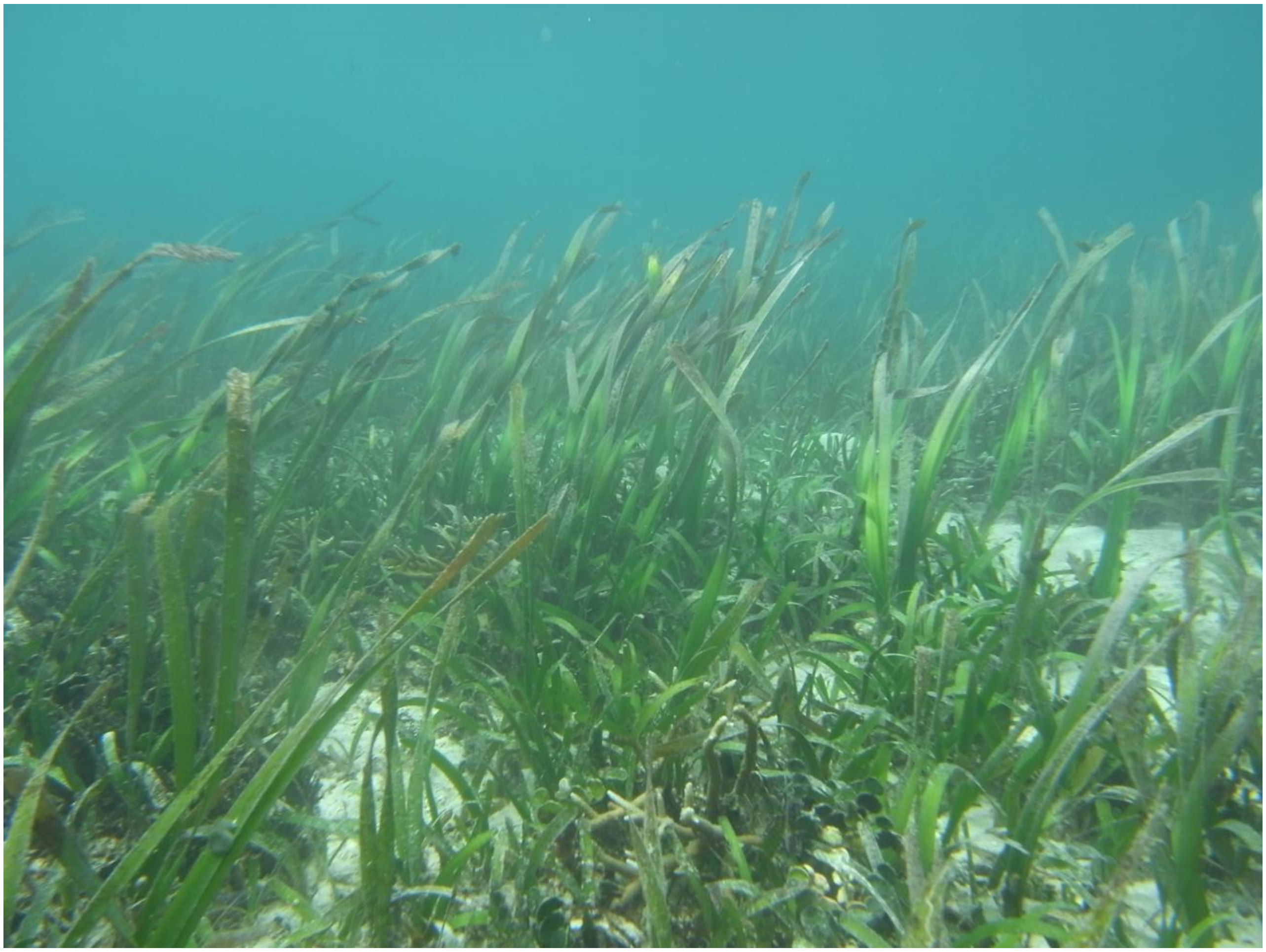
Gaining insight on MPA health through long-term seagrass monitoring in Palau (2014 Update)



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Abstract

Seagrass ecosystems worldwide are increasingly threatened by both climate change and specifically, anthropogenic disturbances. As human populations continue to rise and coastal areas are developed, sedimentation and water quality, paired with increased climate change disturbances, are accelerating the degradation of seagrass ecosystems globally. In Palau, the government developed a nation-wide network of Marine Protected Areas (MPAs) called the Palau Protected Areas Network (PAN). The goal of this initiative is to effectively manage and conserve the marine resources of Palau while providing a sustainable funding mechanism to do so. To assess these goals, the Palau International Coral Reef Center (PICRC) established a seagrass monitoring project, focused on assessing the changes that are occurring in the seagrass MPAs. This survey presents additional results to the long-term monitoring that has been in place since 2011. Results have shown that even though there are some increases in fish size and seagrass cover in two of the sites, the negative trend that appeared in the first surveys is continuing. These negative trends could be due to increased unsustainable land-use in the islands of Babeldaob, Koror and Peleliu as well as possible changes in water temperature and acidity. The results from this survey may be used by local resource management to effectively change and manage their MPAs as well as resources globally, to further understand the changes that are occurring on a local scale. Continued monitoring is still advised as a period of only four years is not sufficient enough to gauge the long-term changes within the seagrass MPAs in Palau.

Introduction

Seagrass beds are an important marine ecosystem worldwide. Even though they only cover 0.1 -0.2% of the ocean, they provide an estimated $1.9 trillion per year in ecosystem benefits in the form of habitats and nurseries for many economically-important fish and invertebrates, reducing land-based nutrients and suspended solids from flowing into the surrounding reefs, and through sequestering atmospheric carbon (Costanza et al. 1997; Duarte, C.M. 2000; Duarte, C.M. 2002; Waycott, M. 2009. Human disturbances has resulted in major losses of seagrass populations throughout the world (Orth, R.J. et al., 2006; Waycott, M. 2009). In response to the loss of seagrass beds, resource managers have developed a variety of monitoring and management actions, which allow resource managers to make effective management decisions (Orth, R.J. et al., 2006). In the Republic of Palau, resource management has evolved from traditional practices to government-established conservation networks, the Palau Protected Areas Network (PAN). The goal of PAN is to effectively and sustainably conserve both the terrestrial and marine habitats of Palau.

In order to effectively and sustainably conserve the seagrass beds in Palau and meet the goals of PAN, the Palau International Coral Reef Center (PICRC) has conducted surveys within four seagrass Marine Protected Areas (MPAs) since 2011, with three main goals: 1. to gauge the effectiveness of the protection; 2. to better understand the status of the seagrass beds throughout Palau; and 3. to assess the status of fish populations within the seagrass beds. The results of the surveys help to give resource managers an indication of the general trends of fish, invertebrate and seagrass populations within their seagrass MPAs, from 2011 to present (2014).

Methods

Study Location

The study was conducted in four different states in Palau and their Marine Protected Areas; Airai (Medal a Ngediull), Koror (Ngederrak), Ngchesar (Ngelukes), and Peleliu (Teluleu). In order to compare the possible benefits of the MPA, surveys have been conducted since 2011 within the MPAs and their reference sites, which are open to fishing. The reference sites were selected based on habitat similarity and distance to their respective MPA. Each MPA and reference site has 3 stations, which were haphazardly chosen.

Field Sampling

Underwater Visual Census (UVC) surveys were conducted along 5 x 5m (wide) x 25m (long) belt transect. Within each transect, fish size and abundance was estimated. Thirty-four commercially important fish species were surveyed twice a year (Appendix, Table 1).

Invertebrate surveys were conducted once a year along 5 x 2m (wide) x 25m (long) belt transect where commercially important invertebrate species abundance were recorded (Table 2).

Benthic cover were recorded once a year using a 0.5m x 0.5m quadrat that is placed at every 0m, 5m, 10m, 15m, 20m and at each location along the transect benthic substrate is identified and the percent cover is estimated for each substrate.

Data Analysis

All analyses were conducted using Microsoft Excel.

Fish density and biomass was compared between the MPA and its reference site. Biomass was calculated using the total length-weight conversion equation below:

*Biomass = a*Total Length^b*

The a and b coefficients can be found in Kulbiki et al. (2005) and in FishBase (http://www.fishbase.org).

The mean invertebrate density was compared between the MPA and its corresponding reference site.

Benthic cover was averaged per MPA and Reference site within Microsoft Excel.

Results

Fish Abundance, Biomass and Size

Within all of the MPAs, the density of commercially important fish was higher each year, compared to the reference site through all years of the study. Biggest differences within fish density was seen in the Peleliu MPA, 33.8 ± 10.5 per 125m^2 and its reference site 12.2 ± 4.0 per 125m^2 and in the Koror MPA, 22.3 ± 4.8 per 125m^2 and its reference site, 9.8 ± 3.2 per 125m^2 in 2014. Though, a general trend is noted as fish densities within the MPAs and their reference sites have continued to decrease from 2011 – 2014, with the most dramatic decreases seen within the MPA and reference site in Koror from 2013 – 2014 (Figure 1).

Biomass of commercially-valued fish was greater within three of the MPAs, Airai, Koror, and Peleliu, when compared to their reference sites from 2013-2014. Significant differences were seen in Peleliu, as the MPA had an average of 15.7 ± 6.0kg of fish per 125m^2 compared to its reference site which only had 2.0 ± 1.4kg per 125m^2 of fish. The major driver of this difference between the MPA and reference site is the high populations of *Bolbometopon muricatum (Kemedukl)* found within the MPA. However, in Ngchesar, the average fish biomass was greater within the reference site compared to the MPA from 2013 – 2014, opposite of Peleliu. Again, similar to fish density, fish biomass within the MPA and reference site has continued to decrease over the past few years from 2011 – 2014 (Figure 2).

The average sizes of commercially-valued fish within the Ngchesar and Peleliu MPAs and reference sites remained steady, from 2013 – 2014, though the Ngchesar MPA and reference site had similar size fish and the Peleliu MPA had larger size fish than the reference site, 19.1 ± 1.7 cm versus 12.0 ± 1.7 cm per 125m^2 respectively. In the Airai sites, the MPA had larger fish than the reference site, but both sites have continuously decreased from 2011 – 2014. Contrarily, in Koror the MPA has larger fish compared to the reference site, 16.1 ± 0.8 cm versus 14.0 ± 1.6 cm in 2014 per $125m^2$, and fish size has increased in both sites from 2013 – 2014 (Figure 3).

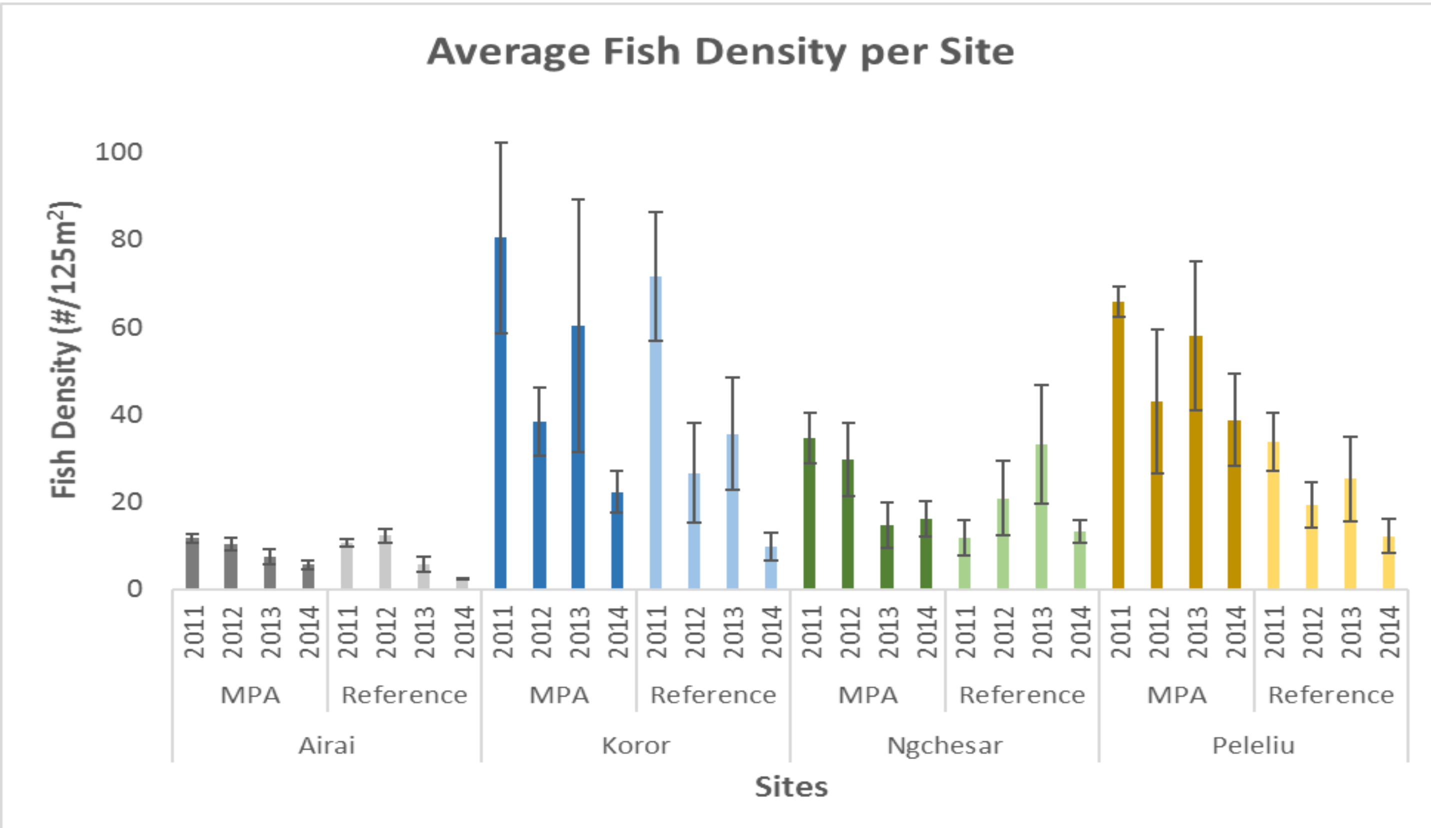

Figure 1. Density of commercially important fish within each MPA and Reference site (mean ± SE).

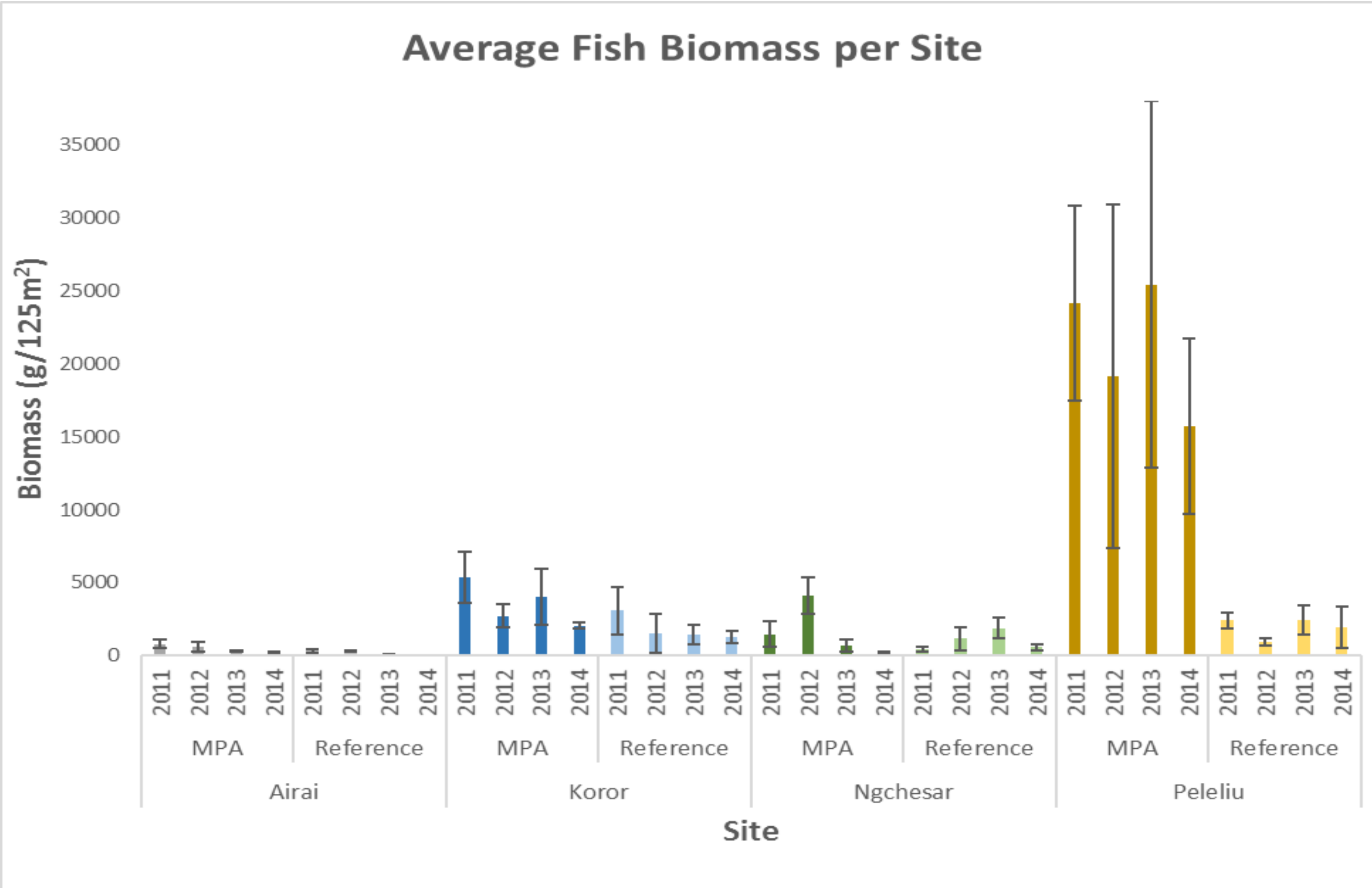

Figure 2. Fish biomass within each MPA and their reference sites (mean ± SE).

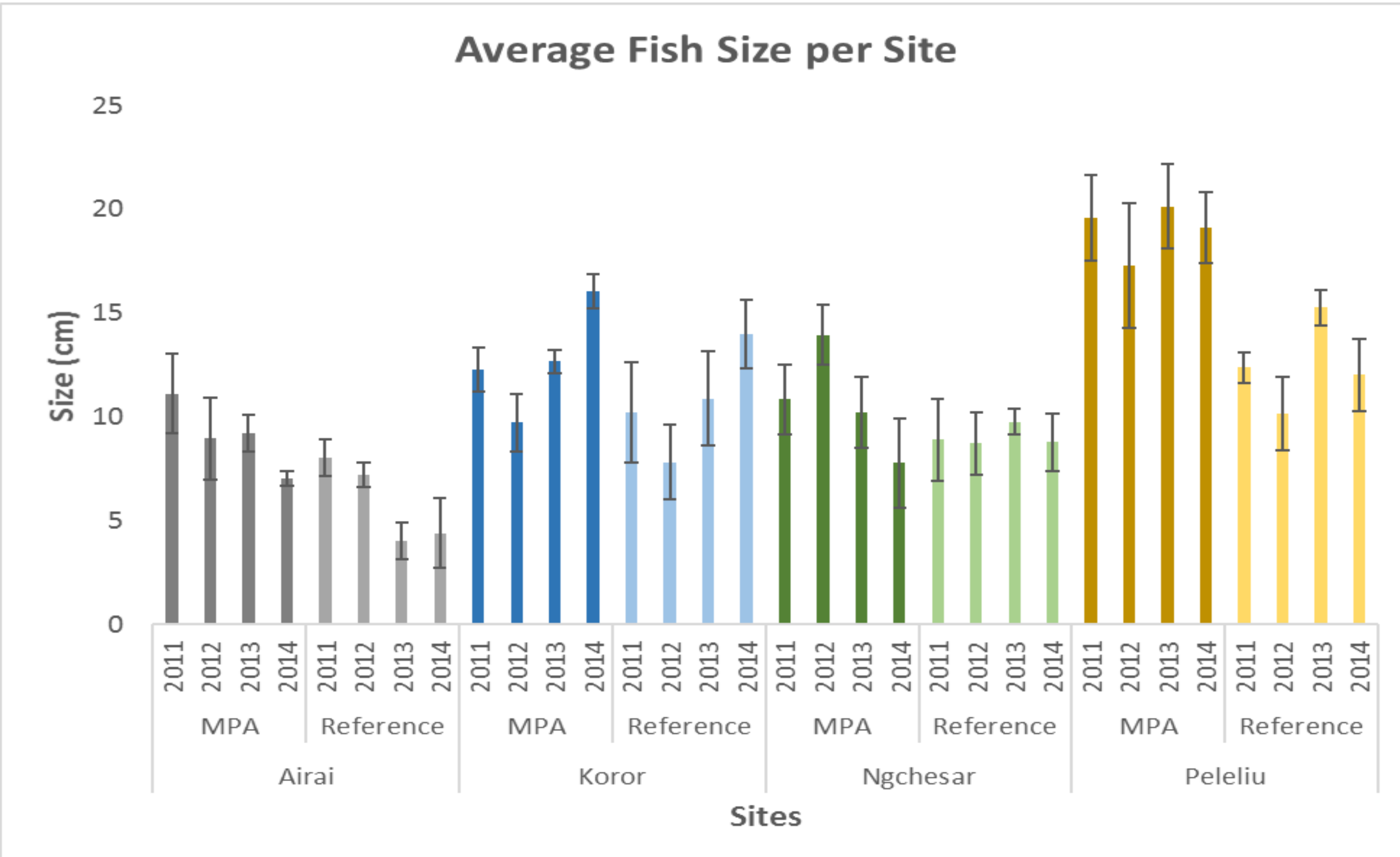

Figure 3. Size of commercially-important fish within the four MPAs and their reference sites (mean ± SE).

Invertebrate Density

The invertebrate populations did not vary among all four of the MPAs, as all sites had low numbers of invertebrates. In Airai, the MPA and reference site saw similar densities from 2013 – 2014. Similarly, Koror and Peleliu's MPA and reference sites had a steady number of invertebrates from 2013 – 2014.

While in Ngchesar, the MPA showed a slight decrease in invertebrates, 1.2 ± 0.7 to 0.2 ± 0.2, from 2013 – 2014 while the reference site had no change during that time (Figure 4).

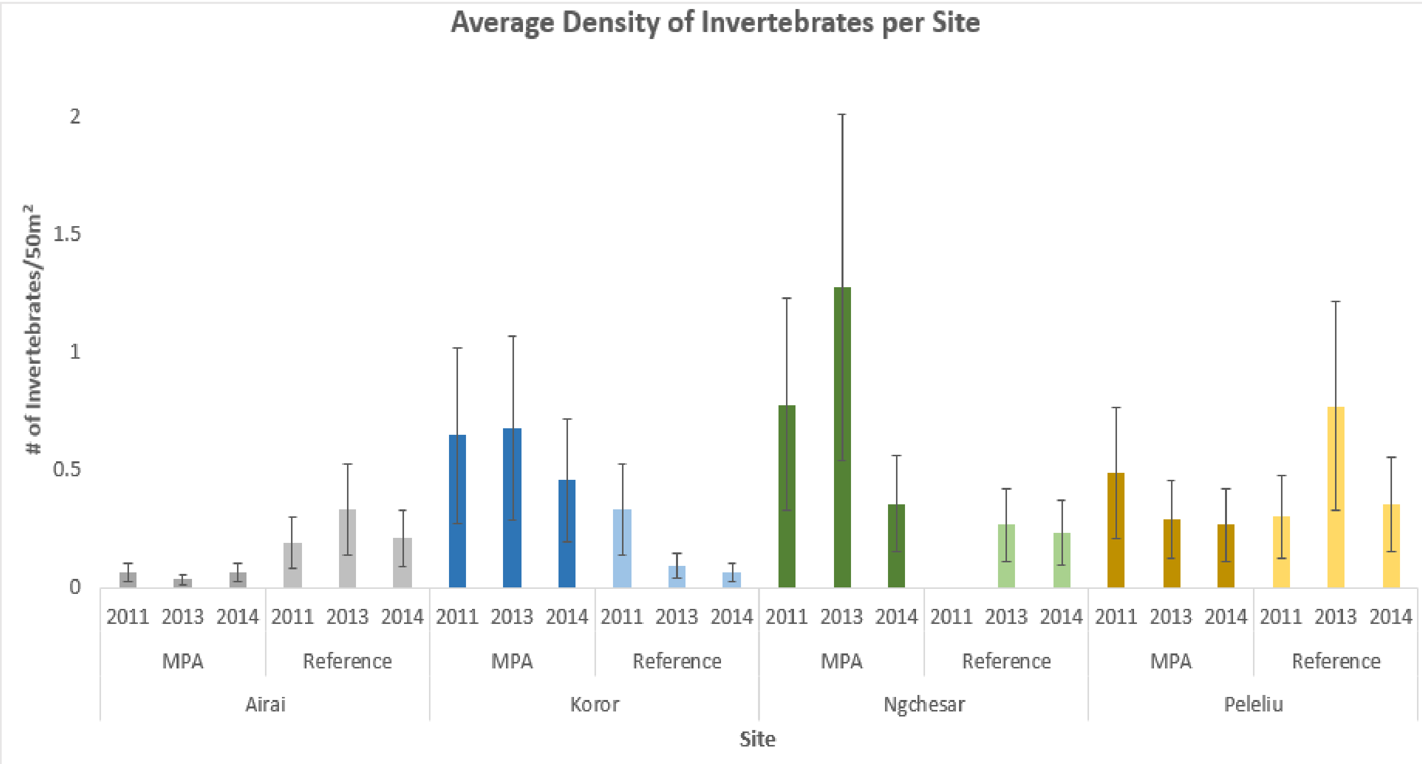

Figure 4. Density of invertebrates with standard error per site, from 2011 – 2014 (mean ± SE).

Seagrass Cover

Since the last survey in 2013, the Airai MPA has seen little change in seagrass cover but the reference site has decreased in average seagrass cover, with a loss of the species *Cymodocea rotundata* from 2013 – 2014. In Koror, both the MPA and the reference sites have reduced in seagrass cover since 2013, with major reductions in the species *Thalassia hemprichii,* from 23.2% to 10.2% in the MPA and *Halodule ovalis,* 5% to 1%, *and Syringodium isoetifolium,* 16.9% to 10.2%, in the reference site. The Ngchesar MPA and reference site increased in seagrass cover, though in the MPA there was a loss of the species

Syringodium isoetifolium and an addition of the seagrass species *Halodule univeris*. In Peleliu, *Halodule ovalis* began to grow in the MPA increasing the seagrass cover from 2013 – 2014 while the reference site showed no noticeable changes in seagrass cover over the same period (Figure 5).

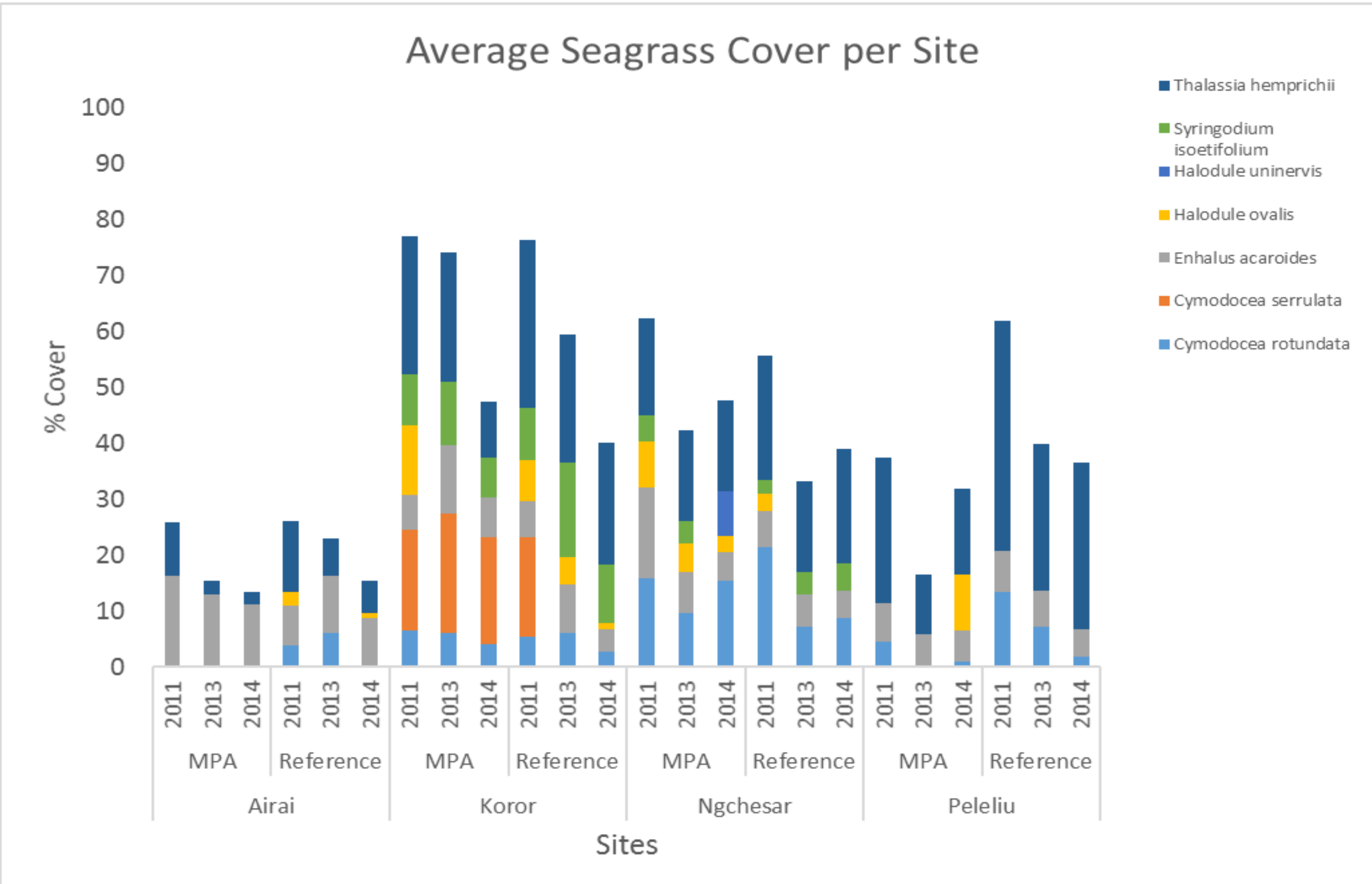

Figure 5. Seagrass cover per site with standard error per site, from 2011 – 2014 (mean ± SE).

Discussion

Since the last seagrass survey in 2013, fish and invertebrate density and fish biomass have continued to decrease in most sites but overall seagrass cover was relatively unchanged, though there were changes in seagrass species present, in most sites from 2013 – 2014. However, over the course of the entire long-term monitoring survey, 2013 – 2014, we are continuing to notice a decrease in invertebrate, fish, and seagrass populations. In Palau, the steep topography, high rainfall, and coastal development have resulted in increased sedimentation levels throughout Palau, which has become significant issue due to its negative effects on coastal ecosystems and a possible driver for the decreases in fish populations, low invertebrate densities and changes within seagrass populations (Koshiba et al. 2013; Norkko et al. 2002; Hewitt et al. 2003).

MPAs provide benefits and services but without proper management of resources outside these MPAs, the services they provide may not be completely recognized. And though the outlook may look bleak, this updated survey serves as a tool for resource managers as they continue to effectively manage their respective MPAs. Continued monitoring as well as strategies to raise awareness of the importance of seagrass beds and mitigate potential threats will enable resource managers to develop a more resilient network of MPAs (Bjork M. et al. 2008).

Acknowledgements

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References

Björk M., Short F., Mcleod, E. and Beer, S. (2008). Managing Seagrasses for Resilience to Climate Change. IUCN, Gland, Switzerland. 56pp.

Costanza R, d'Arge, R and van den Belt M. (1997). The value of the world's ecosystem services and natural capital. Nature, 387, 253–260.

Duarte, C.M. et al., 2000. Á Seagrass ecosystems : their global status and prospects. *Aquatic Ecosystems*.

Duarte, C. M. (2002). The future of seagrass meadows. *Environmental Conservation*, *29*(2), 192–206. doi:10.1017/S0376892902000127

Hewitt, J. E., V. J. Cummings, J. I. Ellis, G. Funnell, A. Norkko, T. S. Talley, and S. F. Thrush. 2003. The role of waves in the colonisation of terrestrial sediments deposited in the marine environment. Journal of Experimental Marine Biology and Ecology 290:19-47.

Koshiba, S. et al., 2013. Palau's taro fields and mangroves protect the coral reefs by trapping eroded fine sediments. *Wetlands Ecology Management*, 21, pp.157–164.

Kulbicki, M., Guillemot, N., & Amand, M. (2005). A general approach to length-weight relationships for New Caledonian lagoon fishes by, *29*(2), 235–252.

Norkko, A., S. F. Thrush, J. E. Hewitt, V. J. Cummings, J. Norkko, J. I. Ellis, G. A. Funnell, D. Schultz, and I. MacDonald. 2002. Smothering of estuarine sandflats by terrigenous clay: the role of wind-wave disturbance and bioturbation in site-dependent macrofaunal recovery. Marine Ecology- Progress Series 234:23-41.

Orth, R. et al., A global crisis for seagrass ecosystems. *Bioscience*, (56), pp.987–996.

Waycott, M., Duarte, C. M., Carruthers, T. J. B., Orth, R. J., Dennison, W. C., Olyarnik, S., … Williams, S. L. (2009). Accelerating loss of seagrasses across the globe threatens coastal ecosystems, *1*(19).

Appendix

Table 1. Scientific names of commercially-important fish surveyed.

Commercially important fish species in Palau			
	Common name	**Palauan name**	**Scientific name**
1	Lined rabbitfish	Kelsebuul	*Siganus lineatus*
2	Forketail rabbitfish	Beduut	*Siganus argenteus*
3	Bluespine unicornfish	Chum	*Naso unicornis*
4	Orangspine unicornfish	Cherngel	*Naso lituratus*
5	Longface enperor	Melangmud	*Lethrinus olivaceus*
6	Orangestripe emperor	udech	*Lethrinus obsoletus*
7	Yellowlip emperor	Mechur	*Lethrinus xanthochilis*
8	Red snapper	Kedesau	*Lutjanus bohar*
9	Humpback snapper	Keremlal	*Lutjanus gibbus*
10	Bluefin trevally	Erobk	*Caranx ignobilis*
11	Giant trevally	Oruidel	*Caranx melampygus*
12	Parrotfish species	Melemau	*Cetoscarus/Scarus Spp.*
13	Pacific longnose parrotfish	Ngeaoch	*Hipposcarus longiceps*
14	Bluespot mullet	Kelat	*Valamugil seheli*
15	Squaretail mullet	Uluu	*Liza vaigiensis*
16	Rudderfish (lowfin)	Komud, Teboteb	*Kyphosus spp (vaigiensis)*
17	Giant sweetlips	Melim ralm, Kosond/Bikl	*Plectorhinchus albovittatus*
18	Yellowstripe sweetlips	Merar	*Plectorhinchus crysotaenia*
19	River snapper	Kedesau'l iengel	*Lutjanus argentimaculatus*
20	Yellow cheek tuskfish	Budech	*Choerodon anchorago*
21	Masked rabbitfish	Reked	*Siganus puellus*
22	Goldspotted rabbitfish	Bebael	*Siganus punctatus*
23	Bicolor parrotfish	Beyadel/ngesngis	*Cetoscarus bicolor*
24	Indian Ocean Longnose parrotfish	Bekism	*Hiposcarus harid*
25	Red gill emperor	Rekruk	*Lethrinus rubrioperculatus*
26	Pacific steephead parrotfish	Otord	*Scarus micorhinos*
Protected Fish Species (yearly and seasonal fishing closure)			
27	Dusky rabbitfish	*Meyas*	*Siganus fuscescens*
28	Bumpead parrotfish	*Kamedukl*	*Bolbometopon muricatum*

29	Humphead parrotfish	*Maml*	*Cheilinus undulatus*
30	Squaretail grouper	*Tiau*	*Plectropomus areolatus*
31	Leopard grouper	*Tiau*	*Plectropomus leopardus*
32	Saddleback grouper	*Tiau, Katuu'tiau, Mokas*	*Plectropomus laevis*
33	Brown-marbled grouper	*Meteungerel'temekai)*	*Epinephelus fuscoguttatus*
34	Marbled grouper	*Kesau'temekai*	*Epinephelus polyphekadion*

Table 2. Scientific names of surveyed invertebrates

Invertebrates
Actinopyga echinites
Actinopyga lecanora
Actinopyga mauritiana
Actinopyga miliaris
Actinopyga palauensis
Actinopyga sp.
Bohadschia argus
Bohadschia similis
Bohadschia vitiensis
Hippopus
Hippopus porcellanus
Holothuria atra
Holothuria coluber
Holothuria edulis
Holothuria fuscogilva
Holothuria fuscopunctata
Holothuria impatiens
Holothuria lessoni
Holothuria leucospilota
Holothuria nobilis
Holothuria scabra
Holothuris falvomaculata

Pearsonothuria graeffei
Stichopus chloronotus
Stichopus hermanni
Stichopus horrens
Stichopus vastus
Thelenota ananas
Thelenota anax
Tridaacna crocea
Tridacna squamosa
Tridacna derasa
Tridacna gigas
Tridacna maxima