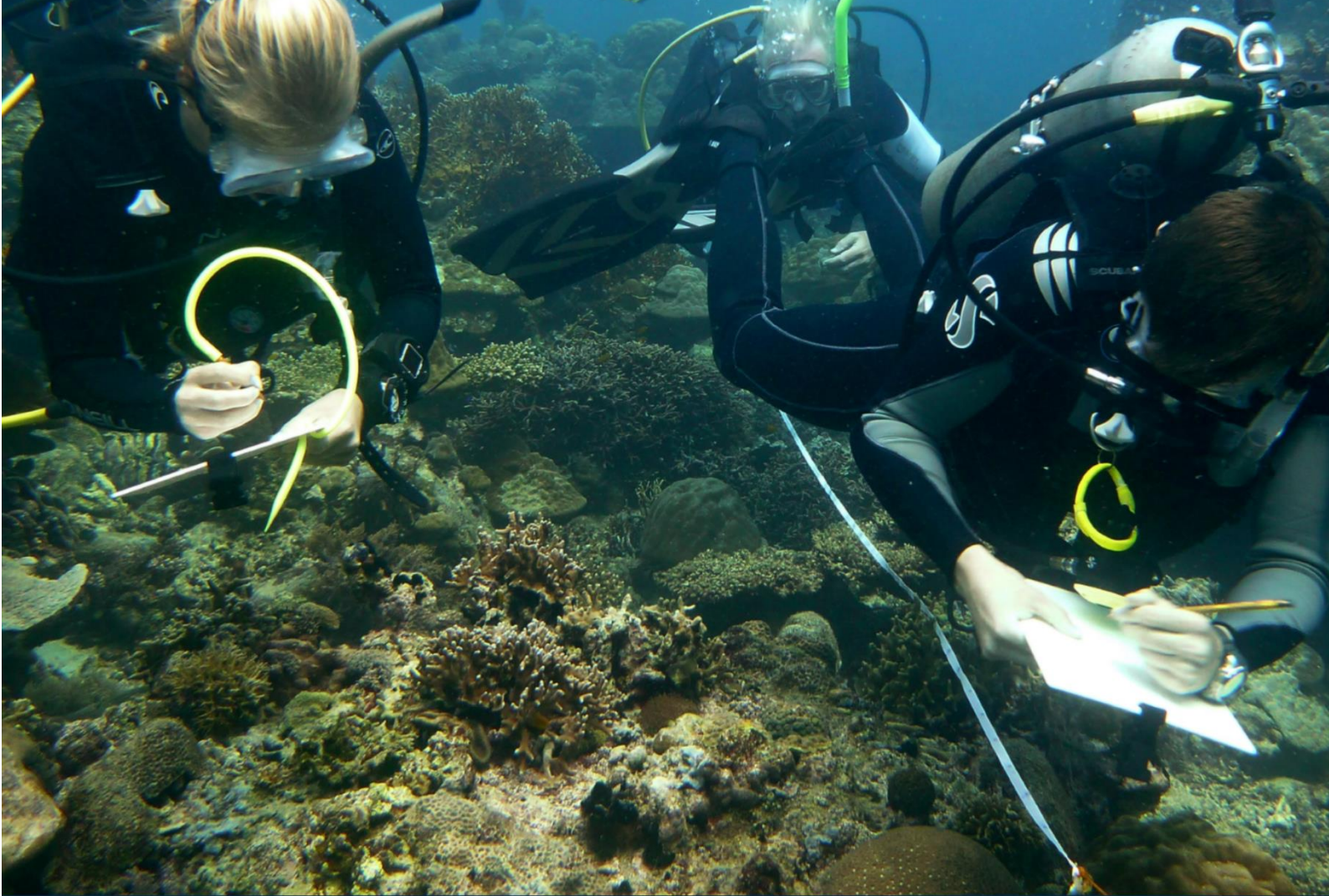




LRCP

Southern Leyte Coral Reef Conservation Project

Coral Cay Conservation Marine Protected Area Assessment Report: Barangay Punta 2017

Report Date: February 2019



Manon Broadribb, Tom Dallison,
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In partnership with the Southern Leyte
Provincial Government, Philippines





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The Provincial Government of Southern Leyte

With thanks to:



The Municipal Government of San Francisco

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Executive Summary

- Coral Cay Conservation (CCC) assessed the reef fish, invertebrates, substrates and anthropogenic impacts inside of the Marine Protected Area (MPA) in Barangay Punta (Municipality Libagon) during April 2017 in order to assess the efficacy of the MPA.
- At the request of Armando Gaviola of PENRMO, and after consulting the Barangay Captain in Punta, CCC conducted Underwater Visual Census (UVC) protocols. An enhanced Reef Check methodology was used to survey six 100m transects each containing four 20m replicates.
- Mean target fish abundance was $N = 27.33 \pm 2.72 \text{ } 500\text{m}^3^{-1}$ with transect I02 obtaining the highest mean abundance ($N = 41.00 \pm 6.16 \text{ } 500\text{m}^3^{-1}$) and transect I03 the lowest ($N = 18.00 \pm 1.47 \text{ } 500\text{m}^3^{-1}$). Mean species Richness (S') was $S = 7.08 \pm 0.47 \text{ } 500\text{m}^3^{-1}$, mean Shannon-Weiner Diversity (H') was $H' = 1.62 \pm 0.08$ per 500m^3 and mean Pielou's Evenness (J) was $J' = 0.85 \pm 0.02 \text{ } 500\text{m}^3^{-1}$.
- Mean Butterflyfish abundance was $N = 2.83 \pm 0.55 \text{ } 500\text{m}^3^{-1}$. Transect I04 had the highest mean abundance ($N = 5.50 \pm 1.85 \text{ } 500\text{m}^3^{-1}$) and transect I06 the lowest ($N = 0.00 \pm 0.00 \text{ } 500\text{m}^3^{-1}$). Of the 68 individuals recorded across the survey area, 64 were categorized as obligate corallivores. This high proportion of obligate corallivores suggests the presence of Scleractinian hard coral is sufficient to support that particular feeding preference.
- Low abundance ($N = 1.04 \pm 0.34 \text{ } 500\text{m}^3^{-1}$) and small size ($<31\text{cm}$) of commercially important fishes, as well as the absence of many commercially important invertebrates is indicative of a highly overfished area, suggesting the no take zone may not be properly enforced.
- Mean abundance of invertebrates was $N = 171.75 \pm 17.85 \text{ } 100\text{m}^2^{-1}$ and mean species richness (S) was $S = 6.75 \pm 0.31 \text{ } 100\text{m}^2^{-1}$. Mean Shannon-Weiner Diversity (H') was $H' = 1.11 \pm 0.04 \text{ } 100\text{m}^2^{-1}$ and mean Pielou's evenness (J') was $J' = 0.59 \pm 0.02 \text{ } 100\text{m}^2^{-1}$. The majority of target species found, although demonstrating structural diversity, were not commercially important, suggesting intensive historic harvesting.
- The dominating substrate was Sand ($30.73 \pm 4.31\%$ per 20m), followed by Rock ($21.88 \pm 2.11\%$ per 20m) and Hard Coral ($13.96 \pm 1.34\%$ per 20m). High level of exposed rocky substrate shows potential for future coral recruitment in the area. No evidence of coral bleaching or disease were found in the survey area.
- Overall anthropogenic impacts were low across all transects, with no evidence of boat, anchor, dynamite, or other coral damage being found. However, general trash was found in high levels on 33.33% of transects, and medium levels on 41.67% of transects, demonstrating that trash is a problem in the area.
- Results from the Barangay Punta, Libagon Municipality Marine Protected Area (MPA) site indicates that the surveyed reef is in a position to support a more diverse reef structure and community assemblages, if properly managed. The high level of exposed rocky substrate gives it the potential for more hard coral recruitment, and its location should assist in creating a connective network between other established MPAs within Sogod Bay. However, evidence of continued overfishing and commercial invertebrate harvesting means the MPA needs increased levels of enforcement in order to allow fish stocks to recover.

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Acknowledgements

Coral Cay Conservation would like to extend its heartfelt gratitude to the following people and organisations, without whom this project would not have been possible:

- The ex-Provincial Governor for Southern Leyte, Hon. Ricardo Mercado (now the current Congressman) for his valued support and guidance throughout CCC's efforts.
- Provincial Governor for Southern Leyte, Hon. Christopherson M. Yap, Vice-Governor, Hon. Jessica Marie E Pano and the Provincial Board members.
- Sir. Nedgar V. Garves and all the staff at the Provincial Tourism Office.
- Ma'am Eva Abad, Sir. Armando Gaviola and all the staff at the Provincial Environmental and Natural Resource Management Office (PENRMO).
- Dr. Arturo Isip, Department of Education, Southern Leyte Division.
- All members of the Sogod Bay Sustainable Marine Management Alliance (SBSMMA).
- Barangay Captain Ronaldo M. Iligan and the Barangay Council of Punta.
- Dr Gloria Reyes, Homer de Dioz and all staff of Southern Leyte State University.
- Our Filipino staff: Bok, Jesse, Dodong and Ricky whose loyalty, trust, and dedication are highly valued.
- All the dedicated international volunteers and staff who gathered the data and made this project possible: Felipe Lei, Toby Staines, Tyler Goebel, Ida Pettersson, Andrea Gaurana, Connor Reynolds, Hannah Maguire, Ellie Corne, Jessa Cortes, Morgan Fujimoto and Adrian Medina.

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 H' Diversity Index
J'	: Pielou's J Evenness
N	: Abundance

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 installatio



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, 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 and Bruno, 2010), species conservation, the general ecological status and fishery productivity (Buxton et al., 2006; McDaniel, 2007), 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, 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).

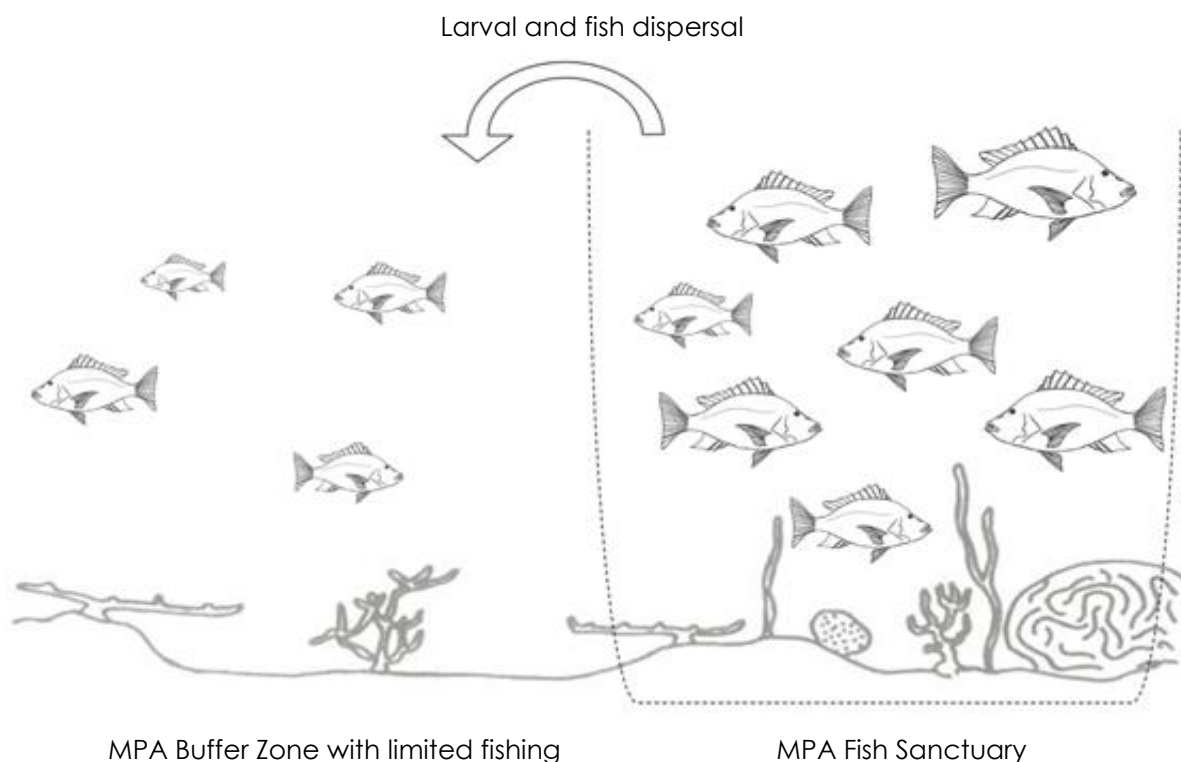


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to 'overspill', increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

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., 2012). 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 Punta

The survey was requested by Sir Armando Gaviola of PENRMO on behalf of the Protected Area Management Enhancement (PAME) Project, which aims to establish and monitor MPAs within the LGUs of San Francisco, Liloan, Limasawa, Padre Burgos and Pintuyan, to help meet the aforementioned 1998 Fisheries Code (Republic Act 8550).

CCC surveyed the coral reefs within the Barangay Punta MPA in April 2017, located between 30-50m from the shoreline of Barangay Punta, in the Libagon Municipality, on the Eastern side of Sogod Bay (Fig 2). The

MPA covers 4.1 hectares (ha) and was approved in 1994. The location of the MPA is close to the northern boundary of the barangay, with the population centre being roughly 0.2km from the MPA and having an estimated population size of 600 (April 2017). The location of Barangay Punta results in the associated reef being exposed annually to the damaging northeast trade winds throughout the months of June to September (Habagat). However, its location being to the north of the bay means it is slightly protected, and thus has had no major storms which would have caused significant coral damage in recent years.

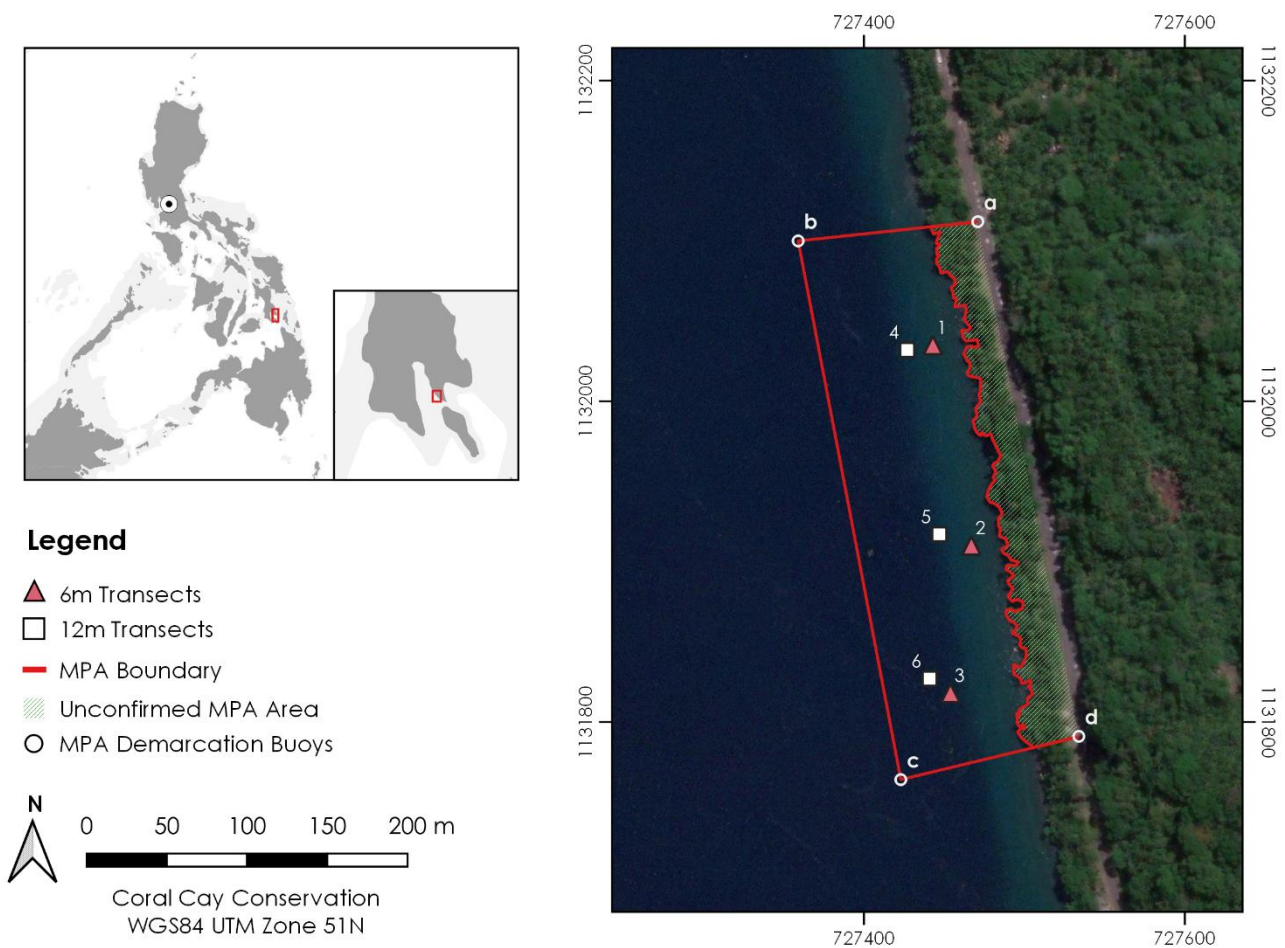


Figure 2: Map showing the location of the Barangay Punta MPA (Punta Fish Sanctuary), Libagon Municipality, Sogod bay, Southern Leyte and the location of Coral Cay Conservation's biophysical assessment transects in 2017.

2.0 Methodology and Data Collection

2.1 Survey Site

CCC's assessment of the MPA at Punta was conducted between April 21st and 25th, 2017, by trained volunteer survey teams. The weather was sunny during this time with no major weather systems moving through the region. Mean air temperature during surveys was 28.7°C, Sea Surface Temperature (SST) was 28.0°C, with a mean of 27.5°C at a depth of 3m and 27.0 at 12m. The mean estimated horizontal visibility throughout the survey was 10.8m.

From discussion with the Barangay Officials, it was found that a combination of the proximity to the river mouth, as well as the enclosed structure of the bay semi-impeding water flow, means siltation can occasionally be an issue during heavy rainfall. Suspended sediments in the water can inhibit the ability for sunlight to penetrate through to the coral tissue, restricting coral growth. The MPA is only 0.2km from the Barangay, situated on the shoreline, and although legal protection is enforced, the proximity to the barangay means there are still low levels of collection of invertebrates and poaching occurring within the MPA.

2.2 Biophysical Survey

The assessment of the MPA site 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 1996 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).

Table 1. Depths (m) and coordinates (UTM) of 100m transects surveyed along the coast of Punta (Libagon), southern Leyte, the Philippines.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
I01	6		
I02	6	727467	1131910
I03	6	727454	1131818
I04	12	727427	1132032
I05	12	727447	1131917
I06	12	727441	1131827

Transects were laid along the reef, parallel to the shore, on a north to south bearing (Fig. 3). Three transects were situated at a depth of 6m and three transects were situated at a depth of 12m (Table 1). 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.

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 (Appendix A). 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 5m x 5m x 20m (W x H x L) box (Fig. 3). 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 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 Punta 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 the 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

Table 2. The calculated Length-Weight allometric coefficients to determine the biomass (kg) of sized Grouper, Snapper and Parrotfish within Punta, Libagon, 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	0.0312
Scaridae	Other	Parrotfish	0.0152	3.0398
	<i>Bolbometapon muricatum</i>	Green Humphead Parrotfish	0.0138	3.03

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 2).

2.2.3 Visual Assessment 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 (*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. 4). 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. 5). 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, submassive, 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.

2.3 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).

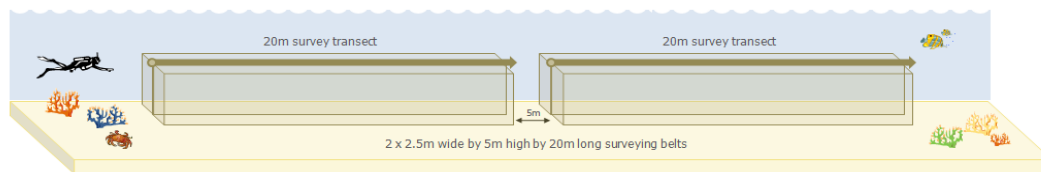


Figure 3. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of fishes within Barangay Punta. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps. The presented schematic only represents two of the four 20m replicates.

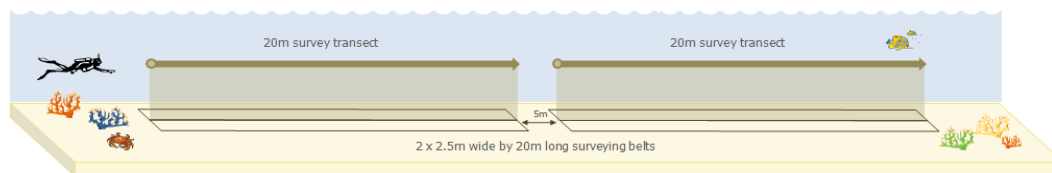


Figure 4. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of invertebrates within Barangay Punta. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps. The presented schematic only represents two of the four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

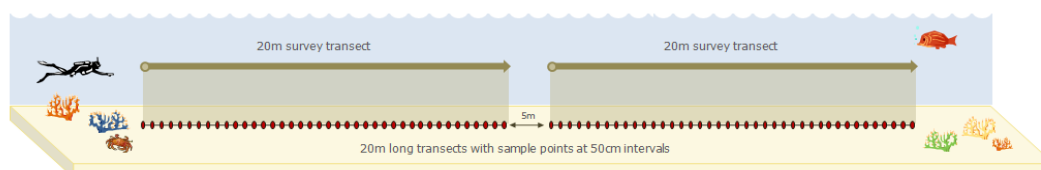


Figure 5. The undertaken point intercept methodology conducted for the assessment of benthic composition within Barangay Punta. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps with the respective benthic substrate recorded at 0.5m intervals. The presented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

3.0 Results

3.1 Fishes

3.1.1 Target Fish

In total, $N = 656$ individual fishes were recorded, representing 48.78% of all target fish families, with a mean abundance of $N = 27.33 \pm 2.72 \text{ } 500\text{m}^3^{-1}$, throughout the survey period. The most represented target organisms were Anemonefish, Sandperch and Crescent Wrasse ($N = 5.67 \pm 1.31 \text{ } 500\text{m}^3^{-1}$, $N = 4.54 \pm 0.52 \text{ } 500\text{m}^3^{-1}$ and $N = 3.83 \pm 0.65 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig. C1). At the transect resolution, transect I02 presented the greatest mean abundance of fishes ($N = 41.00 \pm 6.16 \text{ } 500\text{m}^3^{-1}$), significantly higher than that of transect I01 ($N = 18.75 \pm 2.17 \text{ } 500\text{m}^3^{-1}$) and transect I03 ($N = 18.00 \pm 1.47 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$) (Fig. 6). Transect I03 presented the lowest mean abundance of fishes ($N = 18.00 \pm 1.47 \text{ } 500\text{m}^3^{-1}$), significantly lower than that of transect I02 ($N = 41.00 \pm 6.16 \text{ } 500\text{m}^3^{-1}$) and transect I04 ($N = 40.25 \pm 9.08 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$). Transects I05 and I06 were not found to differ significantly to each other, or any other transects, when compared ($p > 0.05$) (Fig. B1).

Species Richness (S), throughout the sample area, was recorded as $S = 7.08 \pm 0.47 \text{ } 500\text{m}^3^{-1}$, with Shannon Weiner Diversity (H') recorded as $H' = 1.62 \pm 0.08 \text{ } 500\text{m}^3^{-1}$. Transect I04 ($S = 9.75 \pm 0.85 \text{ } 500\text{m}^3^{-1}$) was recorded to be significantly greater than transect I01 ($S = 4.5 \pm 0.96 \text{ } 500\text{m}^3^{-1}$) and transect I03 ($S = 5.5 \pm 0.5 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$). Transect I06 ($S = 8.0 \pm 0.7 \text{ } 500\text{m}^3^{-1}$) was also found to be significantly greater than transect I03 ($S = 5.5 \pm 0.5 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$). Furthermore, transect I04 displayed a greater diversity ($H' = 1.93 \pm 0.09 \text{ } 500\text{m}^3^{-1}$) than transect I03 ($H' = 1.48 \pm 0.04 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$), whilst transect I05 presented a greater degree of Pielou's evenness (J') ($J' = 0.93 \pm 0.02 \text{ } 500\text{m}^3^{-1}$) than transect I02 ($J' = 0.76 \pm 0.06 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$) (Table 3). Transects I02 and I05 were not found to differ significantly in relative fish

S' and H from each other, or any other transects, when compared (Fig. B2).

Table 3. Mean Diversity indices for target fish Species Richness (S) and Shannon-Weiner Diversity (H') and Pielou's Evenness (J') per 500m^3 , with standard error ($\pm SE$) across transects in Punta, Libagon, Southern Leyte.

Transect	$S \text{ (} 500\text{m}^3^{-1}\text{)}$		$H' \text{ (} 500\text{m}^3^{-1}\text{)}$		$J' \text{ (} 500\text{m}^3^{-1}\text{)}$	
	S	$\pm$	H'	$\pm$	J'	$\pm$
I01	4.50	0.96	1.22	0.24	0.83	0.05
I02	7.00	0.71	1.47	0.18	0.76	0.06
I03	5.50	0.50	1.48	0.04	0.88	0.03
I04	9.75	0.85	1.94	0.09	0.86	0.05
I05	7.75	1.11	1.88	0.16	0.93	0.02
I06	8.00	0.71	1.75	0.08	0.85	0.04

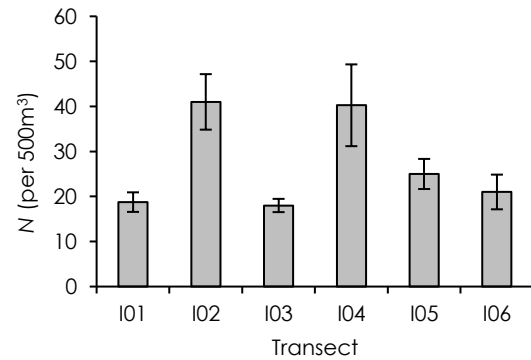


Figure 6: Mean target fish abundance per 500m^3 with standard error ($\pm SE$) between transects in Punta, Libagon, Southern Leyte.

3.1.1 Butterflyfish

Throughout the sample period, a total of $N = 68$ butterflyfish were recorded, representing 25% of all target butterflyfish species, with a mean abundance of $N = 2.83 \pm 0.55 \text{ } 500\text{m}^3^{-1}$. The most represented target organism was the Eastern Triangle Butterflyfish ($N = 2.67 \pm 0.31 \text{ } 500\text{m}^3^{-1}$). At the transect resolution, transect I04 ($N = 5.50 \pm 1.85 \text{ } 500\text{m}^3^{-1}$) presented significantly greater abundance of butterflyfish than transect I06 ($N = 0.00 \pm 0.00 \text{ } 500\text{m}^3^{-1}$) ($p < 0.05$). Transects I05 and I02 ($N = 4.50 \pm 1.19 \text{ } 500\text{m}^3^{-1}$ and $N = 4.00 \pm 0.71 \text{ } 500\text{m}^3^{-1}$, respectively) displayed significantly

greater butterflyfish abundance than transects I03, I01 and I06 ($N = 2.25 \pm 0.25 \text{ } 500\text{m}^3^{-1}$, $N = 0.75 \pm 0.75 \text{ } 500\text{m}^3^{-1}$ and $N = 0.00 \pm 0.00 \text{ } 500\text{m}^3^{-1}$, respectively) ($p = <0.05$). Transect I03 ($N = 2.25 \pm 0.25 \text{ } 500\text{m}^3^{-1}$) was found to present significantly greater abundance of butterflyfish than transect I06 ($p = <0.05$) (Fig. 7). No significant difference in mean butterflyfish abundance were found between transects I04 and I05 or transects I01 and I06 (Fig. B3). When considering Obligate butterflyfish, transect I06 was found to present a significantly lower abundance than transects I02, I03, I04 and I05 ($N = 4.50 \pm 1.19 \text{ } 500\text{m}^3^{-1}$, $N = 2.25 \pm 0.25 \text{ } 500\text{m}^3^{-1}$, $N = 5.50 \pm 1.85 \text{ } 500\text{m}^3^{-1}$ and $N = 4.50 \pm 1.19 \text{ } 500\text{m}^3^{-1}$, respectively) ($p = <0.05$). Transect I05 ($N = 4.50 \pm 1.19 \text{ } 500\text{m}^3^{-1}$) was also found to have greater abundance of obligate butterflyfish than transect I01 ($N = 0.75 \pm 0.75 \text{ } 500\text{m}^3^{-1}$) ($p = <0.05$) (Fig. 8). No Facultative butterflyfish were found throughout the sample area.

3.1.2 Commercially Important Fishes

3.81% ($N = 25$) of all fishes recorded throughout the survey were considered as commercially important (Parrotfish, Grouper and Snapper). Of this overall commercial fish species count, Parrotfish contributed the greatest (68%) with Grouper and Snapper both contributing the same (16% each). Although no commercial fish were recorded in the smallest size class (<10cm) nor were any of the four size classes over 31cm. Parrotfish were recorded only in size classes 11-20cm and 21-30cm ($f = 9$ and $f = 8$, respectively). Snapper were also only found in these two size classes ($f = 3$ and $f = 1$, respectively). All recorded grouper were classed as 21-30cm ($f = 4$) (Fig. 8).

At the transect resolution, transect I06 presented the greatest mean abundance for Parrotfish ($N = 2.25 \pm 0.75 \text{ } 500\text{m}^3^{-1}$), when compared to transects I01, I02 and I03 ($N = 0.00 \pm 0.00 \text{ } 500\text{m}^3^{-1}$ for all three transects) ($p = <0.05$) (Fig. 9). Groupers and Snappers were not found to differ significantly in relative

abundances, when compared between transects.

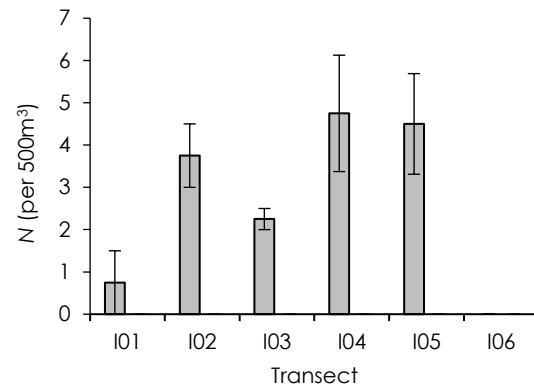


Figure 7: Mean obligate butterflyfish abundance per 500m³ with standard error ($\pm$ SE) between transects in Punta, Libagon, Southern Leyte.

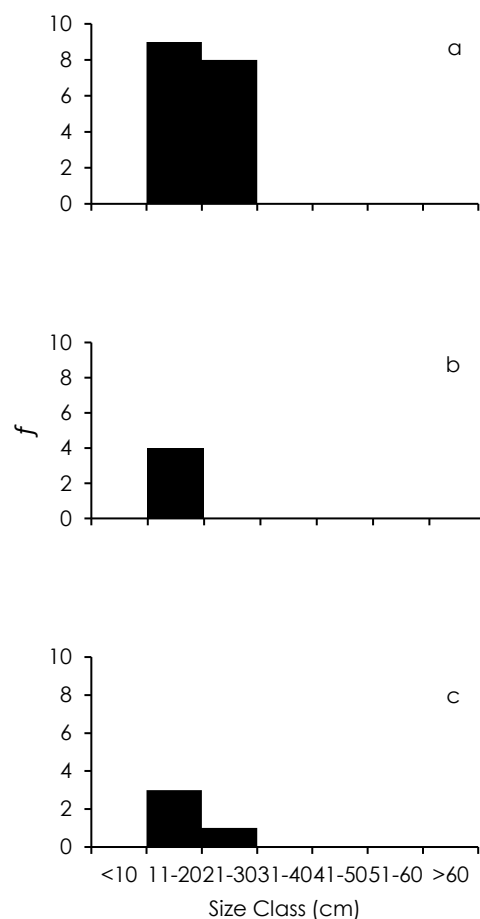


Figure 8: Total frequency (f) of Parrotfish (a), Snapper (b) and Grouper (c) by size class throughout transects in Punta, Libagon, Southern Leyte.

The total standing biomass (kg) recorded throughout the sample period was 3.54kg, with Parrotfish standing biomass (2.86kg) being the greatest, followed by Snapper and Grouper (0.45kg and 0.23kg, respectively). Furthermore, Parrotfish contributed the greatest to overall mean biomass (kg) ($0.15\text{kg} \pm 0.02 \text{ } 500\text{m}^3^{-1}$) (Fig. 10). The biomass (kg) recorded for each transect and respective commercially important fish family reflect similar results to mean abundance, with transect 106 ($0.42\text{kg} \pm 0.25 \text{ } 500\text{m}^3^{-1}$) demonstrating a significantly greater Parrotfish biomass than transects 101, 102 and 103 ($p = <0.05$). Groupers and Snappers were not found to differ significantly in relative biomass, when compared between transects.

3.2 Invertebrates

In total, $N = 4122$ individual invertebrates were recorded throughout the sample period, representing 46.34% of total target invertebrates, with a mean abundance of $N = 171.75 \pm 17.85 \text{ } 100\text{m}^2^{-1}$. Target organisms Feather Stars, Feather Duster Worms and Brittle Stars were recorded in the greatest densities ($N = 88.25 \pm 11.83 \text{ } 100\text{m}^2^{-1}$, $N = 38.33 \pm 8.18 \text{ } 100\text{m}^2^{-1}$ and $N = 35.29 \pm 6.14 \text{ } 100\text{m}^2^{-1}$, respectively) (Fig. C2). At the transect resolution, invertebrate abundance was not found to differ significantly between transects ($p = >0.05$) (Fig. 11). Invertebrate species richness (S), over the sample period, was recorded as $S = 6.57 \pm 0.31 \text{ } 100\text{m}^2^{-1}$ and was not found to differ significantly between transects ($p = >0.05$) (Table 4). In regard to diversity (H'), transect 105 demonstrated the greatest diversity ($H' = 1.20 \pm 0.08 \text{ } 100\text{m}^2^{-1}$) when compared to transect 106 ($H' = 0.98 \pm 0.03 \text{ } 100\text{m}^2^{-1}$) ($p = <0.05$) (Table 4). No other significant differences were found in diversity between transects (Fig. B5).

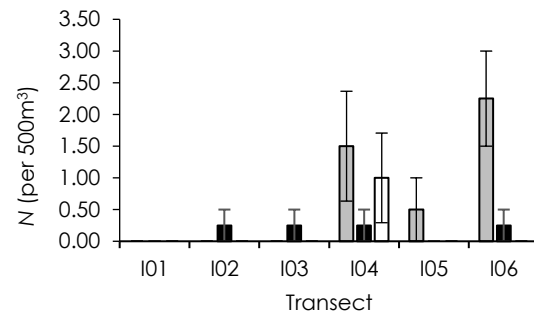


Figure 9: Mean parrotfish (grey), grouper (black) and snapper (white) abundance per 500m³ with standard error ($\pm SE$) between transects in Punta, Libagon, Southern Leyte.

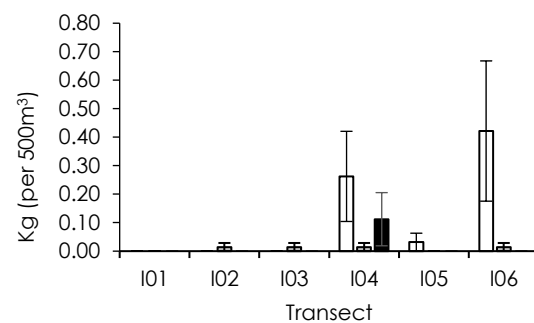


Figure 10: Mean parrotfish (white), grouper (grey) and snapper (white) biomass (kg) per 500m³ with standard error ($\pm SE$) between transects in Punta, Libagon, Southern Leyte.

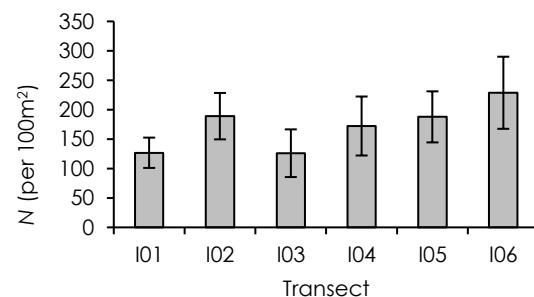


Figure 11: Mean invertebrate abundance per 100m² with standard error ($\pm SE$) between transects in Punta, Libagon, Southern Leyte

Transect 105 was also shown to have a significantly higher degree of evenness ($J' = 0.62 \text{ } 98 \pm 0.03 \text{ } 100\text{m}^2^{-1}$) than transect 106 ($J' = 0.47 \text{ } 98 \pm 0.02 \text{ } 100\text{m}^2^{-1}$) (Table 4). Transects 102 and 104 ($J' = 0.63 \pm 0.05 \text{ } 100\text{m}^2^{-1}$ and $0.63 \pm 0.02 \text{ } 100\text{m}^2^{-1}$, respectively), also showed a greater level of evenness ($p = <0.05$), despite

not being significantly more diverse than transect 106. No other transects were found to differ significantly in either diversity or evenness, when compared. (Fig. B5).

Giant clams were recorded a total of 5 times throughout the sample period and were all found to be within the two smallest size classes: 0-10cm and 11-20cm ($f = 2$ and $f = 3$, respectively) (Fig. 12). Relative abundance of Giant Clams was not found to differ significantly, when compared between transects ($p > 0.05$). There were no Crown of Thorns Sea Stars (*Acanthaster planci*) present throughout the survey site, during the survey period.

3.3 Substrates

Sand (SD) was the dominant substrate throughout the sample area ($30.73 \pm 4.31\%$ $20m^{-1}$) ($p < 0.05$), with Rock (RC) ($21.88 \pm 2.11\%$ $20m^{-1}$) and Hard Coral (HC) ($13.96 \pm 1.34\%$ $20m^{-1}$) having the second and third highest percentage cover ($p = < 0.05$) (Fig. C3). At the transect resolution, SD was found to cover a significantly higher percentage of transect 106 than transect 105 ($43.75 \pm 5.25\%$ $20m^{-1}$ and $25.00 \pm 2.70\%$ $20m^{-1}$, respectively) (Table 4). No other transects were found to differ significantly in SD cover, when compared (Fig B7) ($p = > 0.05$). Transect 101 displayed a significantly lower covering of RC ($10.00 \pm 1.02\%$ $20m^{-1}$) when compared to transects 102, 103, 104, 105 and 106 ($18.75 \pm 0.72\%$ $20m^{-1}$, $33.13 \pm 8.00\%$ $20m^{-1}$, $19.38 \pm 3.13\%$ $20m^{-1}$, $26.88 \pm 3.73\%$ $20m^{-1}$ and $23.13 \pm 3.59\%$ $20m^{-1}$, respectively) ($p = < 0.05$) (Table 5). Transects 102, 103, 104, 105 and 106 were not found to differ significantly in terms of RC cover, when compared ($p = > 0.05$) (Fig. B7). HC cover was not found to differ significantly between transects, when compared ($p > 0.05$).

Of the hard coral cover, the dominant life form throughout the survey area was Acropora Branching (ACB), followed by Non-Acropora Encrusting (CE) and Non-Acropora Massive (CM) (26.87% $20m^{-1}$, 24.63% $20m^{-1}$ and 17.91% $20m^{-1}$, respectively) (Fig. 14).

Table 4. Mean Diversity indices for target invertebrate Species Richness (S) and Shannon-Weiner Diversity (H') and Pielou's Evenness (J') per $100m^2$, with standard error ($\pm SE$) across transects in Punta, Libagon, Southern Leyte.

Transect	S ($100m^2^{-1}$)		H' ($100m^2^{-1}$)		J' ($100m^2^{-1}$)	
	S	$\pm$	H'	$\pm$	J'	$\pm$
101	7.00	0.82	1.01	0.10	0.53	0.05
102	6.00	0.58	1.11	0.06	0.63	0.05
103	5.75	0.75	1.15	0.14	0.67	0.07
104	6.50	0.65	1.18	0.06	0.63	0.02
105	7.25	1.03	1.20	0.08	0.62	0.03
106	8.00	0.41	0.98	0.03	0.47	0.02

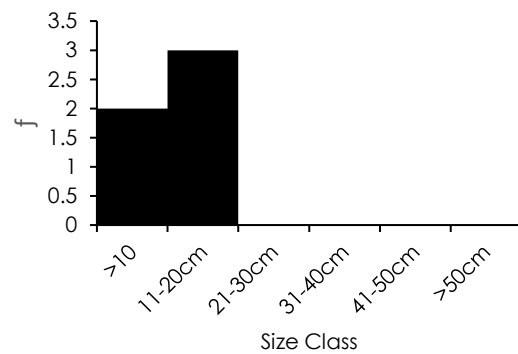


Figure 12. Total frequency (f) of Giant Clams by size class throughout transects in Punta, Libagon, Southern Leyte.

ACB and CE were significantly greater throughout the survey area than all other life forms, except each other ($p < 0.05$) (Fig. B8). At the transect resolution, no significant differences were found between ACB, CE and CM ($p = > 0.05$). Competitor Corals (CC), (41.04% of hard corals $20m^{-1}$) were proven to be the dominant life trait within the hard corals, when compared to Stress Tolerant Corals (ST) (23.13% of hard corals $20m^{-1}$) ($p = < 0.05$). No significant differences ($p = > 0.05$), however, were found between CC and Fast-Growing Corals (FGC) (35.82% of hard corals $20m^{-1}$) (Fig B9). At the transect resolution, CC was found to be significantly higher on transect 105 than transect 104 ($8.75 \pm 0.72\%$ of total substrate $20m^{-1}$ and $3.75 \pm 0.72\%$ of total substrate $20m^{-1}$, respectively) ($p = < 0.05$) (Fig. 15). No other significant differences in CC cover were found between transects (Fig.

B10). No significant differences were found in ST or FGC at the transect level ($p = >0.05$).

3.4. Impacts

During the survey, whilst no direct anthropogenic reef damage was observed (boat, anchor or dynamite damage) indirect reef damage in the form of general trash was recorded 46 times, with 33.33% of transects having 'high' levels (3 or more pieces per transect) and 41.67% of transects having 'medium' levels (2 pieces per transect). Fishing trash was recorded a total of 6 times, with the majority (79.17%) of transects having no recorded fishing trash (Fig. 16). No signs of disease, coral bleaching or predation were recorded across the survey site.

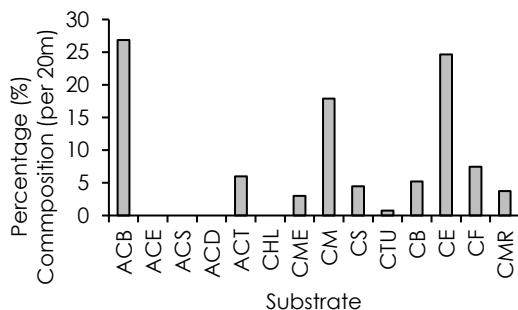


Figure 14. Mean percentage (%) of Hard Coral life forms per 20m in all transects in Punta, Libagon, Southern Leyte. ACB= Acropora Branching, CTU= Tubipora spp., CME= Millepora spp., CHL= Heliopora spp., CMR= Non-acropora Mushroom, CF= Non-acropora Foliose, ACT= Acropora Tabulate, ACD= Acropora Digitate, ACS= Acropora Submassive, ACE= Acropora Encrusting, CS= Non-acropora Submassive, CM= Non-acropora Massive, CB= Non-acropora Branching and CE= Non-acropora Encrusting.

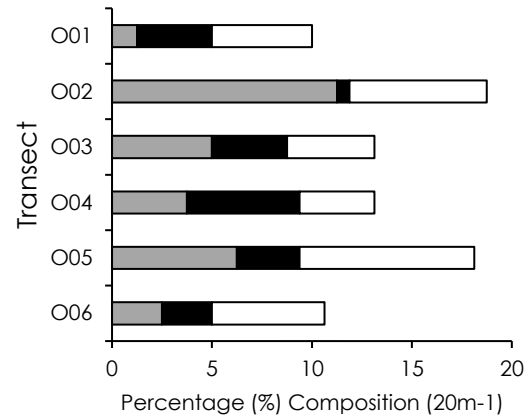


Figure 15. Percentage (%) cover of coral life forms per 20m with standard error ($\pm$ SE) between transects in Punta, Libagon, Southern Leyte. FGC= Fast growing Corals (absent from survey), STC= Stress Tolerant Corals (Grey) and CC= Competitor Corals (Black).

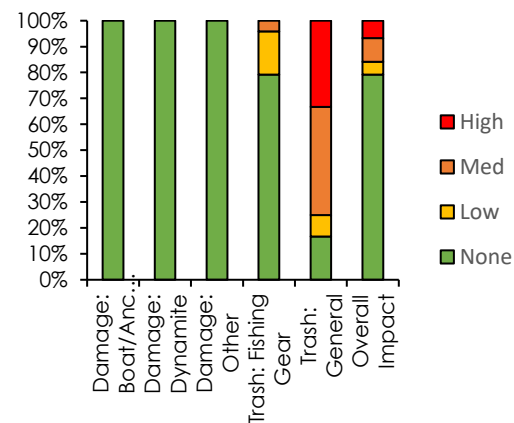


Figure 16. Total impact scale recorded over the complete survey area, Punta, Libagon, Southern Leyte. Counts of impacts are categorized to scale (0= none, 1= low, 2-4= medium and >5= high), which is applied to each recorded impact category as a percentage (%) of the surveyed area, split into two categories (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.

Table 5. Mean percentage (%) cover of benthic substrate types per 20m with standard error ($\pm$) between transects in Punta, Libagon, 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		3RC		SI		RB		SD		NIA		OT	
	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$
I01	10.00	4.56	0.63	0.63	1.25	1.25	0.00	0.00	10.00	1.02	43.75	18.39	1.88	1.20	31.25	21.81	0.63	0.63	0.63	0.63
I02	18.75	4.15	1.88	1.20	16.88	2.13	0.00	0.00	18.75	0.72	0.00	0.00	16.25	2.39	27.50	4.45	0.00	0.00	0.00	0.00
I03	13.13	2.13	4.38	2.77	4.38	1.88	0.00	0.00	33.13	8.00	0.63	0.63	3.75	2.17	37.50	10.21	0.63	0.63	2.50	1.44
I04	13.13	1.57	1.88	1.20	13.13	5.14	0.63	0.63	19.38	3.13	19.38	5.53	11.25	2.17	19.38	9.54	0.00	0.00	1.88	1.20
I05	18.13	2.77	1.25	0.72	10.00	4.68	0.00	0.00	26.88	3.73	1.25	1.25	15.00	1.02	25.00	2.70	1.25	0.72	1.25	0.72
I06	10.63	2.58	1.88	1.88	5.00	1.77	0.00	0.00	23.13	3.59	0.63	0.63	13.75	3.89	43.75	5.25	0.00	0.00	1.25	0.72

4.0 Discussion

This study assessed the current state of the Marine Protected Area (MPA) which was instated at Barangay Punta (Municipality Libagon) in 1994. 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 within the Punta MPA. Results indicated a low abundance and species diversity of coral-reliant fish species, in addition to commercially important fish and invertebrate species. This suggests that overall community assemblages, combined with the lack of specific commercially important species, have been affected by "top-down" reef community impacts from anthropogenic and local environmental stressors. These "top-down" impacts have severe effects on reef community structure and are indicative of low levels of enforcement within the MPA, as it is likely fishing practices and harvesting of invertebrates have continued despite the fact that these activities have been made illegal within the MPA boundaries.

4.1. Fish

Overall fish abundance within the Barangay Punta MPA was relatively low in comparison to other reefs surveyed within Sogod bay in 2017 (e.g. San Bernardo, Limasawa; Cogon, Pintuyan and Cabulihan, Limasawa). This is in spite of the fact that, at the time of surveying, none of the aforementioned sites were designated as MPAs. Furthermore, low results of fish diversity, including mean species richness (S') and mean Shannon's diversity (H'), were found, indicating a lack of

resilience to future disturbances (Downing et al., 2012) and 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). A high level of mean Pielou's evenness (J') (number of members within each species) was recorded within the proposed site. This demonstrates proportional abundances between species, which is not the norm for a community in its natural state (Verberk, 2011), indicating again some level of external influence. There was very little variation between transects, though some did have a higher abundance, diversity and species richness of fishes than others. One notable difference was seen in transect I04 when compared to transect I03. Spatially, these transects were furthest away from each other, both in terms of distance and depth, so it is likely biotic and abiotic factors may differ enough between the two to cause this difference in fish diversity (Bertocci et al., 2017). However, neither benthic composition nor invertebrate community dynamics were seen to differ between the aforementioned transects, so it is likely to be some other external factor causing the above findings.

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 and Reese 1996). By analysing butterflyfish diversity and abundance independently of total fish results, butterflyfish presence can act as an indicator of change 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 as 'facultative' corallivores and tend to be more resilient than 'obligate' corallivores to disturbances that hinder live coral cover (Pratchett et al., 2006).

Results showed that 100% of the 68 butterflyfish recorded within the survey area were obligate feeders. This is indicative of a high level of hard coral cover and structural complexity (Chong-Seng et al., 2012), however, although structurally complex and diverse, hard coral cover was found to be relatively low. Butterflyfish abundance was found to differ significantly between certain transects, whereas hard coral cover, branching *Acropora* cover, and fast-growing coral cover was not. However, transects with higher hard coral cover (102, 3, 4 and 5) were also those with the highest mean abundance of butterflyfish, showing perhaps butterflyfish were aggregating in areas with high coral cover in order to suit their feeding preference. High numbers of obligate butterflyfish are generally associated with high levels of scleractinian coral cover (Pratchett & Berumen, 2008). Although hard coral cover didn't differ between transects, it is likely that cover throughout the survey area is sufficient to support this community of butterflyfish, and other factors are influencing the difference in abundance between transects such as; the cosmopolitan behaviour of butterflyfish, their reaction to divers and their ability to move quickly out of a survey area. Although an indicator of high levels of hard coral cover, and thus likely low levels of destructive fishing practices within the MPA, the complete lack of facultative feeders within the butterflyfish means those present are at risk from any disturbances which cause a decline in coral cover.

When assessing the commercially important fishes, herbivorous fish biomass (Parrotfish)

was greater than other commercially important fish biomass (Snapper, Grouper). Parrotfish and other herbivorous fishes play a profound role in exposing reef substrate for coral settlement, and limiting macroalgal growth (Bellwood, 1994). 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, ensuring that these roles remain a functional part of ecosystem interaction (Mouillot et al., 2014). Although making up 68% of all commercial fish found within the survey area, parrotfish were still only recorded in low numbers on each transect, and in the second smallest size classes, indicating fishing is still occurring within the MPA (Valles & Oxenford, 2014). This is backed up by the low numbers and size of piscivorous predatory fish (Snapper and Grouper), which also indicate high fishing levels (Boaden & Kingsford, 2015).

Low biomass values for Grouper and Snapper species, and a similar low mean length, suggest the possibility that ongoing fishing pressures are inhibiting individual fishes to reach sexual maturation, or length of first maturity (L_m) (Russ & Alcala, 2003). Due to the commercial fish data being obtained at a family level resolution, it cannot be concluded that all recorded species were obtaining sexual maturity at the time of the survey due to differences in maturation rates between species within the same family. However, despite lack of analysis on specific species size and age at reproductive maturity, the small numbers of commercially important predatory fish found is sufficient in indicating the likelihood of high levels of fishing, within the boundaries of the MPA.

These commercially important species are particularly vulnerable to overfishing because they are large and often reside on shallow reef flats and are therefore highly desirable and sought after. Studying the life

history of these species show that they are slow growing, long-lived, with many changing sex as they grow (Shapiro, 1989; Sadovy et al., 1994). Fishing these types of 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 and Colin, 1997). 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. These include 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 & Domeier, 2005). Whilst the MPA fishing laws should support the home range and feeding grounds of Grouper species outside of their reproductive periods (March – April), few reports show the effectiveness of MPAs in limiting or preventing fish spawning aggregation loss, or in improving population level abundance (Nemeth, 2005). This is due to reproductive individuals needing to leave their feeding grounds to access their spawning location. Spawning grounds may thus exist outside of MPA boundaries, exposing fish to exploitation. Further studies to identify where Groupers may concentrate during reproductive periods will be necessary to establish full protection of this commercially important species. Establishing migratory pathways, and no-take areas in fish spawning locations during peak reproductive season (March – April) are suggestive strategies that could ensure adequate and effective protection of these reproductively complex species within Sogod Bay.

In contrast parrotfish have relatively small home ranges (Welsh et al., 2013), and so are

likely to benefit from the protection of a small area, such as the Punta MPA. The higher numbers of parrotfish when compared to other commercially important fish may reflect this (although parrotfish numbers are still very low when compared to other sites within Sogod Bay in 2017). Parrotfish also tend to cover smaller distances on reefs with less algal cover (such as the one studied here) 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, as evidenced in the high abundance of invertebrates across the study site, which in turn indicates increased resilience (Khalil et al., 2017).

There were no observations of other commercially important species including *Bolbometapon muricatum* (Bumphead Parrotfish), *Cromileptes altivelis* (Barramundi Cod) and *Plectorhincus* sp. (Sweetlips) recorded within the surveyed area, supporting the suggestion that these desirable food-fish species have been targeted and the enforcement of site protection is likely lacking.

Results suggest that continued overexploitation of fish resources combined with an MPA that doesn't cover the full range of certain fish species, are likely causing a depletion in fish stocks within the MPA despite fishing regulations in place. If the goal of the MPA is to increase fish abundance within the protected coastal waters, or to supplement the adjacent fishery through the emigration of fish or larval production from the reserve, both goals could be fulfilled by more stringent enforcement of the spatial restriction on fishing. Whilst the size of the reserve relative to the mobility of the fish will influence the degree to which reserve population recovery is undermined by emigration to fished areas, low dispersal

species will still benefit from the MPA being contained within a small area of the Barangay Punta's coastal waters, if properly regulated.

4.2. Invertebrates

Overall, mean target invertebrate abundance within the Punta MPA was relatively higher than other reefs surveyed within Sogod bay in 2017 (e.g. San Bernardo, Limasawa; Cogon, Pintuyan and Cabulihan, Limasawa). The combination of high S and H' , in addition to lower J' values, suggest a site representing a more resilient and diverse community of invertebrates. The extremely high total abundance of invertebrates across the survey area suggests a reef that is complex enough in its structure to support this. No differences were found between transects in either abundance or species richness of invertebrates, suggesting an even spread of structural diversity across the reef, able to support such a complex invertebrate community.

Feather stars, brittle stars, and feather duster worms made up the majority of the total invertebrate abundance recorded across all transects. Although not commercially important, all three of the above families are of ecological importance to the reef. Feather stars and feather duster worms are both filter feeders (Macurda & Meyer, 1983; Fauchald & Jumars, 1979), and thus play an active role in removing detritus and plankton from the water column, reducing 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. In addition, it has been shown that filter feeders are natural biofilters, and therefore can mitigate disease risks to other organisms on the reef (Burge et al., 2016). Brittle stars also play an important role on the reef. They have a wider range of feeding habits than the feather

duster worms and feather stars, such as suspension-feeding, deposit-feeding, scavenging and predation (Stohr et al., 2012), so can occupy a wider variety of niches within the reef community.

As well as the above, relatively high numbers of long-spine sea urchins (*Diadema antillarum*) were found across the site. This is again an indicator of an overfished site, as it is likely the predators of the sea urchins have been removed (Ashworth et al., 2004). This could be a cause of the low levels of algal covering found across the site, as without natural predators keeping populations in check, sea urchins have been known to overgraze areas until the amount of algae becomes the limiting factor on population growth (Lafferty, 2004). Although low algal covering is beneficial to corals on the reef, it may be that it has become so low that it cannot support high numbers of herbivorous fish. Again, this has most likely occurred because of continued fishing within the MPA, which has changed the natural structure of the reef community.

Commercially important invertebrate species including pinkfish sea cucumber (*Holothuria edulis*), squid (*Teuthida*), greenfish sea cucumber (*Stichopus chloronotus*), and Triton's trumpet (*Charonia tritonis*) were absent from the survey. These species, which in many cases are slow growing and slow moving, are particularly vulnerable to over exploitation. Although one lobster (*Nephropidae*) was found in the survey area, results indicate that extraction pressures are high in the area for these species.

Only 5 giant clams (*Tridacna*) were found within the survey area, all of which were below 20cm in size. This indicates a high level of extraction pressure on the site. 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). Future scientific and social surveys of giant clam populations will be needed to determine whether current populations are re-establishing from past or current fishing pressures.

No occurrences of *Acanthaster planci* (CoTS) were recorded throughout the survey. However, future studies will be necessary to address the effects of seasonality on the CoTS numbers. Extreme weather events affecting nutrient influx into the area during the month of July to September each year, potentially trigger a population influx of CoTS plankton in the months that follow. 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, the lack of disease detected on the survey, as well as the high diversity of coral types, shows an absence of CoTS is not having an adverse effect, and is encouraging of the water quality within the area.

4.3. Substrates

The most prevalent substrate within the Punta MPA was sand, followed by rock and hard coral. Although sand does not present an opportunity for future coral larvae settlement, the high levels of rock indicate that, regardless of the seasonal exposure of the MPA to tides and strong currents, settlement potential is still high. Transect I01 had less rocky substrate than all other transects, but no other differences were found, showing a relatively even covering of rocky substrate, and thus similar levels of settlement potential across the MPA. Hard coral coverage also being high in comparison to other substrates 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 (Idjadi & Edmunds, 2006). However, coral cover is still lower within the Punta MPA than the average coral cover in the Philippines, found to be 22% in a nationwide assessment of coral reefs (Licuanan et al., 2017). There is evidence that coral loss is occurring throughout the Indo-Pacific uniformly among sub-regions, even on intensely managed reefs (Bruno & Selig, 2007), therefore the below-average level of cover does not necessarily imply bad management practices within the MPA.

Of the hard coral found, there was no difference in cover between transects. This is evidence for environmental conditions (pH, temperature, turbidity and levels of dissolved CaCO_3) being suitable for the growth of hard coral throughout the survey area. Of the hard coral found within the MPA, the three most prevalent life growth forms were branching corals of the genus *Acropora* (ACB), along with encrusting non-*Acropora* corals (CE) and massive non-*Acropora* corals (CM). These each represent a different life trait: fast growing coral (FGC), competitor coral (CC) and stress tolerant coral (STC), respectively.

Branching corals such as those of the *Acropora* genus found within the MPA fall under the category of fast-growing corals and are therefore able to recover quickly from disturbances (Karlson & Hurd, 1993). This potentially prevents them from long term damage, and increases their resilience to, "Habagat", the seasonal storms which hit Sogod Bay. In addition, branching *Acropora* corals are indicative of high levels of structural complexity. Reefs with high coverings of such corals therefore tend to exhibit higher levels of species richness and abundance (Edinger & Risk, 2000). This is true of the invertebrate community within the MPA, but not of the fish, again indicating a high level of extraction within the survey site. No differences between levels of fast-growing coral or branching *Acropora* corals

were found between transects, suggesting homogeneity in reef structure across the site.

Massive non-*Acropora* corals are slow growing, stress tolerant corals and are less likely to be impacted by disturbances such as seasonal storms and sedimentation (Rogers, 1990). Nearshore reefs dominated by long-lived, stress tolerant corals may be considered of high conservation value due to their longer replacement time and potential adaptation to occurrences such as temperature spikes (McLeod et al., 2009). Competitor corals such as the non-*Acropora* encrusting corals found across the site are similarly tolerant to disturbances and therefore of similar conservation value to the stress tolerant corals found within the site. This shows the MPA to be situated in an area which should benefit from protection, and therefore it is important any current restrictions in place within the MPA are strongly adhered to.

When looking at the three most dominant growth forms (ACB, CE and CM), no differences were found between transects. Similarly, there were few differences in levels of cover of the three life traits (FGC, STC and CC) between transects, except in one transect showing higher levels of CC than one other. These results show a high level of homogeneity across the MPA, both in terms of structural complexity and resilience to disturbances. This is evidence that the MPA has been placed in an area with high conservation value and suggests external damage to the reef itself is low, in spite of other disturbances such as extraction of commercially important fish and invertebrate species seeming high.

4.4 Impacts

The presence of fishing trash suggests that the Barangay Punta MPA is an active fishing ground, despite current restrictions. This is supported by the absence of and the small size groups of key commercially important species. However, the levels of fishing trash are relatively low, and therefore pose the

question of whether the MPA itself is too small to benefit fish stocks, if fishing pressures are high in the area surrounding the MPA. Should they continue, these fishing pressures will be unsustainable for commercially important fish and invertebrate populations. A combination of the absence or small sizing of some key commercially important species suggests fishing pressures and practices within this site are species selective and therefore unsustainable for commercially important fish invertebrate populations.

Other trash was also recorded in high levels across the survey site. If the future success of the MPA is to be secured, more stringent coastal management regimes will 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 can bioaccumulate up the trophic levels on the reef.

4.5 Conclusion

It is apparent from the results discussed above that, although in a prime position in terms of conservation value, there are some issues which have prevented fish stocks from recovering within the MPA, despite it being in place for over 20 years. Either enforcement of fishing restrictions within the MPA is not occurring, or the MPA itself does not cover enough area to ensure the whole home range of commercially important species are protected. If the latter is the case, it may be beneficial to increase the size of the MPA. However, socio-economic drivers such as poverty, lack of appropriate institutions, and population growth which influence the overfishing of reef fisheries (Teh et al., 2013) must be considered. As a result, making the no take zone larger may not be favourable to the local community. Instead, it may be of greater benefit to put in place a marine reserve or "buffer zone" where fishing is allowed but limited to less destructive fishing

practices. A 50m marine reserve is typical for MPAs within Sogod Bay, and restricted fishing practices are kept to 'hook and line' only. MPAs that actively engage fishermen in MPA 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). This suggests that user participation in management can lead to a greater perceived legitimacy of MPA management, which is a critical step towards user compliance. Compliance towards MPA guidelines, whilst initially may be dictated by the level of enforcement, is a necessary step towards long-term sustainability. If stakeholders are not engaged in the management process, more surveillance and enforcement associated with controlling this lack of compliance could lead to a negative attitude of stakeholders toward the MPA (Di Franco et al., 2016; Pollnac et al., 2001). This in turn would distance MPA

managers from stakeholders, potentially resulting in law infringements by local fisherman. Ensuring fishermen participate in either formal or informal rulemaking on the MPA management board safeguards their rights, resulting in informal commitment to the protection of the MPA. Therefore, if any changes are to be made to the MPA, it is strongly suggested that these decisions be made by a local management body made up of active stakeholders.

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 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 Punta. * Indicates species seen and recorded, lack of a * indicates this species was not seen during surveys.

Common Name	Latin Name	Visayan Name
*Angelfish	<i>Pomacanthidae</i>	Adlo
Barracuda	<i>Sphyraenidae</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 sp.</i>	
*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 sp.</i>	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 Punta. * Indicates species seen and recorded, lack of a * indicates this species was not seen during surveys.

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	* <i>Acanthaster planci</i>
Cuttlefish	Squid	*Brittle star
* <i>Linkia laevigata</i>	* <i>Culcita novaeguineae</i>	*Collector urchin
* <i>Choriaster granulatus</i>	*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) surveys of the Barangay Punta.

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 submassive
Acropora digitate	Acropora tabulate	Non-Acropora branching
Non-Acropora encrusting	Non-Acropora foliose	Non-Acropora submassive
Non-Acropora mushroom	<i>Heliopora</i> (blue coral)	<i>Millepora</i> (fire coral)
<i>Tubipora</i> (organ-pipe coral)		
**Other:		
Anemone	Corallimorph	Halimeda
Tunicate	Zoanthid	Gorgonian
Hydroids		

* 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

	O01	O02	O03	O04	O05	O06
O01		-				
O02	+		+			
O03		-		-		
O04			+			
O05						
O06						

Figure B1. Matrix showing significant differences in mean target fish abundance per 500m³ across the survey site in Punta, Libagon, 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 the transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)

	O01	O02	O03	O04	O05	O06
O01				-		
O02						
O03				-		-
O04	+		+			
O05						
O06			+			

b)

	O01	O02	O03	O04	O05	O06
O01						
O02						
O03				-		
O04			+			
O05						
O06						

c)

	O01	O02	O03	O04	O05	O06
O01						
O02					-	
O03						
O04						
O05		+				
O06						

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 Punta, Libagon, 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 the transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)

	O01	O02	O03	O04	O05	O06
O01		-			-	
O02	+		+			+
O03		-			-	+
O04						+
O05	+		+			+
O06		-	-	-	-	

b)

	O01	O02	O03	O04	O05	O06
O01					-	
O02						+
O03						+
O04						+
O05	+					+
O06		-	-	-	-	

Figure B3. Matrices showing significant differences in a) mean target butterflyfish and b) mean obligate butterflyfish abundance per 500m³ across the survey site in Punta, Libagon, 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 the transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

	O01	O02	O03	O04	O05	O06
O01						-
O02						-
O03						-
O04						
O05						
O06	+	+	+			

Figure B4. Matrix showing significant differences in mean parrotfish biomass per 500m³ across the survey site in Punta, Libagon, 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 the transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

a)

	O01	O02	O03	O04	O05	O06
O01						
O02						
O03						
O04						
O05						+
O06					-	

b)

	O01	O02	O03	O04	O05	O06
O01						
O02						+
O03						
O04						+
O05						+
O06		-		-	-	

Figure B5. Matrices showing significant differences in mean target invertebrate a) Shannon's H' Diversity Index and b) Pielou's evenness (J) per 500m³ across the survey site in Punta, Libagon, 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 the transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

	HC	SC	SP	RKC	RC	SI	RB	SD	NIA	OT
HC		+	+	+	-	+		-	+	+
SC	-		-	+	-		-	-	+	
SP	-	+		+	-			-	+	+
RKC	-	-	-		-	-	-	-		+
RC	+	+	+	+		+	+	-	+	+
SI	-			+	-		-	-	+	+
RB		+		+	-	+		-	+	+
SD	+	+	+	+	+	+	+		+	+
NIA	-	-	-		-	-	-	-		
OT	-		-	-	-	-	-	-		

Figure B6. Matrix showing significant differences in mean Substrate type cover per 20m across all transects in Punta, Libagon, 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 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 the transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	O01	O02	O03	O04	O05	O06
O01						
O02						
O03						
O04						
O05						-
O06					+	

a)	O01	O02	O03	O04	O05	O06
O01		-	-	-	-	-
O02	+					
O03	+					
O04	+					
O05	+					
O06	+					

Figure B7. Matrices showing significant differences in mean a) Rock (RC) and b) Sand (SD) cover per 20m across all transects in Punta, Libagon, 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 the transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

	ACB	ACT	CME	CM	CS	CTU	CB	CE	CF	CMR
ACB		+	+		+	+	+		+	+
ACT	-							-		
CME	-			-				-		
CM			+			+		+		+
CS	-							-		
CTU	-			-				-		
CB	-							-		
CE		+	+		+	+	+		+	+
CF	-							-		
CMR	-			-				-		

Figure B8. Matrix showing significant differences in mean hard coral type cover per 20m across all transects in Punta, Libagon, Southern Leyte. ACB; *Acropora branching*, ACT; *Acropora tabulate*, CME, Fire coral, CM; Non-*Acropora* massive, CS; Non-*Acropora* submassive, CTU; Organ pipe, CB; Non-*Acropora* branching, Non-*Acropora* encrusting, Non-*Acropora* foliose, CMR; Mushroom coral. 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 the transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

	FGC	CC	ST
FGC			
CC			+
ST	-		

Figure B9. Matrix showing differences in hard coral life traits per 20m across all transects in Punta, Libagon, Southern Leyte. FGC; Fast Growing Coral, CC; Competitor Coral and ST; Stress Tolerant Coral. A green '+' indicates that percentage cover of the life trait on the left was significantly higher than the life trait at the top ($p < 0.05$). A blue '-' indicates that percent cover of the life trait on the left was significantly lower than the life trait on the top ($p < 0.05$). Blank cells indicate no significant difference.

	O01	O02	O03	O04	O05	O06
O01						
O02						
O03						
O04					-	
O05				+		
O06						

Figure B10. Matrix showing significant differences in competitor coral cover across all transects in Punta, Libagon, 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 the transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

Appendix C

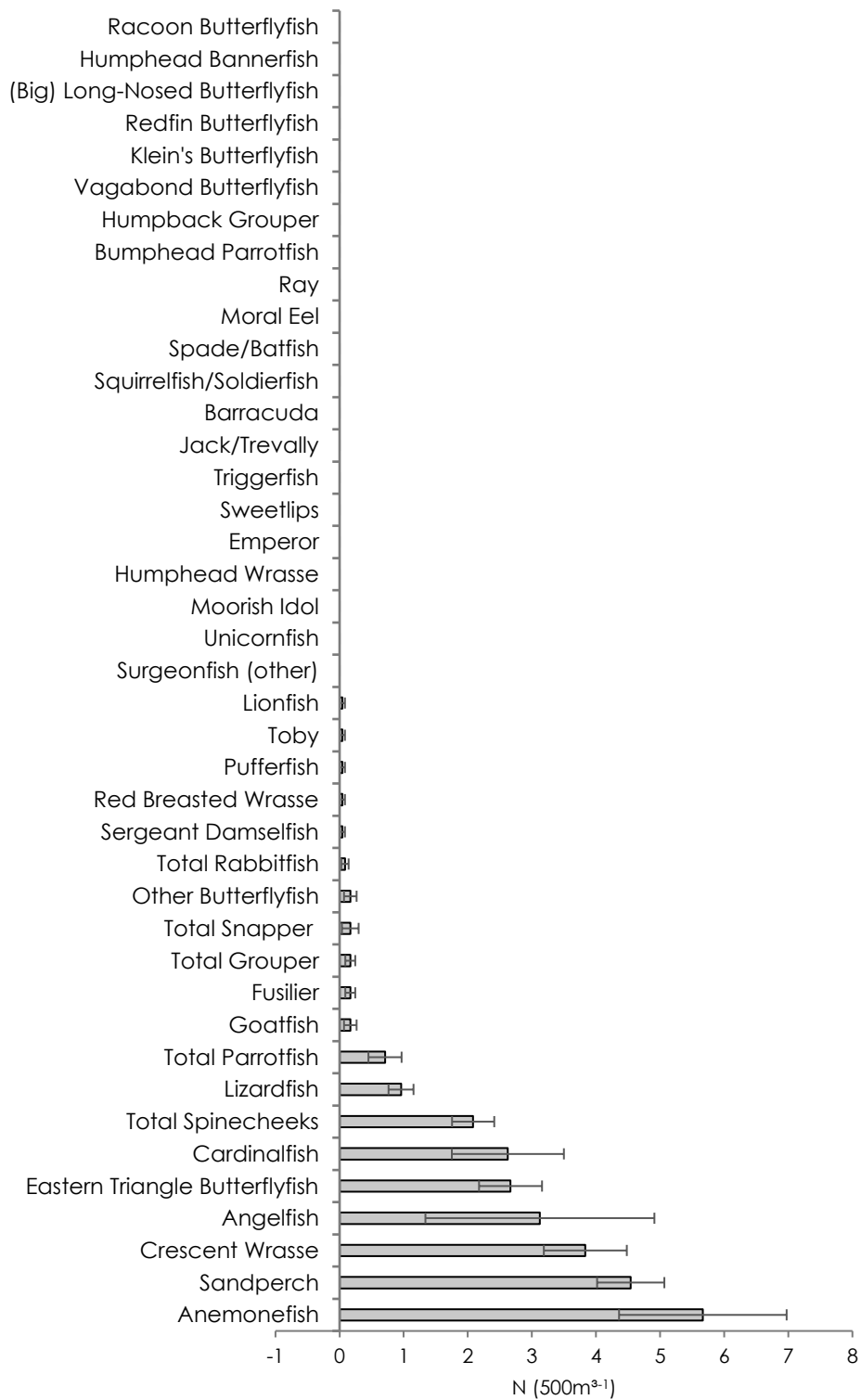


Figure C1. Mean abundance of target fish species and families per 500m³ with standard error ($\pm$ SE) in Punta, Lilbagon, the Philippines.

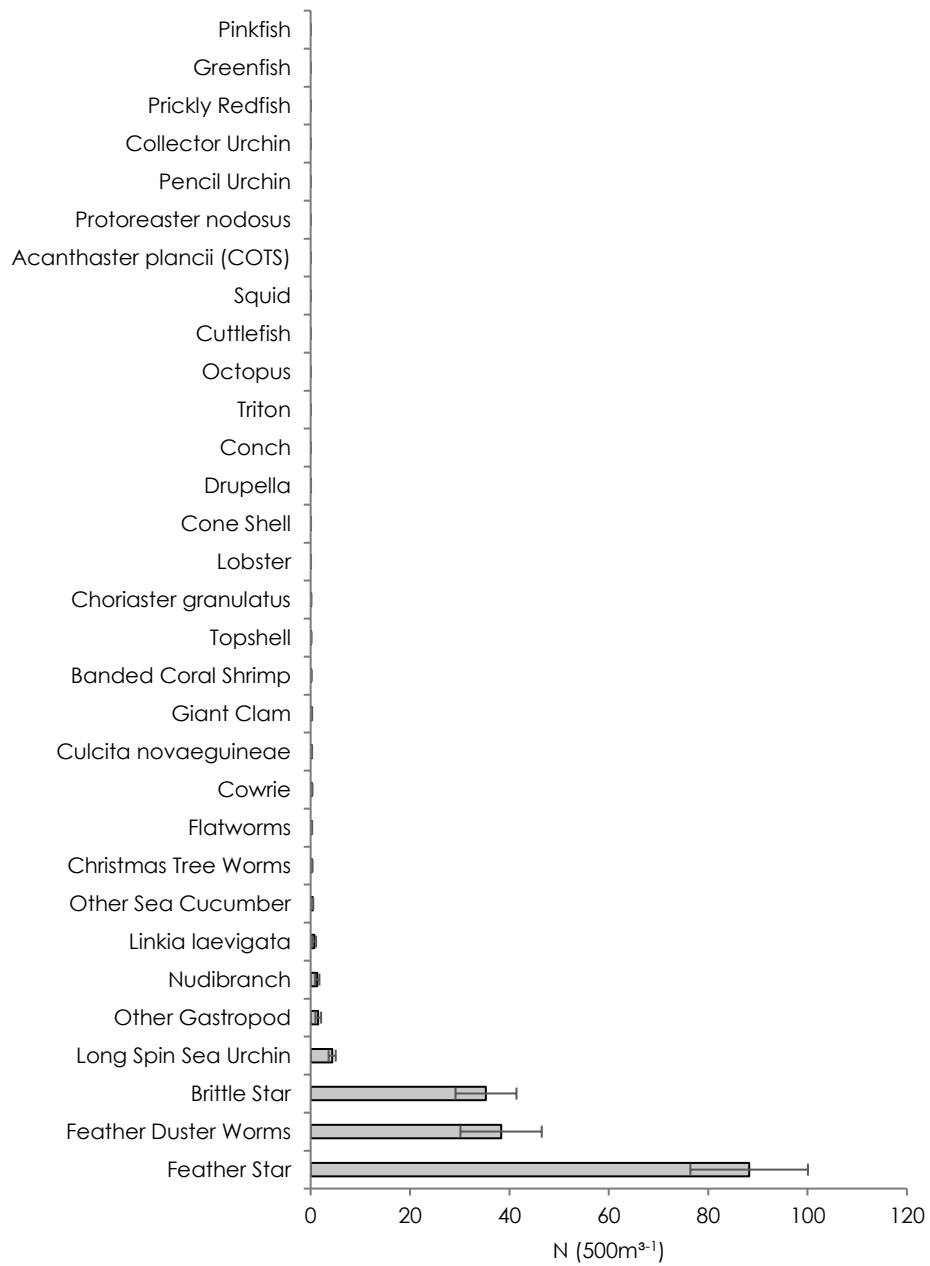


Figure C2. Mean abundance of target invertebrate species and families per 100m² with standard error ($\pm$ SE) in Punta, Libagon, the Philippines.

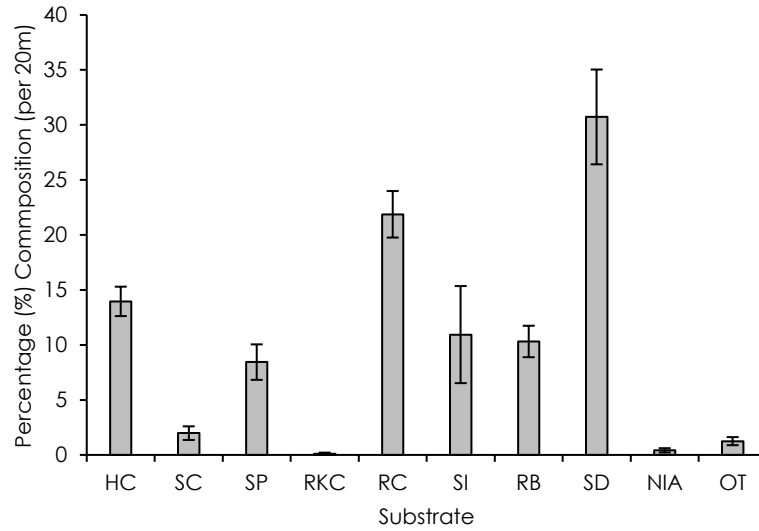


Figure C3. Mean composition (%) substrates per 20m with standard error ($\pm$ SE) in Punta, Libagon, Philippines. RKC= Recently Killed Coral, OT= Other, SC= Soft Coral, SP= Sponge, SI= Silt, HC= Hard Coral, NIA= Nutrient Indicator Algae, RC= Rock, RB= Rubble and SD= Sand.