Ecological assessment of Iuaiu Conservation Area in Angaur State

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Abstract

Palau has a strong conservation history. Traditional conservation knowledge is being applied in modern times, in the form of the marine protected areas (MPA). In 2003, the national government of the Republic of Palau established the Protected Areas Network (PAN). The PAN is a nationwide conservation effort, geared towards effective conservation and management of natural resources in Palau's marine and terrestrial environments. In 2015, PICRC researchers conducted baseline surveys in fourteen PAN MPAs. Beginning in 2017, PICRC researchers continued the study of MPA effectiveness by conducting follow-up surveys in order to assess their effectiveness, in terms of management and protection. This study was conducted in Iuaiu Conservation Area, located in Angaur State and has been protected since 2005 through state legislation. Surveys were conducted on the reef flat habitat, consisting of a seagrass bed and coral reefs. In order to assess effectiveness, surveys were conducted in nearby reference sites to compare results. Data collection consisted of recording the status of fish, macro-invertebrates, juvenile corals, seagrass cover, and benthic cover. Results show that the MPA is not very effective and contrasted between the coral reef area and seagrass beds. In the coral reef area, live coral cover, fish abundance and biomass were found to be significantly higher in the reference site than within the protected area while macro-invertebrates was found to be the same between MPA and reference site. Within the seagrass beds, the fish biomass and seagrass coverage were higher in the protected area, but the fish abundance was not significantly different. Overall, the small size of the Iuiau MPA, encompassing only one habitat (the reef flat), does not seem to effectively protect marine resources, especially in the coral reef area.

Introduction

Palau has a long history of environmental stewardship and natural resource management. Conservation is deeply rooted into the Palauan culture. Through the concept of 'bul'- where traditional chiefs prohibited use of or harvesting of resources for restricted periods of time- Palauans were able to conserve their resources (Johannes 1981). Today, the concept of 'bul' has evolved into modern day conservation techniques like the Marine Protected Areas (MPA). In Palau, the first MPA was established in 1956, called Ngerukewid, located in the Rock Islands Southern Lagoon in Koror State. Since then, Ngerumekaol – in Koror State- and Ebiil Channel – in Ngarchelong State- were later designated as MPAs. Since 2003, when the National Government created the Protected Areas Network (PAN), the PAN has grown to include 14 no-take MPA's and 13 terrestrial protected areas. The PAN is constantly growing to include more protected areas in order to meet the goals of the regional conservation targets of the Micronesia Challenge - to effectively manage and protect its marine and terrestrial resources.

Starting in 2014, Palau International Coral Reef Center (PICRC) began monitoring all MPA's in Palau, gathering baseline data for each site (Gouezo et al. 2016). After these baseline surveys were conducted, every two years after, follow up assessments will be done to monitor long-term trends and status and effectiveness of the resources in the MPAs. This study was conducted in Iuaiu Conservation Area located in Angaur State (Fig.1). Due to limited fringing reefs and increasing fishing pressures, the Angaur State Government passed a law in 2005, to establish a conservation area where Iuaiu Conservation Area is currently located, and at the same time, prohibited fishing activities within the area for a two-year period (Koshiba et al. 2014). It has since been protected under the state and is now part of the Protected Areas Network (PAN), however, a management plan has not been developed and implemented for the conservation area.

Methods

1. *Study sites*

Iuiau Conservation Area is located in Angaur State. It covers approximately 0.80 km^2 and consists of reef flat habitat with coral reefs and a seagrass beds (Figure 1). The conservation area's official boundary ends on the reef crest and does not encompass the fore reef. Reference sites were chosen based on their similarity to the protected area. Due to the lack of other seagrass beds in Angaur State, a similar reference site was chosen in Peleliu State to make comparisons between a protected and unprotected seagrass bed.

Figure 1: Map of Iuaiu Conservation Area (red polygon) with monitoring sites inside and outside the protected area. Seagrass reference site in Peleliu State.

2. *Ecological surveys*

<u>*Seagrass Habitats*</u>

Ecological surveys were conducted at each of the sites within the reef flat habitat. In the seagrass bed, five 25 m transects were laid consecutively, with a few meters separating them. Along these five transects, data on various ecological factors were collected. These included seagrass percentage cover (at the species level) within a 0.5m x 0.5m quadrat that were placed every 5 meters along the transect; fish abundance and size data was collected using visual count census in a 5 m wide belt; and any edible macro-invertebrates found in a 2 m wide belt were also recorded.

Coral Reef Habitat

On the coral reef flat, five 50 m transects were laid consecutively with few meters separating each transect. Benthic photos were taken along the transect using an underwater camera (model Canon G16), mounted on a 0.5 m x 0.5 m photo quadrat PVC frame. A total of 50 photos were taken on each transect. Furthermore, juvenile corals, measuring less than 5 cm, were recorded in the first 10 meters of each transect in a 0.3 m wide belt. Fish data within the coral reef habitat was recorded using a stereo-DOV system, which is a diver operated video system using two GoPRO Hero4 cameras mounted onto a metal frame. Additionally, edible macro-invertebrates were recorded in a 2m wide belt along the transect. Since the site was set in a shallow area, the maximum depth was approximately 5 m.

3. *Data processing and analysis*

Juvenile corals, macro-invertebrate, and fish (visual count) data were entered into excel spreadsheets. In order to estimate benthic cover, the photos taken were analyzed using CPCe (Coral Point Count with excel extension) software (Kohler and Gill 2006). In CPCe, five random points were allocated to each photo, and the substrate below each point was classified into the appropriate benthic category (see the benthic categories list in Appendix 1). In the end, the mean percentage of the benthic cover of each category was calculated for each transect (n= 50 photos per transect, n= 5 transects per site). The fish videos were processed using the software, EventMeasure. Only the fish with economical, subsistence and/or ecological importance were counted and measured. If the measurement precision was too low to be accurate, the fish was counted and the mean fish size within the site was attributed for biomass estimate. The biomass of fish was calculated using the total length-based equation:

$$W = aTL^b$$

where W is the weight of the fish in grams, TL the total length of the fish in centimeters (cm), and a and b are constant values that derive from published biomass-length relationships (Kulbicki et al. 2005) and from Fishbase (http://fishbase.org).

Before analyzing and testing, data were checked for normality using histograms and the Shapiro test. However, when the data was non-normal, the data was transformed and re-tested. When data was normal, Welch Two-sample t-test was used to compare the MPA with the reference area. When the data was non-normal, the non-parametric Mann-Whitney U test was used instead.

Results

The findings from the 2017 monitoring surveys are presented by each habitat and wherever possible, comparisons are made between the 2017 data and the data from the baseline surveys, conducted in 2014.

1. *Reef Flat Habitat: Seagrass bed*

In the seagrass habitats, the main species of seagrass found in the MPA were *C. rotundata* and *T. hemprichii*. In the reference area, *C. rotundata, E. acoroides, H. ovalis,* and *T. hemprichii* were found, but *T. hemprichii* was the most abundant. The coverage of seagrass was significantly greater in the MPA than it was in the reference area (Welch Two-sample T-test, p = 0.04075) (Fig. 2). Data was not compared to the 2014 baseline data due to different methods used to conduct seagrass surveys.

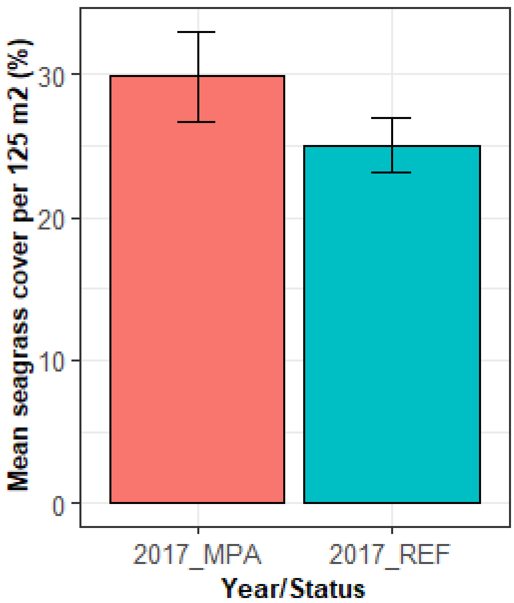

Figure 2: Mean percentage cover (± SE) of seagrass in MPA and reference sites. *n = 15*

Fish abundance was not significantly different in 2017 than in 2014 within the MPA (Welch Two-Sample T-test, $p = 0.2253$), and between the MPA and reference site in 2017 (Welch Two-Sample T-test, $p = 0.9395$) (Fig. 3).

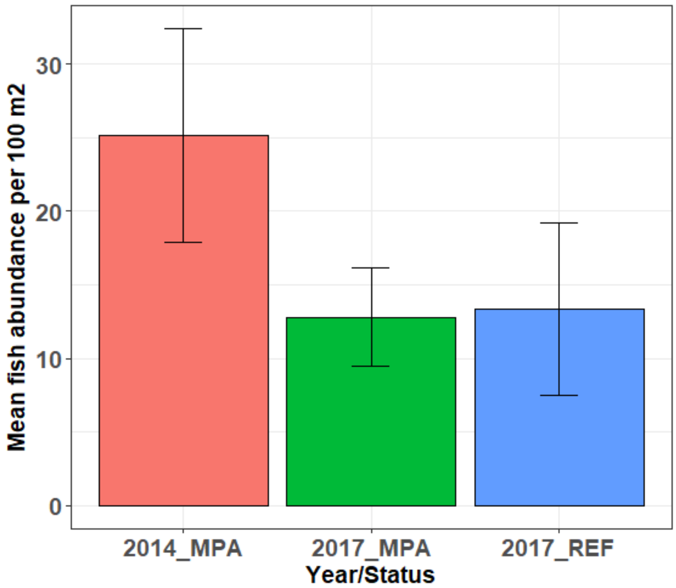

Figure 3: Mean abundance of fish (± SE) in seagrass habitat within MPA and reference sites in 2014 and 2017. *n = 9 (2014); n = 15 (2017)*

In terms of fish biomass, bigger fish was found in the MPA in 2017 as compared to the reference site and found to be marginally significant (Mann-Whitney U test, $p = 0.05$), but was not significant when compared to 2014 data (Welch Two-Sample T-test, $p = 0.2308$) (Fig. 4).

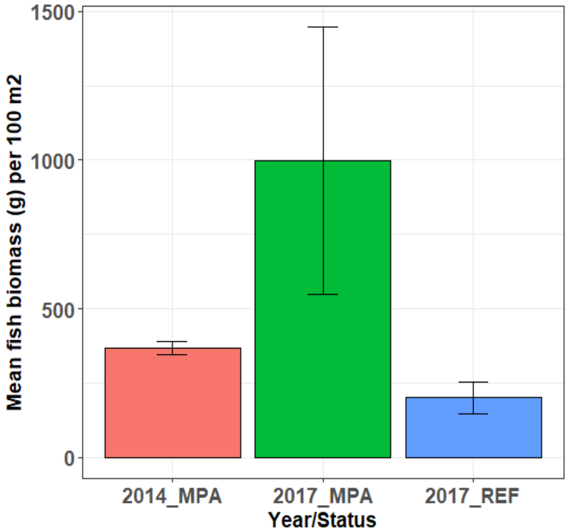

Figure 4: Mean fish biomass (± SE) in seagrass habitat within MPA and reference sites in 2014 and 2017. *n = 9 (2014); n = 15 (2017)*

Furthermore, in 2014, the only recorded edible macro-invertebrate recorded in the MPA was the giant clam species, *Tridacna crocea* (oruer). However, more macro-invertebrates were recorded in the 2017 surveys (Fig. 5). Within the MPA, an average of two macro-invertebrates were recorded, whereas in the reference site, an average of one macro-invertebrates was recorded per 125 m^2. Hence, there was no difference in abundance in invertebrates (Mann-Whitney U Test, $p > 0.05$). The macro-invertebrate species recorded within the MPA consisted of giant clam species, *Tridacna crocea* (oruer) and *Hippopus hippopus* (duadeb). On the other hand, within the reference site, the giant clam species *Tridacna crocea* (oruer) was recorded, in addition to sea cucumber species *Bohadschia marmorata* and *Bohadschia argus* (mermarech).

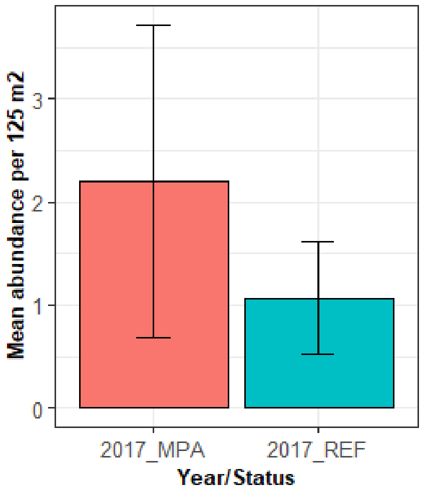

Figure 5: Mean abundance of invertebrates (± SE) in the seagrass habitat. *n = 15*

2. *Reef Flat Habitat: Coral reefs*

The coral reef flat habitat mainly consisted of carbonate, turf algae, sand, and live corals (Fig. 6). The coverage of carbonate increased significantly (Welch Two-Sample t-test, $p = 0.003$) from 2014 within the protected area, while the sand (Mann-Whitney U test, $p < 0.001$) and turf algae (Welch Two-Sample t-test, $p = 0.037$) decreased significantly (Fig. 6). Crustose coralline algae increased significantly within the MPA since 2014 (Mann-Whitney U test, $p = 0.004$). When comparing between MPA and reference sites, the carbonate coverage was lower in the reference site than in the protected area (Welch Two-Sample t-test, $p = 0.095$).

Furthermore, the percentage of turf algae was greater within the reference area than in the protected area (Mann-Whitney U test, $p < 0.001$) (Fig. 6).

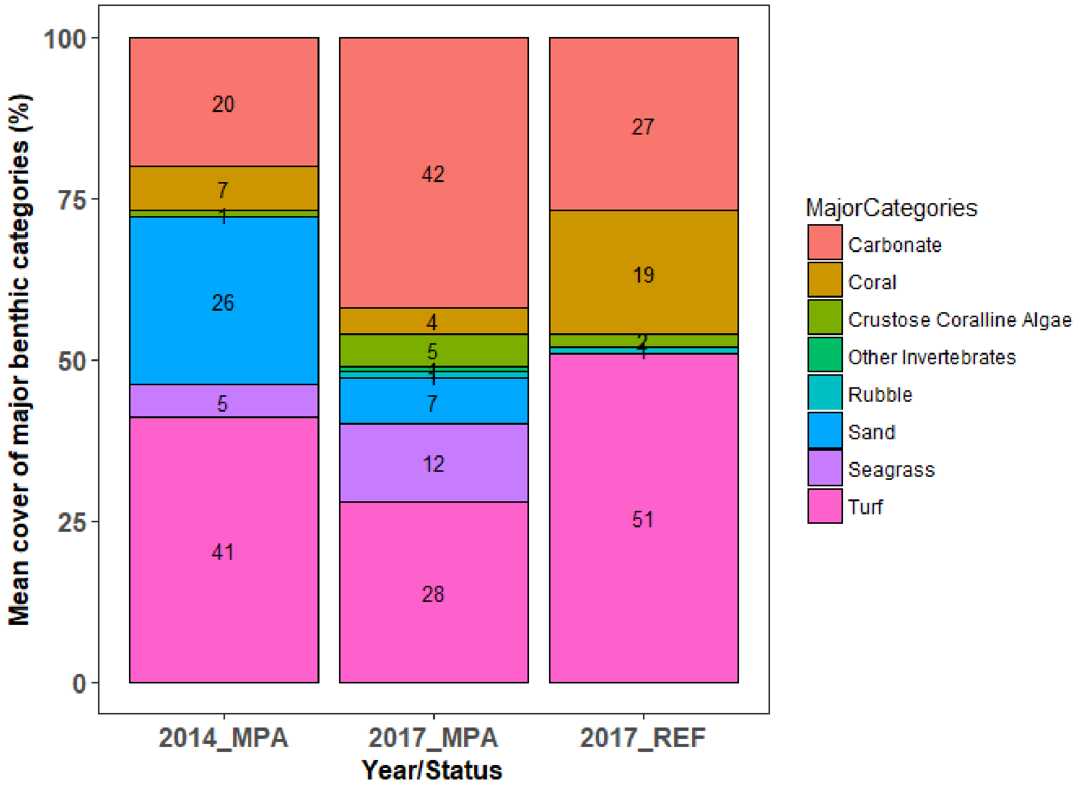

Figure 6: Mean of major benthic categories found in the reef flat habitat inside and outside of the conservation area. *n = 9 (2014)*; *n = 15 (2017)*

The live coral cover was compared between 2014 and 2017 data collected within the protected area. In 2014, the live coral cover was about 11% (±1.58%) and decreased to about 6.8% (±1.26%) (Fig. 7). The difference in means were found to be marginally significant (Welch Two-Sample T-test, $p = 0.055$). Comparing between the MPA and reference area, live coral cover in the reference area (28.5% (±3.9%)) was significantly more than in the MPA (Welch Two-Sample T-test, $p < 0.001$).

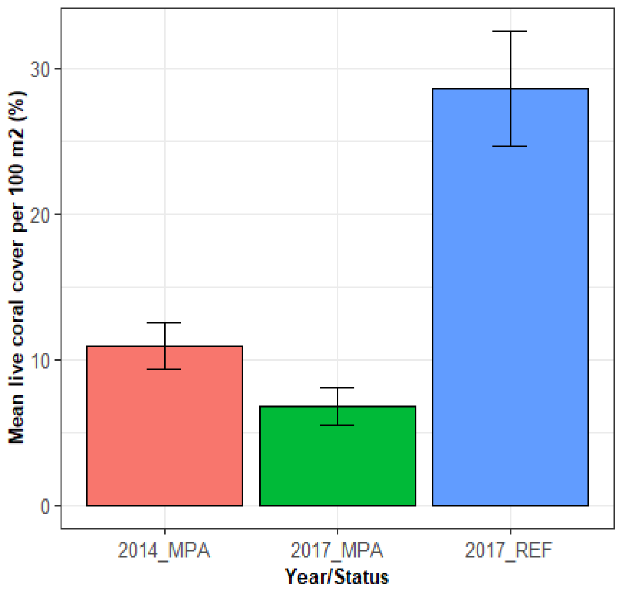

Figure 7: Mean live coral cover (± SE) over time inside and outside the MPA. *n = 9 (2014), n = 15 (2017)*

Juvenile coral data was not recorded in the baseline surveys in 2014. However, in 2017, data collected showed no significant difference between the protected and unprotected areas in terms of juvenile coral density (Welch Two-Sample t-test, $p = 0.4202$) (Fig. 8).

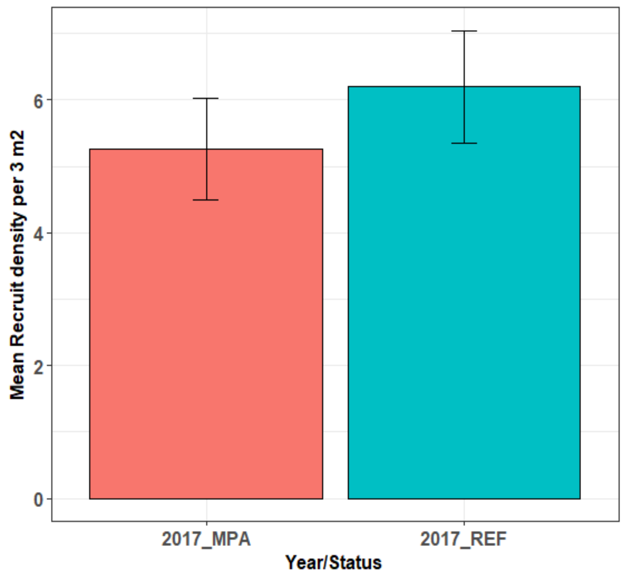

Figure 8: Mean density of coral recruits (± SE) inside and outside of the protected area. *n=15*

In 2014, the abundance of food fish within the MPA was significantly greater than was found in 2017 (Welch Two-Sample t-test, $p < 0.001$) (Fig. 9). In 2017, the abundance of food fish was higher in the reference area than in the protected area (Welch Two-Sample T-test, $p < 0.001$) (Fig. 9).

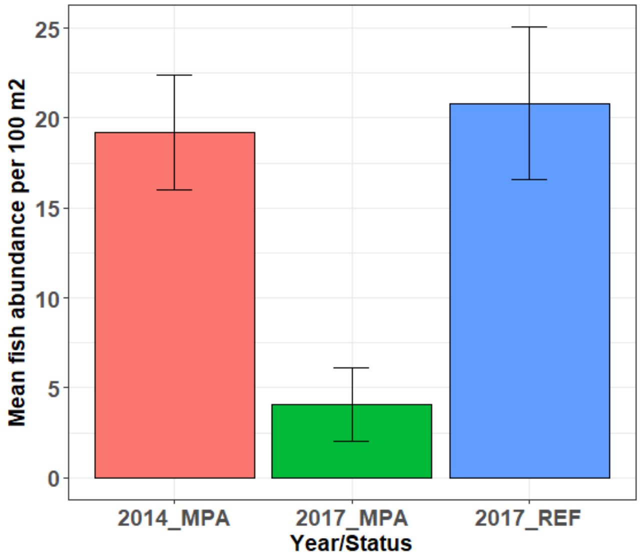

Figure 9: Mean abundance of food fish (± SE) in the MPA and reference area. *n = 9 (2014), n = 15 (2017)*

The biomass of food fish was higher in the reference area with 2.39 kg (±0.93 kg) per 250 m^2 than the conservation area with 0.47 kg (±0.18 kg) per 250 m^2, showing a significant difference (Mann-Whitney U test, $p = 0.045$) (Fig. 10). See the appendix for a complete list of recorded fish species in Iuaiu MPA and reference sites.

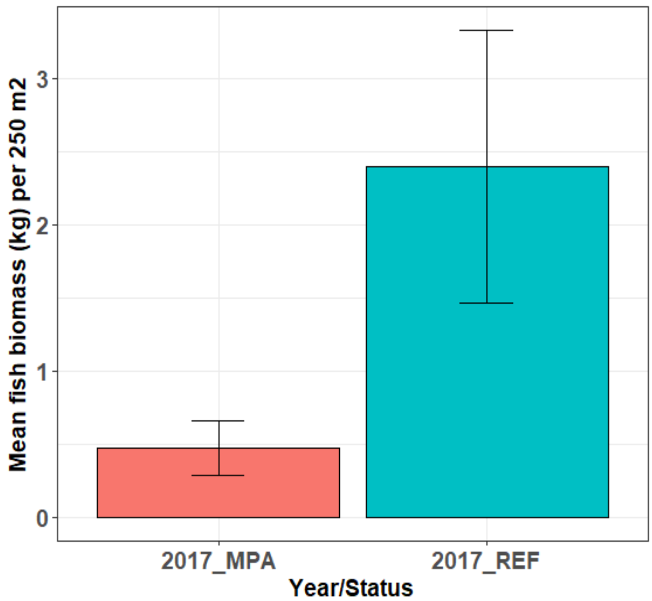

Figure 10: Mean fish biomass (kg) (± SE) inside and outside of MPA (Mann-Whitney test, $p < 0.001$). *n = 15*

In 2017, more macro-invertebrates were recorded within the protected area than in the reference site, recording an average of 8 (±3) individuals per 250 m^2 (Fig. 11).

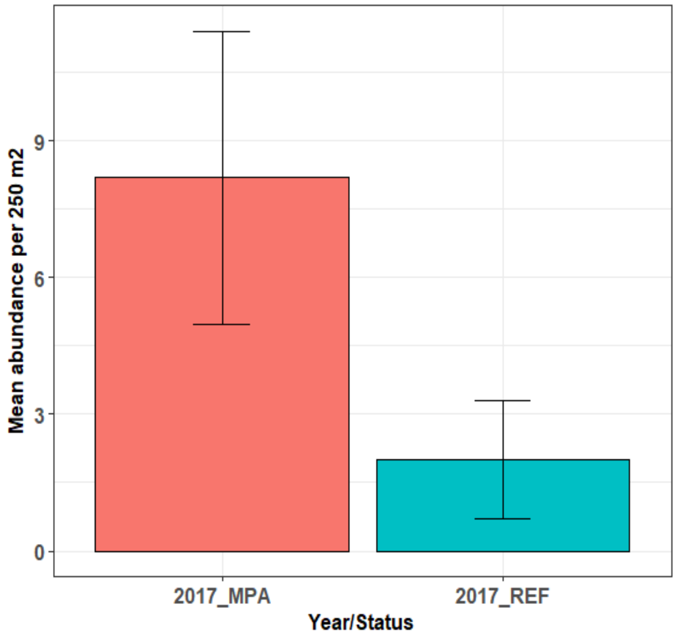

Figure 11: Mean abundance of invertebrates (± SE) in MPA and reference site (marginally significant, t-test, p = 0.059). *n = 15*

Discussion

The data collected from the Iuaiu Conservation Area baseline and follow up assessments indicates that the MPA is not thriving, especially within the coral reef areas of the reef flat habitat. The follow up survey in 2017, showed a decrease in nearly all ecological indicators within the conservation area; in addition, most of the results of ecological indicators were significantly higher within reference areas than in the protected area. This may be due to several factors including habitat structure, overall MPA size, and disturbances such as typhoons.

It is important to look at the structure of the habitat to determine whether or not its functionality is effective. The result of this assessment show that the seagrass beds are healthy and thriving. Within the MPA, the seagrass cover averaged about 30%, while the reference area showed 20% coverage (Fig. 2). Due to its importance as a juvenile fish nursery and shelter, it must be protected to the fullest extent (Duarte 2002; Dorenbosch et al 2005). On the other hand, the coral reef is not as productive, with a decrease in coral cover from 11% in 2014 to about 6.8% in 2017 (Fig. 7) in the

MPA. However, within the reference site, the coral cover was significantly higher with 28.5% cover (Fig. 7). This decrease in live coral cover within the MPA may be attributed to Tropical Storm Lan, which passed over the western outer reefs of Palau in October 2017 (Gouezo & Olsudong 2018). This study showed that Tropical Storm Lan contributed a loss of about 20% coral cover in the Angaur monitoring site at 3 m and 12% loss at 10 m (Gouezo & Olsudong 2018). Since the Iuaiu MPA is located on an exposed reef flat on the western reef, the wave energy may have had more damaging impacts on the conservation area than in the more sheltered reference site.

Furthermore, as a result of the high seagrass cover, fish abundance was higher in the seagrass beds with about 13 fish per 100 m^2 (Fig. 3) compared to the coral reefs with only 4 fish per 100 m^2 (Fig. 9). With barely any cover, fish are most likely to stay within sheltered areas (like the seagrass beds) for protection from predators. On the other hand, looking at the reference area for coral reefs, the coral cover was significantly higher, which contributed to the increased fish abundance, an average of 21 fish per 100 m^2 (Fig. 9). Moreover, in terms of fish biomass, the seagrass beds hosted bigger fish (1 kg per 100 m^2) as compared to the coral reefs (0.5 kg per 250 m^2) in the conservation area. On the contrary, the reference site for seagrass bed showed smaller fish, measuring about 0.09 kg per 100 m^2, and the fish in the coral reef reference area were bigger, measuring 2.4 kg per 250 m^2. A study states that a thriving seagrass habitat with abundant juvenile fish will replenish fish populations within the adjacent coral reef habitats (Dorenbosch et al 2005). Thus, since the coral reef (MPA) is not a productive habitat, it is increasingly important to safeguard the seagrass bed for future productivity within the seagrass bed itself and the adjacent coral reef habitat.

It seems that the MPA is quite beneficial to the macro-invertebrate populations, most specifically the giant clam species, *Tridacna crocea* and *Tridacna maxima*. In one site within the MPA, 23 individual clams were counted and measured, indicating a thriving population of clams within the Iuaiu MPA. Furthermore, the increase in the clam population since 2014 is a positive sign for the conservation area. On the other hand, in terms of sea cucumbers, only a couple *Bohadschia spp.* (sea cucumbers) were recorded within both the seagrass bed and coral reef sites. Gouezo et al emphasized the failures of marine protected areas at protecting sea cucumber species due to its slow mobility, growth rate, and reproductive rate (Gouezo et al 2018; Uthicke et al 2004). Since there is no previous evidence of sea cucumber abundance in this area, it is hard to tell if the sea cucumber population will increase, due to the fact that the present population within the conservation area is already so low.

The low numbers of each ecological indicator may be due to the small size of the conservation area, which measures about 0.80 km^2 and only encompasses one habitat: reef flat, though it includes seagrass beds and coral reef areas. There have been many studies that look at MPA sizes and its effectiveness in safeguarding resources such as fish and macro-invertebrates. For example, Kramer and Chapman emphasized that smaller MPAs give fish smaller “home ranges”, meaning the fish will travel in and out of the MPA more frequently, thus increasing its exposure to fishers (Kramer & Chapman 1999). Also, in terms of fish repopulation, smaller MPAs do not have the capacity to be productive within the protected area and in the surrounding areas, thus losing the main goals of establishing an MPA (Halpern 2003). Finally, Halpern also stressed the need to have a sizeable MPA that will withstand natural disturbances such as typhoons (Halpern 2003). Now that the MPA coral cover is quite low, a source for coral larvae/recruit is needed to repopulate the coral reef area. As the Iuaiu MPA is small and isolated from other similar habitats, recovery post-storm disturbance will take a long time.

Finally, a couple recommendations are made to help ensure a productive and efficient marine protected area. The first recommendation would be to increase the size of the MPA to include the fore reef habitat, where the reef was more productive (personal observation). The boundary of the MPA ends right on the edge of the reef crest, excluding the fore reef where more fish and corals were seen. The exclusion of the fore reef adds to the unproductivity of the MPA, as it is open to fishing and the fish that reside within the MPA are being caught right outside the boundary. In the end, increasing the boundary to encompass the fore reef will be beneficial to the protection of the resources, since it is evident that larger MPAs are more prone to host higher fish abundance and biomass, as well as providing maximum protection and build productivity within the MPA (Friedlander et al 2017).

Another recommendation is to evaluate the overall goals of the establishment of the MPA. Since its initial closure by the Angaur State Government in 2005, and becoming a PAN site, a management plan has not been created for the Iuaiu Conservation Area. This means that there is no clear direction for the protection and conservation of this protected area. Again, Halpern emphasized that the "success in the design and functions of a marine reserve is closely tied to the goals of the reserve" (Halpern 2003). Thus, in order to move forward with conservation area protection, Angaur State must re-evaluate their motives for implementing the protected area in the first place; pinpoint the main reason for protection – whether it be fish, invertebrates, or coral protection – and work with relevant agencies and stakeholders to create a management plan that will effectively aid in achieving the State's goals and objectives for MPA protection.

Acknowledgment

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References

Duarte, C. 2002. *The future of seagrass meadows.* Environmental Conservation 29 (2): 192 – 206.

Friedlander AM, Golbuu Y, Ballesteros E, Caselle JE, Gouezo M, Olsudong D, Sala E (2017) *Size, age, and habitat determine effectiveness of Palau's Marine Protected Areas.* PloS One 12:e0174787

Gouezo M, Koshiba S, Otto E, Olsudong D, Mereb G, Jonathan R. March 2016. *Ecological conditions of coral reef and seagrass marine protected areas in Palau.* PICRC Technical Report 16-06. Palau International Coral Reef Center, Koror, Palau.

Gouezo M. and Olsudong D. 2018. *Impacts of Tropical Storm Lan (October 2017) on the western outer reefs of Palau.* PICRC Technical Report 18-08. Palau International Coral Reef Center. Koror, Palau.

Gouezo M, Nestor V, Dochez M, Jonathan R, Marino L, Olsudong D, Mereb G. June 2018. *Status of seagrass fishes and macro-invertebrates at Teluleu Conservation Area from 2011-2018.* PICRC Technical Report No. 18-13. Palau International Coral Reef Center. Koror, Palau.

Halpern B. 2003. *The Impact of Marine Reserves: Do Reserves Work and Does Reserve Size Matter?* Ecological Applications 13 (1): S117 – S137.

Johannes RE. 1981. *Words of the Lagoon: Fishing and Marine Lore in the Palau District of Micronesia*. University of California Press, CA.

Koshiba S, Jonathan R, Olsudong D, Oruetamor J, Mereb G, Polloi K. 2014. *Baseline Assessment of Angaur Conservation Area*. PICRC Technical Report 14 - 11. Palau International Coral Reef Center. Koror, Palau.

Kramer D.L. and Chapman M. 1999. *Implications of fish home range size and relocation for marine reserve function.* Environmental Biology of Fishes 55: 65 – 79.

Uthicke S, Welch D, and Benzie J.A.H. 2004. *Slow Growth and Lack of Recovery in Overfished Holothurians on the Great Barrier Reef: Evidence from DNA Fingerprints and Repeated Large-Scale Surveys.* Conservation Biology 18 (5): 1395 – 1404.

Appendix 1. Table of benthic categories.

CORAL (C)	Montiporasubmassive (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)
Acroporasubmassive (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 2. Fish species recorded in Iuaiu Conservation Area and reference sites.

Scientific Name	**Common Name**	**Palauan Name**
Acanthurus lineatus	Lined surgeonfish	belai
Acanthurus maculiceps	White-freckled surgeonfish	mesekuuk bad
Acanthurus nigricauda	Blackstreak surgeonfish	chesengel
Acanthurus triostegus	Convict surgeonfish	elas
Bolbometopon muricatum	Bumphead parrotfish	kemedukl
Scarus spp.	Parrotfish	mellemau
Naso lituratus	Orangespine unicornfish	erangel
Lutjanus gibbus	Red snapper	keremlal
Caranx melampygus	Bluefin trevally	oruidel
Cephalopholis argus	Peacock hind	mengardechelucheb
Ctenochaetus striatus	Lined bristletooth	masech
Cheilinus fasciatus	Red breasted wrasse	kerdeu
Cephalopholis miniata	Coral hind	temekai
Lethrinus harak	Thumbprint emperorfish	itotech