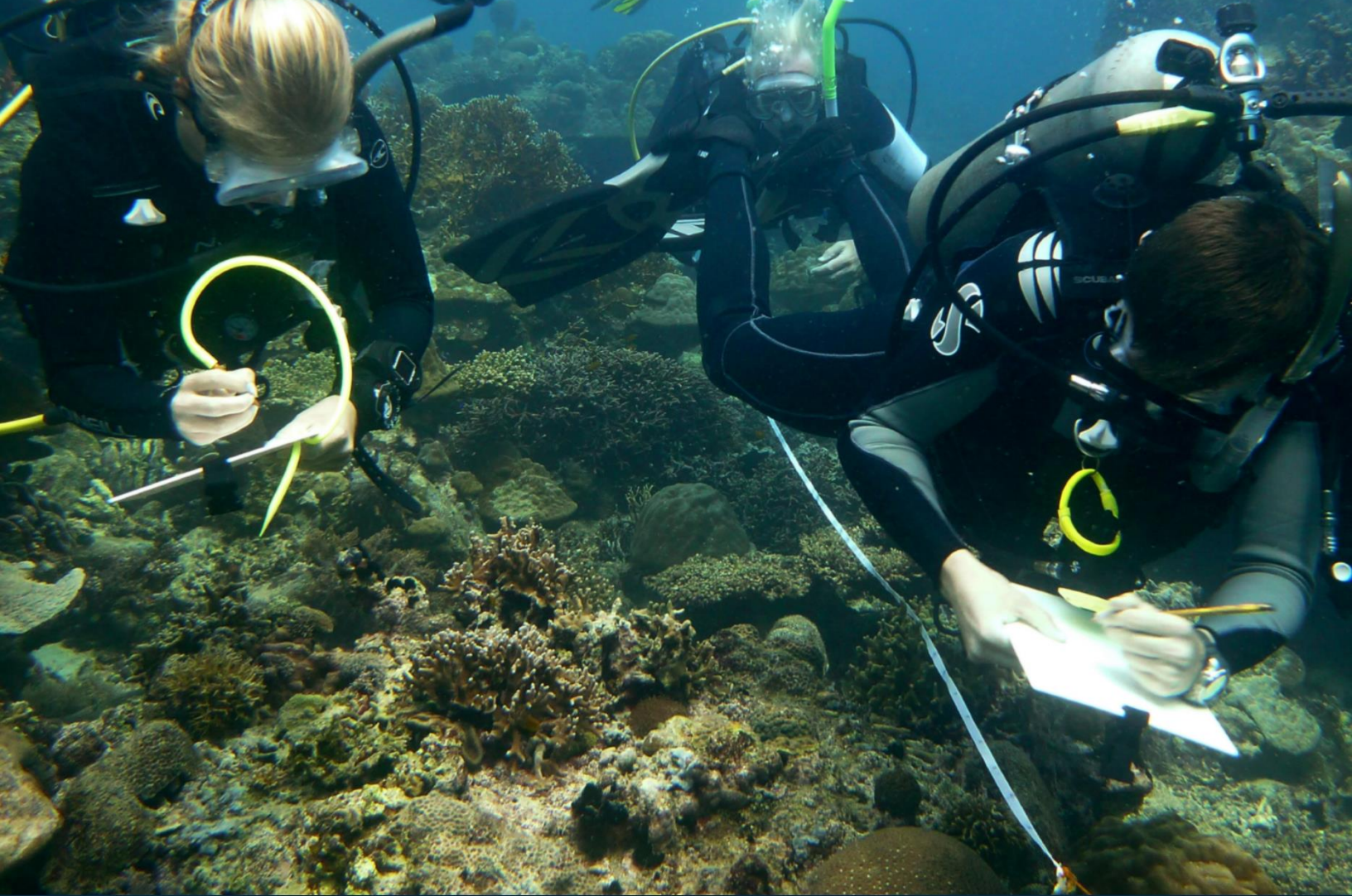




LRCP
Southern Leyte Coral Reef Conservation Project

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

Report Date: February 2019



Manon Broadribb, Tom Dallison,
Morgan Larimer

In partnership with the Southern Leyte
Provincial Government, Philippines





Report by:

Manon Broadribb, Project Scientist¹

Tom Dallison, Head of Science ²

Morgan Larimer, Kings College London

¹Coral Cay Conservation, Napantao Dive Resort, 6613, San Francisco, Southern Leyte, Philippines; lrcp@coralcay.org

²Coral Cay Conservation, The Kiln, Grange Road, Tongham, Surrey, UK; headofscience@coralcay.org

In partnership with:



The Provincial Government of Southern Leyte

With thanks to:



The Municipal Government of San Francisco

All photographs throughout this report are credited to the photographer, where due, or are property of Coral Cay Conservation.

No photograph within this report may be used in other pieces of work without written permission from the photographer or Coral Cay Conservation.

This report and any information within must be cited in accordance with the recommended citation below or where appropriate, the original source reference.

To view an online copy of this report, visit <http://www.coralcay.org/science-research/scientific-reports/>

Recommended Citation: Broadribb, M., Dallison, T., and Larimer, M. (2019). Coral Cay Conservation Marine Protected Area Assessment Report: Barangay Lipanto 2017. *Coral Cay Conservation*.



Copyright 2019 Coral Cay Conservation

www.coralcay.org



Coral Cay Conservation is a division of the Lifesigns Group

www.lifesignsgroup.co.uk

Executive Summary

- Coral Cay Conservation (CCC) assessed the reef fish, invertebrates, substrates and anthropogenic impacts inside of the Marine Protected Area (MPA) in Barangay Lipanto (Municipality St. Bernard) during August 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 $N = 57.22 \pm 7.62 \text{ } 500\text{m}^3^{-1}$ with transect I08 obtaining the greatest mean abundance ($N = 112.25 \pm 24.31 \text{ } 500\text{m}^3^{-1}$). Mean species richness (S) was $S = 9.94 \pm 0.78 \text{ } 500\text{m}^3^{-1}$, mean Shannon-Weiner diversity (H') was $H' = 1.68 \pm 0.11 \text{ } 500\text{m}^3^{-1}$ and mean Pielou's evenness (J') was $J' = 0.75 \pm 0.04 \text{ } 500\text{m}^3^{-1}$.
- Mean Butterflyfish abundance was $N = 5.91 \pm 0.86 \text{ } 500\text{m}^3^{-1}$. Transect I02 had the highest mean abundance ($N = 10.25 \pm 3.47 \text{ per } 500\text{m}^3$) and transect I05 the lowest ($N = 2.00 \pm 1.41 \text{ per } 500\text{m}^3$). Of the 189 individuals recorded across the survey area, 78 were categorized as obligate corallivores, and 34 as facultative feeders. This high abundance of obligate corallivores suggests high levels of fast-growing scleractinian corals (preferential food choice).
- Relatively high abundance ($N = 5.84 \pm 1.33 \text{ per } 500\text{m}^3$), but small size ($<31\text{cm}$), of commercially important fishes indicates a well-managed MPA which may not cover sufficient area to allow for sexual maturity to be reached.
- The mean abundance of invertebrates was $N = 199.09 \pm 17.23 \text{ } 100\text{m}^2^{-1}$ and was highest at transect I03 ($N = 305.00 \pm 19.76 \text{ } 500\text{m}^2^{-1}$) and lowest at transect I05 ($N = 55.25 \pm 13.38 \text{ } 500\text{m}^2^{-1}$). Mean species richness was $S = 8.56 \pm 0.40 \text{ } 500\text{m}^2^{-1}$, mean Shannon-Weiner diversity (H') was $H' = 0.95 \pm 0.07 \text{ } 500\text{m}^2^{-1}$ and mean Pielou's evenness (J') was $J' = 0.44 \pm 0.03 \text{ } 500\text{m}^2^{-1}$. The majority of target species found, although demonstrating structural diversity, were not commercially important, suggesting intensive historic harvesting.
- The dominating substrate was Sand ($21.09 \pm 4.29\% \text{ } 20\text{m}^{-1}$), followed by Rubble ($19.14 \pm 2.85\% \text{ } 20\text{m}^{-1}$) and Hard Coral ($17.50 \pm 2.35\% \text{ } 20\text{m}^{-1}$). The hard coral present in the survey site exhibited all three life traits: competitor coral, fast growing coral, and stress tolerant coral (51.79%, 16.52% and 31.70% respectively). This demonstrates a structurally diverse and resilient reef. Some instances of bleaching and coral disease were present.
- Overall anthropogenic impacts were low across all transects, with no evidence of boat, anchor, dynamite, or other coral damage found. However, general trash was found in high levels on 18.75% of transects and medium levels on 37.50% of transects, and fishing trash was found in high levels on 9.38% of transects and medium levels on 15.63% of transects, demonstrating that trash is a problem in the area.
- Results from the Barangay Lipanto, St. Bernard Municipality Marine Protected Area (MPA) site indicate that the surveyed area is currently well-managed and is therefore in a position to support a more diverse community assemblage. Relatively high levels of hard coral cover in varying growth forms and relatively high invertebrate and fish abundance demonstrate a structurally diverse, well-managed MPA, giving the site the potential to support many other species. The impacts of the small size of the MPA should, however, be addressed, and creating a marine reserve (MR) around the MPA could help mitigate these.

Table of Contents

1.0 Introduction.....	1
1.1 Marine Protected Areas	1
1.2 Coral Reefs and Marine Conservation in the Philippines	3
1.3 Characterisation of Study Region.....	3
1.3.1 Cabalian Bay	3
1.3.2 Lipanto, St. Bernard.....	3
2.0 Methodology and Data Collection	5
2.1 Survey Site	5
2.2 Biophysical Survey	5
2.2.1 Visual Assessment of Reef Fishes	5
2.2.2 Biomass Calculations	6
2.2.3 Visual Assessments of Invertebrates	7
2.2.4 Substrates.....	7
2.2.5 Impacts	7
2.3 Data Analysis.....	8
3.0 Results.....	9
3.1 Fishes	9
3.1.1 Target Fishes	9
3.1.2 Butterflyfish	9
3.1.3 Commercially Important Fishes	10
3.4 Invertebrates	11
3.5 Substrates.....	12
3.6 Impacts	15
4.0 Discussion.....	16
4.1. Fish.....	16
4.2. Invertebrates	18
4.3. Substrates.....	20
4.4 Impacts	21
4.5 Conclusion.....	22
References.....	24
Appendix A.....	28
Appendix B	30
Appendix C	35

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 and the Barangay Council of Lipanto.
- Dr Gloria Reyes, Homer de Dioz and all staff of Southern Leyte State University.
- Our Filipino staff: Bok Bok, Jesse, Dudong 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: Debbie Bartolo, Charlotte Henriksen, Iris Abrigo, Charles Luke, Felipe Lei, Javier Del Campo, Lucy D'Mello, Guisla Virella, Peter Luke, Pau Pamplona, Ben Jack, Jerome Napala, Nathan Hubot and Rachel Taylor.

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 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, 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; 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. 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).

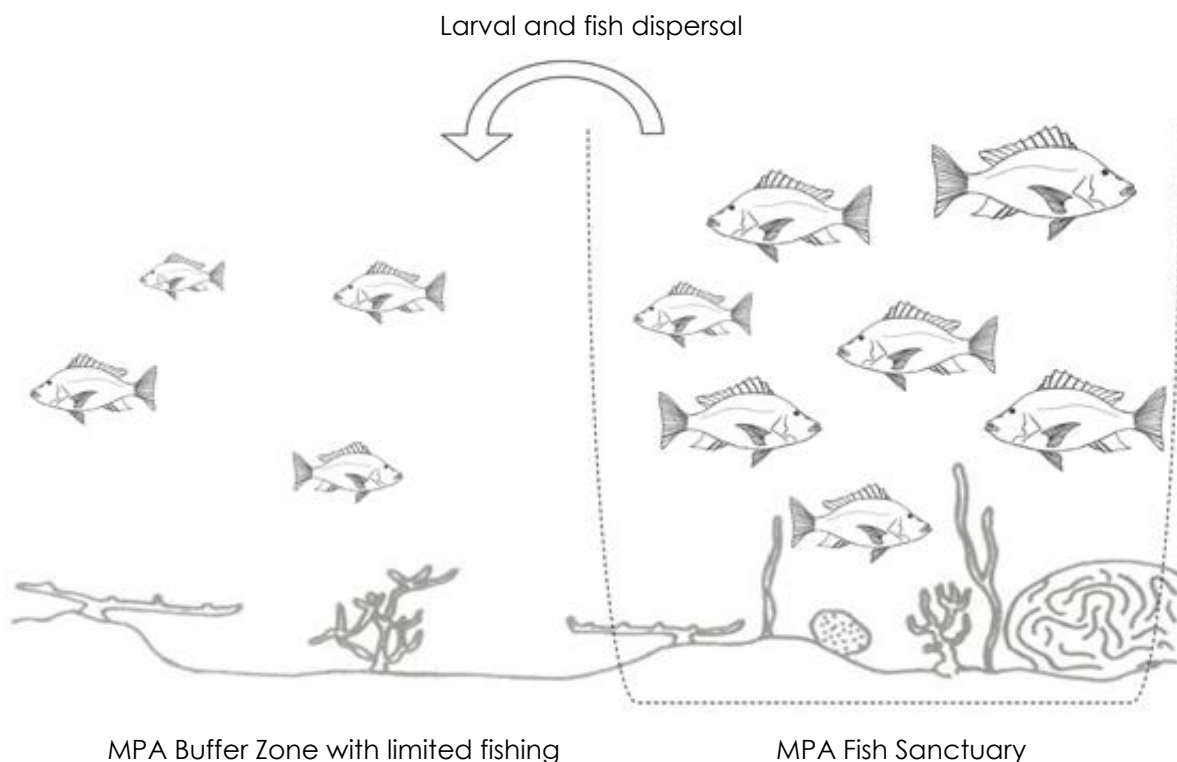


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to 'overspill', increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

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., 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 in 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 Cabalian 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 the 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.

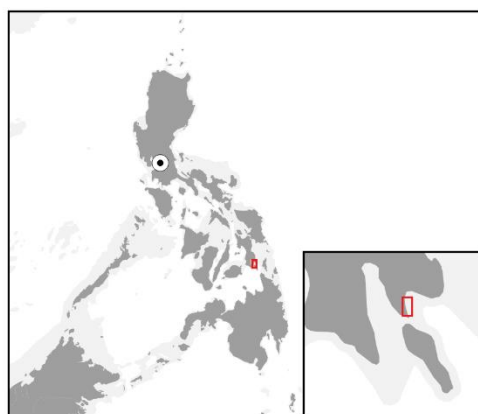
1.3.2 Lipanto, St. Bernard

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 reef within the Barangay Lipanto MPA, located between 25m and 75m from the shoreline. The MPA covers 3.5 hectares (ha) and was approved in 1998. The MPA is situated to the south of Barangay Lipanto, located in the St. Bernard Municipality in Cabalian Bay

(Fig 2). The centre of the Barangay is roughly 2km from the MPA and has a population of 1210 (August 2017). The location of the barangay being in Cabalian bay means that the coast and associated reefs are exposed annually to the damaging northeast trade winds throughout the months of November to May (Aniham). It was hit by the typhoon Basayang in February 2018 and is likely to be subject to more reef damaging storms into the future.



Legend

- ▲ 6m Transects
- 12m Transects
- MPA Boundary
- MPA Demarcation Buoy

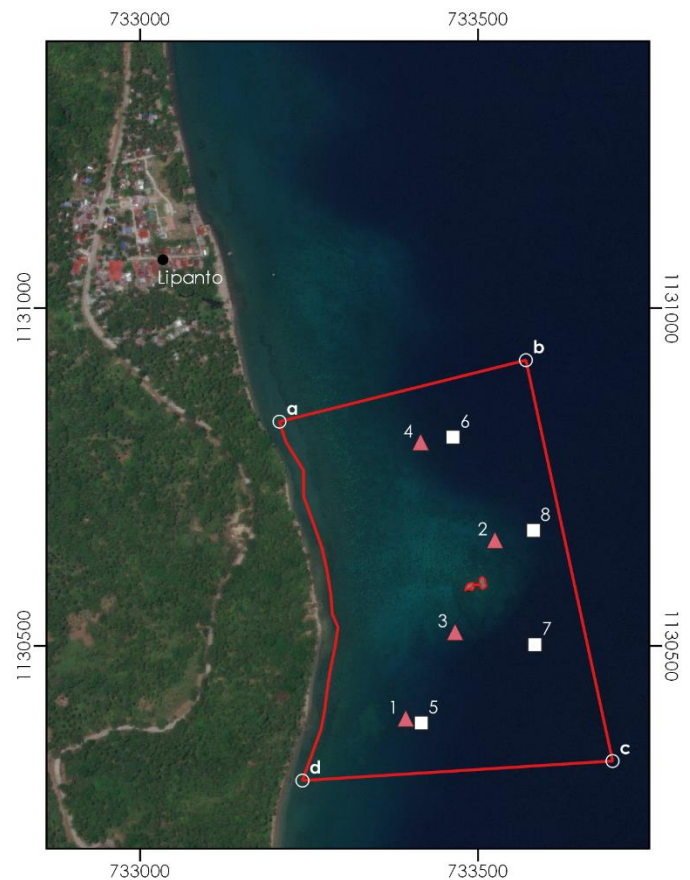
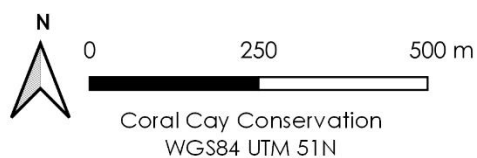


Figure 2. Location of Barangay Lipanto Marine Protected Area, St. Bernard Municipality, Southern Leyte and the location of 6m and 12m transects surveyed by Coral Cay Conservation in 2017.

2.0 Methodology and Data Collection

2.1 Survey Site

CCC's assessment of the MPA at Lipanto was conducted between 15/08/2017 and 01/09/2017 by trained volunteer survey teams. The weather was a mixture of cloudy and sunny for the survey period, with a mean air temperature of 29.75°C. Mean sea surface temperature (SST) was the same at 29.75°C. Temperature at 3m and 10m were also recorded as having a mean of 29.75°C over the survey period. The mean estimated horizontal visibility throughout the survey area was 10.1m.

From discussion with the Barangay captain and officials, it was discerned that there is a small river outlet (mouth less than 10m across) which discharges directly into the MPA and can sometimes cause siltation. There is also a much larger river mouth located roughly 6km to the north of the MPA. Activities banned within the MPA are commercial fishing, recreational fishing, spear fishing, invertebrate harvesting and anchoring. Barangay officials stated these regulations were enforced and none of the above activities occurred inside the MPA; however, some rare instances of poaching were said to occur (less than once a month).

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 & Liebel, 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 Lipanto (St. Bernard), southern Leyte, the Philippines.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
I01	6	733393	1130393
I02	6	733525	1130657
I03	6	733466	1130521
I04	6	733415	1130802
I05	12	733416	1130386
I06	12	733463	1130809
I07	12	733584	1130502
I08	12	733582	1130671

Transects were laid along the reef, parallel to the shore, on a north to south bearing. Four transects were situated at a depth of 6m and four 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 surveyed 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. 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 were recorded using 'belt' transects, where fish were observed along each replicate of the 100m transect within an imaginary 5mx5mx20m (WxHxL) box (Fig. 3). Surveys were conducted by two surveyors swimming slowly along replicates, each counting indicator fish species within 2.5m on 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 Lipanto 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, data sources from FishBase (www.fishbase.org) (Froese & Pauly, 2000) were utilised and 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 compatible with this report's selection criteria, a Bayesian approach was taken in accordance with Froese et al. (2013). If no

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

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 fishes' species-range and native habitat were explored 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 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 within 2.5m on 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 (OT). 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 infected colony. 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).

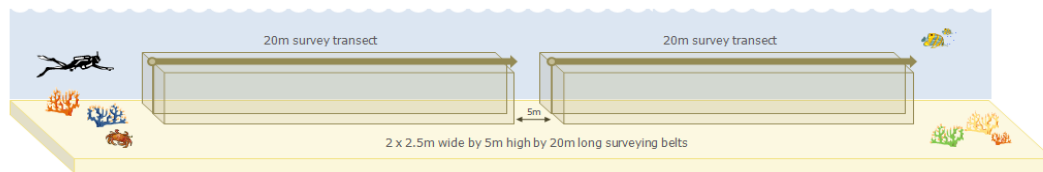


Figure 3. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of fishes within Barangay Lipanto. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps. The presented schematic only represents two of the four 20m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

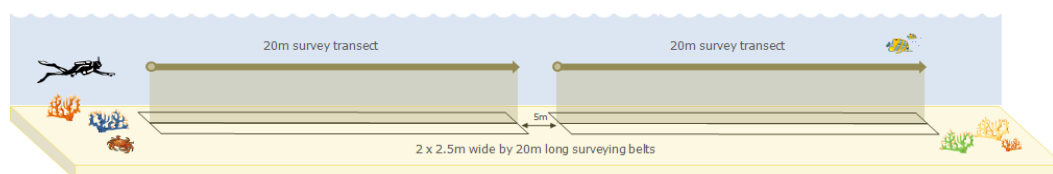


Figure 4. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of invertebrates within Barangay Lipanto. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps. The presented schematic only represents two of the four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

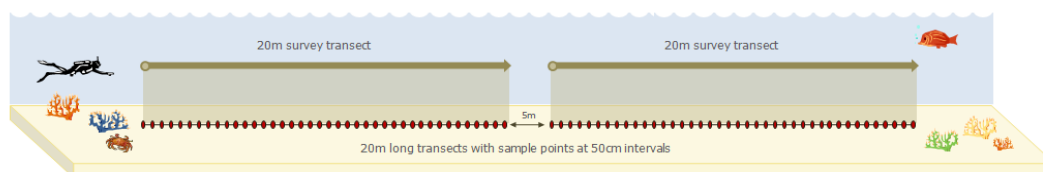


Figure 5. The undertaken point intercept methodology conducted for the assessment of benthic composition within Barangay Lipanto. Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps with the respective benthic substrate recorded at 0.5m intervals. The presented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

3.0 Results

3.1 Fishes

3.1.1 Target Fishes

In total, 1831 individual fishes were recorded (N), representing 80.49% of all target organisms, with a mean abundance of $N = 57.22 \pm 7.62 \text{ } 500\text{m}^3^{-1}$, throughout the survey period of 8 transects. The most represented target organisms were Cardinalfish, Fusiliers and Parrotfish ($N = 15.06 \pm 3.67 \text{ } 500\text{m}^3^{-1}$, $9.22 \pm 3.49 \text{ } 500\text{m}^3^{-1}$ and $4.34 \pm 1.05 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig. C1). At the transect resolution, transect I08 presented the greatest mean abundance of fishes ($N = 112.25 \pm 24.31 \text{ } 500\text{m}^3^{-1}$), significantly greater than that of transects I02 and I06, which had the lowest mean abundances ($N = 28.00 \pm 5.55 \text{ } 500\text{m}^3^{-1}$ and $N = 26.25 \pm 7.79 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Fig. 6). Transect I03 ($N = 85.75 \pm 15.05 \text{ } 500\text{m}^3^{-1}$) was also found to have significantly higher abundance of fishes than transects I02 and I06 ($p < 0.05$). No other transects were found to differ significantly, when compared ($p > 0.05$) (Fig. B1).

Species Richness (S) throughout the sample area was recorded as $S = 9.94 \pm 0.78 \text{ } 500\text{m}^3^{-1}$, with Shannon Weiner Diversity (H') recorded as $H' = 1.68 \pm 0.11 \text{ } 500\text{m}^3^{-1}$. Transect I03 presented the greatest species richness ($S = 15.50 \pm 0.65 \text{ } 500\text{m}^3^{-1}$), significantly greater than that of transects I01, I02, I04, I05 and I06 ($S = 10.00 \pm 0.41 \text{ } 500\text{m}^3^{-1}$, $S = 10.00 \pm 1.35 \text{ } 500\text{m}^3^{-1}$, $S = 8.50 \pm 2.06 \text{ } 500\text{m}^3^{-1}$, $S = 5.50 \pm 1.71 \text{ } 500\text{m}^3^{-1}$ and $S = 7.50 \pm 2.18 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Table. 3). Transect 3 also displayed a greater diversity ($H' = 2.38 \pm 0.07 \text{ } 500\text{m}^3^{-1}$) than transects I01, I02, I04, I05 and I06 ($H' = 1.48 \pm 0.21 \text{ } 500\text{m}^3^{-1}$, $H' = 1.90 \pm 0.08 \text{ } 500\text{m}^3^{-1}$, $H' = 1.72 \pm 0.15 \text{ } 500\text{m}^3^{-1}$, $H' = 1.11 \pm 0.32 \text{ } 500\text{m}^3^{-1}$ and $H' = 1.38 \pm 0.48 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$), and greater degree of Pielou's evenness (J') ($J' = 0.87 \pm 0.03 \text{ } 500\text{m}^3^{-1}$) than transects I05 and I08 ($J' = 0.67 \pm 0.10 \text{ } 500\text{m}^3^{-1}$ and $J' = 0.64 \pm 0.11 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Table. 3). Transect I07 also presented a greater

degree of evenness ($J' = 0.87 \pm 0.02 \text{ } 500\text{m}^3^{-1}$) than transects I05 and I08 ($p < 0.05$) (Table 3). No other transects were found to differ significantly in terms of S, H' or J' , when compared (Fig. B2).

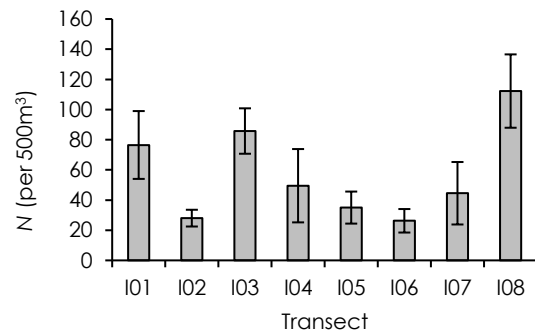


Figure 6: Mean target fish abundance per 500m³ with standard error (±SE) between transects in Lipanto, St. Bernard, Southern Leyte.

Table 3. Mean Diversity indices for target fish Species Richness (S) and Shannon-Weiner Diversity (H') and Pielou's Evenness (J') per 500m³, with standard error (±SE) across transects in Lipanto, St. Bernard, Southern Leyte.

Transec †	S (500m³ ⁻¹)		H' (500m³ ⁻¹)		J' (500m³ ⁻¹)	
	S	±	H'	±	J'	±
I01	10.00	0.41	1.48	0.21	0.64	0.09
I02	10.00	1.35	1.90	0.08	0.84	0.04
I03	15.50	0.65	2.38	0.07	0.87	0.03
I04	8.50	2.06	1.72	0.15	0.85	0.04
I05	5.50	1.71	1.11	0.32	0.67	0.10
I06	7.50	2.18	1.38	0.48	0.61	0.21
I07	9.75	3.38	1.80	0.37	0.87	0.02
I08	12.75	1.44	1.64	0.32	0.64	0.11

3.1.2 Butterflyfish

Throughout the sample period, a total of $N = 189$ butterflyfish were recorded, representing 87.5% of all target butterflyfish species, with a mean abundance of $N = 5.91 \pm 0.86 \text{ } 500\text{m}^3^{-1}$. The most represented target organisms were other butterflyfish,

Redfin butterflyfish and Klein's butterflyfish ($N = 2.41 \pm 0.68 \text{ } 500\text{m}^3^{-1}$, $N = 1.94 \pm 0.36 \text{ } 500\text{m}^3^{-1}$ and $N = 0.75 \pm 0.29 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig C1). At the transect resolution, transect I03 was found to present a greater abundance of butterflyfish ($N = 9.50 \pm 1.76 \text{ } 500\text{m}^3^{-1}$) than transects I05 and I07 ($N = 2.00 \pm 1.41 \text{ } 500\text{m}^3^{-1}$ and $N = 3.25 \pm 1.11 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$). No other transects were found to differ in terms of butterflyfish abundance, when compared (Fig B3.)

When considering obligate and facultative butterflyfish, transect I07 was found to have a significantly greater abundance of obligate butterflyfish than facultative butterflyfish ($N = 3.00 \pm 1.08 \text{ } 500\text{m}^3^{-1}$ and $N = 0.00 \pm 0.00 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Fig. 7). No transects presented a significantly greater abundance of obligate butterflyfish than any others, nor did any transects present a greater abundance of facultative butterflyfish than any others ($p > 0.05$).

3.1.3 Commercially Important Fishes

10.21% ($N = 5.84 \pm 1.33 \text{ } 500\text{m}^3^{-1}$) of all fishes recorded throughout the survey were considered commercially important (Parrotfish, Grouper and Snapper). Of this overall commercial fish species count, Parrotfish contributed the greatest (74.33%) followed by Grouper (13.90%) and Snapper (11.76%). Parrotfish were recorded in size classes <10cm, 11-20cm, 21-30cm and 31-40cm ($f = 94$, $f = 32$, $f = 11$ and $f = 2$, respectively). Grouper were present in size classes <10cm, 11-20cm and 21-30cm ($f = 12$, $f = 8$ and $f = 6$, respectively). Grouper were also found in these three size classes ($f = 1$, $f = 3$ and $f = 18$, respectively) (Fig. 8).

At the transect resolution, transect I03 presented the greatest mean abundance of Parrotfish ($N = 9.75 \pm 3.90 \text{ } 500\text{m}^3^{-1}$) when compared to transect I02 and I06 ($N = 1.00 \pm 0.41 \text{ } 500\text{m}^3^{-1}$ and $N = 0.50 \pm 0.50 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Fig. 9). Transect I03 presented a greater mean abundance of Grouper ($N = 2.25 \pm 0.75 \text{ } 500\text{m}^3^{-1}$), when compared to transects I01 and I05 ($N = 0.25 \pm 0.25 \text{ } 500\text{m}^3^{-1}$ and $N = 0.25 \pm 0.25 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Fig. 9).

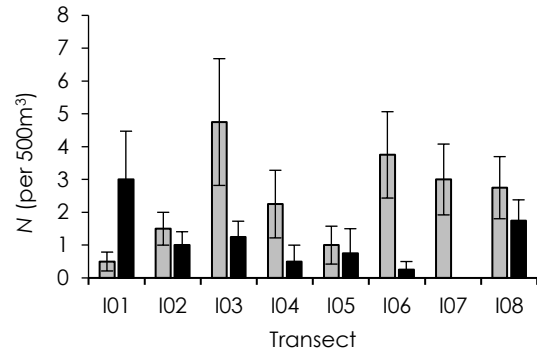


Figure 7: Mean obligate (grey) and facultative (black) butterflyfish abundance per 500m³ with standard error ($\pm$ SE) between transects in Lipanto, St.Bernard, Southern Leyte.

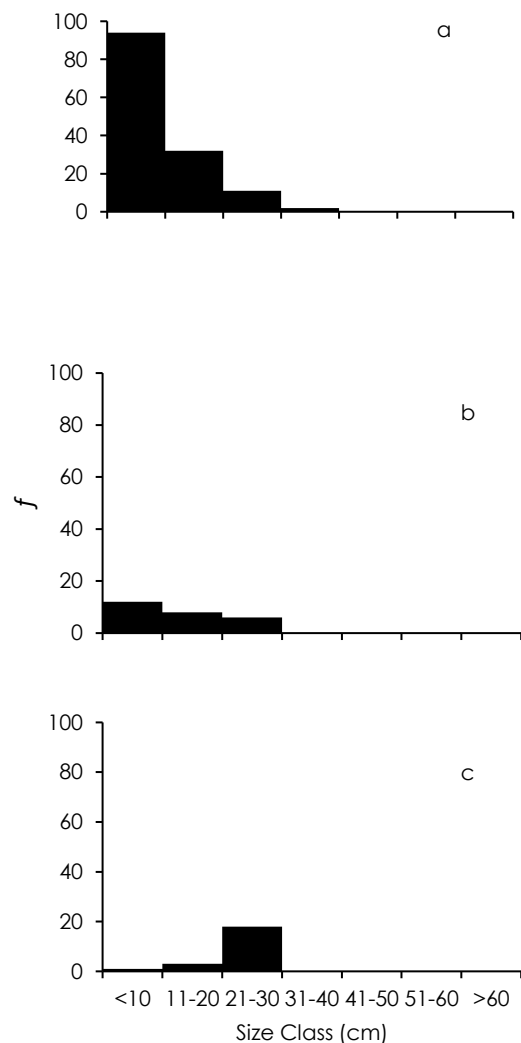


Figure 8: Total frequency (f) of Parrotfish (a), Snapper (b) and Grouper (c) by size class throughout transects in Lipanto, St.Bernard, Southern Leyte.

No other transects were found to differ in terms of Parrotfish or Grouper abundance, when compared. No differences in mean

Snapper abundance were found across transects.

The total standing biomass (kg) recorded throughout the sample period was 12.58kg, with Parrotfish standing biomass (7.00kg) being the greatest, followed by Snapper (4.77kg) and Grouper (0.82kg). Furthermore, Parrotfish contributed the greatest to overall mean biomass ($0.22\text{kg} \pm 0.06 \text{ } 500\text{m}^3^{-1}$). At the transect resolution, transect I03 presented significantly greater mean Parrotfish abundance ($N = 0.28\text{kg} \pm 0.08\text{kg } 500\text{m}^3^{-1}$) than transects I06, I07 and I08 ($N = 0.00\text{kg} \pm 0.00\text{kg } 500\text{m}^3^{-1}$, $N = 0.02 \pm 0.02 \text{ } 500\text{m}^3^{-1}$ and $N = 0.03 \pm 0.03 \text{ } 500\text{m}^3^{-1}$, respectively) ($p < 0.05$) (Fig 11). Transect I03 also presented the greatest Grouper mean biomass ($N = 0.06\text{kg} \pm 0.04\text{kg } 500\text{m}^3^{-1}$), when compared to transect I02 ($N = 0.00\text{kg} \pm 0.00\text{kg } 500\text{m}^3^{-1}$) ($p = < 0.05$) (Fig. 10). No other transects were found to differ significantly in terms of mean Parrotfish and Grouper abundance (Fig. B4). No transects were found to differ in mean Snapper biomass, when compared.

3.4 Invertebrates

In total, $N = 6371$ individual invertebrates were recorded throughout the sample period, composing 43.90% of the total target organism list, with a mean abundance of $N = 199.09 \pm 17.23 \text{ } 100\text{m}^2^{-1}$. Target organisms Feather Stars, Brittle Stars and Long Spine Sea Urchins were recorded in the greatest densities ($N = 150.56 \pm 14.96 \text{ } 100\text{m}^2^{-1}$, $N = 11.59 \pm 1.66 \text{ } 100\text{m}^2^{-1}$ and $N = 1.44 \pm 2.33 \text{ } 100\text{m}^2^{-1}$, respectively). Originally, Other Sea Cucumbers presented the second highest mean abundance ($N = 84.59 \pm 45.61 \text{ } 100\text{m}^2^{-1}$); However, transect I08 was found to be an outlier ($N = 630.25 \pm 240.96 \text{ } 100\text{m}^2^{-1}$) and was thus removed from analysis, leaving the above as the three most abundant target organisms (Fig. C2).

At the transect resolution, transect I03 presented significantly greater mean invertebrate abundance ($N = 305.00 \pm 19.76 \text{ } 100\text{m}^2^{-1}$) than transects I01, I02 and I05 ($N = 126.50 \pm 10.49 \text{ } 100\text{m}^2^{-1}$, $N = 155.75 \pm 24.05 \text{ } 100\text{m}^2^{-1}$ and $N = 55.25 \pm 13.38 \text{ } 100\text{m}^2^{-1}$, respectively) ($p = < 0.05$) (Fig. 12).

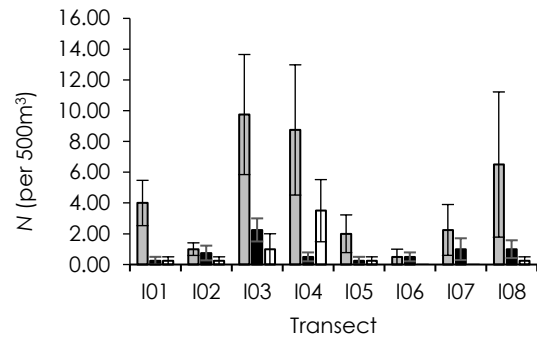


Figure 9: Mean parrotfish (grey), grouper (black) and snapper (white) abundance per 500m³ with standard error ($\pm$ SE) between transects in Lipanto, St. Bernard, Southern Leyte.

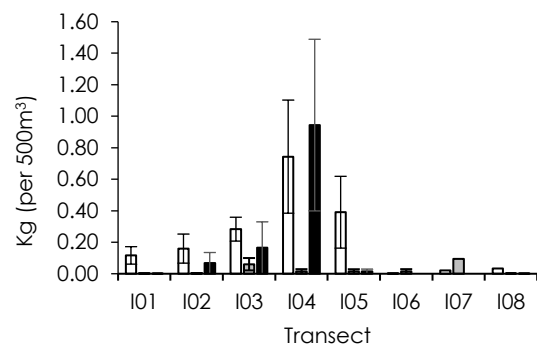


Figure 10: Mean parrotfish (white), grouper (grey) and snapper (black) biomass (kg) per 500m³ with standard error ($\pm$ SE) between transects in Lipanto, St. Bernard, Southern Leyte.

Transect I08 presented significantly greater mean invertebrate abundance ($N = 245.25 \pm 39.59 \text{ } 100\text{m}^2^{-1}$) than transects I04, I05, and I06 ($N = 203.50 \pm 35.95 \text{ } 100\text{m}^2^{-1}$, $N = 55.25 \pm 13.38 \text{ } 100\text{m}^2^{-1}$ and $N = 198.75 \pm 24.30 \text{ } 100\text{m}^2^{-1}$, respectively) ($p = < 0.05$) (Fig. 11). Transects I07 ($N = 302.75 \pm 50.21 \text{ } 100\text{m}^2^{-1}$) and I06 presented greater mean abundances than transects I01 and I05, and transects I01, I02 and I04 all had greater mean abundances than transect I05 ($p = < 0.05$) (Fig. 12). No other transects were found to differ significantly when compared (Fig B5).

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 I05 demonstrated the greatest diversity ($H' = 1.20 \pm 0.08 \text{ } 100\text{m}^2^{-1}$) when compared to

transect I06 ($H' = 0.98 \pm 0.03$ 100m²⁻¹) ($p < 0.05$) (Table 4). No other significant differences were found in diversity between transects (Fig. B5). Transect I05 was also shown to have a significantly higher degree of evenness ($J' = 0.62$ 98 ± 0.03 100m²⁻¹) than transect I06 ($J' = 0.47$ 98 ± 0.02 100m²⁻¹) (Table 4). Transects I02 and I04 ($J' = 0.63 \pm 0.05$ 100m²⁻¹ and 0.63 ± 0.02 100m²⁻¹, respectively), showed a greater level of evenness than transect I06, though were not significantly more diverse ($p < 0.05$). No other transects were found to differ significantly in either diversity or evenness when compared. (Fig. B5).

Giant clams were recorded a total of 4 times throughout the sample period, 3 of which were in the smallest size class (0-10cm), with 1 being in the second smallest size class (11-20cm) (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.

3.5 Substrates

Sand (SD) was recorded as the dominant substrate throughout the sample area ($N = 21.09 \pm 4.29\%$ 20m⁻¹), followed by Rubble (RB) and Hard Coral (HC) ($N = 19.14 \pm 2.85\%$ 20m⁻¹ and $N = 17.50 \pm 2.35\%$ 20m⁻¹, respectively) (Fig. 15), with all three presenting significantly greater mean percentage cover than Soft Coral (SC), Sponge (SP), Recently Killed Coral (RKC) Nutrient Indicator Algae (NIA), Silt (SI) and Other (OT) ($N = 5.31 \pm 0.92\%$ 20m⁻¹, $N = 6.95 \pm 1.05\%$ 20m⁻¹, $N = 0.23 \pm 0.13\%$ 20m⁻¹, $N = 2.19 \pm 0.82\%$ 20m⁻¹, $N = 14.22 \pm 4.77\%$ 20m⁻¹ and $N = 0.31 \pm 0.15\%$ 20m⁻¹, respectively) ($p < 0.05$). Rock (RC) was also found to cover a significantly greater percent of the survey area ($N = 13.05 \pm 1.64\%$ 20m⁻¹) than SC, SP, RKC, NIA, SI and OT, whilst SC and SP had significantly greater cover than RKC, NIA and OT, and SI had greater cover than RKC and OT ($p < 0.05$) (Fig. 14).

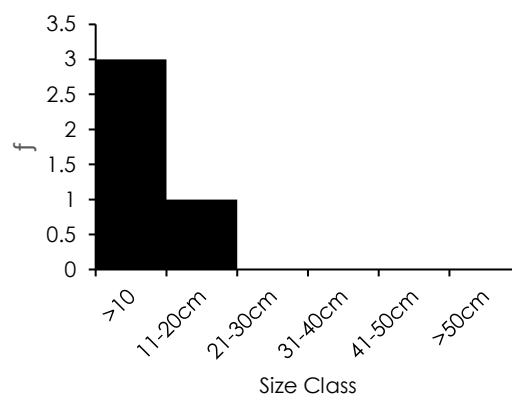


Figure 12: Total frequency (f) of Giant Clams by size class throughout transects in Lipanto, St. Bernard, Southern Leyte

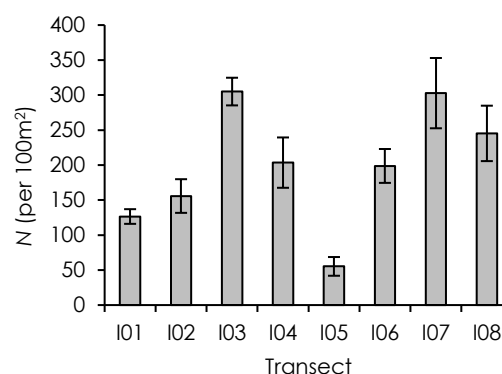


Figure 11: Mean invertebrate abundance per 100m² with standard error ($\pm$ SE) between transects Lipanto, St. Bernard, Southern Leyte

Table 4. 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 Lipanto, St. Bernard, Southern Leyte.

Transec †	S (100m ² ⁻¹)		H' (100m ² ⁻¹)		J' (100m ² ⁻¹)	
	S	$\pm$	H'	$\pm$	J'	$\pm$
I01	8.00	0.41	1.07	0.13	0.51	0.05
I02	7.75	1.65	0.51	0.14	0.25	0.04
I03	9.75	1.31	0.89	0.26	0.38	0.10
I04	9.25	1.25	1.02	0.20	0.47	0.08
I05	7.00	1.08	1.04	0.18	0.56	0.11
I06	8.25	0.95	1.15	0.06	0.55	0.05
I07	10.25	0.95	1.05	0.29	0.44	0.11
I08	8.25	1.25	0.87	0.23	0.40	0.08

No other substrate types were found to differ significantly when compared ($p > 0.05$) (Fig. B7).

At the transect resolution, SD was found to cover a significantly higher percentage on transects I02 and I03 ($35.00 \pm 3.54\%$ $20m^{-1}$ and $44.38 \pm 10.48\%$ $20m^{-1}$, respectively) than transects I01, I06 and I07 ($1.25 \pm 0.72\%$ $20m^{-1}$, $1.88 \pm 1.88\%$ $20m^{-1}$ and $5.00 \pm 5.00\%$ $20m^{-1}$, respectively) (Table 5) ($p < 0.05$). Transect I04 presented a significantly greater mean percentage cover of SD ($16.25 \pm 5.05\%$ $20m^{-1}$) than transects I01 and I06 (Table 5). No other transects were found to differ significantly in SD cover (Fig. B8). Rubble cover was found to be significantly higher at transects I02, I04, I06 and I07 ($26.88 \pm 6.95\%$ $20m^{-1}$, $27.5 \pm 7.43\%$ $20m^{-1}$, $38.75 \pm 4.62\%$ $20m^{-1}$ and $23.75 \pm 6.96\%$ $20m^{-1}$, respectively) than transects I01 and I05 ($1.25 \pm 1.25\%$ $20m^{-1}$ and $1.88 \pm 1.20\%$ $20m^{-1}$, respectively). Transect I06 also presented higher cover of rubble than transect I03 ($12.50 \pm 5.20\%$ $20m^{-1}$) ($p < 0.05$) (Table 5). Hard coral cover was found to be significantly lower at transect I05 ($1.88 \pm 1.20\%$ $20m^{-1}$) than all other transects throughout the survey area ($p < 0.05$) (Table 5). No other transects differed in terms of RB or HC cover (Fig. B8).

Of the hard coral cover, the dominant life form throughout the survey area was non-Acropora massive corals (CM) (25.00% $20m^{-1}$), followed by non-Acropora branching corals (CB) (22.77% $20m^{-1}$) and non-Acropora encrusting corals (CE) (19.64% $20m^{-1}$). These three made up significantly higher percentages of the hard coral cover than all other life forms ($p < 0.05$), excepting each-other, and Acropora branching corals (12.95% $20m^{-1}$) ($p > 0.05$), which also made up a significantly higher percentage of the hard coral than all other life forms excepting CM, CB and CE ($p < 0.05$) (Fig. 16). Encrusting Acropora corals (ACE) made up a significantly lower percentage of the hard coral cover (0.45% $20m^{-1}$) than Millepora species (CME) (1.34% $20m^{-1}$), Non-Acropora Mushroom corals (CMR) (4.46% $20m^{-1}$), Non-Acropora submassive corals (CMS) (6.25% $20m^{-1}$) and non-Acropora foliose corals (CF) (4.91%

$20m^{-1}$) (Fig. 15). No other life forms were found to differ significantly, when compared ($p > 0.05$) (Fig. B9). Coral life forms not present in the survey area were not included in analysis.

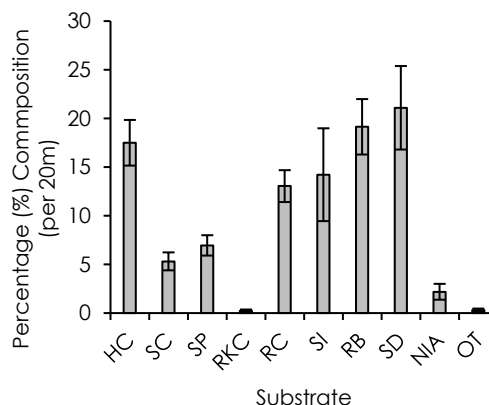


Figure 14: Mean composition (%) substrates per 20m with standard error ($\pm SE$) in Lipanto, St. Bernard, the Philippines. RKC= Recently Killed Coral, OT= Other, SC= Soft Coral, SP= Sponge, SI= Silt, HC= Hard Coral, NIA= Nutrient Indicator Algae, RC= Rock, RB= Rubble and SD= Sand.

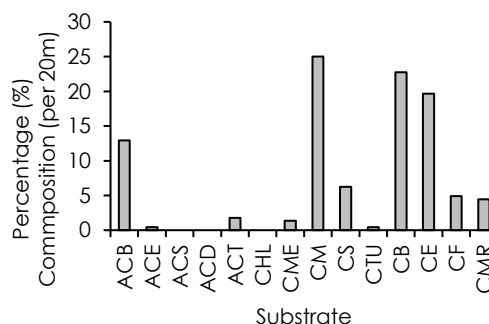


Figure 15. Mean percentage (%) of Hard Coral life forms per 20m in all transects in Lipanto, St. Bernard, Southern Leyte. ACB= Acropora Branching, CTU= Tubipora spp., CME= Millepora spp., CHL= Heliopora spp., CMR= Non-acropora Mushroom, CF= Non-acropora Foliose, ACT= Acropora Tabulate, ACD= Acropora Digitate, ACS= Acropora Submassive, ACE= Acropora Encrusting, CS= Non-acropora Submassive, CM= Non-acropora Massive, CB= Non-acropora Branching and CE= Non-acropora Encrusting.

Table 5. Mean percentage (%) cover of benthic substrate types per 20m with standard error ($\pm$) between transects in Lipanto, St. Bernard, 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	23.13	6.24	4.38	2.77	5.00	1.77	0.00	0.00	25.63	3.59	38.13	11.29	1.25	1.25	1.25	0.72	1.25	1.25	0.00	0.00
I02	11.88	3.87	4.38	2.95	8.13	1.88	1.25	0.72	12.50	1.44	0.00	0.00	26.88	6.95	35.00	3.54	0.00	0.00	0.00	0.00
I03	28.75	9.92	2.50	1.02	5.00	1.02	0.00	0.00	6.88	2.58	0.00	0.00	12.50	5.20	44.38	10.48	0.00	0.00	0.00	0.00
I04	15.00	2.04	6.25	2.17	3.13	1.20	0.63	0.63	16.88	4.25	2.50	1.44	27.50	7.43	16.25	5.05	11.88	3.29	0.00	0.00
I05	1.88	1.20	0.00	0.00	1.88	1.20	0.00	0.00	5.00	2.28	48.75	28.15	1.88	1.20	39.38	22.74	0.63	0.63	0.63	0.63
I06	19.38	6.88	6.25	2.39	8.75	2.17	0.00	0.00	13.75	5.05	8.75	5.45	38.75	4.62	1.88	1.88	1.88	1.88	0.63	0.63
I07	22.50	8.23	6.25	3.31	8.75	4.73	0.00	0.00	16.88	6.16	15.63	9.04	23.75	6.96	5.00	5.00	1.25	1.25	0.00	0.00
I08	17.50	5.10	12.50	1.02	15.00	3.54	0.00	0.00	6.88	1.88	0.00	0.00	20.63	8.25	25.63	10.77	0.63	0.63	1.25	0.72

Within the hard corals, Competitor Corals (CC), (51.79% 20m⁻¹) were found to be the dominant life trait, when compared to Stress Tolerant Corals (STC) (31.70% 20m⁻¹) and Fast-Growing Corals (FGC) (16.52% 20m⁻¹) ($p < 0.05$). No significant differences were found between STC and FGC, when compared (Fig. B10). At the transect resolution, CC was found to be significantly higher on transect I01 than transect I05 ($17.50 \pm 6.21\%$ 20m⁻¹ and $1.88 \pm 1.20\%$ 20m⁻¹, respectively) ($p = < 0.05$) (Fig. 16). FGC cover was significantly higher at transect I02 ($3.75 \pm 0.72\%$ 20m⁻¹) than transect I05 ($p = < 0.05$) (Fig. 16). ST cover was found to be significantly higher at transect I08 ($6.25 \pm 0.72\%$ 20m⁻¹) than transect I02 ($1.25 \pm 0.72\%$ 20m⁻¹). It was also significantly higher at transects I03, I07 and I08 ($16.88 \pm 6.95\%$ 20m⁻¹, $10.63 \pm 4.93\%$ 20m⁻¹ and $6.25 \pm 0.72\%$ 20m⁻¹, respectively) than transect I05 ($0.00 \pm 0.00\%$ 20m⁻¹). No other differences in CC, FGC or STC were found between transects when compared (Fig. B11).

3.6 Impacts

Whilst no direct anthropogenic reef damage was observed (boat, anchor or dynamite damage) was observed during the survey, indirect reef damage in the form of general trash was recorded a total of 47 times, with 18.75% of transects presenting "high" levels (3 or more pieces per transect), and 37.50% presenting "medium" levels (2 pieces per transect) of trash. Fishing trash was recorded a total of 25 times; 18.75% of transects presented "low" levels (1 piece), 15.63% "medium" levels and 15.63% "high" levels (Fig. 17).

There were 13 incidences of coral bleaching found, as well as 5 cases of white band disease and 1 case of black band disease. However, for all three, the percentage of colonies affected was extremely low, with a maximum of 0.9% for coral bleaching and 0.01% for both white and black band disease.

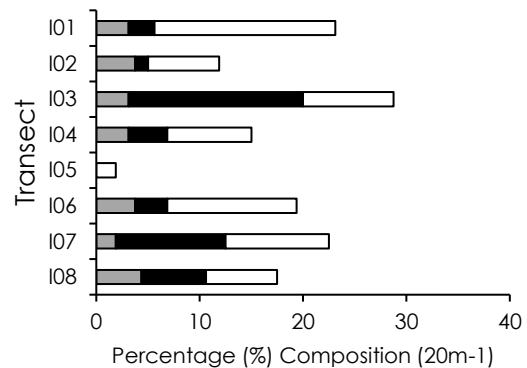


Figure 16. Percentage (%) cover of coral life forms per 20m with standard error ($\pm$ SE) between transects in Lipanto, St. Bernard, Southern Leyte. FGC= Fast growing Corals (white), STC= Stress Tolerant Corals (Grey) and CC= Competitor Corals (Black).

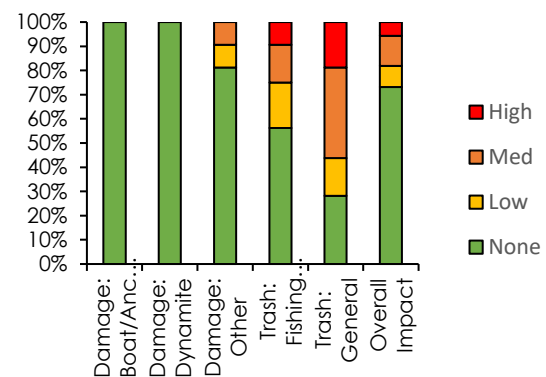


Figure 17. Total impact scale recorded over the complete survey area in Lipanto, St. Bernard, Southern Leyte. Counts of impacts are categorized to scale (0= none, 1= low, 2-4= medium and >5= high), which is applied to each recorded impact category as a percentage (%) of the surveyed area, split into 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 Lipanto (Municipality St. Bernard). 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 be taken into consideration. This study focuses on the current community structure (species richness, diversity, abundance and distribution) of target survey species within the Lipanto MPA. Results indicated an average abundance of coral-reliant fish species, in addition to commercially important invertebrate species, when compared to other sites around Southern Leyte. However, many of the sites around Southern Leyte are known to be subject to excessive fishing practices as many are not under any form of protection, using these sights as a comparison may not be a good indicator of fishing pressures. Conversely, numbers of commercially important fish species are relatively high within the Lipanto MPA, though still generally within the smallest size classes, perhaps suggesting that although enforcement of fishing laws is occurring, the area that the MPA covers is not sufficient to protect the full home range of the species found within (Ormand & Gore, 2003).

4.1. Fish

Overall fish abundance within the Barangay Lipanto MPA was similar to that in the Barangay Hindag-an MPA and in Cabalian Bay surveyed 2017. However, when compared to other sites surveyed in Southern Leyte in 2017, these results were reasonably low (e.g. San Bernardo, Limasawa and Cogon, Pintuyan). Abundances were found to differ at different transects, indicating disparities in habitat types within the MPA. Results of fish diversity, including mean species richness (S') and mean Shannon's diversity (H'),

were also found to differ within the MPA, some being reasonably high, indicating high resilience in certain areas, and others being low, 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 at certain transects within the survey site. This demonstrates proportional abundances between species, which is not the norm for a community in its natural state (Verberk, 2011) again indicating some level of external influence. The trend within the survey area was either high abundances with related high species richness and diversity and low levels of evenness, or low abundances with related low species richness and diversity and high levels of evenness, making it difficult to categorise the state of fish communities throughout the MPA as a whole. Transects with high fish abundances tended to be the same that presented high coral cover and lower coverings of silt and sand. This is as expected, as coral is a food source for many reef fish and also creates structural complexity that provides a suitable habitat for many reef fishes.

Butterflyfish abundance and diversity was recorded in the survey as their energetic demands are intimately linked to the existence and overall condition or "health" of the coral substrate (Crosby and Reese, 1996). By analysing butterflyfish diversity and abundance independent 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 that depend on the live tissue of corals for food. The 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).

Results showed that of the 189 butterflyfish recorded within the survey area, 41% were obligate feeders and 18% were facultative feeders. This is 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. Significant differences in butterflyfish abundance were found between the same transects that differed in hard coral cover, as expected. High numbers of obligate butterflyfish are generally associated with high levels of scleractinian coral cover (Pratchett & Berumen, 2008) which is also reflected in the substrates found across the site.

When assessing the commercially important fishes, herbivorous fish (Parrotfish) abundance 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 (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 and ensuring that these roles remain a functional part of ecosystem interaction (Mouillot et al., 2014). However, although making up 74.33% of all commercial fish found within the survey area, the majority of parrotfish were found to be in the smallest size class. Usually this would indicate fishing is still occurring within the MPA (Valles & Oxenford, 2014), though it is likely that this is simply due to the large amount of juvenile parrotfish found on one transect thereby slightly skewing the data. This is backed up by the reasonably high

numbers and average size of piscivorous predatory fish (Snapper and Grouper), which if were lacking would be a sign of high fishing levels (Boaden & Kingsford, 2015).

Biomass values for Grouper and Snapper species, and similarly mean lengths, suggest the possibility that maturation is being favoured within this site as a result of the lack of fishing pressures (Russ & Alcala, 2003). As the commercial fish data was 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, in spite of specific species analysis, the number and size of commercially important fish species are indicative of a well-managed MPA. The lack of any commercially important fish within the largest size class may be an indicator of low levels of fishing within the MPA or an indicator of high levels in the surrounding areas.

These commercially important species are particularly vulnerable to overfishing because they are large, and 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 and 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 & 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,

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 & 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 feeding grounds to access spawning locations. Spawning grounds may thus exist outside of MPA boundaries, exposing fish to exploitation, and could be the reason for Groupers being the least abundant of the commercially important fish. 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 suggested strategies that could ensure adequate and effective protection of these reproductively complex species within Southern Leyte.

In contrast, parrotfish have relatively small home ranges (Welsh et al., 2013), and are therefore likely to benefit from the protection of such a small area. The higher numbers of parrotfish, when compared to other commercially important fish, may reflect this. 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) and *Cromileptes altivelis* (Barramundi Cod) recorded within the surveyed site, 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 adhered to, but that the MPA may not cover sufficient area to fully protect commercially important species. 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 increasing the area of the MPA and marine reserve in order to fully protect the home ranges of certain species of fish.

4.2. Invertebrates

Overall, mean target invertebrate abundance within the Lipanto 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 than at other sites.

At the transect level, there were some differences in abundance, but none in species richness, with only one transect showing higher diversity and lower evenness than one other. This again shows that, despite the differences in abundance, the communities of invertebrates themselves are similar in their make-up. The lowest abundance of invertebrates was found at the same transect that presented low levels of hard

coral, soft coral and sponge cover and high levels of silt and sand cover. This is as to be expected, as the majority of invertebrates found would either rely on some form of structure in order to have a hold from which to filter feed or would be feeding directly on living substrates.

Feather stars, brittle stars, and long spine sea urchins 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 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 also play an important role on the reef. They have a wider range of feeding habits than the 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.

The relatively high numbers of long-spine sea urchins (*Diadema antillarum*) found across the site could be an indicator of an overfished site, as it is likely the predators of the sea urchins have been removed (Ashworth et al., 2004). Although predators of long spine sea urchins, such as members of Balistidae (triggerfishes), Carangidae (jacks), Diodontidae (porcupinefishes), Labridae (wrasses), and Pomadasyidae (grunts) families (Randall et al., 1964), are not thought to be commercially important in this area, they are still not found in particularly high numbers. Long spine sea urchins have been shown to be important

in reef communities for various reasons, one of which being the provision of a protective habitat for juvenile reef fishes (Miller et al., 2007). As well as this, the high abundance of sea urchins 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 graze 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, sea urchin numbers will have to be kept in check to allow enough algal growth for other herbivorous species to be able to survive.

Commercially important invertebrate species including pinkfish sea cucumber (*Holothuria edulis*), squid (*Teuthida*), greenfish sea cucumber (*Stichopus chloronotus*), lobster (*Nephropidae*), 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. These results indicate that extraction pressures are high in the area for these species, as these species have much smaller home ranges than commercially important fish, so it is unlikely the size of the MPA is having as much of an impact.

Only 4 giant clams (*Tridacna*) were found within the survey area, all of which were below 20cm in size (3 being under 10cm). 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, due to extreme weather events affecting nutrient influx into the area during the month of November to May each year, potentially triggering a population influx of 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. The five instances of white band disease and one of black band disease may have been counteracted by the presence of low numbers of CoTS, as would be found in a natural reef community of this type. As no natural predators of CoTS were found within the survey area, further research would have to be done to find the cause of their absence. The presence of corallivorous snails of the genus *Drupella* may also add to the disease potential through the survey site, as it has been shown they can act as biological vectors for certain coral diseases (Antonius and Reigl, 1997; Nicolet et al., 2013).

One transect presented unusually high numbers of Other Sea Cucumbers, when compared to other transects. This was removed, as it was shown to be an outlier when compared to the other transects. It is important to note that as sea cucumbers feed they can produce silt, and in large numbers can take up space on hard substrate, which can impact coral recruitment, as shown by Zhang et al. (2018). However, this study was species specific, and as our survey did not differentiate between sea cucumber species that were not seen as commercially important, it is impossible to say what might have caused these high abundances, and what effects they may have in the future, without further study.

Overall, although the survey site presented a seemingly healthy community assemblage of invertebrates, the lack of commercially important species, along with low numbers and small size of giant clams, points to the potential of invertebrate harvesting within the study site. Complete lack of CoTS, coupled with the presence of *Drupella* snails, may cause future disease outbreaks on the reefs. Unusually high numbers of other sea cucumbers may lead to high levels of siltation and decrease in coral recruitment, though without further study into specific species abundances it is not possible to predict such events taking place.

4.3. Substrates

The most prevalent substrate within the Lipanto MPA was sand, followed by rubble and hard coral. Sand does not present an opportunity for future coral settlement, though rubble may be able to. As high hard coral coverage is a sign of a “healthy” reef, 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 Lipanto 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, and is declining uniformly among subregions, even on intensely managed reefs (Bruno & Selig, 2007) so this below-average level of cover does not necessarily imply bad management practices within the MPA.

Of the hard coral found, one transect presented significantly lower cover than all others. This was also the transect that presented the highest covering of silt. Siltation, or sedimentation, is known to negatively affect many stages of certain corals life cycles (Jones et al., 2015; Babcock & Smith, 2000), so it is to be expected that hard coral cover would be low. However, this transect is also the furthest away from both the small stream that runs directly into the MPA and the

larger river mouth further north, both of which might be expected to cause higher levels of silt covering. It would be necessary, therefore, to do further study in order to glean the source of the sedimentation in this area. It may be due to the topography of the reef allowing sediment to settle in this area in greater amounts than others. The fact that no other transects differed in hard coral cover is evidence for environmental conditions (pH, temperature, turbidity and levels of dissolved CaCO_3) being suitable for the growth of hard coral throughout the remainder of the survey area. Of the hard coral found within the MPA, the three most prevalent life growth forms were massive non-*Acropora* corals (CM), non-*Acropora* branching corals (CB), and encrusting non-*Acropora* corals (CE). *Acropora* branching corals (ACB) were also prevalent throughout the study area. All four of the above coral types presented a significantly greater covering of the study site than all others (excepting each other). Both CB and CE fall under the category of competitor corals (CC), whilst CM is a stress tolerant coral (STC) and *Acropora* branching corals are fast growing (FGC).

FGC such as the *Acropora* branching corals found within the site are able to recover quickly from disturbances (Karlson & Hurd, 1993), potentially preventing long term damage from, and increasing resilience to, "Aniham", the seasonal north-east trade winds that bring storms which hit Cabalian Bay. As well as this, they 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 and fish communities within the MPA survey site, suggesting good levels of management.

STC such as the massive non-*Acropora* corals found within the survey site 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 and branching 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 is therefore important that any current restrictions in place within the MPA are strongly adhered to.

When looking at the three most dominant growth forms (CM, CB and CE), few differences were found between transects, excepting between the site with the higher coverings of sand and silt discussed above, and some others. This was also the case for differences in levels of cover of the three life traits (FGC, STC and CC) between transects. These results show a high level of heterogeneity 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 invertebrate species likely still occurring. High levels of sand and rubble, along with reasonably high levels of silt, means it is unlikely settlement potential throughout the rest of the survey site is high. It is therefore important to maintain the level of protection currently in place in order to prevent any destructive practices which may lessen settlement potential. However, it is apparent hard coral cover is high enough to provide adequate habitat for the current coral reliant fish and invertebrate communities, as evidenced by the state of the community assemblages found within the survey area.

4.4 Impacts

The presence of high levels of fishing trash (over 30% of transects had either medium or high levels of fishing trash) suggests that

either the Barangay Lipanto MPA is an active fishing ground or that the area surrounding the MPA is fished intensively to the level that fishing nets and lines are regularly being lost and drifting inside the MPA boundaries. 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 around the MPA 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 in turn can bioaccumulate up the trophic levels on the reef and affect the whole reef community.

4.5 Conclusion

Coral reliant fish communities seem to be 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. Relatively high numbers of commercially important fish, though in the lower half of size classes, suggests at least some species are being allowed to reach sexual maturity. However, lack of less common commercially important fish species suggests high levels of fishing in the area immediately outside the MPA, and potentially low levels within the MPA. This could be due to the small size of the MPA, as it is not sufficient to protect those species with larger home ranges, evidenced by higher numbers of fish with smaller home ranges.

The invertebrate community within the MPA, on the other hand, indicates that invertebrate harvesting is likely still occurring within the MPA. This is shown by the complete lack of commercially important invertebrate species, including those which are sessile, such as the giant clam, whose abundance would not be affected by the amount of a species home range protected by the size of the MPA. It is, however, also possible that historic harvesting throughout the whole of Southern Leyte has had enough of an impact to hinder recovery of those commercially important species or that suitable substrate and habitat for said species is not available within the MPA.

The dominant substrate within the MPA being mostly sand may be linked in with this. Sessile invertebrates, such as certain bivalves, sea anemones and polychaete worms, need a solid substrate on which to settle and attach, and the lack of rock and high levels of sand, rubble and silt might hinder this. However, aside from giant clams, most commercially important invertebrates are mobile with the potential to move to a more favourable habitat. The protection of these species could well be aided by an increase in the size of the MPA to include a more diverse range of habitat types.

The relatively high covering of hard coral throughout the site, along with its even make-up of fast growing, stress-tolerant and competitor corals, shows the MPA is placed in an area of high conservation value, which should be able to support diverse communities of fish and invertebrates and act as a nursery ground for many species which could then be fished or harvested outside of the MPA. The instances of coral disease and 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 large 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, it is recommended that the size of the MPA be increased. This would allow for the full home ranges of commercially important fish species to be protected allowing more species to be able to reach sexual maturity. As well as this, it may cover a more diverse range of habitat types, allowing for the recovery of certain commercially important invertebrate species. It is paramount that any current invertebrate harvesting within the MPA be stopped in order to allow these species to recover. It is also recommended that a large buffer zone be put in place around the MPA to help prevent ghost nets and other fishing debris from becoming entangled on the corals within the MPA (although it should be noted that a buffer zone cannot prevent debris from outside of the area reaching the MPA). Finally, reef cleans, or beach cleans should be carried out in order to try and lessen the volume of trash reaching the MPA.

MPAs that actively engage fishermen in MPA management have proven to display a higher level of commitment to the protection of the MPA, than those where fisherman 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; Polnac 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 particular MPA.

References

- Agardy, T., Christie, P. and Nixon, E. (2012). Marine Spatial Planning in the Context of the Convention on Biological Diversity: A Study Carried Out in Line with CBD COP 10 Decision X/29 by the GEF STAP. *CBD Technical Series* **68**.
- Asian Development Bank (ADB) (2014). State of the Coral Triangle: Philippines. Mandaluyong City, Philippines.
- Allen, G. (2008). Conservation hotspots of biodiversity and endemism for Indo-Pacific coral reef fishes. *Aquatic Conservation: Marine and Freshwater Ecosystems* **18**, pp. 541-556.
- Berumen, M., Pratchett, M. and McCormick, M. (2005). Within-reef differences in diet and body condition of coral-feeding butterflyfishes (Chaetodontidae). *Marine Ecology Progress Series* **287**, pp. 217-227.
- Buxton, C., Barrett, N.m Haddon, M., Gardner, C. and Edgar, G. (2006). Evaluating the effectiveness of marine protected areas as a fisheries management tool. *FRDC Final Report*.
- Calumpong, H., Raymundo, L., Solis-Duran, E., Alava, M., and de Leon, R. (1994). Resource and Ecological Assessment of Sogod Bay, Leyte, Philippines - Final Report. Siliman University Marine Laboratory.
- Chapman, R.W., Sedberry, G.R., Koenig, C.C. and Eleby, B.M. (1999). Stock identification of Gag, *Myceroperca microlepis*, along the Southeast coast of the United States. *Marine Biotechnology* **1**, pp. 137-146.
- Chong-Seng, K.M., Mannering, T.D., Pratchett, M.S., Bellwood, D.R. and Graham, N.A.J. (2012). The influence of coral reef benthic condition on associated fish assemblages. *PLoS ONE* **7**(8), e42167.
- Convention on Biological Diversity (CBD) (2010). Aichi Biodiversity Targets. Retrieved 2013 from <http://www.cbd.int/sp/targets>.
- Coleman, F. C., Koenig, C. C., Huntsman, G. R., Musick, J. A., Eklund, A. M., McGovern, J. C., Chapman, R. W., Sed-berry, G. R. , and Grimes, C. B.(2000). *Long-lived reef fishes: the grouper-snapper complex*. *Fisheries* **25**, pp. 14–20.
- Crosby, M. and Reese, E. (1996). A manual for monitoring coral reefs with indicator species: butterflyfishes as indicators or change on Indo-Pacific reefs. Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration. Silver Spring, MD, 45pp.
- Coral Triangle Initiative on Corals, Fisheries and Food Security (CTI-CFF) (2013). Information and guidelines for writing a protected area management plan, Solomon Islands. USAID, Jakarta, Indonesia.
- Dahl-Tacconi, N. (2005). Investigating information requirements for evaluating effectiveness of marine protected areas - Indonesian case studies. *Coastal Management* **33**, pp. 225-246.

- Di Franco, A., Thiriet, P., Di Carlo, G., Dimitriadis, C., Francour, P., Gutierrez, N.L., de Grissac, A.J., Koutsouba, D., Milazzo, M., del Mar Otereo, M., Piante, C., Plass-Johnson, J., Sainz-Trapaga, S., Santarossa, L., Tudela, S., Guidetti, P. (2016). Five key attributes can increase marine protected areas performance for small-scale fisheries management. *Scientific Reports* **6**, 38135.
- Domeier, M.L, and Colin, P.L. (1997). Tropical reef fish spawning aggregations: defined and reviewed. *Bulletin of Marine Science* **60**(3), pp. 698-726.
- Edinger, E. N., and Risk, M. J. (2000). Reef classification by coral morphology predicts coral reef conservation value. *Biological Conservation* **92**(1), pp. 1–13.
- Froese, R. and D. Pauly, Editors (2000). FishBase 2000: concepts, design and data sources. ICLARM, Los Baños, Laguna, Philippines, pp. 344.
- Froese, R., Thorson, J. and Reyes, R. (2013). A Bayesian approach for estimating length-weight relationships in fishes. *Journal of Applied Ichthyology* **30**(1), pp. 78-85.
- Green, A., Smith, S.E., Lipsett-Moore, G., Groves, C., Peterson, N., Sheppard, S., Lokani, P., Hamilton, R.J., Almany, J., Aitsi, J. and Bualia, L. (2009). Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. *Oryx* **43**, pp. 488-498.
- Hall, N.M., Berry, K.L.E., Rintoul, L. and Hoogenboom, M.O. (2015). Microplastics ingestion by scleractinian corals. *Marine Biology* **162**(3), pp. 725-732.
- Hardt, M. (2009). Lessons from the past: the collapse of Jamaican coral reefs. *Fish and Fisheries* **10**, pp. 143-158.
- Hilborn, R. and Walters, C. J. (1992). Quantitative fisheries stock assessment: choice, dynamics and uncertainty. *Reviews in Fish Biology and Fisheries* **2**, pp. 177–178.
- Hodgson, G. (1999). A global assessment of human effects on coral reefs. *Marine Pollution Bulletin* **38**, pp. 345-355.
- Hodgson, G. and Liebel, J. (2002). The Global Coral Reef Crisis: Trends and Solutions. Reef Check Foundation, Los Angeles, CA, 80 pp.
- Human, B., and Davies, A. (2010). Stakeholder consultation during the planning phase of scientific programmes. *Marine Policy* **34**, pp. 645-654.
- Jacinto, G., Alino, P., Villanoy, C., Talaue-McManus, L., and Gomez, E. (2000). The Philippines, in *Seas of the Millennium: An environmental evaluation* (C. Sheppard), pp. 405-423.
- Jackson, J.B., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A., Hughes, T.P., Kidwell, S., Lange, C.B., Lenihan, H.S., Pandolfi, J.M., Peterson, C.H., Steneck, R.S., Tegner, M.J. and Warner, R.R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science* **293**(5530), pp. 629-637.
- Koenig, C.C., Coleman, F.C., Collins, L.A., Sadovy, Y. and Colin, P.L. (1996). Reproduction in gag (*Mycteroperca micolepis*) (Pisces: Serranidae) in the eastern Gulf of Mexico and the consequences of fishing spawning aggregations in *Biology, Fisheries and Culture of*

- Tropical Groupers and Snappers* (Arreguin-Sanchez, F., Munro, J.L., Balgos, M.C. and Pauly, D. eds), pp. 307-323. *ICLARM conference proceedings* **48**.
- Kulbicki, M., and Bozec, Y. M. (2005). The use of butterflyfish (Chaetodontidae) species richness as a proxy of total species richness of reef fish assemblages in the Western and Central Pacific. *Aquatic Conservation: Marine and Freshwater Ecosystems* **15**, pp. 127-141.
- Maliao, R., Webb, E. and Jensen, K. (2004). A survey of stock of the donkey's ear abalone, *Haliotis asinina* L. in the Sagay Marine Reserve, Philippines: evaluating the effectiveness of marine protected area enforcement. *Fisheries Research* **66**, pp. 343-353.
- Mora, C. (2008). A clear human footprint in the coral reefs of the Caribbean. *Proceedings of the Royal Society B* **275**, pp. 767-773.
- Morris, K. E., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T. S., Meiners, T., Muller, C., Obermaier, E., Prati, D., Socher, S. A., Sonnemann, I., Waschke, N., Wubet, T., Wurst, S., and Rillig, M. C. (2014). Choosing and using diversity indices: insights for ecological applications from German Biodiversity Exploratories. *Ecology and Evolution* **4** (18), pp. 3514-3524.
- Mouillot, D., Villéger, S., Parravicini, V., Kulbicki, M., Arias-González, J.E., Bender, M., Chabanet, P., Floeter, S.R., Friedlander, A., Vigliola, L. and Bellwood, D.R. (2014). Functional over-redundancy and high functional vulnerability in global fish faunas on tropical reefs. *Proceedings of the National Academy of Sciences of the United States of America* **111**(38), pp. 13757-13762.
- Myers, R. A., Hutchings, J. A. and Barrowman, N. J. (1997). Why do fish stocks collapse? The example of cod in Atlantic Canada. *Ecological Application* **7**, pp. 91-106.
- Nemeth, R. (2005). Population characteristics of a recovering US Virgin Islands red hind spawning aggregation following protection. *Marine Ecology Progress Series* **286**, pp. 81-97.
- Neo, M., Eckman, W., Vicentuan, K., Teo, S and Todd, P. (2015). The ecological significance of giant clams in coral reef ecosystems. *Biological Conservation* **181**, pp. 111-123.
- O'Hara, R. B., and Kotze, D. J., (2010). Do not log-transform count data. *Methods in Ecology and Evolution* **1**(2), pp. 118-122.
- Pajaro, M., Mulrennan, M. and Vincent, A. (2010). Toward an integrated marine protected areas policy: connecting the global to the local. *Environment, Development and Sustainability* **12**, 945-965.
- Pauly, D., Christensen, V., Guénette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R. and Zeller, D. (2002). Towards sustainability in world fisheries. *Nature* **418**, pp. 689-695.
- PENRMO-CFRU (2014). Marine Protected Areas of Southern Leyte. Based on ordinances of the MPAs and Municipal Agricultural Services Offices (MASO/OMAS) as of April 24, 2010. Prepared by Armando O. Gaviola.
- Pollnac, R. B., Crawford, B. R., and Gorospe, M. L. G. (2001). Discovering factors that influence the success of community-based marine protected areas in the Visayas, Philippines. *Ocean and Coastal Management* **44**, pp. 683-710.

- Pratchett, M. (2005). Dynamics of an outbreak population of *Acanthaster planci* at Lizard Island, Northern Great Barrier Reef (1995-1999). *Coral Reefs* **24**, pp. 453-462.
- Quinn, T. J. and Deriso, R. (1999). *Quantitative Fish Dynamics*. Oxford University Press, New York.
- Roberts, C., McClean, C., Veron, J., Hawkins, J., Allen, G., and McAllister, D. (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science* **295**, pp. 1280-1284.
- Sadovy, Y., Rosario, A. and Roman, A. (1994). Reproduction in an aggregating grouper, the red hind, *Epinephelus guttatus*. *Women in ichthyology: an anthology in honour of ET, Ro and Genie*, pp. 269-286. Springer, Dordrecht.
- Sadovy, Y. J., and M. Domeier (2005). Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. *Coral Reefs* **24**, pp. 254-262.
- Selig, E.R. and Bruno, J.F. (2010). A global analysis of the effectiveness of Marine Protected Areas in preventing coral loss. *PLoS ONE* **5**(2), e9278.
- Shapiro, D.Y. (1989). Sex change as an alternative life-history style. In *Alternative life-history styles of animals* (Bruton, M.N. ed), pp. 177-195.
- Shapiro, S.S. and Wilk, M.B. (1965). An Analysis of Variance Test for Normality (Complete Samples). *Biometrika* **52**(3-4), pp. 591-611.
- Teh, L., Teh, L. and Sumaila, U. (2013). A global estimate of the number of coral reef fishes. *PLoS One* **8**(6).
- Thode, H.C. (2002). *Testing for normality*. Marcel Dekker Inc., New York, NY, USA.
- Tuomisto, H. (2012). An updated consumer's guide to evenness and related indices. *Oikos* **121** (8), pp. 1203-1218.
- Veron, J.E.N., Devantier, L.M., Turak, E., Green, A.L., Kininmonth, S., Stafford-Smith, M., and Peterson, N. (2009). Delineating the Coral Triangle. *Galaxea, Journal of Coral Reef Studies* **11**, pp. 91-100.
- Whittaker, R. H. (1972). Evolution and measurement of species diversity. *Taxon* **21**, pp. 213-251.
- Wilkinson, C. (2008). Status of coral reefs of the world 2008. *Global Coral Reef Monitoring Network and Reef and Rainforest Research Center*, Townsville, Australia, 296pp.
- Wood, L., Fish, L., Laughren, J., and Pauly, D. (2008). Assessing progress towards global marine protection targets: shortfalls in information and action. *Oryx* **42**, pp. 340-351.
- The World Bank (TWB) (2005). *Philippines environment monitor 2005: coastal and marine resource management*. The World Bank, Washington, DC, USA.

Appendix A

Table A1. List of target fish families, genera and species recorded during Coral Cay Conservation (CCC) surveys of the Barangay Lipanto MPA. * 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</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 Lipanto MPA. * 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 Lipanto 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*:		
<i>Acropora</i> branching	<i>Acropora</i> encrusting	<i>Acropora</i> submassive
<i>Acropora</i> digitate	<i>Acropora</i> tabulate	Non- <i>Acropora</i> branching
Non-<i>Acropora</i> encrusting	Non- <i>Acropora</i> foliose	Non- <i>Acropora</i> submassive
Non-<i>Acropora</i> mushroom	<i>Heliopora</i> (blue coral)	<i>Millepora</i> (fire coral)
<i>Tubipora</i> (organ-pipe coral)		
**Other:		
Anemone	Corallimorph	Halimeda
Tunicate	Zoanthid	Gorgonian
Hydroids		

* 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	I04	I05	I06	I07	I08
I01								
I02			-					-
I03		+				+		
I04								
I05								
I06			-					-
I07								
I08		+				+		

Figure B1. Matrix showing significant differences in mean target fish abundance per 500m³ across the survey site in Lipanto, St. Bernard, 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)	I01	I02	I03	I04	I05	I06	I07	I08
I01			-					
I02			-					
I03	+	+		+	+	+		
I04			-					
I05			-					
I06			-					
I07								
I08								

b)	I01	I02	I03	I04	I05	I06	I07	I08
I01			-					
I02			-					
I03	+	+		+	+	+		
I04			-					
I05			-					
I06			-					
I07								
I08								

c)	I01	I02	I03	I04	I05	I06	I07	I08
I01								
I02								
I03					+			+
I04								
I05			-				-	
I06								
I07					+			+
I08			-				-	

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 Lipanto, St. Bernard, 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.

	I01	I02	I03	I04	I05	I06	I07	I08
I01								
I02								
I03					+		+	
I04								
I05			-					
I06								
I07			-					
I08								

Figure B3. Matrices showing significant differences in mean target butterflyfish abundance per 500m³ across the survey site in Lipanto, St. Bernard, 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)	I01	I02	I03	I04	I05	I06	I07	I08
I01								
I02								
I03						+	+	+
I04								
I05								
I06			-					
I07			-					
I08			-					

b)	I01	I02	I03	I04	I05	I06	I07	I08
I01								
I02			-					
I03		+						
I04								
I05								
I06								
I07								
I08								

Figure B4. Matrix showing significant differences in mean a) parrotfish and b) grouper biomass per 500m³ across the survey site in Lipanto, St. Bernard, Southern Leyte. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to the 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.

	I01	I02	I03	I04	I05	I06	I07	I08
I01			-		+	-	-	
I02			-		+			
I03	+	+			+	+		
I04					+			
I05	-	-	-	-		-	-	
I06	+		-		+			
I07	+				+			
I08								

Figure B5. Matrix showing significant differences in mean target invertebrate abundance per 100m² across the survey site in Lipanto, St. Bernard, 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.

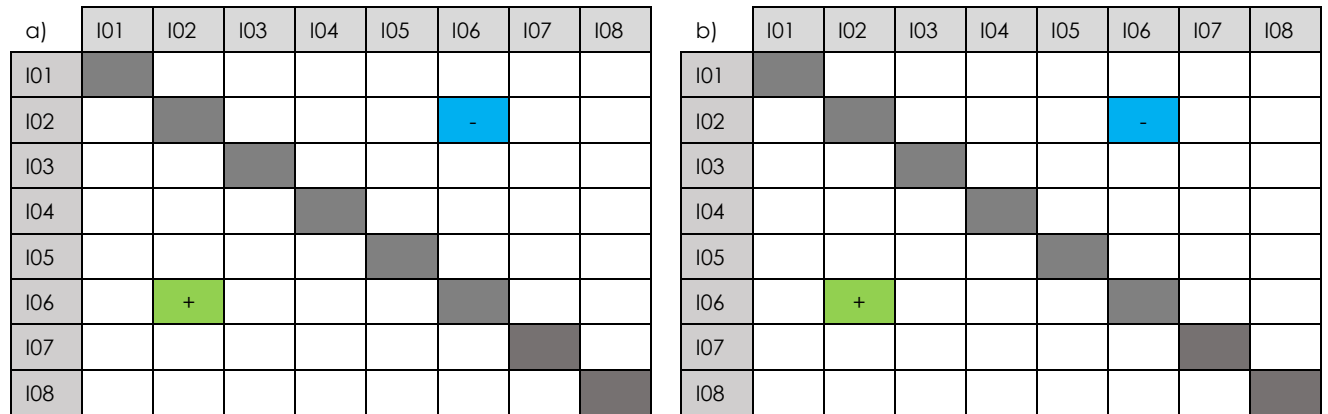


Figure B6. Matrices showing significant differences in mean target invertebrate a) Shannon's H' Diversity Index and b) Pielou's evenness (J) per 100m² across the survey site in Lipanto, St. Bernard, Southern Leyte. A green '+' indicates Shannon's H' Diversity Index (a) or Pielou's evenness (b) was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that Shannon's H' Diversity Index (a) or Pielou's evenness (b) 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 B7. Matrix showing significant differences in mean Substrate type cover per 20m across all transects in Lipanto, St. Bernard, 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)	I01	I02	I03	I04	I05	I06	I07	I08
I01		-	-	-				
I02	+					+	+	
I03	+					+	+	
I04	+					+		
I05								
I06		-	-	-				
I07		-	-					
I08								

b)	I01	I02	I03	I04	I05	I06	I07	I08
I01		-		-		-	-	
I02	+				+			
I03						+		
I04	+				+			
I05		-		-		-	-	
I06	+		-		+			
I07	+				+			
I08								

c)	I01	I02	I03	I04	I05	I06	I07	I08
I01					+			
I02					+			
I03					+			
I04					+			
I05	-	-	-	-		-	-	-
I06					+			
I07					+			
I08					+			

Figure B8. Matrices showing significant differences in mean a) Sand (SD), b) Rubble (RB) and c) Hard Coral (HC) cover per 20m across all transects in Lipanto, St. Bernard, 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 the transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

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

Figure B9. Matrix showing significant differences in mean hard coral type cover per 20m across all transects in Lipanto, St. Bernard, 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 B10. 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.

a)	I01	I02	I03	I04	I05	I06	I07	I08
I01								
I02					+			
I03								
I04								
I05		-						
I06								
I07								
I08								

b)	I01	I02	I03	I04	I05	I06	I07	I08
I01								
I02								-
I03					+			
I04								
I05			-					
I06							-	-
I07					+			
I08		+			+			

c)	I01	I02	I03	I04	I05	I06	I07	I08
I01					+			
I02								
I03								
I04	-							
I05								
I06								
I07								
I08								

Figure B11. Matrix showing significant differences in a) Fast Growing Coral (FGC), Stress Tolerant Coral (STC and Competitor Coral (CC) cover across all transects in Lipanto, St. Bernard, 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

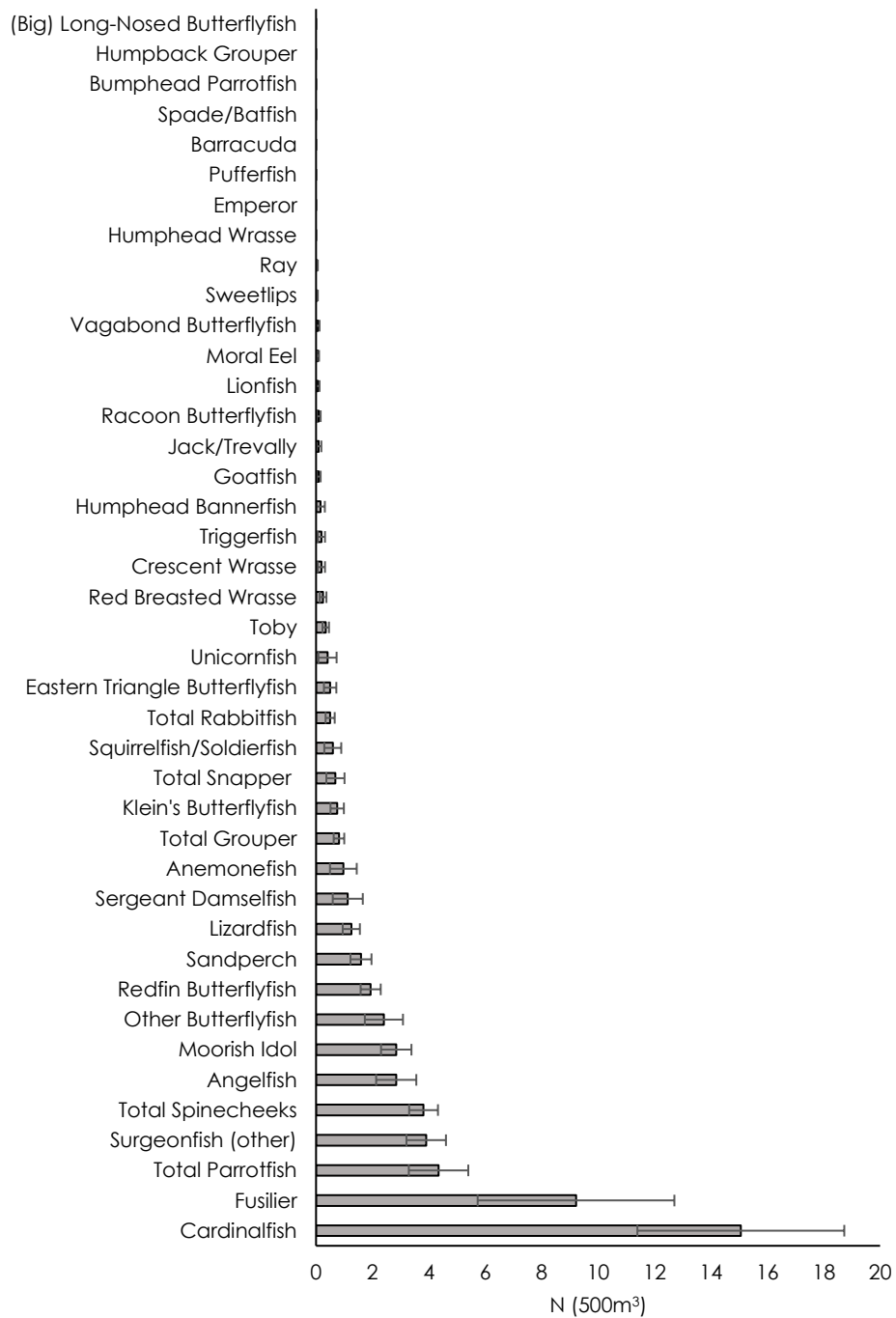


Figure C1. Mean abundance of target invertebrate species and families per 500m³ with standard error ($\pm$ SE) in Lipanto, St. Bernard, the Philippines.



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