

Coral Cay Conservation

Proposed Marine Protected Area Report



Catig

Municipality of Liloan, Southern Leyte, Philippines

September 2015

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EXECUTIVE SUMMARY

- Coral Cay Conservation (CCC) conducted an assessment of the reef fish, invertebrates, substrates and anthropogenic impacts at the Barangay Catig in the Municipality of Liloan. The site has been proposed as a potential Marine Protected Area (MPA).
- A preliminary assessment of the area was carried out in April 2015. Snorkelling the area revealed that, although coral cover was good, fish size and abundance was low and indicated that the site would benefit from protection. A formal survey of the proposed MPA was therefore recommended.
- An enhanced Reef Check methodology was used to complete formal biophysical surveys of eight 100m transects, each containing four 20m replicates. Transects were equally divided between depths of 6m and 12m.
- Fish abundance was highest at transect five, followed by transects six, one and four. There were no significant differences in fish diversity between transects.
- Commercially important species of Parrotfish, Grouper and Snapper were recorded in low abundance across the site, with the exception of transect one which yielded a relatively high abundance of Parrotfish. Commercially important fish recorded were all small; 85% were 10cm or less with no individuals recorded greater than 30cm.
- Invertebrate abundance was highest at transect three, closely followed by transect eight. Large numbers of feather stars were recorded throughout the survey.
- Hard coral was the most dominant substrate recorded with an overall average abundance of 29.06%. Transects three, four and six yielded the highest abundances of hard coral. Nutrient Indicator Algae (NIA) was abundant across all transects.
- Anthropogenic impacts were observed to be moderate – high. Coral damage, trash and discarded fishing nets were recorded. It is suspected that local pollution is leading to eutrophication of the area.
- The low abundance and complete absence of some commercially important fish and invertebrate species indicates that fishing pressures are too high to sustain a healthy population. This is a threat both to the reef and the fishing community of the Catig and Caritas.
- Based on the results of this survey, a scenario has been outlined recommending the implementation of both a Marine Protected Area and a Marine Reserve.
- 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.

ACKNOWLEDGEMENTS

Coral Cay Conservation would like to express our gratitude to the Provincial Government of Southern Leyte (PGSL). Our work would not be possible without the support of the Provincial Environmental and Natural Resource Management Office (PENRMO), the Provincial Tourism Office and other members of the PGSL.

We would also like to thank the Barangay Council of Catig and the Municipality of Liloan for facilitating the MPA assessment. In particular we would like to acknowledge the cooperation of Ma'am Benita Dipay, Liloan Municipal Agricultural Technician and the honourable Captain Manulito, Barangay Captain of Catig. We would also like to thank our trained volunteers, staff and scholars who collected vital data during this proposed MPA assessment; Shannon Cameron, Marvin Gonzales, Sydney Henderson, Agatha Henry, Jen Horn, Jonathan Lloyd-Evans, Josh Milne, Jerome Napala, Zach Parkes, Joe Roche and Phoebe Wilson.

LIST OF ACRONYMS AND ABBREVIATIONS

CCC	: Coral Cay Conservation
CoTs	: Crown of Thorns Seastars (<i>Acanthaster planci</i>)
IUCN	: International Union for the Conservation of Nature
LGU	: Local Government Unit
MAO	: Municipal Agricultural Office
MR	: Marine Reserve
MPA	: Marine Protected Area
MPA MEAT	: MPA Management Effectiveness Assessment Tool
NIA	: Nutrient Indicator Algae
NIPAS	: National Integrated Protected Area System
PENRMO	: Provincial Environmental and Natural Resource Management Office
PGSL	: Provincial Government of Southern Leyte
PRRCFI	: Philippines Reef and Rainforest Conservation Foundation Inc.
PRRP	: Philippines Reef and Rainforest Project
RKC	: Recently Killed Coral
SE	: Standard Error
SLRCP	: Southern Leyte Reef Conservation Project

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 Southern Leyte Reef Conservation Project (SLRCP). The SLRCP 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 (MPAs) and Marine Reserves (MRs)

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.”

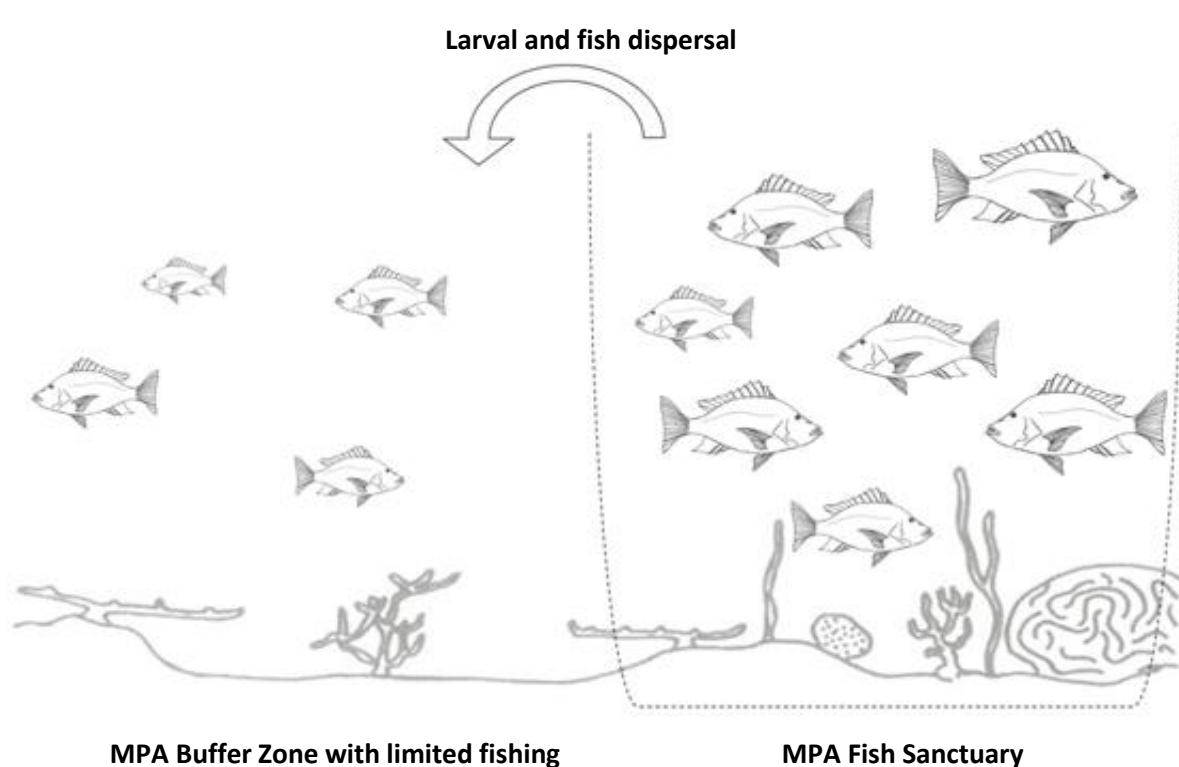


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to ‘overspill’, increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

MPAs have become vital tools in protective management for the conservation of marine resources. MPAs in the Philippines encompass “no take” areas (min. 5 hectares), within which no form of extraction is permitted. These no take areas are surrounded by 50m “buffer zones” where only non-destructive fishing methods, such as hook and line fishing, are permitted (Figure 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).

Generally, the most desired benefit of an MPA is increased fish production. This occurs as a result of overspill and larval export from the “no take” area into surrounding waters (Figure 1). Over time, the displacement of fishing effort from the MPA results in an increase in adult fish biomass and fecundity. This results in adult fish and larvae being exported to the buffer zone and its surrounding waters. Local fishery yields subsequently increase because they have a continual and sustainable supply of stock (Maliao *et al.* 2004). In areas where there is the potential for increased tourism and anthropogenic pressure on the marine environment for food, recreation and other resources, the benefits and necessities of having a network of functioning MPAs are increased.

Marine Reserves (MRs) are areas of the marine environment where fishing is restricted to non-destructive methods, such as 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 and is unselective. All sizes, ages and species of fish and invertebrates within an MR can still be extracted. 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 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 & 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. 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). Box 1 highlights two case studies of successful MPAs in the Philippines.

Box 1 - Case study of successful MPAs in the Philippines:

Apo Island & 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 the chance to recover (Figure 2). 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 that the MPA is a source for net larval export that aids the recovery of fish stocks in the area. Indirect positive effects of the effective management of these MPAs include increased tourism income and the elimination of unsustainable fishing practices such as dynamite fishing (Russ and Alcala, 2004).

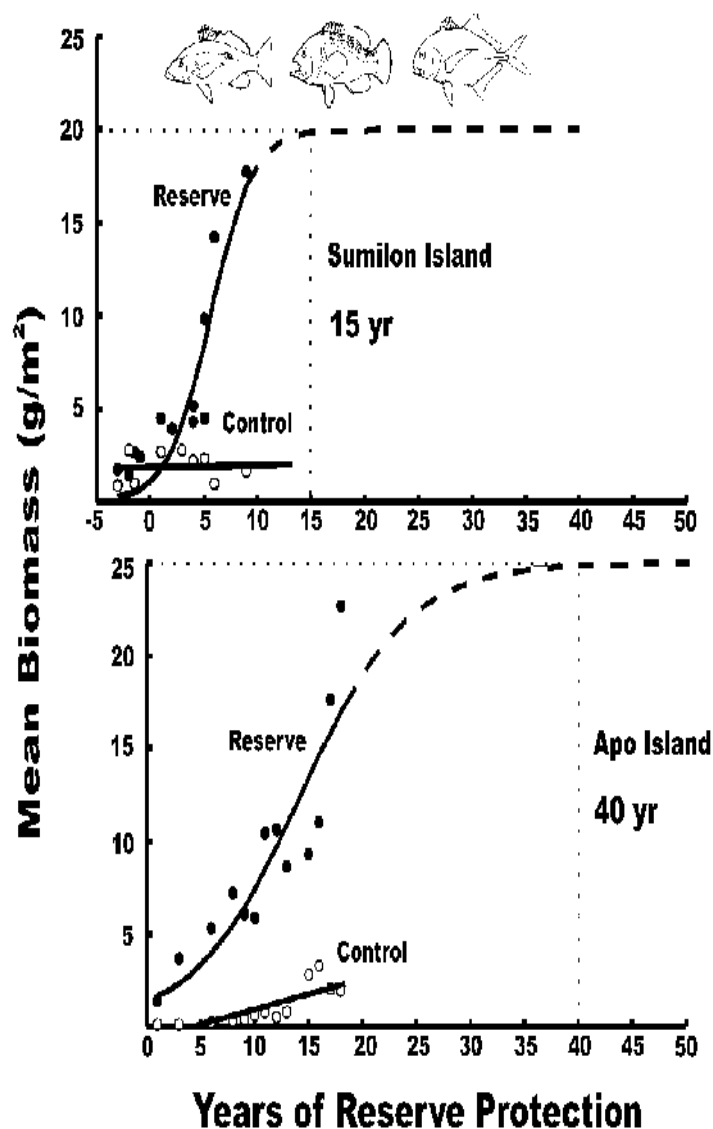


Figure 2. Observed and projected increases in mean biomass of commercially important fish species inside Apo Island and Sumilon Island MPAs (Russ and Alcala, 2004).

1.3 Characterisation of Study Region

1.3.1 Southern Leyte

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 set up. 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 Catig, Liloan: Proposed MPA site

This survey was requested by the Liloan Municipal Agricultural Office (MAO) as they aim to meet the requirements of the aforementioned 1998 Fisheries Code (Republic Act 8550) which states that 15% of all municipal waters should be within an MPA. The Municipality of Liloan is situated on the Northern tip of Panaon Island, extending across both its Western and Eastern coastlines. The West coast of the island outlines the Eastern boundary of Sogod Bay. The East coast and its associated Barangays face on to the Surigao Strait; a narrow waterway connecting the Bohol Sea and the Leyte Gulf of the Philippine Sea. This is the location of Barangay Catig (Figure 3).

The reefs of Catig are exposed to moderate to high wave action caused by North-East trade winds during the season of Amihan. This generally occurs between the months of September and June each year. In April 2004 the area was subjected to a major storm which triggered a landslide directly in to the Barangay of Catig. It is thought that the coral reefs may have been affected however no survey was carried out to substantiate this. In light of the damage on land, the population of the Barangay was relocated approximately 3km north to a new settlement often referred to as Caritas. The current population of this Barangay is 353 persons. CCC surveyed coral reefs located between approximately 50-200m from the shoreline of the original Barangay Catig in a North to South orientation.

2. METHODS

2.1 Survey Site

Coral Cay Conservations assessment of the proposed MPA site for Catig was conducted between July 21st and August 21st 2015 by trained volunteer survey teams. The weather varied between sunny and overcast during this time, with no major weather systems moving through the region. Mean air temperature during surveys was 29.5°. Mean water temperature was 29.63°C on the surface, 29.25°C at a depth of 3m and 29°C at 10m. The mean estimated horizontal visibility throughout the survey was 16.25m.

From discussion with the Barangay Council of Catig it was gathered that there is currently a medium level of anthropogenic pressure in the area. Poison fishing is known to occur regularly along with the recreational harvest of both fish and invertebrates for personal consumption. Nutrification is prevalent in the area regular algal blooms, particularly between the months of December and April.

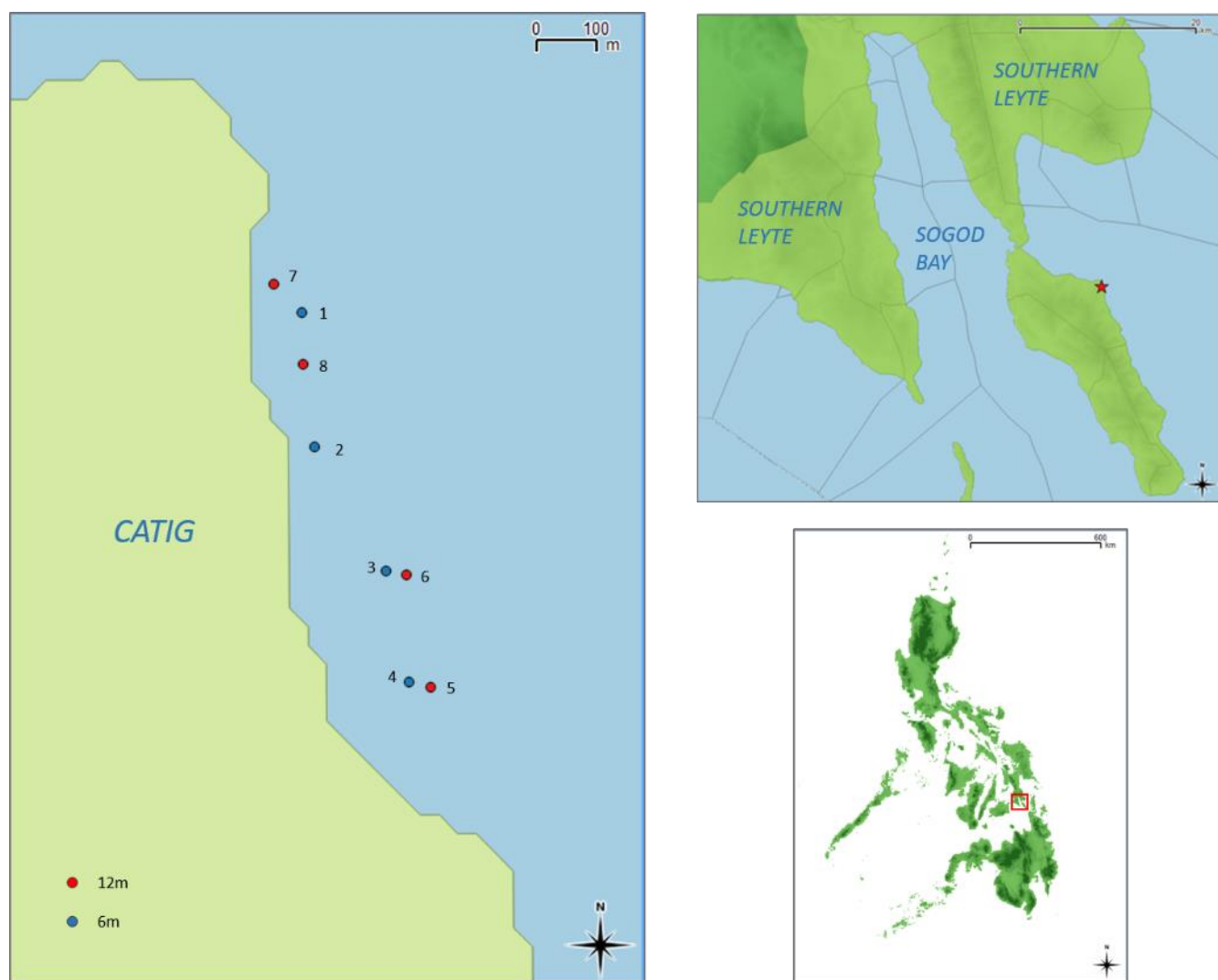


Figure 3. Map of survey location and wider geographic region

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 (see Appendix).

Transects were laid along the reef, parallel to the shore, on a north to south bearing. Four transects were situated at a depth of 6m and four transects were situated at a depth of 12m (Table 1). Each 100m transect was divided up into four 20m replicates, separated by 5m 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.

Table 1. Depths and coordinates for the four transects surveyed along the coast of Barangay Catig.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
1	6	742589	1120076
2	6	742609	1119859
3	6	742728	1119656
4	6	742766	1119476
5	12	742800	1119468
6	12	742761	1119649
7	12	742542	1120123
8	12	742590	1119992

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 (mulmul, *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 (see Appendix).

Data was recorded using 'belt' transects, where fish were observed along each replicate of the 100m transect within an imaginary 5x5x20m (WxHxL) box (Figure 3). Surveys were conducted by two surveyors swimming slowly along replicates, each counting indicator fish species 2.5m either side of the central transect line. Divers paused at 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.

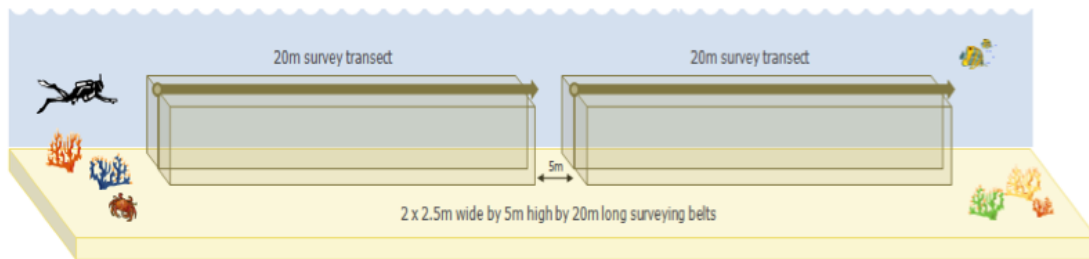


Figure 4. Survey method for recording fish. Diagram shows two of the four 20m replicates within a 100m transect. Fish were recorded within a 5x5x20m imaginary box.

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 (see Appendix). 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 (Figure 4). Divers looked in holes and under overhangs to find cryptic organisms such as lobsters and sea urchins.

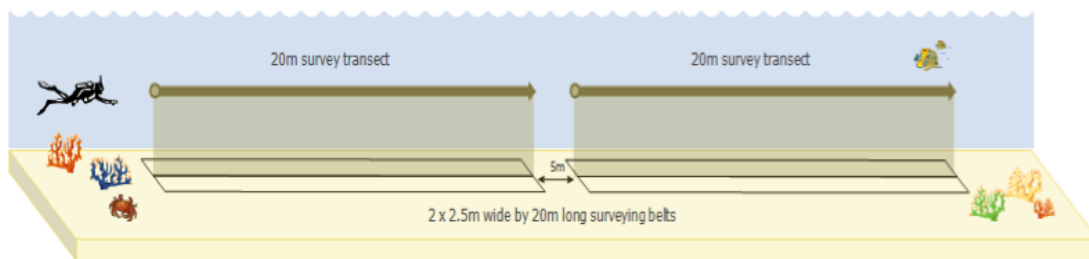


Figure 5. Survey method for recording invertebrates. Diagram shows two of the four 20m replicates within a 100m transect. Invertebrates were recorded within a 5x20m benthic rectangle.

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 (Figure 5). Every 20m replicate contained 40 benthic points. Benthic categories included: sand (SD), rock (RC), rubble (RB), silt/mud (SI), nutrient indicator algae (NIA), sponge (SP), recently killed coral (RKC), soft coral (SC), hard coral (HC) and any other sessile organisms. All hard corals were recorded to life form and genus level, with targets being recorded to species level (see Appendix).

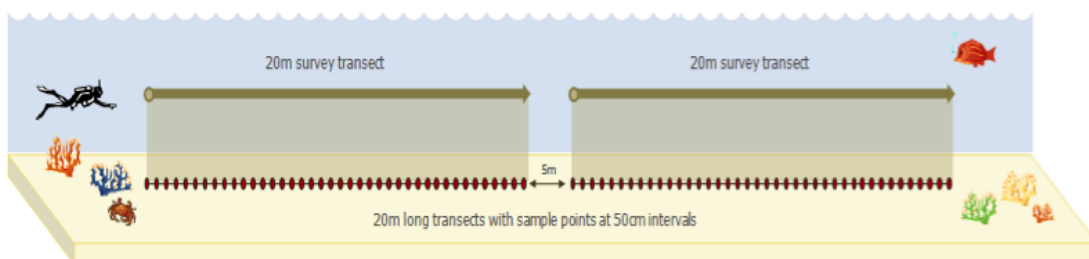


Figure 6. Survey method for recording substrate data. Diagram shows two of the four 20m replicates within a 100m transect. Substrates were recorded along a 'point intercept' line of each 20m replicate.

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=16 at 6 metres and n=16 at 12 metres. Data analysis was undertaken to establish which surveyed areas of the reef were particularly healthy and which were not, with the view of being able to recommend suitable areas for protection. Preliminary inspection of the data revealed that the variances were not homogeneous and the data had a non-normal distribution. Transformations of the data did not sufficiently alter this to warrant using a parametric test so a Mann-Whitney U test was used to determine any statistically significant differences between transect sites.

Species diversity of fish and invertebrates was calculated using the Fisher's α index, which incorporates number of species and number of individuals observed at each transect. Results were also submitted to the Mann-Whitney U test.

3. RESULTS

3.1. Fish

Mean fish abundance across eight transects surveyed in Catig ranged between 11.25 ± 3.77 and 89.75 ± 13.23 per 500m^3 at transects eight and five, respectively (Figure 7). Transects three, four, five and six all yielded significantly higher abundances of fish than both transects seven and eight ($p < 0.05$). Mean fish abundance was significantly higher at transects five and six than transect two, while transect five also contained a higher abundance of fish than transect three ($p < 0.05$). Other significant differences in fish abundance between transects can be reviewed in Figure 8. Fish diversity (fishers α) ranged from 2.58 ± 0.73 and 5.37 ± 0.88 per 500m^3 at transects seven and three, respectively. There were no significant differences in fish diversity between transects.

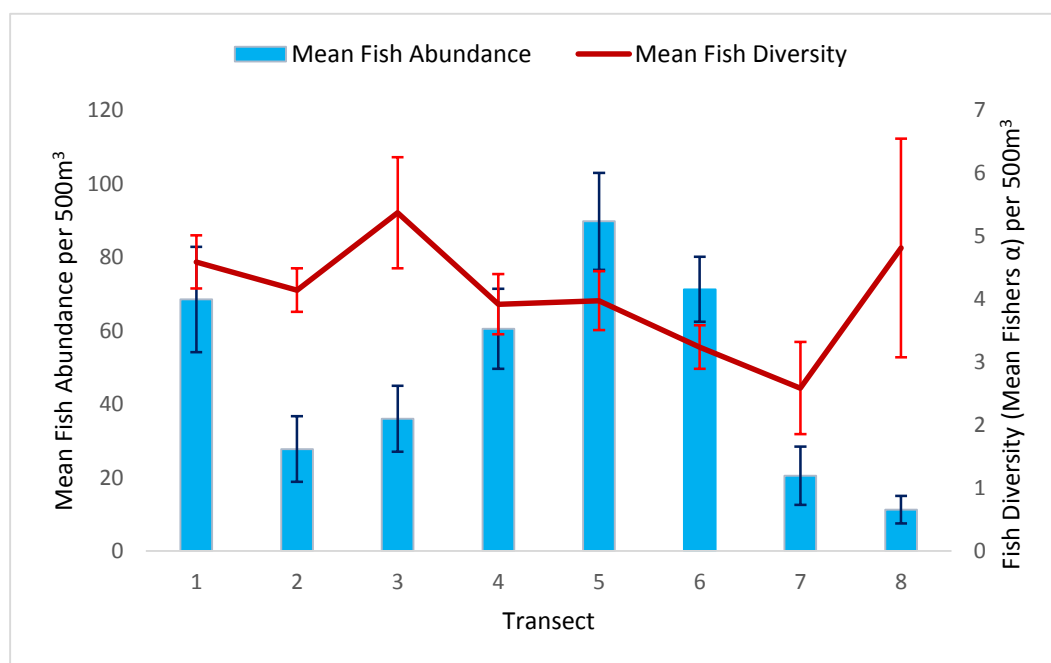


Figure 7. Average fish abundance and diversity at each transect. Blue bars represent mean fish abundance per 500m^3 , black error bars denote standard error from the mean. Red line represents mean fish diversity (fishers α) per 500m^3 , red error bars denote standard error from the mean.

	1	2	3	4	5	6	7	8
1							+	+
2					-	-		
3					-			+
4							+	+
5		+	+				+	+
6		+					+	
7	-			-	-	-		
8	-		-	-	-			

Figure 8. Matrix showing significant differences in mean fish abundance between transects. A green '+' indicates that abundance was significantly higher on the transect in the left column compared to the transect in the top row ($p < 0.05$). A blue '-' indicates that abundance was significantly lower on the transect in the left column compared to the transect in the top row ($p < 0.05$). Blank cells indicate no significant difference.

With the exception of transect one, commercially important fish families Parrotfish, Grouper and Snapper were recorded in very low abundances throughout the survey period (Figure 9). Mean abundance ranged from 0.25 ± 0.25 and 18 ± 5.07 individuals per 500m^3 at transect eight and transect one, respectively. Fish abundance at transect one was significantly higher than transects two, five, seven and eight ($p < 0.05$, see Figure 10). Other commercially important fish species including Bumphead Parrotfish, Humphead Wrasse and Sweetlips were completely absent from the survey area.

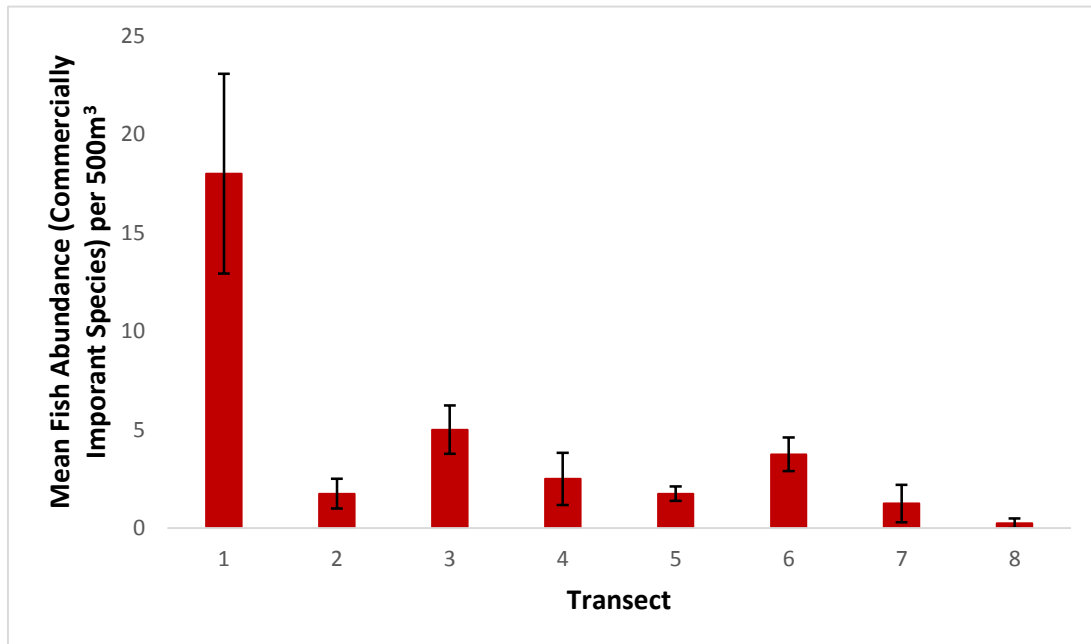


Figure 9. Average abundance of commercially important fish species observed on each transect. Data are mean number of individuals per replicate, error bars denote standard error from the mean.

	1	2	3	4	5	6	7	8
1		+			+		+	+
2	-							
3							+	+
4								
5	-							+
6								+
7	-		-					
8	-		-		-	-		

Figure 10. Matrix showing significant differences in mean fish abundance between transects. Only Parrotfish, Grouper and Snapper were included in this analysis. A green '+' indicates that abundance was significantly higher on the transect in the left column compared to the transect in the top row ($p < 0.05$). A blue '-' indicates that abundance was significantly lower on the transect in the left column compared to the transect in the top row ($p < 0.05$). Blank cells indicate no significant difference.

Of these target families Parrotfish were the most abundant across the site, with a total of 124 individuals recorded throughout the survey period and an overall average abundance of 3.88 ± 1.24 individuals per 500m^3 (Figure 11). Transect one yielded the highest abundance of Parrotfish with 16.75 ± 4.56 individuals per 500m^3 .

Grouper were absent from transect seven, however present in very low abundances across all other transects. The greatest abundance of Grouper was found at transect one which yielded a mean abundance of only 1 ± 0.71 individuals per 500m³. A total of 12 individuals were recorded throughout the survey period.

A single Snapper was recorded throughout the entire survey period. This was observed at transect one, giving a mean abundance of 0.25 ± 0.25 per 500m³.

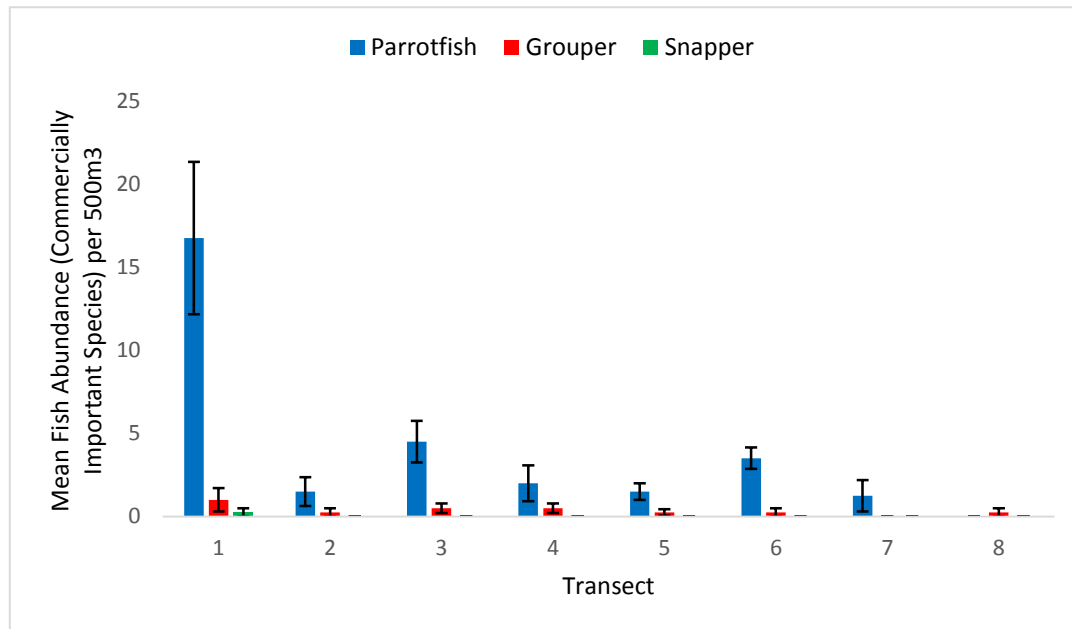


Figure 11. Average abundance of Parrotfish, Grouper and Snapper observed on each transect. Data are mean number of individuals per replicate, error bars denote standard error from the mean.

Of the commercially important fish species observed in Catig, all were small in size. 85.4% fell in to the 0-10cm category, 12.4% were sized between 11-20cm and the remaining 2.2% were 21-30cm. No recorded individuals were of a length greater than 30cm (Figure 12).

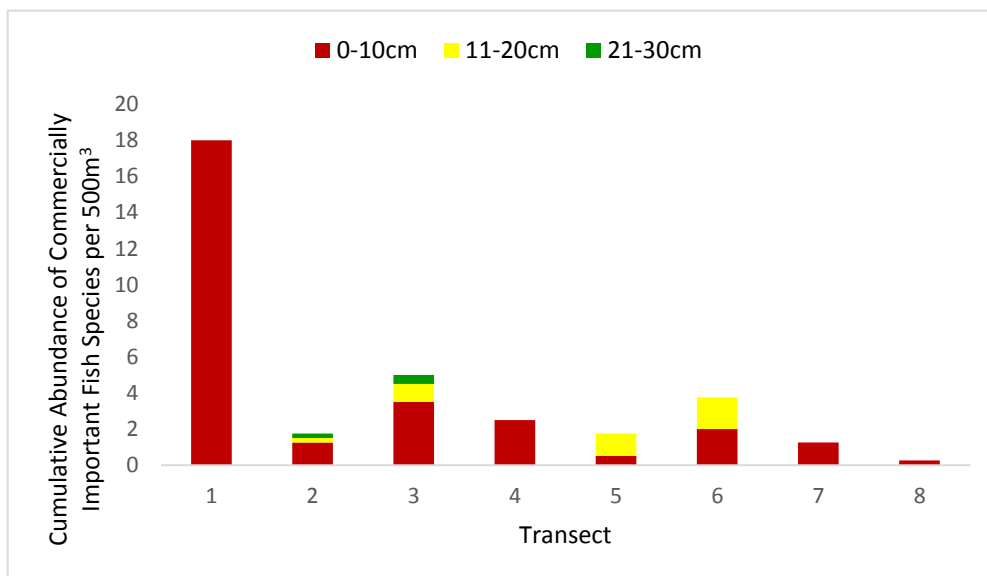


Figure 12. Cumulative abundance of Parrotfish, Grouper and Snapper in size categories 0-10cm, 11-20cm and 21-30cm across four transects.

3.2 Invertebrates

Mean invertebrate abundance across the survey site at Catig, Liloan ranged from 48.5 ± 6.10 individuals per 500m^3 at transect five and 128.25 ± 10.75 at transect three (Figure 13). Transect eight yielded a similarly high abundance of invertebrates with 117.25 ± 13.39 individuals per 500m^3 . A significantly higher abundance of invertebrates were recorded at both transects three and eight than transects five, six and seven ($p < 0.05$, see Figure 14). Invertebrate diversity (fishers α) varied between 1.51 ± 0.26 at transect eight and 3.29 ± 0.48 at transect five. Transects one two and five had a significantly higher invertebrate diversity than transect three while transects one and two were both significantly more diverse than transect eight ($P < 0.05$, see Figure 15).

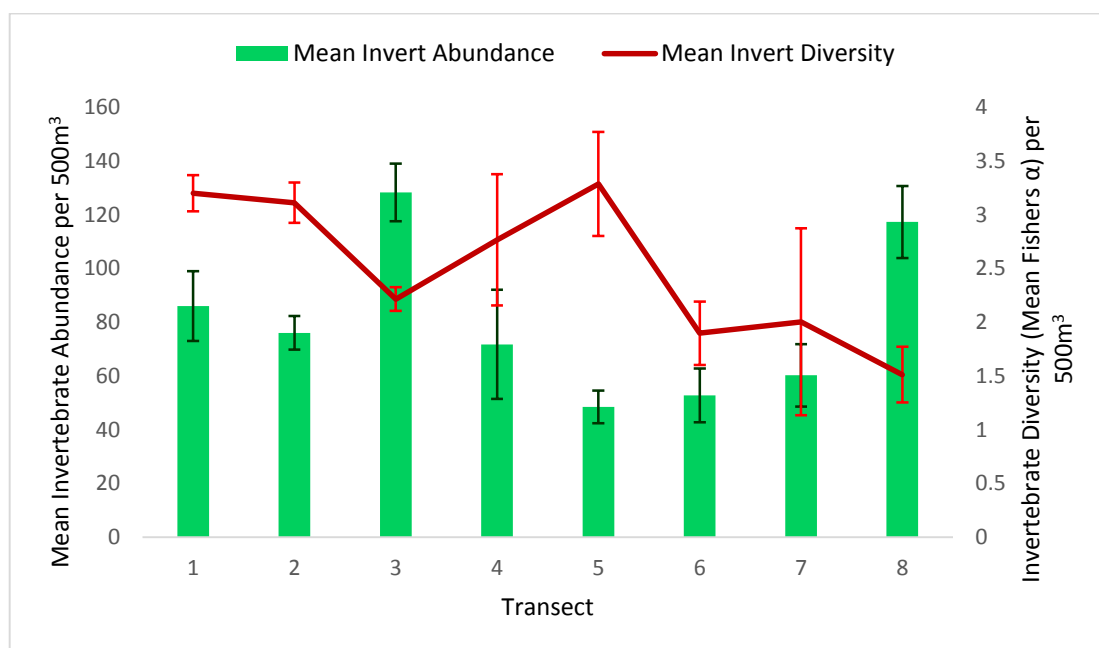


Figure 13. Average invertebrate abundance and diversity at each transect. Blue bars represent mean invertebrate abundance per 500m^3 , black error bars denote standard error from the mean. Red line represents mean invertebrate diversity (fishers α) per 500m^3 , red error bars denote standard error from the mean.

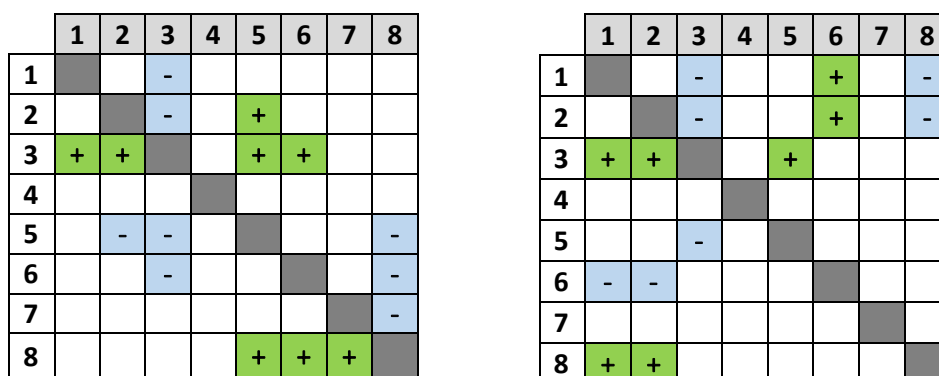


Figure 14 (left). Matrix showing significant differences in mean invertebrate abundance between transects. **Figure 15 (right).** Matrix showing significant differences in invertebrate diversity (Fishers α) between transects. A green '+' indicates that abundance was significantly higher on the transect in the left column compared to the transect in the top row ($p < 0.05$). A blue '-' indicates that abundance was significantly lower on the transect in the left column compared to the transect in the top row ($p < 0.05$). Blank cells indicate no significant difference.

The high invertebrate abundance at both transects three and eight can be largely attributed to a high number of feather stars; the two sites yielded a mean of 87.5 ± 9.88 and 100 ± 13.93 feather stars per 500m^3 , respectively. Feather stars were a common feature throughout the entire survey site with transect five yielding the lowest, yet still high, abundance of 23.25 ± 7.5 .

Commercially important invertebrate species including lobster (*Nephropidae*), abalone (*Haliotidae*), triton's trumpet (*Charonia tritonis*), squid (*Teuthida*), greenfish sea cucumber (*Stichopus chloronotus*) and pinkfish sea cucumber (*Holothuria edulis*) were entirely absent from the survey.

3.3 Substrates

The most abundant substrate across the reefs of Catig, Liloan was hard coral (HC), with a total coverage of 29.06% of the area surveyed. Rubble (RB) was the second most abundant with 23.75%, followed by sand (SD) and rock (RC) with 15.94% and 15.47%, respectively. Nutrient Indicator Algae (NIA) was found in relatively high abundances across the site, covering a total of 11.41% of the total surveyed area (Figure 16).

The highest proportion of hard coral was found at transect four where it composed 60% of the substrate. This was closely followed by transect three with 55% and transect six with 49.4% hard coral cover. The substrate of transects one, two and five were similarly composed of 21.25%, 19.38% and 23.75% coral cover, respectively. There was a significantly higher proportion of hard coral recorded at transects one two, three, four, five and six than at both transects seven and eight ($p < 0.05$, see Figure 17) where the prevalent substrates were sand, rubble and rock.

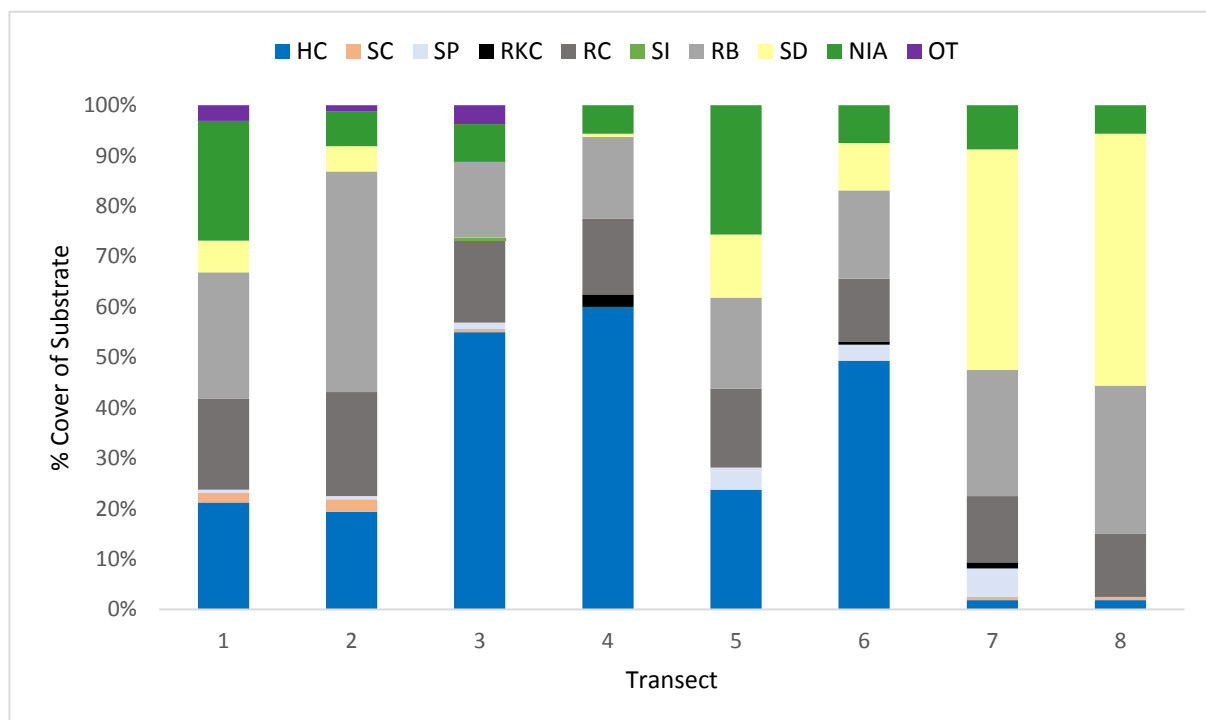


Figure 16. Mean substrate percentage cover at each transect. HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt; NIA – Nutrient indicator algae; OT – Other living organisms.

	1	2	3	4	5	6	7	8
1								
2				-		-	+	+
3							+	+
4		+			+		+	+
5				-			+	+
6		+					+	+
7		-	-	-	-	-		
8		-	-	-	-	-		

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

3.4 Anthropogenic Impacts

The coral reefs of Barangay Catig yielded evidence of moderate levels of anthropogenic impact. Within the surveyed area there were no signs to indicate damage caused directly by boats, anchor or dynamite however two instances of coral damage, the cause of which cannot be determined, were observed on transect three. Discarded fishing nets were found on both transects five and seven while medium – high levels of trash were recorded from transects one, four, five and six. No signs of coral disease were observed during the survey. On average, bleaching was present in less than 1% of hard coral colonies across the site.

4. VISUAL ASSESSMENT

Images taken by CCC staff and volunteers within the survey site of Barangay Catig.



Figure 18 (left). A Black-saddled Toby, *Canthigaster valentini*.



Figure 19 (right). A juvenile Onespot Rabbitfish, *Siganus unimaculatus*.



Figure 20. A pair of Moorish Idols, *Zanclus cornutus*



Figure 21. Ornate Butterflyfish, *Chaetodon ornatissimus*.



Figure 22. Black-backed Butterflyfish, *Chaetodon melannotus*.



Figure 23. A family of *Amphiprion clarkii* anemonefishes.



Figure 24-27 (clockwise from top left). A selection of invertebrate species found on the reefs of Catig; prickly redfish sea cucumber *Thelonota ananas*; thorny feather star *Capillaster sentosus*; kubaryana's nembrotha *Nembrotha kubaryana* nudibranch; ocellated phyllidia nudibranch *Phyllidia ocellata*.





Figure 28. A 'field' of branching *Porites* hard coral dominates the Southern reefs of Catig.



Figure 29. An aggregation of hard and soft coral along with other substrates..

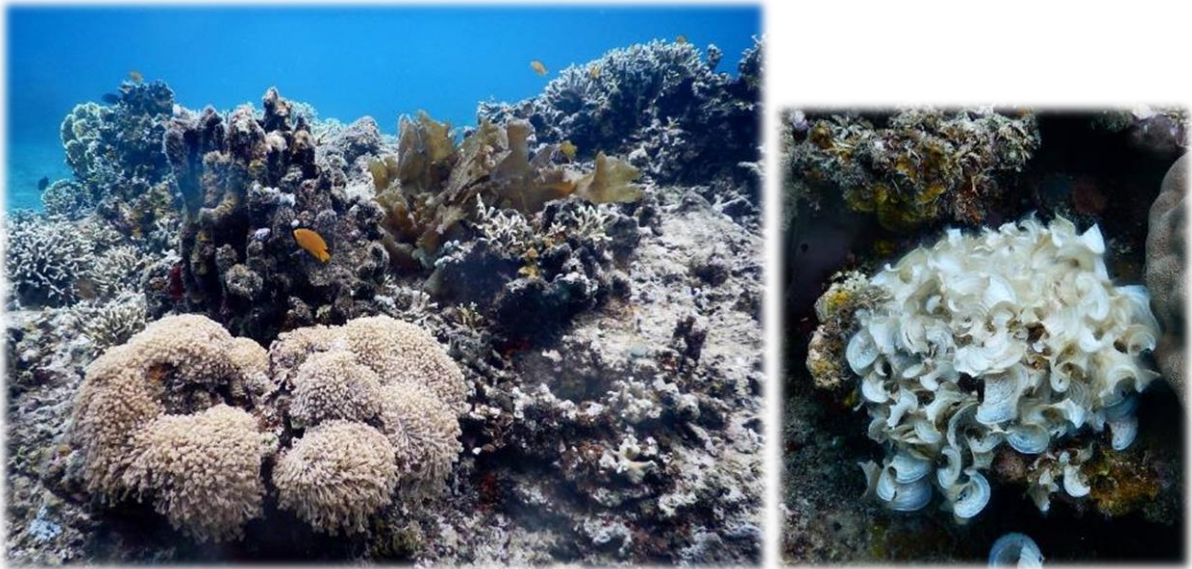


Figure 30 (left) and Figure 30 (right). *Nutrient Indicator Algae (NIA) is abundant across the site.*



Figure 31. *Large areas of coral damage are common in Catig; in many cases the cause is unknown.*

5. DISCUSSION

5.1 Fish

Fish surveys identified that mean fish abundance was significantly higher at transects one, three, four, five and six than both transects seven and eight ($p < 0.05$). Transect two also yielded a relatively low fish abundance, significantly lower than both transects five and six ($p < 0.05$). While transects three to six were the four most Southern points surveyed, transect one was situated the farthest North and closest to the population of Caritas.

The increased abundance of fish at transect one, compared with the three other most Southern transects, can be somewhat attributed to a relatively large population of Parrotfish (mean abundance = 18 ± 5.07 individuals per 500m^3). This, in turn, may be a result of the high abundance of nutrient indicator algae in the area; NIA composes 23.75% of the total substrate at transect one, providing a rich feeding ground for algal grazers. As well as having economic value, Parrotfish are an ecologically important species because they are the largest herbivorous fish found on coral reefs. They graze on large quantities of algae, which would otherwise compete with coral for space.

With the exception of transect one, the commercially important fish families Parrotfish, Grouper and Snapper were recorded in very low abundances across the surveyed area. It is evident from figure 11 that, of these three families, Parrotfish species are the most abundant. A total of 124 Parrotfish were observed (54% of which were observed at transect one), while only 12 grouper and one snapper were recorded throughout the survey period.

Of the commercially important fish recorded, 85.4% were only 10cm or less in length and no individuals were greater than 30cm. This suggests that the reefs of Catig suffer from overfishing and cannot currently support a sustainable population. Snappers, Groupers and Parrotfish take many years to increase in size and reach sexual maturity; Snappers have been shown not to mature until they are approximately 54.6 cm in length. As such, a population with no individuals larger than 30cm will not be able to replenish itself (Froese and Pauly, 2001). The fecundity (or reproductive output) of these families also exponentially increases with size. One 12.5 kg female Snapper can produce the same number of eggs as 212 1.1kg snappers (Bohnsack, 1990). Overfishing of the largest individuals from a reef removes the most reproductively active individuals, inhibiting future growth of the population. It may be beneficial, therefore, to afford protection to the area surrounding transect one in order to allow the growth of its population of commercially important fish.

There were no observations of other commercially important species including Bumphead Parrotfish, Humphead Wrasse, Barramundi Cod or 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 highly priced fish in the live fish trade, with one large individual capable of selling for as much as \$10,000 (Lau and Parry-Jones, 1999).

5.2 Invertebrates

The most prevalent invertebrates found on the reefs of Catig were feather stars. Transects three and eight yielded the highest abundance of invertebrates with 128.25 ± 10.75 and 117.25 ± 13.39 individuals per 500m^3 . However, as the majority of these figures can be attributed to large feather star populations, it was transect five which had the highest invertebrate diversity (3.29 ± 0.48) although it yielded the lowest abundance. Other noteworthy invertebrate observations include a number of nudibranchs, the majority of which were recorded at transect one, which are often an attraction for divers and underwater photographers.

The absence of commercially important invertebrate including lobster, squid, triton's trumpet and prickly redfish, greenfish and pinkfish sea cucumbers from the Catig indicates high levels of overfishing in the area. Each of these species is highly sought after as a food product.

Lobsters are highly prized throughout the world. They can be quickly removed from areas as they are easily caught in traps and nets. As with many fish species, larger lobsters sell for a higher price in the live food trade. The targeting of large individuals removes the most fecund (reproductively successful) females from the community, resulting in population decline.

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 and, as such, are regularly targeted by humans as a food substance (Hodgson and Liebel, 2002). Although these three species were completely absent from the biophysical survey, a prickly redfish sea cucumber was observed during a later photography dive. This is a good sign that this particular species is still present in Catig.

Triton's trumpets are targeted by humans because of their high value as a curio item and easily completely removed from a reef because of 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 (Crown of Thorns Starfish). If top predators such as the triton's trumpet are removed from an ecosystem, the risk of a CoTs outbreak is increased.

Nonetheless, only three individual CoTs were recorded throughout the survey site; a positive sign for the health of the reefs in Catig. High abundances of CoTs indicate that populations could be approaching outbreak levels where they are capable of causing large-scale damage to the reef. 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. 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 most abundant substrate recorded was hard coral which covered 29.06% of the entire survey area. Research implemented by Reef Check between 1997 and 2001 showed that coral reef systems throughout the Indo-Pacific averaged around 40% hard coral cover (Hodgson and Liebel, 2002). Compared with this, the percentage of coral cover in Catig appears to be relatively low. However, transects six, three and four surpass this average with 49.38%, 55% and 60% coral cover, respectively. In a coral reef ecosystem, the presence of hard coral is essential because it provides the main habitat utilised by fish and invertebrates for shelter, spawning and food. In order to protect this habitat, the areas with the highest abundance of hard coral should be afforded protection from destructive fishing practices including dynamite, poison and trawling.

Nutrient Indicator Algae (NIA) was present throughout the survey site with an average cover of 11.41%; the highest abundances of NIA were found at transects one and five. High levels of NIA on coral reefs can be a sign of eutrophication – an increase in nutrients in the water. Anecdotal reports from Barangay Officials indicate there is a small stream which flows directly in to the area only during heavy rains. While it is possible that the run-off is introducing nutrients to the sea water CCC was unable to substantiate this theory during the survey period. In low abundance NIA is a healthy part of the ecosystem and provides food for a number of fish and invertebrate species. As eutrophication increases, however, coral can become smothered; zooxanthellae are unable to access light for photosynthesis and the coral may die of starvation. It is important that the population surrounding

the reefs of Catig are educated in proper waste management to ensure that no additional nutrients are added to the water here.

5.4 Anthropogenic Impacts

The coral reefs of Catig appeared relatively healthy, showing no signs of disease and very low levels of coral bleaching. However, coral damage was regularly observed and at the northern-most transects (one, two, seven and eight) much of the reef has been reduced to rubble. Discarded fishing nets were observed on two occasions along with moderate – high levels of general trash recorded on four of the eight transects. High levels of trash and damage are a concern, however, if protection were enforced upon the reef then these levels could be expected to diminish or disappear over time.

The local community may be unaware that the improper disposal of general waste negatively affects the health of the reefs. It is extremely important, therefore, that people are educated about the consequences of improper waste disposal and given 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, providing they were regularly emptied by the municipality's waste disposal team. Other impacts such as high fishing pressure were also evident in the data. As mentioned in previous sections, several species of fish and invertebrates 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.

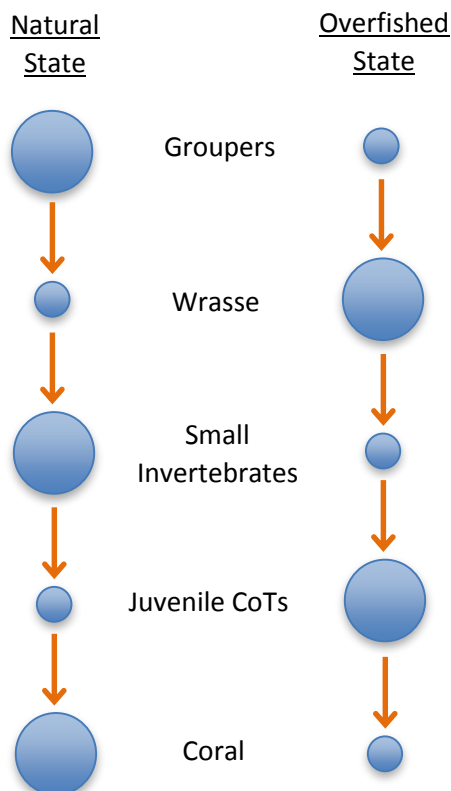


Figure 32. Representation of the indirect effects that overfishing of predatory fish have on the entire coral ecosystem. The size of the circle represents the relative abundance of that organism or trophic level.

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 (*Chelinus 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 (Figure 32).

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 (Figure 17). 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).

6. RECOMMENDATIONS

CCC strongly recommend for the waters of Barangay Catig to be given some level of protection. 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 (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 Gudan. 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 criteria 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. 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.

6.1 Recommendations for a Marine Protected Area (MPA) in Catig, Liloan

Of the area surveyed, the four southernmost transects (three, four five and six) overall have the most to offer in terms of hard coral cover and fish abundance. Hard coral is the most important substrate in a reef ecosystem, providing the main habitat utilised by fish and invertebrates for shelter, spawning and food. As such, it is critical that this area is protected from destructive fishing practices both to preserve the reef and create a safe place for fish populations to grow and reproduce. CCC recommends that the area surrounding transects three, four, five and six be designated a Marine Protected Area, with no fishing permitted within its boundaries (Figure 32).

Of the remaining four transects, there are features which would also benefit from protection. Transect one appears to be habitat to a population of small Parrotfish, currently too small in fish size to sustain itself. Transects one and two also have a reasonable proportion of hard coral cover which, if protected,

has the potential to increase. CCC recommends that this area be designated as a Marine Reserve, permitting only hook and line fishing within its boundaries (Figure 32).

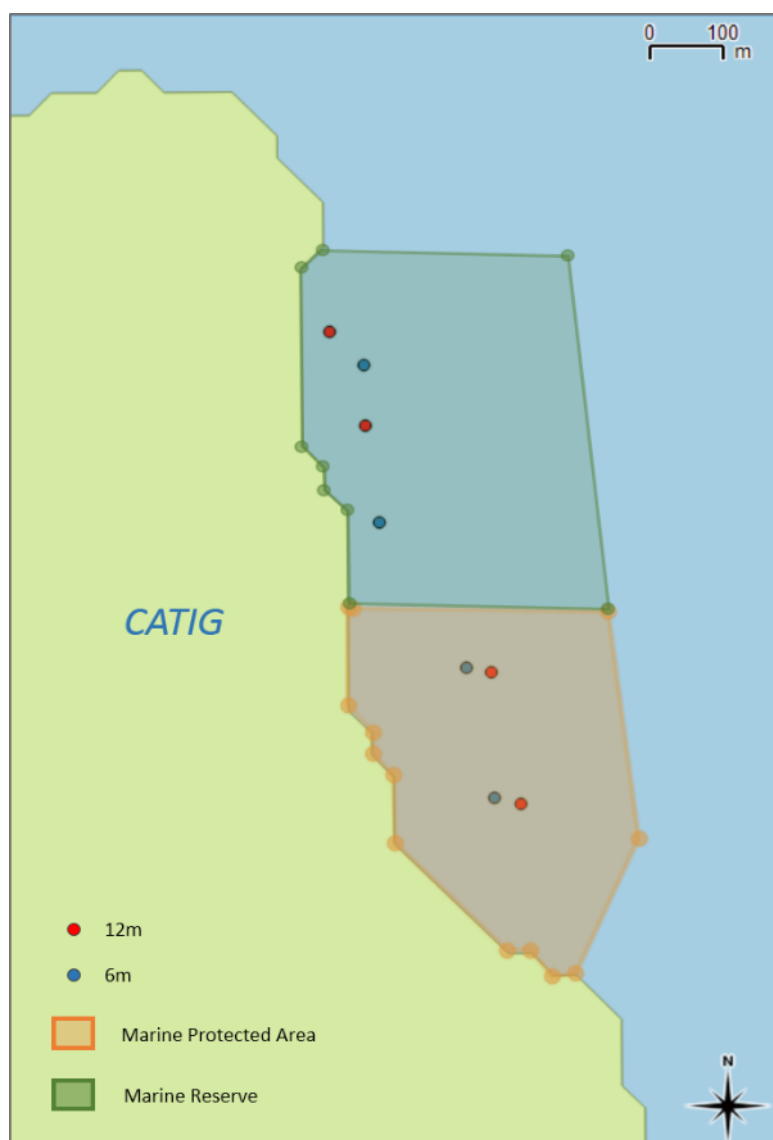


Figure 33. Map illustrating CCCs recommendation for a Marine Protected Area (MPA) and potential Marine Reserve (MR) in Catig, Liloan.

The coordinates for the boundaries of these recommendations are as follows:

Boundary Location (MPA)	Northing	Easting
Northern point at sea	742898	1119751
Southern point at sea	742944	1119411
Southern point on land	742874	1119753
Northern point on land	742564	1119753
Boundary Location (MR)	Northing	Easting
Northern point at sea	742872	1120236
Southern point at sea	742898	1119751
Southern point on land	742564	1119753
Northern point on land	742534	1120249

CCC's recommendations are flexible and the final designation will be the result of a collaboration of CCC with the Municipality of Liloan and the local community of Barangay Catig, in particular the local fisher folk. 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.

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. Demarcation buoys, and signage 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 Catig 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 Catig should be reviewed with consultation between all stakeholders involved. The site is in high need of 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.

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APPENDIX: TARGET SPECIES LISTS

SUBSTRATES

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

Target Invertebrates

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

Target Fish

Common Name	Latin Name	Visayan Name
Angelfish	Pomacanthidae	Adlo
Barracuda	Sphyraenidae	
(Butterflyfish)	Chaetodontidae	Alibangbang
(Big) Longnose Butterflyfish	Forcipiger flavissimus	
Eastern Triangle Butterflyfish	Chaetodon baronessa	
Humphead Bannerfish	Heniochus varius	
Kleins Butterflyfish	Chaetodon	
Raccoon Butterflyfish	Chaetodon lunula	
Redfin Butterflyfish	Chaetodon lunulatus	
Vagabond Butterflyfish	Chaetodon vagabundus	
Cardinalfish	Apogonidae	
(Damsel fish)	(Pomacentridae)	

Anemonefish	<i>Amphiprion</i> sp.	
Sergeant Damselfish	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>Zancluscornutus</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>Thalassomalunare</i>	
Humphead Wrasse	<i>Cheilinusundulatus</i>	
Red Breasted Wrasse	<i>Cheilinusfasciatus</i>	