

Coral Cay Conservation

Proposed Marine Protected Area Report



Gudan

Liloan, Southern Leyte, Philippines

August 2015

Head of Science: Alex Ferguson, headofscience@coralcay.org

Project Scientist: Shannon Cameron, lrcp@coralcay.org



TABLE OF CONTENTS

EXECUTIVE SUMMARY.....	3
ACKNOWLEDGEMENTS.....	5
LIST OF ACRONYMS AND ABBREVIATIONS.....	6
CORAL CAY CONSERVATION.....	7
1. INTRODUCTION.....	8
1.1 Marine Protected Areas (MPAs) and Marine Reserves (MRs).....	8
1.2 Coral Reefs & Marine Conservation in the Philippines.....	10
1.3 Characterisation of Study Region.....	12
1.3.1 Southern Leyte and Sogod Bay.....	12
1.3.2 Barangay Gudan, Proposed MPA site.....	12
2. METHODS.....	13
2.1 Survey Site.....	13
2.2 Biophysical Survey.....	14
2.2.1 Fish.....	14
2.2.2 Invertebrates.....	15
2.2.3 Substrate.....	15
2.2.4 Impacts.....	16
2.3 Data Analysis.....	16
3. RESULTS.....	17
3.1. Fish.....	17
3.2 Invertebrates.....	21
3.3 Substrate.....	22
3.4 Anthropogenic Impacts.....	23
3.5 Qualitative Assessment of 'Olly's Wall'.....	24
3.5.1 Fish.....	24
3.5.2 Invertebrates.....	24
3.5.3 Substrates.....	24
3.5.4 Anthropogenic Impacts.....	24
4. VISUAL ASSESSMENT.....	25
5. DISCUSSION.....	27
5.1 Fish.....	27
5.3 Substrates.....	29

6. RECOMMENDATIONS.....	32
6.1 Recommended Scenarios for Gudans Marine Protected Area	33
REFERENCES.....	36
APPENDIX: TARGET SPECIES LISTS.....	38

EXECUTIVE SUMMARY

- Coral Cay Conservation (CCC) conducted an assessment of the reef fish, invertebrates, substrates and anthropogenic impacts at the Barangay Gudan in the Municipality of Liloan. The site has been proposed as a potential Marine Protected Area (MPA).
- An enhanced Reef Check methodology was used to complete biophysical surveys of four 100m transects, each containing four 20m replicates. Transects were equally divided between depths of 6m and 12m.
- A qualitative assessment was carried out at the popular dive site 'Olly's Wall' which, due to the gradient of the slope, is unsuitable for Reef Check survey methodology.
- Fish abundance was highest at transect three, with significantly more fish than transects one and two. There were no significant differences in fish diversity between transects. Abundance of fish observed at 'Olly's Wall' was low, however diversity was high with almost all target species recorded.
- Commercially important species of Parrotfish, Groupers and Snappers were recorded in low abundance across the site with no individuals greater than 30cm in length. Grouper were entirely absent from transects one and three; those recorded were all less than 20cm in length. The highest abundance of commercially important fish families was recorded at transect two.
- Invertebrate abundance was significantly highest at transects three and four. Invertebrate diversity did not significantly differ between transects. Abundance and diversity of invertebrates at 'Olly's Wall' was very high, with almost all target species recorded.
- Rare sightings of fish and invertebrates across the site included a blue-spotted ribbontail ray, giant frogfish, spotted eagle ray and flamboyant cuttlefish.
- Sand was the most commonly recorded substrate recorded during the biophysical survey followed by rock and hard coral. Transects two and four had the highest percentage cover of hard coral, although this was still relatively low in comparison to a 'healthy' reef. The same transects also offered a high percentage cover of rock. 'Olly's Wall' yielded a wide variety of substrates, the most abundantly observed were anemones, followed by soft coral, black (whip) coral and hard coral.
- Anthropogenic impacts were observed to be moderate – high. A high abundance of fishing and general trash was recorded both during the biophysical survey and qualitative assessment of 'Olly's Wall'. Coral damage was also observed upon occasion.

- 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 community of the Barangay Gudan.
- Based on the results of this survey, three MPA implementation scenarios have been outlined ranging between the highest and lowest chance of success; all scenarios would benefit from the inclusion of marine reserve buffer zones restricting all but hook and line fishing.
- 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 Gudan 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 Albert, Barangay Captain of Gudan. We would also like to thank our trained volunteers, staff and scholars who collected vital data during this proposed MPA assessment.

LIST OF ACRONYMS AND ABBREVIATIONS

CCC	: Coral Cay Conservation
CoTs	: Crown of Thorns Seastars (<i>Acanthaster planci</i>)
IEC	: Information and Education Campaign
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
PMR	: Proposed Marine Reserve
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 PGSI 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.”

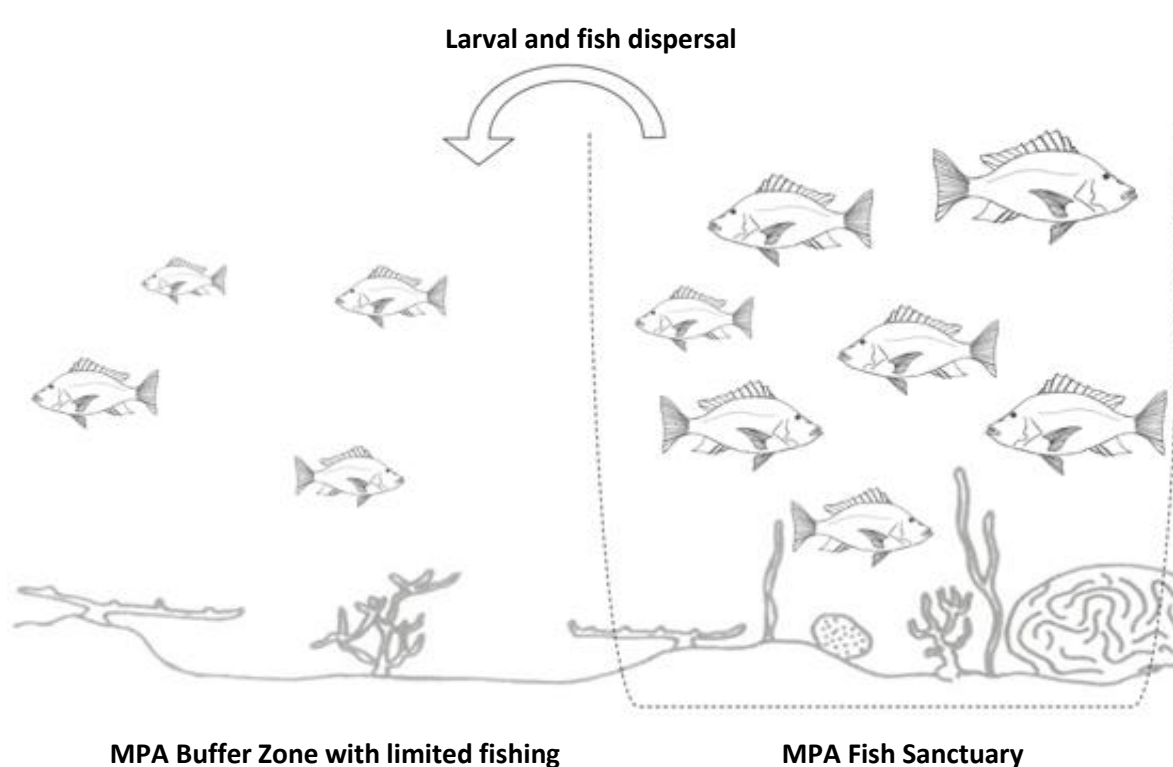


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to ‘overspill’, increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

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).

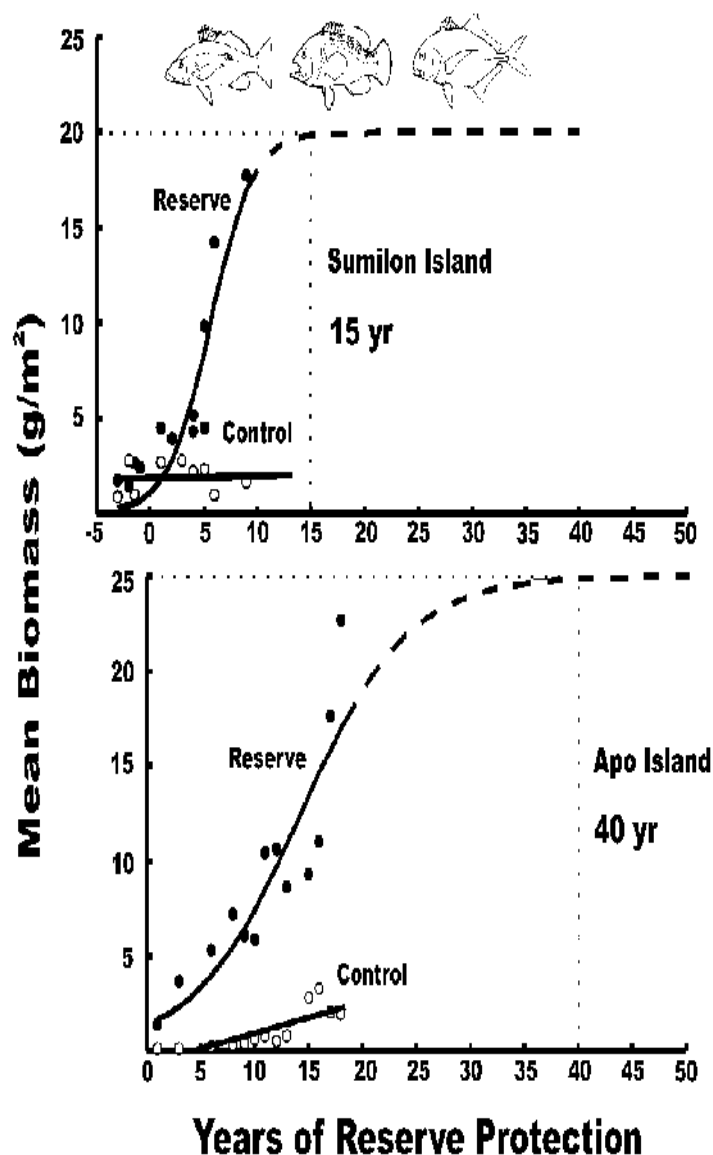


Figure 2. Observed and projected increases in mean biomass of commercially important fish species inside Apo Island and Sumilon Island MPAs (Russ and Alcala, 2004).

1.3 Characterisation of Study Region

1.3.1 Southern Leyte and 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 northeastern 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. Sogod bay has been targeted by the Fisheries Sector Program of the Department of Agriculture as one of the country's ten largest bays in need of assessment and management (Calumpong *et al.* 1994). 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).

Currently there are ~25 established MPAs within Sogod 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 Barangay Gudan, Proposed MPA site

This survey was requested by the Liloan 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. CCC surveyed the coral reefs located between 50-130m from the shoreline of the Barangay Gudan, on the eastern side of Sogod Bay. The area was surveyed in a North to South orientation. As requested by the Liloan MAO, a second qualitative analysis of the dive site locally known as 'Olly's Wall' was also carried out between, 731941E; 1120040N and 731935E; 1120555N. This is considered to be the best reef in the area. Due to the semi-enclosed structure of the bay, the reefs of Barangay Gudan are sheltered from prevailing weather systems coming across the Pacific. However during the monsoon season of Habagat, Southwest winds leave the East Coast of Sogod Bay exposed to moderate to high wave action. The Barangay has a population of approximately 600 people, all of which live within close proximity to the coast. A river mouth of <10m is located approximately 500m away from the proposed site.

2. METHODS

2.1 Survey Site

CCC's assessment of the proposed MPA site for Gudan was conducted between 15th and 25th May 2015 by trained volunteer survey teams. Weather throughout the survey period was sunny, with no major weather systems moving through the region. Mean air temperature during surveys was 30.75°C. Mean water temperature was 29°C on the surface, 28.5°C at a depth of 3m and 27.75°C at 10m. The mean estimated horizontal visibility throughout the survey was 12.25m.

From discussions with the Barangay Captain of Gudan it was gathered that there are currently medium-high levels of anthropogenic pressure in the area. This is posed largely from high levels of both commercial and artisanal fishing along with an often large number of recreational divers, particularly in the area of “Ollie’s Wall”. Currently no protection is afforded to any site within the waters of Barangay Gudan.

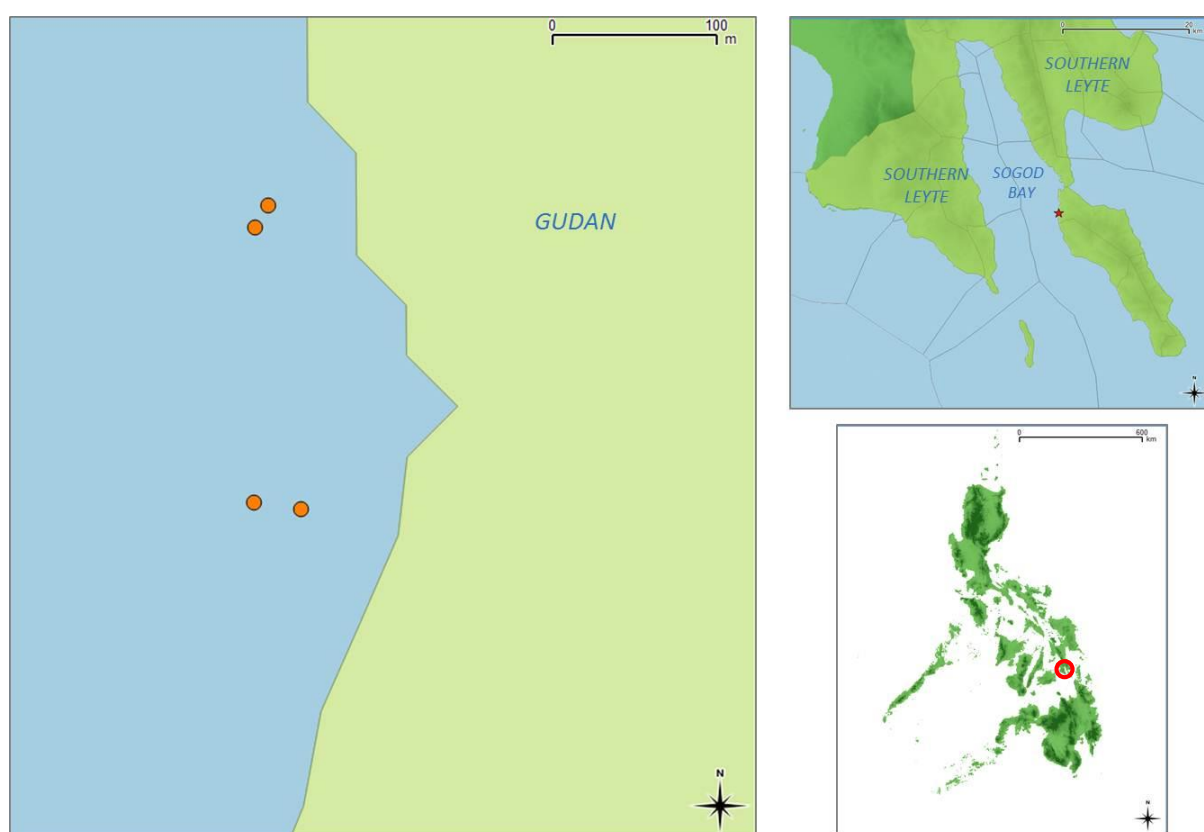


Figure 2: Map of survey location and wider geographic region.

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. Two transects were situated at a depth of 6m and two 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 Gudan.

2.2.1 Fish

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
1	12	731967	1119775
2	12	731968	1119942
3	6	731996	1119771
4	6	731975	1119955

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.

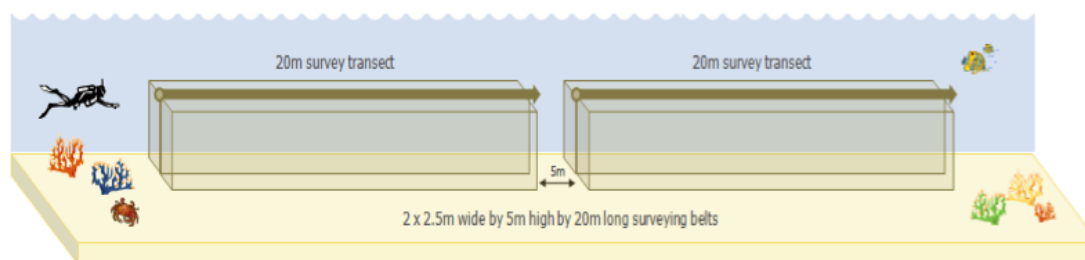


Figure 3. Survey method for recording fish. Diagram shows two of the four 20m replicates within a 100m transect. Fish were recorded within a 5x5x20m imaginary box.

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.

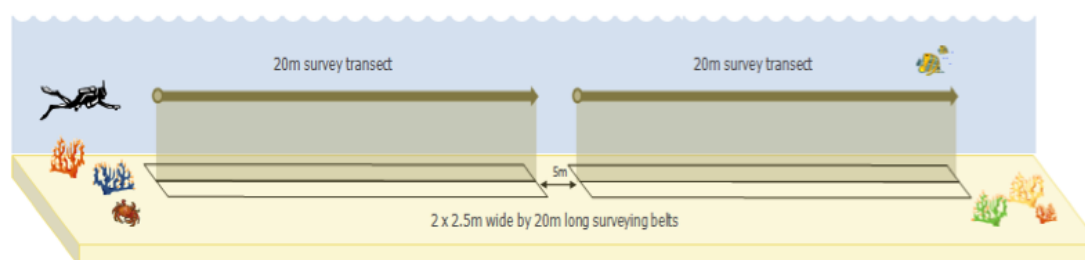


Figure 4. Survey method for recording invertebrates. Diagram shows two of the four 20m replicates within a 100m transect. Invertebrates were recorded within a 5x20m benthic rectangle.

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 minimise 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).

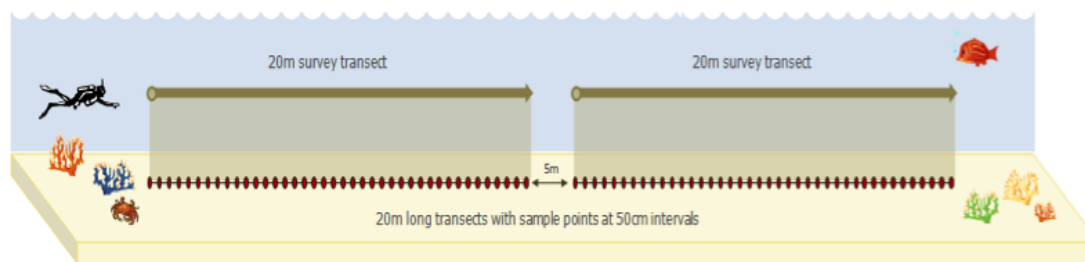


Figure 5. Survey method for recording substrate data. Diagram shows two of the four 20m replicates within a 100m transect. Substrates were recorded along a 'point intercept' line of each 20m replicate

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 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 $n=8$ at 6 metres and $n=8$ 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.

Fusiliers were removed from statistical analyses of fish abundance as they were often found in large groups, which skewed overall abundance data.

3. RESULTS

3.1. Fish

Fish abundances across four transects surveyed at Barangay Gudan ranged between 45.25 ± 6.57 per 500m^3 at transect one and 175 ± 80.45 at transect three (Figure 6). Transect three was significantly more abundance than transects one and two ($p=0.02$). Fish diversity (fishers α) ranged from 2.84 ± 0.25 at transect 4 and 4.06 ± 0.5 at transect one (Figure 6). There was no significant difference between fish diversity.

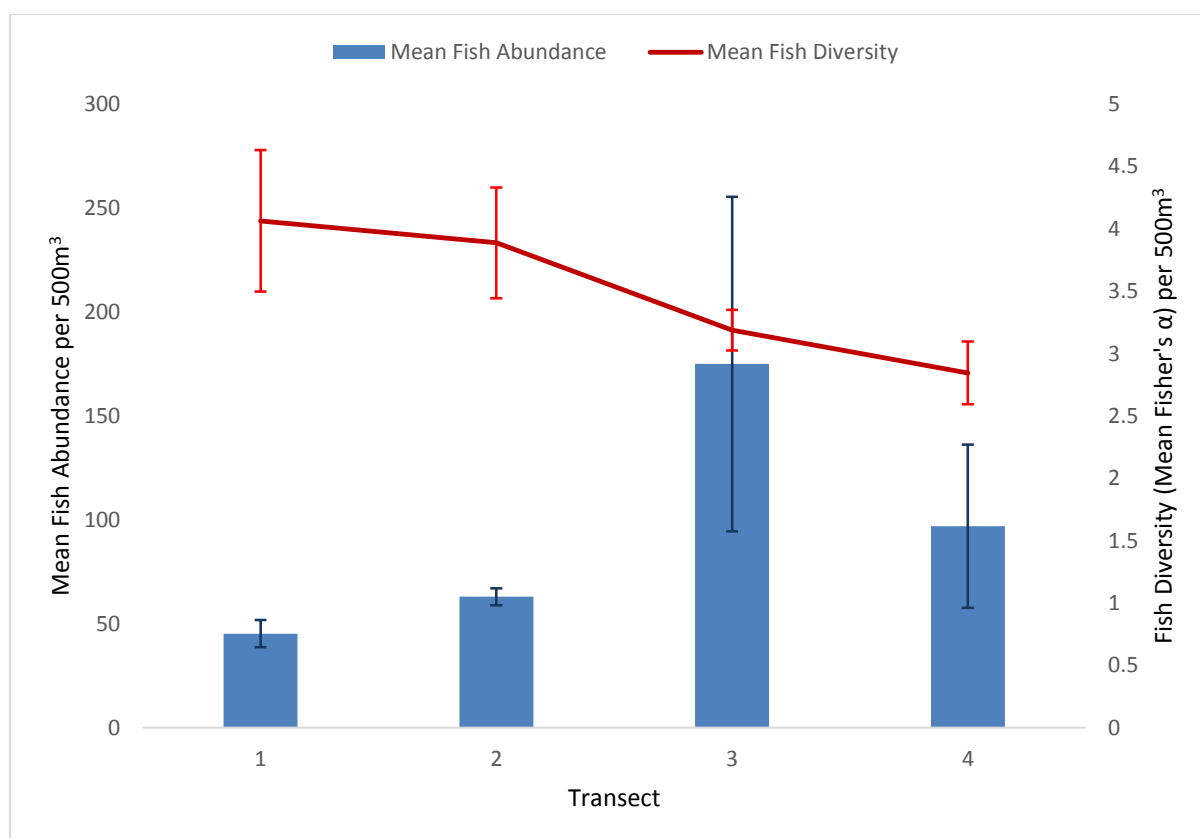


Figure 6. Average fish abundance and diversity at each transect. Blue bars represent mean fish abundance per 500m^3 , black error bars denote standard error from the mean. Red line represents mean fish diversity (fishers α) per 500m^3 , red error bars denote standard error from the mean.

The increased fish abundance at transect three can be largely attributed to a school of 300 fusiliers recorded in a single replicate. Schools of this scale are common however while individual fusiliers were recorded on other transects in lower abundance, no other schools were observed. As large schools of fusiliers can skew the data they were removed from the data set. In the absence of Fusiliers, mean fish abundance at transect three is reduced to 100 ± 6.89 individuals per 500m^3 (Figure 7). Both transects two and three were significantly higher than transect one ($p=0.02$) and transect three was significantly higher than transect two ($p=0.02$) (Figure 8).

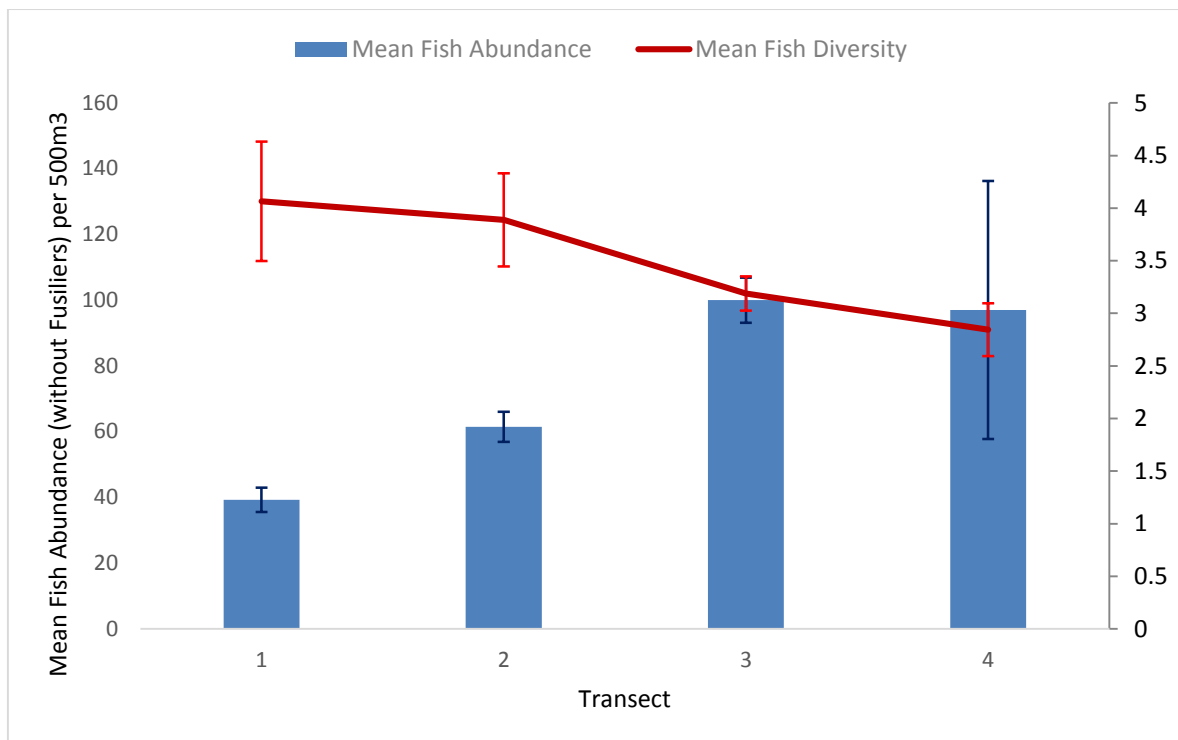


Figure 7. Average fish abundance and diversity at each transect. Blue bars represent mean fish abundance per 500m³(without Fusiliers), black error bars denote standard error from the mean. Red line represents mean fish diversity (fishers α) per 500m³(with Fusiliers), red error bars denote standard error from the mean.

	1	2	3	4
1		-	-	
2	+		-	
3	+	+		
4				

Figure 8. Matrix showing significant differences in mean fish abundance between transects. Fusiliers are not included in the analysis. A green '+' indicates that abundance was significantly higher at 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 at the transect in the left column compared to the transect in the top row ($p < 0.05$). Blank cells indicate no significant difference.

Low densities of the commercially important fish families Parrotfish, Grouper and Snapper were recorded throughout the survey period (Figure 7). Of the three families, Parrotfish were recorded most, with a total of 57 fish recorded across the site and an overall average abundance of 3.56 ± 1.59 per 500m³. Transects two and four yielded the highest numbers of parrotfish with an average abundance of 4.75 ± 2.63 and 4.5 ± 2.1 , respectively.

Grouper were completely absent from all replicates of transects one and three however a total of nine individuals were recorded at transect two with an average abundance of 2.5 ± 1.31 per 500m^3 . A single grouper was observed on transect four equating a total of 10 recorded across the site.

Snapper were present in small numbers on all transects, with a total of 13 recorded across the site. The highest density of Snapper was observed at transect two where an average abundance of 2.25 ± 0.86 per 500m^3 was recorded.

Overall, commercially important fish were least abundant at transect three (2.75 ± 0.9) and most abundant at transect two (9.5 ± 4.8). Fish abundance was significantly higher at transect two than at both transects one and three ($p=0.02$).

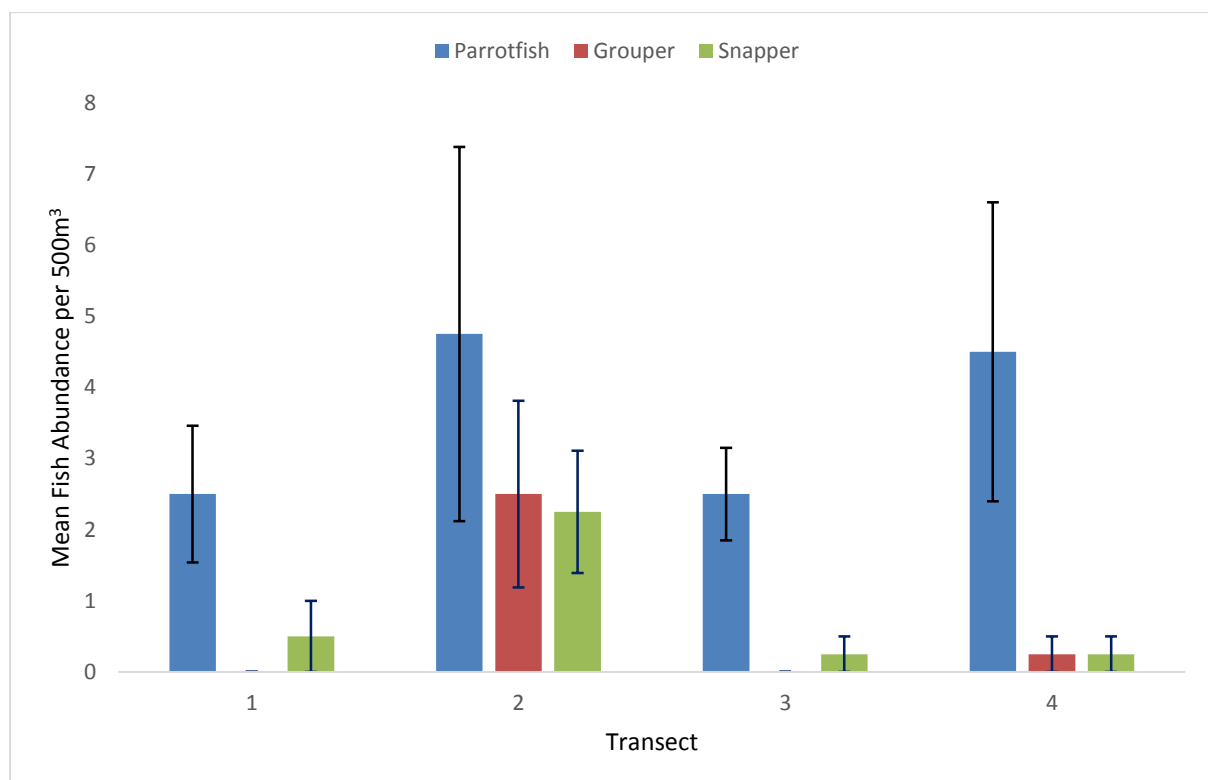


Figure 9. Average abundance of Parrotfish, Grouper and Snapper observed on each transect. Data are mean number of individuals per replicate, error bars denote standard error from the mean.

Of the commercially important fish observed in Gudan, all were small in size. 52.56% fell into the 0-10cm category, 34.62% were between 11-20cm and the remaining 12.82% of commercially important fish were 21-30cm. No recorded individuals reached a length greater than 30cm (Figure 10). The biomass of fish within these families was generally low, ranging between 0.01 ± 0.01 kg/ 500m^3 at transect four and 0.28 ± 0.17 at transect two (Figure 11).

Other commercially important fish species including Bumphead Parrotfish, Humphead Wrasse and Sweetlips were completely absent from the survey area. However, a number of rare fish species were observed including a blue-spotted ribbontail ray (*Taeniura lymma*) on transect one, a giant frogfish (*Atennarius commersoni*) on transect two and a spotted eagle ray (*Aetobatus ocellatus*) on transect three.



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

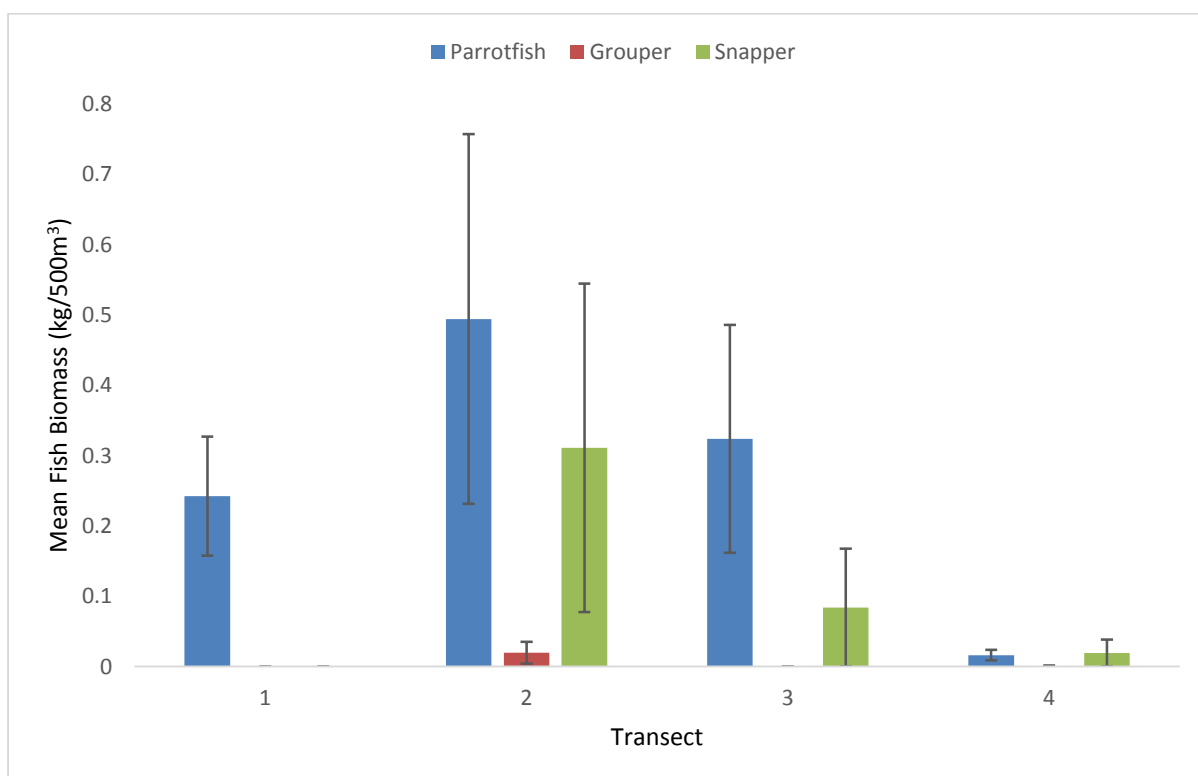


Figure 11. Biomass of Parrotfish, Grouper and Snapper observed on each transect. Data are mean biomass of individuals per replicate, error bars denote standard error from the mean.

3.2 Invertebrates

Mean invertebrate abundance across the four transects surveyed at Barangay Gudan ranged between 44.75 ± 7.36 individuals per 500m^3 at transect one and 123.75 ± 13.89 at transect four. Transect three yielded a similarly high invertebrate abundance of 112.5 ± 2.25 per 500m^3 (Figure 12). Statistically, there were significantly more invertebrates at transects three and four than at transects one and two (Figure 13).

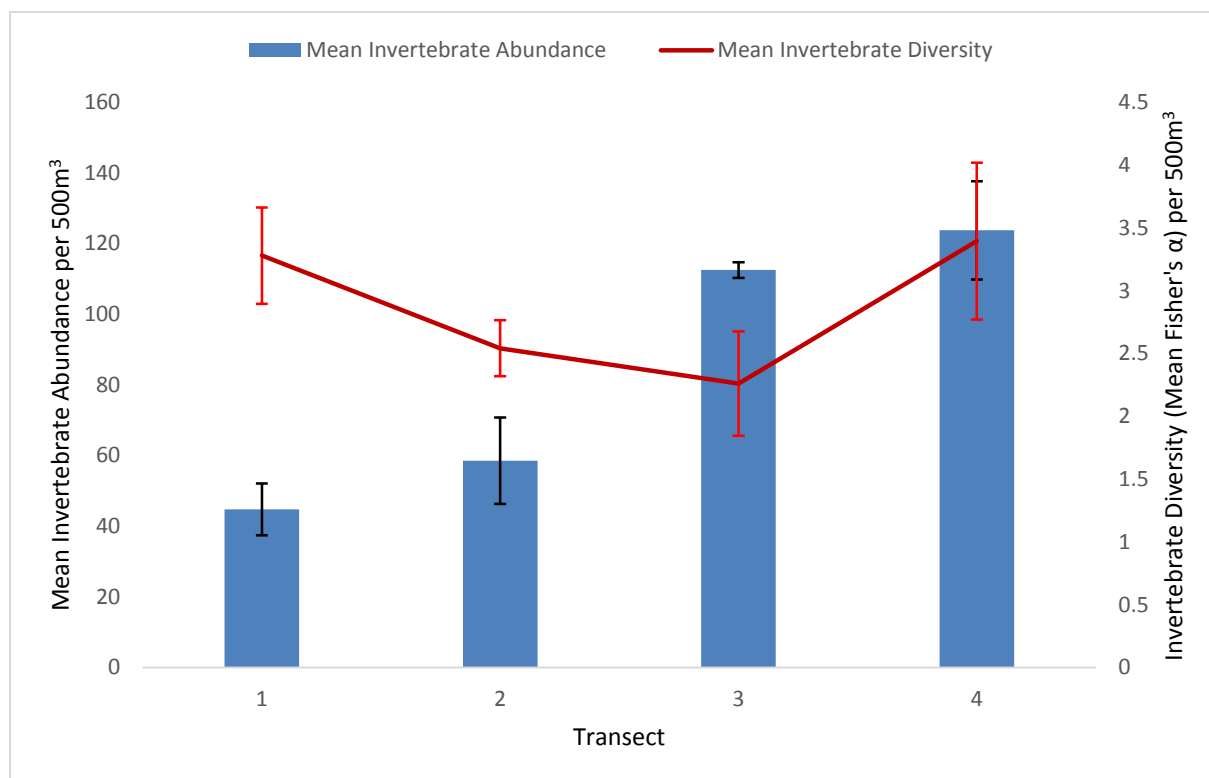


Figure 12. Average invertebrate abundance and diversity at each transect. Blue bars represent mean invertebrate abundance per 500m^3 , black error bars denote standard error from the mean. Red line represents mean invertebrate diversity (fishers α) per 500m^3 , red error bars denote standard error from the mean.

	1	2	3	4
1			-	-
2			-	-
3	+	+		
4	+	+		

Figure 13. Matrix showing significant differences in mean invertebrate abundance between transects. A green '+' indicates that abundance was significantly higher at 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 at the transect in the left column compared to the transect in the top row ($p < 0.05$). Blank cells indicate no significant difference.

Invertebrate diversity (Fishers α) ranged between 2.54 ± 0.22 and 3.39 ± 0.63 , with transect four yielding both the highest abundance and highest diversity of invertebrates across the site (Figure 12). Although transect three contained a high density of invertebrates it exhibited the lowest species richness with 2.26 ± 0.41 . In contrast, transect one contained the lowest density of invertebrates however exhibited relatively high species diversity of 3.28 ± 0.38 . There were no significant differences in invertebrate diversity between transects.

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. However, the extremely rare flamboyant cuttlefish (*Metasepia pfefferi*) was observed on transect two. Crown of Thorn Seastars (*Acanthaster planci*, CoTs) were recorded on two occasions, both at transect three.

3.3 Substrate

The most abundant substrate in the area was sand, covering an average of 38.59% of the total surveyed area (Figure 14). Rock was the second most abundant substrate (23.44%) followed by hard coral (16.72%). Within the surveyed area transect two contained the highest abundance of hard coral with 27.50% substrate cover, closely followed by transect four with 25.63%. Transect four contained a significantly higher proportion of hard coral than transect three ($p=0.04$), while transect two was significantly higher than transects one and three ($p=0.02$) (Figure 15B). Both transects two and four also contained a significantly higher proportion of rock than one and three, with 30% and 43.75%, respectively ($p=0.02$) (Figure 15C).

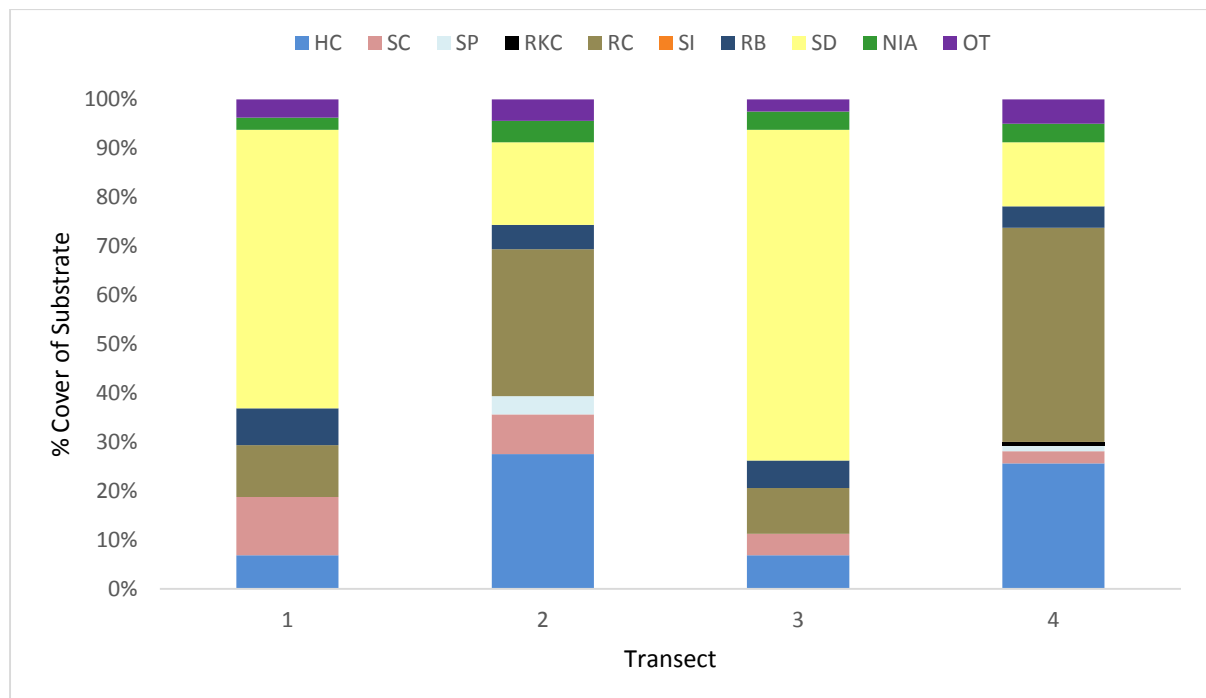


Figure 14. Mean substrate percentage cover at each transect. HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt; NIA – Nutrient indicator algae; OT – Other living organisms.

A	1	2	3	4
1				+
2			-	
3		+		+
4	-		-	

B	1	2	3	4
1		-		
2	+		+	
3		-		-
4			+	

C	1	2	3	4
1		+		+
2	-		+	
3		-		+
4	-		-	

Figure 15 - Matrix showing significant differences in percentage of sand (A), hard coral cover (B) and rock (C) 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 surveyed area of Barangay Gudan showed medium-high levels of anthropogenic impact. There were no signs of damage caused directly by boats, anchors or dynamite however 2-4 instances of coral damage were observed on both transects three and four. One fishing net was found on transect two and another on transect three while more than four pieces of fishing trash were recorded on transect four. General trash was found on all transects, with the largest number of occurrences on transect four. There were no signs of coral disease within the survey; on average bleaching was present in less than 1% of hard coral colonies across the site.

3.5 Qualitative Assessment of ‘Olly’s Wall’

3.5.1 Fish

Overall total fish abundance was low however species diversity was extremely high; all target species were observed with the exception of Bumphead Parrotfish, Humphead Wrasse and Barramundi Cod. Of the fish families present it was observed that snappers, anemonefish, triggerfish and fusiliers were the most abundant in the area.

3.5.2 Invertebrates

Overall total invertebrate abundance was high at this site. The most abundant target family observed was feather stars, closely followed by brittle stars. Invertebrate diversity was also very high; all target species were observed with the exception of lobster, squid, octopus, prickly redfish sea cucumber (*Thelenota ananas*), greenfish sea cucumber (*Stichopus chloronotus*) and pinkfish sea cucumber (*Holothuria edulis*).

3.5.3 Substrates

The wall was densely covered with a multitude of substrates; the three most abundant substrates were observed to be anemones, soft corals and black corals. It was also recorded that there were a number of large barrel sponges and a wide variety of hard coral lifeforms present. All other substrates outlined in the Reef Check methodology were observed with the exception of silt.

3.5.4 Anthropogenic Impacts

High levels of fishing trash were observed at this site including the presence of three fishing nets and numerous instances of fishing line or rope discarded along the reef.

4. VISUAL ASSESSMENT

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

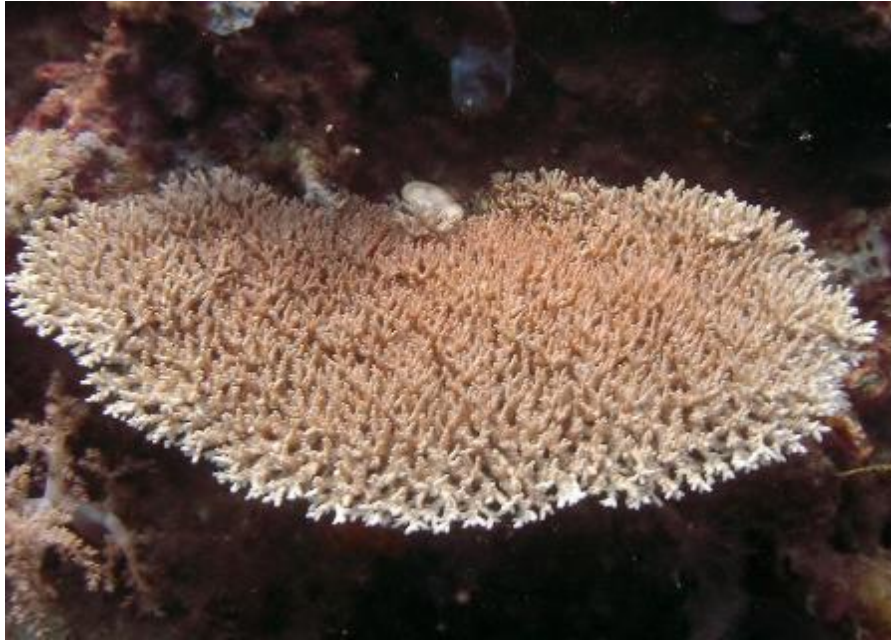


Figure 12. A healthy *Acropora tabulat* colony

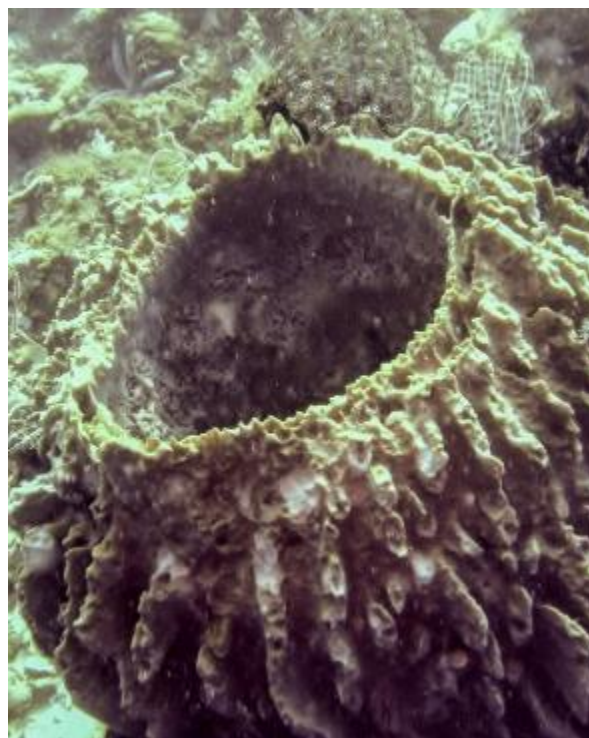


Figure 13. Large barrel sponges are a common sight on 'Olly's Wall'



Figure 14. A *Phyllidiopsis annae* nudibranch



Figure 15. Two *Amphiprion clarkii* anemonefishes



Figure 16. The elusive Flamboyant Cuttlefish *Metasepia pfefferi*

5. DISCUSSION

CCC's assessment of the reefs at Barangay Gudan revealed that the reef itself appears to be in a moderate condition. 'Olly's Wall' offers a beautiful, diverse and already popular dive site whereas the adjoining surveyed area is made up largely of sand and has not historically been considered to be as aesthetically pleasing or full of life. However, the data shows that this area is home to a number of rare species which are highly attractive to visiting tourists and also has a small population of commercially important fish. Overfishing is a major threat to the area and high levels of general and fishing trash are a cause for concern. Trends observed across the reefs of Gudan are discussed in relation to management strategies in the following sections.

5.1 Fish

Fish abundance was significantly higher at transect three than at both transects one and two ($p=0.02$); this indicates that there may be a preference of fish to the reef in this area. Despite containing the second highest fish abundance of 97 ± 39.26 per 500m^3 transect four was not significantly higher than any other transect. This is due to the large margin of error generated by a group of 154 cardinal fish which were recorded during a single replicate.

Fusiliers, a commercially important schooling fish, were also recorded in high abundance (approximately 300 individuals) on transect three; this is a positive indication of reef health. However, within a truly healthy reef system large schools of fusiliers would be expected to occur at multiple transects. Fusiliers were not included in the main analysis of fish abundance as they are often observed in large mobile schools capable of moving between transects and this can misrepresent the data.

Low abundances and small sizes of Parrotfish, Grouper and Snapper across all transects indicate that these commercially important families are being overfished in the area. That significantly more commercially important fish were identified at transect two than one and three ($p=0.02$) suggests that this area would benefit from protection against all types of fishing to allow the population to grow in size and number. Individuals larger than 30cm were completely absent from the survey and there were no Groupers greater than 20cm. Large individuals of these families are highly valued as a food fish and easily targeted by spear fishing, hook and line fishing and net fishing when they aggregate in large numbers to spawn (Hodgson and Liebel, 2002).

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. This suggests that 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 large individuals from a reef will, therefore, remove the most reproductively active individuals and create a population with a highly skewed sex ratio, which will inhibit future growth of the population. 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.

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).

‘Olly’s Wall’ offered a higher diversity of fish species than the surveyed area; all target species and families were observed with the exception of Bumphead Parrotfish, Humphead Wrasse and Barramundi Cod. One of the most abundant families in the area was Snapper, a commercially important fish which yielded relatively low numbers during the biophysical survey. The steep gradient of ‘Olly’s Wall’ offers a higher level of natural protection from fishing than the somewhat flat area where formal survey lines were laid, however without protection fish can still be taken from this area. If there were a no take zone surrounding Ollie’s Wall, commercially important fish species could thrive, growing in size and number and eventually spilling over in to the surrounding waters of Gudan, much to the benefit of the local fishing community.

Rare fish sightings included a blue-spotted ribbontail ray (*Taeniura lymma*), a giant frogfish (*Atennarius commersoni*) and a spotted eagle ray (*Aetobatus ocellatus*) across three different transects. This is a very positive sign that the site provides habitat for a number of rare species which are a desirable attraction for scuba divers. This suggests that there is potential to promote the waters of Barangay Gudan outside of ‘Olly’s Wall’ as a dive site, offering the rare opportunity to spot these unusual marine creatures. If this area were protected and properly promoted, diving and snorkelling fees could make a healthy contribution to the economy of the local barangay who currently do not benefit from the visitation of divers to ‘Olly’s Wall’ and the surrounding waters of Gudan.

5.2 Invertebrates

There was a significantly higher abundance of invertebrates recorded at transects three and four than at one and two ($p=0.02$). Although transect two yielded relatively low figures in terms of both abundance and diversity of invertebrates it was home to the very rare flamboyant cuttlefish species *Metasepia pfefferi*. Such rare sightings, if promoted well, can bring value to the reef in the form of eco-tourism.

The absence of commercially important invertebrate including lobster, squid, triton’s trumpet and prickly redfish, greenfish and pinkfish sea cucumbers from both the surveyed area and ‘Olly’s Wall’ indicates high levels of overfishing in the area. Each of these species is highly sought after for food.

Lobsters are a highly prized food item 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 Liebeler, 2002).

Only two individual CoTs (Crown of Thorns Starfish) were recorded throughout the survey site; a positive sign for the health of the reefs at Barangay Gudan. 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).

Triton's trumpets, as one of the very few predators of CoTs, are another ecologically important invertebrate species on Indo-Pacific reefs. If top predators such as the triton's trumpet are removed from an ecosystem, the risk of a CoTs outbreak is increased. They 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.

5.3 Substrates

The most dominant substrate within the surveyed area was sand with an average coverage of 38.59%. It is a cause for concern that the abundance of hard coral was relatively low; with only 16.72% average substrate coverage; 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 Liebeler, 2002). Compared with this, the reefs of Barangay Gudan appear to have a low percentage cover of hard coral.

Transect two had the highest percentage of hard coral with 27.0%, followed by transect four with 25.63%. The hard coral cover at transect two was significantly higher than at both one and three ($p=0.02$) while transect four had significantly more hard coral than transect three ($p=0.04$). Although percentage cover is still relatively low in comparison to the recommended 40%, the substrates at both transects also contained a high cover of rock, with 30% at transect two and 43.75% at transect four, both significantly higher proportions than at transects one and three ($p=0.02$). 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. Unlike the sand-dominated sea floor of transects one and three, the rocky surfaces here provide a suitable area for attachment of new coral colonies and creates opportunity for the hard coral community in Gudan to increase. In order to achieve this, the reefs should be protected against destructive fishing practices including dynamite, cyanide and trawling.

Greater diversity was observed at 'Olly's Wall' which was densely covered with a variety of different substrates. Due to this site being a wall, the gradient is largely unsuitable for sand which dominated the formally surveyed area. In particular, anemones, soft corals, black (whip) corals and hard corals were very abundant and there was a strong presence of large

barrel sponges. Sponges are an important part of the reef ecosystem as they filter water at a rapid rate, removing nutrients from the water.

5.4 Anthropogenic Impacts

The Coral Reefs at Barangay Gudan appeared relatively healthy, showing no signs of disease and very low levels of coral bleaching. However, coral damage was observed on occasion and moderate - high levels of general and fishing related trash were recorded across the site. 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 presence of such trash tends to deter divers from visiting or returning to a site, therefore to improve the site for recreational diving trash levels should be greatly reduced.

The local community may be unaware that the improper disposal of general waste negatively affects the health of the reefs at Gudan. 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

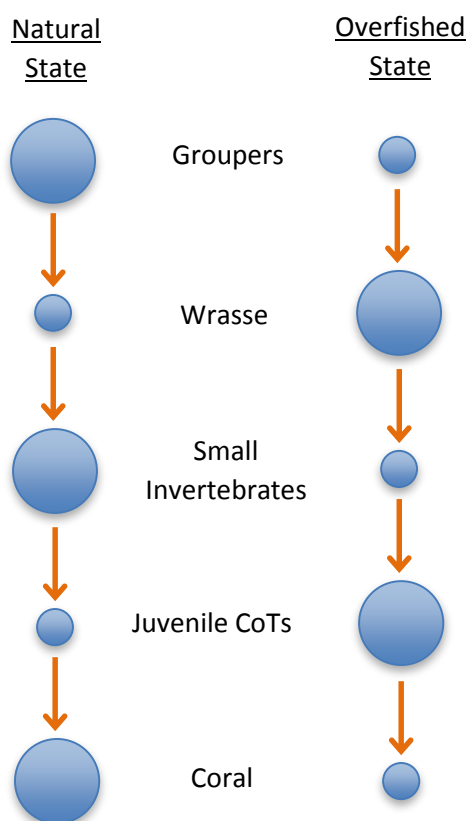


Figure 17. Representation of the indirect effects that overfishing of predatory fish, in this example Groupers can have on the entire coral ecosystem. The size of the circle represents the relative abundance of that organism or trophic level.

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. With such close proximity to a river it is likely that a lot of the non-fishing related trash enters this way. Again educating the community on better waste disposal techniques could have a huge benefit to the ecosystem. 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.

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 24).

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).

The reefs of Barangay Gudan support small populations of economically, ecologically and culturally important species and exhibit excellent potential to increase in hard coral cover and fish abundance. They are also known to be habitat for a number of rare species which are highly attractive to divers thus providing a major selling point for eco-tourism. However, in their current state the reefs are in danger of declining further and if protection is not afforded fish densities may decrease beyond a point from where they can recover. Data suggests that fishing pressure is high and unsustainable at current levels. The implementation of an MPA could reverse these trends and allow the reef to fully recover, with lasting benefits for the community of Barangay Gudan.

6. RECOMMENDATIONS

CCC strongly recommend for the waters of Barangay Gudan 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, and can assist in training local Bantay Dagats, at the request of Gudan.

6.1 Recommended Scenarios for Gudans Marine Protected Area

Of the area formally surveyed, transects two and four held the highest percentage of hard coral cover in an otherwise sandy environment, with the greatest potential for colonisation. It is critical that these are included in the protected area in order to allow all other elements of the ecosystem to recover. This also includes the area with the highest abundance of commercially important fish families and sightings of the Giant Frogfish and Flamboyant Cuttlefish (transect two). Transect three yielded a significantly high abundance of both fish and invertebrates which suggested a preference to this area despite the low coral cover; it would be beneficial to include this in the protected area to allow these populations to grow and spill over into the surrounding waters. A spotted eagle ray was also recorded on this transect. Although transect one had little to offer in terms of fish, invertebrates or hard coral one blue spotted ribbontail ray was observed in the sand. As rare species such as this are attractive to divers and can create funding in the form of eco-tourism, it may be beneficial to the community of Barangay Gudan include this in the protected area.

Taking these facts into consideration, the final designated MPA site for Gudan must be decided in consultation with the local Barangay, the local fishers and the municipal government of Liloan. Outlined below are Coral Cay Conservations preliminary recommendations for the creation of a successful MPA in Gudan, ranging from most effective (Scenario A) to least effective (Scenario C).

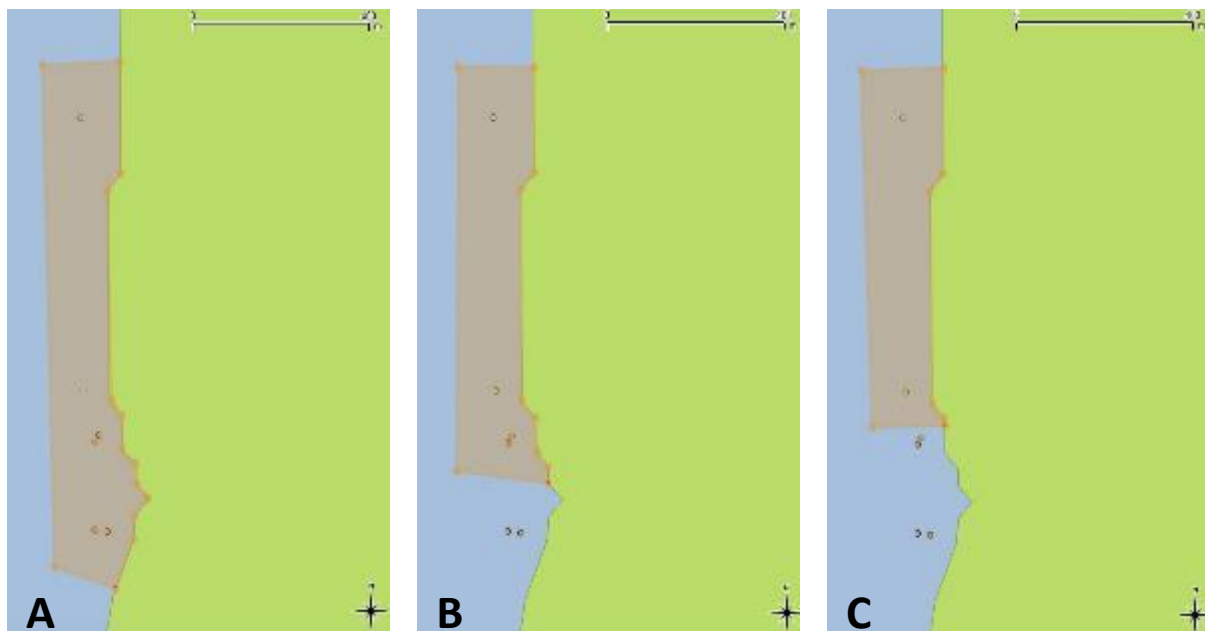


Figure 18. Visual representation of three possible scenarios for an MPA designation in Gudan. Scenario A represents the option likely to be the most effective, B the next best and C the least effective MPA.

Scenario A (Figure 18A) is the creation of an MPA which covers an area of 15.6ha, encompassing all four transects and the entire length of “Olly’s Wall” within its boundaries. As the reef is showing considerable signs of overfishing and pollution, this option would undoubtedly allow the best chance of a full recovery.

A second option (Scenario B) is outlined in Figure 18B. This option would eliminate transects one and three from the proposed MPA site; the resulting MPA would be 12.3ha in area and include transects two and four along with 'Olly's Wall'. Selection of this scenario, as opposed to Scenario A, would reduce the size of the MPA therefore leaving a larger area available to fisherfolk however will also reduce the functionality of the MPA. While this size of MPA will allow fish stocks to recover, it is likely that it would take longer to do so. A potential alternative to scenario B is to create a smaller MPA containing transects two and four, which contain the best coral cover in Gudan, and designating the remaining area as a Marine Reserve (MR) which permits only hook and line fishing. Again, this will reduce the functionality of the MPA however leave a greater area available for (restricted) fishing and allow the Barangay to profit from fees collected from visitors to 'Olly's Wall'.

The third and final option (Scenario C) is shown in Figure 18C. The boundaries of this potential MPA would solely encompass 'Olly's Wall', excluding all four transects from protection and enclosing an area of 10.5ha. The main benefit of this scenario to the community of Gudan would be the ability to collect fees from visiting dive boats. However, in comparison to Scenarios A and B this MPA would offer minimal protection to the reef, leaving the area of highest coral cover unprotected, and contribute less to the regeneration of fish stocks. All three scenarios would benefit additionally by having Marine Reserve buffer zones of 50m which restrict all but hook and line fishing.

All 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 Gudan, 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.

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 Gudan 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 Barangay Gudan 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.

REFERENCES

- Allen, G.R. (2008). Conservation hotspots of biodiversity and endemism for Indo-Pacific coral reef fishes. *Aquatic Conservation: Marine and Freshwater Ecosystems*. **18**: 541–556.
- Bohnsack, J.A. (1990). The potential of marine fishery reserves for reef fish management in the U.S. Southern Atlantic. *NOAA Technical Memorandum NMFS-SEFC-261*, Miami, USA. 40p.
- Calumpong, H.P., Raymundo, L.J., Solis-Duran, E.P., Alava M.N.R. and de Leon, R.O. (Eds.). (1994). Resource and Ecological Assessment of Sogod Bay, Leyte, Philippines - Final Report.
- CBD. (2010). Convention on Biological Diversity - Aichi Biodiversity Targets. <http://www.cbd.int/sp/targets/>
- CRC Reef Research Centre Ltd. (2003). Crown-of-thorns starfish on the Great Barrier Reef: Current state of knowledge (revised edition).
- CTI. (2012). Coral Triange Initiative – State of the Coral Triangle Highlights – Philippines. 4p.
- Edgar, G. J. et al., (2014), Global conservation outcomes depend on marine protected areas with five key features, *Nature*, pp. 1-6
- Froese, R. and Pauly, D. (2001). Fishbase. World Wide Web electronic publication. <http://www.fishbase.org>
- Green, A., Smith, S.E., Lipsett-Moore, G., Groves, C., Peterson, N., Sheppard, S., Lokani, P., Hamilton, R., Almany, J., Aitsi, J. and Bualia, L. (2009). Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. *Oryx*. **43**: 488-498.
- Hardt, M. J. (2009). Lessons from the past: the collapse of Jamaican coral reefs. *Fish and Fisheries*. **10**:143-158.
- Hodgson G. (1999). A global assessment of human effects on coral reefs. *Marine Pollution Bulletin*. **38**: 345-355.
- Hodgson G. and Liebel J. (2002). The Global Coral Reef Crisis: Trends and Solutions: 5 Years of Reef Check. 37p.
- Human, B. A. and Davies, A. (2010). Stakeholder consultation during the planning phase of scientific programs. *Marine Policy*. **34**: 645-654.
- Jacinto G.L., Alino P.M., Villanoy C.L., Talaue-McManus L. and Gomez E.D. (2000). The Philippines. In *Seas of the Millennium: An environmental evaluation*. C. Sheppard (Ed.), Elsevier Science. **Chapter 79**: 405-423.
- Jackson, J.B.C., Kirby, M.X., Berger, W.H., Bjorndal, K.A., Botsford, L.W., Bourque, B.J., Bradbury, R.H., Cooke, R., Erlandson, J., Estes, J.A., Hughes, T.P., Kidwell, S., Lange, C.B., Lenihan, H.S., Pandolfi, J.M., Peterson, C.H., Steneck, R.S., Tegner, M.J., Warner, R.R. (2001). Historical overfishing and the recent collapse of coastal ecosystems. *Science*. **293**:629–38.

- Lau, P.P.F and 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.
- 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**: 343-353.
- Myers, R.A., Hutchings, J.A. & Barrowman, N.J., (1997). Why do fish stocks collapse? The example of cod in Atlantic Canada. *Ecological Application*. **7**: 91–106.
- 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**: 1846–50.
- Pauly, D., Christensen, V., Guenette, S., Pitcher, T.J., Sumaila, U.R., Walters, C.J., Watson, R. and Zeller, D. (2002). Towards sustainability in world fisheries. *Nature*. **418**: 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: 683–710.
- Roberts, C.M., McClean, C.J., Veron, J.E.N., Hawkins, J.P., Allen, G.R., McAllister, D.E. et al., (2002). Marine biodiversity hotspots and conservation priorities for tropical reefs. *Science*. **295**: 1280–1284.
- Russ, G.R., and Alcala, A.C. (2004). Marine reserves: long-term protection is required for full recovery of predatory fish populations. *Oecologia*. **138**: 622-627.
- Veron, J.E.N., Devantier, L.M., Turak, E., Green, A.L., Kininmonth, S., Stafford-Smith, M. and Peterson, N. (2009). Delineating the Coral Triangle. *Galaxea, Journal of Coral Reef Studies*. **11**: 91-100
- Wilkinson, C. (2008). Status of Coral Reefs of the World: 2008 Global Coral Reef Monitoring Network and Reef and Rainforest Research Centre, Townsville, Australia, 296p.
- Wood, L.J., Fish, L., Laughren, J. and Pauly, D. (2008). Assessing progress towards global marine protection targets: shortfalls in information and action. *Oryx*. **42**: 340-351.
- World Bank. (2005). Philippines Environment Monitor on Coastal and Marine Resource Management. World Bank, Washington DC, USA.

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	

(Damselfish)	(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>	