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Status, benthic composition and generic diversity of coral resources in Tinabilan Fish and Shell Sanctuary, Northwest Leyte, Eastern Philippines

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Abstract

Marine Protected Areas (MPAs) were recognized as an effective strategy to improve the hard coral cover through the reduction of anthropogenic stressors and pressures. With the absence of baseline data on the status of the coral reef community structure in Tinabilan Fish and Shell Sanctuary, the enforced protection and management effectiveness could not be determined. Baseline data on the hard coral cover, taxonomic composition, and benthic community structure were gathered using the enhanced Point Intercept Transect (PIT) method supplemented with the Taxonomic Agglomeration Units (TAUs). The outside stations of the protected area were recorded to have a slightly higher cover and generic diversity of hard corals compared to the inside stations. However, it was revealed during informal interviews that the present location of the MPA was heavily bombarded with illegal fishing activities decades ago. The data suggest that the protection implemented in the MPA may have gradually improved the benthic community structure of the coral reef.

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Introduction

Several natural events and anthropogenic activities caused coral reef status to decline worldwide (Hughes *et al.,* 2017). The continuous decline results to poor biodiversity and alter the massive ecosystem services they provide (Mouillot *et al.,* 2016). The recent nationwide assessment of coral reef areas research program revealed the one-third loss of hard coral cover (Licuanan *et al.,* 2020). Despite this, coral reefs remain to be one of the food and livelihood source by the communities inhabiting nearby contributing a total economic value of US$ 352,249.00/ha/year (Azanza *et al.,* 2017). The challenge to attain sustainability of resources drives coastal resource managers to significantly provide strong protection to coral reefs.

One of the effective management strategies is the establishment of Marine Protected Areas (MPAs) where coral reefs and its associated benthic organisms are given the chance to replenish stocks, improve hard coral cover, and reduce further degradation (Edgar *et al.,* 2014). All these can be attained through strong implementation of protection by reducing the stressors and pressures within the MPA (Groves & Game, 2016). With this, biodiversity will be improved attaining sustainable resources and food security (Sale *et al.,* 2005).

The Tinabilan Fish and Shell Sanctuary was established to promote conservation of biodiversity in the barangay. Unfortunately, since its establishment in 2016, no comprehensive and detailed baseline assessment was conducted to determine the increase in fish stocks, biodiversity, and hard coral cover. With this, the effectiveness of the management strategy cannot be determined without the results of the baseline and monitoring activities (Tuang-tuang, 2021). Thus, baseline data should be established to undertake temporal trend of hard coral cover and biodiversity to determine the effectiveness of conservation management tool.

Materials and methods

Sampling Area

Tinabilan Fish and Shell Sanctuary is located in Barangay Tinabilan, Palompon, Leyte. It is one of the coastal barangays in the northern part of the municipality. A total of four stations were surveyed in this study: two (2) stations inside the sanctuary and two (2) stations outside the sanctuary. These stations will also serve as monitoring stations for future assessments.

Data Collection and Further Analyses

Benthic communities and the underlying substrates were assessed using the modified point-intercept method based on Reef Check Worldwide survey methodology. In each station, three 50-m transect lines were laid to the reef crest, following topographic contours at 5-m tide corrected depth. The substratum was identified along the transect. A total of 201 points were gathered at 0.25m interval starting from 0m of the transect line. The substratum directly under each point was identified. For hard corals, the genus and lifeform were determined. Gathered data enabled the researcher to evaluate the percentage cover of the coral colonies and associated benthos present in the reefs surveyed. Categories used for the coral reef description was based on Licuanan, 2020.

Results and discussions

Benthic community structure

The average percentage cover of hard coral in the Tinabilan Fish and Shell Sanctuary was 25.81% which falls under the Hard Coral Cover (HCC) Category C on the revised hard coral cover scheme by Licuanan, 2020 (Fig. 2). Algal assemblages covering dead coral colonies have 34.20% mean cover. Abiotic components were mostly dominated by sand (10.45%) and rubble (1.93%) which can be associated by moderate sedimentation rate and coral damages in the area. Macroalgae have mean percentage cover of 8.71%. Other organism which was mostly dominated by some branching and encrusting sponges have 10.14% mean cover. Soft corals have low mean percentage cover with only 0.19% which is significantly lower compared to the HCC.

Hard Coral Benthos

The overall mean cover of all the stations was 25.81% which also belongs to HCC category C (Fig. 3) while mean HCC in the outside stations was 26.37%, which was slightly higher from the HCC in the inside

stations. The outside stations were known as an open fishing ground, however, hard coral cover was slightly higher owing to the preponderance of fragile *Montipora* branching and *Porites* encrusting in the station. It was observed that developing coral colonies from different hard coral species thriving on top of the dead coral colonies.

The hard coral cover in the sampling area were mostly associated to the family Acroporidae, Faviidae, Poritidae. The encrusting lifeform of the genus *Porites* has the highest hard coral cover in the inside stations. The species under this genus are tolerant to physical stress and change in seawater chemistry (Guest *et al.,* 2016; Pichon, 2011; Alcala & Bagaliho, 2003). Moreover, they usually dominate in coral reef area which have percentage covers belonging to HCC Categories B, C, and D (Licuanan *et al.,* 2019). In the outside stations, the fragile *Montipora* branching dominated the reef area with 15.61% mean cover followed by the *P.* encrusting (10.57%); *Cyphastrea* (8.24%) and *Favites* (7.36%).

Other hard coral genera from family Agariciidae, Agathiphyliidae, Euphyllidae, Fungiidae, Mussidae and Pocilloporidae were also recorded in the sampling stations. The branching *Pocillopora* have 5.93% and 5.27% mean cover in the inside and outside stations, respectively. Also, other branching hard corals like *Seriatopora* has higher mean cover in the inside stations with 6.08% while only 2.40% mean cover was recorded in the outside stations. The stress tolerant genus *Diploastrea* has low mean percentage cover both in the inside (3.40%) and outside stations (2.96%).

Other members of the Family Acroporidae which are known sensitive to various stressors were noted with low coral percentage covers. These genera and their corresponding mean covers were the following: *Acropora* (with the different lifeforms, corymbose (0.71%), digitate (0.56%), and hispidose (0.52%)), and the massive *Astreopora* (4.46%). The low percentage covers of the coral colonies belonging to this family could denote that the current seawater chemistry does not meet the optimum requirements of these hard corals to flourish. The genus *Acropora* positively contributed to the complexity of the reef which harbors different reef-associated organisms.

The biodiversity in the coral reef are totally dependent on the complexity of the substrate as complex reef structure offers huge ecosystem services to reef-associated organisms and communities nearby (Graham & Nash, 2012; Cinner *et al.,* 2009). Each coral reef lifeform provides exclusive ecosystem services, environmental conditions, and functions (Edinger & Risk, 2000). For example, branching corals provide refuge for fish and increase tourism services (Stella *et al.,* 2011) while massive corals significantly contribute to coastal protection (Edinger & Risk, 2000).

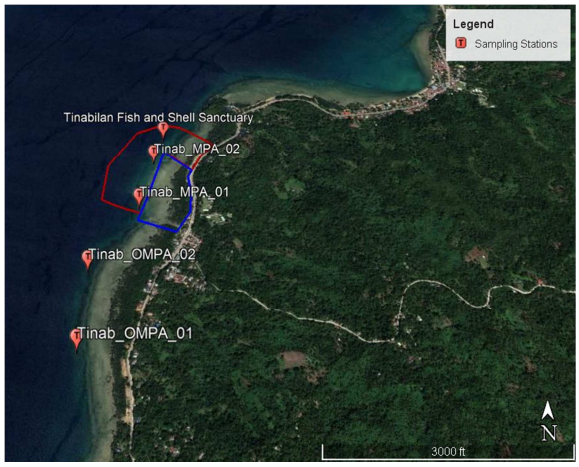

Fig. 1. Map showing the location of the sampling stations in Tinabilan Fish and Shell Sanctuary, Palompon, Leyte.

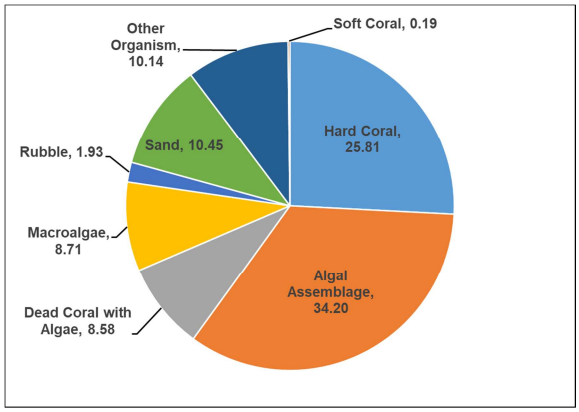

Fig. 2. Mean percentage cover of the hard coral and reef-associated benthos in the Tinabilan Fish and Shell Sanctuary, Tinabilan, Palompon, Leyte.

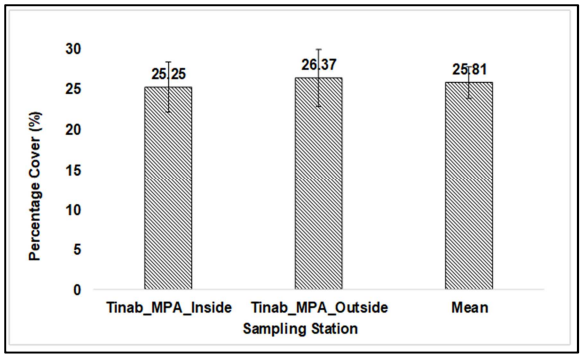

Fig. 3. Percentage covers of the hard coral resources in Tinabilan Fish and Shell Sanctuary, Tinabilan, Palompon, Leyte.

Coral Generic Diversity

Coral generic diversity has an average of 24.0 coral TAUs which falls under Diversity Category B (Licuanan, 2020 (Table 1). The mean coral TAUs recorded in the outside stations was 25.0 coral TAUs while only 23.0 mean coral TAUs observed in the inside stations. The data could suggest that the outside stations positively contributed to the coral recruitment inside the sanctuary. Also, inside stations were heavily affected by destructive illegal fishing methods years ago as confirmed by local officials. The protection in the sanctuary provided opportunity for coral larvae to settle down and develop into coral juveniles, which will gradually improve the coral cover through time. The average generic diversity in Tinabilan Fish and Shell Sanctuary is slightly higher to the mean generic diversity in Tubbataha Reef Natural Rank with an average of 18 coral TAUs recorded (Licuanan *et al.,* 2019; 2016). This natural park was used as basis for the proposed generic scheme and threshold of generic diversity (Licuanan *et al.,* 2016). Also, this mean generic diversity in Tinabilan Fish and Shell Sanctuary is in consonance with the average coral cover recorded in the Visayan Sea bioregion (Licuanan, 2020).

Table 1. Summary of the generic diversities in the Tinabilan Fish and Shell Sanctuary, Tinabilan, Palompon, Leyte.

Sampling Area	Station 1	Station 2	Mean
Inside Sanctuary	22	24	23.0
Outside Sanctuary	25	25	25.0
Mean Generic Diversity			24.0

Other Reef Associated Benthos

Turf algae which cover dead coral colonies have 34.20% mean cover. The inside stations have the highest mean cover with 40.92% compared to the outside stations with only 27.49% average cover (Table 2). As observed, the outside stations have lower mean cover because dead coral colonies were also dominated with macroalgae and encrusting sponges. The high turf algal cover in the inside station denotes a degraded reef (Licuanan *et al.,* 2017; Sandin *et al.,* 2008)). Turf algae dominate the available space that was left by coral colonies (Littler *et al.,* 2006). However, these algal assemblages were considered possible settlements for coral juveniles which were apparent in the inside stations (Licuanan *et al.,* 2019).

Table 2. Summary of the percentage cover of the major benthos in Tinabilan Fish and Shell Sanctuary, Tinabilan, Palompon, Leyte.

Category	Tinab_In_ MPA	Tinab_Out _MPA	Mean
Hard Coral	25.25	26.37	25.81
Algal Assemblage	40.92	27.49	34.20
Dead Coral with Algae	8.33	8.83	8.58
Macroalgae	4.10	13.31	8.71
Rubble	1.37	2.49	1.93
Sand	11.82	9.08	10.45
Other Organisms	8.08	12.19	10.14
Soft Coral	0.12	0.25	0.19

Moreover, macroalgae have lower mean percentage cover with only 8.71% while the outside stations have the highest cover of macroalgae with 13.31%. Macroalgae outcompete with the growth of hard corals in the area. On the other hand, the inside stations have only 4.10% mean cover. Most of the macroalgae which thrived and dominated in the stations were brown algae belonging to the genera *Gracilaria* spp., *Sargassum* spp., *Dictyota* spp., *Padina* spp. and red algae, *Jania* spp. and *Actinotrichia* spp.

Looking at the details, shift from coral dominance to macroalgal dominance was apparent in the reef area. Phase shifts of reef dominated areas to other benthic organisms like corallimorpharians, zoantharians and macroalgae were also documented in the other areas of the Indo-Pacific (Ward-Paige *et al.,* 2015; Hughes *et al.,* 2007). This shift can be associated to poor

water quality and other anthropogenic activities leading to the decline of the hard corals (Fabricius & De'ath, 2004). Locals also confirmed through informal interviews those decades ago, illegal fishing activities (i.e. blast fishing and cyanide fishing) were widely practiced to increase fish catch, without considering the effects to reefs. The decline of the hard coral colonies as a result of illegal activities paved way for the dominance of macroalgae. This can also be attributed to the high influx of nutrients in the area brought by current and the mangrove ecosystem nearby. Also, the road widening project in the barangay affects the water quality of the seawater. Water turbidity was heavily affected as well as entry of nutrients coming from terrestrial environment leading to possible eutrophication in the area (Cooper *et al.,* 2009). Though nutrient content analysis in the seawater was not included in this assessment, future studies may be considered in order to correlate the physiology and rampant growth of macroalgae with the water quality.

In addition, abiotic components, particularly sand, have considerably higher mean percentage covers in the sanctuary. Sand has 10.45% mean cover where inside stations have highest cover with 11.82% while the outside stations have 9.08% mean cover. Sand can be found in the grooves of the reef. Sand accretion in the reef can be attributed to the mangrove forests and the on-going road widening project which does not only contribute nutrients in the seawater but also sediments. This sand accretion can affect water turbidity which limits the light penetration essential for coral growth and photosynthesis of its symbiotic algae. Sediments tend to smother corals and other resources (Flower *et al.*, 2016). With this, developing coral colonies present in the reef area could not grow into bigger sizes due to the factors mentioned. Moreover, coral rubble has 1.93% overall mean cover. The outside stations have higher cover with 2.49% while the inside stations have 1.37%. The outside stations are open fishing ground which were exposed to different anthropogenic activities like illegal fishing practices. Also, it was observed during the sampling that these coral rubbles were fragments of branching coral colonies.

Conclusions

This study revealed the status of coral reef resources in Tinabilan Fish and Shell Sanctuary. The average hard coral covers in the outside stations were considerably higher compared to the protected stations in the sanctuary. This can be associated to rampant illegal activities in the inside stations before the establishment of the sanctuary. However, the results showed possible recovery of the coral reef areas from severe damage. The size of the sanctuary may be expanded integrating mangrove and seagrass ecosystems as they are interconnected to create a marine protected area with a more holistic approach of conservation. With the establishment of the baseline data, the findings can be utilized for future monitoring activities to detect changes and improvements through time to implore and plan more effective interventions to attain sustainability of marine resources and food security.

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