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RESEARCH ARTICLE

Initial Assessment of the Benthic Profile and Reef Fish Composition of the Damilisan Marine Sanctuary, Miagao, Iloilo, Philippines

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A B S T R A C T

Coral reefs are among the world's most diverse and productive ecosystems. They provide valuable ecosystem services, including support for fisheries production and the livelihood of coastal communities. However, coral reefs are also threatened by anthropogenic and climate stressors. Establishing a marine protected area (MPA) is a typical coastal management tool widely used in the Philippines for conserving coral reefs and managing the fishing effort. This study presents initial information on the benthic and fish community profiles of the Damilisan Marine Sanctuary (DMS) in Miagao, Iloilo, Philippines. A modified point-intercept transect method was used to characterize the benthic profile, while the underwater visual census (UVC) was used to determine the fish community profile (diversity and density). The substrate was mainly composed of hard coral (HC) (39.3±18.3%), and the common HC observed were massive *Porites* and *Goniopora,* each contributing 12.8% of the total HC cover. Twenty coral reef fish species belonging to 10 families were identified during the UVC and had an overall density of 99±69 ind./1000 m^2. Damselfishes (Family Pomacentridae) was the most abundant family (23±0.4 ind./500 m^2), while *Lutjanus semicinctus* was the most abundant species (8.5±1.4 ind./500 m^2). It is recommended that regular coral reef monitoring surveys be conducted in the DMS and in other MPAs in Miagao to monitor trends and changes in the HC cover and reef fish density and diversity in the MPA.

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1. INTRODUCTION

Coral reefs are highly productive and diverse coastal ecosystems in tropical regions (Spalding et al. 2001). They provide valuable ecosystem services such as coastal protection from intense wave action, habitat for commercially important fish and invertebrates, and increased biodiversity (Burke and Spalding 2022; Knowlton et al. 2005). The coral reefs, together with other coastal ecosystems, play a vital role in supporting the livelihood and food security of coastal communities across the Philippines (Cabral and Geronimo 2018; Muallil et al. 2014). The total economic value of the ecosystem services from the country's reefs was estimated to be four billion US$/year or 140,000 US$/km^2/year (Tamayo et al. 2018).

Coral reefs in the Philippines are facing multiple threats, mainly from natural and anthropogenic sources. Natural causes of the coral decline include mortality from diseases, predation, typhoons, and elevated sea temperatures (Bos et al. 2013; Shaish et al. 2010; Lesser et al. 2007; Arceo et al. 2001), while common anthropogenic stresses to coral reefs include overfishing, sedimentation, pollution, coastal development, and climate change (Magdaong et al. 2014a; White et al. 2014).

The status of coral reefs in the Philippines has steadily declined over the past decades (Licuanan et al. 2019). Many coral reef fishes and nearshore fisheries have experienced extensive reduction due to overfishing and habitat destruction (Santos et al. 2017; Muallil et al. 2014).

The establishment of Marine Protected Areas (MPAs) is one of the most common tools used for conserving coral reef ecosystems and managing fishing efforts in the coastal areas in the country (Cabral et al. 2014). An MPA is defined as "the area of the sea established and set aside by law, administrative regulation, or any other effective means, in order to conserve and protect a part of or the entire enclosed environment, through the establishment of management guidelines" (White et al. 2014). They are classified based on governance levels as nationally managed MPAs (established through the Republic Act 7586 or National Integrated Protected Area System (NIPAS) Act of 1992) and locally managed MPAs (established through the Republic Act 8550 or the Fisheries Code of 1998). It is estimated that at least 1,800 MPAs are established in the Philippines, most of which are locally managed (Muallil et al. 2019; Cabral et al. 2014).

Proper implementation and management of MPAs in the country have been shown to improve the status of coral reef live hard coral cover and coral reef fish populations in the Philippines (Fidler et al. 2017; Magdaong et al. 2014a; Maypa et al. 2012). Regular assessments of important aspects of the coral reef ecosystem, such as the hard coral cover and diversity, coral reef fish density, and diversity, are necessary to measure the effectiveness of the MPA (Magdaong et al. 2014b).

The Damilisan Marine Sanctuary (DMS) is a locally managed MPA located at Brgy. Damilisan, Municipality of Miagao in Iloilo Province. It was established in 2015 through the Municipal Sanctuaries Ordinance (Municipal Ordinance No. 2015-26). Three locally managed MPAs were established through this ordinance, including the DMS and two other MPAs, the Lanutan MPA and the Calampitao-Gines MPA. Among the three MPAs, however, the DMS is the only one established with no baseline information about the status of the coral reef. To help address this gap, the study conducted an initial assessment of the DMS coral reef. This study was conducted to help provide initial information about the coral reef condition by estimating hard coral (HC) cover and HC generic diversity, and the status of coral reef fish diversity and density through an underwater visual census. The study also provided recommendations for improving the management of the DMS.

2. MATERIALS AND METHODS

2.1 Study site

The Damilisan Marine Sanctuary (DMS) is located in Brgy. Damilisan, Miagao, Iloilo (Figure 1). It has a total area of 0.0495 km^2 and a core zone of 0.03 km^2 based on the Municipal Ordinance 2015-26. Fishing and other human activities are prohibited within the "core zone," while regulated fishing practices, such as hook and line and net fishing, are allowed within the "buffer zone" or the area outside the core zone but within the delimited area of the MPA.

An initial reconnaissance survey of the extent of the coral reef area was done before choosing the location of the transects through snorkeling and examining the area with a small, motorized boat. The extent of the coral reef area was found within the core zone only of the DMS. Sand made up the substrate surrounding the coral reef area, the buffer zone, and beyond it. Thus, the coral reef assessment was only conducted in the core zone.

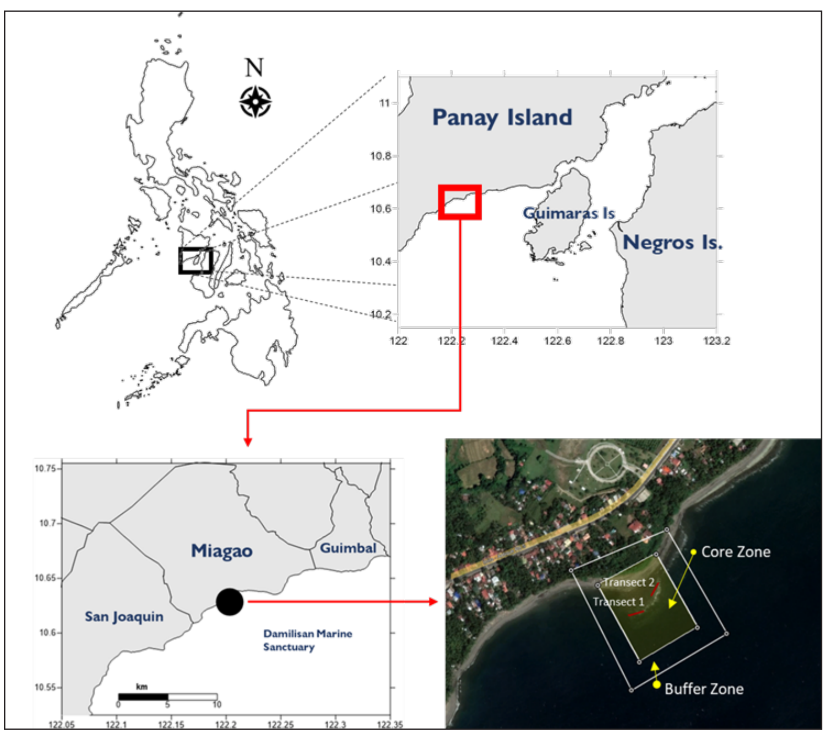

Figure 1. Map showing the location of the Damilisan Marine Sanctuary (DMS), Miagao, Iloilo, Philippines.

2.2 Benthic profiling and assessment of hard corals

The benthic profiling was conducted in March 2019 using a modified point-intercept transect (PIT) Method described in Uychiaco et al. (2001). Two 50m transects were laid parallel to the shore at depths of 1–2.5 m in the reef flat with a distance of about 50 m apart within the core zone. Due to the unavailability of SCUBA gear and the shallow depth of the site, the benthic profiling was conducted by snorkeling. The first transect was located from 10° 37′ 49.9″ N, 122° 11′ 57.8″ E to 10° 37′ 50.1″ N, 122 11′ 59.1″ E, while the second transect was located from 10° 37′ 51.27″ N, 122° 11′ 59.7″ E° to 10° 37″ 52.3′ N, 122° 12″ 0.3′ E.

The major benthic categories, their subcategories, and hard coral taxonomic amalgamated units (TAUs) described by Licuanan et al. (2019) were used for profiling the benthic components of the reef. The major benthic categories include algal assemblage (AA), abiotic material (AB), *Halimeda* (HA), hard coral (HC), macroalgae (MA), and other biota (OT). Table 1 shows the major benthic categories and subcategories. Algal assemblage has subcategories which include algal assemblage (AA), dead coral (DC), dead coral with algae (DCA), and crustose coralline algae (CA). Subcategories under AB include gravel (GRV), rubble (RB), sedimentary rock (RCK), sand (S), and silt (SI). The subcategories under the OT include soft coral (SC), seagrass (SG), sponge (SP), zoanthind (ZO), and other invertebrates (OT). The HC category is comprised of 59 TAU subcategories, which are found in Table 1.

The benthic category in every 0.25 m interval along the 50 m transect was identified and tallied using an underwater slate and pencil. The percent cover of each TAU was calculated using the formula below:

$$\frac{\textit{Number of recorded points in the transect where the benthic category or TAU was observed}}{\textit{Total number of recorded points in the transect}} \times 100$$

Table 1. The major benthic categories, benthic subcategories, and Taxonomic Amalgamation Unit (TAU) of Hard Coral used in characterizing the benthic profile.

Major Benthic Categories	Benthic Subcategories and Hard Coral TAU	
Algal assemblage (AA)	Algal assemblage (AA)	Dead coral with algae (DCA)
	Dead Coral (DC)	Crustose Coralline algae (CA)
Abiotic material (AB)	Gravel (G)	Sand (S)
	Rubble (RB)	Silt (SI)
	Sedimentary rock (RCK)	
Halimeda (HA)	Not applicable	
Hard coral (HC)	*Acanthastrea*	*Heliopora*
	Acropora branching	*Hydnophora*
	Acropora corymbose	*Leptoria*
	Acropora digitate	*Leptoseris*
	Acropora hispidose	*Oulastrea*
	Acropora robusta group	*Oulophyllia*
	Isopora	*Oxypora*
	Acropora plate	*Lobophyllia*
	Attached fungiids	*Merulina*
	Astreopora	*Millepora*
	Other bubble corals	*Montastrea*
	Other branching corals	*Montipora* branching
	Other encrusting corals	*Montipora* encrusting
	Other foliose corals	*Montipora* foliose
	Other massive corals	*Mycedium*
	Caulastrea	*Pachyseris* encrusting
	Fungia	*Pachyseris* foliose

Continuation of Table 1. The major benthic categories, benthic subcategories, and Taxonomic Amalgamation Unit (TAU) of Hard Coral used in characterizing the benthic profile.

Major Benthic Categories	Benthic Subcategories and Hard Coral TAU	
	Coeloseris	*Pavona*
	Coscinarea	*Pectinia*
	Cyphastrea	*Platygyra*
	Diploastrea heliopora	*Pocillopora*
	Euphyllia	*Porites* branching
	Echinopora	*Porites* encrusting
	Echinophyllia	*Porites* massive
	Favia	*Seriatopora*
	Other free living fungiids	*Stylophora*
	Favites	*Symphyllia*
	Galaxea	*Tubipora musica*
	Goniastrea	*Turbinaria*
	Goniopora	
Macroalgae (MA)	Not applicable	
Other biota (OT)	Soft coral (SC)	Sponge (SP)
	Seagrass (SG)	Zoanthid (ZO)
	Other invertebrates (OT)	

The HC cover and diversity were categorized using the scales described in Licuanan et al. (2019) (Table 2). Hard coral cover categories were based on the percent cover, while HC diversity was categorized based on the number of HC TAUs observed. The percent cover of the major benthic categories, benthic subcategories, and the number of HC TAUs were calculated and presented as the mean (± standard error) from the two transects surveyed.

2.3 Underwater visual census

Coral reef fish diversity and density were determined using the underwater visual census (UVC) method modified from Uychiaoco et al. (2001). The same two 10 m x 50 m belt transects (500 m^2) used in the benthic profiling were surveyed. The UVC was conducted through snorkeling after the benthic profiling was performed for each transect. All fish species observed within 5 m of both sides of the transect line were identified and counted. To reduce the effect of the human presence on fish abundance, fish observation commenced 10–15 minutes after laying the transects.

Photos and video clips were taken during the survey to help with the species identification. Reef fish identification guides by Allen et al. (2005) and Kuiter and Debelius (2006) were used as references to verify initially identified coral reef fishes during the UVC. The status of the reef fish species diversity and density were evaluated based on the categories described in Hilomen et al. (2000) (Table 3). The coral reef fish species diversity and density were calculated and presented as the mean (± standard error) from the two transects surveyed.

2.4 Statistical analysis

The data was analyzed using descriptive statistics, including the mean, sums, and standard error.

Table 2. Assessment scales for interpretation of Hard Coral Cover and Hard Coral Diversity based on Licuanan et al. (2019).

Hard Coral (HC) Cover		Hard Coral Diversity	
HC Cover Category A	>44%	Diversity Category A	>26 TAUs
HC Cover Category B	>33%-44%	Diversity Category B	>22-26 TAUs
HC Cover Category C	>22%-33%	Diversity Category C	>18-22 TAUs
HC Cover Category D	0-22%	Diversity Category D	0-18 TAUs

Table 3. Fish density and fish diversity evaluation criteria by Hilomen et al. (2000).

Fish Species Diversity (species/1000 m^2)				
Very Poor	Poor	Moderate	High	Very High
0-26	27-47	48-74	76-100	>100
Fish Density (individuals/1000 m^2)				
Very Poor	Poor	Moderate	High	Very High
0-201	202-676	677-2267	2268-7592	>7592

3. RESULTS

3.1 Benthic profile, Hard Coral Cover Category, and Hard Coral Generic Diversity

The percentage cover of the major benthic components observed during the survey is shown in Figure 2. The HC cover had the highest percentage at 39.3±18.3%, followed by AA at 32.5±8%, AB at 27.5±10%, and MA at 0.8±0.2%. The AA category comprised of DCA (24.8±11.3%) and AA (7.8±3.3%). The AB category was composed of S (26.8±9.3%) and RCK (0.8±0.8%). The HC cover in DMS can be classified as HC cover Category B which means having HC cover higher than 33% but less than 44%.

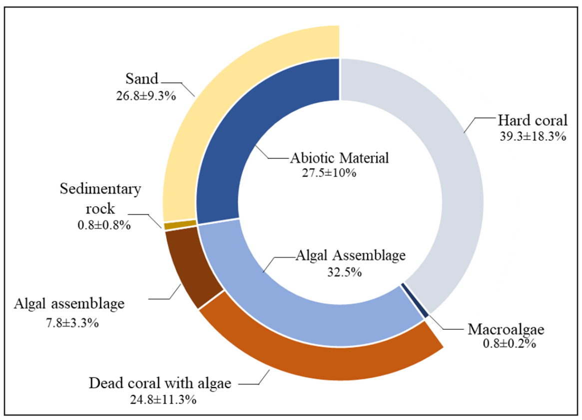

Figure 2. Percentage cover of each major benthic category and subcategories used in characterizing the benthic profile of the Damilisan Marine Sanctuary (DMS), Miagao, Iloilo, Philippines.

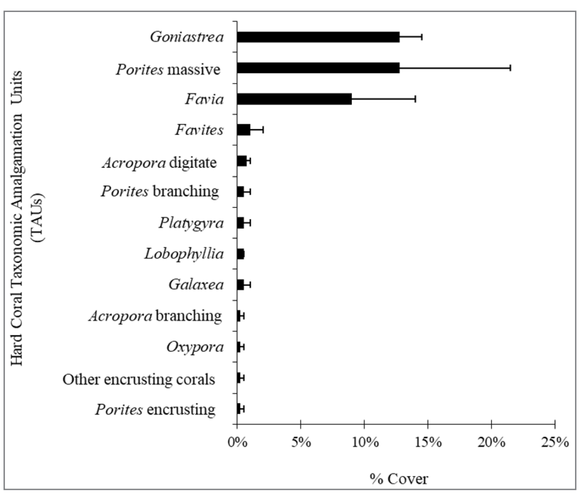

Figure 3. Percentage cover of Hard Coral TAUs in Damilisan Marine Sanctuary (DMS), Miagao, Iloilo, Philippines. Error bars are standard errors.

A total of 13 TAUs were observed in DMS (Figure 3). *Porites* massive (12.8±0.1%) and *Goniastrea* (12.8%) had the highest HC percentage cover. Photos of observed HC TAUs in DMS are shown in Figures 4 and 5. The HC generic diversity of DMS was classified in the HC Coral Diversity Category D with less than 18 TAUs.

3.2 Reef fish species diversity and density

During the survey, 20 reef fish species belonging to 10 families were identified (Figure 6). The damselfishes (family Pomacentridae) had the highest

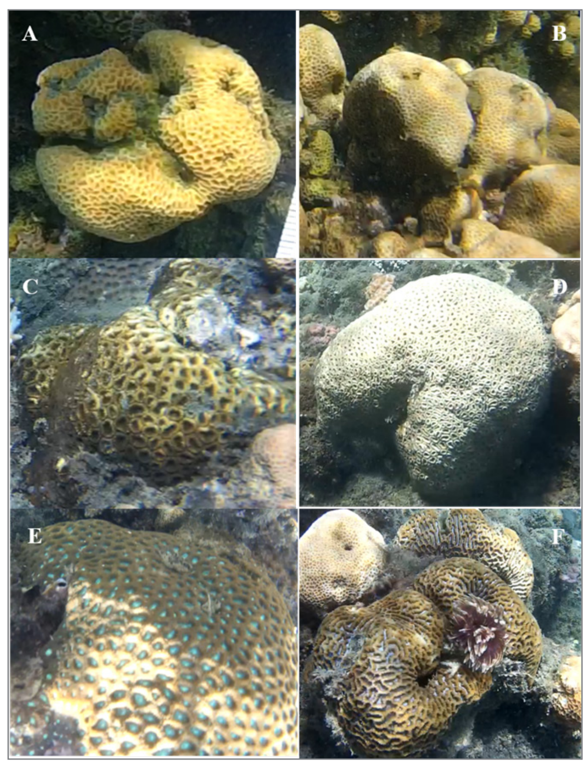

Figure 4. Hard coral TAUs observed in DMS: *Goniastrea sp.* (A and B), *Favia* (C and D), *Favites* (E), *Platygyra* (F).

Figure 5. Hard coral TAUs observed in DMS: *Porites* massive (A and B), *Lobophyllia* (C), *Porites* branching (D), *Acropora* digitate (E and F).

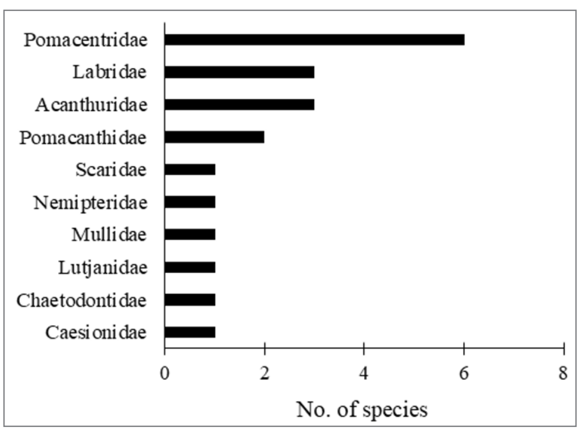

Figure 6. Number of reef fish species per family observed in Damilisan Marine Sanctuary (DMS), Miagao, Iloilo, Philippines.

number of species, with six. The coral reef fish diversity observed during the survey in DMS was within the "very poor" category, with 20 species/1000 m².

In terms of density per family, damselfishes (family Pomacentridae) had the highest with 23±0.4 ind./500 m² and made up 46% of the fish density observed during the study (Figures 7 and 8). In terms of density per species, the Black-banded Snapper, *Lutjanus semicinctus,* had the highest density at 8.5±1.4 ind./500 m² (Figure 8). The mean coral reef fish density observed in DMS was 99±69 ind./1000 m², categorized as "very poor."

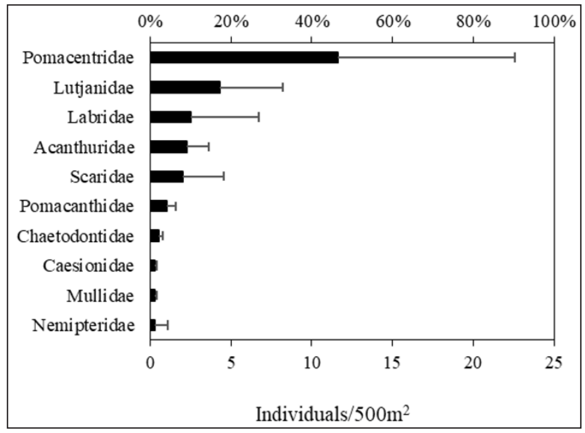

Figure 7. Percentage contribution and density of coral reef fishes by family in Damilisan Marine Sanctuary (DMS), Miagao, Iloilo, Philippines. Error bars are standard errors.

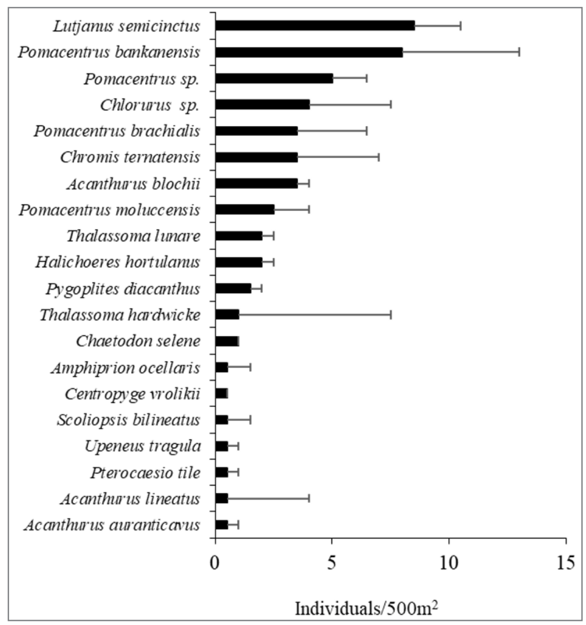

Figure 8. Density (individuals/500 m²) of reef fishes in Damilisan Marine Sanctuary (DMS), Miagao, Iloilo, Philippines. Error bars are standard errors.

4. DISCUSSION

4.1. Benthic profile

Hard coral cover and diversity are important indicators of the health of coral reefs. The higher coral cover provides more structures and habitat complexity that support various reef-associated species (Komyakova et al., 2013). Hard coral diversity also influences the species composition and richness of coral reef fish (Komyakova et al. 2018; Komyakova et al. 2013; Messmer et al. 2011). A previous assessment of five coral reefs in Miagao, Iloilo conducted by Gulbranson (2014) showed areas in Kirayan Norte (65.5%) and Calampitao (44.3%) had higher HC cover compared to the one observed in DMS in this study (Figure 9). Meanwhile, the other coral reef areas in Miagao, namely Gines (30.5%), San Rafael (13.5%), and Lanutan (21%) had lower HC cover (Figure 9). The HC cover in DMS is higher compared to the average Philippine HC cover (22.8±1.2%), Visayas Bioregion (22.9±2.2%), and the Sulu Sea Bioregion (28.4% ± 2.4%) (Licuanan 2020; Licuanan et al. 2019).

Most of the TAUs observed in this study are considered stress-tolerant hard corals, which include Porites and those belonging to the family Faviidae (e.g., *Favia, Favites, Goniastrea, Platygyra*) (Darling et al. 2012; Guest et al. 2012). These hard corals are characterized to have slow growth, high energy storage capacity, and high fecundity that allow them to withstand thermal stress, physical stress, and low sunlight conditions (Darling et al. 2012; Guest et al. 2012). The TAUs with the highest percentage cover in this study (i.e., *Porites* massive and *Goniastrea*) are usually found in shallow depths and reef-flat areas and can persist in high-stress environments with stressors, such as thermal stress, sedimentation, oil pollution, sewage, tourism, and eutrophication (De Vantier et al. 2020; Qin et al. 2019; Brown et al. 2002).

On a broader scale, the coral community structure in the Philippines is highly influenced by the degree of wave exposure and the reversing monsoon system (Feliciano et al. 2023; Licuanan et al. 2019; Quibilan and Aliño 2006). The DMS's location and the coastal areas of Miagao are windward and exposed during the months when the southwest monsoon (*habagat*) is prevalent. The southwest monsoon is characterized by relatively higher rainfall than the northeast monsoon (*amihan*) and with winds coming from the southwest, which occur around June–October (Villanoy et al. 2013; Chang et al. 2005). The coastal areas of Miagao and the area surrounding DMS are usually exposed to strong waves, and experience increased rainfall during the southwest monsoon season. Strong waves and rainfall during the southwest monsoon season can also cause increased sedimentation and soil erosion in the coastal areas, negatively impacting coral reefs (Magdaong et al. 2014a).

Aside from broad-scale factors, local hydrological regimes and environmental conditions can influence the density, structure, and distribution of coral assemblages (Angkotasan et al. 2023). Biological factors, such as the availability of coral larvae, post-settlement mortality, and growth of early coral recruits, can influence the abundance of corals (Miller et al. 2000). The reef-flat area of fringing reefs, like the DMS, are more susceptible to changes in temperature, wave action from strong typhoons, physical damage from anthropogenic activities, such as fishing (DeVantier et al. 2020). The current HC cover and HC generic diversity observed in the DMS reflect the site-specific factors, ambient physical conditions, and stressors the coral reef is exposed to.

The study of Licuanan et al. (2019) observed that the Porites massive was the TAU with the highest mean HC cover from surveyed coral reefs in the Philippines belonging to HC Cover Category B, similar to what was observed in this study. Using these assessment scales and categories allows for a better comparison of results to more recent baselines from different localities in the Philippines. Furthermore, the assessment scales use the letter "grades" instead of potentially value-laden terms from previous methodologies (e.g., "poor" or "fair") (Licuanan 2020), which local managers can use when evaluating their coral reefs. The HC cover and diversity information and benthic profile in this study will be

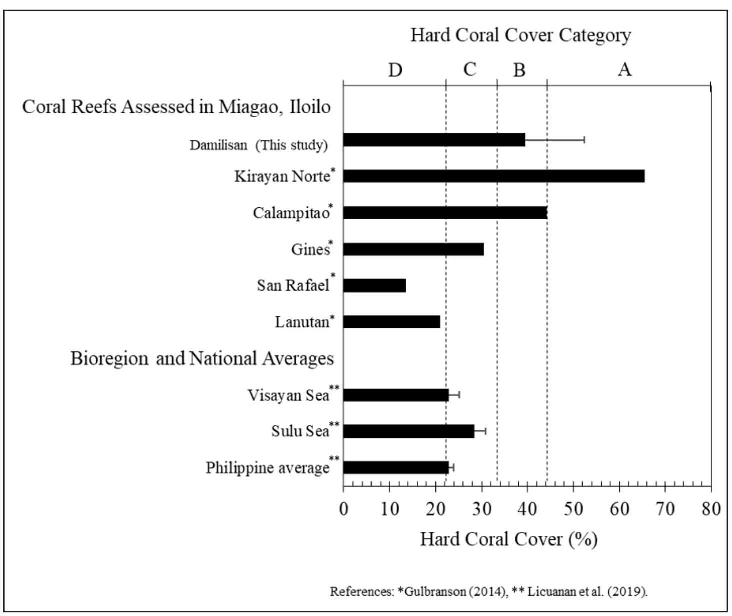

Figure 9. Hard coral cover of Damilisan Marine Sanctuary (DMS) compared to those observed in other reef areas in Miagao, Iloilo, the Visayan and Sulu Seas, and the mean Philippine hard coral cover. Error bars are standard errors.

useful as a reference for future monitoring of the coral reef condition.

4.2. Reef fish communities

It is well acknowledged that MPAs if managed correctly, result in an increase in the fish populations inside the reef (Russ 2002). Coral reef fish diversity and density in the DMS, as shown in the results, is considered "very poor" based on criteria described by Hilomen et al. (2000). The fish diversity of DMS is lower compared to previous estimates from other coral reefs in Miagao (Gulbranson 2014) (Figure 10). Additionally, the fish diversity and density in DMS are significantly lower when compared to estimates from other coral reef MPAs from different localities in the Philippines (Figure 10) as described in studies by Corrales et al. (2015) and Campos and Nabuab (2011). Despite this, the DMS may play an essential role in providing habitats to commercially important fish species from families such as Lutjanidae (snappers), Mullidae (goatfishes), and Nemipteridae (breams), which were found to be among the families observed during the survey (Figure 7). These coral reef fish families are important as they are primarily targeted for food by small-scale fishers in the Philippines (Muallil et al. 2015).

The lack of previous information on the reef fishes and fishing effort before the establishment of the DMS makes it challenging to determine whether the low fish diversity and density observed in this study was caused by overfishing and environmental degradation or reflects the inherent natural state of the coral reef. It is possible, however, that the reason for the low fish density and diversity is the naturally small coral reef area in DMS. The average size of locally managed MPAs in the Philippines is 0.15 km^2 (Muallil et al. 2019), while the total area of the DMS is around three times lower at 0.0495 km^2. The DMS "core zone," where the coral reef is located, has an area of 3 ha or 0.3 km^2.

Despite the small area of the coral reef, it is still vital that the DMS is appropriately managed and that the coral reef resources be conserved. The survey results showed that various coral reef species, including commercially important ones, were observed in the coral reef. Significant changes in coral reef fish populations in MPAs and spillover to adjacent areas may take several years (Fidler et al. 2017). The existence of the coral reef in the DMS increased the overall biodiversity and habitat complexity since the substrates surrounding the reef are composed only of sand. Furthermore, the DMS coral reef provides other valuable ecosystem services, such as coastal protection from strong waves, and as an educational site for students and researchers.

5. CONCLUSION

The study provides initial information on the benthic profile and the coral reef fishes of the Damilisan Marine Sanctuary. Local MPA managers can use this information to help plan and implement activities to improve management.

The DMS is a relatively small MPA in terms of area but hosts various coral reef fish species, including those considered commercially important. It contributes to the local coral reef fish biodiversity and plays a role in supporting the livelihoods of local coastal communities. Fisherfolks utilizing the buffer zone for fishing would directly benefit from an improvement in coral reef fish density if the DMS is properly managed.

The HC cover and generic diversity observed in the DMS typify coral reefs in the Visayan bioregion and the Philippines. The high cover of stress-tolerant HCs reflects the high-stress environmental conditions in the DMS, as it is located in the reef flat and is seasonally exposed to strong waves. Other potential anthropogenic stressors to the reef should be assessed and lessened to help ensure the survival of these HCs and the coral reef. The benthic profile, HC cover, and HC diversity can serve as references for future monitoring studies to elucidate long-term changes in the coral reef.

It is recommended that a more detailed and updated assessment of the coral reef status be conducted to supplement the information obtained from this study. Future studies should consider increasing the survey area by assessing more transects and including an estimation of coral reef fish biomass. Additionally, future assessments may adopt coral reef assessment methods recently applied by Philippine government agencies (e.g. photo-transects method) for easy comparison with other coral reef assessments from other parts of the country.

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AUTHOR CONTRIBUTIONS

Regalado JM: Conceptualization, Methodology, data collection, data processing and analysis, writing and review of the manuscript. **Magracia RMD**: Data collection, data processing and analysis, writing and review of the manuscript. **Olaer GMD**: Data collection, field work, data processing and analysis, writing and review of the manuscript.

CONFLICTS OF INTEREST

The authors of this paper declare that no conflict of interest exists.

ETHICS STATEMENT

The authors of this paper declare that no animal or human studies were carried out by the authors..

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