Third assessment of Medal Ngediull MPA reveals a decrease in coral recruitment and an increase in macroalgal cover

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Abstract

Communities throughout Palau have established marine protected areas to help preserve important food and cultural resources. This study aims to assess the efficiency of Medal Ngediull Marine Protected Area (MPA) in protecting these resources, and is the third follow-up assessment since the baseline in 2017. This MPA is located in an enclosed bay in front of two rivers, thus it is subjected to high suspended sediment and turbidity. Seagrass beds and lagoon habitats were surveyed, within the MPA and in a close- by area without protection (reference site), to assess differences in benthic community composition, coral recruits, macroinvertebrates and fish populations. Seagrass beds in this area have also been monitored every year from 2011 to 2015 as part of a long term monitoring project. Results showed that coral recruits had a 60% decline between 2017 and 2019, whereas macroalgal cover increased from 0 to ~12%. Seagrass cover and fish inhabiting the seagrass habitat varied over time, eventually declining in the last two years of assessment. Coral cover and macroinvertebrate number were always low, but stable over time. No significant difference was identified between protection status over the years; therefore, we could assume that this MPA is not effective in protecting the targeted marine resources. The decline in coral recruits and increase in macroalgae suggest that runoff and nutrient input from the rivers are the main cause of negative impacts on the marine resources protected by Medal Ngediull MPA.

1. Introduction

Marine Protected Areas (MPAs) are an effective management tool utilized to protect the marine environment from resource exploitation. MPAs can have different regulations and protection levels, from complete no take and no entry to sustainable use and non-extractive use. Palau has 35 locally managed MPAs, 14 of which are part of the Palau Protected Areas Network (PAN), which was set up in 2003 to preserve Palau's marine resources (Friedlander et al., 2017). Every two years, the Palau International Coral Reef Center (PICRC) conducts surveys to assess benthic community, fish assemblages and seagrass beds within these MPAs, and compares them to adjacent reference (REF) areas open to human exploitation.

Medal Ngediull MPA is an important nursery area for food fish such as rabbitfish (Siganidae), and other fully protected iconic species such as the Napoleon wrasse (maml, *Cheilinus undulatus*) and the bumphead parrotfish (kemedukl, *Bolbometopon muricatum*). From traditional knowledge it is known that this area hosted abundant commercially and culturally important fish and invertebrates species but the impacts of sedimentation, overgrown mangroves and poaching have caused a substantial decline in these resources (Airai state, 2013). The MPA receives discharge from two rivers: Ngerikiil on the north-west and Ngerimel on the east, which drain a small catchment area characterized by highly erodible soils. Therefore, sediment load is very high in this area, sometimes exceeding 1500 mg/L. About 98% of the riverine fine sediment settles in Airai Bay, and only 15–30% is retained by mangroves forests during river floods. This mud remains trapped in Airai Bay because it is enclosed by a wide and shallow reef where it smothers the benthic community (Golbuu et al. 2003). An area near the MPA has also been subjected to dredging to build up a passage for boats within the reefs in 2016-2017 (Palau EQPB data, 2023). This study is the third assessment of Medal Ngediull MPA, following Gouezo et al. (2018) and Nestor et al. (2020).

2. Methods

2.1 Study site

Figure 1. Map of Medal Ngediull MPA sites and reference sites in different habitats: lagoon (LG, purple) and seagrass (SG, green).

Medal Ngediull PAN MPA is ~0.32 km^2 wide and includes seagrass dominated reef flats and lagoons. It hosts three small limestone islands located in the middle of the MPA. Seagrass beds and lagoon habitat were surveyed during the present study (Figure 1).

2.2 Data collection

Seagrass beds and reef flat sites were surveyed at high tide. Lagoon environments were surveyed at low tide at a depth of ~10m. Seagrass bed surveys were done by snorkeling, laying down five 25 m transects with 1-2 m gap between transects. A 0.5 m quadrat was placed every 5 m to assess the percentage of seagrass cover to species level and the presence of other benthic organisms such as sponges and macroalgae. The abundance and size of fisheries targeted and commercially important fish species (see Appendix C, Table 1) was recorded by visual census along the transects within a 5 m wide belt. Similarly, edible macroinvertebrates (see Appendix B, Table 1) size and abundance were recorded along the transect on a 2 m wide belt. Seagrass sites were surveyed each year from 2011 to 2015 as part of a long term seagrass monitoring program. After 2015 the same sites were surveyed once every two years for both seagrass and MPA monitoring purposes.

Lagoon environments were surveyed every two years from 2017 to 2021, using scuba diving along five 50 m transects laid consecutively with ~2 m gaps in between. Benthic cover of the sites were recorded using a Canon G16 mounted on a 0.5 x 0.5 m photoquadrat, taking one picture per meter (50 pictures in total), on the right side of the tape, while trying to keep the quadrat frame as close as possible to the substrate. Edible macroinvertebrate (See Appendix B for list) size and abundance was recorded over the five transects on a 2 m wide belt (1 m on each size of the tape) using a 1 m long stick as a reference. Coral recruit (<5 cm in size) abundance and size was recorded only for the first 10 m of each transect, over 0.3 m on the right side of the tape. Fish assemblages were recorded with a diver-operated stereo-video (stereo-DOV) composed of two GoPro hero 8 cameras mounted at the two ends of a metal bar. This system is calibrated annually and can be used to compute accurate fish lengths. Lagoon environments have been surveyed every two years since 2015.

2.3 Data processing

Data collected for seagrass cover, fish density and biomass, macroinvertebrates and coral recruits' density were entered into excel spreadsheets. Percentage of each species of seagrass was summed to obtain the total seagrass cover in each quadrat and the average seagrass cover was calculated for each transect. For macroinvertebrates and coral recruits, the total number of individuals counted per transect were summed and then divided by the transect length multiplied by the width to get the density. Fish videos from the fore reef habitat were analyzed using the SeaGIS EventMeasure software (Version 4.42). The Length/3D rules in EventMeasure were set up as in Goetze et al. (2019), where the maximum range = 8000 mm, maximum RMS = 20 mm, maximum precision to length ratio = 10%, minimum x coordinate = -2500 mm and maximum x coordinate = 2500 mm. Fork length measurements were made for all commercially important fish (see Appendix C for list of commercially important fish species included in stereo-DOV analysis). In addition, key herbivorous fish from six families were also measured (Acanthuridae, Ephippidae, Kyphosidae, Pomacanthidae, Labridae-Scarinae and Siganidae), based on Green & Bellwood (2009). Where the precision to length ratio exceeded 10%, the fish was counted and an estimated length was calculated based on the mean fish length of that species within the MPA or the reference site (Goetze et al, 2019). Fish weight was estimated by using the length-weight conversion equation from FishBase (Froese and Pauly, 2021): $W = a\ FL \wedge b$, where a and b are constants of the allometric growth equation, FL is the fork length in cm, and W is the weight in grams. Constants a and b were selected from studies from the closest locations to Palau where possible.

Average fish biomass and density per transect was then quantified by dividing the total weight and total number of fish by the transect length multiplied by the transect width.

Benthic photos were analyzed using CPCe software (Kohler & Gill, 2006), where five random points were allocated to each photo. The substrate below each point was then classified into benthic categories (see Appendix A, Table 1 for benthic categories list), used to calculate the percentage of cover per each category over the five quadrats.

2.4 Data analysis

The aim of the data analysis was to identify differences between MPA and reference zones within each habitat and differences between study years. Histograms were used to check if data showed a normal distribution. Normally distributed data were analyzed with linear mixed effect models. Non-normal data, that failed log, square root or cube root transformation, were analyzed with generalized linear mixed effect models. Both models were run using the 'lme4' R package. When significance was found, post-hoc pairwise comparison was conducted using the 'emmeans' R package.

3. Results

3.1 Seagrass environment

3.1.1 Seagrass

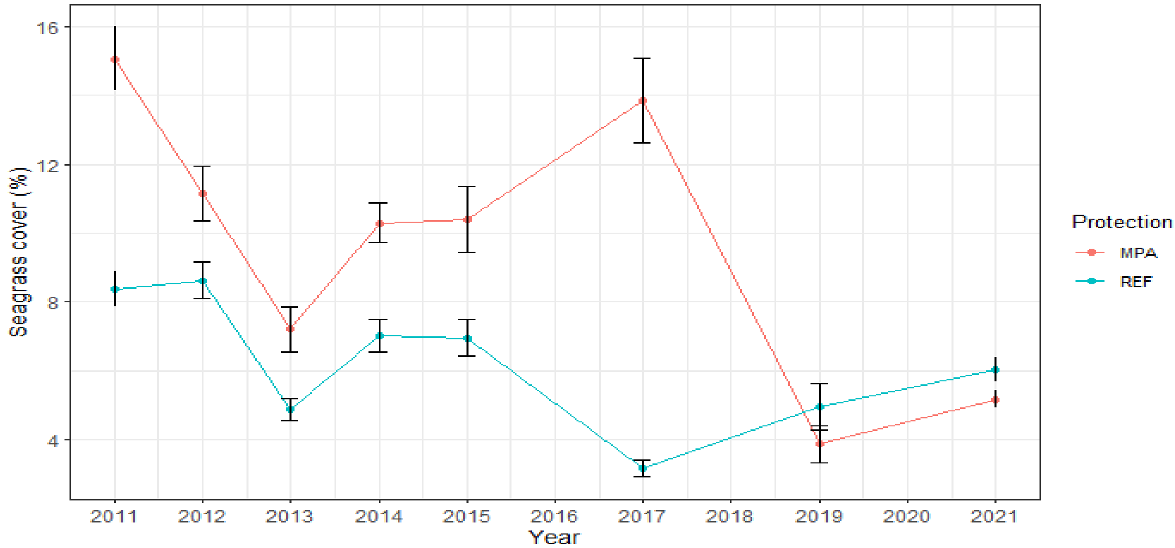

Figure 2. Graph showing seagrass cover change over the years in MPA and reference sites. Error bars represent standard error.

Seagrass cover in the MPA had a significant ($P < 0.001$) decline from 2011 to 2013 (15.0 ± SE 0.9% to 7.2 ± SE 0.6%), then increased significantly in 2014-2015 to 10.4 ± SE 0.9%, and further significantly increased ($P < 0.001$) to 13.8 ± SE 1.2% in 2017. In 2019, seagrass cover had a significant sharp decline ($P < 0.001$) to 3.8 ± SE 0.5%. No significant increase ($P>0.05$) was detected between 2019 and 2021, when cover accounted for 3.8 ± SE 0.5 % and 5.16 ± SE 0.2% respectively (Figure 2). In reference area there was a similar trend up to 2015, showing a significant decline ($P<0.001$) between 2011 and 2013 (from 8.4 ± SE 0.5% to 4.9 ± SE 0.3%) and a significant increase ($P<0.001$) in 2014 and 2015 where cover accounted for 6.9 ± SE 0.5%. In 2017 there was again a significant decline ($P<0.001$) to 3.2 ± SE 0.2%. In 2019 there was a significant increase ($P<0.001$) in seagrass cover up to 4.9 ± SE 0.7%, which remained stable ($P>0.05$) in 2021, with a cover of 6.0 ± SE 0.4 (Figure 2).

Figure 3. Proportion of cover of different species of seagrass across protection status and years of study.

Seagrass species composition also changed over time. Medal Ngediull MPA sites were always dominated by the species *Enhalus acoroides* and had variable cover of *Thalassia hemprichii* over the years of monitoring (Figure 3). The reference area hosted more species, which changed in their proportions over the years. In 2021, more than 90% of total seagrass cover was *Enhalus acoroides* (Figure 3). The species *Cymodocea rotundata* was seen only in the reference sites for the first two years of monitoring (Figure 3).

3.1.3 Food fishes

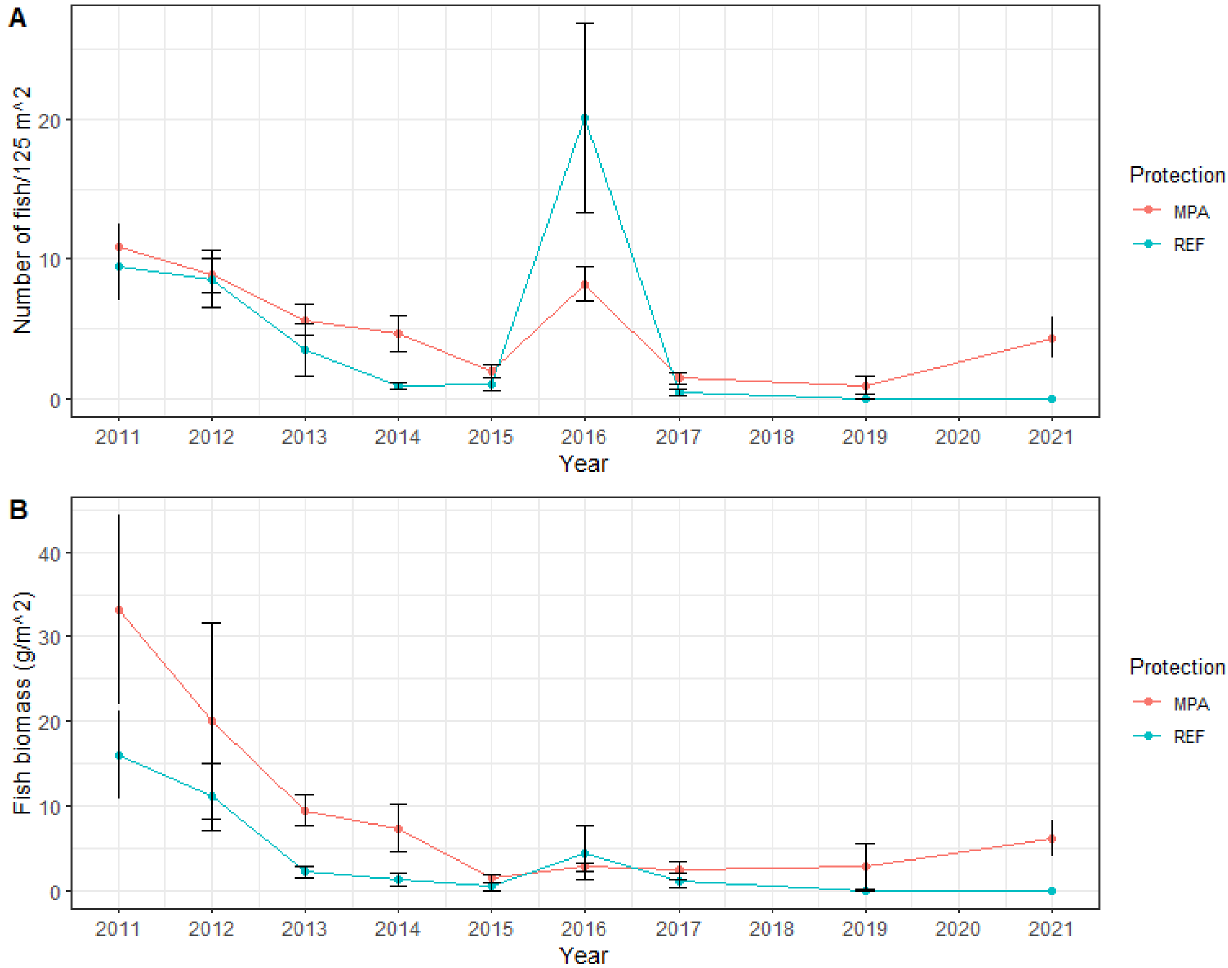

Figure 4. Average number of fish in the seagrass environment across protection status and years of study (A) and average fish biomass across protection status and year of study (B). Error bars represent standard error.

Count of fish in the MPA sites was stable between 2011 and 2012 ($P > 0.05$) but decreased significantly ($P=0.02$) between 2011, with 11.7 ± SE 1.5 fish, and 2013, with 7.46 ± SE 1.2 fish/125 m^2. Number of fish remained stable between 2013 and 2014 ($P > 0.05$) with 5.6 ± SE 1.2 fish in 2014. Between 2014 and 2015 there was a significant decrease in fish abundance ($P = 0.02$). In 2015, the average number of fish/625 m^2 was 2.7 ± SE 0.3. Between 2015 and 2016 there was a significant increase ($P <0.001$) with 9.9 ± SE 1.6 fish per site in 2016. Another significant decrease ($P < 0.001$) happened in

2017, where average number of fish per site was 1.5 ± SE 0.4, but fish number remained stable until 2019 ($P > 0.05$) where average fish count was 1.0 ± SE 0.7 fish. In 2021 there was a significant increase ($P < 0.001$) in fish number, with an average of 5.7 ± SE 1.9 fish/625 m^2. Average fish count in 2021 was significantly lower than in 2016 ($P = 0.008$) and 2011 ($P < 0.001$). See Figure 4A.

Reference areas showed a similar trend, but in 2016 the increase in fish count was larger than in MPA, accounting for 21.47 ± SE 6.7 average fish per site. Reference areas did not show significant increase or decrease between 2019 and 2021 ($P > 0.05$) because no fish was sighted during surveys (Figure 4A).

In MPA sites, fish biomass did not significantly change ($P > 0.05$) between 2011 and 2013, accounting for 33.1 ± SE 11.2 g/m^2 and 11.2 ± SE 1.5 g/m^2 respectively. The first significant decline compared to the 2011 baseline survey happened in 2014 ($P = 0.02$), where biomass was 7.4 ± SE 2.7 g/m^2. In 2015 biomass was 1.5 ± SE 0.8 g/m^2 but did not significantly differ from 2014 ($P = 0.9$). From 2014 and 2021, biomass remained low and stable ($P > 0.05$ Figure 4B).

Reference areas showed a similar trend, but no fish was seen within this seagrass beds in the last two monitoring years (Figure 4B).

In total, 19 targeted species of fish from four different families were identified during the 10 years of surveys: Labridae (and Labridae: Scarinae or parrotfish), Lethrinidae, Lutjanidae, Mullidae and Siganidae. The latter was the dominant family in the MPA sites between 2011 and 2014, but no species from this family was seen between 2017 and 2019 (see Appendix B, Table 2 for fish species list).

3.1.2 Edible macroinvertebrates

Average macroinvertebrate number per site did not change significantly over time (P >0.05) or between MPA and reference areas (P > 0.05). See Figure 5.

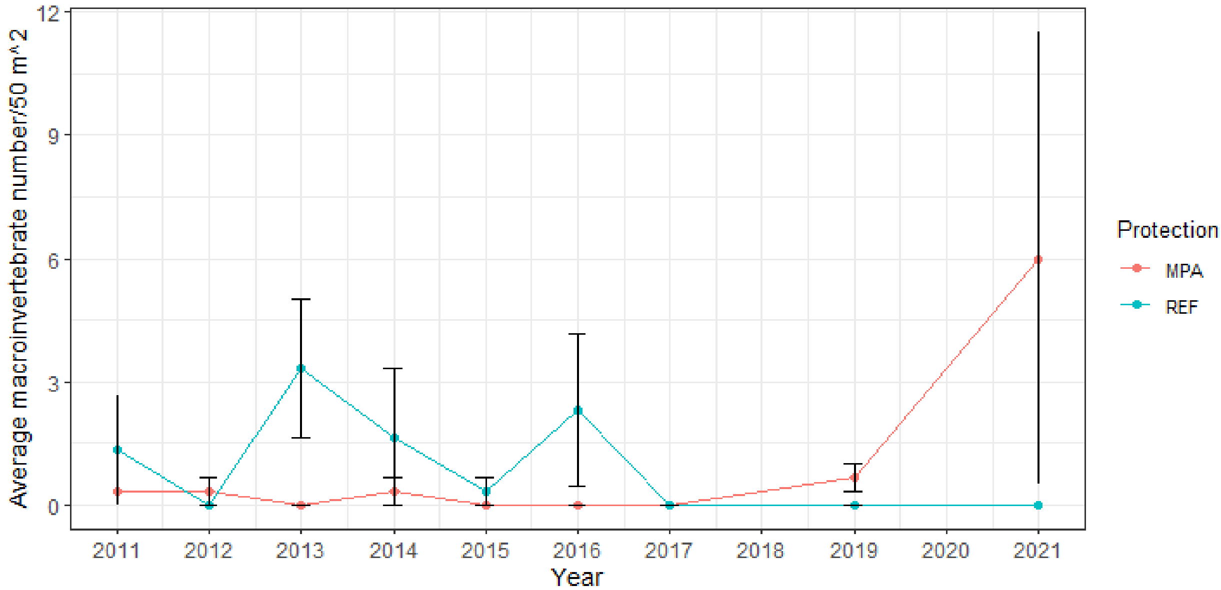

Figure 5. Average macroinvertebrate number per site across protection status and year of study. Error bars show standard error.

3.2 Lagoon environment

3.2.1 Benthic cover and coral recruits

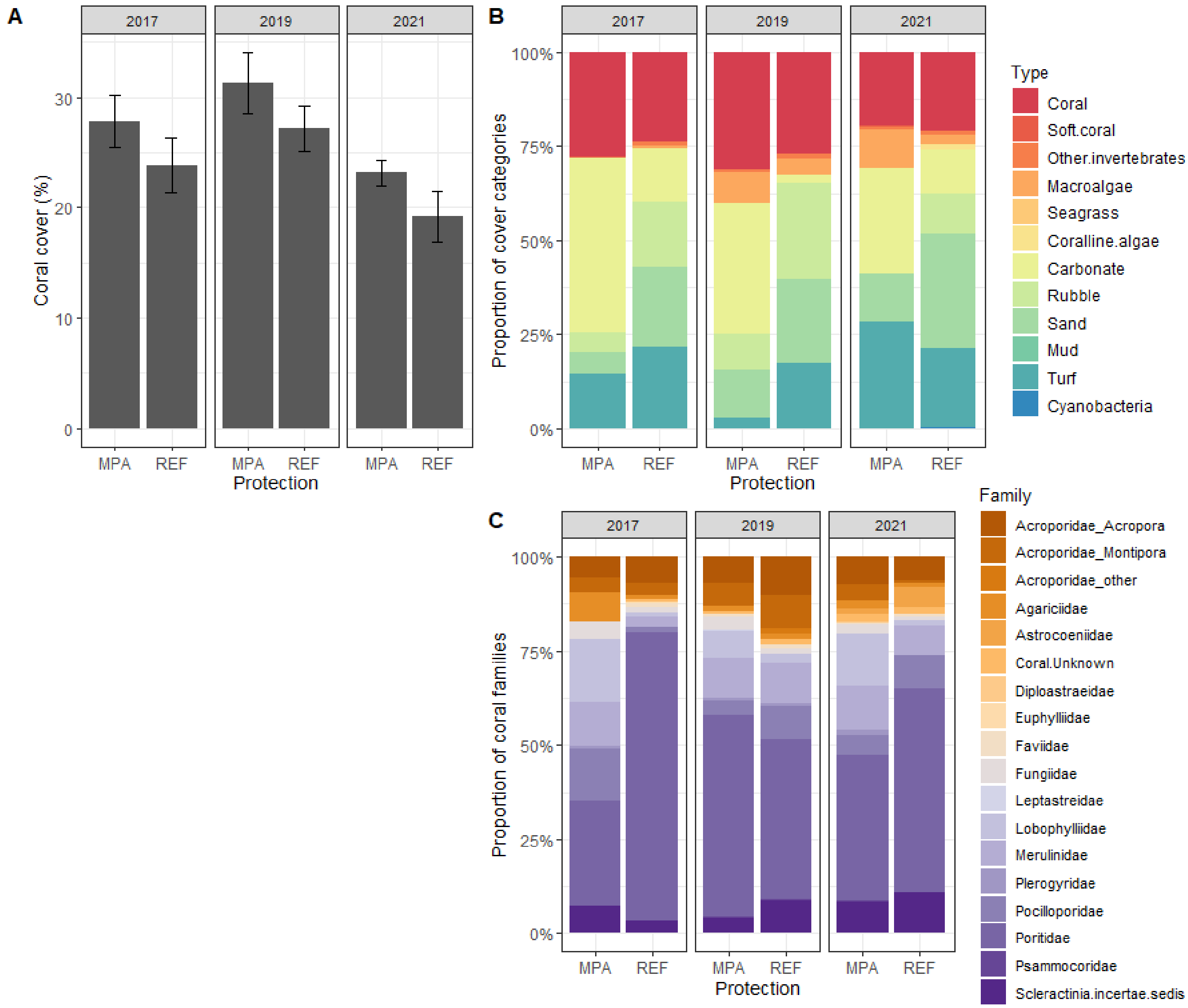

Figure 6. Coral cover (A), substrate category proportions (B) and proportion of coral families (C) across protection status and year of study. Error bars (A) represent standard error.

No significant difference (P>0.05) in coral cover was detected between study years and protection status (Figure 6A). The benthic community was relatively stable between the 5-year period (Figure 6B), as well as coral family composition which has always been dominated by corals from the family Poritidae (Figure 6C).

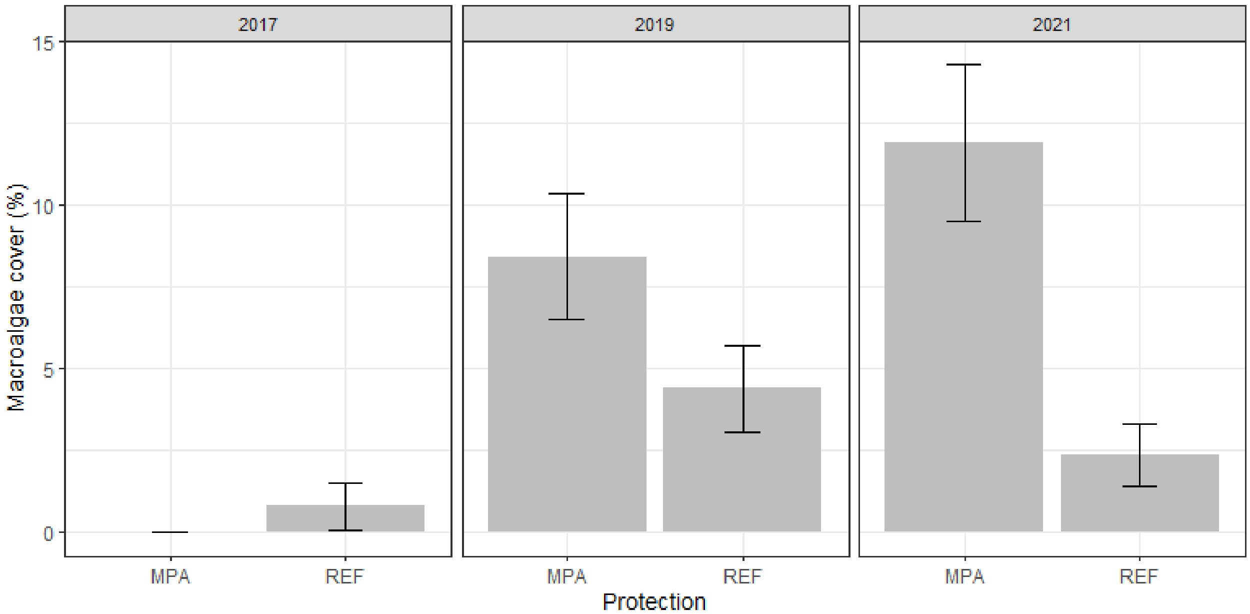

Figure 7. Macroalgae cover across protection status and study years. Error bars represent standard error.

Macroalgae cover increased significantly (P<0.001) in MPA areas, from 0 in 2017 to 8.42 ± SE 1.9 in 2019, to 11.9 ± SE 2.4 in 2021 (Figure 7). In reference areas there was no significant change over time (P > 0.05).

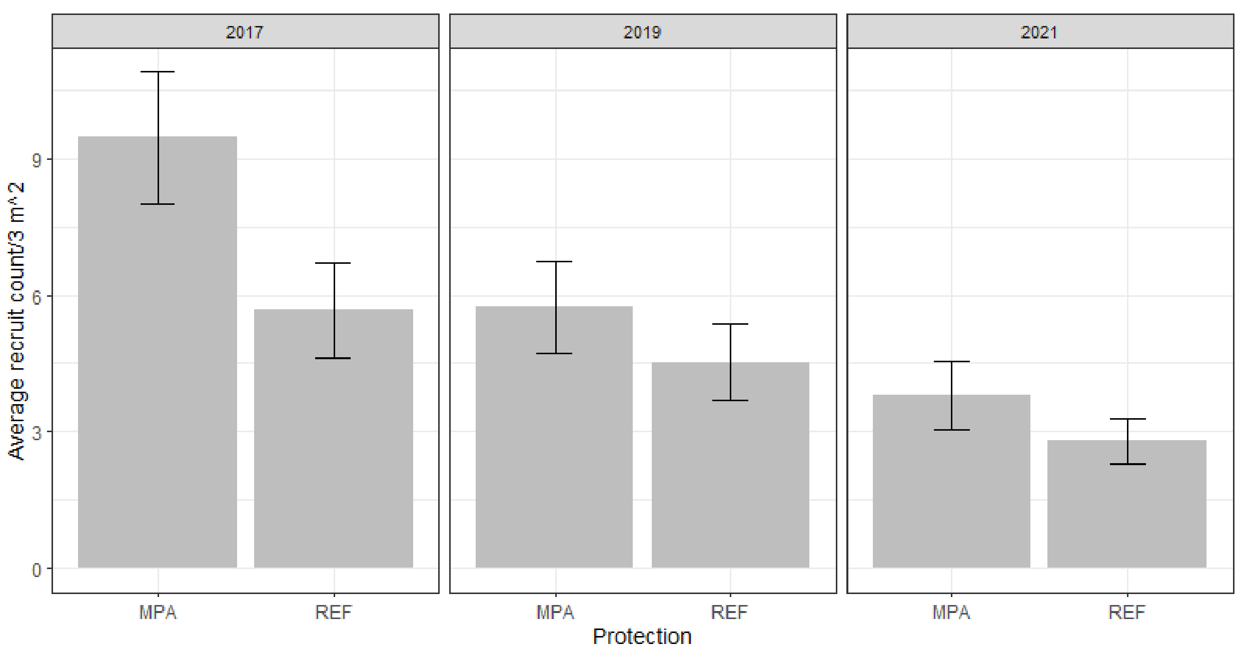

Figure 8. Average recruit count across protection status and years of study. Error bars represent standard error.

Average recruit count significantly declined in MPA sites between 2017 and 2019 (P=0.003) and between 2019 and 2020 (P<0.001). A significant decline also happened in reference sites but only between 2017 and 2021 (P=0.002). Average recruit count (individuals/250 m^2) in the MPA was 47.3 ± SE 9.1 in 2017, 28.7 ± SE 7.5 in 2019 and 19.0 ± SE 2.1 in 2021. In reference sites, average recruit count (individuals/250 m^2) was 28.3 ± SE 7.44 in 2017, 22.7 ± SE 5.4 in 2019, 14.0 ± SE 4.0 in 2021.

3.2.2 Food fishes

No significant difference (P > 0.05) in average number of fish was detected between MPA and reference sites and over time. Fish assemblages are dominated by herbivorous species, with half of the MPA fish population being characterized by surgeonfish (Acanthuridae), followed by parrotfish (Labridae: Scarinae) in abundace in 2017. In the subsequent years there was a shift to a parrotfish dominated community in both MPA and reference sites. Average fish number per MPA site significantly increased (P < 0.001) from 3.8 ± SE 0.7 to 13.7 ± SE 2.8 between 2017 and 2019, then significantly decreased (P < 0.001) to 3.9 ± SE 1.0 in 2021. In reference areas there was a similar trend, where average number of fish significantly increased (P <0.001) from 15.6 ± SE 3.9 to 22.4 ± SE 4.8 between 2017 and 2019, the significantly decreased to 16.9 ± SE 2.6 in 2021 (Figure 9A).

There was no significant difference in fish biomass between protection status (P > 0.05) or years of study (P > 0.05, Figure 9B).

The fish assemblage was dominated by parrotfish (Labridae: Scarinae) in both MPA and reference areas across all the study period (Figure 9C).

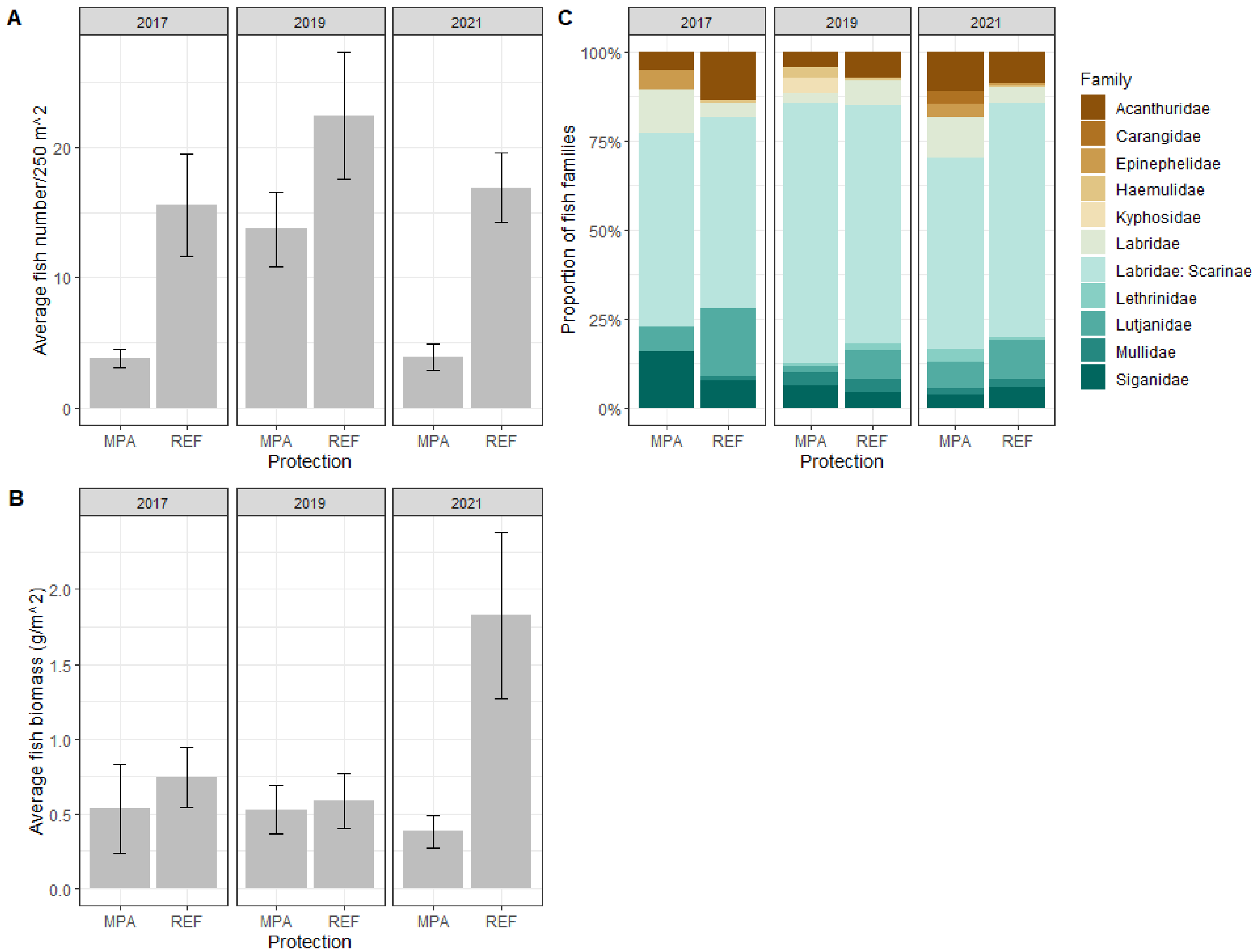

Figure 9. Average fish number (A), average fish biomass (B) per transect, and fish family composition (C) across protection status and years of study. Error bars (A, B) represent standard error.

3.2.3 Edible macroinvertebrates

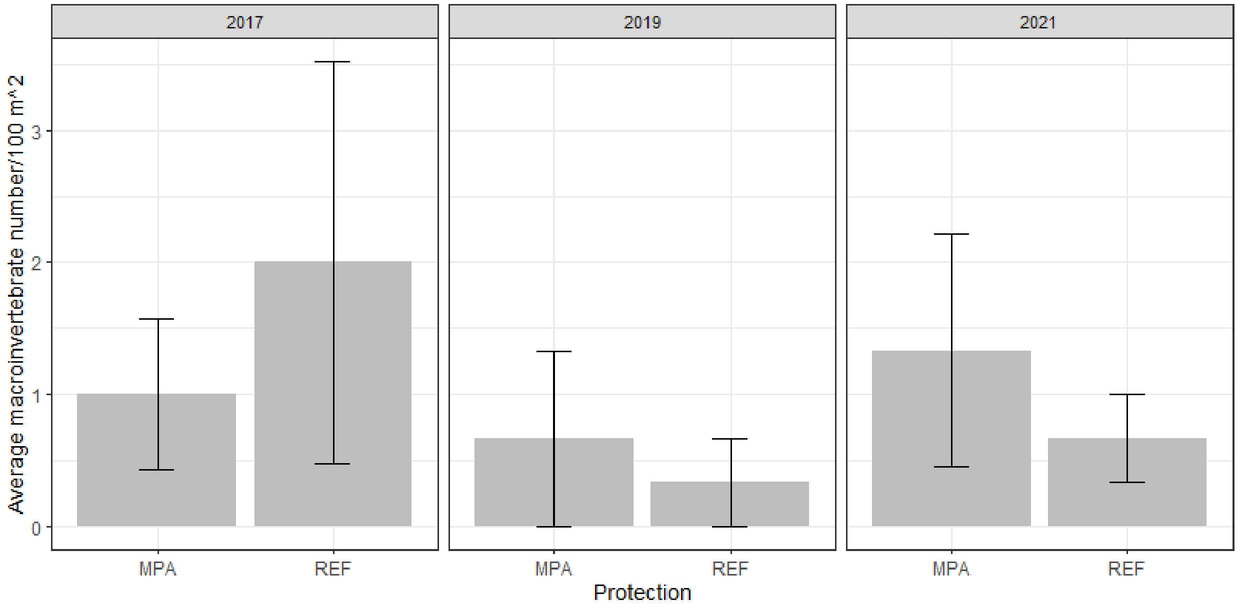

Figure 10. Average macroinvertebrate number per transect across protection status and years of study. Error bars represent standard error.

No significant difference for macroinvertebrate number was found between protection status (P > 0.05) and between years of study (P > 0.05).

4. Discussion

4.1 Seagrass habitat

4.1.1 Seagrass cover

Seagrass cover of Medal Ngediull MPA was not stable over time and showed wide decreases and increases. Eutrophication, climate change, typhoons, river runoff and other natural causes can lead to changes in seagrass cover (Duarte, 2002). The first significant decrease happened in 2013 and could be related to Typhoon Bopha which caused heavy rains that increased sedimentation and could also have modified the sand distribution in the bay. In 2016, seagrass cover increased in the MPA, but remained low in the reference sites. In 2015-2016 there was a strong El Nino event (Colin, 2018), which significantly decreased rain and sea water temperature, and this may have relieved seagrass from thermal stress, enhancing its growth (Collier and Waycott, 2014). Moreover, the channel dredged in 2016-2017 could have increased sediment transport outside the bay, decreasing seagrass smothering by Ngerimel river sediments. However, this trend is not reflected by the reference sites. This could be because the reference sites are located outside of the enclosed Airai bay, in front of the dredged channel, and closer to the river mouth of Ngerikiil, which is the largest of the two watersheds. Seagrass then decreased again to 4-5% in 2021 in the MPA, and nearly disappeared in reference sites highlighting that under average weather conditions the sediment coming from Ngerikiil and Ngerimel watersheds has a negative impact on the seagrass beds. From 2011 to 2021, Airai state issued 536 building permits, of which 61% (329 permits) were issued between 2017 and 2021. The increase in land development is likely on of the main causes of the drastic decline in seagrass cover starting from 2017. There was also a reduction in species richness, with an increase in *Enhalus acoroides* over time. This species of seagrass is taller than any other species and has low shoot mortality under prolonged sedimentation exposures (Cabaço et al. 2008).

4.1.2 Seagrass fish

Number of fish in seagrass beds decreased over time both in the MPA and reference areas. In 2016, there was a sharp increase, more accentuated in reference than MPA areas. This sharp increase could be related with the change in seagrass that happened in the same year in the MPA. In 2015-2016 there was also a powerful El Nino event, which decreased average water temperatures around Palau (Colin 2018). Fish biomass also decreased over time, and had a less sharp increase in 2016. The high number of fish in this year reflects in a small increase in biomass, showing that there might have been an increase in small fish, potentially following increased recruitment thanks to the lower temperatures offered by El Nino (Donelson et al. 2013) and the increase in seagrass cover.

4.1.3 Edible macroinvertebrates

Macroinvertebrates number has always been low (~3 individuals per site) and remained stable over time in seagrass habitats. We could postulate that even if the MPA protection was having an effect on them, we would not be able to see it because their habitat (seagrass) is shrinking over the years.

4.2 Lagoon habitat

4.2.1 Benthic cover & coral recruits

Coral cover did not change over time and did not show differences between protection status. The coral assemblage was dominated by Porites, which are known to adapt to high turbidity (Padilla-Gamiño et al. 2012) and generally dominate estuarine or murky coastal environments in Palau (personal observation). However, coral recruitment showed a ~60% decrease in MPA sites over the study period. Coral larval dispersal is highly affected by sedimentation, with organic and clay sediment binding to sperm or eggs and not allowing successful reproduction (Ricardo et al. 2018). Coral settlers also need a stable substrate to attach and grow, and surfaces often smothered by sediment cannot offer a suitable habitat for recruitment (Golbuu and Richmond 2007). Medal Ngediull is heavily impacted by organic and clay sediment and this is most certainly having an effect on coral recruitment (PICRC and JICA unpublished data, 2022). Macroalgae showed an 85% increase in 2019, and 120% increase over the study period in the MPA. Even if the coral population of this bay has always been adapted to low light levels and turbid water (see coral cover stability over time), the sedimentation pressure became high enough to affect recruitment of new colonies and coral replenishment. Between 2017 and 2021, 329 building permits were issued by Airai state (Palau EQPB data, 2023), suggesting that land development happened during the study years may be enhancing nutrient and sediment runoff to Medal Ngediull MPA. Golbuu et al. (2003) already predicted a shift to algae dominated communities in these areas 20 years back. Corals still have higher cover than macroalgae as of this last assessment in 2021, but results suggest that a change in dominant benthic community could happen soon, therefore it is vital to improve river discharge management in this area before it is too late. This could be achieved by collecting water quality and sedimentation data (as suggested by Nestor et al. 2020), which will inform integrated land-reef management.

4.2.2 Food fishes

Number of fish was generally higher in reference areas than in MPA sites. Number of fish in the lagoon was also higher in 2019 compared to 2017 and 2021. However, this trend was not reflected by biomass, which did not change significantly over the years. Following these observations, the higher number of fish in 2019 could have just been caused by better environmental conditions. This area is characterized by high suspended sediment, thus cloudy and rainy days may decrease the already low visibility. The visibility in the Stereo-DOV videos for 2019 in the MPA was better than in 2021, and this could have caused a spurious increase in counted fish. Following this observation, it is hard to make any solid conclusion about the fish population status in the lagoon of Medal Ngediull MPA. An underwater visual census may be more effective than the Stereo-DOV method in these sites where visibility conditions can vary a lot. However, this MPA is not proving its effectiveness on any of the targeted marine resources, so we could assume that fish populations are not benefitting from protection either.

4.2.3 Edible macroinvertebrates

Macroinvertebrates did not change over time or benefitted from MPA protection. Only one or two macroinvertebrates were found in the lagoon sites since the baseline in 2017, suggesting that this may not be a suitable habitat for these species.

Conclusions

The present MPA appears to be ineffective in protecting the marine environment. The few significant differences identified were between years of study, not between protection status, with reference areas often having similar results to MPAs. The increases in seagrass cover in 2017 and in seagrass fish number in 2016 are represented by an isolated spike, which suggests that the increase may be caused by external causes and not by the protection offered by the MPA. The clearest decreasing trend is found for coral recruits, which seem to be the most negatively impacted by the local conditions in both MPA and reference sites. A significant increase in macroalgae cover suggests that the runoff of the two rivers is enhancing nutrient concentration in the water other than sedimentation. These results suggest that extractive activities are a secondary problem in this area, and that growing land development could be the cause of the inefficiency of this MPA. To improve environmental conditions in this area it will be necessary to mitigate the runoff coming from the surrounding watersheds.

Acknowledgements

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Appendix A

Table 1. Categories and subcategories used for benthic survey analysis

Categories	Subcategories
Coral	Hard coral genus
Soft coral	*NA (no subcategories)*
Other invertebrates	Anemone, Ascidian, Clams, Corallimorph, Discosoma, Distichopora, Gorgonians, Heliopora, Millepora, Sponge, Zoanthid
Macroalgae	Macroalgae genus
Seagrass	Seagrass species
Crustose coralline algae	Amphiroa, Crustose coralline algae, Fleshy coralline algae, Jania
Substrate	Carbonate, rubble, sand, turf

Appendix B

Table 1. List of macroinvertebrates considered during the development of this report

Common name	Palauan name	Species
Crown-of-thorns starfish	Rusch	*Acanthaster planci*
Deepwater redfish	Eremrum, cheremrum	*Actinopyga echinites*
Stonefish	Ngelau	*Actinopyga lecanora*
Surf red fish	Badelchelid	*Actinopyga mauritiana*
Hairy blackfish	Eremrum, cheremrumedelekelk	*Actinopyga miliaris*
Deepwater blackfish	Eremrum, cheremrum	*Actinopyga palauensis*
Hariy greyfish	Eremrum, cheremrum	*Actinopyga* spp.
Leopard fish	Meremarech, esobel	*Bohadschia argus*
Chalk fish	Meremarech	*Bohadschia similis*
Brown sandfish	Meremarech	*Bohadschia vitiensis*
	Meremarech	*Bohadschia* spp.
White teatfish	Bakelungal-cherou	*Holothuria fuscogilva*
Elephant trunkfish	Delal a molech	*Holothuria fuscopunctata*
Slender sea cucmber	Sekesaker	*Holothuria impatiens*
Golden sandfish	Delalamolech	*Holothuria lessoni*
Sandfish	Molech	*Holothuria scabra*
Black teatfish	Bakelungal-chedelkelek	*Holothuria whitmaei*

Flowerfish	Meremarech	*Pearsonothuria graeffei*
Curryfish	Delal a ngimes/ngimesratmolech	*Stichopus hermanni*
Dragonfish	Irimd	*Stichopus horrens*
Brown curryfish	Ngimes	*Stichopus vastus*
	Ngimes	*Stichopus* spp.
Prickly redfish	Temetamel	*Thelenota ananas*
Amberfish	Belaol	*Thelenota anax*
Crocus giant clam	Oruer	*Tridacna crocea*
Smooth giant clam	Kism	*Tridacna derasa*
True giant clam	Otkang	*Tridacna gigas*
Elongate giant clam	Melibes	*Tridacna maxima*
Teardrop giant clam		*Tridacna noae*
Fluted giant clam	Ribkungel	*Tridacna squamosa*
Bear paw giant clam	Duadeb	*Hippopus hippopus*
China giant clam		*Hipppopus porcellanus*
Sea urchin	Ibuchel	*Tripneustes gratilla*
Trochus	Semum	*Trochus niloticus*
Trochus	Semum	*Trochus* spp.

Appendix C

Table 1. Fisheries targeted species in Palau considered during the development of this report.

	Common name	**Palauan name**	**Species name**
Acanthuridae	Epaulette surgeonfish	Chesengel	*Acanthurus nigricauda*
	Yellowfin surgeonfish	Mesekuuk	*Acanthurus xanthopterus*
	Orangespine unicornfish	Cherangel	*Naso lituratus*
	Bluespine unicornfish	Chum	*Naso unicornis*
Carangidae	Blue trevally	Yab	*Carangoides ferdau*
	Yellowspotted trevally	Uii	*Carangoides fulvoguttatus*
	Island trevally	Otewot	*Carangoides orthogrammus*
	Barcheek trevally		*Carangoides plagiotaenia*
	Trevally/jack species		*Carangoides spp*
	Giant trevally	Erobk	*Caranx ignobilis*
	Black jack	Omektutau	*Caranx lugubris*
	Bluefin trevally	Oruidel	*Caranx melampygus*
	Bigeye trevally	Esuch	*Caranx sexfasciatus*
	Rainbow runner	Desui	*Elagatis bipinnulata*
	Snubnose pompano	Luichlbuil	*Trachinotus blochii*

Chanidae	Milkfish	Aol, Mesekelat	*Chanos chanos*
Haemulidae	Painted sweetlips		*Diagramma pictum*
	Giant sweetlips	Melimralm, Kosond, Bikl	*Plectorhinchus albovittatus*
	Harlequin sweetlips	Bechol	*Plectorhinchus chaetodonoides*
	Yellowstripe sweetlips	Merar	*Plectorhinchus chrysotaenia*
	Harry hotlips		*Plectorhinchus gibbosus*
	Lesson's thicklip		*Plectorhinchus lessonii*
	Diagonal-banded sweetlips	Yaus	*Plectorhinchus lineatus*
	Painted sweetlip		*Plectorhinchus picus*
	Indian Ocean oriental sweetlips	Yaus	*Plectorhinchus vittatus*
Kyphosidae	Blue sea chub	Komud, Beab	*Kyphosus cinerascens*
	Brassy chub	Komud, Beab	*Kyphosus vaigiensis*
Labridae	Humphead wrasse	Ngimer, Maml	*Cheilinus undulatus*
	Yellow cheek tuskfish	Budech	*Choerodon anchorago*
Lethrinidae	Pacific yellowtail emperor		*Lethrinus atkinsoni*
	Orange-spotted emperor	Menges	*Lethrinus erythracanthus*
	Longfin emperor	Kroll	*Lethrinus erythropterus*
	Thumbprint emperor	Itotech	*Lethrinus harak*
	Orangestripe emperor	Udech	*Lethrinus obsoletus*
	Longface emperor	Melangmud	*Lethrinus olivaceus*
	Ornate emperor		*Lethrinus ornatus*
	Red gill emperor	Rekruk	*Lethrinus rubrioperculatus*
	Yellowlip emperor	Mechur	*Lethrinus xanthochilus*
	Humpnose bigeye bream	Besechamel	*Monotaxis grandoculis*
Lutjanidae	Green jobfish	Udel	*Aprion virescens*
	Mangrove red snapper	Kedesau'liengel	*Lutjanus argentimaculatus*
	Red snapper	Kedesau	*Lutjanus bohar*
	Blackspot snapper	Dodes	*Lutjanus ehrenbergii*
	Blacktail snapper	Reall	*Lutjanus fulvus*
	Humpback snapper	Keremlal	*Lutjanus gibbus*
	One-spot snapper	Kesebii	*Lutjanus monostigma*
	Blubberlip snapper	Korriu	*Lutjanus rivulatus*
	Sailfin snapper	Chedui	*Symphorichthys spilurus*
Mugilidae	Squaretail mullet	Uluu	*Ellochelon vaigiensis*
	Bluespot mullet	Kelat	*Crenimugil seheli*
Mullidae	Dash-and-dot goatfish	Bang	*Parupeneus barberinus*
	Gold-saddle goatfish	Bang	*Parupeneus cyclostomus*
	Goatfish species		*Parupeneus spp*
Labridae: Scarinae	Bumphead parrotfish	Berdebed, Kemedukl	*Bolbometopon muricatum*
	Spotted parrotfish	Beyadel, Ngesngis	*Cetoscarus ocellatus*
	Bleeker's parrotfish		*Chlorurus bleekeri*

	Pacific slopehead parrotfish		*Chlorurus frontalis*
	Palecheek parrotfish		*Chlorurus japanensis*
	Pacific steephead parrotfish	Otord	*Chlorurus microrhinos*
	Pacific bullethead parrotfish		*Chlorurus spilurus*
	Pacific longnose parrotfish	Ngiaoch	*Hipposcarus longiceps*
	Filament-finned parrotfish	Udoud ungelel	*Scarus altipinnis*
	Chameleon parrotfish		*Scarus chameleon*
	Yellowbarred parrotfish	Butiliang	*Scarus dimidiatus*
	Yellowfin parrotfish		*Scarus flavipectoralis*
	Forsten's parrotfish	Mul	*Scarus forsteni*
	Bridled parrotfish		*Scarus frenatus*
	Bluebarred parrotfish	Mertebetabek	*Scarus ghobban*
	Globehead parrotfish	Ngemoel	*Scarus globiceps*
	Dusky parrotfish	Kiuiid	*Scarus niger*
	Dark capped parrotfish		*Scarus oviceps*
	Greenthroat parrotfish	Melechotech a chau	*Scarus prasiognathos*
	Common parrotfish		*Scarus psittacus*
	Quoy's parrotfish		*Scarus quoyi*
	Rivulated parrotfish	Besachel-otengel	*Scarus rivulatus*
	Redlip parrotfish	Mesekelat mellemau	*Scarus rubroviolaceus*
	Yellowband parrotfish		*Scarus schlegeli*
	Greensnout parrotfish		*Scarus spinus*
	Parrotfish species	Mellemau	*Scarus spp*
	Tricolour parrotfish		*Scarus tricolor*
	Red parrotfish	Butiliang	*Scarus xanthopleura*
Scombridae	Double-lined mackerel	Beterturech	*Grammatorcynus bilineatus*
	Dogtooth tuna	Kerengab	*Gymnosarda unicolor*
	Narrow barred Spanish mackerel	Ngelngal	*Scomberomorus commerson*
Serranidae	Redmouth grouper	Chubei	*Aethaloperca rogaa*
	Slender grouper	Choloteachi	*Anyperodon leucogrammicus*
	Peacock hind	Mengardechelucheb	*Cephalopholis argus*
	Bluespotted hind	Temekai	*Cephalopholis cyanostigma*
	Coral hind	Temekai	*Cephalopholis miniata*
	Tomato hind	Temekai	*Cephalopholis sonnerati*
	Hind species		*Cephalopholis spp*
	Humpback grouper	Meleches	*Cromileptes altivelis*

	Whitespotted grouper		*Epinephelus coeruleopunctatus*
	Coral grouper	Imirechorch	*Epinephelus corallicola*
	Brown-marbled grouper	Meteungerel'temekai	*Epinephelus fuscoguttatus*
	One-blotch grouper		*Epinephelus melanostigma*
	Marbled grouper	Ksau'temekai	*Epinephelus polyphekadion*
	Masked grouper		*Gracila albomarginata*
	Squaretail grouper	Tiau (black)	*Plectropomus areolatus*
	Saddleback grouper	Katuu'tiau, Mokas	*Plectropomus laevis*
	Leopard grouper	Bekerkard el tiau	*Plectropomus leopardus*
	Highfin coral grouper		*Plectropomus oligacanthus*
	White-edged lyretail	Baslokil	*Variola albimarginata*
	Yellow-edged lyretail	Baslokil	*Variola louti*
Siganidae	Forketail rabbitfish	Beduut	*Siganus argenteus*
	Blue-spotted spinefoot	Reked	*Siganus corallinus*
	Barred spinefoot	Reked	*Siganus doliatus*
	Dusky rabbitfish	Meyas	*Siganus fuscescens*
	Lined rabbitfish	Kelsebuul	*Siganus lineatus*
	Masked rabbitfish	Reked	*Siganus puellus*
	Peppered spinefoot	Bebael	*Siganus punctatissimus*
	Goldspotted rabbitfish	Bebael	*Siganus punctatus*
	Great barracuda	Ai	*Sphyraena barracuda*
Sphyraenidae	Bigeye barracuda	Lolou	*Sphyraena forsteri*
	Blackmargin barracuda	Meyai	*Sphyraena qenie*