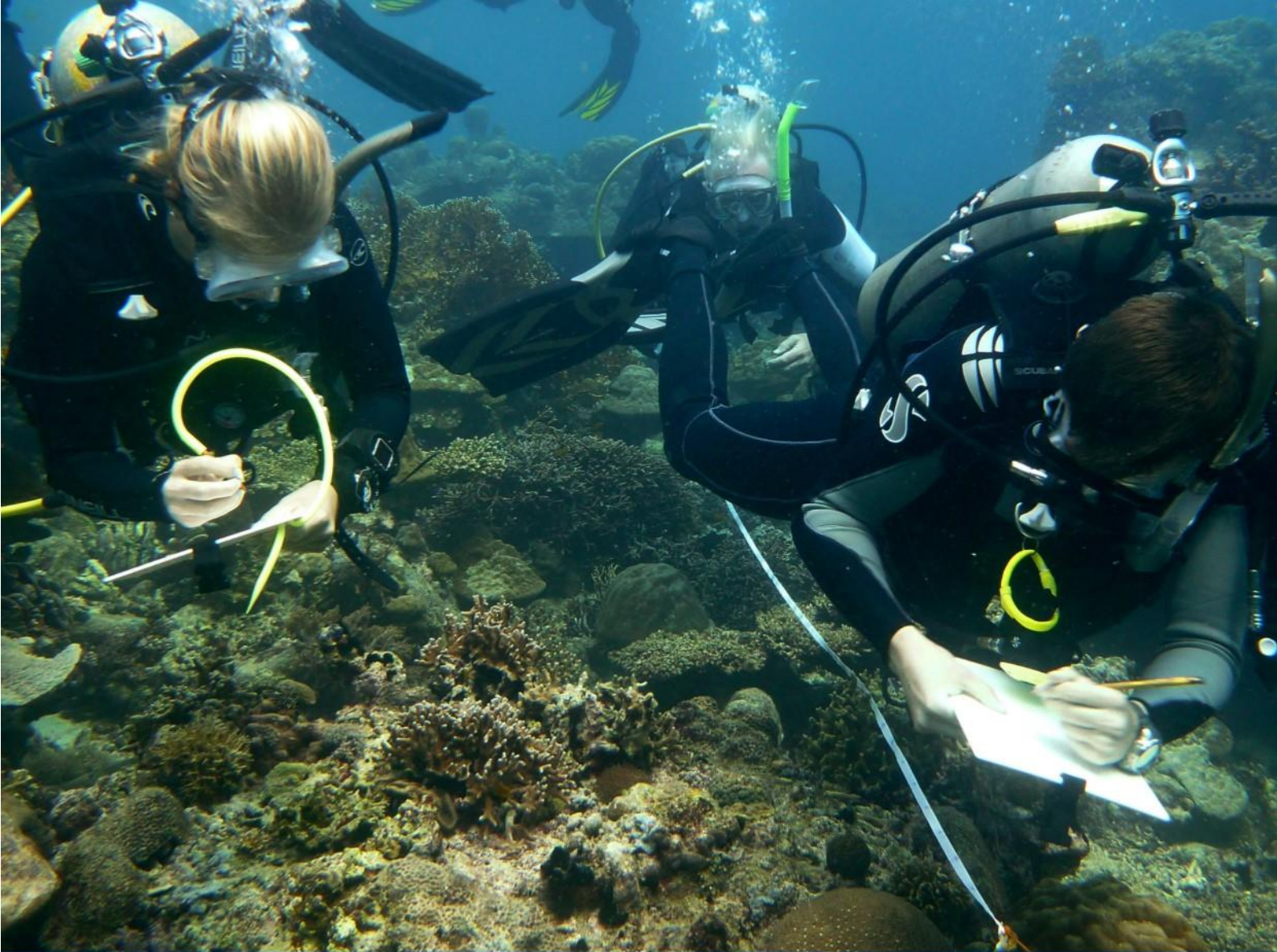




LRCP

Southern Leyte Coral Reef Conservation Project

Coral Cay Conservation Proposed Marine Protected Area Report: Barangay Estela

Report Date: October 2016

**CORAL CAY
CONSERVATION**



Expeditions

Darienne Lancaster, Tom Dallison,
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In partnership with the Southern Leyte
Provincial Government, Philippines



Coral Cay Conservation
Proposed Marine Protected Area Assessment Report
Estela 2016 Assessment
Liloan, Southern Leyte, the Philippines

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Suggested Articles:

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

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

Executive Summary

- Coral Cay Conservation (CCC) conducted an assessment of the reef fish, invertebrates, substrates and anthropogenic impacts in the waters of Barangay Estela in the Municipality of Liloan. The site has been proposed as a potential Marine Protected Area (MPA).
- At the request of the Municipal Agriculture Office and after consulting with the Barangay Captain we surveyed the southern end of the bay of Estela for the purpose of a proposed MPA.
- An enhanced Reef Check methodology was used to complete formal biophysical surveys of eight 100m transects, each containing four 20m replicates. Transects were equally divided between depths of 6m and 12m.
- Overall, the Estela proposed MPA site showed moderate levels of fish abundance (42.09 ± 9.48 per 500m³). In comparison, the Marine Protected Area in Napantao, San Francisco- surveyed in 2015, conferred a higher average fish abundance (93.33 ± 19.03 per 500m³).
- Commercial fish species showed low abundances and were small in size, suggesting levels of overfishing within the area.
- The moderate abundance, species richness, and diversity of butterflyfish in Estela indicate that, although the proposed area is currently in moderate health, there is room for ecological improvement through adequate protection.
- The proposed MPA site showed relatively low levels of invertebrate abundance. This may suggest a lack of hard coral shelter or food for invertebrates and an unbalanced predator prey relationship between fish and invertebrates.
- A worrying, though locally common, result from the data is the lack of many commercially important species of invertebrates such as Triton's Trumpet, Squid and species of Sea Cucumber. These species, which in many cases are slow growing and slow moving, are particularly vulnerable to over exploitation.
- The proposed MPA was dominated by sand, which is not ideal for hard coral recruitment that requires hard surfaces to attach and grow. However, the second most prevalent substrate was rock, which is a positive sign for future coral recruitment. Hard coral was the third most common substrate.
- The majority of the surveyed area showed some level of fishing related and general trash (ranging from low to high impact), and levels of coral damage are a concern, however, if the reef were protected these levels may diminish or disappear over time.
- We believe the Estela reef would make an excellent MPA with enough coral cover and fish diversity to promote reef improvement with adequate protection. The implementation of an MPA could help to reverse the effects of historical overfishing and allow the reef to recover, with lasting benefits for the community of Estela.
- 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.

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List of Acronyms and Abbreviations

CCC	: Coral Cay Conservation
CoTs	: Crown of Thorns Seastars (<i>Acanthaster planci</i>)
HC	: Hard Coral
IUCN	: International Union for the Conservation of Nature
LGU	: Local Government Unit
LRCP	: Leyte Reef Conservation Project
MPA	: Marine Protected Area
MPA MEAT	: MPA Management Effectiveness Assessment Tool
MR	: Marine Reserve
NIA	: Nutrient Indicator Algae
NIPAS	: National Integrated Protected Area System
NTA	: No Take Area
OT	: Other
PENRMO	: Provincial Environmental and Natural Resource Management Office
PGSL	: Provincial Government of Southern Leyte
PRRCFI	: Philippines Reef and Rainforest Conservation Foundation Inc.
PRRP	: Philippines Reef and Rainforest Project
RC	: Rock
RKC	: Recently Killed Coral
SC	: Soft Coral
SD	: Sand
SE	: Standard Error
SI	: Silt
SP	: Sponge
UVC	: Underwater Visual Census

Coral Cay Conservation

Initially founded in 1986, CCC is an internationally renowned, not for profit organisation, which provides host countries with appropriate resources for the protection and sustainable use of tropical ecosystems. This protection is established to enable future generations the continued use of local ecosystem resources. These goals are outlined in CCC's mission statement:

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

CCC achieves its mission via the formation of long-term programmes of collaborative research with local institutions and governments. Such research programmes require technical support from CCC, in the form of scientific data collection, data analysis and the production of reports and integrated coastal zone management plans. CCC also provides communities with education, training and alternative livelihood opportunities to strengthen local human resources to the point where research can be continued independently by the host country.

CCC has carried out conservation projects all over the world, including the Philippines, the Caribbean, Belize, Honduras, Malaysia, Cambodia and Fiji. CCC has successfully set up numerous Marine Protected Areas (MPAs) throughout these regions and provided essential scientific data for the management of their local marine resources. Successfully established areas in the Philippines are a result of the Philippines Reef and Rainforest Project (PRRP). CCC established PRRP in collaboration with the Philippine Reef and Rainforest Conservation Foundation Inc. (PRRCFI) and the World Land Trust in 1995. Such protected areas include the coastal regions of the Southern Negros Occidental, Anilao, Palawan, Danjungan Island, the forests of North Negros and Padre Burgos.

In 2002, the PGSL invited CCC and the PRRCFI to conduct research in Sogod Bay. This resulted in the formation of the Leyte Reef Conservation Project (LRCP). The LRCP utilises trained volunteers to survey the region's coral reefs and provide training and conservation education opportunities for project counterparts. The aim of this is to develop local capacity and ensure the long-term protection and sustainable use of marine resources throughout Southern Leyte. Between 2002 and 2013, CCC focused on implementing baseline surveys throughout Sogod Bay to obtain information on the distribution of fish and invertebrate populations, benthic cover and reef health. In 2013, having surveyed much of the accessible area in the Bay, CCC shifted its focus to concentrate on MPA monitoring surveys. Under this new protocol surveys are implemented inside and outside of existing MPAs to evaluate their efficacy and in unprotected areas to assess their potential for MPA installation.

1. Introduction

1.1. Marine Protected Areas

Marine resources are under increasing pressure from an ever growing global population (Jackson *et al.*, 2001). Strong declines in catch from worldwide fisheries, such as the North Atlantic Cod (Myers 1997) and Caribbean reef fisheries (Hardt 2009), have illustrated that biological marine resources are limited and highly vulnerable to overfishing (Jackson *et al.*, 2001; Pauly *et al.*, 2002). Additional pressures such as pollution, coastal development and climate change exacerbate this vulnerability. As a result, there is an increased drive for conservation efforts and resource management in the marine environment (Wood *et al.*, 2008; CBD 2010). The protection of marine areas can achieve conservation and resource management targets simultaneously and are therefore considered instrumental to sustainable ocean utilisation (Pauly *et al.*, 2002). The International Union for the Conservation of Nature (IUCN) defines an MPA as:

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

MPAs have become vital tools in protective management for the conservation of marine resources. MPAs in the Philippines encompass “no take” areas (NTA) (min. 5 hectares), within which no form of extraction is permitted. These NTAs are surrounded by 50m “buffer zones” where only non-destructive fishing methods, such as hook and line fishing, are permitted (Fig. 1). These large areas of no extraction combat resource exploitation by providing local communities with a sustainable supply of goods; such as fish and invertebrates; and services, such as shoreline protection and tourism (World Bank, 2005).

To assess the beneficial impact of an MPA, resource managers often seek to measure its respective effectiveness. Effectiveness can be measured on a range of factors, however, most commonly addresses the goals established by the MPA. Measuring the MPA's impact on ecology, biodiversity, (Mora *et al.*, 2006; Selig and Bruno 2010; Solan-Fernandez *et al.*, 2012), species conservation, the general ecological status and fishery productivity (Buxton *et al.*, 2006; McDaniel 2007) as well as meeting the stakeholder-defined parameters of success (Dahl-Tacconi *et al.*, 2005) can often satisfy the quantifiable conclusion of effectiveness. The definition of effectiveness was given by Pajaro (2010) and states that effectiveness is the achievement of the ecological, socio-economic, and governance objectives outlined during the planning process. However, generally, the most desired benefit of an MPA is increased fish production. This occurs as a result of overspill and larval export from the NTA into surrounding waters (Fig. 1). Over time, the displacement of fishing effort from the MPA results in an increase in adult fish biomass and fecundity. This results in adult fish and larvae being exported to the buffer zone and its surrounding waters. Local fishery yields subsequently increase because they have a continual and sustainable supply of stock (Maliao *et al.*, 2004). In areas where there is the potential for increased tourism and anthropogenic pressure on the marine environment for food, recreation and other resources, the benefits and necessities of having a network of functioning MPAs are increased.

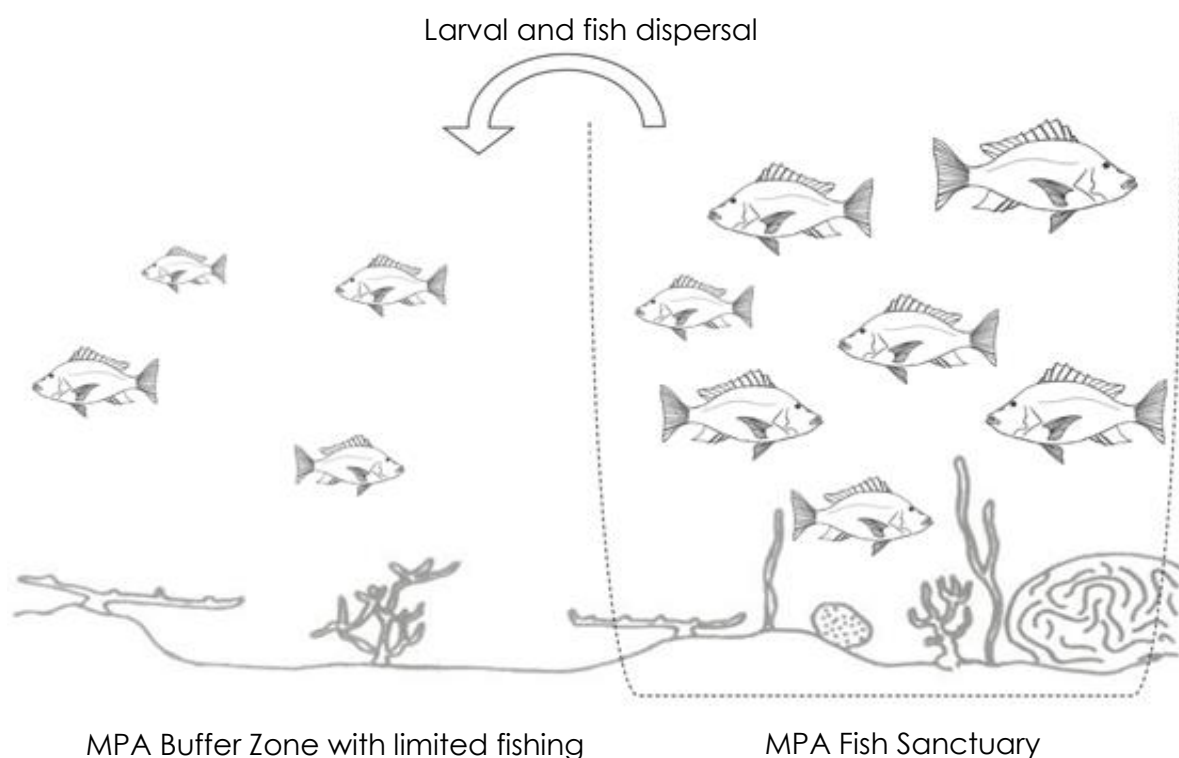


Figure 1. Schematic diagram of MPA functioning. Protected fish within the MPA fish sanctuary grow and produce offspring. This leads to 'overspill', increasing fish numbers inside and outside of the MPA. In addition, the corals inside the MPA are not disturbed by destructive fishing methods.

Marine Reserves (MRs) are areas of the marine environment where fishing is restricted to non-destructive methods, such as hook and line fishing. This reduces habitat damage often caused by destructive fishing methods, such as dynamite fishing, net fishing or trawling. MRs are preferable to areas of no protection but are not as effective as MPAs because fishing pressure remains present. The fauna within the MR, their size, biomass and life-stage are all at the discretion of the by-laws set for the MR during the planning stage regarding levels of exploitation. Enforcement in this regard can be fully functioning through closed seasons or restrictions on certain gears and activities, or can be minimal resulting in high levels of exploitation of all cohorts. Therefore, when enforcement is minimal on non-apparent the majority of fish and invertebrates within an MR can still be extracted. With by-catch being a void concept within tropical subsistence coral reef fisheries, it is often the case, as fishery production decreases, juveniles, unprecedentedly retain a social and economic value to fishermen. As a result, juveniles are often removed before they can reach reproductive age or size, causing populations to decline. Environmentally important species, such as algae-grazing parrotfish, are also removed, potentially allowing algae to proliferate and smother vital coral habitat.

"The key to success and broad acceptance, whether for multiple use MPAs or NTAs, is a clear articulation of the management problem that the MPA is meant to solve. Such objective setting should be done with scientists working in concert with local communities, user groups and management authorities – not scientists in isolation." - Agardy *et al.*, (2012).

The success of a protected area is entirely dependent upon the cooperation of local stakeholders. Research has shown that the involvement of resource users in the planning, implementation and management of their own MPA increases their sense of ownership and pride. Only when local stakeholders feel they are adequately considered and regularly consulted on their MPA's management, will it be possible for the full potential of the MPA to be attained (Green *et al.*, 2009, Human and Davies 2010). It is, therefore, essential that the local community is involved with the entire process of protected area establishment. Stakeholders must be consulted about key aspects of the MPA establishment process, such as size and location and directly involved in their management e.g. via community Bantay Dagats (marine guards).

1.2 Coral Reefs and Marine Conservation in the Philippines

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

The waters of the Philippines contain roughly 25,000 km² of coral reefs. An estimated 60% of the country's 92 million citizens live in coastal regions within close proximity to coral reefs and over half of the consumed animal protein comes from marine sources (CTI, 2012). This heavy reliance on marine resources has caused large areas of coral reef ecosystems to become threatened. In 1980, 33% of coral reefs were characterised as being in poor condition, in 2008 this figure had increased to 40% (Wilkinson, 2008). These figures make a strong case for increased marine conservation efforts within the Philippines. Jacinto *et al.* (2000) stated that legislation concerning marine conservation in the Philippines is some of the most advanced within the Coral Triangle. 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). Fig. 2 highlights two case studies of successful MPAs in the Philippines.

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

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

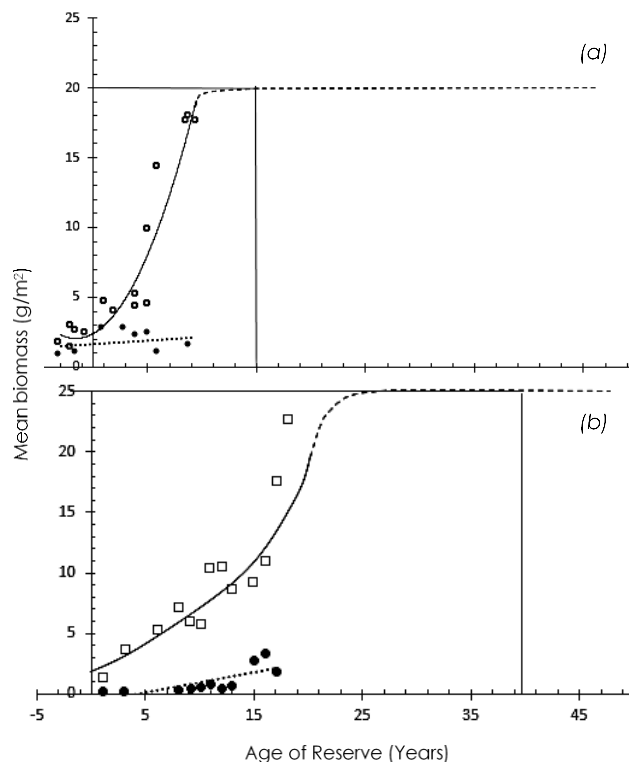


Figure 2. Observed (no-fill markers), control (filled markers) and projected (dashed line) increases in mean biomass (g/m²) of commercially important fish species inside Apo Island (a) and Sumilon Island (b) MPAs. Data and figures adapted from Russ and Alcala (2004).



1.3. Characterisation of Study Region

1.3.1. Southern Leyte

The coral reefs of Southern Leyte remain some of the least disturbed habitats in the Philippines. The coastal regions that include Canigao Channel in the west, Sogod Bay, Cabalian Bay, the 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. The region is also a feeding ground for attractive charismatic mega-fauna such as pilot whales, melon-headed whales, dolphins, manta rays and whale sharks. The coast is characterised by naturally limited mangrove areas, narrow fringing coral reefs, limited seagrass beds and narrow intertidal areas and beaches (Calumpong *et al.* 1994).

CCC generally works alongside the municipalities with waters lying within Sogod Bay. Currently there are ~25 established MPAs within the bay covering an estimated 292 hectares. These figures will increase in the coming years as more MPAs are set up. Sizes of MPAs range from 3.5 hectares (Maujon/Juangon Fish Sanctuary) to 55 hectares (Limasawa Fish Sanctuary), with a mean average size of 11.7 hectares (± 2.2 SE) and a median average of 7.9 hectares (PENRMO-CFRU, 2014). The sizes for several MPAs are not known, as accurate GPS coordinates are not available.

1.3.2 Estela, Liloan: Proposed MPA Site

This survey was requested by Ma'am Benie Dipay of the Municipal Agricultural Office in Liloan to help meet 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 40-200m from the shoreline of the Barangay Estela, on the pacific side of Panaon Island, Southern Leyte. Estela is overlooked by palm trees and rocky beach.

The reefs of Estela, located within Cabalian Bay, are partially sheltered from strong winds coming across the Pacific. The Barangay has a population of approximately 1,069 people, all of which live within close proximity to the coastline. A river mouth of <10m is located approximately 1.5km away from the proposed site.

2. Methodology and Data Collection

2.1 Survey Sites

CCC's assessment of the proposed MPA site at Estela was conducted between April 26th and May 11th 2016 by trained volunteer survey teams. The weather was sunny during this time with no major weather systems moving through the region. Mean air temperature during surveys was $30.88^{\circ}\text{C} \pm 0.48^{\circ}\text{C}$. Mean water temperature was $29.38^{\circ}\text{C} \pm 0.18^{\circ}\text{C}$ at the surface, and $28.88^{\circ}\text{C} \pm 0.13^{\circ}\text{C}$ at a depth of 3m and at 10m. The mean estimated horizontal visibility throughout the survey was $16.88\text{m} \pm 0.92\text{m}$.

From discussions with the Barangay Council of Estela it was gathered that there is currently a low level of anthropogenic pressure in the area in the form of invertebrate harvest for food, and no pressure from industrial pollution. Siltation from terrestrial runoff occasionally occurs during and after heavy rainfall.

2.2 Biophysical Survey

Assessment of the proposed MPA site was 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 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 (Fig. 3, Table 1). Each 100m transect was divided into four 20m replicates, separated by 5m inter-replicate gaps in which no data was collected.

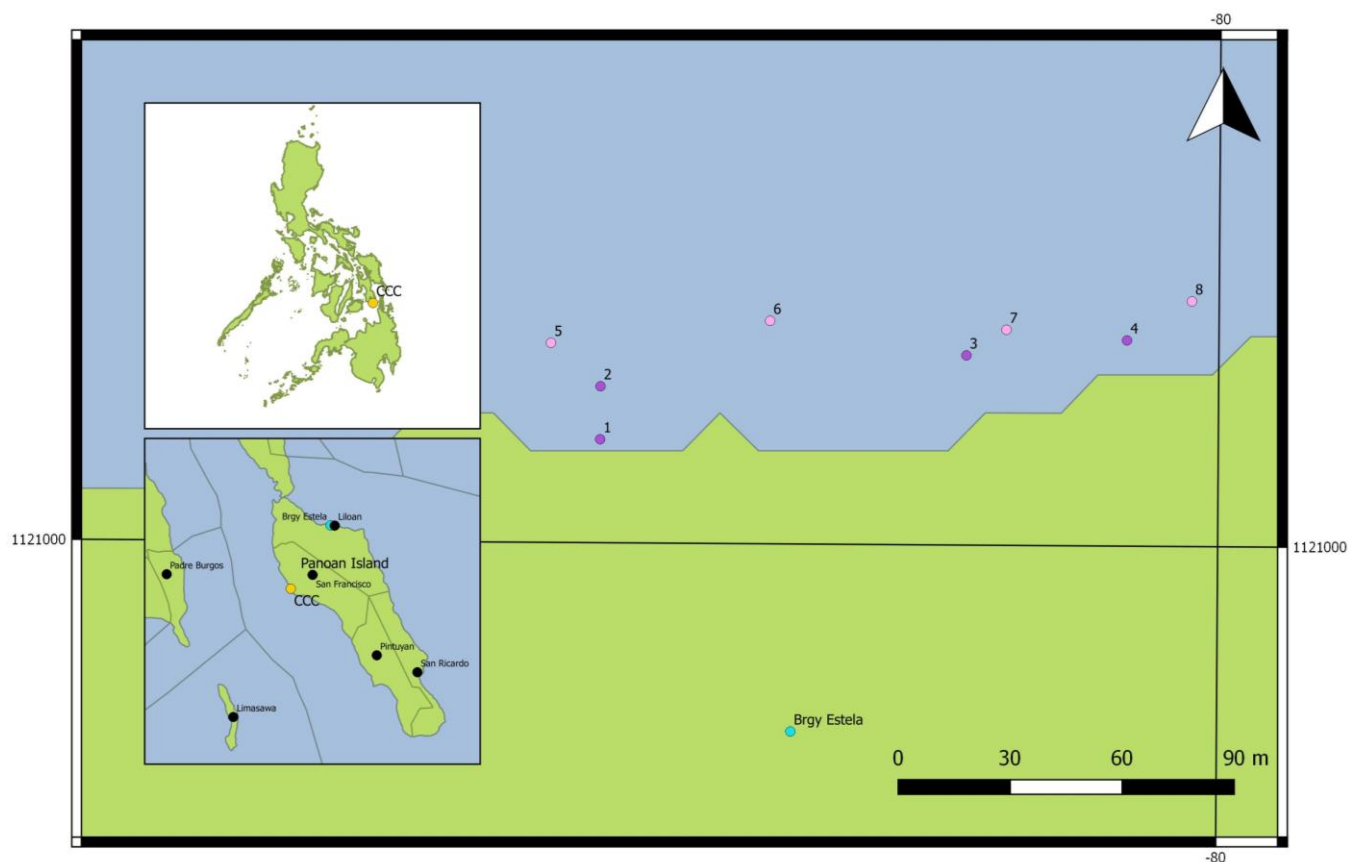


Figure 3. Map of survey site in the waters of Barangay Estela. Four 100m transects were conducted at a depth of 12m (pink) labelled 5, 6, 7 and 8 with the remaining four sites located at a depth of 6m (purple) labelled 1, 2, 3 and 4. Barangay Estela is located on the northeast coastline of Panoan Island in the municipality of Liloan. Created using QGIS (2016).

Table 1. Depths and coordinates of transects surveyed along the coast of Barangay Estela, Sogod Bay, southern Leyte, the Philippines.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
1	6	738503	1121084
2	6	738503	1121127
3	6	738797	1121154
4	6	738926	1121167
5	12	738463	1121162
6	12	738639	1121181
7	12	738829	1121175
8	12	738978	1121199

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.

2.2.1 Fish

Fish diversity and abundance data was collected using Underwater Visual Census (UVC). 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 (mol-mol, Scaridae); Groupers (lapu lapu, Serranidae) and Snappers (maya-maya, 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 A).

Data was recorded using 'belt' transects, where fishes were observed along each replicate of the 100m transect within an imaginary 5x5x20m (WxHxL) box (Fig. 4) equating to a total volume surveyed of 500m³. Surveys were conducted by two surveyors swimming slowly along replicates, each counting indicator fish species 2.5m either side of the central transect line. Divers paused at five metre intervals along each replicate to wait one minute for fish to acclimatise to surveyor presence. Data collection continued during this one-minute pause.

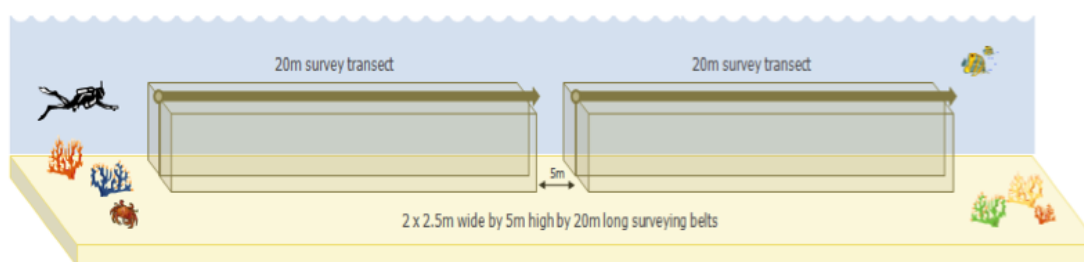


Figure 4. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target species within an imaginary 5x5x5m box (500m³), sizing those that are commercially important. Once located within the 5m replicate interval, no fish are recorded, this is as to produce independent replicates.

2.2.2 Invertebrates

The diversity and abundance of selected invertebrate families and species were recorded along the same belt transect used for fish. Recorded species are typically targeted for food, collected as curios or important to the ecological balance of the reef (see 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 equating to a total surveyed area of 100m² per 20m replicate (Fig. 5). Divers looked in holes and under overhangs to find cryptic organisms such as lobsters and sea urchins.

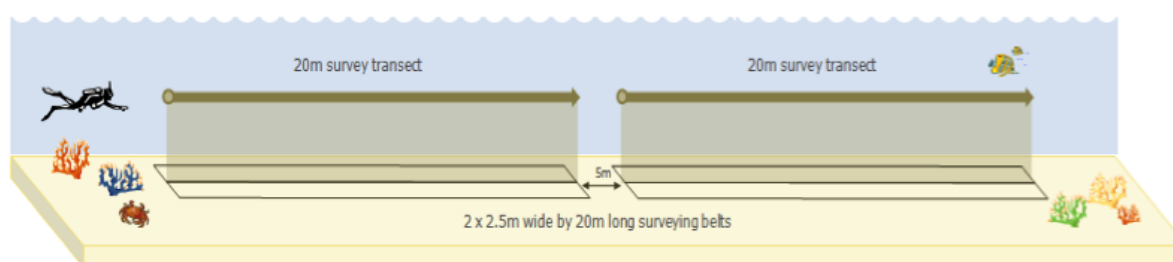


Figure 5. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target species within 2.5m of the central transect line (equating to a surveyed area of 100m²). Once located within the 5m replicate interval, no invertebrates are recorded, this is as to produce independent replicates.

2.2.3 Substrate

Benthic diversity was measured by recording living and non-living substrate categories along a 'point-intercept' transect using a plumb line to minimize bias. Benthic organisms and substrate types directly underneath the transect line were recorded at 50cm intervals along each 20m replicate (Fig. 6). Every 20m replicate contained 40 benthic points spaced at 50cm intervals. Benthic categories included: sand (SD), rock (RC), rubble (RB), silt/mud (SI), nutrient indicator algae (NIA), sponge (SP), recently killed coral (RKC), soft coral (SC), hard coral (HC) and any other sessile organisms. All hard corals were recorded to life form and level, with targets being recorded to species level (see Appendix A).

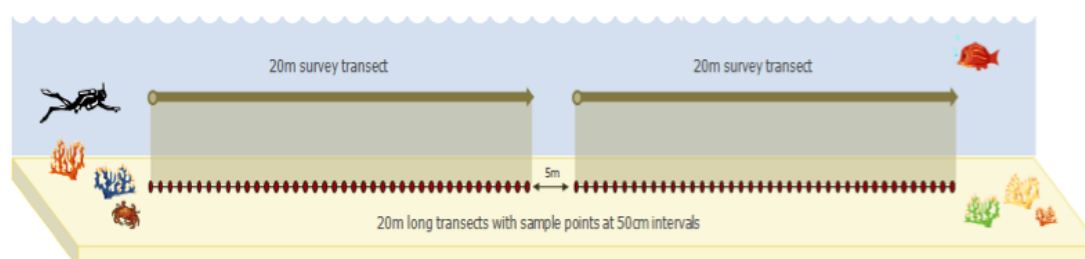


Figure 6. An augmented method that Coral Cay Conservation utilises to carry out MPA assessments that is adapted from a standardised Reef Check method. This schematic demonstrates two of the normal four replicates, of which, are separated by a 5m replicate interval. As the divers swim along the transect tape for the first 20m, they will record the specified target abiotic substrates and biotic benthic organisms using a plumb-line every 50cm. Once located within the 5m replicate interval, no data are recorded, this is as to produce independent replicates.

2.2.4 Impacts

Within the same area assessed for invertebrates, divers recorded impacts on the reef. The total percentage of bleached coral cover was estimated together with the percentage of bleaching on each individual bleached coral colony. Coral diseases were identified where present and recorded as a percentage of the colony infected. Damage was recorded in three categories: boat/anchor, dynamite and other, on a categorical scale from 0 to 3 (0 = none, 1=low, 2= medium, 3 = high). The impact of trash was recorded on the same scale and separated into general and fishing nets/traps.

2.3 Data Analysis

Each 20m belt transect was treated as an independent replicate. This produced $n=16$ at 6 metres and $n=16$ at 12 metres. Shapiro-Wilks tests, typically used on small data sets to check for normality, showed much of the data was non-parametric (Shapiro & Wilk, 1965; Thode, 2002). Square-root transformations of the non-parametric data did not sufficiently alter the data to warrant using a parametric test (O'Hara & Kotze, 2010; Morris, 2014). Thus, non-parametric Wilcoxon-Mann-Whitney U tests were used to test for statistically significant ($p = <0.05$) differences in the abundance of fishes, commercially important fishes, target butterflyfishes, invertebrates, and substrates between all transects. Wilcoxon-Mann-Whitney U tests were also utilised to test for significant differences in biomass (kg) between commercially important fishes as well as invertebrate diversity. Species diversity of fish and invertebrates as determined using Species Richness (S), Shannon's Diversity Index (H'), and Pielou's Evenness (J'). S represents the number of different species found in an ecological community (Whittaker, 1972). H' is used to characterize species diversity based on abundance and evenness and represents the degree of uncertainty relating to an individual's species identity (Morris *et al.*, 2014). J' is used to calculate species evenness by dividing (H') by (S) (Tuomisto, 2012).

Butterflyfish were also grouped into obligate corallivores (feed exclusively on coral polyps), and facultative corallivores (feed non-exclusively on coral polyps), since the presence of obligate corallivores on reefs can be used as an indicator of hard coral abundance. The two target obligate Butterflyfish, Redfin (*Chaetodon lunulatus*) and Eastern Triangle (*Chaetodon baronessa*) were grouped and the five other facultative target species, Longnose (*Forcipiger flavissimus*), Humphead (*Heniochus varius*), Klein's (*Chaetodon kleinii*), Raccoon (*Chaetodon lunula*), and Vagabond (*Chaetodon vagabundus*) were grouped with all other, unspecified Butterflyfish species.

Hard corals were further grouped and analysed for abundance in three conservation classes: disturbance adapted fast growing corals (i.e. *Acropora* sp., Fire coral (*Millepora* sp.), Blue coral (*Heliopora* sp.); competitor corals (i.e. branching, foliose, encrusting, mushroom Non-*Acropora* sp.); and stress tolerant corals (i.e. massive, submassive, organ pipe (*Tubipora* sp.)), as defined by Edinger and Risk (2000).

3. Results

3.1. Fish

Average total fish abundance per transect was 42.09 ± 9.48 per 500m³ (Fig. 7). Transect O02 showed low abundances, with significant differences between O02 and O05, O06, and O07 (Fig. 8). Transect O06 also showed significantly greater abundances ($p = <0.05$) than transect O04 and O05, and transect O08 had significantly greater abundances ($p = <0.05$) than transect O04 and O07 (Fig. 8). Average total fish species richness (S) was 9.94 ± 0.91 per 500m³ (Fig. 9). Average H' was 1.87 ± 0.14 per 500m³ and J' was 0.82 ± 0.04 per 500m³ (Fig. 9). Significant differences ($p = <0.05$) were found across numerous transect sites for S , H' , and J' . Notably, transect O06, O07, and O08 all showed significantly greater ($p = <0.05$) S compared to transects O02, O03, and O04 (Fig. 10a). Transect O03 also showed

significantly lower ($p = <0.05$) H' compared to transects O02, O04, O05, and O07 (Fig. 10b).

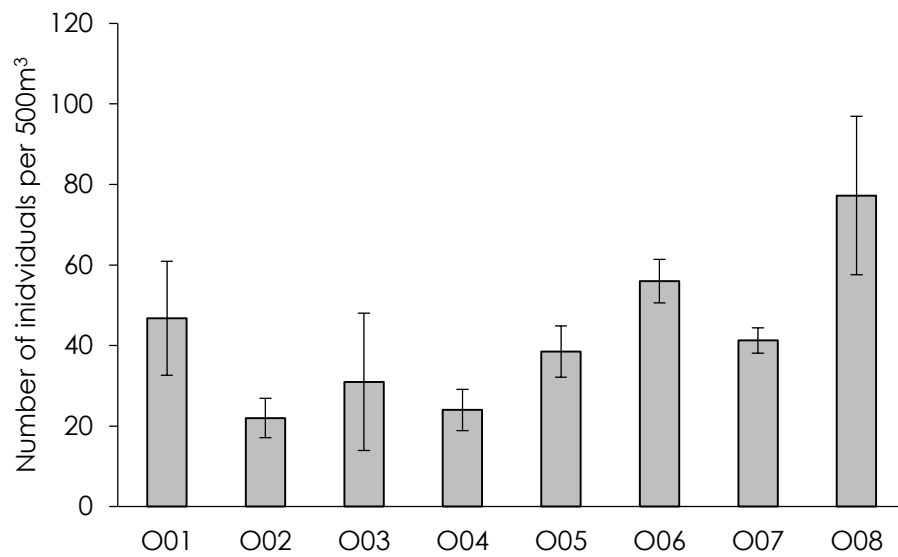


Figure 7. Average total fish abundance with standard error in Estela proposed marine protected area (MPA), southern Leyte, the Philippines.

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2					-	-	-	
O3								
O4						-		-
O5		+				-		
O6		+		+	+			
O7		+						-
O8				+			+	

Figure 8. Matrix showing significant differences in total fish abundance per 500m³ across all survey sites. Species richness is not pictures a there were no significant differences across transects. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

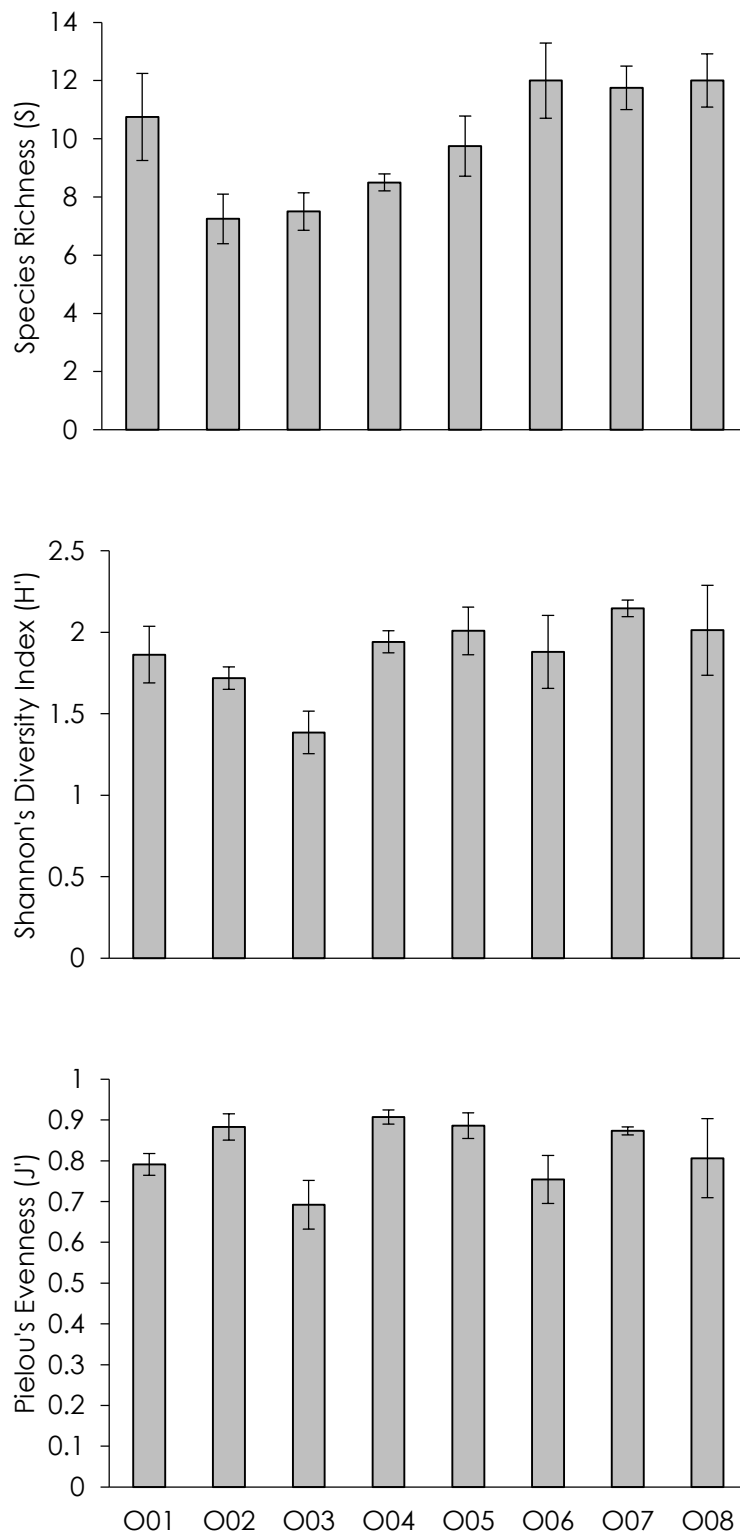


Figure 9. Total fish Species Richness (i.e. number of species), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) with standard error per 500m³ on Estela proposed marine protected area (MPA), southern Leyte, the Philippines.

a)

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2						-	-	-
O3						-	-	-
O4						-	-	-
O5								
O6		+	+	+				
O7		+	+	+				
O8		+	+	+				

b)

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2			+				-	
O3		-		-	-		-	
O4			+				-	
O5			+					
O6								
O7		+	+	+				
O8								

c)

	O1	O2	O3	O4	O5	O6	O7	O8
O1		-		-	-			
O2	+		+			+		
O3		-		-	-		-	
O4	+		+			+		
O5	+		+			+		
O6		-		-	-			
O7			+					
O8								

Figure 10. Matrix showing significant differences in total fish (a) Species Richness, (b) Shannon's Diversity Index values, and (c) Pielou's Evenness values per 500m³ across all survey sites. Species richness is not pictures a there were no significant differences across transects. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

Mean total commercial fish abundance was 3.63 ± 1.54 per 500m^3 (Fig. 11). Transect O08 commercial fish abundance was significantly higher ($p = <0.05$) than transect O01, O02, and O03 commercial fish abundance (Fig. 12). Transect O05 and O06 also had significantly greater ($p = <0.05$) commercial fish abundance than transect O03 (Fig. 12). Transect O08 yielded the highest number of commercially important fish with an average of 6.75 ± 3.01 individuals per 500m^3 (Fig. 12). Average Parrotfish, and Snapper abundance was 3.18 ± 1.20 per 500m^3 , and 0.45 ± 0.34 per 500m^3 , respectively (Fig. 13). No Grouper were recorded on any transects. Transect O06 had significantly greater Parrotfish abundance than transect O03 (Fig. 14). No other commercial fish species showed significant differences across transects (Fig. 14).

Of the Parrotfish, Grouper and Snapper observed in Estela, all were relatively small in size. The majority were between 11-20 cm in length (0.57 ± 0.38 per 500m^3) (Fig. 15). No individuals longer than 30cms were recorded on any transects.

Average total commercial fish biomass was $0.12 \text{ kgs} \pm 0.08$ per 500m^3 (Fig. 16). Parrotfish held the greatest biomass with $0.35\text{kgs} \pm 0.18$ per 500m^3 , followed by Snapper with $0.03\text{kgs} \pm 0.03$ per 500m^3 (Fig. 17).

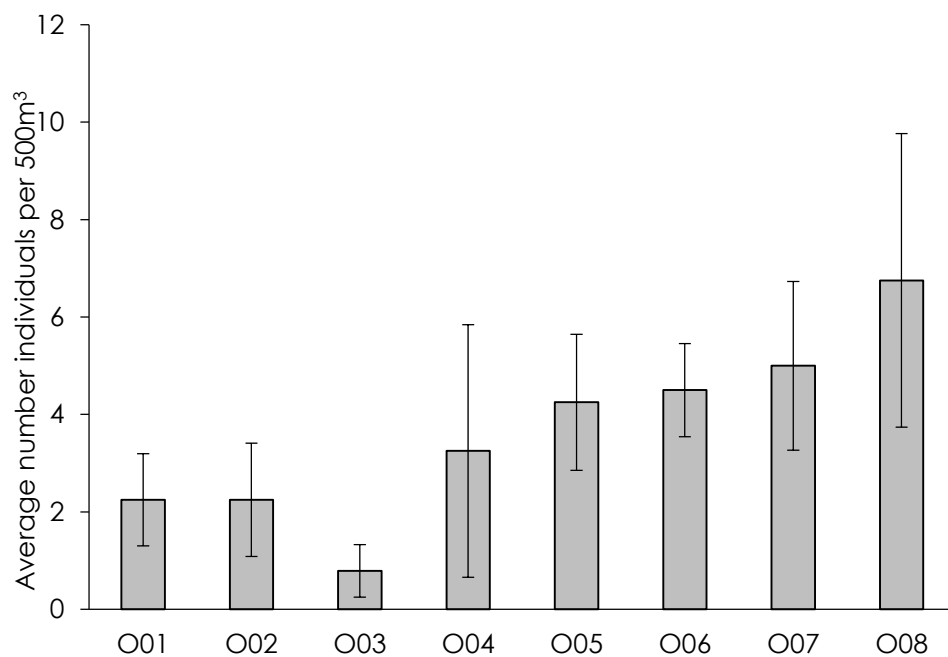


Figure 11. Average abundance of commercially important fish species observed on each transect with standard error per 500m^3 in Estela proposed marine protected area (MPA), southern Leyte, the Philippines.

	O1	O2	O3	O4	O5	O6	O7	O8
O1								-
O2								-
O3					-	-		-
O4								
O5			+					
O6			+					
O7								
O8	+	+	+					

Figure 12. Matrix showing significant differences in mean commercial fish abundance per 500m³ across all survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

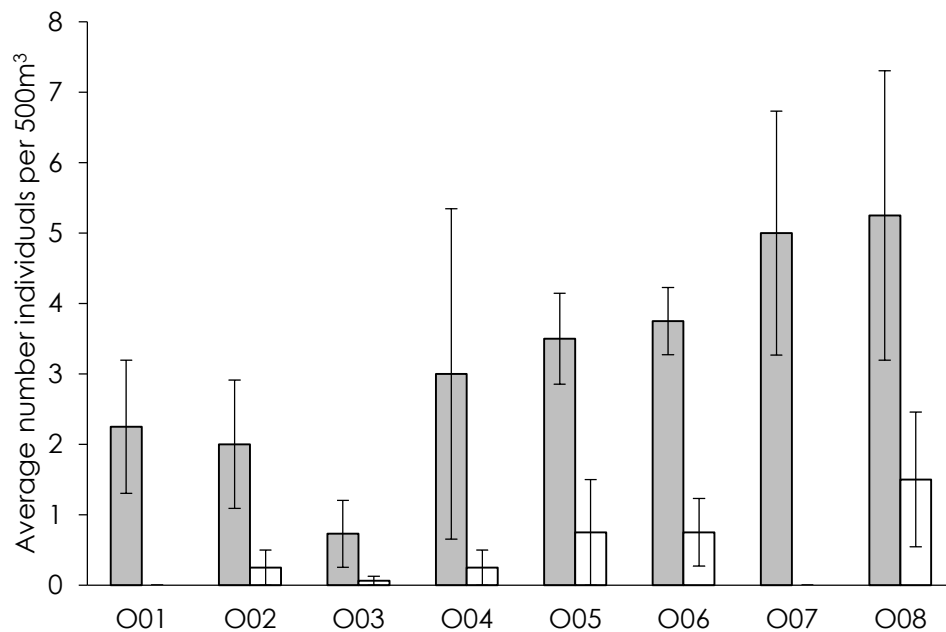


Figure 13. Average abundance of Parrotfish and Snapper observed on each transect with standard error per 500m³ in Estela proposed marine protected area (MPA), southern Leyte, the Philippines. Grey = Parrotfish, White = Snapper. Grouper were not present on any transects.

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2								
O3						-		
O4								
O5								
O6			+					
O7								
O8								

Figure 14. Matrix showing significant differences in mean parrotfish fish abundance per 500m³ across all survey sites. No other commercial fish species showed significant differences in abundance. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

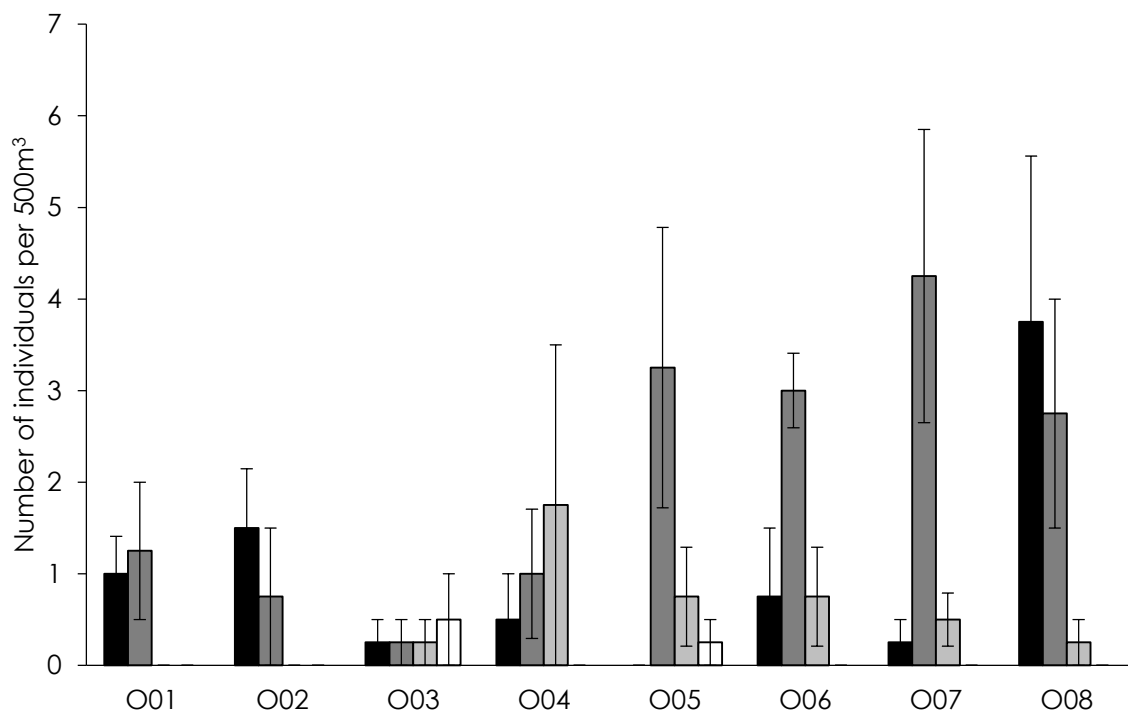


Figure 15. Mean cumulative abundance of Parrotfish, Grouper and Snapper in size categories 0-10cm, 11-20cm, 21-30cm and 31-40cm across eight transects with standard error per 500m³ in Estela proposed marine protected area (MPA), southern Leyte, the Philippines. Black = 0 – 10cm, Dark Grey = 11-20cm, Light Grey = 21-30cm, White = 31-40cm. Larger size categories are excluded as no individuals greater than 40cms were recorded.

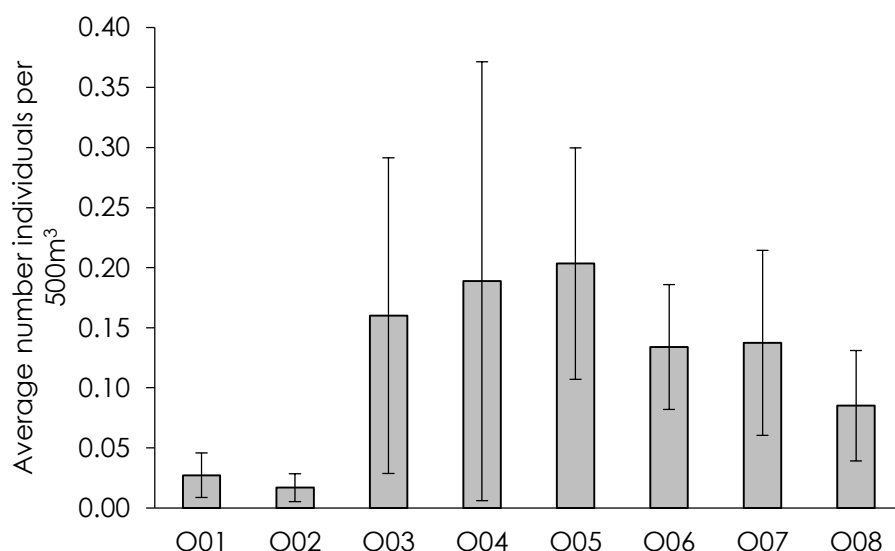


Figure 16. Average commercial fish biomass with standard error per 500m³ in Estela proposed marine protected area (MPA), southern Leyte, the Philippines.

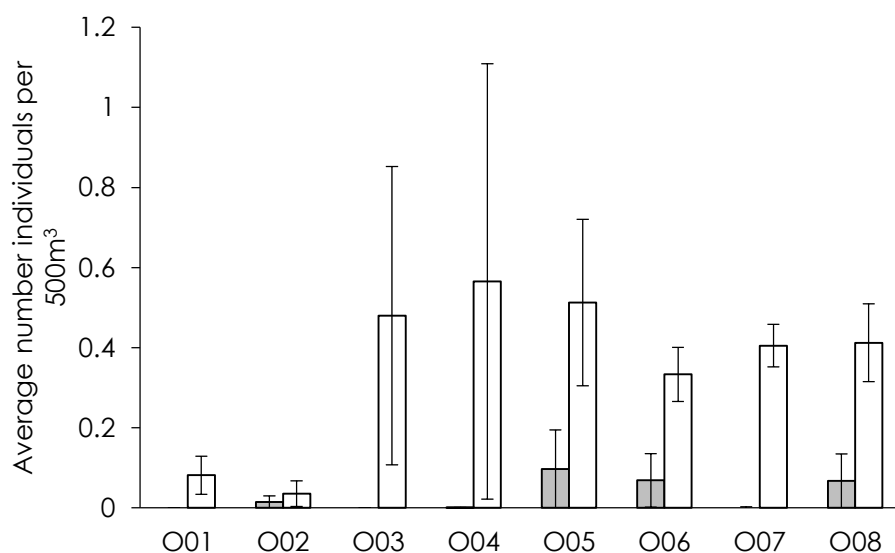


Figure 17. Average commercial fish biomass by target family (Snapper, Parrotfish) with standard error per 500m³ in Estela proposed marine protected area (MPA), southern Leyte, the Philippines. Grey = Snapper, White = Parrotfish. Grouper were not present on any transects.

Other commercially important fish species including *Bulbometopon muricatum* (Bumphead Parrotfish), *Cromileptes altivelis* (Barramundi Cod), and *Cheilinus undulatus* (Humphead Wrasse) were completely absent from the survey area. However, a number of rare marine organisms were sighted including a ribbon eel and a whale shark seen in between dives.

Average butterflyfish abundance per transect was 3.81 ± 1.17 per 500m³ (Fig. 18). Transects O08 had significantly higher ($p = <0.05$) butterflyfish abundance than transect O02 through O06 (Fig. 19). Average total butterflyfish S was 1.63 ± 0.47 per 500m³ (Fig. 20). Average H' was 0.37 ± 0.19 per 500m³ and evenness (Pielou's J) was

0.81 ± 0.13 per 500m³ (Fig. 20). Transect O08 species richness was significantly higher ($p = <0.05$) than transect O03 (Fig. 21). Transect O08 evenness (J') was significantly greater ($p = <0.05$) than transect O02 And O03, and transect O07 was significantly greater ($p = <0.05$) than transect O08 (Fig. 21). Average facultative corallivore Butterflyfish abundance per transect was 2.22 ± 1.32 per 500m³, and average obligate corallivore Butterflyfish abundance per transect was 1.66 ± 0.83 per 500m³ (Fig. 22).

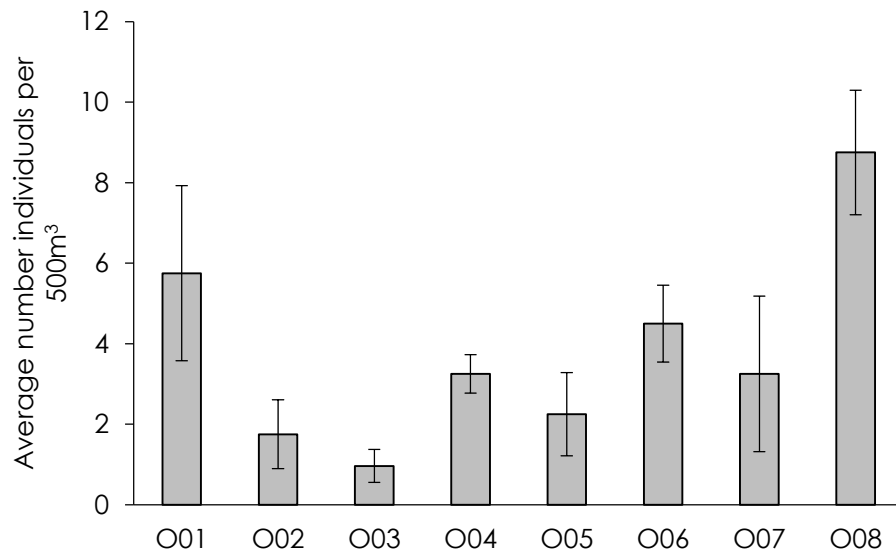


Figure 18. Average total Butterflyfish abundance with standard error per 500m³ in Estela proposed marine protected area (MPA), southern Leyte, the Philippines.

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2								-
O3								-
O4								-
O5								-
O6								-
O7								
O8		+	+	+	+	+		

Figure 19. Matrix showing significant differences in mean butterflyfish abundance per 500m³ across all survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

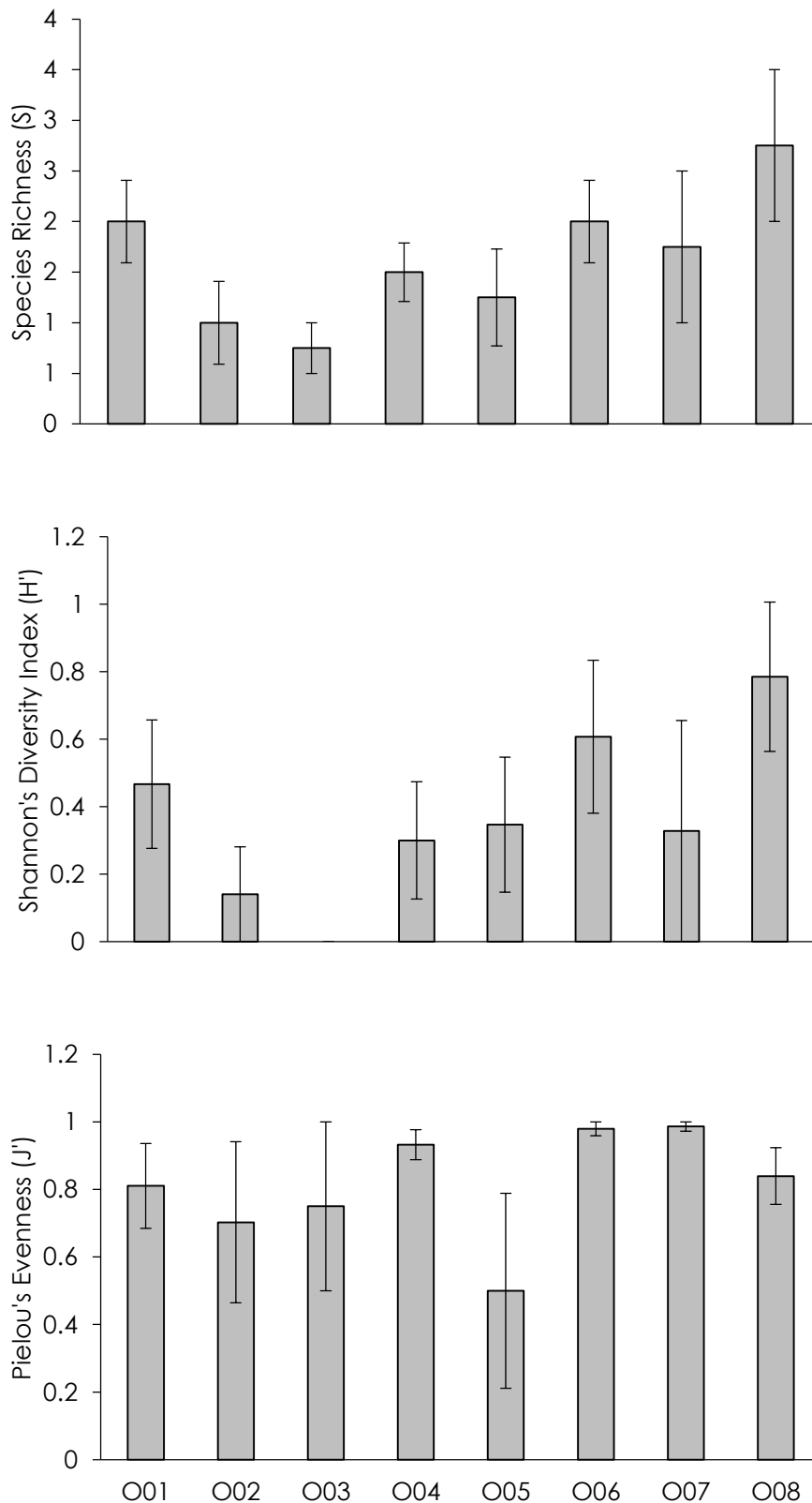


Figure 20. Butterflyfish Species Richness (i.e. number of species), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) with standard error per 500m³ in Estela proposed MPA, southern Leyte, the Philippines.

a)

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2								
O3								-
O4								
O5								
O6								
O7								
O8			+					

b)

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2								-
O3								-
O4								
O5								
O6								
O7								+
O8		+	+				-	

Figure 21. Matrix showing significant differences in Butterflyfish a) Species Richness (S), and b) Pielou's Evenness (J') values per 500m³ across all survey sites. Species richness and Shannon's Diversity Index is not pictured as they showed no significant differences. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

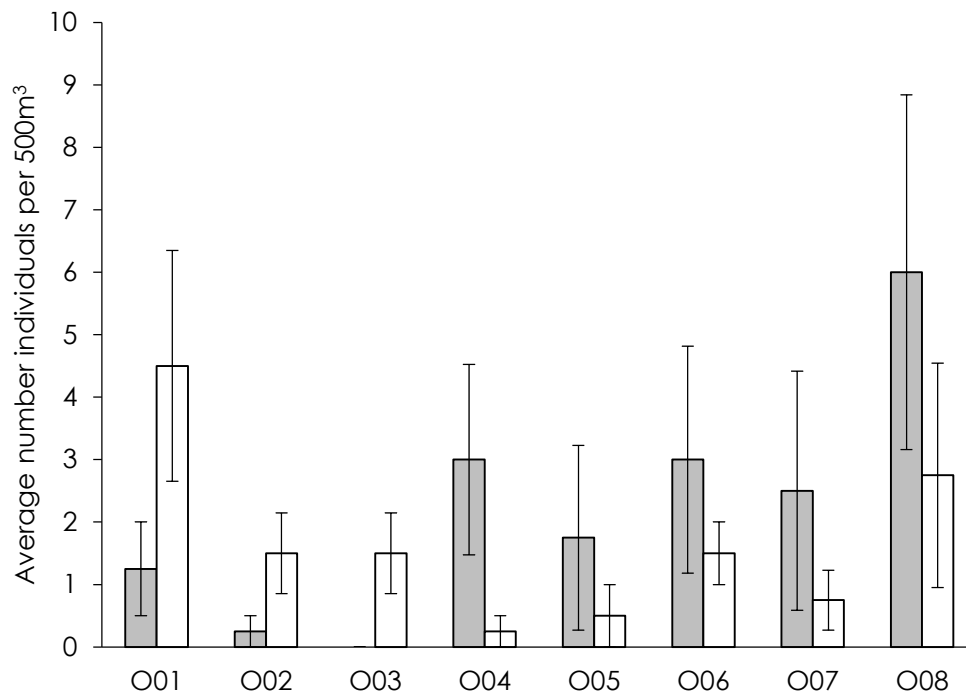


Figure 22. Average facultative corallivore and obligate corallivore Butterflyfish abundance with standard error per 500m³ in Estela proposed marine protected area (MPA), southern Leyte, the Philippines. Grey = Facultative corallivore, White = Obligate corallivore.

3.2 Invertebrates

Average invertebrate abundance across all transects was 86.00 ± 15.61 per 100m² (Fig. 23). Transect O08 had significantly lower ($p = <0.05$) invertebrate abundance than all other transects (Fig. 24). Additionally, transect O05 ($p = <0.05$) had significantly greater ($p = <0.05$) invertebrate abundance than transect O02, O03, and O07, and transect O06 had significantly greater ($p = <0.05$) abundance than transect O01, O02, and O03 (Fig. 24). On average, feather stars ($n = 37.59 \pm 4.58$), other sea cucumbers (excluding commercially important species) ($n = 10.93 \pm 4.78$), and long spine sea urchins ($n = 9.03 \pm 1.99$), dominated the survey area (Appendix B).

Average invertebrate species richness (S) was 10.50 ± 0.85 per 100m². Average invertebrate diversity (H') was 1.63 ± 0.12 per 100m², and evenness (J') was 0.70 ± 0.04 per 100m² (Fig. 25). There were numerous significant differences ($p = <0.05$) in S , H' , and J' across transects (Fig. 26). Notably, transect O01 had significantly higher ($p = <0.05$) species richness than transect O08. Additionally, transect O06 had generally low invertebrate diversity with significant differences ($p = <0.05$) across transect O01, O02, and O05 (Fig. 26).

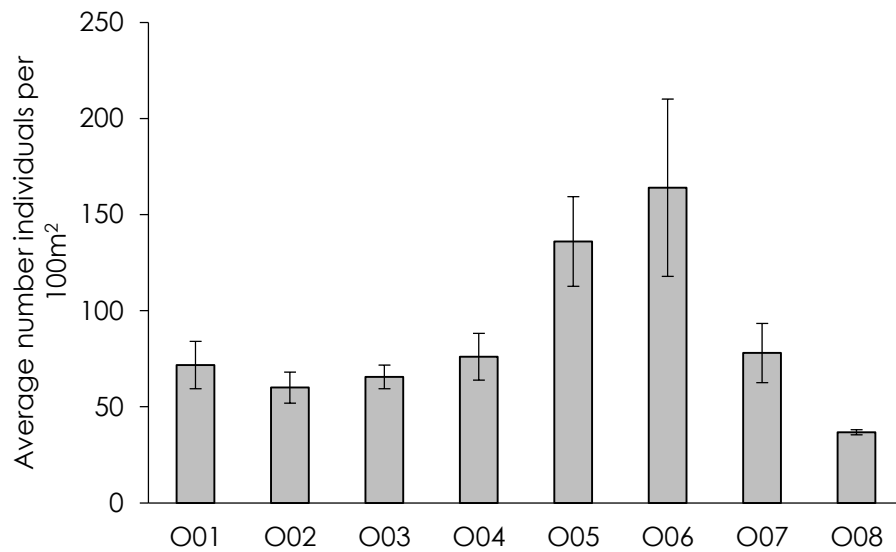


Figure 23. Average invertebrate abundance at each transect with standard error per 100m² in Estela proposed marine protected area (MPA), southern Leyte, the Philippines.

	O1	O2	O3	O4	O5	O6	O7	O8
O1						-		+
O2					-	-		+
O3					-	-		+
O4								+
O5		+	+				+	+
O6	+	+	+					+
O7					-			+
O8	-	-	-	-	-	-	-	

Figure 24. Matrix showing significant differences in invertebrate abundance per 500m³ across all survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

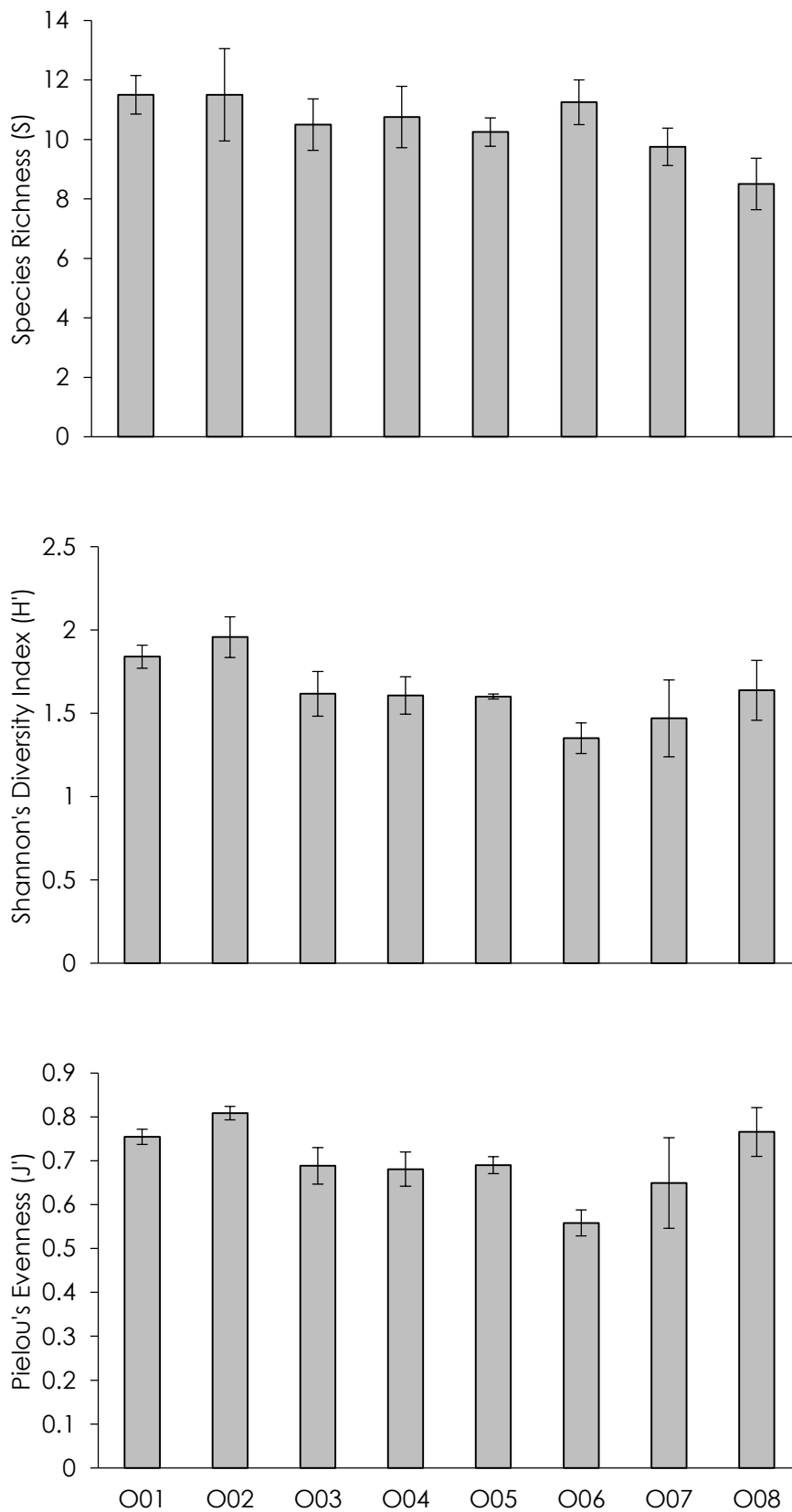


Figure 25. Invertebrate Species Richness (i.e. number of species), diversity (Shannon's Diversity H' Index), and evenness (Pielou's J' Evenness) with standard error per 100m² in Estela proposed marine protected area (MPA), southern Leyte, the Philippines.

a)

	O1	O2	O3	O4	O5	O6	O7	O8
O1								+
O2								
O3								
O4								
O5								
O6								
O7								
O8	-							

b)

	O1	O2	O3	O4	O5	O6	O7	O8
O1					+	+		
O2					+	+		
O3								
O4								
O5	-	-				+		
O6	-	-			-			
O7								
O8								

c)

	O1	O2	O3	O4	O5	O6	O7	O8
O1						+		
O2			+	+	+	+		
O3		-				+		
O4		-						
O5		-				+		
O6	-	-	-		-			-
O7								
O8						+		

Figure 26. Matrix showing significant differences in invertebrate species richness (a), and Shannon's Diversity Index (b), and Peilou's Evenness (c) per 100m² across all survey sites. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p = <0.05$). Blank cells indicate no significant difference.

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. 32 Giant Clams were recorded in the survey area with no individuals larger than 40cm. The majority of Giant Clams were <10cm. No Crown of Thorns Starfish (CoTs, *Acanthaster planci*) were seen within the survey area.

3.4 Substrates

The most prevalent substrate was sand, covering an average of $39.61\% \pm 5.81\%$ per 20m. This was followed by rock with $25.47\% \pm 4.58\%$ per 20m, and hard coral with $10.31\% \pm 2.65\%$ per 20m (Fig. 27). Hard coral was significantly ($p = <0.05$) more abundant on transect O01 compared to all other transects, and on transect O05 compared to O06 and O08 (Fig. 28). Nutrient indicator algae was significantly more abundant ($p = <0.05$) on transect O04 compared to all other transects, and on transect O03 compared to transect O05, and O06. Significant differences were also found for sponge, rock, and rubble (Fig. 28). No other bottom types showed significant differences across transects.

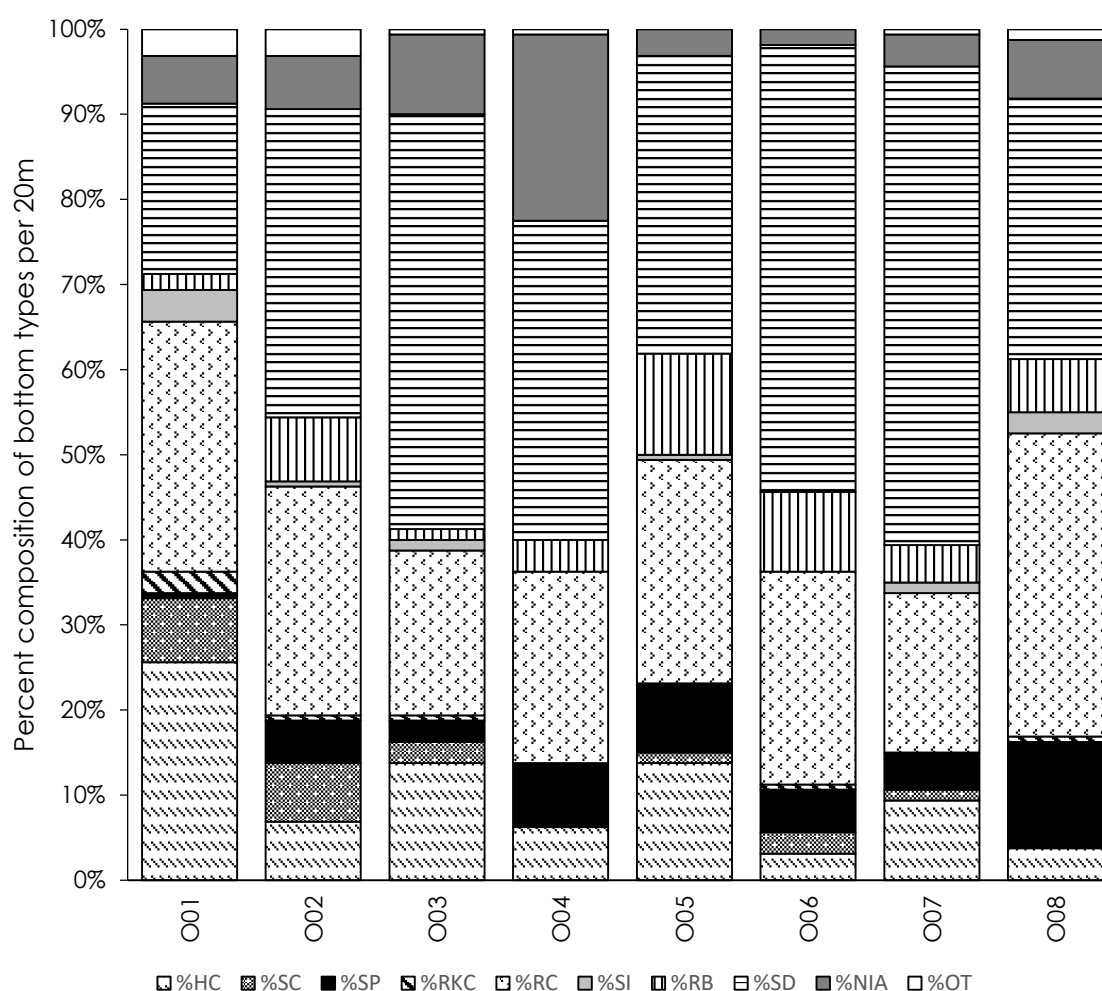


Figure 27. Mean substrate percentage cover at each transect per 20m in Estela proposed marine protected area (MPA), southern Leyte, the Philippines. HC – Hard coral; SC – Soft coral; SP – Sponge; RKC – Recently killed coral; RC – Rock; RB – Rubble; SD – Sand; SI – Silt; NIA – Nutrient indicator algae; OT – Other living organism.

a)

	O1	O2	O3	O4	O5	O6	O7	O8
O1				-				
O2				-				
O3				-	+	+		
O4	+	+	+		+	+	+	+
O5			-	-				
O6			-	-				
O7				-				
O8				-				

b)

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2								
O3								-
O4								
O5								
O6								
O7								
O8			+					

c)

	O1	O2	O3	O4	O5	O6	O7	O8
O1								
O2								
O3								
O4								
O5								
O6								
O7								-
O8							+	

d)	O1	O2	O3	O4	O5	O6	O7	O8
O1		-		-	-			-
O2	+							
O3					-			-
O4	+							
O5	+		+					
O6								
O7								
O8	+		+					

e)	O1	O2	O3	O4	O5	O6	O7	O8
O1		+	+	+	+	+	+	+
O2	-							
O3	-							
O4	-							
O5	-					+		+
O6	-				-			
O7	-							
O8	-				-			

Figure 28. Matrix showing significant differences in substrate abundance per 20m across all survey sites. Substrate category: a) nutrient indicator algae, b) rubble, c) rock, d) sponge, e) hard coral. Substrate categories not listed showed no significant differences across transects. A green '+' indicates abundance was significantly higher at the surveyed transect on the left compared to transect at the top ($p = <0.05$). A blue '-' indicates that abundance was significantly lower at the transect on the left compared to transect at the top ($p < 0.05$). Blank cells indicate no significant difference.

More specifically, Non-acropora encrusting corals dominated the proposed MPA with an average cover of $27.11\% \pm 10.71\%$ per 20m (Fig. 29). These were followed by non-acropora submassive corals with $23.52\% \pm 12.24\%$ coverage per 20m, and non-acropora branching corals with $22.65\% \pm 10.61\%$ coverage per 20m (Fig. 29, Appendix B). There were significantly ($p = <0.05$) more competitor corals ($59.34\% \pm 9.51\%$ per 20m) compared to stress tolerant corals ($28.16\% \pm 7.95\%$ per 20m) (Fig. 30). There were no disturbance adapted fast growing corals recorded during the survey (Fig. 30).

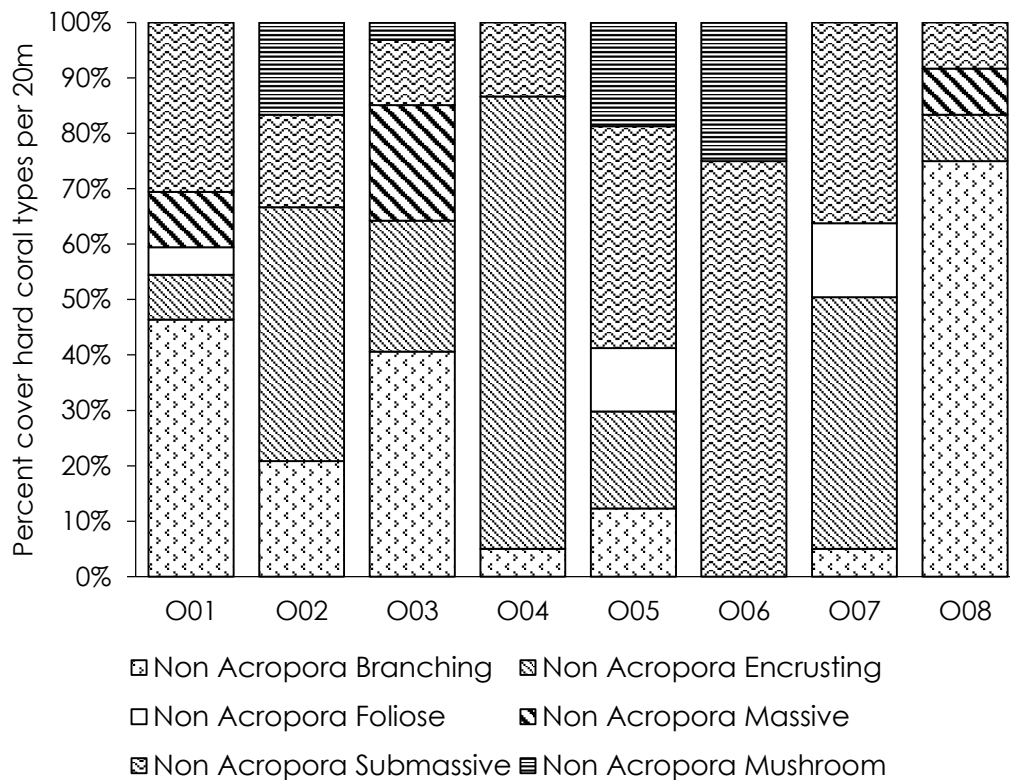


Figure 29. Average percent cover hard coral by classification per transect per 20m in Estela proposed marine protected area (MPA), southern Leyte, the Philippines. No *Acropora* species, blue coral (*Heliopora* sp.), fire coral (*Millepora* sp.), or organ pipe coral (*Tubipora* sp.) were recorded on any transects.

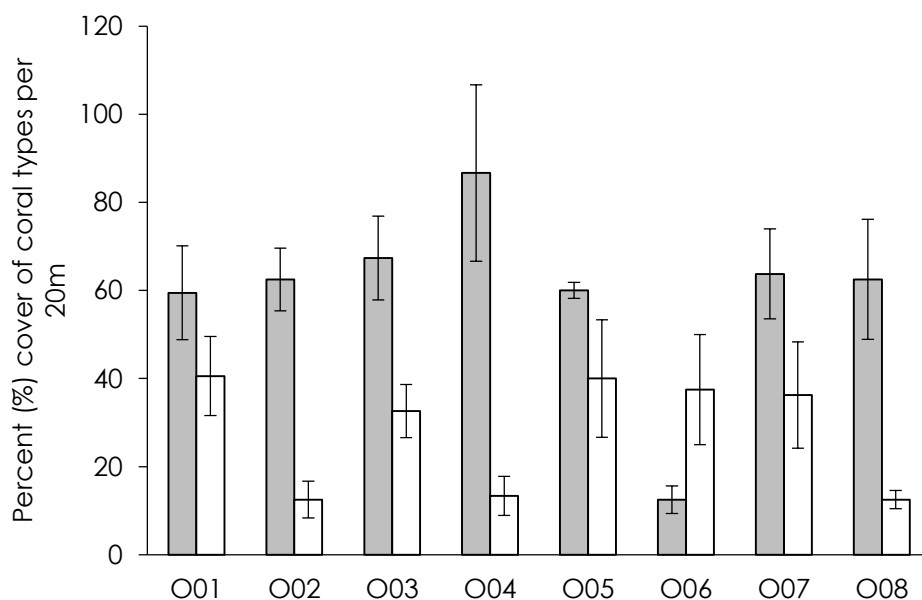


Figure 30. Average percent cover of coral types with Standard Error per 20m on the Estela proposed marine protected area (MPA), Southern Leyte, the Philippines. Grey = Competitor corals (i.e. branching, foliose, encrusting, mushroom Non-*Acropora* sp.); White = Stress tolerant corals (i.e. massive, sub-massive, organ pipe (*Tubipora* sp.)) (Edinger and Risk 2000). No disturbance adapted fast growing corals (i.e. *Acropora* sp., Fire coral (*Millepora* sp.), Blue coral (*Heliopora* sp.)) were recorded during the survey.

3.2 Anthropogenic Impacts

During the survey period the reefs of Barangay Estela showed varying levels of anthropogenic impact. Tourism is low within the area and there are no commercial fishing activities. Artisanal fishing was self-reported by the community as low, with similarly low levels of invertebrate harvesting for food purposes. There is no cyanide, blast, or LRFFT fishing in the area and no industrial pollution was reported.

General trash was recorded 24 times during the survey, with 53% of the surveyed area showing no impact, 22% showing low impact, 22% showing moderate impact, and 3% showing high impact. Fishing related trash (e.g. nets, lines) was recorded 41 times, with 31% of the surveyed area showing no impact, 34% showing low impact, 13% showing moderate impact, and 22% showing high impact. There were no obvious signs of boat, anchor, or dynamite damage. Undetermined coral damage was observed 22 times, with 59% of the surveyed area showing no impact, 13% showing low impact, and 28% showing moderate impact.

Coral bleaching was recorded on five of the eight transects and ~3% of the population was affected with an average of $51.75\% \pm 18.42\%$ bleaching on individual colonies. Two cases of white band disease were recorded, covering ~1% of the affected coral colony. No other incidents of black band or other coral diseases were recorded.

4. Visual Assessment

Images taken by CCC volunteers on the reefs of Estela.



Figure 31. Folios and soft corals creating the reef in Estela proposed MPA.



Figure 32. Orange-banded coral fish (*Coradion chrysozonus*).



Figure 33. Fimbriated Moray (*Gymnothorax fimbriatus*).



Figure 34. Feather stars (*Crinoids* sp.) perched on rocks in the Estela proposed MPA.



Figure 35. A head shield slug (*Chelidonura inornata*) crawling on a Soft Tree Coral.



Figure 36. Soft corals and hard coral *Goniopora* sp. in Estela proposed MPA.



Figure 37. Slender pipefish (*Trachyrhamphus longirostris*) swimming on a sandy bottom at Estela proposed MPA.



Figure 38. A sea slug or dorid nudibranch (*Phyllidia varicosa*).



Figure 39. A sea slug or dorid nudibranch (*Nembrotha kubaryana*).



Figure 40. Close up of a nudibranch's rhinophores in Estella proposed MPA.



Figure 41. Hard coral (*Euphyllia* sp.) in Estela proposed MPA.

5. Discussion

The proposed Estela MPA gives the overall impression of a moderately healthy reef ecosystem. There are some trends that are of concern, indicating activities such as overfishing, which require consideration to ensure the preservation and restoration of the coral reef in Barangay Estela. However, there are also encouraging signs that the reef is currently healthy enough to benefit from MPA protection. In this section the trends observed in the data are discussed and recommendations for future management are provided.

5.1. Fish

Overall, the Estela proposed MPA site showed moderate levels of fish abundance (42.09 ± 9.48 per 500m^3). In comparison, the Marine Protected Area in Napantao, San Francisco- surveyed in 2015, conferred a higher average fish abundance (93.33 ± 19.03 per 500m^3) (Lancaster *et al.*, 2016). The Napantao MPA, however, is known locally as a popular dive/snorkel site because of its fish diversity and healthy reef ecosystem. Furthermore, the Napantao MPA has been in place for twenty years, which may contribute to its greater fish abundances (Edgar *et al.*, 2014). As such, the comparatively modest fish abundance found at Estela is still indicative of a relatively healthy reef ecosystem that could show dramatic improvements with proper protection (Russ and Alcala, 2004). Similarly, the proposed Estela site showed moderate species richness and diversity, yet both index values were lower than those at the previously mentioned Napantao MPA. A greater H' value is often associated with healthier reef systems as high diversity typically increases a reef's resilience to anthropogenic and non-anthropogenic stressors (e.g. overfishing, ocean acidification) (Chapin *et al.*, 2002), where a representative decrease in the measured S values is thought to indicate anthropogenic stress, both acute and chronic (Morris *et al.*, 2014). Protecting the Estela proposed MPA site could help to increase overall fish species richness and diversity, which would make the area more resistant to serious reef stressors.

Commercial fish abundance at the proposed site was low. Commercially important Snapper, and Parrotfish were rare and, when present, small in size. Grouper, another commercially important species, were completely absent from the survey area. These trends are indicative of overfishing. The small size of commercially important fish at the site means most fish are sexually immature, making it difficult for important fish populations to recover, especially without protection and with continued fishing pressure. Grouper, along with other commercially important reef fish families such as Snappers, are often long lived and slow growing, with life spans often ranging from 25 to 40 years (Coleman, *et al.*, 2000). Most Grouper species take a long time to reach sexual maturity and their reproductive capacity is greatly affected by size, which is in turn directly related to age. These life history traits make species like Groupers particularly susceptible to overfishing as individuals are often removed before they have the chance to spawn, thus not replenishing the population sizes within the region. Not only does it take these slower growing species a long time to recover when their population is decreased by extraction, but preferential selection of larger individuals by fishermen also reduces the fecundity of the population as a whole and can disrupt sex ratios and population dynamics (Collins *et al.*, 1998). Understanding

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

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

Butterflyfish are often used as indicators of reef health and resilience through their species richness (S) and species diversity (H') (Bozec *et al.*, 2005). Studies have shown a correlation between Butterflyfish species richness, total fish species richness, and coral cover (Bozec *et al.*, 2005). Additionally, their relative ease of identification and, their large habitat (both Atlantic and Pacific), make Butterflyfish an excellent international proxy for fish and coral abundance and health (Bozec *et al.*, 2005).

In Estela, the moderate abundance, species richness, and diversity of butterflyfish again indicate that, although the proposed area is currently in moderate health, there is room for ecological improvement through adequate protection. However, the dominance of the facultative corallivorous species in place of obligate corallivorous species (*C. baronessa* (Eastern Triangle) and *C. lunulatus* (Redfin)) may suggest there is currently not enough hard coral to support large fish communities that depend heavily upon hard coral, not only for shelter, but also for food. A study of the Australian Great Barrier Reef found that, after extensive (>90%) bleaching related hard coral damage, obligate corallivore Butterflyfish abundance showed marked declines (Pratchett *et al.*, 2006). This association between hard coral cover and obligate corallivore Butterflyfish abundance is supported in Estela at transect O01, which showed the highest abundance of both hard coral coverage and obligate corallivore Butterflyfish. Monitoring of these Butterflyfish and hard coral species should be continued to measure any population declines or increases, which could indicate failing or improving reef health. It is likely that an increase in both hard coral coverage and the presence of *Acropora* species - preferentially predated by *C. baronessa* and *C. lunulatus* (Berumen, 2006)- would increase populations of obligate corallivores on the reef of Estela.

5.2 Invertebrates

The proposed MPA site showed relatively low levels of invertebrate abundance. Interestingly, transect O08, which showed high abundance and diversity of fish but low hard coral cover, had significantly lower invertebrate abundance than all other transects. This may suggest a lack of hard coral shelter or food for invertebrates and an unbalanced predator prey relationship between fish and invertebrates. For example, facultative corallivores, which often feed on invertebrates, were most abundant at transect O08.

A worrying, though locally common, result from the data is the lack of many commercially important species of invertebrates such as Triton's Trumpet, Squid and species of Sea Cucumber. These species, which in many cases are slow growing and slow moving, are particularly vulnerable to over exploitation.

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

Triton's trumpets are targeted by humans because of their high value as a curios item and are easily removed from a reef due their conspicuous appearance and large size. They are an ecologically important invertebrate species on Indo-Pacific reefs as one of the very few predators of CoTs. If top predators such as the triton's trumpet are removed from an ecosystem, the risk of a CoTs outbreak is increased. However, no CoTs were recorded in the Estela proposed MPA, which is a promising sign for the recovery of hard coral species. Continued monitoring of the area is necessary to ensure CoTs outbreaks do not occur in the absence of Triton's trumpet.

Giant Clams, another important commercial species, were observed relatively frequently on the surveys but most individuals were very small in size (<10cm). These results indicate that extraction pressure may be high in the area. However, the presence of small giant clam may indicate slow but continued recruitment of new individuals at the site.

5.3 Substrates

The proposed MPA was dominated by sand, which is not ideal for hard coral recruitment that requires hard surfaces to attach and grow. However, the second most prevalent substrate was rock, which is a positive sign for future coral recruitment. Furthermore, indicators of coral health including nutrient indicator algae and recently killed coral did not dominate the area and incidents of bleaching and coral disease were relatively rare. Hard coral was the third most common substrate. Thus, in terms of hard corals, the proposed site would make a promising MPA with plenty of rock for more coral attachment and a pre-established coral base to provide juvenile recruits. However, research implemented by Reef Check between 1997 and 2001 shows that coral reef systems throughout the Indo-Pacific averaged ~40% hard coral cover (Hodgson and Liebel, 2002). Compared to this Indo-Pacific average, the ~10% hard coral cover at Estela is very low. The presence of hard coral is essential as it provides the main habitat utilised by fish and invertebrates for shelter, spawning and food. Protecting the Estela site from fishing pressure, dynamite, boat damage, and CoTs outbreaks could be an important first step towards increasing hard coral cover in the region.

The significantly higher abundance of competitor corals than stress tolerant corals may suggest a relatively healthy reef environment sheltered from large coral damaging storms and high wave action. Reefs dominated by stress-tolerant corals generally exist in polluted or heavily sedimented waters. Competitor corals tend to dominate on many Indo-Pacific reefs that have been left relatively untouched for a long period. Competitor corals take longer to grow than delicate but fast-growing fast growing, disturbance adapted *Acropora* species (Edinger and Risk, 2000). This may suggest that non-acropora encrusting, branching, foliose, and mushroom corals have simply out-competed *Acropora* species. However, this may also suggest unfavourable conditions at the reef site that are causing severe breakage of delicate

Acropora corals. Nevertheless, the presence of both competitor and stress-tolerant corals is a promising sign for this reef as greater coral diversity generally indicates greater reef health (Edinger and Risk, 2000).

5.4 Anthropogenic Impacts

The Coral Reefs in Estela showed varying levels of human impacts. The majority of the surveyed area showed some level of fishing related and general trash (ranging from low to high impact), and levels of coral damage are a concern, however, if the reef were protected these levels may diminish or disappear over time. The presence of trash tends to deter divers from visiting or returning to a site, therefore to improve the site for recreational diving trash levels should be reduced.

Improper disposal of general waste can negatively affect the health of reefs by smothering corals and choking marine life that eat these items. Education about the consequences of improper waste disposal is extremely important and local communities require the right facilities to safely dispose of their waste. The installation of covered bins throughout the barangay and above the high tide line of its beaches

would prevent people from dropping their waste where it will eventually end up in the sea. It is essential that any bins provided to the community are emptied regularly by the municipality's waste disposal team to encourage their continued use.

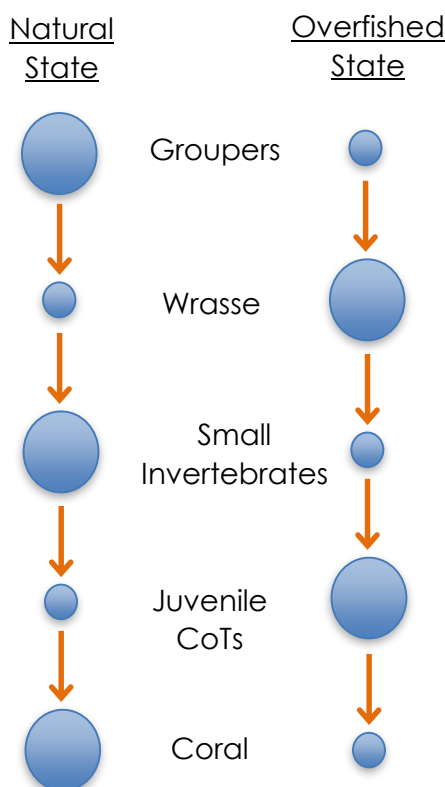


Figure 42. Representation of indirect effects that overfishing of predatory fish, Groupers can have on the entire coral ecosystem. The size of the circle represents the relative abundance of that organism or

As mentioned in previous sections, several species of fish and invertebrates (e.g. barramundi cod, triton's trumpet snails) targeted for human consumption were observed in low numbers or completely absent. The most concerning aspect of these findings is that several of these species are known keystone species. This means that these organisms play a vital role in the reef system and if removed could seriously affect the stability of the entire ecosystem. This can happen in two ways: (1) direct effects or (2) indirect effects. Direct effects occur when predators are removed from an ecosystem and facilitate the ecological release of prey species. For example, the removal of predators such as humphead wrasse (*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 (Fig. 42).

The removal of apex predators such as groupers causes a decrease in the predation of species such as wrasse, allowing prey populations to increase. Many wrasse species feed on benthic invertebrates that in turn predate juvenile settlement stage CoTs. With an increase in wrasse numbers there is a corresponding decline in these invertebrates and thus an increase in juvenile CoT

survivorship (Fig. 42). Indirect top-down effects from depletion of apex predators have been shown to have wide spread impacts on ecosystems around the world (Myers *et al.*, 2007).

We believe the Estela reef would make an excellent MPA with enough coral cover and fish diversity to promote reef improvement with adequate protection. Low levels of fish, especially commercially important fish, suggest prolonged overfishing has occurred in the region. The implementation of an MPA could help to reverse these trends and allow the reef to recover, with lasting benefits for the community of Estela.

6. Recommendations

CCC strongly recommend creating an MPA in the Estela. 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 NTAs 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 Estela. 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 NTA. 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. Even minimal instances of poaching (whether intentional or accidental) inside an MPA can destroy years of recovery in a relatively short period of time (McCook, *et al.*, 2010). For this CCC advise the creation of a management committee to oversee the effective running of the MPA. The committee would coordinate the collection of MPA fees for possible dive and snorkel sites, provide training and support to Bantay Dagats, oversee the enforcement of the MPA and be a link to the Municipal Government for matters concerning the MPA. It will be important for the management committee to establish goals and objectives

for the MPA based on the criteria of species protection, fisheries and tourism. Reviewing these objectives will help inform management decisions. CCC can offer support throughout this process, and can assist in training local Bantay Dagats, at the request of Estela.

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

The surveyed site in Estela shows great promise as a Marine Protected Area. Protecting this area would allow the hard coral cover to increase, allow fish stocks to recover and potentially create funding in the form of eco-tourism. Taking this in to consideration, Coral Cay Conservation recommends that a new Marine Protected Area be established in an area encompassing the eight transects surveyed (Fig. 43, Table. 2).

This would additionally benefit by having Marine Reserve buffer zones of 50m which restrict all but hook and line fishing.

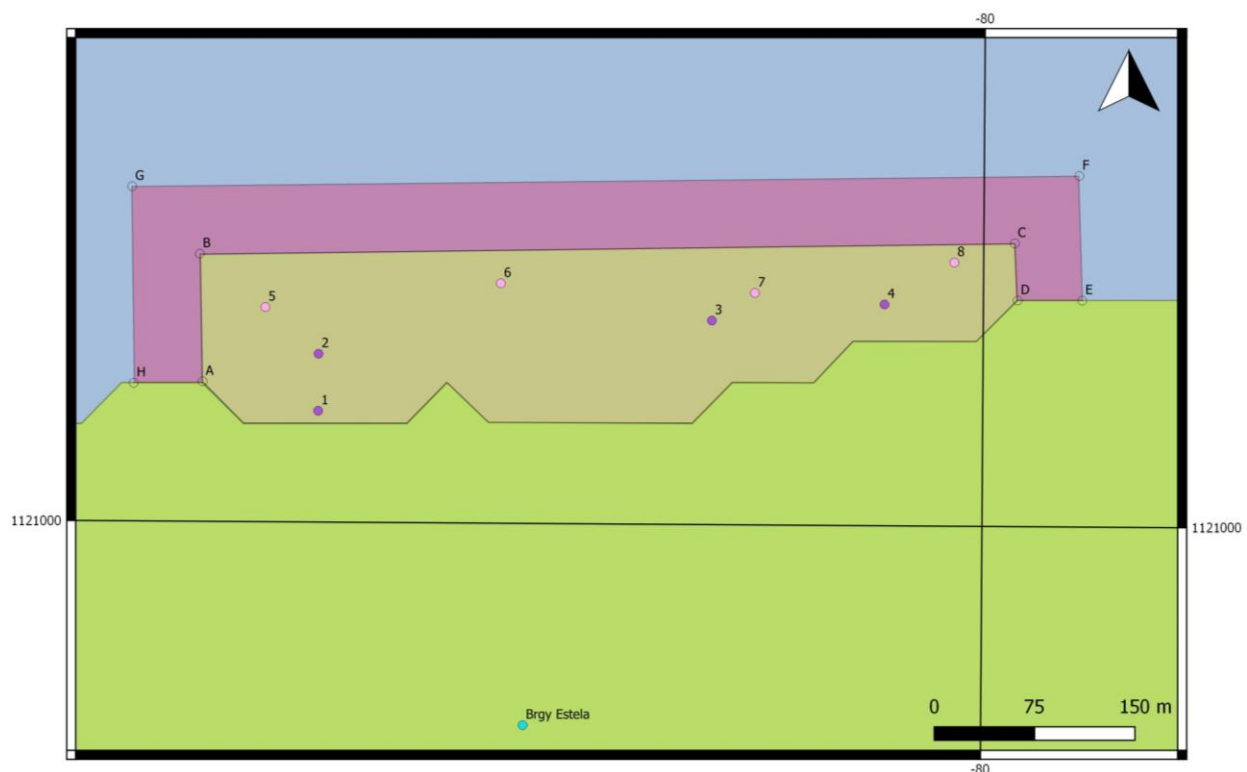


Figure 43. Proposed boundary location for Barangay Estela Marine Protected Area (MPA) of the municipality Liloan. The recommended MPA utilises a zoned spatial design that incorporates a central no-take area (NTA) that prevents all fishing and maritime related activities, although through establishment, ordinance will enable Barangay Estela to charge fees for recreational tourism such as diving and snorkelling. The NTA is surrounded by a 50m buffer marine reserve (MR) of which still holds strong ordinance but allows the practice of artisanal single-hook and line fishing as well as maritime access. The recommended ordinance still prescribes the restriction of commercial fishing practices as well as the use of gill nets. The boundaries of the NTA and MR, constituting the MPA, protects the eight 100m transect survey sites that were conducted at two depths; 6m (purple and labelled 1, 2, 3 and 4) and 12m (pink and labelled 5, 6, 7 and 8).

Table 2. Boundary coordinates for proposed Marine Protected Area in Barangay Estela, Liloan. The total area of the proposed MPA (no-take area (NTA) and marine reserve (MR)) are also given in hectares (ha).

Boundary Point	Easting (UTM)	Northing (UTM)
A	738416.4	1121105.6
B	738413.6	1121201.9
C	739023.1	1121213.7
D	739025.5	1121170.6
E	739073.8	1121170.9
F	739071	1121264.9
G	738362.8	1121252.4
H	738364.9	1121104.2
Total MPA area (ha)	Total NTA area (ha)	Total MR area (ha)
11.25	6.84	4.41

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 Estela, in particular the local fisherfolk. CCC provide suggestions on what is the ecological ideal, but understand that there are other factors to consider during the decision making process. As such, the scenarios outlined here should be used as the initial step in opening a dialogue between all relevant aforementioned stakeholders in order to come to the best possible conclusion for all parties. Combining an ecosystem approach to fisheries (EAF) and community-based management (CBM), empowering the local user group level and conferring high levels of transparency in a triangulated consortium, CCC aims to facilitate the local Barangay Estela in achieving measurable levels of effectiveness from their designated MPA. By establishing clear, community driven objectives and goals during the formation of the Estela MPA, CCC hopes to address the key challenge to successful MPAs by ensuring that the MPA's by-laws, policies and restrictions fit into the greater ecological, social and economic context, contextualising not only the needs for the fauna and flora present within its boundaries but the needs of the local stakeholders and that of the municipality under the Republic Act No. 8550.

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

Support for the establishment of an MPA is available from both Municipal and Provincial government levels. It will be important to secure funding from the outset to aid in the establishment of the MPA. 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 Estela, 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 Estela 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 LIST

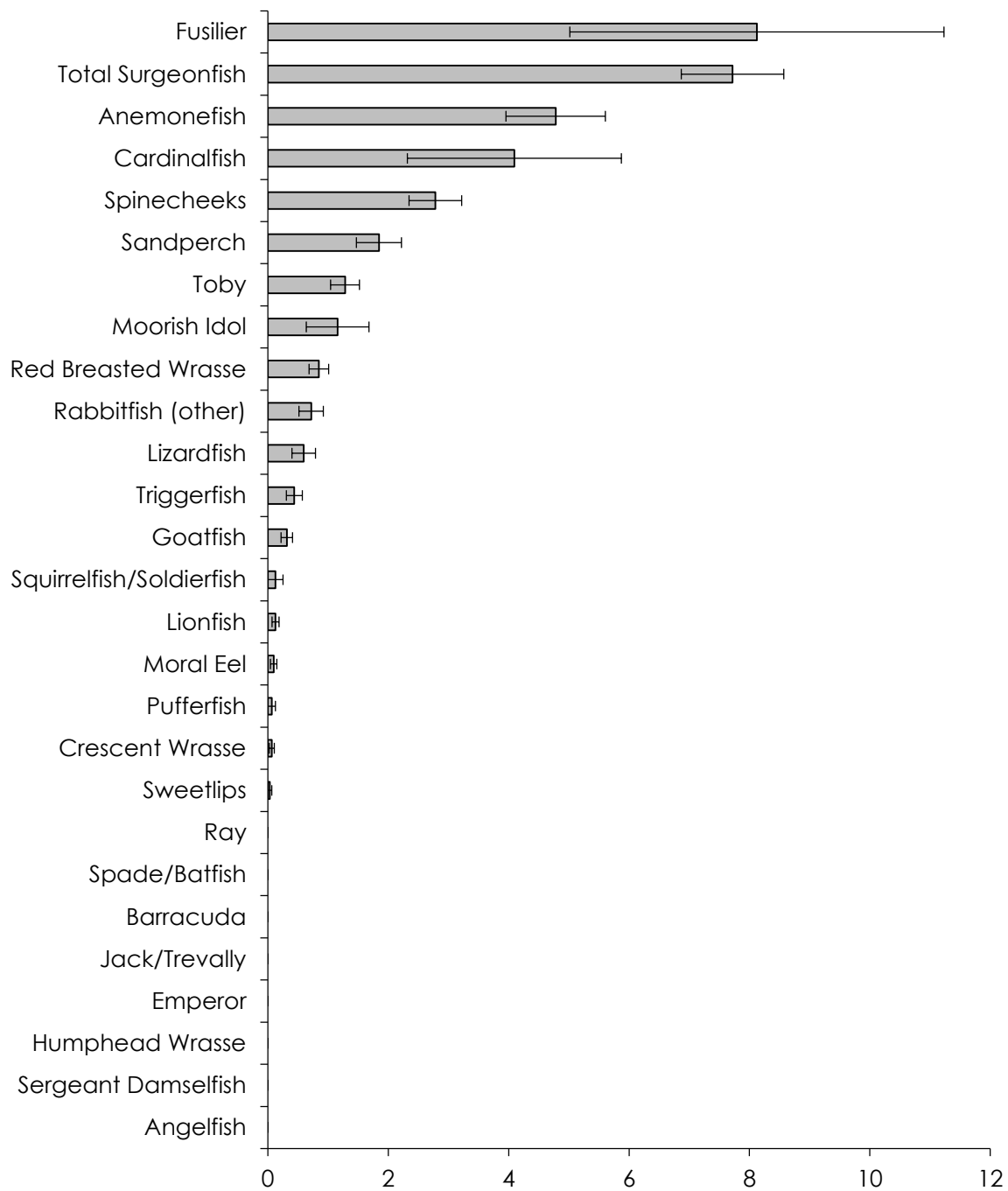
SUBSTRATES		
Soft Coral	Sponge	Recently killed coral
Rock	Silt/mud	Rubble
Sand	Nutrient indicator algae	Other*
Hard Coral Lifeforms**:		
Acropora branching	Acropora encrusting	Acroporasubmassive
Acroporadigitate	Acropora tabulate	Non-Acropora branching
Non-Acropora encrusting	Non-Acropora foliose	Non-Acroporasubmassive
Non-Acropora mushroom	Heliopora (blue coral)	Millepora (fire coral)
Tubipora (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	

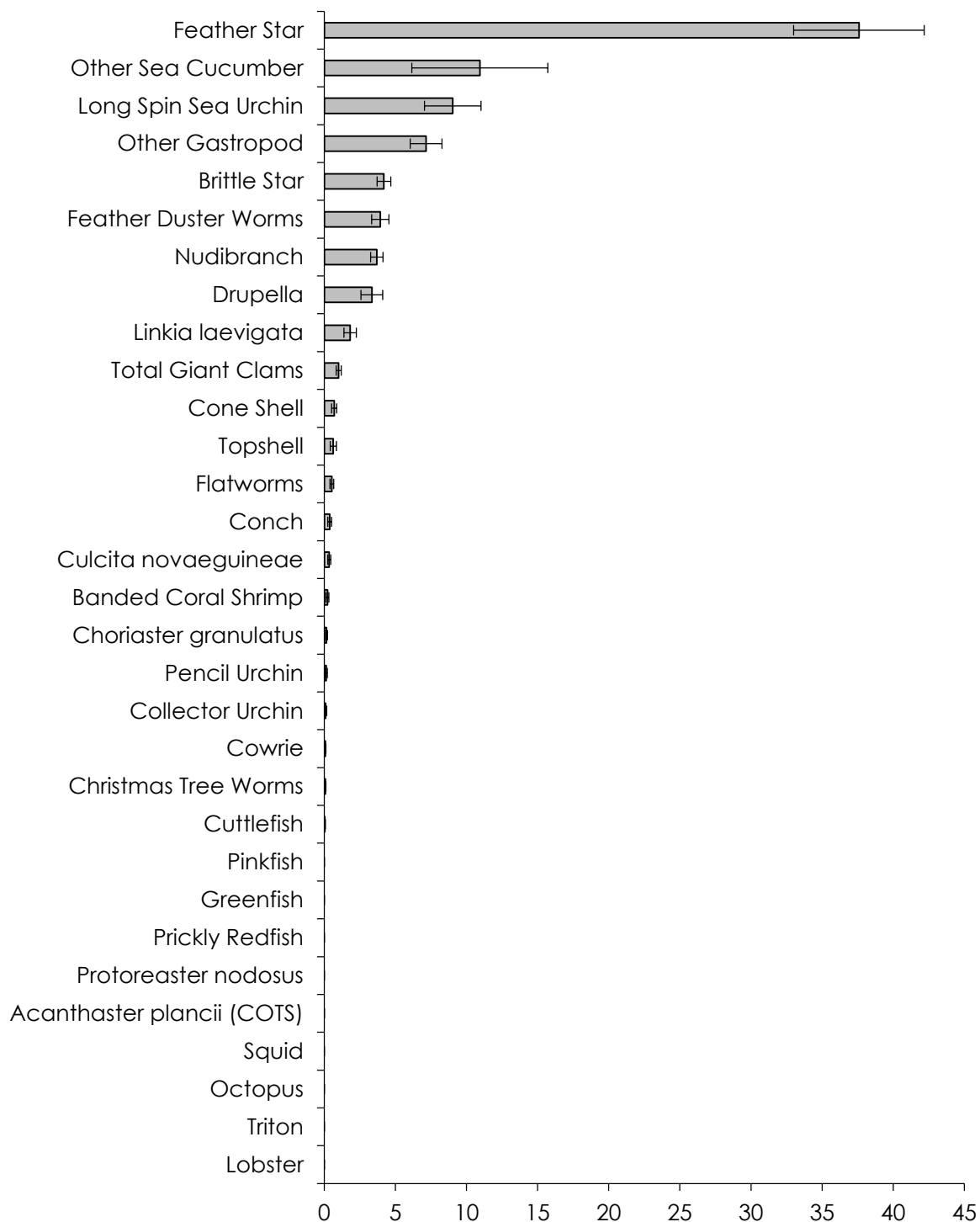
Common Name	Latin Name	Visayan Name
Angelfish	Pomacanthidae	Adlo
Barracuda	Sphyraenidae	
(Butterflyfish)	Chaetodontidae	Alibangbang
(Big) Longnose Butterflyfish	Forcipiger flavissimus	
Eastern Triangle Butterflyfish	Chaetodon baronessa	
Humphead Bannerfish	Heniochus varius	
Kleins Butterflyfish	Chaetodon kleinii	
Raccoon Butterflyfish	Chaetodon lunula	
Redfin Butterflyfish	Chaetodon lunulatus	
Vagabond Butterflyfish	Chaetodon vagabundus	
Cardinalfish	Apogonidae	
(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 sp.</i>	
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>	

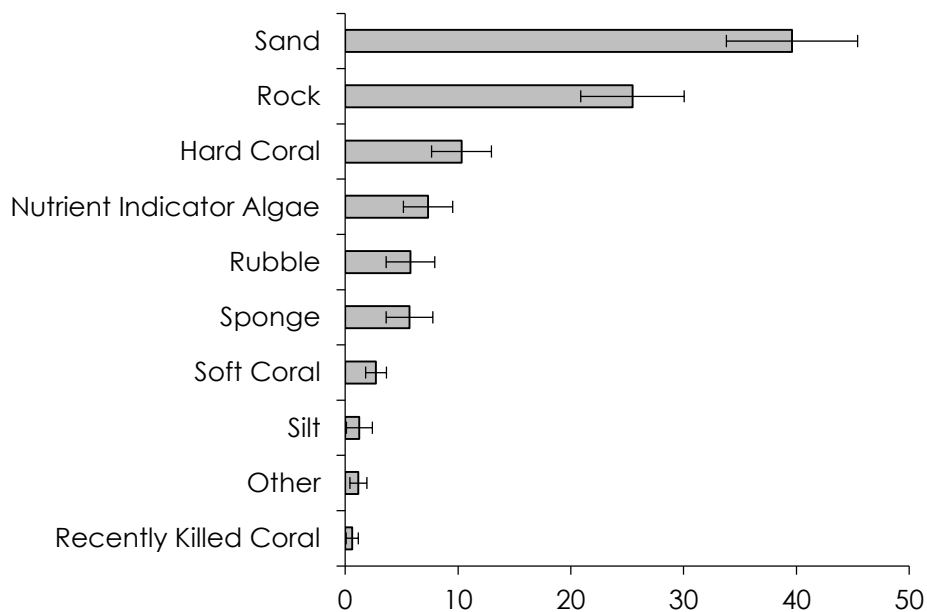
APPENDIX B: TARGET ORGANISM AVERAGE ABUNDANCES



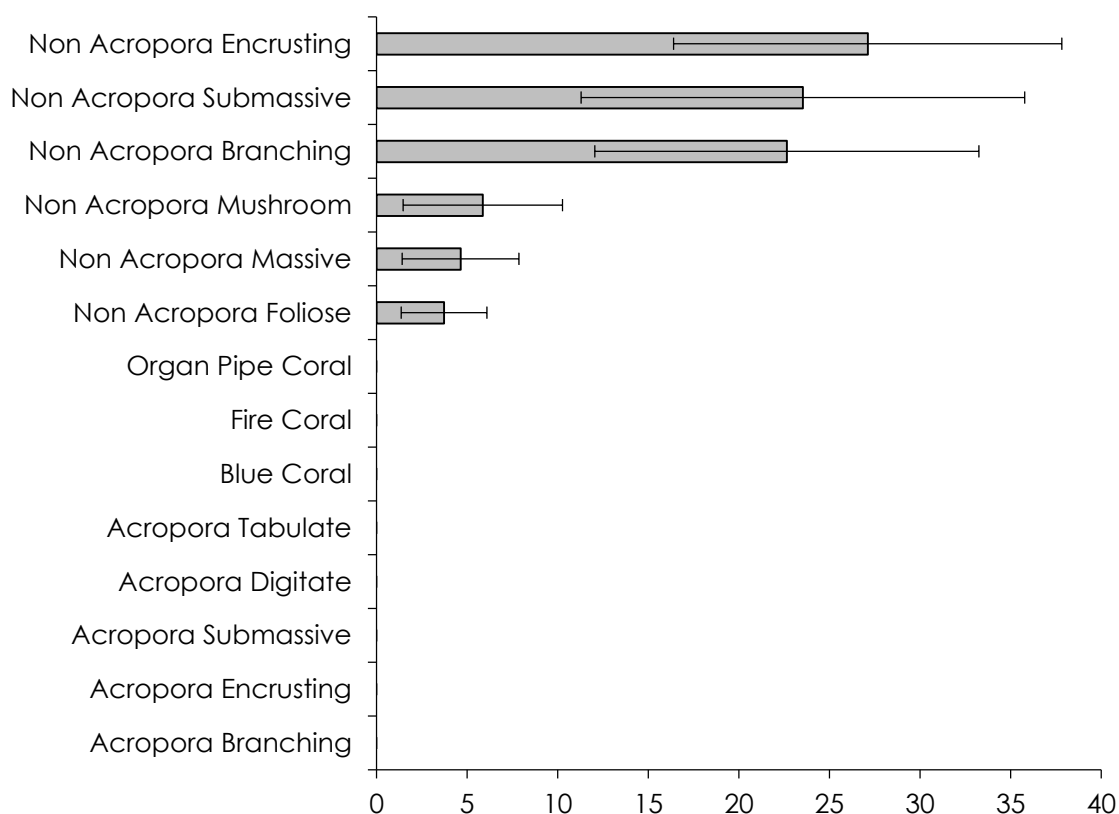
Average abundance of target fish families per 500m³ with Standard Error for Estela proposed MPA site, Municipality Liloan, Southern Leyte, Philippines.



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



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



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