

Coral Cay Conservation Philippines; Current Ecological Status of Barangay Himbangan's Coral Reef and Proposals for Future Management Practices

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Coral Cay Conservation Philippines; Current Ecological Status of Barangay Himbangan Coral Reef and Proposals for Future Management Practices

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Abstract/Executive Summary

Coral Cay Conservation (CCC) conducted an assessment of the biological status and anthropogenic impacts inside and outside the Himbangan MPA (municipality St Bernard), in September and October 2017 to review the effectiveness of the legislation. An enhanced Reef Check methodology was used to survey 9 transects, containing 4x20m replicates. Five transects (3x6m and 2x2m) were placed inside and four transects (2x6 m and 2x12m) outside the MPA.

Mean target fish abundance was not significantly different inside compared to outside the MPA but it was larger ($N = 130.30 \pm 23.18 \text{ } 500\text{m}^3^{-1}$ and $N = 79.19 \pm 23.32 \text{ } 500\text{m}^3^{-1}$). There was also, low abundance of commercially important species both inside and outside the MPA ($N = 5.85 \pm 1.09 \text{ } 500\text{m}^3$ and $N = 0.65 \pm 0.21 \text{ } 500\text{m}^3$) and Parrotfish and Groupers were significantly lower outside the MPA ($P < 0.05$). In addition, no commercially fish were $> 50\text{cm}$ across the survey site indicative of fishing activity occurring both inside and outside of the MPA regardless of regulation. Mean abundance of invertebrates was significantly lower outside the MPA compared to inside ($P < 0.05$) and the dominating substrate type across the whole survey area was silt, with significantly higher abundance outside the MPA ($P < 0.05$). The second most common substrate type was hard coral, with significantly higher abundance inside the MPA ($P < 0.05$). This may be indicative of a recovering substrate from alleviated fishing pressure yet could be attributed the original MPA location choice. Rock was the third most abundant substrate across the survey site (not significantly different with MPA presence) and as an important settlement substrate for coral colonisation, this is promising for recovery.

In addition to biological data, there was no direct anthropogenic impacts observed but evidence of indirect impacts were recorded. General trash was at high levels and fishing trash was especially abundant across the survey area with 36.11% of the transects showing above medium levels. This assessment suggests that management needs improvement, further training is necessary with the inclusion of community education with appropriate Bantay Dagat allocation. Without clear aims for this site, further destruction may occur and benefits of an MPA will not be maximised.

Keywords: *ecological spatial assessment, Marine Protected Areas, coral reefs, fish assemblages, substrate composition, commercial fish biomass, subsistence fishery*

Introduction

Human-induced climate change, species depletion and the unsustainable over-exploitation of marine resources are having a profound effect on the marine environment, altering key ecosystem processes, detrimentally influencing biodiversity and community composition, and inhibiting their capacity to provide ecosystem services, with undisputed consequences for humanity (Barnosky *et al.*, 2011; Cardinale *et al.*, 2012; Mouillot *et al.*, 2014; Mouillot *et al.*, 2016). For example, the IPCC (2018) report has stated that human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels which is likely to reach 1.5°C from 2030. The IPCC (2018) projections are forecasted to be devastating for the status of the marine biome with major shifts to the range of many marine species, increases in damage to many systems and, at an increase of 1.5°C, a decline by a **further** 70-90% of coral reefs (with larger losses of 99% with 2°C increase (predicted with very *high confidence*)). The ever-threatening impact of global climate change, coupled with more localised, acute, perturbations place coral reefs, their associated ecosystems and the health of the oceans in serious jeopardy, further threatening the livelihoods and health of billions of people.

Coral reef ecosystems hold critical importance to the human population through the many ecosystem functions and services (e.g. habitat, protein provision, coastal defence, recreation) and are key components of coastal economies (Weijerman *et al.*, 2017). For example, global marine fisheries employ over 200 million people and are a key source of primary protein for 1 billion people (Teh and Sumaila, 2013). Of those 200 million employed, 6 million are estimated to be direct reef fishers, with 3.5 million populating South East Asia (Teh and Sumaila, 2013). However, direct reef fisher numbers are likely to be higher than reported due to the data paucity, undervalued and underappreciated

nature of nearshore fisheries, especially when considering gender and illegal, unreported and unregulated fisheries (IUU) within studies (Kleiber *et al.*, 2013; Grafeldt *et al.*, 2013; NIC 2016).

In addition to fishery-related services, coral reefs provide substantial services through coastal protection and tourism, with an estimated economic value of US\$ 30 billion per annum, globally (Chen *et al.*, 2015). The mean economic value of reefs, specifically regarding Tourism, range from US\$482,428 to US\$7 million per km², annually (Spalding *et al.*, 2017), highlighting their importance to coastal dwelling communities, national economies and the international community. As such, in the face of global and local threats, as well as varying projections on the future of coral reefs, it is imperative that resources are protected, ecosystem impacts remediated, and resilience built.

Marine Protected Areas (MPAs) are strongly advocated within conservation science through the limitation and/or restriction of access to marine resources within a defined area; utilised as a tool to manage coral reef fisheries (Lester and Halpern, 2008; Lester *et al.*, 2009; Sala *et al.*, 2016; Hastings *et al.*, 2017), reduce or eliminate localised stressors (Di Franco *et al.*, 2016), build resilience to climate impacts (Micheli *et al.*, 2012; Roberts *et al.*, 2017) and to increase marine biodiversity (and marine biomass (Aburto-Oropeza *et al.*, 2011)) (Villaseñor-Derbez *et al.*, 2018). The protection of marine areas and coral reefs can achieve conservation and resource management targets simultaneously and are therefore considered instrumental in sustainable marine resource utilisation.

Dependency and impacts are prevalent throughout the Philippines, in line with trends seen throughout South East Asia. The coastal waters surround the Philippines (composed of 7,461 islands) contain approximately 26,000 km² of coral reefs with 70% of the population's consumed animal protein derived from fish (ADB, 2014). With an increasing population, and demands for protein, as well coastal

development, including global impacts (climate change), there is a pressing need for increased protection of the Philippines' coral reefs (and associated ecosystems).

As of 2012, it is estimated the Philippines has over 1,500 MPAs designated (The Coral Triangle Atlas, 2012), however, this number is likely to be larger due to an increase MPA designation or due to smaller MPAs not recognised. Within the Philippines, it is common to find MPAs composed of two zoned areas of varying protection; a No-Take Area (NTA) and Marine Reserve (MR) buffer. NTAs are protected areas of coastal region and/or coral reefs where all fishing pressures and/or access (tourism, boat access, anchoring etc) are removed. MRs varying in their respective inhibiting by-laws but often result in a reduction in fishing pressure by limiting certain practices (such as purse seining or gill-netting) but permitting less impactful, and more selective, practices (such as hook and line). As a result, this often leads to the MR area of an MPA the most heavily exploited area on a reef due fisherfolk exploiting the natural influence of the established NTA through effects such as ecological and fishery spill over (Lorenzo *et al.*, 2016). Therefore, MRs are preferable to areas of no protection, due to the by-laws implemented, but they are not as effective as NTAs, respectively due to varying activities, such as fishing, likely to be present. Resource managers must consider these aspects in the planning phase of MPAs as well as ensuring the inclusion of stakeholders within the planning and establishment phases, through bottom-up approaches. Only when local stakeholders feel they adequately considered and regularly consulted, when social responsibility, community ownership and user group empowerment increase, will it be possible for the MPA to achieve its full potential (Green *et al.*, 2009; Human and Davies 2010).

CCC have been established since 1986 and have the following mission:

"Providing resources to help sustain livelihoods to alleviate poverty

through the protection, restoration and management of coral reefs and their associated ecosystems"

CCC were invited by the Provincial Government of Southern Leyte (PGSL) to undertake ecological-based coral assessments in Southern Leyte, in 2002, to support current conservation efforts to protect the marine resources of the region, under the project title of The Southern Leyte Coral Reef Conservation Project (LRCP). The LRCP is based in Barangay Napantao, San Francisco Municipality and utilises trained volunteers to survey the region's coral reefs and provide training and conservation education opportunities for project counterparts (Fig 1). The aim of this is to develop local capacity and ensure the long-term protection and sustainable use of marine resources throughout Southern Leyte.

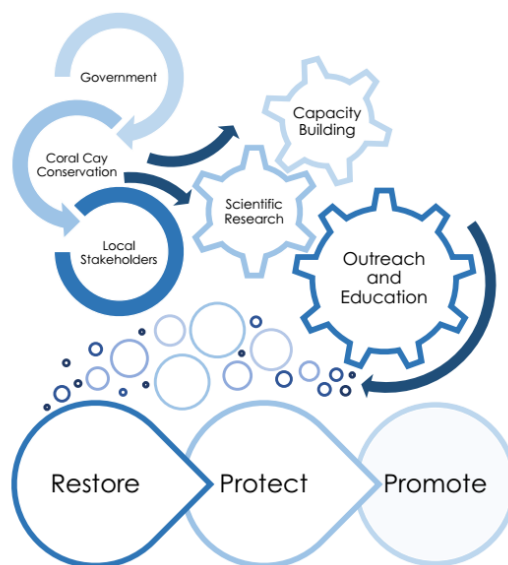


Figure 1. Schematic diagram demonstrating Coral Cay Conservation's (CCC) implementation strategy within a specified host country, regarding marine conservation and sustainable resource management.

Survey Site

An Assessment of Barangay Himbangan's, Municipality of Saint Bernard, established Marine Protected Area (MPA) was conducted between 4th September and 15th October 2017 by trained volunteer survey teams (Fig. 2). The weather conditions were generally cloudy through

the survey period with no recorded major weather events. Mean air temperature was 30.3°C, mean sea surface temperature (SST) was 30.3°C and average bottom temperature (6 m and 12 m) was 29.5°C.

There are an estimated 2,400 people living in Barangay Himbangan and from discussions with the barangay captain and community members, the coral community is expected to experience low overall anthropogenic impact, with no harmful fishing practices taking place (blast fishing, poison fishing, aquarium fishing). However, there are some occurrences of invertebrate extraction (considered low impact). There is no recorded tourist activity and no sewage pollution or industrial waste. There is however, occasional siltation on the reef as there is a nearby river (~1km away from MPA) where the mouth is ~10m wide.

Results

Fishes (incl. Butterflyfishes)

In total, 3873 individual fish were recorded, representing 80.49% of all target organisms ($N = 107.58 \pm 16.86 \text{ } 500\text{m}^3^{-1}$), throughout the survey area. Total fish abundance did not differ significantly inside compared to outside of the MPA ($P > 0.05$) (Fig. 3).

Inside the MPA, a total of 2606 individual fish were recorded, representing 80.49% of all target species ($N = 130.30 \pm 23.18 \text{ } 500\text{m}^3^{-1}$, Med=102). The most abundant fish species within the MPA were Cardinalfish, Fusiliers and Other Butterfly fishes ($N = 41.70 \pm 16.17 \text{ } 500\text{m}^3^{-1}$, $N = 32.30 \pm 10.76 \text{ } 500\text{m}^3^{-1}$ and $N = 9.75 \pm 1.78 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig. SM1).

Outside the MPA, a total of 1267 individual fish were recorded, representing 56.10% of all target organisms ($N = 79.19 \pm 23.32 \text{ } 500\text{m}^3^{-1}$, Med=37). The most abundant fish species were Cardinalfish, Spinecheeks and

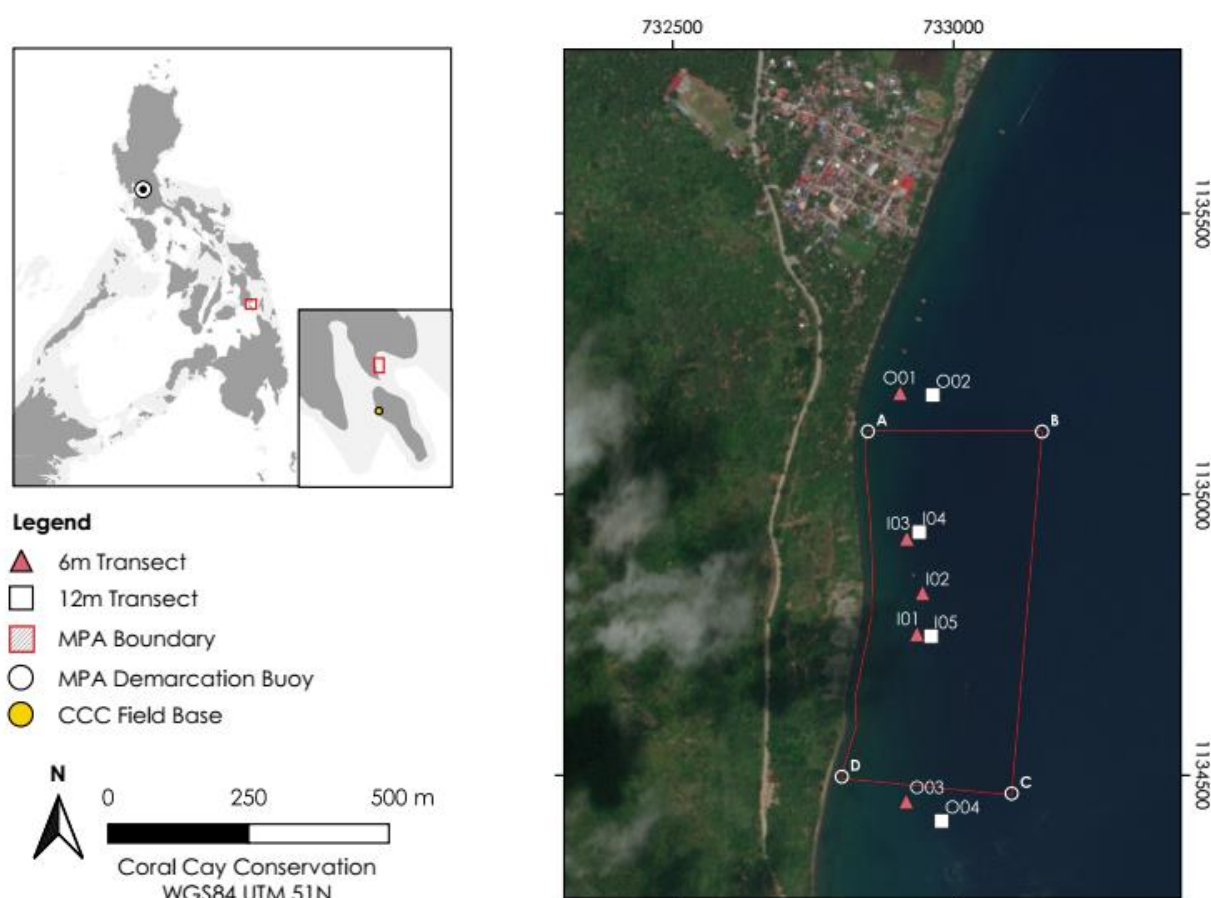


Figure 2. Spatial location of 6m (triangle) and 12m (square) 100m transects positioned to survey the established Marine Protected Area (MPA) (red) within the coastal waters of Barangay Himbangan, Municipality of Saint Bernard, Southern Leyte.

Sandperch ($N = 67.69 \pm 22.60 \text{ } 500\text{m}^3^{-1}$, $N = 3.00 \pm 1.34 \text{ } 500\text{m}^3^{-1}$ and $N = 1.50 \pm 0.60 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig. SM1, Fig. SM2).

Mean Species Richness (S) inside the MPA was $S = 13.75 \pm 1.46 \text{ } 500\text{m}^3^{-1}$ (Med=15.00) with Shannon Weiner Diversity (H') recorded as $H' = 1.65 \pm 0.16 \text{ } 500\text{m}^3^{-1}$ (Med=1.83) and Pielou's evenness (J) recorded as $J = 0.67 \pm 0.04 \text{ } 500\text{m}^3^{-1}$ (Med=0.70). Comparative to outside the MPA, where diversity indices were, $S = 5.81 \pm 0.95 \text{ } 500\text{m}^3^{-1}$ (Med=4.50), $H' = 0.74 \pm 0.13 \text{ } 500\text{m}^3^{-1}$ (Med= 0.65) and $J = 0.46 \pm 0.07 \text{ } 500\text{m}^3^{-1}$ (Med=0.36). S , H' and J' were all significantly higher inside the MPA compared to outside ($P < 0.05$) (Table 1).

Butterflyfish

Throughout the survey period, a total of 346 butterfly fish were recorded, representing 87.50 % of the target Butterflyfish species ($N = 10.81 \pm 2.27 \text{ } 500\text{m}^3^{-1}$). Overall Butterflyfish abundance was significantly higher inside the MPA than outside ($P < 0.05$) (Fig. 4).

Inside the MPA, a total of 317 butterflyfish were recorded, representing 87.50% of all target butterflyfish species ($N = 15.85 \pm 3.10 \text{ } 500\text{m}^3^{-1}$, Med=15.50). The most abundant target butterflyfish within the MPA were 'other' Butterflyfish, Redfin Butterflyfish, Eastern Triangle Butterflyfish and Humphead Bannerfish ($N = 9.75 \pm 1.78 \text{ } 500\text{m}^3^{-1}$, $N = 3.95 \pm 0.91 \text{ } 500\text{m}^3^{-1}$, $N = 0.65 \pm 0.29 \text{ } 500\text{m}^3^{-1}$ and $N = 0.65 \pm 0.35 \text{ } 500\text{m}^3^{-1}$, respectively) (Fig. 3).

Outside the MPA, a total of 29 butterflyfish were recorded, representing 37.50% of all target butterflyfish species, ($N = 2.42 \pm 0.94 \text{ } 500\text{m}^3^{-1}$, Med=0.00). The most abundant target butterflyfish outside of the MPA was 'other' Butterflyfish, Redfin Butterflyfish and Klein's Butterflyfish ($N = 1.00 \pm 0.48 \text{ } 500\text{m}^3^{-1}$, $N = 0.88 \pm 0.36 \text{ } 500\text{m}^3^{-1}$ and $N = 0.25 \pm 0.14 \text{ } 500\text{m}^3^{-1}$ respectively) (Fig. 4).

Butterflyfish were then categorised by feeding traits. Within the MPA, a total of 92 obligate corallivores and 30 facultative feeders were recorded, compared to 15

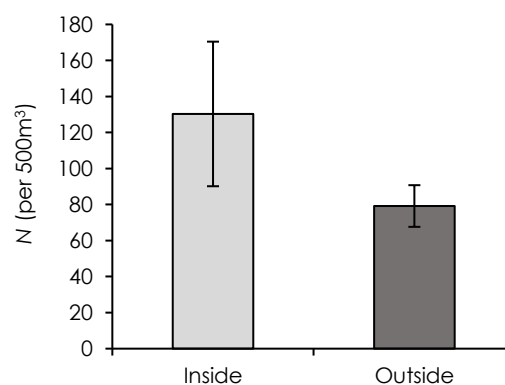


Figure 3. Mean target fish abundance per 500m³ with standard error (SE) between transects in Himbangan, Saint Bernard, Southern Leyte.

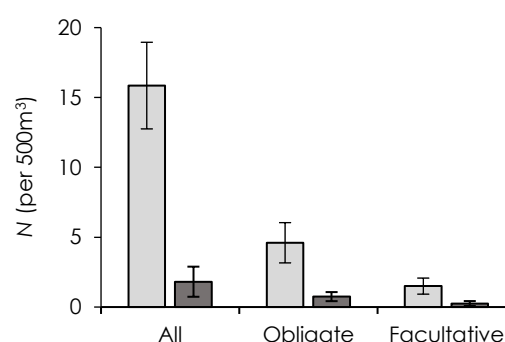


Figure 4. Mean target butterfly fish abundance per 500m³ with standard error (SE) Himbangan, Saint Bernard, Southern Leyte. Grey bars represent inside the MPA where black bars represent outside the MPA.

obligate corallivores and 4 facultative feeders outside of the MPA (Fig SM4).

Commercially Important Fishes

Commercial species such as Parrotfish, Grouper and Snapper composed 3.25 % of the fish species identified. Of the commercial fish species count, Parrot fish contributed the greatest abundance (46.83%) followed by Grouper (35.71%) and Snapper (17.46%).

There were significantly higher abundances of both Parrotfish and Grouper inside the MPA than outside ($P < 0.05$). However, Snapper were not deemed to differ in abundance transboundary.

Inside the MPA, 3.02% ($N = 117$) of all fishes recorded throughout the survey were considered commercially important (Parrotfish, Grouper and Snapper) ($N = 5.85 \pm 1.09 \text{ } 500\text{m}^3^{-1}$).

Table 1. Mean (with SE ($\pm$)) and Median (Med) Diversity indices for target fish Species Richness (S) and Shannon-Weiner Diversity (H') and Pielou's Evenness (J) per 500m³, with standard error ($\pm$ SE) across transects in Himbangan, Saint. Bernard, Southern Leyte. Transects that were significantly different are indicated with 'A', 'B', 'C', 'D' and the transects they differed from indicated with corresponding 'a', 'b', 'c', 'd'.

Transect	S (500m ³ ⁻¹)			H	H (500m ³ ⁻¹)		J	J (500m ³ ⁻¹)	
	S	$\pm$	Med		$\pm$	Med		$\pm$	Med
I01	10.75	3.09	12.50	1.53	0.35	1.51	0.77	0.11	0.77 ^A
I02	17.00	1.08	17.50 ^A	2.40	0.14	2.47 ^A	0.85	0.03	0.86 ^B
I03	17.25	0.75	17.00 ^B	1.88	0.15	2.00 ^B	0.66	0.06	0.71 ^{b,c}
I04	18.00	3.81	18.50 ^C	1.52	0.31	1.52	0.52	0.07	0.52 ^b
I05	5.75	1.89	5.00 ^{a,b}	0.91	0.36	0.73 ^a	0.54	0.12	0.57
O01	8.25	1.70	7.50 ^{a,b,D}	1.03	0.25	0.94 ^a	0.54	0.16	0.52
O02	4.25	0.85	4.50 ^{a,b,c}	0.73	0.33	0.59 ^a	0.51	0.20	0.49
O03	7.25	3.01	6.00 ^b	0.58	0.24	0.49 ^{a,b}	0.31	0.05	0.29 ^{a,b,c}
O04	3.50	0.29	3.50 ^{a,b,c,d}	0.64	0.25	0.5 ^{a,b}	0.49	0.17	0.47
Inside	13.80	1.46	15.00	1.65	0.16	1.83	0.67	0.04	0.70
Outside	5.81	0.95	4.50	0.74	0.13	0.65	0.46	0.07	0.36

Parrotfish contributed the greatest (50.43%; $N = 2.95 \pm 0.76$ 500m³⁻¹, Med=2.00), followed by Grouper (32.48%; $N = 1.90 \pm 0.40$ 500m³⁻¹, Med=1.50) and Snapper (17.09%; $N = 1.00 \pm 0.35$ 500m³⁻¹, Med=0.00) (Fig. SM6).

Parrotfish were present in size classes <10cm, 11-20cm, 21-30cm, 31-40cm and 41-50cm ($f=6$, $f=15$, $f=27$, $f=10$ and $f=1$, respectively). Grouper were present in size classes <10cm, 11-20cm, 21-30cm and 31-40cm ($f=19$, $f=10$, $f=6$ and $f=3$, respectively). Snapper were present in size classes <10cm, 11-20cm and 31-40cm ($f=3$, $f=12$ and $f=5$, respectively) (Fig. 5).

This is in comparison to outside the MPA, where commercially important fishes contributed to 0.34% ($N = 13$) of the total fish abundance ($N = 0.65 \pm 0.21$ 500m³⁻¹). Grouper contributed the greatest (69.23%; $N = 0.45 \pm 0.15$ 500m³⁻¹, Med=0.00) followed by Snapper and Parrotfish equally (15.38%; Parrotfish, $N = 0.10 \pm 0.10$ 500m³⁻¹ (Med=0.00), Snapper, $N = 0.10 \pm 0.07$ 500m³⁻¹ (Med=0.00), respectively) (Fig. 6).

Grouper were present in size classes <10cm, 11-20cm and 21-30cm ($f=6$, $f=2$ and $f=1$ respectively), outside the MPA. Parrotfish were present only in size classes <10cm ($f=2$), and Snapper were present in size classes <10cm and 11-20cm ($f=1$ and $f=1$) (Fig. 6).

The total standing commercial fish biomass (kg) recorded throughout the sample period was 26.62kg, where Parrotfish

contributed the most (18.21kg) then Snapper (4.46kg) then Grouper (3.95kg).

The total standing biomass (kg) of commercially important fish recorded inside the MPA was 26.49kg, with a mean biomass of 1.10 ± 0.11 kg 500m³⁻¹. Parrotfish standing biomass (18.21kg) was the greatest, followed by Snapper (4.40kg) and Grouper (3.88kg) (Fig. SM 7).

The total standing biomass (kg) of commercially important fish recorded outside of the MPA was 0.13kg, with a mean biomass of $0.01 \pm <0.00$ kg 500m³⁻¹. Grouper standing biomass (0.07kg) was the greatest. Total biomass of commercially important fish was significantly higher inside compared to outside of the MPA ($P < 0.05$) (Fig. SM7).

Invertebrates

In total, 2389 individual invertebrates were recorded, representing 48.78% of all the target organisms ($N = 73.75 \pm 13.94$ 100m²⁻¹). The most represented organisms were the Feather Star, Other Gastropods and Brittle Stars ($N = 26.22 \pm 5.47$ 100m²⁻¹, $N = 12.47 \pm 4.47$ 100m²⁻¹ and $N = 10.58 \pm 4.01$ 100m²⁻¹ respectively). Overall, there was significantly more invertebrates inside the MPA than outside ($P < 0.05$).

In total, 2127 individual invertebrates were recorded inside the MPA, representing 89.03% of total site invertebrates ($N = 106.35$

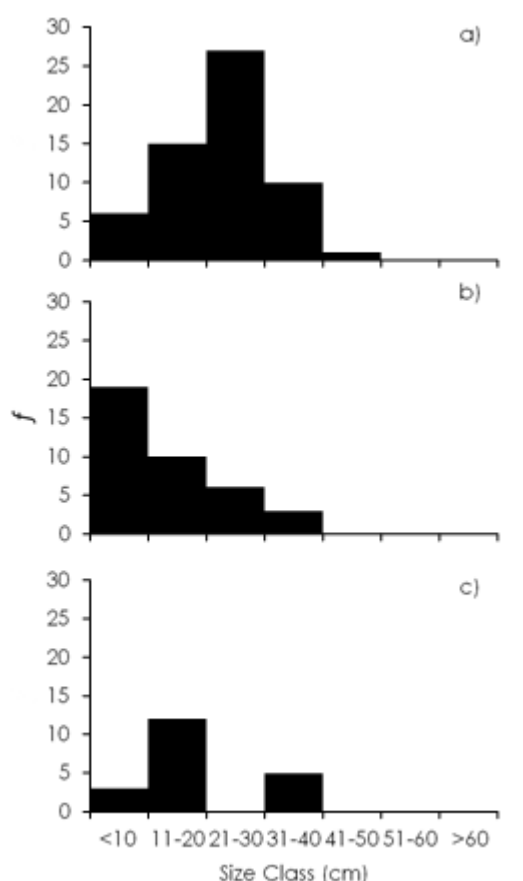


Figure 5. Total frequency (f) of Parrotfish (a), Grouper (b) and Snapper (c) by size class inside the MPA at Himbangan, Saint Bernard, Southern Leyte.

$\pm 21.01 \text{ } 100\text{m}^2^{-1}$, Med= 97.00). Target organisms Feather Stars, Other Gastropods and Brittle Stars were recorded in the greatest densities ($N= 43.55 \pm 7.92 \text{ } 100\text{m}^2^{-1}$, $N= 21.30 \pm 7.54 \text{ } 100\text{m}^2^{-1}$ and $N= 16.70 \pm 6.84 \text{ } 100\text{m}^2^{-1}$, respectively) (Fig. SM8). This is in comparison to outside of the MPA, where a total of 262 individual invertebrates were recorded, composing 10.96% of total site invertebrates ($N= 19.42 \pm 4.54 \text{ } 100\text{m}^2^{-1}$, Med=11.00). Target organisms Feather Stars, Feather Duster Worms and Brittle Stars were recorded in the greatest densities ($N= 4.56 \pm 1.19 \text{ } 100\text{m}^2^{-1}$, $N= 3.00 \pm 0.56 \text{ } 100\text{m}^2^{-1}$ and $N= 2.94 \pm 1.89 \text{ } 100\text{m}^2^{-1}$, respectively) (Fig. SM8).

Mean invertebrate Species Richness (S) inside the MPA was $S=6.75 \pm 0.64 \text{ } 100\text{m}^2^{-1}$ (Med=7.00), with $H'=1.23 \pm 0.09 \text{ } 100\text{m}^2^{-1}$ (Med=1.28) and $J=0.68 \pm 0.02 \text{ } 100\text{m}^2^{-1}$ (Med=0.67). In comparison, outside the MPA, $S=4.00 \pm 0.64 \text{ } 100\text{m}^2^{-1}$ (Med=4.00),

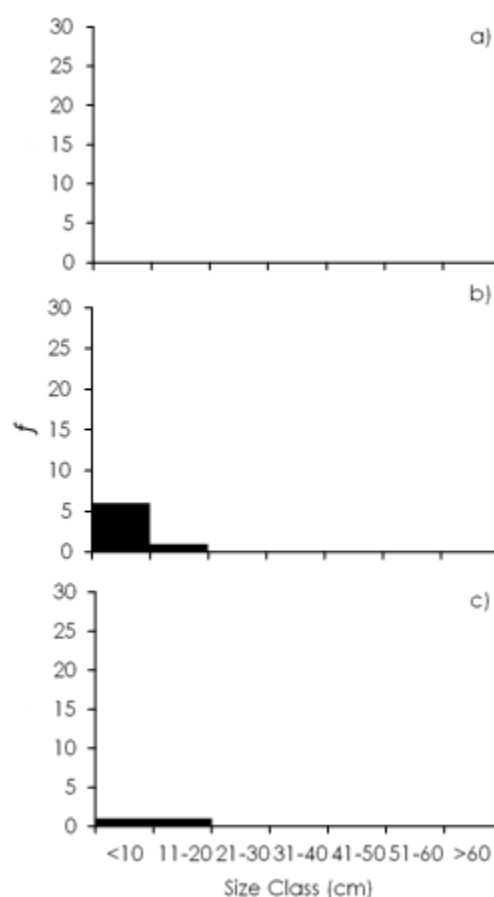


Figure 6. Total frequency (f) of Parrotfish (a), Grouper (b) and Snapper (c) by size class outside the MPA at Himbangan, St. Bernard, Southern Leyte.

$H'=1.00 \pm 0.16 \text{ } 100\text{m}^2^{-1}$ (Med=1.00) and $J=0.71 \pm 0.09 \text{ } 100\text{m}^2^{-1}$ (Med=0.71). S , H' and J' were all significantly higher inside the MPA compared to outside ($P<0.05$) (Table 2).

In this survey, only one record of Giant Clam was detected, within the MPA, on transect I02 and within the size class of 21-30 cm. There were no recorded abundances of Crown of Thorns on any transect.

Substrates

Inside the MPA, Silt (SI) was the dominant substrate ($47.13 \pm 7.21\% \text{ } 20\text{m}^{-1}$, Med=42.5% 20m^{-1}), followed by hard coral (HC) ($24.38 \pm 4.51\% \text{ } 20\text{m}^{-1}$, Med= 21.25% 20m^{-1}) and then rock (RC) ($9.00 \pm 1.75\% \text{ } 20\text{m}^{-1}$, Med= 6.25% 20m^{-1}). Outside of the MPA, SI was the dominant substrate ($85.78 \pm 3.44\% \text{ } 20\text{m}^{-1}$, Med=90% 20m^{-1}), followed by HC ($6.09 \pm 1.98\% \text{ } 20\text{m}^{-1}$, Med=3.75% 20m^{-1}) and then

Table 2. Mean (with SE ($\pm$)) and Median (Med) Diversity indices for target invertebrate Species Richness (S) and Shannon-Weiner Diversity (H') and Pielou's Evenness (J) per 500m², with standard error ($\pm$ SE) across transects in Himbangan, Saint. Bernard, Southern Leyte. Transects that were significantly different are indicated with 'A', 'B', 'C', 'D', 'E' and the transects they differed from indicated with corresponding 'a', 'b', 'c', 'd', 'e'.

Transect	S (500m ² -1)			H	H (500m ² -1)		J	J (500m ² -1)	
	S	$\pm$	Med		$\pm$	Med		$\pm$	Med
I01	5.25	0.63	5.00	1.02	0.09	1.02 ^A	0.63	0.05	0.59 ^A
I02	8.00	0.82	8.00 ^A	1.27	0.09	1.29 ^B	0.61	0.01	0.62 ^B
I03	7.25	0.63	7.00 ^B	1.31	0.14	1.33	0.66	0.07	0.64 ^C
I04	10.00	1.47	10.00 ^C	1.73	0.10	1.73 ^{a,b,c}	0.76	0.02	0.76 ^{b,d}
I05	3.25	0.63	3.00 ^{a,b,c,d}	0.83	0.18	0.75 ^{c,d}	0.73	0.04	0.74 ^E
O01	7.00	0.91	7.00 ^{d,e}	1.68	0.11	1.69 ^{a,d,e}	0.88	0.02	0.89 ^{a,b,c,d,e}
O02	2.75	0.85	2.50 ^{a,b,c,e}	0.73	0.30	0.72 ^c	0.64	0.22	0.82
O03	3.75	1.18	3.00 ^c	1.04	0.21	0.97	0.92	0.05	0.95 ^{a,b}
O04	2.50	0.96	2.00 ^{a,b,c,e}	0.54	0.32	0.47 ^{c,e}	0.40	0.23	0.38
Inside	6.75	12.80	7.00	1.23	1.71	1.28	0.68	0.43	0.67
Outside	4.00	0.63	3.50	1.00	0.16	1.08	0.71	0.09	0.86

RC (5.94 $\pm$ 1.60% 20m⁻¹, Med=3.75% 20m⁻¹) (Fig. 7, Table 3).

Silt abundance as significantly higher outside of the MPA than inside ($P < 0.05$), HC was significantly higher inside the MPA than outside ($P < 0.05$) and RC had no significant variation inside/outside the MPA (Fig. 6). Of the HC cover, the dominant life form throughout the survey area was Acropora Branching (ACB) (28.63%), followed by Non-Acropora Massive (CM) (24.79%) and then Non-Acropora Encrusting (CE) (23.93%).

Within the MPA, the dominant life form was ACB (29.74%), followed by CE (28.21%) then CM (22.05%). Outside of the MPA, the dominant life form was CM (38.46%) then ACB (23.08%), then Non-Acropora Sub-Massive (CS) (15.38%). ACB and CE were significantly higher in abundance.

Within the MPA, the dominant life form was ACB (29.74%), followed by CE (28.21%) then CM (22.05%). Outside of the MPA, the dominant life form was CM (38.46%) then ACB (23.08%), then Non-Acropora Sub-Massive (CS) (15.38%). ACB and CE were significantly higher in abundance inside the MPA than outside ($P < 0.05$) but there was no significant difference between the abundance of CM inside or outside the MPA boundaries ($P > 0.05$).

Stress Tolerant Corals (ST) were found to be the dominant life trait within hard corals (35.90%), followed by Fast Growing Corals

(FGC) (33.33%) and then Competitor Corals (CC) (30.77%). Abundance of ST was not significantly higher inside the MPA compared to outside ($P > 0.05$), however abundance for both FGC and CC were both significantly higher inside the MPA ($P < 0.05$) (Fig. 8).

Site Impacts

During the survey, no evidence of direct anthropogenic impact was observed (boat, anchor or dynamite damage), but there was indirect reef damage from trash. Inside the MPA, there was general trash recorded on 70% of transects (5% with high levels, 45% with medium levels and 20% with low levels) More specifically, fishing trash was recorded on 60% of transects inside the MPA (5% having high levels, 30% having medium levels and 25% with low levels) (Fig. 9). Outside the MPA, there was 68.75% of the transects with general trash (37.50% with high levels, 18.75% with medium levels and 12.50% with low levels) and fishing trash recorded on 43.75% of transects (18.75% with high levels, 18.75% with medium levels and 6.25% with low levels) (Fig. 9).

Discussion

This study assessed the current condition of the Marine Protected Area in the barangay Himbangan (Municipality, Saint Bernard). Both biophysical and social data were retrieved, producing this comprehensive report on the health of the coral reef in the barangay waters. The results of this assessment should be considered in future

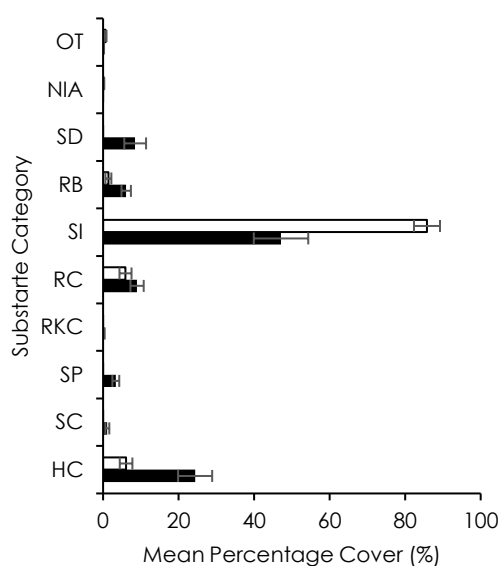


Figure 7. Mean composition (%) substrates per 20m inside the MPA (black) and outside the MPA (white) Himbangan, Saint Bernard, Southern Leyte, with Standard Error ($\pm$ SE). RKC= Recently Killed Coral, OT= Other, SC= Soft Coral, SP Sponge, SI= Silt, HC= Hard Coral, NIA= Nutrient Indicator Algae, RC= Rock, RB= Rubble and SD= Sand.

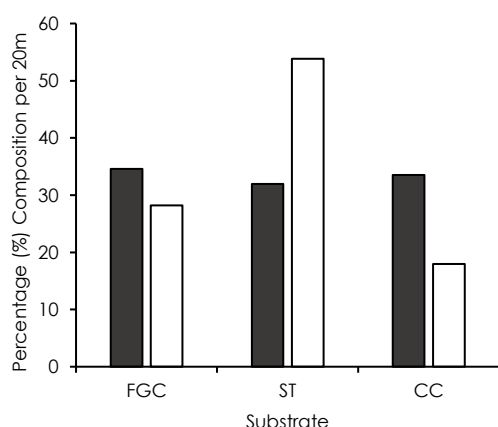


Figure 8. Percentage (%) cover of coral life forms per 20m inside (grey) and outside (white) the MPA at Himbangan, Saint Bernard, Southern Leyte. FGC= Fast growing Corals, STC= Stress Tolerant Corals and CC= Competitor Corals

management strategy to ensure continual benefits from the established MPA.

Fish

Overall the fish abundance at the survey site was good for Sogod Bay comparable assessments, although abundances did not significantly vary between inside the MPA compared to outside, there are some indications of MPA success. As species

richness (S') is higher inside the MPA when compared to outside, this is positive and similar species richness results to some of the most successful MPA's in Sogod Bay (Napantao Fish Sanctuary) (Broadribb *et al.*, 2018) but also suggests that the exploitation of fishes outside of the boundary, where extraction is legal, is occurring. If this activity is excessive, then the benefits of the MPA protection will not be seen in fished areas, especially if the protected area is small or in a slow recovery state. Shannon-Weiner diversity (H') was higher inside the MPA in comparison to the outside, which suggests that the MPA community is more resilient to future disturbances (Downing *et al.*, 2012). This level of diversity is also considered similar to Napantao Fish Sanctuary (Broadribb *et al.*, 2018). Pielou's Evenness is also higher inside of the MPA which suggests

However, the positive results found within the MPA are not mimicked outside. There are severe decreases in all indices which indicate an increase in pressure experienced by communities outside of the MPA boundary. For sustainable benefits from this MPA, such pressures outside the MPA should be assessed. This study highlights the presence of fishing trash in the area, further suggesting fishing activity yet a specific assessment could be conducted to understand the true pressure.

It must be noted, however, that during the implementation phase of many MPAs, it is common for MPA boundaries to encompass areas of reef considered to hold a greater ecological status than adjacent areas. As such, the results obtained inside the MPA, hosting greater diversity, abundance and resilience, maybe an artefact from the MPAs respective placement.

Butterflyfish

Due to the energetic demands of butterfly fish species, the abundance of such species can be linked directly to the existence and overall condition of coral reef substrates (Crosby and Reese 1996). In this study, the isolation of butterfly fish

analysis contributes to an indication of change or condition across the reef (Crosby and Reese 1996).

By further categorising such species into feeding strategy, respective feeding-trait abundance can provide more information about the reef itself. Obligate corallivores depend directly on the live tissue of corals for their food. The obligate corallivores used in this study all show strong preferences for Fast Growing Coral (FGC) *Acropora* spp., providing further dimensions of sensitivity to the community (Cole *et al.*, 2008). Facultative corallivores are characterised as including coral only as part of their diet and also utilise other food items. These tend to be more resilient than 'obligate' corallivores to disturbances that hinder live coral cover, due to their ability to transfer food type (Pratchett *et al.*, 2006).

This study found that the majority of butterflyfish species were obligate corallivores both inside and outside of the MPA. This can be indicative of hard coral cover to support such species, yet abundances were low outside the MPA. This is supported as where there is an increase in HC cover (inside) there are also increased butterflyfish abundance. This baseline HC cover therefore must be continually protected to grow and proceed to support such fish populations (Chong-Seng *et al.*, 2012).

Commercially important fishes

Investigating commercially important fish populations is an important element of this study due to the aim of continuous protection and support to local livelihoods. The average commercial fish abundance, although significantly higher within the MPA, is considerably lower than other Sogod MPA's (Broadribb *et al.*, 2018). In addition, these species smaller in size and considered sexually immature.

Parrotfish, Grouper and Snapper were included specifically in this study as they are particularly vulnerable to unsustainable fishing practices. Species within each family are larger and slower growing as well as being heavily associated with shallow

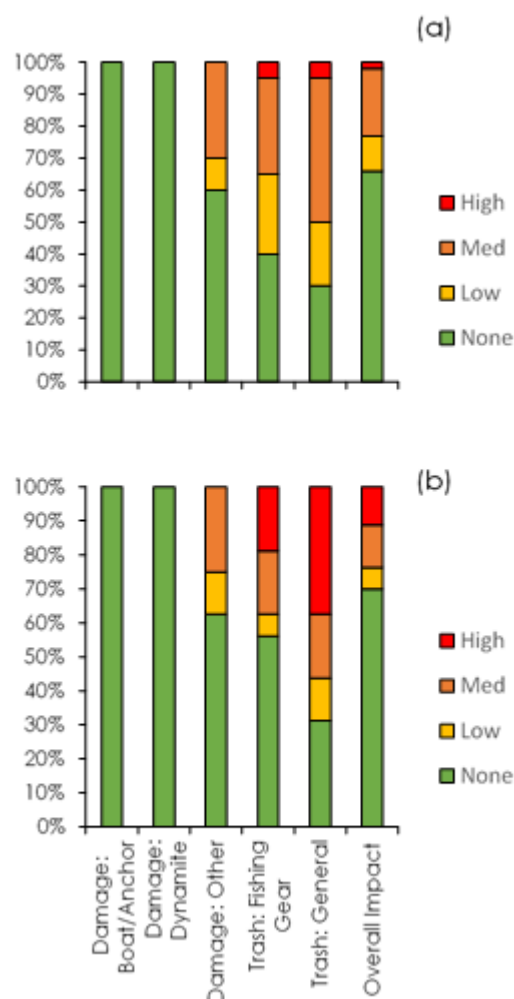


Figure 9. Total impact scale recorded inside (a) and outside (b) the MPA at Himbangan, Saint Bernard, Southern Leyte. Counts of impacts are categorized to scale (0= none, 1= low, 2-4= medium and >5= high), which is applied to each recorded impact category as a percentage (%) of the surveyed area, split into two categories (coral damage and trash); Boat/Anchor Damage, Dynamite, Other, Fishing Gear, and General. Total overall impact count is also given that incorporates impact counts from the other 5 categories.

reef flats. As such, due to their heavy-bodied traits, they are highly desirable in the Philippines (Broadribb *et al.*, 2017). In addition to high fishing pressure, these species are also K-selected life history strategists (slow growing, long-lived) and many exhibit sexual dimorphism during maturation (Shapiro 1989; Sadovy *et al.*, 1994). Fishing such species can significantly impact the population as by removing larger (sexually mature) individuals result in differential loss of larger males leading to female biased sex ratios and vice versa

(Koenig *et al.*, 1996; Domeier and Colin 1997; Broadribb *et al.*, 2018).

Although, abundances of Grouper and Parrotfish were significantly higher within the MPA than outside, the size classes of such individuals are still small and a reflection on the little to no individuals detected outside the MPA. This is indicative of fishing methods such as hook and line, as the larger individuals are removed first due to ease of catch (Pauly *et al.*, 1999). This activity will directly impact the effectiveness of the MPA. The biomass of such species was also significantly higher within the MPA but due to the evidence of smaller size classes, this is result of higher abundance only.

Parrotfish was the most abundant species inside and outside of the MPA. These herbivorous species play a substantial role in facilitating coral settlement on hard substrate through limiting macroalgal growth (Bonaldo *et al.*, 2014). Typically, in a coral reef system, there are few species that perform this integral role and therefore, such species are extremely important in ecosystem functioning in addition to their commercial importance. Interestingly, the most common size class inside the MPA was 21-30cm. In this study, Parrotfish have been documented at family level only, yet within species, there is great variation in length at sexual maturity, often dependent on maximum length (DeMartini and Howard, 2016). It is however, considered that for a many parrotfish species, known to be common in Sogod Bay, sexual maturity is often met >30cm so it is considered that the individuals in Himbangan are still smaller than needed for viable reproduction (DeMartini and Howard, 2016). That considered, if these individuals are adequately protected, this is still a viable sub-class to aid repopulation in the near future.

Groupers are among the most vulnerable coral reef fish to overexploitation as in addition to their k-selected life history strategy, they also exhibit fidelity in spawning grounds. This results in mass

Table 3. Mean percentage (%) cover of benthic substrate types per 20 m with standard error ($\pm$ SE) between transects in Himbangan, Southern Leyte. HC = Hard coral, SC = Soft coral, SP = Sponge, RKC = Recently Killed Coral, RC = Rock, SI = Silt, RB = Rubble, SD = Sand, NIA = Nutrient Indicator Algae and OT = Other.

Transect	HC		SC		SP		RKC		RC		SI		RB		SD		NIA		OT	
	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$	%	$\pm$
I01	10.63	4.00	1.25	0.72	3.13	1.88	0.00	0.00	8.13	2.13	45.63	12.93	8.75	3.89	22.50	5.10	0.00	0.00	0.00	0.00
I02	45.00	8.84	3.13	2.37	7.50	2.70	0.00	0.00	10.00	1.77	26.25	8.20	5.00	1.77	3.13	2.37	0.00	0.00	0.00	0.00
I03	34.38	9.09	1.25	0.72	3.13	1.88	0.00	0.00	21.25	3.31	30.00	7.91	9.38	2.95	0.63	0.63	0.00	0.00	0.00	0.00
I04	29.38	7.80	0.00	0.00	3.13	1.57	1.25	0.72	3.13	0.63	41.88	20.65	5.00	2.89	16.25	9.60	0.00	0.00	0.00	0.00
I05	2.50	1.02	0.00	0.00	0.00	0.00	0.00	0.00	2.50	1.44	91.88	1.88	2.50	1.77	0.00	0.00	0.00	0.00	0.63	0.63
O01	12.50	3.68	0.00	0.00	0.00	0.00	0.00	0.00	13.75	3.31	71.25	4.84	1.88	0.63	0.00	0.00	0.00	0.00	0.63	0.63
O02	2.50	1.02	0.00	0.00	0.00	0.00	0.00	0.00	1.88	1.20	94.38	2.58	0.00	0.00	0.00	0.00	0.00	0.00	1.25	0.72
O03	6.25	3.89	0.00	0.00	0.00	0.00	0.00	0.00	6.25	2.39	83.75	9.16	3.13	3.13	0.00	0.00	0.63	0.63	0.00	0.00
O04	3.13	2.37	0.00	0.00	0.00	0.00	0.00	0.00	1.88	1.20	93.75	2.39	0.63	0.63	0.00	0.00	0.00	0.00	0.63	0.63

aggregations of individuals in predictable locations (Coleman *et al.*, 2000; Sadovy and Domeier 2005) which has led to global depletion of stocks as fishermen target spawning areas for increased catch per

unit effort. Although, MPAs offer protection to much of the Groupers feeding grounds, often the spawning aggregation sites are left unprotected. Currently, grouper spawning aggregation sites are unknown in the Sogod area and therefore, this species remains vulnerable during reproductive seasons. Abundances are low across both sights but significantly so outside of the MPA and the size categories in which they are found are insufficient to repopulate at present, so protection is vital to allow for growth and maturity.

Due to slow growth rate of coral species the effects of an MPA can take years to quantitatively notice and recovery is largely dependent on substrate type and carrying capacity of each reef. Therefore, continued protection and compliance are necessary to allow development of the reef and the young (small) fish to reach sexual maturity and reproduce. It is also beneficial that throughout the bay there has been an increased abundance of MPA implantation and success. This creates a network of protected areas which can be utilised by many mobile fish species as they translocate throughout the bay.

Invertebrates

The abundance of target invertebrates inside the MPA are considerably higher than outside. As the majority of the species counted inside and outside of the MPA were Feather stars, Other Gastropods and Brittle stars, this can offer some insight into the functions of this reef. Filter feeding organisms such as Feather Stars can remove detritus and other suspended particles from the water column which can improve the quality and quantity of light reaching the substrate. This assists the productivity of photosynthetic organisms and improves coral abundance. Brittle stars exhibit a wider range of feeding preference and, in addition to filter feeding, they are able to feed off deposits, scavenge and have shown predation (Stohr *et al.*, 2012; Broadribb *et al.*, 2018). Due to this wide ability, they are able to populate an area well.

Unfortunately, there were no sightings of any commercially important invertebrate species such as prickly redfish sea cucumber (*Thelenota ananas*), pinkfish sea cucumber (*Holothuria edulis*), squid (*Teuthida*), greenfish sea cucumber (*Stichopus chloronotus*), lobster (*Nephropidae*), and Triton's trumpet (*Charonia tritonis*). All are slow growing, slow moving, large and easily targeted by fishermen. Similar to the commercially important fish species, such K-selected organisms are particularly vulnerable. In addition to that, relatively sessile invertebrates rely on the Allee effect for re-population. This is where individuals require high densities to allow for re-population, when density fall too low, the ability to repopulate becomes increasingly difficult.

In other areas of Sogod Bay, there are common counts of Giant clams, however completely absent from this site. It is suggested that their absence is a result of overfishing. Giant clams play a very important role in a reef ecosystem, both biologically and physically. They counteract impacts from eutrophication due to their ability to filter water at an exceptional rate and are able to provide a calcium carbonate (CaCO_2) shell which offers a hard substrate for coral settlement and growth without harming the bivalve itself (Broadribb *et al.*, 2018). They are also commercially exploited within the Philippines, which could explain their absence from Himbangan.

Substrates

Across the whole survey site, silt was the most common substrate. Unfortunately, silt offers minimal protection or benefit for marine fauna and future settlement of coral is limited. Coral recruits prefer to adhere to rock/rubble/hard substrate (bivalve shells) to ensure stability.

Although levels of silt are high, the next dominant substrate type is hard coral (HC), with significantly more HC cover within the MPA. Levels of HC cover in the Philippines are estimated to be around 22% and within the MPA the HC cover was more than the national average (~24%) (Licuanan *et al.*,

2017). In addition, the common abundance of rock substrate also provides promise for the future settlement of coral species. In addition, high abundance of *Acropora* branching have increased structural complexity to the reef and as they are fast growing coral, they are able to recover quickly from disturbance. These are good characteristics to have on the reef during attempt of protection and they offer increased structural complexity for refugia.

Minimising continued destructive practices is highly advised to protect the coral present. Direct damage can occur in instances of trash or fishing discards, which can entangle on the complex structures and cause physical damage, therefore, it is advised that this is considered. Also, with additional invertebrate species, there may be opportunity for hard substrate increase, which would be beneficial for early coral colonisation.

Impacts

If there is to be maximum benefit from the establishment of the MPA, fishing activities must remain outside of the MPA, with consideration for a 50m buffer zone. This buffer zone would allow for fishing activity by use of hook and line and fish nets, but some more destructive methods would not be permitted. This would assist the protection from anthropogenic impacts further whilst appeasing the community pressure for livelihood. The high counts of fishing trash both inside and outside of the MPA support the suspicion of fishing practices where such trash items include, discarded nets, lines, hooks etc. This type of trash can continue to cause damage when left in the ocean through 'ghost fishing' and physical damage to the coral. Other trash items were also discovered, at high levels yet the origin is difficult to deduce as we do not know if they have been directly discarded into the MPA or if they have drifted from another location. Either way, waste management deserves consideration.

Recommendations

This area is showing signs of healthy reef substrate and fish abundance and with the continued correct protection, re-establishment is very viable.

For maximum benefits to occur, further enforcement is advised. Further Bantay Dagat training would assist the understanding of the regulations of an enforced MPA to effectively inhibit fishing practices, with the opportunity for the barangay to gain financial profit from correct procedure.

If fishing continues within the MPA or very close to its boundaries, this will directly impair the benefits. This most likely, will lead to a lack of confidence in the MPA system and subsequent lack of compliance for the regulations and therefore, a 50m buffer zone around the periphery of the MPA should be implemented and enforced.

Community support is vital for the future success of this MPA. Understanding of the aims and potential of the ordinance by the whole community is crucial. This can be done in conjunction with CCC.

The amount of trash in the area needs to be reduced. This could occur through increased efficiency of waste management in the barangay or community beach cleans. In addition, reduction of fishing in/close to the MPA should naturally reduce the amount of fishing trash in the MPA.

The area of the MPA could be increased, this would provide further area for protection for ecologically important species. Generally, commercially important species such as Parrotfish, Snapper and Grouper are mobile individuals so would benefit from a larger area of protection. Although, this option needs careful consideration as if there are fishermen within the barangay which solely rely of marine resources, this could cause conflict.

It is also important to consider that due to the substrate type in this area, visible

improvement will still take years and maximum improvement depends on numerous variables, including compliance and enforcement standards. In the meantime, alternative resources may need to be considered to minimise the need for individuals to fish the waters.

All recommendations and suggestions provided by CCC are based on what data suggests is ecologically ideal. It is important to consider other factors in decision making and information provided in the study should be used to begin an inclusive dialogue between all stakeholders. Through thorough inclusion, this will result in least conflict and security of future regulations.

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Methods

The assessment of the surveyed areas was conducted through an enhanced Reef Check protocol (Hodson and Liebeler, 2002). CCC has augmented the protocol to reflect the high biodiversity of the focus region with the addition of extra target organisms (Table SM1, Table SM2, Table SM3).

100m transects were laid along the survey area substrate, parallel to the shoreline, on a north to south bearing. $N=5$ transects were placed at a depth of 6m with $N=4$ placed a depth of 12m (Table 4). Each 100m transect was segmented into four 20m sections, separated by a 5m gap, where no data are collected, to ensure independent samples. This equated to a total surveyed transect length of 80m per transect. Each transect was separated by approximately 100m. This survey design enables for robust statistical analysis.

Target fish abundance, diversity and evenness data were collected through Underwater Visual Census (UVC) techniques through SCUBA. Data were recorded using 'belt' transects where fish were observed along each 20m segment within an imaginary 5x5x20m (WxHxL) box, equating to a surveyed volume of 500m³. Two surveyors collected fish abundance data within 2.5m of the central transect line. Surveyors paused at 5m intervals for one-minute to allow for the fishes to acclimatise to their presence. Data collection continued during this period. In addition, the abundance and estimated size (TL) (placed into 10cm size increments (0-10cm, 11-20cm, 21-30cm, 31-40cm, 41-50cm, 51-60cm and >60cm)) of fishes considered to be commercially important in the Philippines (Parrotfish (Scaridae), Grouper (Epinephelinae), and Snapper (Lutjanidae) were also recorded. The biomass (kg) of commercially important fishes was estimated through Length-Weight Relationships (LWRs) (Equation 1).

(1)

$$W = aL^b$$

Equation 1. Length-Weight relationship used to determine the biomass (kg) of individual fishes recorded during Underwater Visual Census (UVC) surveys. W = mass (g), a = the condition factor (Hilborn and Walters, 1992), b = species-specific growth parameter (Quinn and Deriso, 1999). L = total length (TL) measured of the individual fish.

Data were sourced from Fish Base (www.fishbase.org) to generate the appropriate allometric coefficients for the commercially important fishes, with geometric means calculated due to the differing variables associated between studies and the various species (with a high degree of exposure to surveyors due to home ranges) within each surveyed family (Table 5).

Table 4. Depths (m) and coordinates (UTM) of the 100 m transects surveyed along the coast in Himbangan, St Bernard, Southern Leyte, Philippines.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
I01	6	732910	1134749
I02	6	732920	1134822
I03	6	732892	1134919
I04	12	732914	1134930
I05	12	732935	1134745
O01	6	732880	1135178
O02	12	732938	1135174
O03	6	732891	1134451
O04	12	732954	1134416

The abundance and diversity of selected target invertebrate organisms (SM1) were recorded along the same belt transect utilised for fish data collection. Giant clams (*Tridacna gigas*) were placed into 10cm size categories; 0-10cm, 11-20cm, 21-30cm, 31-40cm, 41-50cm, 51-60cm and >60cm.

Two divers recorded invertebrates 2.5m either side of the transect line whilst swimming in a U-shaped pattern. A total area of 100m² was surveyed per 20m segment. Divers ensured to investigate hooks and under overhangs due to the cryptic nature of invertebrates.

Benthic diversity and community composition were measured by recording biotic and abiotic substrate categories (SM1) along a Point Intercept Transect (PIT), using a plumb line to minimise surveyor biasedness. Abiotic and Biotic benthic substrates were recorded directly beneath each 50cm increment along the same 20m segment (resulting in 40 recorded points per 20m) and respective 100m transect. All hard corals, within the HC category, were further identified to lifeform (SM1). The recorded lifeforms were then subsequently grouped into three conservation classes (as defined by Edinger and Risk (2000)); disturbance adapted fast growing corals; competitor corals; and stress tolerant corals.

Within the same area assessed for invertebrates, divers also recorded impacts on the reef. The total percentage (%) of bleached coral cover was estimated together with an indication of severity through the percentage (%) of bleaching present on each 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 damage, dynamite, and other. Impacts were graded on an ordinal scale from 0-3 (0 = none, 1 = low, 2 = medium, 3 = high). The impact of trash was recorded on the same scale and sub-categorised into 'general' and 'fishnet nets/traps'.

Data analysis

Each 20m belt transect segment was treated as an independent sample. This produced N= 20 at 6 meters and N= 16 at 12 meters. Shapiro Wilks test, typically used on small data sets to check for normality, indicated the data deviated from a normal distribution (non-parametric) (Shapiro and Wilk 1965; Thode 2002). Transformations of did not satisfy

parametric testing assumptions (O'Hara and Kotze 2010; Morris *et al.*, 2014). Thus, nonparametric Wilcoxon-Mann-Whitney U tests were used to test for statistically significant ($P < 0.05$) median 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 were 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).

References

- Aburto-Oropeza, O., Erisman, B., Galland, G., Mascareñas-Osorio, I., Sala, E. and Ezcurra, E. (2011). Large Recovery of Fish Biomass in a No-Take Marine Reserve. *PLoS ONE*, **6**(8), pe23601.
- Asian Development Bank (ADB) (2014). State of the Coral Triangle: Philippines. Mandaluyong City, Philippines.
- Barnosky, A., Matzke, N., Tomiya, S., Wogan, G., Swartz, B., Quental, T., Marshall, C., McGuire, J., Lindsey, E., Maguire, K., Mersey, B. and Ferrer, E. (2011). Has the Earth's sixth mass extinction already arrived? *Nature*, **471**(7336), pp. 51-57.
- Bonaldo, R., Hoey, A.S. and Bellwood, D.R. (2014) The ecosystem roles of parrotfishes on tropical reefs. *Oceanography and Marine Biology* **52**, pp. 81-132.
- Braodribb, M. and Dallison, T. (2018). Coral Cay Conservation Marine Assessment; Current Ecological Status of Barangay Napantao Coral Reef and Proposal for Future Management Practices. *Coral Cay Conservation*.
- Cardinale, B., Duffy, J., Gonzalez, A., Hooper, D., Perrings, C., Venail, P., Narwani, A., Mace, G., Tilman, D., Wardle, D., Kinzig, A., Daily, G., Loreau, M., Grace, J., Larigauderie, A., Srivastava, D. and Naeem, S. (2012). Biodiversity loss and its impact on humanity. *Nature*, **486**(7401), pp. 59-67.
- Crosby, M. and Reese, E. (1996). A manual for monitoring coral reefs with indicator species: butterflyfishes as indicators or change on Indo-Pacific reefs. Office of Ocean and Coastal Resource Management, National Oceanic and Atmospheric Administration. Silver Spring, MD, pp. 45.
- Chen, P., Chen, C., Chu, L. and McCarl, B. (2015). Evaluating the economic damage of climate

- change on global coral reefs. *Global Environmental Change*, **30**, pp.12-20.
- Chong-Seng, K.M., Mannering, T.D., Pratchett, M.S., Bellwood, D.R. and Graham, N.A.J. (2012). The influence of coral reef benthic condition on associated fish assemblages. *PLoS ONE* **7**(8), e42167.
- Coleman, F. C., Koenig, C. C., Huntsman, G. R., Musick, J. A., Eklund, A. M., McGovern, J. C., Chapman, R. W., Sedberry, G. R., and Grimes, C. B. (2000). *Long-lived reef fishes: the grouper-snapper complex*. *Fisheries* **25**, pp. 14–20.
- DeMartini, E.E. and Howard, K.G., 2016. Comparisons of body sizes at sexual maturity and at sex change in the parrotfishes of Hawaii: input needed for management regulations and stock assessments. *Journal of fish biology*, **88**(2), pp.523-541.
- Di Franco, A., Thiriet, P., Di Carlo, G., Dimitriadis, C., Francour, P., Gutiérrez, N., Jeudy de Grissac, A., Koutsoubas, D., Milazzo, M., Otero, M., Piante, C., Plass-Johnson, J., Sainz-Trapaga, S., Santarossa, L., Tudela, S. and Guidetti, P. (2016). Five key attributes can increase marine protected areas performance for small-scale fisheries management. *Scientific Reports*, **6**(1)
- Di Lorenzo, M., Claudet, J. and Guidetti, P. (2016). Spillover from marine protected areas to adjacent fisheries has an ecological and a fishery component. *Journal for Nature Conservation*, **32**, pp. 62-66.
- Domeier, M.L. and Colin, P.L. (1997). Tropical reef fish spawning aggregations: defined and reviewed. *Bulletin of Marine Science* **60**(3), pp. 698-726.
- Downing, A.S., van Nes, E.H., Mooij, W.M. and Scheffer, M (2012) The resilience and resistance of an ecosystem to a collapse of diversity. *PLoS ONE* **7**(9).
- Green, A., Smith, S., Lipsett-Moore, G., Groves, C., Peterson, N., Sheppard, S., Lokani, P., Hamilton, R., Almany, J., Aitsi, J. and Bualia, L. (2009). Designing a resilient network of marine protected areas for Kimbe Bay, Papua New Guinea. *Oryx*, **43**(04), pp. 488.
- Hastings, A., Gaines, S. and Costello, C. (2017). Marine reserves solve an important bycatch problem in fisheries. *Proceedings of the National Academy of Sciences*, **114**(34), pp. 8927-8934.
- Hilborn, R. and Walters, C. J. (1992). Quantitative fisheries stock assessment: choice, dynamics and uncertainty. *Reviews in Fish Biology and Fisheries*, **2**, pp. 177–178.
- Hodgson, G. and Liebeler, J. (2002). *The Global Coral Reef Crisis: Trends and Solutions*. Reef Check Foundation, Los Angeles, CA, pp. 80.
- Human, B. and Davies, A. (2010). Stakeholder consultation during the planning phase of scientific programs. *Marine Policy*, **34**(3), pp. 645-654.
- Intergovernmental Panel on Climate Change (IPCC), Global warming of 1.5°C. (2018). Switzerland: IPCC.
- Koenig, C.C., Coleman, F.C., Collins, L.A., Sadovy, Y. and Colin, P.L. (1996). Reproduction in gag (*Mycteroperca micolepis*) (Pisces: Serranidae) in the eastern Gulf of Mexico and the consequences of fishing spawning aggregations in *Biology, Fisheries and Culture of Tropical Groupers and Snappers* (Arreguin-Sanchez, F., Munro, J.L., Balgos, M.C. and Pauly, D. eds), pp. 307-323. *ICLARM conference proceedings* **48**.
- Lester, S. and Halpern, B. (2008). Biological responses in marine no-take reserves versus partially protected areas. *Marine Ecology Progress Series*, **367**, pp. 49-56.
- Lester, S., Halpern, B., Grorud-Colvert, K., Lubchenco, J., Ruttenberg, B., Gaines, S., Airamé, S. and Warner, R. (2009). Biological effects within no-take marine reserves: a global synthesis. *Marine Ecology Progress Series*, **384**, pp. 33-46.
- Licuanan, A.M., Reyes, M.Z., Luzon, K.S., Chan, M.A.A. and Licuanan, W.Y., 2017. Initial findings of the nationwide assessment of Philippine coral reefs. *Philippine Journal of Science*, **146**(2), pp. 177-185.
- Micheli, F., Saenz-Arroyo, A., Greenley, A., Vazquez, L., Espinoza Montes, J., Rossetto, M. and De Leo, G. (2012). Evidence That Marine Reserves Enhance Resilience to Climatic Impacts. *PLoS ONE*, **7**(7), pe40832.
- Morris, K. E., Caruso, T., Buscot, F., Fischer, M., Hancock, C., Maier, T. S., Meiners, T., Muller, C., Obermaier, E., Prati, D., Socher, S. A., Sonnemann, I., Waschke, N., Wubet, T., Wurst, S., and Rilling, M. C. (2014). Choosing and using diversity indices: insights for ecological applications from German Biodiversity Exploratories. *Ecology and Evolution*, **4** (18), pp. 3514-3524.
- Mouillot, D., Parravicini, V., Bellwood, D., Leprieux, F., Huang, D., Cowman, P., Albouy, C., Hughes, T., Thuiller, W. and Guilhaumon, F. (2016). Global marine protected areas do not secure the evolutionary history of tropical corals and fishes. *Nature Communications*, **7**(1).
- Mouillot, D., Villeger, S., Parravicini, V., Kulbicki, M., Arias-Gonzalez, J., Bender, M., Chabanet, P., Floeter, S., Friedlander, A., Vigliola, L. and Bellwood, D. (2014). Functional over-redundancy and high functional vulnerability in global fish faunas on tropical reefs. *Proceedings of the National Academy of Sciences*, **111**(38), pp. 13757-13762.

- National Intelligence Council (NIC). (2016). Global Implications of Illegal, Unreported, and Unregulated (IUU) Fishing 2016.
- O'Hara, R. B., and Kotze, D. J., (2010). Do not log-transform count data. *Methods in Ecology and Evolution*, **1**(2), pp. 118-122.
- Pauly, D., Christensen, V., Dalsgaard, J., Froese, R. and Torres, F., 1998. Fishing down marine food webs. *Science*, **279**(5352), pp. 860-863.
- Pratchett, M., Wilson, S.K. and Baird, A.H. (2006) Declines in the abundance of Chaetodon butterflyfishes following extensive coral depletion. *Journal of Fish Biology* **69**, pp. 1269-1280.
- Quinn, T. J. and Deriso, R. (1999). Quantitative Fish Dynamics. Oxford University Press, New York.
- Roberts, C., O'Leary, B., McCauley, D., Cury, P., Duarte, C., Lubchenco, J., Pauly, D., Sáenz-Arroyo, A., Sumaila, U., Wilson, R., Worm, B. and Castilla, J. (2017). Marine reserves can mitigate and promote adaptation to climate change. *Proceedings of the National Academy of Sciences*, **114**(24), pp. 6167-6175.
- Sadovy, Y. J., and M. Domeier (2005). Are aggregation-fisheries sustainable? Reef fish fisheries as a case study. *Coral Reefs* **24**, pp. 254-262.
- Sadovy, Y., Rosario, A. and Roman, A (1994). Reproduction in an aggregating grouper, the red hind, *Epinephelus guttatus*. *Women in ichthyology: an anthology in honour of ET, Ro and Genie*, pp. 269-286. Springer, Dordrecht.
- Sala, E., Costello, C., De Bourbon Parme, J., Fiorese, M., Heal, G., Kelleher, K., Moffitt, R., Morgan, L., Plunkett, J., Rechberger, K., Rosenberg, A. and Sumaila, R. (2016). Fish banks: An economic model to scale marine conservation. *Marine Policy*, **73**, pp. 154-161.
- Shapiro, D.Y. (1989). Sex change as an alternative life-history style. In *Alternative life-history styles of animals* (Bruton, M.N. ed), pp. 177-195.
- Shapiro, S.S. and Wilk, M.B. (1965). An Analysis of Variance Test for Normality (Complete Samples). *Biometrika* **52**(3-4), pp. 591-611.
- Spalding, M., Burke, L., Wood, S., Ashpole, J., Hutchison, J. and zu Ermgassen, P. (2017). Mapping the global value and distribution of coral reef tourism. *Marine Policy*, **82**, pp.104-113.
- Stohr, S., O'Hara, T.D. and Thuy, B. (2012) Global diversity of brittle stars (Echinodermata: Ophiuroidea). *PLoS ONE* **7**(3): e31940.
- Teh, L., Teh, L. and Sumaila, U. (2013). A global estimate of the number of coral reef fishes. *PLoS One* **8**(6): e65397.
- Thode, H.C. (2002). *Testing for normality*. Marcel Dekker Inc., New York, NY, USA
- Tuomisto, H. (2012). An updated consumer's guide to evenness and related indices. *Oikos* **121**(8), pp. 1203-1218.
- Villaseñor-Derbez, J., Faro, C., Wright, M., Martínez, J., Fitzgerald, S., Fulton, S., Mancha-Cisneros, M., McDonald, G., Micheli, F., Suárez, A., Torre, J. and Costello, C. (2018). A user-friendly tool to evaluate the effectiveness of no-take marine reserves. *PLOS ONE*, **13**(1), pe0191821.
- Weijerman, M., Gove, J., Williams, I., Walsh, W., Minton, D. and Polovina, J. (2018). Evaluating management strategies to optimise coral reef ecosystem services. *Journal of Applied Ecology*, **55**(4), pp. 1823-1833.
- Whittaker, R. H. (1972). Evolution and measurement of species diversity. *Taxon* **21**, pp. 213-251.

Supplementary Material

Table SM1. List of target fish families, genera and species recorded during Coral Cay Conservation (CCC) surveys of the Barangay Himbangan MPA. * Indicates species seen and recorded inside the MPA, lack of a * indicates this species was not seen inside of the MPA.

Common Name	Latin Name	Visayan Name
*Angelfish	Pomacanthidae	Adlo
Barracuda	Sphyrnidae	
(Butterflyfish)	Chaetodontidae	Alibangbang
*(Big) Longnose Butterflyfish	Forcipiger flavissimus	
*Eastern Triangle Butterflyfish	Chaetodon baronessa	
*Humphead Bannerfish	Heniochus varius	
*Kleins Butterflyfish	Chaetodon kleinii	
*Raccoon Butterflyfish	Chaetodon lunula	
*Redfin Butterflyfish	Chaetodon lunulatus	
*Vagabond Butterflyfish	Chaetodon vagabundus	
*Cardinalfish	Apogonidae	
(Damsel)	(Pomacentridae)	
*Anemonefish	Amphiprion sp.	
*Sergeant Damsel	Pomacentridae	
*Emperor	Lethrinidae	Katambak
*Fusilier	Caesionidae	Dalagangbukid
*Goatfish	Mullidae	Timbongan
*Groupers	Serranidae	Lapu-lapu
*Jack/Trevally	Carangidae	Talakitok
*Lionfish	Scorpaenidae	
*Lizardfish	Synodontidae	
*Moorish Idol	Zanclus cornutus	Sanggowanding
Moray Eel	Muraenidae	
*Parrotfish	Scaridae	Mulmul
Bumphead Parrotfish	Bolbometopon muricatum	
*Pufferfish	Tetraodontidae	
*Rabbitfish	Siganidae	Kitong
Ray	Rajiformes	
*Sandperch	Pinguipedidae	
*Snapper	Lutjanidae	
*Spinecheeks	Nemipteridae	Maya-maya
*Squirrelfish/Soldierfish	Holocentridae	Silay
*Surgeonfish	Acanthuridae	
*Unicornfish	Naso sp.	Indangan
Sweetlips	Haemulidae	
*Toby	Tetraodontidae	Lipti
*Triggerfish	Balistidae	
(Wrasse)	(Labridae)	Pakol
*Crescent Wrasse	Thalassoma lunare	
Humphead Wrasse	Cheilinus undulatus	
*Red Breasted Wrasse	Cheilinus fasciatus	

Table SM2. List of target Invertebrate families, Genera and species recorded during Coral Cay Conservation (CCC) surveys of the Barangay Himbangan MPA. * Indicates species seen and recorded within the MPA, lack of a * indicates this species was not seen during surveys within the MPA.

Target Invertebrates		
*Feather duster worms	*Christmas tree worms	*Flatworms
Crabs	Shrimps	*Banded coral shrimp
Lobster	*Nudibranch	Triton's trumpet
*Conch	*Cowrie	*Top shell
*Cone shell	*Drupella	Octopus
*Other gastropod	Giant clam	*Acanthaster planci
Cuttlefish	Squid	*Brittle star
*Linkia laevigata	*Culcita novaeguineae	Collector urchin
*Choriaster granulatus	*Feather star	Greenfish
*Longspine sea urchin	*Pencil urchin	*Giant Clam
Prickly redfish	Pinkfish	
*Other sea cucumber		

Table SM3. List of target substrates recorded during Coral Cay Conservation (CCC) survey of the Barangay Himbangan MPA.

Substrate		
Soft Coral (SC)	Sponge (SP)	Recently killed coral (RKC)
Rock (RC)	Silt/mud (SI)	Rubble (RB)
Sand (SD)	Nutrient indicator algae (NIA)	Other* (OT)
Hard Coral (HC)		
Hard Coral (HC) Lifeforms*:		
Acropora branching	Acropora encrusting	Acropora Sub-Massive
Acropora digitate	Acropora tabulate	Non-Acropora branching
Non-Acropora encrusting	Non-Acropora foliose	Non-Acropora Sub-Massive
Non-Acropora mushroom	Heliopora (blue coral)	Millepora (fire coral)
Tubipora (organ-pipe coral)		
**Other:		
Anemone	Corallimorph	Halimeda
Tunicate	Zoanthid	Gorgonian
Hydroids		

* Hard coral colonies are placed into categories to allow for greater resolution whilst removing the risk of identification errors when attempting to consider colonies to the Genus or Species resolution. Lifeforms are defined by the growth structure exhibited by each colony.

** The category "Other" is defined as any substrate that is encountered within the substrate surveys that does not conform to the criteria of the other categories. For succinctness, the "Other" categories are limited to the most common encountered.

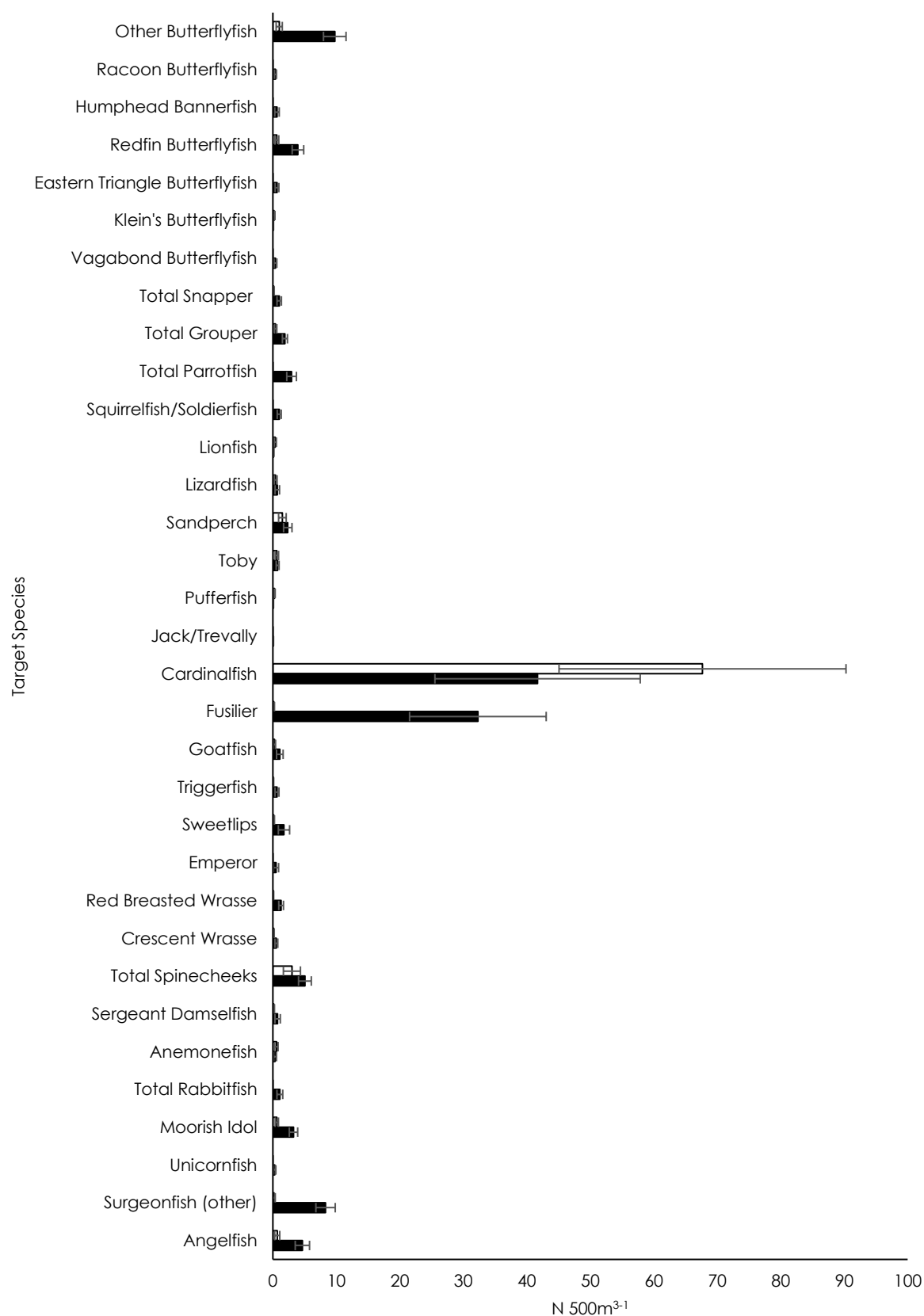


Figure SM1. Mean abundance of target fish species and families per 500m² with standard error ($\pm$ SE) inside (black) and outside (white) of the MPA in Himbangan, St Bernard, the Philippines.

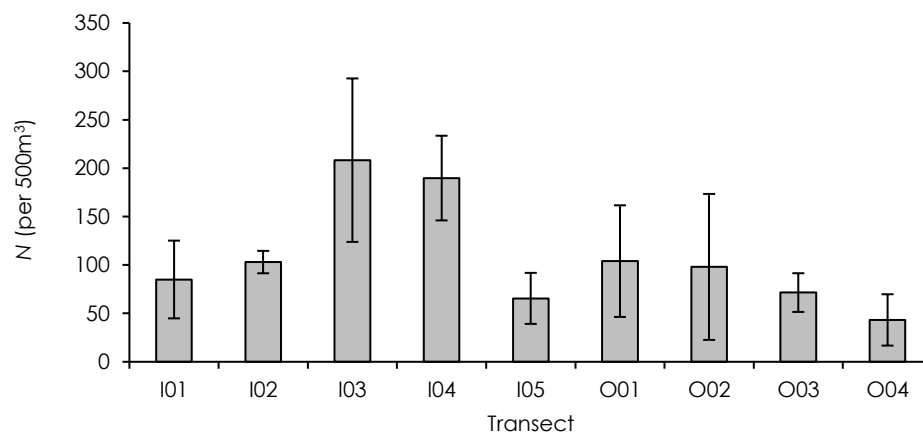


Figure SM2. Mean target fish abundance per 500m³ with standard error (SE) between transects in Himbangan, Saint Bernard, Southern Leyte. No transects were significantly different in fish abundance, $P > 0.05$.

A)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01									
I02					+	+	+		+
I03					+	+	+	+	+
I04							+		+
I05		-	-						
O01		-	-						+
O02		-	-	-					
O03			-						
O04		-	-	-		-			
B)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01									
I02					+	+	+	+	+
I03								+	+
I04									
I05		-							
O01		-							
O02		-							
O03		-	-						
O04		-	-						
C)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01								+	
I02			+	+				+	
I03		-						+	
I04		-							
I05									
O01									
O02									
O03	-	-	-						
O04									

Figure SM3. Matrices showing significant differences in mean target fish a) Species Richness, b) Shannon's H' Diversity Index and c) Pielou's evenness (J) per 500m³ across the survey site in Himbangan, St Bernard, Southern Leyte. A green '+' indicates Species Richness (a) Shannon's H' Diversity Index (b) was significantly higher at the surveyed transect on the left compared to transect at the top ($P < 0.05$). A blue '-' indicates that Species Richness (a), Shannon's H' Diversity Index (b) or Pielou's evenness (c) was significantly lower at the transect on the left compared to transect at the top ($P < 0.05$). Blank cells indicate no significant difference.

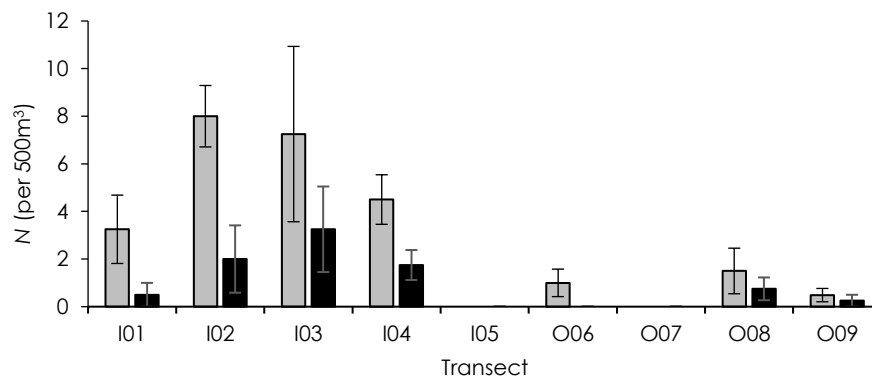


Figure SM4. Mean obligate (grey) and facultative (black) butterflyfish abundance per 500m³ with standard error ($\pm$ SE) between transects in Himbangan, St.Bernard, Southern Leyte. No transects differed significantly in facultative butterflyfish abundance ($P > 0.05$). Transect I02 presented a greater abundance of obligate feeders than transects I05, O01, O02, O03 and O04 ($P < 0.05$)

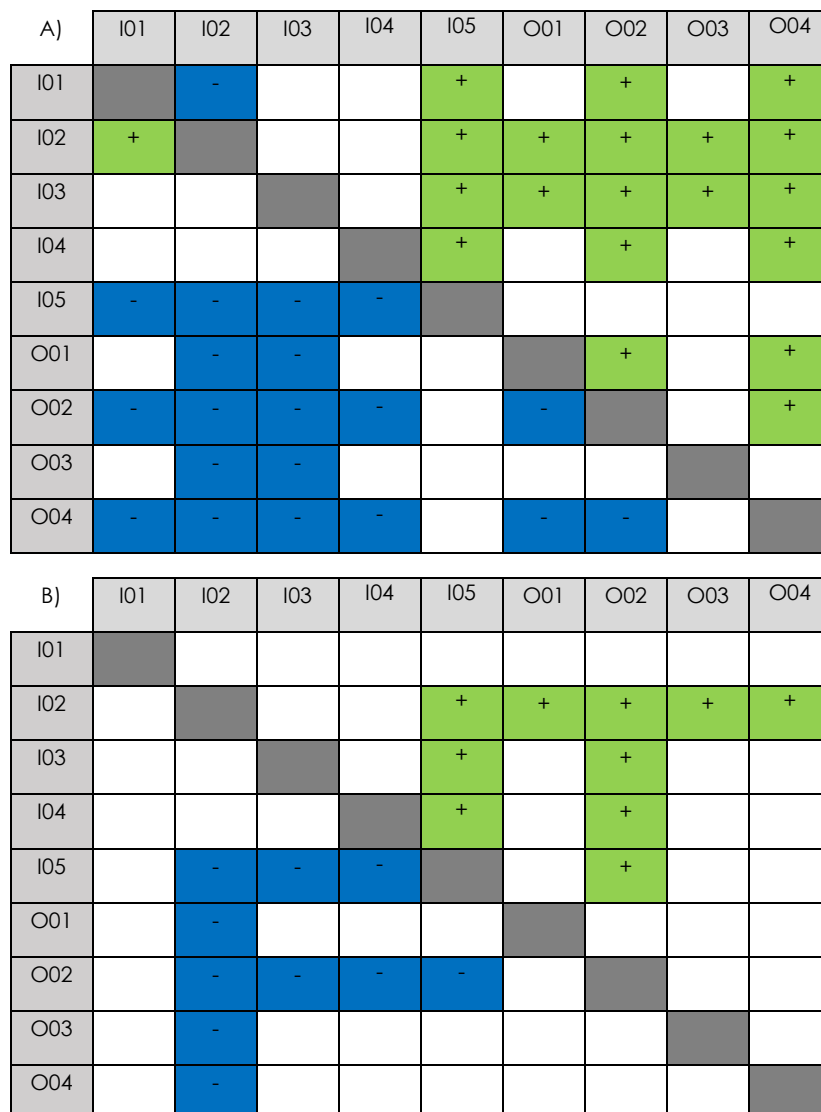


Figure SM5. Matrices showing significant differences in mean target A) All target Butterfly fish and B) Obligate butterfly fish abundance per 500m³ across the survey site in Himbangan, St Bernard, Southern Leyte. A green '+' indicates abundance was significantly higher at the surveyed transect on the 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.

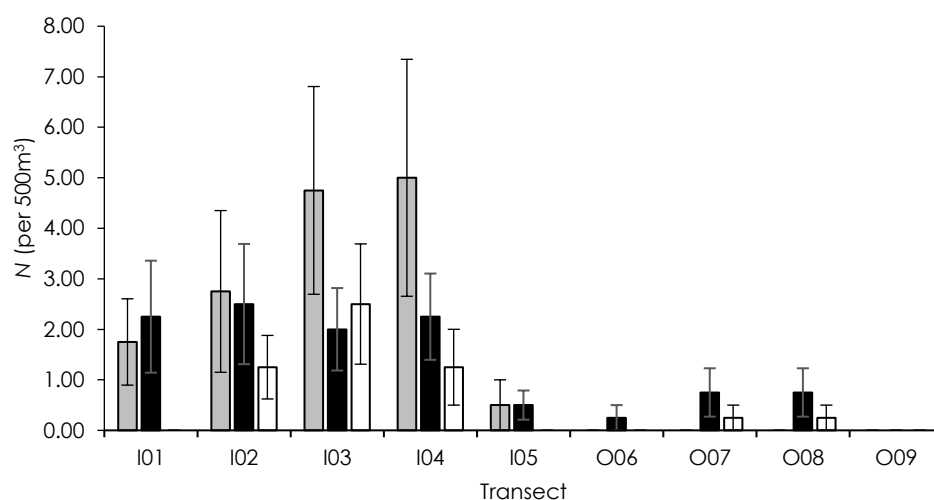


Figure SM6. Mean parrotfish (grey), grouper (black) and snapper (white) abundance per 500m³ with standard error ($\pm$ SE) between transects in Himbangan, St Bernard, Southern Leyte.

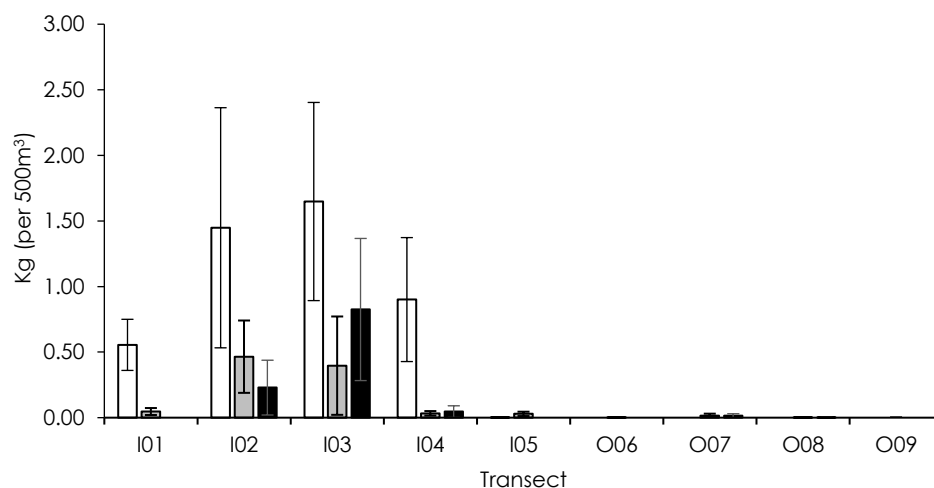


Figure SM7. Mean parrotfish (white), Snapper (black) and Grouper (grey) biomass (kg) per 500m³ with standard error ($\pm$ SE) between transects in Himbangan, St Bernard, Southern Leyte.

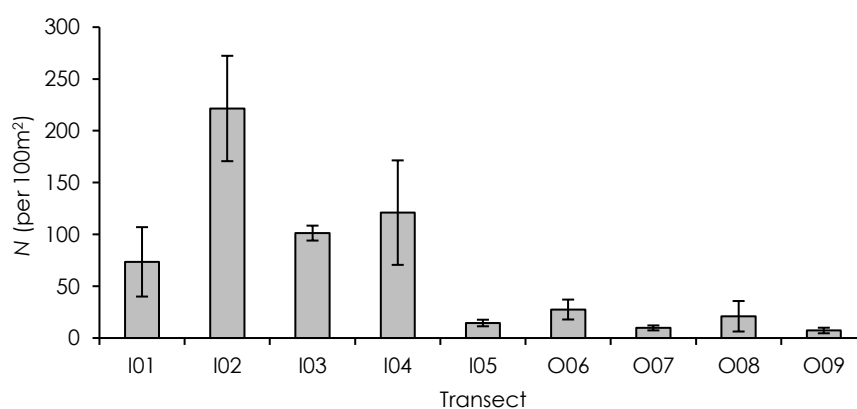


Figure SM8. Mean abundance of target invertebrate species and families per 500m² with standard error ($\pm$ SE) inside (black) and outside (white) of the MPA in Himbangan, St Bernard, Southern Leyte, the Philippines.

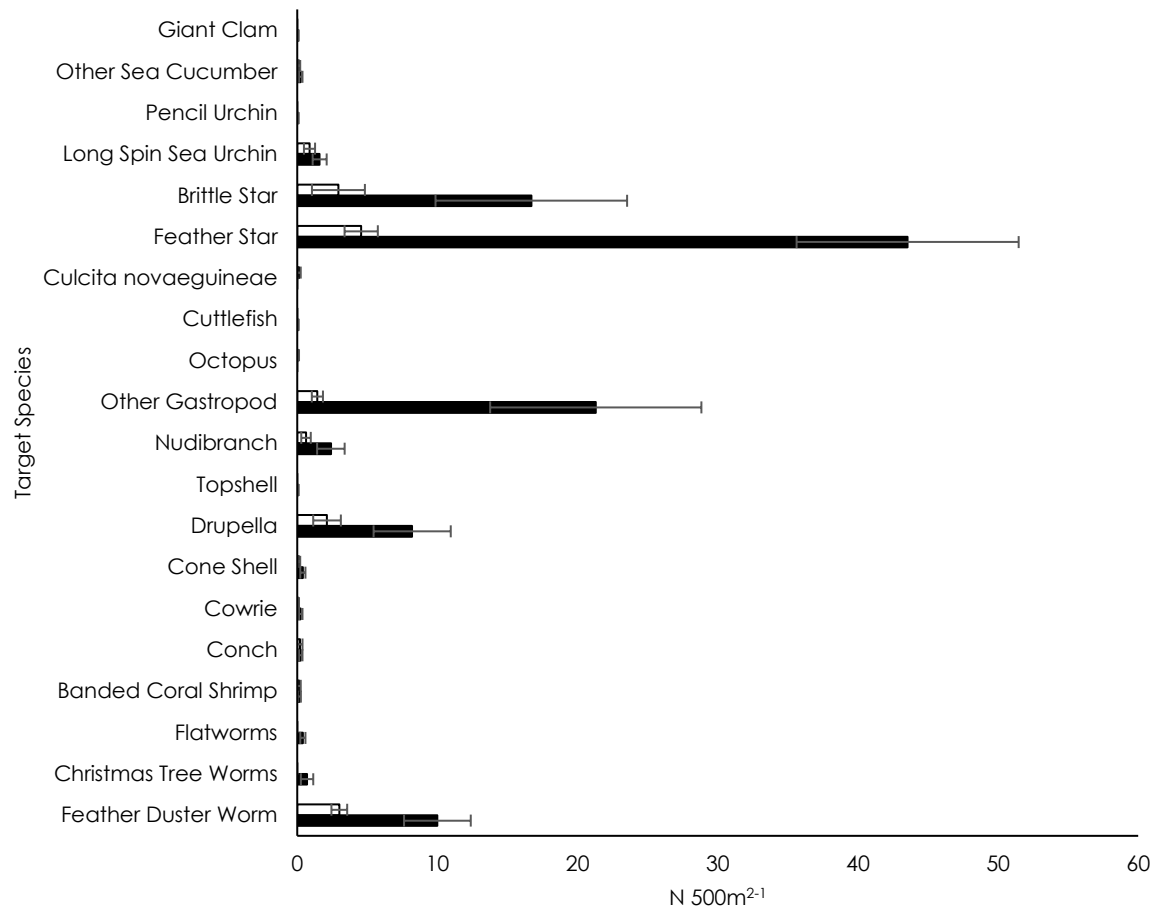


Figure SM9. Mean invertebrate abundance per 100m² with standard error ($\pm$ SE) between transects in Himbangan, St Bernard, Southern Leyte

	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01							+		+
I02					+	+	+	+	+
I03					+	+	+	+	+
I04					+		+		+
I05		-	-	-					
O01		-	-						
O02	-	-	-	-					
O03		-	-						
O04	-	-	-	-					

Figure SM10. Matrix showing significant differences in mean target invertebrate abundance per 100m² across the survey site in Himbangan, St Bernard, Southern Leyte. 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.

A)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01				-					
I02					+		+		+
I03					+		+		+
I04	+				+		+	+	+
I05		-	-	-		-			
O01					+		+		+
O02		-	-	-		-			
O03				-					
O04		-	-	-		-			

B)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01				-		-			
I02				-					
I03									
I04	+	+			+		+		+
I05				-		-			
O01	+				+				+
O02				-					
O03									
O04				-		-			

C)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01						-		-	
I02				-		-		-	
I03						-			
I04		+				-			
I05						-			
O01	+	+	+	+	+				
O02									
O03	+	+							
O04									

Figure SM11. Matrices showing significant differences in target invertebrate A Species Richness (S) B) Shannon-Weiner Diversity (H') and C) Pielou's evenness (J') per 100m² across the survey site in Himbangan, Saint Bernard, Southern Leyte. A green '+' indicates that A) S, B) H' or C) J' was significantly higher at the surveyed transect on the left compared to transect at the top ($P < 0.05$). A blue '-' indicates that A) S, B) H' or C) J' was significantly lower at the transect on the left compared to transect at the top ($P < 0.05$). Blank cells indicate no significant difference.

A)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01					-		-		-
I02					-	-	-	-	-
I03					-	-	-	-	-
I04					-		-		-
I05	+	+	+	+		+			
O01		+	+		-		-		-
O02	+	+	+	+		+			
O03		+	+						
O04	+	+	+	+		+			

B)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01		-			+		+		
I02	+				+	+	+	+	+
I03					+		+		+
I04					+		+		+
I05	-	-	-	-		-			
O01		-			+		+		
O02	-	-	-	-		-			
O03		-							
O04		-	-	-					

C)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01			-						
I02			-	+			+		+
I03	+	+		+	+		+	+	+
I04		-	-			-			
I05			-			-			
O01				+	+		+		+
O02		-	-			-			
O03			-						
O04		-	-			-			

Figure SM12. Matrices showing significant differences in mean A) Silt (SI), B) Hard Coral (HC) and C) Rock (RC) cover per 20m across all transects in Himbangan, St Bernard, Southern Leyte. A green '+' indicates cover 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.

A)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01									
I02					+		+		+
I03					+		+		+
I04									
I05		-	-						
O01									
O02		-	-						
O03									
O04		-	-						

B)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01				-					
I02									
I03									
I04	+				+		+	+	
I05				-					
O01							+		
O02				-		-			
O03				-					
O04									

C)	I01	I02	I03	I04	I05	O01	O02	O03	O04
I01									
I02					+			+	+
I03					+	+	+	+	+
I04					+			+	+
I05		-	-	-					
O01			-						
O02			-						
O03		-	-	-					
O04		-	-	-					

Figure SM13. Matrix showing significant differences in a) Fast Growing Coral (FGC), Stress Tolerant Coral (STC) and Competitor Coral (CC) cover across all transects in Himbangan, St Bernard, Southern Leyte. A green '+' indicates cover was significantly higher at the surveyed transect on the left compared to transect at the top ($P < 0.05$). A blue '-' indicates that cover was significantly lower at the transect on the left compared to transect at the top ($P < 0.05$). Blank cells indicate no significant difference.