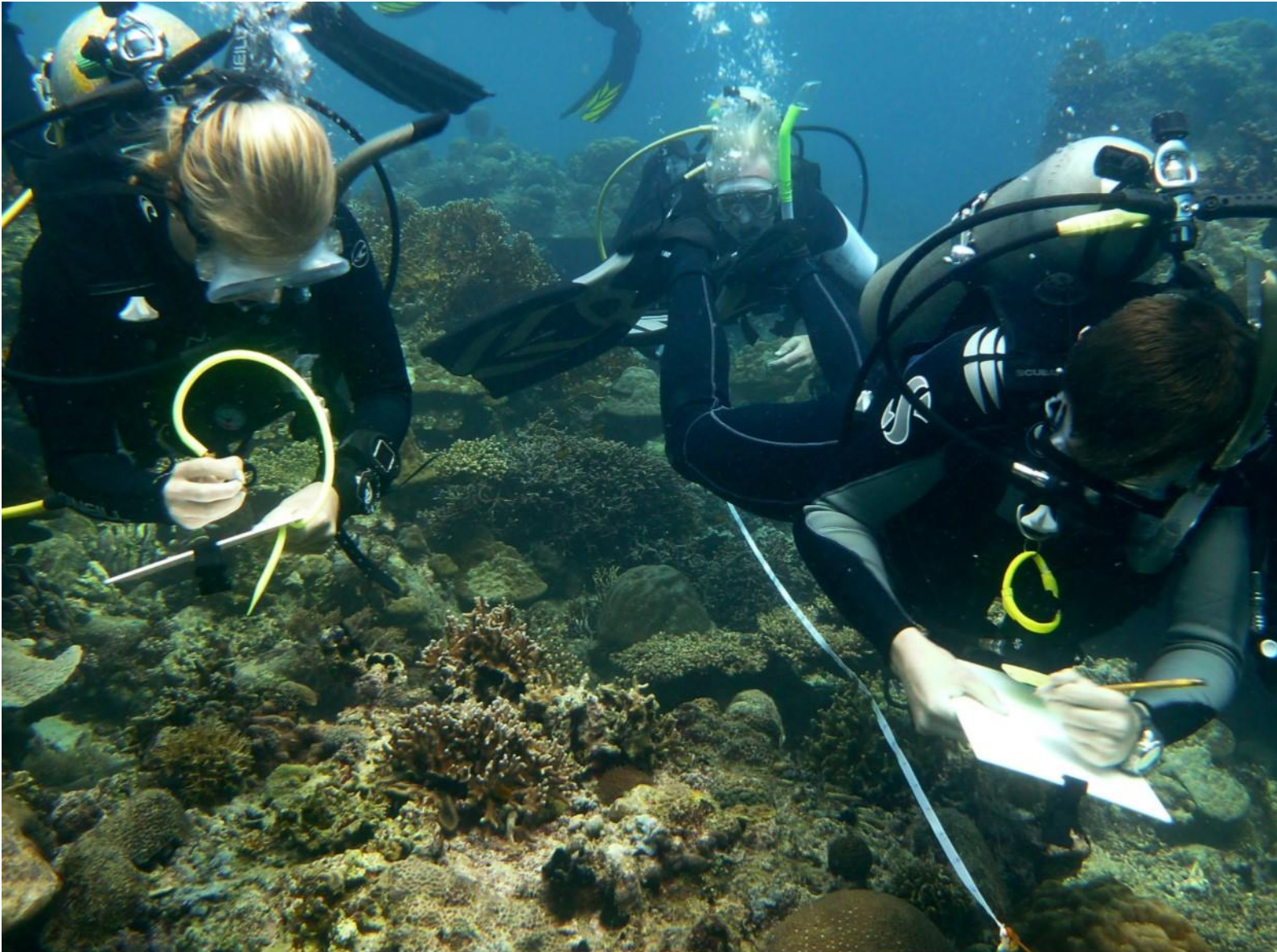




LRCP

Southern Leyte Coral Reef Conservation Project

Coral Cay Conservation Marine Protected Area Annual Report: Barangay Napantao 2016

Report Date: May 2017

**CORAL CAY
CONSERVATION**



Expeditions

Jamie Parker, Tom Dallison,

Felipe Lei

In partnership with the Southern Leyte
Provincial Government, Philippines





Report by:

Jamie Parker

Tom Dallison, Head of Science ¹

Felipe Lei, Project Scientist ²

¹Coral Cay Conservation, The Kiln, Grange Road, Tongham, Surrey, UK;
headofscience@coralcay.org

²Coral Cay Conservation, Napantao Dive Resort, 6613, San Francisco, Southern Leyte,
Philippines; lrcp@coralcay.org

In partnership with:



The Provincial Government of Southern Leyte

With thanks to:



The Municipal Government of San
Francisco

thewaterloofoundation*

The Waterloo Foundation

All photographs throughout this report are credited to the photographer, were 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: Parker, J., Dallison, T. & Lei, F. (2017). Coral Cay Conservation Marine Protected Area Annual Report: Barangay Napantao 2016. Coral Cay Conservation: Philippines.



Copyright 2017 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) conducted an assessment of the reef fish, invertebrates, substrates and anthropogenic impacts inside and outside the Napantao MPA, in April and October 2016.
- An enhanced Reef Check methodology was used to survey 6 permanent transects, each containing four 20m replicates. Three transects were placed inside and three outside the MPA at a depth of 12m.
- The reef is currently in a healthy state with high coral cover and fish diversity. Fish abundance was not significantly different inside ($N = 106.04 \pm 10.06$) vs. outside ($N = 85.21 \pm 11.08$) the MPA. However, species richness and Shannon's Diversity Index (H') were higher inside ($S = 1.85 \pm 0.10$ and $H' = 2.13 \pm 0.09$) than outside ($S = 1.20 \pm 0.85$ and $H' = 1.50 \pm 0.91$) the MPA on the majority of transects.
- Low abundance and small size of commercially important fish species suggest a history of overfishing and possibly continued illegal fishing inside the MPA; an even smaller size of the commercially important fish species outside of the MPA also suggests heavy fishing activity.
- Invertebrate abundance was not significantly different between inside and outside transects ($N = 106.25 \pm 9.03$ and $N = 125.17 \pm 11.46$, respectively). Many commercially important species of invertebrates (e.g. squid and triton's trumpet) were completely absent from the surveys. This suggests intensive harvesting, either past or present. Crown of Thorns seastar (CoTs) were found at a healthy, low level.
- There was a significantly greater composition of hard coral within the MPA (44.06%) than outside (31.87%) which may be explained by higher levels of rock within the MPA, which aid coral recruitment. Overall, bleaching and coral disease were low inside and outside.
- The composition of disturbance adapted fast growing corals (e.g. Branching *Acropora* sp.) was significantly greater inside the MPA ($35.10\% \pm 7.70$ per 20m). Significantly higher abundances of stress tolerant ($28.10\% \pm 0.68$ per 20m) and competitor corals ($24.70\% \pm 3.33$ per 20m) outside the MPA. This may suggest both effective MPA protection and possibly anthropogenic impacts from high recreational diving inside the MPA.
- CCC recommends enhanced monitoring and protection from Bantay Dagats to decrease illegal fishing activities within the MPA. Additionally, continued monitoring of the reef is required to note and address any changes from anthropogenic and natural stressors. It is evident from stakeholder communication that community members are not aware of the MPA ordinance. Therefore, it is also recommended that efforts on education and capacity building initiatives are increased within the community of Napantao by CCC. Efforts should continue to focus on basic education of conservation, MPAs and the ecosystem services of coral reefs whilst providing opportunities for dissemination of ordinance.

Table of Contents

Executive Summary	iii
List of Acronyms and Abbreviations	vi
Coral Cay Conservation	vii
1. 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 Sogod Bay	3
1.3.2 Napantao MPA	3
2.0 Methodology and Data Collection	5
2.1 Survey Sites	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
2.2.6 Data Analysis	7
3.0 Results	9
3.1 Fishes	9
3.3 Invertebrates	11
3.4 Substrates	12
3.2 Anthropogenic Impacts	14
4. Discussion	16
5.1. Fish	16
5.2. Invertebrates	17
5.3. Substrates	18
5.4. Impacts	18
6. Recommendations	20
References	21
Appendices	25
Appendix A: Target species list	25
Appendix B: Analysis of variance for surveyed transects	27
Appendix C: Target organism average abundances	31

Acknowledgements

Coral Cay Conservation would like to extend its heartfelt thanks 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. Damian G. Mercado, Vice-Governor 'Coco', Hon. Christopherson M. Yap 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).
- Hon. Samson Gumutan Jr., Municipal Mayor of San Francisco.
- Servando Tio Jr., San Francisco SB Secretary.
- Barangay Captain Sir Joy Cindeeza and Barangay Council of Napantao
- Dr Gloria Reyes, Homer de Dioz and all staff of Southern Leyte State University.
- Our Filipino staff: Tata, 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; Joel Brown, Rianne Heijboer, Jules Butlig, Alec Lambon, Jon Cabiles, Charlotte Hesterman, Jose Ydel, Jesse Tinapay, Janie Morton, Matthew Pearcey, V.Q. Villero, Chris Cruz, Darienne Lancaster, Claire Ogg and Jerome Napala.

List of Acronyms and Abbreviations

CCC	: Coral Cay Conservation
CoTs	: Crown of Thorns Seastars (<i>Acanthaster planci</i>)
HC	: Hard Coral
IUCN	: International Union for the Conservation of Nature
LGU	: Local Government Unit
LRCP	: Leyte 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
PENRMO	: Provincial Environmental and Natural Resource Management Office
PGSL	: Provincial Government of Southern Leyte
PIT	: Point Intercept Transects
PRRCFI	: Philippines Reef and Rainforest Conservation Foundation Inc.
PRRP	: Philippines Reef and Rainforest Project
RC	: Rock
RKC	: Recently Killed Coral
SC	: Soft Coral
SD	: Sand
SE	: Standard Error ($\pm$)
SI	: Silt
SP	: Sponge
SST	: Sea Surface Temperature
UVC	: Underwater Visual Census

Coral Cay Conservation

Initially founded in 1986, CCC is an internationally renowned non-governmental organisation, 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. Successfully established areas in the Philippines are 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 PGSL invited CCC and the PRRCFI to conduct research in Sogod Bay. This resulted in the formation of the Leyte 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. 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) (min. 5 hectares), 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 (Fig. 1). 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 (World Bank, 2005).

To assess the beneficial impact of an MPA, resource managers often seek to measure

its respective effectiveness. Effectiveness can be measured on a range of factors, however, most commonly addresses the goals established by the MPA. Measuring the MPA's impact on ecology, biodiversity, (Mora *et al.*, 2006; Selig and Bruno 2010), species conservation, the general ecological status and fishery productivity (Buxton *et al.*, 2006; McDaniel 2007) as well as meeting the stakeholder-defined parameters of success (Dahl-Tacconi 2005) can often satisfy the quantifiable conclusion of effectiveness. The definition of effectiveness was given by Pajaro (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.

Increases in fish production occurs 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 results in 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. The fauna within the MR, their size, biomass and life-stage are all at the discretion of the by-laws set for the MR during the planning

stage regarding levels of exploitation. 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, 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 habitat.

"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 (Polnac *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 and Davies 2010). It is, therefore, essential that the local community is involved throughout 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).

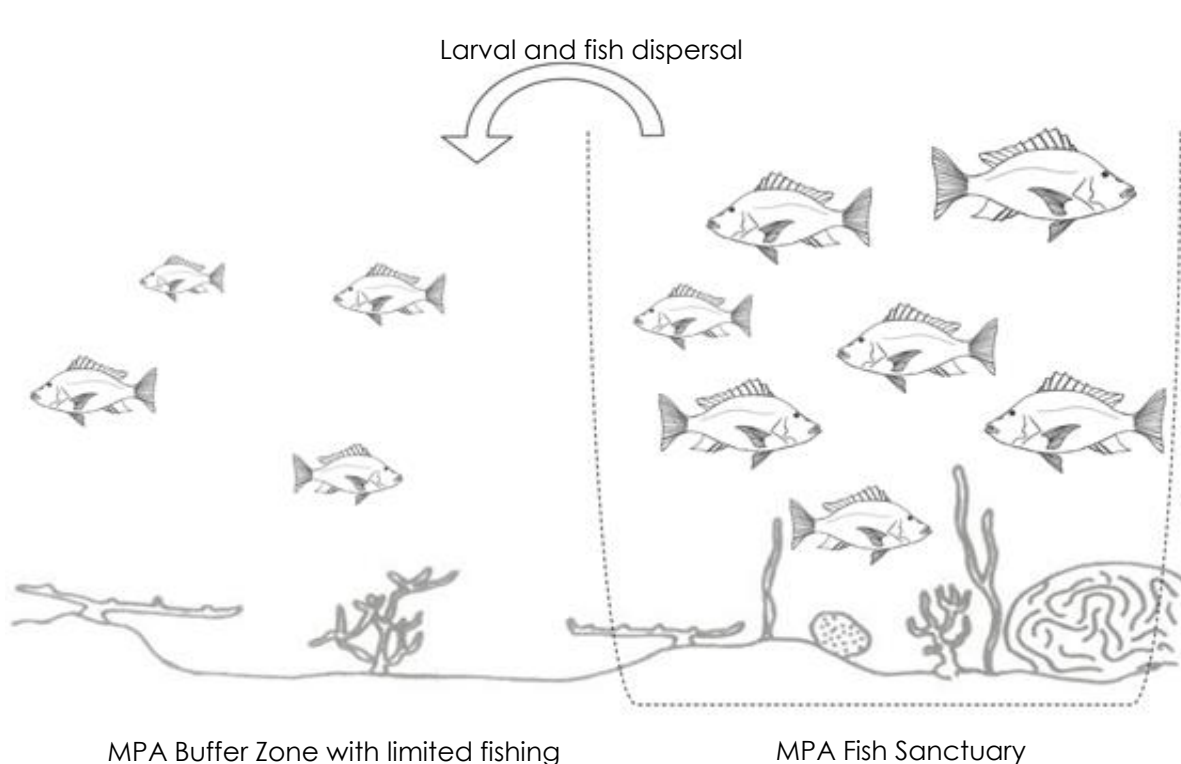


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to 'overspill', increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

1.2 Coral Reefs and Marine Conservation in the Philippines

The Philippines lies 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 oldest 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). The same extraordinary diversity is also found in other types of marine organisms; with over 3,000 species of fish recorded, even higher figures for molluscs and new species still being discovered regularly (Allen 2008).

The waters of the Philippines contain roughly 25,000 km² of coral reefs. An estimated 60% of the country's 98 million citizens live in coastal regions within proximity to coral reefs and over half of the consumed animal protein comes from marine sources (CTI, 2012). This heavy reliance on marine resources has caused large areas of coral reef ecosystems to become threatened. In 1980, 33% of coral reefs were characterised as being in poor condition, in 2008 this figure had increased to 40% (Wilkinson, 2008). These figures make a strong case for increased marine conservation efforts within the Philippines. Jacinto *et al.* (2000) stated that legislation concerning marine conservation in the Philippines is some of the most advanced within the Coral Triangle. Important laws currently instigated in the Philippines include:

- 1998 Fisheries Code (Republic Act 8550): 15% of municipal waters should be within an MPA.
- Marine and Coastal Resource Protection Act 2011: Each municipality should have at least one MPA that is bigger than 10 hectares (if the total municipal waters are larger than 15 hectares).
- The Philippine Marine Sanctuary Strategy (2002): By 2020, 10% of all the Philippine marine waters will be fully protected.

Currently there are roughly 1,869 MPAs in the Philippines. Of these MPAs, 33 have been declared at the national level as National Integrated Protected Area System (NIPAS) sites and the remainder are managed by Local Government Units (LGUs).

1.3 Characterisation of Study Region

1.3.1 Sogod Bay

The coral reefs of Southern Leyte remain some of the least disturbed habitats in the Philippines. The coastal regions that include Canigao Channel in the west, Sogod Bay, Cabalian Bay, the north eastern Pacific coast and the Surigao Strait are rich in marine life and are 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 1,225.79 hectares. Nowadays, using reef check methodology CCC has been directly involved in the monitoring and survey of 26 different sites around Sogod Bay, these figures will increase in the coming years as more MPAs are in process of being established. Sizes of MPAs range from 3.5 hectares (Maujon/Juangon Fish Sanctuary) to 55 hectares (Limasawa Fish Sanctuary), with a mean average size of 11.7 hectares (± 2.2 SE) and a median average of 7.9 hectares (PENRMO-CFRU, 2014). The sizes for several MPAs are not known, as accurate GPS coordinates are not available.

1.3.2 Napantao MPA

The Napantao MPA was established in 1996 and covers 5 hectares. It is located in the Municipality of San Francisco, in the waters of the Barangay Napantao, which is home to around 300 people, of which approximately 25 are fishermen. The boats

used by the local fisherfolk are mostly non-motorised. The MPA is to the east of the village (Fig. 2). There is a Bantay Dagat hut which is occasionally supervised. Currently, the MPA infrastructure is held to a commendable standard (Table 1). Fishing takes place in the area surrounding the MPA on a regular basis and poaching is relatively common (Bantay Dagat, Pers. Comms).

Table 1. Summary of the Barangay Napantao marine protected area (MPA) infrastructure

MPA Infrastructure	Present	Comment
Bantay Dagats	Yes	Require environmental and enforcement training
Permanent Bantay Dagat presence	No	Not always present
MPA guardhouse	Yes	Bantay Dagat not always present
Demarcation buoys	Yes	Not placed at exact boundaries
Patrol boat	Yes	Not always available
Bantay Dagat gear (flashlight, fins, mask, etc.)	Yes	Available but rarely used
User fees collected	Yes	User fees regularly collected

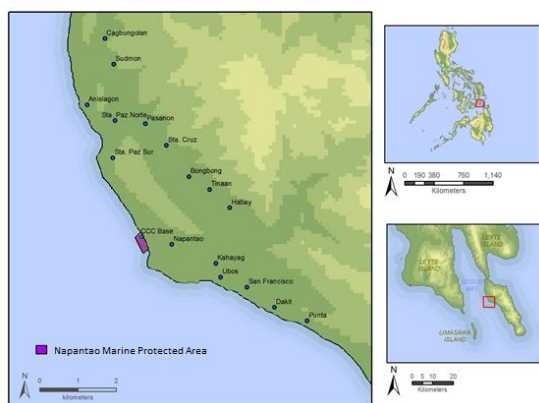


Figure 2. Map detailing to location of the Barangay Napantao marine protected area (MPA) in Southern Leyte, Philippines.



2.0 Methodology and Data Collection

2.1 Survey Sites

CCC's assessment of the Napantao MPA was conducted over two survey periods during 2016; the first between March 24th and April 2nd, and the second between October 8th and November 4th, by trained volunteer survey teams. The weather varied between sunny and raining/overcast during this time with no major weather systems moving through the region. Mean air temperature during surveys was 28.3°C, Sea Surface Temperature (SST) was 28.2°C, and 28°C at a depth of 3m and 27.8°C at 10m. The mean estimated horizontal visibility throughout the survey was 13.3m.

2.2 Biophysical Survey

The assessment of the Napantao MPA was conducted using an enhanced Reef Check methodology which is widely recognised and used to survey coral reefs around the world (Hodgson and Liebler 2002). It was developed in the 1990s with the aim of gathering as much data as possible about the global status of coral reefs (Hodgson 1999). Data from around the world is analysed on a yearly basis to enable the production of global coral reef status updates. Reef Check surveys produce a representation of the ecological status of a reef and its human impacts. CCC has augmented the methodology to reflect the high biodiversity of the area with the addition of extra target species of fish, coral and invertebrates (Appendix A).

Permanent transects at 12m (three inside and three outside the MPA - marked with rebar) were surveyed starting in both March and October (Table 2, Fig. 3). Each 100m transect was divided up into four 20m replicates, separated by 5m inter-replicate gaps in which no data were collected. This produced a total surveyed length of 80m. Approximately 100m was left between each whole transect. This survey design allowed for robust statistical analysis of collected data.

Table 2. Permanent transect coordinates for sites inside and outside Napantao Marine Protected Area, southern Leyte, the Philippines.

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

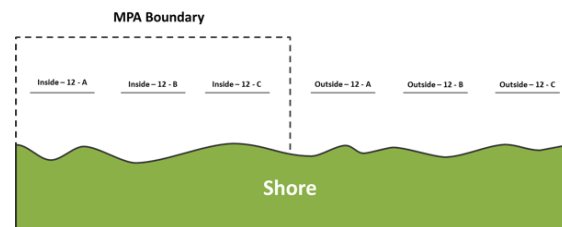


Figure 3. Survey plan for the assessment of the Barangay Napantao Marine Protected Area (MPA) utilised by Coral Cay Conservation (CCC). Each transect is 100 meters long and is sub-divided into four 25 metre replicates. Of these 25 metres, only 20 metres are surveyed with the resultant 5 metres used to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

2.2.1 Visual Assessment of Reef Fishes

Fish diversity and abundance data were collected using Underwater Visual Census (UVC). 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 also 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 5x5x20m (WxHxL) box (Fig. 4).

Surveys were conducted by two surveyors swimming slowly along replicates, each counting indicator fish species 2.5m either side of the central transect line. Divers paused at five metre 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 (cm) (L) 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 (g) (W) 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 and 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 the Barangay Napantao coral reef, Sogod Bay, southern Leyte, Philippines. W = mass (g), *a* = the condition factor (Hilborn and Walters, 1992), *b* = species specific growth parameter (Quinn and Deriso, 1999), L = the total length (TL) (cm) measured of the individual fish.

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

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

The respective genera within each family were individually analysed and the subsequent geometric mean determined for the allometric LWR coefficients. To establish the overall allometric coefficient values for the family, the geometric mean was also calculated. For genera that did not supply studies of values that complied with this report's selection criteria, a Bayesian approach was taken in accordance with Froese *et al.* (2013). If no Bayesian approach was readily available, the following geometric means were used for data deficient families of the three families: *a* = 0.0112 and *b* = 3.04. When a target species was categorised as a differing body-form to 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.

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

Genera	Species	Common Name	Allometric Coefficients	
			a	b
Serranidae	Other	Grouper	0.0145	3.0225
	<i>Cromileptes altivelis</i>	Barramundi Cod	0.0138	3.28
Lutjanidae	Other	Snapper	0.0147	0.0312
Scaridae	Other	Parrotfish	0.0152	3.0398
	<i>Bolbometapon muricatum</i>	Green Humphead		
		Parrotfish	0.0138	3.03

If the location of the study and reference were not obtainable, the species-range and native habitat were explored of the fish species through FishBase archives. If the species resided within the central Indo-Pacific region, the assumption was made that the allometric coefficients were obtained from individuals caught within the native habitat – the desired range. If the native range was outside the central Indo-Pacific region, the study was excluded.

Following the discussed process, the appropriate *a* and *b* values for each commercially important fish family were determined (Table 3).

2.2.3 Visual Assessments of Invertebrates

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

2.2.4 Substrates

Benthic diversity was measured by recording living and non-living substrate categories along a 'point-intercept' transect (PIT) using a plumb line to minimize bias. Benthic organisms and substrate types directly underneath the transect line were recorded at 50cm intervals along each 20m replicate (Fig. 6). Every 20m replicate contained 40 benthic points. Benthic

categories included: sand (SD), rock (RC), rubble (RB), silt/mud (SI), nutrient indicator algae (NIA), sponge (SP), recently killed coral (RKC), soft coral (SC), hard coral (HC) and any other sessile organisms. All hard corals were recorded to life form and level, with targets being recorded to species level (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 and Risk (2000).

2.2.5 Impacts

Within the same area assessed for invertebrates, divers recorded impacts on the reef. The total percentage of bleached coral cover was estimated together with the percentage of bleaching on each individual bleached coral colony. Coral diseases were identified where present and recorded as a percentage of the colony infected. Damage was recorded in three categories: boat/anchor, dynamite and other, on a categorical 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.

2.2.6 Data Analysis

Transect data from April and October were combined and averaged across the two temporal periods to reduce the influence of seasonality (e.g. greater fish abundance during breeding seasons). Each 20m belt

transect was treated as an independent replicate. This produced $n=24$ inside the MPA and $n=24$ outside the MPA. Shapiro-Wilks tests, typically used on small data sets to check for normality, showed much of the data was non-parametric (Shapiro and Wilk 1965; Thode 2002). Square root transformations of the non-parametric data did not sufficiently alter the data to warrant using a parametric test (O'Hara and 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 as 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).

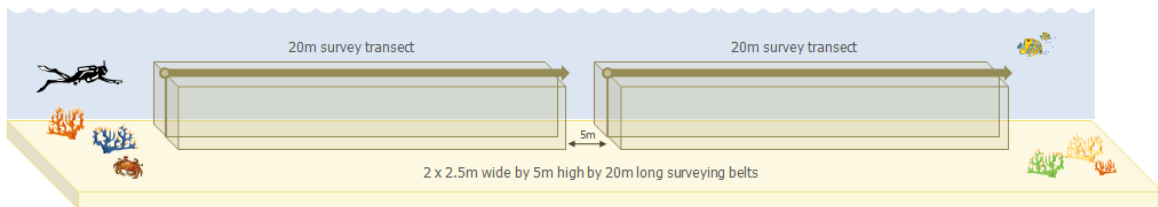


Figure 4. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of fishes within the Barangay Napantao marine protected area (MPA). Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps.

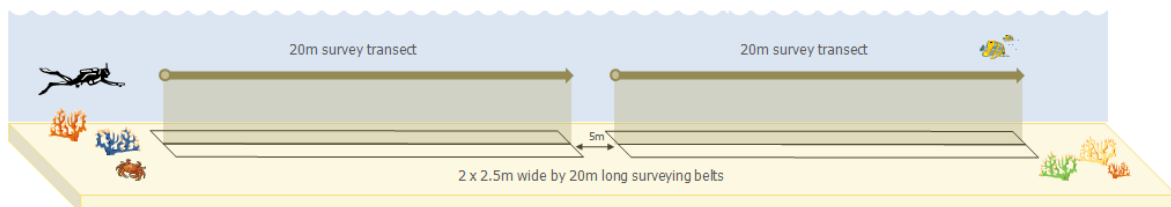


Figure 5. The augmented Reef Check methodology conducted for the assessment of the diversity and abundance of invertebrates within the Barangay Napantao marine protected area (MPA). Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps.

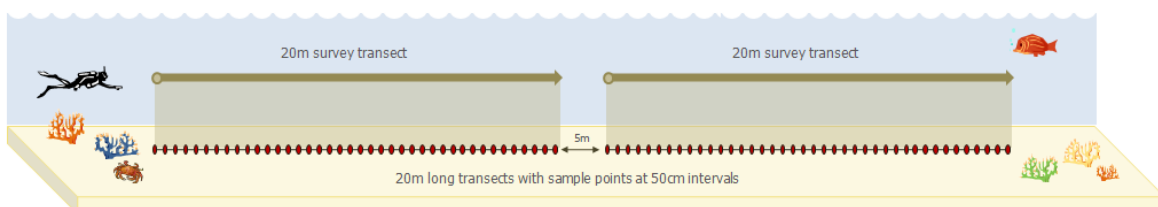


Figure 6. The undertaken point intercept methodology conducted for the assessment of benthic composition within the Barangay Napantao marine protected area (MPA). Each conducted transect is separated into 4 x 20m replicates segmented by 5m inter-replicate gaps with the respective benthic substrate recorded at 0.5m intervals. The presented schematic only represents two of the four 20m replicates.

3.0 Results

3.1 Fishes

Average total fish abundance for transects inside the Napantao MPA was $N=106.04 \pm 10.06$ and $N=85.21 \pm 11.08$ per 500m³ for transects outside the MPA (Fig. 7). No significant differences were found in total fish abundance between transects ($p > 0.05$).

Average total fish S inside the MPA was $S=15.00 \pm 0.91$ per 500m³ and $S=12.04 \pm 0.85$ per 500m³ outside the MPA (Fig. 8). Average H' was $H'=2.13 \pm 0.09$ per 500m³ and $H'=1.85 \pm 0.10$ per 500m³ inside and outside the MPA, respectively. Overall, average J' within the MPA was $J'=0.80 \pm 0.03$ per 500m³, while outside it was $J'=0.76 \pm 0.04$ per 500m³. More specifically, transect O01 was found to have significantly lower total fish S than transects I01, I02, I03 and O02 (Fig. B1a) ($p < 0.05$). In terms of total fish H' , I01 was found to be significantly greater than all transects except I02 (Fig. B1b) ($p < 0.05$), while also exhibiting significantly higher total fish J' compared with transects I02 and O02 ($p < 0.05$) (Fig. B1c).

Mean total commercial fish abundance for transects inside and outside the Napantao MPA was $N=14.63 \pm 2.30$ and $N=12.29 \pm 2.39$ per 500m³, respectively (Fig. 9).

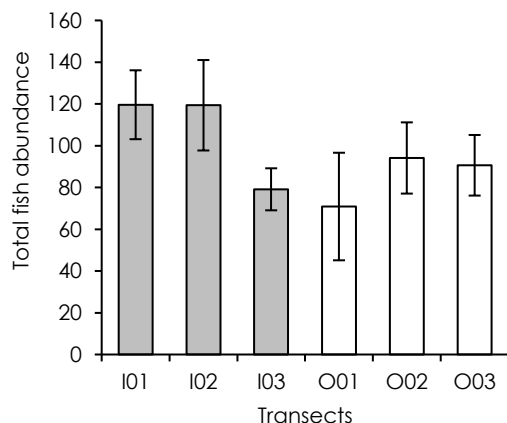


Figure 7. Average total fish abundance with standard error (SE) across transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. Grey = inside MPA transects, White = outside MPA transects.

Total commercial fish abundances showed no significant differences between transects ($p > 0.05$). Average parrotfish, grouper and snapper abundances for transects inside the MPA were $N=6.75 \pm 1.15$, $N=2.42 \pm 0.72$, and $N=5.46 \pm 1.40$ per 500m³, respectively (Fig. 10). Transects outside the MPA showed an average parrotfish abundance of $N=8.42 \pm 2.24$ per 500m³, an average grouper abundance of $N=0.71 \pm 0.16$ per 500m³ and an average

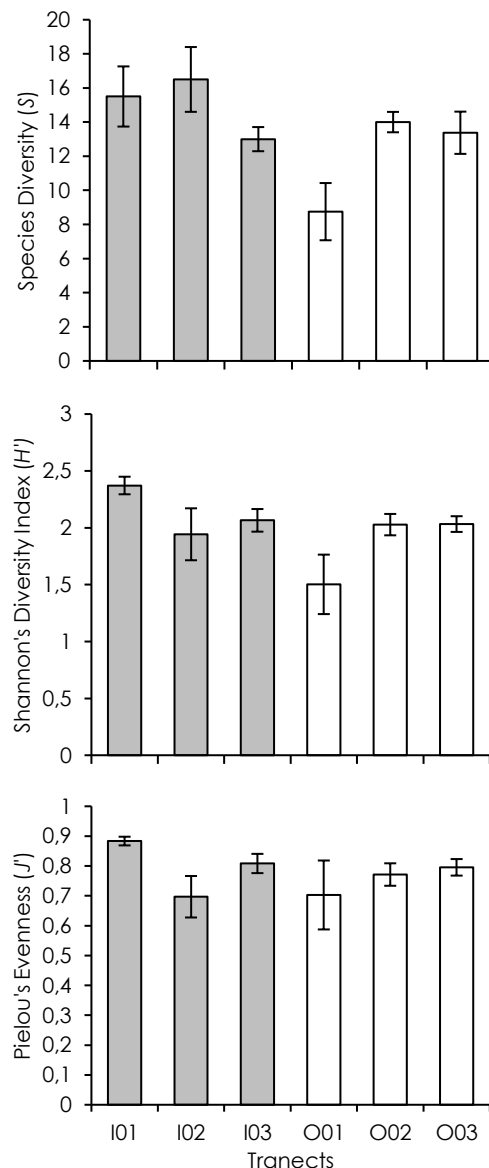


Figure 8. Total fish Species Richness (S), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) with standard error (SE) across all transects, inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. Grey = inside MPA transects, White = outside MPA transects.

snapper abundance of $N=3.17 \pm 0.70$ per 500m³. No significant differences were found between transects with regards to total Parrotfish numbers. However, Grouper abundances were shown to be significantly greater on all inside transects and one outside transect (O03) compared with O04 ($p= <0.05$) (Fig. B2a). Transect I01 and O03 Snapper abundances were also found to be significantly higher than O04 ($p= <0.05$) (Fig. B2b).

More size classes of commercial fish species were found inside MPA than outside, however, the majority of Parrotfish, Grouper and Snapper observed within the

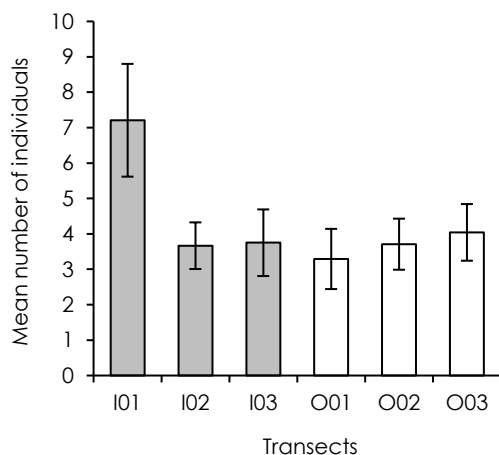


Figure 9. Average total abundance of commercially important fish species observed per 500m³ with standard error (SE) across transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. Grey = inside MPA transects, White = outside MPA transects.

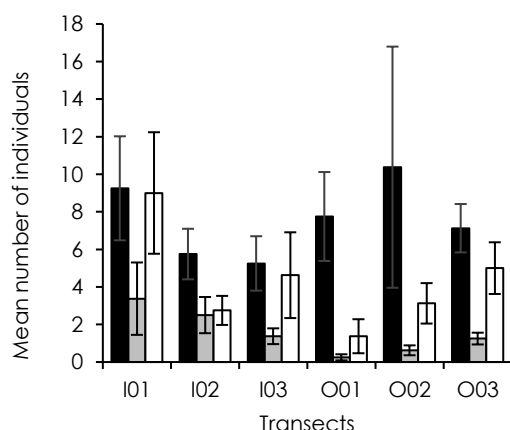


Figure 10. Average abundance of Parrotfish, Grouper and Snapper observed per 500m³ with standard error (SE) across transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. Black = Parrotfish, Grey = Grouper, White = Snapper.

Napantao MPA were small in length, most falling between 11-20 cm ($N=4.88 \pm 0.71$ per 500m³) (Fig. 11). The longest individual recorded was between 40-50cm. Outside the Napantao MPA the majority of commercial fish species were found to be even smaller, between 0-10cm ($N=6.67 \pm 2.07$ per 500m³), with the largest observed no larger than 40cm.

Average total commercial fish biomass was higher inside (0.26 ± 0.09 kg per 500m³) than outside (0.10 ± 0.04 kg per 500m³) the Napantao MPA (Fig. 12). Of the commercial fish, Parrotfish held the greatest biomass both inside and outside the MPA with 0.60 ± 0.26 kg and 0.31 ± 0.10 kg per 500m³, respectively (Fig. 13), however no significant differences were found between transects. This was followed by Snapper with 0.16 ± 0.07 kg (inside MPA) and 0.12 ± 0.05 kg per 500m³ (outside MPA) and grouper with 0.04 ± 0.01 kg (inside MPA) and 0.02 ± 0.01 kg per 500m³ (outside MPA). Transect O04 showed significantly lower Grouper biomass than I01, I02, I03 and O06, while I01 also showed significantly greater Grouper biomass than O02 ($p= <0.05$) (Fig. B3a). Snapper biomass estimations were significantly greater on transects I01, I02 and O02 than on transect O04 ($p= <0.05$) (Fig. B3b). Other commercially important fish species including *Bolbometapon muricatum* (Bumphead Parrotfish), *Cromileptes altivelis* (Barramundi Cod), or *Plectorhincus* sp. (Sweetlips) were completely absent from the survey area.

Average butterflyfish abundance per transect was $N=10.96 \pm 1.57$ per 500m³ (Fig. 15) within the Napantao MPA. These findings were found to be greater than those found outside the MPA, with average butterflyfish abundances averaging $N=6.33 \pm 0.93$. Transects O02 and I01 both showed significantly higher total butterflyfish abundances than O01 ($p= <0.05$) (Fig. B4). Average total Butterflyfish S was found to be higher ($S=2.92 \pm 0.28$ per 500m³) inside than outside ($S=1.50 \pm 0.19$ per 500m³) the Napantao MPA (Fig. 16). In regards to S, all inside transects and O02 were shown to be significantly greater than transect O01 ($p= <0.05$) (Fig. B5a); S was also found to be significantly higher on transects I01 and I02

when compared with transect O03 ($p < 0.05$). Inside the MPA, the average total Butterflyfish H' was $H' = 0.85 \pm 0.10$ per 500m³ and $H' = 0.28 \pm 0.06$ per 500m³ outside; all inside transects exhibited significantly higher H' than transects O01 and O03 ($p < 0.05$) (Fig. B5b). Mean total Butterflyfish J' was found to be $J' = 0.83 \pm 0.05$ per 500m³ (inside) and $J' = 0.60 \pm 0.08$ per 500m³ (outside). However, no differences between transects for J' were found to be significant ($p > 0.05$). Average obligate corallivore Butterflyfish abundances per transect was $N = 3.35 \pm 0.47$ per 500m³ within the MPA and $N = 2.69 \pm 0.56$ per 500m³ outside the MPA. Average facultative corallivore Butterflyfish abundances were found to be lower both inside and outside the MPA, $N = 0.49 \pm 0.11$ per 500m³ and $N = 0.08 \pm 0.03$ per 500m³, respectively (Fig. 17).

3.3 Invertebrates

Average invertebrate abundances inside the Napantao MPA were found to be less, $N = 106.25 \pm 9.03$ individuals per 100m², than abundances outside the MPA, $N = 125.17 \pm 11.46$ individuals per 100m² (Fig. 18). Transect O02 showed significantly higher invertebrate abundances than transects I02, I03 and O01 ($p < 0.05$), while I01 and O03 also exhibited a greater average total number of invertebrates than transects I03 and O01 ($p < 0.05$) (Fig. B6). On average, brittle stars ($N = 35.04 \pm 6.80$ (inside), $N = 40.46 \pm 6.14$ (outside)), feather stars ($N = 27.67 \pm 4.57$ (inside), $N = 30.83 \pm 4.11$ (outside)) and other gastropods ($N = 12.38 \pm 2.38$ (inside), $N = 10.63 \pm 2.35$ (outside)), dominated transects.

Average invertebrate S was found to be higher outside ($S = 10.75 \pm 0.58$ per 100m²) the MPA than inside ($S = 9.83 \pm 0.30$ per 100m²) (Fig. 19). More specifically, transect O03 showed significantly greater S than I03 and O01 ($p < 0.05$), while O02 S was also significantly higher than at I03 ($p < 0.05$) (Fig. B7a).

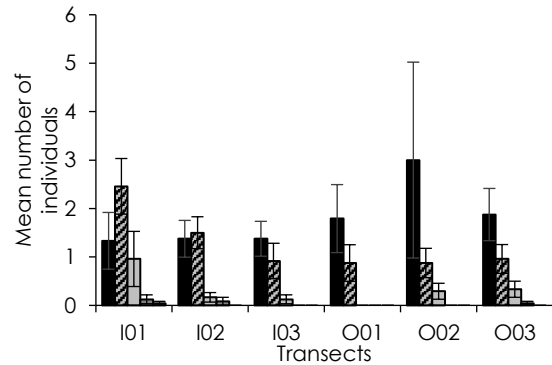


Figure 11. Cumulative abundance of Parrotfish, Grouper and Snapper in size categories 0-10cm (Black), 11-20cm (Black/Grey Shade), 21-30cm (Grey), 31-40cm (Dark grey) and 41-50cm (White) per 500m³ with standard error (SE) between transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines.

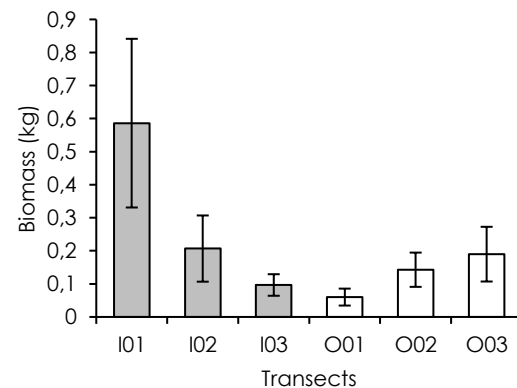


Figure 12. Average total commercial fish biomass per 500m³ with standard error (SE) between transects inside (grey) and outside (white) the Napantao marine protected area (MPA), Southern Leyte, the Philippines.

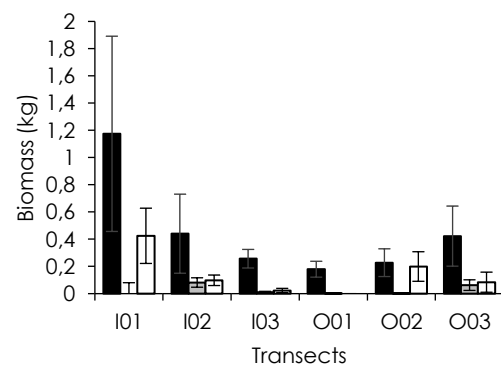


Figure 13. Average commercial fish biomass by target family (Parrotfish (black), Grouper (grey), Snapper (white)) per 500m³ with standard error (SE) between transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines.

Average invertebrate H' was found to be very similar inside ($H'=1.61 \pm 0.05$ per 100m²) and outside the MPA ($H'=1.62 \pm 0.07$ per 100m²). Transect O02 exhibited significantly greater invertebrate H' than I01 and O01, while transects I03 and O03 showed significantly higher H' than transect I01 and O01, respectively ($p= <0.05$) (Fig. B7b). Average invertebrate J' was $J'=0.71 \pm 0.02$ per 100m² (inside) and $J'=0.66 \pm 0.04$ per 100m² (outside), with transect I03 in particular showing a significantly greater invertebrate J' than all other transects except O02 ($p= <0.05$) (Fig. B7c).

Commercially important invertebrate species including lobster (*Nephropidae*), abalone (*Haliotidae*), triton's trumpet (*Charonia tritonis*), squid (*Teuthida*), prickly redfish sea cucumber (*Thelenota ananas*), greenfish sea cucumber (*Stichopus chloronotus*) and pinkfish sea cucumber (*Holothuria edulis*) were entirely absent from the survey. 9 Giant Clams were recorded within the Napantao MPA and 19 were recorded outside the MPA, with no individuals larger than 40cm. 1 Crown of Thorns Starfish (CoTs, *Acanthaster planci*) was recorded outside the Napantao MPA, whilst being completely absent within the surveyed MPA area.

3.4 Substrates

Hard coral was the most prevalent substrate across both inside and outside MPA transects, covering an average of $44.06 \pm 8.45\%$ per 20m and $31.86 \pm 6.85\%$ per 20m, respectively. This was followed by rock with $21.98 \pm 2.53\%$ per 20m (inside) and $15.63 \pm 1.72\%$ per 20m (outside), while sand with $25.31\% \pm 6.91$ per 20m was a prominent feature on transects outside the Napantao MPA (Fig. 20). Transect O01 showed significantly lower hard coral percentage cover than all other transects ($p= <0.05$); conversely transect I01 exhibited significantly higher hard coral percentage cover than all other transects ($p= <0.05$) (Fig. 27a). Sponges were significantly more abundant on transect I01 compared with transects I02 and I03 ($p= <0.05$), similarly, O03 was found to have a significantly greater sponge coverage than I02 (Fig. 27b). Transects I01 and O03 showed

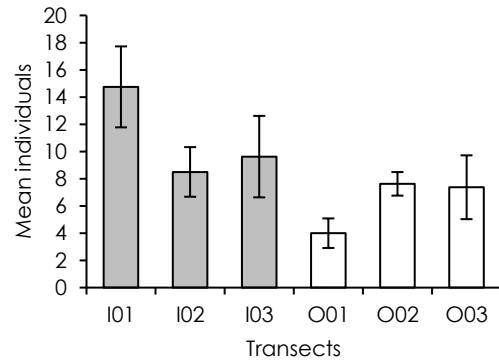


Figure 15. Average total butterflyfish abundance per 500m³ with standard error (SE) across transects inside (grey) and outside (white) the Napantao marine protected area (MPA), Southern Leyte, the Philippines.

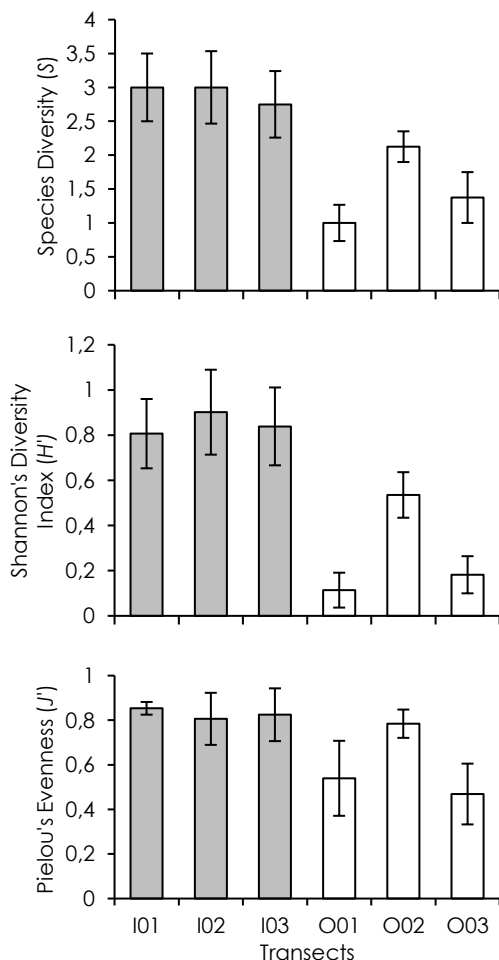


Figure 16. Butterflyfish Species Richness (S), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) with standard error (SE) across transects inside (grey) and outside (white) the Napantao marine protected area (MPA), Southern Leyte, the Philippines.

significantly higher rock coverage than O02 ($p= <0.05$) (Fig. 27c). Sand findings for transect I01 were significantly lower than all transects except O03 ($p= <0.05$), while O01

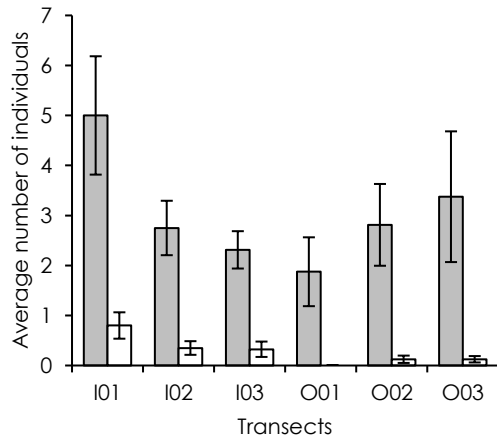


Figure 17. Average obligate corallivore and facultative corallivore butterflyfish abundances with standard error (SE) per 500m³ across transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. Grey = Obligate corallivore, White = Facultative corallivore.

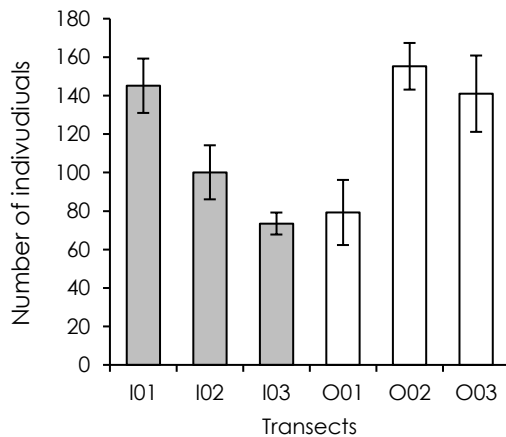


Figure 18. Average invertebrate abundance at each transect per 100m² with standard error (SE) across transects inside (grey) and outside (white) the Napantao marine protected area (MPA), Southern Leyte, Municipality San Francisco, the Philippines.

showed significantly higher sand coverage than transects I02 and I03 also (Fig. 27d). There were no significant differences ($p = >0.05$) across transects for other substrate categories.

More specifically, *Acropora* sp. branching corals dominated the Napantao MPA and the surrounding survey transects with an average cover of $27.20 \pm 4.98\%$ per 20m and $23.01 \pm 5.53\%$ per 20m, respectively (Fig. 28). These were followed by non-*Acropora* sp. submassive corals with $19.18 \pm 4.30\%$ per 20m (inside) coverage and $20.40 \pm 3.25\%$ per 20m (outside). Non-*Acropora* branching corals; $10.29 \pm 2.18\%$ per 20m

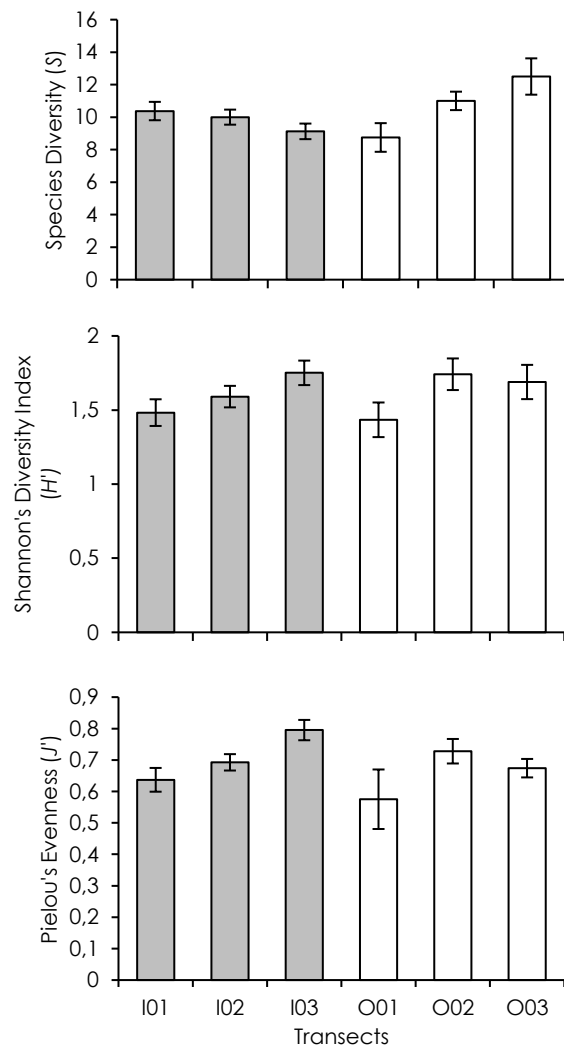


Figure 19. Invertebrate Species Richness (S), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) per 100m² with standard error (SE) across transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, Municipality San Francisco, the Philippines. Grey = inside MPA transects, White = outside MPA transects.

(inside) and $12.05 \pm 2.43\%$ per 20m (outside), along with non-*Acropora* foliose; $14.14 \pm 2.97\%$ per 20m (inside) and $7.03 \pm 1.90\%$ per 20m (outside), were also found to be prevalent. A comparatively low coverage of non-*Acropora* massive species were found within the MPA, accounting for only $11.70 \pm 2.54\%$ per 20m of the hard coral coverage. There were significantly ($p = <0.05$) more disturbance adapted fast growing corals ($35.10 \pm 7.70\%$ per 20m) compared to both competitor corals ($17.02 \pm 3.98\%$ per 20m) and stress tolerant corals ($15.50 \pm 3.73\%$ per 20m) within the Napantao MPA (Fig. 22).

Conversely, disturbance adapted, competitor and stress tolerant corals outside the MPA were all evenly represented ($29.50 \pm 10.33\%$ per 20m, $28.10 \pm 9.68\%$ per 20m and $24.70 \pm 3.33\%$ per 20m, respectively).

3.2 Anthropogenic Impacts

It was reported that there was no blast or poison fishing inside or outside the MPA or collections for the curios, aquarium or Large Reef Fish Food Trade (LRFFT). There is occasional artisanal and subsistence fishing within the MPA buffer zone which also experiences illegal fishing practices from time to time. Enforcement of MPA rules (no anchoring, commercial fishing, shell collection, recreational fishing, spearfishing) is rare by either local or municipal Bantay Dagats. There are medium to low levels of artisanal fishing outside the MPA and little to no known commercial fishing in the area. The area is a popular, regularly visited site for recreational divers, primarily from Coral Cay Conservation divers and local Sogod Bay dive resorts. In December 2014, Typhoon Hagupit damaged some corals inside and outside of the Napantao MPA.

Inside the Napantao MPA general trash was recorded 11 times during the survey, with 54% of the surveyed area showing no impact (0) and 46% showing low impact (1). Fishing related trash (e.g. nets, lines) was recorded 10 times with 75% of the surveyed area showing no impact, 13% showing low impact, 8% showing moderate impact and 4% showing high impact. There were no obvious signs of boat, anchor, or dynamite damage. Undetermined coral damage was observed 34 times with 46% of the surveyed area showing no impact, 25% showing low impact, 8% showing both moderate and high impact. On average, less than 1% of the population, within the Napantao MPA, expressed signs of coral bleaching, with an average of $35.04 \pm 7.52\%$ bleaching on those individual colonies. White band disease was recorded on four occasions, with an average covering of $10.75 \pm 0.48\%$ of the affected coral colonies. No other incidents of black band or other coral diseases were recorded.

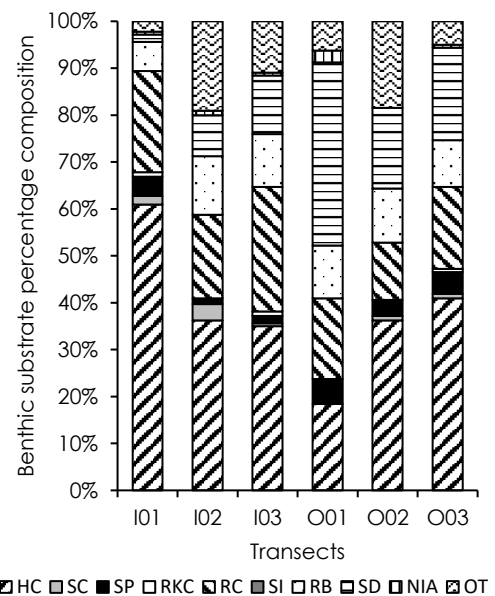


Figure 20. Average substrate percentage cover at each transect inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt; NIA – Nutrient indicator algae; OT – Other living organisms.

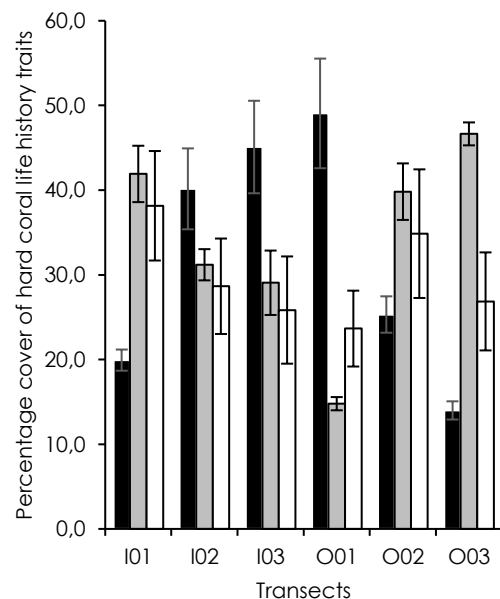


Figure 22. Average percentage cover of coral types per 20m with standard error (SE) across transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. Black = Disturbance adapted fast growing corals (i.e. *Acropora* sp., Fire coral (*Millepora* sp.), Blue coral (*Heliopora* sp.); Grey = Competitor corals (i.e. branching, foliose, encrusting, mushroom non-*Acropora* sp.); White = Stress tolerant corals (i.e. massive, submassive, organ pipe (*Tubipora* sp.)) (Edinger and Risk 2000).

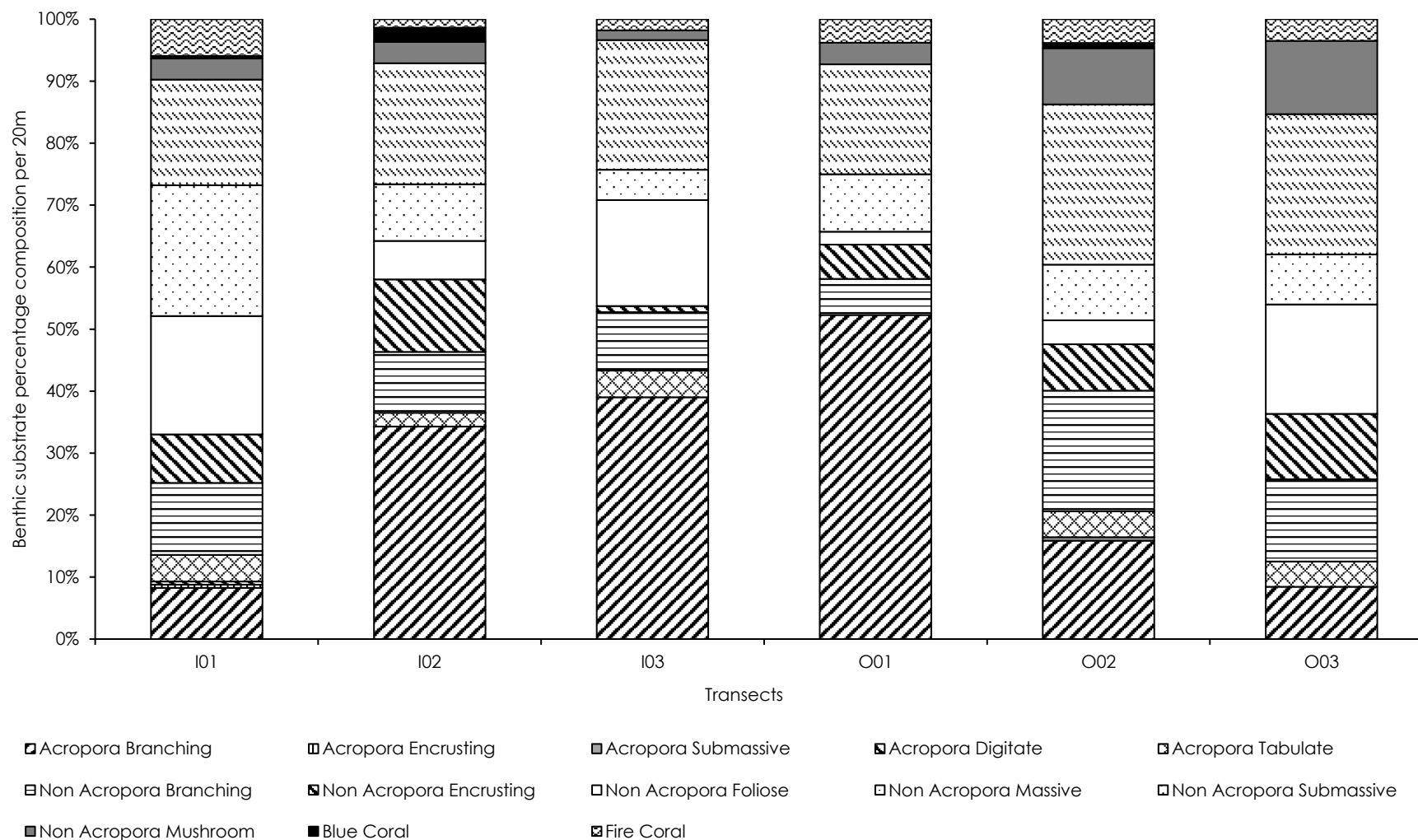


Figure 21. Average percentage hard coral cover per 20m by classification with standard error (SE) across transects inside and outside the Napantao MPA, Southern Leyte, the Philippines. Organ pipe coral (*Tubiapora* sp.) was not recorded on any transects and are excluded from the figure.

4. Discussion

The assessment of the Napantao MPA and the area adjacent to it gave the overall impression of a healthy reef ecosystem. There are some trends that are of concern, indicating activities such as illegal fishing, of which require consideration to ensure the continued condition of the reefs in the area. However, there are also encouraging signs that the MPA is having a positive impact on the reef ecosystems at Napantao. In this section the spatial results observed in the data are discussed and recommendations for future management are provided.

5.1. Fish

Mean total fish abundance was shown to have increased from assessments conducted in 2015 (Lancaster *et al.*, 2016). However, total fish abundance inside and outside the MPA in this study was not significantly different. This could be due to a large spill-over effect from the MPA or it may suggest high levels of illegal fishing within its boundaries (Russ & Alcala 2004). However, the fact that average S and H' were higher inside the MPA could indicate a positive effect within the MPA; a result that has been found on the three previous Napantao MPA assessments (Dallison and Ferguson 2017). A greater H' value is often associated with healthier reef systems as high diversity typically increases a reef's resilience to anthropogenic and non-anthropogenic stressors (e.g. overfishing, ocean acidification) (Chapin *et al.*, 2002). Thus, although the unprotected areas surrounding the MPA may have similar fish abundances they may be less resistant to ecosystem stress. Additionally, when considering individual target species, including commercially important species such as grouper and ecological indicator species such as butterflyfish, significant differences were observed. Grouper abundance, in particular, was significantly higher on the majority of inside transects. This could indicate that the MPA is providing refuge for highly targeted

species, and may suggest the MPA is achieving one of its conservation objectives of enhancing fish stocks. However, compared with 2015 (Lancaster *et al.*, 2016), Grouper species numbers have decreased outside the MPA, yet average Snapper abundances showed a marked improvement. Such low numbers of commercial fish species found in 2016 epitomise the gradual depletion of the stocks shown since 2013 (Dallison and Ferguson 2017). This may suggest that commercial fish stock recovery rates are still being exceeded by the rate of exploitation outside the Napantao. Grouper, along with other commercially important reef fish families such as Snappers, are often very long lived and slow growing, with life spans often ranging from 25 to 40 years (Coleman, *et al.*, 2000). Most grouper species take a long time to reach sexual maturity and their reproductive capacity is greatly affected by size, which is in turn directly related to age. These life history traits make species like groupers particularly susceptible to overfishing as individuals are often removed before they have the chance to spawn, thus not replenishing the population sizes within the region (Collins, *et al.*, 1998). Not only does it take these slower growing species a long time to recover when their population is decreased by extraction, but preferential selection of larger individuals by fishermen also reduces the fecundity of the population and can disrupt sex ratios and population dynamics.



The low overall numbers of commercially important fish, as well as the near absence of individuals over 30cm in length, recorded both inside and outside the Napantao MPA is indicative of historical overfishing in the area. However, a few fish sightings ranging in size 31-50cm, particularly within the MPA, could be indication that protection from fishing effort is advantageous. The low number of these large fish could also suggest that continued illegal fishing of large individuals from both the protected and unprotected areas is occurring. Understanding the life history traits outlined above, it is evident that any recovery of these species within the MPA is going to be slow. However, the significantly higher abundance recorded inside the MPA and their larger average size and total biomass, is an extremely positive sign, which could indicate that an element of recovery is underway.

There were no observations of other commercially important species including *Bolbometapon muricatum* (Bumphead Parrotfish), *Cromileptes altivelis* (Barramundi Cod) or *Plectorhincus* sp. (Sweetlips). This supports the suggestion that these desirable food-fish species have been overfished in the area.

Butterflyfish are often used as indicators of reef health and resilience through their species richness S and H' (Kulbicki and Bozec 2005). Butterflyfish species richness is highly correlated with both, total fish species richness and coral cover because many species are corallivorous (Pratchett

et al., 2006). Additionally, their relative ease of identification and, their large habitat (Atlantic, Pacific and Indian oceans), make Butterflyfish an excellent international proxy for fish and coral abundance and health (Kulbicki and Bozec 2005). In Napantao, the significantly greater S and H' of these fishes on inside transects is another positive sign that the reef is in a healthy state. The dominance of the obligate corallivorous species *Chaetodon baronessa* (Eastern Triangle) and *Chaetodon lunulatus* (Redfin) may suggest that the scleractinian hard coral cover is sufficient to support fish communities that hold a dietary dependence upon hard coral (Stella *et al.*, 2011). High coral cover and butterflyfish S exhibited by all inside transects strongly supports the correlation between the two measurements highlighted in previous studies (Kulbicki and Bozec 2005).

5.2. Invertebrates

Although the abundance of invertebrates was not found to be significantly different inside and outside the MPA, a worrying result from the data is the lack of many commercially important species. Invertebrates such as Triton's Trumpet, Squid and species of Sea Cucumber were all absent; a finding which is congruent with those in the 2015 Napantao assessment (Lancaster *et al.*, 2016). These species, which in many cases are slow growing and slow moving, are particularly vulnerable to over exploitation. Giant Clams, another important commercial species, were observed but in low numbers. Furthermore, all the individuals observed were less than 40cm in length. These results indicate that extraction pressure may be high in areas surrounding the MPA and that for certain species the MPA is not enhancing stocks. This could be as a result of historical fishing pressure removing all individuals from the area prior to the establishment of the MPA. Despite being low, the abundance of small giant clam on the survey may indicate, that for this species, recruitment of new individuals is occurring but at a slow rate. The presence of only 1 Crown of Thorns Seastar (CoTs, *Acanthaster planci*) outside



the Napantao MPA is a healthy sign. This seastar is a voracious predator of corals and at high levels of abundance can cause catastrophic damage to reef communities. The number of observed CoTs in the surveyed Napantao waters was low and presents no cause for alarm. At low abundances CoTs are a natural component of reef systems and play a vital role in 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.

5.3. Substrates

The differences in substrates recorded inside the MPA compared to outside may simply be attributable to natural variation. The area outside the MPA is characterised by sand interspersed with rocky outcrops. Contrastingly, inside the MPA, a greater quantity of rock was recorded. Coral recruits require a hard substrate on which to settle and grow. Therefore, sand is a poor substrate for coral recruitment and this may explain the lower abundance of hard coral outside the MPA. Furthermore, the greater abundance of hard coral inside the MPA may be attributable to the greater quantity of hard substrate such as rock.

Indicators of coral health; nutrient indicator algae, evidence of recently killed coral, bleaching and coral disease, were observed in only a few instances or were totally absent from the survey area. Thus, in terms of hard corals, the reef both inside and outside appear in good condition.

The significantly higher abundance of disturbance adapted fast growing coral within the MPA may suggest that the MPA is effectively protecting these fragile corals from anthropogenic stressors such as Muroami fishing and anchoring (Edinger and Risk, 2000). However, Hawkins et al. (1999) also found that intensive recreational diving can lower abundances

of stress tolerant massive corals at popular dive sites as continuous diver abrasion to coral surfaces increases the risk of coral disease. The MPA site experiences higher rates of recreational diving than the outside sites, which is consistent with the significantly higher abundance of stress tolerant corals outside the MPA. Although disturbance adapted corals, like branching *Acropora* sp. are vulnerable to diver breakage, they also grow more quickly and can rapidly take over spaces left by diseased massive corals (Hawkins et al., 1999). Nevertheless, the presence of all three coral classifications: disturbance adapted fast growing; competitor; and stress tolerant, suggests an overall healthy and diverse reef ecosystem both inside and outside the MPA (Edinger and Risk, 2000).

The overall high quantity and good health of hard coral inside the MPA and in the surrounding area means that the Napantao MPA remains one of the best dive sites in Southern Leyte. Tourist boats are frequent visitors to the MPA and this is largely due to the abundance of hard coral and diversity of species. The role of tourism for the future of the MPA is discussed further in Section 6.

5.4. Impacts

The observation of over twice as many instances of general coral damage inside the MPA compared with the outside is a concern. As a popular recreation snorkel and dive site, in regular use all year around, the chances of accidental minor coral reef destruction are high. Additionally, the signs of other anthropogenic impacts such as coral damage from boats and trash were similar in number to those found in 2015 (Lancaster et al., 2016). Although there is high recreational use in the area from divers, studies have shown that these activities do not significantly impact reef fish assemblages and behaviour (Hawkins et al., 1999). Fishing does occur in the immediate vicinity of the MPA and up to the boundary (*Bantay Dagat, Pers. Comms.*), and illegal fishing within the MPA is common, especially at night. Subsistence

fishing is a necessity for the local fisher folk who rely on the fishing grounds around the MPA for food and income. This level of fishing, in addition to illegal activities within the MPA, does place a sustained pressure on the MPA. Many fish species such as Fusiliers (Caesionidae) and Jacks (Carangidae) are extremely mobile, travelling over large distances in search of food. Thus, the ability of a small MPA such as Napantao to protect such species is limited. Contrary to this, other species including Grouper can be more geographically restricted and will associate to particular habitats or home ranges. As discussed in Section 3.1, the significantly higher abundance of Grouper inside the MPA suggests that for less wide ranging species, the MPA may be mitigating the fishing pressure and increasing fish stocks. It is vital that local enforcement is improved in order to continue this trend. Minimal instances of poaching inside the MPA can destroy years of recovery in a relatively short period of time (McCook, *et al.*, 2010).

Furthermore, although the higher abundance of Grouper inside the MPA is a positive sign, the overall abundance of all commercially important species of both fish and invertebrates was low both inside and outside the MPA. Furthermore those individuals observed were all generally small indicating a population structure dominated by juveniles and small adults. This trend may indicate that pressure from fishing is removing large individual keystone species; vital for the control of species diversity and maintaining a balanced ecosystem. It could, however, be an indicator that fishing pressure has been high in the past since any recovery from intensive overfishing will be slow. On-going monitoring of the MPA over time will help to give an impression of trends in population dynamics over time and highlight on-going threats to the coral reef ecosystems within the MPA.

The removal of important species of herbivorous fish such as Parrotfish

(Scaridae), Rabbitfish (Siganidae) and Surgeonfish (Acanthuridae) through overfishing, can cause additional impacts to an ecosystem, such as phase shifts from coral dominated ecosystems to ones dominated by fleshy algae. In fact, although high diversity is linked to greater reef resilience (Chapin *et al.*, 2000), the removal of a single keystone species like parrotfish can cause major phaseshifts (Bellwood *et al.*, 2003). Herbivorous fish help control the abundance of algae in reef systems by constantly grazing new growth. When grazing fishes are removed algae cover increases. Coral species are easily outcompeted by algae, which can lead to a reduction in coral cover and a shift to an algal dominated ecosystem which cannot support the same diversity of species (McClanahan *et al.*, 1996). Even if herbivore numbers were to increase again at a later stage, reversing this phase shift i.e. going back to a coral dominated reef, is extremely difficult (Lotze *et al.*, 2006). *Diadema sp.*, an urchin that thrives in the absence of herbivorous fishes (Lessios *et al.*, 1984), were found in low abundance on the surveys, suggesting that at present, competition for algae from herbivorous fish is high.

Nevertheless, indirectly or directly, the effects of over fishing can be extremely serious. The relationships between organisms of different trophic levels are very complex and scientific understanding is limited. However, cases of both, trophic cascade and phase shift, have been recorded on reefs around the world where overfishing has played a critical role in the reduction of fish stocks (Bellwood *et al.*, 2004).



6. Recommendations

In the past, the presence of Bantay Dagats at the Napantao MPA meant that compliance and enforcement were strong within the boundaries (Ferguson and Green, 2015). We recommend a team of Bantay Dagats implement a patrolling rota, ensuring the MPA waters being watched during the most vulnerable times of the day and night. The infrastructure and equipment, such as a guard house, marker buoys, flashlights and a patrol boat are all in place so enhancing current Napantao MPA patrols could be relatively simple.

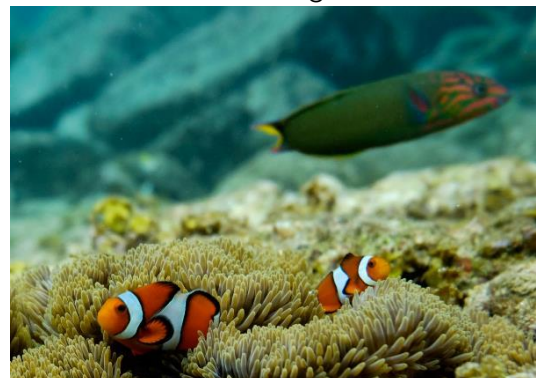
Since CCC moved to Napantao in 2008 we have conducted numerous awareness and education events within the barangay and the municipality. This may have helped maintain the existing sense of pride and ownership exhibited by the local community and raised the level of understanding and institutionalization of the MPA. This continued support will help the MPA to develop and remain one of the preeminent dive sites within Sogod Bay and Southern Leyte.

It is highly recommended that ecological monitoring of the MPA continues on a regular basis. On-going monitoring of the reefs within the MPA and around its borders will provide data to indicate whether management measures continue to be successful and will highlight new natural or anthropogenic threats to the reefs. Knowing the ecological status of the reef will enable adaptive management to be practiced, ensuring that management measures are responsive to the current situation. Additionally, long-term datasets will enable the study of temporal changes on the reefs within the MPA and will provide evidence as to whether the MPA is achieving its conservation goals.

Tourism provides some income to the local community through fees collected from dive tour operators that visit the MPA.

Further development in this area could increase this and provide other alternative livelihoods. Any development however must be conducted with the protection of the reef as a primary concern. Too many divers on one site at one time can lead to the degradation of the reef through physical contact and irresponsible dive practices. Monitoring of the number of divers visiting the MPA and diver behaviour (e.g. responsible coral avoidance), in conjunction with ecological surveys, should be used to help inform managers as to a sustainable level of tourism interaction (Hawkins *et al.*, 1999).

Finally, the MPA Management Effectiveness Assessment Tool (MPA MEAT) was designed by the Philippine Government to allow managers and local communities to evaluate the effectiveness of their MPA and identify areas which need improving. Using simple criteria and documented evidence, the current management situation of an MPA can be ascertained. This report should be used as part of the evidence for the Napantao MPA to help identify further areas that could be improved. To maximize the benefits of the MPA, for both, the health of the reef ecosystem and for the people who depend on it, communication participation and involvement is crucial. In consequence, the dissemination of the data and rules applying to the MPA and education are key point to address in order to achieve a well-managed MPA.



References

- Agardy, T., P. Christie, and E. Nixon. (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*, No. **68**.
- 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.
- Bellwood, David R., Andrew S. Hoey, and J. Howard Choat. (2003). Limited functional redundancy in high diversity systems: resilience and ecosystem function on coral reefs. *Ecology letters* **6** (4), pp. 281-285.
- Bellwood, D., Hughes, T., Folke, C., and Nystrom, M. (2004). Confronting the coral reef crisis. *Nature*, **429**, pp. 827-833.
- 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.
- Bozec, Y., Doleddec, S. and Kulbicki, M. (2005). An analysis of fish-habitat associations on disturbed coral reefs: chaetodontid fishes in New Caledonia. *Journal of Fish Biology*, **66**(4), pp. 966-982.
- Buxton, C. D., N. S. Barrett, M. Haddon, C. Gardner, and G. J. Edgar. (2006). Evaluating the Effectiveness of Marine Protected Areas as a Fisheries Management Tool. *Technical Report. Tasmanian Aquaculture and Fisheries Institute*, Tasmania, Australia.
- Calumpong, H., Raymundo, L., Solis-Duran, E., Alava, M., & de Leon, R. (1994). *Resource and Ecological Assessment of Sogod Bay, Leyte, Philippines - Final Report*. Siliman University Marine Laboratory.
- CBD. (2010). *Convention on Biological Diversity - Aichi Biodiversity Targets*. Retrieved 2013 from <http://www.cbd.int/sp/targets>
- Chapin, F.S.I., Zavaleta, E.S., Eviner, V.T., Naylor, R.L., Vitousek, P.M., Reynolds, H.L. et al. (2000). Consequences of changing biodiversity. *Nature*, **405**, pp. 234-242.
- Chapin, F. S., Matson, P. A., and Mooney, H. A. (2002). *Principles of Ecosystem Ecology*. Springer Verlag, New York.
- Coleman, F., Hunstman, C., Musick, J., Eklund, A., McGovern, J., Chapman, R., et al. (2000). Long-lived reef fishes: The Grouper-Snapper complex. *Fisheries*, **25** (3), pp. 14-21.
- Collins, L., Johnson, A., Koenig, C., & Baker, M. (1998). Reproductive patterns, sex ratio, and fecundity in gag, *Mycteroperca microlepis* (Serranidae), a protogynous grouper from the northeastern Gulf of Mexico. *Fishery Bulletin*, **96**, pp. 415-427.
- CTI. (2012). *Coral Triangle Initiative - State of the Coral Triangle Highlights - Philippines*. Pasig City, Philippines: Coral Triangle Initiative.

- Dahl-Tacconi, N. (2005). Investigating Information Requirements for Evaluating Effectiveness of Marine Protected Areas: Indonesian Case Studies. *Coastal Management*, **33**(3), pp. 225-246
- Dallison, T & Ferguson, A. (2017). Assessing the Efficacy of Small-Scale Marine Protected Areas in the Philippines: A Triennial Case Study, Barangay Napantao 2013 – 2015. *Coral Cay Conservation*.
- 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.
- Ferguson, A. and Green, A. (2015). Napantao MPA Annual Assessment Report. *Coral Cay Conservation*. pp. 1-52.
- 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. *J. Appl. Ichthyology*, **30**(1), pp. 78-85.
- Green, A., Smith, S., Lipsett-Moore, G., Groves, C., Peterson, N., Sheppard, S., *et al.* (2009). Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. *Oryx*, **43**, pp. 488-498.
- Hardt, M. (2009). Lessons from the past: the collapse of Jamaican coral reefs. *Fish and Fisheries*, **10**, pp. 143-158.
- Hawkins, J. P. *et al.* (1999). Effects of recreational scuba diving on Caribbean coral and fish communities. *Conservation Biology*, **13**, pp. 888-897.
- Hilborn, R. & 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 Liebler J. (2002). The Global Coral Reef Crisis: Trends and Solutions: 5 Years of Reef Check. pp. 37.
- Human, B., & 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., & Gomez, E. (2000). The Philippines. In C. Sheppard, *Seas of the Millennium: An environmental evaluation*, pp. 405-423. Elsevier Science.
- Jackson, J., Kirby, M., Berger, W., Bjorndal, K., Botsford, L., Bourque, B., *et al.* (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science*, **293**, pp. 629-638.
- Kulbicki, M., and Bozec, Y. M. (2005). The use of butterflyfish (Chaetodontidae) S as a proxy of total S of reef fish assemblages in the Western and Central Pacific. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **15**, pp. 127-141.
- Lancaster, D., Dallison, T., & Ferguson, A. (2016). Coral Cay Conservation Marine Protected Area Annual Report: Barangay Napantao 2015. *Coral Cay Conservation: Philippines*.

- Lessios, H., Robertson, D., & Cubitt, D. (1984). Spread of *Diadema* mass mortality through the Caribbean. *Science*, **226**, pp. 335-337.
- Lotze, H., Lenihan, H., Bourque, B., Bradbury, R., and Cooke, R. (2006). Depletion, degradation and recovery potential of estuaries and coastal seas. *Science*, **312**, pp. 1806-1809.
- Maliao, R.J., Webb, E.L., Jensen, K.R. (2004). A Survey of Stock of the Donkey's ear abalone, *Haliotis asinina* L. in Sagay Marine Reserve, Philippines: evaluating the effectiveness of marine protected area (MPA) enforcement. *Fisheries Research*, **66**, pp. 343-353.
- McClanahan, T., Kamukuru, A., Muthiga, N., Yebio, M., and Obura, D. (1996). Effect of sea urchin reductions on algae coral and fish populations. *Conservation Biology*, **10**, pp. 136-154.
- McCook, L., Ayling, T., Cappo, M., Choat, J., Evans, R., De Freitas, D., et al. (2010). Adaptive management of the Great Barrier Reef: A globally significant demonstration of the benefits of networks of marine reserves. *Proceedings of the National Academy of Sciences*, **107** (43), pp. 18278-18285.
- McDaniel, E. M. (2007). The Effectiveness of Rotating Marine Protected Areas (MPAs) in Fisheries Management: A Case Study of the NC Hard Clam Fishery. *Dissertation*, The University of North Carolina at Chapel Hill, <http://dc.lib.unc.edu/cdm/ref/collection/etd/id/1788>.
- Mora, C., S. Andrefouet, M. J. Costello, C. Kranenburg, A. Rollo, J. Veron, K. J. Gaston, and R. A. Myers. (2006). Coral Reefs and the Global Network of Marine Protected Areas. *Science*, **312**(5781), pp. 1750-1751.
- 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.
- 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.
- Myers, R., Baum, J., Shepherd, T., Powers, S., & Peterson, C. (2007). Cascading effects of the loss of apex predatory sharks from a coastal ocean. *Science*, **315**, pp. 1845-1850.
- 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. G. (2010). Indicators of Effectiveness in Community-Based Marine Protected Areas. *Dissertation*, The University of British Columbia, Vancouver, http://circle.ubc.ca/bitstream/handle/2429/17676/ubc_2010_spring_pajaro-marivic.pdf?sequence=3
- Pauly, D., Christensen, V., Guenette, S., Pitcher, T., Sumaila, U., Walters, C., et al. (2002). Towards sustainability in world fisheries. *Nature*, **418**, pp. 687-689.
- 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.
- Pratchett, M., Wilson, S. and Baird, A. (2006). Declines in the abundance of *Chaetodon* butterflyfishes following extensive coral depletion. *Journal of Fish Biology*, **69**(5), pp. 1269-1280.
- Quinn, T. J., and R. Deriso. (1999). *Quantitative Fish Dynamics*. Oxford University Press, New York
- Roberts, C., McClean, C., Veron, J., Hawkins, J., Allen, G., & McAllister, D. (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science*, **295**, pp. 1280-1284.
- Russ, G., & Alcala, A. (2004). Marine reserves: long-term protection is required for full recovery of predatory fish populations. *Oecologia*, **138**, pp. 622-627.
- Selig, E. R and J. F. Bruno. (2010). A Global Analysis of the Effectiveness of Marine Protected Areas in Preventing Coral Loss. *PLoS ONE*, **5**(2), pp. 9278.
- Shapiro, S. and Wilk, M. (1965). An Analysis of Variance Test for Normality (Complete Samples). *Biometrika*, **52**(4), pp. 591.
- Stella, J., Pratchett, M., Hutchings, P. and Jones, G. (2011). Coral-associated invertebrates: diversity, ecology importance and vulnerability to disturbance. *Oceanography and Marine Biology: An Annual Review*, **49**, pp. 43-104.
- Thode, H. (2002). *Testing for normality*. New York: Marcel Dekker.
- Tuomisto, H. (2012). An updated consumer's guide to evenness and related indices." *Oikos*, **121**(8), pp. 1203-1218.
- Veron, J., Devantier, L., Turak, E., Green, A., Kininmonth, S., Stafford-Smith, M., et al. (2009). Delineating the Coral Triangle. *Galaxea, Journal of Coral Reef Studies*, **11**, pp. 91-100.
- Wilkinson, C. (2008). *Status of Coral Reefs of the World*. Townsville, Australia: Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre.
- Whittaker, R. H. (1972). Evolution and measurement of species diversity. *Taxon* **21**, pp. 213–251.
- Wood, L., Fish, L., Laughren, J., & Pauly, D. (2008). Assessing progress towards global marine protection targets: shortfalls in information and action. *Oryx*, **42**, pp. 340-351.
- World Bank. (2005). *Philippines Environment Monitor on Coastal and Marine Resource Management*. Washington DC, USA: World Bank.

Appendices

Appendix A: Target species list

Table A1. List of target fish families, genera and species recorded during Coral Cay Conservation (CCC) surveys of the Barangay Napantao marine protected area (MPA).

Common Name	Latin Name	Visayan Name
Angelfish	<i>Pomacanthidae</i>	Adlo
Barracuda	<i>Sphyrnaeidae</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>	
(Damselfish)	<i>(Pomacentridae)</i>	
Anemonefish	<i>Amphiprion sp.</i>	
Sergeant Damselfish	<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
Pufferfish	<i>Tetraodontidae</i>	
Rabbitfish	<i>Siganidae</i>	Kitong
Ray	<i>Rajiformes</i>	
Sandperch	<i>Pinguipedidae</i>	
Scorpionfish/Stonefish	<i>Scorpaenidae</i>	
Snapper	<i>Lutjanidae</i>	Maya-maya
Spinecheeks	<i>Nemipteridae</i>	Silay
Squirrelfish/Soldierfish	<i>Holocentridae</i>	
Surgeonfish	<i>Acanthuridae</i>	Indangan
Unicornfish	<i>Naso sp.</i>	
Sweetlips	<i>Haemulidae</i>	Lipti
Toby	<i>Tetraodontidae</i>	
Triggerfish	<i>Balistidae</i>	Pakol
(Wrasse)	<i>(Labridae)</i>	
Crescent Wrasse	<i>Thalassoma lunare</i>	
Humphead Wrasse	<i>Cheilinus undulatus</i>	
Red Breasted Wrasse	<i>Cheilinus fasciatus</i>	

Table A2. List of target Invertebrate families, Genera and species recorded during Coral Cay Conservation (CCC) surveys of the Barangay Napantao marine protected area (MPA).

Target Invertebrates		
Feather duster worms	Christmas tree worms	Flatworms
Crabs	Shrimps	Banded coral shrimp
Lobsters	Nudibranch	Abalone
Conch	Cowrie	Triton's trumpet
Cone shell	Drupella	Top shell
Other gastropod	Giant clam	Octopus
Cuttlefish	Squid	<i>Acanthaster planci</i>
<i>Linkia laevigata</i>	<i>Culcita novaeguineae</i>	<i>Protoreaster nodosus</i>
<i>Choriaster granulatus</i>	Feather star	Brittle star
Long spine sea urchin	Pencil urchin	Collector urchin
Prickly redfish	Pinkfish	Greenfish
Other sea cucumber		

Table A3. List of target substrates recorded during Coral Cay Conservation (CCC) surveys of the Barangay Napantao marine protected area (MPA).

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

Appendix B: Analysis of variance for surveyed transects

b)	I1	I2	I3	O1	O2	O3
I1			+	+	+	+
I2						
I3	-					
O1	-					
O2	-					
O3	-					

a)	I1	I2	I3	O1	O2	O3
I1				+		
I2				+		
I3				+		
O1	-	-	-		-	
O2				+		
O3						

c)	I1	I2	I3	O1	O2	O3
I1		+			+	
I2	-					
I3						
O1						
O2	-					
O3						

Figure B1. Matrix showing significant differences in fish species richness (a), Shannon's Diversity Index (b) and Pielou's evenness (c) per 500m³ across survey sites inside (I) and outside (O) the Napantao marine protected area (MPA). A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	I1	I2	I3	O1	O2	O3
I1				+		
I2				+		
I3				+		
O1	-	-	-			-
O2						
O3				+		

b)	I1	I2	I3	O1	O2	O3
I1				+		
I2						
I3						
O1	-					-
O2						
O3				+		

Figure B2. Matrices showing significant differences in Grouper (a) and Snapper (b) abundances per 500m³ across survey sites inside (I) and outside (O) the Napantao marine protected area (MPA). A green '+' indicates abundance was significantly higher ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	I1	I2	I3	O1	O2	O3
I1				+	+	
I2				+		
I3				+		
O1	-	-	-			-
O2	-					
O3				+		

b)	I1	I2	I3	O1	O2	O3
I1				+		
I2				+		
I3						
O1	-	-			-	
O2				+		
O3						

Figure B3. Matrix showing significant differences in Grouper (a) and Snapper (b) biomasses per 500m³ across survey sites inside (I) and outside (O) the Napantao marine protected area (MPA). Parrotfish are not shown as no significant differences were found between transects. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

	I1	I2	I3	O1	O2	O3
I1				+		
I2						
I3						
O1	-				-	
O2				+		
O3						

Figure B4. Matrix showing significant differences in mean total butterflyfish abundance per 500m³ across all survey sites, both inside (I) and outside (O) the Napantao marine protected area (MPA). A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	I1	I2	I3	O1	O2	O3
I1				+		+
I2				+		+
I3				+		
O1	-	-	-		-	
O2				+		
O3	-	-				

b)	I1	I2	I3	O1	O2	O3
I1				+		+
I2				+		+
I3				+		+
O1	-	-	-			
O2						
O3	-	-	-			

Figure B5. Matrix showing significant differences in butterflyfish species richness (a), and Shannon's Diversity Index (b), per 500m³ across survey sites inside (I) and outside (O) the Napantao marine protected area (MPA). Pielou's evenness is not pictured as it showed no significant differences. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

	I1	I2	I3	O1	O2	O3
I1			+	+		
I2					-	
I3	-				-	-
O1	-				-	-
O2		+	+	+		
O3			+	+		

Figure B6. Matrix showing significant differences in invertebrate abundance per 100m² across all survey sites, both inside (I) and outside (O) the Napantao MPA. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	I1	I2	I3	O1	O2	O3
I1						
I2						
I3					-	-
O1						-
O2			+			
O3			+	+		

b)	I1	I2	I3	O1	O2	O3
I1			-		-	
I2						
I3	+					
O1					-	-
O2	+			+		
O3				+		

c)	I1	I2	I3	O1	O2	O3
I1			-			
I2			-			
I3	+	+		+		+
O1			-			
O2						
O3			-			

Figure B7. Matrix showing significant differences in invertebrate species richness (a), Shannon's Diversity Index (b) and Pielou's evenness (c) per 100m² across survey sites inside (I) and outside (O) the Napantao marine protected area (MPA). A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

a)	I1	I2	I3	O1	O2	O3
I1		+	+	+	+	+
I2	-			+		
I3	-			+		
O1	-	-	-		-	-
O2	-			+		
O3	-			+		

b)	I1	I2	I3	O1	O2	O3
I1		+	+			
I2	-					-
I3	-					
O1						
O2						
O3		+				

c)	I1	I2	I3	O1	O2	O3
I1					+	
I2						
I3					+	
O1						
O2	-		-			
O3						

d)	I1	I2	I3	O1	O2	O3
I1		-	-	-	-	
I2	+			-		
I3	+			-		
O1	+	+	+			
O2	+					
O3						

Figure B8. Matrix showing significant differences in substrate abundance per 20m across all survey sites inside (I) and outside (O) the Napantao marine protected area (MPA). Substrate category: a) hard coral, b) sponge, c) rock, and d) sand. Substrate categories not listed showed no significant differences across transects. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

Appendix C: Target organism average abundances

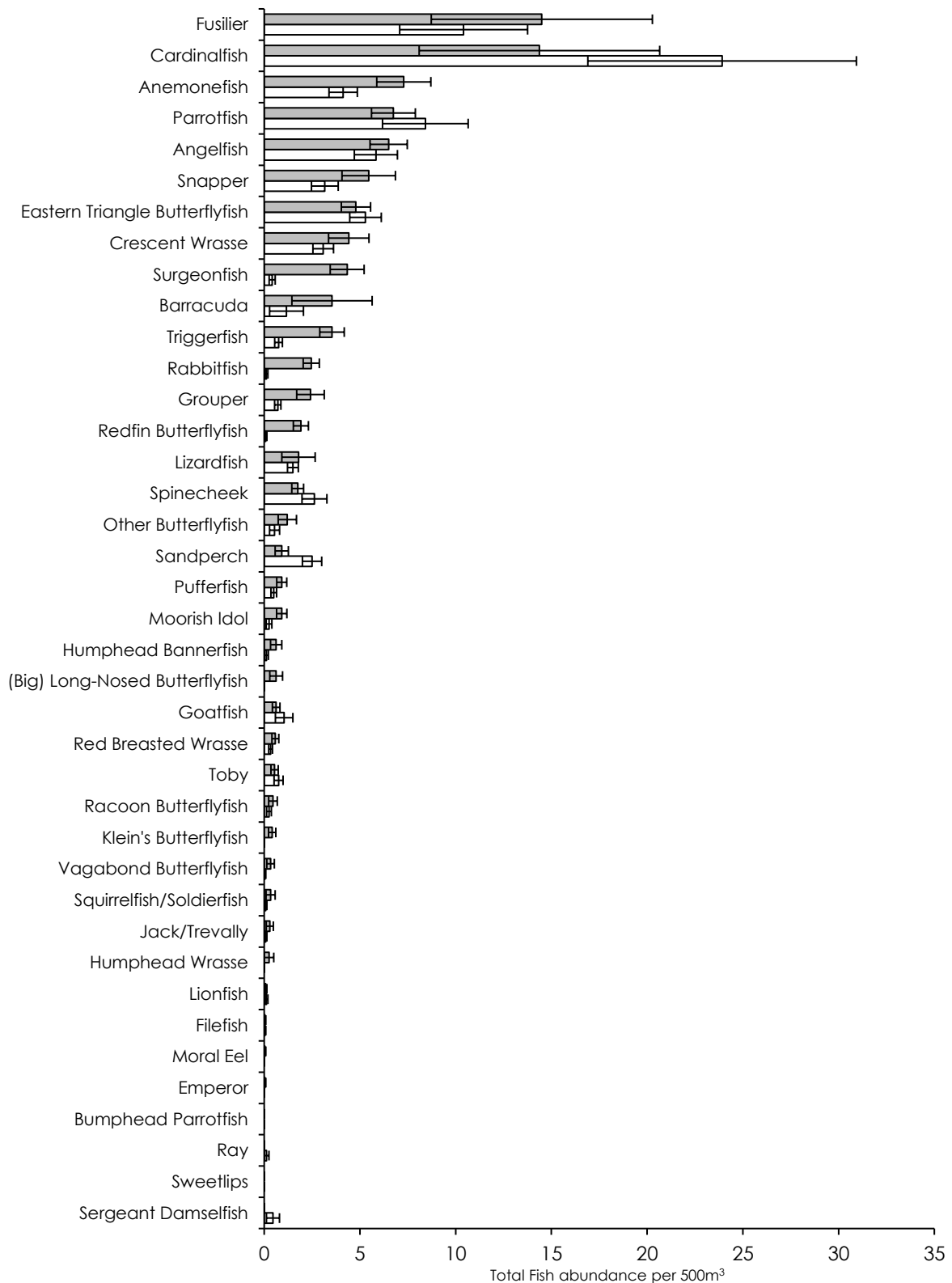


Figure C1. Average abundance of target fish species and families with standard error (SE) for Napantao marine protected area (MPA), Southern Leyte, the Philippines. Grey = inside MPA transects, White = outside MPA transects.

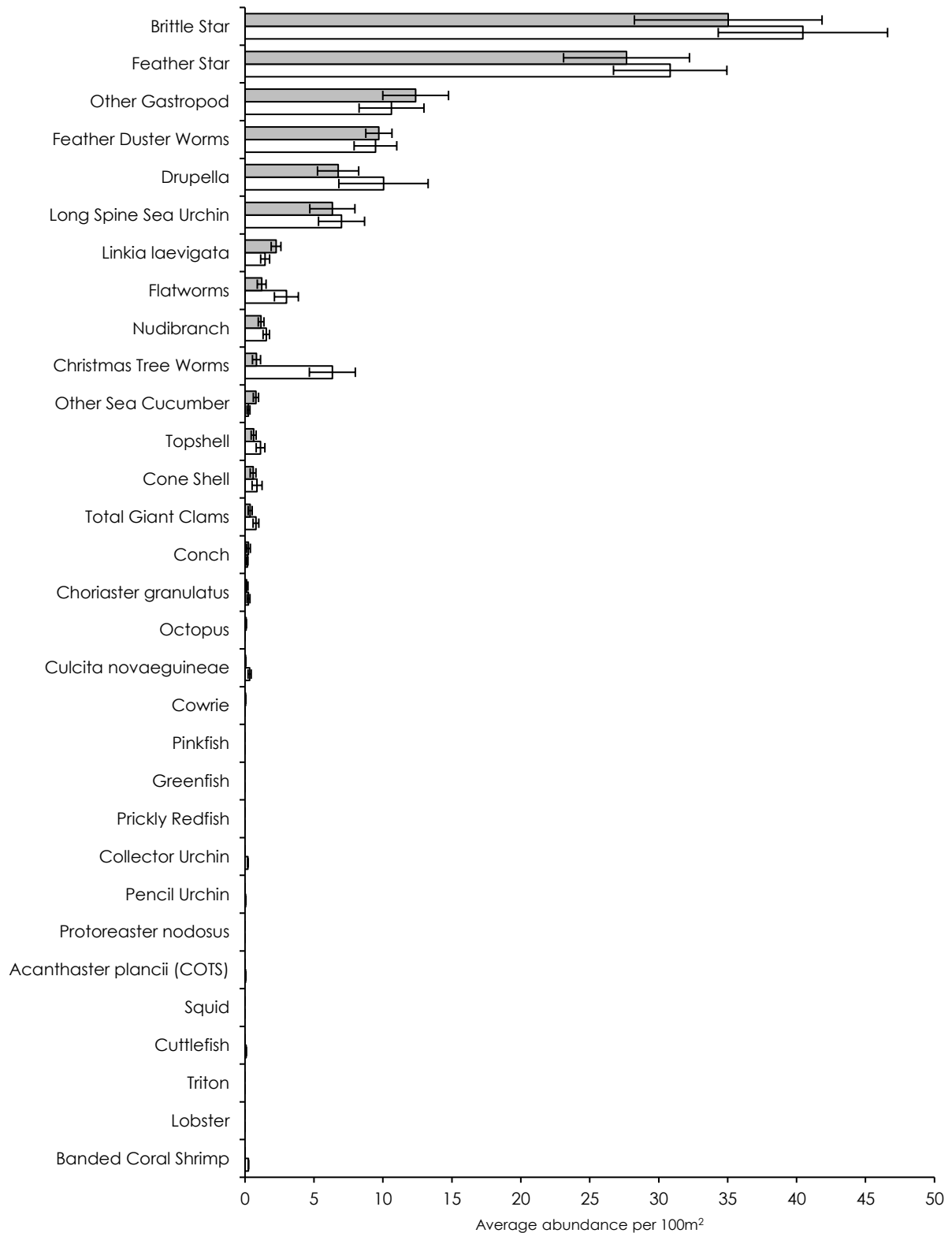


Figure C2. Average abundance of target invertebrate species and families with standard error (SE) for Napantao marine protected area (MPA), Southern Leyte, the Philippines. Grey = inside MPA transects, White = outside MPA transects.

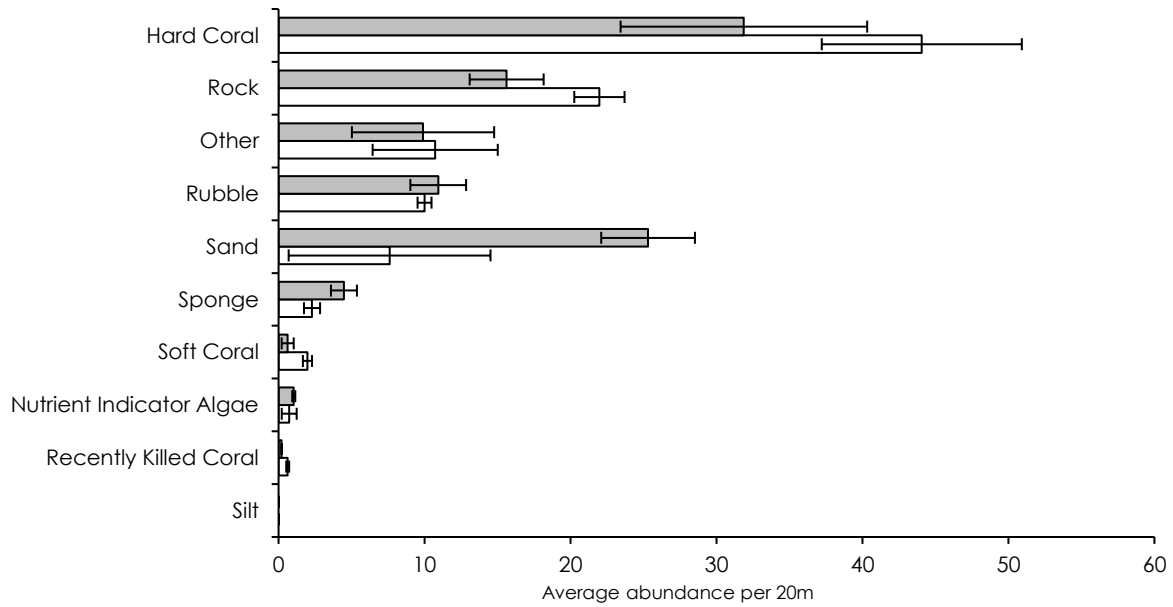


Figure C3. Average abundance of target substrates per 20m with standard error (SE) for the Napantao marine protected area (MPA), Southern Leyte, Philippines. Grey = inside MPA transects, White = outside MPA transects.

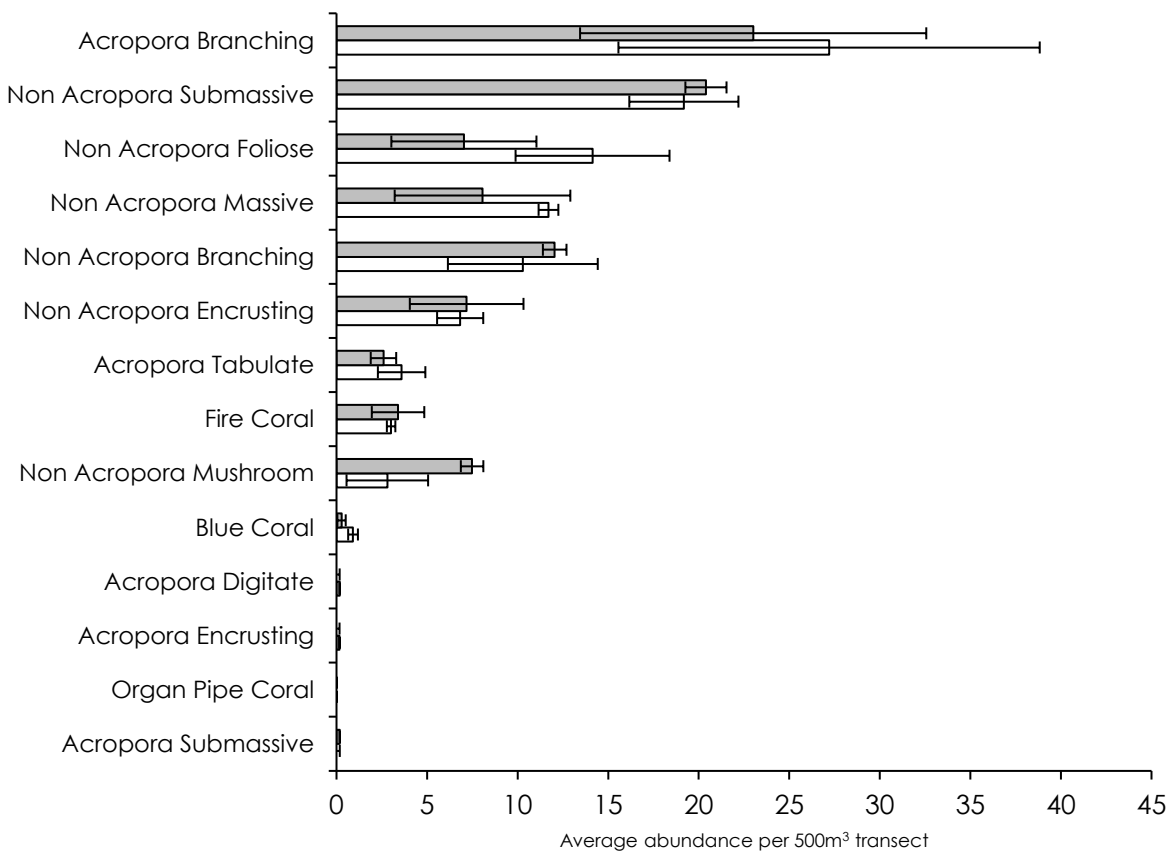


Figure C4. Average abundance of coral lifeforms with standard error (SE) across transects inside and outside the Napantao marine protected area (MPA), Southern Leyte, the Philippines. Grey = inside MPA transects, White = outside MPA transects.