

Coral Cay Conservation Philippines; Current Ecological Status of Barangay Santa Paz Norte Coral Reef & Proposals for Marine Protected Area Implementation

2019

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Expeditions

Coral Cay Conservation Philippines; Current Ecological Status of Barangay Santa Paz Norte Coral Reef & Proposals for Marine Protected Area Implementation

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Report made available for distribution; July 2019

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Abstract:

Coral Cay Conservation (CCC) assessed the biological status and anthropogenic impacts inside the Barangay waters of Santa Paz Norte, in April and May 2019 to provide recommendations for Marine Protected Area implementation. An enhanced Reef Check methodology was used to survey 8 transects, containing 4x20m replicates (4x6 m and 4x12m) evenly distributed throughout the waters.

Mean target fish abundance was lower than other Sogod Bay survey sites ($N=63.13 \pm 6.72$ 500m³⁻¹) with significant variances across transects, strongly correlated to substrate type. Transects I02 had the highest fish abundance of $N=105.25 \pm 17.47$ 500m³⁻¹, significantly higher than transects I03, I04 and O08 ($P<.05$). This was also found to be associated to high abundances of hard coral cover, whereas, the lowest fish abundance was recorded on transects O08 ($N=26.00 \pm 6.04$ 500m³⁻¹) correlating to the high abundance of Sand substrate. This directly indicates the importance of complex coral structures for supporting fish abundances and population and causes justification for protection of the remaining coral reef community. In addition, there was also, low abundance of commercially important species at Santa Paz Norte ($N=6.53 \pm 0.89$ 500m³⁻¹), with the most common species being Parrotfishes (contributing to 79.43%). Abundances of commercially important fishes was also correlated to the transects with increases substrate complexity, further supporting the need for protection to secure future livelihoods of the fishers in Santa Paz Norte.

In addition to biological data, there was no direct anthropogenic impacts observed but evidence of indirect impacts were recorded. General trash was recorded on 62.50 % of the survey transects and fishing trash in particular was recorded on 59.38% of the survey transects. Although these numbers are high and detrimental to reef health, this is expected for an area of fisher population and no legislation. This assessment finds that the coral reefs at Santa Paz Norte are certainly viable for protection and with appropriate locations (provided), education and enforcement, there could be many benefits to be gained from introducing fisher restrictions to select areas of the barangay waters. Recommendations are provided and further discussions are encouraged with Municipal and Government level.

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

Recommended Citation; Heney, C. & Dallison, T. (2019). Coral Cay Conservation Marine Assessment; Current Ecological Status of Barangay Santa Paz Norte Coral Reef & Proposal for Future Marine Protected Area Implementation. *Coral Cay Conservation*.

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 & 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 & 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; Grafeld *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 & 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 & 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 & 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

CCC's assessment of the barangay waters of Santa Paz Norte (SPN) was conducted originally in 2014 where it was described as a popular 'muck diving' location. A term used for a type of diving aimed at small, interesting creatures rather than large abundance of fish or hard coral (Fey *et al.*, 2014). During the 2014 assessment, requested by PGSL and SPN Barangay Council, a recommendation was made for the inclusion of the reef area as a marine protected area. Unfortunately, this was not agreed, with incomplete implementation, resulting in the recent request to re-assess the area and complete the ordinance. The 2019 survey was conducted from the 22nd April and 6th May 2019 by trained volunteer survey teams (Fig. 2). The weather varied between sunny, and cloudy throughout the survey period, with a mean air temperature of 30.25°C. Mean sea surface temperature (SST) was 28.00°C. The water at 3m was recorded as having a mean of 27.5°C and

27.25°C at 10m, over the survey period. The mean estimated horizontal visibility throughout the survey area was 16.25m.

From discussions with the Barangay captain and officials, SPN has a population size of 751 people and there is a river outlet (mouth 11-50m wide) at the front of the barangay, and siltation is said to occur often. This site is sometimes exposed (dependant on annual season) and this may also increase occurrence of siltation in the area. Overall anthropogenic activities were described as low in the area with minimal fishing activity, low sewage pollution but regular diver visitation. At this site, as there is no protection, there is no enforcement of any activity and no activity considered 'banned', therefore exploitation has the potential of being unsustainable without appropriate mitigation.

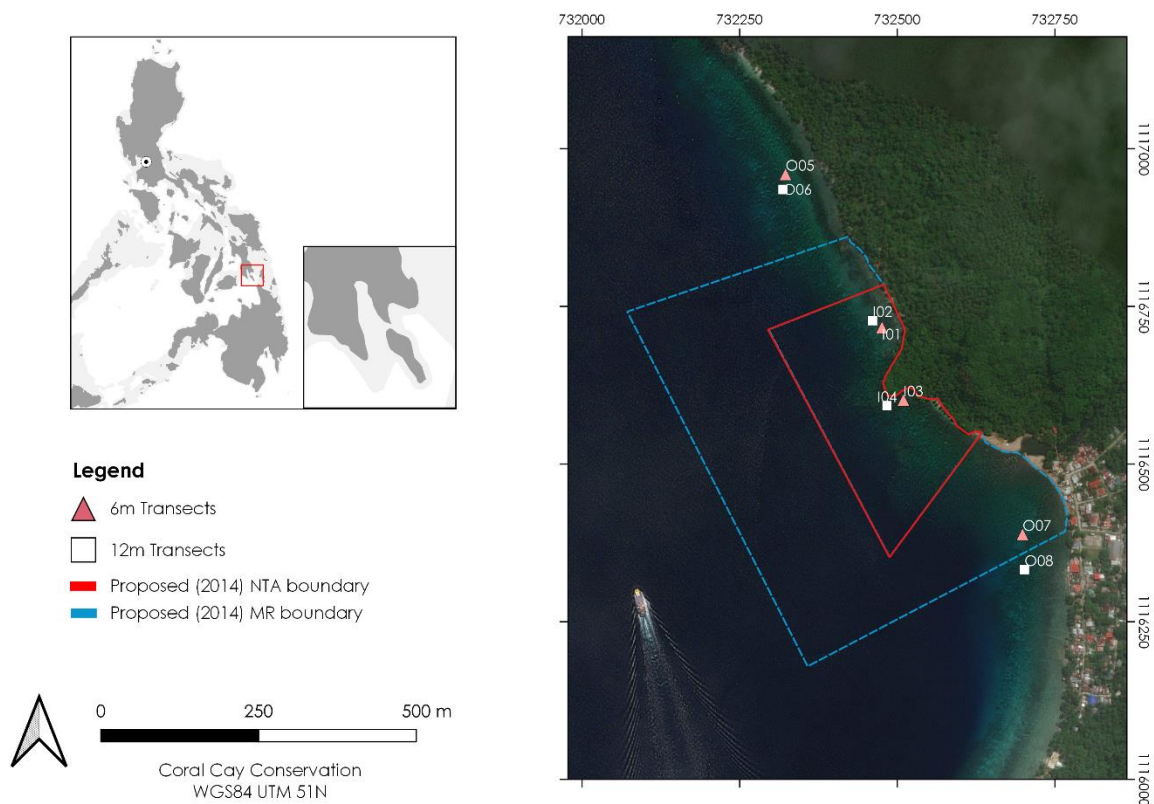


Figure 2. Map of ecological spatial survey transects at both 6m (triangle) and 12m (square) in the coastal waters of Barangay Santa Paz Norte, San Francisco. Previous Marine Spatial Management recommendations are presented; No-Take Area (NTA) – red – and Marine Reserve (MR) – blue.

Table 1. Mean ($\pm$ SE) and Median diversity indices for target fish Species Richness (S), Shannon Weiner Diversity (H') and Pielou's Evenness (J') per 500m³ across the transects in Santa Paz Norte, San Francisco, Southern Leyte. Transects are found to be significantly different are indicated with 'A,B,C,D,E,F' with the transects in which they were found to significantly differ from indicated with the corresponding 'a,b,c,d,e,f'. P values included below.

Transect	S (500m ³ -1)			H' (500m ³ -1)			J' (500m ³ -1)		
	S	$\pm$	Med*	H'	$\pm$	Med**	J'	$\pm$	Med
I01	10.75	1.03	11.00 ^A	1.99	0.13	2.08 ^A	0.84	0.02	0.85
I02	16.00	1.68	14.50 ^{a,B}	2.18	0.18	2.27 ^B	0.79	0.05	0.82
I03	12.50	0.87	12.50 ^C	2.00	0.09	1.97 ^C	0.79	0.02	0.79
I04	13.00	1.78	14.00 ^D	2.15	0.19	2.13 ^D	0.85	0.04	0.87
O05	13.00	2.38	13.00 ^E	1.88	0.27	2.01 ^E	0.74	0.06	0.78
O06	13.50	0.87	14.00 ^F	2.23	0.09	2.22 ^F	0.86	0.02	0.87
O07	4.50	0.87	4.00 ^{a,b,c,d,e,f}	0.76	0.16	0.73 ^{a,b,c,d,e,f}	0.57	0.15	0.57
O08	4.75	0.25	5.00 ^{a,b,c,d,e,f}	0.93	0.18	0.92 ^{a,b,c,d,f}	0.60	0.12	0.62

Results

Fishes (incl. Butterflyfishes)

In total, 2020 individual fish were recorded, representing 73.17% of all target organisms, with a mean abundance of $N=63.13 \pm 6.72$ 500m³-1, throughout the survey area (Med = 56.50).

At the transect resolution, transect I02 had the highest fish abundance of $N= 105.25 \pm 17.47$ 500m³ -1 (Med=101.50). This was significantly higher than abundances found at transects I03, I04 and O08 ($P=.028$, $P=.042$ and $P=.028$, respectively). The lowest fish abundance found on any transect was transect O08

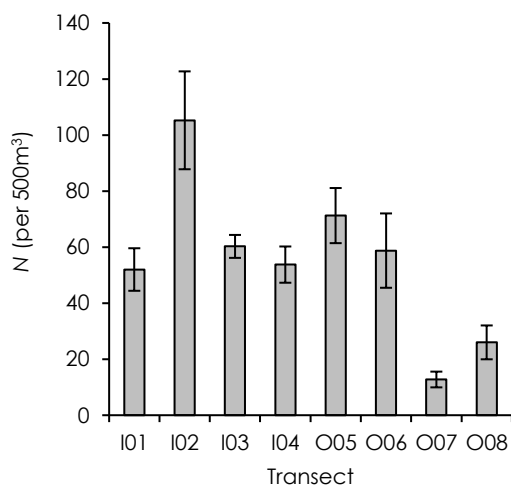


Figure 3. Mean target fish abundance (N) per 500m³ with standard error ($\pm$ SE) between transects in Santa Paz Norte, San Francisco, Southern Leyte.

($N=26.00 \pm 6.04$ 500m³ -1 (Med= 22.50)), significantly lower than transects O01, I04, I03 and I02 ($P=.028$ for all) (Fig. 3).

Cardinal fish were the most abundant species across the survey site ($N=14.03 \pm 5.75$ 500m³ -1) however, this was largely influenced by anomalous counts of cardinal fish on transect O07 and therefore were removed from further analysis. The next most represented fish species were Fusilier ($N=8.78 \pm 3.09$ 500m³ -1), Anemonefish ($N= 8.19 \pm 1.10$ 500m³ -1) and Crescent Wrasse ($N=7.44 \pm 1.19$ 500m³ -1)

(Fig. SM1).

Mean species richness was $S= 11.00 \pm 0.82$ 500m³-1 while mean Shannon Weiner Diversity (H') was $H'= 1.76 \pm 0.11$ 500m³-1 and Pielou's Evenness $J= 0.75 \pm 0.03$ 500m³-1. There was significantly lower S found on transects O07 and O08 (Table 1). Transects O07 and O08 were also significantly lower than other transects for H' (Table 1). There was no significant variance of J .

Butterflyfish

Across SPN, there were 129 butterflyfishes recorded, representing 100% of all target species ($N=4.03 \pm 0.90$ 500m³-1, Med = 3.00). At the transect level, transect O05 had the highest abundance ($N= 7.00 \pm 3.89$ 500m³-1, Med= 6.00) but was not significantly different from any other transect. Transects O07 and O08 had the lowest recorded

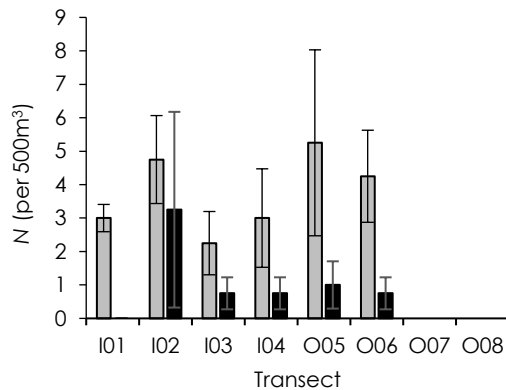


Figure 4. Mean target butterflyfish abundance (N) per 500m³ ($\pm$ SE) for Santa Paz Norte, San Francisco, Southern Leyte. Grey bars represent Obligate corallivores and black bars represent facultative corallivore species.

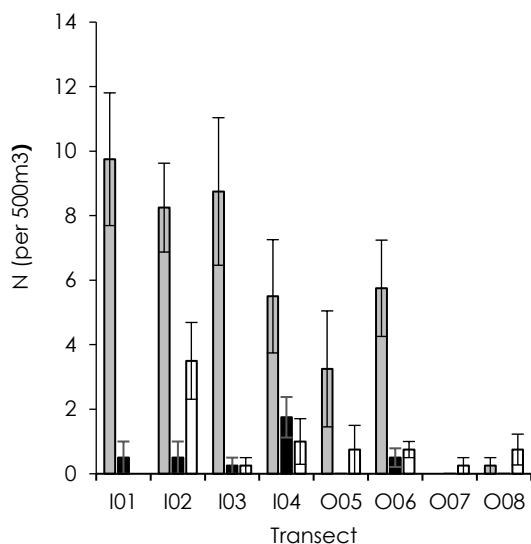


Figure 5. Mean Parrotfish (grey), Grouper (black) and Snapper (white) abundance per 500m³ ($\pm$ SE) between transects in Santa Paz Norte, San Francisco, Southern Leyte.

abundance ($N = 0.00 \pm 0.00$ 500m³⁻¹, Med=0.00) which was significantly lower than transects I01, I02, I03, I04 and O06 ($P=.017$, $P=.021$, $P=.020$, $P=.020$ and $P=.021$ respectively) (Fig.4).

Upon categorisation of butterflyfishes into feeding strategy; obligate corallivores were recorded as $N = 2.81 \pm 0.29$ 500m³⁻¹ (Med=0.00) and facultative corallivores $N = 0.81 \pm 0.06$ 500m³⁻¹ (Med=0.00).

Obligate corallivores were found in the greatest abundance on transect O05 ($N = 5.25 \pm 2.78$ 500m³⁻¹, Med=5.00), however was not found to be significantly higher

than any other transects. As there were no butterflyfishes recorded on transects O07 and O08, the next lowest abundance of obligate corallivores was found on transect I03 ($N = 2.25 \pm 0.95$ 500m³⁻¹, Med= 1.50), which was significantly higher from transects O07 and O08 ($P=.020$ for both) (Fig.4).

Facultative corallivores were recorded in the greatest abundance on transect I02 ($N = 3.25 \pm 2.93$ 500m³⁻¹, Med=0.50) but no significant variation was observed between transects. Again, as there were no recordings of any butterflyfish on transects O07 and O08, the next lowest abundance of facultative corallivores was recorded on transect I01 $N = 0.00 \pm 0.00$, Med= 0.00) (Fig. 4). No significant variation between transects was recorded.

Commercially Important Fishes

Across the survey site, there were a total 209 commercially important fishes recorded that contributed to 10.35% of all the recorded species during the survey. Average commercially important species abundance was $N = 6.53 \pm 0.89$ 500m³⁻¹, Med=6.00.

Parrotfishes contributed greatest to total abundance (79.43%), followed by Snapper (13.88%) and Grouper (6.70%).

Parrotfish abundance was the highest on transect I01 ($N = 9.75 \pm 2.06$ 500m³⁻¹, Med= 9.00) which was significantly higher than transects O07 and O08 ($P=.021$ and $P=.026$ respectively) where no sightings of Parrotfish were recorded (Fig. 5).

Snapper abundance was the highest on transect I02 ($N = 3.5 \pm 1.19$ 500m³⁻¹, Med=3.50) which was significantly greater than transects I01, I03 and O07 ($P=.021$, $P=.037$ and $P=.037$, respectively). The lowest abundance of Snapper was found on transect I01 with no sightings at all (Fig. 5).

Grouper abundance was highest on transect I04 ($N = 1.75 \pm 0.63$, Med=2.00) however no significant variation was observed. Grouper species were absent from transects O05, O07 and O08 (Fig. 5).

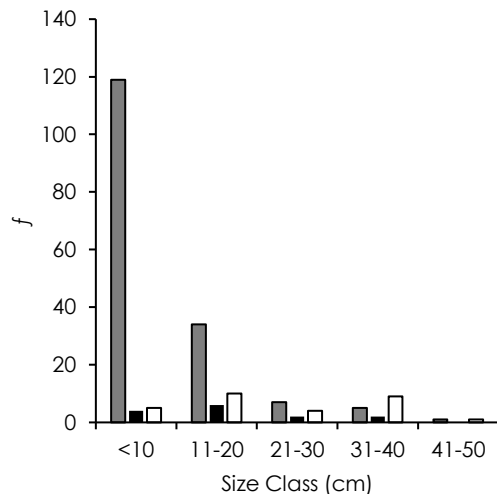


Figure 6. Mean Parrotfish (grey), Grouper (black) and Snapper (white) frequency (f) per size class (cm) found across the survey site of Santa Paz Norte, San Francisco, Southern Leyte.

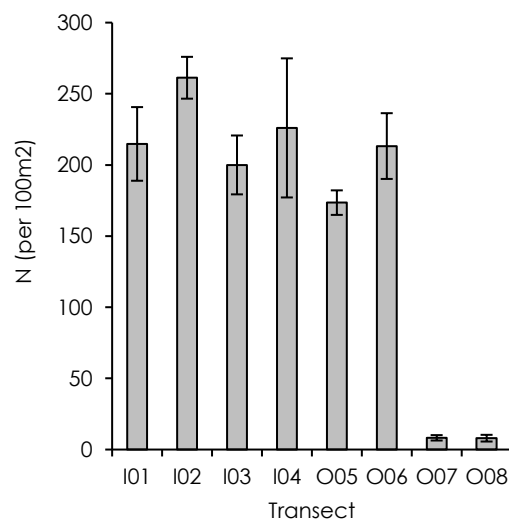


Figure 7. Mean invertebrate abundance ($\pm$ SE) per 100m² at Santa Paz Norte, San Francisco, Southern Leyte.

Parrotfish were represented the greatest by small individuals in the size class <10cm ($f=119$) and the least in size class 41-50cm ($f=1$) with no individuals larger than 50cm. Grouper were represented the most in size class 11-20cm ($f=6$) and the least in size class 21-30cm and 31-40cm ($f=2$ each) with no individuals larger than 40cm. The most abundant Snappers were in the size class 11-20cm ($f=10$) and the least in size class 41-50cm ($f=1$) with none larger than 50cm (Fig.6).

The accumulative biomass (kg) of commercially important fishes recorded was 18.42 kg across Santa Paz Norte. Parrotfish contributed the most to the recorded biomass (10.06kg), followed by Snapper 6.08kg and then Grouper 2.28kg (Fig SM2).

Cumulatively, the transects with the highest biomass of all three-target fishes was transect I04 (5.21 kg) with the lowest being transect O07 with cumulative biomass of 0.06kg.

Invertebrates

In total, 5220 invertebrates were recorded across the site ($N= 163.13 \pm 18.10$ 100m²⁻¹, Med= 182), representing 48.78% of the target invertebrate species. The most abundant organisms were Brittle Stars, Feather Stars and Long Spine Sea Urchins ($N= 50.19 \pm 6.46$ 100m²⁻¹, Med=55.00; $N= 43.21 \pm 8.36$ 100m²⁻¹, Med=29.50; $N= 22.66 \pm 4.32$ 100m²⁻¹, Med= 15.00, respectively) (Fig. SM 4).

At the transect level, transect I02 had the highest target invertebrate abundance ($N= 261.25 \pm 14.70$ 100m²⁻¹, Med = 259.00), which was significantly higher than that found on transects O05, O07 and O08 ($P=.028$, $P=.028$ and $P=.029$ respectively). Transect O08 had the lowest target invertebrate abundance ($N= 8.00 \pm 2.35$ 100m²⁻¹, Med= 6.00) which was significantly lower than transects I01, I02, I03, I04, O05 and O06 ($P=.029$ for all) (Fig. 7).

Mean species richness was $S= 8.41 \pm 0.54$ 500m³⁻¹ while mean Shannon Weiner Diversity (H') was $H'= 1.46 \pm 0.06$ 500m³⁻¹ and Pielou's Evenness $J= 0.73 \pm 0.02$ 500m³⁻¹. There was significantly lower species richness found on transects O07 and O08 (Table 2). Transect O08 was also significantly lower than other transects for H' (Table 2). The samples collected from transect O08 demonstrated a greater degree of evenness when compared to transects I01, I02 and O06 (Table 2).

Giant Clams were found in low abundance ($N= 0.25 \pm 0.13$ 100m²⁻¹, Med=0.00) in a range of size classes not exceeding 50cm

and the majority falling into the <30cm size classes (Fig. SM 5). There was also documentation of *Acanthaster planci* (Crown of thorns) in the survey area with a mean abundance of $N=0.78 \pm 0.23$ 100M⁻², Med= 0.00.

Substrates

The dominant substrate type across the survey area was Sand (SD) contributing to 34.92 ± 6.82 % 20m⁻¹, Med= 18.75 (Fig SM 7). The second most dominant substrate type was Hard Coral (HC) contributing to 27.89 ± 3.66 % 20m⁻¹, Med= 28.75, followed by rubble (RB), 12.89 ± 2.42 % 20m⁻¹, Med=10.00 (Fig. SM 7).

Transect O07 had the highest abundance of SD (96.25 ± 3.75 % 20m⁻¹, Med = 100), significantly higher than that on transects I01, I02, I03, I04, O05 and O06 ($P=.017$, $P=.026$, $P=.025$, $P=.026$, $P=.026$ and $P=.025$ respectively). Transect I01 had the lowest abundance of SD substrate (0.00 ± 0.00 % 20m⁻¹, Med=0.00), significantly lower than

I02, O06, O07 and O08 ($P=.021$, $P=.020$, $P=.017$ and $P=0.02$ respectively) (Fig.8).

Hard Coral cover was the highest on transect I01 (47.50 ± 7.22 % 20m⁻¹), significantly higher than transects O06, O07 and O08 ($P=.028$, $P=.019$ and $P=.019$ respectively). Hard coral was absent from both O07 and O08 transects (Fig.8).

Rubble was the most dominant on transect O06 (26.87 ± 9.15 % 20m⁻¹, Med= 21.25) which was significantly higher than transects O07 and O08 ($P=.021$ for both). No rubble was recorded on transects O07 and O08 (Fig. 8).

Among the hard coral, the dominant life form was Non-Acropora Branching (CB) (21.85 %) followed by Non-Acropora Submassive (CS) (18.77 %) then Non-Acropora Encrusting (CE) (16.81 %) (Fig SM 8).

CB was the most abundant on transect I01 (51.32 %) which was significantly higher than transects I02, I03, I04, O05, O06, O07 and O08 ($P=.029$, $P=.029$, $P=.029$, $P=.028$, $P=.029$, $P=.021$ and $P=.021$ respectively). CS was the most abundant on transect I03 (24.62%) which was significantly higher than that on transects O07 and O08 ($P=0.21$ for both). CE was most abundant on transect I04 (26.67%) which was significantly higher than that on transects O07 and O08 ($P=.020$ for both).

Competitor Corals (CC) were found to be the most dominant life trait amongst hard corals (52.38 %), followed by Stress Tolerant Corals (STC) (35.85 %) and Fast-Growing Corals (FGC) (11.76 %). CC was most abundant on transect I01 (80.26 %) significantly higher than CC on transects I02, I03, I04, O05, O06, O07 and O08 ($P=.039$, $P=.029$, $P=.029$, $P=.029$, $P=.028$, $P=.020$ and $P=.020$ respectively). STC was most abundant on transect O06 (41.94 %) which was not significantly higher than any other transect. FGC was the most abundant on transect O06 (22.58 %) significantly higher than transects O07 and O08 ($P=.017$ for both).

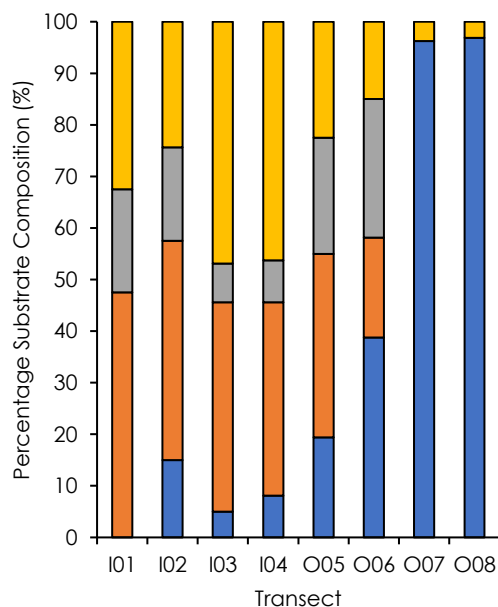


Figure 8. Proportionate composition of the three most dominant substrate types identified at each transect of Santa Paz Norte, San Francisco, Southern Leyte. SD = Sand (blue), HC = Hard Coral (orange), RB = Rubble (grey) and OT = consists of all other substrate types (yellow); Soft Coral, Sponge, Recently Killed Coral, Rock, Silt, Nutrient Indicator Algae and Other substrate types.

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. General trash recorded on 62.50% of transects (6.25% with high levels, 40.63% with medium levels and 15.63% with low levels). More specifically, discarded fishing gear was recorded on 59.38% of transects (9.38% having high levels, 18.75% having medium levels and 31.25% with low levels) (Fig. 9).

Discussion

Through assessment data can be combined with previous recommendation reports conducted by CCC to implement the most effective Marine Protected Area (MPA) for Santa Paz Norte to maximise fish stocks, coastal protection and future livelihood security.

Fish

The fish assemblages in Santa Paz Norte (SPN) are similar in composition to other survey sites in Sogod Bay. However, it is clear that the substrate composition strongly influences fish abundance. The structural complexity of tropical benthic habitats has significant impact on the fish assemblages (Epstein and Kingsford, 2019). Hard coral is well known to offer valuable resources such as food and shelter and therefore, the carrying capacity of a reef system is often directly linked to hard coral presence (Epstein and Kingsford, 2019). As both transects O07 and O08 have exceptionally low fish abundance, this can be directly linked to the lack of any complex hard substrate (mostly sand). This is further supported as the transects with higher fish abundances, were also abundant in hard coral (Fig SM7). It is therefore, suggested that such transects would not provide the barangay with any future benefits if put under protection and focus should be made on the other areas of increased biodiversity, resource availability and future livelihood security.

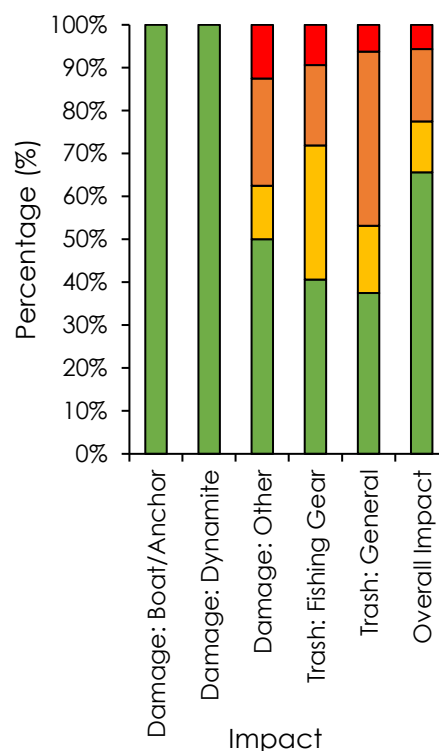


Figure 9. Total impact scale recorded across the survey site of Santa Paz Norte, San Francisco, Southern Leyte. Counts of impacts are categorised to scale (0=none (green), 1=low (yellow), 2-4=medium (orange) and >5=high (red)), which is applied to each recorded impact category as a percentage (%) of 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.

Alternatively, there are areas of the waters that exhibit good coral reef structures evident on transects I01 and I02 where the elevated fish abundances are paired with increased substrate complexity. Also, as the population is linked to substrate type, this is due to their ecological role in maintain a healthy reef system, (feeding habits, symbiotic relationships, interspecific interactions etc), and through protection, such relationships are maintained in order to sustain current

Butterflyfish

The separation of indicator species from broad analysis allows for further understanding of the stressors that may be present on a coral reef system. Butterflyfish

show strong association with hard coral abundance as they rely on live polyps for the majority of their food resource, therefore assumptions can be deduced from population abundance (Slattery and Gochfeld, 2016). Furthermore, as coral is sessile, during incidences of environmental stress, they are unable to avoid damage, yet if the health of the polyp is not sufficient in supplying butterflyfish with enough resource, the mobile fish species are able to find more favourable habitats (Slattery and Gochfeld, 2016). This strong coral-butterflyfish correlation is also very evident here as both species are absent from transects O07 and O08 and also increased hard coral cover supports increased butterflyfish abundance (Fig. SM 9).

Commercially Important Fishes

As the Philippines are heavily reliant on subsistence fisheries, the specific investigation into such popular commercial fish species is vital when implementing an MPA due to the importance of understanding resource use prior to implementation of legislative restrictions. This biological information can be used in support to the sociodemographic information obtained to inform policy makers the most viable restrictions which enable the mitigation of harmful practices and protect local fish stocks, without unnecessary 'blanket bans' which often result in failure and public animosity.

The commercially important fishes abundance at Santa Paz Norte are suspected to be depleted due to the abundance and size classes observed. These small size classes are indicative of immature individuals; therefore, it is suggested that without protection and continued fishing pressure, these young individuals will not reach maturity sufficient to support future generations. Proportionately, the abundance of Parrotfish species is a good indicator of reef health due to their important role in limiting macroalgal growth (Bonaldo *et al.*, 2014). Considering that coral reefs are at constant competition for resources (light, space, food) with algal communities, Parrotfish are

needed to support coral prevalence, another reason to introduce protection measures.

Snappers also offer important ecosystem function due to their predatory nature. The abundance of Snapper at SPN is however, low, indicating fishing activity but protection is important to allow for the ecosystem to remain in balance. Without reef predator abundance, this can elicit meso-predator release, a reaction known to cause significant imbalance and subsequent deterioration of coral reef ecosystems (Luo *et al.*, 2009).

Groupers however, were in extremely low abundance, only documented on 5 of the 8 transects. Groupers are an extremely vulnerable species due to their slow growing nature and varied reproductive strategies (Rhodes and Sadovy, 2002). Within Sogod Bay, there are multiple species of Grouper, often exhibiting varied reproductive strategies, but the most common cause for Grouper global depletion has been due to their aggregation spawning traits. This is a phenomenon known to occur intermittently throughout the year (often on a full moon) and high densities of individuals aggregate in a high energy environment to mass spawn (Rhodes and Sadovy, 2002). If such locations are identified by fishers, this causes selective depletion of reproductive population with significant detrimental impact. Within Sogod Bay, such locations are unknown and therefore implementation of MPA can only protect individuals whilst showing site fidelity for feeding grounds. However, the inclusion of multiple small scale MPA systems within Sogod Bay will support a 'network' of MPAs and increase the potential for protection of individuals until maturity.

As expected from substrate analysis, all target commercially important species were practically absent from transects O07 and O08. This further supports the exclusion of these transects from any future protection due to available resources best

placed in areas that hold greater conservation potential.

Invertebrates

Tropical invertebrates are vital to coral reefs due to their ability to improve the water quality of the water column through filtration (Reid *et al.*, 2009), contribution to the complexity of food webs, and assist the transfer of energy (Reid *et al.*, 2009). In SPN, the most abundant invertebrate was the Feather Star, indicating healthy filtration of particles from the water column creating a more beneficial environment for coral proliferation (Reid *et al.*, 2009). Feather Stars also have calcareous tubes in which they inhabit for protection, often bored into massive coral substrates. These tubes further contribute to the stable structure of the reef system (Reid *et al.*, 2009).

Brittle Stars also offer important ecosystem service through providing the connectivity between benthic and pelagic food webs (Geraldi *et al.*, 2017). This is a process known as benthic-pelagic coupling and is an important function in nutrient cycling energy from benthic to pelagic ecosystems (Griffiths *et al.*, 2017).

The high abundance of Long Spine Sea urchin also indicates the processes occurring at SPN. Long Spine Sea urchins are another keystone herbivore and also significantly contribute to the primary productivity, algal settlement and Scleractinia coral recruitment (Luza and Malay, 2019). These urchins are very widespread and occur in high abundance throughout Sogod Bay but specific studies on their feeding habits are common but highlight the significant role in mitigating algal phase shifts in many coral reefs (Luza and Malay, 2019).

Similar to the fish abundance data, it is clear that there is significantly less biodiversity associated with the sandy substrate located on O07 and O08, this is supported by the minimal abundance of invertebrates in this area.

Substrates

It is very clear at SPN that the biodiversity of coral reef associated fauna communities is heavily reliant on complex substrate. When the focus area is considered for prospective marine spatial management, following the exclusion of transects O07 and O08, it is evident that due to the high composition of Scleractinian corals, the area holds high conservation management value. Coral lifeform can offer valuable insight into the functions of the reef, carrying capacity and the environmental conditions in which it is situated. Abundant species such as Non-Acropora Branching and Non-Acropora Submassive can therefore offer complex 3-dimensional structures useful for fish refugia and also such complexity has shown to be a positive attribute in disturbance recovery (Graham and Nash, 2012). In addition to the biological benefits branching coral provide to an area, they are also known to increase ecosystem services such as tourism and coastal defence beneficial to economy posing a valuable system to protect (Graham and Nash, 2012).

Non-Acropora Encrusting can also provide insight into the dynamics of a reef and considering that most new coral recruits may start to establish a colony in the form of an encrusting lifeform, this could be indicative of a recovering system. If this is the case, further removal of anthropogenic disturbance would be highly advised to protect this viable area. Fully formed encrusting species however, do not offer the 3-dimensional structure needed to support fish communities as well as perform sufficient coastal protection through wave action dispersal.

Impacts

Although no evidence was observed in regard to direct anthropogenic impacts, it is suggested that heavy fishing effort is present within the study area, and adjacent, due to the high levels of discarded gear. It is suggested that through implementation of an MPA, fishing pressure, to a degree, on juvenile stocks would be alleviated. In addition, the high quantities

of recorded trash must be addressed through region-wide efforts to educated stakeholders in responsible waste management practices. Unfortunately, neglected fishing items, large trash items (plastic bags) can cause severe harm to marine organisms when discarded, a term known as 'ghost fishing' and will directly mitigate any future benefits from ordinance.

Recommendations

Santa Paz Norte is a very viable location for future marine protected area (MPA) implementation.

The first suggestion is that the whole area surveyed here is included in protection, excluding O07 and O08 (Fig 10A, Table 3)).

Transects 1-6 were the most diverse and would offer the community great benefits if ordinances were respected. This is also in accordance to the previous recommendations made. This recommendation however, would need respectful consultation with barangay officials and community members to ensure viability and support.

With any degree of ordinance that protects areas from activities, particularly fishing efforts, fisherfolk displacement is inevitable. Therefore, it is highly recommended that following the submission of these recommendations, consultations are established between all key stakeholder groups with Santa Paz Norte. Discussions, through participatory planning, enabling

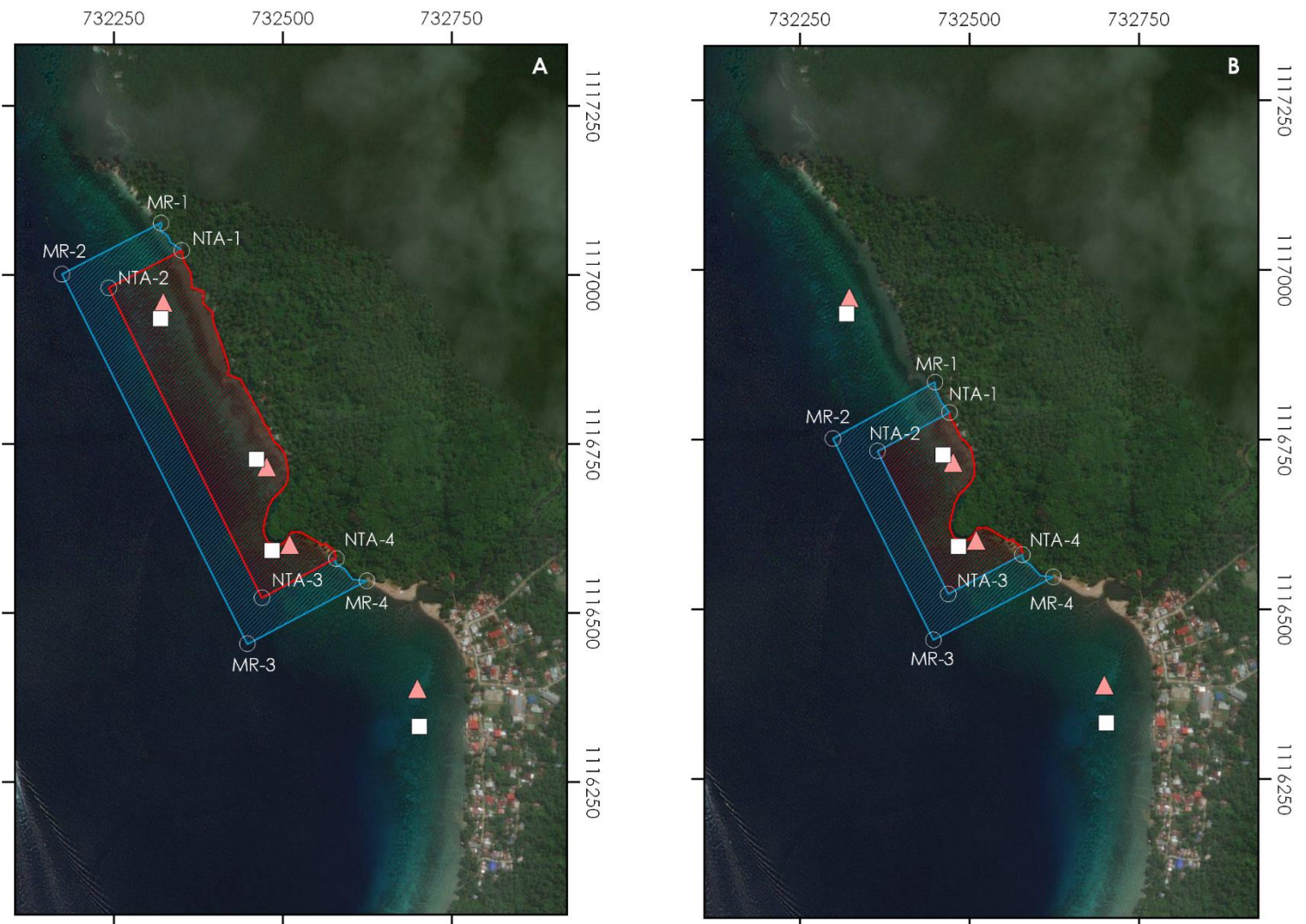


Figure 10. Marine Spatial Management recommendations (A & B) for the establishment of a No-Take Area (red) and Marine Reserve (blue) in barangay Santa Paz Norte, San Francisco, following a marine spatial ecological assessment.

Table 3. Marine Spatial Management recommendation respective UTM coordinates for demarcation buoy locations including each recommendation's area (ha).

Option	Demarcation Buoy	Easting (UTM)	Northing (UTM)
A	NTA-1	732350.21	1117036.21
	NTA-2	732242.23	1116980.90
	NTA-3	732468.92	1116522.64
	NTA-4	732578.60	1116581.30
	MR-1	732319.60	1117077.20
	MR-2	732172.80	1117001.70
	MR-3	732447.20	1116454.90
	MR-4	732624.10	1116548.30
NTA (ha)		5.88	
MR (ha)		4.40	
Total		9.98	
B	NTA-1	732470.40	1116789.90
	NTA-2	732363.60	1116734.00
	NTA-3	732468.69	1116522.61
	NTA-4	732578.02	1116580.42
	MR-1	732449.20	1116834.80
	MR-2	732298.46	1116751.70
	MR-3	732446.93	1116454.70
	MR-4	732623.90	1116548.00
NTA (ha)		2.38	
MR (ha)		2.94	
Total		5.32	

each key group to contribute to the proposed ordinance, will allow for mitigation against displacement, empower stakeholders and ultimately, increase compliance. If the original ordinance cannot be agreed, it is recommended that transects 1-4 are sort for protection with the establishment of an NTA, encapsulated by a 50m buffer zone (Fig. 10B, Table 3). The 50m buffer zone would enable extraction, but it is recommended such extraction methods are limited to highly selective gear types.

Community education is vital in the planning and implementation phases of this ordinance. Through inclusive discourse, plans can be made to the benefit of all members and through education, it can be taught that through protection, future generations can benefit from the ordinance. Without protection, this area of Sogod Bay is vulnerable to further destruction under the increasing anthropogenic interactions and climatic impacts.

If ordinance is approved, it is important that a Bantay Dagat is employed by the barangay to enforce legislation in the early

stages of implantation. It is known that with consistent and thorough patrol of MPA systems, they are more respected by the community and benefits occur quicker. Payment of such role can be funded through thorough management of the MPA itself. As there is already known interest in the site among divers, charging a fee for use can directly be used to assist payment of Bantay Dagat salary.

Clear demarcation is vital to ensure clear visual aid for the ordinance. If there are not clear demarcation buoys, then this allows for mistakenly fishing within the boundaries or makes it extremely difficult to reprimand any person(s) who participate in any illegal activity.

Coral Cay Conservation is able to assist in all stages of planning and implementation and, with the contributions from PGSL and the Municipality of San Francisco, this could be a valuable asset to SPN and the community.

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 inclusion, this will result in least conflict and security of future regulations.

Acknowledgments

Coral Cay Conservation would like to extend its heartfelt gratitude to the following people and organisations, without whom this project would not have been possible.

Firstly, our government partners, Provincial Governor for Southern Leyte, Hon. Damian G Mercado, Vice-Governor, Hon. Jessica Marie E Pano and the Provincial Board members and Sir. Nedgar V. Garves and all the staff at the Provincial Tourism Office.

Secondly, Ma'am Eva Abad, Sir. Armando Gaviola and all the staff at the Provincial Environmental and Natural Resource Management Office (PENRMO) who

provide requests for survey sites and assist the establishment of MPA ordinance following reports such as this.

The compliance from the Barangay Captain and the Barangay Council of Himbangan have been integral for attaining the data supporting this study.

Our Filipino staff, Bok, Dodong and Ricky whose loyalty, trust, and dedication are highly valued for continued work throughout Southern Leyte. Finally, all the dedicated international volunteers and staff who gathered the data and made this project possible; Charlie Heney, Stuart Ross, Jose Ydel, Edmund Keall, Maria Villegas, Leonie Messmer and Katie Dyson.

Methods

The assessment of the surveyed areas was conducted through an enhanced Reef Check protocol (Hodson & Liebler, 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 at 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 & Walters, 1992), b = species-specific growth parameter (Quinn & 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).

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 & 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

Table 4. Depths (m) and coordinates (UTM) of 100m transects surveyed Barangay Santa Paz Norte, San Francisco, Southern Leyte.

Transect Number	Depth (m)	Easting (UTM)	Northing (UTM)
I01	6	732451	1116714
I02	12	732436	1116725
I03	6	732485	1116599
I04	12	732459	1116590
O05	6	732298	1116957
O06	12	732294	1116933
O07	6	732674	1116386
O08	8	732677	1116330

Table 5. The calculated Length-Weight allometric coefficients to determine the biomass (kg) of sized Grouper, Snapper and Parrotfish within Santa Paz Norte, Southern Leyte, the Philippines.

Genera	Species	Common Name	Allometric Coefficients	
			<i>a</i>	<i>b</i>
Serranidae	Other	Grouper	0.0145	3.0225
	<i>Cromileptes altivelis</i>	Barramundi Cod	0.0138	3.28
Lutjanidae	Other	Snapper	0.0147	3.0312
Scaridae	Other	Parrotfish	0.0152	3.0398
	<i>Bolbometapon muricatum</i>	Green Humphead Parrotfish	0.0138	3.03

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).

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

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 submassive
Acropora digitate	Acropora tabulate	Non-Acropora branching
Non-Acropora encrusting	Non-Acropora foliose	Non-Acropora submassive
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.

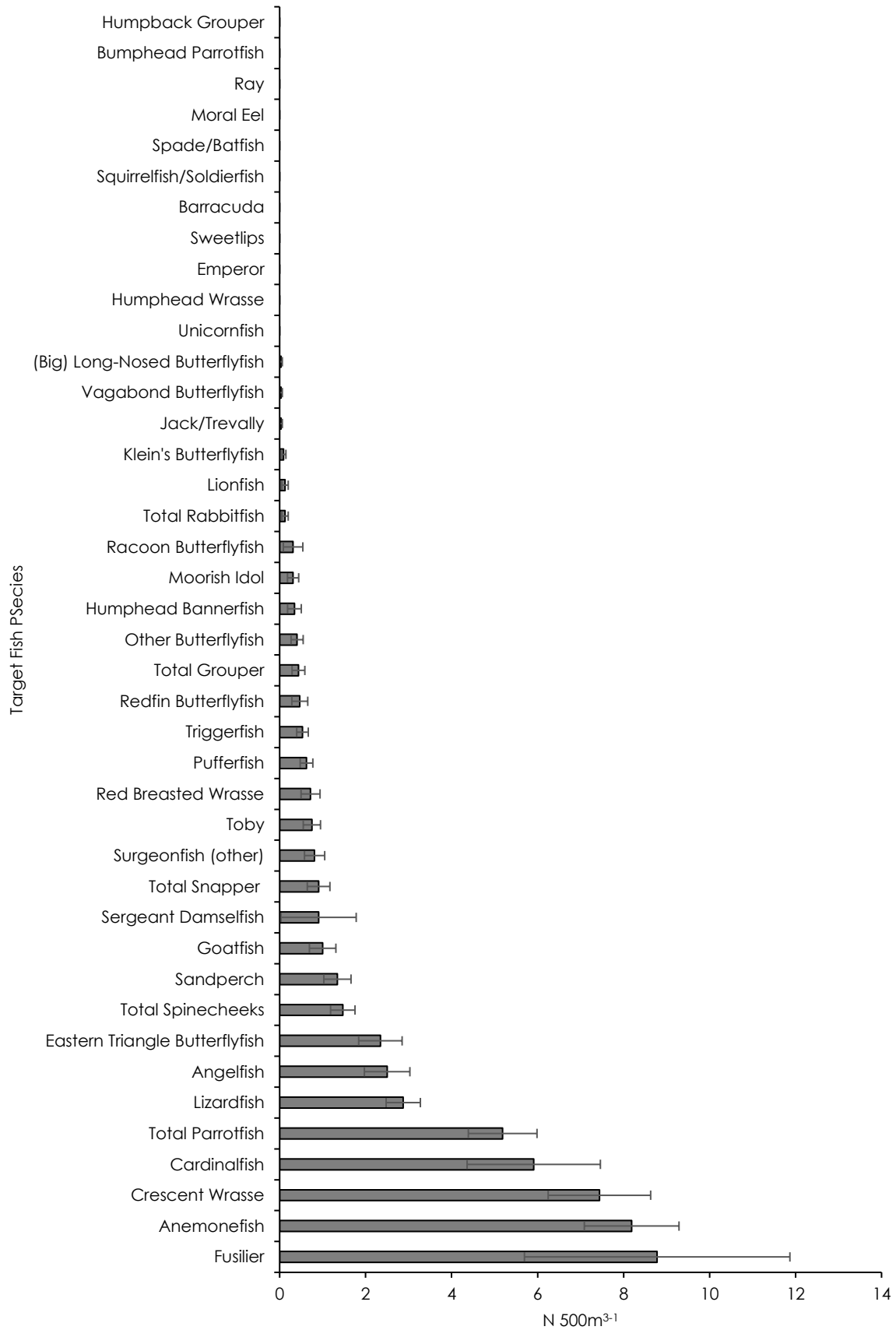


Figure SM 1. Mean abundance of target fish species and families per 500m²⁻¹ (± SE) across the survey site of Santa Paz Norte, San Francisco, Southern Leyte.

A)	I01	I02	I03	I04	O05	O06	O07	O08
I01		.028					.028	.025
I02	.028						.028	.025
I03							.027	.024
I04							.029	.026
O05							.029	.026
O06							.028	.025
O07	.028	.028	.027	.029	.029	.028		
O08	.025	.025	.024	.026	.026	.025		

B)	I01	I02	I03	I04	O05	O06	O07	O08
I01							.028	.028
I02	.028						.028	.028
I03							.028	.028
I04							.028	.028
O05							.028	
O06							.028	.028
O07	.028	.028	.028	.028	.028	.028		
O08	.025	.028	.028	.028		.028		

Figure SM 2. Matrices showing significant differences in mean A) SPECIES Richness (S) and B) Shannon Weiner Diversity (H') per 500m³ across all transects in Santa Paz Norte, Liloan, Southern Leyte. A green cell indicates cover was significantly higher at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue cell 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. P-values included where relevant.

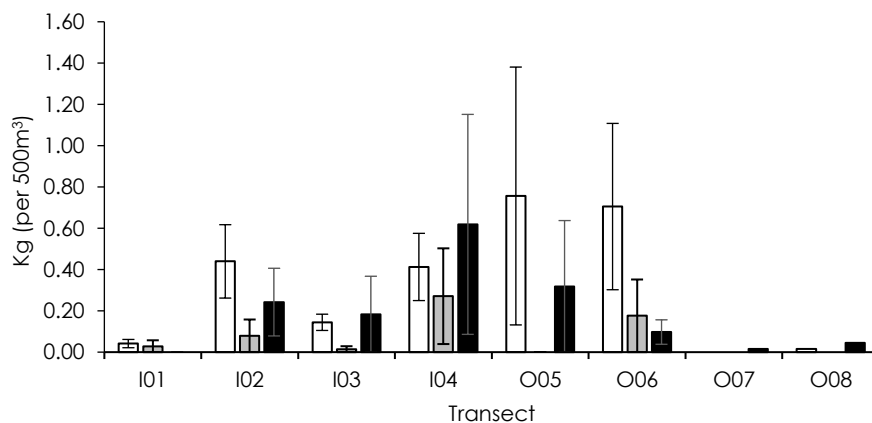


Figure SM 3. Mean Parrotfish (white), Snapper (black) and Grouper (grey) biomass (kg) per 500m³ ($\pm$ SE) between transects at Santa Paz Norte, San Francisco, Southern Leyte.

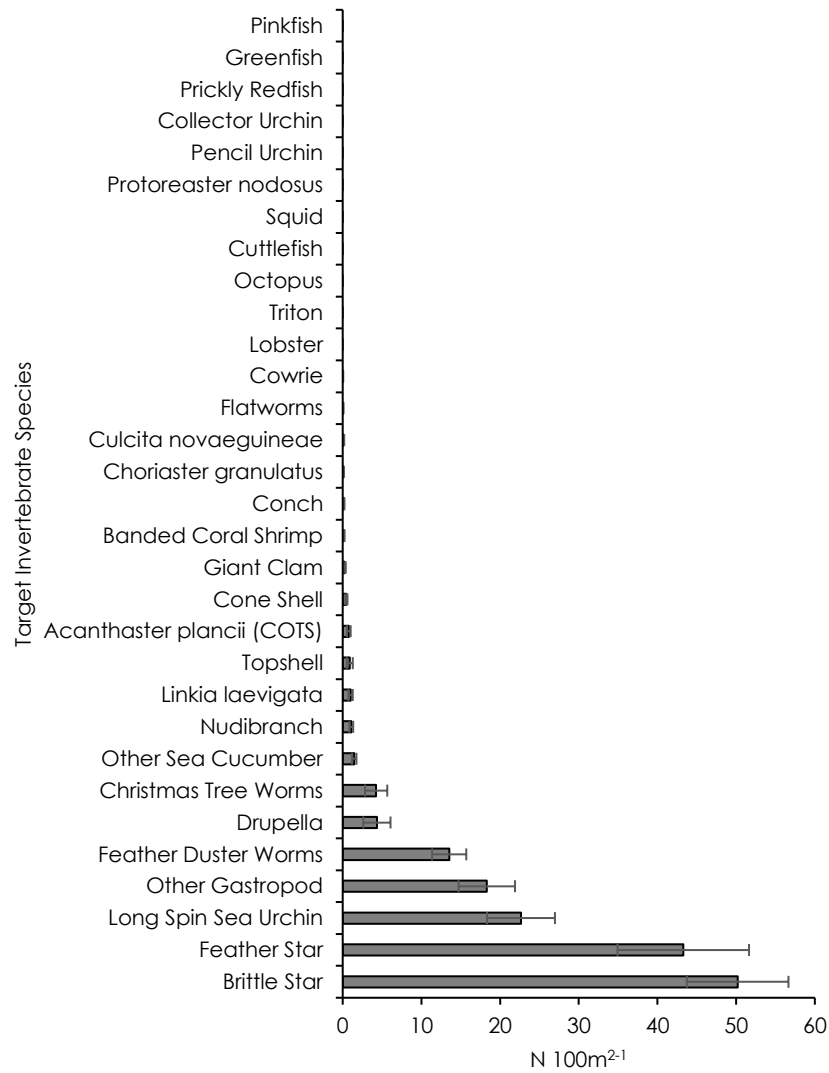


Figure SM 4. Mean abundance of target invertebrate species and families per 100m²⁻¹ (±SE) ACROSS THE SURVEY SITE OF Santa Paz Norte, San Francisco, Southern Leyte.

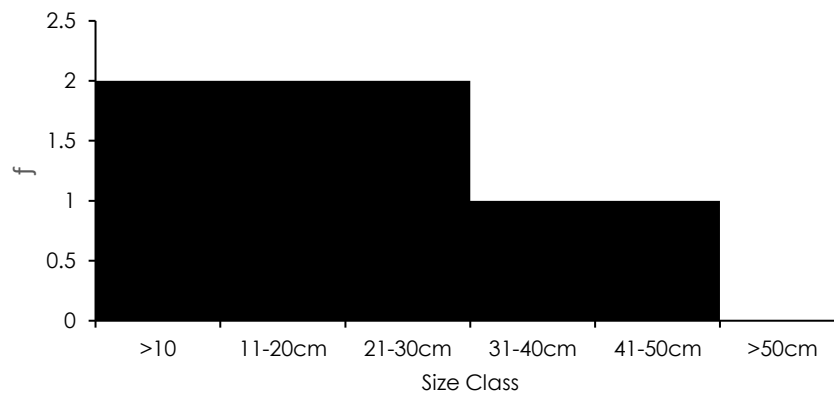


Figure SM 5. Total frequency of Giant Clams found in various size categories across the survey site of Santa Paz Norte, San Francisco, Southern Leyte.

A)	I01	I02	I03	I04	O05	O06	O07	O08
I01							.028	.025
I02							.028	.025
I03							.028	.025
I04							.028	.025
O05							.028	.025
O06							.027	.024
O07	.028	.028	.028	.028	.028	.027		
O08	.025	.025	.025	.025	.025	.024		

B)	I01	I02	I03	I04	O05	O06	O07	O08
I01						.028		.028
I02								.028
I03								.028
I04								.028
O05								.028
O06	.028							.028
O07								
O08	.028	.028	.028	.028	.028	.028		

C)	I01	I02	I03	I04	O05	O06	O07	O08
I01								
I02								.028
I03								
I04								
O05								
O06								.028
O07								
O08		.028				.028		

Figure SM 6. Matrices showing significant differences in mean invertebrate A) Species Richness (S) and B) Shannon Weiner Diversity (H') per 500m³ across all transects in Santa Paz Norte, Liloan, Southern Leyte. A green cell indicates cover was significantly high and C) Pielou's Evenness (J) per at the surveyed transect on the left compared to transect at the top ($p < 0.05$). A blue cell 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. P-values included where relevant.

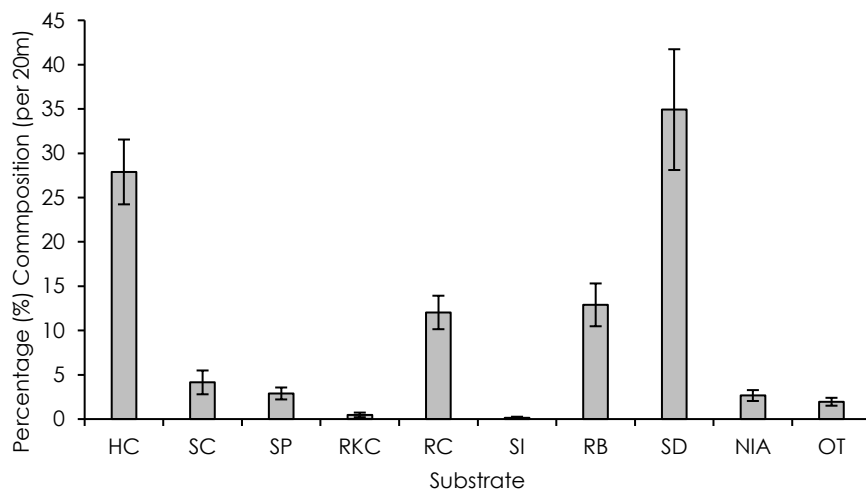


Figure SM 7. Mean composition (%) substrate per 20m across the survey site of Santa Paz Norte, San Francisco, Southern Leyte. ($\pm$ SE). RKC= Recently Killed Coral, OT= Other, SC= Soft Coral, SP= Sponge, SI= Silt, HC= Hard Coral, NIA= Nutrient Indicator Algae, RC= Rock, RB= Rubble and SD= Sand.

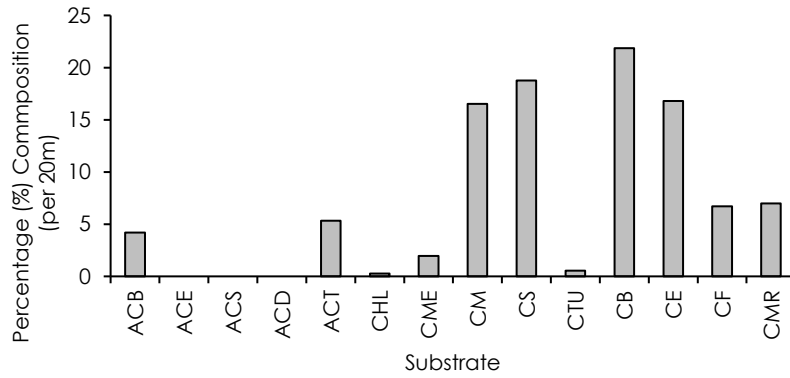


Figure SM 8. Mean percentage (%) of Hard Coral life forms per 20m within the survey site at Santa Paz Norte, San Francisco, Southern Leyte. ACB= Acropora Branching, CTU= Tubipora spp., CME= Millepora spp., CHL= Heliopora spp., CMR= Non-acropora Mushroom, Cf= Non-acropora Foliose, ACT= Acropora Tabulate, ACD= Acropora Digitate, ACS= Acropora Submassive, ACE= Acropora Encrusting, CS= Non-acropora Submassive, CM= Non-acropora Massive, CB= Non-acropora Branching and CE= Non-acropora Encrusting.

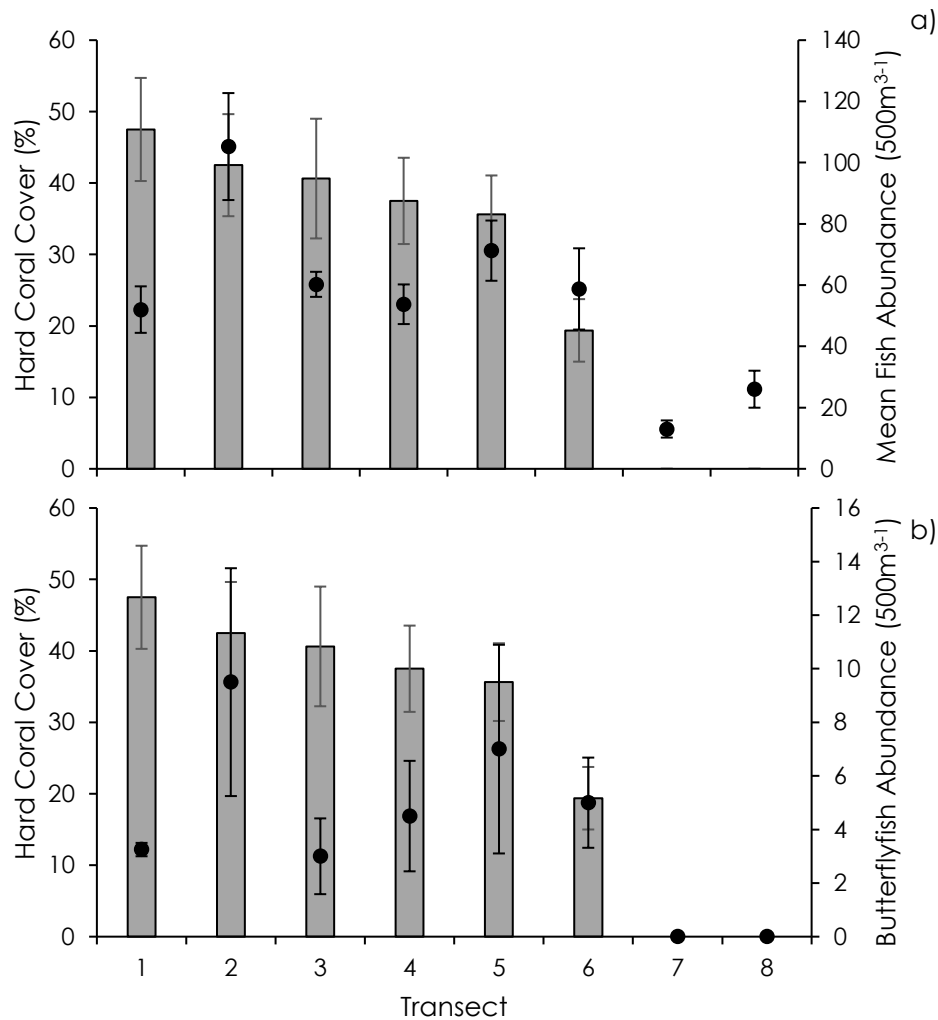


Figure SM 9. Mean Hard Cover composition (grey bars) at each transect surveyed in Santa Paz Norte, San Francisco, Southern Leyte compared to a) Mean Fish Abundance (500m³-1) ($\pm$ SE) and b) Butterflyfish abundance (500m³-1) ($\pm$ SE).

Table SM4. Mean percentage (%) cover of benthic substrate types per 20m with standard error ($\pm$ SE) between transects in Santa Paz Norte, San Francisco, Southern Leyte. HC = Hard coral, SC = Soft coral, SP = Sponge, RKC = Recently Killed Coral, RC = Rock, SI = Silt, RB = Rubble, SD = Sand, N/A = Nutrient Indicator Algae and OT = Other.

Transect	HC			SC			SP			RKC			RC			SI			RB			SD			N/A			OT		
	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med	%	$\pm$	Med
I01	47.50	7.22	47.50	0.63	0.63	0.00	1.88	1.88	0.00	1.88	1.88	0.00	25.00	5.10	25.00	0.63	0.63	0.00	20.00	8.10	16.25	0.00	0.00	0.00	0.63	0.63	0.00	1.88	0.63	2.50
I02	42.50	7.14	41.25	6.25	2.98	3.75	2.50	1.02	2.50	0.63	0.63	0.00	10.63	3.59	10.63	0.00	0.00	0.00	18.13	5.53	17.50	15.00	2.70	16.25	1.25	1.25	0.00	3.13	0.63	2.50
I03	40.63	8.38	40.00	8.13	4.13	7.50	8.13	1.57	7.50	0.00	0.00	0.00	22.50	3.06	22.50	0.00	0.00	0.00	7.50	2.50	10.00	5.00	4.21	1.25	3.13	1.20	3.75	5.00	2.04	5.00
I04	37.50	6.04	33.75	15.63	7.02	17.50	6.25	2.60	6.25	0.00	0.00	0.00	17.50	4.68	17.50	0.63	0.63	0.00	8.13	3.13	8.75	8.13	5.04	5.00	4.38	1.20	3.75	1.88	1.20	1.25
O05	35.63	5.44	33.75	1.25	0.72	1.25	2.50	1.02	2.50	1.25	0.72	1.25	14.38	2.58	14.38	0.00	0.00	0.00	22.50	6.04	18.75	19.38	8.56	21.25	1.25	0.72	1.25	1.88	1.88	0.00
O06	19.38	4.38	18.75	1.25	1.25	0.00	1.88	1.88	0.00	0.00	0.00	0.00	5.63	2.77	5.63	0.00	0.00	0.00	26.88	9.15	21.25	38.75	2.39	37.50	4.38	2.13	3.75	1.88	0.63	2.50
O07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.25	3.75	###	3.75	3.75	0.00	0.00	0.00	0.00
O08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.63	0.63	0.63	0.00	0.00	0.00	0.00	0.00	0.00	96.88	1.20	96.25	2.50	1.44	2.50	0.00	0.00	0.00