

Coral Cay Conservation Marine Protected Area Assessment Report

San Agustin-Lugsongan MPA



San Agustin-Lugsongan
Limasawa, Southern Leyte, the Philippines

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EXECUTIVE SUMMARY

- Coral Cay Conservation conducted an assessment of the reef fish, invertebrates, substrate and anthropogenic impacts in and around the San Agustin-Lugsongan MPA, between March and April 2013.
- A modified Reef Check protocol was used to survey 8 transects, each containing four 20m replicates. Four transects were placed inside and 4 outside the MPA equally divided between 12m and 6m depths.
- Overall, fish abundance was not significantly higher inside the MPA. At 12m there were significantly more fish than at 6m. Abundance and diversity of Butterflyfish species was also higher inside the MPA.
- Overall abundance of invertebrates was not significantly different between inside and outside the MPA or at different depths.
- Crown of thorns seastars (*Acanthaster planci*) were observed in low numbers across the entire survey area. Drupella, another coral predator were found to be more abundant inside the MPA.
- Hard coral was significantly more abundant inside the MPA and sand and rubble were more abundant outside.
- Commercially important species, such as Groupers, Sweetlips, Giant Clams, Tritons Trumpet, were observed in low abundances or were absent wholly from the entire area that was assessed. Non-target Sea Cucumbers were more abundant outside the MPA although commercially important species were wholly absent from the survey area.
- Damaging impacts such as discarded fishing gear and anchor damage were observed in very low frequency or not observed at all. Household trash was observed at a relatively high level on a number of transects outside the MPA.
- Low abundances of commercially important species both in- and outside the MPA is indicative of unsustainable fishing pressure and of poaching inside the MPA.
- It is recommended that management of the San Agustin-Lugsongan MPA be assessed using the MPA Management Effectiveness Assessment Tool (MEAT) and steps to improve management taken. These should include active enforcement of the MPA and an information, education and communication (IEC) campaign to raise awareness and understanding of the potential benefits that the MPA can provide to the local stakeholders.

ACKNOWLEDGEMENTS

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LIST OF ACRONYMS AND ABBREVIATIONS

CCC	: Coral Cay Conservation
CoTs	: Crown of Thorns Seastars (<i>Acanthaster planci</i>)
GPS	: Global Positioning System
IEC	: Information, Education, Communication
LGU	: Local Government Unit
MPA	: Marine Protected Area
MPA MEAT	: MPA Management Effectiveness Assessment Tool
MWU	: Mann-Whitney U test
NIA	: Nutrient Indicator Algae
NIPAS	: National Integrated Protected Area System
PRRCFI	: Philippines Reef and Rainforest Conservation Foundation Inc.
RKC	: Recently Killed Coral
SE	: Standard Error

CORAL CAY CONSERVATION

Coral Cay Conservation (CCC) is a not for profit organisation, founded in 1986 by a British scientist. CCC's mission is:

"Providing resources to help sustain livelihoods & alleviate poverty through the protection, restoration & management of coral reefs & tropical forests."

In order to achieve this mission, CCC has carried out conservation projects all over the world, including the Philippines, Belize, Honduras, Malaysia, Cambodia and Fiji. CCC successfully set up Marine Protected Areas and provided scientific data that has been used to manage local marine resources. The project in Danjungan Island in the Philippines between the years 1996-1999 was particularly successful and the reefs around the island received the accolade of Best Managed Reef in the Philippines in 2002. Since 1995, CCC has worked with the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and local communities to survey and safeguard reef and rainforest areas in the Philippines. To date these have included coastal regions of the Southern Negros Occidental, Anilao, Palawan, Danjungan Island and the forests of North Negros.

At the invitation of the Provincial Government of Southern Leyte, CCC began its survey work in Sogod Bay in September 2002. CCC is conducting a collaborative program to survey the region's coral reefs and provide training and conservation education opportunities for project counterparts. The aim is to develop local capacity and ensure the long-term protection and sustainable use of marine resources throughout Southern Leyte.

1. INTRODUCTION

1.1 Marine Protected Areas

Marine resources have come under increasing pressure from an ever growing world population (Jackson *et al.* 2001). Strong declines in catch from fisheries worldwide, such as the North Atlantic Cod (Myers 1997) and reef fisheries in the Caribbean (Hardt 2009), have illustrated that biological marine resources are limited (Jackson *et al.* 2001; Pauly *et al.* 2002). Additional pressures such as pollution, coastal development and the effects of climate change contribute to the stress the marine environment is under. This has given rise to the increased drive for conservation efforts and resource management in the marine environment (Wood *et al.* 2008; CBD 2010). Marine protected areas (MPAs) can achieve conservation and resource management targets simultaneously and are therefore considered instrumental to sustainable ocean utilization (Pauly *et al.* 2002). The International Union for the Conservation of Nature (IUCN) defines a MPA as:

“A clearly defined geographical space, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with the associated ecosystem services and cultural values.”

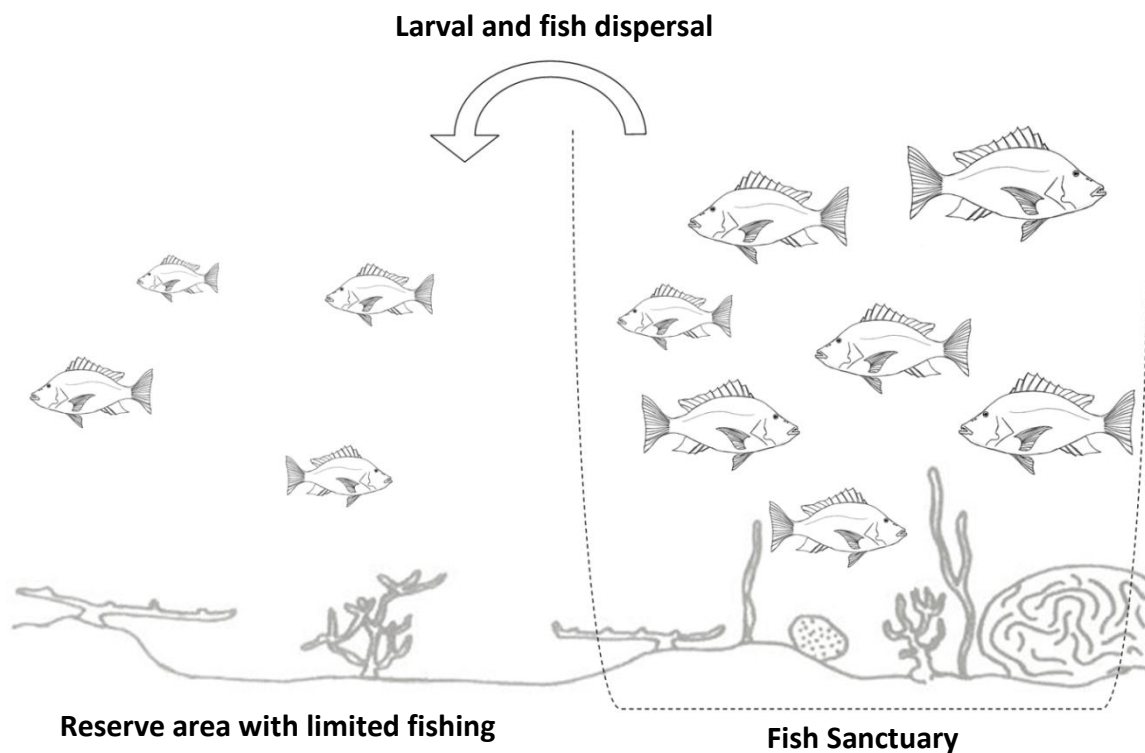


Figure 1 – Schematic diagram of MPA functioning. Protected fish in the MPA grow larger and produce more offspring, this leads to ‘overspill’, increasing fish numbers outside the MPA. In addition, the corals inside the MPA are not disturbed by direct human impacts.

MPAs have become vital tools in conserving marine resources, not only for their own intrinsic value but also for the services they can provide humanity. The ecosystem within the MPA, if left undisturbed for an extended amount of time, has the potential to provide a sustainable supply of goods - such as fish, algae and salt - and services - such as shoreline protection, maintaining water quality and recreation (World Bank 2005). Increased fish catch is perhaps the most sought after potential benefit of MPAs. There are two ways that this can happen; through spillover and larval export (Figure 1).

However, the success of MPAs is for a large part dependent on the willingness of local people to adhere to the rules. Experience from around the world has shown that closely involving local people in the planning, implementation and management of their own MPA can increase their sense of ownership and pride. Only when the local stakeholders feel their concerns are taken seriously and they are consulted on management of the MPA regularly, will it be possible for the full beneficial potential of the MPA to be attained (Green *et al.* 2009, Human and Davies 2010).

1.2 Coral Reefs & Marine Conservation in the Philippines

The Philippines lies within a region known as the Coral Triangle. The Coral Triangle, which includes Indonesia, Malaysia, Papua New Guinea, Timor-Leste and the Solomon Islands, is recognized as the global centre of marine biodiversity (Roberts *et al.* 2002). It is home to the oldest coral reefs in the world and the largest expanses of mangrove forest. More than 75% of the known coral species and over 30% of all the coral reefs in the world are found in the Coral Triangle (Veron *et al.* 2009). The same extraordinary diversity is found in the other types of marine creatures; with over 3,000 species of fish recorded, even higher figures for molluscs and new species are still being discovered regularly (Allen 2008).

The waters of the Philippines contain roughly 25,000 km² of coral reefs. An estimated 60% of the country's 92 million citizens live in coastal regions, i.e. in close proximity to coral reefs, and over half of the consumed animal protein comes from marine sources (CTI 2012). This heavy reliance on marine resources has caused large areas of coral reef ecosystems to become threatened. In 1980 33% of coral reefs were characterized as being in poor condition, in 2008 this figure had increased to 40% (Wilkinson 2008). These figures make a strong case for increased marine conservation efforts. Legislation concerning marine conservation in the Philippines is probably one of the most advanced within the Coral Triangle (Jacinto *et al.* 2000). Some important laws include:

- 1998 Fisheries Code (Republic Act 8550): 15% of municipal water should be within a MPA
- Marine and Coastal Resource Protection Act: Each municipality should have at least one MPA that is bigger than 10 hectares (if the total municipal waters are larger than 15 hectares)

- The Philippine Marine Sanctuary Strategy (2002): By 2020, 10% of all the Philippine marine waters will be fully protected

Currently there are about 1,640 MPAs in the Philippines. Of these MPAs, 33 have been declared at national level as NIPAS sites and the remainder is managed by Local Government Units (LGU) (DENR-CMMO presentation, March 19 2013). Box 1 highlights a case study of successful MPAs in the Philippines.

Box 1 - Case study of successful MPAs in the Philippines: Apo Island & Sumilon Island

The MPAs at Apo Island and Sumilon Island are some of the best-known examples of successful tropical marine conservation efforts in the world. Years of monitoring have provided accurate data that shows what can be achieved if the coral reef inside a MPA is given the chance to recover (Figure 2). These figures also show that although an increase of biomass was observed in the first years of reserve protection, the biggest increase in biomass took several years to become evident (5-10 years). Unequivocal evidence of spillover from these MPAs remains elusive but the increased number and size of fish within the reserve make it likely that the MPA is a source for net larval export, which can aid recovery of fish stocks in the area. Indirect positive effects of the effective management of these MPAs include increased tourism income and elimination of unsustainable fishing practices such as dynamite fishing (Russ and Alcala 2004).

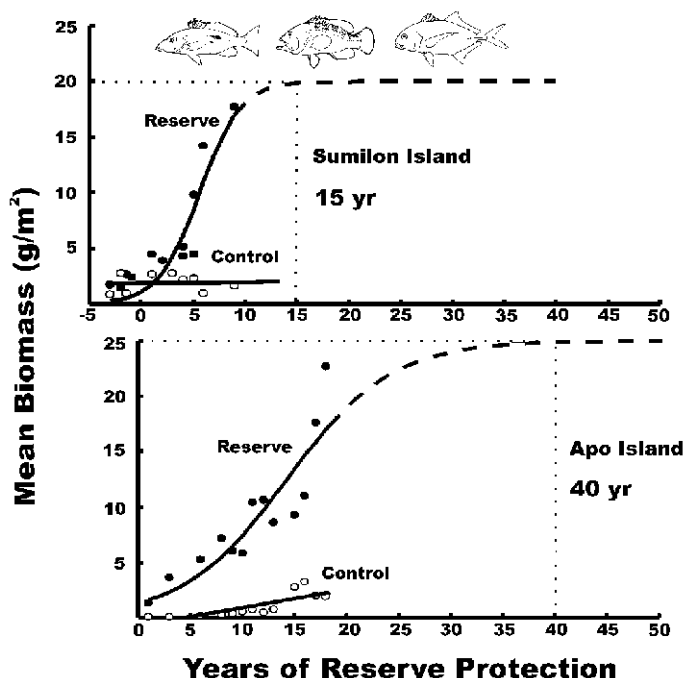


Figure 2 - observed and projected increase in mean biomass of commercially important species of fish inside the MPAs at Apo Island and Sumilon Island.

Figure from: Russ and Alcala (2004).

1.3 – Characterization of Study Region

1.3.1 – *Sogod Bay*

The coral reefs of Southern Leyte remain some of the least disturbed habitats in the Philippines. Sogod Bay is an important fishing ground and the area is rich in tuna, flying fish, herrings, anchovies, shell-fish and Spanish mackerel. The bay has been targeted by the Fisheries Sector Program of the Department of Agriculture as one of the country's ten largest bays in need of assessment and management (Calumpong *et al.* 1994). Sogod Bay is also a feeding ground for attractive mega-fauna such as pilot whales, melon-headed whales, dolphins, manta rays and whale sharks. The bay is characterised by naturally limited mangrove areas, narrow fringing coral reefs, limited seagrass beds and narrow intertidal areas and beaches (Calumpong *et al.* 1994). Depths in the bay reach a maximum of approximately 1,400 metres in the central channel.

Currently there are 23 established MPAs within Sogod Bay covering an estimated 170 hectares. These figures will increase in the coming years as more MPAs are currently being set up. The size of the MPAs ranges from 2 hectares (Maujon/Juargon Fish Sanctuary) to 45 hectares (Limasawa Fish Sanctuary), with a mean average size of 8.7 hectares (± 2.1 SE) and a median average of 5 hectares. The sizes for several MPAs are not known, as accurate GPS coordinates are not available.

1.3.2 – *San Agustin-Lugsongan MPA (Limasawa Fish Sanctuary)*

The San Agustin-Lugsongan MPA, was established in 2008 and covers 45 hectares. It is located in the Municipality of Limasawa, in the waters of the barangays San Agustin and Lugsongan. The MPA is to the south of the village (Figure 3). Currently, the MPA infrastructure is fairly good with trained Bantay Dagats and a Patrol boat (Table 1). Fishing takes place in the area surrounding the MPA and on one occasion the CCC survey team witnessed poaching inside the MPA.

Table 1 – Summary of MPA infrastructure at Santa Paz Sur MPA

MPA Infrastructure	Present?
Trained Bantay Dagats	√
Permanent Bantay Dagat presence	X
MPA guardhouse	√
Demarkation buoys	X
Patrol boat	√
Bantay Dagat gear (flashlight, fins, mask, etc.)	X
User fees collected	√

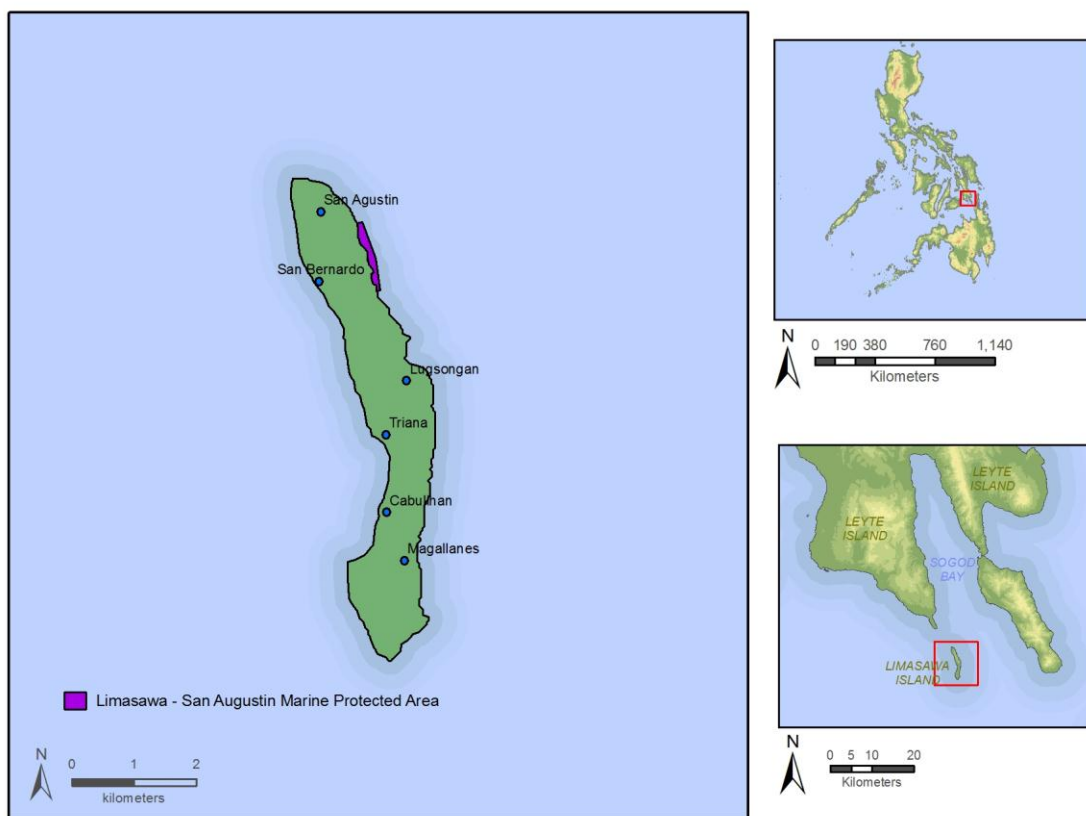


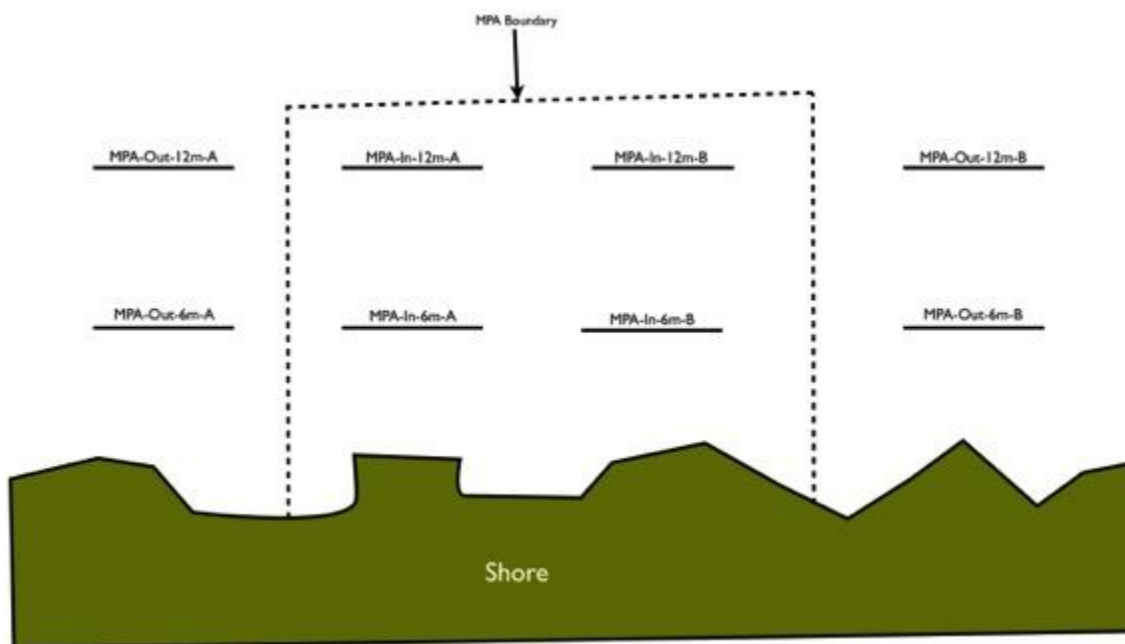
Figure 3 – Map showing the location of the San Agustin-Lugsongan Marine Protected Area

2. METHODS

2.1 Biophysical Survey

The assessment of the MPA was conducted using an enhanced Reef Check method. The Reef Check methodology is widely recognised and is used to survey coral reefs around the world. It was developed in the 1990s with the aim of gathering as much data as possible about the global status of coral reefs (Hodgson 1999). The data from around the world is analyzed on a yearly basis and updates about the status of coral reefs are published. Reef Check provides a general picture of the ecological status of a reef and the human impacts affecting it. CCC has augmented the methodology by adding additional target species of fish, coral and other invertebrates to better reflect the high biodiversity of the area (see Appendix A for target species).

Survey transects were conducted at depths of 6 metres and 12 metres, both inside and outside the MPA (Figure 4). Each transect was 100 metres long and divided into 4 replicates of 20 metres each. Between each replicate there was a 5 metre gap where no data was recorded. This survey set up allows for robust statistical analysis of the collected data.

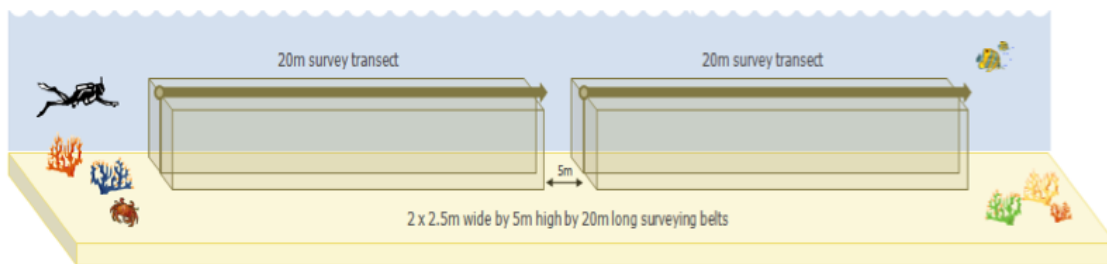


*Figure 4 – Survey plan of the MPA assessment.
Each transect was 100 meters long and is divided into 4 replicates.*

2.1.1 Fish

The fish diversity and abundance data was collected using Underwater Visual Census. Selected fish families and species recognized as being good indicators of fishing pressure, aquarium collection and reef health were recorded. Three families of commercially important fish were also recorded by size: Groupers, Parrotfish and Snappers.

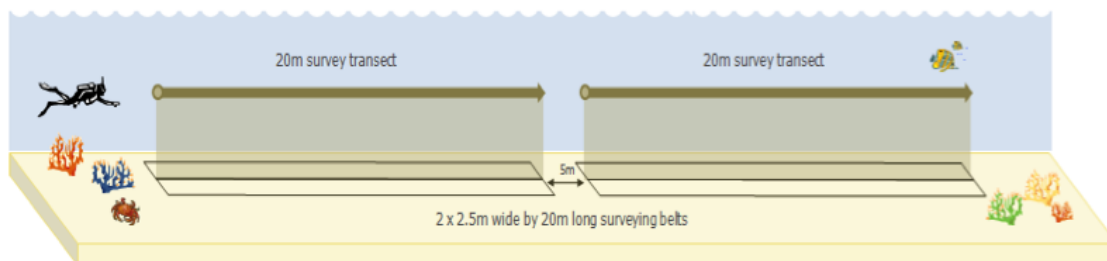
Fish data was recorded along a 'belt' transect, where fish were counted within an imaginary 5x5x5m box along the four 20m replicates (Figure 5). Surveying was carried out by two divers swimming slowly side by side along the transect and counting the indicator fish. The divers stopped every 5 metres and waited 1 minute for the indicator fish to come out of hiding before proceeding to the next 5 metre stop-point.



*Figure 5 – Survey method for recording fish.
The diagram shows 2 of the 4 replicates in a 100m transect.*

2.1.2 Invertebrates

The same areas used for the fish belt transect were used to record the diversity and abundance selected invertebrate species typically targeted as food species, collected as curios or important to the ecological balance of the reef. The divers recorded invertebrates 2.5m either side of the transect line (Figure 6). Divers looked in holes and under overhangs to look for organisms such as lobsters, sea urchins or other cryptic species.

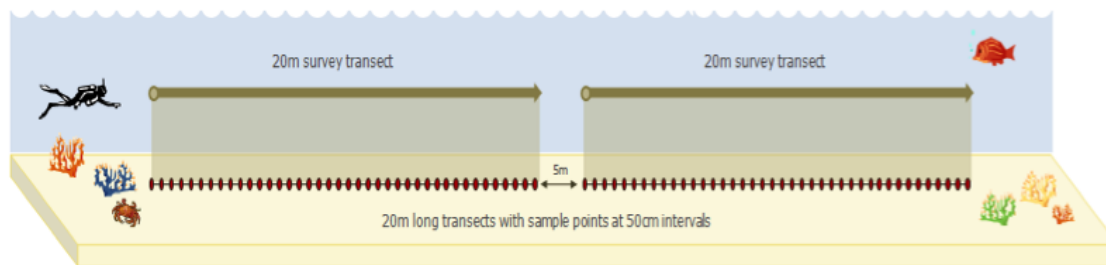


*Figure 6 – Survey method for recording invertebrates.
The diagram shows 2 of the 4 replicates in a 100m transect.*

2.1.3 Substrate

Benthic diversity was measured by recording living and non-living benthic categories along a point intercept transect. Along the transect line, benthic organisms and substrate types were recorded at 50cm intervals (Figure 7). To minimize bias, a plumb line was dropped at each designated 50cm point and the substrate type underneath was recorded. Every replicate contained 40 benthic points.

Benthic categories were: sand, rock, rubble, silt/mud, nutrient indicator algae, sponge, recently killed coral, soft coral, hard coral and any other biotic lifeforms. Hard corals were noted to species or genus level if the coral was a target species, otherwise, a note was made of the coral life form (see Appendix A).



*Figure 7 – Survey method for recording substrate data.
The diagram shows 2 of the 4 replicates in a 100m transect.*

2.1.4 Impacts

Within the same area assessed for invertebrates divers recorded a number of impacts on the reef. They estimated the total percentage of bleached coral cover as well as the estimated percentage of each individual coral colony that was bleached. Coral diseases were recorded as a percentage of the colony infected and where possible, the disease was identified. Damage was recorded in three categories: boat/anchor, dynamite and other, on a categorical scale from 0 to 3 (0 = none, 1=low, 2= medium, 3 = high). Impact on the site from trash was recorded on the same scale and separated into general and fishing nets/traps.

2.2 Data Analysis

Each 20m belt transect was treated as an independent replicate. This produced n=16 inside the MPA and n=16 outside the MPA, when not considering depth. At each of the survey depths, 6m and 12m, there were n=8 replicates inside and outside the MPA. To test for statistically significant differences between inside and outside the MPA, Mann-Whitney U tests were used. Preliminary inspection of the data revealed that the variances were not homogeneous and the data had a non-normal distribution.

Transformations of the data did not sufficiently alter this to warrant using a parametric test.

Species diversity of fish and invertebrates was calculated using the Fishers α index. These index values too were then submitted to the Mann-Whitney U test to check for significant differences.

3. RESULTS

The assessment of the San Agustin-Lugsongan MPA was conducted between the 26th of March 2013 and the 17th of April 2013. It was conducted over 24 dives by trained volunteer survey teams from Coral Cay Conservation. In general, the weather throughout the survey period was bright, with no major weather systems moving through the region. On average the air temperature was 32.0°C. The water temperature was, on average, 28.2°C at the surface and 28.0°C at 3m as well as at 10m. Estimated horizontal visibility was 19m on average.

3.1 – Fish

Overall mean fish abundance inside the MPA was 210.4 ± 27.1 per 500m^3 (mean $\pm$ SE). Outside the MPA, the overall mean fish abundance was 228.3 ± 31.87 per 500m^3 (Figure, 8A). The difference in overall abundance inside and outside the MPA was not found to be significant. Overall abundance of Butterflyfish was significantly higher inside the MPA than outside (19 ± 1.5 ; 8.9 ± 1.3 per 500m^3 respectively, $p = <0.001$). When considering differences in abundance between depths, fish were significantly more abundant at 12m (280 ± 29.3 per 500m^3) than 6m (158.7 ± 20.21 per 500m^3) ($p = 0.004$). Schools of Fusiliers were observed on a number of occasions during the surveys. The overall difference between inside and out was not significant. However, Fusiliers were more abundant at 12m than 6m (147 ± 28.9 , 15.9 ± 7.3 respectively per 500m^3 , $p = <0.001$). Furthermore, at 6m no Fusiliers were recorded outside the MPA and thus returned a significant result at this depth (31.8 ± 12.5 ; 0 per 500m^2 , $p = 0.01$). Appendix B shows the overall abundance for each target fish species recorded both inside and outside the MPA.

Although the overall diversity of fish observed was higher inside than outside the MPA the difference was not significant (Figure, 8B). Many fish species and families occurred in very small numbers or not at all. Both inside and outside the MPA important food fish species such as Sweetlips and Humphead Wrasse were not observed. Other families including, Snapper, Groupers and Jacks were only observed in low numbers (0.5 ± 0.2 ; 0.8 ± 0.2 ; 0.5 ± 0.2 respectively per 500m^2). In general the size of individuals observed was small; less than 30 cm. For Parrotfish 86% of individuals were below 20cm with the remainder all less than 30cm. A total of 5 turtles (3 inside and 2 outside) and 4 sea snakes (2 inside and 2 outside) were observed during the assessment. No sharks or rays were observed.

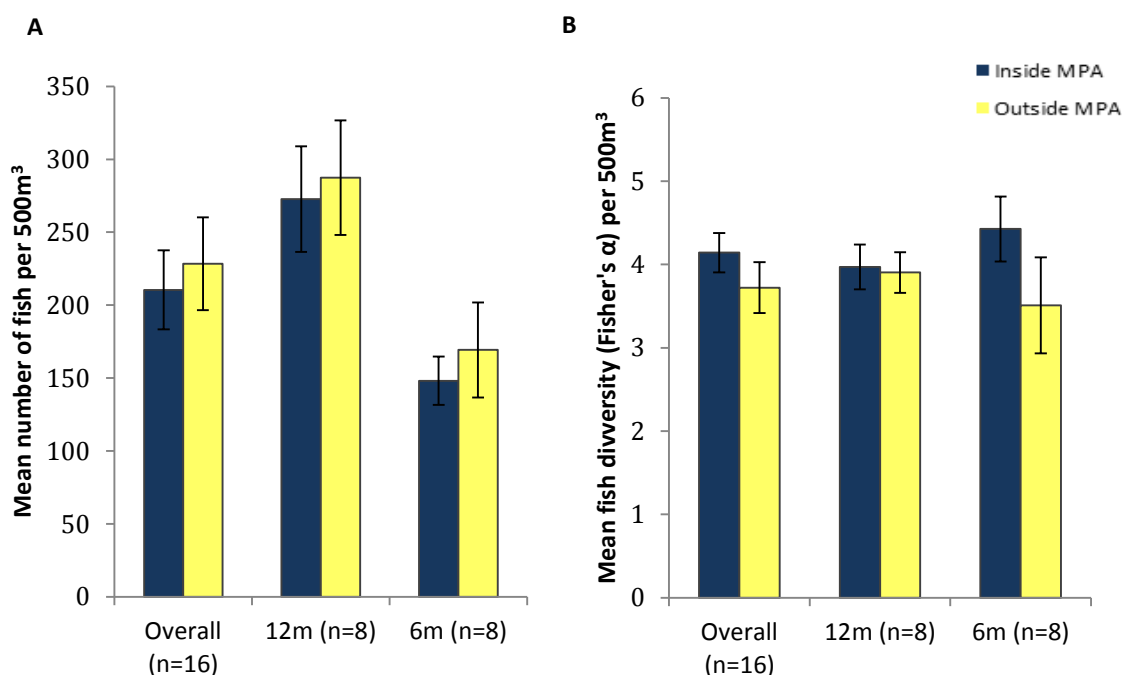


Figure 8 – Average abundance (A) and diversity (B) of fish inside and outside the MPA. Data are mean average per replicate, error bars indicate standard error of the mean.

3.2 – Invertebrates

Inside the MPA the average overall abundance of invertebrates was 116.9 ± 8.3 per 100m^2 (Figure 9A). Outside the MPA the average overall abundance of invertebrates was 132.6 ± 15.3 per 100m^2 (Figure 9A). The difference between inside and outside was not significantly different. A number of target species and families were observed at significantly different abundances inside and outside the MPA, including *Drupella* (inside: 11.9 ± 2.2 per 100m^2 , outside: 4.6 ± 1.8 per 100m^2 , $p = 0.004$), Feather stars (inside: 8.1 ± 1.1 per 100m^2 , outside: 25.3 ± 3.0 per 100m^2 , $p < 0.001$) and non-target Sea Cucumbers (inside: 1.3 ± 0.4 per 100m^2 , outside: 17.9 ± 8.3 per 100m^2 , $p = 0.02$). At both 12m and 6m there was a similar trend in the overall abundance of invertebrates. Neither depth reported a significant difference between inside and outside the MPA. Appendix C shows the overall abundance for each target invertebrate species recorded both inside and outside the MPA.

The diversity of invertebrates between inside and outside the MPA was significantly different (inside: 4.10 ± 0.17 per 100m^2 , outside: 3.45 ± 0.26 per 100m^2 , $p = 0.03$). Several species and families were completely absent on the surveys, including lobster, Triton's Trupest (*Charonia tritonis*), cephalopods and target species of sea cucumber (for a full list of target species see Appendix A). Crown of Thorns sea stars (CoTs) (*Acanthaster planci*) were observed in low numbers both inside and outside the MPA (< 1 per 100m^2).

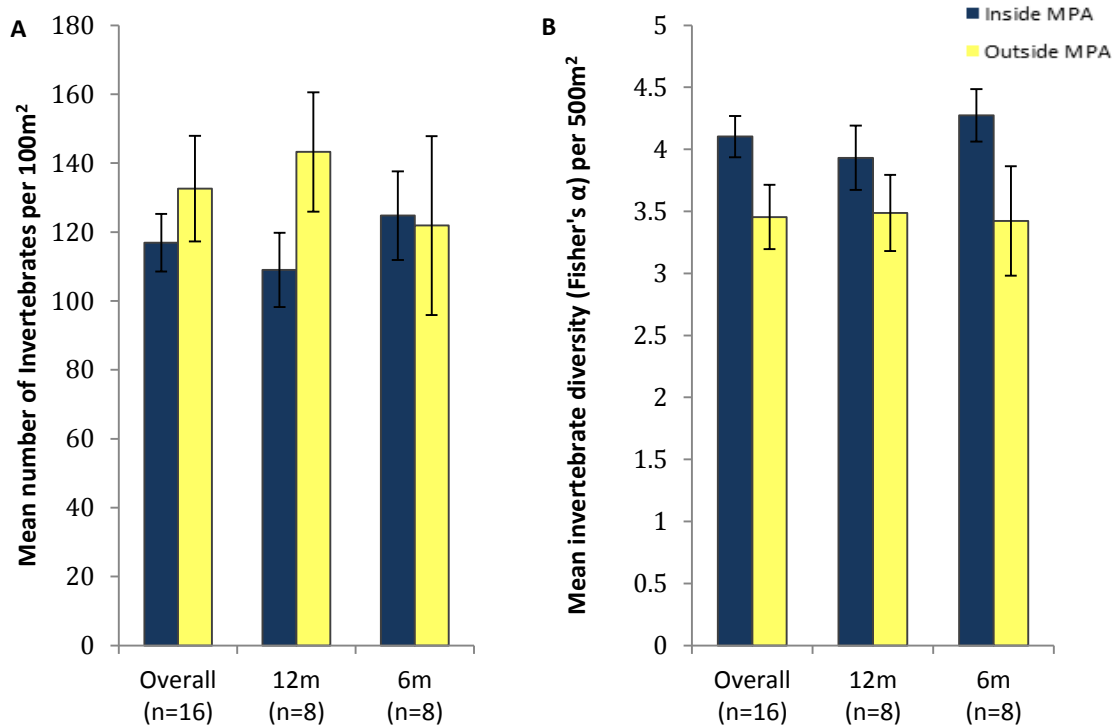


Figure 9 – Average abundance (A) and diversity (B) of invertebrates inside and outside the MPA. Data are mean average per replicate, error bars indicate standard error of the mean. *=significant difference ($p < 0.05$)

3.3 ~ Substrate

Inside the MPA the most commonly recorded substrate category was rock, followed by hard coral (Figure 10). Outside the MPA, sand was the most common substrate followed by rubble and rock. When considering the entire survey area hard coral was significantly more abundant inside the MPA (11.7 ± 0.97 points per replicate and 4.9 ± 1.1 points per replicate respectively, $p = 0.001$) (Figure 10). Following this trend hard coral cover at 12m and 6m was significantly higher inside than outside ($p = 0.02$ at 12m and $p < 0.001$ at 6m). The area outside the MPA is characterized by a high abundance of sand, rock and rubble with patches of hard coral. In general Recently Killed Coral and Nutrient Indicator Algae were found in low abundance both inside and outside the MPA (Figure 10). Organisms that fall under the “Other” category including, Anemone, Tunicates and Gorgonians were recorded in very low abundance if at all (for a full list of organisms in the category “Other”, see Appendix A)

Inside the MPA 25 different target species of hard coral were recorded. Outside the MPA 16 target species of hard coral were recorded (see Appendix C). The most commonly recorded hard coral category inside the MPA was *Non-Acropora*, Branching. Outside the MPA the most common hard coral category was *Non-Acropora*, Sub-massive. Inside the MPA the most common species of hard coral was *Porites cylindrica*, with Massive *Porites* and *Porites nigrescens* also common. Outside the most commonly

recorded hard coral species were both Massive *Porites* and *Tubastrea micrantha*, *Pocillopora* (small) was also fairly common.

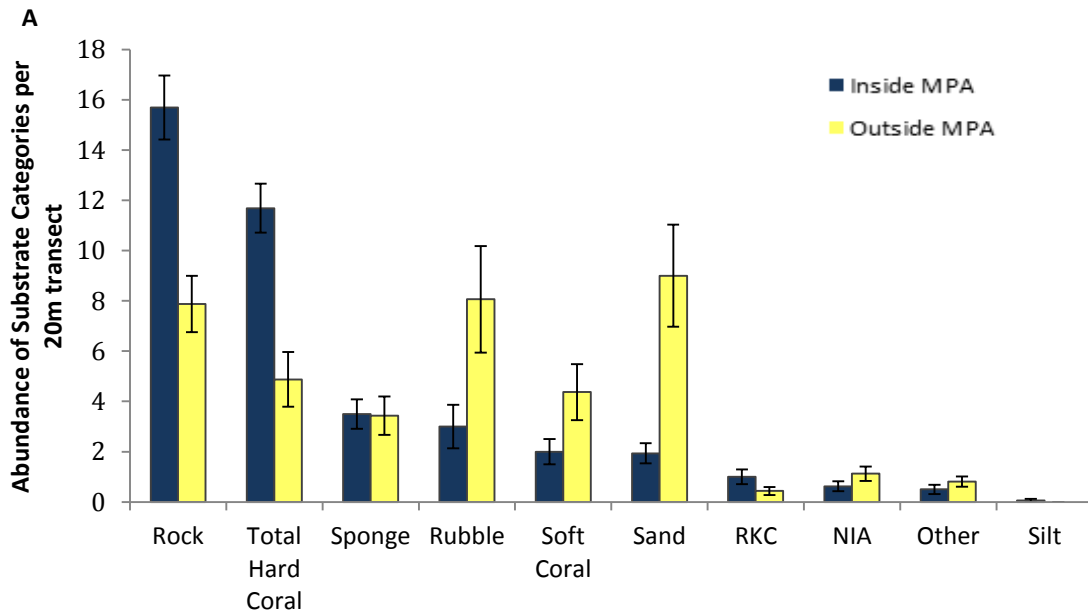


Figure 10 – Average abundance of substrate categories inside and outside the MPA overall. NIA = nutrient indicator algae, RKC = recently killed coral. Data are mean average per replicate, error bars indicate standard error of the mean.

3.4 ~ Anthropogenic Impacts

Anthropogenic impacts were generally low both inside and outside the MPA. No boat or anchor damage was observed and there was no evidence of dynamite fishing. Trash was observed on the reef. Inside the MPA household trash was found to a level of 1.6 ± 0.2 per replicate on the impact scale. Outside the MPA household trash was observed at level 3 on the impact scale on 50% of the replicates and was at an average level of 2.1 ± 0.3 per replicate. Trash categorized as discarded or lost fishing gear was recorded inside the MPA on only 1 instance. Outside the MPA it was recorded 6 times.

Coral predation was more commonly observed inside the MPA compared to outside the MPA, 1.75 ± 0.2 and 0.81 ± 0.3 respectively. For the most part this predation was attributed to *Drupella* species. Coral bleaching was recorded at a very low overall level across the entire assessment. No coral disease was recorded on any of the surveys.

4. DISCUSSION

The assessment of the area inside the San Agustin-Lugsongan MPA gave the impression of a reef ecosystem in a generally good state of health. Inside the MPA, there was a good level of hard coral cover from the reef crest down to a depth beyond the survey limit. Abundance and diversity of fish and invertebrates was also relatively high. Outside, the area was to a greater extent characterized by sand and rubble with patches of good hard coral cover. There are however a number of trends in the data that are worth discussing in relation to improving management and reducing negative impacts. In this section these trends are reviewed and recommendations for future management are presented.

4.1 – Fish

The overall trend in abundance of fish species and families revealed no significant difference between inside and outside the MPA. There was however a significantly greater abundance of fish at a depth of 12m compared to 6m. This is likely as a result of the greater hard coral cover at this depth providing an increase in topographic complexity and thus a broader range of habitats for species such as Cardinals (*Apogonidae*) and Butterflyfish (*Chaetodontidae*) which were both recorded at relatively high abundances (differences in substrate cover will be discussed in greater detail in Section 4.3). The higher abundance at this depth is however mainly a result of the numbers of recorded Fusiliers (*Caesionidae*). This highly mobile species preferentially feed on zooplankton in mid-water and thus will be more likely to be observed on deeper transects. Worryingly they were not observed at all on the 6m transects outside the MPA and this could indicate high fishing pressure. Butterflyfish were found to be significantly more abundant inside the MPA. Many species within this family are corallivores, feeding on the polyps of living corals. Their greater abundance within the MPA is likely therefore linked to the higher hard coral cover, for reasons of increased food resource availability and suitable habitat. The overall diversity of Butterfly species was not found to be significantly different between inside and outside the MPA. However, at 6m there was a greater diversity inside than outside. Again this is likely a factor of higher sand substrate cover outside the MPA limiting suitable habitat.

The most noteworthy result of this MPA assessment was the absence or low abundance of large predatory fish, namely Groupers, Snappers, Sweetlips, Emperors, Humphead Wrasse and Jacks. These families are highly prized by commercial and subsistent fishers alike. Parrotfish, are also key species for human consumption and were observed in greater numbers during the surveys but were generally small in size. The implications of these trends shall be discussed in Section 4.4.

4.2 – Invertebrates

The overall abundance of invertebrates was not significantly different between inside and outside the MPA. A number of target families were however observed at significant abundances between inside and out; Drupella, Feather Stars and Non-target Sea Cucumbers.

The higher abundance of Drupella species inside the MPA is likely due to the higher abundance of hard coral. Drupella are natural predators of coral and consume coral polyps, removing the flesh and leaving the exposed skeleton. The abundance on the reef inside the MPA was at a sustainable level that provides no major cause for concern. However, at greater densities, as discovered on the Ningaloo reef in Western Australia, Drupella are capable of destroying large areas of reef habitat. Feather stars were recorded in greater abundances outside the MPA and in particular on areas with low coral cover. Feather Stars provide an excellent microhabitat for numerous species of invertebrates such as shrimp and squat lobster, as well as fish such as the Ornate Ghost Pipefish, a species much sought after by recreational divers.

The high occurrence of sea cucumbers outside the MPA is likely due to the higher density of sand and rubble substrates. Many species of sea cucumber feed by traversing sand and rubble patches either picking up food with extended feeding tentacles or by filtering sand. The lack of target species; Prickly Redfish (*Thelenota ananas*), Greenfish (*Stichopus chloronotus*) and Pinkfish (*Holothuria edulis*), is of concern as these are prized as food species. Their absence may be an indication of extensive extraction pressure. This trend will be discussed more in section 4.4.

Several of the species that were found in low numbers or were absent entirely, are targeted for consumption. Many of these species, such as the Triton's Trumpet and Giant Clam, are important species in maintaining the stability of the coral reef ecosystem. These two specific examples are known to be instrumental in suppressing populations of CoTs. Possible consequences of the low abundances of these species will be discussed further in section 4.4.

Crown of Thorns seastars were observed in low numbers across the whole survey area (2 inside and 3 outside). This is a positive sign for the reef as a high abundance could indicate that the reef may be at risk of an outbreak. At outbreak levels CoTs are capable of large scale damage to reef environments and can cause phase shifts from coral dominated, diverse reefs to algal dominated ecosystems characterized by herbivorous fish species and other algal consumers such as Long Spine Sea Urchins (*Diadema* sp.).

Municipalities around Sogod Bay, including Limasawa have recently experienced outbreak of CoTs. In response, CoTs extractions were undertaken to physically remove the sea stars and thus reduce the impact on coral colonies. Extractions were carried out in the area of the MPA and this likely explains the lack of CoTs recorded. Continued

monitoring of CoTs numbers should be undertaken to ensure that outbreaks are reported quickly.

4.3 – Substrate

The differences in substrates inside and outside the MPA were attributed to natural distributions. Inside the MPA hard coral cover was significantly higher than outside and there was significantly more at 12m than at 6m. It is common practice for MPAs to be located on sections of reef that exhibit the best example of a particular habitat, i.e. hard coral. Due to the fact the MPA was only established 5 years ago it is hard to conclude that the MPA is increasing hard coral cover. More likely is that it was high to start with and thus was selected because of that fact. Outside the MPA hard coral was also more abundant at 12m with 6m characterized by sand and rubble with patchy areas of coral. Sandy areas are less suitable for the settlement of hard coral recruits and so it follows there would be less coral cover.

Indicators of poor hard coral health, such as Nutrient Indicator Algae, signs of recently killed coral, bleaching and coral disease were either not observed at all or only in a few instances. From these observations it can be concluded that as far as hard corals are concerned, the reef inside the MPA as well as in the area around it is in good condition.

4.4 – Impacts

Generally anthropogenic impacts such as anchor damage and dynamite fishing were very low. Outside the MPA however household trash was observed relatively frequently and at times in high quantities. Trash can have a large impact on the survival of marine organisms. Plastics such as cellophane and polystyrene are often confused as food when floating in the water column and can kill many species. Proper waste management on land is vital for healthy reef ecosystems. Other impacts such as high fishing pressure were also evident in the data. As mentioned in previous sections, several species of fish and invertebrates that are known to be popular for consumption were only observed in low numbers or were absent from the surveyed area entirely. The most concerning aspect of these findings is that several of these species are known keystone species. This means that these organisms play a vital role in the ecosystem which if removed can seriously affect the stability of the entire ecosystem. This can happen in two ways: (1) direct effects or (2) indirect effects.

Direct effects occur when predators are removed from an ecosystem and facilitate the ecological release of prey species. For example the removal of predators such as Titan Triggerfish (*Balistoides viridescens*) which are known to feed on CoTs can result in an expansion in CoTs numbers through a lack of predation pressure. Indirect effects are more complex as they often involve many species of families and cascade down through

trophic levels. In severe cases this can lead to phase shifts and alter ecosystem dynamics.

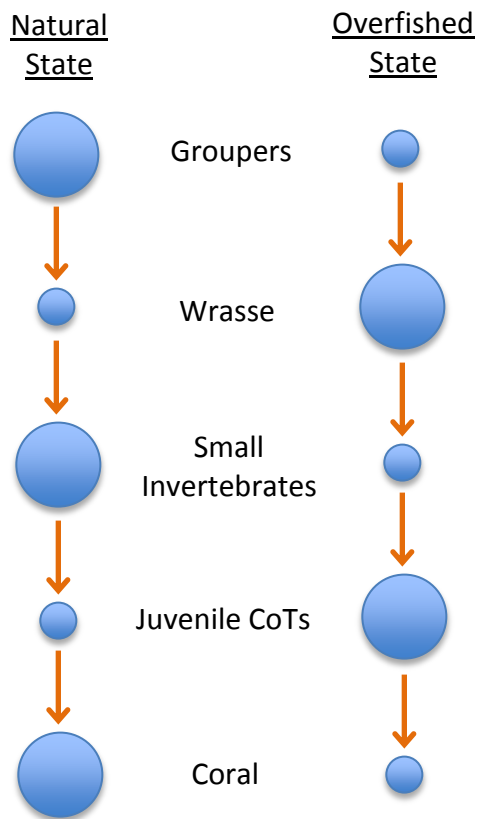


Figure 11 – Representation of the indirect effects that overfishing of predatory fish, in this example Groupers can have on the entire coral ecosystem. The size of the circle represents the relative abundance of that organism or trophic level.

It is important to note that as discussed previously there has recently been a CoTs extraction in the area due to an outbreak threatening the reef. Although the cause of CoTs outbreaks are widely debated, one of the most respected theories focuses on the impact of trophic cascades due to the removal of top predators (Figure 11). With the removal of apex predators such as Groupers, prey species including Wrasse suffer less predation pressure and populations increase. Many Wrasse species feed on benthic invertebrates that in turn predate juvenile settlement stage CoTs. With an increase in Wrasse numbers there is a corresponding decline in these invertebrates and thus an increase in juvenile CoT survivorship. This cascade effect through the trophic levels could be a causal factor in the CoTs outbreak that was experienced. Indirect top-down effects from depletion of apex predators have been shown to have widespread impacts on ecosystems around the world (Myers et al. 2007).

Furthermore *Drupella* abundance inside the MPA was significantly higher than outside. Whilst this is likely related to higher hard coral cover the absence of suitable predators, could result in a similar cascade effect. As *Drupella* are predators of coral polyps this may pose a further problem for the reef ecosystem.

Overall the trends in the data are positive and suggest that at present the ecosystem inside the MPA is balanced and after 5 years of protection in a state of recovery. The lack of large and abundant predatory fish is troubling but this may be a historical trend. Many species of predatory fish, especially Groupers, have very slow growth rates and take a long time to reach sexual maturity. Others such as Emperors reproduce at a faster rate and so may recover faster (McClanahan and Kaunda-Arara 1996; Russ and Alcala 2004). It is also relevant to note that recovery will be quicker if overfishing is halted before the population reaches critically low levels (Russ and Alcala 2004). When the

abundances of fish and invertebrates begin to rise and people start to notice, enforcement of the MPA should be extra vigilant as poaching inside the MPA can destroy years of recovery in a short time (McCook et al. 2010).

5. RECOMMENDATIONS

Enforcement within the MPA is generally good. The presence of trained Bantay Dagats on site that collect fees from tourist is a positive and should also deter poaching. Furthermore the presence of a guard house and patrol boat are visible signs that help prevent illegal fishing. However during the survey effort, staff from CCC noted that a number of fishermen were fishing either inside or very close to the boundary of the MPA. This may not have been in direct defiance of the rules of the MPA but more a factor of not knowing the exact extent of the MPA boundaries. For this reason the implementation of demarcation buoys would be of great assistance in preventing unauthorized practices within the MPA. Moreover the use of buoys would also ease the job of the Bantay Dagats by clearly indicating the MPA boundary and removing possible claims of ignorance from fishermen. If the MPA is to become increasingly successful, prosecution of violators should be central in its management.

CCC is aiming to start a Bantay Dagat training program in the San Francisco Municipality in which it is based. If the initial trial goes well we will be extending it to other municipalities. This could provide Limasawa with more fully trained Bantay Dagats and help increase effective enforcement of the MPA.

By conducting an 'Information, Education and Communication' campaign in the barangays associated with the MPA citizens would be more aware of the state of their natural resources and increase local support of the MPA. Increased support from the local stakeholders leads to an increased sense of ownership of the MPA and people take on a stewardship role whereby compliance with the MPA does not need to be enforced but is simply a given. Until this level of support and sense of stewardship for the MPA has been reached enforcement of the MPA needs to be effective.

The MPA Management Effectiveness Assessment Tool (MPA MEAT) was designed by the Philippines government and allows local stakeholders and managers to identify areas of MPA management that are good as well as aspects that need improving. The MPA MEAT uses simple criteria to outline the current management situation regarding the MPA and can be used to plan steps to improve the management. The methodology and more information can be obtained from the CCC Project Scientist. Only when the coral reef ecosystem inside the MPA is given a proper chance to recover from unsustainable fishing pressure, will the benefits of protection become evident. Action towards achieving this is needed in the near future in order to avoid the damage to the ecosystem to reach such an extent that recovery will take decades rather than years.

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APPENDIX A: Target Species Lists

SUBSTRATES

Soft Coral	Sponge	Recently killed coral
Rock	Silt/mud	Rubble
Sand	Nutrient indicator algae	Other*
Hard Coral Lifeforms**:		
<i>Acropora</i> branching	<i>Acropora</i> encrusting	<i>Acropora</i> submassive
<i>Acropora</i> digitate	<i>Acropora</i> tabulate	Non- <i>Acropora</i> branching
Non- <i>Acropora</i> encrusting	Non- <i>Acropora</i> foliose	Non- <i>Acropora</i> submassive
Non- <i>Acropora</i> mushroom	<i>Heliopora</i> (blue coral)	<i>Millepora</i> (fire coral)
<i>Tubipora</i> (organ-pipe coral)		
*Other:		
Anemone	Corallimorph	Halimeda
Tunicate	Zoanthid	Gorgonian
Hydroids		

** If hard coral, also record target species

TARGET HARD CORALS

Brain small	Brain medium	Brain large
<i>Ctenactis echinata</i>	<i>Diploastrea heliopora</i>	<i>Echinopora</i>
<i>Euphyllia</i>	<i>Favia</i>	<i>Favites</i>
Foliose <i>Montipora</i>	<i>Galaxea</i>	<i>Goniopora/Alveopora</i>
<i>Herpolitha limax</i>	<i>Hydnophora</i>	<i>Lobophyllia</i>
Massive <i>Porites</i>	<i>Montipora digitata</i>	<i>Mycedium elephantotus</i>
<i>Pachyseris rugosa</i>	<i>Pachyseris speciosa</i>	<i>Pavona clavus</i>
<i>Pectinia lactuca</i>	<i>Plerogyra</i>	<i>Pocillopora</i> small
<i>Pocillopora</i> medium	<i>Pocillopora</i> large	<i>Polyphyllia talpina</i>
<i>Porites cylindrica</i>	<i>Porites nigrescens</i>	<i>Porites rus</i>
<i>Seriatopora hystrix</i>	<i>Tubastrea micrantha</i>	<i>Turbinaria</i>
Upside-down Bowl		

Target Invertebrates

Feather duster worms	Christmas tree worms	Flatworms
Crabs	Shrimps	Banded coral shrimp
Lobsters	Nudibranch	Abalone
Conch	Cowrie	Triton's trumpet
Cone shell	Drupella	Top shell
Other gastropod	Giant clam	Octopus
Cuttlefish	Squid	<i>Acanthaster planci</i>
<i>Linkia laevigata</i>	<i>Culcita novaeguineae</i>	<i>Protoreaster nodosus</i>

<i>Choriaster granulatus</i>	Feather star	Brittle star
Long spine sea urchin	Pencil urchin	Collector urchin
Prickly redfish	Pinkfish	Greenfish
Other sea cucumber	Giant Clam	

Target Fish

Common Name	Latin Name	Visayan Name
Angelfish	Pomacanthidae	Adlo
Barracuda	Sphyraenidae	
Blenny	Blenniidae	
Butterflyfish*	Chaetodontidae	Alibangbang
Cardinalfish	Apogonidae	
(Damsel fish)	(Pomacentridae)	
Anemonefish	<i>Amphiprion</i> sp.	
Sergeant Damsel fish	Pomacentridae	
Emperor	Lethrinidae	Katambak
Filefish	Monacanthidae	Ilak
Fusilier	Caesionidae	Dalagang bukid
Goatfish	Mullidae	Timbongan
Goby	Gobiidae	
Groupers	Serranidae	Lapu-lapu
Flagtail Grouper	<i>Cephalopholis urodeta</i>	
Honeycomb Grouper	<i>Epinephelus</i> sp.	
Humpback Grouper	<i>Cromileptes altivelis</i>	
Lyretail Grouper	<i>Variola louti</i>	
Peacock Grouper	<i>Cephalopholis argus</i>	
Jack/Trevally	Carangidae	Talakitok
Lionfish	Scorpaenidae	
Lizardfish	Synodontidae	
Moorish Idol	<i>Zanclus cornutus</i>	Sanggowanding
Moral Eel	Muraenidae	
Parrotfish	Scaridae	Mulmul
Pipefish	Syngnathidae	
Porcupinefish	Diodontidae	
Pufferfish	Tetraodontidae	
Rabbitfish	Siganidae	Kitong
Virgate rabbitfish	<i>Siganus virgatus</i>	
Ray	Rajiformes	
Sandperch	Pinguipedidae	
Scorpionfish/Stonefish	Scorpaenidae	
Snapper	Lutjanidae	Maya-maya
Black and White Snapper	<i>Macolor macularis</i>	
Checkered Snapper	<i>Lutjanus decussatus</i>	

Two Spot Snapper	<i>Lutjanus biguttatus</i>	
Spade/Batfish	Ephippidae	
Spinecheeks	Nemipteridae	Silay
Twoline Spinecheek	<i>Scolopsis bilineatus</i>	
Squirrelfish/Soldierfish	Holocentridae	
Surgeonfish	Acanthuridae	Indangan
Unicornfish	<i>Naso</i> sp.	
Sweeper	Pempheridae	
Sweetlips	Haemulidae	Lipti
Toby	Tetraodontidae	
Triggerfish	Balistidae	Pakol
Trunk/Box/Cowfish	Ostraciidae	
(Wrasse)	(Labridae)	
Crescent Wrasse	<i>Thalassoma lunare</i>	
Humphead Wrasse	<i>Cheilinus undulatus</i>	
Red Breasted Wrasse	<i>Cheilinus fasciatus</i>	

*Target Butterflyfish

Vagabond Butterflyfish	Spot-Banded Butterflyfish	Merten's Butterflyfish
Klein's Butterflyfish	Dot and Dash Butterflyfish	Chevroned Butterflyfish
Latticed butterflyfish	Singular Bannerfish	Threadfin Butterflyfish
Eastern Triangle Butterflyfish	Longfin Bannerfish	Teardrop Butterflyfish
Redfin Butterflyfish	Masked Bannerfish	Spot-Nape Butterflyfish
Pyramid Butterflyfish	Pennant Bannerfish	Lined Butterflyfish
(Big) Long-Nosed Butterflyfish	Raccoon Butterflyfish	Yellow-Dotted Butterflyfish
Copper-Banded Butterflyfish	Dotted Butterflyfish	Black-Backed Butterflyfish
Orange-Banded Butterflyfish	Ovalspot/Mirror Butterflyfish	Spot-Tail Butterflyfish
Humphead Bannerfish	Bennett's/Eclipse Butterflyfish	Panda Butterflyfish
Asian Butterflyfish	Bluespot Butterflyfish	Eight-Banded Butterflyfish
Burgess' Butterflyfish	Highfin Coralfish	Reticulated Butterflyfish
Ornate Butterflyfish	Two-Eyed Coralfish	Saddled Butterflyfish
Meyer's Butterflyfish	Brown Banded Butterflyfish	Spotted Butterflyfish
Speckled Butterflyfish	Ocellate Coralfish	Yellowtail Butterflyfish
Pacific Double-Saddle Butterflyfish		

APPENDIX B: TARGET FISH FAMILY ABUNDANCE

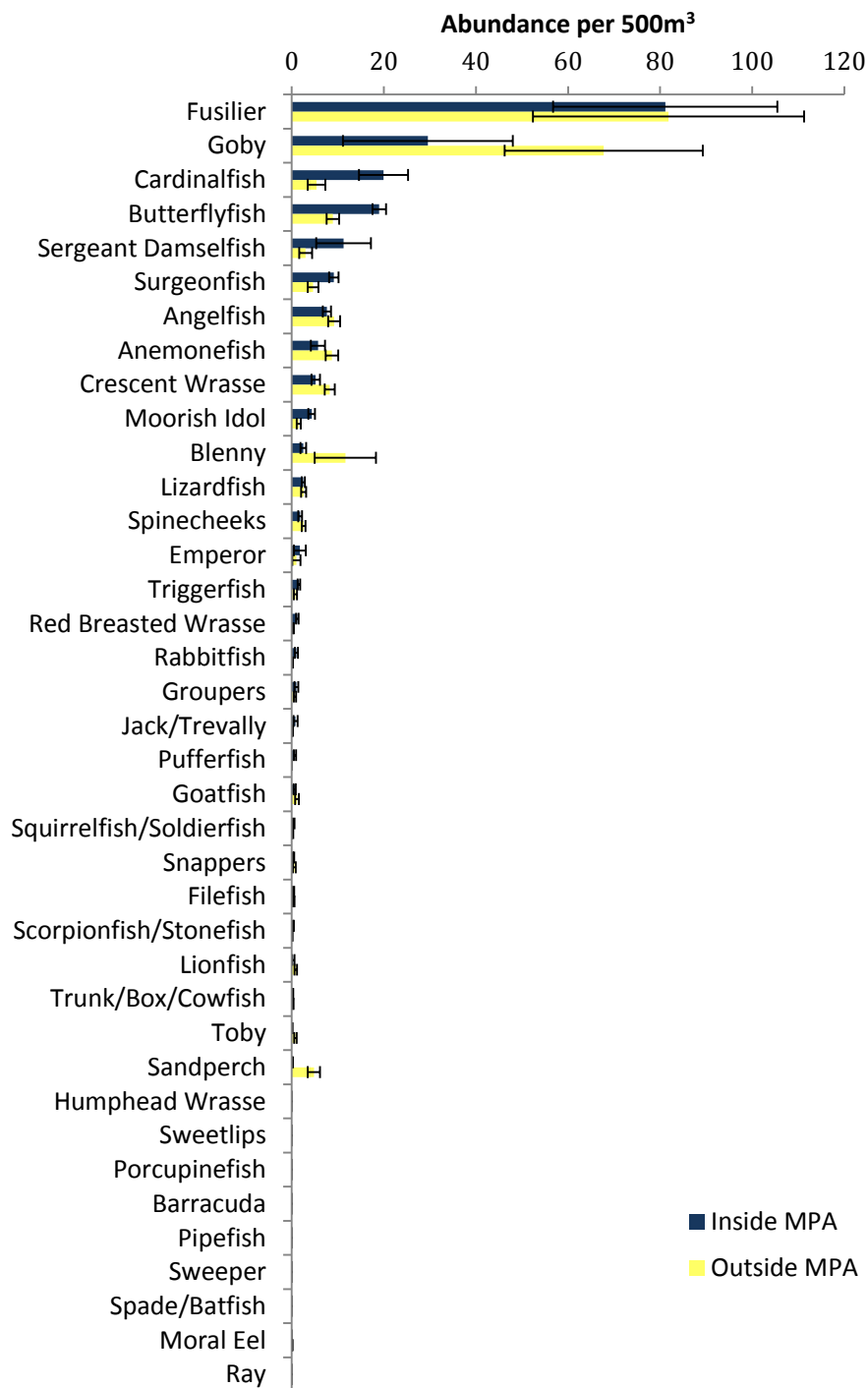


Figure 12 – Average abundance of target fish families. Data are mean average per replicate, error bars indicate Standard Error of the Mean.

APPENDIX C: TARGET INVERTEBRATE ABUNDANCE

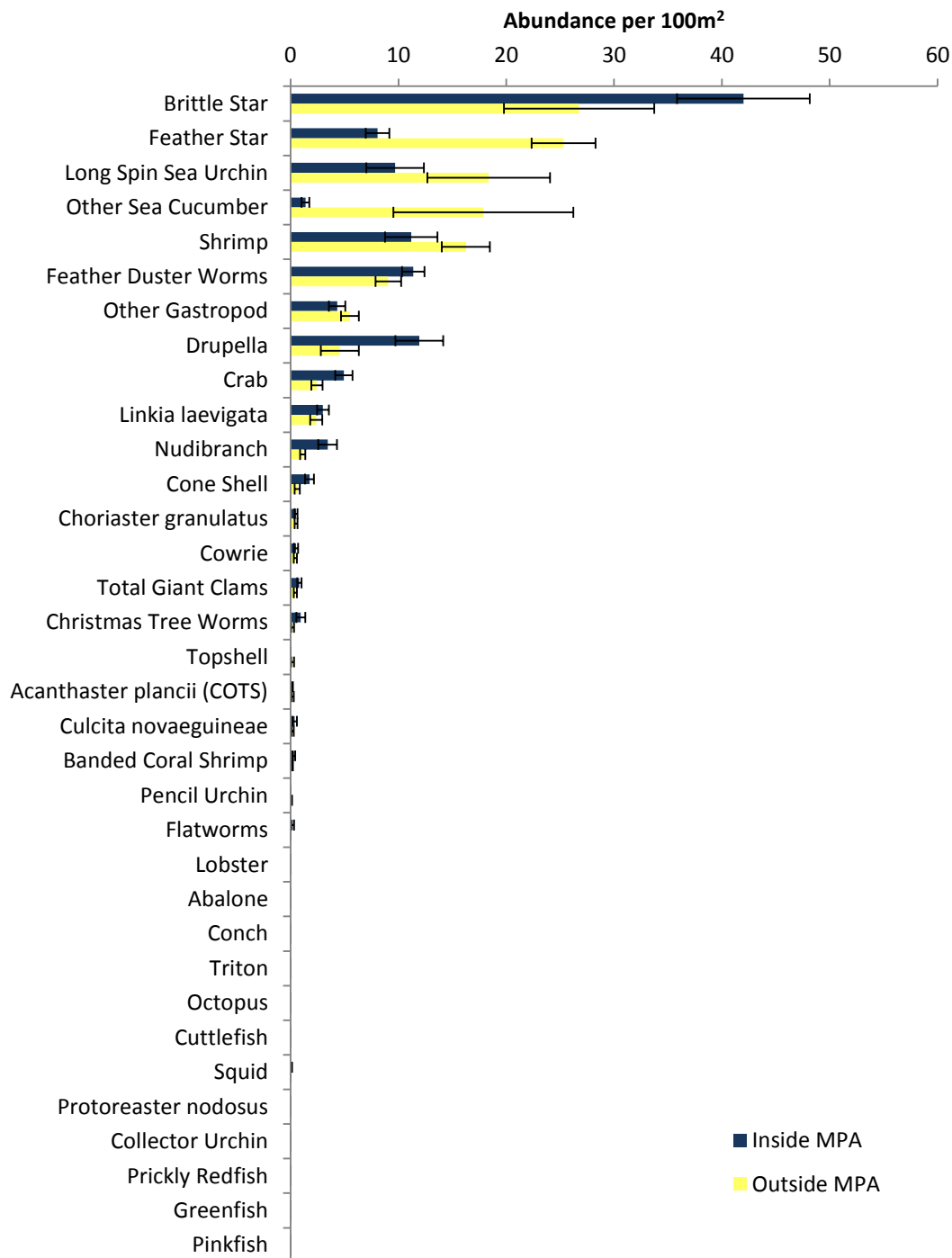


Figure 13 – Average abundance of target invertebrate species and families. Data are mean averages per replicate, error bars indicate standard error of the mean.

APPENDIX D: TARGET SUBSTRATES ABUNDANCE

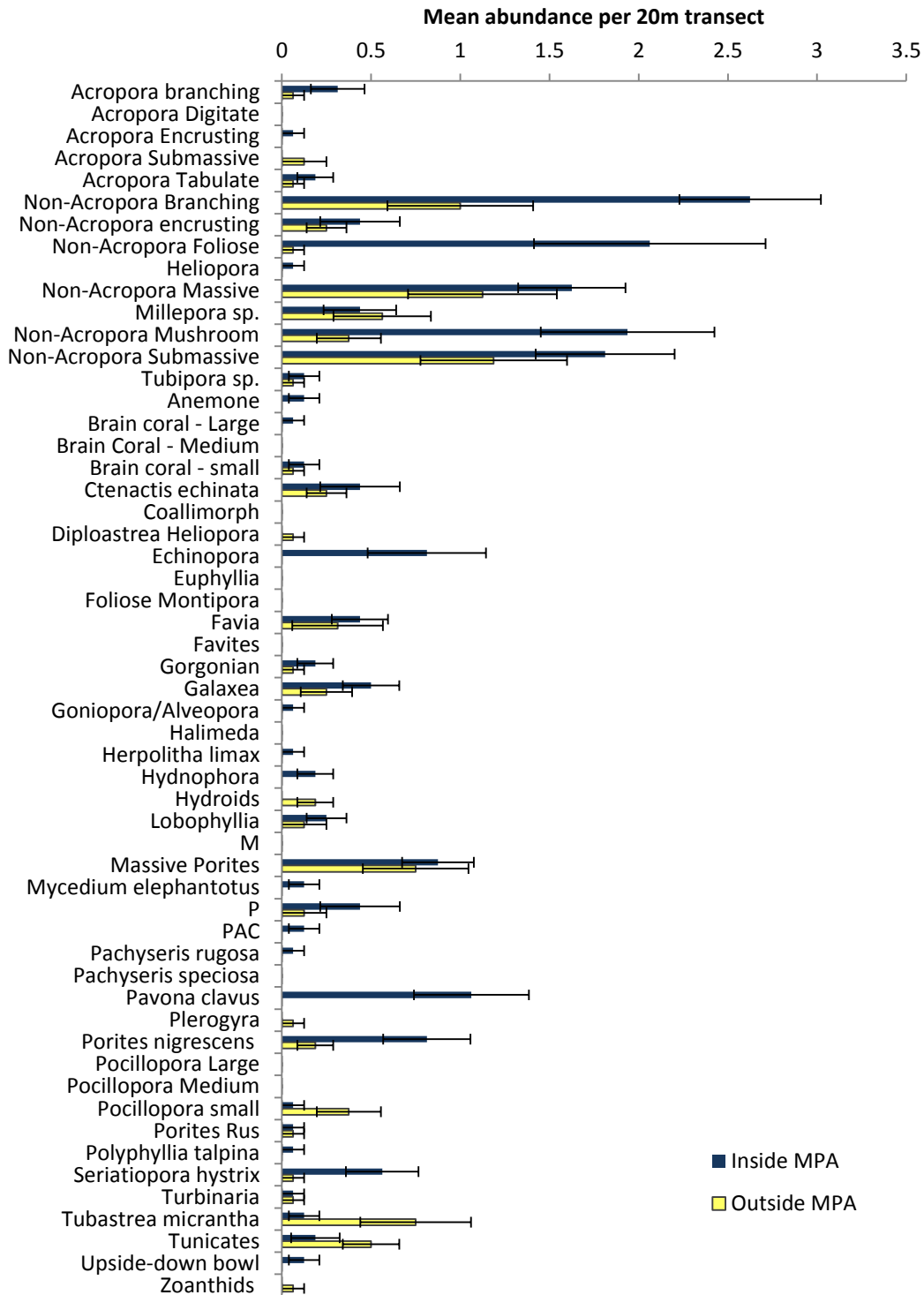


Figure 14– Average abundance of hard coral lifeform, target coral species and benthic organisms classed under 'other'. Data are mean average per replicate, error bars indicate Standard Error of the Mean.