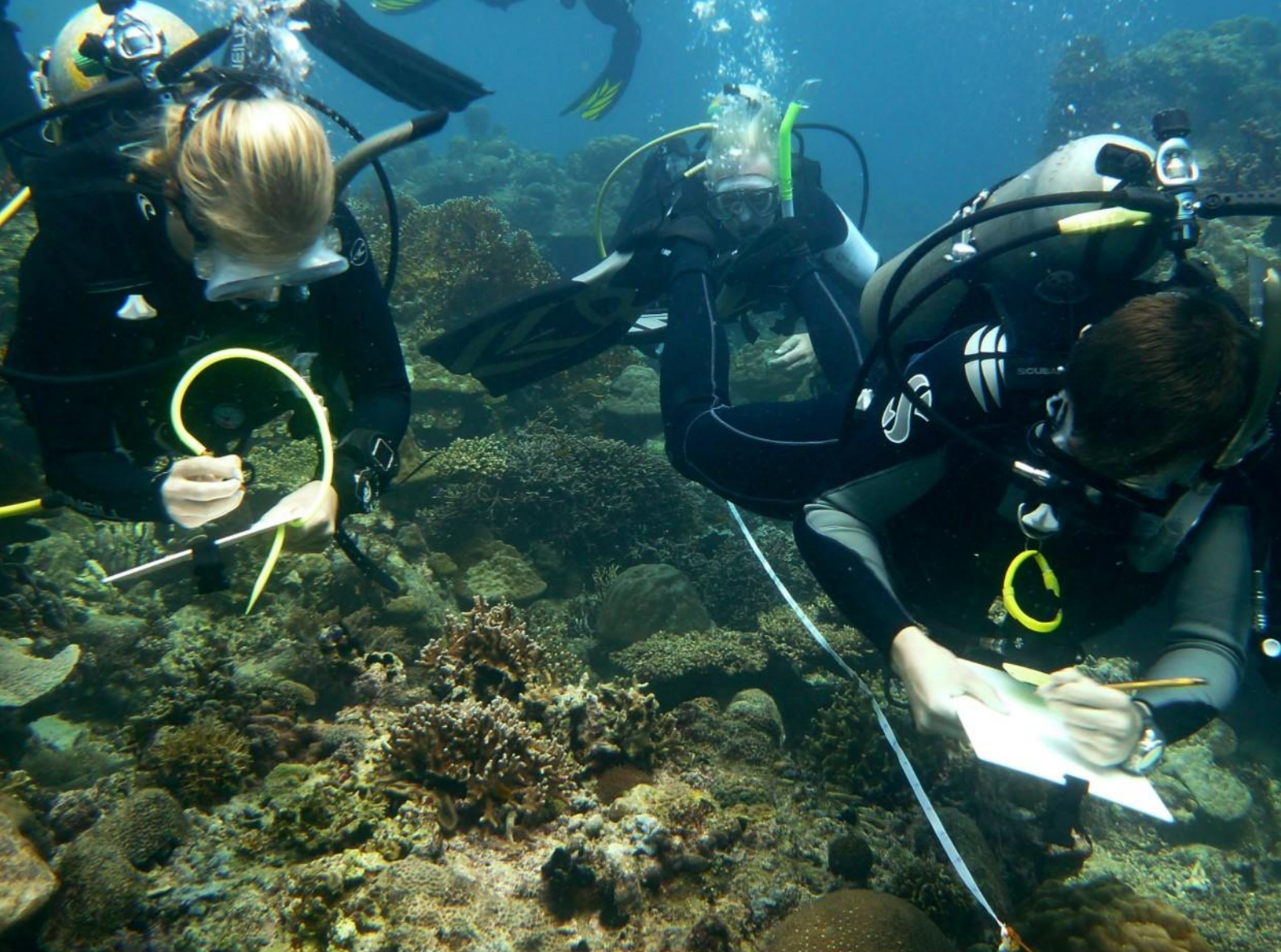




LRCP

Southern Leyte Coral Reef Conservation Project

Coral Cay Conservation Marine Protected Area Annual Report: Barangay Napantao 2015

Report Date: July 2016



Darienne Lancaster, Tom Dallison,
Alex Ferguson

In partnership with the Southern Leyte
Provincial Government, Philippines



Coral Cay Conservation
Marine Protected Area Assessment Report
Napantao MPA – 2015 Assessment
San Francisco, Southern Leyte, the Philippines

Contacts

Alex Ferguson – headofscience@coralcay.org

Tom Dallison – science@coralcay.org

Darienne Lancaster – lrcp@coralcay.org

Additional Contributors: Marie Seraphim, Joel Brown, Maryann Watson

Suggested Articles:

Edinger, Evan N., and Michael J. Risk. (2000). Reef classification by coral morphology predicts coral reef conservation value. *Biological Conservation*, **92**(1), pp. 1-13.

Russ, G. R., and A. C. Alcala. (2004). Marine reserves: long-term protection is required for full recovery of predatory fish populations." *Oecologia*, **138**, pp. 622-627.

Table of Contents

Executive Summary	iv
Acknowledgements.....	v
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.....	2
.....	3
1.3. Characterisation of Study Region	4
1.3.1. Sogod Bay	4
1.3.2 Napantao MPA.....	4
2. Methodology and Data Collection.....	6
2.1. Biophysical Survey	6
2.1.1 Fish	7
2.1.2 Invertebrates	8
2.1.3 Substrate	8
2.1.4. Impacts	9
2.2. Data Analysis.....	10
3. Results.....	10
3.1. Fish	10
3.1.1 Total Fish.....	10
3.1.2 Commercially Important Fish	12
3.1.3 Butterflyfish.....	16
3.2 Invertebrates	17
3.3 Substrate	19
3.4 Anthropogenic Impacts	22
4. Visual Assessment	23
5. Discussion.....	28
5.1. Fish	28
5.2. Invertebrates	29
5.3. Substrates.....	30

5.4. Impacts	31
6. Recommendations.....	32
References	34
Appendix A: Target Species Lists	38
Appendix B: Total Fish Species Richness, Shannon's Diversity Index, Pielou's Evenness Matrix.....	41
Appendix C: Commercially Important Fish Abundance Matrix	42
Appendix D: Commercially Important Fish Biomass Matrix	43
Appendix E: Butterflyfish Species Richness, Shannon's Diversity Index, Pielou's Evenness Matrix.....	44
Appendix F: Invertebrate Species Richness, Shannon's Diversity Index, Pielou's Evenness Matrix.....	45
Appendix G: Substrate Abundance Matrix	46
Appendix H: Target Fish Family Abundance	48
Appendix I: Target Invertebrate Abundance	51
Appendix J: Target Substrates Abundance	54

Executive Summary

- Coral Cay Conservation conducted an assessment of the reef fish, invertebrates, substrate and anthropogenic impacts inside and outside the Napantao MPA, in April and October 2015.
- A modified Reef Check protocol was used to survey 6 permanent transects, each containing four 20m replicates. Three transects were placed inside and three outside the MPA all at a depth of 12m.
- The reef is currently in a healthy state with high coral and fish diversity. Fish abundance was not significantly different inside vs. outside the MPA. However, species richness and Shannon's Diversity Index were higher inside than outside 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 and heavy fishing outside the MPA.
- Invertebrate abundance was not significantly different between inside and outside transects. Many commercially important species of invertebrates (e.g. squid, triton's trumpet) were completely absent from the surveys. This suggests intensive harvesting, either past or present. Crown of Thorns starfish were found at a healthy, low level.
- There is significantly more hard coral within the MPA than outside which may be explained by higher levels of rock within the MPA, which may aid coral recruitment. Overall, bleaching and coral disease were low inside and outside.
- There were significantly more disturbance adapted fast growing corals (e.g. Branching *Acropora* sp.) inside the MPA, and significantly more stress tolerant and competitor corals 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.

Acknowledgements

Coral Cay Conservation would like to express our gratitude to the Provincial Government of Southern Leyte (PGSL). Our work would not be possible without the support of the Provincial Environmental and Natural Resource Management Office (PENRMO) and other members of the PGSL. We would also like to thank the Barangay Council of Napantao and the Municipality of San Francisco for facilitating the MPA assessment. In particular, we would like to acknowledge the cooperation and continued support of Sir Joy Condeeza, Barangay Captain of Napantao and Servando Tio Jr., San Francisco SB Secretary. Finally, we would like to thank our trained volunteers and staff who collected the data during this MPA assessment.

List of Acronyms and Abbreviations

CCC	: Coral Cay Conservation
CoTs	: Crown of Thorns Seastars (<i>Acanthaster planci</i>)
GPS	: Global Positioning System
IUCN	: International Union for the Conservation of Nature
LGU	: Local Government Unit
MPA	: Marine Protected Area
MPA MEAT	: MPA Management Effectiveness Assessment Tool
NIA	: Nutrient Indicator Algae
NIPAS	: National Integrated Protected Area System
PRRCFI	: Philippines Reef and Rainforest Conservation Foundation Inc.
RKC	: Recently Killed Coral
SE	: Standard Error
LRFFT	: Live Reef Fish Food Trade
UVC	: Underwater Visual Census
S	: Species Richness
H'	: Shannon's Diversity Index
J'	: Pielou's Evenness

Coral Cay Conservation

Coral Cay Conservation (CCC) is a conservation orientated organisation, founded in 1986 by a British scientist, that holds the following mission statement:

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

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

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

1. Introduction

1.1. Marine Protected Areas

Marine resources have come under increasing pressure from an ever growing world population (Jackson, et al., 2001). Strong declines in catch from fisheries worldwide, such as the North Atlantic Cod (Myers, Baum, Shepherd, Powers, & Peterson, 2007) and reef fisheries in the Caribbean (Hardt, 2009), have illustrated that biological marine resources are limited (Pauly, et al., 2002; Jackson, et al., 2001). Additional pressures such as pollution, coastal development and the effects of climate change contribute to the stress the marine environment is under. This has given rise to the increased drive for conservation efforts and resource management in the marine environment (Wood, Fish, Laughren, & Pauly, 2008; CBD, 2010). Marine protected areas (MPAs) can achieve conservation and resource management targets simultaneously and are therefore considered instrumental to sustainable ocean utilization (Pauly, et al., 2002). The International Union for the Conservation of Nature (IUCN) defines a MPA as:

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

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

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

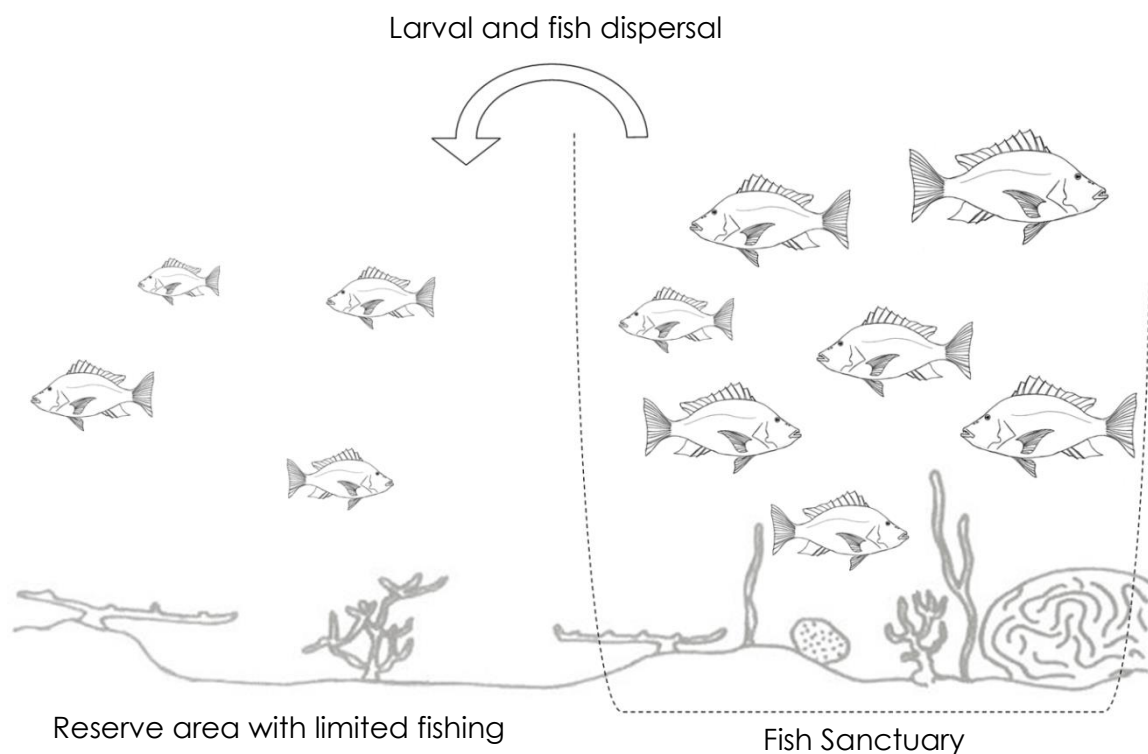


Figure 1. Schematic diagram of MPA functioning. Protected fish in the MPA grow larger and produce more offspring, this leads to 'overspill', increasing fish numbers outside the MPA. In addition, the corals inside the MPA are not disturbed by direct human impacts.

1.2. Coral Reefs and Marine Conservation in the Philippines

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

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

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

Currently there are about 1,640 MPAs in the Philippines. Of these MPAs, 33 have been declared at national level as National Integrated Protected Area System (NIPAS) sites and the remainder is managed by Local Government Units (LGU) (DENR-CMMO presentation, 2013). Box 1 highlights a case study of successful MPAs in the Philippines (Figure 2).

Case Study: The success of MPAs within the Philippines – Apo Island and Sumilon Island

The MPAs at Apo Island and Sumilon Island are some of the best known examples of successful tropical marine conservation efforts in the world. Years of monitoring have provided accurate data that shows what can be achieved if the coral reef inside an MPA is given chance to recover (Fig. 1). Results also show that although an increase of biomass was observed in the first years of reserve protection, the biggest increase in biomass took several years to become evident (5-10 years). Unequivocal evidence of overspill from these MPAs remains elusive but the increased number and size of fish within the fish sanctuary make it likely the MPA is a source for net larval export that aids recovery of fish stocks in the area. Indirect positive effects of the effective management of these MPAs include increased tourism income and the elimination of unsustainable fishing practices such as dynamite fishing (Russ and Alcala, 2004)

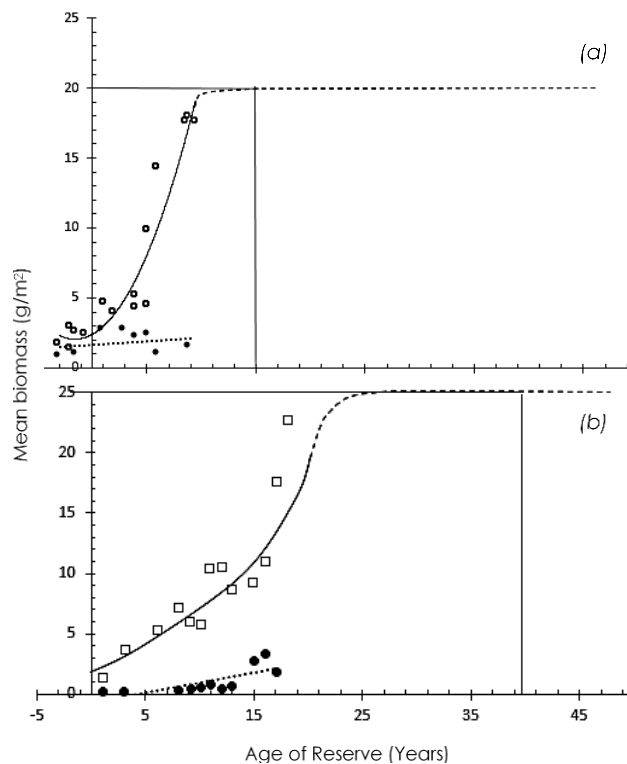


Figure 2. Observed (no-fill markers), control (filled markers) and projected (dashed line) increases in mean biomass (g/m²) of commercially important fish species inside Apo Island (a) and Sumilon Island (b) MPAs. Data and figures adapted from Russ and Alcala (2004).



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. Sogod Bay is an important fishing ground and the area is rich in tuna, flying fish, herrings, anchovies, shell-fish and Spanish mackerel. The bay has been targeted by the Fisheries Sector Program of the Department of Agriculture as one of the country's ten largest bays in need of assessment and management (Calumpong *et al.*, 1994). Sogod Bay is also a feeding ground for attractive charismatic mega-fauna such as pilot whales, melon-headed whales, dolphins, manta rays and whale sharks. The bay is characterised by naturally limited mangrove areas, narrow fringing coral reefs, limited seagrass beds and narrow intertidal areas and beaches (Calumpong *et al.*, 1994). Depths in the bay reach a maximum of approximately 1.4km in the central channel.

Currently there are 23 established MPAs within Sogod Bay covering an estimated 170 hectares (ha). These figures will increase in the coming years as more MPAs are established. The size of the MPAs' range from 2 (Maujon/Juargon Fish Sanctuary) to 45 hectares (Limasawa Fish Sanctuary). 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. The barangay is home to around 300 people, of which 25 are fishers. The boats used by the local fisherfolk are mostly non-motorised. The MPA is to the east of the village (Figure 2). There is a Bantay Dagat hut which is occasionally supervised. Currently, the MPA infrastructure is very good (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 Marine Protected Area (MPA) infrastructure at Napantao MPA, southern Leyte, the Philippines.

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

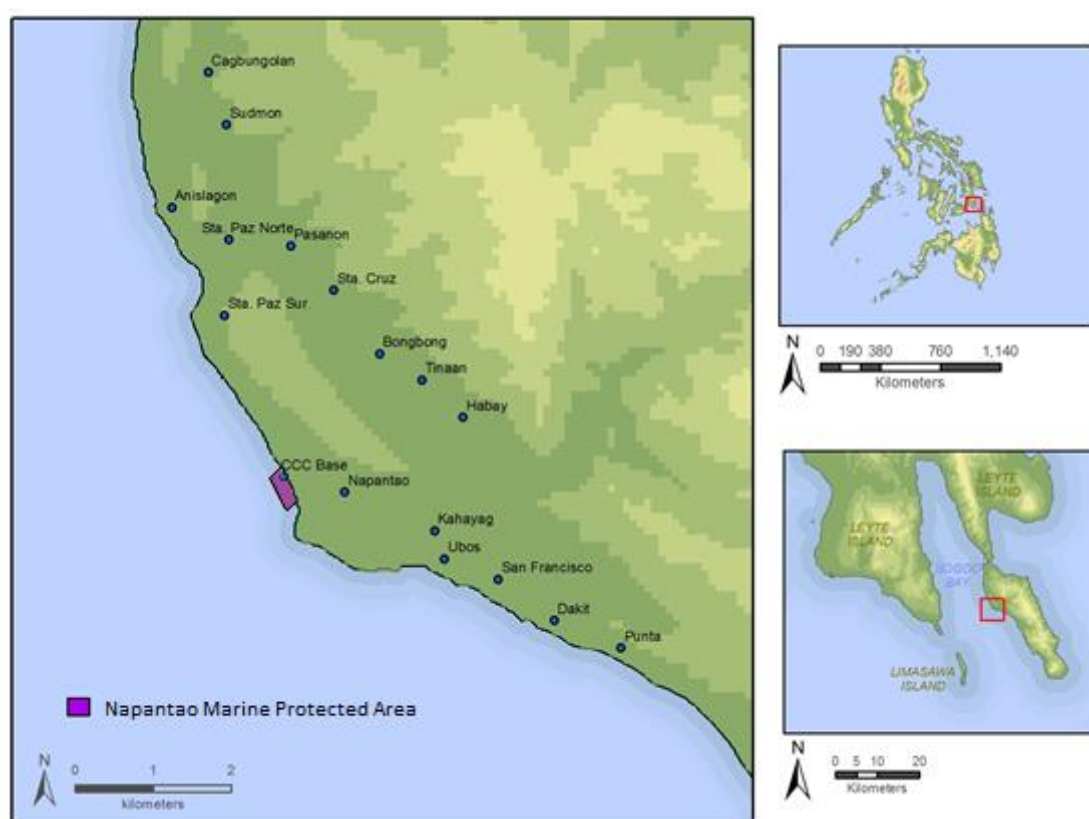


Figure 2. Napantao Marine Protected Area boundaries in Southern Leyte, Philippines.

2. Methodology and Data Collection

2.1. Biophysical Survey

The assessment of the Napantao MPA was conducted between the 30th of March 2015 to the 13th April 2015 and the 21st of October 2015 to the 9th of November. It was conducted over 24 dives by trained volunteer survey teams from Coral Cay Conservation. Permanent transects (three inside and three outside the MPA – marked with rebar) were surveyed in both April and October (Table 2).

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

Transect	Easting	Northing
I01	733901	1113091
I02	733987	1113334
I03	733971	1113380
O01	733902	1113605
O02	733818	1113799
O03	733708	1113956

MPA assessments are conducted using an enhanced ReefCheck method. The Reef Check methodology is widely recognised and is used to survey coral reefs around the world. It is a mode of underwater visual census (UVC) that allows for a diverse range of divers to easily and efficiently conduct surveys, with respectable results (Léopold *et al.*, 2009). It was developed in the 1990s with the aim of gathering as much data as possible about the global ecological status of coral reefs (Hodgson, 1999). The globally retrieved data is analysed annually with updates and evaluations on the ecological status being published. ReefCheck provides a general picture of the ecological status of a reef and the human impacts affecting it. CCC has augmented the methodology through additional target species of fish, coral and other invertebrates to better reflect the high biodiversity within Sogod Bay (Appendix A).

Survey transects are conducted at depths of 6 metres and 12 metres where topography allows, both inside and outside the MPA (Fig. 4). The total number of transects assessed depends on the size of the MPA, with a minimum of three inside and three outside. Each transect is 100 metres long and divided into 4 replicates of 20 metres each. Between each replicate there is a 5 metre gap where no data is recorded. This survey set up allows for robust statistical analysis of the collected data from independent samples.

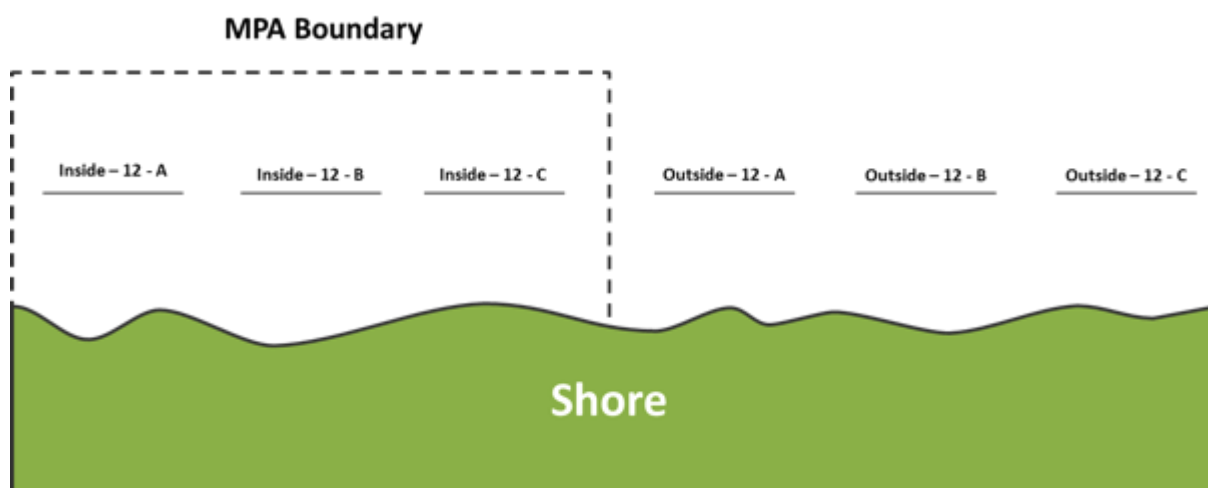


Figure 3. Survey plan for the assessment of the Barangay Napantao Marine Protected Area (MPA) utilised by Coral Cay Conservation (CCC). Each transect is 100 meters long and is sub-divided into four 25 metre replicates. Of this 25 metres, only 20 metres are surveyed with the resultant 5 metres used to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

2.1.1 Fish

Fish diversity and abundance data was collected using UVC methodologies. Selected fish families and species that are recognised as biological indicators on coral reefs for a range of anthropogenic perturbations such as fishing pressure, Live Reef Food Fish Trade (LRFFT) and the ecological status of the reef are recorded. In addition, butterflyfish species are recorded as they provide an accepted method of indicating the status of the coral reef: *The Butterflyfish Indicator Method* (Crosby and Reese, 1996). The size classes of three commercially important fish families are recorded; Grouper (*Lapu Lapu*, Serranidae), Parrotfish (*Mulmul*, Scaridae) and Snapper (*Maya Maya*, Lutjanidae).

Fish data are recorded along a 100m 'belt' transect, where the abundance of fish is recorded within an imaginary 5x5m box along four 20m replicates. Between each 20m replicate, the divers will wait, and not record any fish for a 5m interval, this separates the total 100m transect into four 20m independent replicates (Fig. 5). Each replicate sums to a total of 500m³ with total transect area surveyed of 2,000m³.

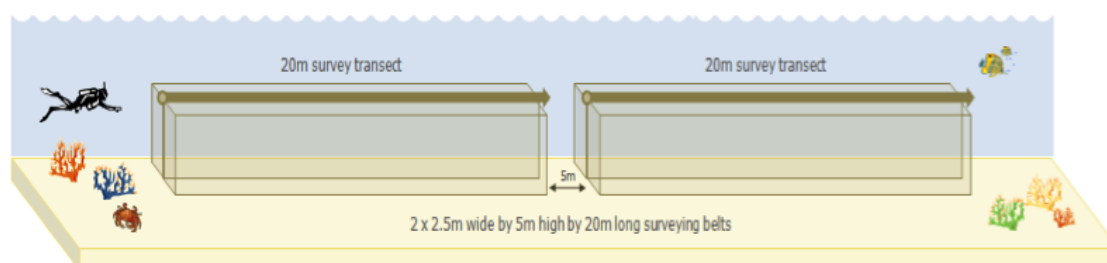


Figure 4. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target species within an imaginary 5x5m box, sizing those that are commercially important. Once located within the 5m replicate interval, no fish are recorded, this is as to produce independent replicates.

2.1.2 Invertebrates

The location of the transect used for the fish UVC was also used to assess the invertebrate abundance and diversity within the area. The invertebrates recorded are target invertebrates that are typically targeted by local stakeholders as food species, collected as curios or important to the ecological balance of the reef. Due to the sessile and/or benthic nature of the targeted invertebrates, i.e. non-locomotive species, divers record their abundance 2.5m either side of the central transect tape (Fig. 6). Special care is taken to assess and explore each geo and biomorphic structure contributing to the rugosity of the transect area for cryptic species and those seeking refuge such as lobsters, *Diadema* sp. and *Holothuridae* sp.. Each replicate equates to 100m² summing to a total area of 400m² surveyed for invertebrate surveys.

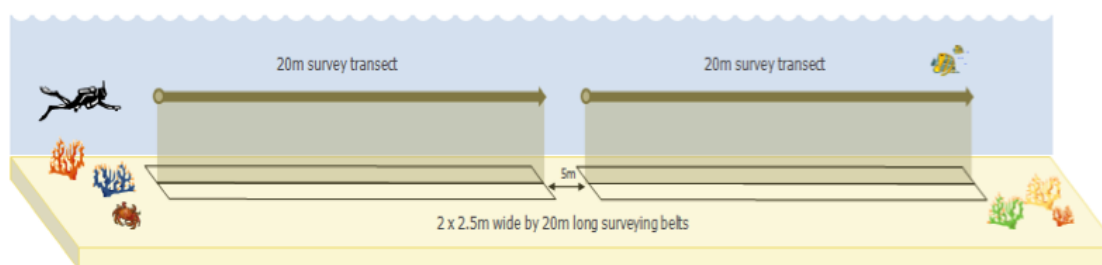


Figure 6. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target species within 2.5m of the central transect line. Once located within the 5m replicate interval, no invertebrates are recorded, this is as to produce independent replicates.

2.1.3 Substrate

Benthic diversity is measured by recording biotic and abiotic benthic categories along a point-intercept transect. Along the transect line, benthic organisms and substrate types are recorded at 50cm intervals (Fig. 7). To reduce bias, a plumb-line is dropped at each designated 50cm point and the substrate that comes into contact with the plumb-line is recorded (Table 3). Every 20m replicate contains 40 benthic points. Further categories are given in Appendix A.

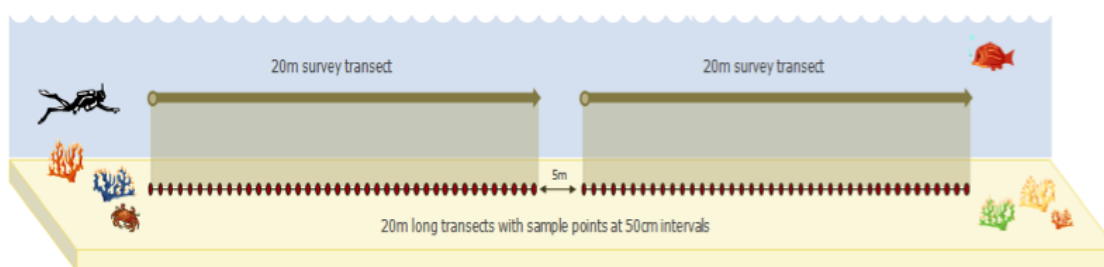


Figure 7. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target abiotic substrates and biotic benthic organisms using a plumb-line every 50cm. Once located within the 5m replicate interval, no data are recorded, this is as to produce independent replicates.

Table 3. Table consisting of the specific codes used by divers undertaking an MPA survey under the augmented Reef Check methodologies by Coral Cay Conservation (CCC). Each substrate type, whether biotic or abiotic is recorded every 50cm along a 20m replicate that accumulate over a total transect length of 100m. Every 50cm a diver will lower a plumb-line, and record whichever substrate category that plumb-line comes into contact with. *HC (Hard Coral) is further sub-divided into a range of categories based on the lifeform. ** OT (Other) is further sub-divided into categories based on their biological identification, these codes are specified.

Biotic Benthic Organisms	Code	Abiotic Substratum	Code
Nutrient Indicator Algae	NIA	Rock	RC
Sponge	S	Silt/Mud	SI
Recently Killed Coral	RKC	Rubble	RB
Soft Coral	SC	Sand	SD
Hard Coral*	HC*		
Other**	OT**		
Anemone	OT ANE		
Corallimorph	OT COM		
Halimeda	OT HA		
Tunicates	OT TU		
Zooanthids	OT ZO		
Gorgonian	OT GO		
Hydroid	OT HY		

2.1.4. Impacts

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

2.2. Data Analysis

Transect data from April and October were combined and averaged across the two temporal periods to lessen the influence of seasonality on results (e.g. greater fish abundance during breeding seasons). Each permanent 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 & 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 & Kotze, 2010; Morris, 2014). Thus, non-parametric Wilcoxon-Mann-Whitney U tests were used to test for statistically significant ($p \leq 0.05$) differences in the abundance of fishes, commercially important fishes, target butterflyfishes, invertebrates, and substrates between all transects, both inside and outside the MPA. 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). Hard corals were also grouped and analysed for abundance in three conservation classes: disturbance adapted fast growing corals (i.e. *Acropora* sp., Fire coral (*Millepora* sp.), Blue coral (*Heliopora* sp.); competitor corals (i.e. branching, foliose, encrusting, mushroom Non-*Acropora* sp.); and stress tolerant corals (i.e. massive, submassive, organ pipe (*Tubipora* sp.)), as defined by Edinger and Risk (2000).

3. Results

During the data collection period, the weather conditions were mainly sunny with some periods of cloudy skies. Air temperature in April averaged 30°C. The water temperature averaged 27.5°C at the surface and 26.8°C at a depth of both 3m and 10m. Average air temperature in October was 29.2°C. Water temperature averaged 28.5°C at the surface, 28.2°C at 3m, and 27.5°C 10m. Average estimated underwater horizontal visibility was 9m in April increasing to 14m in October.

3.1. Fish

3.1.1 Total Fish

Overall mean fish abundance inside was 93.33 ± 19.03 per 500m³ and 70.25 ± 4.94 per 500m³ outside the MPA in April and October combined (Fig. 8). Differences in total fish abundance between transects were not significant inside or outside the MPA.

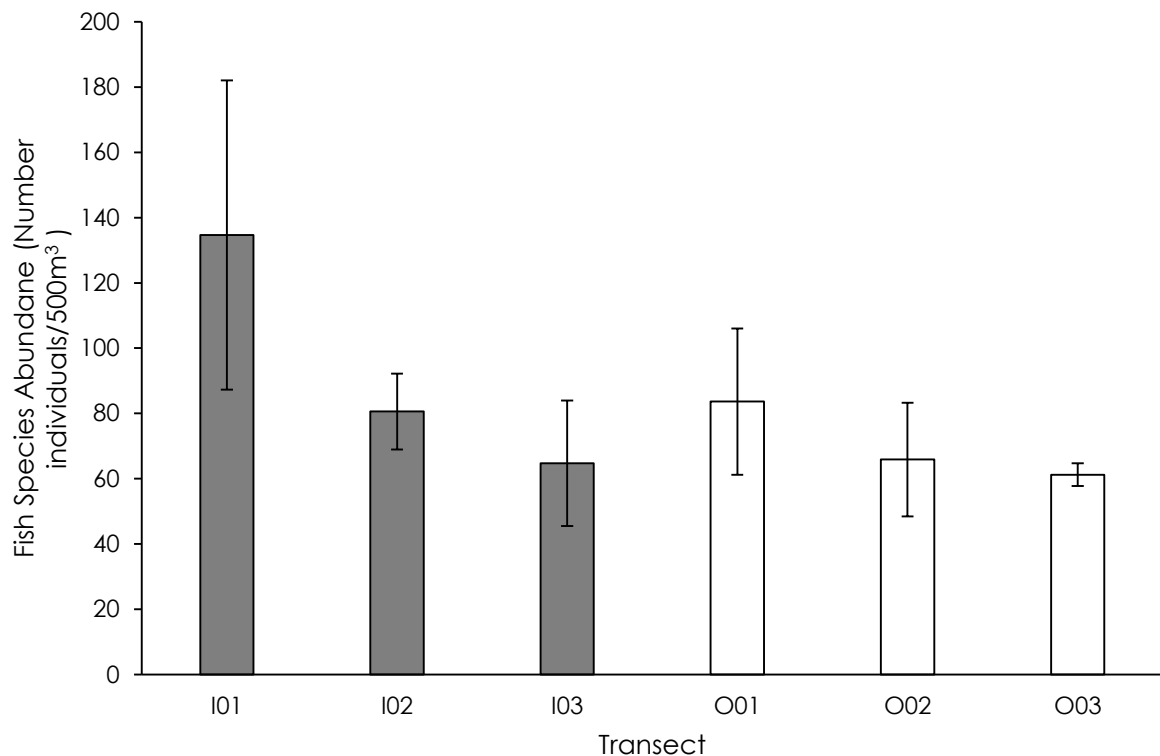


Figure 8. Average total fish abundance (October and April) with standard error on Napantao Reef 2015, Napantao marine protected area (MPA), southern Leyte, the Philippines. Grey = inside MPA transects, White = outside MPA transects.

Average total fish S was 16.1 ± 0.12 per 500m^3 inside and 11.6 ± 0.3 per 500m^3 with the majority of inside transects showing significantly higher S than outside transects (Fig. 9, Appendix B). Average total fish H' was also higher inside (2.27 ± 19.03 per 500m^3) than outside ($H' = 1.78 \pm 19.03$ per 500m^3) the MPA, and J' was higher inside (0.82 ± 0.02) than outside (0.76 ± 0.01), though not significantly different (Appendix B).

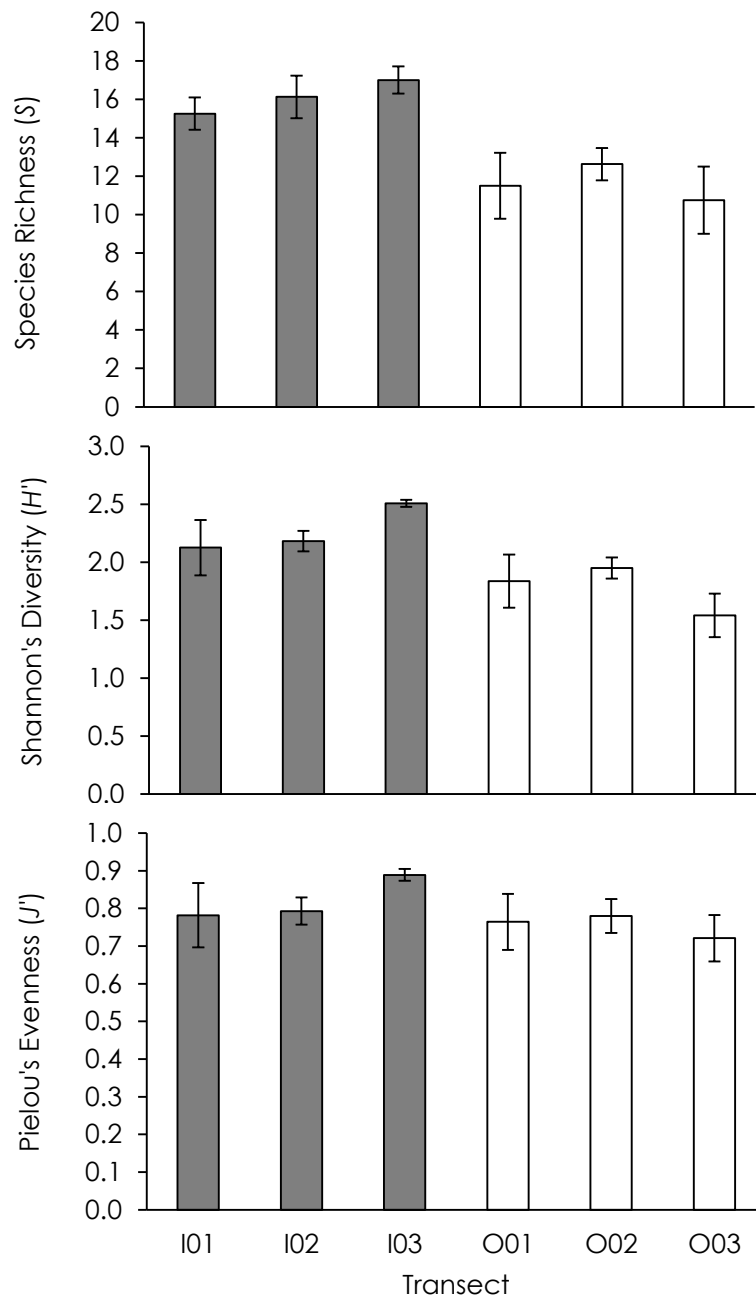


Figure 9. Total fish Species Richness (i.e. number of species), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) with standard error on Napantao Reef, southern Leyte, the Philippines (April and October) 2015.

3.1.2 Commercially Important Fish

Total commercial fish abundance averaged 11.46 ± 0.57 per 500m^3 inside and 5.7 ± 1.34 per 500m^3 outside the MPA. There were significantly more commercially important fish (i.e. Grouper, Snapper, Parrotfish) in all three inside transects compared to outside transect 2 and 3 ($p < 0.05$) (Fig. 10).

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

Figure 10. Matrix showing significant differences in Commercially Important Fish Abundance between sites surveyed within the Napantao marine protected area (MPA), southern Leyte, the Philippines. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Specifically, average parrotfish abundance inside was 6.54 ± 1.32 per 500m^3 and 3.96 ± 1.1 per 500m^3 outside (Fig. 11). Parrotfish were significantly more abundant on inside transect 1 and 2 than outside transects 2 and 3 ($p=<0.05$), and grouper were significantly more abundant on inside transect 1 and 2 compared to outside transects 1 and 3 ($p=<0.05$) (See Appendix C). Furthermore, Grouper abundance on inside transect 3 was significantly higher than all outside transects ($p=<0.05$). Average grouper abundance was 3.83 ± 0.16 per 500m^3 inside and 1.33 ± 0.58 per 500m^3 outside, and average snapper abundance inside was 1.08 ± 0.35 per 500m^3 and 0.42 ± 0.08 per 500m^3 outside.

On average there were more commercially important fish of all size classes inside the MPA than outside (Table 4, Fig. 12). Average biomass was also higher inside ($6.81\text{kg} \pm 2.76$) than outside (4.53 ± 2.28) the MPA (Fig. 13). Grouper biomass was significantly higher on all inside transects compared to outside transect 3 ($p=<0.05$). Inside transect 3 was also significantly higher than outside transect 1 ($p=<0.05$) (Appendix D).

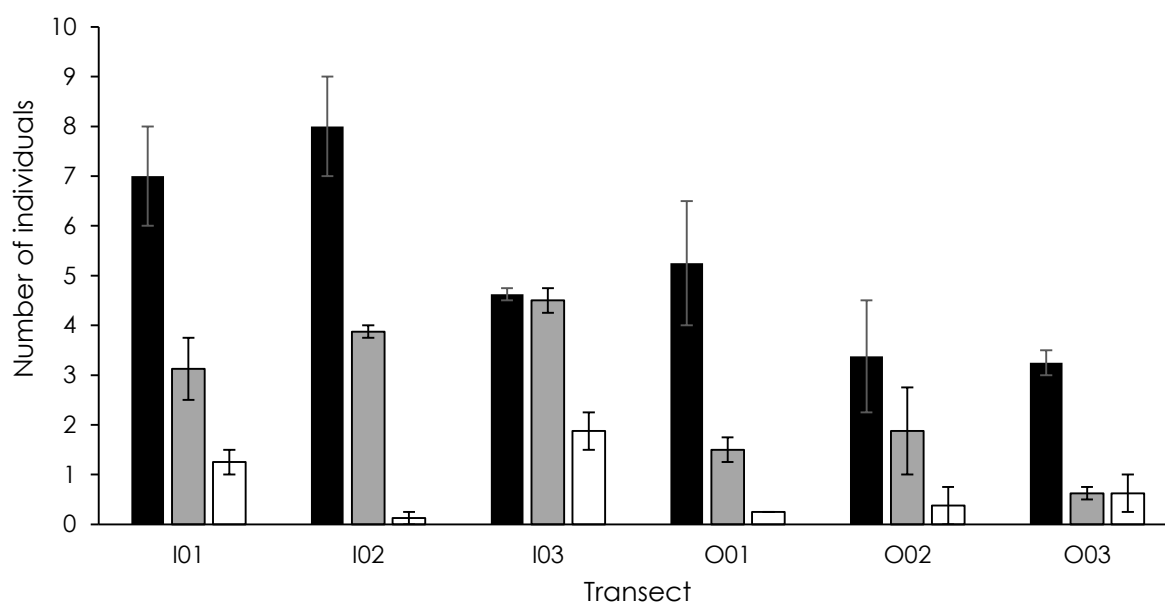


Figure 11. Average commercial fish abundance by target fish family with standard error on Napantao Reef 2015, southern Leyte, the Philippines. Black = Parrotfish, Grey = Grouper, White = Snapper.

Table 4. Inside and outside Napantao marine protected area, southern Leyte, the Philippines combined average commercial fish abundance by size class with standard error (SE).

Size Class (cm)	Inside	SE	Outside	SE
0-10cm	3.5	0.54	1.25	0.08
11-20cm	4.5	0.11	1.83	0.17
21-30cm	2.67	0.22	2.13	0.51
31-40 cm	0.71	0.07	0.46	0.11
41-50cm	0.08	0.08	0.04	0.04

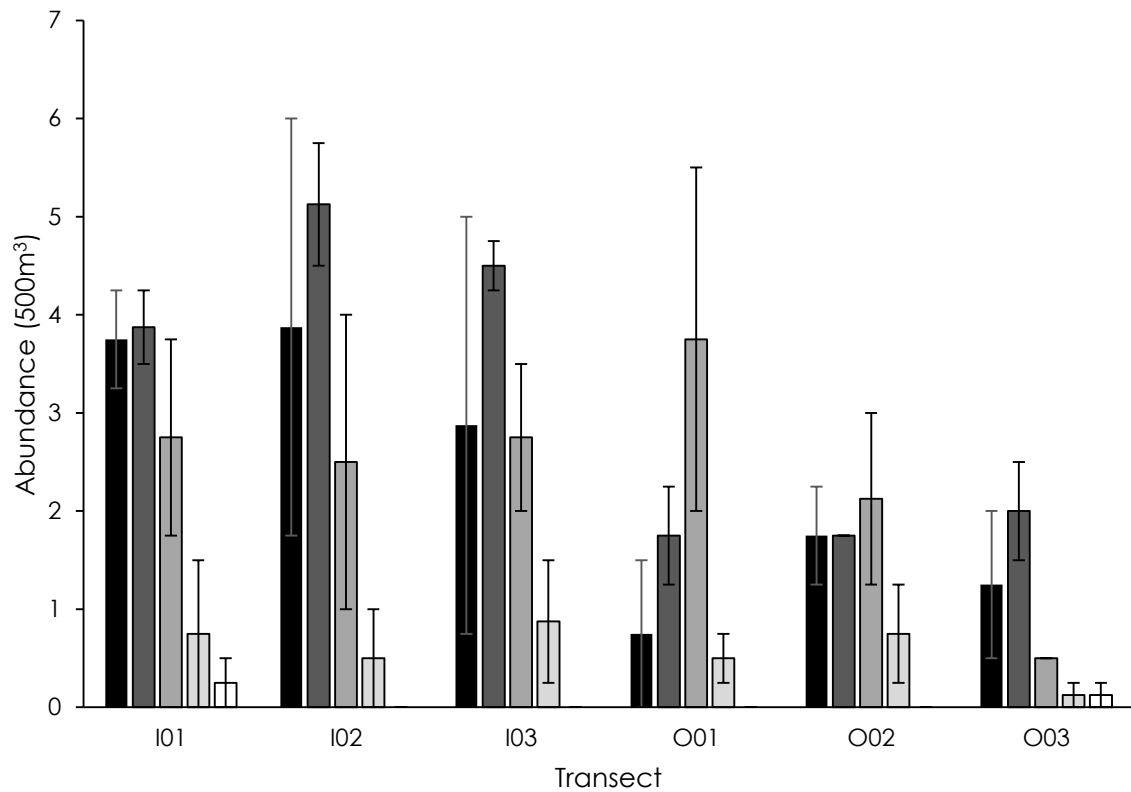


Figure 12. Average total commercial fish size estimations by transect on Napantao Reef 2015, southern Leyte, the Philippines with Standard Error. Black = 0-10 cm, Dark Grey = 11-20 cm, Medium Grey = 21-30 cm, Light Grey = 31-40 cm, White = 41-50 cm.

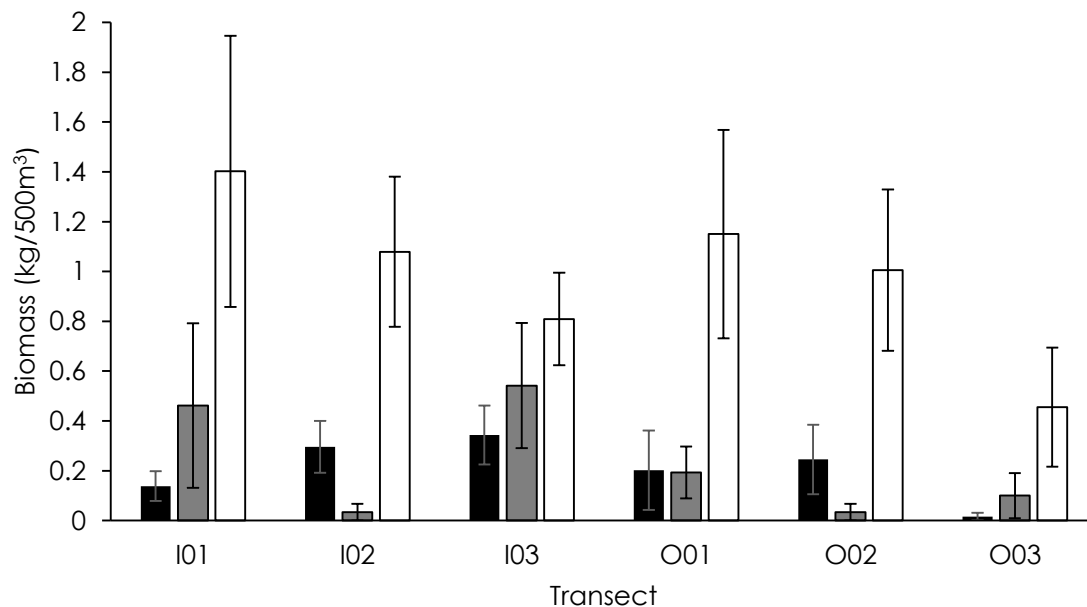


Figure 13. Biomass (kg/500m³) for commercially important fish species recorded over the sample sites, Napantao, southern Leyte, the Philippines, 2015. Black = Grouper, Grey = Snapper, White = Parrotfish.

3.1.3 Butterflyfish

On average, Butterflyfish (*Chaetodontidae* sp.) were more abundant inside (9.75 ± 0.13) than outside (6.3 ± 0.22) the MPA (Fig. 14). Specifically, Butterflyfish were significantly more abundant on inside transect 1 than all outside transects ($p < 0.05$) (Fig. 15). Average Butterflyfish S was higher inside (3.17 ± 0.03) than outside (1.71 ± 0.03) as was H' (inside = 0.95 ± 0.01 , outside = 0.42 ± 0.01) (Fig. 16, Appendix E). Average species evenness was also higher inside (0.86 ± 0.01) than outside (0.48 ± 0.01) the MPA. S and H' were significantly more abundant on inside transect 1 compared to all other transects, and on inside transects 2 and 3 compared to outside transect 3 ($p < 0.05$) (Fig 16, Appendix E).

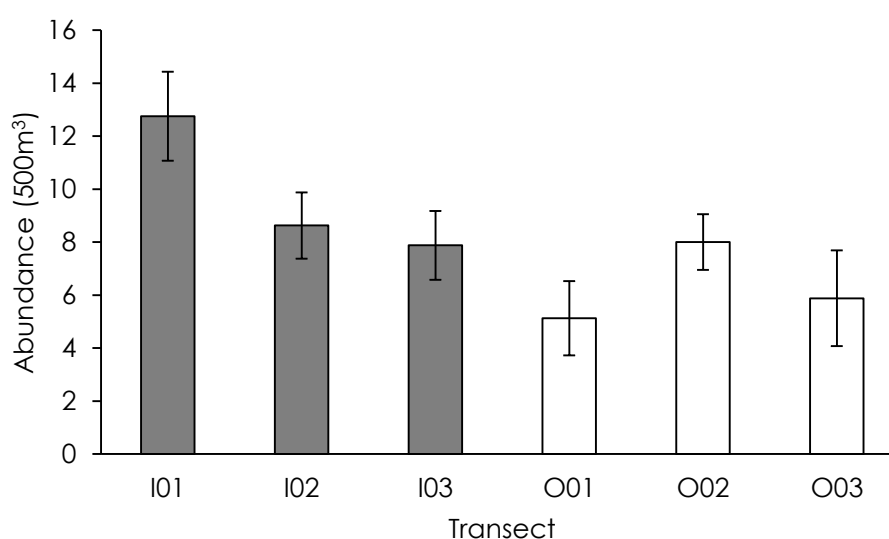


Figure 14. Average Butterflyfish abundance (*Chaetodontidae* sp.) inside and outside Napantao marine protected area (MPA), southern Leyte, the Philippines (April and October) 2015.

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

Figure 15. Matrix showing significant differences in butterflyfish abundance between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p < 0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

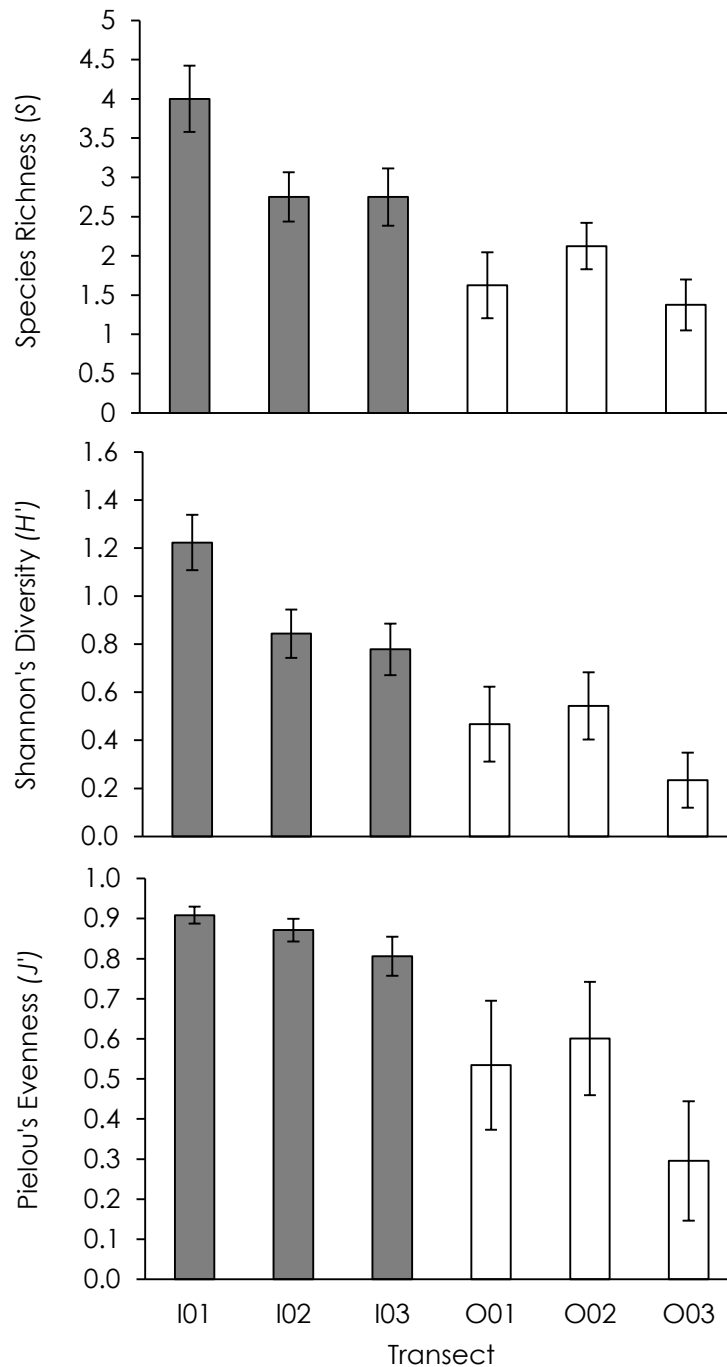


Figure 16. Total butterflyfish Species Richness, diversity (Shannon's Diversity Index), and evenness (Pielou's Evenness) with standard error on Napantao Reef, southern Leyte, the Philippines (April and October) 2015.

3.2 Invertebrates

Invertebrate abundance did not vary considerably between sites. Only inside transect 3 showed significantly higher invertebrate abundance compared to outside transect 3 ($p = <0.05$) (Figure 17). Invertebrate H' and S were not significant across inside outside transect comparisons (Fig. 18, Appendix F). Species were significantly

more even (J') on inside transect 2 and 3 compared to outside transect 2 (Fig. 18, Appendix F).

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. Only two Crown of Thorns starfish (*Acanthaster planci*) were seen, with one inside and one outside the MPA.

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

Figure 17. Matrix showing significant differences in invertebrate abundance between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

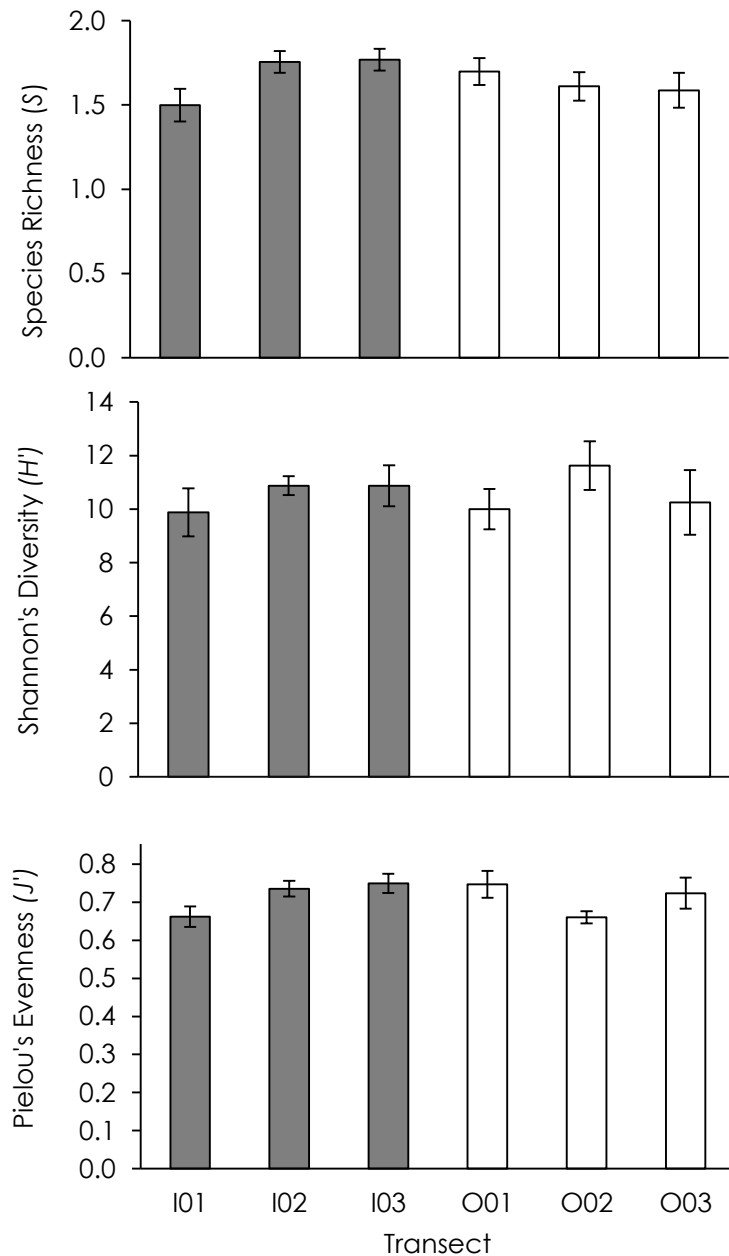


Figure 18. Total invertebrate Species Richness (i.e. number of species), diversity (Shannon's Diversity Index), and evenness (Pielou's Evenness) with standard error on Napantao Reef, southern Leyte, the Philippines (April and October) 2015.

3.3 Substrate

Hard coral was the dominant substrate both inside (36.35 ± 5.58) and outside (29.48 ± 5.95) the MPA. Inside transect 1 had significantly higher hard coral abundance than all other transects inside and outside ($p < 0.05$), and inside transects 2 and 3 had significantly higher hard coral abundance than outside transect 1 ($p < 0.05$) (Fig. 19, Fig. 20).

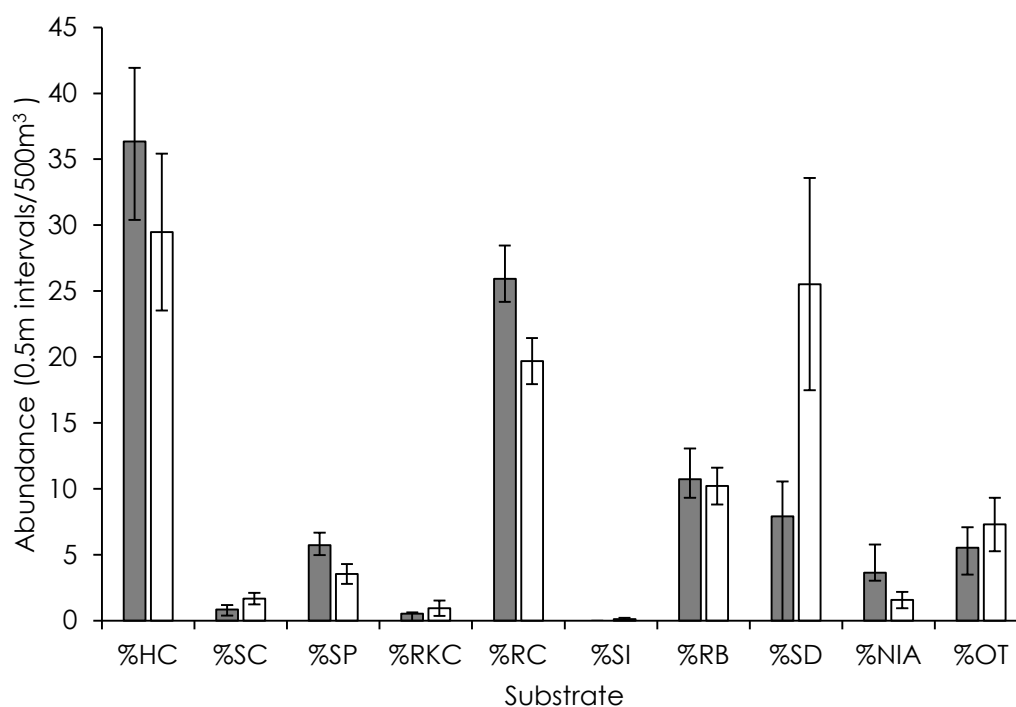


Figure 19. Average percent cover of bottom types with Standard Error inside and outside Napantao MPA, southern Leyte, the Philippines. Grey = Inside, White = Outside. HC = Hard Coral, SC = Soft Coral, SP = Sponge, RKC = Recently Killed Coral, RC = Rock, Si = Silt, RB = Rubble, SD = Sand, NIA = Nutrient Indicator Algae, OT = Other substrates.

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

Figure 20. Matrix showing significant differences in hard coral abundance between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Acropora sp. branching coral significantly ($p = <0.05$) dominated hard coral coverage (%) within the MPA (29.67 ± 1.77) compared to outside (3.19 ± 3.19) (Fig. 21). Inside

sites also showed significantly higher coverage ($p < 0.05$) of non-acropora submassive corals (25.39 ± 3.01) compared to outside sites (8.79 ± 8.79). Only non-acropora massive (14.09 ± 14.01) and mushroom coral (3.35 ± 3.35) were more abundant outside the MPA than inside (non-acropora massive = 12.8 ± 2.21 , mushroom = 1.24 ± 0.45). However, these differences were not significant.

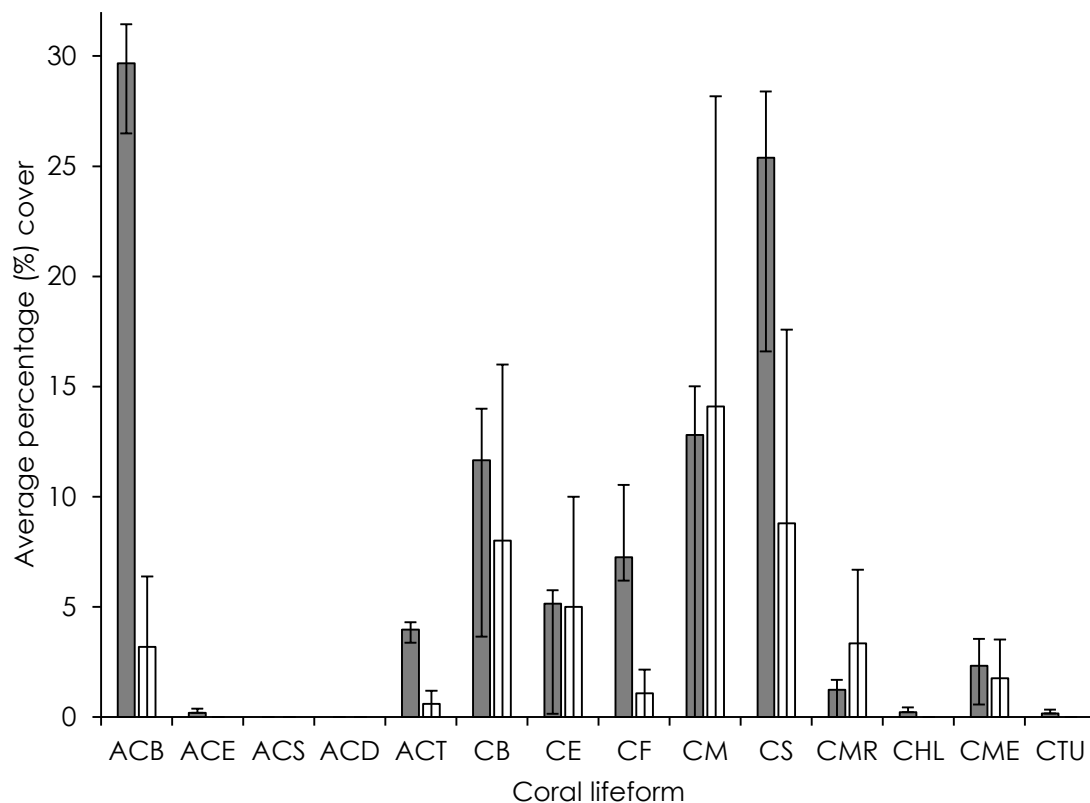


Figure 21. Average percent cover hard coral by classification with standard error inside and outside MPA. Grey = Inside, White = Outside. ACB = Acropora Branching, ACE = Acropora Encrusting, ACS = Acropora Submassive, ACD = Acropora Digitate, ACT = Acropora Tabulate, CB = Non-acropora Branching, CE = Non-acropora Encrusting, CF = Non-acropora Foliose, CM = Non-acropora Massive, CS = Non-acropora submassive, CMR = Non-acropora Mushroom, CHL = Blue Coral, CME = Fire Coral, CTU = Organ Pipe Coral.

There were significantly more competitor and stress tolerant corals outside the MPA than inside ($p < 0.05$) (Fig. 22). Conversely there were significantly more disturbance adapted fast growing corals inside the MPA than outside ($p < 0.05$).

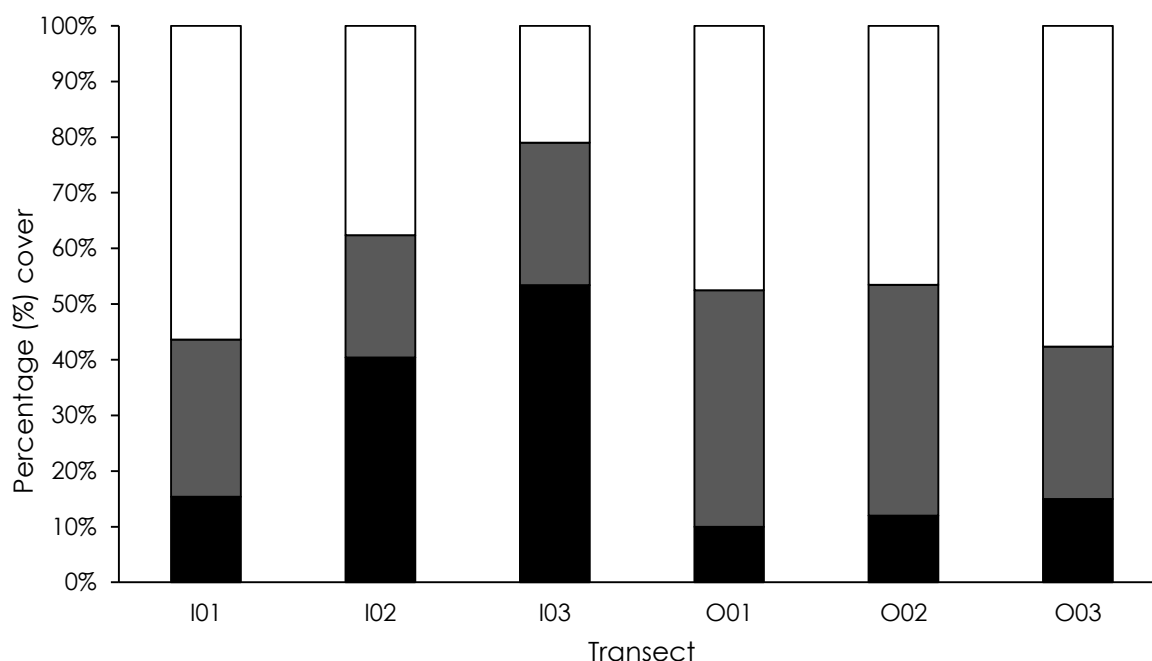


Figure 22. Average percent cover of coral types on the Napantao reef, southern Leyte, the Philippines, 2015. Black = Disturbance adapted fast growing corals (i.e. *Acropora* sp., Fire coral (*Millepora* sp.), Blue coral (*Heliopora* sp.); Grey = Competitor corals (i.e. branching, foliose, encrusting, mushroom Non-*Acropora* sp.); White = Stress tolerant corals (i.e. massive, submassive, organ pipe (*Tubipora* sp.)) (Edinger and Risk 2000).

Of the other recorded benthic substrates, soft coral, nutrient indicator algae, recently killed coral, and silt were not significantly different between any transects inside or outside. Rock was significantly more abundant ($p < 0.05$) in all inside transects compared to outside transects, excluding outside transect 2 compared to inside transect 1 which was not significant (Appendix G).

3.4 Anthropogenic Impacts

There is no blast or poison fishing inside or outside the MPA or collections for the curio, aquarium trade or Large Reef Fish Food Trade (LRFFT). There is occasional artisanal and subsistence fishing outside and inside the MPA which has a high level of illegal fishing (described as more than one fishing event per week). 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 commercial fishing in the area. The area experiences medium levels of recreational diving, 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. There was also a high level of general and fishing trash inside (general = 6 items, fishing = 10) and outside (general = 15 items, fishing = 9). There was high coral damage both inside (8 locations) and outside (23 locations) with the outside sites showing significantly ($p < 0.05$) higher amounts of damage. There was no

evidence of either boat or anchor damage to coral and no instances of coral damage related to dynamite fishing were recorded. Coral bleaching was recorded at low levels on the majority of transects ($\leq 5\%$ of the population in all instances). There were no instances of black band disease and only one instance of white band on one inside transect (2% of colony).

4. Visual Assessment

The following section contains images of the reef and marine creatures found within the Napantao MPA.



Figure 23. Bubble coral (*Plerogyra* sp.) inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 24. Fire coral (*Millepora* sp.) inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 25. Chromis (*Chromis* sp.) inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 26. *Tubastrea* sp. inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 27. School of Spadefish (*Platax* sp.) inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 28. A tree soft coral inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 29. Coral reef inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 30. Nudibranch (*Chromodoris annae*), inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 31. Nudibranch, (*Nembrotha chamberlaini*), inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.



Figure 32. Hawksbill sea turtle (*Eretmochelys imbricate*) inside the Napantao marine protected area (MPA), southern Leyte, the Philippines.

5. 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 trends observed in the data are discussed and recommendations for future management are provided.

5.1. Fish

Overall, the abundance of fish inside and outside the MPA 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 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, 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 objective of enhancing fish stocks.

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. 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 as a whole 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, it could also suggest continued illegal fishing of large individuals from both the protected and unprotected areas. 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 this recovery is underway.

Butterflyfish are often used as indicators of reef health and resilience through their species richness (S) and species diversity (H') (Kulbicki and Bozec, 2005). Butterflyfish species richness is highly correlated with both, total fish species richness and coral cover because many species are corallivores. Additionally, their relative ease of identification and, their large habitat (both Atlantic and Pacific), 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 the majority of inside transects is another positive sign that the reef is in a healthy state.

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 of invertebrates such as Triton's Trumpet, Squid and species of Sea Cucumber. 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 on the surveys 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 apparent on the survey may indicate that for this species, recruitment of new individuals is occurring but at a slow rate.

Crown of Thorns Starfish (CoTs, *Acanthaster planci*) were recorded both inside and outside the MPA. This seastar is a voracious predator of corals and at high levels of abundance can cause catastrophic damage to reef communities. The total number of observed CoTs on the survey was low and presents no cause for alarm. At low abundance levels CoTs are a natural part of reef systems and play vital a 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 help control the spread 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 rock outcrops. Inside, a greater quantity of rock was recorded. Coral requires 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. However, significantly higher levels of coral damage outside the MPA may indicate reef destruction through Muroami fishing (a method of scaring fish into nets by dropping rocks on the reef).

Indicators of coral health including 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 & 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 abundant 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

Although signs of anthropogenic impacts such as coral damage from boats or trash were low across the survey area, there are indicators that other impacts are high around the MPA. 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. Comm.*), 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. As a result 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 5.1, 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 individuals from keystone species that are 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, Kamukuru, Muthiga, Yebio, & Obura, 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, Lenihan, Bourque, Bradbury, & Cooke, 2006). *Diadema sp.*, an urchin that thrives in the absence of herbivorous fishes, 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, Hughes, Folke, & Nystrom, 2004).

6. Recommendations

In the past, the presence of a permanent Bantay Dagat at the Napantao MPA meant that compliance and enforcement were strong within the boundaries (Ferguson and Green, 2015). We recommend a permanent Bantay Dagat return to full-time duty patrolling the MPA for illegal fishing. 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 as a whole. 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. Ultimately, the MPA is being managed effectively and community support is high. If this continues, it is hoped that the benefits of the MPA for both the health of the reef ecosystem and for the people who depend on it will increase.

References

- 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.
- Calumpong, H., Raymundo, L., Solis-Duran, E., Alava, M., and de Leon, R. (1994). *Resource and Ecological Assessment of Sogod Bay, Leyte, Philippines - Final Report*. Siliman University Marine Laboratory.
- CBD. (2010). *Convention on Biological Diversity - Aichi Biodiversity Targets*. Retrieved 2013, from <http://www.cbd.int/sp/targets>
- Coleman, F., Hunstman, C., Musick, J., Eklund, A., McGovern, J., Chapman, R., . . . Grimes, C. (2000). Long-lived reef fishes: The Grouper-Snapper complex. *Fisheries*, **25**(3), pp. 14-21.
- Collins, L., Johnson, A., Koenig, C., and 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.
- 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.
- Crosby, M.P. and E.S. Reese. (1996). A Manual for Monitoring Coral Reefs with Indicator Species: Butterflyfishes as Indicators of Change on Indo Pacific Reefs. *Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration*, Silver Spring, MD. pp. 45.
- CTI. (2012). *Coral Triangle Initiative - State of the Coral Triangle Highlights - Philippines*. Pasig City, Philippines: Coral Triangle Initiative.
- Edinger, Evan N., and Michael J. Risk. (2000). Reef classification by coral morphology predicts coral reef conservation value. *Biological Conservation*, **92** (1), 1-13.
- Ferguson, A. and A. Green. (2015) Napantao MPA Annual Assessment Report. *Coral Cay Conservation*. pp. 1-52.

- Green, A., Smith, S., Lipsett-Moore, G., Groves, C., Peterson, N., Sheppard, S., Bualia, L. (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. Effects of recreational scuba diving on Caribbean coral and fish communities. *Conservation Biology* 13.4 (1999): 888-897
- Hodgson, G. (1999). A global assessment of human effects on coral reefs. *Marine Pollution Bulletin*, **38**, pp. 345-355.
- Human, B., and Davies, A. (2010). Stakeholder consultation during the planning phase of scientific programmes. *Marine Policy*, **34**, pp. 645-654.
- Jacinto, G., Alino, P., Villanoy, C., Talaue-McManus, L., and Gomez, E. (2000). The Philippines. In 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., Warner, R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science*, **293**, pp. 629-638.
- Kulbicki, M., and Y. M. Bozec. (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. S127-S141.
- Léopold, M., Cakacaka, A., Meo, S., Sikolia, J. and Lecchini, D. (2009). Evaluation of the effectiveness of three underwater reef fish monitoring methods in Fiji. *Biodiversity and Conservation*, **18**, pp. 3367-3382.
- Lessios, H., Robertson, D., and Cubit, 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.
- 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., . . . Williamson, D. (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.

- Morris, E. Kathryn, et al. (2014). Choosing and using diversity indices: insights for ecological applications from the German Biodiversity Exploratories. *Ecology and evolution*, **4** (18), pp. 3514-3524.
- Myers, R., Baum, J., Shepherd, T., Powers, S., and Peterson, C. (2007). Cascading effects of the loss of apex predatory sharks from a coastal ocean. *Science*, **315**, pp. 1845-1850.
- O'Hara, R. and Kotze, D. (2010). Do not log-transform count data. *Methods in Ecology and Evolution*, **1**(2), pp.118-122.
- Pauly, D., Christensen, V., Guenette, S., Pitcher, T., Sumaila, U., Walters, C., . . . Zeller, D. (2002). Towards sustainability in world fisheries. *Nature*, **418**, pp. 687-689.
- 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.
- Rhodes, K., and Tupper, M. (2008). The vulnerability of reproductively active Squaretail Coral Grouper (*Plectropomus areolatus*) to fishing. *Fishery Bulletin*, **106**, pp.194-203.
- Roberts, C., McClean, C., Veron, J., Hawkins, J., Allen, G., and McAllister, D. (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science*, **295**, pp. 1280-1284.
- Russ, G., and Alcala, A. (2004). Marine reserves: long-term protection is required for full recovery of predatory fish populations. *Oecologia*, **138**, pp. 622-627.
- Sadovy, Y., Rosario, A., and Roman, A. (1994). Reproduction in an aggregating grouper, the Red Hind, *Epinephelus guttatus*. *Environmental Biology of Fishes*, **41**, 269-286.
- Shapiro, S. and Wilk, M. (1965). An Analysis of Variance Test for Normality (Complete Samples). *Biometrika*, **52**(4), pp.591.
- Thode, H. (2002). *Testing for normality*. New York: Marcel Dekker.
- Tuomisto, Hanna. (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., and Peterson, N. (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.

Wood, L., Fish, L., Laughren, J., and Pauly, D. (2008). Assessing progress towards global marine protection targets: shortfalls in information and action. *Oryx*, **42**, pp. 340-351.

World Bank. (2005). *Philippines Environment Monitor on Coastal and Marine Resource Management*. Washington DC, USA: World Bank.

Appendix A: Target Species Lists

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

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

TARGET FISH

Common Name	Latin Name	Visayan Name
Angelfish	Pomacanthidae	Adlo
Barracuda	Sphyraenidae	
Blenny	Blenniidae	
Butterflyfish*	Chaetodontidae	Alibangbang
Cardinalfish	Apogonidae	
(Damsel fish)	(Pomacentridae)	
Anemonefish	<i>Amphiprion</i> sp.	
Sergeant Damsel fish	Pomacentridae	
Emperor	Lethrinidae	Katambak
Filefish	Monacanthidae	Ilak
Fusilier	Caesionidae	Dalagang bukid
Goatfish	Mullidae	Timbongan
Groupers	Serranidae	Lapu-lapu
Jack/Trevally	Carangidae	
Lionfish	Scorpaenidae	
Lizardfish	Synodontidae	
Moorish Idol	<i>Zanclus cornutus</i>	
Moral Eel	Muraenidae	
Parrotfish	Scaridae	Talakitok
Porcupinefish	Diodontidae	
Pufferfish	Tetraodontidae	
Rabbitfish	Siganidae	Sanggowanding
Ray	Rajiformes	Mulmul
Sandperch	Pinguipedidae	
Snapper	Lutjanidae	
Spinecheeks	Nemipteridae	
Squirrelfish/Soldierfish	Holocentridae	
Surgeonfish	Acanthuridae	
Unicornfish	<i>Naso</i> sp.	
Sweetlips	Haemulidae	Silay
Toby	Tetraodontidae	
Triggerfish	Balistidae	
(Wrasse)	(Labridae)	
Crescent Wrasse	<i>Thalassoma lunare</i>	
Humphead Wrasse	<i>Cheilinus undulatus</i>	Lipti
Red Breasted Wrasse	<i>Cheilinus fasciatus</i>	

*Target Butterflyfish

Vagabond Butterflyfish

Klein's Butterflyfish

Eastern Triangle Butterflyfish

Redfin Butterflyfish

(Big) Long-Nosed Butterflyfish

Racoon Butterflyfish

Humphead Bannerfish

Other Butterflyfish*

* All other Butterflyfish

recorded as Other

Appendix B: Total Fish Species Richness, Shannon's Diversity Index, Pielou's Evenness Matrix

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			-			

Matrix showing significant differences in total fish a) S, b) H, c) J, between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Appendix C: Commercially Important Fish Abundance Matrix

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			-			

Matrix showing significant differences in a) Parrotfish, b) Grouper, c) Snapper between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Appendix D: Commercially Important Fish Biomass Matrix

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						

Matrix showing significant differences in a) Parrotfish, b) Grouper, c) Snapper between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Appendix E: Butterflyfish Species Richness, Shannon's Diversity Index, Pielou's Evenness Matrix

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	-	-	-			

Matrix showing significant differences in butterflyfish a) S, b) H, c) J between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Appendix F: Invertebrate Species Richness, Shannon's Diversity Index, Pielou's Evenness Matrix

a

	I1	I2	I3	O1	O2	O3
I1						
I2						
I3						
O1						
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						

Matrix showing significant differences in invertebrate a) S, b) H, c) J, between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Appendix G: Substrate Abundance Matrix

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	-	-	-			

b)

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

d)

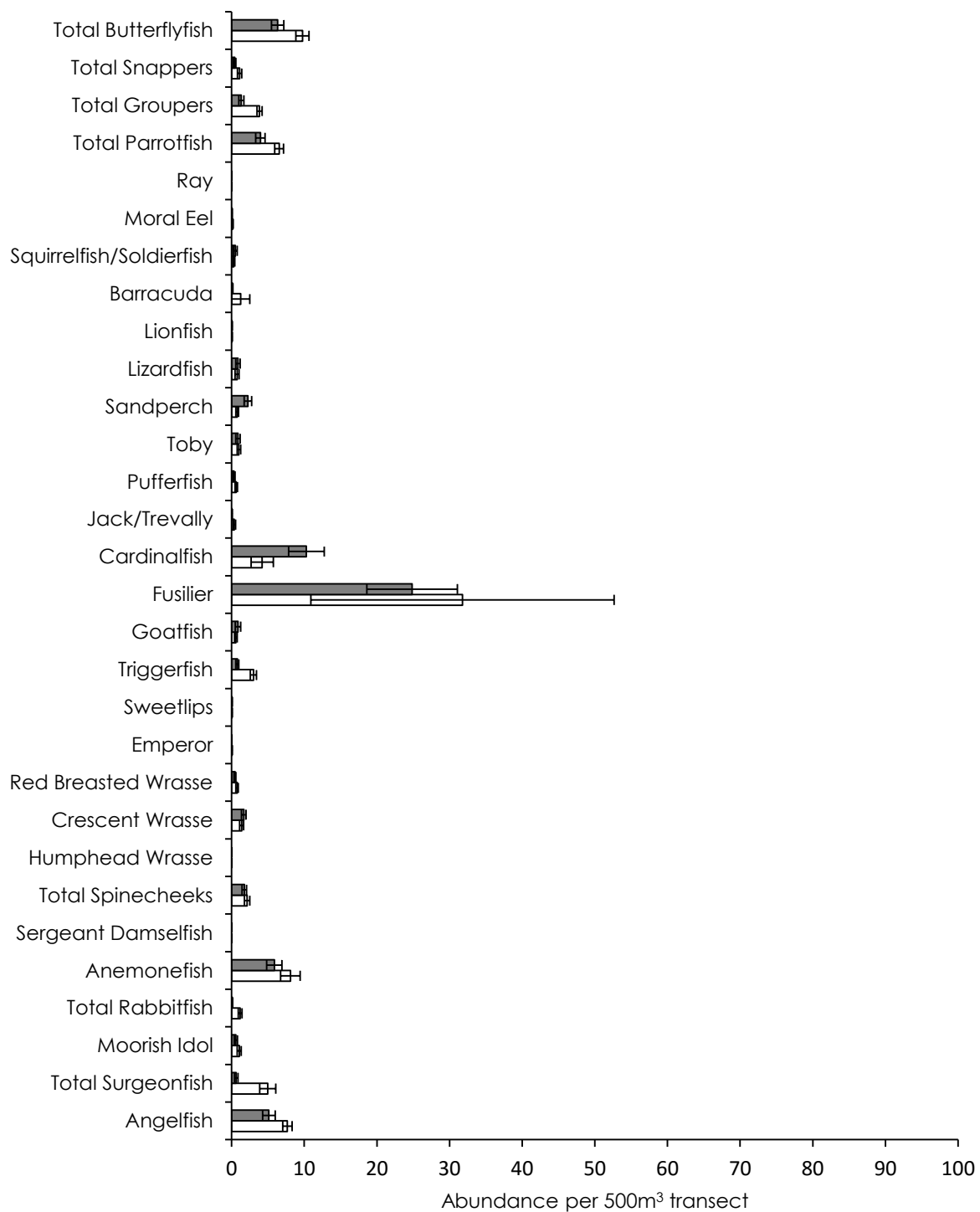
	I1	I2	I3	O1	O2	O3
I1				+		+
I2				+	+	+
I3				+	+	+
O1	-	-	-			
O2		-	-			
O3	-	-	-			

e)

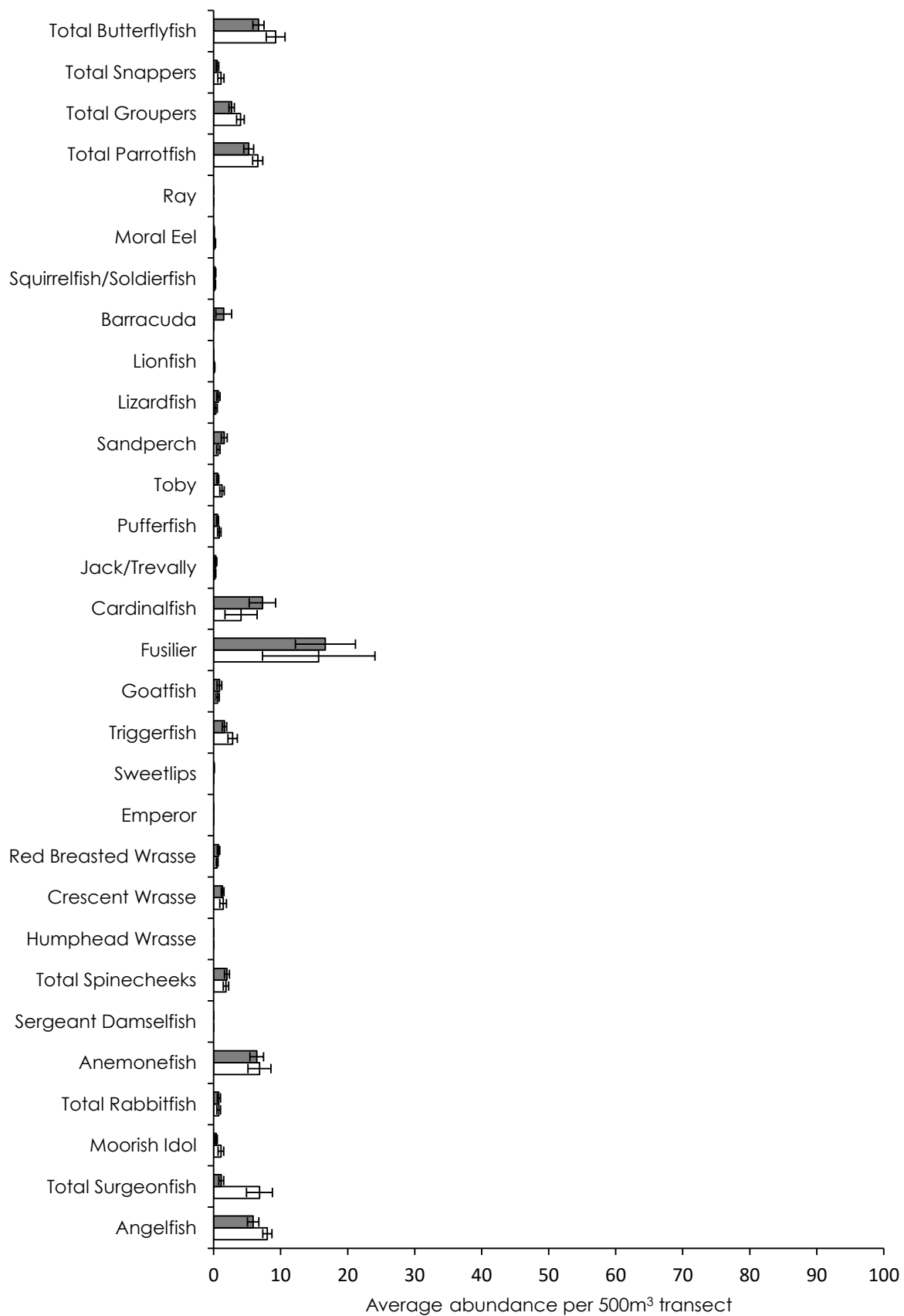
	I1	I2	I3	O1	O2	O3
I1		-	-			
I2	+					
I3	+					
O1						
O2						
O3						

Matrix showing significant differences in substrate abundance: a) Sponge, b) Other, c) Rubble, d) Rock, e) Sand, between sites. Bottom types not shown (i.e. soft coral, nutrient indicator algae, recently killed coral, silt) were not significantly different between sites. A green '+' indicates abundance was significantly higher at transect on the left compared to transect at the top ($p = <0.05$). A red '-' indicates that abundance was significantly lower at transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

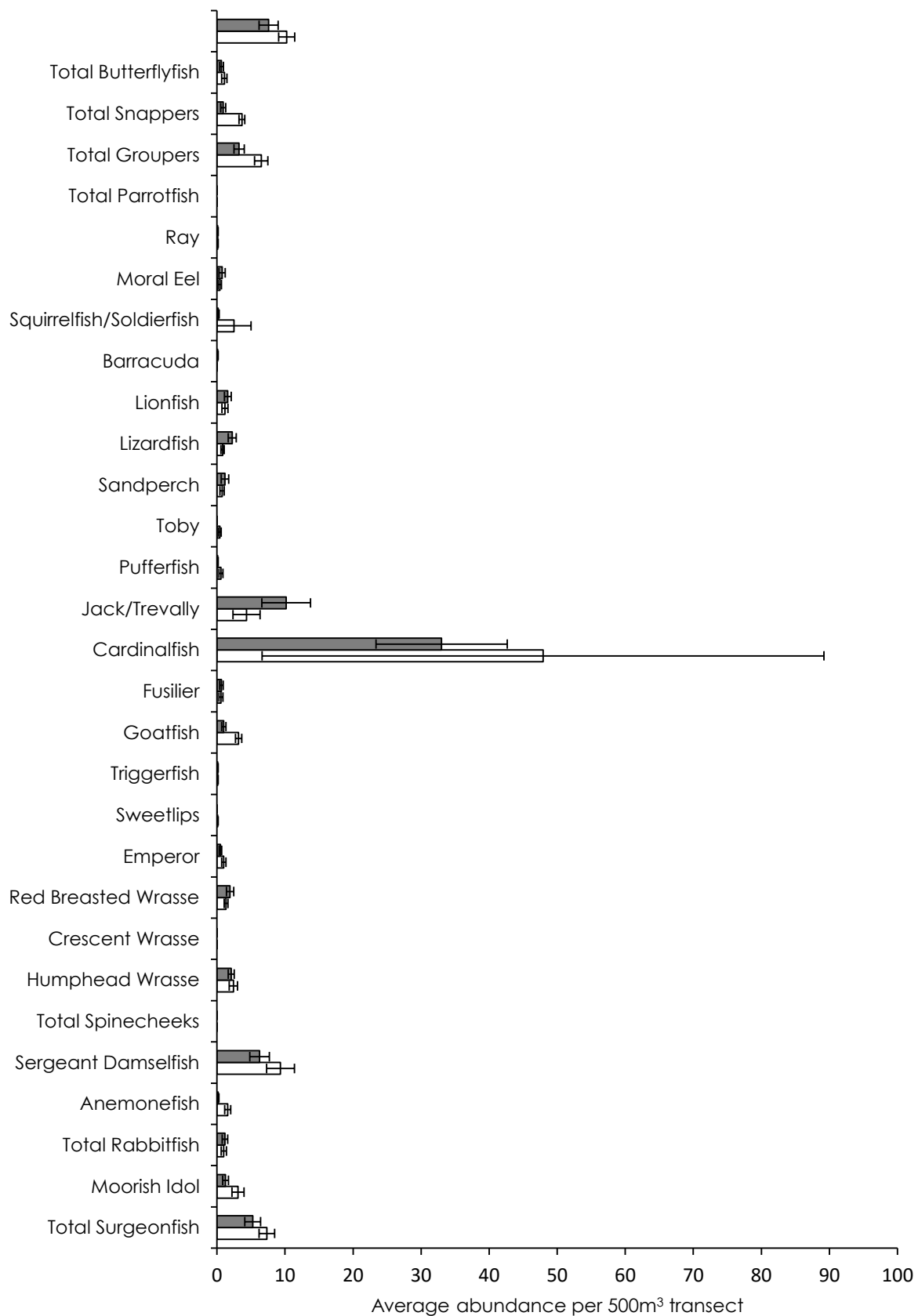
Appendix H: Target Fish Family Abundance



Average abundance of target fish families with Standard Error for April and October combined. Grey = outside, White = inside.

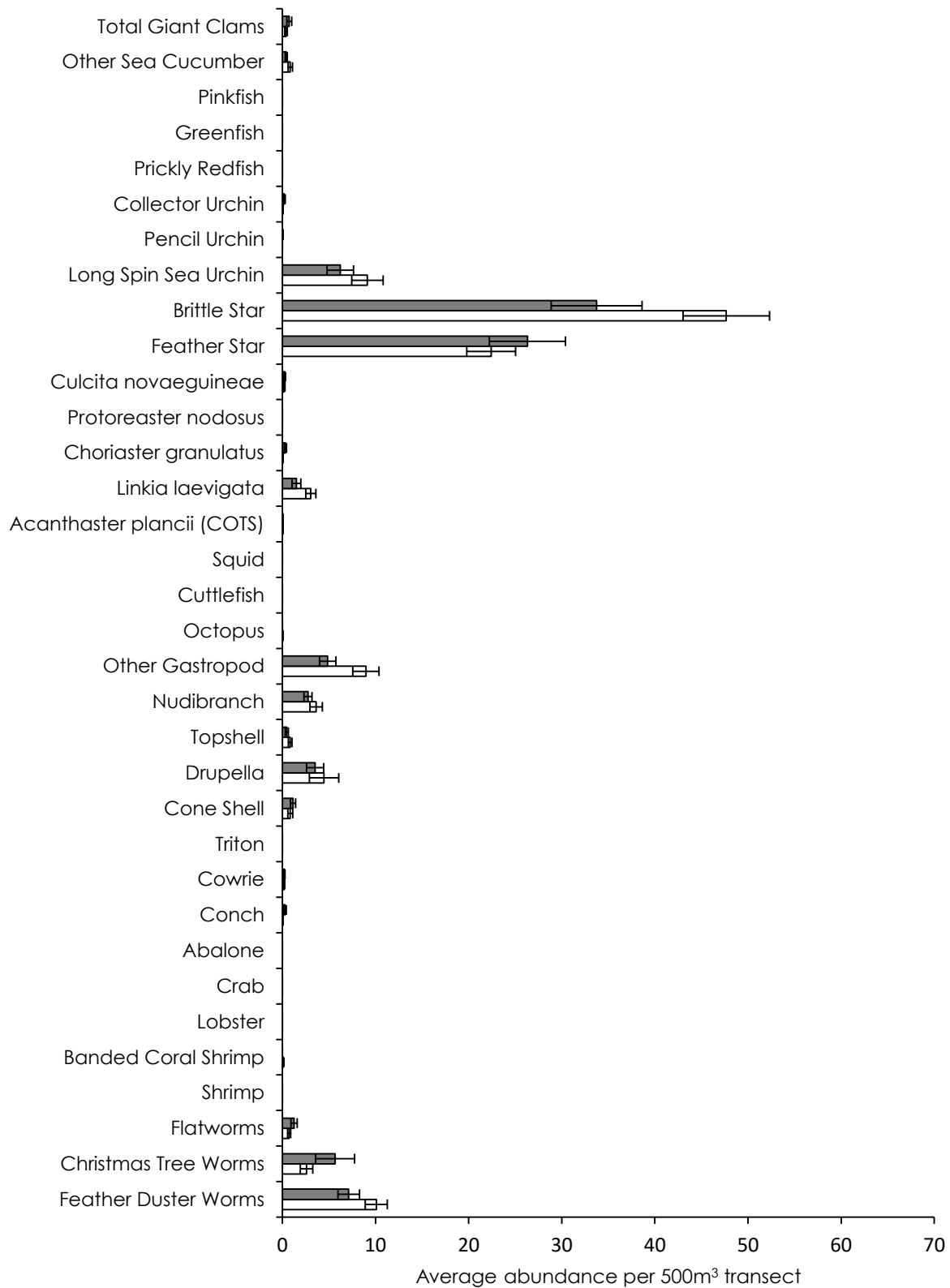


Average abundance of target fish families with Standard Error for April. Grey = outside, White = inside.

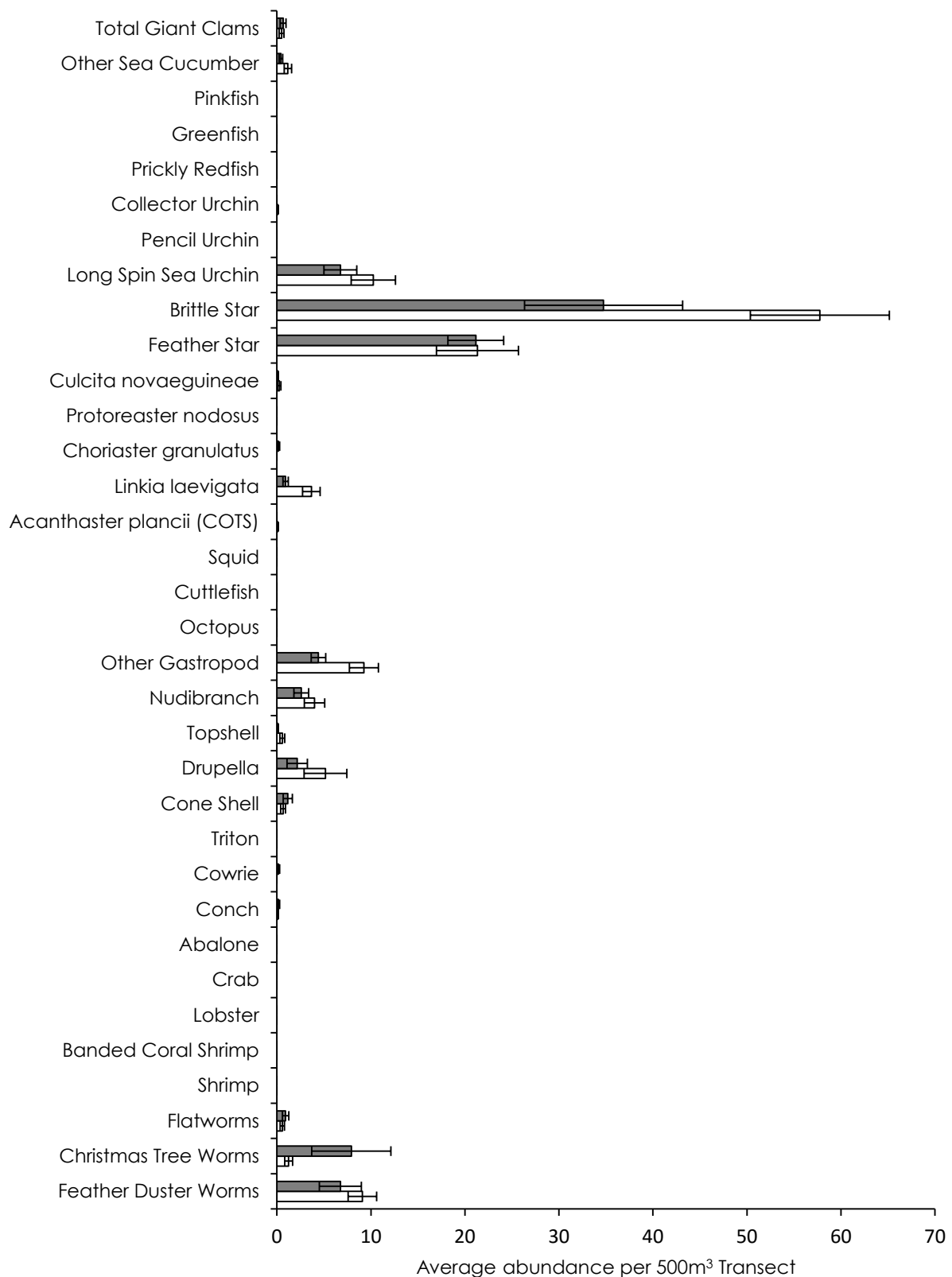


Average abundance of target fish families with Standard Error for October. Grey = outside, White = inside.

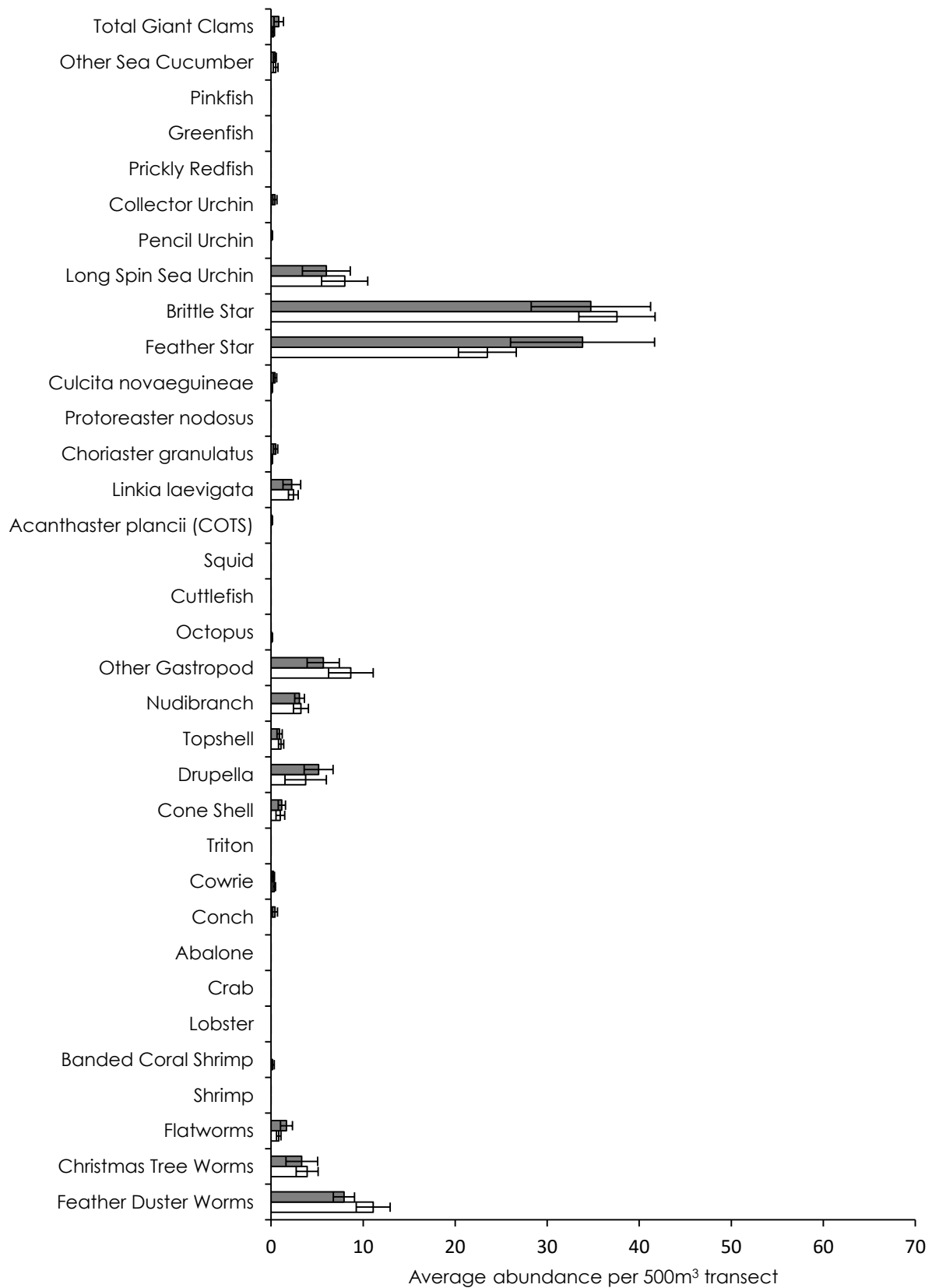
Appendix I: Target Invertebrate Abundance



Average abundance with Standard Error of target invertebrate species and families for April and October. Grey = outside, White = inside.

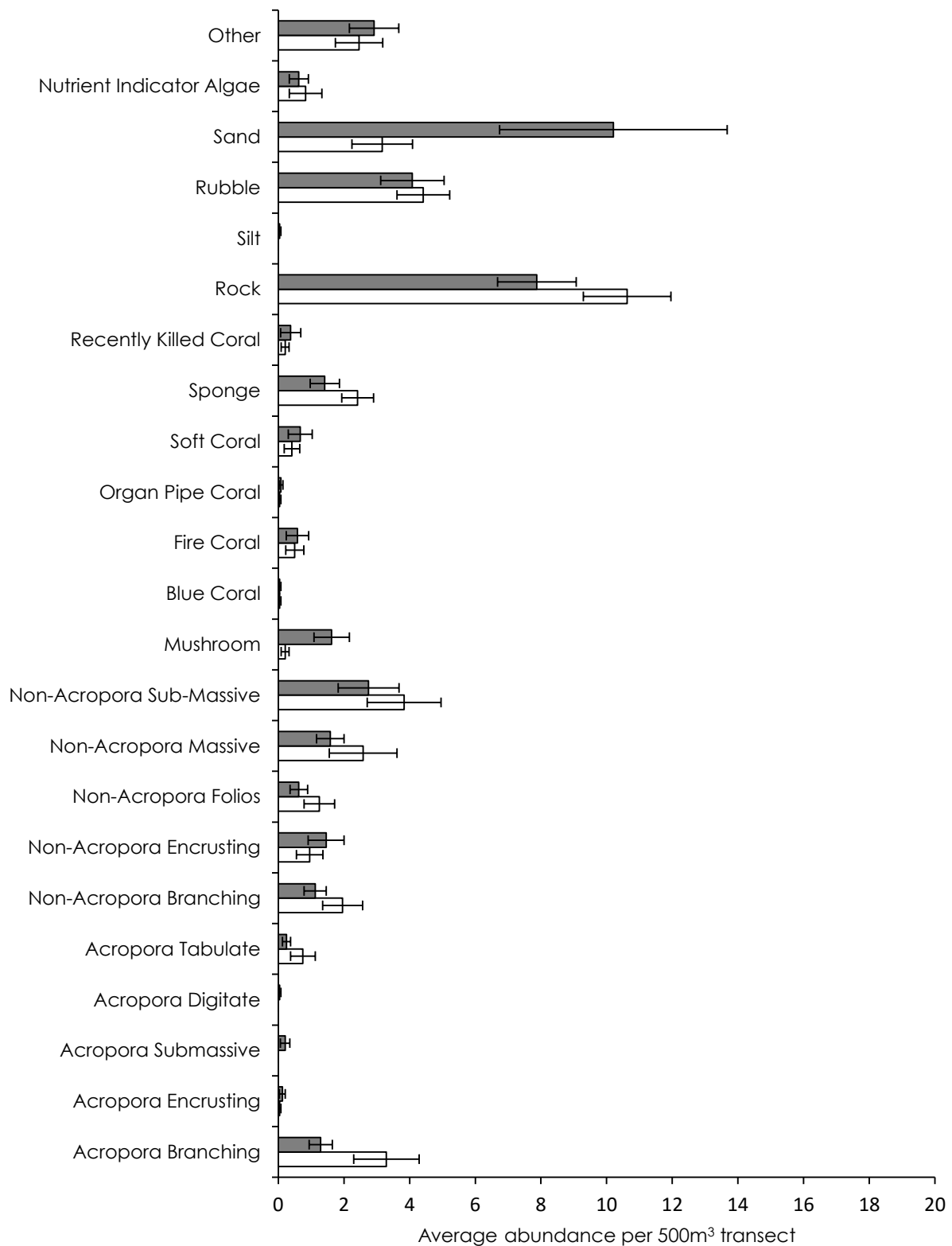


Average abundance with Standard Error of target invertebrate species and families for April. Grey = outside, White = inside.

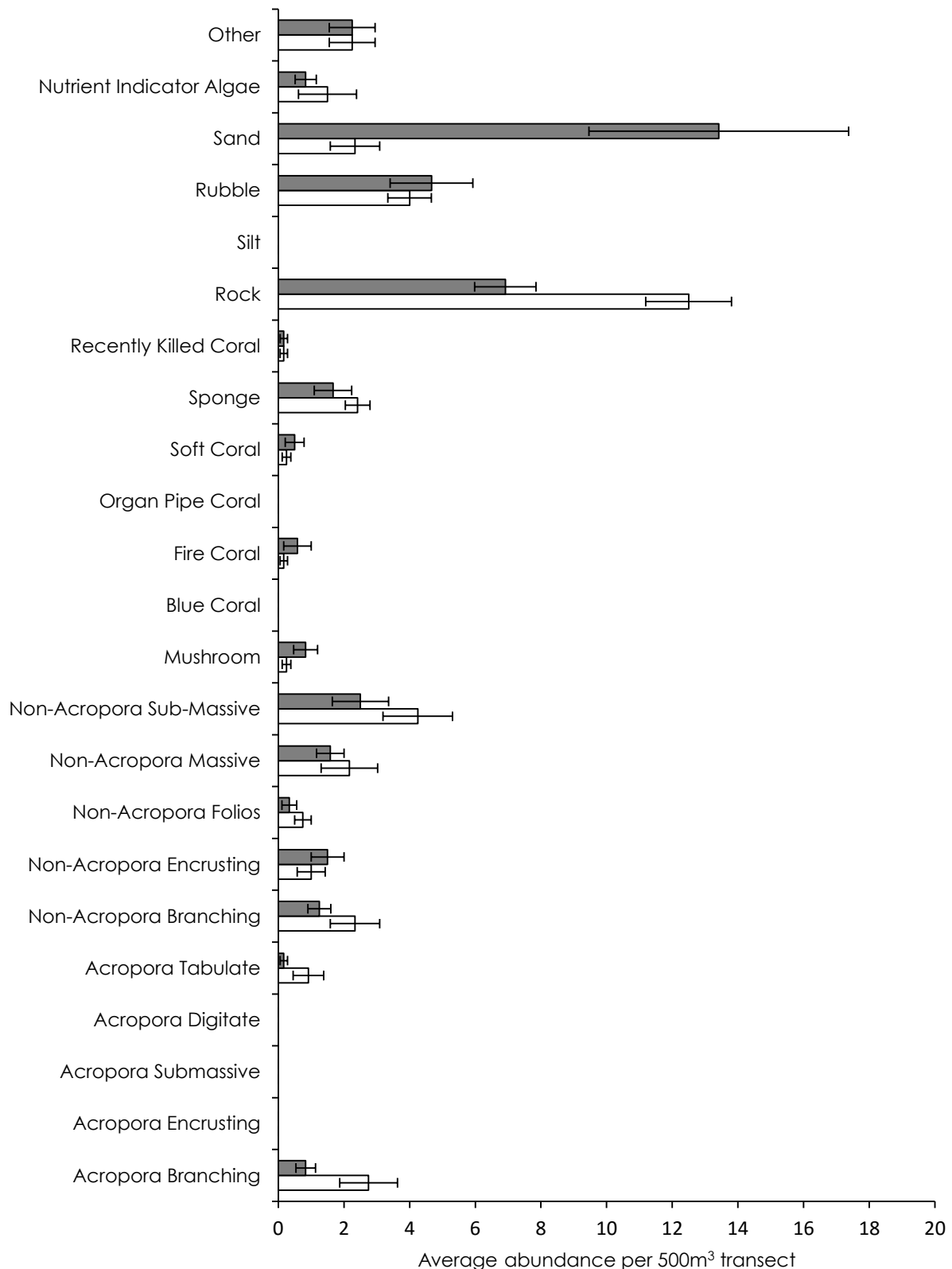


Average abundance with Standard Error of target invertebrate species and families for October. Grey = outside, White = inside.

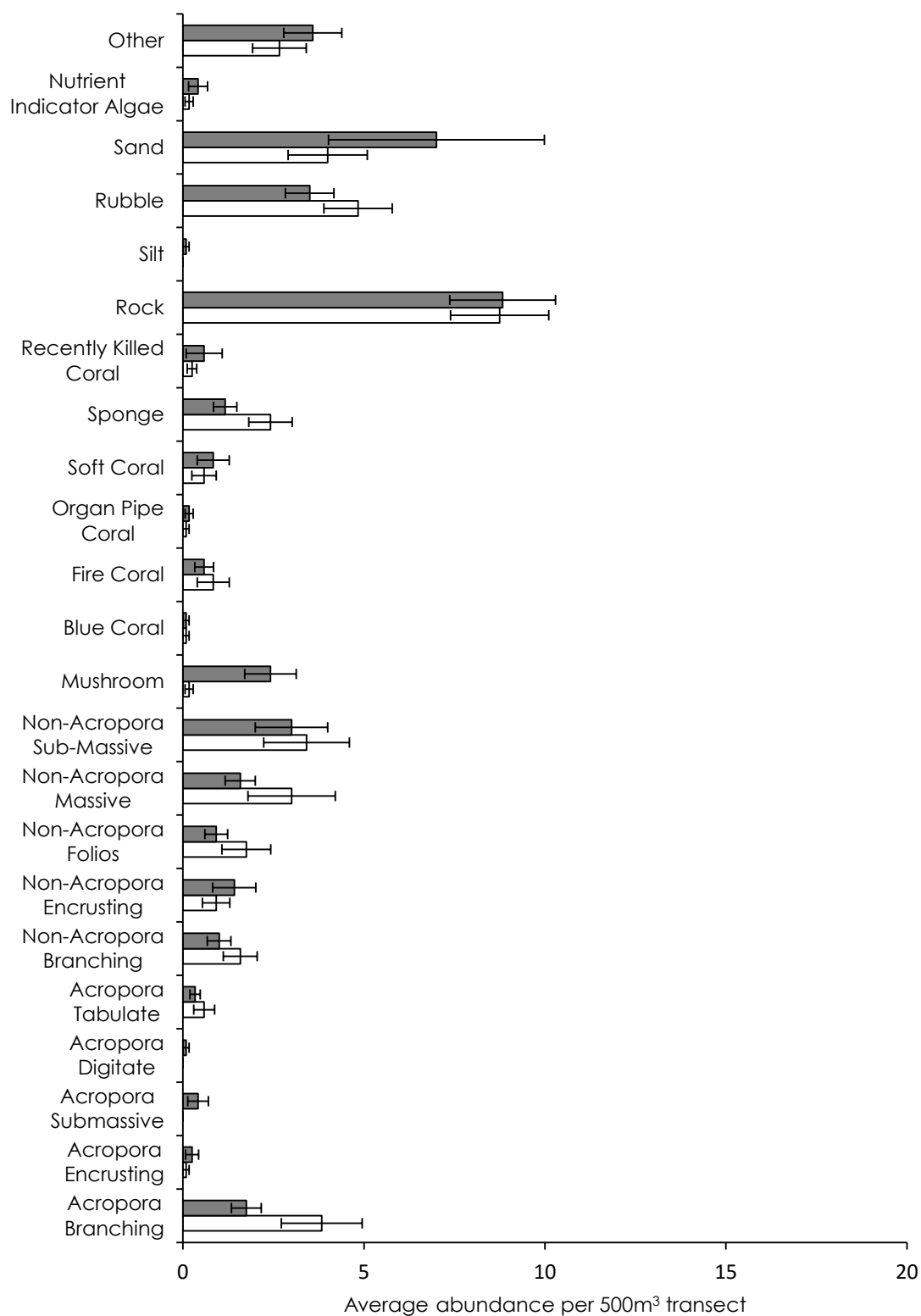
Appendix J: Target Substrates Abundance



Average abundance with Standard Error of target benthic organism's species and families for April and October. Grey = outside, White = inside.



Average abundance with Standard Error of target benthic organism's species and families for April. Grey = outside, White = inside.



Average abundance with Standard Error of target benthic organism's species and families for October.
 Grey = outside, White = inside.