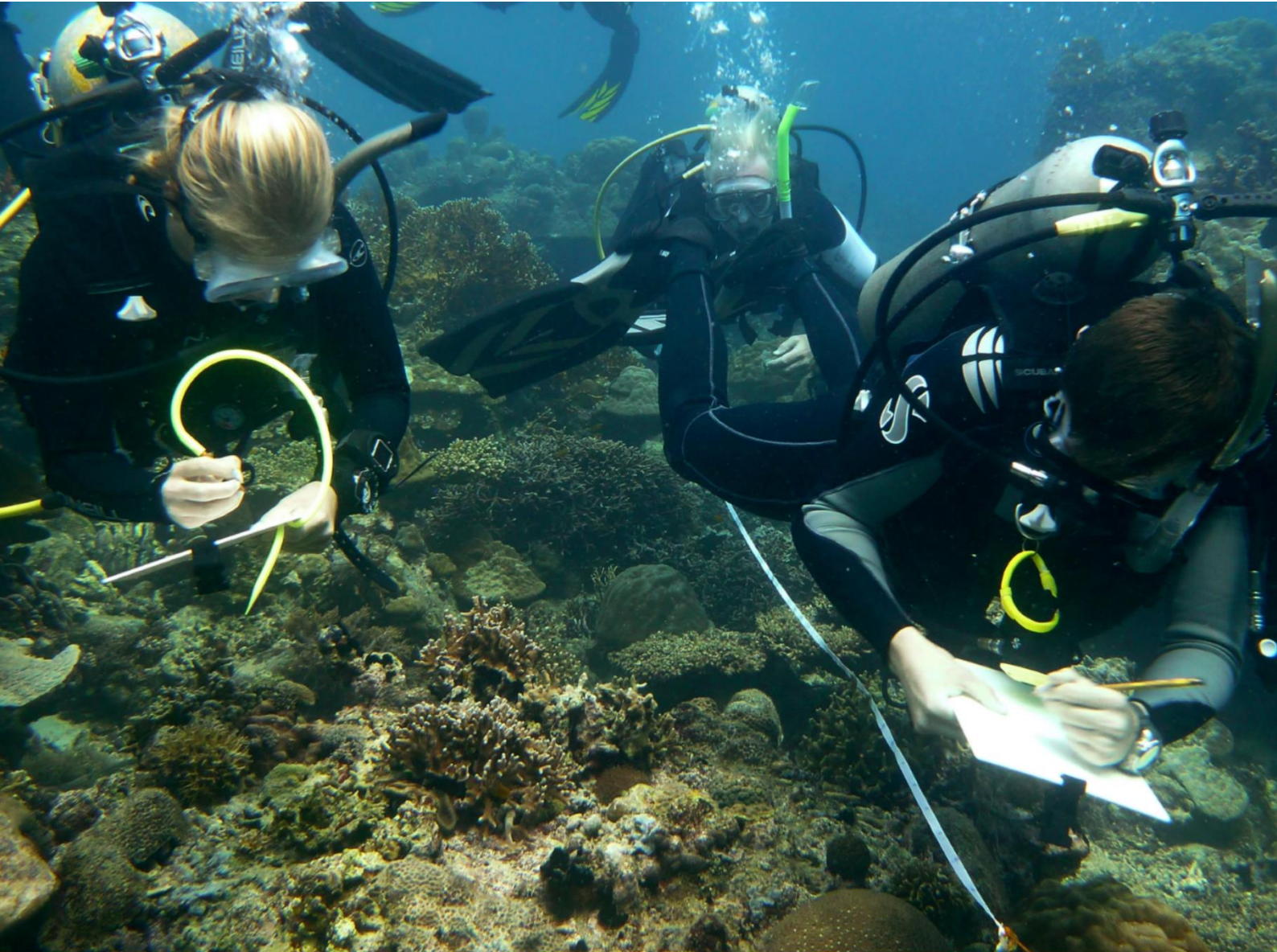




LRCP

Southern Leyte Coral Reef Conservation Project

Coral Cay Conservation Marine Protected Area Report: Barangay Napantao 2017

Report Date: May 2019

**CORAL CAY
CONSERVATION**



Expeditions

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In partnership with the Southern Leyte
Provincial Government, Philippines





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Executive Summary

- Coral Cay Conservation (CCC) conducted an assessment of the reef fish, invertebrates, substrates and anthropogenic impacts inside and outside the Napantao MPA (municipality San Francisco), in March and October 2017.
- An enhanced Reef Check methodology was used to survey 6 permanent transects, biennially, each containing four 20m replicates. Three transects (I01, I02 and I03) were placed inside and three transects (O01, O02 and O03) outside the MPA at a depth of 12m.
- Mean target fish abundance inside the MPA was $N = 170.88 \pm 43.14 \text{ } 500\text{m}^3^{-1}$ and $N = 86.08 \pm 16.94 \text{ } 500\text{m}^3^{-1}$ outside the MPA. Mean Species Richness (S) was $S = 17.88 \pm 0.66 \text{ } 500\text{m}^3^{-1}$ inside the MPA, and $S = 12.91 \pm 0.80 \text{ } 500\text{m}^3^{-1}$ outside the MPA, mean Shannon-Weiner Diversity (H') was $H' = 2.23 \pm 0.08 \text{ } 500\text{m}^3^{-1}$ inside the MPA and $H' = 1.95 \pm 0.10 \text{ } 500\text{m}^3^{-1}$ outside the MPA and mean Pielou's Evenness (J') was $J' = 0.77 \pm 0.023 \text{ } 500\text{m}^3^{-1}$ inside the MPA and $J' = 0.78 \pm 0.04 \text{ } 500\text{m}^3^{-1}$ outside the MPA.
- Mean Butterflyfish abundance was $N = 14.63 \pm 1.48 \text{ } 500\text{m}^3$ inside the MPA and $N = 9.13 \pm 1.22 \text{ } 500\text{m}^3$ outside the MPA. Of the 351 individuals recorded within the MPA, 240 (68.38%) were categorised as obligate corallivores, and 65 as facultative feeders. Of the 219 recorded outside the MPA, 190 (86.76%) were categorised obligate corallivores and 20 as facultative feeders. The high proportion of obligate feeders both inside and outside the MPA is supportive of dominance of hard coral, both inside and outside the MPA ($p = <0.05$).
- A greater abundance ($N = 14.96 \pm 2.37 \text{ } 500\text{m}^3$) of commercially important fishes inside the MPA was recorded compared to outside ($N = 5.00 \pm 0.94 \text{ } 500\text{m}^3$), as well as a greater frequency of those fish being in the higher size classes (48 individuals over 21cm inside, including 4 over 31cm, compared to only 5 over 21cm outside, none of which were over 31cm) which suggests the MPA is being managed well, where fish are allowed to grow to maturity inside the MPA, and larger individuals are fished outside of the MPA.
- The mean abundance of invertebrates inside the MPA was $N = 133.29 \pm 12.01 \text{ } 100\text{m}^2^{-1}$ and $N = 119.21 \pm 10.59 \text{ } 100\text{m}^2^{-1}$ outside the MPA. Mean species richness inside the MPA was $S = 10.25 \pm 0.48 \text{ } 100\text{m}^2^{-1}$, and $S = 10.96 \pm 0.56 \text{ } 100\text{m}^2^{-1}$ outside the MPA, mean Shannon-Weiner Diversity (H') was $H' = 1.86 \pm 0.04 \text{ } 100\text{m}^2^{-1}$ inside the MPA, and $H' = 1.87 \pm 0.05 \text{ } 100\text{m}^2^{-1}$ outside the MPA and mean Pielou's Evenness (J') was $J' = 0.74 \pm 0.01 \text{ } 100\text{m}^2^{-1}$ both inside and outside the MPA.
- Inside the MPA, the dominating substrate was hard coral ($53.44 \pm 3.06\% \text{ } 20\text{m}^{-1}$), followed by rock ($15.32 \pm 1.53\% \text{ } 20\text{m}^{-1}$) and other substrates ($12.08 \pm 1.77\% \text{ } 20\text{m}^{-1}$), with the hard coral composition exhibiting all three life traits: stress tolerant coral, competitor coral and fast growing coral (38.01%, 27.88% and 34.11% respectively). Outside the MPA, the dominating substrate was also hard coral, though with a lower coverage than inside ($40.42 \pm 4.34\% \text{ } 20\text{m}^{-1}$), followed by sand ($21.88 \pm 5.15\% \text{ } 20\text{m}^{-1}$) and rock ($11.98 \pm 1.53\% \text{ } 20\text{m}^{-1}$). As with inside the MPA, the hard coral present exhibited all three life traits: stress tolerant coral, competitor coral and stress tolerant coral (31.70%, 28.35% and 39.95% respectively).

- Overall, anthropogenic impacts were lower inside the MPA than outside. However, general trash was still found on an average of 54.17% of replicates inside, compared to 87.50% of replicates outside. Unfortunately, levels of fishing trash found within the MPA were similar to that of outside the MPA (33.33% and 29.17%, respectively) but counts were considered low. One replicate also showed signs of boat/anchor damage inside the MPA.
- Results from the assessment of the Barangay Napantao's MPA, in the municipality of San Francisco, suggest it is well managed but there is room for improvement. High overall abundance of fish within the MPA compared to others around Sogod bay, coupled with high levels of diversity, suggest laws prohibiting fishing are being complied to, as is also evidenced by high abundance and large size of commercially important fish within the MPA. Though numbers of fish tended to differ significantly inside and outside the MPA, invertebrate numbers were fairly similar. This is likely due to the substrate being optimum both inside and outside the MPA, with high levels of hard coral cover (though higher inside the MPA – this may be due to the placement of the MPA rather than improvement over time). One issue that must be addressed is the level of trash, both general and fishing trash. Although it is possible it is drifting in from outside the MPA, care must be taken within the local community to try and minimise the amount of waste being allowed to reach the sea and eventually the MPA.

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List of Acronyms and Abbreviations

CBM	: Community-based Management
CC	: Competitor Corals
CCC	: Coral Cay Conservation
CoTs	: Crown of Thorns Seastars (<i>Acanthaster planci</i>)
EAF	: Ecosystem Approach to Fisheries
FGC	: Fast Growing Corals
HC	: Hard Coral
IUCN	: International Union for the Conservation of Nature
LGU	: Local Government Unit
LRCP	: Southern Leyte Coral Reef Conservation Project
MPA	: Marine Protected Area
MPA MEAT	: MPA Management Effectiveness Assessment Tool
MR	: Marine Reserve
NIA	: Nutrient Indicator Algae
NIPAS	: National Integrated Protected Area System
NTA	: No Take Area
OT	: Other
PAME	: Protected Area Management Enhancement
PENRMO	: Provincial Environmental and Natural Resource Management Office
PGSL	: The Provincial Government of Southern Leyte
PIT	: Point Intercept Transects
PRRCFI	: Philippines Reef and Rainforest Conservation Foundation Inc.
PRRP	: Philippines Reef and Rainforest Project
SE	: Standard Error ($\pm$)
SST	: Sea Surface Temperature ($^{\circ}\text{C}$)
STC	: Stress Tolerant Corals
UVC	: Underwater Visual Census
S'	: Species Richness
H'	: Shannon-Weiner Diversity Index
J'	: Pielou's J Evenness
N	: Abundance

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Coral Cay Conservation

Initially founded in 1986, CCC is an internationally renowned, non-governmental organisation (NGO), which provides host countries with appropriate resources for the protection and sustainable use of tropical ecosystems. This protection is established to enable future generations the continued use of local ecosystem resources. These goals are outlined in CCC's mission statement:

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

CCC achieves its mission via the formation of long-term programmes of collaborative research with local institutions and governments. Such research programmes require technical support from CCC, in the form of scientific data collection, data analysis, and the production of reports and integrated coastal zone management plans. CCC also provides communities with education, training and alternative livelihood opportunities to strengthen local human resources to the point where research can be continued independently by the host country.

CCC has carried out conservation projects all over the world, including the Philippines, the Caribbean, Belize, Honduras, Malaysia, Cambodia and Fiji. CCC has successfully set up numerous Marine Protected Areas (MPAs) throughout these regions and provided essential scientific data for the management of their local marine resources. Historically, successfully established areas in the Philippines were a result of the Philippines Reef and Rainforest Project (PRRP). CCC established PRRP in collaboration with the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and the World Land Trust in 1995. Such protected areas include the coastal regions of the Southern Negros Occidental, Anilao, Palawan, Danjungan Island, the forests of North Negros and Padre Burgos. In 2002, the Provincial Government of Southern Leyte (PGSL) invited CCC to

conduct research in Sogod Bay. This resulted in the formation of the Southern Leyte Coral Reef Conservation Project (LRCP). The LRCP utilises trained volunteers to survey the region's coral reefs and provide training and conservation education opportunities for project counterparts. The aim of this is to develop local capacity and ensure the long-term protection and sustainable use of marine resources throughout Southern Leyte. Between 2002 and 2013, CCC focused on implementing baseline surveys throughout Sogod Bay to obtain information on the distribution of fishes and invertebrate populations, benthic cover and reef health. In 2013, having surveyed much of the accessible area in the Bay, CCC shifted its focus to concentrate on MPA monitoring surveys. Under this new protocol, surveys are implemented inside and outside of existing MPAs to evaluate their efficacy and in unprotected areas to assess their potential for MPA installation



Schematic diagram demonstrating Coral Cay Conservation's implementation strategy within a specified host country. The sustainment of livelihoods and poverty alleviation are facilitated through the restoration and protection of valuable socio-economic ecosystems, accompanied by the promotion of sustainable resource exploitation and local capacity building.

1.0 Introduction

1.1 Marine Protected Areas

Marine resources are under increasing pressure from an ever growing global population (Jackson et al., 2001). Strong declines in catch from worldwide fisheries, such as the North Atlantic Cod (Myers et al., 1997) and Caribbean reef fisheries (Hardt, 2009), have illustrated that biological marine resources are limited and highly vulnerable to overfishing (Jackson et al., 2001; Pauly et al., 2002). Additional pressures such as pollution, coastal development and climate change exacerbate this vulnerability. As a result, there is an increased drive for conservation efforts and resource management in the marine environment (Wood et al., 2008; CBD, 2010). The protection of marine areas can achieve conservation and resource management targets simultaneously and are therefore considered instrumental to sustainable ocean utilisation (Pauly et al., 2002). The International Union for the Conservation of Nature (IUCN) defines an 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."

MPAs have become vital tools in protective management for the conservation of marine resources. MPAs in the Philippines encompass No-Take Areas (NTAs), within which no form of extraction is permitted. These NTAs are surrounded by 50m "buffer zones" where only non-destructive fishing methods, such as single hook and line fishing, are permitted. These large areas of no extraction combat resource exploitation by providing local communities with a sustainable supply of goods; such as fish and invertebrates; and services, such as shoreline protection and tourism (TWB, 2005).

To assess the beneficial impact of an MPA, resource managers often seek to measure its respective effectiveness. Effectiveness can be measured by assessing a range of factors, most commonly addressing the goals established by the MPA. Measuring the MPA's impact on ecology, biodiversity, (Mora, 2006; Selig & Bruno, 2010), species conservation, the general ecological status and fishery productivity (Buxton et al., 2006), as well as meeting the stakeholder-defined parameters of success (Dahl-Tacconi, 2005), can often satisfy the quantifiable conclusion of effectiveness. The definition of effectiveness was given by Pajaro et al. (2010) and states that "...effectiveness is the achievement of the ecological, socio-economic, and governance objectives outlined during the planning process." However, generally, the most desired benefit of an MPA is to increase fish production and conserve respective fauna and flora of interest.

Increases in fish production occur as a result of overspill and larval export from the NTA into surrounding waters (Fig. 1). Over time, the displacement of fishing effort from the MPA results in an increase in adult fish biomass and fecundity. This can lead to adult fish and larvae being exported to the buffer zone and its surrounding waters. Local fishery yields subsequently increase because they have a continual and sustainable supply of stock (Maliao et al., 2004). In areas where there is the potential for increased tourism and anthropogenic pressure on the marine environment for food, recreation and other resources, the benefits and necessities of having a network of functioning MPAs are increased. Marine Reserves (MRs) are areas of the marine environment where fishing is restricted to non-destructive methods, such as single hook and line fishing. This reduces habitat damage often caused by destructive fishing methods, such as dynamite fishing, net fishing or trawling.

MRs are preferable to areas of no protection but are not as effective as MPAs because fishing pressure remains present. Levels of exploitation of the fauna within the MR considering various size, biomass and life-stage classes -are all at the discretion of the by-laws set during the planning stage of the MR. Enforcement in this regard can be fully functioning through closed seasons or restrictions on certain gears and activities or can be minimal resulting in high levels of exploitation of all cohorts. Therefore, when enforcement is minimal or non-apparent, most fish and invertebrates within an MR can still be extracted. With by-catch being a void concept within tropical subsistence coral reef fisheries, it is often the case that as fishery production decreases, juveniles unprecedentedly retain a social and economic value to fishermen. Thus, juveniles are often removed before they can reach sexual maturity, causing populations to decline. Environmentally important species such as algae-grazing Parrotfish are also removed, potentially allowing algae to proliferate and smother vital coral habitats.

"The key to success and broad acceptance, whether for multiple use MPAs or NTAs, is a clear articulation of the management

problem that the MPA is meant to solve. Such objective setting should be done with scientists working in concert with local communities, user groups and management authorities – not scientists in isolation."

Agardy et al. (2012)

The success of a protected area is entirely dependent upon the cooperation of local stakeholders (Pollnac et al., 2001). Research has shown that the involvement of resource users in the planning, implementation and management of their own MPA increases their sense of ownership and pride. Only when local stakeholders feel they are adequately considered and regularly consulted on their MPA's management, will it be possible for the full potential of the MPA to be attained (Green et al., 2009; Human & Davies, 2010). It is therefore essential that the local community is involved throughout the entire process of protected area establishment. Stakeholders must be consulted about key aspects of the MPA establishment process such as size and location, whilst being directly involved in their management, e.g. via community Bantay Dagats (marine guards).

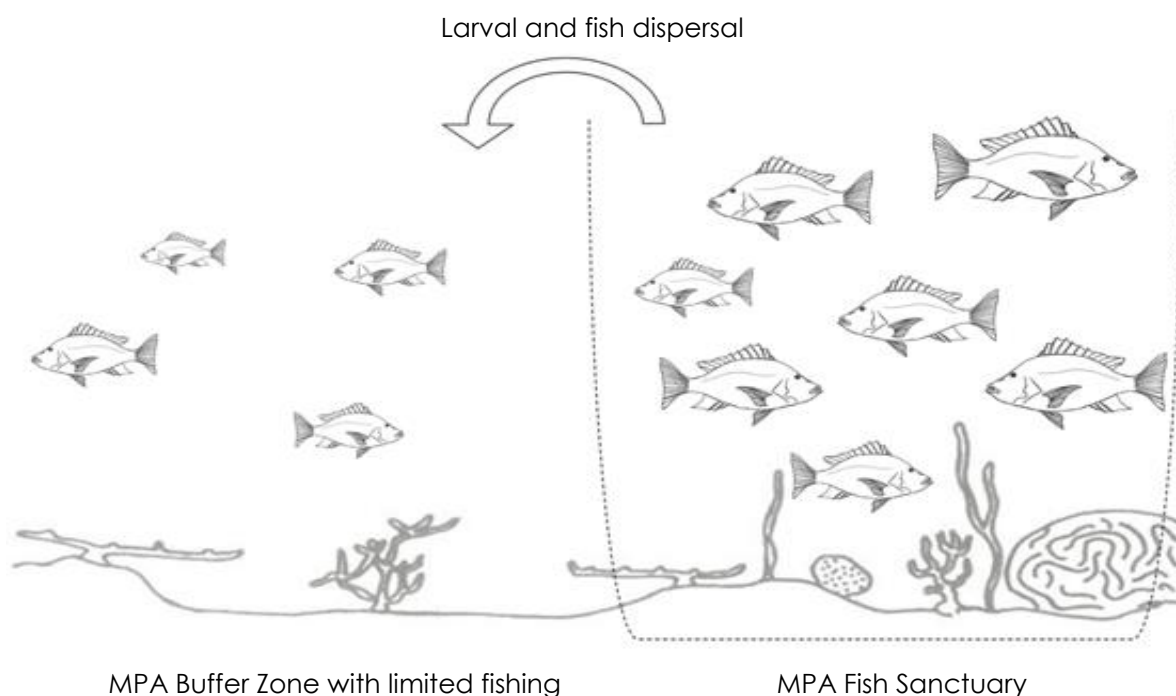


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to 'overspill', increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

1.2 Coral Reefs and Marine Conservation in the Philippines

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

The waters of the Philippines contain roughly 26,000 km² of coral reefs (Burke et al., 2002). In 2012, it was estimated that 60% of the country's 98 million citizens live proximity to coral reefs and that fish accounts for nearly 70% of the consumed animal protein (ADB, 2014). This heavy reliance on marine resources has caused large areas of coral reef ecosystems to become threatened. In 1980, 33% of coral reefs were characterised 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 within the Philippines. Jacinto et al. (2000) stated that legislation concerning marine conservation in the Philippines is some of the most advanced within the Coral Triangle. Important laws currently instigated in the Philippines include:

- 1998 Fisheries Code (Republic Act 8550): 15% of municipal waters should be within an MPA.
- Marine and Coastal Resource Protection Act 2011: 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 roughly 1,869 MPAs in the Philippines. Of these MPAs, 33 have been declared at the national level as National Integrated Protected Area System (NIPAS) sites and the remainder are managed by Local Government Units (LGUs).

1.3 Characterisation of Study Region

1.3.1 Sogod Bay

The coral reefs of Southern Leyte remain some of the least disturbed habitats in the Philippines. The coastal regions that include Canigao Channel in the west, Sogod Bay, Cabalian Bay, the north eastern Pacific coast and the Surigao Strait, are rich in marine life and important fishing grounds for local communities. The area is rich in tuna, flying fish, herrings, anchovies, shellfish and Spanish mackerel. The region is also a feeding ground for attractive mega-fauna such as pilot whales, melon-headed whales, dolphins, manta rays and whale sharks. The coast is characterised by naturally limited mangrove areas, narrow fringing coral reefs, limited seagrass beds, and narrow intertidal areas and beaches (Calumpong et al., 1994).

CCC works alongside the municipalities with waters lying within Southern Leyte. Currently there are ~66 established MPAs covering an estimated 1,226 hectares. Utilising Reef Check's methodology, CCC has been directly involved in the monitoring and surveying of 26 different sites around Sogod Bay. These figures will increase in the coming years as more MPAs are in process of being established. Sizes of MPAs range from 3.5 hectares (Maujon/Juangon Fish Sanctuary) to 55 hectares (Limasawa Fish Sanctuary), with a mean size of 11.7 hectares (± 2.2 SE) and a median of 7.9 hectares (PENRMO-CFRU, 2014). The sizes for several MPAs are not known, as accurate GPS coordinates are not available.

1.3.2 Napantao, San Francisco

The Napantao MPA was established in 1996 and covers 5 hectares. It is located in the Municipality of San Francisco, in the waters of the Barangay Napantao, which is home to around 600 people, of which approximately 25 are fishermen. The boats used by the local fisherfolk are mostly non-motorised. The MPA

is to the east of the village. There is a Bantay Dagat hut which is rarely supervised.

Currently, the MPA infrastructure is held to a commendable standard (Table 1). Fishing takes place in the area surrounding the MPA on a regular basis and poaching is relatively common (according to the Bantay Dagat).

Table 1: Summary of the Barangay Napantao Marine Protected Area (MPA) infrastructure.

MPA Infrastructure	Present?	Comments
Bantay Dagats	Yes	Require environmental and enforcement training
Permanent Bantay Dagat presence	No	Not always present
MPA guardhouse?	Yes	Rarely occupied
Demarcation buoys	Yes	Not at exact boundaries
Patrol boat	Yes	Rarely used
Bantay Dagat gear (flashlight, fins, mask etc.)	Yes	Rarely used
User fees collected	Yes	Fees regularly collected from dive boats

2.0 Methodology and Data Collection

2.1 Survey Site

CCC's assessment of the MPA at Napantao was conducted over two periods during 2017: the first between 24/03/2017 and 03/04/2017, and the second between 06/10/2017 and 31/10/2017, by trained volunteer survey teams (Fig 2). The weather varied between sunny, overcast and raining throughout the survey period, with a mean air temperature of 28.41°C. Mean sea surface temperature (SST) was 28.25°C. The water at 3m was recorded as having a mean of 28.08°C and 27.58°C at 10m, over the survey period. The mean estimated horizontal visibility throughout the survey area was 15.10 m.

From discussion with the Barangay captain and officials, it was discerned that there is a small stream outlet (mouth <10m wide) around 100m from the MPA, and siltation isn't said to be a problem. Activities banned within the MPA are commercial fishing, recreational fishing, spear fishing, invertebrate harvesting and anchoring. Barangay officials stated these regulations were enforced, and it is rare that any of the above activities occurred inside the MPA. However, some instances of poaching were said to occur (less than once a month).

As CCC base is located at Napantao, members regularly dive this site. It is agreed that siltation is minimal yet very can be quite

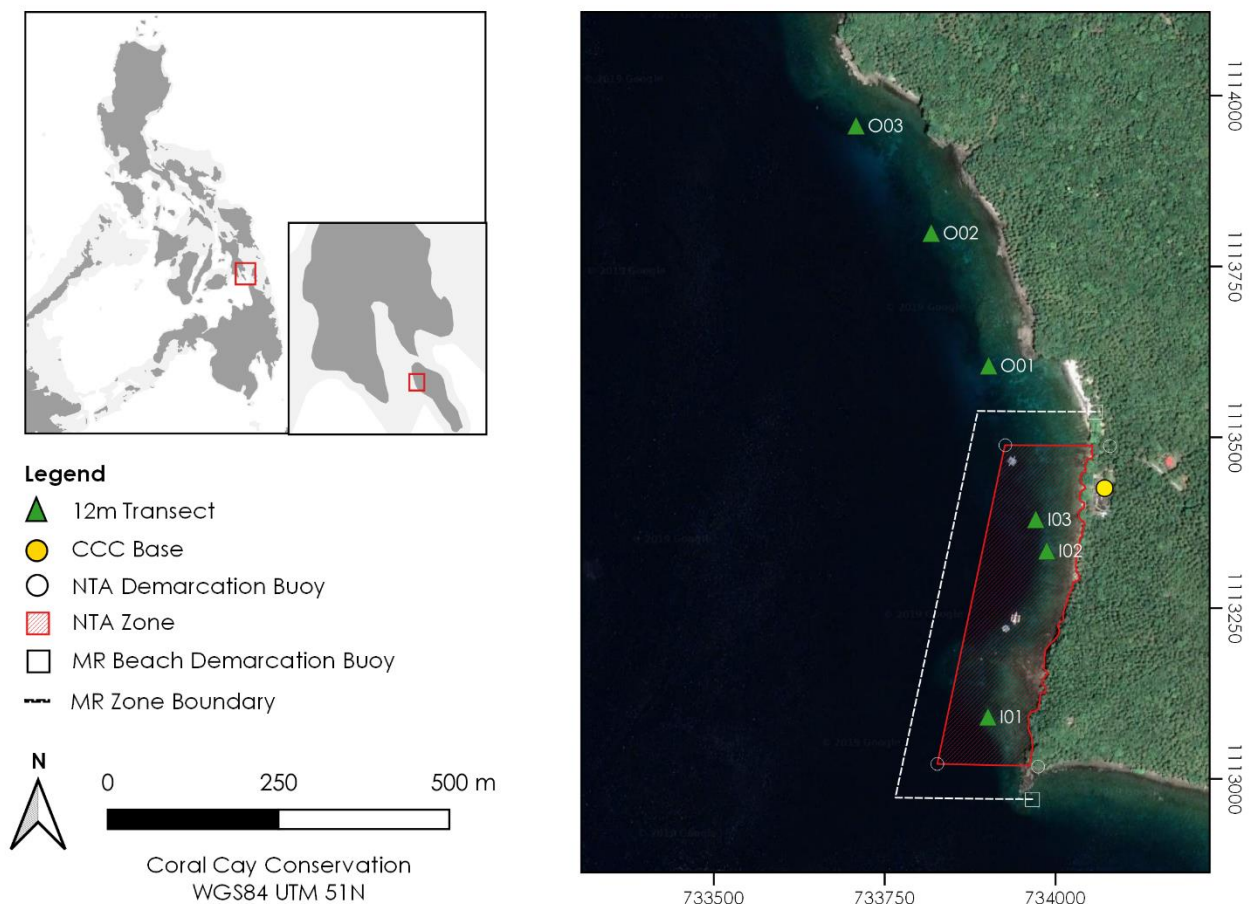


Figure 2. Marine Protected Area (MPA) temporal assessment of Barangay Napantao's Fish Sanctuary, San Francisco Municipality, Southern Leyte. Map produced through QGIS.

substantial with heavy rainfall due to the relief of the land (steep hill) that encourages run-off directly onto the reef. There is also anecdotal evidence of some poaching within the MPA, especially at night, where enforcement is reduced.

2.2 Biophysical Survey

The assessment of the Napantao MPA was conducted using an enhanced Reef Check methodology which is widely recognised and used to survey coral reefs around the world (Hodgson & Liebler, 2002). 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). Data from around the world is analysed on a yearly basis to enable the production of global coral reef status updates. Reef Check surveys produce a representation of the ecological status of a reef and its human impacts. CCC has augmented the methodology to reflect the high biodiversity of the area with the addition of extra target species of fish, coral and invertebrates (Appendix A). Permanent transects at 12m (three inside and three outside the MPA - marked with rebar) were surveyed starting in both March and October (Table 2, Fig. 3). Each 100m transect was divided up into four 20m replicates, separated by 5m inter-replicate gaps in which no data were collected. This produced a total survey length of 80m. Approximately 100m was left between each whole transect. This survey design allowed for robust statistical analysis of collected data.

Table 2. Depths (m) and coordinates (UTM) of 100m transects surveyed inside and outside the MPA at Barangay Napantao, San Francisco.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
I01	12	733901	1113091
I02	12	733987	1113334
I03	12	733971	1113380
O01	12	733902	1113605
O02	12	733818	1113799
O03	12	733708	1113956

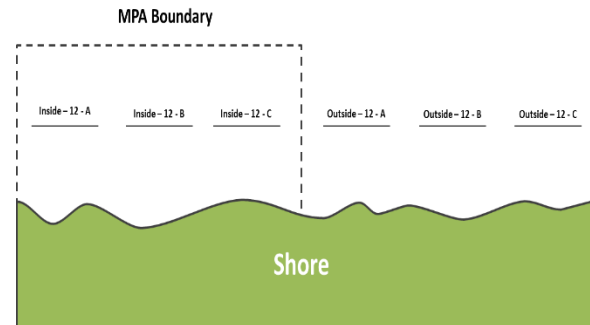


Figure 3. Survey plan for the assessment of the Barangay Napantao Marine Protected Area (MPA) utilised by Coral Cay Conservation (CCC). Each transect is 100 meters long and is sub-divided into four 25 metre replicates. Of these 25 metres, only 20 metres are surveyed with the resultant 5 metres used to divide the replicates, this area is called the inter-replicate zone.

2.2.1 Visual Assessment of Reef Fishes

Fish diversity and abundance data were collected using Underwater Visual Census (UVC) techniques. Selected fish families and species recognised as being good indicators of fishing pressure, aquarium collection and reef health were recorded. The abundance of three commercially important fish families: Parrotfish (Mol-mol, Scaridae); Groupers (Lapu-lapu, Serranidae) and Snappers (Maya-maya, Lutjanidae) were recorded and classified into size classes; 0-10cm, 11-20cm, 21-30cm, 31-40cm, 41-50cm, 51-60cm and >60cm (Appendix A). Commercial fish biomass (kg) was also investigated between transects and commercial fish species.

Data was recorded using 'belt' transects, where fish were observed along each replicate of the 100m transect within an imaginary 5mx5mx20m (WxHxL) box (Fig. 4). Surveys were conducted by two surveyors swimming slowly along replicates, each counting indicator fish species 2.5m either side of the central transect line. Divers paused at 5m intervals along each replicate to wait one-minute for fish to acclimatise to surveyor presence. Data collection continued during this one-minute pause.

Butterflyfish were grouped into obligate corallivores (feed exclusively on coral), and facultative corallivores (feed non-exclusively on corals), since the presence of obligate

Table 3. The calculated Length-Weight allometric coefficients to determine the biomass (kg) of sized Grouper, Snapper and Parrotfish within Napantao MPA, Southern Leyte, the Philippines.

Genera	Species	Common Name	Allometric Coefficients	
			<i>a</i>	<i>b</i>
Serranidae	Other	Grouper	0.0145	3.0225
	<i>Cromileptes altivelis</i>	Barramundi Cod	0.0138	3.28
Lutjanidae	Other	Snapper	0.0147	3.0312
Scaridae	Other	Parrotfish	0.0152	3.0398
	<i>Bolbometapon muricatum</i>	Green Humphead Parrotfish	0.0138	3.03

corallivores on reefs can be used as an indicator of hard coral abundance. The two target obligate Butterflyfish, Redfin (*Chaetodon lunulatus*) and Eastern Triangle (*Chaetodon baronessa*) were grouped and the five other facultative target species, Longnose (*Forcipiger flavissimus*), Humphead (*Heniochus varius*), Klein's (*Chaetodon kleinii*), Raccoon (*Chaetodon lunula*), and Vagabond (*Chaetodon vagabundus*) were grouped with all other, unspecified Butterflyfish species (Berumen et al., 2005).

2.2.2 Biomass Calculations

During UVC fish surveys, the individual size of commercially important fish families were characterised through length ((L) cm) estimations, which were subsequently placed into appropriate size classes: 0-10cm; 11-20cm; 21-30cm; 31-40cm; 41-50cm; 51-60cm; >60cm. Length-weight relationships (LWR) (Equation. 1) were utilised to calculate the individual mass ((W) g) and biomass (kg). The individual weight of species in each sample can vary considerably, therefore within this study, specific steps were taken when assessing the W of individuals in each commercially important fish family in accordance with Froese et al. (2013) and Froese & Pauly (2000).

The biomass (kg) of each size class of family was derived through allometric LWRs. The relationship between L and W for fish species is expressed by equation (1):

(1)

$$W = aL^b$$

Equation 1. Length-weight relationships were used to determine the biomass (kg) of each individual recorded on Barangay Napantao coral reef, Sogod Bay, southern Leyte, Philippines. W = mass (g), *a* = the condition factor (Hilborn and Walters, 1992), *b* = species specific growth parameter (Quinn and Deriso 1999), L = the total length (TL) (cm) measured of the individual fish.

a and *b* are termed allometric coefficients, and each LWR requires both values. *a* is the condition factor in that it describes the body-shape of the species, where parameter *b* indicates the isometric growth of a species (Froese et al., 2013).

To determine the respective *a* and *b* coefficients for the three prescribed commercially important fish families, utilising data sources from FishBase (www.fishbase.org) (Froese & Pauly, 2000), the geometric mean value for *a* and *b* was calculated. This was due to the described potential variation of individual subjects. The components of each calculation were selected based on their reported location (Philippines, Central Indo-Pacific) due to natural abiotic impacts as well as differential spatial fishing intensity. Studies that categorically stated the species body-form and length measurements reported in TL were recorded. Therefore, standard Length ((SL) cm) studies and where FishBase listed the study as "doubtful" were excluded.

The respective genera within each family were individually analysed and the subsequent geometric mean determined for

allometric LWR coefficients. To establish the overall allometric coefficient values for the family, the geometric mean was also calculated. For genera that did not supply studies of values that complied with this report's selection criteria, a Bayesian approach was taken in accordance with Froese et al. (2013). If no Bayesian approach was readily available, the following geometric means were used for data deficient families of the three families: $a = 0.0112$ and $b = 3.04$. When a target species was categorised as a differing body-form to the status-quo of the family, such as Barramundi Cod (*Cromileptes altivelis*) considered as short and deep by FishBase, special consideration was taken with the species' respective allometric coefficients.

If the location of the study and reference were not obtainable, the species-range and native habitat were explored of the fish species through FishBase archives. If the species resided within the central Indo-Pacific region, the assumption was made that the allometric coefficients were obtained from individuals caught within the native habitat – the desired range. If the native range was outside the central Indo-Pacific region, the study was excluded. Following the discussed process, the appropriate a and b values for each commercially important fish family were determined (Table 3).

2.2.3 Visual Assessments of Invertebrates

The diversity and abundance of selected invertebrate families and species were recorded along the same belt transect used for fish. Recorded species are typically targeted for food, collected as curios or important to the ecological balance of the reef (Appendix A). Giant clams (*Takubo*, *Tridacna gigas*) were recorded into the size classes 0-10cm, 11-20cm, 21-30cm, 31-40cm, 41-50cm, 51-60cm and >60cm. Two divers each recorded invertebrates 2.5m either side of the transect line while swimming in a U-shaped search pattern (Fig. 5). Divers looked

in holes and under overhangs to find cryptic organisms such as lobsters and sea urchins.

2.2.4 Substrates

Benthic diversity was measured by recording living and non-living substrate categories along a 'point-intercept' transect (PIT) using a plumb line to minimize bias. Benthic organisms and substrate types directly underneath the transect line were recorded at 50cm intervals along each 20m replicate (Fig. 6). Every 20m replicate contained 40 benthic points. Benthic categories included: sand (SD), rock (RC), rubble (RB), silt/mud (SI), nutrient indicator algae (NIA), sponge (SP), recently killed coral (RKC), soft coral (SC), hard coral (HC) and any other sessile organisms. All hard corals were recorded to life form and level, with targets being recorded in greater detail (Appendix A).

Hard corals were further grouped and analysed for abundance in three conservation classes: disturbance adapted fast growing corals (i.e. *Acropora* spp., Fire coral (*Millepora* sp.), Blue coral (*Heliopora* sp.); competitor corals (i.e. branching, foliose, encrusting, mushroom non-*Acropora* spp.); and stress tolerant corals (i.e. massive, sub-massive, organ pipe (*Tubipora* sp.)), as defined by Edinger & Risk (2000).

2.2.5 Impacts

Within the same area assessed for invertebrates, divers recorded impacts on the reef. The total percentage of bleached coral cover was estimated together with the percentage of bleaching on each individual bleached coral colony. Coral diseases were identified where present and recorded as a percentage of the colony infected. Damage was recorded in three categories: boat/anchor, dynamite and other, on an ordinal scale from 0 to 3 (0=none, 1=low, 2=medium, 3=high). The impact of trash was recorded on the same scale and separated into general and fishing nets/traps.

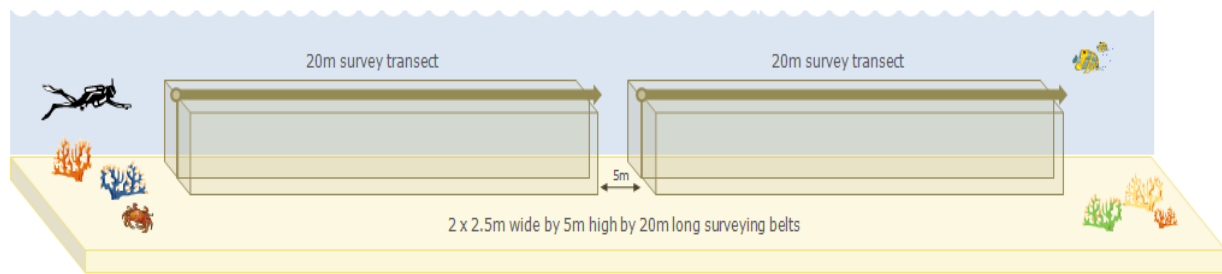


Figure 4. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of fishes within Barangay Napantao. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps. The above represents 2 replicates.

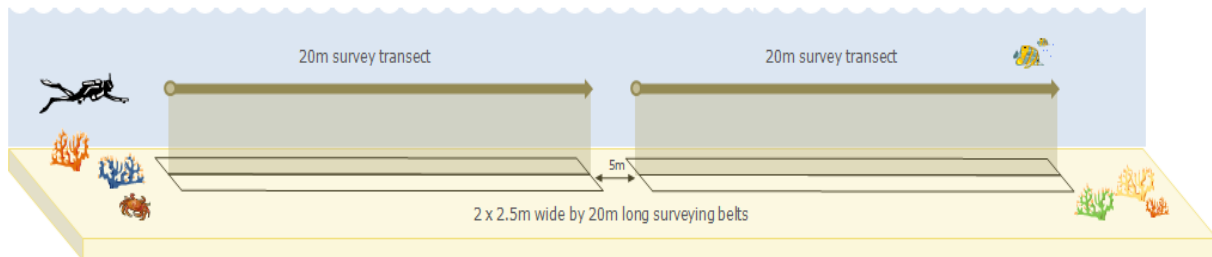


Figure 5. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of invertebrates within Barangay Napantao. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps. The above represents 2 replicates.

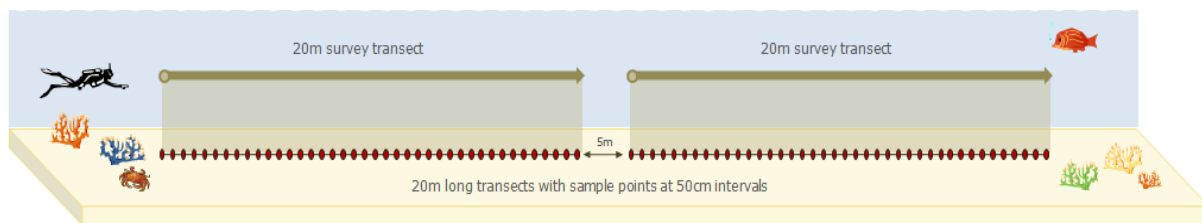


Figure 6. The undertaken point intercept methodology conducted for the assessment of benthic composition within Barangay Napantao. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps with the respective benthic substrate recorded at 0.5m intervals. The above represents 2 replicates.

2.2.6 Data Analysis

Each 20m belt transect was treated as an independent replicate. This produced $n=12$ at 6 meters and $n=12$ at 12 meters. Shapiro-Wilks tests, typically used on small data sets to check for normality, showed much of the data was non-parametric (Shapiro & Wilk, 1965; Thode, 2002). Square root transformations of the non-parametric data did not sufficiently alter the data to warrant using a parametric analysis (O'Hara & Kotze 2010; Morris et al., 2014). Thus, non-parametric Wilcoxon-Mann-Whitney U tests were used to test for statistically significant ($p < 0.05$) differences in the abundance of fishes, commercially important fishes, target butterflyfishes, invertebrates, and substrates between all transects.

Wilcoxon-Mann-Whitney U tests were also utilised to test for significant differences in

biomass (kg) between commercially important fishes as well as invertebrate diversity. Species diversity of fish and invertebrates were determined using Species Richness (S), Shannon's Diversity Index (H'), and Pielou's Evenness (J'). S represents the number of different species found in an ecological community (Whittaker, 1972). H' is used to characterize species diversity based on abundance and evenness and represents the degree of uncertainty relating to an individual's species identity (Morris et al., 2014). J' is used to calculate species evenness by dividing (H') by (S) (Tuomisto, 2012).

Preliminary analysis highlighted the presence of 1000 Fusiliers recorded at transect I01 as an outlier and were subsequently removed from analysis.

3.0 Results

3.1. Fishes

3.1.1. All Fishes

In total, $n = 3101$ individual fishes were recorded inside the MPA, representing 85.37% of all target organisms, with a mean abundance of $N = 129.21 \pm 9.83 \text{ } 500\text{m}^3^{-1}$, throughout the survey period. The most represented target organisms were Fusiliers, Cardinalfish, and Angelfish ($N = 27.25 \pm 7.19 \text{ } 500\text{m}^3^{-1}$, $N = 19.13 \pm 4.83 \text{ } 500\text{m}^3^{-1}$ and $N = 10.79 \pm 1.33 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig. C1).

Outside the MPA, a total of $n = 2066$ individual fishes were recorded, representing 73.17% of all target organisms, with a mean abundance of $N = 86.08 \pm 16.94 \text{ } 500\text{m}^3^{-1}$, throughout the survey period. The most represented target organisms were Cardinalfish, Eastern Triangle Butterflyfish, and Angelfish ($N = 36.25 \pm 15.59 \text{ } 500\text{m}^3^{-1}$, $N = 7.75 \pm 0.94 \text{ } 500\text{m}^3^{-1}$ and $N = 7.42 \pm 1.21 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig. C1).

At the transect resolution, transects I01, I02 and I03 all presented significantly greater total fish abundances ($N = 126.50 \pm 23.21 \text{ } 500\text{m}^3^{-1}$, $N = 126.75 \pm 7.90 \text{ } 500\text{m}^3^{-1}$ and $N = 134.38 \pm 18.56 \text{ } 500\text{m}^3^{-1}$, respectively) than transect O03 ($N = 64.13 \pm 14.77 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$). Transects I02 and I03 also presented a greater total fish abundance than transect O02 ($N = 86.13 \pm 9.55 \text{ } 500\text{m}^3^{-1}$) (Fig 7). No other transects were found to differ significantly, when compared ($p > 0.05$) (Fig. B1).

Mean Species Richness (S) inside the MPA was recorded as $S = 17.88 \pm 0.66 \text{ } 500\text{m}^3^{-1}$, with Shannon-Weiner Diversity (H') recorded as $H' = 2.23 \pm 0.08 \text{ } 500\text{m}^3^{-1}$ and Pielou's evenness (J) recorded as $J = 0.77 \pm 0.02 \text{ } 500\text{m}^3^{-1}$. Outside the MPA, mean S was recorded as $S = 12.91 \pm 0.80 \text{ } 500\text{m}^3^{-1}$, with Shannon-Weiner

Diversity (H') recorded as $H' = 1.95 \pm 0.10 \text{ } 500\text{m}^3^{-1}$ and Pielou's evenness (J) recorded as $J = 0.78 \pm 0.04 \text{ } 500\text{m}^3^{-1}$.

Mean fish abundance, S and H were all found to be significantly higher within the MPA compared to outside ($p < 0.05$). Pielou's Evenness was not found to differ significantly inside the MPA compared to outside ($p > 0.05$).

At the transect resolution, species richness was found to be greater at transects I01 and I03 ($S = 19.00 \pm 1.13 \text{ } 500\text{m}^3^{-1}$ and $S = 18.38 \pm 1.02 \text{ } 500\text{m}^3^{-1}$, respectively) than that of transects O01 and O03 ($S = 11.25 \pm 1.22 \text{ } 500\text{m}^3^{-1}$ and $S = 12.75 \pm 1.36 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Table. 4). Species richness was also greater at transect I02 ($S = 16.25 \pm 1.19 \text{ } 500\text{m}^3^{-1}$) than transect O01 ($p < 0.05$). Transect I01 displayed a greater diversity ($H' = 2.58 \pm 0.04 \text{ } 500\text{m}^3^{-1}$) than all other transects ($p < 0.05$) (Table 4). Transect O02 displayed a greater diversity than transect O01 ($H' = 2.14 \pm 0.09 \text{ } 500\text{m}^3^{-1}$ and $H' = 1.67 \pm 0.20 \text{ } 500\text{m}^3^{-1}$, respectively). Transect I01 presented a greater degree of Pielou's evenness (J') ($J' = 0.89 \pm 0.01 \text{ } 500\text{m}^3^{-1}$) than transects I02, I03 and O02 ($J' = 0.72 \pm 0.04 \text{ } 500\text{m}^3^{-1}$, $J' = 0.73 \pm 0.04 \text{ } 500\text{m}^3^{-1}$ and $J' = 0.80 \pm 0.03 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$). Transect O02 also presented a greater degree of evenness than transect I02 ($p < 0.05$) (Table. 4). No other transects were found to differ in terms of S , H' or J , when compared ($p > 0.05$) (Fig. B2).

Table 4. Mean Diversity indices for target fish Species Richness (S) and Shannon-Weiner Diversity (H') and Pielou's Evenness (J) per 500m³, with standard error ($\pm SE$) across transects in Napantao, San Francisco, Southern Leyte.

Transect	S (500m ³ ⁻¹)		H' (500m ³ ⁻¹)		J' (500m ³ ⁻¹)	
	S	$\pm$	H'	$\pm$	J'	$\pm$
I01	19	1.13	2.58	0.04	0.88	0.01
I02	16.25	1.19	1.99	0.15	0.72	0.04
I03	18.37 5	1.02	2.11	0.11	0.73	0.04
O01	11.25	1.22	1.67	0.20	0.72	0.10
O02	14.75	1.42	2.14	0.09	0.81	0.03
O03	12.75	1.36	2.02	0.16	0.80	0.05

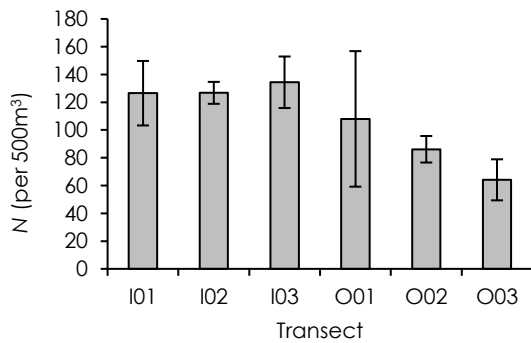


Figure 7: Mean target fish abundance per 500m³ with standard error ($\pm SE$) between transects in Napantao, San Francisco, Southern Leyte.

3.1.2. Butterflyfish

Throughout the sample period, a total of $n = 351$ butterflyfish were recorded inside the MPA, representing 100% of all target butterflyfish species, with a mean abundance of $N = 14.63 \pm 1.48$ 500m³⁻¹. The most represented target butterflyfish within the MPA were Eastern Triangle Butterflyfish, Redfin Butterflyfish and other, undescribed, Butterflyfish ($N = 7.63 \pm 0.74$ 500m³⁻¹, $N = 2.38 \pm 0.44$ 500m³⁻¹ and $N = 1.92 \pm 0.39$ 500m³⁻¹, respectively). Outside the MPA, a total of $n = 219$ butterflyfish were recorded, representing 75% of all target butterflyfish species, with a mean abundance of $N = 9.13 \pm 1.22$ 500m³⁻¹. The most represented target butterflyfish outside of the MPA were Eastern Triangle Butterflyfish, Vagabond Butterflyfish and other, undescribed, Butterflyfish ($N = 7.75 \pm$

0.94 500m³⁻¹, $N = 0.33 \pm 0.16$ 500m³⁻¹ and $N = 0.38 \pm 0.13$ 500m³⁻¹, respectively).

At the transect resolution, transects I01, I02 and I03 presented greater abundance of target butterflyfish species ($N = 18.75 \pm 2.85$ 500m³⁻¹, $N = 11.38 \pm 2.65$ 500m³⁻¹ and $N = 13.75 \pm 1.56$ 500m³⁻¹, respectively) than transects O01 and O02 ($N = 6.88 \pm 1.97$ 500m³⁻¹ and $N = 11.88 \pm 1.20$ 500m³⁻¹, respectively) ($p < 0.05$). Transect O03 ($N = 8.63 \pm 2.73$ 500m³⁻¹) also had a greater abundance of butterflyfish than transect O01 ($p < 0.05$). No other transects were found to differ in terms of overall butterflyfish abundance, when compared (Fig B3).

Butterflyfish were categorised by feeding traits. Within the MPA, a total of $n = 240$ obligate corallivores and $n = 65$ facultative feeders, compared to $n = 190$ obligate corallivores and $n = 20$ facultative feeders outside of the MPA. At the transect resolution, transects I01, I03 and O02 presented greater abundances of obligate corallivores ($N = 11.25 \pm 1.95$ 500m³⁻¹, $N = 10.00 \pm 1.09$ 500m³⁻¹ and $N = 10.25 \pm 1.01$ 500m³⁻¹, respectively) than transect O01 ($N = 6.13 \pm 1.79$ 500m³⁻¹) ($p < 0.05$) (Fig. 8). Transect I01 presented a greater abundance of facultative feeders ($N = 5.38 \pm 1.60$ 500m³⁻¹) than all other transects ($p < 0.05$) (Fig. 8). All transects presented significantly greater abundances of obligate corallivores than facultative feeders ($p < 0.05$) (Fig. 8).

3.1.3. Commercially Important Fishes

Inside the MPA, 17.38% ($n = 359$) of all fishes recorded throughout the survey were considered as commercially important (Parrotfish, Grouper and Snapper), giving a mean commercial fish abundance of $N = 14.96 \pm 2.37$ 500m³⁻¹. Of this overall commercial fish count within the MPA, Parrotfish contributed the greatest (69.64%), with a mean abundance of $N = 11.90 \pm 3.71$ 500m³⁻¹, followed by Grouper (26.18%), with a mean abundance of $N = 4.48 \pm 1.82$ 500m³⁻¹,

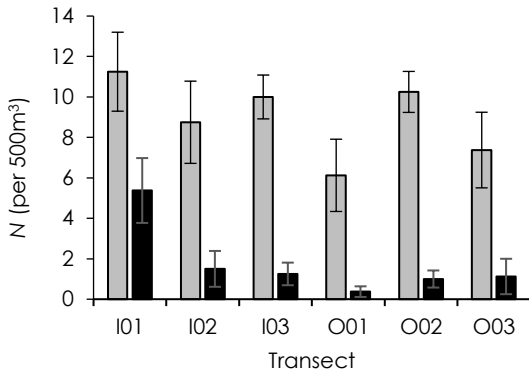


Figure 8: Mean obligate (grey) and facultative (black) butterflyfish abundance per 500m³ with standard error ($\pm$ SE) between transects in Napantao, San Francisco, Southern Leyte.

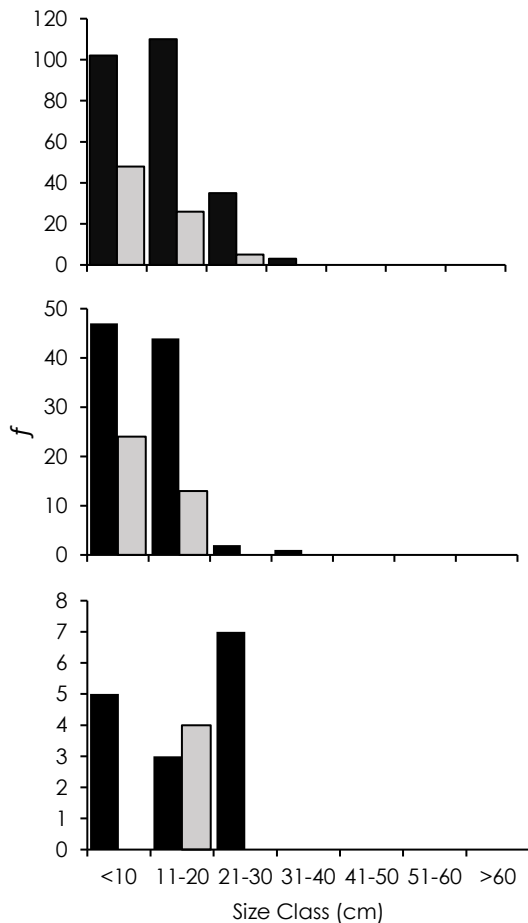


Figure 9: Total frequency (f) of Parrotfish (a), Snapper (b) and Grouper (c) by size class inside (Black) and outside (Grey) of the MPA at Napantao, San Francisco, Southern Leyte.

and Snapper (4.18%), with a mean abundance of $N = 0.48 \pm 0.26$ 500m⁻³.

Parrotfish and Grouper were present in size classes <10cm, 11-20cm, 21-30cm and 31-40cm (Parrotfish $f = 102$, $f = 110$, $f = 35$ and $f = 3$, respectively and Grouper $f = 47$, $f = 44$, $f = 2$ and $f = 1$, respectively). Snapper were present in size classes <10cm, 11-20cm and 21-30cm ($f = 5$, $f = 3$ and $f = 7$, respectively) (Fig. 9).

This is in comparison to outside the MPA, where 5.81% ($n = 120$) of all fishes recorded throughout the survey were considered as commercially important, giving a mean commercial fish abundance of $N = 5.00 \pm 0.94$ 500m⁻³. Of this overall commercial fish count outside the MPA, again Parrotfish contributed the greatest (65.83%), with a mean abundance of $N = 3.76 \pm 1.33$ 500m⁻³, followed by Grouper (30.83%), with a mean abundance of $N = 1.76 \pm 0.74$ 500m⁻³, and Snapper (3.33%, with a mean abundance of $N = 0.19 \pm 0.15$ 500m⁻³). Parrotfish were present in size classes <10cm, 11-20cm and 21-30cm ($f = 48$, $f = 26$ and $f = 5$, respectively), Grouper were present in size classes <10cm and 11-20cm ($f = 24$ and $f = 13$, respectively) and Snapper were only present in size class 11-20cm ($f = 4$) (Fig. 9).

At the transect resolution, transect I01, I02 and I03 all presented greater abundances of Parrotfish ($N = 14.63 \pm 5.50$ 500m⁻³, $N = 9.75 \pm 1.76$ 500m⁻³ and $N = 6.88 \pm 0.85$ 500m⁻³, respectively) than transects O01 and O02 ($N = 2.88 \pm 0.97$ 500m⁻³ and $N = 3.75 \pm 0.59$ 500m⁻³, respectively) ($p = <0.05$) (Fig. 10). Transect I01 presented greater mean abundance of Grouper ($N = 6.63 \pm 2.54$ 500m⁻³) than transects O01 and O03 ($N = 0.88 \pm 0.40$ 500m⁻³ and $N = 1.50 \pm 0.65$ 500m⁻³, respectively) ($p = <0.05$). Transect I02 also presented a greater mean abundance of Grouper ($N = 2.25 \pm 0.31$ 500m⁻³) than transect O01 ($p = <0.05$) (Fig. 10). Transect I02 presented a greater abundance of Snapper ($N = 0.75 \pm 0.37$ 500m⁻³) than transect O03 ($p = <0.05$) (Fig. 10). No other transects were found to differ significantly in either Parrotfish, Grouper or Snapper.

The total standing biomass (kg) of commercially important fish recorded within the MPA was 25.55kg, with a mean biomass of $0.35 \pm 0.07\text{kg } 500\text{m}^3$. Parrotfish standing biomass (19.61kg) was the greatest, with a mean biomass of $0.82 \pm 0.17\text{kg } 500\text{m}^3$, followed by Grouper (3.86kg), with a mean biomass of $0.16 \pm 0.06\text{kg } 500\text{m}^3$, and Snapper (2.08kg), with a mean biomass of $0.09 \pm 0.05\text{kg } 500\text{m}^3$. The total standing biomass (kg) of commercially important fish recorded outside of the MPA was 4.25kg, with a mean biomass of $0.06 \pm 0.02\text{kg } 500\text{m}^3$. Parrotfish standing biomass (3.20kg) was the greatest, with a mean biomass of $0.13 \pm 0.04\text{kg } 500\text{m}^3$, followed by Grouper (0.81kg), with a mean biomass of $0.03 \pm 0.01\text{kg } 500\text{m}^3$, and Snapper (0.24kg), with a mean biomass of $0.01 \pm 0.01\text{kg } 500\text{m}^3$.

At the transect resolution, transects I01, I02 and I03 all had greater mean biomass of Parrotfish ($1.44 \pm 0.41\text{kg } 500\text{m}^3$, $0.42 \pm 0.08\text{kg } 500\text{m}^3$ and $0.59 \pm 0.12\text{kg } 500\text{m}^3$, respectively) than transects O01, O02 and O03 ($0.15 \pm 0.11\text{kg } 500\text{m}^3$, $0.11 \pm 0.03\text{kg } 500\text{m}^3$ and $0.14 \pm 0.07\text{kg } 500\text{m}^3$, respectively) ($p < 0.05$) (Fig. 11). The same was true of Grouper, with mean biomass being higher at transects I01, I02 and I03 ($0.38 \pm 0.16\text{kg } 500\text{m}^3$, $0.03 \pm 0.01\text{kg } 500\text{m}^3$ and $0.07 \pm 0.03\text{kg } 500\text{m}^3$, respectively) than transects O01, O02 and O03 ($0.02 \pm 0.01\text{kg } 500\text{m}^3$, $0.04 \pm 0.02\text{kg } 500\text{m}^3$ and $0.04 \pm 0.04\text{kg } 500\text{m}^3$, respectively), and was also higher at transect I01 than I02 ($p < 0.05$) (Fig. 11). Mean Snapper biomass was higher at transect I02 ($0.01 \pm 0.01\text{kg } 500\text{m}^3$) than transect O03 ($p < 0.05$) (Fig. 11). No other transects were found to differ in terms of Parrotfish, Grouper or Snapper biomass, when compared ($p > 0.05$) (Fig. B5).

3.2. Invertebrates

In total, $n = 3199$ individual invertebrates were recorded within the MPA, composing 61.29% of the total target organism list, with a mean abundance of $N = 133.29 \pm 12.01 \text{ } 100\text{m}^2$. Target organisms Brittle Stars, Feather Stars

and Drupella were recorded in the greatest densities ($N = 41.92 \pm 4.14 \text{ } 100\text{m}^2$, $N = 30.83 \pm 6.14 \text{ } 100\text{m}^2$ and $N = 16.63 \pm 3.63 \text{ } 100\text{m}^2$, respectively) (Fig. C2). This is in comparison to outside of the MPA, where a total of $n = 2861$ individual invertebrates were recorded, composing 70.79% of the total target organism list, with a mean abundance of $N = 119.21 \pm 10.59 \text{ } 100\text{m}^2$. Target organisms Brittle Stars, Feather Stars and other Gastropods were recorded in the greatest densities ($N = 34.25 \pm 4.57 \text{ } 100\text{m}^2$, $N = 30.46 \pm 2.91 \text{ } 100\text{m}^2$ and $N = 16.79 \pm 2.94 \text{ } 100\text{m}^2$, respectively) (Fig. C2).

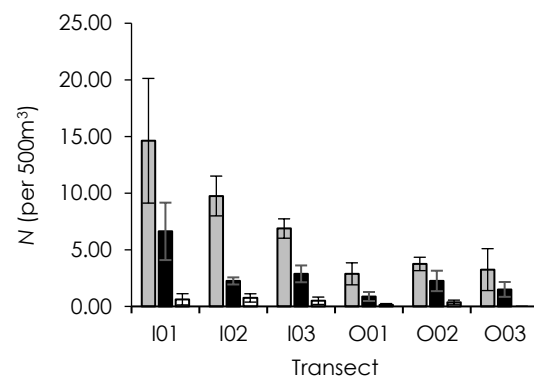


Figure 10: Mean parrotfish (grey), grouper (black) and snapper (white) abundance per 500m³ with standard error ($\pm$ SE) between transects in Napantao, San Francisco, Southern Leyte.

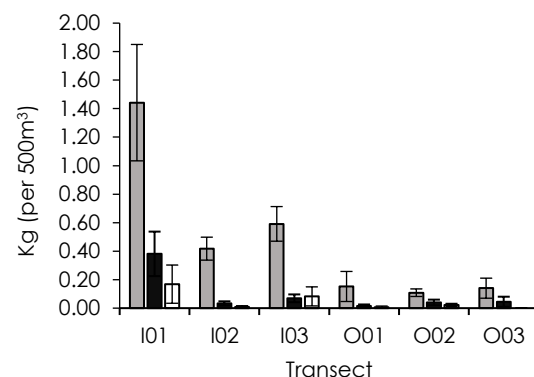


Figure 11: Mean parrotfish (grey), grouper (black) and snapper (white) biomass (kg) per 500m³ with standard error ($\pm$ SE) between transects in Napantao, San Francisco, Southern Leyte.

At the transect resolution, transect I01 presented a greater mean invertebrate abundance ($N = 182.63 \pm 26.35 \text{ } 100\text{m}^2^{-1}$) than transects I02 and O03 ($N = 97.75 \pm 8.10 \text{ } 100\text{m}^2^{-1}$ and $N = 103.00 \pm 19.33 \text{ } 100\text{m}^2^{-1}$, respectively) ($p = <0.05$) (Fig. 12). Transect O02 presented greater mean invertebrate abundance ($N = 151.88 \pm 5.24 \text{ } 100\text{m}^2^{-1}$) than transects I02 and I03 ($N = 97.75 \pm 8.10 \text{ } 100\text{m}^2^{-1}$ and $N = 119.50 \pm 10.27 \text{ } 100\text{m}^2^{-1}$, respectively) ($p = <0.05$) (Fig. 12). No other transect were found to differ in mean invertebrate abundance, when compared ($p = >0.05$) (Fig. B6).

Mean invertebrate species richness (S), over the sample period, was recorded as $S = 10.25 \pm 0.48 \text{ } 100\text{m}^2^{-1}$ inside the MPA, compared to as $S = 10.96 \pm 0.56 \text{ } 100\text{m}^2^{-1}$ outside the MPA. At the transect resolution, transect O02 presented greater species richness ($S = 10.63 \pm 0.94 \text{ } 100\text{m}^2^{-1}$) than transect O01 ($S = 9.50 \pm 0.78 \text{ } 100\text{m}^2^{-1}$) ($p = <0.05$) (Table 5). Mean diversity (H') over the sample period within the MPA was $H' = 1.86 \pm 0.04 \text{ } 100\text{m}^2^{-1}$, compared to $H' = 1.87 \pm 0.05 \text{ } 100\text{m}^2^{-1}$ outside the MPA. At the transect resolution, transect I03 presented greater diversity ($H' = 1.96 \pm 0.05 \text{ } 100\text{m}^2^{-1}$) than transect I01 ($H' = 1.73 \pm 0.07 \text{ } 100\text{m}^2^{-1}$) ($p = <0.05$) (Table 4). Mean Pielou's evenness (J') was found to be $J' = 0.74 \pm 0.01 \text{ } 100\text{m}^2^{-1}$ both inside and outside the MPA. At the transect resolution, transects I02, I03 and O03 presented a greater degree of evenness ($J' = 0.76 \pm 0.02 \text{ } 100\text{m}^2^{-1}$, $J' = 0.77 \pm 0.01 \text{ } 100\text{m}^2^{-1}$ and $J' = 0.76 \pm 0.02 \text{ } 100\text{m}^2^{-1}$, respectively) than transect I01 ($J' = 0.70 \pm 0.01 \text{ } 100\text{m}^2^{-1}$) ($p = >0.05$) (Table 5). Transect I03 also presented a greater degree of evenness than transect O02 ($J' = 0.72 \pm 0.02 \text{ } 100\text{m}^2^{-1}$) ($p = >0.05$) (Table 5). No other significant differences were found in S , H' or J' between transects, when compared ($p = >0.05$) (Fig. B7).

In total, $n = 9$ giant clams were present within the MPA, with a mean of $N = 0.38 \pm 0.12 \text{ } 100\text{m}^2^{-1}$. They were present in size classes 0-10cm, 11-20cm, 21-30cm, 31-40cm and 41-

50cm ($f = 1$, $f = 3$, $f = 1$, $f = 3$ and $f = 1$, respectively) (Fig. 13). This is compared to outside the MPA, where a total of $n = 5$ giant clams were present, with a mean of $N = 0.21 \pm 0.21 \text{ } 100\text{m}^2^{-1}$. They were present in size classes 0-10cm and 11-20cm ($f = 1$ and $f = 4$, respectively) (Fig. 13). Crown of Thorns Sea Stars (COTS) were also present both inside ($n = 12$) and outside ($n = 14$) the MPA, with a mean abundance of $N = 0.50 \pm 0.17 \text{ } 100\text{m}^2^{-1}$ inside the MPA and $N = 0.58 \pm 0.23 \text{ } 100\text{m}^2^{-1}$ outside the MPA.

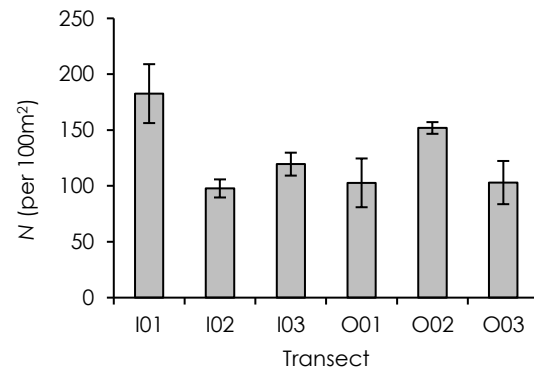


Figure 12: Mean invertebrate abundance per 100m² with standard error ($\pm$ SE) between transects in Napantao, San Francisco, Southern Leyte.

Table 5. Mean Diversity indices for target invertebrate Species Richness (S) and Shannon-Weiner Diversity (H') and Pielou's Evenness (J') per 100m², with standard error ($\pm$ SE) across transects in Napantao, San Francisco, Southern Leyte.

Transect	S (100m² ⁻¹)		H' (100m² ⁻¹)		J' (100m² ⁻¹)	
	S	$\pm$	H'	$\pm$	J'	$\pm$
I01	10.00	0.65	1.73	0.07	0.70	0.01
I02	10.00	0.71	1.89	0.07	0.76	0.02
I03	10.75	1.15	1.96	0.05	0.77	0.01
O01	9.50	0.78	1.75	0.10	0.72	0.03
O02	12.75	0.90	1.94	0.07	0.72	0.02
O03	10.63	0.94	1.91	0.07	0.76	0.02

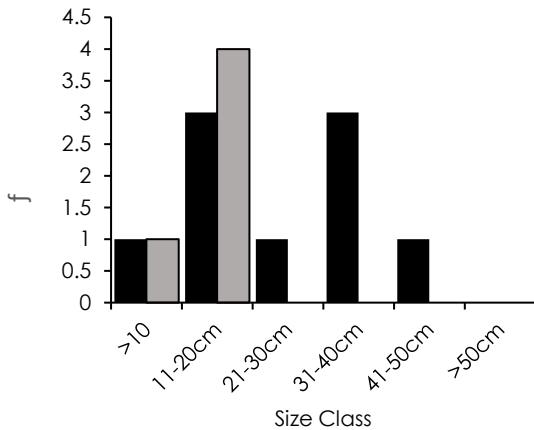


Figure 13: Total frequency (f) of Giant Clams by size class inside (Black) and outside (Grey) of the MPA at Napantao, San Francisco, Southern Leyte.

3.3 Substrates

Hard Coral (HC) was recorded as the dominant substrate within the MPA ($53.44 \pm 3.06\% \text{ } 20\text{m}^{-1}$), followed by Rock (RC) and Other (OT) ($15.31 \pm 1.53\% \text{ } 20\text{m}^{-1}$ and $12.08 \pm 1.77\% \text{ } 20\text{m}^{-1}$, respectively) (Fig. 14). Similarly, outside of the MPA Hard Coral (HC) was also recorded as the dominant substrate ($40.42 \pm 4.34\% \text{ } 20\text{m}^{-1}$). This was followed by Sand (SD) and Rock (RC) ($21.88 \pm 5.15\% \text{ } 20\text{m}^{-1}$ and $11.98 \pm 1.53\% \text{ } 20\text{m}^{-1}$, respectively) (Fig. 14).

HC cover was significantly higher than all other substrates both inside and outside the MPA ($p = <0.05$) (Fig. 14). RC cover was significantly higher than Silt (SI), Rubble (RB), Sand (SD), Nutrient Indicator Algae (NIA), Soft Coral (SC), Recently Killed Coral (RKC) and Sponge (SP) both inside and outside of the MPA ($p = <0.05$) (Fig. 14). Other Substrate (OT) cover was significantly higher than SI, RB, SD, NIA, SC, RKC and SP inside the MPA, and higher than all of these except SD outside the MPA, which was higher than SC, SP, RKC, SI and NIA ($p = <0.05$) (Fig. 14). Overall, HC cover was higher inside than outside the MPA ($p = <0.05$) and SD cover was higher outside than inside the MPA ($p = <0.05$) (Fig. 14). No other substrates were found to differ significantly from each other inside and outside of the MPA ($p = >0.05$) (Fig. B8).

At the transect resolution, HC cover was significantly higher at transect I01 ($69.69 \pm 1.80\% \text{ } 20\text{m}^{-1}$) than all other transects, and significantly higher at transect I03 ($53.13 \pm 1.88\% \text{ } 20\text{m}^{-1}$) than transects I02 and O02 ($37.50 \pm 3.37\% \text{ } 20\text{m}^{-1}$ and $39.38 \pm 4.00\% \text{ } 20\text{m}^{-1}$, respectively) ($p = <0.05$) (Table 6). RC cover did not differ significantly at any transects ($p = >0.05$) (Table 6). OT cover was significantly higher at transects I02 and O02 ($17.81 \pm 3.29\% \text{ } 20\text{m}^{-1}$ and $21.25 \pm 3.66\% \text{ } 20\text{m}^{-1}$, respectively) than transects I01, O01 and O03, and higher at transect I03 ($12.81 \pm 2.34\% \text{ } 20\text{m}^{-1}$) than transect I01 ($p = <0.05$) (Table 6). SD cover was higher at transect O01 ($31.25 \pm 8.13\% \text{ } 20\text{m}^{-1}$) than transects I01, I02, I03 and O02 and higher at transects I03 and O02 ($6.25 \pm 1.89\% \text{ } 20\text{m}^{-1}$ and $13.44 \pm 6.44\% \text{ } 20\text{m}^{-1}$, respectively) than transect I01 ($p = <0.05$) (Table 6). No other transects were found to differ in terms of HC, OT or SD cover when compared ($p = >0.05$) (Fig. B9).

Of the hard coral cover, the dominant life form throughout the survey area was *Acropora* Branching Coral (ACB), both inside ($29.43\% \text{ } 20\text{m}^{-1}$) and outside ($18.30\% \text{ } 20\text{m}^{-1}$) the MPA. This was followed by non-*Acropora* Sub-massive Corals (CS) both inside ($13.84\% \text{ } 20\text{m}^{-1}$) and outside ($18.04\% \text{ } 20\text{m}^{-1}$) the MPA. The third most dominant life form inside the MPA was non-*Acropora* Massive Corals (CM) ($13.26\% \text{ } 20\text{m}^{-1}$) and outside the MPA was non-*Acropora* branching corals (CB) ($12.11\% \text{ } 20\text{m}^{-1}$) (Fig. 15). ACB cover was significantly higher inside the MPA compared to outside ($p = <0.05$) (Fig. 15). No other hard coral types differed from each other inside and outside the MPA ($p = >0.05$).

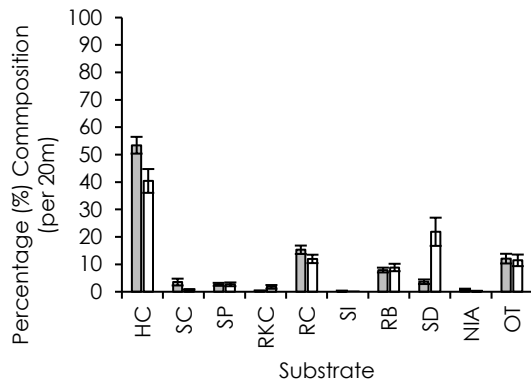


Figure 14: Mean composition (%) substrates per 20m with standard error ($\pm$ SE) inside (grey) and outside (white) of the MPA at Napantao, San Francisco, the Philippines. RKC= Recently Killed Coral, OT= Other, SC= Soft Coral, SP= Sponge, SI= Silt, HC= Hard Coral, NIA= Nutrient Indicator Algae, RC= Rock, RB= Rubble and SD= Sand.

Inside the MPA, Fast Growing Corals (FGC) made up 38.01%, Stress Tolerant Corals (STC) made up 27.88% and Competitor Corals (CC) made up 34.11% of total hard coral cover. None of these were found to differ significantly, when compared ($p = >0.05$). Outside the MPA, FGC made up 31.70%, STC made up 28.35% and CC made up 39.95% of total hard coral cover, and none differed significantly from each other ($p = >0.05$).

At the transect resolution, transect I03 had a significantly higher covering of FGC ($30.94 \pm 4.25\%$ $20m^{-1}$) than transects I01, O02 and O03, and was higher at transect I02 ($18.44 \pm 3.06\%$ $20m^{-1}$) than transect I01 ($p = <0.05$) (Fig. 16). STC cover was significantly higher at transect I01 ($28.75 \pm 3.69\%$ $20m^{-1}$) than all other transects ($p = <0.05$) Fig. 16). CC cover was significantly higher at transect I01 ($29.38 \pm 3.23\%$ $20m^{-1}$) than all transects except O03 ($25.31 \pm 6.10\%$ $20m^{-1}$), and higher at transect O03 than transect O01 ($p = <0.05$) (Fig. 16). No other transects were found to differ in terms of either FGC, STC or CC cover, when compared ($p = >0.05$) (Fig. B10).

3.4 Impacts

During the survey, 1 instance of a direct anthropogenic impact was recorded within

the MPA in the form of boat/anchor damage. No direct anthropogenic impacts were recorded (boat/anchor/dynamite damage) outside of the MPA. Other, undescribed, damage was recorded a total of 10 times inside the MPA, and 13 times outside of the MPA.

Fishing trash was recorded in low levels (1 piece) on 12.50% of replicates, in medium levels (2 pieces) on 12.50% of replicates and in high levels (3+ pieces) on 8.33% of replicates inside the MPA. Fishing trash was recorded in low levels on 25.00% and medium levels on 4.17% of replicates outside of the MPA. Overall levels of fishing trash, however, did not differ significantly inside and outside of the MPA ($p = >0.05$) (Fig. 17). General trash was recorded in low levels on 29.17% of replicates, medium levels on 20.83% of replicates and high levels on 4.17% of replicates inside the MPA, and in high levels on 37.50%, medium levels on 45.83% and high levels on 4.17% of replicates outside of the MPA. Levels of general trash were significantly higher outside the MPA than inside ($p = <0.05$) (Fig. 17).

Three instances of black band disease were recorded throughout the survey period, all outside of the MPA and all affecting less than 0.1% of the total population on the replicate on which they were found. Bleaching was recorded a total of 13 times inside the MPA and 17 times outside of the MPA. Bleaching never affected more than 1% of the colony on which it was recorded.

Table 6: Mean percentage (%) cover of benthic substrate types per 20m with standard error ($\pm$) between transects in Napantao, San Francisco, Southern Leyte. HC= Hard Coral, SC= Soft Coral, SP= Sponge, RKC= Recently Killed Coral, RC= Rock, SI= Silt, RB= Rubble, SD= Sand, NIA= Nutrient Indicator Algae, and OT= Other.

Transect	HC		SC		SP		RKC		RC		SI		RB		SD		NIA		OT	
	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$
I01	69.69	1.80	1.25	0.67	2.81	1.00	0.31	0.31	13.75	2.06	0.00	0.00	5.31	1.00	0.94	0.46	0.31	0.31	5.63	1.93
I02	37.50	3.37	7.81	3.18	1.88	0.63	0.31	0.31	19.69	2.93	0.63	0.63	9.69	2.14	3.75	1.06	0.94	0.46	17.81	3.29
I03	53.13	1.88	1.56	0.81	3.44	1.15	0.31	0.31	12.50	2.45	0.00	0.00	8.75	0.67	6.25	1.89	1.25	0.67	12.81	2.34
O01	33.13	8.75	0.31	0.31	2.19	1.29	4.38	1.69	10.00	4.06	0.00	0.00	12.19	3.58	31.25	8.13	0.31	0.31	6.25	2.67
O02	39.38	4.00	0.63	0.41	2.50	1.06	0.94	0.46	14.38	1.13	0.00	0.00	7.19	1.10	13.44	6.44	0.31	0.31	21.25	3.66
O03	48.75	8.69	1.25	0.47	3.44	1.33	0.00	0.00	11.56	2.00	0.00	0.00	20.94	1.29	20.94	11.43	0.00	0.00	6.88	1.62

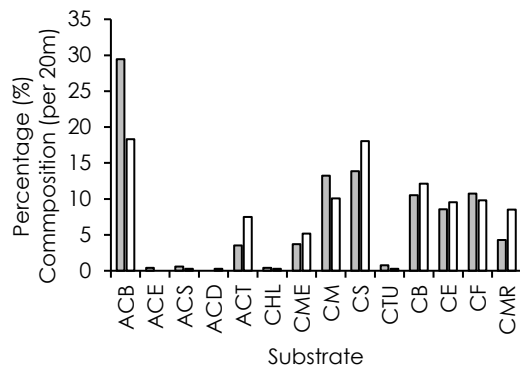


Figure 15. Mean percentage (%) of Hard Coral life forms per 20m in all transects inside (grey) and outside (white) the MPA Napantao, San Francisco, Southern Leyte. ACB= Acropora Branching, CTU= Tubipora spp., CME= Millepora spp., CHL= Heliopora spp., CMR= Non-acropora Mushroom, CF= Non-acropora Foliose, ACT= Acropora Tabulate, ACD= Acropora Digitate, ACS= Acropora Sub-massive, ACE= Acropora Encrusting, CS= Non-acropora Sub-massive, CM= Non-acropora Massive, CB= Non-acropora Branching and CE= Non-acropora Encrusting.

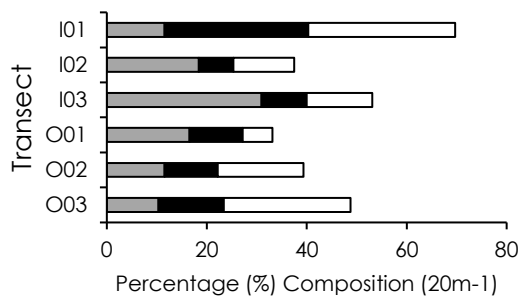


Figure 16. Percentage (%) cover of coral life forms per 20m with standard error ($\pm$ SE) between transects in Napantao, San Francisco, Southern Leyte. FGC= Fast growing Corals (Grey), STC= Stress Tolerant Corals (Black) and CC= Competitor Corals (White)

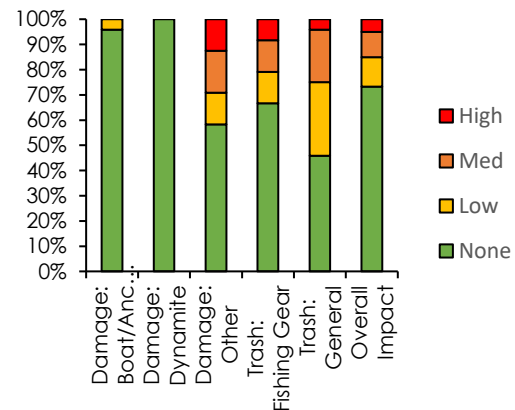


Figure 17a. Total impact scale recorded inside the MPA at Napantao San Francisco, Southern Leyte. Counts of impacts are categorized to scale (0= none, 1= low, 2-4= medium and >5= high), which is applied to each recorded impact category as a percentage (%) of the surveyed area, split into two categories (coral damage and trash); Boat/Anchor Damage, Dynamite, Other, Fishing Gear, and General. Total overall impact count is also given that incorporates impact counts from the other 5 categories.

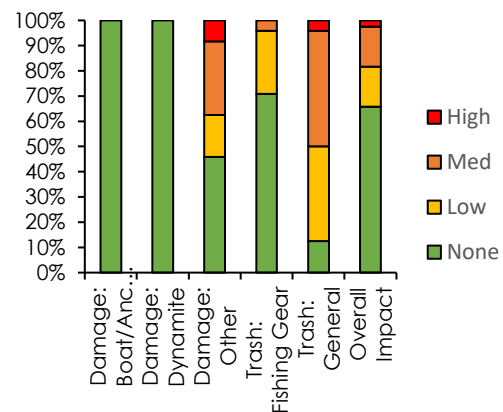


Figure 17b. Total impact scale recorded outside the MPA at Napantao San Francisco, Southern Leyte. Counts of impacts are categorized to scale (0= none, 1= low, 2-4= medium and >5= high), which is applied to each recorded impact category as a percentage (%) of the surveyed area, split into two categories (coral damage and trash); Boat/Anchor Damage, Dynamite, Other, Fishing Gear, and General. Total overall impact count is also given that incorporates impact counts from the other 5 categories.

4.0 Discussion

This study assessed the current state of the Marine Protected Area (MPA) which is instated at Barangay Napantao (Municipality San Francisco). To ensure all potential indicators of the health of the community within the MPA were included in the assessment, factors including current community status, connectivity, larval supply, resilience capacity, and community resistance to environmental stressors must all be taken into consideration. This study focuses on the current community structure (species richness, diversity, abundance and distribution) of target survey species inside and outside of the Napantao MPA.

Results indicated an above average abundance of coral-reliant fish species both inside and outside of the MPA when compared to other sites around Sogod Bay, Southern Leyte in 2017. Commercially important fish species were found in higher abundances and in larger size classes inside the MPA compared to outside, indicating that current protection is beneficial to individuals inside the MPA and areas with no protection (outside the MPA), fishers are benefitting from these larger individuals. Commercially important invertebrate species weren't present inside or outside of the MPA, indicative of historic harvesting. Levels of hard coral and exposed rocky substrate were higher inside the MPA than outside, and the amount of sand cover was higher outside than in. However, it is important to note the substrate within the MPA likely had a higher conservation value at the time of ordinance, as this is often one criterion used to select areas for protection (Selig & Bruno, 2010). Therefore, the results obtained inside the MPA, whilst positive, cannot be conclusively a result of the MPA's ordinance over time and could be a result of the MPA's spatial establishment.

4.1. Fish

Overall, fish abundance was higher inside of the MPA than outside, with significant differences being found between individual transects inside compared to outside of the MPA. Fish abundance this year was also higher inside the MPA, and lower outside of the MPA, than during the 2016 survey (Parker et al., 2017). Transect O03, the furthest from the MPA, was found to present significantly lower abundance of fish than all three transects within the MPA. This is as to be expected from an MPA of this size, where the spill over effect is most noticeable close to the boundaries of the MPA (Perez-Rufaza et al., 2008), and demonstrates effective protection.

Analysis of diversity indices showed species richness S to be higher inside the MPA than outside, indicating high levels of fishing outside of the MPA, potentially targeting specific families/species of fish. Shannon-Weiner diversity H' was higher at some transects inside the MPA than outside. As well as this, some differences were found between transects outside of the MPA, but no transects outside the MPA showed a higher level of H' than any inside. This suggests the community within the MPA is more resilient to future disturbances than the community outside of the MPA (Downing et al., 2012), however further analysis on functional guilds is required, and to have a higher level of reliability where reliability refers to the probability that a system will provide a consistent level of performance over a given unit of time (Naeem & Li, 1997). Though it differed between transects, levels of Pielou's evenness J' were not overall higher or lower inside than outside of the MPA, which could be an indicator of a diverse, habitat inside and outside of the MPA which supports different community

assemblages, preventing the dominance of particular species. It must be noted that due to the pre-assigned target organisms surveyed, as well as family and genus grouping, as apposed to recording the true presence of all fish species, dominance of particular species, or functional guilds, may not have been recorded.

The most dominant fish inside the MPA were Fusiliers, even once a school of 1000 individuals was removed from analysis as an outlier. Although not important in industrial fishing, Fusiliers often make up a significant part of artisanal multi-species catches in areas where they are present (Carpenter, 1998), so their high abundance within the MPA is likely to supplement local fish stocks. Outside of the MPA, the most abundant fish were Cardinalfish. At diurnal resting sites, Cardinalfish have been shown to be strongly associated with branching corals (Gardiner & Jones, 2010), in which they hide away. Their cryptic nature and small size mean they are less likely to be targeted, or removed through accidental catch, which could explain their high abundance both inside and outside of the MPA.

Generally, abundance, diversity and species richness were all higher outside of the MPA than inside. This shows effective protection and suggests that spillover is occurring, and the fish that move outside of the MPA are being fished. As increasing fish stocks is one aim of this MPA, the results indicate the MPA is proving beneficial. It is also likely indicative of the substrate and habitat type inside the MPA being able to support a complex community assemblage when compared to outside the MPA, which is likely why the site was selected.

4.1.1 Butterflyfish

Butterflyfish abundance and diversity was also recorded in the survey, due to their energetic demands being so intimately linked to the existence and overall condition or "health" of the coral substrate (Crosby & Reese 1996). By analysing butterflyfish

diversity and abundance independently of total fish results, butterflyfish presence can act as indicators of changes in conditions on coral reefs (Crosby & Reese 1996). Many species of butterflyfish are obligate corallivores, depending on the live tissue of corals for their food. These obligate corallivores used in the survey show strong preferences for FGC *Acroporid* species, providing a further dimension of sensitivity to the system (Cole et al., 2008). Other corallivorous butterflyfish include coral as a measurable part of their diet, but also utilise other food items. These are referred to 'facultative' corallivores, and tend to be more resilient than 'obligate' corallivores to disturbances that hinder live coral cover (Pratchett et al., 2006).

The butterflyfish abundance results within the report are indicative of a high level of hard coral cover and structural complexity (Chong-Seng et al., 2012), which is reflected in the results found when analysing the substrate data. Transect 101 presented a significantly higher abundance than all three transects outside of the MPA and also had the highest level of hard coral cover. These results are as to be expected as high numbers of butterflyfish are generally associated with high levels of hard coral cover (Pratchett & Berumen, 2008). This is also reflected in the fact that on all transects, abundances of obligate feeders were significantly higher than that of facultative feeders. These results further support the notion that the study of organism functions and their respective functional abundance can be utilised to highlight the ecological status of substrate community compositions.

4.1.2 Commercially Important Fishes

When assessing the commercially important fishes, both inside and outside of the MPA the fish found in the highest abundances were Parrotfish, followed by Grouper and Snapper. These commercially important fishes are particularly vulnerable to overfishing

because they are large, their life history is heavily correlated with shallow reef flats, and therefore highly desirable and sought after. Studying the life history of these species show that they are slow growing, long-lived, with many changing sexes as they grow (Shapiro 1989; Sadovy et al. 1994). Fishing such species can result in size selective mortality due to the differential loss of larger males leading to female biased sex ratios and vice versa (Koenig et al. 1996; Domeier & Colin 1997), as well as growth and recruit overfishing.

Abundances of all three commercially important fish categories were found to be higher inside the MPA compared to outside and this was also reflected in the biomass data. Total biomass of commercially important fishes was found to be over 5 times higher inside the MPA than outside. The high numbers and average size of piscivorous predatory fish (Grouper in particular), indicates a low level of fishing pressure (Boaden & Kingsford, 2015), showing the MPA fishing laws are likely being adhered to. The differences in abundances, size and biomass inside and outside the MPA also indicate that it is likely the spill-over effect is occurring, and those individuals that leave the MPA boundaries are being fished, but those within the MPA are able to mature. This is reflected in biomass values, and similarly mean length, which suggest that maturation is being favoured within this site due to lack fishing pressures (Russ & Alcala, 2003).

Herbivorous fish abundance and biomass (Parrotfish) was greater than other commercially important fish (Snapper, Grouper). Parrotfish and other herbivorous fishes play a profound role in exposing reef substrate for coral settlement, and limiting macroalgal growth (Bonaldo et al., 2014). Due to only a handful of species having the capacity to perform this herbivorous role in favouring coral growth and larval settlement, it is important that herbivores are given protection from unsustainable fishing practices and ensuring that these roles

remain a functional part of ecosystem interaction (Mouillot et al. 2014).

Epinepheline serranids (Groupers) are among the most vulnerable coral reef fishes to overexploitation due to the formation of temporally and spatially predictable fish spawning aggregations (Coleman et al. 2000; Sadovy & Domeier 2005). Targeting both fish spawning aggregations and reproductively active individuals may cause population-level changes that affect reproductive output, including skewed aggregation sex ratios due to sexual selection, size reductions, changes in genetic diversity, and loss or decline of fish spawning aggregation (Chapman et al. 1999; Sadovy and Domeier 2005). Whilst MPA's aim to protect the home range and feeding grounds of Grouper species outside of their reproductive periods (March – April), ensuring protection during reproductive times is difficult unless spawning aggregation location is known (Nemeth 2005). Reproductive individuals leave their feeding grounds to access their spawning location, which unless directly protected by an MPA itself, will expose fish to exploitation. Napantao Fish Sanctuary is not a known spawning aggregation area and therefore does not offer this protection. Further studies to identify where Grouper spawning aggregations are located within Sogod Bay are necessary to establish full protection of this commercially important species.

In contrast parrotfish have relatively small home ranges (Welsh et al., 2013), and so benefit the most from the protection of an area as small as the Napantao MPA, which is potentially why the difference in abundance of Parrotfish inside and outside the MPA is the biggest, compared to the other commercially important species. Parrotfish also tend to cover smaller distances on reefs with less algal cover (such as the one within the Napantao MPA) as they tend to concentrate their feeding efforts on the small patches available (Nash et al., 2016). This is

again beneficial for the parrotfish found in the survey area, as it means they are less likely to move outside the boundaries of the MPA. Higher numbers of herbivores such as parrotfish promote invertebrate settlement (Khalil et al., 2017) and the high abundance of Parrotfish is reflected in invertebrate numbers.

There were no observations of other commercially important species including *Bolbometapon muricatum* (Bumphead Parrotfish) and *Cromileptes altivelis* (Barramundi Cod) recorded within the surveyed area, however these are rare within the Southern Leyte area (as evidenced by the fact they are usually lacking from surveys around the Sogod bay and Cabalian bay areas), so this absence is not necessarily due to localised fishing pressures. Results suggests that the MPA regulations are being strictly adhered to, and fish stocks are increasing within the MPA. The difference in biomass and abundances inside and outside the MPA is most likely due to fishing pressures outside of the MPA, indicating the spill-over effect to be occurring. As the goal of this MPA, as well as protecting the reef, is to increase fish stocks for the local community, in this respect it is successful, especially for an MPA of this size.

4.2. Invertebrates

Abundance of invertebrates overall was higher inside the MPA than outside, with a higher percentage of total targetspecies being found outside the MPA. This could be due to increased predation within the MPA from now protected fish species, as has been observed on other protected reefs (Barrett et al., 2009). However, both inside and outside of the MPA had a relatively high abundance of invertebrates compared to other sites surveyed in Sogod Bay in 2017, suggesting good community assemblage resilience to future disturbances across the survey area (Stella et al., 2011). Abundances of invertebrates within the MPA were very similar to the previous year (Parker et al., 2017),

again showing stability in populations, yet this could be indicative of a community unable to recover as populations of invertebrates are not believed to be at saturation.. This needs to be monitored in future reports and considered annually.

Brittle Stars, Feather Stars and *Drupella* spp. composed the majority of the total invertebrate abundance recorded across all transects within the MPA, and similarly Brittle Stars and Feather Stars were the most abundant outside the MPA (along with Other Gastropods). Although not commercially important, all three of the above families are of ecological importance to the reef. Feather Stars are filter feeders (Macurda & Meyer, 1983), and thus play an active role in removing detritus and plankton from the water column, leading to a lessening in turbidity. Suspended sediments decrease the quality and quantity of incidental light levels, resulting in a decline in photosynthetic productivity of the symbiotic microalgae, zooxanthellae, living within coral tissue (Erftemeijer et al., 2012). As such, a decrease in turbidity is beneficial to corals. As well as this, it has been shown that filter feeders such as these are natural biofilters, and therefore can mitigate disease risks to other organisms on the reef (Burge et al., 2016). Brittle Stars have a wider range of feeding traits than Feather Stars, such as suspension-feeding, deposit-feeding, scavenging and predation (Stohr et al., 2012), so are able to occupy a wider variety of niches within the reef community.

Gastropods of the genus *Drupella*, though a natural part of the reef community, can have detrimental effects as they tend to be obligate corallivores which aggregate in large numbers (Cumming, 2009). They were found in higher numbers within the MPA, and this could be due to the higher covering of branching corals, including those of the genus *Acropora*, within the boundaries, which have been shown to be their preferential food choice (Al-Horani et al.,

2011). Although fast growing and therefore previously able to recover from predation more easily than other coral forms, these corals are also most susceptible to bleaching and mortality (Stella et al., 2011) and these combined stressors may put the coral community within the MPA at risk in the future, reducing the ability of the reef to cope with local and global perturbations.

Both inside and outside the MPA, the absence of commercially important invertebrate species including prickly redfish sea cucumber (*Thelenota ananas*), pinkfish sea cucumber (*Holothuria edulis*), squid (*Teuthida*), greenfish sea cucumber (*Stichopus chloronotus*), lobster (*Nephropidae*), and Triton's trumpet (*Charonia tritonis*) was noted. These species, which in many cases are slow growing and slow moving, are particularly vulnerable to over exploitation. It could be that historically, invertebrate harvesting was at such a level that these populations have been unable to recover, even with protection.

Giant clams were found in greater abundance and larger sizes inside the MPA compared to outside, which indicates either they may be removed from the substrate outside of the MPA boundaries, or the substrate is not suitable for them outside the MPA boundaries (they prefer Rock and Hard Coral, as many species either fully or partially bore into reef substrate (Neo et al., 2015)). Giant clams play various ecological roles in coral reef ecosystems, by potentially counteracting eutrophication via water filtering, as well as producing large quantities of calcium carbonate (CaCO_3) shell material that are eventually incorporated into the reef framework (Neo et al. 2015)

Abundance of COTs (*Acanthaster planci*) inside and outside the MPA was at a similar level and, though they are coral predators, it must be noted that CoTS presence is important for maintaining healthy, diverse coral communities. By feeding on diseased

coral and preferentially predating fast-growing species such as *Acropora* sp. (Pratchett, 2005), they can facilitate the control of disease and increase competition between coral species leading to higher diversity. However, their total absence within the MPA the previous year (Parker et al., 2017) demonstrates the population to be increasing. This should be monitored as a single adult can consume approximately 10 m² of coral per year and large "outbreak" populations can have a major impact on local cover (Keesing & Lucas, 1992). At present, CCC conducts COTs removal dives once abundance meet the threshold of 8 (total) across all transects surveyed. Once this threshold is met, then a removal dive is conducted to mitigate an outbreak in population. This may have been the cause of absence in previous surveys and therefore, documentation of COTs removal dives should be incorporated in future Napantao Fish Sanctuary reports.

Overall, the community assemblage both inside and outside of the MPA seems to be in a healthy state. Abundance of invertebrates being lower within the MPA is likely to reflect an increase in predatory fish numbers, following protection. Numbers of *Drupella* and COTs should be monitored within the MPA in order to predict any future impacts on live coral cover, but at present are not in high enough numbers to cause concern.

4.3. Substrates

Within the MPA, the most abundant substrate type was hard coral. This was also true of the area outside of the MPA, though the covering was lower. High hard coral coverage is a sign of a "healthy" reef, as levels of live scleractinian coral cover can be used as a good predictor of fish and invertebrate diversity and abundance (Komyakova et al., 2013; Idjadi & Edmunds, 2006). Hard coral cover was higher on all transects, both inside and outside of the MPA, than the average coral cover in the Philippines, found to be 22% in a nationwide

assessment of coral reefs (Licuanan et al., 2017). Hard coral cover was higher on many transects this year compared to last year (2016) which, given the fact there is evidence that coral loss is occurring throughout the Indo-Pacific, and is declining uniformly among subregions, even on intensely managed reefs (Bruno & Selig, 2007), shows this particular reef to be benefitting greatly from protection.

Rock was the second most abundant substrate within the MPA, and with Sand outside the MPA. High levels of sand have been shown to significantly decrease coral settlement potential (Hodgson, 1990), which may be a reason for hard coral cover being lower within the MPA. However, it could also be due to the fact the site was selected for protection due to its higher levels of hard coral and exposed rocky substrate and, therefore, its higher settlement potential.

Of the hard coral found within the MPA, the three most prevalent life growth forms were branching *Acropora* corals (ACB), along with sub-massive non-*Acropora* corals (CS) and massive non-*Acropora* corals (CM). Non-*Acropora* branching corals (CB) were more prevalent than CM outside of the MPA. *Acropora* branching corals are Fast Growing Corals (FGC) and are therefore able to recover quickly from disturbances (Karlson & Hurd, 1993), potentially preventing long term damage from, and increasing resilience to, "Habagat", the seasonal north-east trade winds that bring storms which hit Sogod Bay. As well as this, they give a high level of structural complexity. Their extremely high levels are therefore indicative of a reef which is structurally diverse and resilient, and therefore exhibits high levels of species richness and abundance (Edinger & Risk, 2000), which is true of the invertebrate and fish communities within the MPA survey site. Stress Tolerant Corals (STC) such as the massive and sub-massive non-*Acropora* corals found commonly within the MPA are less likely to be impacted by disturbances

such as seasonal storms and sedimentation (Rogers, 1990). Although, such corals do not offer much refugia for fauna, they do offer a substantial amount of coastal protection. Massive Non-*Acropora* species also provide a very strong structure for a reef to form around and their presence suggest longevity and stability in the future. Nearshore reefs dominated by long-lived, stress tolerant corals of high conservation concern due to their longer replacement time and potential adaptation to occurrences such as temperature spikes (McLeod et al., 2009).

When looking at the levels of cover of the three life traits (FGC, STC and CC), the hard coral both inside and outside of the MPA was split almost evenly between the three, and this was true of all transects. These results show homogeneity across the MPA. This is evidence that the MPA has been placed in an area with high conservation value which should be resilient to many different stressors and disturbances in the future. This is evidenced by the increase in hard coral cover since the previous survey year, and the high level of overall hard coral cover compared to the rest of the Philippines. The high levels of Other substrates recorded (sessile invertebrates such as tunicates and anemones) also point to a very diverse reef with complex structure and community assemblage and indicate high levels of conservation value.

Overall, the substrate within the MPA is more varied and diverse than outside, and has higher coral cover and recruitment potential. However, even the area outside the MPA is in a healthier state than most sites surveyed around Sogod Bay in 2016, which could be important in aiding the 'spill-over' effect of fish and invertebrates and increasing these stocks outside of the MPA. Protection and size of the MPA seems to be completely adequate in terms of substrate recovery.

4.4. Impacts

Though overall impacts were lower inside the MPA than outside, levels of fishing trash were

higher inside the MPA than outside, which would usually indicate some form of fishing pressures within the MPA. However, the fish data collected inside and outside of the MPA contradicts this, and it is instead more likely that fishing trash (nets, lines etc.) are being dropped outside of the MPA boundaries and drifting in. This could be due to the small size of the MPA meaning no one point within it is far enough away from the area outside, where fishing activities are occurring, to prevent ghost nets and lines being carried there.

General trash was found in high levels outside of the MPA, with only 12.5% of replicates having no trash at all. Over half of the replicates within the MPA also had some level of general trash found on them. Whether this is being put directly into the MPA, or drifting in from outside, it is difficult to tell. If the future success of the MPA is to be secured, more stringent coastal management regimes will therefore need to be created to effectively control threats originating outside of the MPA boundary (CTI-CFF 2013). Due to corals being non-selective feeders, ingestion of microplastics have been recorded when the plastics are present in seawater (Hall et al., 2015), which in turn can bioaccumulate up the trophic levels on the reef, and affect the whole reef community.

Coral bleaching was also prevalent across the survey area, both inside and outside of the MPA. However, percentages of colonies and populations affected were extremely low (always less than 1% of the population of each replicate, both inside and outside of the MPA). Levels were recorded to be lower than the previous year (Parker et al., 2017). Coral bleaching levels are increasing globally (Donner et al., 2005), and can have many different causes, from increased temperature to high solar irradiance levels and coral disease (Brown, 1997). However, these instances seem to be isolated, shown in the generally low percentage of bleaching of each colony, which perhaps points to

disease/pollution being the stressor rather than habitat-wide change in environmental conditions. Unfortunately, bleaching is a global issue and generally not one which can be tackled by the enforcement put in place by MPAs.

4.5. Conclusion

Coral reliant fish communities are reflective of a well-managed MPA, with high species richness and diversity and low evenness showing the community assemblage to be in a reasonably stable state. The difference in abundance inside and outside the MPA shows the spill-over effect seems to be occurring, and those fish outside of the MPA are being fished by the local community. High numbers and large size of commercially important fish when compared to other sites within Sogod bay suggests at least some species are being allowed to reach sexual maturity. Low numbers of the less common commercially important fish species suggests high levels of fishing in the area immediately outside the MPA. This could also be down to the small size of the MPA, as it is not sufficient to protect those species with larger home ranges, as evidenced by higher numbers of fish with smaller home ranges.

Overall, the invertebrate community both inside and outside the MPA is in a healthy state. The lower numbers of invertebrates within the MPA is likely indicative of a higher number of predatory fish. Absence of many commercially important invertebrates, which is the norm throughout Sogod Bay, indicates that historic harvesting within this area has had enough of an impact to hinder recovery. Numbers of corallivorous invertebrates such as COTS and *Drupella* should be monitored to prevent any future outbreaks.

The high covering of hard coral throughout the site shows the MPA is placed in an area of high conservation value, which is able to support diverse communities of fish and invertebrates, and act as a nursery ground for other species which could then be fished or harvested outside of the MPA. High levels

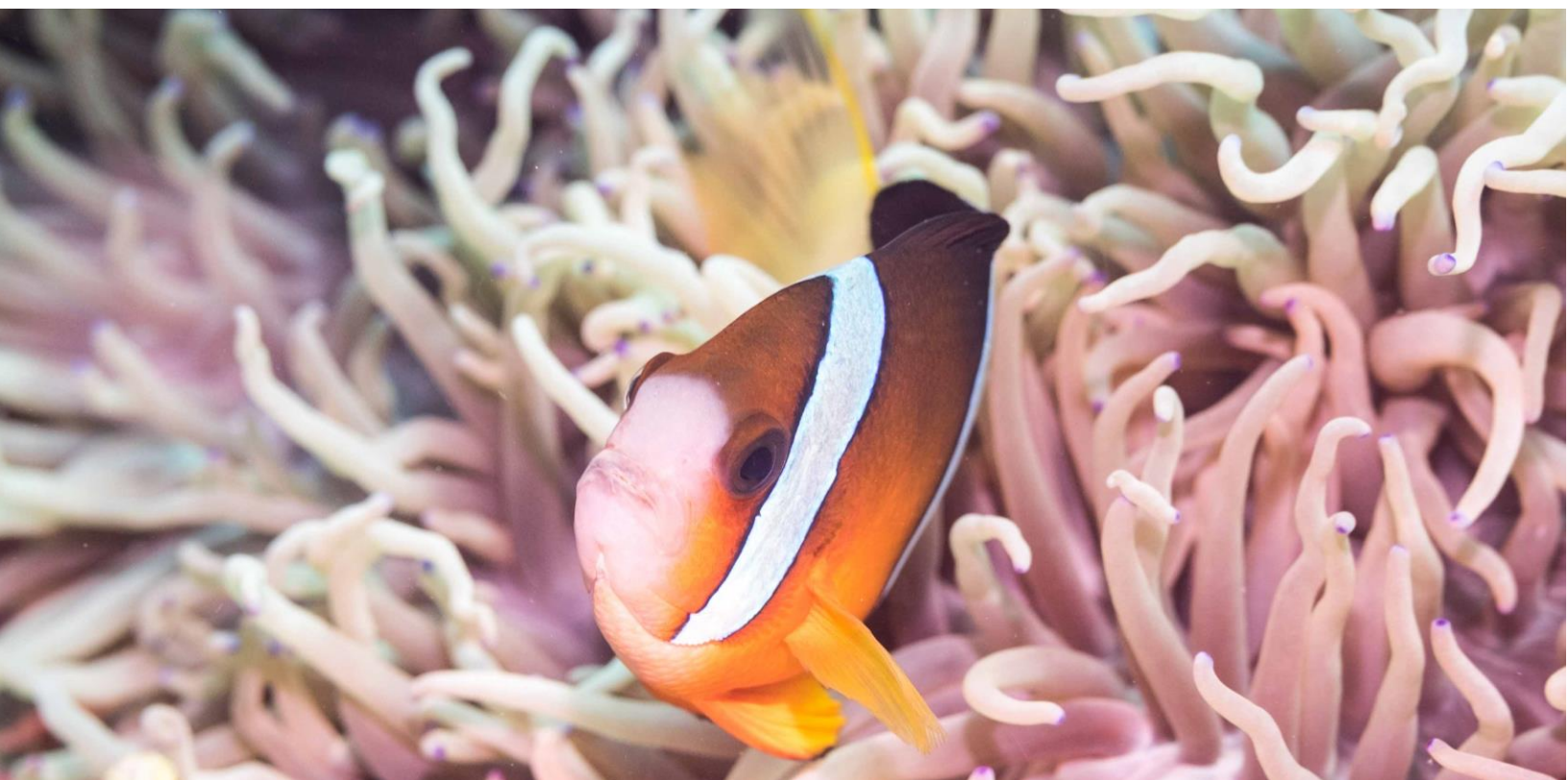
of rocky substrate within the MPA also means settlement potential for coral larvae is high, and coral covering is able to increase (as seen since the previous survey in 2016). The instances of coral bleaching recorded are difficult to manage, but affect low enough percentages of the coral as to not raise too much of a management issue. The complete lack of coral damage from external sources such as boats, anchors or destructive fishing practices suggests the MPA laws are being adhered to. However, the amounts of general and fishing trash found within the MPA suggest external influences are still affecting the benthos within the MPA, and more stringent management practices would need to be put in place to prevent this.

Overall, this MPA is a prime example of how good management can lead to a healthy community assemblage and therefore increase fish stocks even when the area protected is smaller than the recommended optimum size for a community managed MPA. MPAs that actively engage fishermen in management have proved to display a higher level of commitment to the protection of the MPA, than fisherman that have a marginal or passive role (Di Franco et al.,

2016), and the Bantay Dagats who patrol the MPA here being members of the local community may be an example of this.

Education programs delivered by CCC since 2008 may increase awareness and engage local stakeholders. An increase in fish stocks over the years will also have improved attitudes to the MPA. As well as this, the frequent divers to the reef act as a source of income and yet another incentive to protect the reef within the MPA. All these factor seem to add up to the MPA being well managed and well protected. The only recommendation is that trash be dealt with more effectively in order to limit the amount entering the ocean and the MPA.

All recommendations and suggestions provided by CCC are based on what is ecologically ideal. However, there are supplementary factors to consider in the decision-making process. As such, the discussion outlined here should be used as the initial step in opening a dialogue between all relevant stakeholders in order to come to the best possible conclusion for all parties when moving forward with the management of this particular MPA.



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Appendix A

Table A1. List of target fish families, genera and species recorded during Coral Cay Conservation (CCC) surveys of the Barangay Napantao MPA. * Indicates species seen and recorded inside the MPA, lack of a * indicates this species was not seen inside of the MPA.

Common Name	Latin Name	Visayan Name
*Angelfish	<i>Pomacanthidae</i>	Adlo
*Barracuda	<i>Sphyrnidae</i>	
(Butterflyfish)	<i>Chaetodontidae</i>	Alibangbang
* (Big) Longnose Butterflyfish	<i>Forcipiger flavissimus</i>	
*Eastern Triangle Butterflyfish	<i>Chaetodon baronessa</i>	
*Humphead Bannerfish	<i>Heniochus varius</i>	
*Kleins Butterflyfish	<i>Chaetodon kleinii</i>	
*Raccoon Butterflyfish	<i>Chaetodon lunula</i>	
*Redfin Butterflyfish	<i>Chaetodon lunulatus</i>	
*Vagabond Butterflyfish	<i>Chaetodon vagabundus</i>	
*Cardinalfish	<i>Apogonidae</i>	
(Damsel fish)	(<i>Pomacentridae</i>)	
*Anemonefish	<i>Amphiprion</i> sp.	
Sergeant Damsel fish	<i>Pomacentridae</i>	
*Emperor	<i>Lethrinidae</i>	Katambak
*Fusilier	<i>Caesionidae</i>	Dalagangbukid
*Goatfish	<i>Mullidae</i>	Timbongan
*Groupers	<i>Serranidae</i>	Lapu-lapu
*Jack/Trevally	<i>Carangidae</i>	Talakitok
*Lionfish	<i>Scorpaenidae</i>	
*Lizardfish	<i>Synodontidae</i>	
*Moorish Idol	<i>Zanclus cornutus</i>	Sanggowanding
*Moray Eel	<i>Muraenidae</i>	
*Parrotfish	<i>Scaridae</i>	Mulmul
Bumphead Parrotfish	<i>Bolbometopon muricatum</i>	
*Pufferfish	<i>Tetraodontidae</i>	
*Rabbitfish	<i>Siganidae</i>	Kitong
Ray	<i>Rajiformes</i>	
*Sandperch	<i>Pinguipedidae</i>	
*Snapper	<i>Lutjanidae</i>	
*Spinecheeks	<i>Nemipteridae</i>	Maya-maya
*Squirrelfish/Soldierfish	<i>Holocentridae</i>	Silay
*Surgeonfish	<i>Acanthuridae</i>	
*Unicornfish	<i>Naso</i> sp.	Indangan
*Sweetlips	<i>Haemulidae</i>	
*Toby	<i>Tetraodontidae</i>	Lipti
*Triggerfish	<i>Balistidae</i>	
(Wrasse)	(<i>Labridae</i>)	Pakol
*Crescent Wrasse	<i>Thalassoma lunare</i>	

Humphead Wrasse	<i>Cheilinus undulatus</i>
*Red Breasted Wrasse	<i>Cheilinus fasciatus</i>

Table A2. List of target Invertebrate families, Genera and species recorded during Coral Cay Conservation (CCC) surveys of the Barangay Napantao MPA. * Indicates species seen and recorded within the MPA, lack of a * indicates this species was not seen during surveys within the MPA.

Target Invertebrates		
*Feather duster worms	*Christmas tree worms	*Flatworms
Crabs	Shrimps	*Banded coral shrimp
Lobster	*Nudibranch	Triton's trumpet
*Conch	*Cowrie	*Top shell
*Cone shell	*Drupella	Octopus
*Other gastropod	Giant clam	*Acanthaster planci
Cuttlefish	Squid	*Brittle Star
*Linkia laevigata	Culcita novaeguineae	Collector urchin
Choriaster granulatus	*Feather Star	Greenfish
*Longspine sea urchin	Pencil urchin	
Prickly redfish	Pinkfish	
*Other sea cucumber		

Table A3. List of target substrates recorded during Coral Cay Conservation (CCC) survey of the Barangay Napantao MPA.

Substrate		
Soft Coral (SC)	Sponge (SP)	Recently killed coral (RKC)
Rock (RC)	Silt/mud (SI)	Rubble (RB)
Sand (SD)	Nutrient indicator algae (NIA)	Other* (OT)
Hard Coral (HC)		
Hard Coral (HC) Lifeforms*:		
Acropora branching	Acropora encrusting	Acropora sub-massive
Acropora digitate	Acropora tabulate	Non-Acropora branching
Non-Acropora encrusting	Non-Acropora foliose	Non-Acropora sub-massive
Non-Acropora mushroom	Heliopora (blue coral)	Millepora (fire coral)
Tubipora (organ-pipe coral)		
**Other:		
Anemone	Corallimorph	Halimeda
Tunicate	Zoanthid	Gorgonian
Hydroids		

* Hard coral colonies are placed into categories to allow for greater resolution whilst removing the risk of identification errors when attempting to consider colonies to the Genus or Species resolution. Lifeforms are defined by the growth structure exhibited by each colony.

** The category "Other" is defined as any substrate that is encountered within the substrate surveys that does not conform to the criteria of the other categories. For succinctness, the "Other" categories are limited to the most common encountered.

Appendix B

	I01	I02	I03	O01	O02	O03
I01						+
I02					+	+
I03					+	+
O01						
O02		-	-			
O03	-	-	-			

Figure B1. Matrices showing significant differences in mean target fish abundance per 500m³ across the survey site in Napantao, San Francisco, Southern Leyte. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	I01	I02	I03	O01	O02	O03
I01				+		+
I02				+		
I03				+		+
O01	-	-	-			
O02						
O03	-		-			

b)	I01	I02	I03	O01	O02	O03
I01		+	+	+	+	+
I02	-					
I03	-					
O01	-				-	
O02	-			+		
O03	-					

c)	I01	I02	I03	O01	O02	O03
I01		+	+		+	
I02	-				-	
I03	-					
O01						
O02	-	+				
O03						

Figure B2. Matrices showing significant differences in mean target fish a) Species Richness, b) Shannon's H' Diversity Index and c) Pielou's evenness (J) per 500m³ across the survey site in Napantao, San Francisco, Southern Leyte. A green '+' indicates Species Richness (a), Shannon's H' Diversity Index (b) or Pielou's evenness (c) was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that Species Richness (a), Shannon's H' Diversity Index (b) or Pielou's evenness (c) was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

	I01	I02	I03	O01	O02	O03
I01		-		+	+	+
I02	+					
I03				+		
O01	-		-			
O02	-					
O03	-					

Figure B3. Matrix showing significant differences in mean target butterflyfish abundance per 500m³ across the survey site in Napantao, San Francisco, Southern Leyte. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)

	I01	I02	I03	O01	O02	O03
I01					+	+
I02					+	+
I03					+	+
O01						
O02	-	-	-			
O03	-	-	-			

b)

	I01	I02	I03	O01	O02	O03
I01				+		+
I02				+		
I03						
O01	-	-				
O02						
O03	-					

c)

	I01	I02	I03	O01	O02	O03
I01						
I02						+
I03						
O01						
O02						
O03		-				

Figure B4. Matrix showing significant differences in mean a) Parrotfish, b) Grouper and c) Snapper abundance per 500m³ across the survey site in Napantao, San Francisco, Southern Leyte. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	I01	I02	I03	O01	O02	O03
I01		+			+	+
I02	-			+	+	
I03				+	+	+
O01		-	-			
O02	-	-	-			+
O03	-		-		-	

b)	I01	I02	I03	O01	O02	O03
I01		+		+	+	+
I02	-			+	+	+
I03				+	+	+
O01	-	-	-			
O02	-	-	-			
O03	-	-	-			

c)	I01	I02	I03	O01	O02	O03
I01						
I02			+			
I03		-				
O01						
O02						
O03						

Figure B5. Matrix showing significant differences in mean a) Parrotfish, b) Grouper and c) Snapper biomass per 500m³ across the survey site in Napantao, San Francisco, Southern Leyte. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

	I01	I02	I03	O01	O02	O03
I01		+				+
I02	-				-	
I03					-	
O01						
O02		+	+			
O03	-					

Figure B6. Matrix showing significant differences in mean target invertebrate abundance per 100m² across the survey site in Napantao, San Francisco, Southern Leyte. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

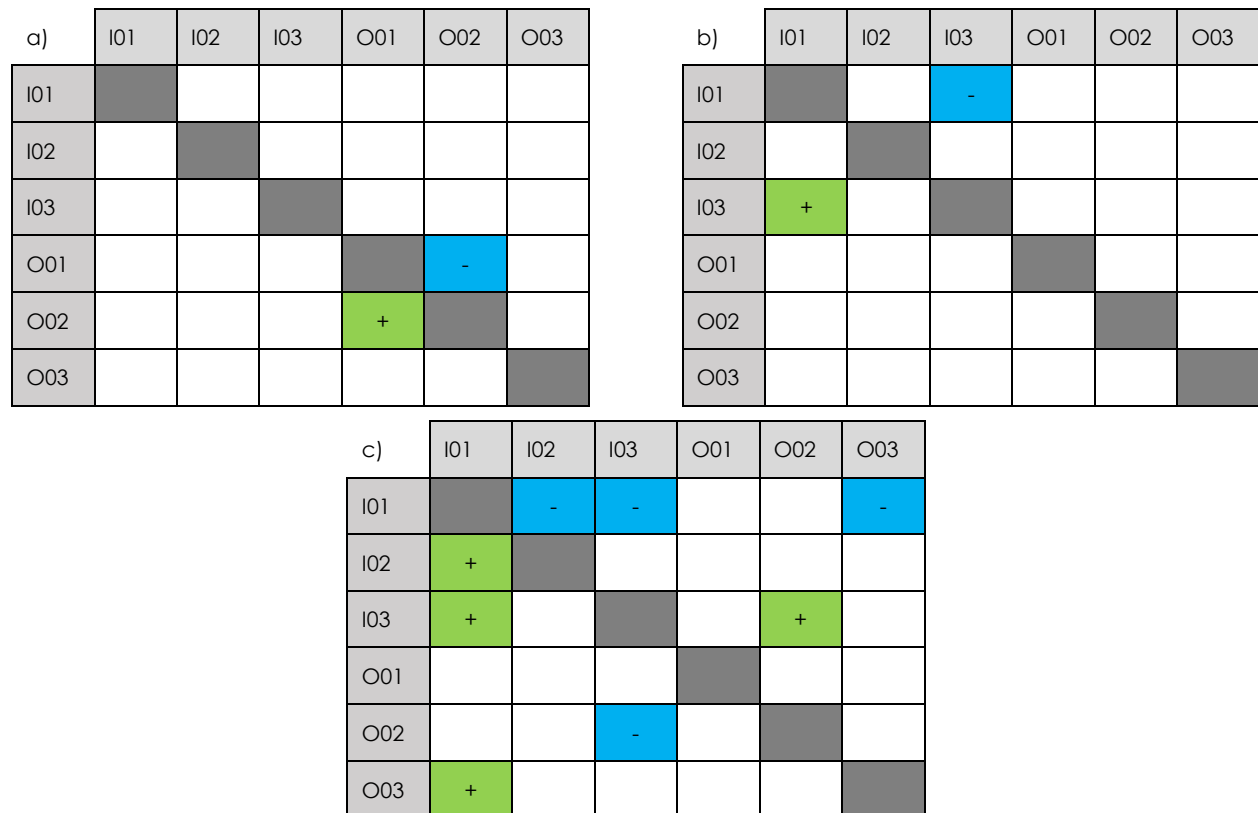


Figure B7. Matrices showing significant differences in mean target invertebrate a) Species Richness $S()$, b) Shannon-Weiner Diversity (H') and c) Pielou's evenness (J') per 100m² across the survey site in Napantao, San Francisco, Southern Leyte. A green '+' indicates a) S , b) H' or c) J' was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that a) S , b) H' or c) J' was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

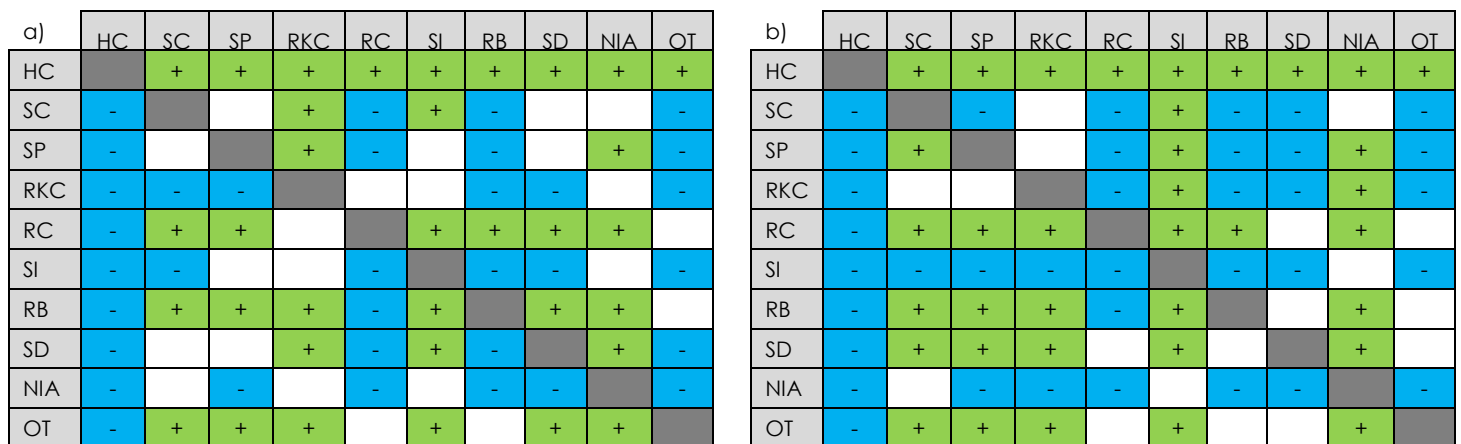


Figure B8. Matrix showing significant differences in mean Substrate type cover per 20m across a) inside of and b) outside of the MPA in Napantao, San Francisco, Southern Leyte. HC; Hard Coral, SC; Soft Coral, SP; Sponge, RKC; Recently Killed Coral, RC; Rock, SI; Silt, RB; Rubble, SD; Sand, NIA; Nutrient Indicator Algae and OT; Other. A green '+' indicates the substrate on the left covered a significantly higher percentage than the substrate on the top ($p < 0.05$). A blue '-' indicates

the substrate at the top covered a significantly higher percent than the substrate on the left ($p = <0.05$). Blank cells indicate no significant difference.

a)	I01	I02	I03	O01	O02	O03
I01		+	+	+	+	+
I02	-		-			
I03	-	+			+	
O01	-					
O02	-		-			
O03	-					

b)	I01	I02	I03	O01	O02	O03
I01			-	-	-	
I02				-		
I03	+			-		
O01	+	+	+		+	
O02	+			-		
O03						

c)	I01	I02	I03	O01	O02	O03
I01		-	-		-	
I02	+			+		+
I03	+					
O01		-			-	
O02	+			+		+
O03		-			-	

Figure B9. Matrices showing significant differences in mean a) Hard Coral (HC), b) Sand (SD) and c) Other (OT) cover per 20m across all transects in Napantao, San Francisco, Southern Leyte. A green '+' indicates cover was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

a)	I01	I02	I03	O01	O02	O03
I01		-	-			
I02	+					
I03	+				+	+
O01						
O02			-			
O03			-			

b)	I01	I02	I03	O01	O02	O03
I01		+	+	+	+	+
I02	-					
I03	-					
O01	-					
O02	-					
O03	-					

c)

	I01	I02	I03	O01	O02	O03
I01		+	+	+	+	
I02	-					
I03	-				-	-
O01	-					
O02	-			+		
O03				+		

Figure B10. Matrix showing significant differences in a) Fast Growing Coral (FGC), Stress Tolerant Coral (STC) and Competitor Coral (CC) cover across all transects in Napantao, San Francisco, Southern Leyte. A green '+' indicates cover was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that cover was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Appendix C



Figure C1. Mean abundance of target fish species and families per 500m³ with standard error ($\pm$ SE) inside (grey) and outside (white) the MPA in Napantao, Southern Leyte, the Philippines.

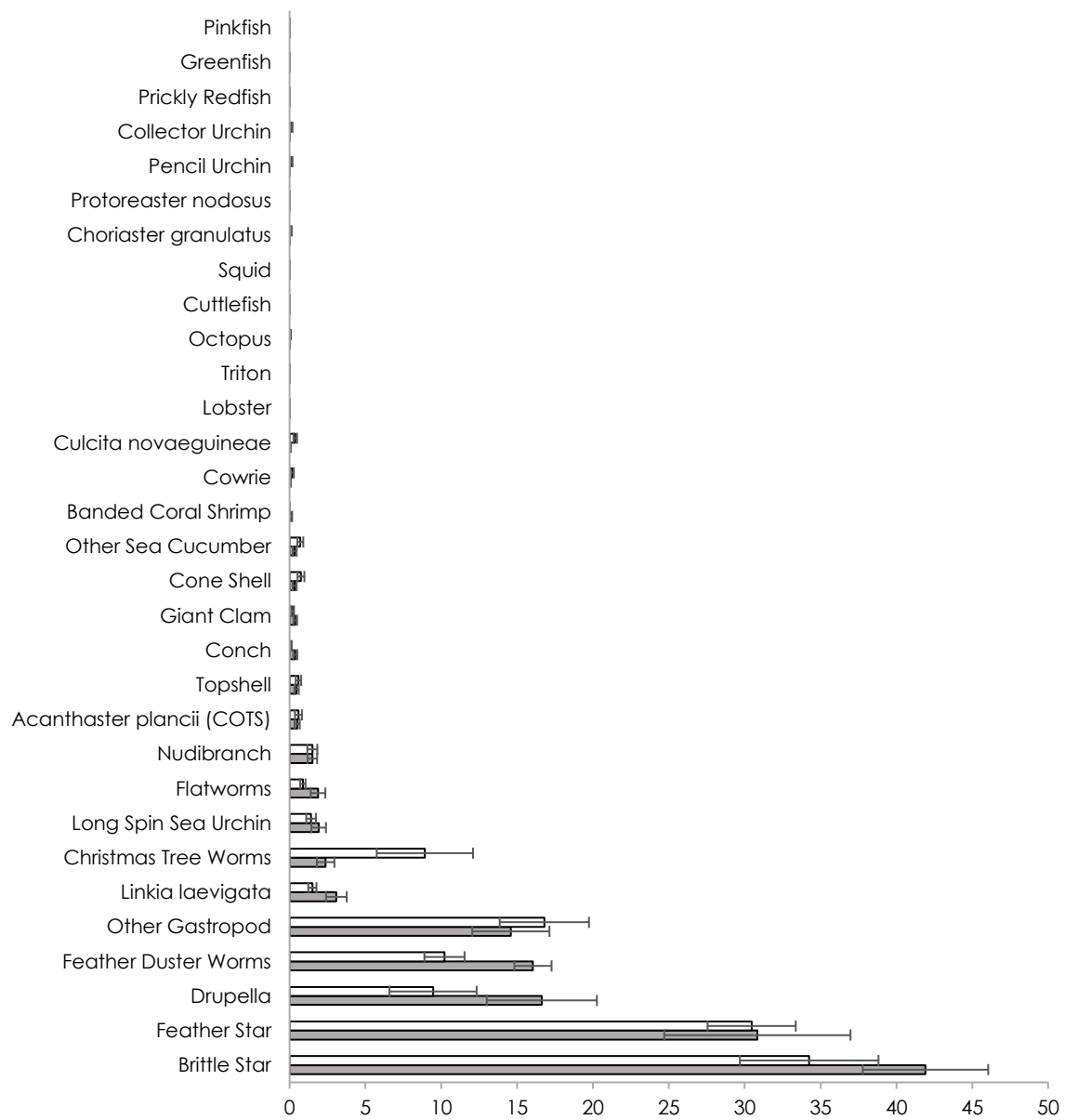


Figure C2. Mean abundance of target invertebrate species and families per 100m² with standard error ($\pm$ SE) inside (grey) and outside (white) of the MPA in Napantao, Southern Leyte, the Philippines.