Medal Ngediull Conservation Area

2017 Monitoring Assessment

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Abstract

Palau has a protected area network (PAN), established in 2003, which consists of 14 marine protected areas. Palau International Coral Reef Center (PICRC) conducts ecological monitoring at these MPAs to follow the ecological conditions within their different habitats and their effectiveness at protecting marine resources. This study was conducted at Medal Ngediull Conservation Area (CA) located in Airai state, which has been protected since 2005. Surveys recording the status of fish, macro-invertebrates, juvenile corals, seagrass cover and benthic cover were conducted within three stations in the reef flat habitat and three stations in the lagoon habitat, both inside and outside the conservation area. Our findings demonstrate that inside the conservation area, fish and invertebrates were found in low in abundance and biomass, the seagrass cover has decreased over the past five years, and the coral cover has also decreased since the 2015 baseline surveys were conducted in the CA. We suggest that the diminished status of marine resources in Airai may be the result of chronic terrestrial runoff that is un-managed. PICRC recommends that Airai State and the national government take appropriate measures to control sediment loads from Ngerikiil watershed.

Introduction

Natural resource conservation is anchored deep in Palau's traditions (Johannes 1981). The concept of 'bul,' which traditionally prohibited the use of natural resources for restricted periods of time (Johannes 1981), has now evolved into modern conservation management through the concept of Marine Protected Areas (MPAs) or Conservation Areas (CAs). The first MPA to be established in Palau was Ngerukeuid in the southern lagoon of Koror State in 1956. Later, spawning aggregation areas such as Ngerumekaol and Ebiil channel became MPAs. Today, there are 35 Marine Protected Areas in Palau (Friedlander et al. 2017) and 22 of them are full no- take zones. The government of Palau established the Protected Area Network (PAN) in 2003, which currently consists of 14 no-take MPAs and 13 terrestrial protected areas. The PAN is one tool used by the government of Palau to protect the country's biodiversity and resources from overuse, and to participate in regional and global conservation initiatives, such as the Micronesia Challenge (Houk et al. 2015). The PAN is constantly evolving by using novel research findings to improve its design in order to make it as effective as possible.

The Palau International Coral Reef Center (PICRC) is monitoring PAN MPAs to provide scientific support on the effectiveness of protected areas. In 2014 and 2015, PICRC gathered baseline information at all PAN MPAs in Palau (Gouezo et al. 2016). Subsequently, every two years, PICRC will re-visit the PAN MPAs to monitor the status and trends of natural resources and assess their effectiveness over time.

This study was conducted in Medal Ngediull Conservation Area (CA) in Airai (7°20' 46.14''N, 134°33' 2.88'' E) (Fig.1), which has been protected since 2005 under state legislation and became a PAN site in 2012. The objectives of this study are (1) to show the status of natural resources within the two main habitats (lagoon and reef flat) of the conservation area, (2) to compare them to available baseline data, and (3) to compare them to nearby non-protected reference areas.

Methods

1. Study sites

Medal Ngediull CA covers an area of 3.2 km^2 and encompasses two main habitats: reef flat and lagoon. Three survey sites per habitat were surveyed inside the CA and outside (Fig. 1).

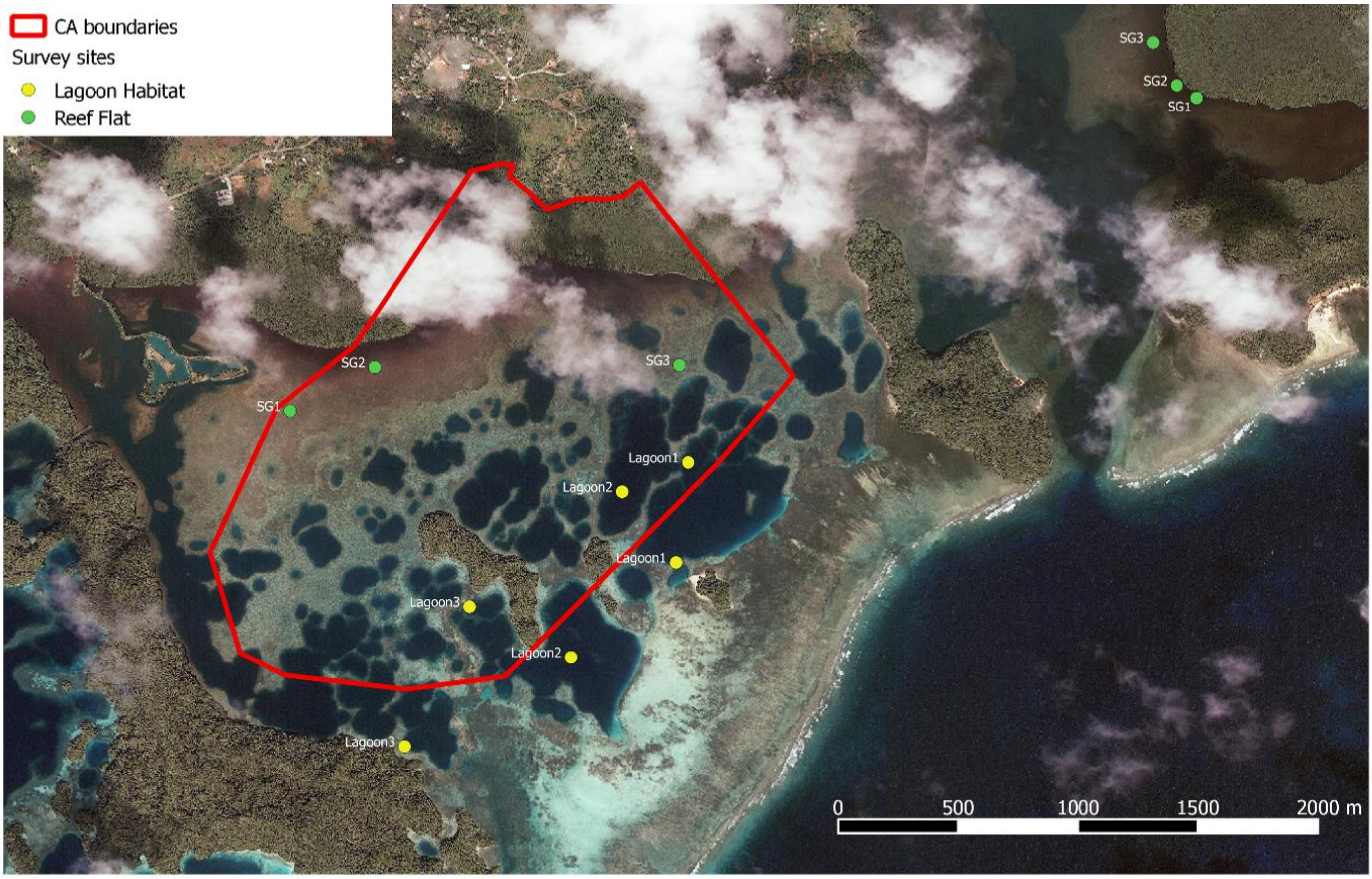

Figure 1: Map of Medal Ngediull conservation area with monitoring sites inside and outside the protected area (red polygon)

2. Ecological surveys

Ecological surveys were conducted at each study site. In the reef flat, five 25 m transects were laid consecutively, with a few meters separating each of them. Data recorded along these transects included seagrass percentage cover (at the species level) in 0.5 m quadrat placed every 5 meters, fish size and abundance in 5 m wide belt, and edible macro-invertebrates in 2 m wide belt. In the lagoon, five 50 meters transects were laid consecutively with five meters in between them at 10 m depth. To estimate benthic cover, photographs were taken every meter along the transect using an underwater camera (model: Canon G16, mounted on a 0.5 m x 0.5 m photo-quadrat PVC frame), for a total of 50 photos per transect. Juvenile corals (size < 5 cm) were recorded in the first 10 m of each transect in 0.3 m belt. Fish abundance and size were recorded using stereo-DOV in 5 m wide belt, and edible macro-invertebrates were recorded in 2 m wide belt, along each transect.

3. Data processing and analysis

Juvenile corals and macro-invertebrates' data were entered into excel spreadsheets. To estimate benthic cover, photo-quadrats were analyzed using CPCe software (Kohler and Gill 2006). Five random points were allocated to each photo and the substrate below each point was classified into benthic categories (see benthic categories list in Appendix 1). The mean percentage benthic cover of each category was calculated for each transect (n = 50 photos per transect, n = 5 transects per site). Fish videos were processed using the software Event Measure. All fish that have an economical and/or subsistence importance were counted and measured (excluding butterflyfish, damselfish). 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 from published biomass-length relationships (Kulbicki et al. 2005) and from Fishbase (http://fishbase.org).

Prior to running statistical tests, the data was checked for normality using histograms and shapiro test. When non-normal, data was transformed and re-tested. When data were normal, One-way ANOVA was used to compare CA with reference area. When data were non-normal, non-parametric Mann-Whitney U test was used instead.

Results

Findings from the 2017 monitoring surveys are presented according to ecological habitat type, comparing this year's results with data from previous years of available monitoring data for each ecological indicator.

1. Reef Flat Habitat

PICRC's long-term monitoring data at seagrass beds in Airai show that the coverage of seagrass has decreased significantly, by half, over the past five years (LMM, $P < 0.001$), regardless of whether the seagrass beds were located inside or outside the conservation area (Figure 2).

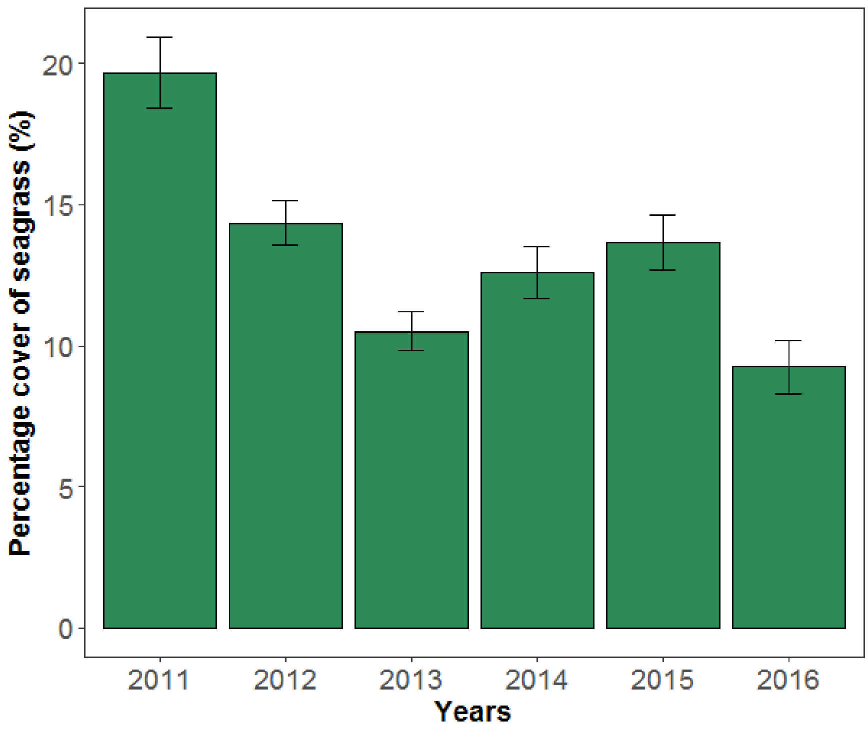

Figure 2: Bar plots showing the mean percentage cover (± SE) of seagrass through time

The abundance of food fish in the seagrass beds was low overall (< 2 individuals per 125 m^2), but significantly higher in the conservation area than the reference area (Mann Whitney test, $P = 0.02$, Figure 3). Most of the fish observed in this habitat were Budech (*Choerodon anchorago*), Itotech (*Lethrinus harak*), Bang (*Parupeneus barberinus*), Meyas (*Siganus fuscescens*) and small Mellemau (*Scarus* spp.).

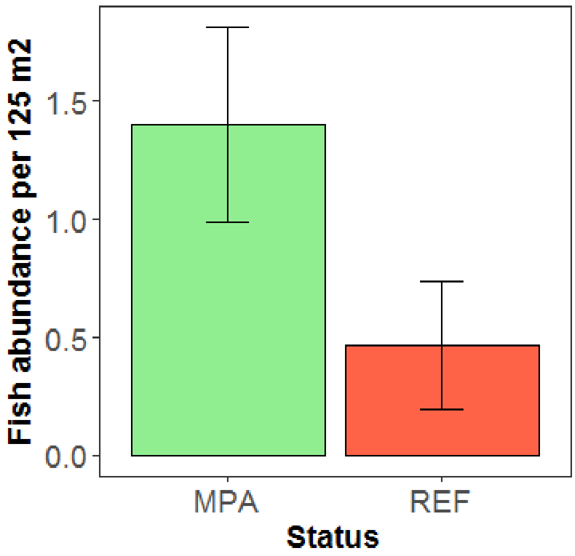

Figure 3: Bar plot showing the abundance of food fish (± SE) in the MPA (green) and the reference area (red)

In 2017, there were no edible macro-invertebrates recorded at our study sites, neither inside nor outside the conservation area.

2. Lagoon habitat

The lagoon habitat mostly consisted of live corals, turf algae, carbonate, rubble and sand (Figure 4). While the live coral cover was similar between the MPA and the reference area in 2017, the cover of live corals decreased significantly from 43% (± 6%) in 2015 to 28% (± 2%) in 2017 (ANOVA, $P < 0.01$). The coverage of turf algae and carbonate increased in 2017 in the conservation area.

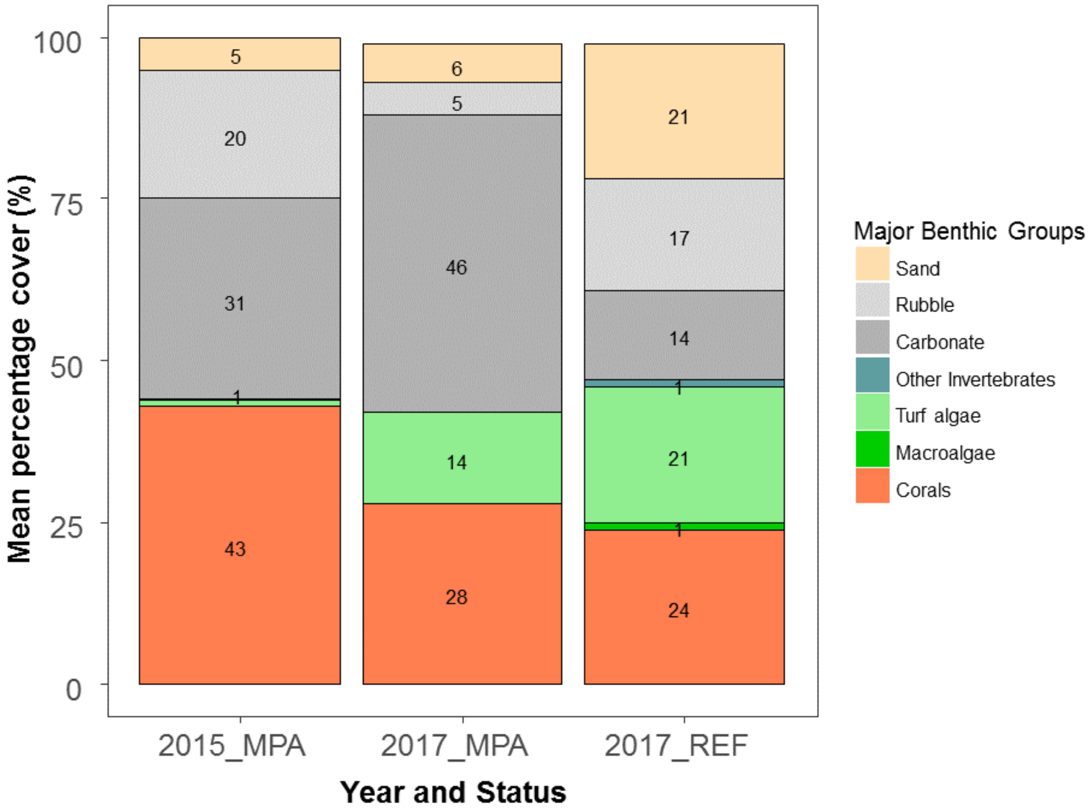

Figure 4: Stacked area bar plot of main benthic categories found in the conservation area in 2015 and 2017 and the reference area in 2017. Numbers show the percentage cover.

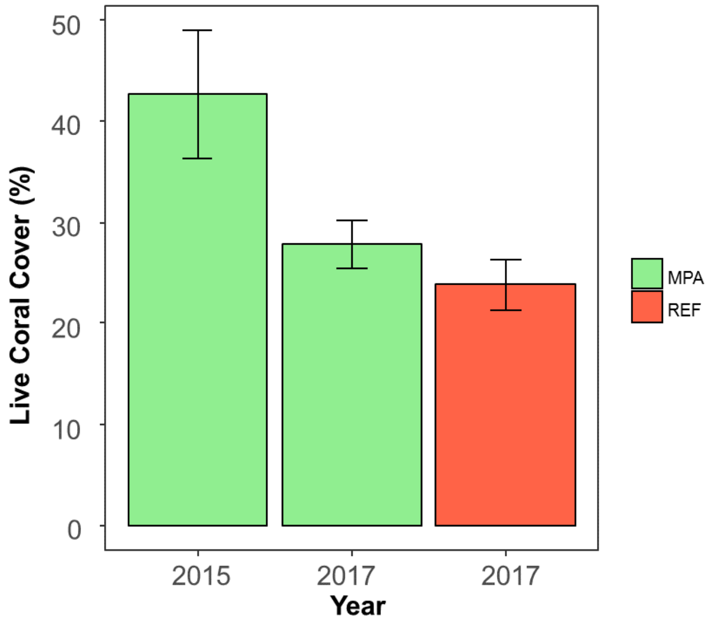

Figure 5: Bar plot showing the mean live coral cover (± SE) in the conservation area (green) in 2015 and 2017 and the reference area (red) in 2017.

The density of juvenile corals was higher in the conservation area in 2017 with 9.5 juvenile corals per 3 m^2 (± 1.6) compared to the 2015 and the reference area (< 6 juvenile corals per 3 m^2) but marginally significant (ANOVA, $P = 0.06$, Figure 6).

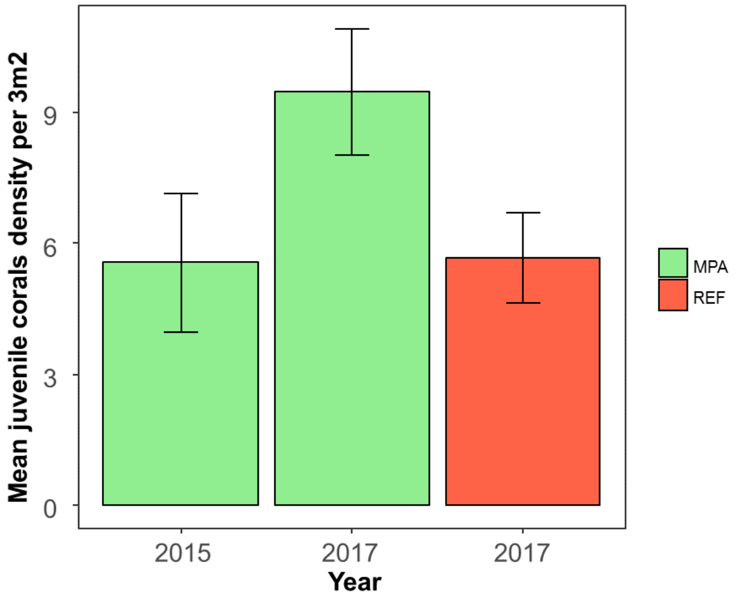

Figure 6: Bar plot showing the mean number of juvenile corals (± SE)

The biomass of food fish was higher in the reference area with 1.5 kg (± 0.37 kg) per 250 m^2 than the conservation area with 0.75 kg (± 0.33 kg) per 250 m^2 but was not found to be significantly different (Mann Whitney test, P = 0.28, Figure 7). Most of the fish species observed within this habitat were Mellemau (*Scarus* and *Chlororus* spp.), Keremlal (*Lutjanus gibbus*), Ngiaoch / Berkism (*Hipposcarus longiceps*), Masech (*Ctenochaetus striatus*), and Mesekuuk (*Acanthurus xanthopterus*).

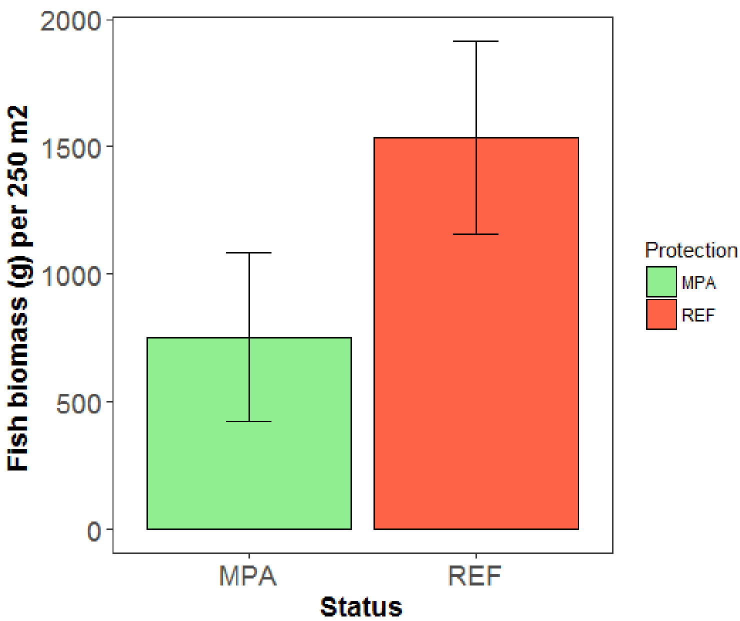

Figure 7: Bar plot showing the mean food fish biomass in grams (± SE) at the conservation area (green) and the reference area (red)

The abundance of edible macro-invertebrates was low overall with less than one individual per 100 m^2 and did not differ through time or with protection (Figure 8).

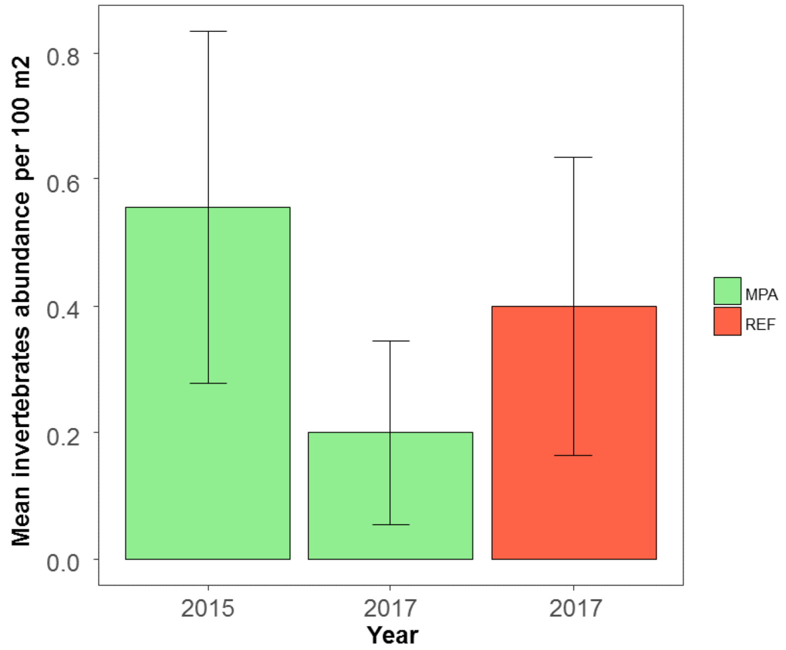

Figure 8: Bar plot showing the mean abundance of edible macro-invertebrates (± SE) at the conservation area through time (green) and at the reference area (red)

Discussion

PICRC monitoring data showed that in both of the studied habitats, ecosystem conditions and marine resource statuses are not different than the nearby unprotected areas in Airai. This may be caused by chronic stressors other than fishing, such as terrestrial run-off.

PICRC has been monitoring seagrass beds inside and outside Medal Ngediull CA since 2011. Our findings show that the coverage of seagrass species has decreased by half in the past five years. Seagrass beds are dynamic ecosystems that border lands and are susceptible to anthropogenic impacts such as terrestrial run-off (Duarte 2002). The location of Medal Ngediull CA is close to one of the biggest watersheds in Palau, Ngerikiil. Ngerikiil watershed covers an area of 28.5 km^2 and has been shown to have high sediment flux and rate (Golbuu et al. 2011). The sediment loads discharged in the bay, especially after heavy rainfalls and storms are not managed by either Airai State or the national government. We suggest that this could be the cause of the observed decline in overall seagrass cover in Airai since 2011. In addition, the abundance of fish was very low with less than 2 individuals per transect, but still higher in the CA than the reference area. Macro-invertebrates were absent from all the study sites which indicates that the sea cucumbers which used to inhabit this habitat have been depleted.

PICRC conducted surveys in 2015 and 2017 in the lagoon habitat of Medal Ngediull CA. Our findings show that the live coral coverage has decreased since 2015, and now has similar coverage to the reference area. In the absence of a major coral bleaching event since 2015, the decrease in coral cover may be caused by run-off. Run-off has been shown to have negative effects on the ecology of corals, affecting their reproduction, settlement, growth and survival due to nutrient enrichment, light reduction and increased settling of sediments particles (Fabricius 2005). The decrease in live corals did not lead to an increase in macroalgae cover, meaning that nutrients and herbivore levels are controlling macroalgae biomass (Bruno et al. 2009). The biomass of valuable fish species and macro-invertebrates was not found to be higher in the CA. Unlike other conservation areas in Palau (Friedlander et al. 2017), it appears that protection from fishing and harvesting does not lead to high resource biomass in Airai. It is likely that other chronic stressors, such as terrestrial run-off, is undermining the effectiveness of the closure.

The study shows that overall, marine resource statuses are not maximized by the conservation area. Several studies have shown that terrestrial run-off can have negative impacts on ecosystems in Palau and in Micronesia (Golbuu et al. 2003, 2008, 2011). Therefore, we urge both Airai State and the national government to take appropriate measures to adequately manage the Ngerikiil watershed to reduce sediment loads discharged into the bay.

Acknowledgment

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Appendix

Table: Benthic categories used when analyzing benthic photos

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)	