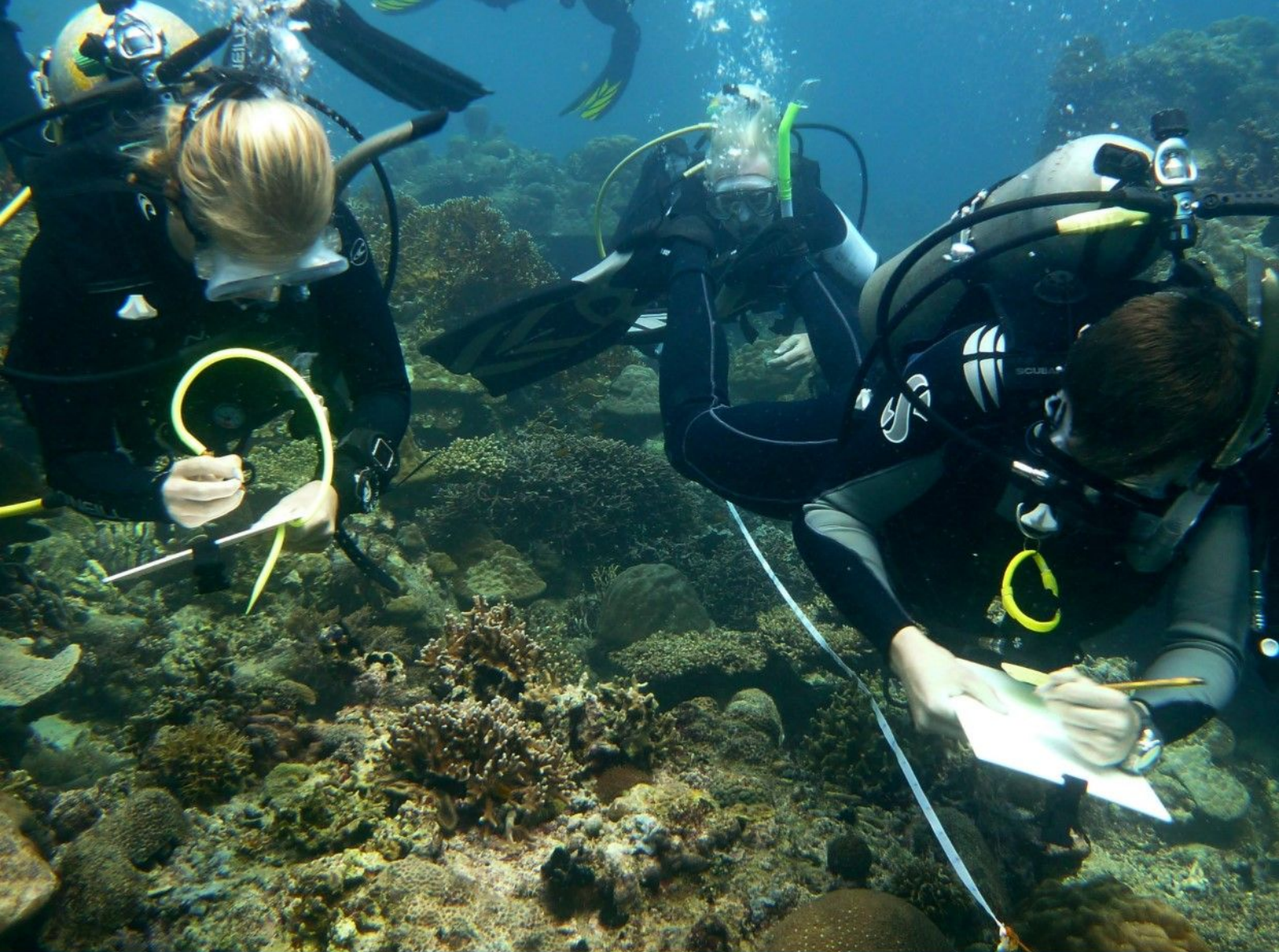




LRCP

Southern Leyte Coral Reef Conservation Project

Coral Cay Conservation Proposed Marine Protected Area Report: Barangay Cuasi 2016

Report Date: December 2016

**CORAL CAY
CONSERVATION**



Jamie Parker, Tom Dallison,
Alex Ferguson

In partnership with the Southern Leyte
Provincial Government, Philippines



Coral Cay Conservation
Proposed Marine Protected Area Assessment Report
Cuasi 2016 Assessment
San Francisco, Southern Leyte, the Philippines

Contacts

Alex Ferguson – headofscience@coralcay.org

Tom Dallison – science@coralcay.org

Jamie Parker – lrcp@coralcay.org

Additional Contributors: Marie Seraphim, Joel Brown, Maryann Watson,
Dariennc Lancaster

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

Edgar, G. J., Stuart-Smith, R. D., Willis, T. J., Kininmonth, S., Baker, S. C., Banks, S., Barrett, N. S., Becerro, M. A., Bernard, A. T. F., Berkhout, J., Buxton, C. D., Campbell, S. J., Cooper, A. T., Davey, M., Edgar, S. C., Försterra, G., Galván, D. E., Irigoyen, A. J., Kushner, D. J., Moura, R., Parnell, P. E., Shears, N. T., Soler, G., Strain, E. M. A. and Thomson, R. J. (2014). Global conservation outcomes depend on marine protected areas with five key features. *Nature*, **506**(7487), pp. 216-20.

Ferre, S. C. a., Máñez Costa, M., Máñez, K. S., Adhuri, D. S. and Glaser, M. (2010). Allies, not aliens: increasing the role of local communities in marine protected area implementation. *Environmental Conservation*, **37**, pp. 23-34.

Graham, N. A. J. and Nash, K. L. (2013). The importance of structural complexity in coral reef ecosystems. *Coral Reefs*, **32**(2), pp. 315-326.

Executive Summary

- Coral Cay Conservation (CCC) conducted an assessment of the reef fish, invertebrates, substrates and anthropogenic impacts in the waters of Barangay Cuasi in the Municipality of San Francisco. The site has been proposed as a potential Marine Protected Area (MPA).
- At the request of Arman Gaviola of PENRMO, Maasin, on behalf of the PAME Project after consulting with the Barangay Captain the Cuasi was surveyed for the purpose of a proposed MPA.
- An enhanced Reef Check methodology was used to complete formal biophysical surveys of six 100m transects, each containing four 20m replicates. Transects were equally divided between depths of 6m and 12m.
- In terms of total fish abundance, Cuasi proposed MPA can be considered a healthy reef, as its fish abundances were found to be only marginally lower than those at the longstanding Napantao MPA.
- There are some trends that are of concern, indicating activities such as overfishing, which require consideration to ensure the preservation and restoration of the coral reef in Barangay Cuasi. However, there are also encouraging signs that the reef is currently healthy enough to benefit from MPA protection.
- Although the proposed MPA shows total fish abundances similar to that of Napantao MPA, low abundances of commercially important fish species are indicative of overfishing in the area.
- The composition of hard coral throughout the site is indicative of being able to support a populous community of corallivorous Butterflyfish species.
- The site showed moderate levels of invertebrate abundance but no important commercial species were recorded. Additionally, a low number of Crown of Thorns Starfish were found.
- The site is dominated by hard coral and rock, which is a positive sign for future coral recruitment. Non-*Acropora* foliose and branching species were found to be abundant which is encouraging, as an anecdotal increased structural complexity is beneficial to both fish and invertebrate species.
- The significantly higher abundance of competitor corals like non-*Acropora* branching, foliose and encrusting, compared with stress tolerant or fast growing corals, at the proposed MPA site may suggest that the area experiences lower levels of anthropogenic stressors (e.g. anchoring, fishing) or natural stressors (e.g. storms, sedimentation) compared with other Filipino reefs in the area.
- The coral reefs in Cuasi show low levels of human impact. However, if the reef were protected these levels may diminish or disappear completely over time.

- CCC strongly recommend creating an MPA in the Barangay Cuasi. Considering the levels of overfishing suggested from the survey, an MPA, that bans all fishing on at least some of the reef, is the recommended course of action. Ideally this would be buffered with designated MR zones allowing some restricted (single hook and line only) fishing in the area.
- Combining an ecosystem approach to fisheries (EAF) and community-based management (CBM), empowering the local user group level and conferring high levels of transparency in a triangulated consortium, CCC aims to facilitate the local Barangay Cuasi in achieving measurable levels of effectiveness from their designated MPA.
- It is recommended that consultation be started between the local community, municipal and provincial government and CCC on the creation of a marine protected area.



Table of Contents

Executive Summary.....	ii
------------------------	----

Acknowledgements.....	v
1.2 Coral Reefs and Marine Conservation in the Philippines.....	3
1.3.2 Cuasi, San Fransisco: Proposed MPA Site.....	5
2.1 Survey Sites.....	5
2.2.1 Fish.....	7
2.2.2 Invertebrates.....	8
2.2.3 Substrate.....	8
2.2.4 Impacts.....	8
2.3 Data Analysis.....	9
3.1. Fish.....	10
3.3 Invertebrates.....	18
3.4 Substrates.....	21
3.2 Anthropogenic Impacts.....	25
4. Visual Assessment.....	26
5. Discussion.....	28
5.1. Fish.....	28
5.2 Invertebrates.....	30
5.3 Substrates.....	31
5.4 Anthropogenic Impacts.....	31
6.1 Recommendation for the Establishment of a Marine Protected Area in Cuasi	34
References.....	37
APPENDIX A: TARGET SPECIES LIST.....	41
APPENDIX B: TARGET ORGANISM AVERAGE ABUNDANCES.....	43

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.
- Sir. Bandoy Tio Jr., Secretary of San Francisco.
- Barangay Captain Joy Amplayo and Barangay Council of Cuasi
- 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; Maryann Watson, Jack Walton, Darienne Lancaster, Dan Bocharnikov, Jay Ann Quiliste, Jesse Lou Tinapay, Angelie Cabales, Jose Ydel, Danielle Contrada, Jan Japay, Dominic Revell, Camille De Castro and Gareth Turner.

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
LWR	: Length-Weight Relationships
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
SI	: Silt
SP	: Sponge
UVC	: Underwater Visual Census

Coral Cay Conservation

Initially founded in 1986, CCC is an internationally renowned, not for profit 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 fish 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.

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; Solan-Fernandez *et al.*, 2012), 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 *et al.*, 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 increased fish production. This 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.

Larval and fish dispersal

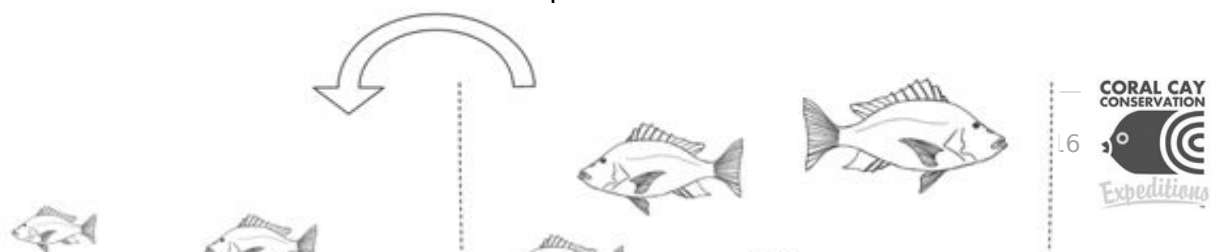


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to 'overspill', increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

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 on non-apparent the majority of 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. As a result, juveniles are often removed before they can reach reproductive age or size, 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. 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 with the entire process of protected area establishment. Stakeholders must be consulted about key aspects of the MPA establishment process, such as size and location and directly involved in their management e.g. via community Bantay Dagats (marine guards).

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 92 million citizens live in coastal regions within 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, 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 (Fig. 2). 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 1,640 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 are managed by Local Government Units (LGUs) (DENR-CMMO presentation, March 19th 2013). The case study below highlights the success of two MPAs in the Philippines.

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)

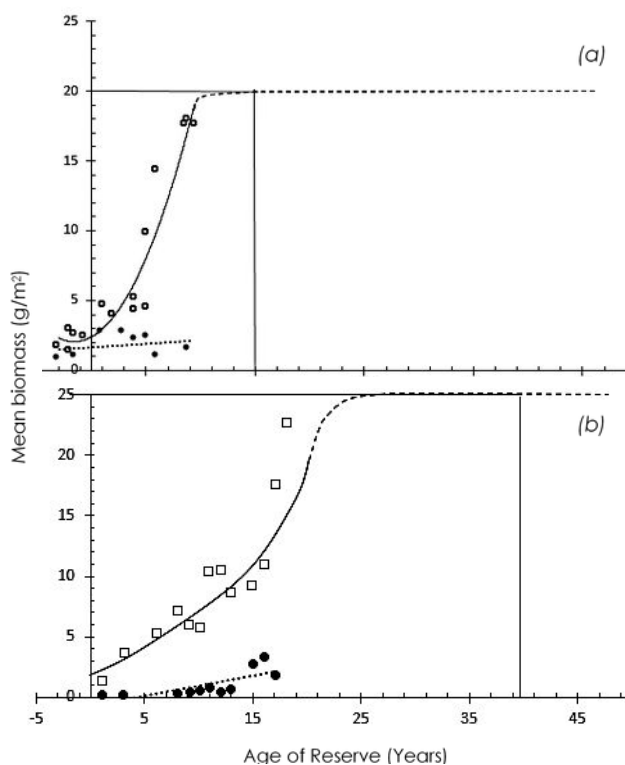


Figure 1. Observed (no-fill markers), control (filled markers) and projected (dashed line) increases in mean biomass (g/m²) of commercially important fish species inside Apo Island (a) and Sumilon Island (b) MPAs. Data and figures adapted from Russ and Alcala (2004).



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. 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 generally works alongside the municipalities with waters lying within Sogod Bay. Currently there are ~25 established MPAs within the bay covering an

estimated 292 hectares. These figures will increase in the coming years as more MPAs are 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 Cuasi, San Francisco: Proposed MPA Site

This survey was requested by Sir Armando Gaviola of PENRMO, Maasin, on behalf of the Protection Area Management Enhancement (PAME) Project to help meet the aforementioned 1998 Fisheries Code (Republic Act 8550) which states that 15% of all municipal waters should be within an MPA. As well as helping to reach the goal of protecting 10% of Philippine waters by 2020 (The Philippine Marine Sanctuary Strategy). The PAME project aims to set up 12-18 new MPAs in the next year (2016) within the LGUs of San Francisco, Liloan, Limasawa, Padre Burgos and Pintuyan.

CCC surveyed the coral reefs located between 50-200m from the shoreline of the Barangay Cuasi, on the eastern side of Sogod Bay south of Napantao. The southern region of the bay from the barangay boundary was chosen as the proposed location for an MPA (Fig. 3). Barangay Cuasi is located in the hills above the survey site, lying next to a set of palm trees and a rocky beach.

Due to the semi-enclosed structure of the bay, the reefs of Cuasi are sheltered from prevailing trade winds coming across the Pacific. However, during the monsoon season of Habagat (June-October), Southwest winds leave the East Coast of Sogod Bay exposed to moderate to high wave action. The Barangay has a population of approximately 300,000 people, all of which live within close proximity to the coastline.

2. Methodology and Data Collection

2.1 Survey Sites

CCC's assessment of the proposed MPA site at Cuasi was conducted between June 18th and July 19th 2016 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 32°C, water temperature was 29.8°C at the surface, and 29.2°C at a depth of 3m and 10m. The mean estimated horizontal visibility throughout the survey was 17.5m.

From discussions with the Barangay Council of Cuasi it was gathered that there is currently a low level of anthropogenic pressure in the area in the form of sewage pollution and the harvest of invertebrates for food. Siltation is occasional during and after heavy rainfall; have experienced landslides and extreme siltation during typhoons.

2.2 Biophysical Survey

Assessment of the proposed MPA site as conducted using an enhanced Reef Check methodology which is widely recognised and used to survey coral reefs around the world. 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 in order to reflect the high biodiversity of the area with the addition of extra target species of fish, coral and invertebrates (Appendix A).

Transects were laid along the reef, parallel to the shore, on a north to south bearing. Three transects were situated at a depth of 6m and three transects were situated at a depth of 12m (Fig. 3, Table 1). Each 100m transect was divided up into four 20m replicates, separated by 5m inter-replicate gaps in which no data was collected. This produced a total surveyed length of 80m. A distance of approximately 100m was left between each whole transect. This survey design allowed for robust statistical analysis of the collected data.



Figure 3. A map indicating the location of the Barangay Cuasi (Black) Coral Cay Conservation (CCC) proposed marine protected area (MPA) coral reef survey, Sogod Bay, Southern Leyte, the Philippines. The survey constituted a total of six 100m transects; three at 6m (Purple); and three at 12m (Pink). The location of the CCC research base is also given (Yellow).

Table 1. Depths (m) and coordinates (UTM) of 100m transects surveyed along the coast of Barangay Cuasi, Sogod Bay, Southern Leyte, the Philippines.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
1	6	740620	1107929
2	6	741204	1107078
3	12	740554	1107971
4	6	741032	1107512
5	12	741170	1107031
6	12	741017	1107466

2.2.1 Fish

Fish diversity and abundance data was collected using Underwater Visual Census. Selected fish families and species recognised as being good indicators of fishing pressure, aquarium collection and reef health were recorded. Three commercially important fish families: Parrotfish (molmol, *Scaridae*); Groupers (lapulapu, *Serranidae*) and Snappers (mayamaya, *Lutjanidae*) and were also classified into the 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 utilising length-weight relationships (LWR) observed in fishes.

Data was 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.

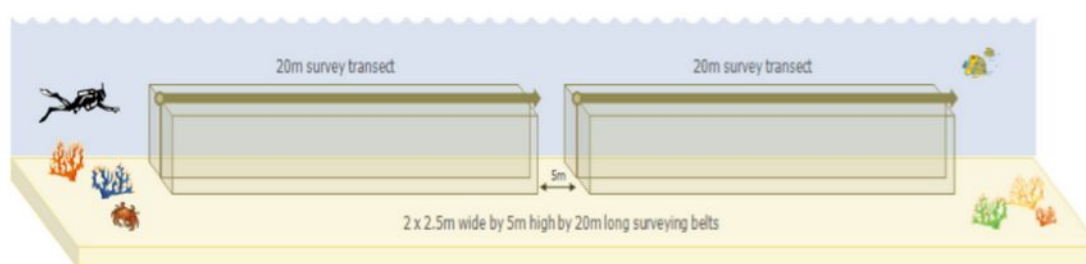
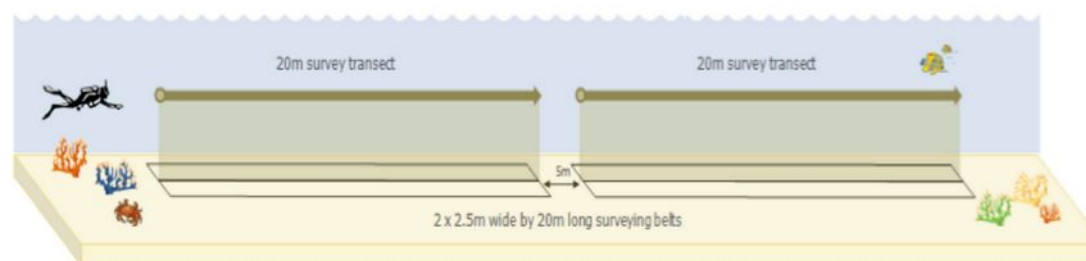


Figure 4. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target fish 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.

2.2.2 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.

Figure 5. 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 invertebrate 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.

2.2.3 Substrate

Benthic diversity was measured by recording living and non-living substrate categories along a 'point-intercept' transect 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).

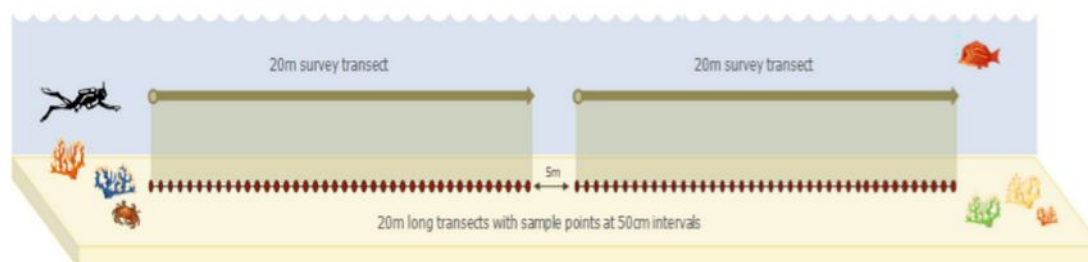


Figure 6. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target 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.

2.2.4 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.

2.3 Data Analysis

Each 20m belt transect was treated as an independent replicate. This produced $n=12$ at 6 metres and $n=12$ at 12 metres. 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 ($p < 0.05$) 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).

Butterflyfish were also 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.

Hard corals were further 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

3.1. Fish

Average total fish abundance per transect was 89.25 ± 8.27 per 500m^3 (Fig. 7). Transect O06 fish abundance was found to be significantly less ($p < 0.05$) than transect O01, O02 and O05 average fish abundance respectively (Fig. 8). Average total fish species richness was 14 ± 0.7 per 500m^3 . Average H' was 2.13 ± 0.09 per 500m^3 and J' was 0.81 ± 0.03 per 500m^3 (Fig. 9). However, no significant differences were found between transects for fish S , H' and J' ($p > 0.05$).

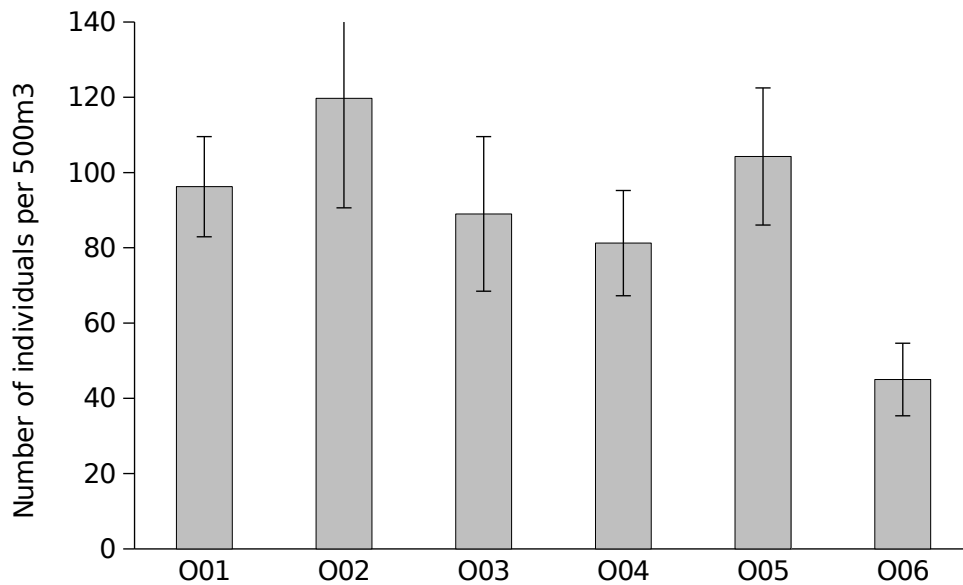


Figure 7. Average total fish abundance per 500m³ with standard error (SE) in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines.

	O 1	O 2	O 3	O 4	O 5	O 6
O 1						+
O 2						+
O 3						
O 4						
O 5						+
O 6	-	-			-	

Figure 8. Matrix showing significant differences in total fish abundance values per 500m³ across all Cuasi survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Figure 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 Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines.

Mean total commercial fish abundance was 10 ± 1.59 per 500m^3 , while transect 004 yielded the highest number of commercially important fish with an average of 14.75 ± 4.05 individuals per 500m^3 (Fig. 10). Transect 001 commercial fish abundance was significantly higher ($p = <0.05$) than transect 006 commercial fish abundance (Fig. 11). Average Parrotfish, Grouper and Snapper abundance was 8.92 ± 1.49 , 0.17 ± 0.22 , and 0.38 ± 0.12 per 500m^3 , respectively (Fig. 12).

Of the Parrotfish, Grouper and Snapper observed in Cuasi, all were small in size. The majority were between 0-10 cm in length (2.25 ± 0.48 per 500m^3) (Fig. 13). No individuals longer than 40cm were recorded on any transects.

Average total commercial fish biomass was $0.06\text{kg} \pm 0.04$ per 500m^3 (Fig. 14). Parrotfish held the greatest biomass with $0.13\text{kg} \pm 0.10$ per 500m^3 , followed by Snapper with $0.04\text{kg} \pm 0.04$ per 500m^3 , and grouper with $0.01\text{kg} \pm 0.01$ per 500m^3 (Fig. 15).

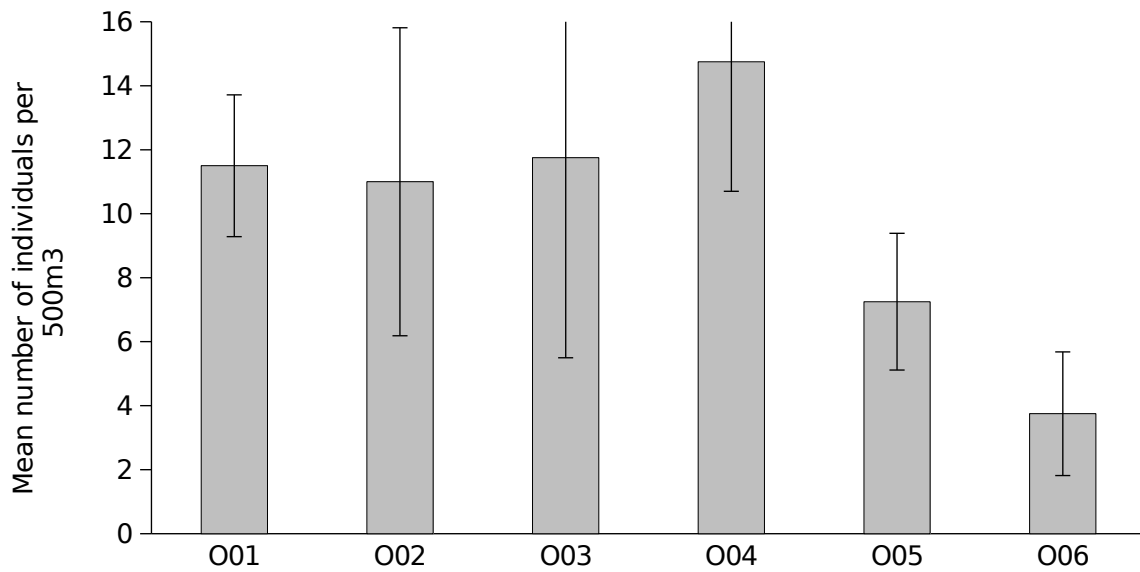


Figure 10. Average abundance of commercially important fish species observed per 500m³ with standard error in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines

	O1	O2	O3	O4	O5	O6
O1						+
O2						
O3						
O4						
O5						
O6	-					

Figure 11. Matrix showing significant differences in mean commercial fish abundance per 500m³ across all Cuasi survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

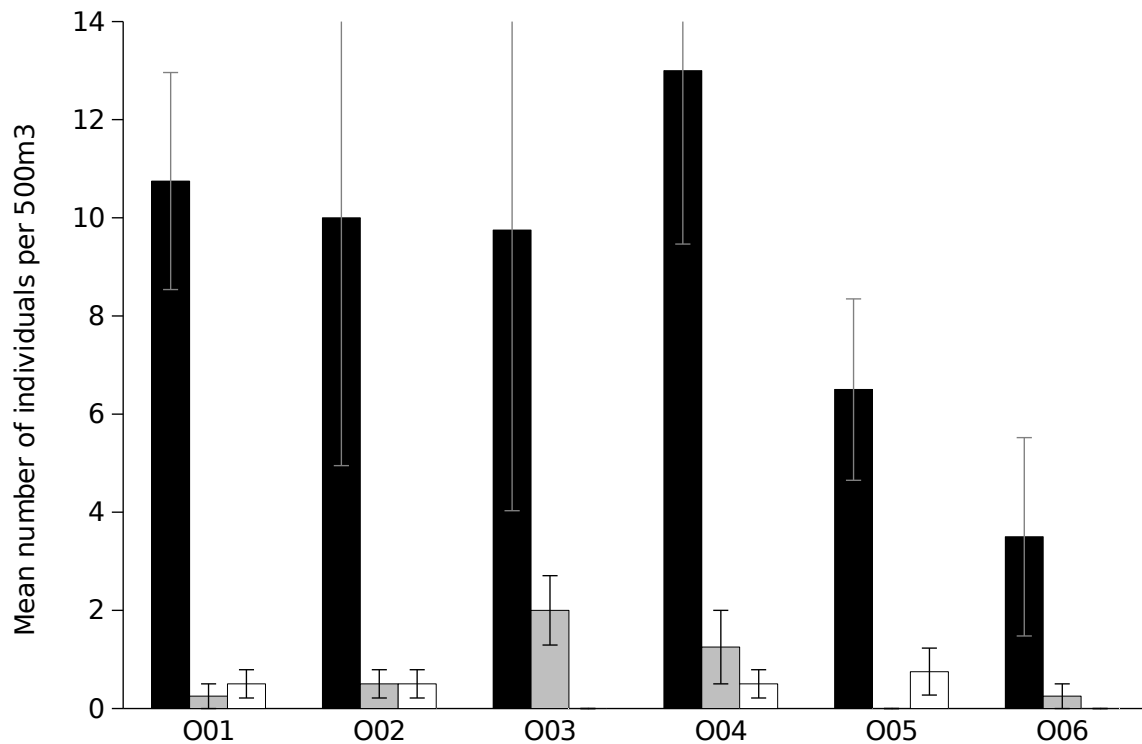


Figure 12. Average abundance of Parrotfish, Grouper and Snapper observed per 500m³ with standard error in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines. Black = Parrotfish, Grey = Grouper, White = Snapper.

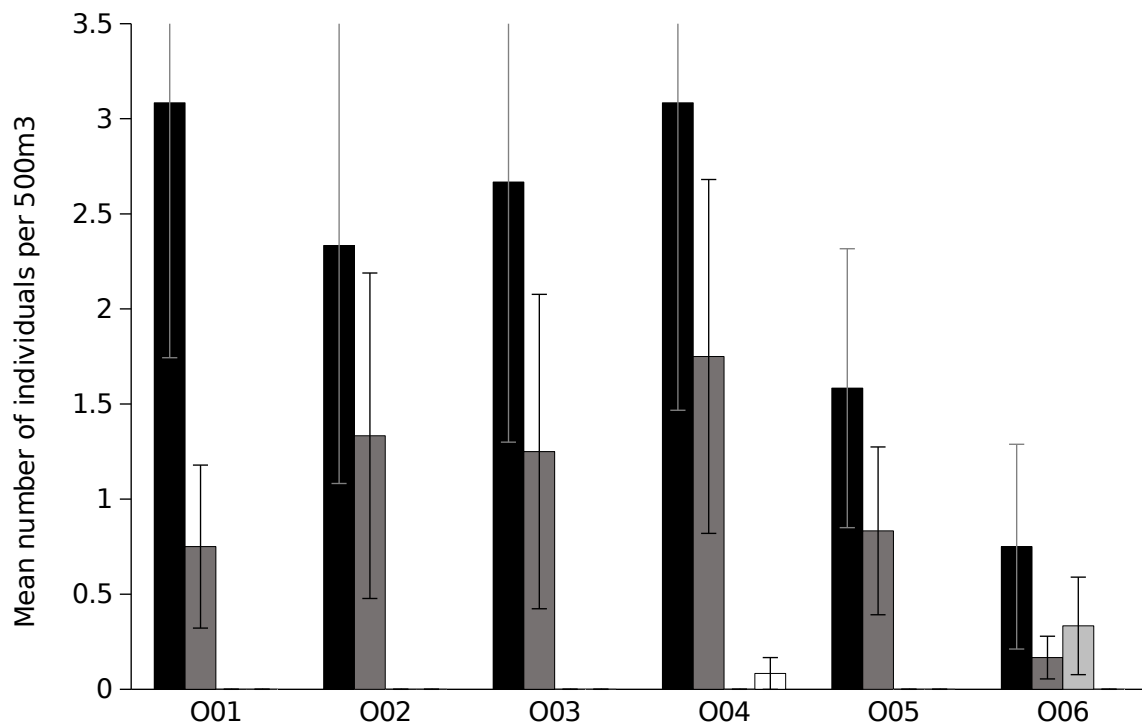
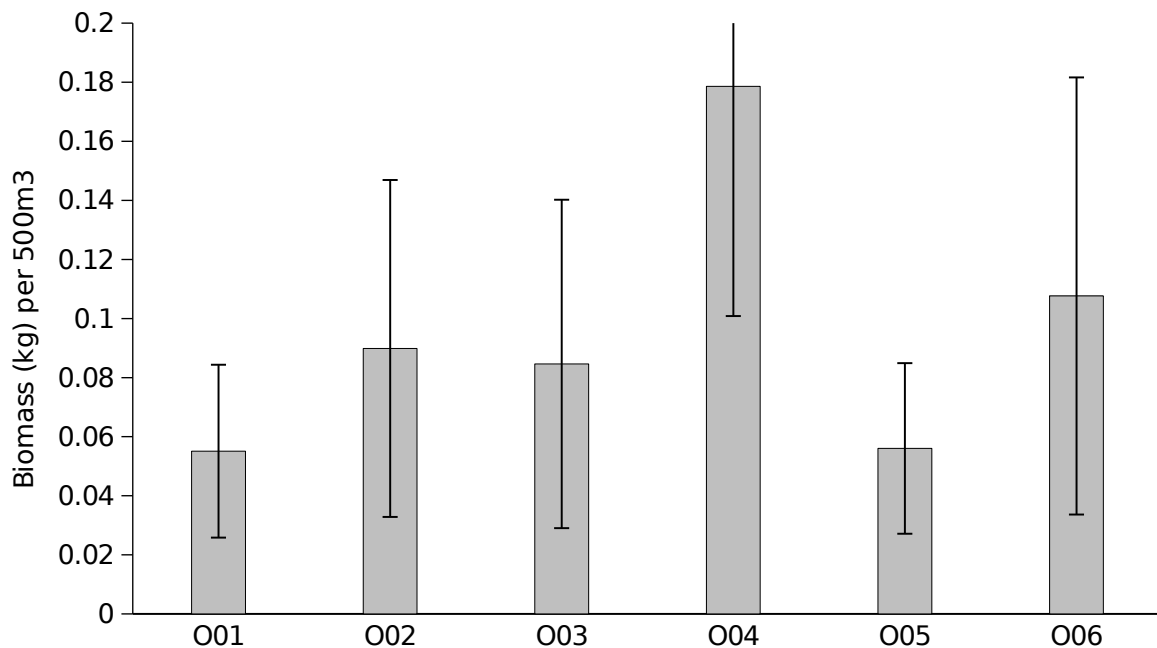


Figure 13. Cumulative abundance of Parrotfish, Grouper and Snapper in size categories 0-10cm, 11-20cm, 21-30cm and 31-40cm across six transects per 500m³ with standard error in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines. Black = 0 - 10cm, Dark grey = 11-20cm, Grey = 21-30cm, White = 30-40cm. Larger size categories are excluded as no individuals greater than 40cms were recorded.

Figure 14. Average commercial fish biomass per 500m³ with standard error in Cuasi proposed marine



protected area (MPA), Southern Leyte, the Philippines.

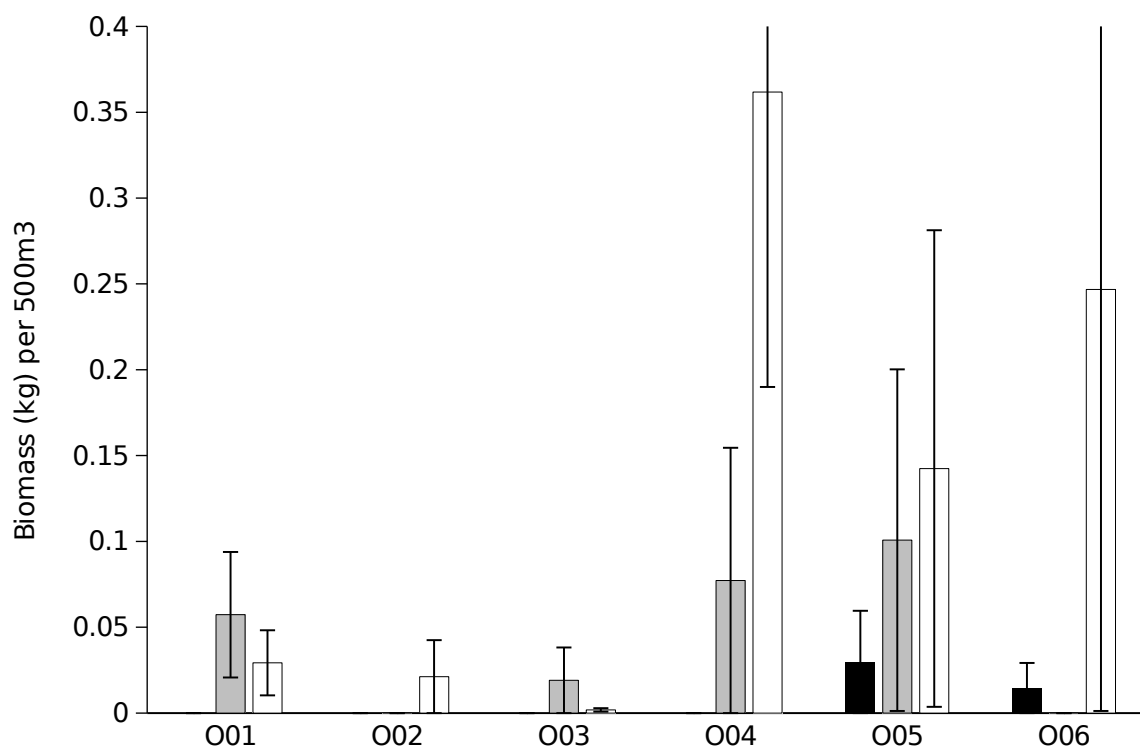


Figure 15. Average commercial fish biomass by target family (Grouper, Snapper, Parrotfish) per 500m³ with standard error in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines. Black = Grouper, Grey = Snapper, White = Parrotfish.

Other commercially important fish species including *Bolbometapon muricatum* (Bumphead Parrotfish), *Cheilinus undulates* (Humphead Wrasse) *Cromileptes*

altivelis (Barramundi Cod), or *Plectorrhincus sp.*(Sweetlips) were completely absent from the survey area.

Average butterflyfish abundance per transect was 7.04 ± 1.18 per 500m^3 (Fig. 16). Transect O02, had significantly higher ($p = <0.05$) butterflyfish abundance than transects O01, O03, O04 and O06, while transect O05 was shown to have a significantly greater average number of butterflyfish than transects O01, O04 and O06 ($p = <0.05$) (Fig. 17). Average total Butterflyfish S was 1.92 ± 0.22 per 500m^3 , average diversity H' was 0.5 ± 0.08 per 500m^3 and J' was 0.54 ± 0.10 per 500m^3 (Fig. 18). However, differences between transects for S , H' and J' were found not to be significant ($p = >0.05$). Average obligate corallivore Butterflyfish abundance per transect was 2.9 ± 1.04 per 500m^3 , and average facultative corallivore Butterflyfish abundance per transect was 0.05 ± 0.03 per 500m^3 (Fig. 19).

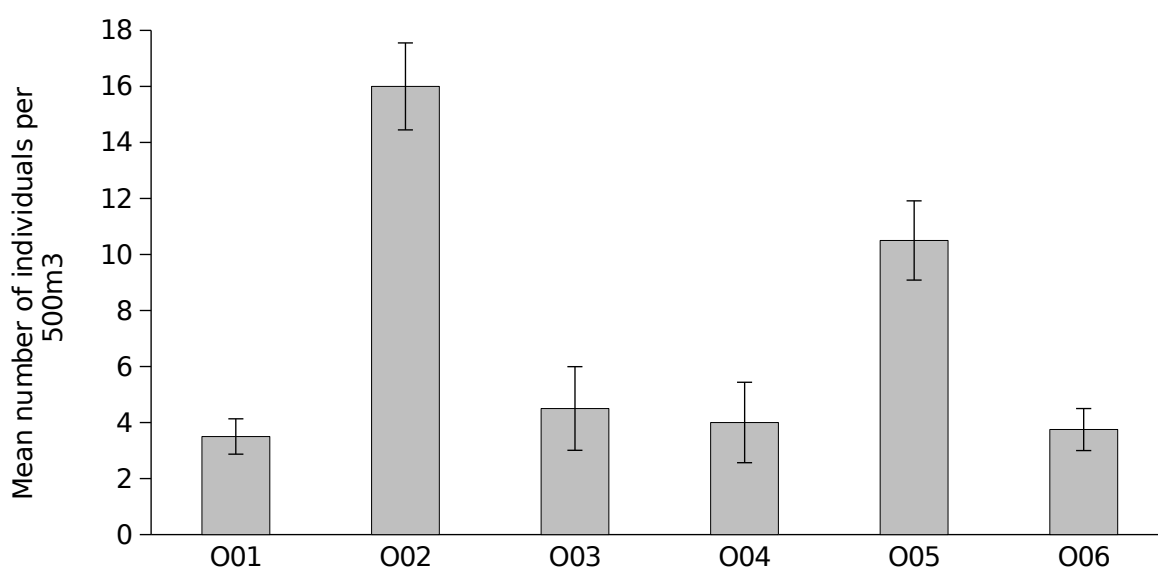


Figure 16. Average total Butterflyfish abundance per 500m^3 with standard error (SE) in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines.

	O 1	O 2	O 3	O 4	O 5	O 6
O 1		-			-	
O 2	+		+	+		+
O 3		-				
O 4		-			-	
O 5	+			+		+
O 6		-			-	

Figure 17. Matrix showing significant differences in mean total butterflyfish abundance per 500m^3 across all Cuasi survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that

abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

Figure 18. Butterflyfish Species Richness (i.e. number of species), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) with standard error in Cuasi proposed MPA, Southern Leyte, the Philippines.

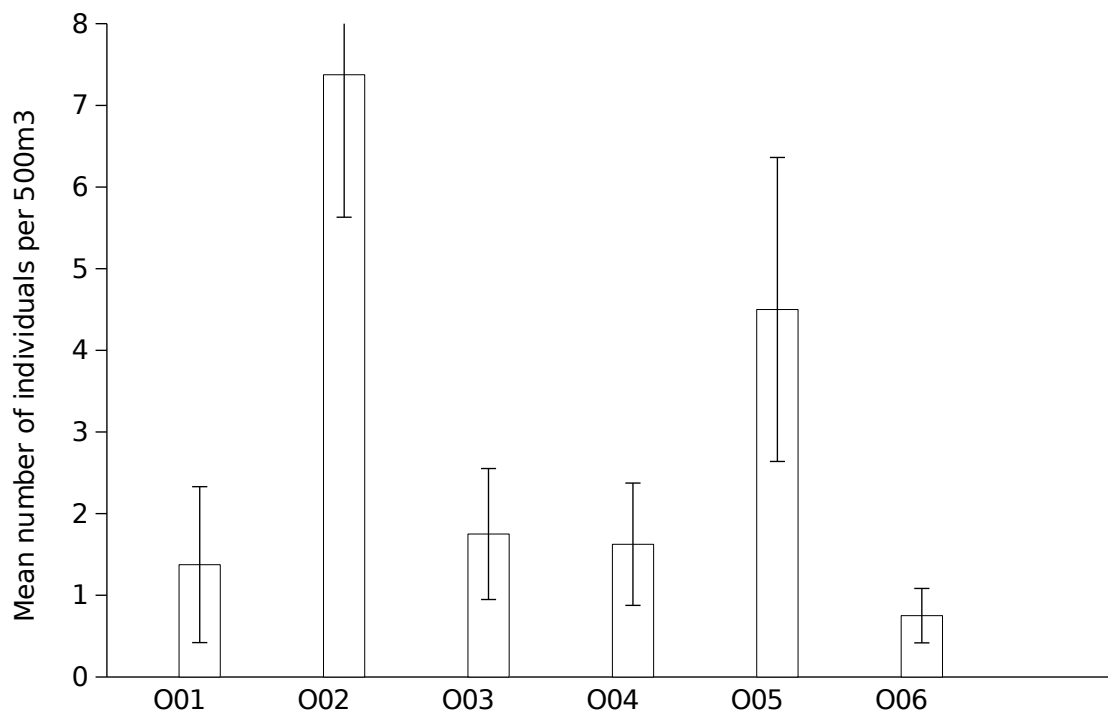


Figure 19. Average facultative corallivore and obligate corallivore Butterflyfish abundance with standard error per 500m³ in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines. Grey = Facultative corallivore, White = Obligate corallivore.

3.3 Invertebrates

Average invertebrate abundance across all transects was 108.25 ± 11.32 individuals per 100m² (Fig. 20). Transects O01 and O04 had significantly higher ($p = <0.05$) invertebrate abundance than both transect O05 and O06 (Fig. 21). Transect O06 also showed significantly fewer invertebrates than O02 and O05, while O01 showed significantly higher invertebrate abundances than O02 ($p = <0.05$). On average, brittle stars ($n = 26.13 \pm 3.29$), other gastropods ($n = 21.92 \pm 3.97$), and feather stars ($n = 16.25 \pm 3.67$), dominated transects (Appendix B).

Average invertebrate S was 11 ± 1 per 100m², average invertebrate H' was 1.74 ± 0.08 per 100m², and J' was 0.77 ± 0.01 per 100m² (Fig. 22). Transect O01 and O04 had significantly higher species richness and diversity than O03 ($p = <0.05$), while O05 also exhibited a significantly higher diversity than transect O03 also ($p = <0.05$) (Fig. 23).

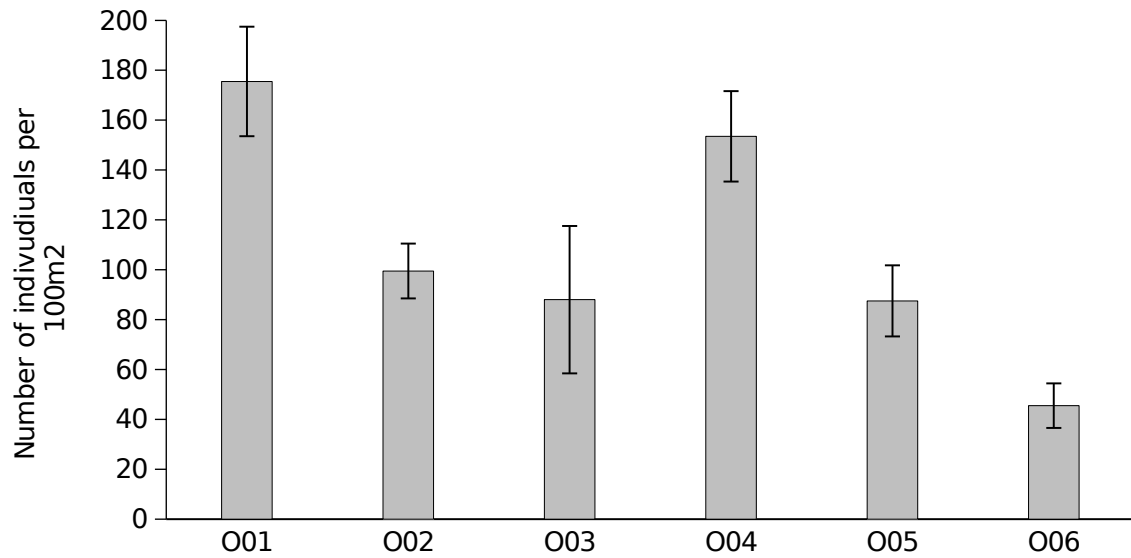


Figure 20. Average invertebrate abundance at each transect per 100m² with standard error in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines.

	O 1	O 2	O 3	O 4	O 5	O 6
O 1		+			+	+
O 2	-					+
O 3						
O 4					+	+
O 5	-			-		+
O 6	-	-		-	-	

Figure 21. Matrix showing significant differences in invertebrate abundance per 100m² across all Cuasi survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Figure 22. Invertebrate Species Richness (i.e. number of species), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) per 100m² with standard error in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines.

a)

	O1	O2	O3	O4	O5	O6
O1			+			
O2						
O3	-			-		
O4			+			
O5						
O6						

b)

	O1	O2	O3	O4	O5	O6
O1			+			
O2						
O3	-			-	-	
O4			+			
O5			+			
O6						

Figure 23. Matrix showing significant differences in invertebrate species richness (a), and Shannon's Diversity Index (b), per 100m² across all Cuasi survey sites. 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.

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. 17 Giant Clams were recorded in survey areas with no individuals larger than 40cm. 2 Crown of Thorns Starfish (CoTs, *Acanthaster planci*) were recorded within the survey area.

3.4 Substrates

The most prevalent substrate was hard coral, covering an average of $37.5\% \pm 3.5$ per 20m. This was followed by rock with $24.27\% \pm 2.62$ per 20m, and sand with $18.65\% \pm 4.46$ per 20m (Fig. 24). Hard coral was significantly ($p = <0.05$) more abundant on transect O01 than on all but transect O05, while transect O01 and O05 were also found to show significantly higher hard coral cover than that of transect O06 (Fig. 25a). Sponges were significantly more abundant on transect O03 and O04 compared with transect O01 ($p = <0.05$) (Fig. 25b). Transects O01, O02 and O04 showed significantly higher rock coverage than O05 ($p = <0.05$), O04 and O01 were significantly higher than O03, while O01 rock recordings were

greater than all transects apart from O04 ($p = <0.05$) (Fig. 25c). Rubble findings for transect O06 were significantly higher than those found on O01 and O02 transects ($p = <0.05$) (Fig. 25d). The same result was found for sand composition, however O05 was also found to have significantly higher sand coverage than O01 and O02 ($p = <0.05$) (Fig. 25e). Finally, NIA was significantly more abundant on transect O01 compared to transect O02 and O05 ($p = <0.05$) (Fig. 25f). There were no significant differences ($p = >0.05$) across transects for other substrate categories.

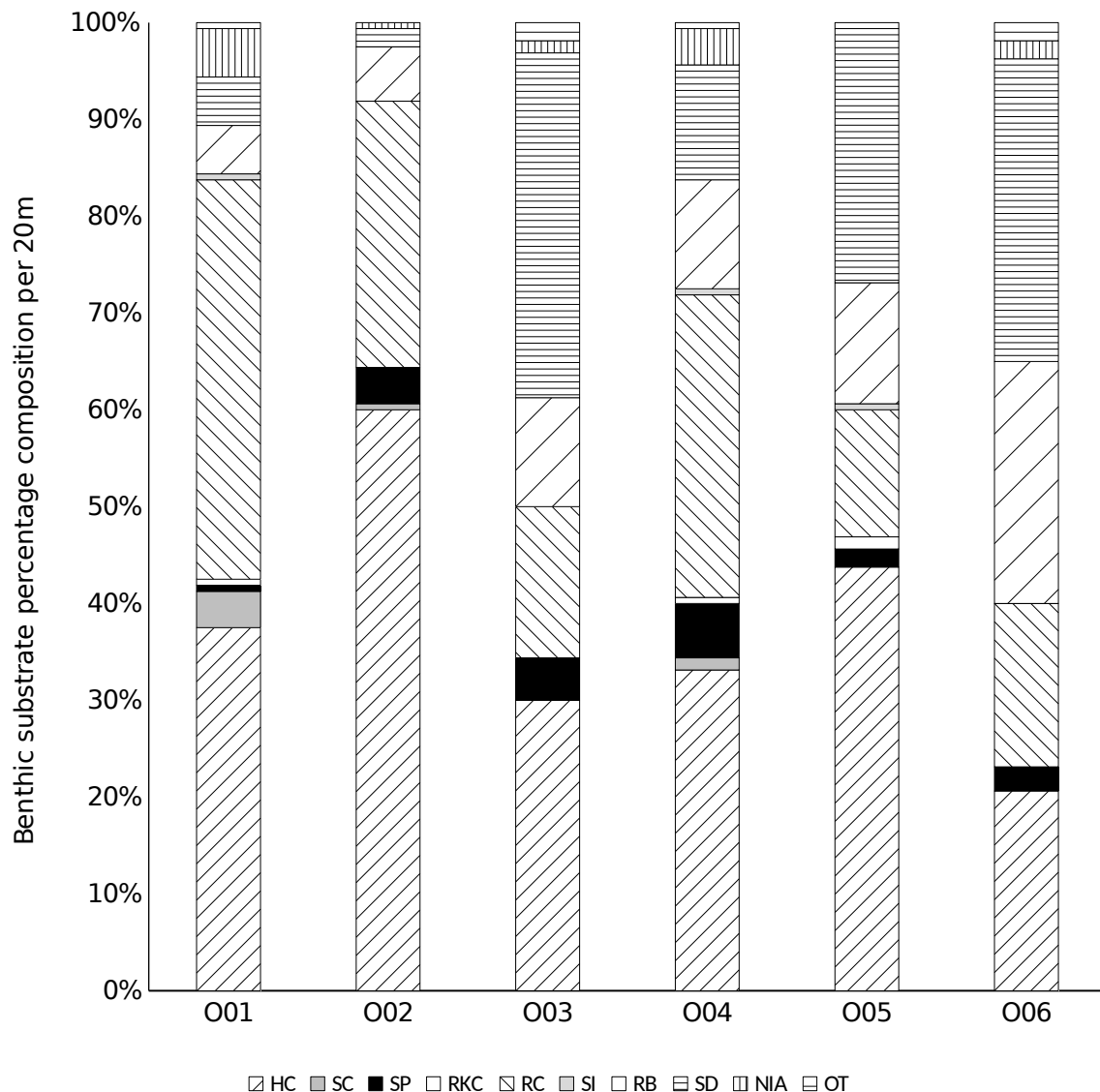


Figure 24. Mean substrate percentage cover at each transect in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines. HC - Hard coral; SC - Soft coral; SP - Sponge; RKC - Recently killed coral; RC - Rock; RB - Rubble; SD - Sand; SI - Silt; NIA - Nutrient indicator algae; OT - Other living organisms.

a)

O	O	O	O	O	O
1	2	3	4	5	6

O		-				+
1						

0	+		+	+		+
2		-				
0						
3						
0						
4						
0						+
5						
0	-	-			-	
6						

c)

	O1	O2	O3	O4	O5	O6
O1		+	+		+	+
O2	-				+	
O3	-			-		
O4			+		+	
O5	-	-		-		
O6	-					

b)

O1	O2	O3	O4	O5	O6

e)

	O1	O2	O3	O4	O5	O6
O1					-	-
O2					-	-
O3						
O4						
O5	+	+				
O6	+	+				

0			-	-		
1						
0						
2						
0	+					
3						
0	+					
4						
0						
5						
0						
6						

d)

	O1	O2	O3	O4	O5	O6
O1						-
O2						-
O3						
O4						
O5						
O6	+	+				

f)

	O1	O2	O3	O4	O5	O6
O1		+			+	
O2	-					
O3						
O4						
O5	-					
O6						

Figure 25. Matrix showing significant differences in substrate abundance per 20m across all survey sites. Substrate category: a) hard coral, b) sponge, c) rock, d) rubble, e) sand, f) nutrient indicator algae. 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.

More specifically, non-*Acropora* branching corals dominated the proposed MPA site with an average cover of $23.4\% \pm 3.28$ per 20m (Fig. 26). These were followed by non-*Acropora* massive corals with $15.95\% \pm 3.18$ per 20m coverage, non-*Acropora* encrusting corals with $14\% \pm 2.72$ per 20m, and non-*Acropora* submassive corals with $13.22\% \pm 2.75$ per 20m (Fig. 26, Appendix B). However,

Acropora branching species only accounted for $6.35\% \pm 2.3$ per 20m of the hard coral coverage. There were significantly ($p = <0.05$) more competitor corals ($52.25\% \pm 2.93$ per 20m) compared to both stress tolerant corals ($30.63\% \pm 2.92$ per 20m) and disturbance adapted fast growing corals ($8.95\% \pm 1.9$ per 20m) at the proposed MPA site (Fig. 27).

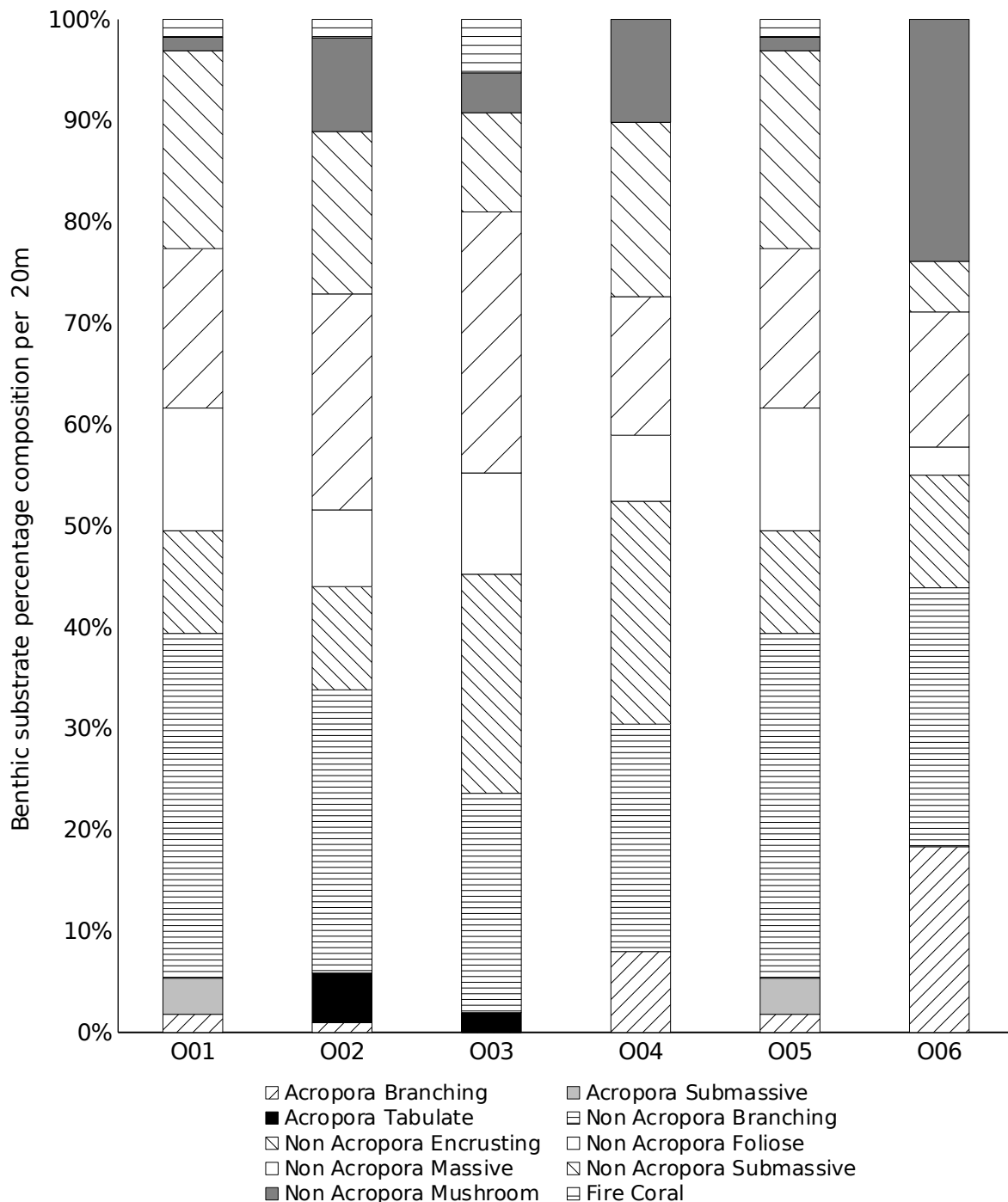


Figure 26. Average percent cover per 20m hard coral by classification per transect in Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines. *Acropora* encrusting digitate, blue (*Heliopora* sp.) and organ pipe coral (*Tubipora* sp.) were not recorded on any transects and are excluded from the figure.

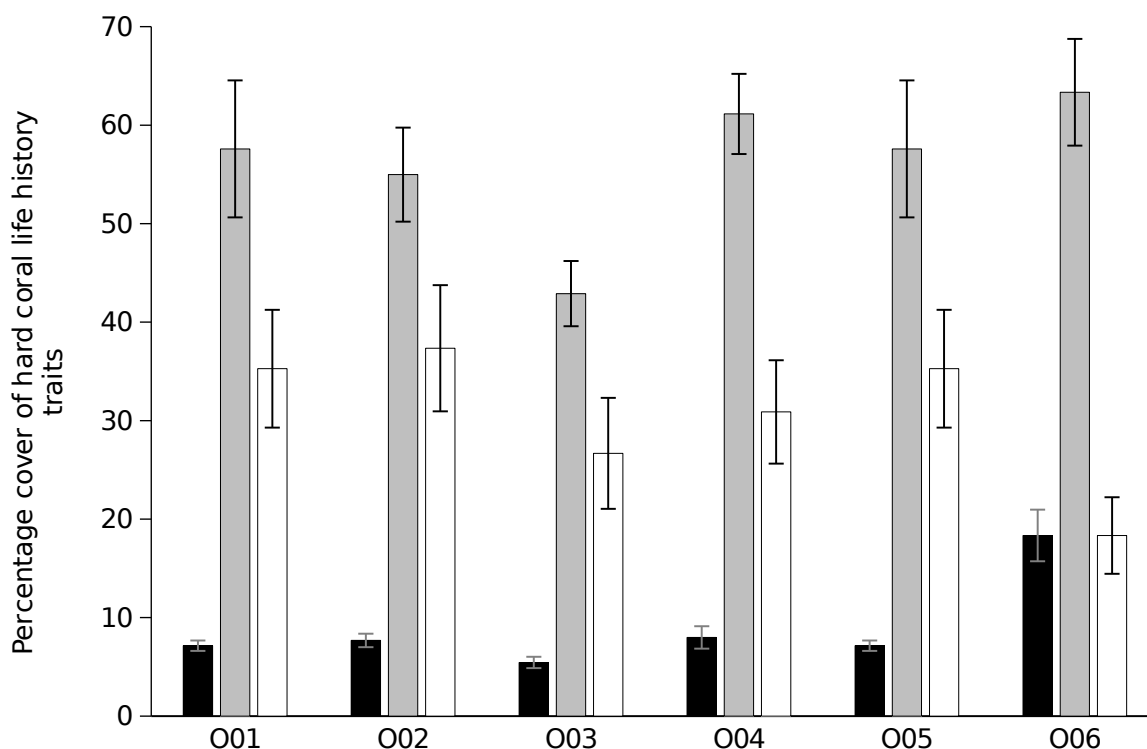


Figure 27. Average percentage cover of coral types per 20m with Standard Error on the Cuasi proposed marine protected area (MPA), Southern Leyte, the Philippines. Black = Disturbance adapted fast growing corals (i.e. *Acropora* sp., Fire coral (*Millepora* sp.), Blue coral (*Heliopora* sp.); Grey = Competitor 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).

3.2 Anthropogenic Impacts

The reefs of Barangay Cuasi showed primarily low levels of anthropogenic impact. Tourism was reported by barangay officials as very low within the area, with no recreational diving reported, commercial fishing activities were reported as low. Artisanal fishing and invertebrate harvesting for food and sales was also reported to be low in the region. There is no reported cyanide, blast, or fishing to provide the LRFFT in the area and pollution was reported as low.

General trash was recorded 14 times during the survey, with 41% of the surveyed area showing no impact, 29% showing low impact, 16% showing moderate impact and 8% exhibiting high impact. Fishing related trash (e.g. nets, lines) was recorded 13 times with 46% of the surveyed area showing no impact, 25% showing low impact, 13% showing moderate impact and 16% showing high impact. There were no obvious signs of boat, anchor, or dynamite damage. Undetermined coral damage was observed 5 times with 79% of the surveyed area showing no impact, 13% showing moderate impact and 8% showings high impact.

Coral bleaching was recorded on all but one transect, however, on average less than 1% of the population was affected with an average of $23.87\% \pm 6.9$ bleaching on individual colonies. White band disease was recorded on four occasions, with an average covering of 10.9 % of the affected coral colonies; one colony in particular was found to have as much as half of its colony infected. No other incidents of black band or other coral diseases were recorded.

4. Visual Assessment

Images taken by CCC volunteers on the reefs of Cuasi.



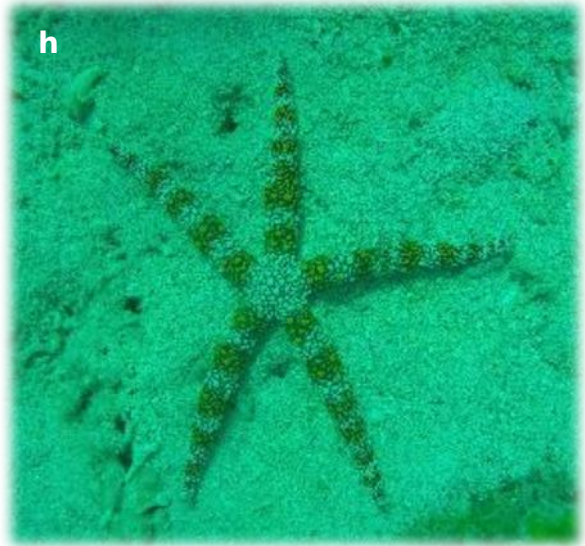


Figure 28. a) *Plerogyra sinuosa* and *Goniapora lobata* colonies surrounded by damsel fish; b); Black-saddled toby (*Canthigaster valentini*); c) One-spot rabbitfishes (*Siganus unimaculatus*); d) Bluestreak cleaner wrasse (*Labroides dimidiatus*) amongst a colony of foliose *Turbinaria* sp.; e) discarded fishing gear; f) coral bleaching; g) a pair of Redfin butterflyfish (*Chaetodon lunulatus*) and a Lined butterflyfish (*Chaetodon lineolatus*); h) Friant's sea star (*Nardoa frianti*); i) an array of Cuasi's hard coral lifeforms.

5. Discussion

Surveys conducted by CCC highlighted some trends that are of concern, indicating activities such as overfishing of commercial species, which require consideration to ensure the preservation and restoration of the coral reef in Barangay Cuasi. However, when referring to total fish abundance and sea floor substrate distribution, Cuasi's proposed site shows signs of being a healthy reef ecosystem which would benefit from MPA protection. In this section the trends observed in the data are discussed and recommendations for future management are provided.

5.1. Fish

In comparison to the Cuasi proposed MPA, the MPA in Napantao, San Francisco - surveyed in 2015, conferred a higher average fish abundance (93.33 ± 19.03 per 500m^3) (Lancaster *et al.*, 2016). The Napantao MPA, however, is known locally as a popular dive/snorkel site because of its fish diversity and healthy reef ecosystem. Furthermore, the Napantao MPA has been in place for twenty years, which may contribute to its greater fish abundances (Edgar *et al.*, 2014). As such, the fish abundances found at Cuasi is still indicative of a relatively healthy reef ecosystem that could show marked improvements with efficient and sustained protection (Russ and Alcala, 2004). Additionally, the proposed Cuasi site showed moderate species richness and diversity, yet both index values were lower than those at the previously mentioned Napantao 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), where a representative decrease in S is thought to indicate both acute and chronic anthropogenic stress (Morris *et al.*, 2014). Protecting the Cuasi proposed MPA site could help to increase overall fish species richness and diversity, enabling the area to become more resistant to serious reef stressors and environmental fluctuations. Additionally, the advent of increased fish species diversity would likely improve the reef's desirability to recreational divers and consequently contribute to the Southern Leyte tourism sector.

Commercial fish abundance at the proposed site was low. Commercially important Grouper, Snapper, and Parrotfish were rare and, when present, small in size. These trends are indicative of overfishing. The small size of commercially important fish at the site suggests most fish are sexually immature, making it difficult for important fish populations to recover, especially without protection and with continued fishing pressure. Grouper, along with other commercially important reef fish families such as Snappers, are often 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 (Collins *et al.*, 1998). Understanding the life history traits

outlined above, it is evident that any recovery of these species would require site protection and a stop or extreme reduction in fishing pressure.

There were no observations of other commercially important species including *Bolbometopon muricatum* (Bumphead Parrotfish), *Cheilinus undulatus* (Humphead Wrasse), *Cromileptes altivelis* (Barramundi Cod), or *Plectorhinchus sp.* (Sweetlips). This supports the suggestion that these desirable food-fish species have been overfished in the area. The Humphead Wrasse is the most sought after and high priced fish in the LRFFT, with one large individual capable of selling for as much as \$10,000 USD (Lau and Parry-Jones, 1999).

Butterflyfish are often used as indicators of reef health and resilience through their species richness (S) and species diversity (H') (Bozec *et al.*, 2005). Studies have shown a correlation between Butterflyfish species richness, total fish species richness, and coral cover (Bozec *et al.*, 2005). Moreover, 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 (Bozec *et al.*, 2005). In Cuasi, the low to moderate abundance, species richness, and diversity of butterflyfish, compared to findings within the Napantao MPA, indicate that, while the proposed area is in moderate health, there is room for ecological improvement through adequate protection. Interestingly, Cuasi exhibited a higher butterflyfish species richness, S , H' and J' than findings recorded just outside the Napantao MPA (Lancaster *et al.*, 2016). This is a further indication that with an appropriately implemented MPA, the reef health at Cuasi could improve markedly over time. The dominance of the obligate corallivorous species *Chaetodon baronessa* (Eastern Triangle) and *Chaetodon lunulatus* (Redfin) may suggest there is enough scleractinian hard coral to support fish communities that hold a dietary dependence upon hard coral (Stella *et al.*, 2011). A study of the Australian Great Barrier Reef found that, after extensive (>90%) bleaching related coral damage, obligate corallivore Butterflyfish abundance showed marked declines (Pratchett *et al.*, 2006). *Chaetodon baronessa* Butterflyfish are known to feed preferentially upon *Acropora hyacinthus*, an *Acropora* tabulate hard coral, however, they will feed upon many other coral species in the absence of *Acropora hyacinthus* (Berumen, 2006). The relative scarcity of *Acropora sp.* on the reefs of Cuasi, when compared with non-*Acropora* growth forms, suggest that corallivorous Butterflyfish are likely expanding their coral diet to include species such as *Porites sp.*, another preferred coral for *Chaetodon lunulatus* in the absence of many *Acropora* species (Berumen, 2006). If *Acropora sp.* exhibited increases with MPA protection it is likely that corallivorous Butterflyfish populations would also increase. As a result, it is possible the data obtained from UVC and PIT methodologies are exhibiting obligate Chaetodontids in an abundance lag-phase, of which temporal data will demonstrate a decrease in Chaetodontid abundance following a decrease in their respective preferred prey. Contrastingly, the high abundances of obligate corallivores in combination with poor prey availability is supported by results obtained by Berumen, Pratchett and McCormick (2005). Ecological evidence supports the results, suggesting that the *C. baronessa* and *C. lunulatus* individuals recorded were exhibiting a reduced physical condition and therefore a reduction in fitness, having implications for future populations and their respective recruitment. Monitoring of these Butterflyfish and hard coral

species should be continued to measure any population fluctuations, which could indicate failing or improving reef health.

5.2 Invertebrates

The proposed MPA site showed similar total invertebrate abundances as those recorded in the recent Napantao MPA monitoring surveys, implying to a degree that the Cuasi's invertebrate populations are in a positive state (Lancaster *et al.*, 2016). Many invertebrates feed preferentially upon hard coral species, particularly *Pocillopora*, *Acropora* and *Stylophora* species (Stella *et al.*, 2011). *Pocillopora* and *Stylophora* species are typically grouped into lifeform non-*Acropora* submassive, which covered ~13% of the area surveyed. However, *Acropora* species in this region of the Philippines typically belong to the lifeform *Acropora* branching, which covered only ~6% of the surveyed area. An increase in *Acropora* branching species within the proposed MPA may improve invertebrate abundance and diversity in the region.

A worrying, though locally common, 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 moving, are particularly vulnerable to over exploitation.

Prickly redfish, greenfish and pinkfish are all edible species of sea cucumber. Their presence on the reef is ecologically significant because they filter and digest sand, producing pellets that aid in reef formation. However, they are easily extracted from the reef by free divers or fishers at low tide during gleaning activities and, as such, are regularly targeted by humans as a food substance (Hodgson and Liebeler, 2002).

Triton's trumpets are targeted by humans because of their high value as a curios item and are easily removed from a reef due their conspicuous appearance and large size. They are an ecologically important invertebrate species on Indo-Pacific reefs as one of the very few predators of CoTs. If top predators such as the Triton's Trumpet are removed from an ecosystem, the risk of a CoTs outbreak is increased.

Giant Clams, another important commercial species, were observed on the surveys but in low numbers and small sizes (<40cm). These results indicate that extraction pressure may be high in the area. Despite low abundance however, the presence of small giant clam may indicate slow but continued recruitment of new individuals at the site.

CoTs were recorded in relatively low in the proposed MPA. This promising finding suggests that the reef ecosystem is ecologically resilient enough to withstand the small scale predation by CoTs, while also keeping population numbers to a minimum. This seastar is a voracious predator of corals and at high levels of abundance can cause catastrophic damage to reef communities. They can predate on live coral at such a fast rate that they can trigger phase shifts from healthy, coral-dominated reefs to algae-dominated reefs, with little habitat for fish. At low abundance levels CoTs are a natural part 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 help control the spread of disease and increase competition between coral species leading to higher diversity. While CoTs abundance levels were found to be low on Cuasi's proposed MPA site, frequent monitoring and removal of individuals, if populations rise, should be considered a high priority. As

after a reef has been exposed to an outbreak population of CoTs it can take in excess of 15 years to recover, depending upon the reef's herbivore population and coral larval supply (CRC Reef Research Centre, 2003).

5.3 Substrates

The proposed MPA was dominated by hard coral; a very promising indication of the reefs healthy state. The presence of hard coral is essential as it provides the main habitat utilised by fish and invertebrates for shelter, spawning and food. Research implemented by Reef Check between 1997 and 2001 shows that coral reef systems throughout the Indo-Pacific averaged ~40% hard coral cover (Hodgson and Liebler, 2002), which is not too dissimilar to the coverage found in Cuasi. The next most prevalent substrate was rock, which insured that over 60% of Cuasi's proposed MPA is covered by either hard coral or rock. This is a positive sign for future coral recruitment as coral requires a hard substrate on which to settle and grow. Furthermore, indicators of coral health including nutrient indicator algae, evidence of recently killed coral, bleaching and coral disease were observed in only a few localised instances or were totally absent from the survey area. Thus, in terms of hard corals, the proposed site would make a promising MPA with plenty of rock for more coral attachment and a good, pre-established coral base to provide juvenile recruits. Protecting the Cuasi site from fishing pressure, dynamite, boat damage, and potential CoTs outbreaks could be an important step towards sustaining and improving the high hard coral cover in the region.

The significantly higher abundance of competitor corals like non-*Acropora* branching, foliose and encrusting at the proposed MPA site may suggest that the area experiences lower levels of anthropogenic stressors (e.g. anchoring, fishing) or natural stressors (e.g. storms, sedimentation) (Edinger and Risk, 2000). The complex structure of many non-*Acropora* branching and foliose species, provide a basis for increased fauna and community structure. It is therefore encouraging to see such a high percentage of these coral types dominating the region, and highlights the importance of preserving Cuasi's proposed MPA. Stress tolerant corals, as the name suggests, can survive in harsher conditions than many branching and foliose corals, which typically break and die more easily. The moderate coverage of stress tolerant corals and low coverage of fast growing corals suggests that Cuasi is only occasionally subjected to environmental and anthropogenic stressors. Overall, the proposed Cuasi MPA exhibits a high hard coral diversity, capable of supporting a myriad of marine organisms, owing to increased structural complexity. Importantly, it has been shown that a greater diversity in coral populations is ideal, as there is a link between greater coral diversity and increased fish and invertebrate diversity (Edinger and Risk, 2000).

5.4 Anthropogenic Impacts

The coral reefs in Cuasi show low levels of human impacts in terms of trash and coral damage, however, the low abundances and small sizes, of commercial fish in particular, suggest historic overfishing has impacted the reef environment. Furthermore, the relatively small amounts of fishing related and general trash, and coral damage are still a concern. If the reef were protected these levels may diminish or disappear over time. The presence of trash tends to deter divers from visiting or returning to a site, therefore to improve the site for recreational diving trash levels should be reduced.

Improper disposal of general waste can negatively affect the health of reefs by smothering corals, and potentially poisoning or choking marine life that eat these items. Education about the consequences of improper waste disposal is extremely important and local communities require the right facilities to safely dispose of their waste. The installation of covered bins throughout the barangay and above the high tide line of its beaches would prevent people from dropping their waste where it will eventually end up in the sea. It is essential that any bins provided to the community are emptied regularly by the municipality's waste disposal team to encourage their continued use.

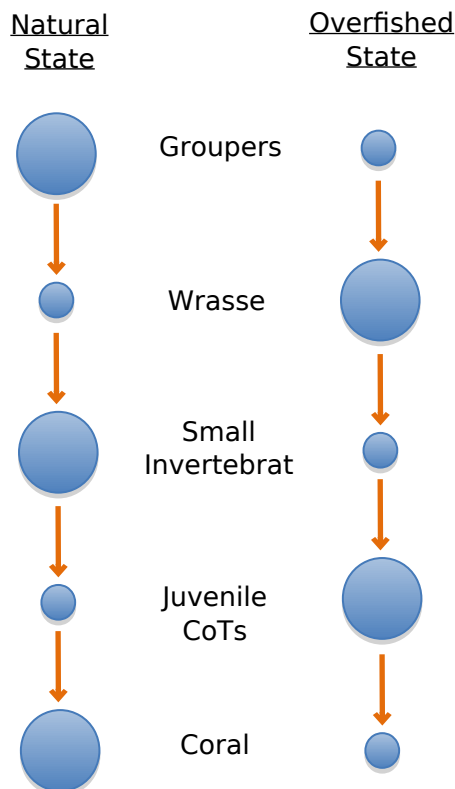


Figure 29. Representation of indirect effects that overfishing of predatory fish, Groupers can have on the entire coral ecosystem. The size of the circle represents the relative abundance of that organism or trophic level.

As mentioned in previous sections, several species of fish and invertebrates (e.g. barramundi cod, triton's trumpet snails) targeted for human consumption were observed in low numbers or completely absent. The most concerning aspect of these findings is that several of these species are known keystone species. This means that these organisms play a vital role in the reef system and if removed could seriously affect the stability of the entire ecosystem. This can happen in two ways: (1) direct effects or (2) indirect effects.

Direct effects occur when predators are removed from an ecosystem and facilitate the ecological release of prey species. For example, the removal of predators such as humphead wrasse (*Cheilinus undulatus*), which are known to feed on CoTs can result in an expansion in CoTs numbers through a lack of predation pressure. Indirect effects are more complex as they often involve many species of families and cascade down through trophic levels. In severe cases this can lead to phase shifts and alter ecosystem dynamics (Fig. 29).

The removal of apex predators such as groupers causes a decrease in the predation of species such as wrasse, allowing prey populations to increase. Many wrasse species feed on benthic invertebrates that in turn predate juvenile settlement stage CoTs. With an increase in wrasse numbers there is a corresponding decline in these invertebrates and thus an increase in juvenile CoT survivorship (Fig. 29). Indirect top-down effects from depletion of apex predators have been shown to have wide spread impacts on ecosystems around the world (Myers *et al.*, 2007).

We believe the Cuasi reef would make an excellent MPA with sufficient coral cover and fish diversity to promote reef improvement with adequate protection. Low levels of fish, especially commercially important fish, suggest prolonged overfishing has occurred in the region. The implementation of an MPA could help to

reverse these trends and allow the reef to recover, with lasting benefits for the community of Cuasi.

6. Recommendations

CCC strongly recommend creating an MPA in the Barangay Cuasi. Considering the levels of overfishing suggested from the survey; an NTA that bans all fishing on at least some of the reef is the recommended course of action. Ideally this would be buffered with designated MR zones allowing some restricted (single hook and line only) fishing in the area. The no-take zone created by an MPA would provide a sanctuary for economically important fish species to begin to repopulate the area. By allowing fish and invertebrates to grow to larger sizes within MPA they would produce more offspring and replenish fish stocks more quickly than an MR.

A recent study by Edgar *et al.* (2014) argues that the effectiveness of MPAs relies on five criteria: that they should be no-take zones and well enforced, that they should be both large and old (>10 years), and that they should be isolated by deep water or sand. This is an ideal, but something that should be considered in the process of setting up an MPA within the waters of Barangay Cuasi. MPAs throughout the Philippines are characteristically small and this size restriction will dictate the length of time it takes stocks to recover. Local fishers must be considered and it is unreasonable to suggest the designation of large MPAs restricting a local barangay of any fishing in the area. By zoning the area, allowing some restricted level of fishing in buffer zones surrounding the MPA local fishers can continue to benefit from subsistence fishing whilst allowing their reef to recover for future generations.

That successful MPAs should be old (Edgar *et al.*, 2014) is something that needs to be considered when setting up this reserve. Response times can be slow and it may be a number of years before fishers see the benefits of a no-take zone. To ensure this is understood and realistic expectations are set a consultation and presentation of data is recommended to inform the local barangay of the health of their reef and expected timeframe of results if an MPA is created.

Perhaps the most important criterion ensuring the success of an MPA is that it is well enforced. If an MPA is designated without anyone taking notice the process becomes useless and further degradation will occur. Even minimal instances of poaching (whether intentional or accidental) inside an MPA can destroy years of recovery in a relatively short period of time (McCook, *et al.*, 2010). For this, CCC advise the creation of a management committee to oversee the effective running of the MPA. The committee would coordinate the collection of MPA fees for possible dive and snorkel sites, provide training and support to Bantay Dagats, oversee the enforcement of the MPA and be a link to the Municipal Government for matters concerning the MPA. It will be important for the management committee to establish goals and objectives for the MPA based on the criteria of species protection, fisheries and tourism. Reviewing these objectives will help inform management decisions. CCC can offer support throughout this process, and can assist in training local Bantay Dagats, at the request of Barangay Cuasi.

6.1 Recommendation for the Establishment of a Marine Protected Area in Cuasi

The surveyed site in Cuasi shows great promise as an MPA. Protecting this area would allow the hard coral cover to increase, allow fish stocks to recover and

potentially create funding in the form of eco-tourism. Taking this in to consideration, CCC recommends that a new MPA be established in an area encompassing the six transects surveyed (Fig. 30a & 30b, Table 2). This would additionally benefit by having MR buffer zones of 50m that restrict all but single hook and line fishing. After completing the surveys, the two most southerly transects (2 and 5) were found to be situated outside the San Francisco municipality waters. Discussions should be held between San Francisco and Pintuyan with regards to the establishment of this particular stretch of reef.



Figure 30a. Proposed boundary location for Barangay Cuasi Marine Protected Area (MPA). Pink/red area = MR, grey/speckled area = NTA.

All recommendations are flexible and the final designation will be the result of a collaboration of CCC with the Municipality of San Francisco and the local community of Cuasi, in particular the local fisherfolk. CCC provide suggestions on what is the ecological ideal, but understand that there are other factors to consider during the decision making process. As such, the scenarios outlined here should be used as the initial step in opening a dialogue between all relevant aforementioned stakeholders in order to come to the best possible conclusion for all parties. Combining an ecosystem approach to fisheries (EAF) and community-based management (CBM), empowering the local user group level and conferring high levels of transparency in a triangulated consortium, CCC aims to facilitate the local Barangay Cuasi in achieving measurable levels of effectiveness from their designated MPA. By establishing clear, community driven objectives and goals during the formation of the Cuasi MPA, CCC hopes to address the key challenge to successful MPAs by ensuring that the MPA's by-laws, policies and restrictions fit into the greater ecological, social

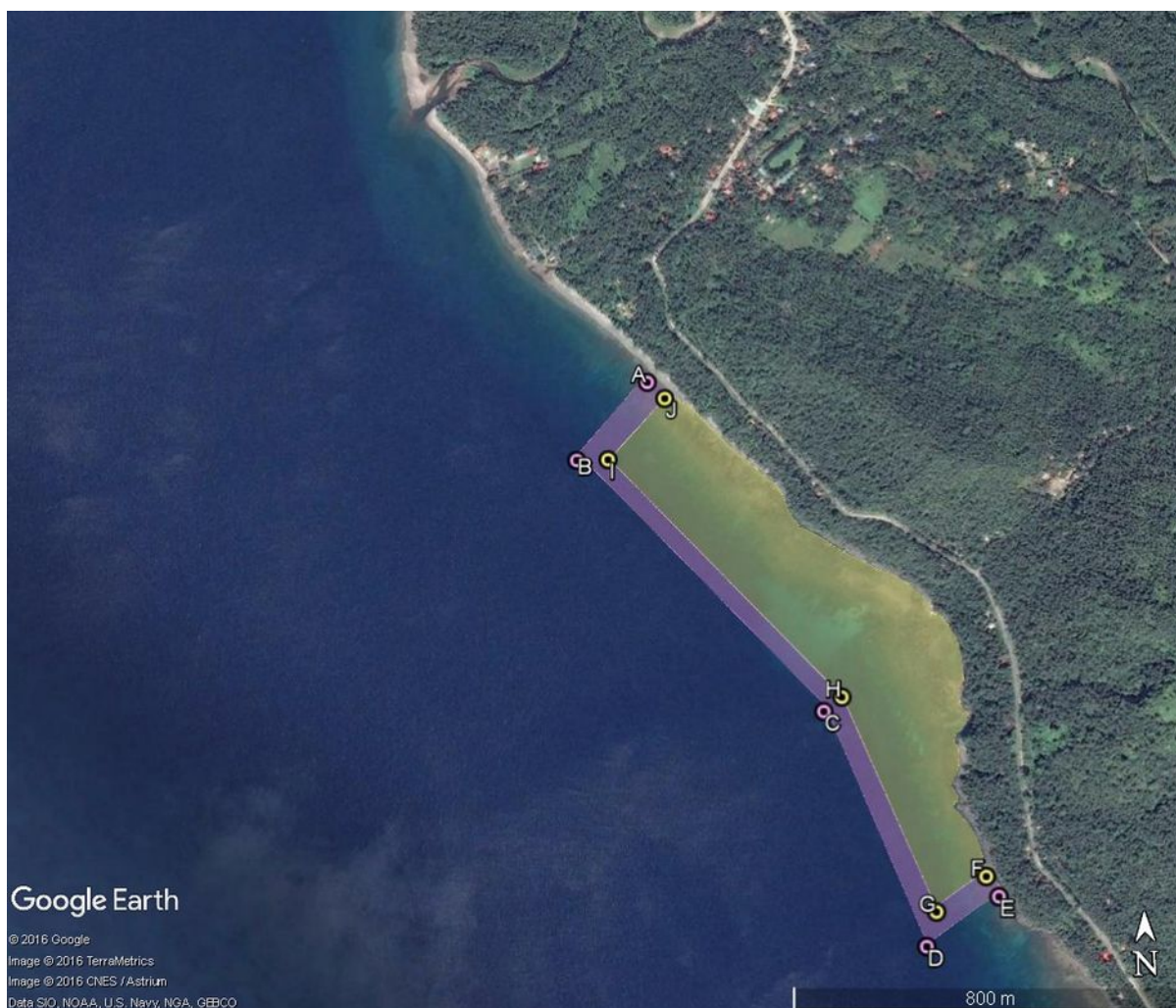


Figure 30b. Proposed boundary location for Barangay Cuasi Marine Protected Area (MPA) produced through GoogleEarth Pro to enable point-utilisation amongst fishers. As a result, awareness of the proposed MPA boundaries with respect to specific terrestrial land points will increase. Purple = MR, Yellow area = NTA.

and economic context, contextualising not only the needs for the fauna and flora present within its boundaries, but the needs of the local stakeholders and that of the municipality under the Republic Act No. 8550.

Extensive consultation will be essential within the local community to enable compliance with the MPA. The livelihoods of many local fishers may be affected by the designation of an MPA so their agreement is essential to its success. Many studies (e.g. Pollnac *et al.*, 2001) from existing MPAs have shown that without the involvement of the local community the effectiveness of a MPA is greatly reduced. If individuals from the community are involved in the planning processes they will have a vested interest in the effective running and management of the MPA. If an MPA is declared, an awareness campaign is essential to ensure that everyone is aware of the new MPA, its extent and the rules that they will be expected to follow. CCC can help at all levels of this process by providing educational support to the community with information on how and why MPA can be successful. Support for the establishment of an MPA is available from both Municipal and Provincial government levels. It will be important to secure funding from the outset to aid in the establishment of the MPA.

Table 2. Boundary coordinates for proposed Marine Protected Area (MPA) in Barangay Cuasi. Coordinates are given in the Universal Transverse Mercator (UTM) coordinator system.

Boundary Point	Easting (UTM)	Northing (UTM)
A	740598.156	1108125.079
B	740441.019	1107964.022
C	740949.393	1107415.258
D	741145.616	1106920.531
E	741297.950	1107022.614
F	741274.221	1107064.207
G	741169.428	1106990.892
H	740989.064	1107444.311
I	740508.430	1107962.925
J	740634.414	1108089.081
Total MPA area:	NTA = 22.7ha MR = 7.8ha	Total = 30.5ha

Demarcation buoys, signage and an easily decipherable MPA map are essential tools for raising awareness and promoting enforcement. Securing sustainable financing will help to secure the long-term future and success of an MPA.

If, after detailed consultation and evaluation, an MPA is designated in Cuasi, it will be important to ensure that monitoring of the MPA is conducted on a regular basis. Assessing temporal trends in abundance and diversity is crucial in determining how successfully the MPA is achieving its goals. The MPA Management Effectiveness Assessment Tool (MPA MEAT) is a national government programme designed to enable MPA manager to assess the effectiveness of their MPA. It uses detailed questionnaires and documentation to highlight limitations of MPA management and also suggests ways to improve it. CCC can provide further support by conducting MPA assessments to provide the biophysical data required by the MPA MEAT. CCC can also provide training to allow the barangay to develop their own MPA monitoring team.

Overall the future of a protected area in Cuasi should be reviewed with consultation between all stakeholders involved. The site would be greatly benefitted by protection but this should only be established with the support of the local community and with management and monitoring coming from both Barangay and Municipal levels.

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.
- 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.
- Berumen, L. (2006). Influence of resource availability on lifehistory traits in coral - feeding butterflyfishes (Pisces: Chaetodontidae). Ph.D. James Cook University.
- Bozec, Y., Doledec, 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>
- 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.
- CRC Reef Research Centre Ltd. (2003). Crown-of-thorns starfish on the Great Barrier Reef: Current state of knowledge (revised edition).
- 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

- Edgar, G. J. et al., (2014), Global conservation outcomes depend on marine protected areas with five key features, *Nature*, pp. 1-6
- 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.
- 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.
- Lancaster, D., Dallison, T., & Ferguson, A. (2016). Coral Cay Conservation Marine Protected Area Annual Report: Barangay Napantao 2015. Coral Cay Conservation: Philippines.
- Lau, P.P.F & R. Parry-Jones. (1999). The Hong Kong Trade in Live Reef Fish For Food. TRAFFIC East Asia and World Wide Fund For Nature Hong Kong, Hong Kong.
- Lessios, H., Robertson, D., & Cubit, D. (1984). Spread of *Diadema* mass mortality through the Caribbean. *Science* , **226**, pp. 335-337.
- 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.
- McCook, L., Ayling, T., Cappel, 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
- 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.
- Myers R.A., Baum J.K., Shepherd T.D., Powers S.P., Peterson C.H. (2007). Cascading effects of the loss of apex predatory sharks from a coastal ocean. *Science*. **315**, pp. 1846-50.
- 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., 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.
- 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, 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., 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.

APPENDIX A: TARGET SPECIES LIST

SUBSTRATES		
Soft Coral	Sponge	Recently killed coral
Rock	Silt/mud	Rubble
Sand	Nutrient indicator algae	Other*

Hard Lifeforms**:	Coral	
<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		

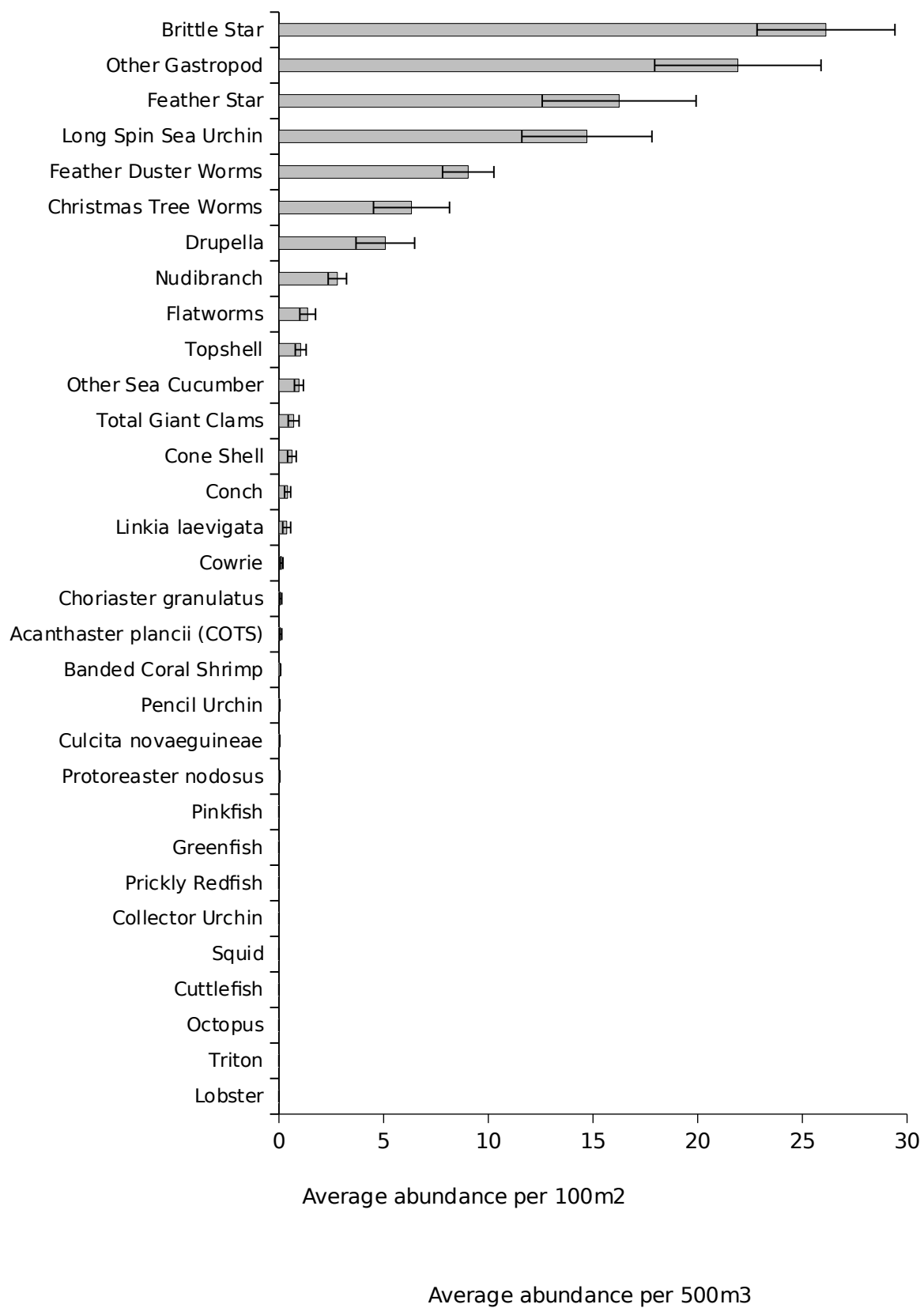
Common Name	Latin Name	Visayan Name
Angelfish	Pomacanthidae	Adlo
Barracuda	Sphyraenidae	
(Butterflyfish)	Chaetodontidae	Alibangbang
(Big) Longnose Butterflyfish	Forcipiger flavissimus	
Eastern Triangle Butterflyfish	Chaetodon baronessa	
Humphead Bannerfish	Heniochus varius	
Kleins Butterflyfish	Chaetodon kleinii	
Raccoon Butterflyfish	Chaetodon lunula	
Redfin Butterflyfish	Chaetodon lunulatus	
Vagabond Butterflyfish	Chaetodon vagabundus	
Cardinalfish	Apogonidae	
(Damsel fish)	(Pomacentridae)	
Anemonefish	<i>Amphiprion</i> sp.	
Sergeant Damsel fish	Pomacentridae	
Emperor	Lethrinidae	Katambak
Fusilier	Caesionidae	Dalagangbukid
Goatfish	Mullidae	Timbongan

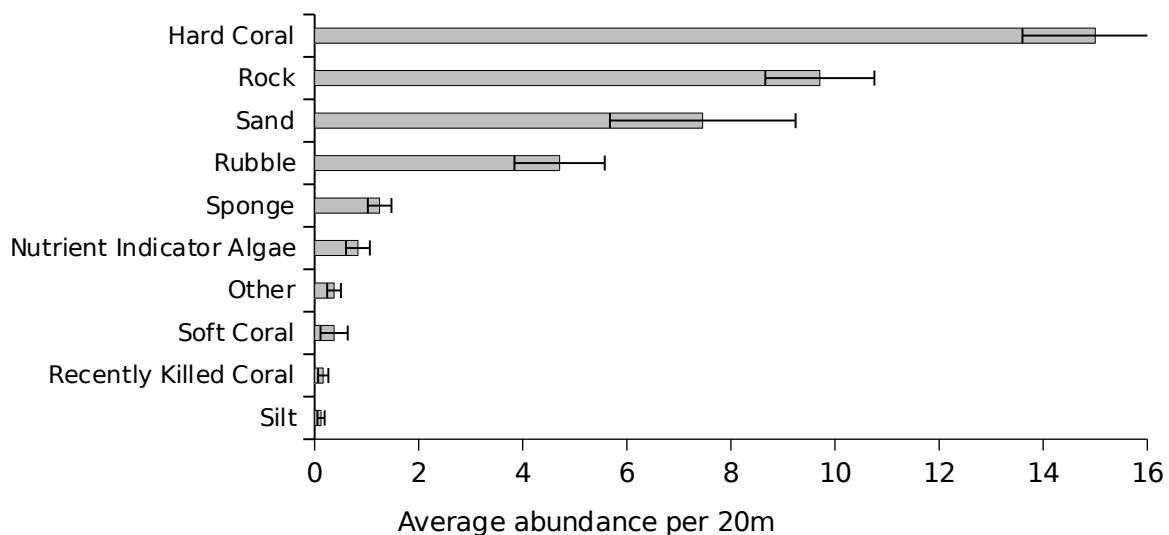
Groupers	Serranidae	Lapu-lapu
Jack/Trevally	Carangidae	Talakitok
Lionfish	Scorpaenidae	
Lizardfish	Synodontidae	
Moorish Idol	<i>Zanclus cornutus</i>	Sanggowanding
Moray Eel	Muraenidae	
Parrotfish	Scaridae	Mulmul
Pufferfish	Tetraodontidae	
Rabbitfish	Siganidae	Kitong
Ray	Rajiformes	
Sandperch	Pinguipedidae	
Scorpionfish/Stonefish	Scorpaenidae	
Snapper	Lutjanidae	Maya-maya
Spinecheeks	Nemipteridae	Silay
Squirrelfish/Soldierfish	Holocentridae	
Surgeonfish	Acanthuridae	Indangan
Unicornfish	<i>Naso</i> sp.	
Sweetlips	Haemulidae	Lipti
Toby	Tetraodontidae	
Triggerfish	Balistidae	Pakol
(Wrasse)	(Labridae)	
Crescent Wrasse	<i>Thalassoma lunare</i>	
Humphead Wrasse	<i>Cheilinus undulatus</i>	
Red Breasted Wrasse	<i>Cheilinus fasciatus</i>	

APPENDIX B: TARGET ORGANISM AVERAGE ABUNDANCES

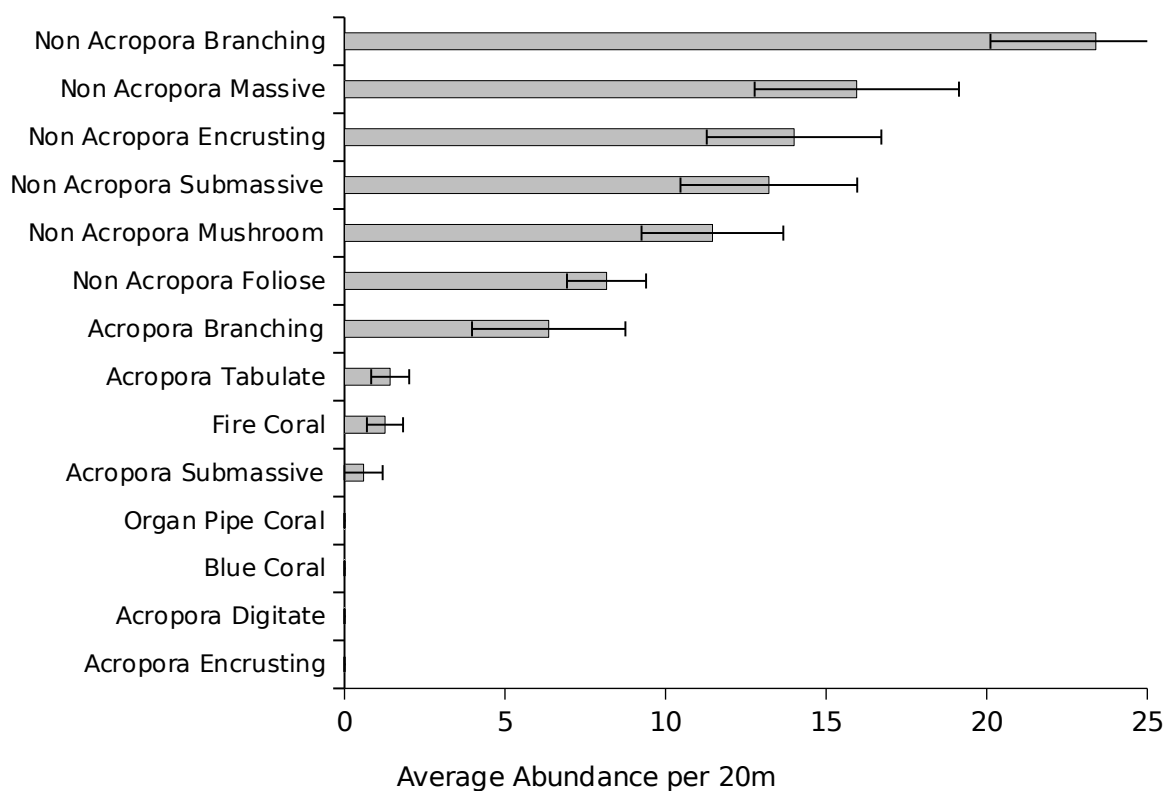
Average abundance of target fish families per 500m³ with Standard Error for Cuasi proposed MPA site, Municipality San Francisco, Southern Leyte, Philippines.

Average abundance of target invertebrates per 100m² with Standard Error for Cuasi proposed MPA site, Municipality San Francisco, Southern Leyte, Philippines.





Average abundance of target substrates per 20m with Standard Error for Cuasi proposed MPA site, Municipality San Francisco, Southern Leyte, Philippines.



Average abundance of target hard coral lifeforms per 20m with Standard Error for Cuasi proposed MPA site, Municipality San Francisco, Southern Leyte, Philippines.