



Coral cover, fish populations, and management practices of Marine Protected Areas (MPAs) in Tuburan, Cebu

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ABSTRACT

A practical implementation of marine management practices will warrant long-term sustainability of marine protected areas (MPAs) and stability of the fishers' livelihood in the area. This research presents the coral cover, fish diversity and describes the management practices of Barangay Sto. Nino and Barangay Apalan marine protected areas in Tuburan, Cebu, Philippines. Coral reef survey, visual fish census, and MPA Management Effectiveness Assessment Tool (MEAT) are employed. Results showed that the reef in Sto. Niño exhibits a high percentage of live hard corals at 49%, and dead corals with algae and rubble with only 15%. The fish density in the area is 508 individuals/250sqm whereas live hard coral (LHC) cover in Apalan is 24%. A dead coral percentage is relatively high at 38%, and fish density is 349 individuals/250sqm. Massive corals dominated the two MPAs, followed by submassive and branching corals. Both MPAs recorded damselfish (Pomacentridae), wrasse (Labridae), and coral health indicator fishes (CHI), such as butterflyfish (Chaetodontidae), and angelfish (Pomacanthidae). Overall evaluation of the reef conditions of Sto. Niño and Apalan MPAs are "fair" and "poor," respectively. Accordingly, there is a need to periodically prioritize local biological monitoring and MPA evaluation through institutional collaborations (i.e., local government, academe) to improve and sustain the MPAs in Tuburan, Cebu.

KEYWORDS: *coral reef condition, fish populations, Marine protected area (MPA), MEAT, marine protected area management practices*

1 INTRODUCTION

Marine protected areas (MPAs) are needed to protect and rebuild coastal and marine ecosystems, which are instrumental to coastal conservation and management policies (Pelletier, 2020). Its effectiveness relates to traditional resource use patterns of the people who live within or near the area. The establishment of these areas must include a complete understanding of the activities of the people in their local environment, the ecology of the target species, and the critical habitat (DENR 2001).

A site chosen for high productivity and biodiversity serves a particular ecological function as a spawning and feeding ground for one or more marine species. Moreover, in the advent of climate change, MPAs are thought to be one of the answers to preserving our much-threatened marine resources amidst the negative impacts brought about by natural calamities (i.e., typhoons, storm surges, earthquakes). As coastal communities continually and gradually face diminishing resources from land and sea, the urgency to assess MPAs is necessary (Liquete, 2013) and instrumental in determining community-based marine conservation.

Local MPA managers are now using certain monitoring activities and management evaluation tools to assess their effectiveness in the long term. Guides to coral reef monitoring are made accessible to local communities and managers to keep track of the changes on coral reefs, determine their present use and improve their management (Uychiaoco *et al.*, 2010). The MPA Management Effectiveness Assessment Tool (MEAT) is a management tool that allows managers to measure the effectiveness of their locally managed MPAs, looking at several criteria or governance indicators combined with the biophysical and socioeconomic impact indicators (CCF; Arceo *et al.*, 2001). Moreover, assessing the governance in enforcement, implementation, and maintenance of MPAs is also essential.

In the Philippines, the formation of MPA networks is a way to enhance management practices of existing MPAs by forging collaborative partnerships among local governments to coordinate initiatives and share essential data and resources among stakeholders (Horigue *et al.*, 2014). MPA management in the context of governance approaches in the Philippines is not limited to the physical management of the MPA only but also includes direct and indirect uses, threats, people, and the systematic interactions between people and resources. Nonetheless, the attitudes and actions of individuals in the community can be vital in influencing support towards MPA's effectiveness (Chaigneau and Daw, 2015).

Recently, marine tourism has begun to exert influence on local communities to promote the establishment of MPAs, such as in Moalboal, Cebu,

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Philippines (Lucas & R. Kirit, 2009). The succeeding stages of MPA establishment are the management of the reef. This call for the formation of a management structure or body and the creation of a management plan, which is crucial for the sustainability of an MPA, monitoring protected areas in quantitative condition assessments (Pelletier, 2020) should be repeated at regular intervals, and conduct qualitative MPA assessment (Addison *et al.*, 2015) throughout the management process.

Tuburan is one of the municipalities of Cebu Province with MPA networks along its coast. Two MPAs in Tuburan, Cebu --Sto. Niño and Apalan--while long-established, lack information on its fish stocks, coral cover, and management practices to assess its effectiveness. In order to address these information gaps and inform their management practices, the study undertakes biophysical assessments to check the MPAs reef conditions, coral health, and fish populations after significant climatic (i.e., typhoon Frank) or anthropogenic (i.e., dynamite or other illegal fishing) events, and conducted a management assessment using the available tool as the MEAT.

2 MATERIALS AND METHODS

A. Study Site

Tuburan is a second-class municipality located in the Northwest part of the Province of Cebu. Barangay Sto. Niño is in the southern part of Tuburan, while Barangay Apalan is in the northern part. Barangay Sto. Niño was declared a Marine Reserve with Fish Sanctuary under Resolution No. 2015-165 Ordinance No. 95 on December 7, 2015, with approximately 5.4721 hectares with technical description stated in the resolution.

Barangay Apalan was declared part of the Bagasawe, Apalan, Daan Lungsod and Antipolo (BADAAN) Community-Based Resource Management Project Marine Resource (CBRMP) with Fish Sanctuary under Resolution No. 2003-89 Ordinance No. 50 on August 18, 2003. The MPA has 53.37 hectares, and its technical description and location are described in the said resolution. The MPA's location at Barangay Sto. Niño and Barangay Apalan in Tuburan, Cebu (Figure 1).



Figure 1. Map of the sampling stations in Tuburan, Cebu

Both MPAs impose a penalty to any person conducting any fishing operation or take, catch, destroy, or kill any fish in any place within the body of water or any manner disturb, drive away or take from that place fish fry or fish egg or grasses and diving or taking a bath within the prohibited area. Penalties were laid against violators to ensure enforcement of the said declaration as MPA and keep the sanctuary from illegal fishing and destructive activities.

B. Coral reef survey

The point line intercept transect (PIT) method was used to assess the sessile benthic components in the MPA of the coral reef community in the marine sanctuary. It followed the process as described in English *et al.* 1997. A total of three 50-meter transect tapes was laid along the reef crest of the sampling areas/sites.

Readings of the benthic life forms were made every 0.5 m along the total length of the transect, starting from the zero mark of each transect. The benthic components were characterized using the categories cited in English *et al.* (1997). These components are: live hard corals, soft corals, dead corals, "others" for other invertebrates, and abiotic. The biotic components shall comprise the live hard corals and soft corals. Live hard corals morphologies or forms, i.e., branching, massive, sub-massive, encrusting, millepora (fire coral), are the basis of their category. In contrast, dead coral with algae, newly dead coral, and rubble composed the dead corals. Algae are considered flora. Abiotic components were non-coraline rocks, sand, and silt.

PIT raw data points were collated and summarized into data codes per transects. Each data point identified was given a score of one point. Points were added, divided by a total number of points from all transects, and % was taken by multiplying this by 100. Percent cover for live hard corals (LHC) was derived by adding the % cover of each coral morphologies found in the area. Similarly, % dead coral with algae and rubble were pooled, which comprises the total % cover for dead corals.

C. Fish Visual Census

The belt transect method was used for the visual fish census (Samoilys *et al.*, 2007). Four (4) 50-m transects were laid in sampling stations within the MPA, and the average depth zones were determined. The four transects covered a total of 1000m². Two surveyors within 2.5 m of the transect in the area swam along the transect to visually scan, identify, and estimate the number of fish species encountered within 15 minutes. In the data analysis, fishes identified in the survey were clustered under their corresponding fish families.

Fish Populations. Fish species were clustered in 21 coral reef fish families. Fish density is derived by dividing the total number of individual fishes in a 250

sqm area. Fish biomass is the entire body weight of all fishes within the sample area (metric ton/kg²). Fish biomass was calculated following the standard computation using the constants *a* and *b* (Froese R, 2000). The analysis uses the formula $Biomass = an \times size^b \times count$. The *a* and *b* values are corresponding length-weight parameter constants per species (Fishbase), size is the estimated size observed, and the count is the estimated count marked. All biomass was summed up to obtain total fish biomass per site.

D. Assessment of the Management Practices

The utilization of the Management Assessment and Evaluation Tool (MEAT) was done to account for the management level of the MPAs. The MEAT considered the key informant interviews in gathering the information from identified local stakeholders who were well versed and knowledgeable of the management practices in the marine sanctuary. It had helped identify issues and problems associated with its management, and recommendations were then formulated for the reef fish conservation and marine sanctuary's future management decisions. Random household interviews were also conducted within the area.

3 RESULTS AND DISCUSSION

Biological Conditions

A. Coral Cover

1. Sto. Niño

The reef in Sto. Niño was composed of live hard coral (LHC), dead coral (DC), soft coral, algae, abiotic components, and other marine invertebrates such as sponges (Fig.2). The reef exhibited a high % cover of LHC at 49%, and dead corals with algae and rubble with only 15%. Other algae species, dead corals, and sand are referred to as "abiotic."

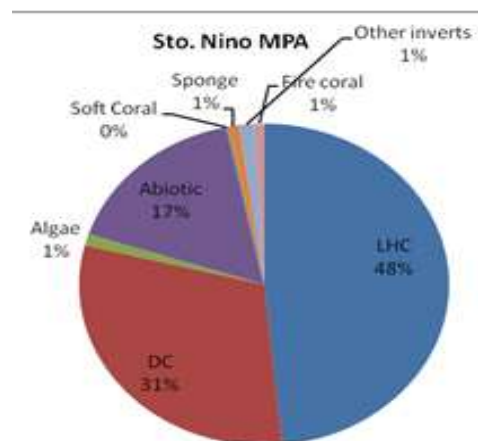


Figure 2. Benthic % cover in Sto. Niño MPA

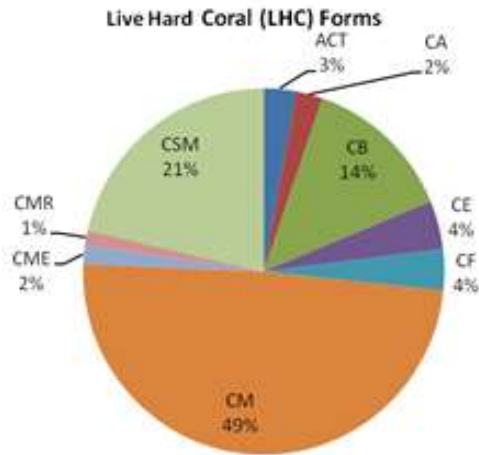


Figure 3. % Cover of live hard coral (LHC) forms in Sto. Niño MPA

There were eight LHC forms accounted for in Sto. Niño MPA. Massive (CM) and Submassive (CSM) coral forms have high % cover at ~49% and ~21%, respectively (Fig. 3 and Photo 1). Massive corals dominated the area. These coral forms indicate that the reef is old as these coral forms take a longer time to develop. Keeping these types of corals intact is a good indication that the reef was less affected or disturbed by any form of destruction, natural or anthropogenic. They were also branching corals (CB), with 14% cover. Other intricate coral forms found in the area were fire coral (CME), Mushroom corals (CMR), Submassive (CSM) coral, encrusting (CE) corals, and foliose (CF) corals.



Photo 1. Most common in Sto are massive corals (CM) and submassive coral (CSM) forms in Sto. Niño MPA.

2. Apalan

Live hard coral (LHC) cover in Apalan was 24% (Fig.5). Dead coral percentage is high at 38%. Abiotic components, which included silt and sand also had relatively high cover at 32%. Dead corals with algae were observed to be corals which algae and silt have smothered. Horizontal visibility during the survey was between 6 to 7 meters, and the water column was observed to have some suspended particles. Rubble composition was low at ~1% only. It would also indicate that the area did not suffer from damages caused by highly destructive activities.

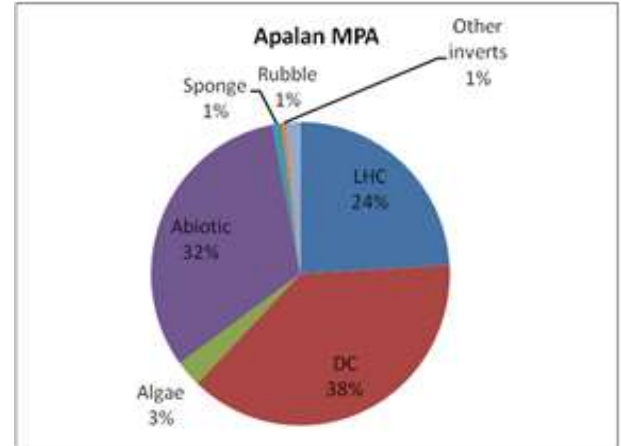


Figure 5. Benthic composition in Apalan MPA

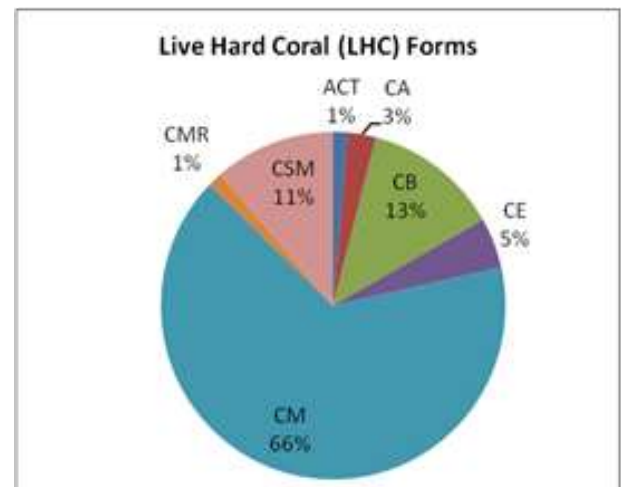


Figure 6. % Cover live hard coral (LHC) forms in Apalan MPA

There were six (6) LHC forms observed in Apalan. Massive (CM) coral forms had a relatively high % cover at ~66% compared to other coral forms present (Fig.6 & Photo 2). These coral forms cover a wide area within the surveyed reef. There are also branching corals (CB) with 13 % cover. This rest, encrusting (CE), massive (CM), and mushroom corals (CMR), had low coral coverage at ~ 5% and 1%, respectively.



Photo 2. Massive corals (CM) were the most common coral forms in Apalan MPA

Results showed that Sto. Niño marine sanctuary has a higher LHC of 48% than Apalan with 24%, while abiotic components are higher in Apalan (32%) than in Sto. Niño (17%). It could be because of Sto. Niño MPA was less affected by natural calamities (i.e.typhoons) in the past, and illegal fishing activities were managed and kept at bay. It is important to note that recovery of degraded sanctuaries is slow or worse; it will never occur naturally once overgrown with algae. Macroalgae can flourish and take over the reef area affecting the MPA condition and % coral cover (Gonzales *et al.*, 2014).

Waters in Apalan are more turbid than Sto. Niño. Higher abiotic components contribute to more turbid waters in the sanctuary, which does not guarantee better coral cover. Turbid water has adverse effects on corals, and the nutrients drained in the sea may lead to algal growth, which could outgrow corals and compete for sunlight and space (Gonzales *et al.*, 2014).

Sto. Niño MPA has lower massive coral (49%) cover than Apalan MPA (66%). It suggests that coral composition in the Apalan MPA is older than that in Sto. Niño. Massive corals are relatively slow-growing than other forms of coral. Thus, it takes years to grow massively as it only increases its size from 0.5 up to two centimeters (0.2 to 0.8 inches) per year under favorable conditions. On the other hand, Apalan reef has less total

LHC and more DC percentage. This result could mean that Apalan MPA exposure to climate change or illegal and destructive fishing activities affect the area's overall LHC. Adding to it is the more extensive area of the MPA, which was 53.37 hectares compared to 5.47 hectares for Sto. Niño MPA. It only means that Apalan MPA needs more human resources, like local fish wardens or "Bantay dagats," to administer the area and prevent these damaging practices that could affect the MPAs' biological conditions. Moreover, persisting impacts of climate change (i.e.typhoon, damage, increased sea temperature) may have also hampered the growth of more LHC and accounted for more percent of DC in the area.

B. Fish Population

1. Sto Niño

Overall mean fish density in Sto. Niño MPA was 508 individuals/250sqm. It was mainly composed of non-target fish families with a mean fish density of 463 individuals/250sqm; target fish density and the CHI were relatively lower, with 30 and 15 individuals/250sqm, respectively (Fig.7).

Fish biomass in Sto. Niño was 43.3 mt/sq km (Fig.8). Mean fish biomass of non-target fishes was highest at 32.5 mt/sq km, followed by target fish biomass with 9.8 mt/sq km, and CHI had the lowest at 1 mt/sq km.



Figure 7. Mean fish density in Sto. Niño MPA

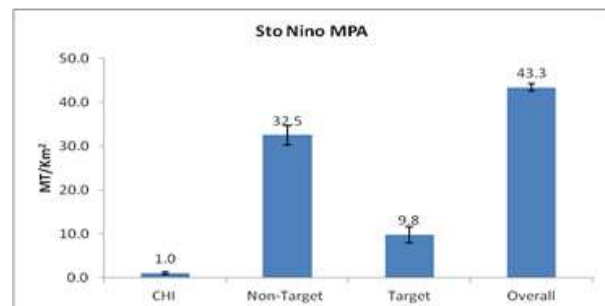


Figure 8. Mean Biomass in Sto Niño MPA

There were 80 species identified in the Sto. Niño MPA. Most of which belonged to the family of

damselfishes (Pomacentridae) with 27 out of 33 species. It was followed by wrasses (Labridae) with 15 out of 17 species and butterflyfishes (Chaetodontidae) with 9 out of 10 species.

2. Apalan

Overall fish density in the Apalan MPA was 349 individuals/250sqm (Fig.9). Non-target fishes mainly contributed to the overall density with a mean density of 309 individuals/250sqm. Target fish species and CHI had very low densities with 31 and 8 individuals/250sqm, respectively.

Fish biomass in Apalan was 23.8 mt/sq km (Fig.10). Mean fish biomass of non-target fishes was highest at 15.1 mt/sq km, followed by target fish biomass with 8 mt/sq km, and CHI had the lowest with only 0.7 mt/sq km.

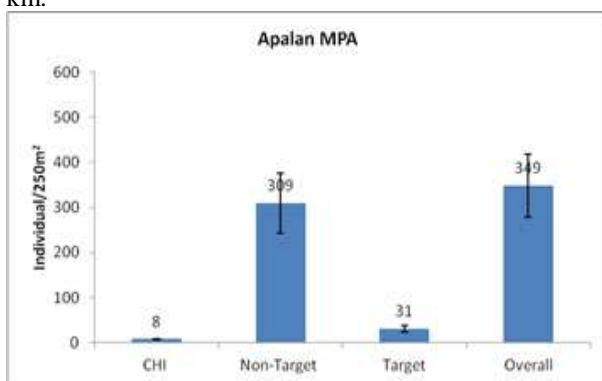


Figure 9. Mean Fish Density in Apalan MPA

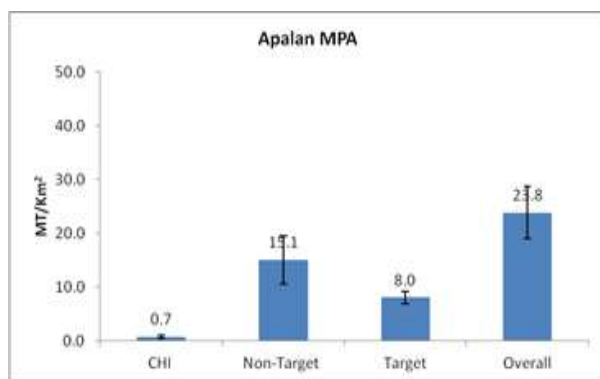


Figure 10. Mean Fish Biomass in Apalan MPA

There were 67 species identified in the Apalan MPA, most of which belonged to the family of damselfishes (Pomacentridae) with 19 out of 33 species, followed by wrasses (Labridae) with 14 out of 17 species and butterflyfishes (Chaetodontidae) with ten species.

Results show that there are more fish present in Sto. Niño MPA (508 individuals/250 sqm) than in Apalan MPA (349 individual/250 sqm). Also, non-target and CHI species are relatively higher in Sto. Niño (453 and 15 respectively) than Apalan (309 and 8 respectively). However, there is not much difference in target species

found in both sanctuaries, Sto. Niño with 30 individuals/250 sqm and Apalan with 31 individuals/250 sqm. These fish stocks belonged to various fish families (Table 1)—the higher number of CHI species in Sto. Niño is due to the higher account of LHC in the area, which helps sustain CHI fish stocks. Hence, a suitable MPA allows more fishes to survive and flourish.

Table 1. Fish families identified in Sto. Niño and Apalan MPA.

Family Name	Common Name	Local Names	Trophic Level
1.Acanthuridae	Surgeonfish/unicornfish	inggetan,bagis,sunghan	Top trophic
2.Balistidae	Triggerfish	pakol	Top trophic
3.Carangidae	Jacks,trevallies	karabalyas,mansa	Pelagic
4.Caesionidae	Fusiliers	bilason,dalagang bukid	Mid-trophic
5.Haemulidae	Sweetlips/grunts	lipiti	Top trophic
6.Holocentridae	Soldierfish/squirrelfish	bagabaga	Low trophic
7.Labridae	Wrasse	labayan,lupit,lamon-lamon	Mid-trophic
8.Lethrinidae	Emperor	katambak,dugso	Top trophic
9.Lutjanidae	Snapper	mangagat,awoman,islawan,manilaon,maymaya	Top trophic
10.Mullidae	Goatfish	timbongan	Mid-trophic
11.Nemipteridae	Breams	salingukod,sily,bisugo	Top trophic
12.Scaridae	Parrotfish	molmol,bontugon	Mid-trophic
13.Serranidae	Grouper/Anthias	pagapo	Top trophic
14.Siganidae	Rabbitfish	danagrit,kitong	Mid-trophic
15.Chaetodontidae	Butterflyfish/Bannerfish	alibangbang	Coral health indicator fish (CHI)
16.Pomacanthidae	Angelfish	adlo	Coral health indicator fish (CHI)
17.Pomacentridae	Damselfish	peta,kapal	Low trophic
18.Scorpaeidae	Scorpionfish/Lionfish	bantol	Low trophic
19.Synodontidae	Lizardfish	Tikiki, banghotan	Top trophic
20.Cirrhitidae	Hawkfish		Low trophic
21.Zanclidae	Moorish idol		Low trophic

Sto. Niño MPA have more fish species than Apalan. Sto. Niño sanctuary recorded many damselfishes (Pomacentridae), 27 out of 33 species, compared to Apalan, with 19 species. A total of 21 fish families were found in both MPAs. The wrasses (Labridae) account is relatively the same in the two MPAs, and all ten butterflyfish (Chaetodontidae) species were present in both MPAs. The presence of coral health indicator butterflyfishes implies that the MPAs are sustainable. Wrasse's species are also important as they eat and control crown of thorns, a damaging coral reef predator. While damselfishes vigorously bite and eliminate tissue of living coral, promoting impenetrable algal lawns on coral skeletons (Kaufman, 1977), and are essential intermediaries for interactions between corals and herbivores and algae (Precht *et al.*, 2010). If not improved, these fish species found should be maintained to make these MPAs effective and productive in the succeeding years.

Destructive fishing practices and climate change may damage MPAs, which could lessen the fish catch of fishermen (Dubinsky, 1990; White and Calumpang, 1993). The establishment of MPAs in these reefs will provide the sustainable fishing livelihood of the surrounding community. Though the climate change

effect may be inevitable, strict implementation of the ordinance will ensure the usefulness of the MPAs. Evaluation of the MPAs' management practices determines how the ordinance was implemented in these areas and will help better manage the sanctuary for sustainable development.

C. MPA Management Evaluation

The marine biodiversity may be at stake when planning does not account for ecological context, as sites selected for conservation action may be in poor condition and unlikely to contribute effectively towards conservation outcomes. Nevertheless, habitat conditions or proxies have rarely played in MPA design (Klein *et al.*, 2013). With this rising concern, it is appropriate to assess the effectiveness of MPA and monitor its management practices.

According to the MEAT or Management Effectiveness Assessment Tool, the two MPAs, Sto. Niño, and Apalan, were evaluated in terms of management levels. Findings showed that both MPAs had not passed the MEAT requirements for MPAs to reach a Level 1 management rating. While both MPAs were more than a year since their establishments, --- Apalan for 16 years, and Sto. Niño about three (3) years now---these MPAs still lacked some management components to earn them a management rating level in the MEAT evaluation system.

As of their initial MEAT evaluation, Sto. Niño MPA only got a total cumulative score of 20 points out of 84, while Apalan had a total cumulative score of 10 out of 84. In the MEAT, an MPA to be considered established must be at least one year since its legal implementation, must have at least 20 total cumulative scores, and meet all the Level 1 threshold questions.

Sto. Niño and Apalan Marine Reserve with Fish Sanctuary

In terms of management focus, Sto. Niño and Apalan MPAs have well met the legal instrument (i.e., Municipal ordinances) that legally recognizes the existence of their MPAs. Sto. Niño MPA was lawfully established under Municipal Resolution 2015-165, Ordinance no.95 and officially known as the Sto. Niño Marine reserve with fish sanctuary. An ordinance was approved to control and monitor the sanctuary in Sto. Niño. In a recent focused-group discussion and MEAT orientation in the area, it was apparent that the Barangay captains, including a group of fish wardens, have been managing the site since its establishment in 2015. While Apalan MPA was part of the BADAAN (Bagasawe, Apalan, Daan Lungsod, Antipolo) CBRMP Marine reserve with fish sanctuary under the Municipal Resolution No.2003-80, Ordinance No. 50.

Results showed that Sto. Niño MPA has better management practices, with 20/84 denoting "fair" management, while Apalan has 10/84, indicating "poor" management practices. Nevertheless, these MPAs sufficed community participation, implying that the MPAs were accepted and approved by their communities and local governments. Other management categories which need more attention are in Table 2. It includes the lack of creation of management plan and site development planning for Sto Niño, while lack of funds, and lack of site development planning for Apalan. Creating a management plan is vital to protect and sustain the marine species found in these MPAs joining hand in hand with the barangays' site development plan and funds needed to mobilize the plans.

Both MPAs establish corresponding legal identities in management evaluation, with a corresponding management body --limited to the support and leadership of their respective leaders or barangay captains and supported by an enthusiastic group of fish wardens (Bantay Dagat). While these MPAs have individually existed for three (3) to as long as 16 years, some aspects of management still need improvement for these MPAs to become more effective. In terms of the MEAT results, categories that needed improvement were as follows: management plan, management body's clarity on roles, financing, IEC, Enforcement, Monitoring and Evaluation, and site development. Being oriented with the MEAT (tool) could help the management body improve and adapt to the new management process advocated by this evaluation tool. These management categories could guide the management bodies to gauge their strengths and weaknesses and objectively identify areas for improvement.

4 CONCLUSIONS

The reef conditions of Sto. Niño and Apalan MPAs were "fair" and "poor," respectively. Despite these ratings, both MPAs showed relatively stable coral reefs' condition and composition. Moreover, it depicts good potential for fish populations with more coral health indicators fish species identified. However, it must improve or sustain to provide "target" fish species conditions to increase and replenish fish stocks within these habitats. Both MPAs have not fully complied with the MEAT requirements to meet a Level 1 rating in management. Hence, refining and preserving the biological conditions in the MPAs be prioritized through appropriate management practices and regular monitoring.

Table 2. Management focus scores per MPA

Management Focus	MEAT Total available Points	Sto.Nino MPA		Remarks	Apalan MPA %		Remarks
		Score	%		Score	%	
Management Plan	9	0	0	Lacks creation of a management plan	5	9.10	Lacking review and updating
Management Body	11	1	9.10	Lacks clarity of roles	1	9.10	Lacks clarity of roles
Legal Instrument	5	5	100	Accomplished	5	100	Accomplished
Community Participation	2	2	100	Accomplished	2	100	Accomplished
Financing	12	7	58	Needs improvement	0	0	Lacks financing; source of funds
IEC	7	1	14	Needs improvement	1	14	Needs improvement
Enforcement	20	8	40	Needs improvement	8	40	Needs improvement
Monitoring & Evaluation	16	5	31.25	Needs regular or periodic monitoring	1	6.25	Needs regular or periodic monitoring
Site Development	2	0	0	Lacks site development planning	0	0	Lacks site development planning

RECOMMENDATIONS

The municipality of Tuburan and other government (MLGU) offices, such as the Bureau of Fisheries and Aquatic Resources (BFAR), will need to support these MPAs, duly stated as having administrative control over these MPAs. Biological monitoring of these MPAs is necessary, and these can be done by BFAR, MLGU, and even other institutions, like the academe, which has the needed expertise to conduct such monitoring activities. Moreover, the MPA management body should undergo a general orientation to familiarize the evaluation process under the MEAT. More accessible institutions like the academe--such as the CTU Tuburan, can be enjoined to help the MPA management bodies improve these areas and IEC (Information, Education, and Communication) and monitor and evaluate (i.e., MEAT), given their technical expertise. These institutions (i.e., LGU and academe) can collaborate to conduct periodic monitoring and evaluations to inform the management and develop their respective MPAs.

It is also encouraged for these MPAs -already with baseline MEAT information--to provide their updated information to the MPA central database of the Philippines handled by the MPA Support Network (MSN) that holds competitive opportunities for these MPAs to be part of the national network of MPAs across the Philippines.

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