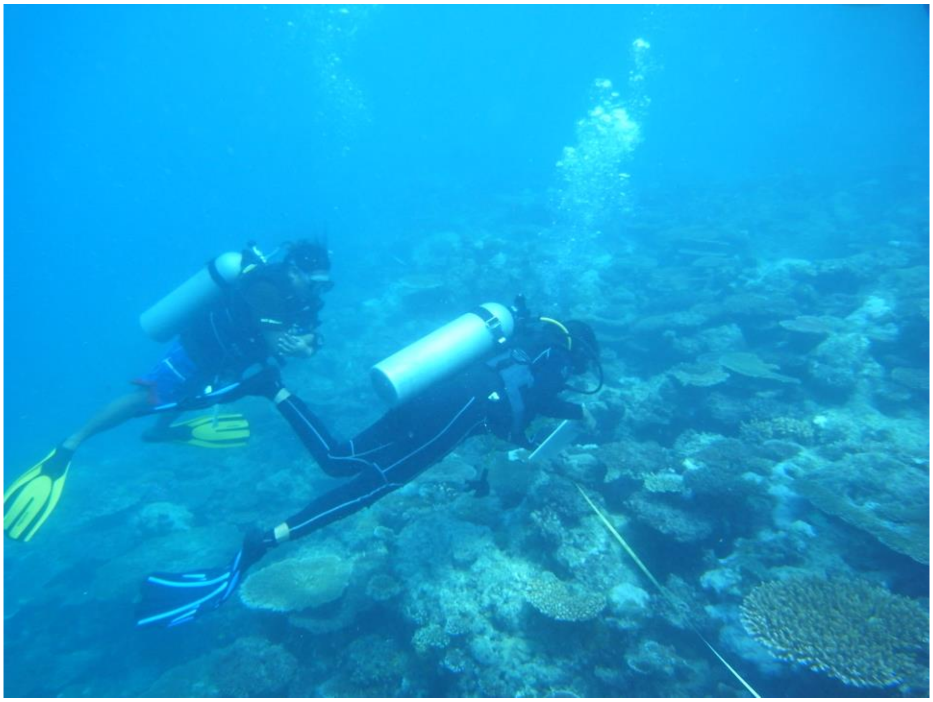
Effectiveness of marine protected areas in Palau: Ileyakl Beluu Conservation Area, Ngardmau State



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Abstract

Marine protected areas (MPAs) are considered great tools for resource management. A challenge for many resource managers is to identify the effectiveness of their MPA. This study focuses on an MPA, a no-take reserve, in an effort to determine the effectiveness of a marine reserve. The study took a random sampling approach to examine the status of marine resources in the Ileyakl Beluu Conservation Area (0.62-km^2) located on the barrier reef offshore to Ngardmau State, Palau. The monitoring period was 2010-2012, and the environmental variables observed were 1) fish density, species richness, and biomass, 2) density and diversity of invertebrates and coral recruits, and 3) coral cover. With fish biomass, PERMANOVA determined that fish community was similar in Ileyakl Beluu compared to the reference site. Fish density did not vary greatly except for a huge increase on April 2011. During this survey period *Lutjanus gibbus* (keremlal) was most abundant in the reserve, while *Naso lituratus* (cherangel) was most abundant at the reference site. Sea cucumbers were rare compared to small giant clams *Tridacna crocea* (oruer) and *Tridacna maxima* (melibes). Benthic community for Ileyakl Beluu was dominated by hard corals (36%) and carbonates (27%). Density of coral recruits inside Ileyakl Beluu was similar to the reference site (~9 ind m^{-2}). Overall, there were mixed results when comparing environmental variables between Ileyakl Beluu and the reference site, and the small size of the reserve may be the reason why no obvious effect from protection was observed for this study.

Introduction

The Palau International Coral Reef Center's (PICRC) Marine Protected Area (MPA) Evaluation Project was initiated with the primary goal to improve conservation of Palau's unique marine resources, via adaptive management. Four MPAs in Palau were monitored for three years. Each MPA was from 4 different states of Palau: Ngarchelong, Ngiwal, Ngardmau, and Peleliu. This report will focus on Ileyakl Beluu Conservation Area, which is one of two Ngardmau State MPAs. The results of these evaluations are intended to guide management on what is working, and what is not, so that investments in MPAs will succeed in achieving their desired objectives. Such objectives include biodiversity conservation, fisheries management, income generation, and/or a combination of all these objectives.

Fish are the major source of protein for people in Pacific Island countries (Skinner et al. 2011), but most of the world's reefs are overfished (Pandolfi et al. 2003, Jackson et al. 2001). Because conventional, top-down management cannot combat unprecedented human impacts to reefs (Bellwood et al. 2004), community-initiated MPAs have become a popular fisheries and conservation management tool in coral-reef ecosystems (Hamilton et al. 2011). In fact, no-take reserves (reserves) are one of few viable management options in developing nations (Russ & Alcala 2004). Reserves are the best way to protect species and habitats (Lubchenco et al. 2003), and to restore fish assemblages and ecological processes (Micheli et al. 2004). As such, advocates argue the global reserve network should expand to combat reef decline (Bellwood et al. 2004).

Reserves have been shown to increase the biomass (Abesamis et al. 2006, Palumbi 2004, Halpern 2003), size (Palumbi 2004, Halpern 2003), abundance (Abesamis et al. 2006, Micheli et al. 2004, Halpern 2003), and diversity (Halpern 2003, Lubchenco et al. 2003) of fish species exploited outside the reserve. These enduring increases can begin soon after reserves are created, but are not always evident immediately after the reserve's establishment (Lubchenco et al. 2003, Halpern & Warner 2002). Of particular importance to local fisherman, the benefits of reserves are not restricted to the area under protection; in a process known as spillover, migration increases the size and abundance of exploited fish near the reserve (Lubchenco et al. 2003, Harrison et al. 2012).

Though fewer large reserves are better than many small reserves at protecting ecosystem function (Mills et al. 2010), small reserves still benefit exploited fish species (Lubchenco et al. 2003). In fact, increase in fish size, biomass, and abundance within the reserve are proportional to reserve size (Halpern 2003, Halpern & Warner 2002), and even small reserves can produce spillover effects (Abesamis et al. 2006). This means that small reserves measure up to large reserves in fisheries benefits per unit area, but large reserves produce more benefits on an absolute scale. Though the magnitude of fisheries benefits is limited by reserve size, small reserves can be of further benefit by supplying larval reef fish to unprotected areas (Harrison et al. 2012) and protecting spawning aggregations (Hamilton et al. 2011).

Reserve benefits are not restricted to fish, and in some instances, protection can improve invertebrate stocks. A meta-analysis of tropic and temperate systems found reserves increase invertebrate density and size (Halpern 2003). Despite this result, there are few studies of traditionally harvested reef invertebrates in the insular Pacific (Dumas et al. 2013). Results have been mixed, finding that some reserves benefited some species, but that others had little or no effect (e.g. Dumas et al. 2013, Dumas et al. 2010, and Lincoln-Smith et al. 2006).

Reserves can protect corals from superficial damage and algal overgrowth, but do not guard against large scale damage from disease and coral bleaching. Reserves directly benefit corals by limiting damage by anchors and destructive fishing practices (Selig & Bruno 2010). Through indirect ecosystem effects, reserves enhance fish grazing and depress macroalgal cover (Mumby et al. 2006), preventing phase shifts from coral-dominated to algal-dominated systems. However, local protection does not prevent coral decline caused by high water temperatures, storms, or disease (Selig & Bruno 2010, Coelho & Manfrino 2007, Jones et al. 2004).

Though reserves enhance fisheries and ecosystem health in many case studies, success is not guaranteed. Reserve management must include periodic monitoring and evaluation to guide management (Lubchenco et al. 2003, Agardy et al. 2003). Our study quantifies the efficacy of Ileyakl Beluu Reserve, Ngardmau State (population 166 in 2005), Palau. Ileyakl Beluu is a small (0.62-km^2), community initiated no-take marine reserve, protected since 2005. We surveyed fish size and abundance, invertebrate size and abundance, benthic cover, and coral recruit abundance in the reserve and at a nearby reference site between 2010 and 2012. Differences between the reserve and reference site were documented, as well as trends over time, to determine Ileyakl Beluu's effect on the marine environment. These results will guide management of the reserve to benefit fisheries in the future.

Methods

Study Site

Ileyakl Beluu (7° 38.83'N x 134° 32.90'E) is part of a large barrier reef system on the western side of the main island of Palau (Figure 1). It is a small patch of reef bordered by channels. Ileyakl Beluu became a marine reserve under Ngardmau State Law in 2005, NSL 5-28. Removal of any material, living or nonliving, inside Ileyakl Beluu is strictly prohibited. Ileyakl Beluu was then inducted into the Ngardmau System of Conservation Areas (NSCA) in 2009 through NSPL 7-11. The management plan is also known as Ongedechuul System of Conservation Areas (OSCA) Ecosystem-based management plan 2011-2016. The current management plan, implemented in 2011, began with community meetings held in October 2009. These meetings identified overfishing, poaching by community members and outsiders, and illegal fishing as high level threats to the marine environment. The community voiced that their ability to manage the reserve was limited by a lack of management plans, monitoring, public knowledge of regulations, conservation officers, infrastructure, and boat fuel.

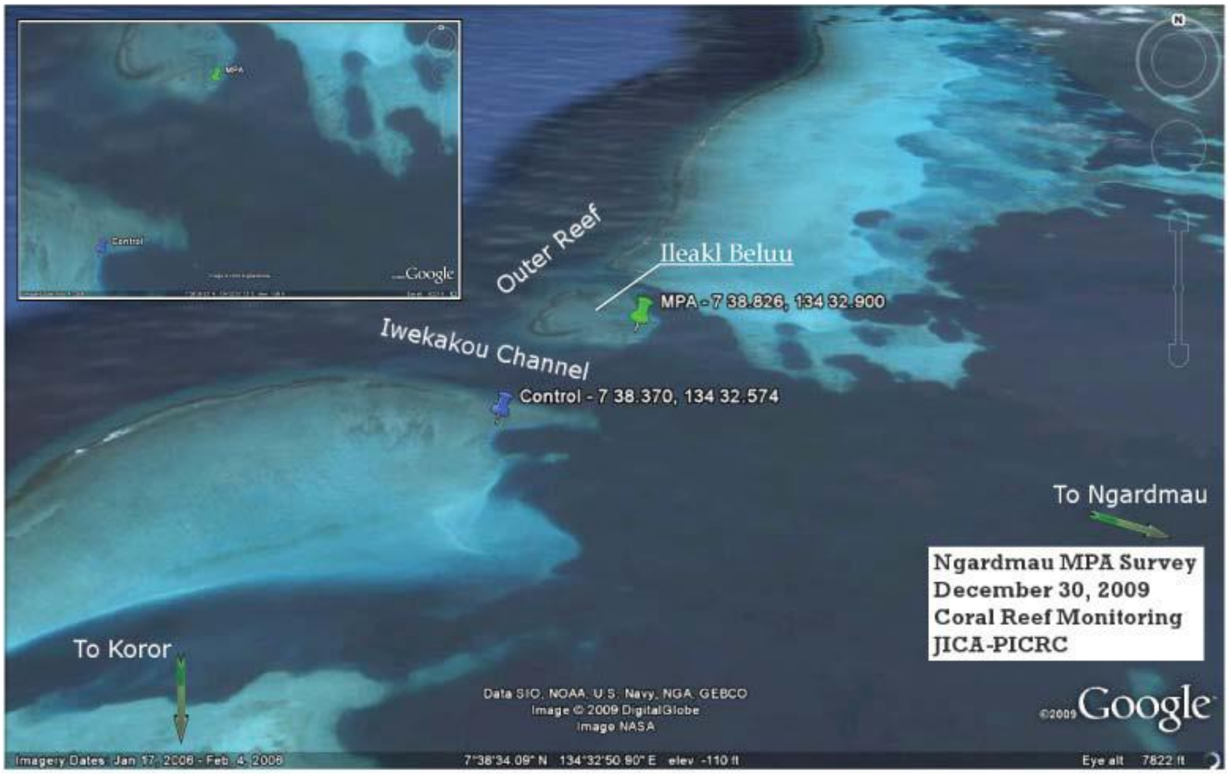

Figure 1. Ileyakl Beluu conservation area is denoted by the green pin, and the reference site is marked by the blue pin.

The current management plan stipulates that dredging, dumping, aquaculture, and harvesting of the mother-of-pearl snail *Trochus niloticus* (semum) are prohibited in the reserve. Fishing for community purposes is allowed, but requires permission from the State Governor and the Traditional Chiefs. Entry for tourism requires a fee, but no diving activities currently take place inside the reserve.

The reference site was an area of barrier reef (7° 38.37'N x 134° 32.57'E) located across Iwekakou Channel approximately 1 km south of the reserve. Selection of the reference site was based on similar physical characteristic of the reef and its close proximity to the MPA.

Field Techniques

We conducted surveys at three randomly selected stations inside the reserve and three randomly selected stations in the reference area. Fish surveys were conducted on September 30, 2010; April 20, 2011; July 20, 2011; October 5, 2011; and April 3-4, 2012. An invertebrate survey was conducted on December 6, 2010, a benthic cover survey was conducted on November 26, 2012, and a survey for coral recruits was conducted on February 3, 2011. All surveys were conducted at 10-m depth along five 50-m replicate transects aligned end to end and spaced 1-m apart. The surveys were conducted as described below.

At each station, a diver recorded the size and species of target fish on five 5 x 50-m belt transects at a rate of 0.5-m sec^{-1}. Fish targeted for the study were protected species and reef fish important for both commerical and subsistence use (Table 1). Fish size data was converted to biomass using published length-weight relationships, $W = a \bullet L^b$, where W is weight in grams, L is fish length from the visual census, and parameters a and b are constants obtained from Fishbase website (Froese and Pauly, 2013).

Invertebrates were surveyed by a diver on five 2 x 50-m belt transects. Surveyed species were edible sea cucumber, bivalves, and trochus (Table 2). Species identification and size were recorded.

Benthic cover was assessed using 0.25 m^2 photoquadrats taken with a digital camera (Sea&Sea 2G, DX-2G) at each meter of a 50 meter transect (totalling 50 photos per transect). To calculate benthic cover percetages, five points were superimposed on each photo using Coral Point Count with excel software. Each point was identified to the lowest possible taxon.

The coral recruit survey was done on 0.3 x 10-m belt transects at the beginning of each replicate transect. Size of each coral recruit was measured and identified to the lowest taxon level possible. Maximum size of coral recruits considered for this study was 5-cm.

Data Analysis

Permutational multivariate analysis of variance (PERMANOVA) was used to analyze fish size, community structure (using biomass), density and species richness. Analysis design consisted of Survey Period and Status as fixed factors and Station (nested in Status) as a random factor. Principal component ordination (PCO), with Pearson correlation > 0.05, was then used to determine which variable drove differences between Ileyakl Beluu (MPA) and the reference site.

Total fish biomass (log transformed) was analyzed using a 2-way ANOVA with Survey Period and Status as fixed factors and Station (nested in Status) as a random factor. *Bolbometopon muricatum* (kemedukl) were the largest and fewest fish recorded. To avoid skewed data for biomass, *B. muricatum* was excluded in all analyses of fish biomass.

PERMANOVA was also used to compare density, community structure, and species richness of invertebrates inside Ileyakl Beluu to the unprotected area with Status as the fixed factor and Station (nested in Status) as random factor. T tests were used to compare density and size of *Tridacna crocea* and *Tridacna maxima* in the protected and unprotected areas. Shapiro-Wilks test was used for normality test, and if the data was not normal Wilcoxon test was used instead.

Benthic community was analyzed using PERMANOVA with Status as the fixed factor and Station, nested in Status, as a random factor. The analysis considered percent cover of coral, soft coral, other invertebrates, macroalgae, crustose coralline algae, carbonate, rubble, and sand. PCO, with Pearson correlation > 0.05, was used to determine which benthic group drove differences between Ileyakl Beluu and the reference site.

In order to determine the effect of MPA on coral recruits, a T test was used to compare the average density of recruits in the MPA and the reference site. Shapiro-Wilk test was used to test for normality, and if the data was not normal Wilcoxon test was used instead. The same analytical method was used to compare species richness and mean size of coral recruits inside the MPA to the reference site.

Results and Conclusion

Fish

Size of all fish surveyed had a range of 10 to 110-cm (Figure 2). Over time, mean size of all fish surveyed had a range of 25-35 cm. There was no significant difference for fish size between the two sites over time (PERMANOVA: P > 0.05, Figure 3).

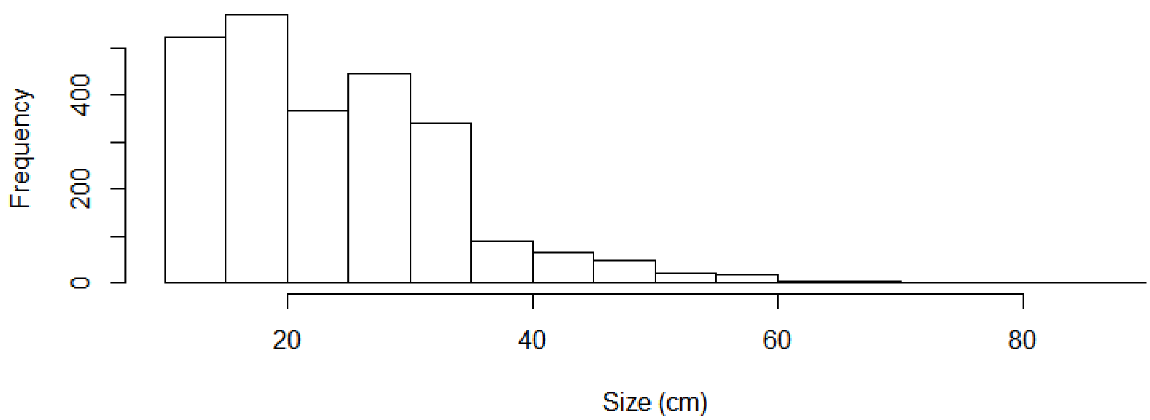

Figure 2. Size distribution of all fish surveyed (*n*=3).

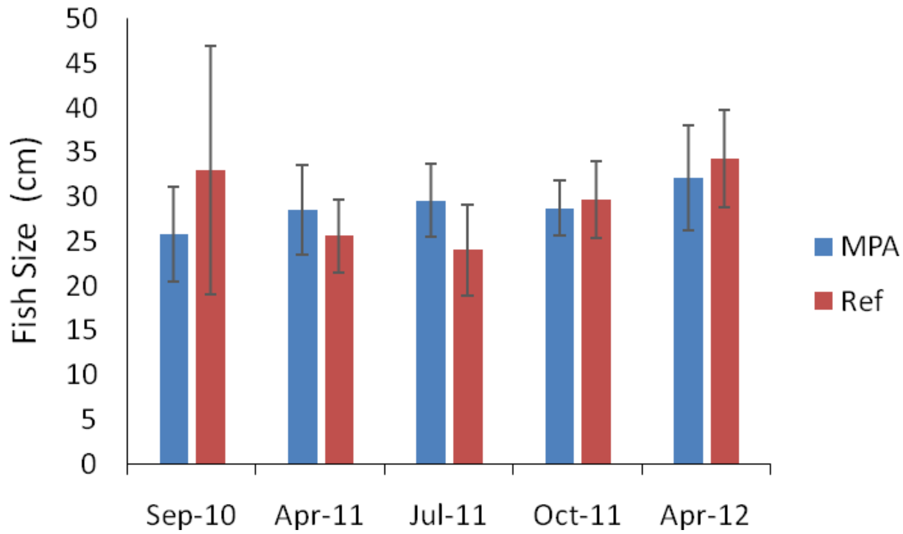

Figure 3. Fish size (mean ± SE) inside the MPA and the reference site (*n*=3).

A 2-way ANOVA determined that there was a significant difference in total biomass inside Ileyakl Beluu to the reference site over time. Total biomass on September 2010 was significantly less than April 2011 and October 2011 (2-way ANOVA: $P < 0.05$, Figure 4). Looking at Status alone, there was no significant difference between total fish biomass inside Ileyakl Beluu and the reference site (2-way ANOVA: $P > 0.05$).

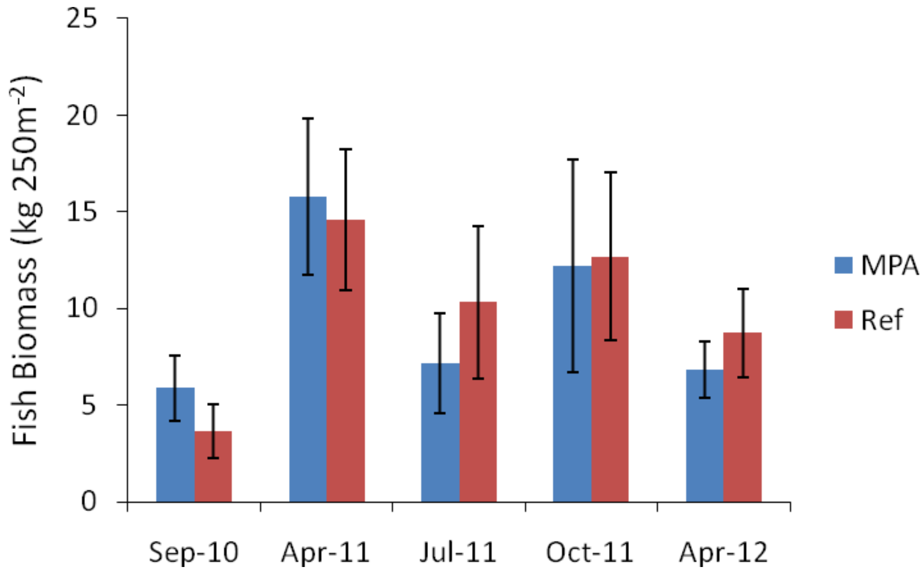

Figure 4. Total fish biomass (mean ± SE) inside MPA and the unprotected area (*n* = 3).

Moreover, PCO of fish functional groups showed that piscivores were more correlated with the MPA and the herbivores were more correlated to the unprotected area (Figure 5). Despite these findings, there was no significant difference on fish community structure between Ileyakl Beluu and the reference site over time (PERMANOVA: $P > 0.05$, Figure 6).

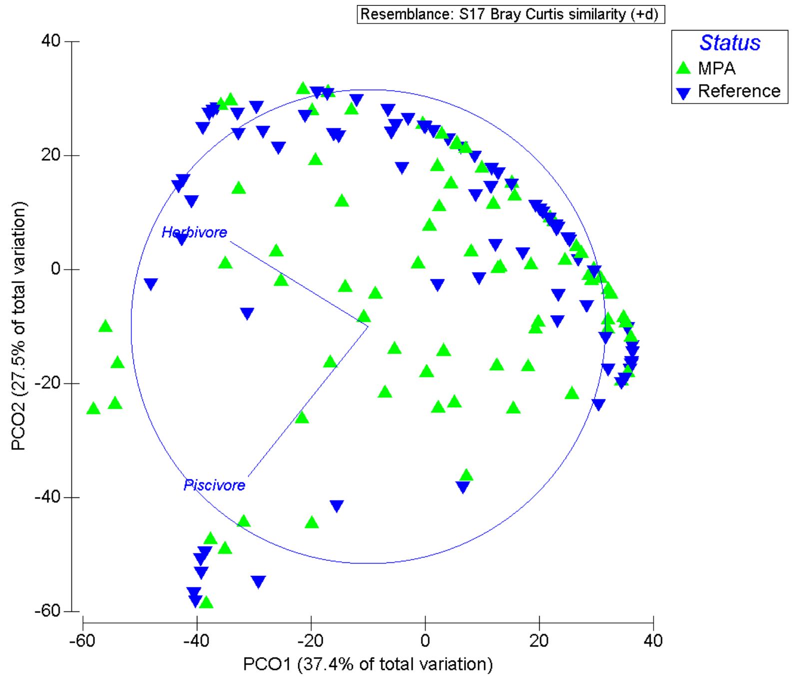

Figure 5. PCO plot (Pearson correlation > 0.5) of fish functional group in the MPA and unprotected area (*n*=3).

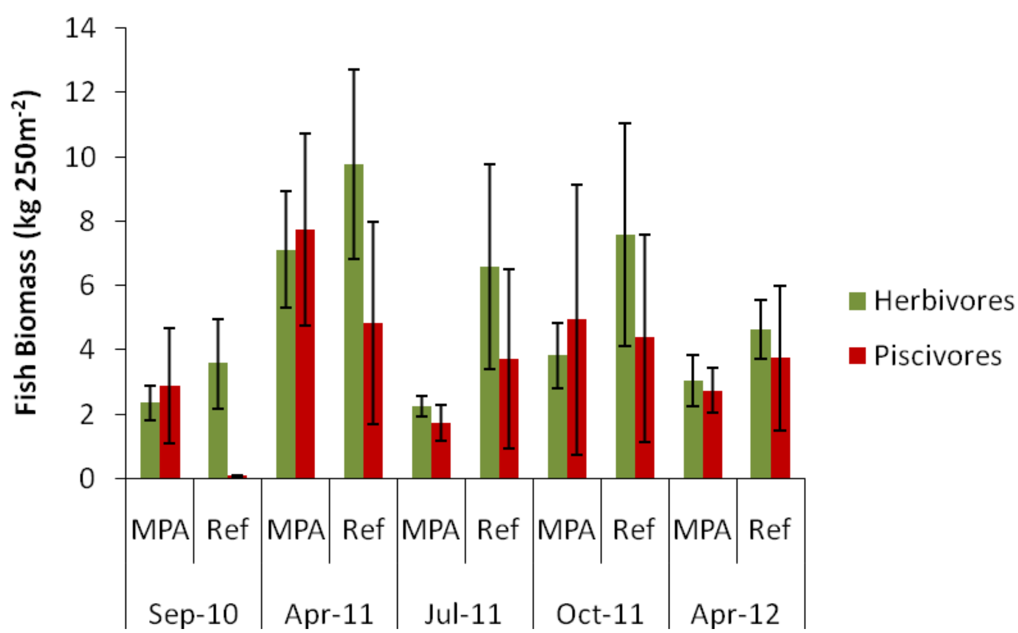

Figure 6. Biomass (mean ± SE) of herbivorous and piscivorous fish inside the MPA and unprotected area (*n*=3).

Fish density was very similar for the two sites over time, with the exception of a huge increase on April 2011. The spike was from 561 *Lutjanus gibbus* (keremlal) recorded in MPA and 225 *Naso lituratus* (cherangel) recorded at the reference site during this survey period. Despite the huge increase, fish density was similar inside the MPA and the unprotected area over time (PERMANOVA: P > 0.05, Figure 7). PCO indicated *Lutjanus bohar* (kedesau), which was more correlated with the MPA, drove the difference of fish abundance between the MPA and the unprotected area; however, this was only minor and was not significant (Figure 8). PERMANOVA also determined no significant difference for species richness over time, status, and time x status interaction (P > 0.05, Figure 9).

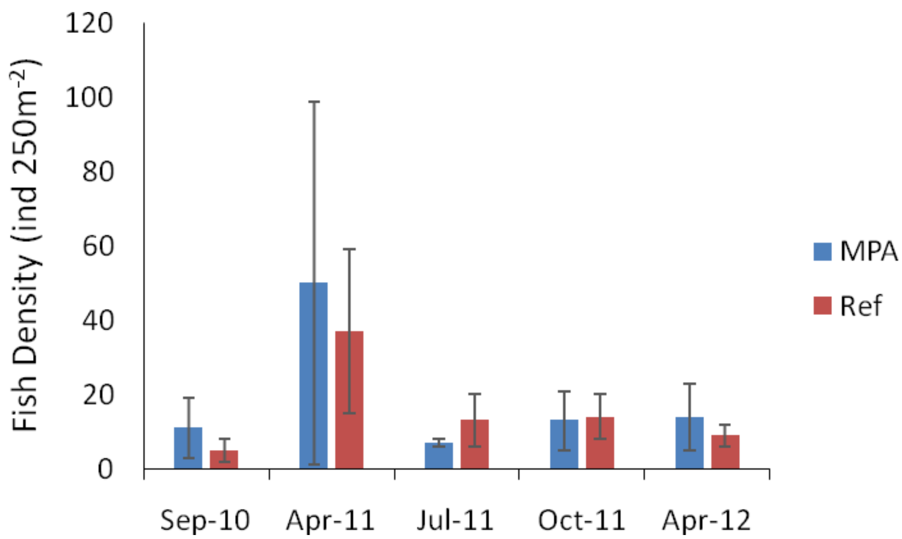

Figure 7. Density (mean ± SE) of total fish inside the MPA and at the reference site (*n*=3).

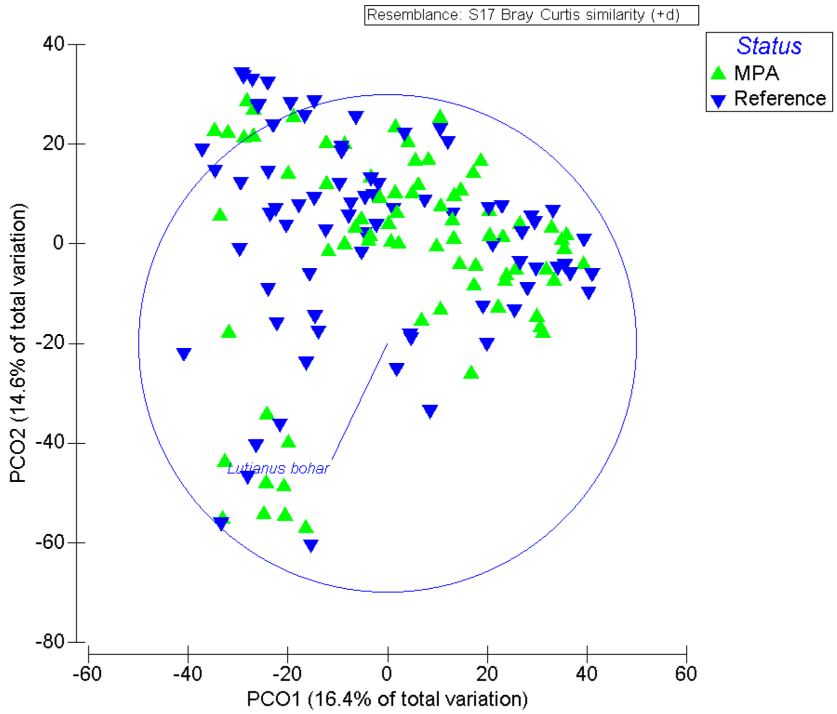

Figure 8. PCO plot (Pearson correlation > 0.5) for fish abundance in Ileyakl Beluu and the reference site (*n*=3).

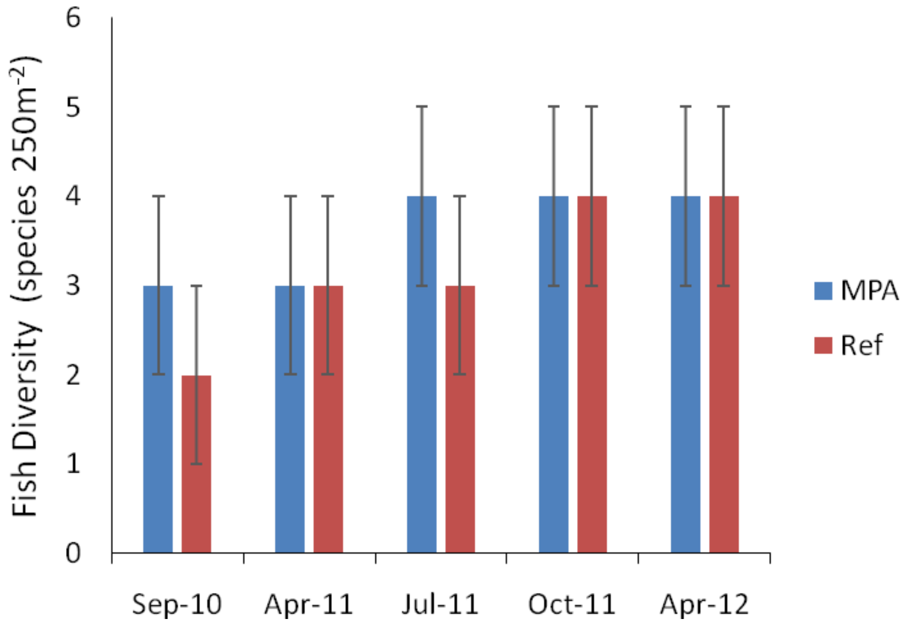

Figure 9. Species richness (mean ± SE) of fish inside the MPA and at the reference site (*n*=3).

Invertebrates

PERMANOVA revealed the invertebrate community within Ileyakl Beluu was not different from that found outside the MPA ($P > 0.05$). The invertebrate population at Ileyakl Beluu was composed almost entirely of clams. *Tridacna crocea* (oruer) and *Tridacna maxima* (melibes) were the most common species, contributing 77% and 18% of total invertebrates observed, respectively. Sea cucumbers were rare both inside and outside the protected area, with only four individuals observed inside the reserve and three observed outside the reserve.

Density of *T. maxima* inside the marine reserve was significantly larger, nearly double that of the reference site (Wilcoxon test: $P < 0.05$), while density of *T. crocea* was not significantly different inside the reserve to the reference site (Wilcoxon test: $P > 0.05$, Figure 10). Mean size of *T. maxima* at the MPA was over three times greater than the unprotected area, and a T test determined this difference was significant ($P < 0.05$), while *T. crocea* was significantly similar in the MPA to the unprotected area (Wilcoxon test: $P > 0.05$, Figure 11). Finally, species richness of invertebrates did not vary with protection status (PERMANOVA: $P > 0.05$).

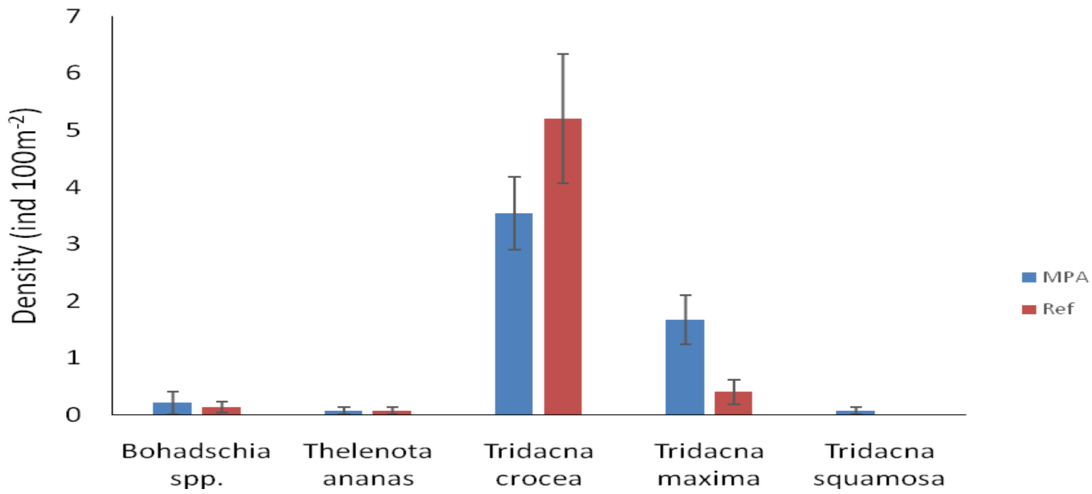

Figure 10. Invertebrate density (mean ± SE) inside the MPA and at the Reference site (*n*=3).

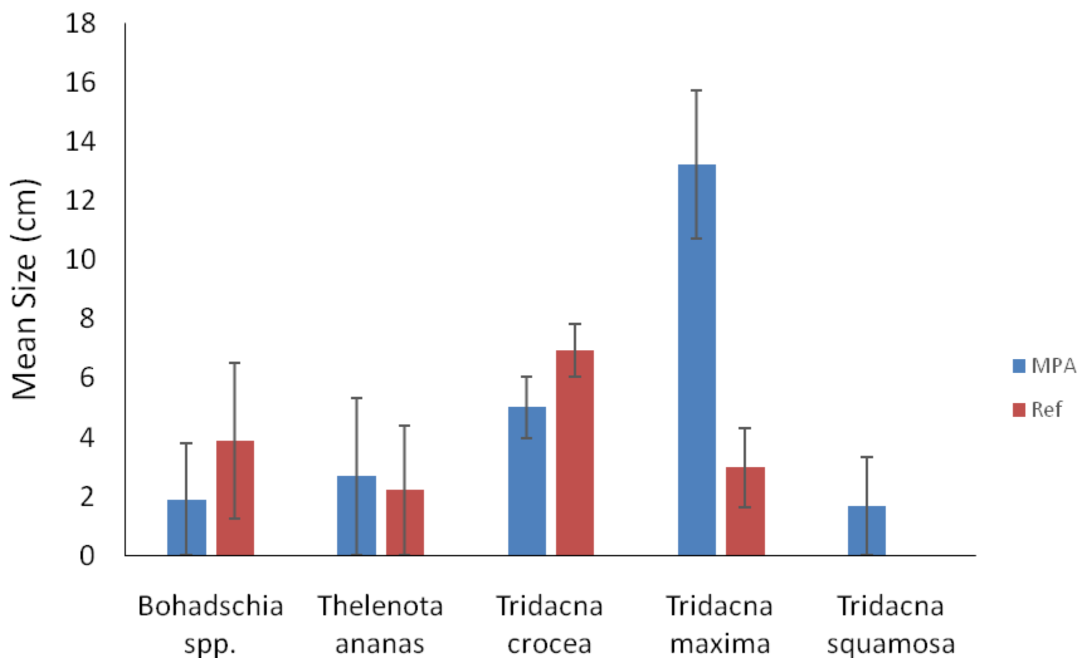

Figure 11. Invertebrate size (mean ± SE) inside the MPA and at the Reference site (*n*=3).

Benthic Cover

PERMANOVA showed that benthic community was similar between Ileyakl Beluu and the reference site (P > 0.05, Figure 12). Both areas had relatively high cover of coral (36-38%), followed by carbonates (27-37%), and rubble (8-23%). Also, both areas similarly had low cover (<5%) of soft coral, macroalgae, other invertebrates, and crustose coralline algae. PCO indicated that rubble (25%) was more correlated to the MPA, while carbonates and other invertebrates were more correlated to the reference site (Figure 13).

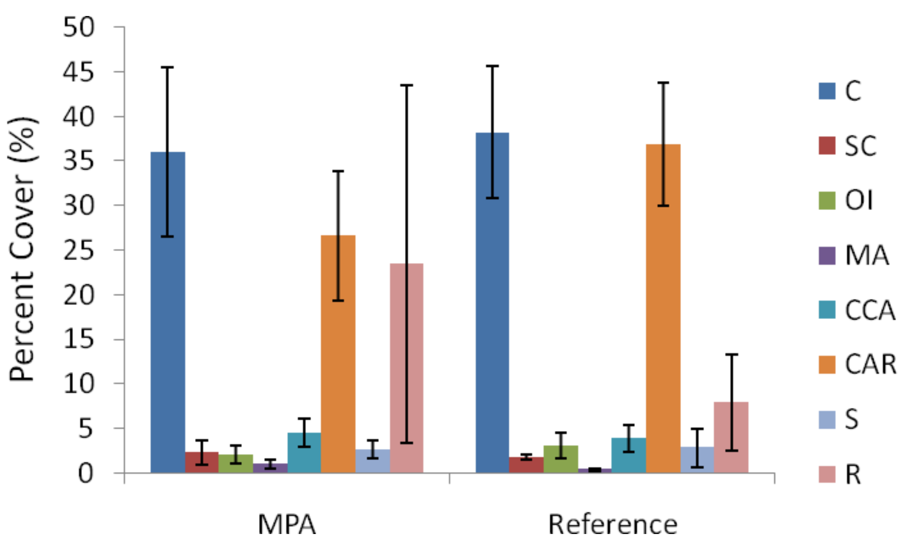

Figure 12. Percent cover (mean ± SE) of benthic community inside the MPA and the Reference site (*n*=3). Benthic community at the two sites was composed of coral (C), soft coral (SC), other invertebrates (OI), macroalgae (MA), crustose coralline algae (CCA), carbonate (CAR), sand (S), and rubble (R).

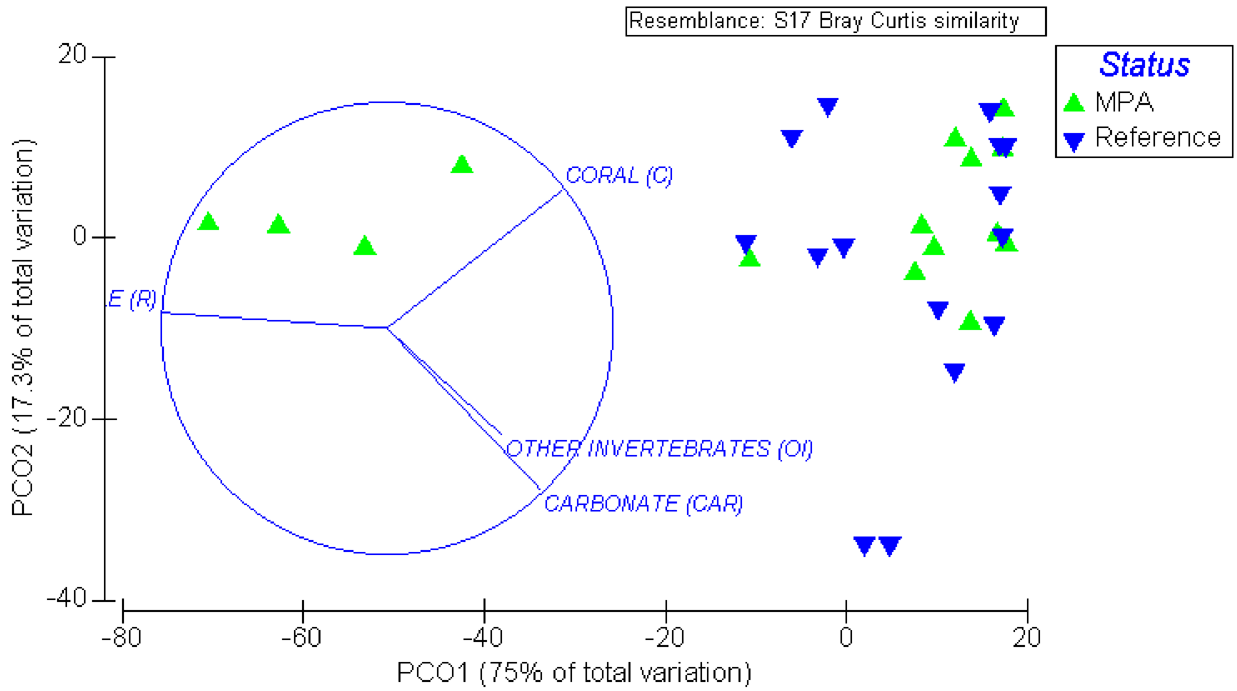

Figure 13. PCO of benthic plot (Pearson correlation > 0.5) of benthic community inside the MPA and the unprotected area. Benthic community at the two sites was composed of coral (C), soft coral (SC), other invertebrates (OI), macroalgae (MA), crustose coralline algae (CCA), carbonate (CAR), sand (S), and rubble (R).

Coral Recruits

Coral recruit density was very similar between Ileyakl Beluu and the reference site. Although there were on average 7 recruits more per unit area at the reference site compared to the reserve, this difference was non-significant (Wilcoxon test: P > 0.05, Figure 14).

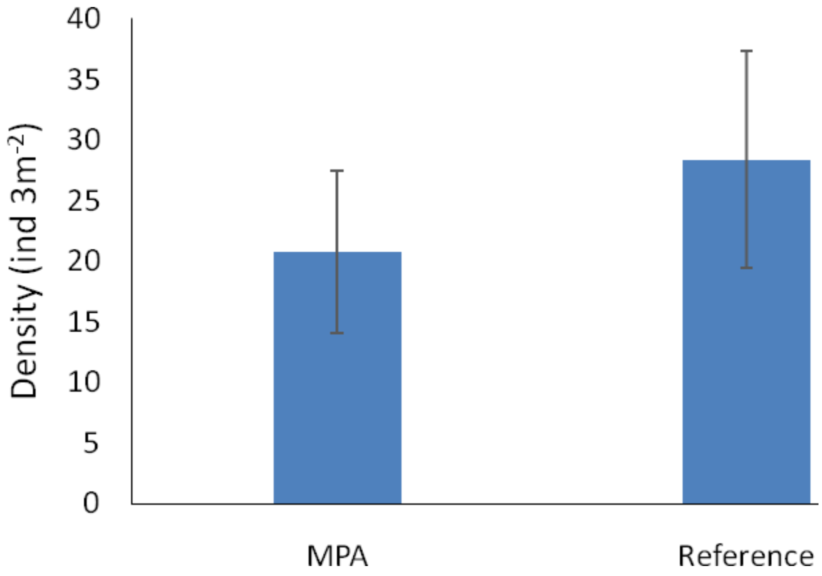

Figure 14. Coral recruit density (mean ± SE) inside the MPA and at the Reference site (*n*=3).

Mean size of coral recruits at the reference site was 0.3 cm greater than the reserve but recruit size in the reference site was not significantly (Wilcoxon test: P > 0.05) different than the MPA (Figure 15).

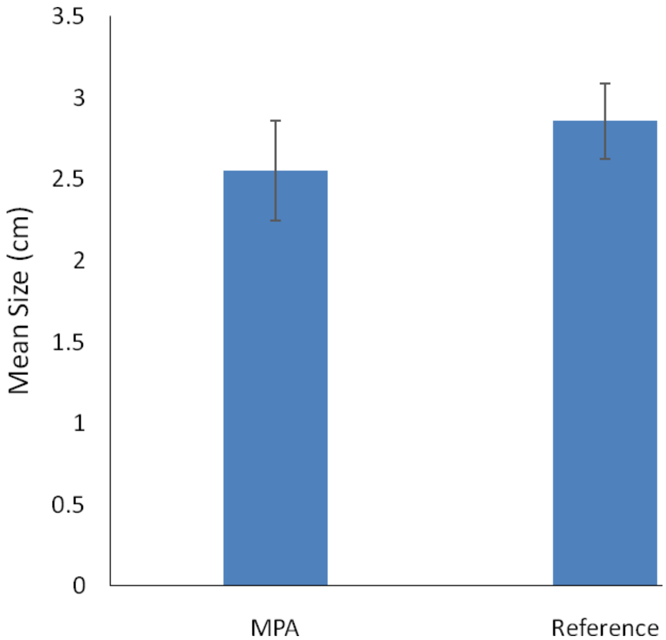

Figure 15. Size (mean ± SE) of coral recruits inside the MPA and at the Reference site (*n*=3).

Species diversity of coral recruits at the reserve was one species per unit area less than that of the reference site; however, the difference was not significant (Wilcoxon test: $P > 0.05$, Figure 16).

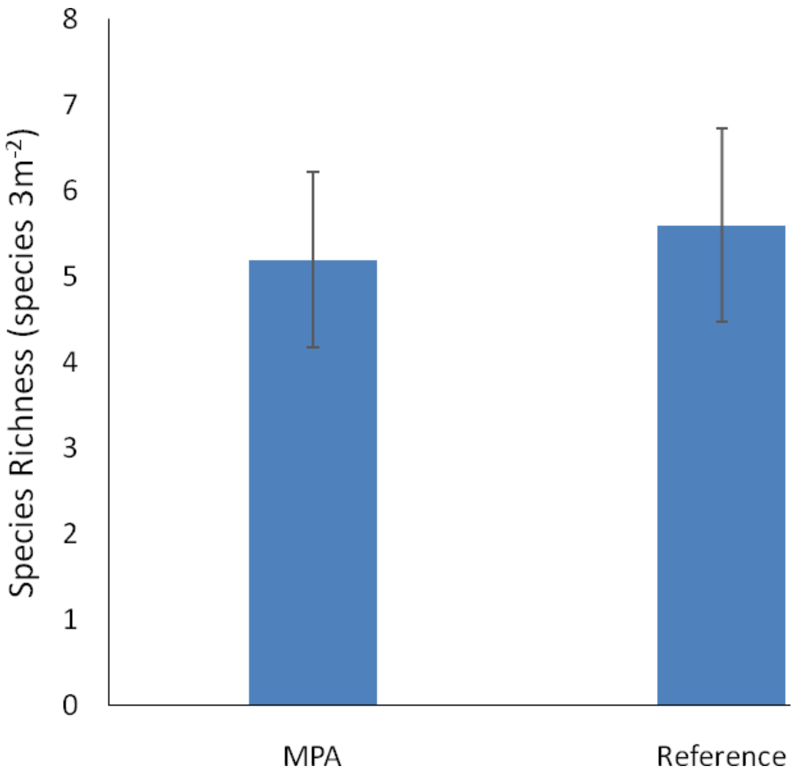

Figure 16. Species diversity (mean ± SE) of coral recruits inside the MPA and at the Reference site (*n*=3).

Discussion

Fish

We found no significant differences in fish size, density, or community structure between Ileyakl Beluu and the reference site. Examining trends over the entire survey period and over one-year periods yielded mixed results. From our data, there were no consistent trends toward increasing or decreasing of density for any fish guild in the reserve or the reference. Total biomass showed a weak positive trend over time but the trend was not consistent for all survey periods. Rather, total biomass in both the reserve and the reference site similarly varied, suggesting factors operating in both locations (e.g. lunar or tidal cycle, turbidity) are influencing the fish community.

Seven years after its establishment, the reserve's benefit for fish populations, if they exist, should be evident. A review of over 100 studies found reserves exhibit significant increases in fish density and biomass after just 1-3 years (Halpern & Warner 2002). Ileyakl Beluu has been protected for longer than three years, yet neither of these increases has occurred.

One explanation is that Ileyakl Beluu has reached its capacity to support the present fish population. Theoretically, to remove fishing pressure on a coral reef would increase fish population. However, this may not always be true because there are other factors that affect fish population such as larvae dispersal, competition for food and availability of living space.

Another explanation for the observed equality of the reserve and reference area is that the reserve is too small to protect the fish species targeted by our surveys. Some studies conclude small MPAs do not provide adequate protection for large, mobile species (Hamilton et al. 2011). Reserves work best for species that are sedentary as adults (Hastings &Bostsford 2003), but the home range of reef fish targeted by fishermen can be several square kilometers (Mora et al.

2006). Fish at Ileyakl Beluu likely travel into and out of the protected area, and at times expose themselves to fishermen.

It is also possible that our study failed to observe an existing reserve effect. Our data may not be powerful enough to detect slight increases in abundance. Visual census data for fish can be too variable to detect reserve effects if survey effort is limited (Ojeda-Martinez et al. 2007). One study in the Mediterranean found 5-6 years of monitoring was needed to detect the effect of protection (Ojeda-Martinez et al. 2007). Perhaps the statistical power gained from more surveys would reveal trends masked by the ecological noise in our data. The variability in our data is confounded by the fact that increases in size and abundance of large fish species may still be small. Changes in slow-growing, late maturing species may take longer to detect than the time scales mentioned previously (Halpern & Warner 2002). Furthermore, initial increases in biomass and abundance may be small**.** While piscivore abundance increases in the first ten years of protection, the effect was four to six times greater if the reserve had been protected for more than ten years (Micheli et al. 2004). This result agrees with Russ and Alcala's (2004) finding that fish biomass within a newly protected reserve increases exponentially, meaning initial rates of change are small. In fact, full recovery of high trophic level fish populations requires decades (Micheli et al. 2004, Russ & Alcala 2004). Time and additional surveys could reveal fisheries benefits that were not detected by this study.

Invertebrates

Between the two sites, we found no difference in abundance or size of *T. crocea* (oruer), which was the most abundant small giant clam species, but we found that *T. maxima* (melibes) were larger and more abundant inside the reserve. The apparent similarity of small giant clam populations between protected and unprotected areas in these studies may be because the reserve is too young to benefit *Tridacna* spp., whose reproductive strategies are erratic and often unsuccessful (Dumas et al. 2013). Ileyakl Beluu's effect on *T. maxima* is even more prolific than the aforementioned reserve effect in New Caledonia, with density of *T. maxima* increasing more than fourfold. Ileyakl Beluu has been protected for longer than the studied reserves that did not benefit small giant clams, so our result supports the hypothesis that small giant clams do not recover immediately following protection.

Benthic Cover

Though we observed no significant difference in substrate cover between the reserve and reference, these averages masked high inter-site variability. Coral reefs are heterogeneous at small scales (Dumas et al. 2013), and our results conform to this trend. Still, our benthic cover percentages should be viewed cautiously, as we may not have surveyed enough area to accurately capture variability in the Ileyakl Beluu benthic community.

Coral Recruits

As it is true for demography of any living organism, one of the most important stages for the survival of a coral species is the survival of its offspring, the coral recruits. Coral recruits are the next generation, and they will replace the adult corals when the adult corals are killed by bleaching, disease, physical (e.g. sedimentation, typhoon/storm) disturbances, or senesce naturally. A study by Mumby et. al. (2007) in the Caribbean Islands showed that reserves indirectly increase coral recruits; and as a result, increase coral cover (Mumby & Harbourne 2010). After comparing the average density, species richness, and size of coral recruits inside and outside Ileyakl Beluu, we conclude that coral recruits are similar at both sites.

Recommendations

Scientific study

Future surveys should include non-exploited species to test the assumed similarity of the reserve and reference areas. If the habitat of one area is inherently better than the other, we would expect to see higher biomass of non-target as well as target fish in that area (Palumbi 2004). Occasional surveys should consider a broader fish population than just those targeted by fisheries. Reef resilience depends on intact functional groups of fish (Mora et al. 2006), and some suggest future management should focus on ecosystem function (e.g. protecting grazers) (Bellwood et al. 2004). Moreover, diverse baseline data could be invaluable in assessing holistic changes in future reef health.

Ileyakl Beluu's management plan prohibits the harvest of *Trochus niloticus* (semum) in the reserve. Although considered in this study, *T. niloticus* was not present at either site during the invertebrate survey. The abundance and size of *T. niloticus* increased with protection in several studies (Dumas et al. 2013, Dumas et al. 2010, Lincoln-Smith et al. 2006), though the result of Dumas et al. (2010) was biased by fishermen moving the snails into the protected area. Future surveys should increase sampling periods or methodology in order to capture the presence of trochus inside Ileyakl Beluu as being observed by the local community.

Management

The Management Board of Ngardmau System of Conservation Areas should consider expanding the size of Ileyakl Beluu MPA. Reserves are subject to economies of scale, meaning small reserves are the most expensive to operate per unit area (Balmford et al. 2004). Increasing the reserve's size is cost effective, and could create currently unrealized fisheries benefits.

The implemention of Ongedechuul System of Conservation Areas (OSCA) management plan is a great achievement. However, Ileyakl Beluu's long term goals are not clear from the management plan. Whether its purpose is to improve fisheries, provide revenue through tourism, or conserve biodiversity and ecosystem function, it is not stated clearly. Community meetings held in October 2009 established the goal of increasing fish abundance inside reserves by 20% by 2015, but this goal was not included in the management plan. It is best to state the long-term goals clearly and the required objectives on a timeline. Resource managers can then easily track progress in achieving the long-term goals.

Acknowledgement

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Appendix

Table 1. Target species for fish.

	Species name	Palauan name	Status	Feeding group
1	*Siganus lineatus*	Kelsebuul	Commercial	Herbivore
2	*Siganus argenteus*	Beduut	Commercial	Herbivore
3	*Naso unicornis*	Chum	Commercial	Herbivore
4	*Naso lituratus*	Cherangel	Commercial	Herbivore
5	*Lethrinus olivaceus*	Melangmud	Commercial	Piscivore
6	*Lethrinus obsoletus*	Udech	Commercial	Piscivore
7	*Lethrinus xanthochilis*	Mechur	Commercial	Piscivore
8	*Lutjanus bohar*	Kedesau	Commercial	Piscivore
9	*Lutjanus gibbus*	Keremlal	Commercial	Piscivore
10	*Caranx ignobilis*	Erobk	Commercial	Piscivore
11	*Caranx melampygus*	Oruidel	Commercial	Piscivore
12	*Cetoscarus spp.*	Melemau	Commercial	Herbivore
13	*Hipposcarus longiceps*	Ngeaoch	Commercial	Herbivore
14	*Valamugil seheli*	Kelat	Commercial	Detritivore
15	*Liza vaigiensis*	Uluu	Commercial	Detritivore
16	*Plectorhinchus chaetodonoides*	Bikl	Commercial	Omnivore
17	*Siganus fuscescens*	Meyas	Protected	Herbivore
18	*Bolbometopon muricatum*	Kemedukl	Protected	Omnivore
19	*Cheilinus undulatus*	Maml	Protected	Invertivore
20	*Plectropomus areolatus*	Tiau	Protected	Piscivore
21	*Plectropomus leopardus*	Tiau	Protected	Piscivore
22	*Plectropomus laevis*	Tiau, Katuu'tiau, Mokas	Protected	Piscivore
23	*Epinephelus fuscoguttatus*	Meteungere'temekai	Protected	Piscivore
24	*Epinephelus polyphekadion*	Ksau'temekai	Protected	Piscivore

Table 2. Targets species for invertebrates.

	Scientific name	Palauan name
1	*Actinopyga sp.*	Eremrum
2	*Bohadschia vitiensis*	Mermarech
3	*Hippopus hippopus*	Duadeb
4	*Holothuria scabra*	Molech
5	*Holothuria whitmaei*	Bakelungal
6	*Stichopus vastus*	Ngimes
7	*Tridacna crocea*	Oruer
8	*Tridacna derasa*	Kism
9	*Tridacna gigas*	Otkang
10	*Tridacna maxima*	Melibes
11	*Tridacna sp.*	Kim
12	*Trochus niloticus*	Semum