

Coral Cay Conservation Proposed Marine Reserve Report



Molopolo

Liloan, Southern Leyte, The Philippines

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TABLE OF CONTENTS

Executive Summary.....	3
Acknowledgements	4
List of Acronyms and Abbreviations	5
Coral Cay Conservation	6
1. Introduction.....	7
1.1 Marine Protected Areas (MPAs) and Marine Reserves (MRs).....	7
1.2 Coral Reefs & Marine Conservation in the Philippines.....	9
1.3 Characterisation of Study Region	10
1.3.1 Sogod Bay	10
1.3.2 Molopolo, Proposed MR Site	11
2. Methods	11
2.1 Survey Site.....	11
2.2 Biophysical Survey	13
2.2.1 Fish.....	13
2.2.2 Invertebrates	14
2.2.3 Substrate.....	14
2.2.4 Impacts.....	15
2.3 Data Analysis.....	15
3. Results	16
3.1 Fish.....	16
3.2 Invertebrates	22
3.3 Substrate.....	23
3.4 Anthropogenic Impacts	25
5. Discussion.....	32
5.1 Fish.....	32
5.3 Substrate.....	34
5.4 Impacts	35
6. Recommendations	36
References	39
Appendix A: Target Species Lists.....	41

EXECUTIVE SUMMARY

- Coral Cay Conservation (CCC) conducted an assessment of the reef fish, invertebrates, substrates and anthropogenic impacts at the Barangay Molopolo in the Municipality of Liloan. The site is proposed as a potential Marine Reserve.
- An enhanced Reef Check methodology was used to survey eight 100m transects, each containing four 20m replicates. The transects were equally divided between 6m and 12m depths.
- Abundance and diversity of fish families and species varied significantly between transects. Overall fish abundance was significantly higher at transect 2 than at all other transects. Fish diversity was significantly higher at transects 6 and 7 than at transects 2, 4 and 8.
- Snappers and groupers across all transects were observed in low abundances and small sizes. Parrotfish were the most abundant commercially important fish family observed throughout the survey but juveniles and large adults were low in abundance.
- Abundance and diversity of invertebrate species did not vary significantly between sites. Transect 3 exhibited the lowest invertebrate abundance but this was only significantly lower than at transect 7. Transect 3 had the highest diversity but this was only significantly higher than at transects 7 and 8.
- Sand was the most commonly recorded substrate across the survey area followed by rock and hard coral. Hard coral cover did not differ significantly between transects but was highest at transects 1, 4 and 5.
- Instances of damaging impacts such as trash and discarded fishing gear were present throughout the survey site with general trash being the most abundant.
- The reef appears in good health although lack of commercially important fish and invertebrate species indicates that overfishing is a threat to the area.
- It is recommended that consultation be started between the local community, municipal and provincial government and CCC on the creation of a protected area in the centre of the surveyed area to incorporate the areas of highest fish abundance. This area is suggested as 8.12 hectares.

ACKNOWLEDGEMENTS

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The Provincial Government of Southern Leyte (PGSL). Our work would not be possible without the support of the Provincial Environmental and Natural Resource Management Office (PENRMO) and other members of the PGSL.

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Our trained volunteers and staff for data collection during this Proposed Marine Reserve (PMR) 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 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.”

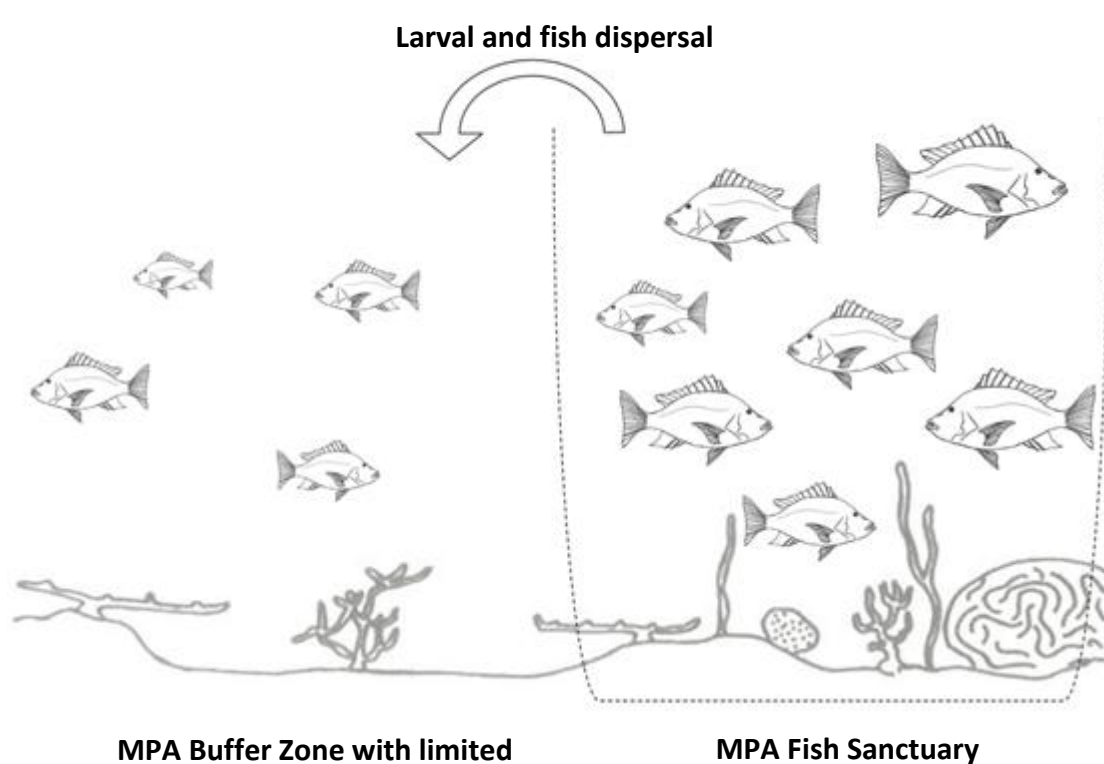


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to ‘overspill’, increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

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).

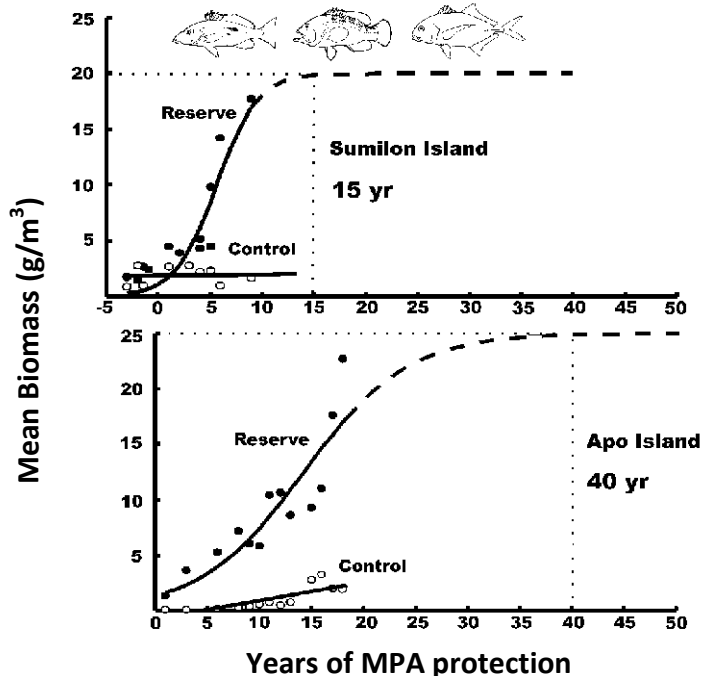


Figure 2. Observed and projected increases in mean biomass of commercially important fish species inside Apo Island and Sumilon Island MPAs (Russ and Alcala, 2004).

1.3 Characterisation of Study Region

1.3.1 Southern Leyte 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 Molopolo, Proposed MR Site

Liloan MAO requested that CCC survey the coral reefs of the barangay, Molopolo on the Pacific side of the municipality. Molopolo has a population of 861, all living within close proximity to the coast. Boats used by local fishers are small, non-motorised pump boats. A particular area of Molopolo's barangay waters has been designated as a proposed MR. This is the area that Liloan government officials requested CCC surveyed in order to assess the site for its MR suitability. Currently, Tabugon is the only barangay in Liloan with an MPA. The Liloan MAO are expending efforts to increase this number to meet the requirements of the aforementioned 1998 Fisheries Code (Republic Act 8550), which states that 15% of municipal waters should be within an MPA.

2. METHODS

2.1 Survey Site

CCC's assessment of the Molopolo Proposed MR was conducted between the 5th of May 2014 and the 24th June 2014 by trained volunteer survey teams. Weather throughout the survey period was fair, with no major weather systems moving through the region. Mean air temperature during surveys was 30.3°C. Mean water temperatures were 28.8°C at the surface, 28.1°C at a depth of 3m and 27.8°C at a depth of 10m. Mean estimated horizontal visibility during surveys was 12.6m. The site was slightly more exposed than regular survey sites due to its location on the Pacific side of Panaon Island rather than inside the shelter of Sogod Bay (Figure 3). A major storm event in November 2013 impacted upon the reef, causing serious coral damage. It was also observed that artisanal fishing in the area was high. The presence of these stressors indicate a strong need for protecting the area.

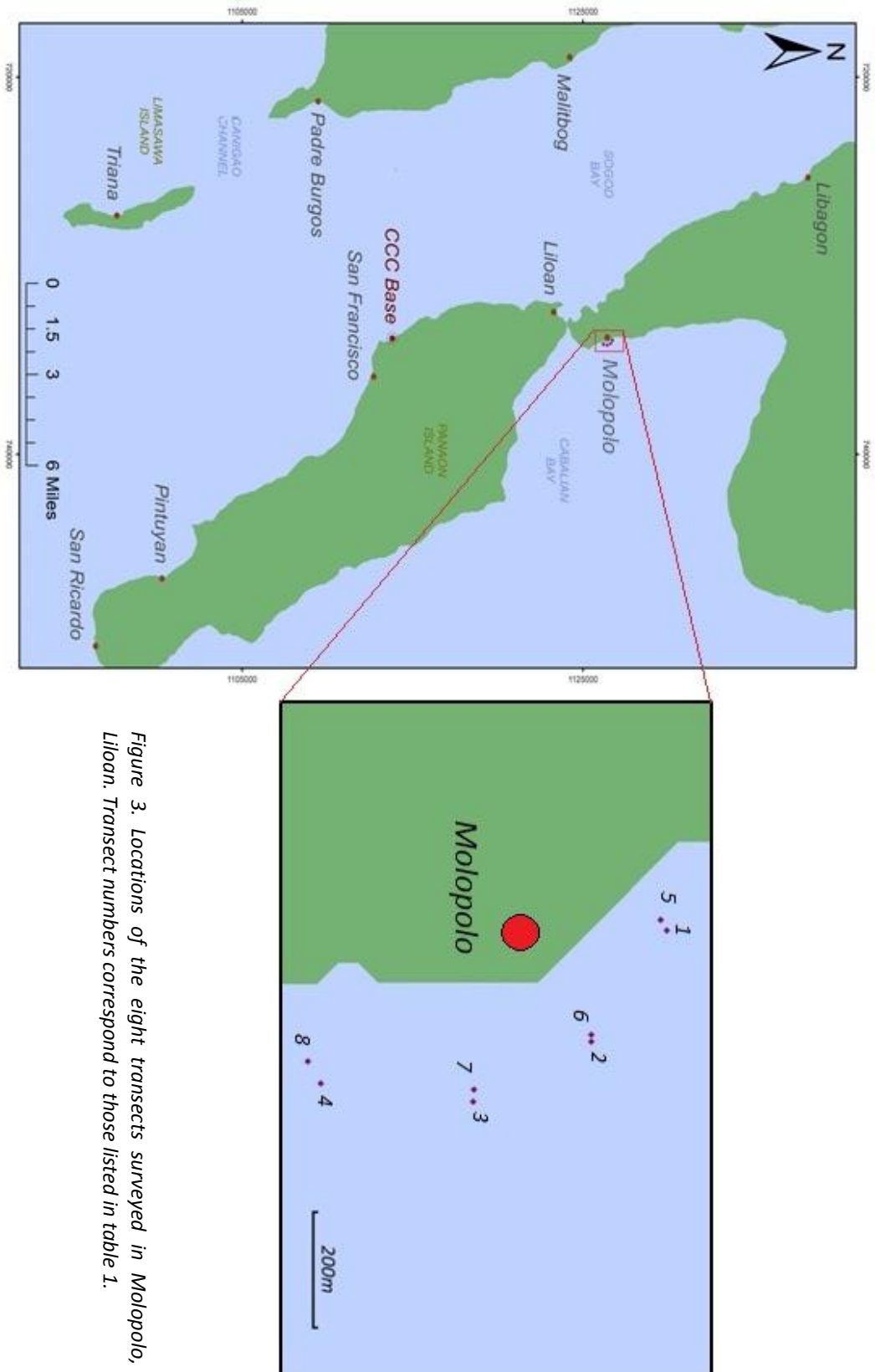


Figure 3. Locations of the eight transects surveyed in Molopolo, Liloan. Transect numbers correspond to those listed in table 1.

2.2 Biophysical Survey

Assessment of the proposed MR was conducted using an enhanced Reef Check method. The Reef Check methodology 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 by adding additional target species of fish, coral and invertebrates (Appendix A).

Transects were laid along the reef, parallel to the shore, on a North to South bearing. 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 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 eight transects surveyed along the coast of Molopolo.

Transect Number	Depth (m)	Easting	Northing
1	12	733946	1126743
2	12	734117	1126627
3	12	734210	1126446
4	12	734182	1126213
5	6	733930	1126734
6	6	734107	1126627
7	6	734191	1126447
8	6	734147	1126193

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: groupers (lapulapu, *Serranidae*), parrotfish (mulmul, *Scaridae*) and snappers (mayamaya, *Lutjanidae*); were also classified into the size classes 0-10cm, 11-20cm, 21-30cm, 31-40cm, 41-50cm, 51-60cm and >60cm (Appendix A).

Data was recorded using 'belt' transects, where fish were observed along each replicate of the 100m transect within an imaginary 5x5x20m (WxHxL) box (Figure 4). Surveys were conducted by two surveyors swimming slowly along replicates, each counting indicator fish species 2.5m either side of the central transect line. Divers paused at five metre intervals along each

replicate to wait one minute for fish to acclimatise to surveyor presence. Data collection continued during this one minute pause.

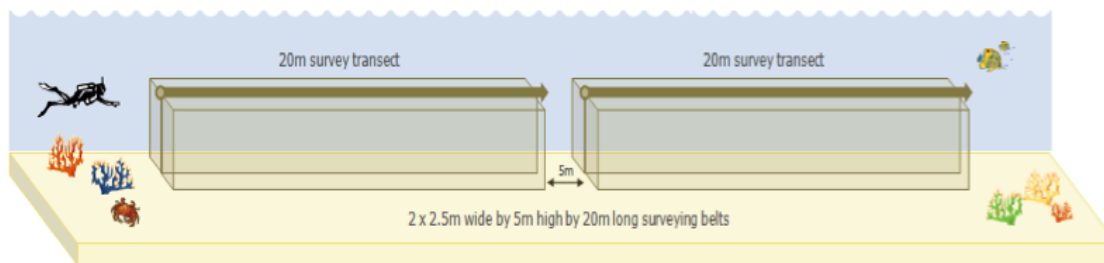


Figure 4. Survey method for recording fish. Diagram shows two of the four 20m replicates within a 100m transect. Fish were recorded within a 5x5x20m imaginary box.

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 (Appendix A). Giant clams (*takubo*, *Tridacna gigas*) were recorded into the size classes 0-10cm, 11-20cm, 21-30cm, 31-40cm, 41-50cm, 51-60cm and >60cm. Two divers each recorded invertebrates 2.5m either side of the transect line while swimming in a U-shaped search pattern (Figure 5). Divers looked in holes and under overhangs to find cryptic organisms such as lobsters and sea urchins.

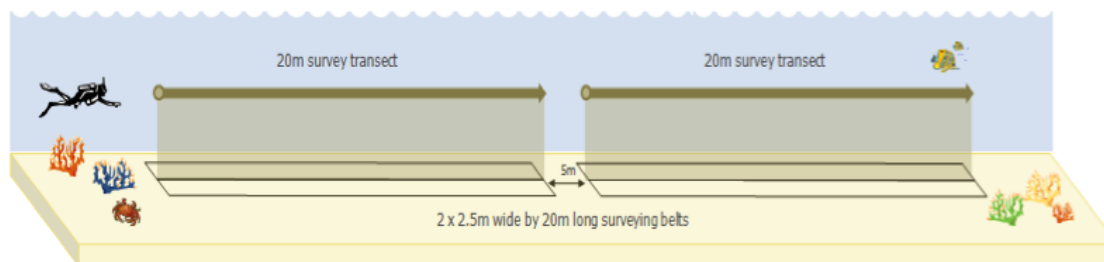


Figure 5. Survey method for recording invertebrates. Diagram shows two of the four 20m replicates within a 100m transect. Invertebrates were recorded within a 5x20m benthic rectangle.

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 minimise bias. Benthic organisms and substrate types directly underneath the transect line were recorded at 50cm intervals along each 20m replicate (Figure 6). Every 20m replicate contained 40 benthic points. Benthic categories included: sand (SD), rock (RC), rubble (RB), silt/mud (SI), nutrient indicator algae (NIA), sponge (SP), recently killed coral (RKC), soft coral (SC), hard coral (HC) and any other sessile organisms. All hard corals were recorded to life form and genus level, with targets being recorded to species level (Appendix A).

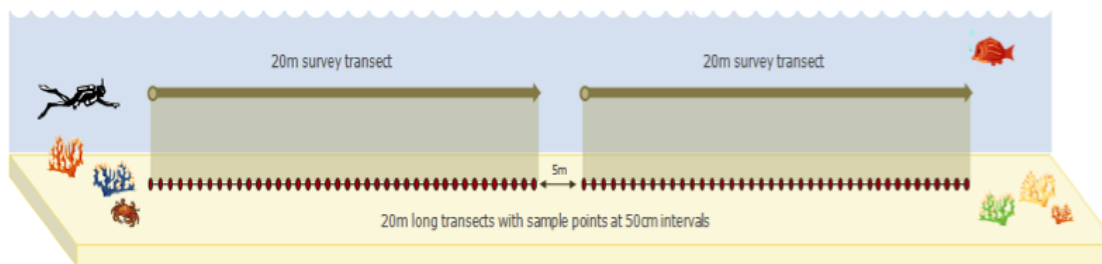


Figure 6. Survey method for recording substrate data. Diagram shows two of the four 20m replicates within a 100m transect. Substrates were recorded along a 'point intercept' line of each 20m replicate

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 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 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 depths and 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.

Gobies were removed from statistical analyses of fish abundance as they were often found in large groups, which skewed overall abundance data. They are not a key indicator species of reef health and therefore will not affect protected area recommendations.

3. Results

3.1 Fish

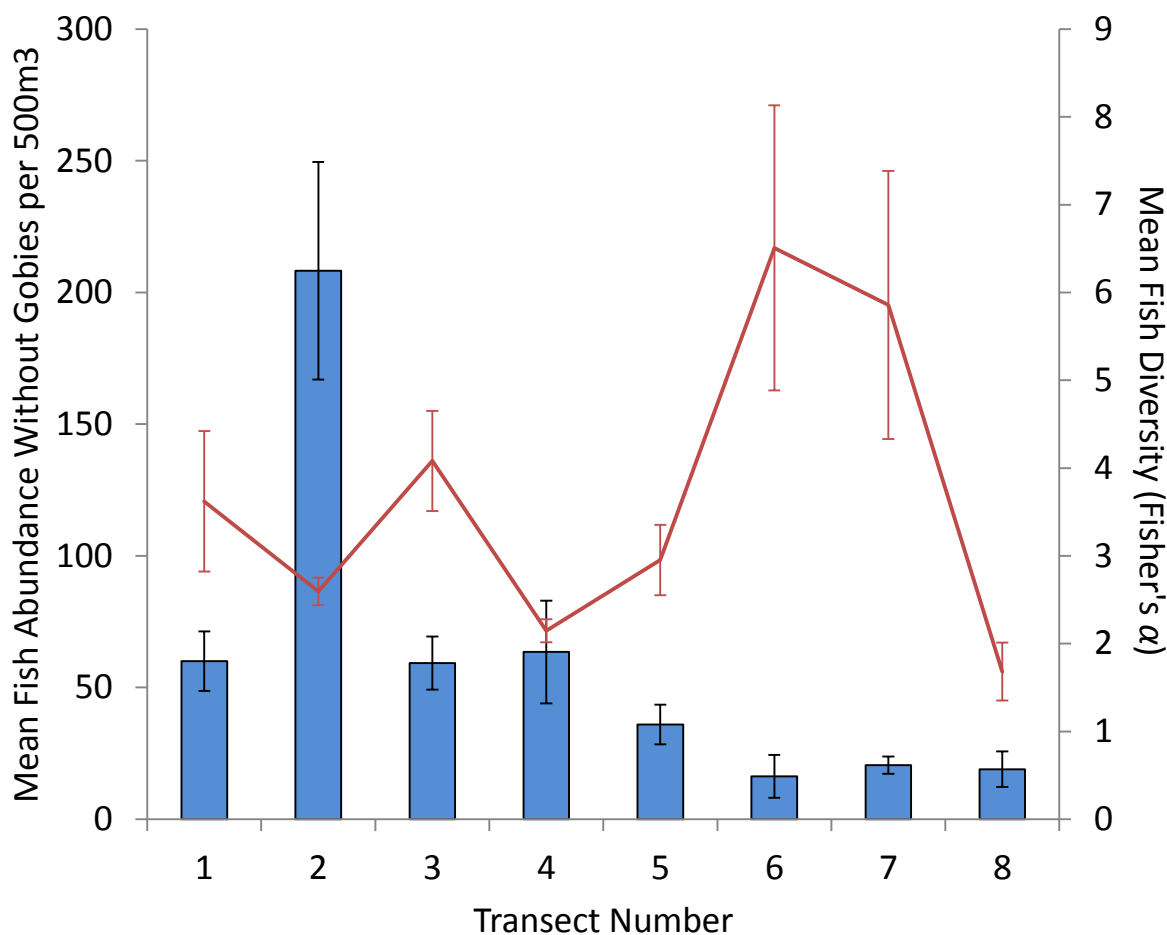


Figure 7. Average fish abundance (without gobies) and diversity (with gobies) per transect at 12m and 6m depths. Blue bars represent mean fish abundance per 500m³, whilst black error bars denote standard error from the mean. Red line graph portrays mean fish diversity per 500m³ using the Fisher's α index. Red error bars denote standard error of the mean.

Mean fish abundance observed at transect 2 was 208 ± 41 fish per 500m³, which was significantly higher than at all other transects, Mann-Whitney: $U = 0$, $Z = 2.31$, $p = 0.03$ (Figures 7 and 8). Transects 6, 7 and 8 exhibited the lowest mean abundances with 16 ± 8 , 21 ± 3 and 19 ± 7 fish per 500m³ respectively. These values were significantly lower than those observed at transects 2 and 3, Mann-Whitney: $U = 0$, $Z = 2.3$, $p = 0.03$.

Mean fusilier (*Caesionidae*) abundance at transect 2 was 176 ± 44 fish per 500m³, which was significantly higher than at any other transect, Mann-Whitney: $U = 0$, $Z = -2.31$, $p = 0.03$. Mean surgeonfish (*Acanthuridae*) abundance at transect 2 was 6 ± 1 fish per 500m³, which was significantly higher than at transects 5, 6 and 8, Mann-Whitney: $U = 0$, $Z = 2.34$, $p = 0.03$.

Mean butterflyfish (alibangbang, *Chaetodontidae*) abundance at transect 1 was 7 ± 2 , which was significantly higher than at transects 2, 4 and 8, Mann-Whitney: $U = 0$, $Z = 2.31$, $p = 0.03$. Mean parrotfish abundance at transect 8 was 1 ± 0 , which was significantly lower than at transects 1, 2 and 3, Mann-Whitney: $U = 0$, $Z = 2.34$, $p = 0.03$. Mean abundances of snappers and groupers did not differ significantly between transects. No barracuda (*Sphyraena*), humphead wrasse (*Helinus undulatus*) or barramundi cod (*Cromileptes altivelis*) were observed on any transect and only 6 sweetlips (lipti, *Plectorhinchus*) were recorded throughout the entire survey.

A low abundance of fish distributed between a high number of species caused mean fish diversity (Fisher's α index) to be highest at sites 6 and 7, with values of 6.5 ± 1.6 and 5.9 ± 1.5 respectively (Figure 7). These values were significantly higher than those observed at transects 2, 4 and 8, Mann-Whitney: $U = 0$, $Z = -2.31$, $p = 0.03$ (Figure 9). Transect 6 was one of the few transects where filefish (ilak, *Monacanthidae*) or trunk/box/cowfish (*Ostraciidae*) were observed, whilst transect 7 was one of the few where lionfish (Láwung, *Pterois*), and squirrelfish (*Holocentridae*) were observed.

	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 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.

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

Figure 9 - Matrix showing significant differences in mean fish diversity (Fisher's α index) between transects. A green '+' indicates that diversity 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 diversity 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.

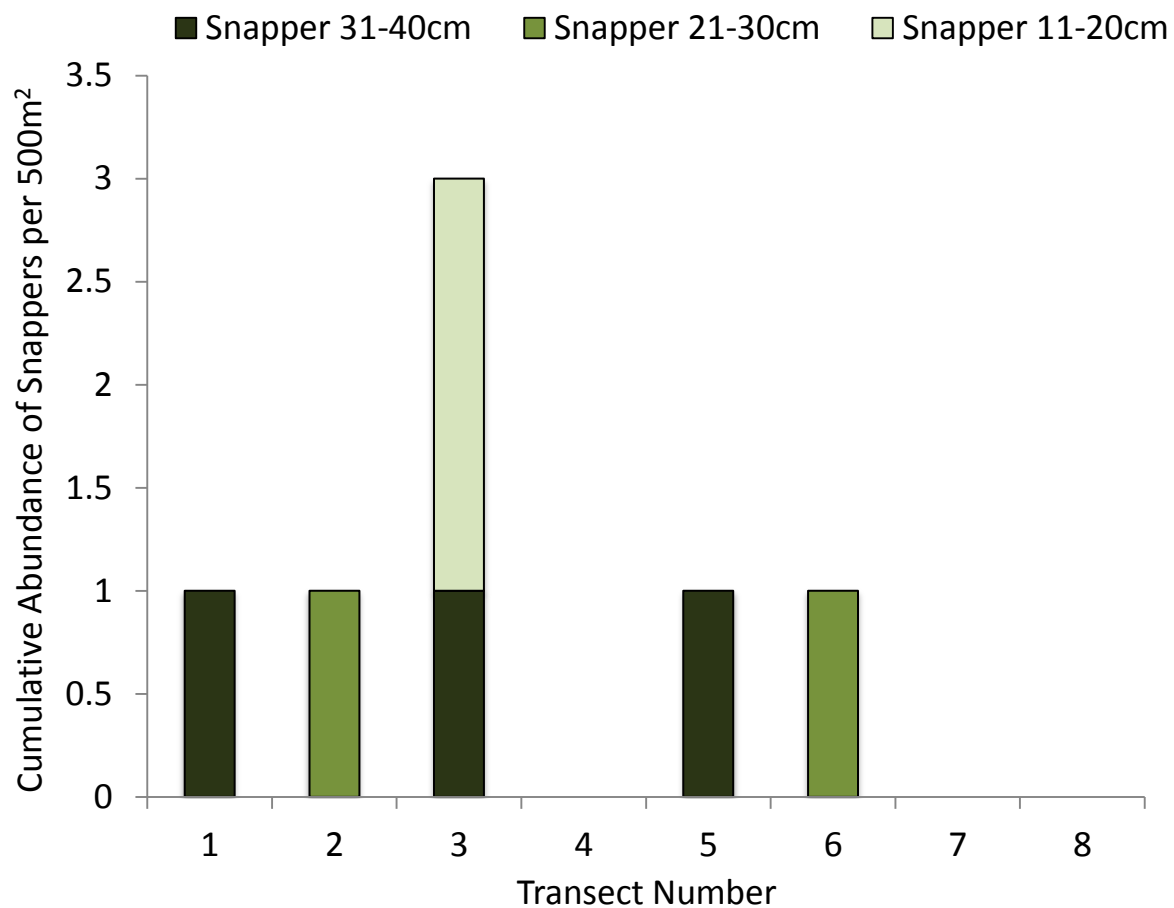


Figure 10. Cumulative snapper abundance, separated into 10cm size classes, per transect at 12m and 6m depths.

Snappers and groupers across all transects were observed in low abundances and were small in size. The highest abundance of snappers, observed at transect 3, was only 3 individuals (Figure 10) and all individuals were less than 41 cm. Transects 2 and 3 had the highest abundance of groupers but there were only 5 individuals at each transect (Figure 11). The majority of groupers were between 11 and 20 cm in size and the largest groupers observed were less than 31 cm.

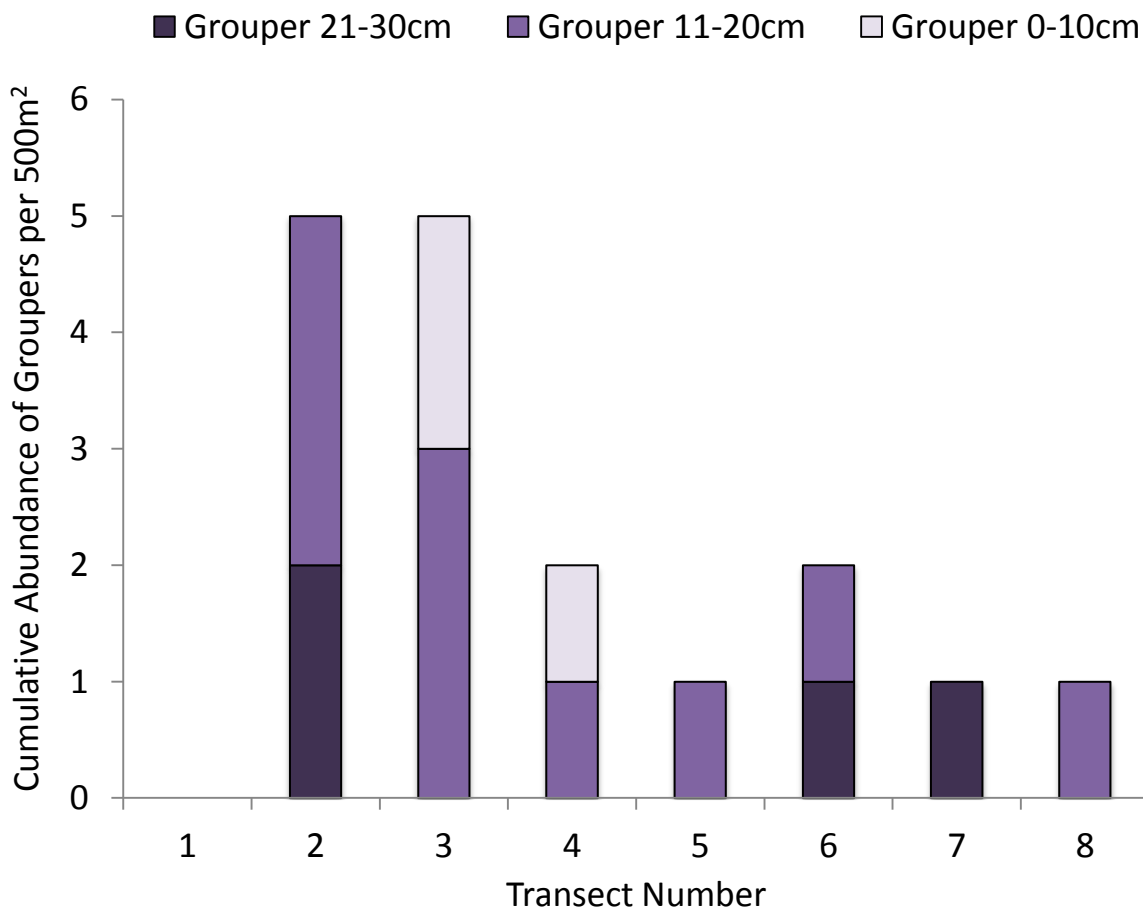


Figure 11. Cumulative grouper abundance, separated into 10cm size classes, per transect at 12m and 6m depths.

Parrotfish were the most abundant commercially important fish family observed throughout the survey (Figure 12). A total of 161 individuals were recorded, 92 of which were within the 11-20 cm size bracket. Only 15 individuals were recorded in each of the 0-10 cm and the 31-40 cm size classes, indicating that juveniles and large adults were low in abundance. Overall, transect 3 exhibited the highest abundance of parrotfish and had the highest abundance of individuals within the largest size class of 31-40cm.

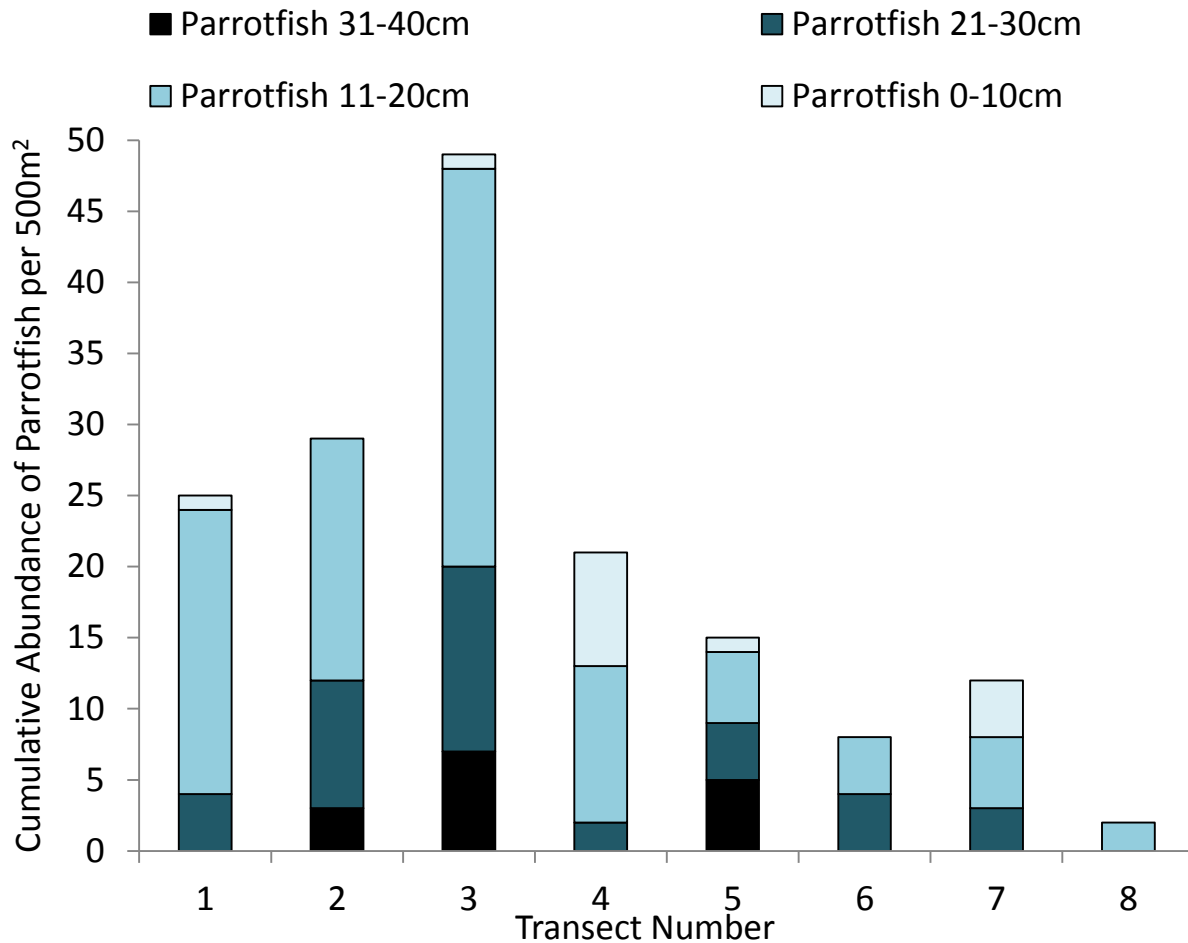


Figure 12. Cumulative parrotfish abundance, separated into 10cm size classes, per transect at 12m and 6m depths.

The low abundance and small size of snappers and groupers at Molopolo caused low biomass observations across all transects (Figure 13). Highest mean snapper biomasses were present at transects 1, 3 and 5, with 0.22 ± 0.22 , 0.25 ± 0.22 and 0.19 ± 0.19 kg per 500m^3 respectively. Biomass recordings per 20m replicate for transects 1, 3 and 5 varied from 0 to 0.90kg per 500m^3 , causing extremely large standard errors and a lack of statistical difference. Zero snappers were observed at transects 4, 7 or 8. Highest mean grouper biomass was observed at transects 2, 6 and 7 with 0.11 ± 0.08 , 0.08 ± 0.07 and 0.07 ± 0.07 kg per 500m^3 (Figure 13). There were no groupers observed at transect 1 but large standard errors caused a lack of statistically significant difference between transects.

Mean parrotfish biomass was higher than snapper and grouper biomass; with the highest biomass of 3.73 ± 2.2 kg per 500m^3 being observed at transect 3 and the lowest biomass of 0.04 ± 0.02 kg per 500m^3 at transect 8 (Figure 14). Mean parrotfish biomass at transect 3 was significantly higher than at transects 4, 7 and 8, Mann-Whitney: $U = 0$, $Z = 2.31$, $p = 0.03$.

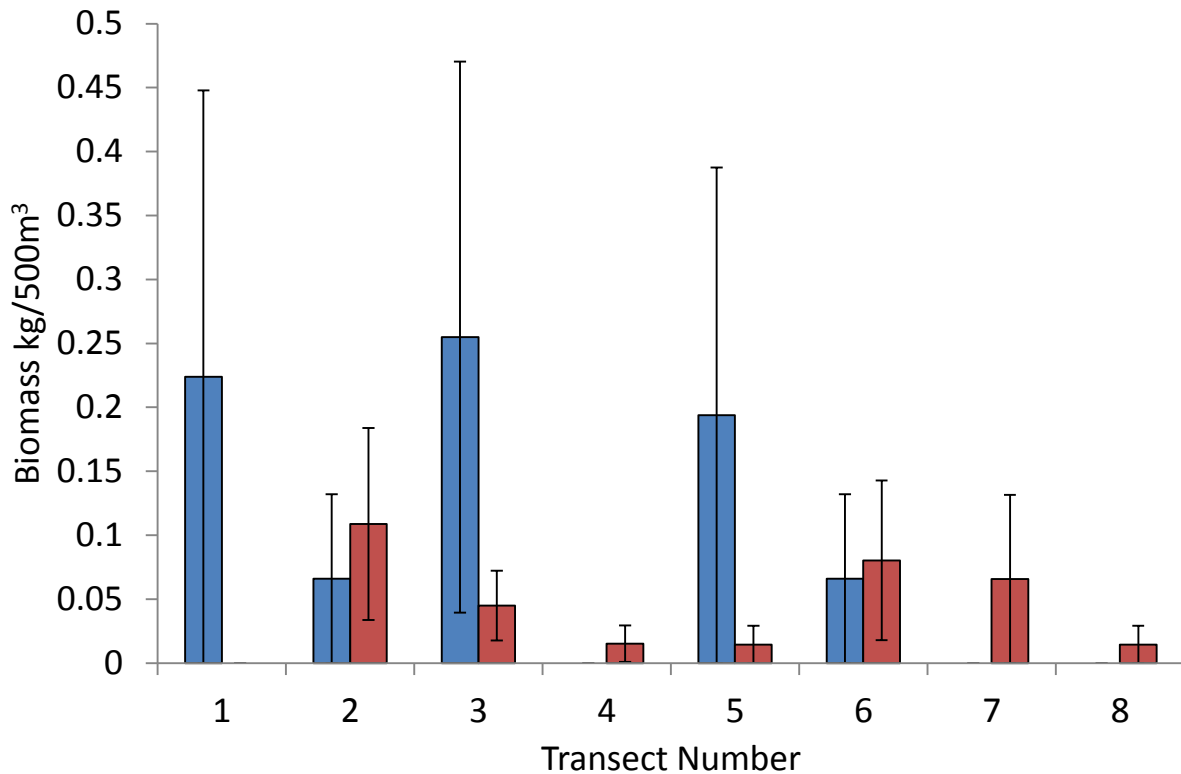


Figure 13. Average snapper and grouper biomass per transect at 12m and 6m depths. Blue bars represent mean snapper biomass and red bars represent mean grouper biomass in kg per 500m³. Black error bars denote standard error from the mean.

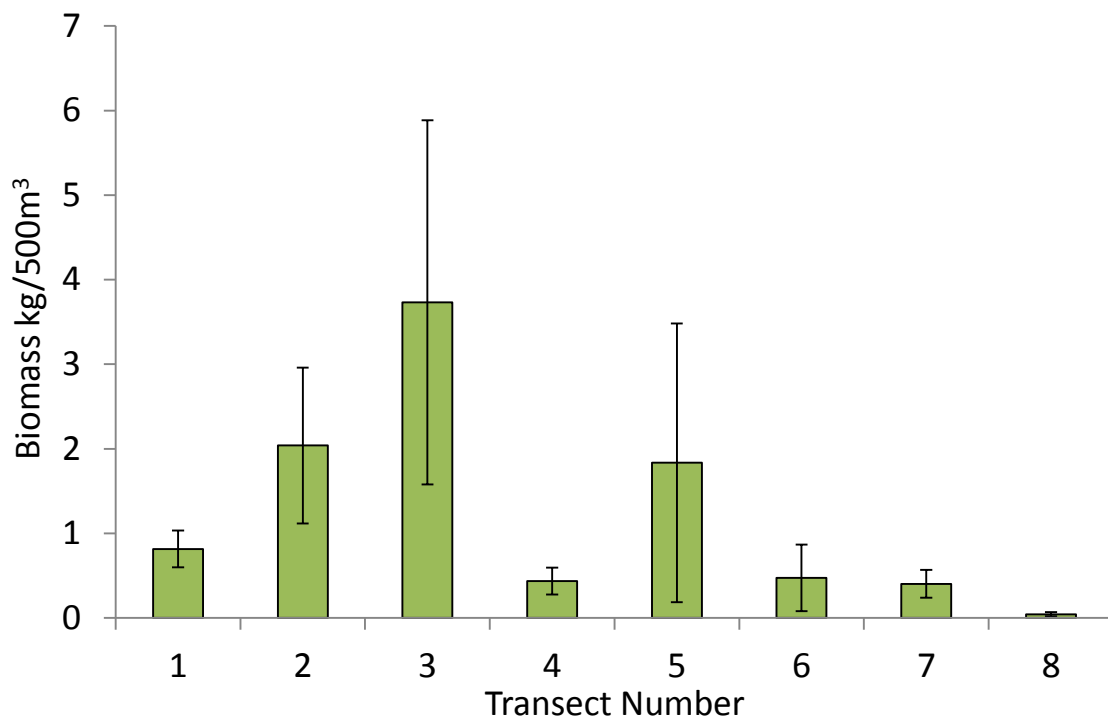


Figure 14. Average parrotfish biomass per transect at 12m and 6m depths. Green bars represent mean parrotfish biomass in kg per 500m³. Black error bars denote standard error from the mean.

3.2 Invertebrates

Mean invertebrate abundance was consistent across all transects, except transect 3, which had the lowest mean abundance of 71 ± 7 invertebrates per 100m^2 (Figure 15). Due to high amounts of standard error from the mean, invertebrate abundance at transect 3 was only significantly lower than transect 7, Mann-Whitney: $U = 0$, $Z = -2.31$, $p = 0.029$. A mean abundance of 18 ± 8 feather stars (*Crinoidea*) per 100m^2 was observed at transect 3. This was significantly lower than transects 1, 4 and 6, which had 45 ± 13 , 51 ± 7 and 48 ± 17 individuals per 100m^2 respectively. Transect 3 exhibited a mean abundance of 7 ± 1 brittle stars (*Ophiuroidea*) per 100m^2 , which was significantly lower than transects 5 and 7, which had 33 ± 11 and 28 ± 3 individuals per 100m^2 , Mann-Whitney: $U = 0$, $Z = -2.32$, $p = 0.03$. Mean abundance of long spine sea urchins (*Diadema*) was significantly lower at transect 3 (7 ± 1 individuals per 100m^2) than at transects 6 (19 ± 5 per 100m^2) and 7 (37 ± 9 per 100m^2) Mann-Whitney: $U = 0.5$, $Z = -2.18$, $p = 0.03$ and $U = 0$, $Z = -2.31$, $p = 0.03$ respectively. Mean shrimp (*Caridea*) abundance at transect 3 was 13 ± 2 individuals per 100m^2 , which was significantly lower than at transects 4 and 8, which exhibited 31 ± 6 and 55 ± 13 individuals per 100m^2 respectively, Mann-Whitney: $U = 0$, $Z = -2.31$, $p = 0.03$.

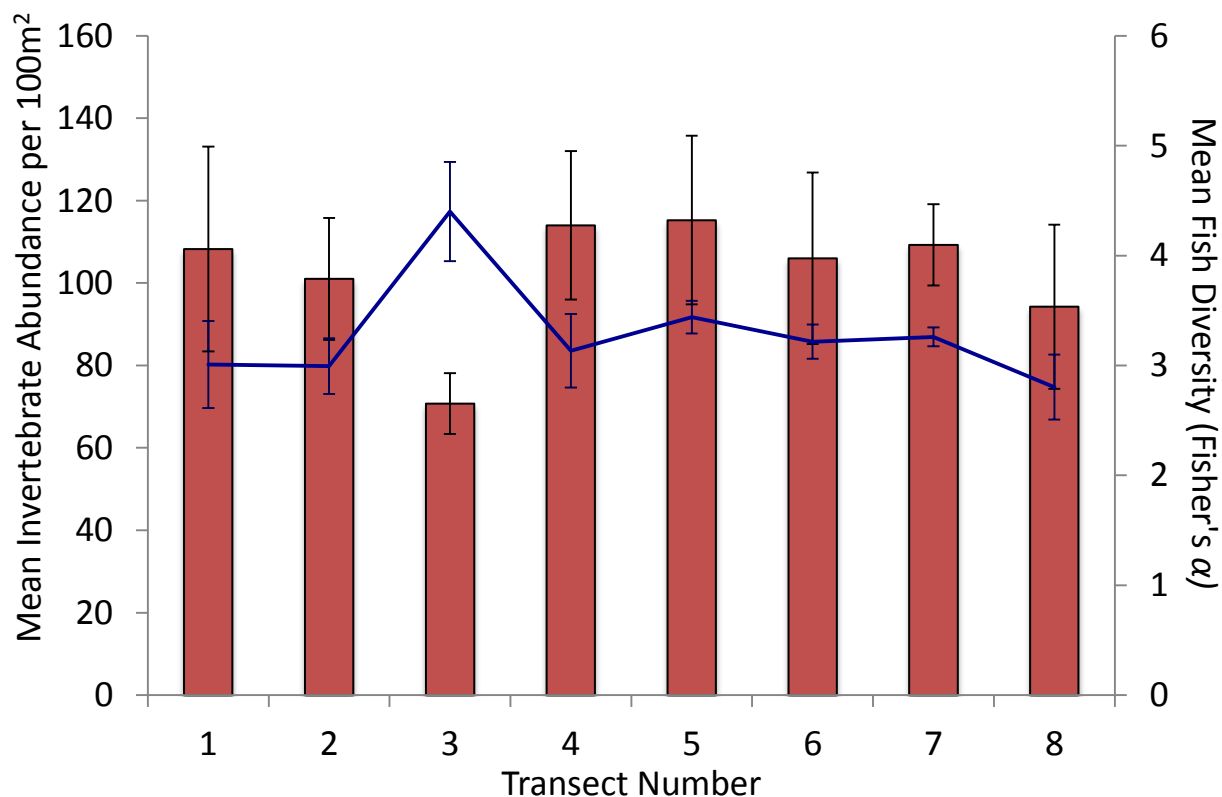


Figure 15. Average invertebrate abundance and diversity per transect at 12m and 6m depths. Red bars signify mean invertebrate abundance per 100m^2 . Black error bars denote standard error from the mean. Blue line graph portrays mean invertebrate diversity per 100m^2 using the Fisher's α index. Blue error bars denote standard error from the mean.

Although transect 3 had the lowest abundance of invertebrates per 100m², it exhibited the highest Fisher's α index of diversity (4.40 ± 0.45 per 100m²). This is because it contained the highest mean species richness (12.25 ± 0.50 species) across the lowest mean number of individuals (70.75 ± 7.37) (Figure 15). This was only significantly higher than transects 7 and 8, however, which had values of 3.26 ± 0.09 and 2.80 ± 0.30 respectively, Mann-Whitney: $U = 0$, $Z = 2.31$, $p = 0.03$.

Commercially important species, such as lobster (*Nephropidae*), abalone (*Haliotidae*), triton's trumpet (*Charonia tritonis*), squid (*Teuthida*), prickly redfish sea cucumber (*Thelenota ananas*), greenfish, sea cucumber (*Stichopus chloronotus*) or pinkfish sea cucumber (*Holothuria edulis*) were entirely absent from the entire survey. Crown of Thorn Seastars (*Acanthaster planci*, CoTs) were also completely absent and sea snails in the *Drupella* genus were observed in low abundances across the site.

3.3 Substrate

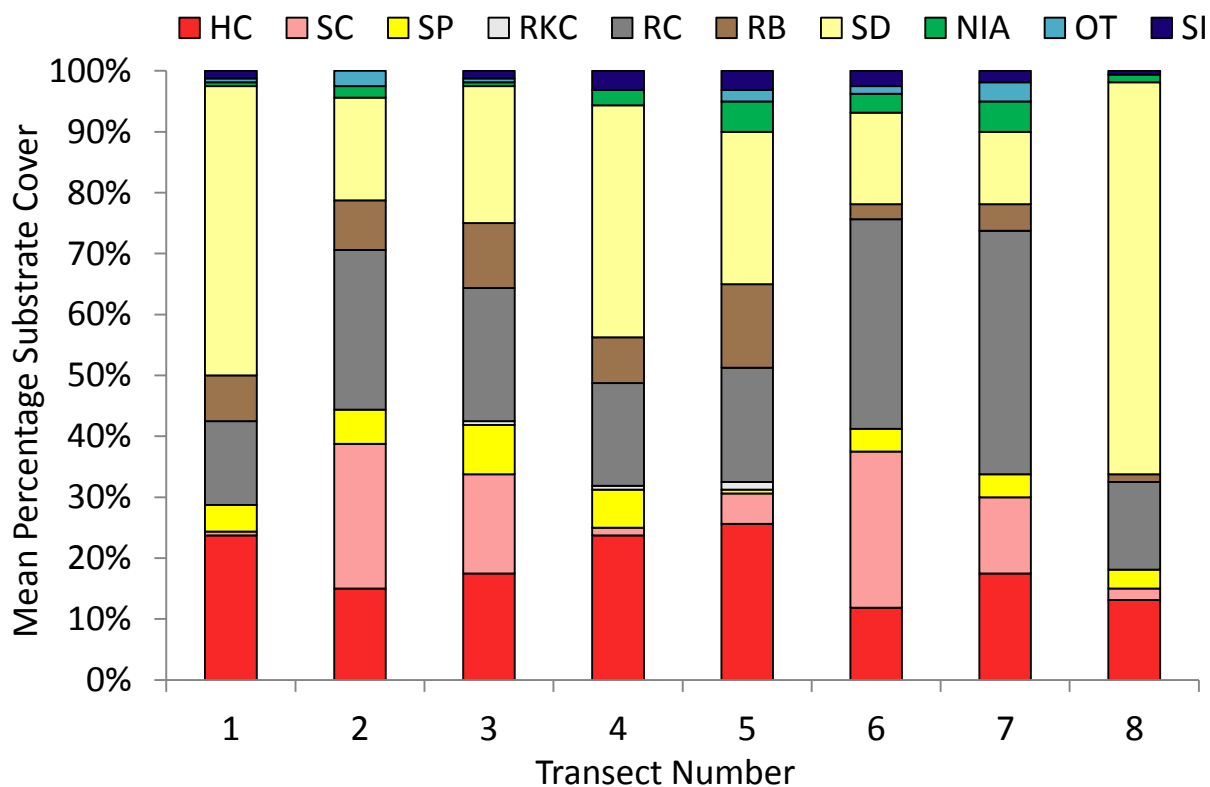


Figure 16. Mean percentage substrate cover per transect at 12m and 6m depths. HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt/mud; NIA – Nutrient indicator algae; OT – Other living organisms.

Sand was the most abundant substrate at the survey site, with a mean percentage cover of 30.16 ± 6.50 % (Figure 16). Rock and hard coral were the next most abundant substrate at the

survey site with mean percentage covers of 23.28 ± 3.40 % and 18.52 ± 1.86 % respectively. Sand was most abundant at transects 1, 4 and 8, exhibiting mean percentage covers of 47.5 ± 23.75 , 38.13 ± 19.01 and 64.38 ± 32.19 % respectively. Sand was significantly more abundant at transect 8 compared to transects 2, 3, 6 and 7, Mann-Whitney: $U = 0$, $Z = -2.31$, $p = 0.03$; $U = 0$, $Z = -2.32$, $p = 0.03$; $U = 0$, $Z = -2.31$, $p = 0.03$; $U = 0$, $Z = -2.31$, $p = 0.03$ respectively. Sand was significantly higher at transect 1 than transect 6, which had a mean percentage cover of 11.88 ± 5.94 %, Mann-Whitney: $U = 0.5$, $Z = 2.18$, $p = 0.03$. Rock was most abundant at transects 6 and 7, with mean percentage covers of 34.38 ± 17.12 and 40.0 ± 20 % respectively. Mean percentage cover of rock at transect 7 was only significantly more abundant than at transect 8, which had a mean percentage cover of 14.38 ± 7.19 %, Mann-Whitney: $U = 0.5$, $Z = 2.19$, $p = 0.03$.

Hard coral cover was highest at transects 1, 4 and 5, with mean percentage covers of 23.75 ± 5.25 , 23.75 ± 3.75 and 25.63 ± 5.04 % respectively. Mean percentage hard coral cover, however, did not differ significantly between transects. Nutrient Indicator Algae (NIA) was highest at transects 5, 6 and 7, which exhibited mean percentage covers of 5 ± 2.5 , 3.13 ± 1.56 and 5 ± 2.5 % respectively. NIA cover at transect 5 was significantly higher than at transects 1, 2, 3 and 8, which had mean percentage covers of 0.63 ± 0.31 , 1.88 ± 0.94 , 0.63 ± 0.31 and 1.25 ± 0.63 respectively, Mann-Whitney: $U = 0$, $Z = -2.31$, $p = 0.03$.

The most abundant hard coral life form across all transects was massive, with a mean percentage cover of 42.27 ± 6.70 % of the total hard coral cover. The next most abundant life form was branching, with a mean percentage cover of 26.66 ± 4.39 % of the total hard coral cover.

Transect 4 showed the highest massive coral cover, with a mean percentage cover of 14.38 ± 3.73 % of the total substrate cover. This was only significantly higher than transect 2, however, which had a mean percentage cover of 3.13 ± 0.63 % of the total substrate cover, Mann-Whitney: $U = 0$, $Z = -2.38$, $p = 0.03$. Transects 7 and 8 also had high massive coral cover, with mean percentage covers of 9.38 ± 3.29 and 10 ± 1.44 % of the total substrate cover respectively. Massive coral cover at transect 8, however, was only significantly higher than at transect 2, Mann-Whitney: $U = 0$, $Z = -2.40$, $p = 0.03$.

Transect 5 exhibited the highest branching coral cover, with a mean percentage cover of 11.88 ± 3.87 % of the total substrate cover but was only significantly higher than transect 8, which had a mean percentage cover of 1.88 ± 1.20 % of the total substrate cover, Mann-Whitney: $U = 0.5$, $Z = 2.19$, $p = 0.03$.

There were 18 different hard coral target species observed at Molopolo, of which Massive *Porites* was the most abundant target species, with a mean percentage cover of 42.34 ± 7.76 % of all target species observed. The second most abundant target species was *Porites cylindrica*, which exhibited a mean percentage cover of 20.31 ± 3.25 % of all target species.

Transect 4 exhibited the highest cover of Massive *Porites*, with a mean percentage cover of 13.13 ± 3.29 % of the total substrate. This was significantly higher than Massive *Porites* cover at transects 1 and 6, which had mean percentage covers of 3.75 ± 1.61 and 2.5 ± 1.77 % of the entire substrate, respectively.

Transect 5 had the highest abundance of *Porites cylindrica*, with a mean percentage cover of 10 ± 3.54 % of the total substrate. This was only significantly higher than transect 4, which had a mean percentage cover of 1.88 ± 0.63 % of the substrate.

Highest target coral species diversity was observed at transect 1, which had 10 different target species. Lowest target species diversity was observed at transect 8, which only had 2 different species. No brain corals were seen throughout the entire survey and one incidence of *Acropora* branching at transect 3 was the only observation of an *Acropora* species.

3.4 Anthropogenic Impacts

The corals at Molopolo were relatively healthy and showed no signs of disease and very low levels of coral bleaching (<2% of the total coral population at each transect). Damage from anchors or dynamite fishing was not observed at any of the transects. Coral damage from other causes, such as predation, was completely absent from transects 1 and 7; only observed once on transects 2, 3 and 6 and observed in low abundances at transects 4, 5 and 8. Discarded fishing gear and other fishing related trash was observed on transects 2 to 8. Fishing related trash was highest on transects 5 and 7, which had a mean occurrence of 1 piece per 100m². General trash was observed in relatively high abundances at all transects. Transects 3 and 4 exhibited the highest prevalence of general trash, with mean abundances of 6.25 ± 1.75 and 5.75 ± 2.93 pieces per 100m² respectively. Trash was lowest at transects 5 and 8, which had mean abundances of 0.5 ± 0.29 and 1.5 ± 1.20 pieces per 100m² respectively.

4. Visual Assessment

Images taken by CCC staff and volunteers at the Molopolo Survey Site.



Figure 17. CCC Surveyors lay a transect line on the reefs of Molopolo.



Figure 18. The coral reef at Molopolo.



Figure 19. Soft coral at Molopolo.



Figure 20. Fishing line caught on the coral reef at Molopolo.



Figure 21. Fishing net caught on the coral reef at Molopolo.



Figure 22. General trash on the coral reef at Molopolo.



Figure 23. A non-target sea cucumber at Molopolo.



Figure 24. A giant clam (takubo, *Tridacna gigas*) at Molopolo.



Figure 25. A twinspot blenny (*Ecsenius bimaculatus*) on a colony of *Porites cylindrica* at Molopolo.



Figure 26. The coral reef at Molopolo.



Figure 27. A regal angelfish (*Pygoplites diacanthus*) at Molopolo.

5. DISCUSSION

CCC's assessment of the reefs at Molopolo revealed that the reef itself appears to be in a good state of health but that overfishing is a threat. Hard coral cover was moderately high across all transects and showed low signs of damage, disease or bleaching. Fishing trash and general trash were present, however and the reef either completely lacked, or exhibited low abundances of commercially important fish and invertebrate species. Trends observed on the reefs of Molopolo are discussed in relation to prospective management strategies in the following sections.

5.1 Fish

Transect 2 exhibited a significantly higher fish abundance than all other transects because it had a significantly higher abundance of fusiliers. Fusiliers are often observed in large mobile schools capable of moving between transects, which could suggest that their high abundance at transect 2 is misrepresentative. However, transect 2 was the only transect throughout the entire survey to contain a large school of fusiliers. On a healthy reef system, large schools of fusiliers would be expected to occur at multiple 12m transects because they preferentially feed on zooplankton in the middle of the water column, therefore their presence at only 1 transect could indicate low fish abundance and high fishing pressure within the area.

Low abundances and small sizes of snappers and groupers across all transects indicate that these commercially important families are being overfished. Individuals larger than 40 cm were completely absent from the survey and only three snappers and zero groupers were observed in the 30 – 40cm size class. 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 Liebler, 2002). Snappers and groupers take many years to increase in size, reach sexual maturity and typically change sex. Snappers have been shown not to reach sexual maturity until they are approximately 54.6 cm in length, suggesting that a population with no individuals larger than 40cm 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.

Parrotfish larger than 40cm or smaller than 10cm were low in abundance, also indicating overfishing. The larger, more reproductively active parrotfish have been removed from the community, resulting in the production of fewer juveniles. 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.

Zero observations of barracuda, humphead wrasse or barramundi cod and a very low abundance of sweetlips in the area also indicate that these species have also been targeted for food and overfished. The humphead wrasse is the most desirable 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). Barramundi cod are also highly targets by fishers because juveniles are highly valued in the aquarium trade and adults are valuable in the Chinese live food fish market (Hodgson and Liebel, 2002).

As snapper and grouper biomasses were generally low throughout the entire site and did not differ significantly between transects, protection of any transect is extremely important to enable the recovery of these commercially important species at Molopolo. Highest parrotfish biomasses were observed at transects 2, 3 and 5; with transect 3 exhibiting the highest abundance of parrotfish in the largest observed size class (31 – 40cm). It would therefore be preferable to protect an area including this transect so that large parrotfish can increase in size and produce high abundances of juveniles that will spillover into surrounding waters.

Transects 6 and 7 exhibited the highest fish diversity (Fisher's α index) because they had the lowest abundance of individuals distributed between the highest number of species. Species observed on transects 6 and 7 that were not present elsewhere, however, were not commercially targeted species. Protection efforts based on fish diversity, therefore, do not need to focus on these transects because species diversity across transects 1 to 5 was still good.

5.2 Invertebrates

Invertebrate abundance and diversity was consistently high across all transects, except transect 3, which exhibited a low abundance and a particularly high Fisher's α value of diversity. This peak in invertebrate diversity at transect 3 was caused by a lower number of individuals being divided by a higher number of species. There were no species, however, that only occurred on transect 3 and were not observed elsewhere. The conspicuous absence of commercially important invertebrate such as lobster, abalone, squid, triton's trumpet, prickly redfish sea cucumbers, greenfish sea cucumbers and pinkfish sea cucumbers indicates high levels of overfishing.

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 regularly targeted by humans as a food substance (Hodgson and Liebel, 2002). They are easily extracted from the reef by free divers or by fishers at low tide. A complete absence of these species from the

reefs at Molopolo indicates severe overfishing. Their presence on the reef is also ecologically significant because they filter and digest sand, producing pellets that aid in reef formation.

Triton's trumpets are an ecologically important invertebrate species on Indo-Pacific reefs because they are one of the few predators of CoTs, which in turn feed upon live coral. 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.

It is crucial that part of the reef at Moloplo is protected to allow the recovery of threatened invertebrate species. As species abundance did not differ significantly between transects 1, 2, 4, 5, 6, 7 and 8; the protection of any of these transects would be beneficial.

The absence of CoTs from the survey area is a positive sign for the health of the reefs at Molopolo. 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 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 Substrate

Mean percentage cover of hard coral did not differ significantly between transects but remained around 20% across the survey site. 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 Liebler, 2002). Compared to this research, the reefs at Molopolo appear to have a low percentage cover of hard coral but there is potential for this to increase. The survey site is characterised by a high abundance of rock and a low percentage cover of NIA, which indicates potential for the area to be colonised by new coral recruits. In a 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. As hard coral percentage cover did not differ significantly between transects, the protection of any area of hard coral within the survey site would benefit the entire ecosystem.

The prevalence of massive *Porites* and *Porites cylindrica* across all transects at Molopolo shows that the area is colonised by both slow-growing and fast-growing species of coral. This indicates that the area is not exposed to high wave action because slow-growing species have been able to settle and grow without being destroyed. New recruits should, therefore, be able to colonise the rocky substrate.

5.4 Impacts

The coral reef at Molopolo appeared relatively healthy, showing no signs of disease and very low levels of coral bleaching. The main sources of damage in the area were fishing related trash and general trash. If protection were to be enforced upon the reef, fishing related trash would be expected to diminish, or even disappear. The local community may be unaware that the improper disposal of general waste negatively affects the health of the reefs at Molopolo. 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. 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.

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

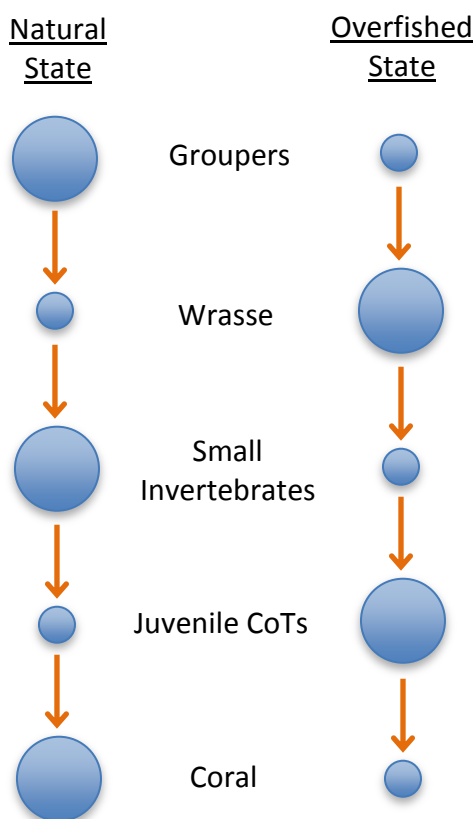


Figure 28. Representation of the indirect effects that overfishing of predatory fish, in this example Groupers can have on the entire coral ecosystem. The size of the circle represents the relative abundance of that organism or trophic level.

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 28).

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

28). 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 Molopolo appear to have a healthy cover of hard coral but are threatened by overfishing. Data collected from the area indicate that fishing pressure is currently unsustainable and will eventually result in the degradation of the reef and the consequential loss of important food species. The implementation of a protected area such as an MR or an MPA could reverse current trends at Molopolo and allow the reef to recover.

6. Recommendations

In order for the reefs at Molopolo to recover their diminishing fish and invertebrate stocks, the area needs to be protected. Currently the area is proposed as an MR, which would restrict fishing in the area but still allow it to continue. Considering the current status of fish and invertebrate stocks at Molopolo, the installation of an MPA would be preferable to an MR. An MPA would provide a no-take zone that fish could utilise as a sanctuary from fishing pressure in the area. Fish and invertebrates would be allowed to grow to larger sizes, produce more young and replenish their populations more quickly and efficiently than within an MR.

It is advised that the area of protection is placed around the central transects of the survey site, encompassing transects 2, 3, 6 and 7, with a connection to the shore (Figure 29). Transect 2 displayed a significantly higher fish abundance than all other transects and the only occurrence of a large school of fusiliers. It would be beneficial to protect this transect because fish will reproduce in high numbers causing fish stocks to recover more quickly than at sites with low abundances. Transect 3 was selected for protection because it exhibited the highest snapper and parrotfish biomasses and the highest abundance of parrotfish within the largest observed size class. Large fish will become fecund more quickly than smaller fish and so their protection will increase fish stocks rapidly. Transects 6 and 7 should be included because the protected area should extend to the shore, enabling more effective enforcement of the regulations of the area.

Our suggested area is 8.12 hectares but is flexible and open to the suggestions of the community and local fishers. This recommendation should be used as the initial step in opening dialogue between all relevant members of the local community, Municipal and Provincial Governments, and CCC. 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 the success of an MPA. 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.

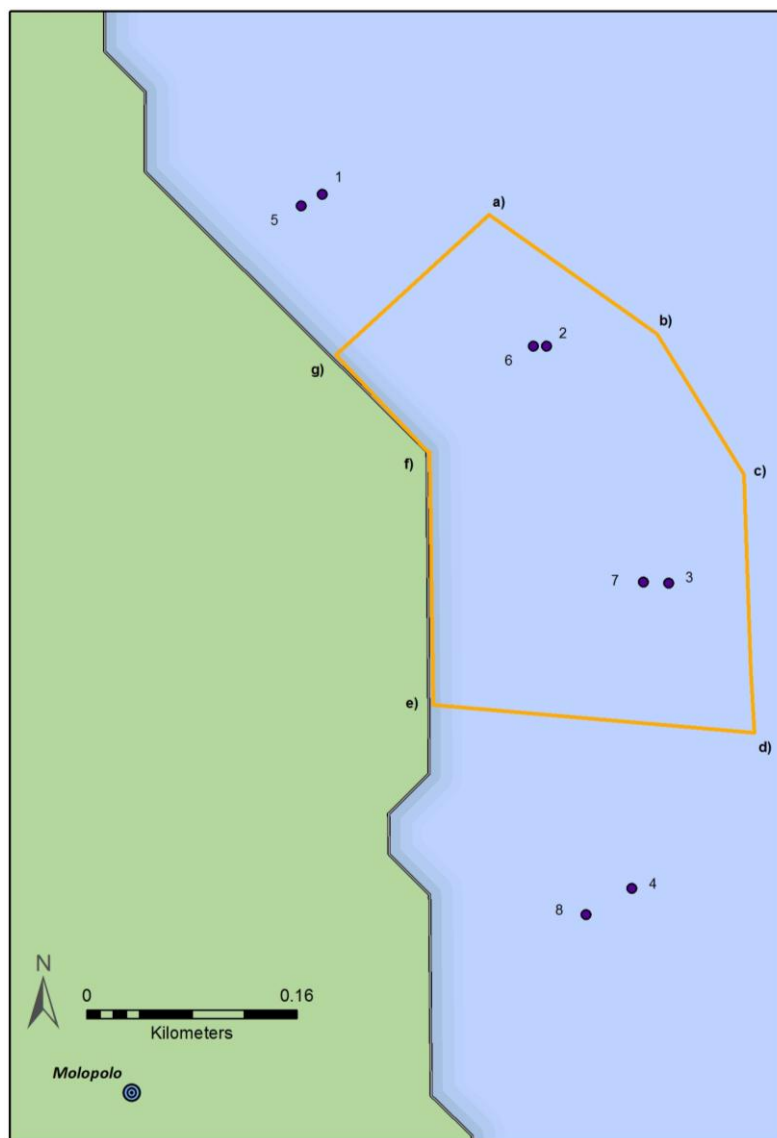


Figure 29. Proposed boundary for protected area including transects 2,3 6 and 7 and the inshore waters. Total area 8.12 hectares.

Boundary points	Easting	Northing
a)	734073	1126726
b)	734203	1126636
c)	734268	1126529
d)	734276	1126332
e)	734030	1126352
f)	734027	1126546
g)	733956	1126618

It is further advised that a management committee be created to oversee the effective running of the MPA once established. The purpose of this committee would be to coordinate the collection of MPA fees for possible dive 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.

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 Molopolo 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 at Molopolo 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 A: TARGET SPECIES LISTS

SUBSTRATES

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

** If hard coral, also record target species

TARGET HARD CORALS

Brain small	Brain medium	Brain large
<i>Ctenactisechinata</i>	<i>Diploastreaheliopora</i>	<i>Echinopora</i>
<i>Euphyllia</i>	<i>Favia</i>	<i>Favites</i>
Foliose <i>Montipora</i>	<i>Galaxea</i>	<i>Goniopora</i> / <i>Alveopora</i>
<i>Herpolithalimax</i>	<i>Hydnophora</i>	<i>Lobophyllia</i>
Massive <i>Porites</i>	<i>Montipora</i> digitate	<i>Mycediumelephantotus</i>
<i>Pachyserisrugosa</i>	<i>Pachyseris</i> speciosa	<i>Pavona</i> clavus
<i>Pectinialactuca</i>	<i>Plerogyra</i>	<i>Pocillopora</i> small
<i>Pocillopora</i> medium	<i>Pocillopora</i> large	<i>Polyphyllia</i> talpina
<i>Porites</i> cylindrica	<i>Porites</i> nigrescens	<i>Porites</i> rus
<i>Seriatopora</i> hystrix	<i>Tubastrea</i> micrantha	<i>Turbinaria</i>
Upside-down Bowl		

Target Invertebrates

Feather duster worms	Christmas tree worms	Flatworms
Crabs	Shrimps	Banded coral shrimp
Lobsters	Nudibranch	Abalone
Conch	Cowrie	Triton's trumpet
Cone shell	<i>Drupella</i>	Top shell
Other gastropod	Giant clam	Octopus
Cuttlefish	Squid	<i>Acanthaster</i> planci
<i>Linkia</i> laevigata	<i>Culcitano</i> vaeguineae	<i>Protoreaster</i> nodosus

<i>Choriastergranulatus</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	Sphyrnidae	
Blenny	Blenniidae	
Butterflyfish*	Chaetodontidae	Alibangbang
Cardinalfish	Apogonidae	
(Damsel fish)	(Pomacentridae)	
Anemonefish	<i>Amphiprion</i> sp.	
Sergeant Damsel fish	Pomacentridae	
Emperor	Lethrinidae	Katambak
Filefish	Monacanthidae	Ilak
Fusilier	Caesionidae	Dalagangbukid
Goatfish	Mullidae	Timbongan
Goby	Gobiidae	
Groupers	Serranidae	Lapu-lapu
Flagtail Grouper	<i>Cephalopholisurodeta</i>	
Honeycomb Grouper	<i>Epinephelus</i> sp.	
Humpback Grouper	<i>Cromileptesaltivelis</i>	
Lyretail Grouper	<i>Variolalouti</i>	
Peacock Grouper	<i>Cephalopholis argus</i>	
Jack/Trevally	Carangidae	Talakitok
Lionfish	Scorpaenidae	
Lizardfish	Synodontidae	
Moorish Idol	<i>Zancluscornutus</i>	Sanggowanding
Moral Eel	Muraenidae	
Parrotfish	Scaridae	Mulmul
Pipefish	Syngnathidae	
Porcupinefish	Diodontidae	
Pufferfish	Tetraodontidae	
Rabbitfish	Siganidae	Kitong
Virgate rabbitfish	<i>Siganusvirgatus</i>	
Ray	Rajiformes	
Sandperch	Pinguipedidae	
Scorpionfish/Stonefish	Scorpaenidae	
Snapper	Lutjanidae	Maya-maya
Black and White Snapper	<i>Macolormacularis</i>	
Checkered Snapper	<i>Lutjanusdecussatus</i>	

Two Spot Snapper	<i>Lutjanusbiguttatus</i>	
Spade/Batfish	Ephippidae	
Spinecheeks	Nemipteridae	Silay
TwolineSpinecheek	<i>Scolopsisbilineatus</i>	
Squirrelfish/Soldierfish	Holocentridae	
Surgeonfish	Acanthuridae	Indangan
Unicornfish	<i>Naso</i> sp.	
Sweeper	Pempheridae	
Sweetlips	Haemulidae	Lipti
Toby	Tetraodontidae	
Triggerfish	Balistidae	Pakol
Trunk/Box/Cowfish	Ostraciidae	
(Wrasse)	(Labridae)	
Crescent Wrasse	<i>Thalassomalunare</i>	
Humphead Wrasse	<i>Cheilinusundulatus</i>	
Red Breasted Wrasse	<i>Cheilinusfasciatus</i>	

*Target Butterflyfish

Vagabond Butterflyfish	Spot-Banded Butterflyfish	Merten's Butterflyfish
Klein's Butterflyfish	Dot and Dash Butterflyfish	Chevroned Butterflyfish
Latticed butterflyfish	Singular Bannerfish	Threadfin Butterflyfish
Eastern Triangle Butterflyfish	Longfin Bannerfish	Teardrop Butterflyfish
Redfin Butterflyfish	Masked Bannerfish	Spot-Nape Butterflyfish
Pyramid Butterflyfish	Pennant Bannerfish	Lined Butterflyfish
(Big) Long-Nosed Butterflyfish	Racoon Butterflyfish	Yellow-Dotted Butterflyfish
Copper-Banded Butterflyfish	Dotted Butterflyfish	Black-Backed Butterflyfish
Orange-Banded Butterflyfish	Ovalspot/Mirror Butterflyfish	Spot-Tail Butterflyfish
Humphead Bannerfish	Bennett's/Eclipse Butterflyfish	Panda Butterflyfish
Asian Butterflyfish	Bluespot Butterflyfish	Eight-Banded Butterflyfish
Burgess' Butterflyfish	HighfinCoralfish	Reticulated Butterflyfish
Ornate Butterflyfish	Two-Eyed Coralfish	Saddled Butterflyfish
Meyer's Butterflyfish	Brown Banded Butterflyfish	Spotted Butterflyfish
Speckled Butterflyfish	OcellateCoralFish	Yellowtail Butterflyfish
Pacific Double-Saddle Butterflyfish		