Ngardmau State at 7°35.085’ N, 134°32.062’E (fig. 1). The conservation area includes three marine ecosystems: mangroves, seagrass beds (inhabiting the reef flat) and coral reefs (lagoon fringing reef). This study focuses on the reef flat and lagoon habitats. Excluding the mangrove area, total area of the CA is 2.92 km^2. The objectives of this study are to evaluate the status and trends of the natural resources within the two main habitat types, assess the effectiveness of the conservation area in protecting resources over time, and compare resources found within the protected area and nearby, non-protected reference area.

Methods

1. *Study sites*

For the purpose of this study, the reef flat and lagoon habitats were surveyed. This study was conducted in November, 2017, at a depth of 10 m along the lagoon and maximum depth (<2 m) on the reef flat. Reference sites were chosen based on the similarities of each habitat in ecological makeup and size to examine the effectiveness of the MPA (fig. 1).

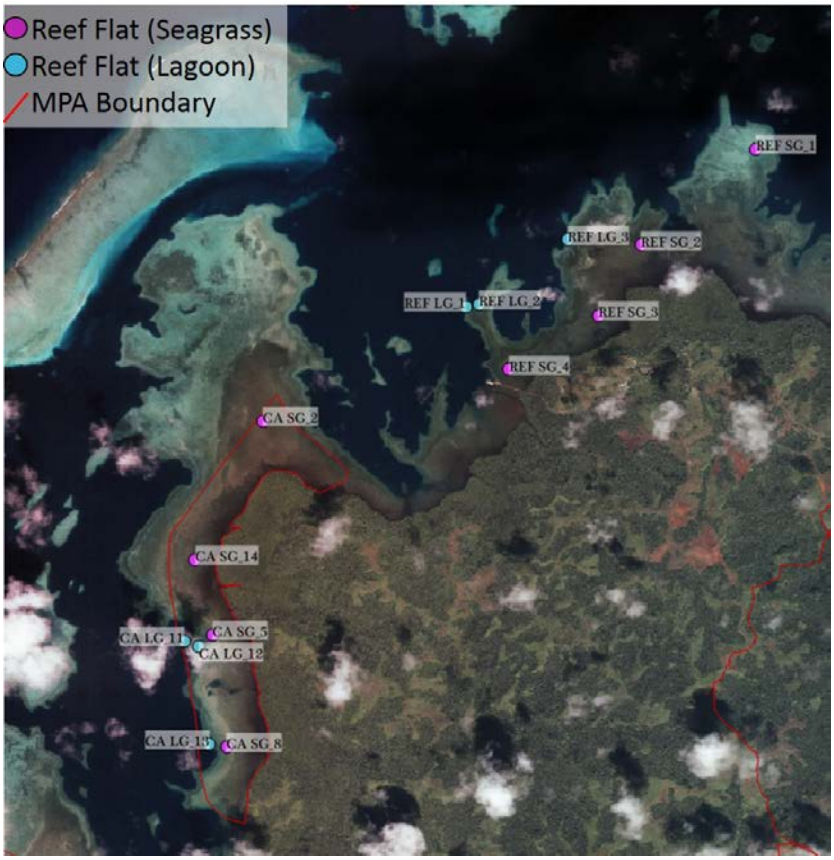

Figure 1: Satellite image of Ngermasech CA with monitoring sites inside (red boundaries) and outside the protected area.

2. Ecological surveys

Two survey methods were used, specific to each habitat.

On the reef flat, where the seagrass bed was surveyed, five 25 m transect tapes were laid on the substrate with 1-3 m gap between each tape. Along each transect, fish size and abundance, macro-invertebrate size and abundance, and seagrass percent coverage data was measured.

Visual fish survey of commercially important fish were recorded by size (cm) and abundance within a 5 m wide belt. Edible macro-invertebrates, such as sea cucumbers and clams, were recorded within a 2 m wide belt along each transect. Seagrass percent coverage was measured using a 0.5 m^2 quadrate placed at every 5 m. All data was compared with the baseline assessment conducted in 2015 as well as the respective 2017 reference site.

In the lagoon, five 50 m transect tapes were laid with a 1-3 m gap between each tape. Data recorded in the lagoon were fish size and abundance, macro-invertebrate size and abundance, benthic community, and coral recruit size and abundance.

Commercially important fish size (cm) and abundance was surveyed using stereo-DOV (Diver Operated Video) within a 5 m wide belt. Edible macro-invertebrates were recorded within a 2 m wide belt along each transect. Benthic community was measured using photographs taken at every meter along each transect using an underwater camera (Canon G16) mounted on a 0.5 m^2 photo-quadrat frame. Coral recruits (juvenile corals ≤ 5 cm) were recorded in the first 10 m of each transect within a 0.3 m wide belt. All data was compared with the baseline assessment with the exception for fish size and abundance due to a change in survey method.

3. Data processing and analysis

Fish videos were processed using a software, *EventMeasure*, where all commercially important fish were counted and measured in length. Biomass of fish was calculated using the total length-base equation $W=aTL^b$ where W is the weight of the fish in grams (g), TL is the total length of the fish in centimeters (cm), and a and b are constant values that derived from published biomass-length relationships (Kulbicki et al. 2005) and from Fishbase (http://fishbase.org). Photographs of the benthic community were analyzed using CPCe (Coral Point Count with excel extensions, Kohler and Gill 2006). Seagrass percent coverage, coral recruits, and invertebrate data were entered into excel for further analysis.

Prior to running statistical test, the data was checked for normality using histograms and Shapiro test. When data were non-normal, data was log transformed and re-tested. Normal data was analyzed using One-Way ANOVA. Non-normal data was analyzed using Mann-Whitney test. All analysis was done using *R* software (R Development Core Team 2017).

Results

Data from the 2017 surveys are presented according to habitat type and, wherever possible, compared to data obtained during the baseline assessment in 2015.

1. Reef Flat Habitat

There was no significant difference found in abundance and size of commercially important fish through time in the CA and between the CA and reference site (ANOVA p-value > 0.05). In 2015, within the CA, the mean fish abundance was 3.67 (±1.42) fish per 125 m^2. Those same sites surveyed in 2017 had a mean abundance of 2.25 (±1.17) fish, while the reference had 3.12 (±1.77) fish per 125 m^2 (fig. 2). The most abundant fish species recorded was meias (*Siganus fuscesens*) with a total of 61, 20, and 44 recorded in the CA in 2015, 2017 and the reference in 2017 (respectively). Only five other commercially important fish were recorded within the CA in 2017 while there were 17 other commercially important fish in 2015, and eight other commercially important fish found within the reference.

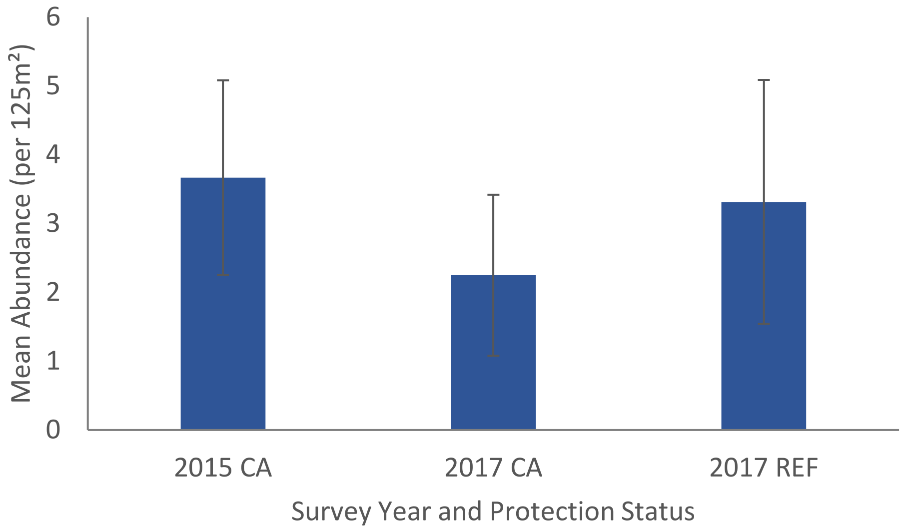

Figure 2: Mean fish abundance (per 125 m^2) (± SE) in the CA in both 2015 and 2017 and reference area in 2017

In 2017, the biomass of commercially important fish in the CA and reference area was not significantly different (Mann-Whitney, p-value > 0.05). When comparing the CA through time and between protection status, fish biomass was not significantly different (Mann-Whitney, p-value > 0.05) (fig. 3).

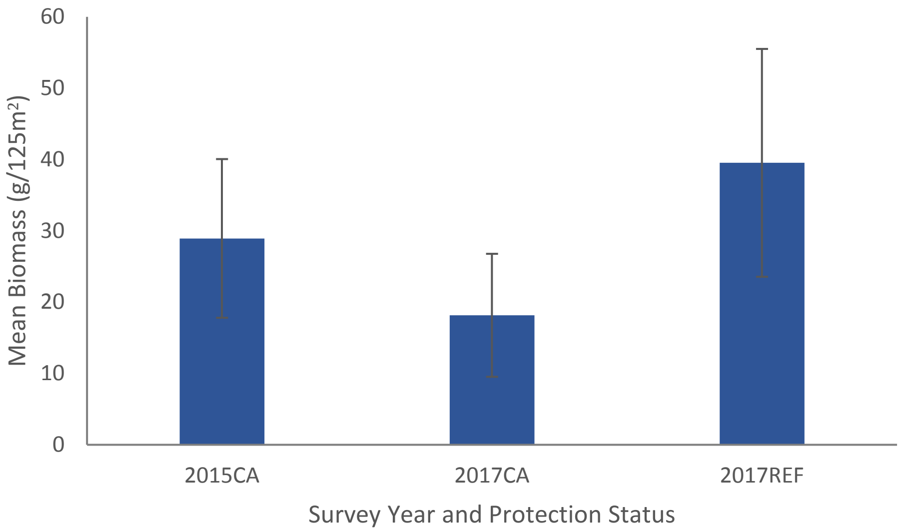

Figure 3: Mean fish biomass (g/125 m²) (± SE) in the CA in both 2015 and 2017 and reference area in 2017

The most abundant macro-invertebrate observed was the sea cucumber, cheremrum (*Actinopyga spp.*). In 2015, 516 sea cucumbers were recorded in the CA. Meanwhile, in 2017, 951 sea cucumbers were recorded in the CA, while only 9 sea cucumbers were counted in the reference area. Analysis at the site level show that 'Site 2' had a significantly higher population of macro-invertebrates than the other three sites – Site 5, Site 8, and Site 14 through time (p-value <0.000). However, there was no significant difference in the macro-invertebrate population at 'Site 2' through time (p-value >0.05). Due to the survey design of the reef flat, results do not capture the patchiness of the sea cucumber population resulting in large standards of error (appendix 1). An assessment of edible macro-invertebrates along the reef flat habitat is being conducted and will be presented separately, therefore is not further discussed in this report.

Due to change in methodology, benthos comparison along the reef flat was only conducted between the CA and the respective reference site in 2017. Between the two levels of protection, there was no significant variation of seagrass coverage (ANOVA p-value >0.05) (fig. 4). Five seagrass species were identified during the survey. *Thalassia hemprichii, Enhalus acoroides,* and *Cymodocea rotundata* were identified within both the CA and the reference site while *Halodule ovalis* was found within the CA and *Holadule pinifolia* found in the reference site. Among these, *T. hemprichii* was the most abundant species at both sites.

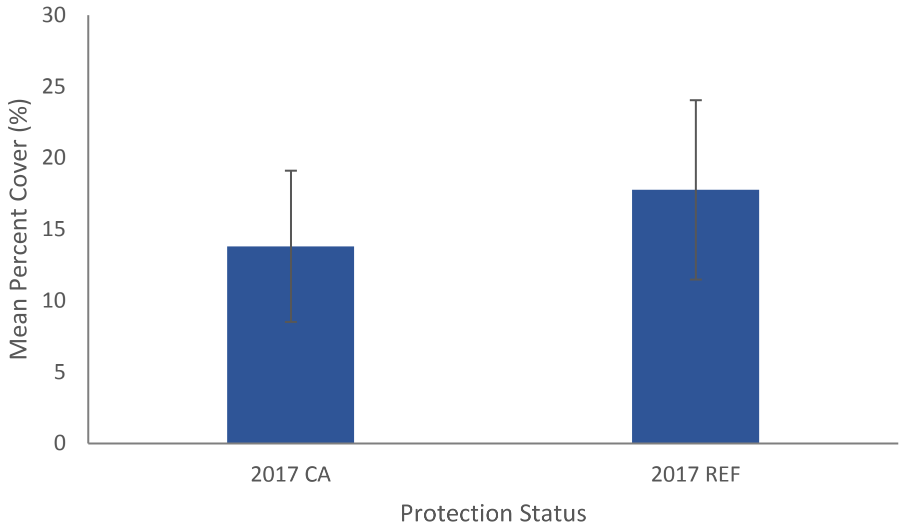

Figure 4: Mean seagrass cover (%) per 125 m^2 (± SE) in the CA and the reference area in 2017

2. *Coral Reef Lagoon Habitat*

The mean abundance of commercially important fish along the lagoon habitat was similar at the CA (6.1 ±1.8) and the reference site (8.8 ±2.1) (ANOVA p-value >0.05) (fig. 5a). Biomass was also similar in the CA (163.8g ±50.7) and the reference (141g ±4.2) (ANOVA p-value >0.05) (fig. 5b). The most abundant fish genus within the CA (2017) was *Lutjanus spp.* (snapper) followed by *Plectropomus spp.* (grouper) and *Cephalopholis spp.* (blue-spotted grouper). In the reference site, the most abundant genus recorded was *Caranx spp*. (bluefin trevally) followed by *Plectropomus spp.* (grouper) (fig. 6).

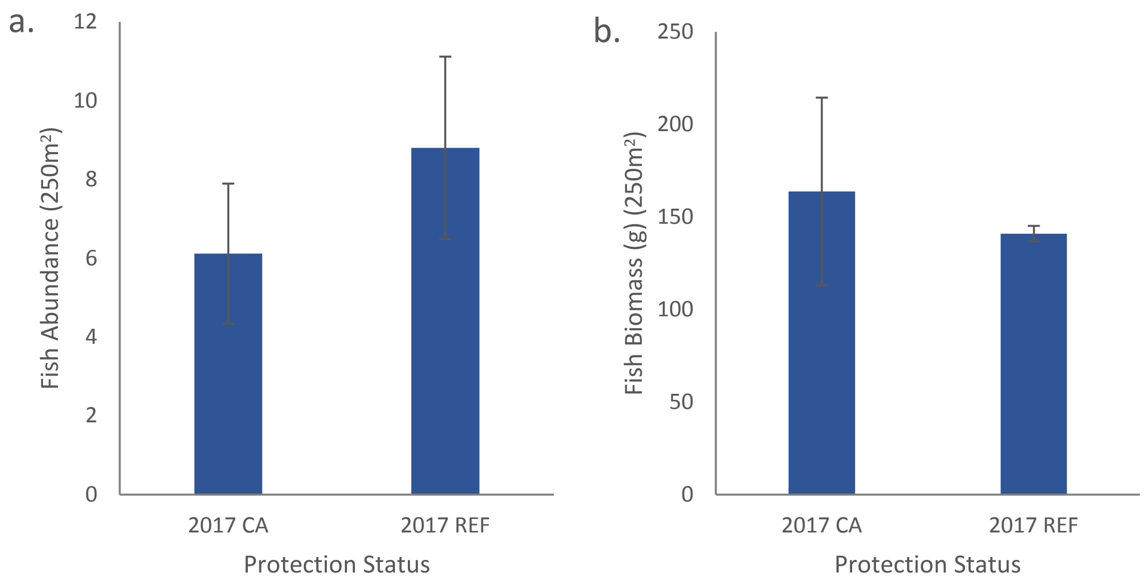

Figure 5: Mean commercially important fish (a.) abundance and (b.) biomass (±SE) per 250m².

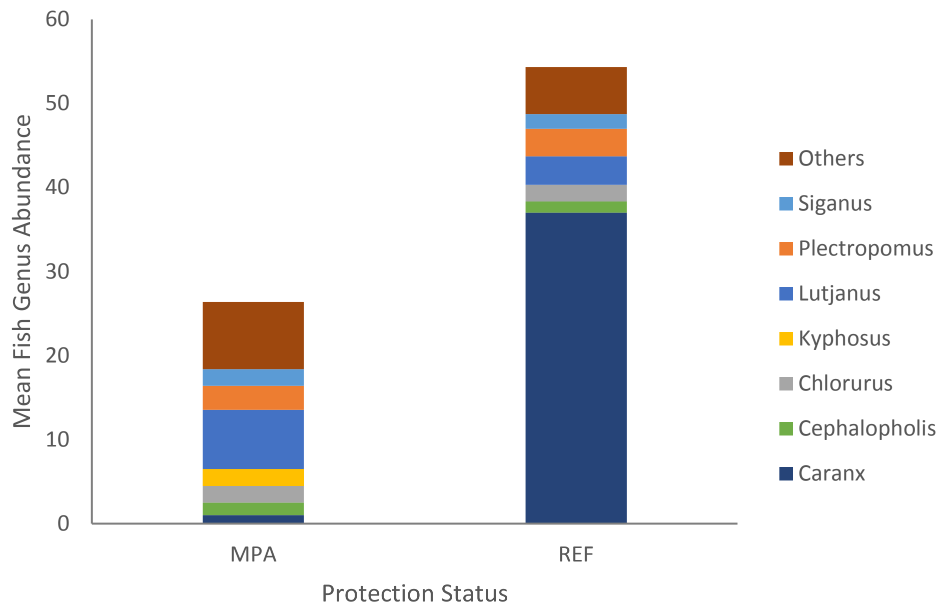

Figure 6: Major fish genus observed within the CA and the reference in 2017.

While there was a decrease in mean macro-invertebrates abundance since 2015, it was not a significant decrease (ANOVA p-value >0.05), and there was no difference between the CA and the reference site in 2017 (fig. 7). Oruer (*Tridacna crocea*) was the most abundant macro-invertebrate, thus inflating the abundance value in 2015. In 2017, mermarch (*Bohadschia argus*) was the most frequently observed species within both the CA and reference site.

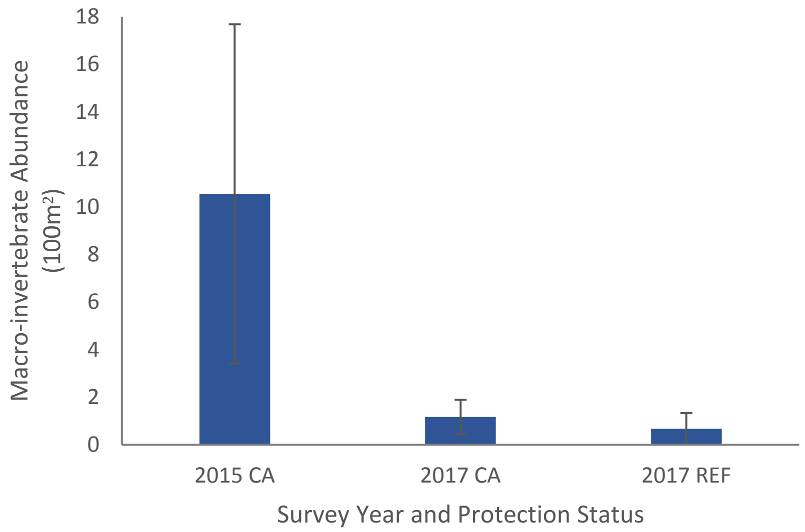

Figure 7: Mean macroinvertebrate abundance (±SE) per 100 m^2 within the CA in 2015 and 2017, and reference site in 2017.

Benthic cover shifted significantly among some major categories through time and protection level. The cover of macroalgae showed the greatest significant difference, where it was higher in the reference site (23.2% ±0.4) compared to the CA (0.1% ±0.1) in 2017 (ANOVA p-value <0.001). There were significantly more soft corals recorded within the reference site (1.7% ±0.6) than the CA in 2017 (0.03% ±0.3) (ANOVA p-value <0.05). Though non-significant, there was an increase in hard coral cover in the CA from 24.9% (±8.5) in 2015 to 44.8% (±11) in 2017. Other invertebrates, comprising mainly of ascidians and sponges, were significantly higher in the reference site (4.2% ±0.7) compared to the CA in 2017 (0.7% ±0.3) (ANOVA p-value <0.01). Additionally, there was a decrease of substrate within the CA in 2017, from 75% (±8.4) in 2015 to 54.3% (±11.1) in 2017, with the reference site having had the lowest substrate cover of 38.3% (±2.7) (fig. 8). However, these differences were not significant.

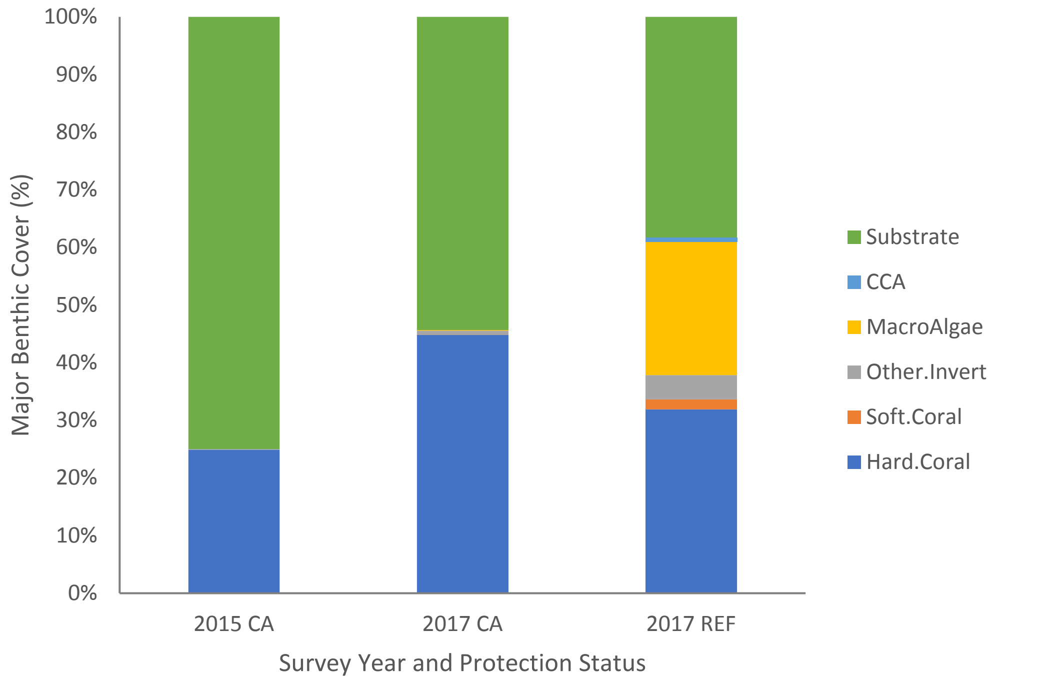

Figure 8: Major benthic categories coverage (%) within the CA in 2015, 2017 and the reference in 2017.

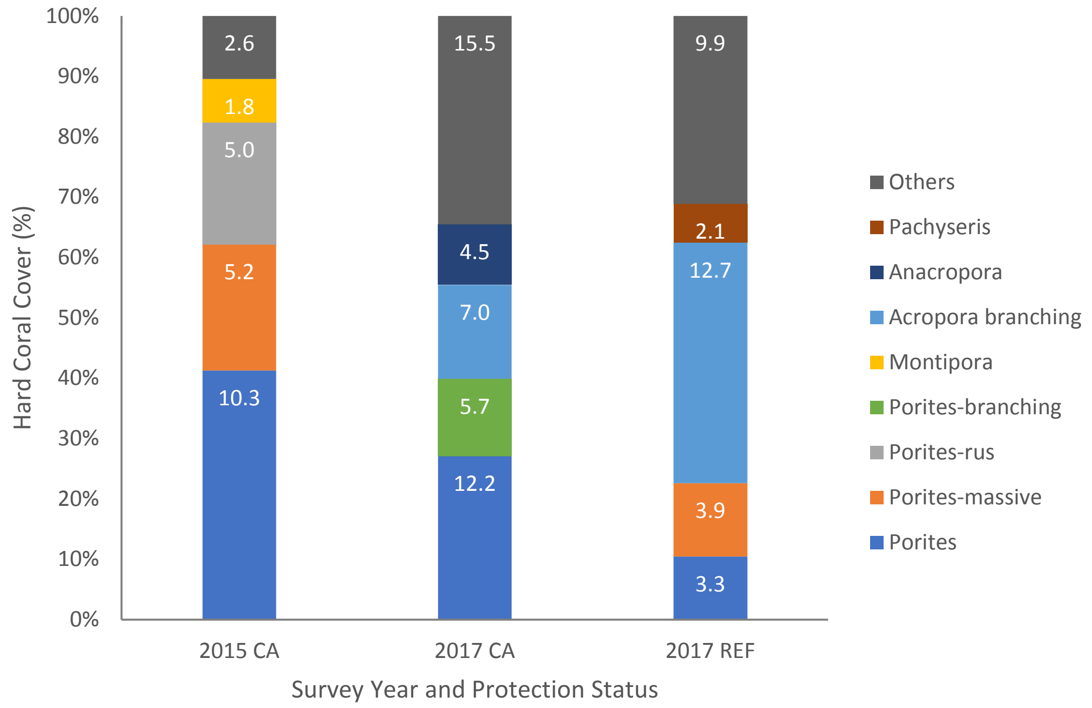

Figure 9: Relative percentage cover to the mean of hard coral categories identified within the CA in 2015, 2017, and the reference site in 2017.

There was no significant difference (ANOVA p-value >0.05) between the coral recruits recorded within the CA in 2015 and the 2017, nor between the CA and the reference site in 2017 (fig. 11). In 2015, an average of 15.6 (±0.9) recruits were recorded, while in 2017, there were 20 (±3.6) recruits per 3 m^2, and 18.5 (±6) recruits 3 m^2 were observed in the reference site in 2017 (fig. 10). Diversity of species recruitment had increased since 2015. In 2015, there were 8 species observed within the Ngermasech CA lagoon while in 2017, 20 species were observed in the CA and 19 total species within the lagoon reference site (fig. 11). Figure 11 below identifies the most abundant coral recruit genera.

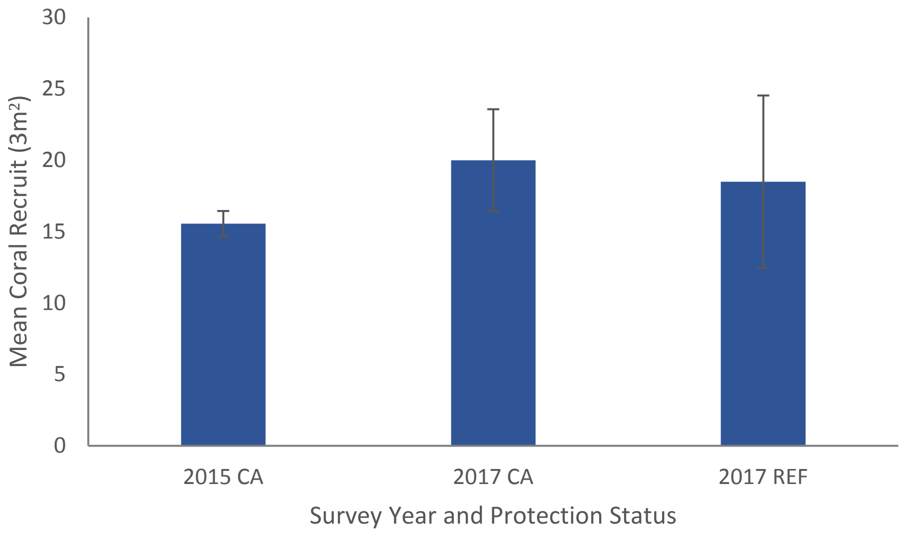

Figure 10: Mean coral recruit abundance (±SE) per 3 m^2 within the CA in 2015 and 2017, and reference site in 2017.

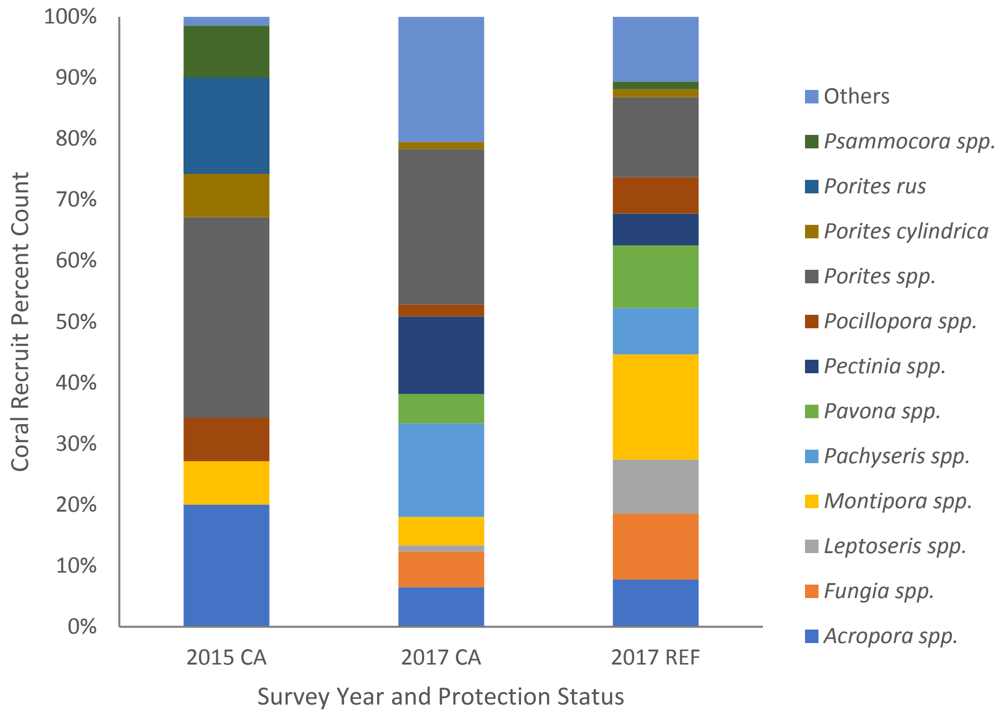

Figure 11: Mean coral recruit abundance (±SE), by species genera per 100 m^2 within the CA in 2015 and 2017, and reference site in 2017.

Discussion

The objective of this study was to examine the effectiveness of Ngardmau's Ngermasech Conservation Area (CA) in conserving natural resources. The baseline data was obtained in 2015 and was used to compared (when possible) to the data collected in 2017 to examine any changes over time. In addition to changes over time, data was also collected at a reference site to compare results in order to determine the effectiveness of the MPA.

Within the lagoon CA, results showed that macroalgae coverage was significantly lower than the reference site. Since there is no significant difference in fish biomass or abundance and change in fish species within the lagoon and reference, this difference in macroalgae within the lagoon CA and the reference lagoon could be caused by other factors such as dissolved nutrient in the seawater or run-off sedimentation. One possible explanation of this would be that the Ngermasech CA includes a mangrove area, where the preservation of this natural sediment filters could possible minimize the effects of runoff onto the reef flat and lagoon habitats (Golbuu, Victor, Wolanski, & Richmond, 2003). The two closest river mouths to the CA boundaries are roughly 1.3 km and 2 km, identified in figure 14 as the two blue lines. In addition to the mangrove protection within Ngermasech CA, the closest residential area to the water in Ngardmau is on the northern end of the state, closest to the reference site (fig. 12). Tree clearing, farming, and other land use would have an indirect impact to the nearby reef flat and lagoon.

Figure 12: Satellite image of Ngardmau State's Ngermasech CA within the (red) polygon, (blue) lines indicating the measured distance from the two river mouths to the CA borders, the (yellow) rectangle indicating the surveyed reference site, and the (yellow) oval identifying the residential community closest to the shore.

While we see an increase in high hard coral cover with very low macroalgal cover in the lagoon CA, the results from the remaining survey parameters show little change over time and/or protection level. And while we cannot compare the lagoon CA in 2015 to 2017 fish survey, there was an expectation that the CA with its full protection would have higher abundance or higher diversity of fish species (A. M. Friedlander, Brown, Jokiel, Smith, & Rodgers, 2003). Our findings show no change of fish biomass or abundance among the reef flat and lagoon CA and their respective non-protected reference sites nor any changes on the reef flat CA between the 2015 baseline and this (2017) follow-up. The lack of variation between the levels of protection could indicate possible poaching. This could also explain the decrease in clams within the CA. Though the fish population within the CA could improve, the fact that there is an increase in hard coral cover and decrease in macroalgae can either indicate that herbivorous fish within the CA are effective grazers, or nutrient conditions are low. Whereas within the lagoon reference site, results show an increase in macroalgae where the most abundant species are not herbivorous fishes but *Caranx ignobilis* (erobk).

Continuous surveying and monitoring over the coming years would indicate trends within the Ngermasech CA. Additionally, water quality monitoring within the CA will show possible trends with the increasing macroalgae within the reference site. According to a socio-economic study conducted in 2014, Ngardmau community members were highly knowledgeable and supportive of OSCA and the Palau PAN (Kleiber & Koshiba, 2014). This level of public awareness and support of Ngardmau's conservation efforts is key in ensuring the effectiveness of their conservation zones. Even with the strong community support, it is strongly recommended to increase surveillance and enforcement of the CA from possible poachers outside of the community. Finally, it is recommended to improve watershed management to minimize sediment run-off into the ocean.

Acknowledgment

Special thanks Michelle Dochez for leading the PICRC research team and completing the Ngermasech CA survey. PICRC would like to thank Ngardmau State Government for allowing us within their conservation area and for providing information for this study. This study was made possible with support from NOAA's Coral Reef Conservation Program, Global Environment Facility, and the Ministry of Natural Resources, Environment and Tourism.

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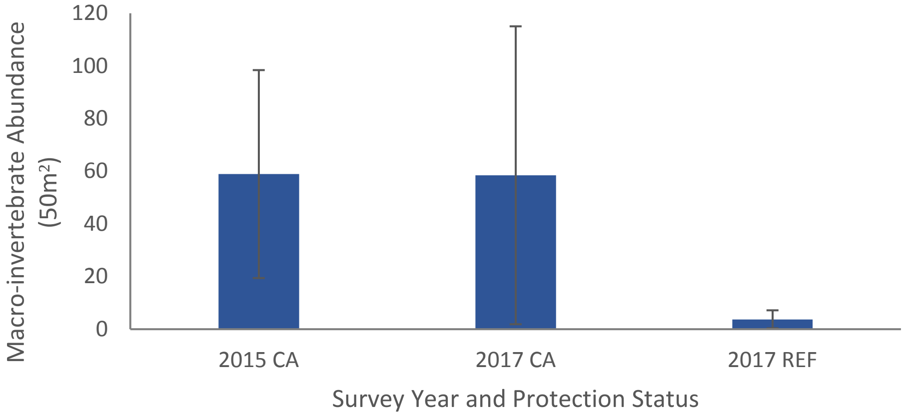
Appendix

Appendix 1: Macro-invertebrate abundance within Ngermasech reef flat.



Appendix 2: Benthic categories used when analyzing benthic data

Coral (C)	Montipora submassive (MONTISB)	Boodlea (BOOD)
Acanthastrea (ACAN)	Mycedium (MYCED)	Bryopsis (BRYP)
Acropora branching (ACB)	Oulophyllia (OULO)	Caulerpa (CLP)
Acropora digitate (ACD)	Oxypora (OXYP)	Chlorodesmis (CHLDES)
Acropora encrusting (ACE)	Pachyseris (PACHY)	Dictosphyrea (DYCTY)
Acropora submassive (ACS)	Paraclavarina (PARAC)	Dictyota (DICT)
Acropora tabular (ACT)	Pavona (PAV)	Galaxura (GLXU)
Alveopora (ALVEO)	Pectinia (PECT)	Halimeda (HALI)
Anacropora (ANAC)	Physogyra (PHYSO)	Liagora (LIAG)
Astreopora (ASTRP)	Platygyra (PLAT)	Lobophora (LOBO)
Caulastrea (CAUL)	Plerogyra (PLERO)	Mastophora (MAST)
Coral Unknown (CRUNK)	Plesiastrea (PLSIA)	Microdictyton (MICDTY)
Coscinaraea (COSC)	Pocillopora-branching (POCB)	Neomeris (NEOM)
Ctenactis (CTEN)	Pocillopora-submassive (POCSB)	Not ID Macroalgae (NOIDMAC)
Cyphastrea (CYPH)	Porites (POR)	Padina (PAD)
Diploastrea (DIPLO)	Porites-branching (PORB)	Sargassum (SARG)
Echinophyllia (ECHPHY)	Porites-encrusting (PORE)	Schizothrix (SCHIZ)
Echinopora (ECHPO)	Porites-massive (PORMAS)	Turbinaria (TURB)
Euphyllia (EUPH)	Porites-rus (PORRUS)	Tydemania (TYDM)
Favia (FAV)	Psammocora (PSAM)	SEAGRASS (SG)
Faviid (FAVD)	Sandalolitha (SANDO)	C.rotundata (CR)
Favites (FAVT)	Scapophyllia (SCAP)	C.serrulata (CS)
Fungia (FUNG)	Seriatopora (SERIA)	E. acroides (EA)
Galaxea (GAL)	Stylocoeniella (STYLC)	H. minor (HM)

Gardininoseris (GARD)	Stylophora (STYLO)	H. ovalis (HO)
Goniastrea (GON)	Symphyllia (SYMP)	H. pinifolia (HP)
Goniopora (GONIO)	Tubastrea (TUB)	H. univervis (HU)
Halomitra (HALO)	Turbinaria (TURBIN)	S. isoetifolium (SI)
Heliofungia (HELIOF)	SOFT CORAL (SC)	Seagrass (SG)
Heliopora (HELIO)	Soft Coral (SC)	T. ciliatum (TC)
Herpolitha (HERP)	OTHER INVERTEBRATES (OI)	T.hemprichii (TH)
Hydnophora (HYD)	Anenome (ANEM)	CORALLINE ALGAE (CA)
Isopora (ISOP)	Ascidian (ASC)	Amphiroa (AMP)
Leptastrea (LEPT)	Clams (CL)	Crustose Coralline (CCA)
Leptoria (LEPTOR)	Corrallimorph (COLM)	Fleshy-Coralline (FCA)
Leptoseris (LEPTOS)	Discosoma (DISCO)	Jania (JAN)
Lobophyllia (LOBOPH)	Dysidea Sponge (DYS)	SUBSTRATE (SUBS)
Merulina (MERU)	Gorgonians (G)	Carbonate (CAR)
Millepora (MILL)	Not Identified Invertebrate (NOIDINV)	Mud (MUD)
Montastrea (MONTA)	Sponges (SP)	Rubble (RUBBLE)
Montipora branching (MONTIBR)	Zoanthids (Z)	Sand (SAND)
Montipora encrusting (MONTIEN)	MACROALGAE (MA)	Turf (TURF)
Montipora foliose (MONTIF)	Asparagopsis (ASP)	
Montipora other (MONTIO)	Bluegreen (BG)	

Appendix 3: List of seagrass species.

Seagrass Species
1. *Enhalus acoroides*
2. *Halophila minor*
3. *Halophila ovalis*
4. *Thalassia hemprichii*
5. *Cymodocea rotundata*
6. *Cymodocea serrulate*
7. *Halodule pinifolia*
8. *Halodule uninervis*
9. *Syringodium isoetifolium*

Appendix 4: List of edible macroinvertebrates.

Common name	Palauan Name	Species
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 iCAtiens*
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	
China giant clam	duadou	*Hippopus porcellanus*

Appendix 5: List of commercially important fish in Palau.

Palauan Name	Common name	Species
Kemedukl	Bumphead parrotfish	Bolbometopon muricatum
Erobk	Bluefin trevally	Caranx ignobilis
Oruidel	Giant trevally	Caranx melampygus
Beyadel/ngesngis	Bicolor parrotfish	Cetoscarus bicolor
Melemau	parrotfish	Cetoscarus/Scarus Spp.
Maml	Humphead parrotfish	Cheilinus undulatus
Budech	Yellow cheek tuskfish	Choerodon anchorago
Meteungerel'temekai	Brown-marbled grouper	Epinephelus fuscoguttatus
Kesau'temekai	Marbled grouper	Epinephelus polyphekadion
Bekism	Indian Ocean Longnose parrotfish	Hiposcarus harid
Ngiaoch	Pacific longnose parrotfish	Hipposcarus longiceps
Komud, Teboteb	Rudderfish (lowfin)	Kyphosus spp
Udech	Orangestripe emperor	Lethrinus obsoletus
Melangmud	Longface enperor	Lethrinus olivaceus
Rekruk	Red gill emperor	Lethrinus rubrioperculatus
Mechur	Yellowlip emperor	Lethrinus xanthochilis
Uluu	Squaretail mullet	Liza vaigiensis
Kedesau'l iengel	River snapper	Lutjanus argentimaculatus
Kedesau	Red snapper	Lutjanus bohar
Keremlal	Humpback snapper	Lutjanus gibbus
Erangel	Orangspine unicornfish	Naso lituratus
Chum	Bluespine unicornfish	Naso unicornis
Melim ralm, Kosond/Bikl	Giant sweetlips	Plectorhinchus albovittatus
Merar	Yellowstripe sweetlips	Plectorhinchus crysotaenia
Tiau	Squaretail grouper	Plectropomus areolatus
Katuu'tiau, Moka	Saddleback grouper	Plectropomus laevis
Tiau	Leopard grouper	Plectropomus leopardus
Otord	Pacific steephead parrotfish	Scarus micorhinos
Udouungelel	Greenthroat parrotfish	Scarus prasiognathus
Beduut	Forketail rabbitfish	Siganus argenteus
Meyas	Dusky rabbitfish	Siganus fuscescens
Kelsebuul	Lined rabbitfish	Siganus lineatus
Reked	Masked rabbitfish	Siganus puellus
Bebael	Goldspotted rabbitfish	Siganus punctatus
Kelat	Bluespot mullet	Valamugil seheli

Appendix 6: Ngermasech CA and Reference site GPS coordinates (UTM)

Name of MPA	Habitat	Site	Lat	Long
Ngermasech_CA	Reef Flat	CA SG_2	840725	449181
Ngermasech_CA	Reef Flat	CA SG_5	838418	448642
Ngermasech_CA	Reef Flat	CA SG_8	837208	448790
Ngermasech_CA	Reef Flat	CA SG_14	839230	448462
Ngermasech_CA	Lagoon	CA LG_11	838349	448341
Ngermasech_CA	Lagoon	CA LG_12	838294	448498
Ngermasech_CA	Lagoon	CA LG_13	837236	448611
Ngermasech_REF	Lagoon	REF LG_1	841961	451344
Ngermasech_REF	Lagoon	REF LG_2	841984	451481
Ngermasech_REF	Lagoon	REF LG_3	842678	452426
Ngermasech_REF	Reef Flat	REF SG_1	843659	454432
Ngermasech_REF	Reef Flat	REF SG_2	842619	453206
Ngermasech_REF	Reef Flat	REF SG_3	841863	452753
Ngermasech_REF	Reef Flat	REF SG_4	841275	451803