International Journal of Multidisciplinary Research and Growth Evaluation.

Coral reef assessment in Malabongot protected area and the proposed Fish Sanctuary And Marine Reserve (FSMR) in Sumaoy, Garchitorena Camarines Sur, Philippines

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Article Info

ISSN (online): 2582-7138
Volume: 03
Issue: 03
May-June 2022
Received: 15-04-2022;
Accepted: 01-05-2022
Page No: 210-214

Abstract
Corals are significant organisms in the marine ecosystem because of their abilities to buffer the intensity of extreme tidal wave or tsunami. They also have reputation in terms of providing spawning ground and habitat for fishes, and other living marine organisms. Despite of these numerous ecosystem services of corals, they are exploited intensively due to anthropogenic activities. One of the actions that can be made to this kind of ecosystem to prevent harm, and become stable is through the establishment of Marine Protected Areas (MPAs). This will help in the protection and improving coral reserves of the ocean. For this purpose, baseline data regarding the characteristics of coral reefs and their status are crucial for analysis. The mean hard coral cover in the study site, Sumaoy, falls under category B reefs (36%HCC) but the diversity is within Diversity Category C reefs (>18-22TAUs). The overall dominant corals or with high abundance status are the mushroom (CMR) corals. This coral is commonly inhabited sheltered reefs or lagoon where their structure as solitary living colonies are well adopted. The fish population in the area is generally poor and the abundance of target species is relatively low. An indication of high fishing effort as exhibited by remnants of fishing lines and nets entangled to coral heads.

Keywords: Corals, fish sanctuary, marine reserves, Garchitorena

Introduction

Coral reefs are important source of food and income in the Philippines and contributed to about 11-29% of the total fisheries production. But a threatened ecosystem due to the increasing impact of human activities. Coral reefs and reef biodiversity are also facing risk due to global climate change (Hoegh-Guldberg *et al*., 2006) [5]. Human-related activities such as coastal development and nutrient pollution may also exacerbate the effects of natural phenomena and climate change (Mumby, 2006).

One important measure to enhance coral reefs' ability to withstand (resistance) or recover (resilience) from any form of disturbance (either natural or anthropogenic) is through the establishment of marine reserves. It plays an important role in maintaining the level of spawning stock biomass necessary to sustain reef fisheries. They have been shown to improve biodiversity within their boundaries and may potentially export adult fish biomass as well as replenish larvae in fished areas (Abesamis & Russ, 2010) [1]. If managed properly, it goes beyond the traditional objectives of fisheries management and biodiversity protection (Alban *et al*., 2006) [2].

Local Government Units (LGUs) are mandated to establish Marine Protected Areas (MPAs) in the municipal waters in order to manage and protect their coastal fishery resources. As these resources are being confronted with burgeoning issues associated with human activities, there is a need to regularly monitor Marine Protected Areas (MPA). In Garchitorena, a national declared MPA, Malabongot Protected Area, was established and another locally-manage Fish Sanctuary and Marine Reserve (FSMR) was proposed in Barangay Sumaoy.

Thus, a baseline assessment is necessary to establish benchmark data of the benthic ecosystem in this proposed FSMR. This report summarizes the result of the coral reef assessment conducted in the municipality of Garchitorena in collaboration with the Community Environment Natural Resources Office (DENR-CENRO) Goa, Camarines Sur. Furthermore, the study assesses the status of the benthic ecosystem of the coral reef in Malabongot Protected area and the proposed Fish Sanctuary and Marine Reserve (FSMR) in Barangay Sumaoy, Garchitorena, Camarines Sur.

Methods and Materials

Survey of Benthic Communities

Sampling stations were haphazardly selected in the center of the proposed FSMR in Sumaoy and in the coral reef facing the northern part of Malabongot Protected Area. However, no data were collected in the latter due to low visibility associated to the prevailing northeast monsoon wind during the sampling period. Thus, this report only represents reef condition in Sumaoy where two stations were randomly selected. Coral reef with 75 meters long and 25 meters wide were selected in the sampling area. Two 50 meters transect line were established bisecting the coral communities following same depth contour (<5m) parallel to the shore. A random number generator was used to determine the starting positions of the second transects relative to transect #1 at the deep edge of the station. The shallower side of each transect was then photographed at 1-meter intervals using a digital camera equipped with an underwater housing mounted on a PVC monopod. Images from transect #1 were also taken, beginning at randomly determined starting point.

Transect images were analyzed using the CPCe software (Kohler & Gill 2006) [6]. Each underwater photographic frame is overlaid by a matrix of 10 randomly distributed points, and the benthic components lying beneath each point was visually identified using the Taxonomic Amalgamation Units (TAUs). TAUs were grouped among six major categories, namely, hard corals, dead corals, abiotic material, Halimeda, macroalgae, and other biotas. Hard coral consists of 59 TAUs that are the common hard coral genera in the Philippines, with species-rich genera such as *Acropora*, *Montipora*, and *Porites* further identified to their growth forms (Licuanan *et al*., 2017) [7]. Hard Coral Cover (HCC) will be based on the new thresholds established by Licuanan *et al*. (2017) [7] for the status of the Philippine reefs.

Table 1: The threshold for evaluating the status of Philippine Reefs (Licuanan *et al*. 2017) [7]

Live Hard Coral Cover	Classification/Condition	
0-22%	Category D	Poor
22-33%	Category C	Fair
33-44	Category B	Good
44>	Category A	Excellent

Fish Visual Survey

Similar transects were used for Fish Visual Census Survey (FVC). Fish Visual Census survey was conducted by identifying each variety of fish species observed within imaginary 2.5 m^2 at either side of the transect. The number and sizes (total length) of fish in cm were estimated and identified to the lowest taxon as possible. Fish Abundance was classified according to three general categories; target species are those commercially important and targeted by fishermen (e.g Serranidae (groupers), Carangidae (jacks/trevally), Lethrinidae (emperorfish), Lutjanidae (snappers), Haemulidae (sweetlips), Caesionidae (fusiliers) Scaridae (parrotfish), Siganidae (rabbitfish), Mullidae (goatfish), and >10 cm individuals of Acanthuridae (surgeonfish/unicornfish); Indicator species are species relies on coral reef health for survival (e.g Chaetodontidae (butterflyfishes) and Non-target species are those serve as tropic link and less valued species (e.g Pomacentridae (damselfishes). Fish identification followed Fish Based 2004 and Allen *et al*. (1997). Fish Biomass was computed using Length and Weight (A and B values) relationship based from Nañola (unpublished) using the formula:

$$\text{Biomass} = \frac{\sum \text{weight (gms)}}{\text{Area of Transects}}$$

$$= \text{gms/m}^2$$

$$\text{Density} = \frac{\sum \text{count of all species}}{\text{Area of Transect Line}}$$

$$= \text{Individuals / m}^2$$

Computed fish biomass was standardized to MT/km^2. Species richness and density measurement of the sites were categorized based on the index of Hilomen *et al*. (2000) as presented in Table 2.

Table 2: Hilomen's species richness and abundance index

Fish Species Diversity (no. of species/1000m²)				
Very Poor	**Poor**	**Moderate**	**High**	**Very High**
0 – 26	27 - 47	48 – 74	76 – 100	>100
Fish Density (no. of fish/1000m²)				
Very Poor	Poor	Moderate	High	Very High
0 – 201	202 - 676	677 - 2,267	2,268 - 7,592	>7,592

Results

Benthic Communities

The coral reef ecosystem in Sumaoy is generally a fully-formed reef with reef flat extended more than 200 meters from the shoreline and reef slope down to around 50 ft. The two stations (Sum A and Sum B) represent varying conditions of the coral ecosystem. Sumaoy B recorded 55% hard coral cover categorized in excellent condition (Fig 1). On the other hand, Sum A has three times lower coral cover (28%) under "poor" condition.

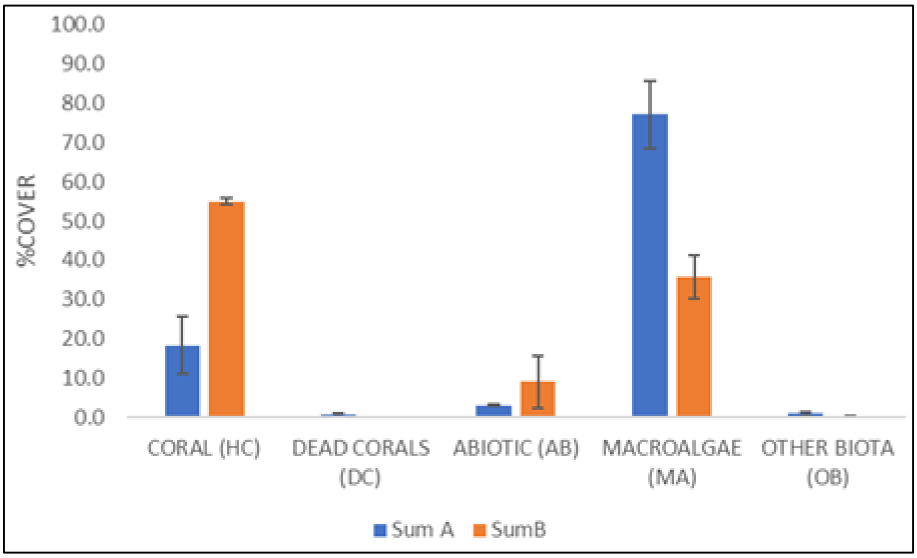

Fig 1: Comparative mean percentages cover of the benthic components in the two stations established in the proposed FSMR in Barangay Sumaoy, Garchitorena, Camarines Sur detailing the prevalent substrate categories (Error Bars =SE)

Among other benthic components, macroalgae recorded relatively high cover in both stations, but doubled in the Sum A. Brown macro-algae generally represents these taxa indicating shift of the primary benthic inhabitants. The common abiotic components in these stations were different wherein rubbles and sand have a minimal percentage in Sum A while silt was common in Sum B. One of the transects in Sum B recorded as much as 14% cover of silt indicating the exposure of corals in this human-associated stressor. Other biotas were generally represented by minimal occurrences of soft corals.

Coral Diversity

Table 3: Comparative ranking of Ten (10) dominant coral TAUs and mean percent cover in the proposed FSMR in Sumaoy, Garchitorena, Camarines Sur

Rank	Sumaoy B	Mean Percentage		Sumaoy A
1	Fungia (CMR)	8.42	6.47	Porites massive (PORM)
2	Acropora corymbose (ACC)	7.12	3.80	Porites branching (PORB)
3	Porites branching (PORB)	7.11	2.92	Porites encrusting (PORE)
4	Hydnophora (HYD)	5.58	1.40	Other encrusting corals (CE)
5	Pavona (PAV)	5.57	0.75	Other massive corals (CM)
6	Other encrusting corals (CE)	5.03	0.65	Euphyllia (EUP)
7	Porites massive (PORM)	2.51	0.54	Other free living fungiids (FOT)
8	Other branching corals (CB)	2.40	0.33	Stylophora (STY)
9	Montipora encrusting (MONTE)	1.86	0.32	Favites (FVI)
10	Other massive corals (CM)	1.20	0.22	Acropora corymbose (ACC)

A total of 52 coral TAUs were recorded in the two stations in Sumaoy. 34 of which were observed in Sumaoy B with *Fungia*, *Acropora*, *Porites*, *Hydnophora*, Other Encrusting corals have the highest mean percentage of occurrence (Table 2). In Sumaoy A, 18 coral TAUs were identified and the three growth forms of genus *Porites* contributed significant percentage of occurrence while the rest were less abundant at <>1% abundance. Consequently, overall diversity (S-W index) in this station is relatively lower (1.99) than that of Sumaoy B at 2.69, respectively.

Fish Visual Census

A total of 133 individual belonging to 13 families, 23 genera and 30 species of reef-fishes were recorded in the coral reef area. The diversity and density index appeared to be in the "poor" category. Non-target species dominates the overall reef-fish population comprising of damselfishes (Pomacentridae) and wrasses (Labridae) consequently having highest estimated biomass. Indicator species were less abundant mostly represented by butterflyfishes (Chaetodontidae) and Moorish idol (Zanclidae).

Target fishes have the lowest estimated biomass (1.2 kgs/hectare) despite second in abundance. Most of the individuals were a depauperate population of grazers and piscivorous species. It could possibly a sign of habitat disturbance and higher extraction rate. The potential biomass (1.5 MT/km^2) is far from than the average value of 30 MT/km^2. Predatory species (e.g groupers and snappers) usually disappears in non-manage and heavily fished reef areas. The objectives of rehabilitation will be met by continuing enforcement activities and become drivers of positive changes in fish population in the protected area (Maliao *et al*. 2009) [8]. Low biomass in most of the reserve in the region is associated with inadequate enforcement activities (per observation).

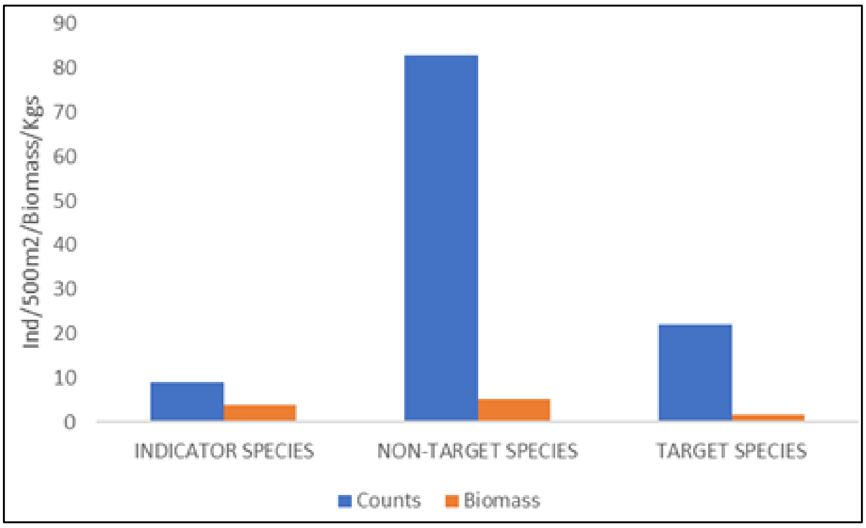

Fig 2: Comparative biomass and abundance of three reef fish categories in Sumaoy, Garchitorena, Camarines Sur

Discussions

On the average, the mean hard coral cover in Sumaoy falls under category B reefs (36%HCC) but the diversity is within Diversity Category C reefs (>18-22TAUs). The overall dominant (Top 10) coral TAUs in these reef areas corresponds also with that of Licuanan (2017) [7] with exception of the high abundance of mushroom (CMR) corals. This coral is commonly inhabited sheltered reefs or lagoon where their structure as solitary living colonies are well adopted. As observed varying exposure of each sampling sites in siltation, wave action and fishing activities influence the relatively different hard coral cover. The high cover of macro-algae in both sites could have influenced by siltation. Apart from smothering corals, it outcompetes corals in space and ultimately outgrown by this growing biota. This resulted to phase-shift from coral dominance to macro-algal dominance commonly observed the reef area closer to human disturbance. This phase shift is driven by nutrient enrichment that promotes the growth of macroalgae. Inshore reefs are low in percentage cover, diversity and vulnerable to ecological changes. Solid waste (plastics) and remnants of fishing materials have been noticed to exacerbate the effect of the above-mentioned factors. Although, it only inflicts small damages but when ignored could result to significantly destroyed reef area.

The present coral condition in the assessed sites requires comprehensive coastal resource management implementation to save the remaining areas with high coral cover and allow recovery of the reef fisheries. If management is in place, the coral will likely take some time to recover from its original condition and large target fishes may take up 15 years to recover in abundance from pre-fished abundances. The occurrence of crown-of-thorns starfish (COTs) is an additional concern as it exacerbates damage and will affect the remaining live corals. Manual removal via scuba can be initiated to address this issue. Although not considered in an outbreak situation, COTS is known voracious predator of reef-building corals and brought substantial effects by reducing the abundance of coral cover, thus, increasing the surface cover of algae. Hence, immediate extraction is necessary to protect corals from infestation.

The fish population in the area is generally poor and the abundance of target species is relatively low. An indication of high fishing effort as exhibited by remnants of fishing lines and nets entangled to coral heads. This situation is common to a non-manage reef and most likely inadequate enforcement have contributed to the poor fish population. Furthermore, fishing removes ecologically important reef fishes such as Acanthurids (Surgeon fishes) and Siganids (Rabbitfishes), which controls algal growth detrimental to reef development.

Conclusions

The use of MPA Management Effectiveness Assessment Tool and Management Effectiveness Tracking Tool might also help to monitor the progress and can be used in planning, decision-making, and implementation. In addition, active restoration via coral transplantation can be an option to facilitate the recovery of the reef considering that an observed number of corals of opportunities (COPs) are present in the studied areas. Furthermore, an annual FSMR management plan is also recommended to be formulated and implemented.

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