Escalante Biodiversity and Ecosystem Report 2020 - Sustainable Priorities and Sustenance

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Escalante Biodiversity and Ecosystem Report – 2020

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Escalante Biodiversity and Ecosystem Report – 2020

Sustainable Priorities and Sustenance

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Preliminary Ecological Assessment Project

Supported by **Escalante City**, **Conservation Diver**, **University of the Philippines Cebu** and **Love Wildlife Foundation**.

 This report is aimed at people with varying degrees of scientific understanding and background, from interested non-academics and representatives of the local governing body, to active biologists and marine biologists around the world.

Abstract

In 2018, the government of Escalante city sought to improve the sustainability of marine resource utilisation within Escalante waters as part of a larger overhaul of sustainable resource use within its borders. As part of this effort, Conservation Diver was approached to provide an ecological assessment of species richness and ecosystem health within Escalante, with a particular focus on assessing the suitability of the Marine Protected Area (MPA) within Escalante waters, 15 years after its initial designation. Surveys were conducted at multiple locations throughout the Escalante coastline to provide an initial inventory of species found, with further ecological assessments being carried out in coral reefs at various sites. A total of 714 species were recorded in Escalante waters during the survey period. Coral reefs surveyed were found to be highly variable in their community structure and coral cover, and were found to support generally low abundances of reef-associated fish and invertebrates, particularly of those groups which were known to be of commercial value. Surveys of the fish market yielded remarkably high levels of legal and illegal catch from within reef areas. Surveys within the currently designated MPA revealed very little coral cover and drastically lower biodiversity or commercially valuable marine resources of virtually any kind when compared to most surveyed locations within Escalante waters. We therefore propose alternative zonation strategies and improvements to the sustainability of resource use at Escalante and provide an initial framework for further assessment and development of sustainability within Escalante waters.

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Contents

1 - Introduction

There is little doubt today that global biodiversity and ecosystem health is suffering under the pressure of natural and human-induced threats. Inaction or underwhelming responses to global challenges, combined with a lack of information on many crucial variables (i.e. the present-day status of most known species) has led to dire predictions for global economic, ecological and environmental health (Braat et al., 2008; Ten Brink et al., 2010; Oliver 2016). Arguably, the most well-known and comprehensive databases of species status and threats is the International Union for the Conservation of Nature Red List, which has assessed the status of over 112,000 species at the time of writing (IUCN 2020). Due to biases and challenges in the assessment protocols of the Red List (Hayward et al., 2015; Collen et al., 2016; Cowie et al., 2017), however, these efforts remain largely ineffective at monitoring overall biodiversity loss as well as local and even complete extinctions of the vast majority of the approximately 2 million known fauna (Cardoso et al., 2012; Cowie et al., 2017). It is therefore apparent that greater efforts must be made in mapping and monitoring biodiversity globally, particularly in ecologically rich and unique areas, as well as those areas that have been overlooked. When combined, localised assessments of such places and of broader taxonomic groups (i.e. those outside of Chordata) can provide a more comprehensive analysis of changes in biodiversity and ecosystem health, while contributing to the understanding of the issue over larger spatial scales. More so, knowledge of an ecosystem, when managed appropriately, can lead to economic gain and sustainability in the surrounding community (Samonte et al., 2016; Spalding et al., 2017).

The Philippines is located within the 'Coral Triangle', a region representing some of the greatest marine biodiversity on the planet (Veron et al., 2009; White et al., 2014). The exceptionally high biodiversity within the Philippines, while objectively well accepted (i.e. Carpenter and Springer 2005; Gosliner et al., 2018), remains largely understudied (Scheffers et al., 2012; Gosliner et al., 2018). The most recent and extensive assessment of coral reefs throughout the Philippines has shown that sizeable areas of the Philippines reefs and coastal habitats remain to be surveyed and assessed (Licuanan et al., 2017). Additionally, the marine protection initiatives in place within the country have been shown to be highly variable in their enforcement and resulting efficacy, with many areas shown to be lacking in protection. Marine Protected Areas (MPAs) are typically coastal or offshore areas theoretically designated to be subjected to higher than local-average levels of protection and enforcement so as to promote recovery and/or growth of marine resources. Within the coral triangle, MPAs are typically designed with at least one of two main factors in mind: a) economic growth or sustainability by promoting fisheries resources or tourism, and b) ecological protection of threatened marine organisms or habitats, often combined with regulated tourism (Abesamis et al., 2006; White et al., 2014).

Numerous reviews and case studies have been conducted about MPAs within the Philippines, which hosts some of the highest numbers of MPAs in the region, however, the success of many has been debatable for years (see White and Cruz-Trinidad 1998; Aliño et al., 2002; 2004; Beger et al., 2004; Samoilys et al., 2007; White et al., 2002; 2014; Espectato et al., 2017; Sato et al., 2017). A lack of comprehensive and cohesive stakeholder involvement and, in particular, insufficient or inefficient enforcement practices leave many MPAs effective on paper only, hence the term 'paper parks' or 'paper-MPAs' (Ross et al., 2002; Launio et al., 2010; Horigue et al., 2012). While consensus on the definition of a 'MPA' or site-specific strategies for optimal marine resource protection are yet to be reached, numerous elements and recommendations are generally agreed upon. These include a) that ineffective enforcement is a weak link, b) a lack of stakeholder and/or political will, results in sub-par zonation and c) that networks and corridors of protected areas are vital instead of isolated MPAs.

Various attempts have been made to provide an economic valuation for the variety of ecosystems in South-East Asia with the more comprehensive reviews (i.e. Conservation International 2008) comparing the Philippines to other regions under some standardised criteria. As values of coral reefs in the Philippines have been calculated using different methodologies, there is variability in the estimations, with total annual benefits of these ecosystems ranging from approximately USD 450 million to USD 1.4 billion (~ USD 266,000 – 827,500 per km^2) (White et al., 2000a; White et al., 2000b; Burke et al., 2002; Samonte-Tan and Armedilla 2004; Samonte-Tan et al., 2007). These are often based on extrapolations from localised assessments and vary on inclusion and exclusion of certain passive benefits such as erosion protection and aesthetic value. Among the leading contributors to the valuation of the Philippines coral reefs is that of tourism which has played an increasingly dominant role in recent decades (see Samonte et al., 2016; Spalding et al., 2017 and others). Similarly, valuations of mangrove and seagrass habitats in the Philippines have highlighted the importance of tourism in such areas (White et al., 2000a; Samonte-Tan et al., 2007; Conservation International 2008). Indeed, tourism related to understudied and ill-defined subtidal soft sediment habitats (or 'muck' habitats) has been shown to support a USD 150 million SCUBA diving industry, to which the Philippines is a large contributor (De Brauwer et al., 2017). Recent assessments by the Philippines Statistics Authority (PSA 2018) suggests the value of coastal and marine tourism nationwide (including all ecosystems) has increased from USD 2.461 billion in 2012, peaking at USD 3.055 billion in 2015, and then USD 2.992 billion in 2016.

With regards to fisheries production associated with coral reefs in the Philippines, precise estimates are limited by a lack of standardisation and accepted definitions. Overall, some attempted assessments have been made in highly localised areas comparing biodiversity and abundance of catch between reef-associated and non reef-associated species (i.e. Galenzoga and Quiñones 2014; Mehrotra et al., 2017). The role of overfishing and habitat loss in shifting fisheries management in the Philippines has been documented for many years, alongside its position as a dominant region for global fisheries production (Green et al., 2003; FAO, 2005). The changes and impacts of such exploitation are also the case for the central Visayas region (Green et al., 2004). For context, over-exploitation and a changing climate have contributed to changes and challenges in global fisheries and have resulted in losses amounting to between 51 and 83 billion USD annually (Cashion et al., 2018). In particular, global tropical fisheries have faced many challenges with many areas, including the Philippines, continuing to employ illegal and destructive fishing practices, with declines in coral coverage associated with parallel declines in fish biodiversity (Jones et al., 2004).

In recent years, members of Conservation Diver have consulted upon the zonation of MPAs and assessments of biodiversity, health, and threats at Toboso, North-East Negros Occidental (Mehrotra et al., 2016; 2017). Escalante is within the Tañon strait and thus management efforts are a part of the Tañon Strait Protected Seascape (TSPS), which remains among the largest bodies of water in the Philippines with a mandate for protection. Unlike other formally designated MPAs elsewhere in the Philippines, the TSPS provides a set of common guidelines and requirements for protection for each of its over 40 bordering municipalities and jurisdictions to then individually delineate and manage (TSPS-GMP 2015). The Tañon Strait and other areas in the Visayas have undergone some assessments regarding the efficacy of MPAs, (i.e. Pollnac et al., 2001; Christie et al., 2009) however, few intensive assessments have been carried out regarding total faunal diversity and high spatial resolution assessments of reef habitats.

Aims and Premise

Escalante is currently classified as a 4th income class city (PSA 2019) in the North-East of Negros Occidental. It hosts an estimated population of 94,000 people, with the main industry being agricultural production of sugar cane, and to a smaller extent, rice and corn (Guadalquiver and Nicavera, 2019). Escalante has 19 Barangays (a Barangay is the smallest administrative division in the Philippines), seven of which are coastal (Amante, 2019). Escalante currently hosts an MPA of over 1,300 hectares, established five years after the creation of the TSPS in 1998 (Escalante city ordinance 156, October 2003), which was later developed and incorporated into the present zonation (Fig 1, Appendix I). As part of efforts by the governing body to update and improve the sustainable use of marine resources at Escalante, members of Conservation Diver were approached to assist in this aim. Specifically, consultation was sought regarding a) classification and diversity of faunal marine resources, b) assessment of status and long-term prognosis of those resources, and c) assessment on suitability of the present MPA currently delineated within Escalante. Here we present the targeted objectives, protocols and findings of this assessment for primary use by the Escalante city to improve sustainable use of the natural marine resources at Escalante.

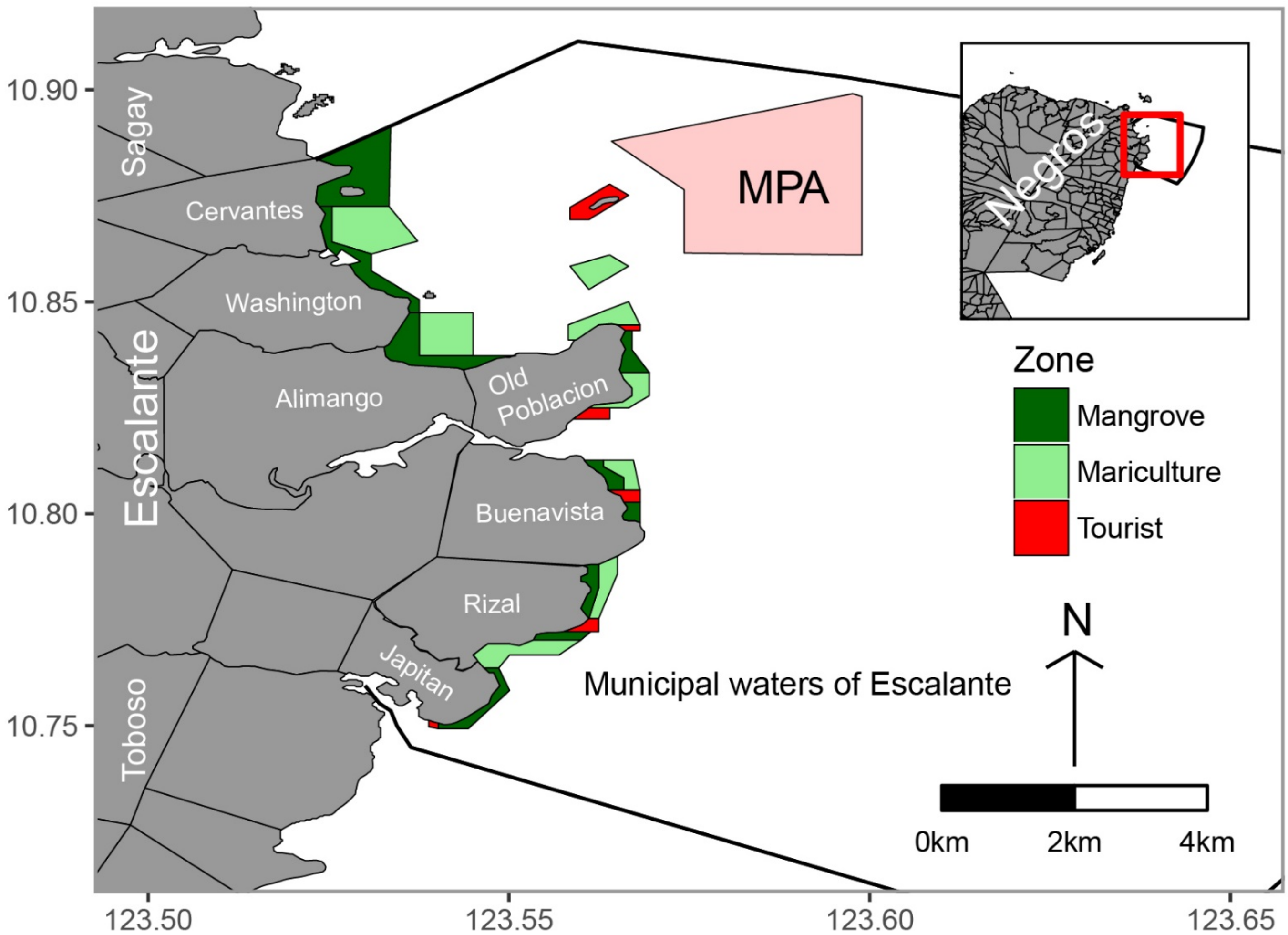


Figure 1 – Partial zonation map of Escalante highlighting areas currently allocated to marine protection (MPA), mangrove restoration, mariculture, and tourism, modified from complete zonation information provided by Escalante city.

Objectives Summary:

1) Conduct a preliminary inventory of marine flora and fauna in the coastal ecosystems of Escalante.

2) Evaluate the current health of and threats to the coastal ecosystems of Escalante, with a particular focus on coral reefs

3) Investigate the status of the fishery at Escalante

3) Assess the state and suitability of the designated MPA at Escalante.

4) Assess the effectiveness of the Coastal Patrol/Bantay Dagat in preventing illegal and unsustainable practices at Escalante

5) Provide recommendations to improve the ecological and economic value of the coastal habitats of Escalante and propose solutions to threats to the longevity and sustainable use of these coastal areas.

2 - Methodology

Field surveys were conducted in the form of transect surveys and roving surveys and were carried out between the 2nd and 25th of March 2018. Roving surveys were implemented at a variety of habitat types, both nearshore and offshore, and were completed via both snorkelling and SCUBA diving at depths ranging from 0.5m to 25m. A focus was applied to coral reef and soft sediment habitats so as to maximise data from both high biodiversity and highly cryptic areas. Surveys were also carried out at some nearshore and offshore mangroves, and seagrass habitats. Photographic documentation was carried out using Olympus TG4 and TG5 cameras and housings. Where possible, the morphology of species was investigated, and size approximated *in-situ* to support photographic species distinctions. Precise GPS coordinates for all sites surveyed were collected using a Garmin eTrex® 20x GPS receiver (Fig. 2, Table 1). Surveys were carried out at both day and night-time and included sites both within and outside the currently designated MPA.

Table 1 – Coordinates for surveyed sites for overall ecological assessment and biodiversity inventory efforts only.

Ecological Assessment Site		Biodiversity Assessment Site
A	10° 54'27.35"N - 123°33'49.79"E	10° 53'43.30"N - 123°33'58.58"E
B	10° 53'33.45"N - 123°34'16.41"E	10° 53'33.83"N - 123°34'10.32"E
C	10°52'28.05"N - 123°32'11.69"E	10° 52'22.53"N - 123°32'59.29"E
D	10° 50'34.54"N - 123°33'20.79"E	10° 53'39.40"N - 123°34'21.76"E
E	10° 53'0.75"N - 123°33'30.17"E	10° 51'59.46"N - 123°33'58.53"E
F	10° 51'10.17"N - 123°33'37.31"E	10° 49'42.81"N - 123°35'12.72"E
G	10° 50'45.16"N - 123°34'04.87"E	10° 52'28.11"N - 123°34'32.98"E
H	10° 52'12.69"N - 123°34'34.53"E	
I	10° 45'24.91"N - 123°33'02.98"E	
J	10° 51'47.67"N - 123°34'19.32"E	
K	10° 49'43.33"N - 123°34'15.04"E	
L	10° 48'26.52"N - 123°33'57.51"E	

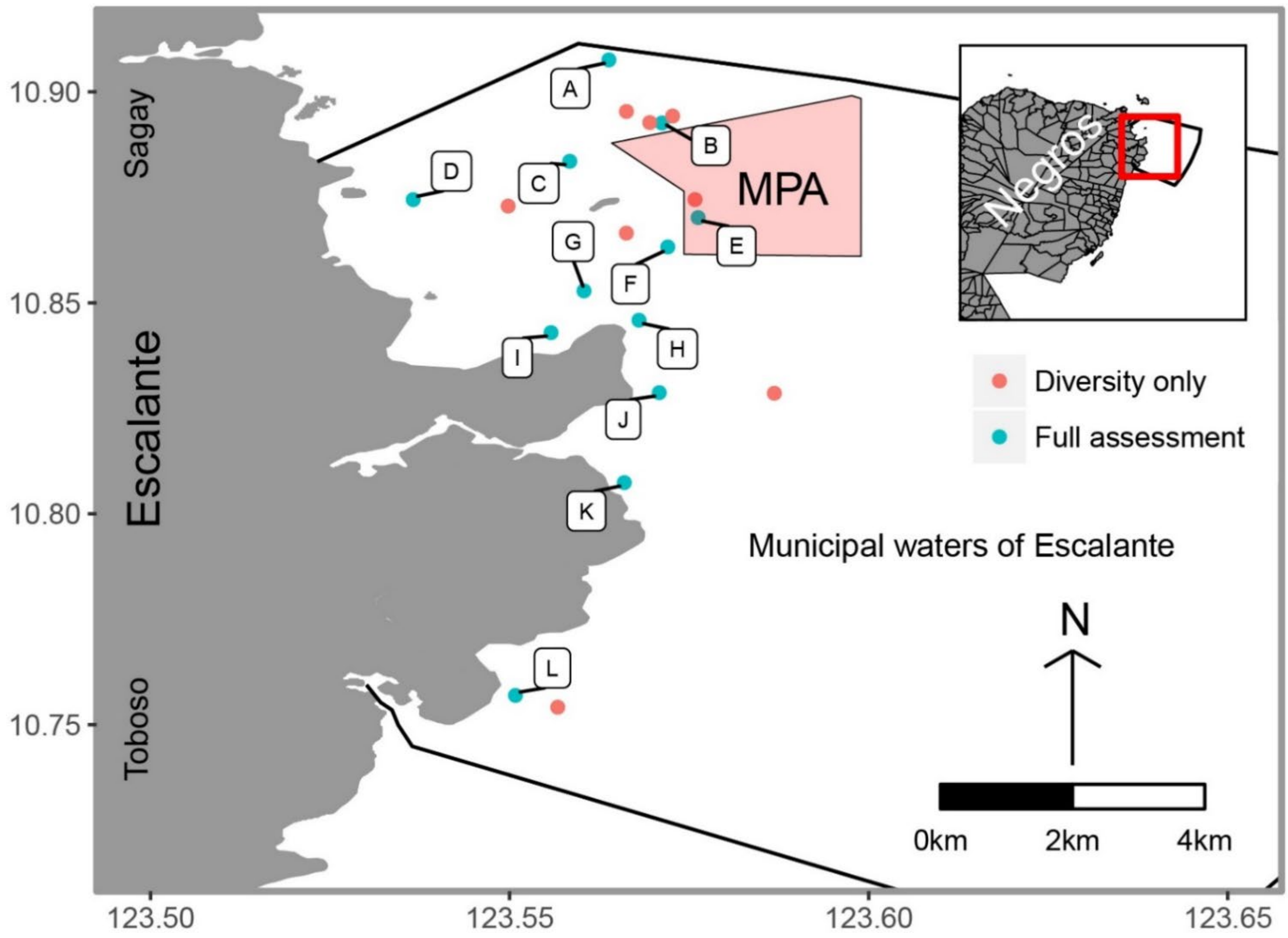


Figure 2 – Map of surveyed sites. Labelled sites correspond to those subject to ecological assessment in addition to biodiversity inventories, unlabelled sites corresponding to sites surveyed for biodiversity monitoring only.

As part of data collection efforts, focused night-time surveys were carried out on the coral reef for seven days starting on the night of the full moon on the 2nd of March. With the aim of investigating spawning patterns among the scleractinian corals, these surveys were conducted in addition to day-time surveys to maximise the observational period for incidental spawning events. During night-time surveys, large and healthy coral colonies were closely observed periodically between sunset and approximately 10pm. Surveys alternated between nearshore and offshore sites due to differences in coral community structure between these (see Results).

Transect surveys were carried out at multiple coral reef areas in both nearshore and offshore sites (Fig 2). All transect surveys followed the Ecological Monitoring Program protocol by Conservation Diver (Scott 2012) and, where possible, were carried out at two depths. Shallow transects were carried at reef areas between 2-4m and deep transects were carried out between 6-8m. Invertebrate indicator species largely overlapped with those carried out at Toboso (Mehrotra et al., 2016; 2017), including Tridacninae and Holothuridae species, with an added focus on those species observed to be of high commercial value to the local fishing community (*Lambis* spp., and Cypraeidae spp.). Additionally, data was collected on the abundances of the corallimorph *Paracorynactis hoplites* due to its well documented capacity as an opportunistic predator of numerous invertebrate taxa (Bos et al., 2011). Data could not be collected on several other commercially important bivalve and gastropod species (i.e. Volutidae spp.) due to these animals neither being active nor visible in the surveyed reefs during daytime. Vertebrate indicator species followed those in the aforementioned earlier studies from Toboso. These included the Acanthuridae (Surgeonfish), Chaetodontidae (Butterflyfish), Epinephelinae (Groupers), Lutjanidae

(Snappers), Pomacanthidae (Angelfish) and Scaridae (Parrotfish), with data being further subdivided arbitrarily into larger individuals (>20cm) and those approximately 20cm or smaller. Data was also collected on various other groups such as specific Pomacentridae and Labridae but these were not included in the present analysis. As with earlier studies, vertebrate transects were calculated per 100m^3 (5m width x 1m depth x 20m length).

Data was collected on the diversity and abundance of illegal fishing catch in Escalante. This was collected by joining the local sea patrol (Bantay Dagat, henceforth 'BD') during standard patrols as well as targeted excursions upon notification of illegal fishing activity. Surveys were also collected in the fish markets of Escalante in an attempt to assess the diversity and abundance of catch from local waters. Surveys lasted approximately 2 hours each and were carried out at least once a day for 15 days during the total 23-day survey period. Key variables included the approximate price of each fish/mix of fish being sold (in PHP) and approximate mass (kg) of fish being landed and sold. It should be noted that previous surveys from the region have shown that some of the catch from Escalante waters are sold elsewhere, often by fisherfolk from surrounding regions.

Fish market surveys allowed for a comparison of reef fish and non-reef fish sold for consumption at Escalante. While most species surveyed occupy distinct ecological niches and the categorisation of 'reef' versus 'non-reef' does not account for species-specific or indeed habitat-specific variability amongst others, species were generalised as one category or another. This was done by estimating the proportion of adult life a given species was known to spend within or in direct vicinity of coral reef areas. This was assessed based on relevant literature as well as in-situ observations conducted. Non-reef species were largely those that were found to inhabit open water or offshore benthos (such as the Menidae, Rhinobatidae, Scombridae, etc.). Benthic associated species that may be found at a variety of habitat types (such as those of the Mullidae, Tetraodontidae etc.) were not included as 'reef' so as to maintain conservative estimates for reef-specific species (such as many species of Chaetodontidae, Pomacentridae, etc.).

Figure 3 – Data is taken along transect lines for ecological assessments.

3 - Results

3.1 - Biodiversity Assessment

An estimated 4.5km^2 of the subtidal area was surveyed, including 1.5km of transect surveys along coral reef habitats in Escalante waters. Throughout the total in-situ and ex-situ (fish market and BD patrols) surveys, a total of 714 species were recorded (see supplement). Given that the prime focus of the biodiversity assessment was documentation of faunal taxa, little emphasis was given to biodiversity of algal and seagrass species which accounted for only 11 species, with the remaining 703 being marine fauna. Additionally, mangrove diversity was not included as comprehensive documentation on the diversity found is held at the local government. The greatest diversity of species were Cnidarians, followed by Chordates and Molluscs, all of which made up 76% of the total diversity presently recorded. Surveys from within the present MPA yielded 12% of the total diversity found in Escalante, with most species being recorded from multiple sites. An overview of taxa as divided by phylum is provided below.

Chordata

Among the most diverse taxa that were identifiable based on photographic and detailed morphological data, the vertebrate diversity in the area was 194 species. Unsurprisingly, this diversity was dominated by fish with only three species of marine reptiles, all snakes (*Acrochordus granulatus, Emydocephalus annulatus* and *Laticauda colubrina*) being recorded. While sea turtles are known from the region, none were recorded during the survey period. Though marine associated birds also make up an important part of the coastal ecology, these were not surveyed. Of the 191 fish species, 70 were documented exclusively ex-situ, primarily from fish market surveys (see supplementary data). For each, estimated location of catch (within or outside of Escalante) was verified in interviews with vendors. Only 22 chordate species were recorded from within the currently designated MPA. The most diverse families recorded were the Pomacentridae (21 species), Nemipteridae and Labridae (14 species each).

Figure 4 – Pomacentridae, *Amphiprion polymnus.*

Cnidaria


Figure 5 – *Acropora* spp., abundant at offshore reefs.

Cnidarians were found to be the most diverse group in Escalante waters with 227 species being recorded. The majority of these species were scleractinian corals comprising 143 species, followed by octocorals at 33 species and actiniarians at 20 species. The high scleractinian diversity is an incredibly promising feature of Escalante waters (see Discussion) and is reflective of the high diversity associated with the Philippines. Most of these reef building corals were successfully identified to tentative species level based on close morphological inspection, however, most octocoral taxa were kept broader due to the inability to sample and assess sclerite morphology. Only 28 of the total 227 species were recorded within the current MPA and all were also recorded at other sites. A total of 217 anthozoan species were identified with non-anthozoan taxa including seven hydrozoan species, two scyphozoans, and a single cubozoan. It is likely that further surveys will dramatically increase the known diversity of these groups.

Crustacea

The majority of documented crustacean diversity were decapod taxa which made up 36 of the total 40 species recorded at Escalante, with a single species of stomatopod and three distinct but unidentified species of Cirripedia. Eight species were found within the MPA site not including the three species of Penaeidae found in Escalante waters with known commercial value in both local and regional fisheries. One species found within the MPA and throughout numerous sites was the crab *Portunus* (*Portunus*) *pelagicus* which is of widespread commercial value. It is strongly believed that more extensive surveys will likely yield rapid increases in the documented diversity of Cirripedia, Decapoda, and Stomatopoda groups.

Echinodermata

Of similar scale to crustacean diversity was that of the echinoderms, of which 58 species were recorded during the surveys. Of these, 12 species were identified to be of commercial value, traded either locally or regionally, and ten species (including one of known commercial value) were found within the MPA site. Echinoderm diversity was largely divided into sea stars (Asteroidea, 19 species), sea urchins (Echinoidea, 14 species), and sea cucumbers (Holothuroidea). Importantly, it was noted that while Holothuroidea diversity was proportionally high (17 species), abundances of most of these sea cucumbers were relatively low which was reflected in both roving and transect surveys. Crinoid, Euryalid and Ophiurid diversity was proportionally low but likely strongly underrepresented, with the taxonomy and systematics of these groups requiring a proportionally greater sampling effort, and Ophiurids in particular being cryptic.

Figure 6 – Gorgonocephalidae, *Astroboa* sp.

Mollusca

Among the best represented phyla in Escalante waters, 120 species of mollusc were found during the surveys, with gastropods (94 species) making up the majority. The remaining diversity was comprised of 18 species of bivalve, seven species of cephalopod, and a single species of polyplacophoran (likely highly underrepresented). Of these, 24 species were found to be of commercial value, and 10 species (including one of commercial value) were found within the MPA. Interestingly, many of the mollusc species found within the MPA were documented in the vast areas of soft sediment habitats and were not documented outside the MPA. None of these, however, are known to be of conservation priority. Documentation of the ecologically and commercially important group Tridacnidae (giant clams) is discussed below.

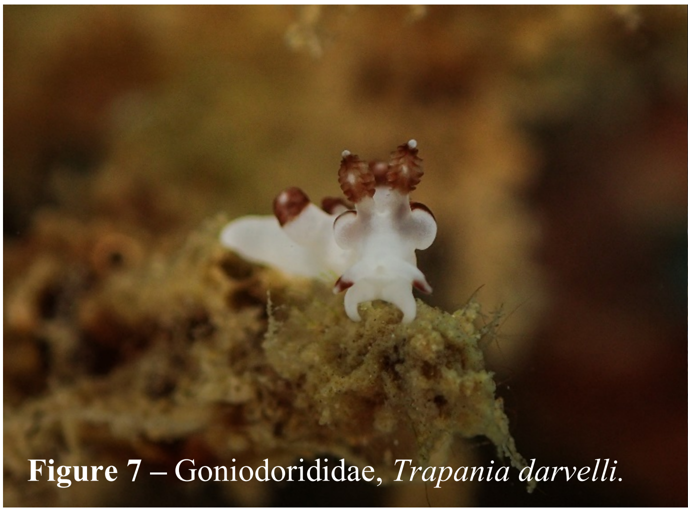


Figure 7 – Goniodorididae, *Trapania darvelli.*

Figure 8 – Volutidae, *Cymbiola vespertilio.*

Platyhelminthes

A relatively high diversity of Platyhelminthes was documented across the different habitats at Escalante with 27 species recorded throughout, including two species within the MPA. Where possible, species were identified based on currently available literature and close examination of their ventral surface and photography of their dorsal surface. The taxonomy of many polyclad flatworms, particularly those in the family Pseudocerotidae, awaits major updates as identification based on the external morphology of many species remains unclear. The cryptic nature of many small and non-aposematic species strongly suggests many more species are to be found in Escalante waters.

Other Groups

Not included in the above groups were those less represented in the overall diversity such as the single species of bryozoan (Bugulidae sp.), a single Acoelomorphan species (*Waminoa* sp. Morphotype A, see Kunihiro et al., 2019), two Nemerteans, two Ctenophora, nine Annelida, and 11 species each of Porifera and Tunicata. A focused study on each of these groups will undoubtedly reveal greater diversity in the area. The bryozoan, a few annelids and the abundant tunicate *Didemnum molle* were all found within the MPA but 31 species were found only outside the area. The only species found to be of commercial value not included in the larger phyla mentioned above were the algae of Caulerpaceae (particularly *Caulerpa racemosa*) and Halymeniaceae.

Figure 9 – Epibiosis on the coral *Goniopora* by the tunicate *Didemnum molle* and by cyanobacteria.

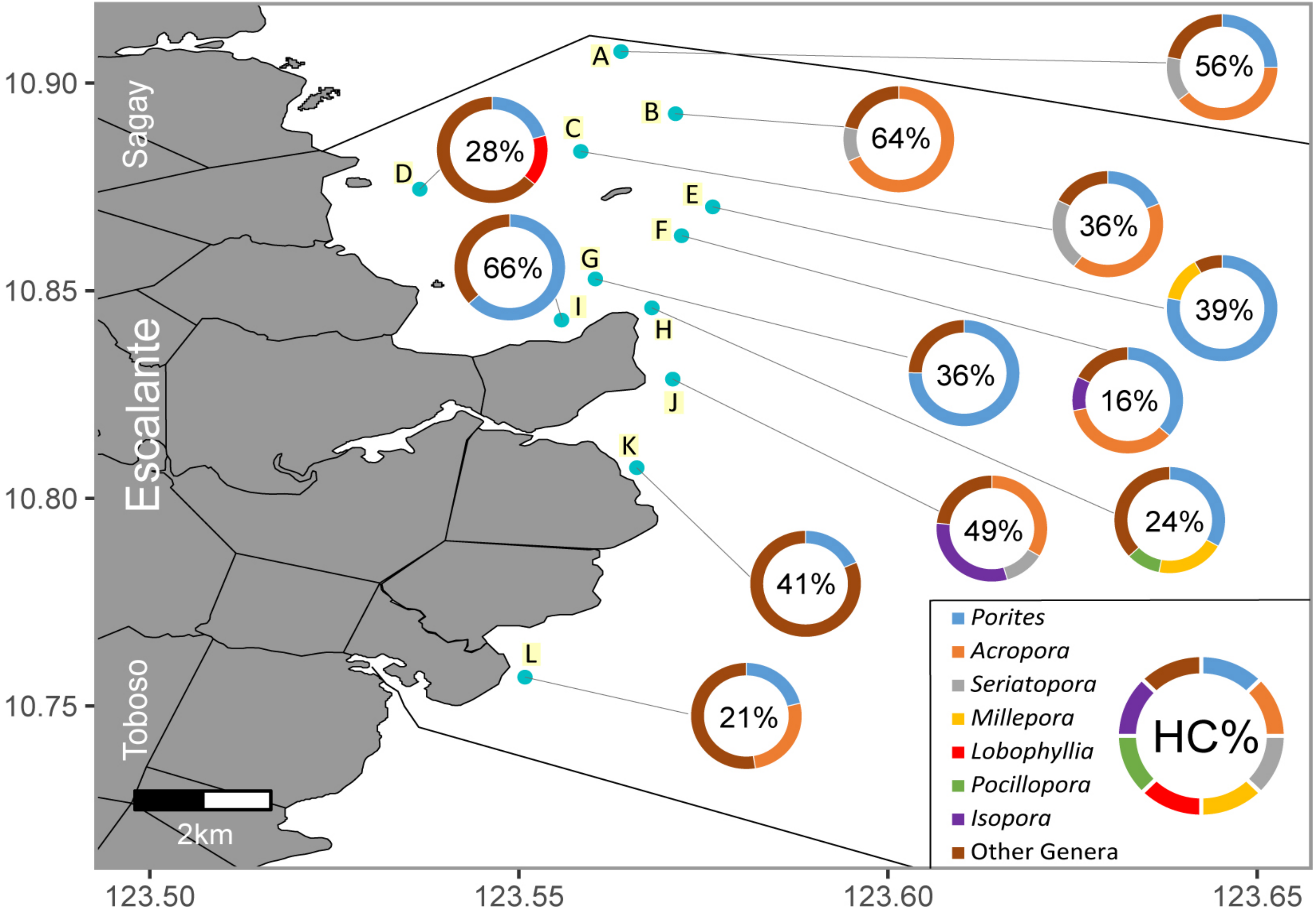
3.2 - Ecological Assessment

Coral Reef

While the different coral dominated reefs at Escalante are highly variable in terms of homogeneity and coral cover (Figs. 11 and 12), some common trends are visible throughout. The vast majority of coral cover at Escalante occurs at depths shallower than 6m, usually showing an abrupt shift from coral dominated substrate to soft sediments. This is particularly the case in the Northern half of the reefs surveyed, with areas of extended coral cover becoming more common further south. In terms of coral composition and community structure, reefs could generally be divided into the categories of nearshore fringing reefs and offshore reef habitats, with the north-south trend particularly prevalent at the fringing reefs. The offshore reefs tend to be more structurally complex (dominated by *Acropora* and *Seriatopora* corals) and possess higher levels of homogeneity (Fig. 11). These reefs are found around areas where the substrate becomes drastically shallower, often acting as submerged islets, and are frequently partially exposed at the lowest tides. Fringing reefs, on the other hand, were found to be more heterogeneous, often supporting a greater diversity of reef building hexacorals and hydrocorals (*Millepora* spp.). These sites, particularly along the northern coast were found to be extremely limited in cover with very short reef slopes, often reaching a maximum width of less than 50m for long stretches (Fig. 10).

Figure 10
Aerial imagery highlighting the short reef slope of the coastal fringing reefs of Escalante, rarely exceeding 50m. Reefs begin abruptly from algal dominated intertidal substrate and rapidly shift to soft bottom habitats at depths greater than ~ 6m.

Figure 11 – (Next Page)
Community structure of reef building corals per site, by proportional cover of dominant genera. Corals comprising <10% at all sites are grouped together as ‘Other’. Central % values correspond to mean coral cover per site.



10.90
10.85
10.80
10.75
123.50
123.55
123.60
123.65
Sagay
Escalante
Toboso
2km
A
B
C
D
E
F
G
H
I
J
K
L
56%
64%
28%
36%
39%
66%
36%
16%
49%
24%
41%
21%
Porites
Acropora
Seriatopora
Millepora
Lobophyllia
Pocillopora
Isopora
Other Genera
HC%

Deeper substrate transects (6-8m) were only possible at three sites, with all other sites having little to no coral cover beyond 6m depth (Fig. 12). As expected, coral cover declined with depth at each of these sites. The aforementioned high variability in coral cover could not be explained entirely by any single variable. For example, site ‘I’ (Seawall Reef) had the highest coral cover throughout the surveyed areas, however, this was dominated by *Porites* corals with only a third of corals at the site belonging to any other genus. Similarly, the second richest site in terms of coral cover was the offshore site ‘B’ (Malabagun Reef) which was dominated by *Acropora* corals with only approximately a third of other corals contributing to the high coverage. The limited coral area within the MPA (site ‘E’) had a coral cover of approximately 39% but was more than 75% dominated in *Porites*. Conversely, more heterogeneous sites such as ‘D’, ‘K’ and ‘L’ (Cervantes, Buenavista, and Japitan) had an estimated coral cover of 28%, 41% and 21% respectively but were each proportionally comprised of a greater diversity of genera.

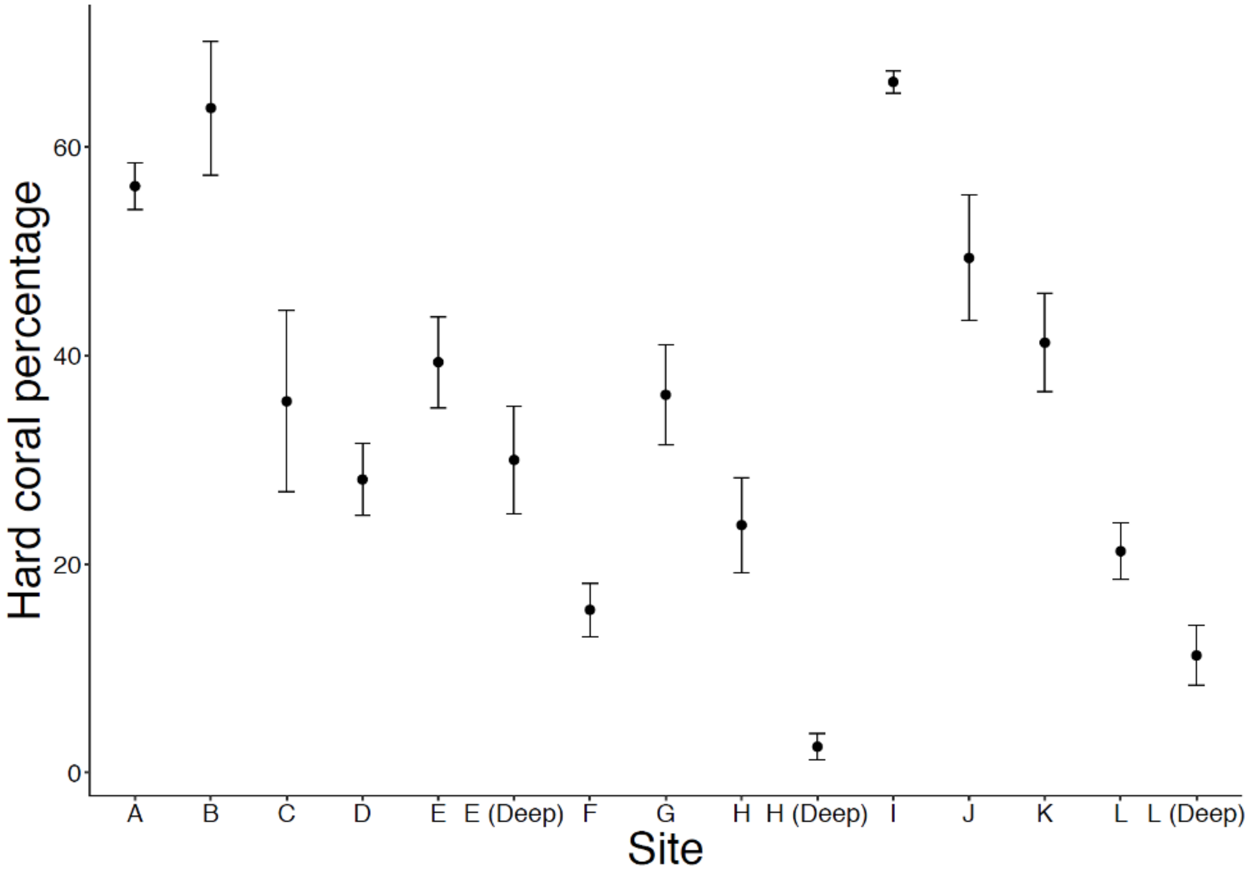


Figure 12 – Mean coral cover per site at Escalante including three deeper sites (‘E’ MPA, ‘H’ Old Poblacion North and ‘L’ Japitan). Error bars correspond to standard error.

<u>Indicator Groups</u>

Fish surveys at the sites also yielded high variation between sites (Fig. 13). Offshore reefs tended to have greater abundances of indicator groups than nearshore reefs with notable exceptions to this being sites ‘C’ (Jomabo Island, West) and ‘E’ (MPA). Unfortunately, a transect survey of indicator fish at the southern-most site could not be conducted due to logistical constraints. With only a small coral-rich area within the current MPA, the ability to isolate broader trends is limited. However, it should be noted that in theory, all non MPA sites are under the same enforcement with regards to local and non-local fishing activities as one another. Representatives of most indicator groups were found to be sold in the local fish market (see below). All sites indicated depleted numbers of larger fish (>20cm) which may be suggestive of fishing pressure throughout the unprotected (or less protected) waters at Escalante. Of particular note are the mesopredator indicator groups of the Epinephelinae and Lutjanidae (groupers and snappers) which are of widespread commercial value and are largely represented by smaller fish (groupers) or relatively under-represented at all sites (snappers). Parrotfish populations were highest at offshore sites ‘B’ and ‘G’ (Malabagun reef and Panansalan reef) with all other sites showing relatively similar numbers. Data was collected on Rabbitfish populations, however, these are not represented here as most sites showed negligible presence (mean <1 individual/100m^3) and a single school of over 150 individuals from a single site skewed the results.

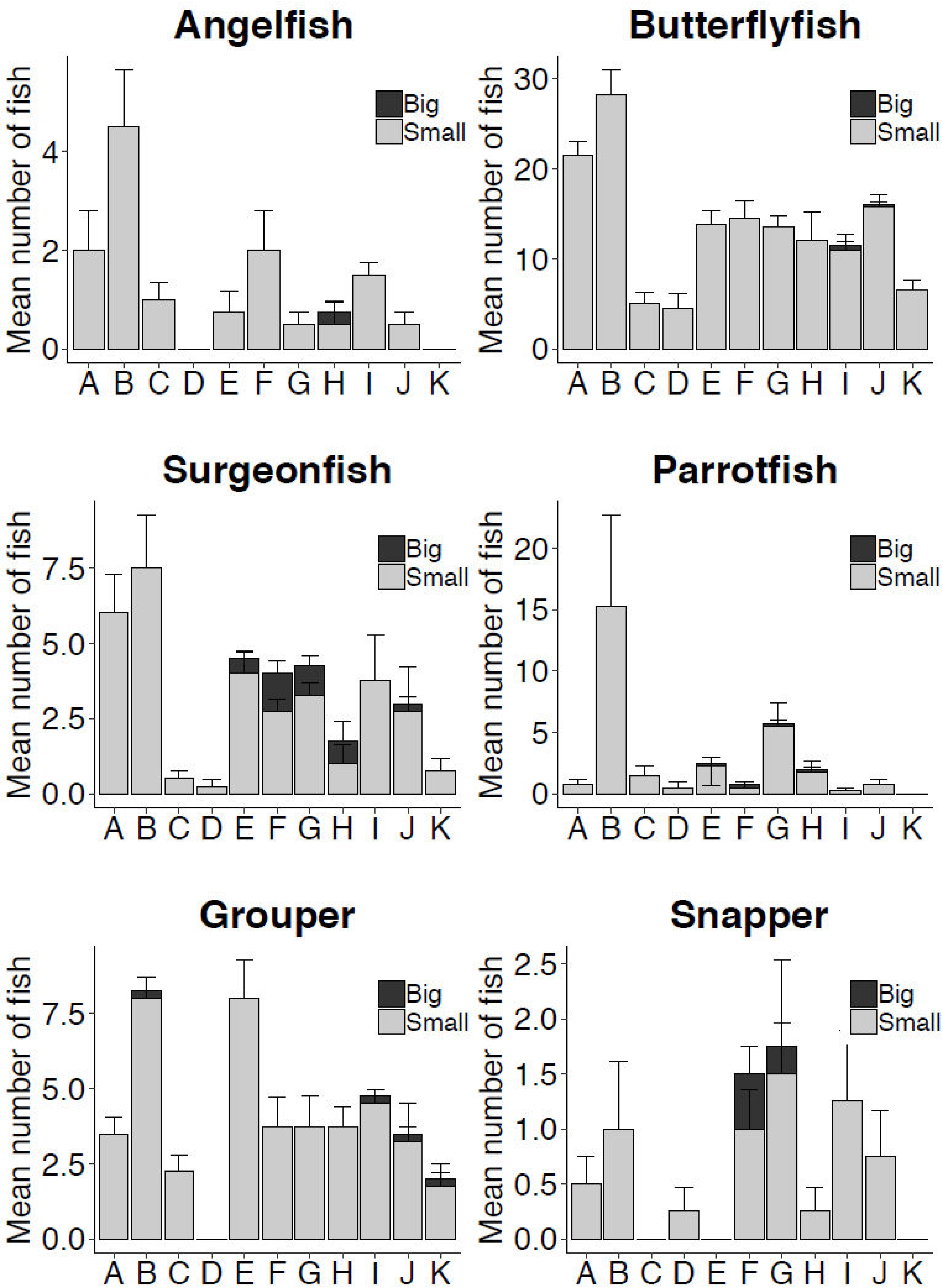


Figure 13 – Mean number of fish per 100m^3 surveyed area. Site name along *x* axis in accordance with sites identified in Figure 2 and Table 1. Fish were classified as ‘Big’ if estimated to be of greater total length than 20cm.

Data on reef-associated invertebrates revealed remarkably different trends. Of particular importance are the heavily depleted populations of ecologically important species such as giant clams (Tridacninae) and sea cucumbers (Holothuroidea) which were only found to be of greater abundance than one individual per $100m^2$ at a few sites (Fig. 14). All species are regularly and abundantly collected from Escalante and are considered relatively high value species in the local fishery. Boring clams (*Tridacna crocea* and *T. maxima*) were most abundant at the offshore reef 'A' (Pamaawan reef), at only six individuals per $100m^2$, and giant clams (*T. squamosa*) were not found to be more abundant that 0.5 individuals per $100m^2$ at any reef in Escalante waters. Sea cucumbers were not found to be of greater abundance than approximately two individuals per $100m^2$ (at 'B', Malabagun reef). Sea cucumbers of the family Synaptidae were not included in this analysis as they were found to be of little to no commercial value at Escalante. Abundances of Diadematidae urchins were not analysed as part of the present study but were found to be high at most sites.

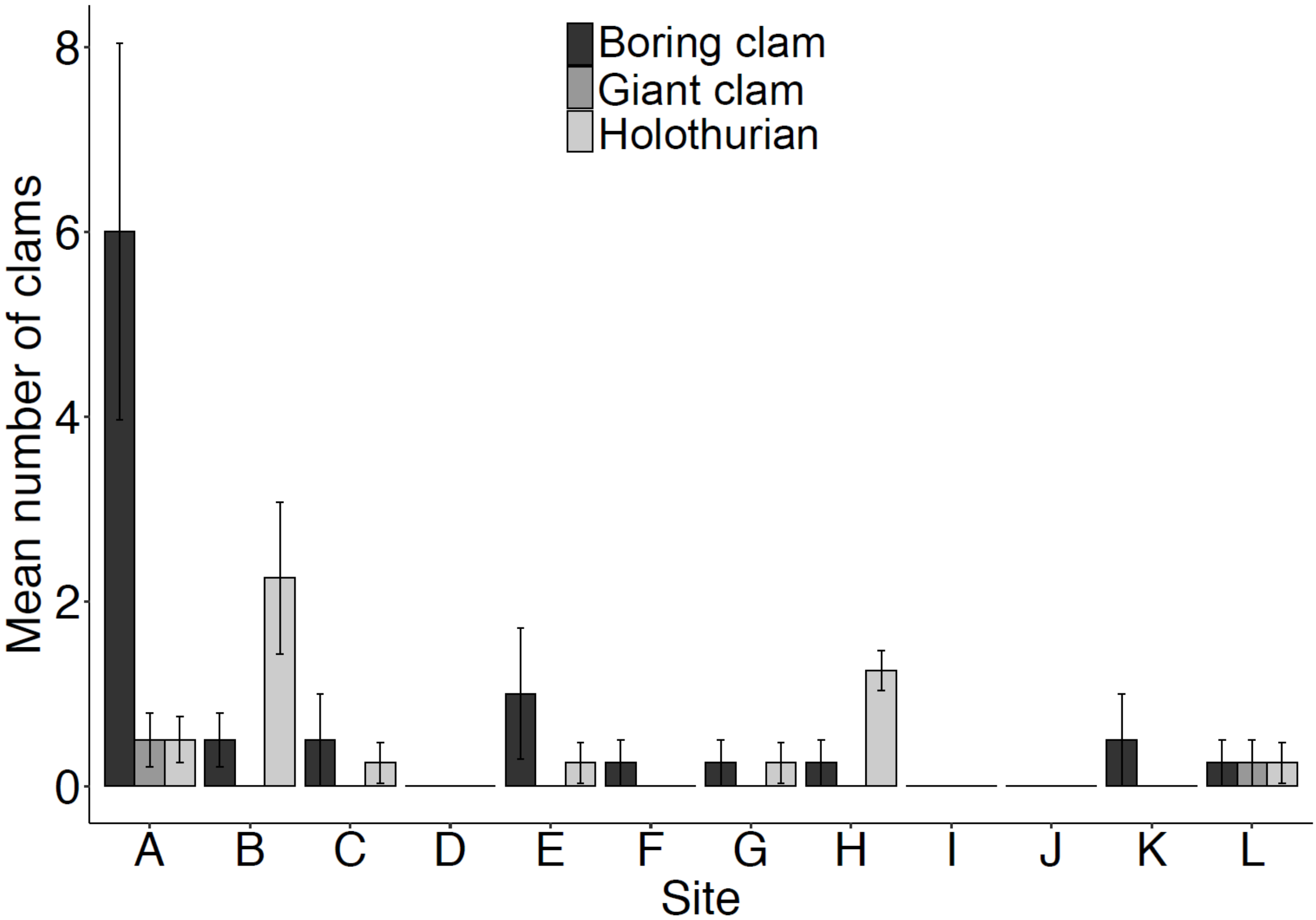


Figure 14 – Mean abundance of Tridacninae and Holothurian spp. per $100m^2$ per surveyed site. Error bars correspond to standard error.

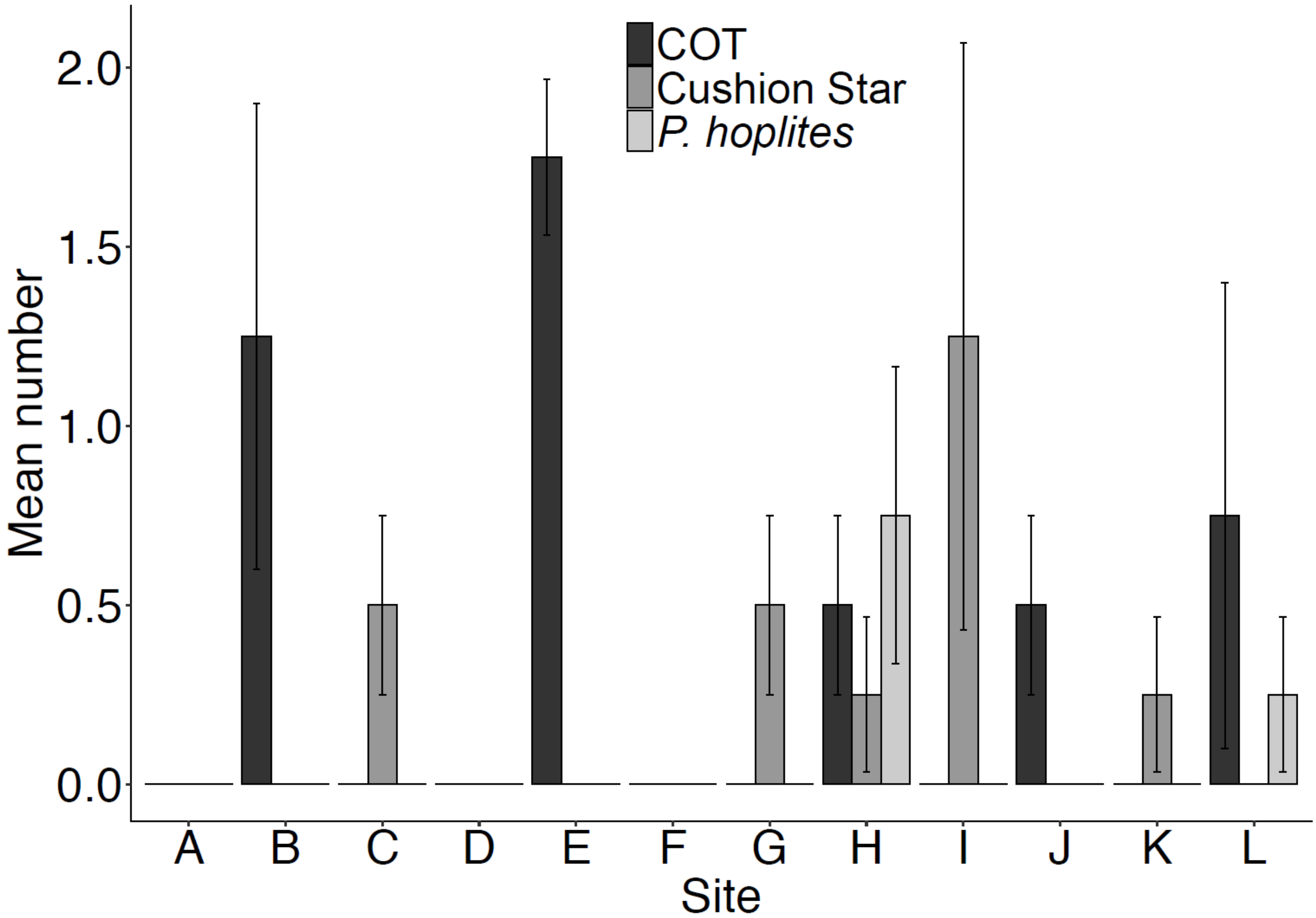


Figure 15 – Mean abundance of corallivorous echinoderms and the corallimorph *P. hoplites* per 100m^2 per surveyed site. Error bars correspond to standard error,

Data was also collected on invertebrate predators of ecological importance (Fig. 15), namely the corallimorph *Paracorynactis hoplites*, the corallivorous snails *Drupella* spp., and the corallivorous echinoderms *Acanthaster* cf. *solaris* (crown of thorns sea star) and *Culcita novaeguinea* (cushion star). Individuals of *P. hoplites* were found in the transects at only two sites ('H', Old Poblacion North and 'L', Japitan) and were entirely absent at other reef sites, including those surveyed by roving diver surveys only. Very few individuals of the snail were found, all at a single site at Escalante (13 individuals at site 'J', Old Poblacion South) and were thus not compared with other sites. Individuals of the crown of thorns sea star were documented from five sites with a maximum abundance of fewer than 2 individuals per 100m^2 (at site 'E', within the current MPA). Abundances of the cushion star were similarly variable and inconsistently distributed. It should be noted that this species was included despite its broader dietary preferences, unlike the obligate corallivory of *Drupella* spp. and the crown of thorns, as it is known to predate upon scleractinian corals as a significant part of its diet (Glynn and Krupp 1986). Coral ectoparasites (such as some nudibranch and Epitoniidae spp.) were observed but abundance data was not collected. The recently described corallivorous nudibranch *Phestilla viei* (Mehrotra et al., 2020) was observed upon eight colonies of the coral *Pavona explanulata*.

Spawning Events

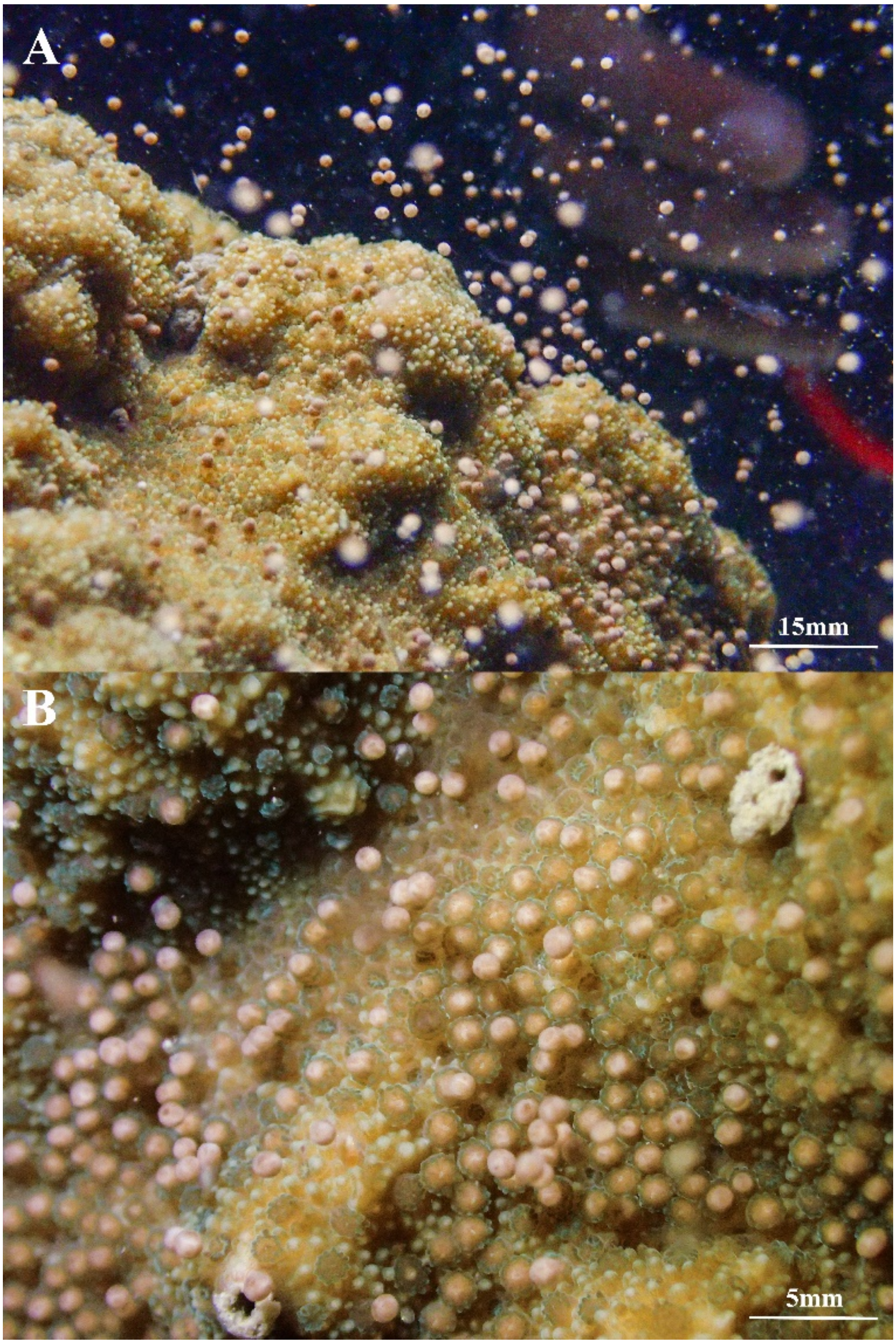


Figure 16 – Egg bundle release of the scleractinian coral *Montipora informis*.

Alongside data on diversity of marine life and on coral reef health, data was collected on natural spawning events. Seven nights of surveys from the full moon in early March yielded spawning of a single colony of *Montipora informis* and partial spawning of a colony of *Lobophyllia recta*. Spawning of both taxa was observed on the 7th of March 2018, 5 nights after the full moon (Fig. 16). Setting of *M. informis* was observed at 18:14 hrs and the first egg bundles were released at 18:00 hrs. Spawning was observed of the whole colony and lasted 11 minutes with approximately 95% of egg bundles being released by 18:29 hrs. At 19:04 hrs, gamete release was observed across approximately 40% of a single colony of *L. recta*. No other corals were observed to be spawning during this period and only a single colony of either species was observed to spawn.

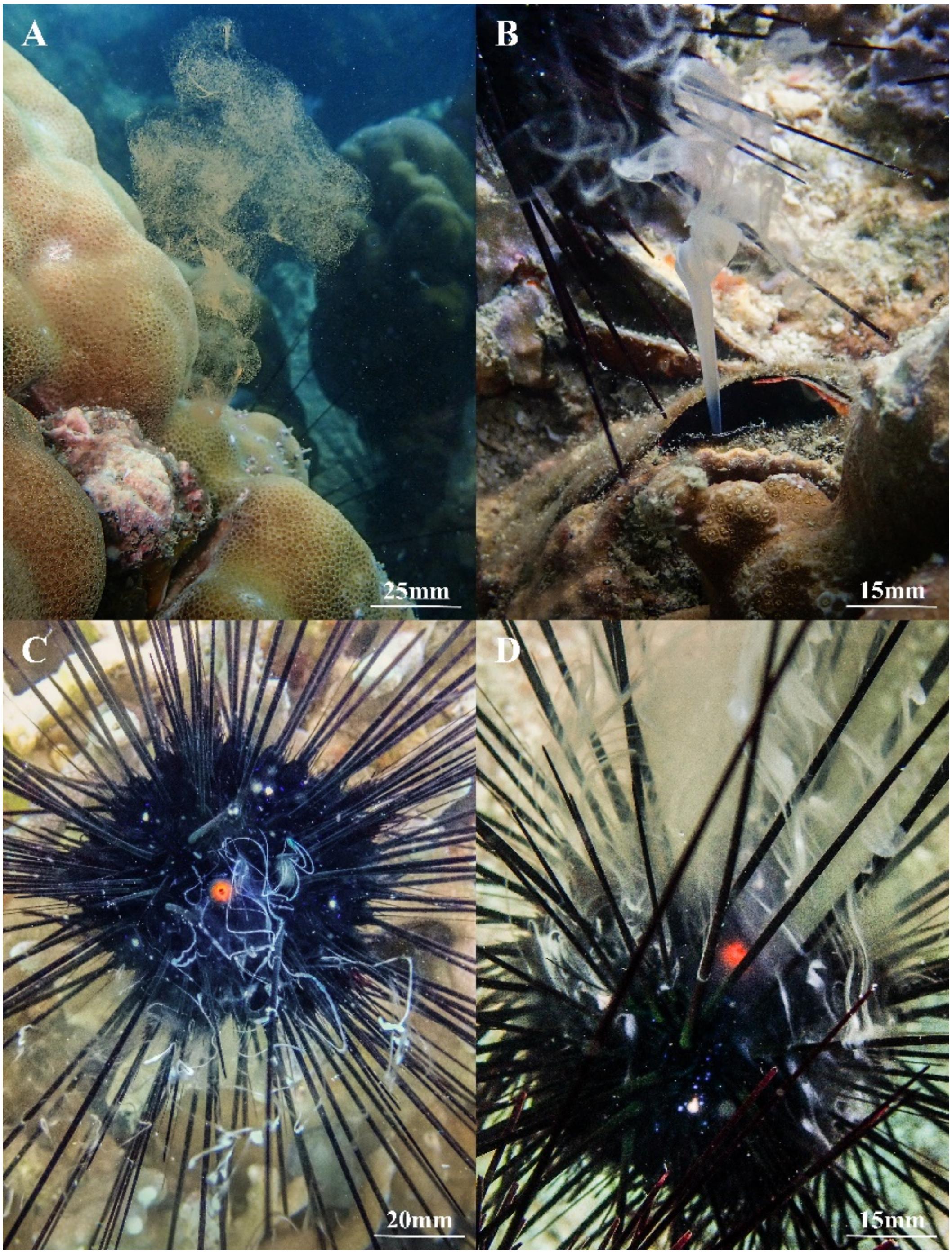


Figure 17 – Gamete release of the bivalve *Beguina semiorbiculata* (A, B) and the urchin *Diadema setosum* (C, D).

During daytime transect surveys, a mass invertebrate spawning event was observed on the 14th of March 2018. At approximately 14:00 hrs in the *Porites* dominated reef habitats at site 'E' within the MPA, synchronous spawning was observed in approximately 418 individuals of the urchin *Diadema setosum* and 39 individuals of the bivalve *Beguina semiorbiculata* (Fig. 17). Overall gamete release lasted for more than 90 minutes with the last confirmed release occurring at 15:38 hrs. Relatively few individuals of *Diadema savignyi* (n = 42) and *Echinothrix calamaris* (n = 6) were observed at the location of the event and of these only two individuals of *D. savignyi* and no individuals of *E. calamaris* were observed to be spawning.

Other Habitats

Snorkelling surveys were conducted at a small number of nearshore and offshore mangrove sites. The Escalante governing body has supported mangrove plantation activities with apparent success throughout much of the coastline, however, these mangroves were found often to not extend far into areas with large intertidal ranges. Offshore mangroves, and the few areas of mangrove growth that were observed to be removed from the majority of onshore growth (i.e. those areas exposed to greater than approx. 50cm of intertidal range) were observed to support greater abundances and diversity of fish, including juveniles of commercial value in the region such as the Lutjanidae (Fig. 18). Areas where mangroves were exposed to greater tidal variation were found at Jomabo Island, including some areas within or fringing the eastern boundaries of the current MPA, and sporadically along the coastline south of Old Poblacion.

Figure 18 – Offshore mangroves and those exposed to greater tidal submergence act as nurseries to snappers (Lutjanidae), pufferfish (Tetraodontidae) and various Pomacentridae.

Most of the benthic substrate at Escalante is unsurprisingly comprised of soft sediments, which support distinctive habitats such as seagrass beds and other dynamic ecosystems. Extensive roving diver surveys were carried out in these areas revealing relatively few seagrass habitats, largely concentrated around the shallow and intertidal areas between the barangays Washington, Alimango, and Old Poblacion. This area supports large populations of the sea slug *Dolabella auricularia*, the eggs of which are commercially sold for consumption at Escalante and around much of the Philippines. In contrast, macroalgal dominated substrates were abundant in the shallow reefs. Deeper soft sediment areas appeared to not support other soft sediment suited colonisers such as hydrozoa, sponges or octocorals, or soft sediment specific scleractinian corals such as *Heteropsammia*, *Heterocyathus* and some *Fungiidae* spp. An exception to this latter category is the numerous but spatially widespread occurrences of the soft sediment tolerant coral *Trachyphyllia geoffroyi*, though these were rarely clustered. Nonetheless, these soft sediment areas did reveal multiple occurrences of charismatic and cryptic fauna.

Transect and roving diver surveys within the MPA revealed the presence of 87 faunal taxa in the area, 12% of the total diversity recorded in the present surveys. Of these, 20 were not recorded in waters outside of the MPA. Interestingly, these were mostly observed in open soft sediment areas and not within the typically diverse coral reef habitats. As mentioned above, the limited reef habitats of the MPA were found to be far more homogenous than other areas, dominated by *Porites* corals and other massive or sub-massive colonies, with far fewer colonies of higher structural complexity. The diversity in the soft sediment habitats included highly charismatic species but none that were found to be under any particular pressure at Escalante (either via natural or anthropogenic means) such as the frogfish *Nudiantennarius subteres*, seahorse *Hippocampus kuda*, and nudibranch sea slugs *Aegires villosus*, *Phidiana militaris,* and *Unidentia sandramillenae*. Other charismatic species such as the sea snake *Emydocephalus annulatus*, sea snail *Naticarius onca* and sea pen octocorals (Pennatulacea) were also found in soft sediment habitats throughout Escalante but were not found from within the MPA.

3.3 - Fish market Assessment

A total of 94 species of fish were recorded from fish market surveys, of which 70 species were not recorded from in-situ surveys conducted. Estimates of commercial value and of approximate catch by weight was calculated for 39 species, with a further 29 species being sold as 'mixed' batches of multiple different species, and thus data was extrapolated per species where possible. Estimates of commercial value and weight for the remaining 26 species were either not available or were inconsistent, therefore deemed unreliable and were excluded from analyses. A further 40 species of invertebrate were found to be of commercial value (4 crustaceans, 12 echinoderms and 24 molluscs) as documented from a combination of fish market surveys and BD patrols of illegal activity. These taxa were, however, also excluded from the analysis of reef versus non-reef fish surveys. A number of taxa were observed in the fishery worthy of additional note. Elasmobranchs of the families Dasyatidae and Rhinobatidae (Fig. 19) were found as part of the catch, however, were not observed in-situ. No sharks were observed as part of the catch during the survey period; however, these have been known to be recorded in the waters of the area and regularly make their way to nearby markets (Mehrotra et al., 2016; 2017). Additionally, a single individual of deep-water fish tentatively identified as *Chauliodus* cf. *sloani* (Fig. 20) was recorded from the market, believed to be caught in the central Tañon Strait, within Escalante waters.

Figure 19 – Small *Rhinobatos whitei* for sale at the fish market at Escalante

Figure 20 – Stomiidae, *Chauliodus* cf. *sloani*

Precisely half of the fish diversity documented from fish market surveys were categorised as reef fish, and the other half as non reef-specific (Fig. 21). Of those that were found to be reef-specific, 17 species were found to be of those groups considered as indicator species of ecosystem health in the above documented reef transect surveys, with the remaining 30 species being considered non-indicator taxa. The proportion of catch by weight and of commercial value as a whole for non-reef fish were remarkably similar with 85.2% of the total fishery being comprised of non-reef fish which sold for approximately 84.6% of the total economic value of the catch surveyed. These amount to approximately 1022kg of fish sold for PHP 137.9k and thus a crude estimation of approximately PHP 135 per kg of fish. Reef-associated fish were also similar in their proportional weight and commercial value, making up 7.8% of the catch (93.5kg) and sold for approximately 9.2% of the total value (approximately PHP 15k) and thus approximately PHP 160 per kg. The remaining catch were sold as mixed batches of reef and non reef-associated species (i.e. not sold at a species-specific level) and thus contributed to both categories in a significant but ill-defined way (7% of catch by weight, 6.2% of total value). Of the total catch 4.4% of catch by weight and 5.2% of economic value were those fish considered as indicator groups during transect surveys.

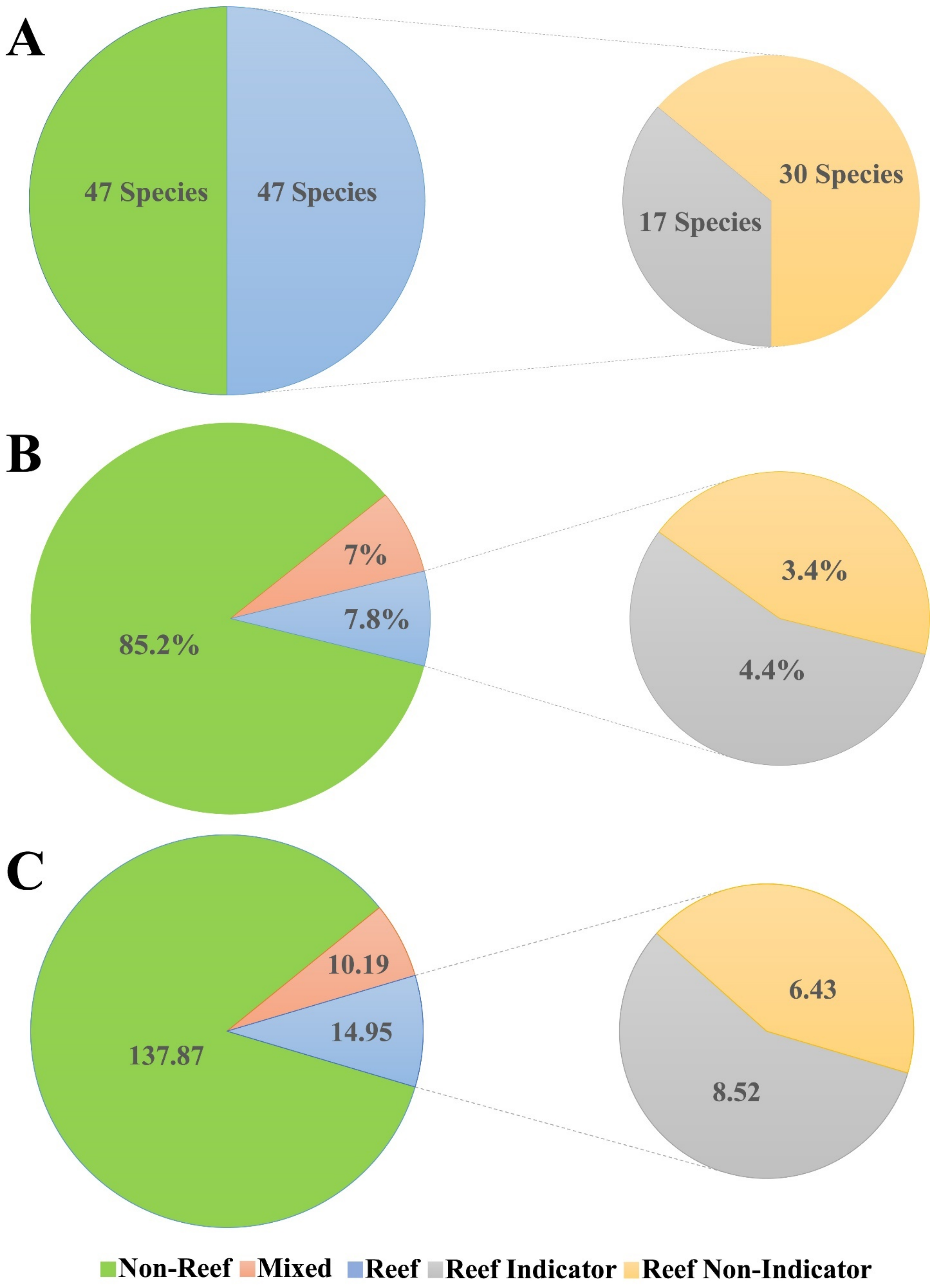


Figure 21 – Diversity (A), proportional abundance (B) and economic value (C) of catch available at the fish market at Escalante during the survey period. Economic value of catch is shown in PHP/1000 (i.e total value of reef-associated catch = 14,950 PHP). Initial breakdown separates species as reef-associated, non reef-associated, and sold as mixed lots of both groups (for definitions, see text). Reef-associated species are further broken down into those families used as indicator groups (see Figure 13) and non-indicator species.

Figure 22 – Fish traps supported by rocks, living and dead coral.

Figure 23 – Confiscated catch of reef fish, Tridacnid and gastropod spp.

Figure 24 – Confiscated catch of Labridae including *Choerodon anchorago*.

4 - Discussion

4.1 - Ecosystem Health

The mean shallow (2-4m) hard coral cover (HCC) of all sites surveyed was approximately 40%, however, this is subjective considering the extensive variability ranging from as low as 16% to as high as 66%. There have been numerous assessments of how HCC reflects the broader reef health in the Philippines, with among the most widely accepted assessment being that of Gomez et al. (1981) who surveyed 619 stations across the Philippines. In the referenced assessment, it was concluded that reefs with up to 24.9% HCC could be considered in 'poor' condition, 25-49.9% as 'fair', 50-74.9% as 'good' and HCC greater than this as 'excellent'. They found the majority (~70%) of reefs could be classified as either 'poor' or fair'. The recently updated nationwide survey of HCC in the Philippines by Licuanan et al. (2017) resulted in over 90% of reefs being classified as 'poor' or 'fair' based on 166 stations. The status of reefs at Escalante therefore align with the findings of previous localised and broad-scale surveys (i.e. Verdadero et al., 2017), with the mean HCC being classified as 'fair' based on the assessment scheme proposed by Gomez et al. (1981.H). However, these findings also show considerable variability with reefs ranging from 'poor' (sites F, H, L) to 'good' (sites A, B, I) but no reefs being classified as 'excellent'. While few specific reefs in the Philippines have undergone long-term monitoring efforts, the trend suggested by nationwide surveys indicates a dramatic decline in Philippine reefs, a pattern documented throughout reef environments globally.

During the surveys conducted in Escalante, minimal incidences of coral bleaching or obvious coral diseases were recorded (<1%). There does, however, exist anecdotal evidence by local surveyors of widespread bleaching in recent years, though active documentation and assessment of this was not carried out. In-spite of this, the reefs at Escalante were found to be under clear threat from sedimentation and sediment-associated issues. Nearshore reefs, for example, were often subjected to highly turbid conditions and often exposed to a high sediment load, possibly from onshore runoff, thus acting as a local chronic stressor. Additionally, naturally occurring fragments of colonies were perpetually found to be at risk of localised small-scale burial or were simply not exposed to sufficiently stable substrate to continue to survive. Nearshore and offshore reef slopes alike were delineated by a well-defined and often abrupt edge beyond which few colonies could survive, likely due to the lack of stable substrate. Additionally, nearshore reefs in particular were found to host greater abundances of sediment-tolerant corals such as *Turbinaria* and *Porites*.

Recent decades have provided numerous case studies on shifting community structure of coral genera in tropical reefs, highlighting regional and sometimes broader trends of resilience of some genera over others (i.e. McClanahan and Obura, 1997; Brown 1997; Riegl 1999; Marshall and Baird, 2000; Harriott and Banks, 2002; Toda et al., 2007; Green et al., 2008; Baker et al., 2008; Adjeroud et al., 2009; Guest et al., 2012; Scott et al., 2017a). For example, *Porites* corals are well documented in many of these cases to be more tolerant to sediment inundation (among other stressors) than *Acropora* and this is largely visible in the community structure of nearshore vs. offshore reefs at Escalante. However, we also see, surprisingly, that surveyed sites closest to the river mouths at Escalante had the lowest abundances of *Porites* and the offshore MPA had the highest. Therefore, its utility as an indicator genus for sediment load input cannot be extrapolated alone. This agrees with the complexity of generalising such inferences in reefs globally as it is also well documented that different genera respond differently in different places, highlighting the need for a significant increase in coral community structure studies. Therefore, while we may suggest that many of the dominant genera at Escalante have likely been influenced by stressors such as sedimentation, thermal bleaching and storms, all of which are currently prevalent threats in the region (Arceo et al. 2001; Yumul et al. 2011; Abreo et al. 2015) and likely to increase in severity (Capili et al. 2005; Yumul et al. 2011), significantly more work is needed to tease out the local ecological dynamics in the area.

Invertebrate transect surveys on the reef provided some of the most striking evidence for depletion of important indicator groups, including species involved in nutrient cycling and filter feeding. Boring clams (*Tridacna crocea* and *T. maxima*) and giant clams (*T. squamosa* and *Hippopus hippopus*) were all found to be heavily depleted throughout the reefs of Escalante with mean densities of 0.79 and 0.06 per $100m^2$ respectively. These bivalves are well documented as ecologically important due to their capacity in filter feeding (thereby helping to maintain the oligotrophic conditions of the reef), as sources of dense and structurally complex substrate for coral recruitment, and as sources of zooxanthellae, facilitating recovery of nearby corals after bleaching events (Neo et al. 2015; Neo et al. 2017; Morishima et al. 2019). Similarly, sea cucumbers which play an important role as detritivores and contribute to bioturbation were not found in excess of two individuals per $100m^2$ (mean 0.42 per $100m^2$). Data was also collected on the number of individuals of the strombid snails *Lambis lambis* and *Strombus* cf. *sinuatus* due to their popularity in regional cuisine, however, almost no individuals were found in surveyed reef or soft sediment environments (i.e. seagrasses). The loss of these commercially valuable species is almost certainly due to exceptional over-harvesting (see below) and may endanger the survivability of the populations of these animals in Escalante. It has already been shown that the waters directly to the south of Escalante are also heavily depleted in clams and sea cucumbers (Mehrotra et al., 2016; 2017) and thus are likely to show reduced potential for population recovery in the wider region. Data was not collected on the populations of large barrel sponges (*Xestospongia testidunaria*) though they too contribute greatly to filter feeding in reef environments (Schrope 2009).

Surveys on the density of predatory invertebrates often revealed greater abundances than the species discussed above. For example, the crown of thorns sea star, a well-documented corallivore, was found at between 0.5 to 1.5 individuals per $100m^2$ at five reef sites. While a specific carrying capacity for the reefs around Negros have yet to be studied in great detail, these abundances are generally considered low and are comfortably short of minimum outbreak parameters for most studied reefs in South-East Asian reefs (i.e. de Dios et al., 2014; Scott et al 2017b). Populations of the cushion star *Culcita novaeguinea* are less studied in the area and were found to be in high abundances at Escalante including throughout seagrass, coral reef and some macroalgal/soft sediment ecosystems. This species, while generally considered a corallivore, is also known to feed on a variety of other organisms (Bell 2008) and has not been associated with large-scale detrimental outbreaks like the crown of thorns. Within the surveyed coral reef habitats of Escalante, *C. novaeguinea* was found in remarkably similar abundances to the crown of thorns, ranging from approximately 0.25 to 1.25 individuals per $100m^2$. It should be noted, however, that the species was generally observed in greater abundances outside of dense coral areas during daytime (during when transect surveys were conducted) and would increase within coral reefs at night. The final predatory invertebrate surveyed was the corallimorph *Paracorynactis hoplites*, which was primarily recorded from Old Poblacion North where its abundance did not exceed 0.75 individuals per $100m^2$ and some individuals recorded at Japitan. This species is currently believed to be unique among tropical cnidarians due to its role as an opportunistic predator of the crown of thorns sea star (Bos et al. 2011, de Dios 2015). While this dramatic example of ecological role reversal suggests a biotic mechanism for population control of the often problematic predator, *P. hoplites* is also known to predate upon a broad range of prey (Bos et al. 2011), and thus its ecological role in reef habitats needs to be investigated further.

The observations of mass invertebrate spawning (*Diadema setosum* and *Beguina semiorbiculata*) highlight the potential for the reefs and coastlines of Escalante to recover. Both species play an important role in nutrient cycling of coral reef habitats and themselves contribute to the complexity of the ecosystem by playing crucial roles in the trophic dynamics of coral reefs. Similarly, the spawning observation of two scleractinian corals (*Montipora informis* and *Lobophyllia recta*) further support the potential for recovery and growth of the coral reefs of Escalante. It should be noted, however, that the spawning events were observed during an early full moon (early March) and at a nearshore reef facing high turbidity. Synchronous coral spawning events in the vicinity of the coral triangle are known to occur following the lunar cycle in March and April and thus the March full moon of 2018 falling relatively early in the month may have resulted in immaturity of gametes and therefore a later spawning. Additionally, the stress of turbid environments on coral spawning events has been studied (Erftemeijer et al., 2012; Ricardo et al., 2015; Jones et al., 2015) and the partial-colony spawning of *L. recta* may be an added indicator of turbidity related stress. One or both of these environmental factors may have contributed to the sparsity of spawning recorded during the observation period and future investigations into coral spawning events in the region should look into a wider window of observation.

Of the in-situ fish surveys, the most suggestive implications are best discussed in conjunction with findings of the fish market surveys. Some results, however, are also clearly visible when considered independently, namely the efficacy of the current MPA in supporting sustainability of the Escalante fishery and the sparsity of larger individuals throughout. Regarding the former, the results strongly indicate that during the survey period, the limited reef currently within the MPA (site 'E') did not support fish populations any more effectively than any other site at Escalante. In fact, when combined with all indicator fish groups, abundances of indicator fish within the MPA were found to be below the mean for Escalante as a whole. The indicator group that appeared to be most abundant within the MPA relative to all other sites surveyed were the groupers, however, no individuals larger than 20cm were documented and a slightly greater abundance was documented at Malabagun (site 'B').

While we concede that a single measurement as an assumption of a generalisable tool as to what constitutes a relatively 'big' fish for all species in all families is not suitable for all groups, a conservative measure of 20cm was chosen so as to be theoretically applied to a majority of species surveyed. Additionally, while not directly informing on true fish biomass, it allows for indications of relative assessments between smaller and larger individuals of commercially valuable species in the region. It has been shown for example (Mehrotra et al. 2017) that all families included as indicator fish are caught and sold for consumption in local fish markets in Negros Occidental. It is therefore telling that so few individuals of parrotfish, grouper, and snapper estimated to be of greater length than 20cm were observed in the surveyed reefs, despite numerous species reaching sizes far larger being well documented from the Visayas region. In a field where the problem of shifting baselines is pervasive and where overexploited fisheries are known to result in reductions of mean fish size (see Pauly 1995; Haedrich and Barnes 1997; Ainsworth et al., 2008; Knowlton and Jackson 2008; and others), it is vital that more effort be applied in documenting size and abundance of commercially valuable species over time.

A remarkable discrepancy is present between the proportional diversity of catch and relative economic value of fish sold in Escalante. While less than 10% of the total surveyed catch by estimated value and biomass were classified as reef-associated, this was equivalent to a total of half of all species available for sale. This, however, doesn't include an additional 5-7% that were sold mixed with non-reef fish and were thus difficult to isolate. The majority of nearshore fishing is broad and unregulated, with few groups (cetaceans, turtles, etc.) illegal to land. Therefore, while many of the fish caught and sold may be considered 'bycatch' elsewhere, all catch is landed to maximise profit, despite relatively low economic returns. All fish found in the market were sold exclusively for consumption and not for souvenirs or the aquarium trade, with families like small Labridae and Pomacentridae (particularly anemonefish of the genus *Amphiprion*) and other 'ornamental' fish populations therefore being exposed to greater anthropogenic pressures with minimal economic return. The majority of these fish were sold in the 'mixed' batches that were locally considered synonymous with miscellaneous and unknown fish and ranged dramatically in price from approximately PHP 75-250 (USD 1.48-4.93) per kilo. This appeared to be determined based on the relative size of the unknown fish but in general did not seem to follow any pattern. In more rural areas in the region, the value of similar species may be as low as PHP 20 (USD 0.39) per kilo. A conclusive idea on the popularity of such fish in local cuisine was not assessed. Nonetheless, the fact that more than 85% of the catch amounts to only 50% of the diversity suggests that increased stringency in policy and enforcement on unregulated and illegal fishing on coral reefs could result in improved protections for dozens of species with minimal economic loss.

As discussed above, many indicator species (both vertebrate and invertebrate) were found not only in coral reef habitats but also in seagrass habitats. While abundance and density for these species was only quantified from coral reef habitats, it should be noted that both coral reef and seagrass habitats at Escalante are threatened by destructive and illegal fishing practices. Besides the active disturbance of intertidal seagrass because of walking for collection of commercially valuable invertebrates, patrols with the BD revealed incidences of seagrass raking, a highly destructive process used in the search of cockles and other commercially valuable infaunal bivalves. An increase in patrols, however, appear to have resulted in a reduction in such practices in recent years, with the most common outcome being a confiscation of equipment and occasional impounding of boats. Though fishing-related disturbances in seagrass habitats at Escalante are present, incidences of illegal methods such as raking were found to be uncommon and often restricted to local communities. A practice that was found to be significantly more frequent were incidences of subtidal collection of invertebrate taxa from coral reef habitats. These were usually carried out during low tide by reef walking (at both nearshore and offshore locations), by freediving, or by unsafe use of a boat-mounted compressor and a tube, and were usually carried out alongside illegal deployment/recovery of fish cages within coral reef areas (Figs. 22-24).

Patrols with the BD found that illegal fishing from nearby or neighbouring municipalities was more pervasive and was carried out at larger spatial scales across seagrass and coral reef habitats. This includes the well documented, harmful practice of dynamite fishing, which is less regulated in some other regions at Negros and was carried out near Escalante waters during the surveys discussed in this report. Bottom trawling, historically carried out within Escalante waters, has been made illegal and was not observed during the survey period, nor were indications of active trawling witnessed in-situ. The combined impacts, however, of unregulated legal fishing, illegal fishing practices by the local community, and illegal fishing within Escalante waters by non-locals is challenging to quantify. The discrepancies between in-situ observations and estimated catch during illegal harvesting seen in BD patrols in conjunction with results presented here from transect surveys and fish market surveys, suggests parts of the nearshore fishery at Escalante are in dire straits. Of potentially greater importance in the long term is the highly depleted populations of ecologically important species. A more sustainable use of these remaining resources is likely to be crucial to support the economic and ecological future of marine environments at Escalante.

4.2 - Zonation

On the 29th of October 2003 (ordinance no. 156) the governing body of Escalante declared a portion of Escalante Bay as an MPA (CFRM 2008). Earlier that year, on the 2nd of January 2003, ordinance no. 141 declared the creation of the 'Bantay Dagat Task Force', which became the BD in operation today. It is unclear to this day how or why this location was chosen, suffice to say that a disparity in Escalante marine-resource information and protection initiatives existed. In its creation, numerous activities were prohibited within the MPA, in an effort to preserve the area. These include prohibition of:

- All forms of fishing
- Collection of any organisms during low tide
- Taking any and all forms of marine species
- Constructions of fish corrals within 300 meters of sanctuary perimeter boundary—Buffer Zone
- Removal/destruction of coral reefs, sea grasses, other forms of vegetation
- Sand mining
- Water skiing
- "Dumping" (presumably of terrestrial waste)

Offenses resulted in a punishment of PHP 2000 or more and/or 3 months + in jail. Boats and all catch were to be taken/impounded. It is believed that between the original designation of the MPA and subsequent zonation strategies implemented, no in-depth investigation into marine ecosystem health has been conducted. Therefore, it is unclear the extent to which any change has occurred, with regards to most metrics assessed in the present study, as a result of the zonation strategies implemented at Escalante in the past 15 years.

Our results suggest that, at least as of 2018, the currently positioned MPA (Fig. 1, also see Appendix I) provides proportionally little to no benefit, either economically or ecologically, to the marine resources of Escalante. While the size of the area is a significant portion of the total area of Escalante waters, it was either accidentally or intentionally chosen to cover among the smallest areas of structurally complex and ecologically diverse habitats possible, with the majority covering bare soft sediments. By almost every measure, the MPA in its current form falls short of the average diversity and abundance of marine resources available at Escalante, and thus plays little more than a figurehead role as a measure of protection for the marine resources in the area. This unfortunately agrees with a broader trend visible regionally and locally (Aliño et al., 2002; Horigue et al., 2012; Mehrotra et al., 2016; 2017). Throughout the coral triangle, MPAs are set up to promote economic and/or ecological sustainability (White et al., 2014), usually assessed by population growth of key organisms of interest. This may be achieved via passive means in combination with active means.

Passively, a given area may be subject to stringent legal protections, prohibiting or penalising certain activities, and is often something that is influenced by both local and regional policy. For example, Escalante is located within the Tañon strait, and thus local management strategies are mandated by regional goals such as by the broader Tañon Strait Protected Seascape management plans (TSPS-GMP 2015). Additionally, nationwide initiatives such as the recent 'Expanded National Integrated Protected Area System Act (E-NIPAS, Republic Act 11038, amendment to Republic Act 7568) mandates an increase in the area legally protected for biodiversity conservation throughout the Philippines, and strengthens stringency of penalties and fines (see RA 7658; La Viña et al., 2010; Mayuga 2018), though these measures are largely without teeth in the absence of active measures of protection.

Passive (often synonymous with policy-driven) measures provide a pathway and act to legitimise active means of protection. Active measures are locally driven and require local enforcement as a primary imperative, particularly in areas where site-specific threats are anthropogenic in nature. A lack of effective enforcement and management is a leading cause of failure in MPA initiatives, in the Philippines and beyond (Aliño et al., 2002; Cabigas et al., 2012; Maypa et al., 2012). Other forms of active management include habitat restoration, regular monitoring, mitigation of non-anthropogenic threats (i.e. disease) and others, however, all these require extensive training to be effective instead of detrimental.

At present, Escalante has an active enforcement body (Bantay Dagat) as well as some onshore habitat restoration programmes (mangrove transplanting). Surveys of habitats across the region indicate a wealth in some marine resources (i.e. coral cover, invertebrate biodiversity) and severe depletion in others (i.e. commercially valuable fish and invertebrates). However, current trends of legal and illegal fishing efforts, lack of sub-tidal restoration efforts and, in particular, ineffective zonation strategies regarding protection suggest a reduced capacity for sustainable coastal resource management. Therefore, we here provide proposed amendments to the designated MPA zonation in Escalante and some additional measures that may be pursued to facilitate effective marine resource management in the area.

The present MPA is 1323.5 hectares in area. Following this measure as an upper bound, we propose an alternate zonation (NMPA1) based on the findings on the surveys conducted (Fig. 25). This strategy supports the creation of 10 smaller MPAs along the coast of Escalante, including three larger offshore areas. The combined area under this proposal is 1000 hectares in size, a reduction of almost 25% from the currently designated area. This proposition relies on the premise that more effective placement and management of MPAs can yield far greater results, despite a coverage of only 75% of the original area. Additionally, these smaller MPAs have been designed so as to have minimal overlap with the current zonation plan and may be managed as an extension of mangrove and mariculture zones already in place. Crucially, this proposal relies on involvement from all coastal barangays (each would be required to manage their own area) in addition to a broader city responsibility which would ideally manage the larger offshore areas.

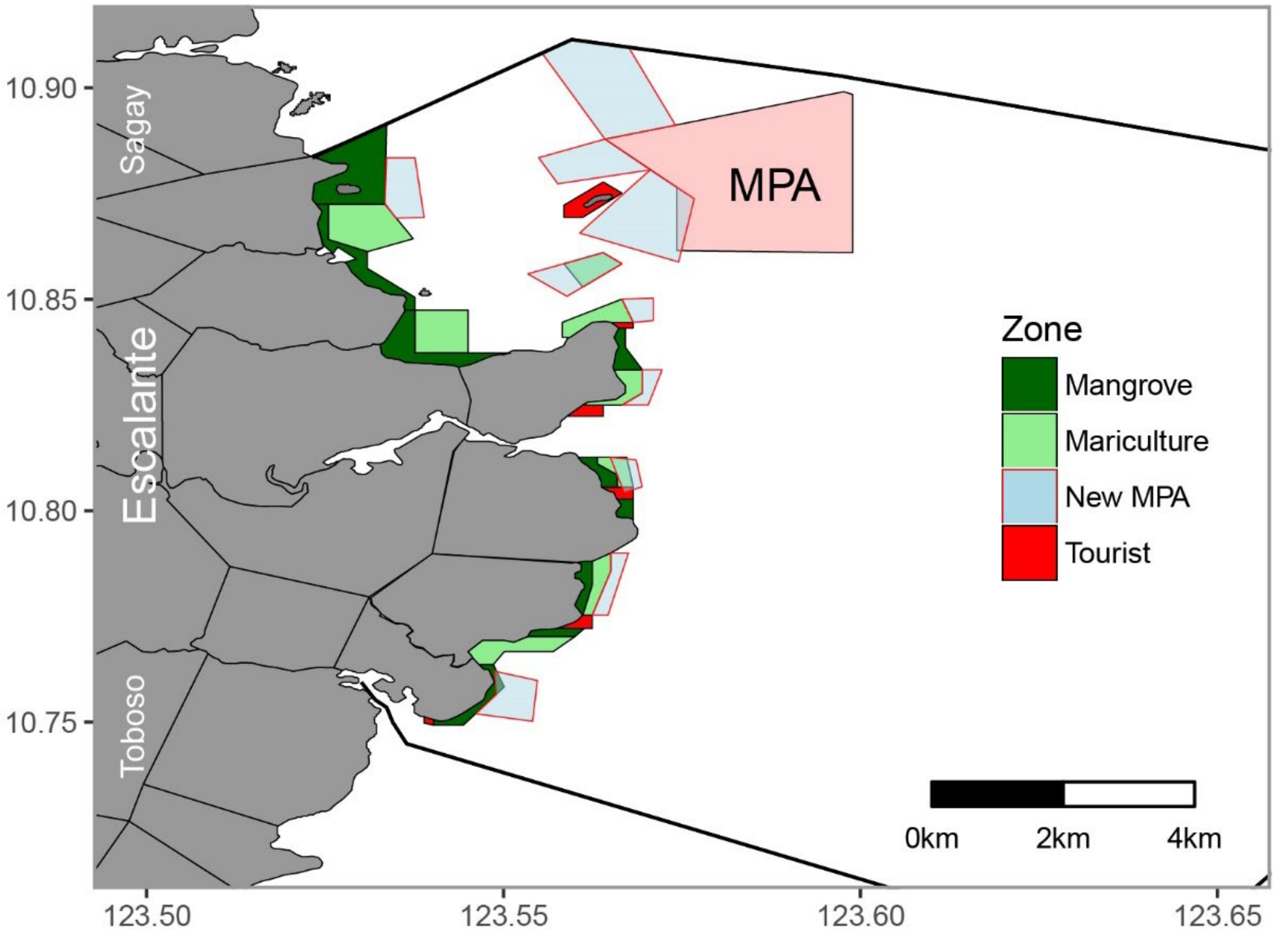


Figure 25 – The first alternate MPA zonation proposal (NMPA1) overlaid in blue on a summarised version of the current zonation at Escalante.

We also propose a second, alternative zonation (Fig. 26), that would support remediation of major oversights in the current MPA placement (NMPA2). We do, however, concede that this second alternative would be less effective at achieving sustainability and recovery of marine resources at Escalante than NMPA1 and should only be considered if the previous proposal does not pass the implementation process. The total area covered by NMPA2 is 1251 hectares which amounts to a reduction in area of over 72 hectares from the current MPA. The major change from the current MPA would be a drastic reduction in protections offered further offshore, which could re-open as deregulated waters, and move the protections to include the seagrass, mangrove and coral reef habitats around Pamaawan, Malabagun, Jomabo, Paliswihan and Panansalan. This would involve the reclassification of the single mariculture zone at Panansalan and would encompass the tourism zone at Jomabo, though it could be regulated such that the tourism zone at Jomabo could be synergised with the updated zonation so as to reinforce both tourism and regulated protection within the area (see below).

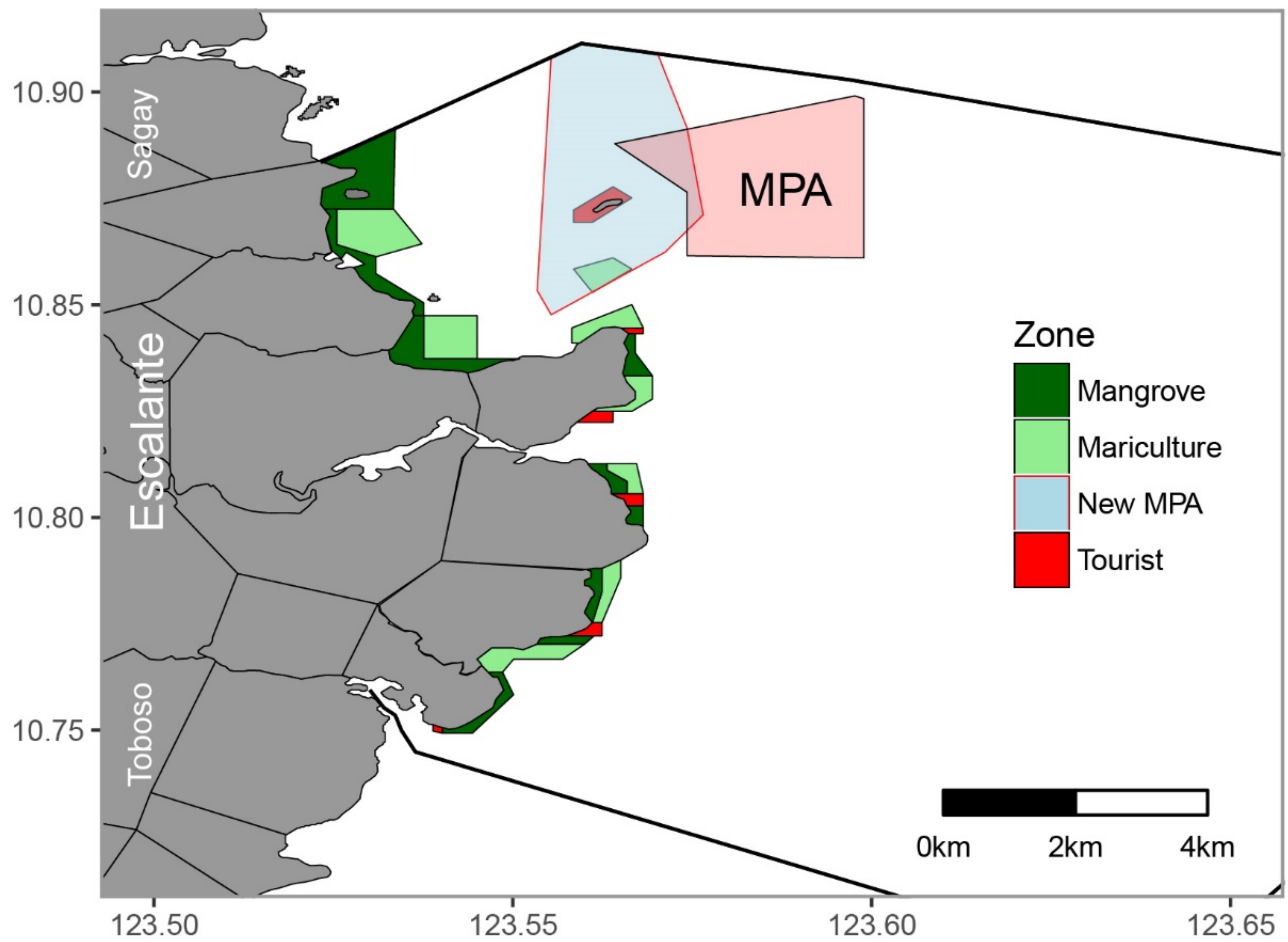


Figure 26 - The second alternate MPA zonation proposal (NMPA2) overlaid in blue on a summarised version of the current zonation at Escalante.

Both proposals NMPA1 and NMPA2 (coordinates in Appendix II) would better reflect the purpose of a marine protected area by promoting preservation of threatened habitats, while also providing safe habitat for fish. Offshore mangrove and coral reef habitats in particular act as important nursery sites for juvenile fish, including those of relatively high commercial value, and would therefore promote recovery of the depleted fishery in the area. Crucially, active enforcement of such areas may allow for a return of key invertebrate groups such as giant clams and sea cucumbers that play important roles in nutrient cycling. Ecologically, both proposals would include far greater proportions of threatened ecosystems that in turn could be used to support economic growth via tourism, when regulated. The current policy of enforcement (highlighted above) is largely reactive and relies heavily on regulation of detrimental activities or penalising illegal ones and we were unable to find any proactive management initiatives tied to the mandate of the current MPA. Therefore, we have suggested an expansion of policy ideas to be tied to the management and/or creation of further MPA zonation process going forwards. The following amendments to local policy, in conjunction with the newly designated area(s), would also greatly support a more sustainable use of marine resources in the area.

1) A stringent and enforced regulation on diversity and biomass of catch from any fishing or collection from coral reef or offshore (subtidal) mangrove areas. This should extend to all such habitats both within and outside of MPAs, with ideally a complete ban from within MPA areas.
2) Direct involvement from barangays in sustainable use and protection of any and all MPAs.
3) Implementation of regular monitoring efforts from all habitat types, within and outside of MPAs.
4) Participation in active offshore restoration efforts such as artificial reef and substrate deployment, offshore mangrove transplantation and other restocking efforts.
5) A comprehensive and stringent set of guidelines, with enforcement, on regulated activities within MPAs and threatened habitat areas (particularly coral reef, mangrove and seagrass habitats). These should involve stakeholder involvement with the clear understanding of purpose and should then be followed by a comprehensive dissemination of these guidelines throughout relevant bodies in Escalante.
6) Increased infrastructure and investment in promoting marine tourism activities, following sustainable guidelines for ecosystem and MPA use.
7) Creation of more permanent moorings within MPA areas, for Bantay Dagat use only, and a complete ban on anchor dropping from within coral reef and seagrass habitats.

Some of these aspects are expanded below.

4.3 - Steps Towards Sustainability

1) Enforcement

Regulation on catch, particularly from all coral reef areas would have proportionally low economic cost (see Fig. 21) and could promote long term recovery and growth of the commercially valuable fishery. Regulation should involve, at minimum, a ban on the sale of several ecologically important fish types and juveniles of commercially valuable species. Additionally, a release program for low-value/non-target species should be implemented, including juvenile and sub-adult individuals of commercially valuable species, such that the broader fishery may be sustained. When carried out in conjunction with habitat protection and restoration initiatives, these measures could improve the sustainability of the coastal fishery at Escalante dramatically.

A collaborative effort between the Bantay Dagat, captains of coastal barangays, fisherfolk and Escalante government would allow for an effective and integrated management and monitoring effort across all relevant zones. Additionally, input should be sought from an environmental or conservation focused body, well versed in marine ecology, to provide expertise from an ecological perspective. This taskforce should be responsible for the creation of guidelines of marine resource use, both within and outside of protected areas, and the creation of effective management plans for key areas of interest in Escalante waters. Management plans should include the following considerations:

2) Monitoring

A lack of comprehensive and regular monitoring has facilitated uninformed resource use decisions at Escalante thus far, which in turn has likely contributed to many of the challenges faced today. Certainly, this fact resulted in the current MPA zonation scheme in place which has little possible support by data on resources and need for protection within. Aguilar and Villamor (2010) provide one of numerous examples in the Philippines where a lack of monitoring renders protection and enforcement efforts largely redundant for diverse marine communities. At present, only a single attempt can be found to assess and document broadly the marine resources at Escalante (CFRM 2008), however, this provides little detail regarding assessments of ecologically important groups or threats and nothing specific from within the MPA.

Appropriate habitat-specific monitoring protocols need to be applied to each of the three main marine ecosystems at Escalante (coral reef, mangrove, and seagrass) as well as biodiversity assessments at other habitat types (such as soft sediment and soft coral dominated). Established protocols designed around specific habitats would be best suited to acquiring the most relevant information. A focus on ecologically and economically important key indicator groups, such as those directed by the ecological monitoring protocol used (Scott 2012), would allow for broader inferences to be made such as isolating sources of disturbance. This would also allow a targeted comparison between preceding surveys (such as the baseline provided here) and subsequent surveys to document change over time. Crucially, monitoring efforts should be carried out both within and outside of designated protected areas to assess efficacy, and the governing body should remain transparent with monitoring and management outcomes resulting from within these areas. Finally, protocols and specific tools should be standardised across all barangays/monitoring bodies (and subsequently each independently monitored zone) so that information may be compared and combined during assessments. It is only with rigorous and systematic assessments that appropriate management and restoration efforts can be applied. These may further inform a core strategy of best practices to be followed by anyone engaging with the marine environment.

3) Management

Alongside monitoring, targeted restoration efforts would actively and dramatically improve the outcome of recovery and growth of much of the depleted marine resources at Escalante. Numerous proactive efforts can be employed to increase resilience, such as the creation of permanent/semi-permanent moorings at MPAs and areas of sensitive substrate. These would allow for easier monitoring and enforcement by the Bantay Dagat and other relevant bodies and, most importantly, would reduce the need for anchoring at these sites. At present, dropping anchor is common throughout the vast majority of Escalante and damage to sensitive marine habitats such as seagrass beds, soft coral and hard coral habitats was apparent. While these appear to by no means be the leading cause of habitat loss, they are a relatively simple problem to solve, such as by the creation of moorings or even by deploying of anchor further away from the often small areas of habitat. The deployment of permanent moorings could be tied into a larger and significantly more important effort, that being the creation of more stable substrate.

Artificial reefs have been deployed in waters throughout the globe, and when maintained properly, have been shown to have incredible potential for recovery and long-term improvements in localised biodiversity and fish abundances (Seaman and Sprague 1991; Rilov and Benayahu 2002). Much of the coastline of Escalante was found to be ideal for the deployment of artificial substrate due to the shallow and well-defined reef edge throughout most of the coral reef areas, followed by extensive, largely barren sandy areas. The deployment of non-plastic and inert, stable substrate would, in the short term, promote rapid colonisation by numerous fish and invertebrate groups. In the long term, these structures could act as extremely important substrate for the settlement of coral recruits and other important invertebrates. New genetic material will be vital in reef ecosystem adaptability to both local and global threats (Baums 2008), and with some spawning already observed, there is strong evidence that substrate availability will promote coral recruitment.

Heavily depleted groups would also benefit from active restocking of wild populations. Key examples of this include large bivalves such as the giant clams (Tridacnidae) and sea cucumbers. Large bivalves contribute significantly to water quality due to their filter feeding nature and, in particular, giant clams have been shown to be extremely important to coral reef areas. Similarly, the importance of sea cucumbers has also been discussed with many known to contribute greatly to organic matter cycling in various benthic environments. While the restocking of both these groups from ex-situ rearing efforts would not only drastically improve the chances of population recovery in the natural environment, eventually (such as in the case of sea cucumbers), the investment of restocking would allow for long-term economic return from sustainable resource use.

4) Maintenance

By far, the leading uses of marine resources at Escalante are exploitative and extraction based (fishing and collection being the largest contributor). It is a well-established perception at Escalante (and nearby Toboso, see Mehrotra et al., 2016; 2017) that a generational decline in the abundance of fish catch has resulted in a reduction in fishing communities, with many residents seeking alternative livelihoods such as agriculture. At present, there is very little marine-based tourism at Escalante. Our findings suggest that a wealth of diversity at Escalante could promote an active tourism industry if more infrastructure were made available. If tourism activities were regulated and sustainability promoted as a priority, marine tourism at Escalante could be a source of income that could support enforcement and management costs incurred, such as those of the Bantay Dagat, or materials for deployment. One such area of high potential value would be the current MPA which, despite hosting little structurally complex habitat, was found to host a remarkable array of non-sessile charismatic fauna. Sea slugs, frogfish, octopus and seahorses were observed residing on the soft sediment habitats north of Jomabo island and are all contributors to a 150 million USD tourism industry of sediment habitats (De Brauwer et al. 2017). Tourism leveraging these habitats could be easily regulated and would avoid incurring the tourism-related damages to more sensitive benthic habitats. Models such as those highlighted by Huang and Coelho (2017) can be taken into consideration to maximise efficacy of such ventures and can in turn be used to support employment opportunities in marine environments in less exploitative ways.

Figure 27 – Some charismatic species of known popularity to the recreational SCUBA industry in the Philippines, all recorded from Escalante waters.

5 - Conclusion

The waters of Escalante have a wealth of faunal diversity, including many species of particular ecological and economic value. Despite active enforcement against illegal fishing activities, resource extraction from the marine environment, particularly in the form of fishing pressure, has left many of these ecologically and economically important species in dire straits. The current MPA offers little to no benefit in the protection of the ecologically and economically important species of Escalante's waters. Our proposed zonation of the Marine Protected Area to be redistributed along the coast offers a more effective placement and, with the involvement of the barangays and the BD, would facilitate the preservation of threatened habitats, a safe habitat for fish, and recovery of this invaluable ecosystems and the depleted fishery. Escalante's current biodiversity offers a wide diversity of hard coral and charismatic species that have intrinsic value in the tourism industry. Effective management and protection of these waters offer not only the recovery of the fishing industry, but an opportunity for economic benefits associated with ecotourism as well. It is crucial that this reallocation of the MPA be coupled with enforcement, monitoring, management and maintenance, including increased policy and enforcement on unregulated and illegal fishing as well as the instillation of permanent mooring lines to be used by the BD in place of dropped anchors. Escalante's location and rich diversity provide an opportunity for improvements in ecological and economic sustainability and highlight the importance of protection and mindful management of the coast.

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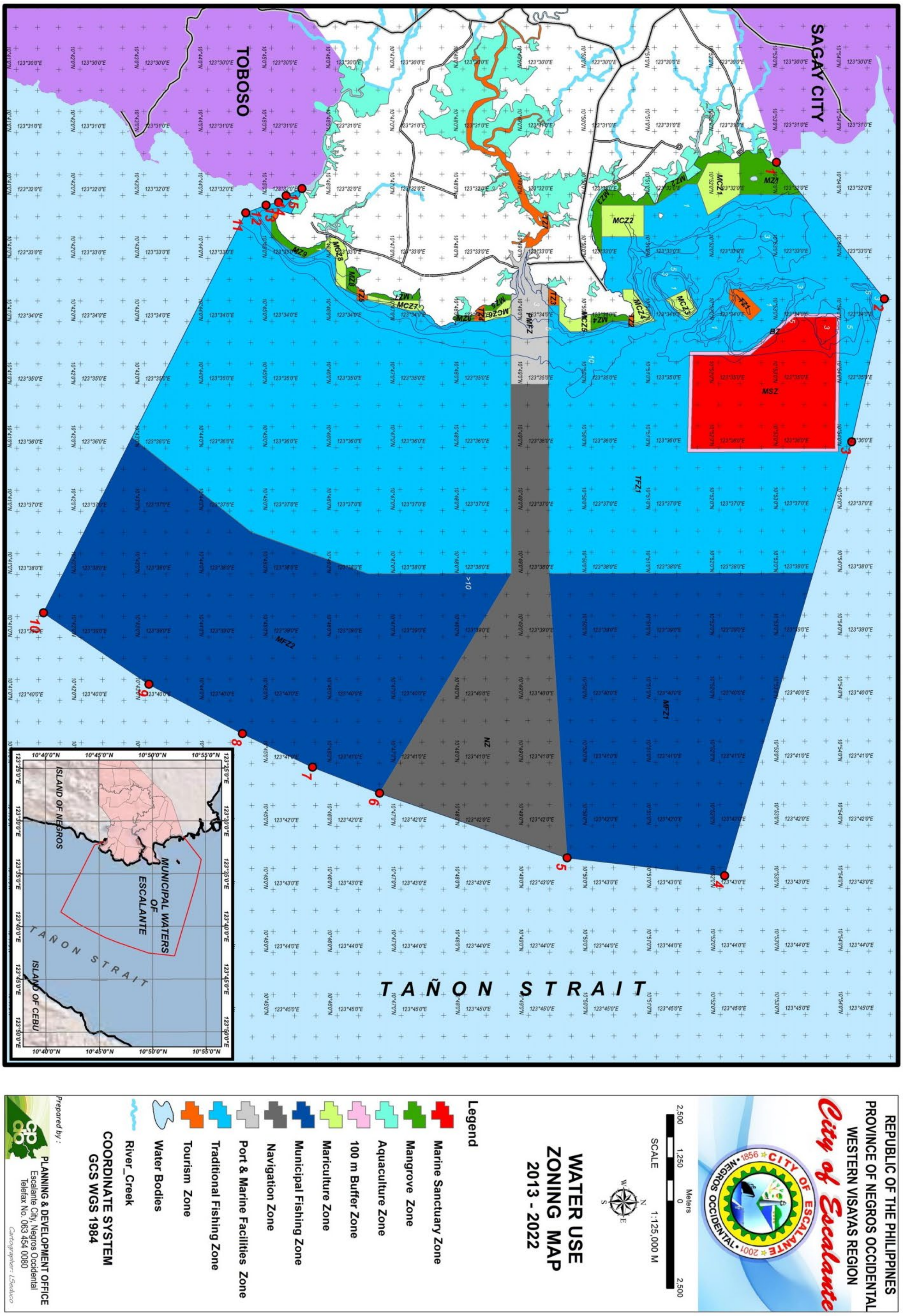
Appendices

Appendix I –

Complete zonation map of Escalante waters, as provided by Escalante city.



Appendix II –

Table of coordinates corresponding to proposals NMPA 1 and NMPA2 (see Figures 25 and 26).

Size (ha)	**NMPA1**
80	**MPA1**
a	10°52'60.00"N - 123°32'00.00"E
b	10°52'20.00"N - 123°32'00.00"E
c	10°52'9.00"N - 123°32'8.00"E
d	10°52'10.00"N - 123°32'20.00"E
e	10°53'0.00"N - 123°32'15.00"E
303	**MPA2**
a	10°54'30.00"N - 123°33'19.00"E
b	10°54'41.00"N - 123°33'34.00"E
c	10°54'35.00"N - 123°34'4.00"E
d	10°54'28.00"N - 123°34'26.00"E
e	10° 53'16.60"N - 123°33'51.00"E
112	**MPA3**
a	10° 53'16.60"N - 123°33'51"E
b	10° 52'50.0"N - 123°34'14.00"E
c	10° 52'38.0"N - 123°33'27.00"E
d	10° 53'00.0"N - 123°33'18.00"E
73	**MPA4**
a	10° 51'20.0"N - 123°33'13"E
b	10° 51'40.0"N - 123°33'50"E
c	10° 51'30.0"N - 123°34'00"E
d	10° 51'3.0"N - 123°33'32"E
23	**MPA5**
a	10° 51'1.00"N - 123°34'15.00"E
b	10° 51'00.0"N - 123°34'00"E
c	10° 50'40.0"N - 123°34'5.00"E
d	10° 50'41.5"N - 123°34'15.00"E
23	**MPA6**
a	10° 50'00.0"N - 123°34'20"E
b	10° 50'00.0"N - 123°34'10"E
c	10° 49'40.0"N - 123°34'10"E
d	10° 49'30.0"N - 123°34'00"E
e	10° 49'30.0"N - 123°34'13"E
28	**MPA7**
a	10° 48'45.0"N - 123°33'48.00"E
b	10° 48'15.0"N - 123°33'55.00"E
c	10° 48'20.0"N - 123°34'4.00"E
d	10° 48'43.0"N - 123°34'1.00"E
33	**MPA8**
a	10° 47'20.0"N - 123°33'50"E
b	10° 47'10.0"N - 123°33'50"E
c	10° 46'30.0"N - 123°33'40"E
d	10° 46'30.0"N - 123°33'48"E
e	10° 47'20.0"N - 123°33'58"E
75	**MPA9**
a	10° 45'43.0"N - 123°32'54"E
b	10° 45'20.0"N - 123°32'54"E
c	10° 45'6.0"N - 123°32'45"E
d	10° 45'35.0"N - 123°33'15"E
e	10° 45'0.0"N - 123°33'12"E
250	**MPA10**
a	10° 52'52.25"N - 123°34'41.00"E
b	10° 52'50.0"N - 123°34'14.00"E
c	10° 51'56.0"N - 123°33'38.00"E
d	10° 51'32.0"N - 123°34'28.00"E
1000	**Total Area**

	NMPA2
a	10°54'30.00"N - 123°33'19.00"E
b	10°54'41.00"N - 123°33'34.00"E
c	10°54'35.00"N - 123°34'4.00"E
d	10°54'28.00"N - 123°34'26.00"E
e	10°54'12.00"N - 123°34'34.00"E
f	10°51'4.00"N - 123°34'18.00"E
g	10°50'53.00"N - 123°33'17.00"E
h	10°51'12.00"N - 123°33'12.00"E
1251	**Total Area**

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