DO BUTTERFLYFISH INDICATE CORAL REEF HEALTH IN GUIMPUTLAN MARINE SANCTUARY?

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Abstract

The coral reef habitat strongly influences the associated organisms such as fishes, mollusks, and others. Butterflyfish (family Chaetodontidae) are marine fishes that are closely associated with the topic group as dietary specialization. Changes in preferred corals may cause obligate species to respond, and it may be reflected in their densities. However, varied consequences of habitat degradation may include switching feeding to a less favored food source. The presence or absence of butterflyfish on coral reefs can serve as an indicator of overall reef health due to their widespread prevalence. A survey in a Marine Protected Area (MPA) and adjacent fished area in Brgy. Guimputlan was conducted to determine the linear relationship between butterflyfish density and percent live hard coral cover (%LHC). Chaetodontidae abundance was surveyed using Fish Visual Census (FVC) and Line Intercept Transect (LIT) method to evaluate the benthos including the %LHC. Out of the fourteen (14) butterflyfish species in Brgy. Guimputlan, there are 3 dominant species namely, Chaetodon baronessa, Chaetodon lunulatus, and Chaetodon kleinii comprising 21.0536 % of the listed species Using Pearson Product Moment Correlation, the study revealed a significant result (r = 0.622, p =0.031) between obligate corallivore density (19.33333333 ± 12.29436925) and %LHC inside the MPA and none in the fished area. Correlation tests also yielded no significant results. This suggests that a minor loss of coral cover can result in a dramatic loss of butterflyfish abundance. Since they are extremely vulnerable to environmental and habitat disturbances, the role of marine protected areas coral reef protection and marine biodiversity conservation is of utmost importance. Comparison of overall butterflyfish density between the MPA and the adjacent fished area yielded a significant result (p = 0.019, T-value = 2.71, DF = 11). However, in comparing %LHC between the two sites, the result was not significant. This confirms that there is an MPA effect on the density of butterflyfishes in Brgy. Guimputlan.

Keywords: *butterfly fish, coral reef health, MPA, Dapitan City*

Introduction

In the Philippines, coral reefs contribute to food security (Burke *et al*. 2012) but are in decline from several anthropogenic stressors, climate change including increased storm intensity (Emanuel, 2005; Marler, 2014), and thermal bleaching (McLeod *et al.* 2010). These environmental disturbances to benthic habitats such as coral reefs can affect fish assemblages with dietary specialists like corallivorous butterflyfishes of the family Chaetodontidae. Chaetodontids are particularly sensitive in the decline of hard coral cover (Garry *et al.* 2017).

Fishes of the family Chaetodontidae, are found in all tropical seas of the world. There are 114 species in 10 genera with 90 of the species in the genus

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Chaetodon (Weinheimer 2021) that includes butterflyfishes. The butterflyfishes are characterized as diurnally active and are brightly colored inhabitants of coral reefs. They can be separated into three distinct feeding guilds: facultative, obligate, and generalist feeders (Andrews and Kownacki 2021). Studies on butterflyfishes has contributed greatly to the general understanding of the biology and ecology of coral reef fishes (Almany *et al.* 2007).

Butterflyfishes are excellent candidates for indicators of changes in conditions in the coral reef because their metabolic or energetic demand is so intimately linked to the existence and overall condition or "health" of the coral substrate (Bell and Galzin 1984), that several fish families, including butterflyfishes, as well as an entire reef fish assemblage, showed positive correlations with coral cover. The distribution and abundance of these fishes should be directly correlated with the distribution and abundance of the corals. If the corals are adversely affected by stressful environmental conditions such as chronic low levels of pollution, their health will deteriorate. This deterioration should be detected by the fishes which feed on them (Crosby *et al.* 1996).

Moreover, according to Tissot and Hallacher (2003), *Chaetodon* can be negatively impacted by collection for the aquarium trade and are also vulnerable to fishing techniques destructive to benthic habitats, such as drive nets and bombs (Russ and Alcala 1989, 1998a). These butterflyfishes were mostly the first species of reef fishes to go extinct due to global climate change, but alternatively may also provide important insights into the mechanisms that prevent global extinctions despite the increasing incidence of large-scale disturbances (Lawton *et al.* 2011).

Marine Protected Areas (MPAs) acts to maintain biodiversity for both endangered and commercial species, as the removal of human presence, allows for many different species to thrive without anthropogenic influence (Gili Shark Conservation 2018). They also protect certain habitats from being damaged by destructive fishing gear such as dredging and trawling and allow for these habitats to recover from previous destructive fishing practices as well. MPAs were also proven effective tools for marine conservation and management; they also have other important economic and social benefits, such as providing income and livelihood through tourism (Kelleher *et al.* 1995).

In the Philippines, MPAs can be categorized into two governance levels: nationally established MPAs and locally established MPAs (Cabral *et al.* 2014). MPA in general takes four forms: (1) Marine sanctuary or no-take marine reserve, where all forms of extractive activities are prohibited; (2) Marine reserve, where extractive and non-extractive activities are regulated; (3) marine parks, where uses are designated into zones; and (4) Protected landscape and seascape, where protection may include non – marine resources (Miclat and Ingles 2004, White *et al.* 2014). Marine protected areas have many proven benefits to both ecosystem and the surrounding communities.

Giumputlan is one of the barangays in Dapitan City, Province of Zamboanga del Norte in the southern Philippine Island of Mindanao. This barangay has 12.28 (ha) of Marine Reserve that was established in 2003. This place has a no-take marine protected area (MPA) that was established in 2003 under Resolution No. 2005-227 a Barangay Ordinance No. 05, series of 2005, “An ordinance imposing fees for every person or group of persons snorkeling and diving for sightseeing at the Fish Sanctuary in Guimputlan, Dapitan City.” No-take Marine Protected Areas (MPA), commonly known as marine sanctuary in our area, is a zone of the marine environment in which all forms of extraction by humans, including primary fisheries, are banned permanently (Roberts and Polunin 1991, Allison *et a1.,* 1998).

This study aims to assess the butterflyfishes and investigate the relationship between butterflyfish (Chaetodontidae) abundance (density) and coral reef health in Guimputlan Marine Protected Area. The result from this study can be used to identify potential benefits for long-term Marine Protected Area (MPA) protection (Garry *et al*. 2017). This study also aims to contribute to the growing body of information on the understanding the broad-scale and long-term effects of coral loss and reef degradation on coral reef fishes.

Methods and Materials

Study Site

This study was conducted in Brgy. Guimputlan during January and February 2022. Brgy. Guimputlan is a coastal component barangay in Dapitan City, Province of Zamboanga del Norte with approximate geographical coordinates of 8º43’21” N, and 123º23’33” E. A total population of 817 in 17 households based on 2020 Census of Population and Housing (PhilAtlas 2022).

In this study, two sampling stations were established in Brgy. Guimputlan, i.e., Guimputlan Marine Sanctuary (8º43’32” N, 123º24’15” E) and its adjacent fished area (8º43’38” N, 123º23’47” E) (Figure 1). The Marine Protected Area (station 1) was a fringing reef located near the shore in front of a beach resort covered with huge limestone and cottages. The area has a high percentage of live corals covered especially in the reef crest and reef slope, there are also coral recruits in reef flats. This station was prone to huge waves because it was an open sea, bounded by Sulu and the Bohol Sea.

The fished area, (station 2), was 1 km away from station 1. The topography was similar to station 1 and also extremely exposed to big waves, and fishing boats observed in the area. Crown – of – thorns starfish (COTs) were observed in the area.

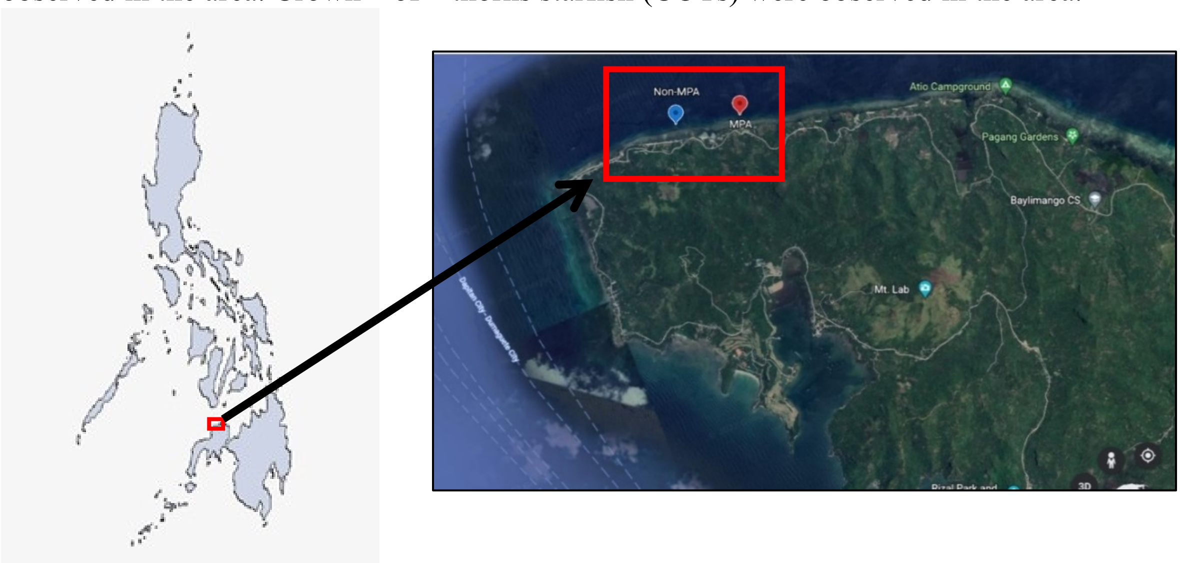

Figure 1. *Location of Barangay Guimputlan, the study site in Northwestern Mindanao, Philippines. The* ***Red dot*** *represents the Marine Sanctuary while the* ***Blue dot*** *is the adjacent fishing area (Source: Google Earth).*

Data Collection Procedure

A reconnaissance survey was conducted first in selected areas where butterflyfish could be found within Guimputlan Marine Sanctaury. Before that, the researcher sent a letter to the City Mayor's Office and the City Agriculture Office of Dapitan City to asked for permission to conduct the study in the area noted by the research adviser and program head.

The Fish Visual Census (FVC) method used in this study is a modification of the study of English *et. al.* (1997). FVC of butterflyfish species was carried out in two stations (i.e., inside the MPA and in the adjacent fishing ground). Six (6) 20-m transects were laid at each station in the reef crest were laid 5 to 10 meters apart (Fig. 2). Each sampling area was 200 m^2 (i.e, 20 x10 m). Along each transect, every butterflyfish species was counted and identified to the species level. Allen (2003) was used as the identification guide of butterflyfish species found in the sampling area. A photo of the research and the materials used in this study is shown in Figure 3.

Figure 2. *Marine Sanctuary and adjacent fished area showing the location of transects.*

Substrate evaluation (n =12) in both sites which included the percentage of live hard coral cover (%LHC) were recorded using the Line Intercept Method (LIT) using the method of English *et al*. (1997). Substrate evaluation used the same transects utilized for FVC. The following lifeforms and categories were used hard coral (HC), soft coral (SC), dead coral (DC), dead coral with algae (DCA), rubble (R), coral massive (CM), coral foliose (CF), coral encrusting (CE), and sand (SD).

Figure 3. *Photo taken during Fish Visual Census (FVC) and materials used during the conduct of the study.*

Data analysis

A Two Sample T-Test was used to compare butterflyfish density between the Marine Protected Area and non-Marine Protected Area. Percent live hard coral cover was also compared using the same test between these two stations.

A Pearson Product Moment Correlation Test was used to determine whether there was a direct linear association between butterflyfish density and %LHC in the Marine Protected Area and Non-Marine Protected Area. Further, the density of obligate corallivores was also tested against %LHC using the same correlation test. Prior to all analyses, data exploration was made using Anderson-Darling Test to assess the normality of data sets. Variance equality was assessed using Levene's Test. [Log and squareroot transformations were used were appropriate. All analyses were performed using the software, Minitab 17®.

Results and Discussions

The average percent coral lifeform categories include, i.e., coral branching (CB), coral massive (CM), coral encrusting (CE), coral tabulate (CT), and coral foliose (CF), while the general substrate categories are as follows, live hard coral (LHC), soft coral (SC), and non-living (NL) composed of dead coral (DC), sand (SD), rubble (RB), and dead coral with algae (DCA) and silt (S) (Figure 4).

The result revealed the percent cover of live hard coral substrates in Marine Protected Area (68.19 ± 14.57) was high compared to the Non-Marine Protected Area with a percent cover of (48.39 ± 21.77). However, based on the statistical result using the Two-Sample T-Test (Table 2), the percent cover of live hard coral doesn't show significant differences in marine sanctuary and non-marine sanctuary. The protection of the Marine Protected Area in Brgy. Guimputlan was generally effective in reducing or preventing coral loss in the area compared to the non-Marine Protected Area when enforced strictly.

Moreover, the second-highest percent cover was the non-living category which was (45.87 ± 21.96). According to Selig and Bruno (2010) "MPAs could prevent destructive fishing practices, anchor damage, and terrestrial run-off if they include a terrestrial component that reduces sedimentation and nutrient pollution." However, (Russ and Leahy 2017) stated that coral degradation may also be affected by environmental disturbances such as; coral bleaching, rapid storm intensity, and illegal fishing methods. Farther, a second major cause of the decline of the world's coral cover was the presence of crown-of-thorns starfish or COTS outbreaks (De Dios and Sotto 2015). Latest study of De'ath *et al.* (2012) in Great Barrier Reef showed that COTS outbreak is considered as the second major cause of the decline of the world's coral cover, a loss of 50.7% from 1985-2012.

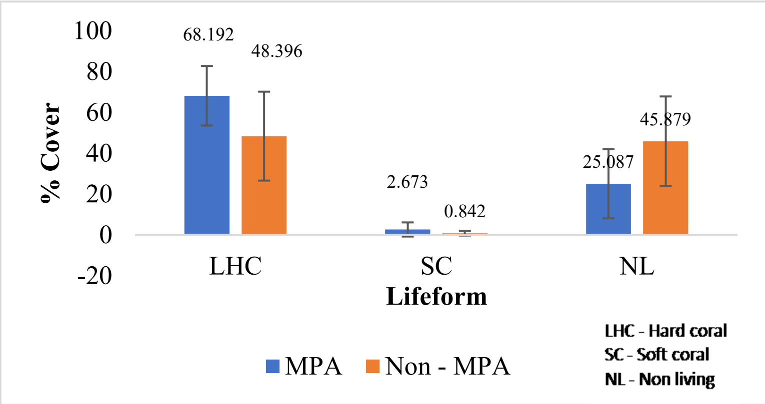

Figure 4. *Composition and percent cover of substrate categories in Guimputlan Marine Sanctuary and adjacent fished area, Dapitan City.*

Chaetodon density and live hard coral abundance

Figure 5 shows that inside the MPA the density of butterflyfish (28.75 ± 13.79/200 m^2) is significantly higher (df = 11, T-value = 2.71, p = 0.019) compared to that found in the Non-Marine Protected Area which is the adjacent fishing area (17.5 ± 4.10/200 m^2) in Brgy. Guimputlan, Dapitan City. Since butterflyfish density is higher inside in the MPA compared to the non-MPA and the %LHC in both stations are similar, this indicates that there is an MPA effect (Fig. 6).

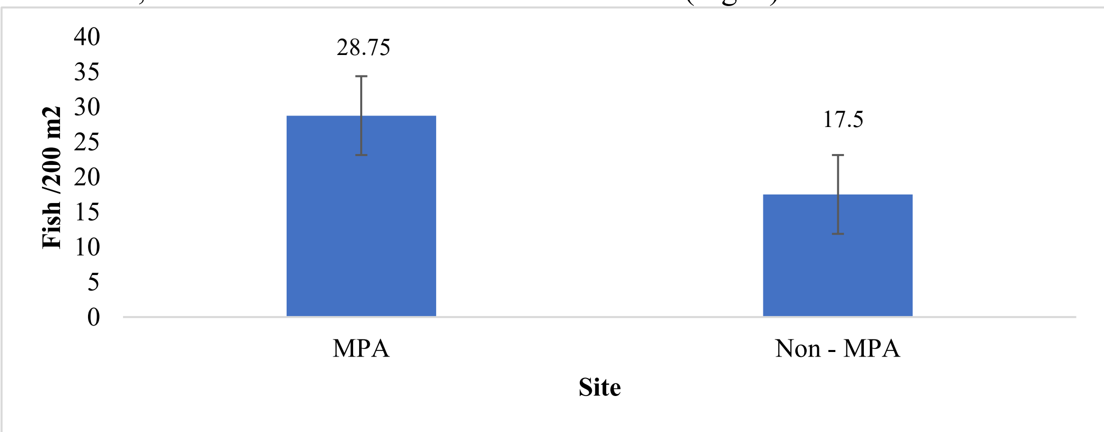

Figure 5. *Butterflyfish densities (28.75 ± 13.79) found in Guimputlan Marine Sanctuary and adjacent fished area, Dapitan City.*

Similar to the study of Russ and Leahy (2017), the density of butterflyfish was affected by the protection of MPA since anthropogenic disturbances were prohibited. However, their difference in the benthic composition of each site: (MPA: high coral cover, little sand, and rubble cover; NMPA: low coral cover, high level of sand and rubble cover) could influence the density of butterflyfish assemblages. This evidence suggested that factors other than MPA protection were derived from the abundance of different guilds of butterflyfish. They were significantly different (Table 1) in terms of their abundance. Between stations, species compositions may show different rules and have a relation with benthic substrate composition. Butterflyfish is locally known as "Pisos-pisos" or "Alibangbang". In both stations, the dominant species found were C. *baronessa, C. lunulatus, C.kleinii*. *C. baronessa,* and *C. lunulatus* and are considered obligate corallivorous species since they only feed on live hard coral polyps (Allen and Erdmann 2012) (Table 1). It was observed in this study too *C. rafflesi* was only seen in the MPA but was not in the fished area.

A previous study on the relationship between butterflyfish species richness and coral cover showed a positive relationship (Faricha, Edrus, and Utama *et al.* 2020). The same study revealed that butterflyfish density could be influenced by zonation patterns where the butterflyfish moves among different reef zones and territories. Other than that, competition may also affect the abundance of some species. *C. kleinii* was almost found on all sites. This species was categorized as omnivorous which mostly feeds on soft coral and was able to change to planktivores. Typically found on stony reefs and lagoons with abundant coral. It can also be found in sandy coral reef habitats (Adrim and Hutomo 1989). In this study, fishing likely influenced species richness. However, this need to be further investigated.

Table 1. *Results of the statistical analysis using T-Test while comparing MPA and NMPA using specific parameters in Guimputlan Marine Sanctuary and adjacent fished area, Dapitan City.*

T-test			
Factor	df	T-value	P
Butterflyfish density	11	2.71	0.019
%LHC	11	0.17	2.62

Fourteen butterflyfish species were recorded across 12 transects in Brgy. Guimputlan, Dapitan City (Table 2). The primary genus found was *Chaetodon*. The *Chaetodon baronessa, Chaetodon lunulatus, Chaetodon kleinii, Chaetodon vagabundus, Chaetodon trifacialis, Chaetodon lunula, Chaetodon unimaculatus, Chaetodon rafflesi, Chaetodon mellanutos, Chaetodon citrinellus, Chaetodon auriga, and Chaetodon reticulatus*. Other than that, two more genera were also found during the sampling the *Forcipiger longirostris* and *Heniochus varius*. These species were higher inside MPA (28.75 ± 13.79) compared to fishing area. However, there were only eight species found in fishing area. The *Chaetodon lunula, Chaetodon rafflesi, Chaetodon mellanutos, Chaetodon auriga, Chaetodon reticulatus,* and the *Forcipiger longirostris* were not observed.

Table 2. *Butterflyfish densities (28.75 ± 13.79) in Guimputlan Marine Sanctuary and adjacent fished area.*

Fish species	**MPA**	**NMPA**
Chaetodon baronessa	0.76±0.38	0.54±0.28
Chaetodon lunulatus	0.52±0.41	0.30±0.28
Chaetodon kleinii	0.31±0.22	0.48±0.65
Chaetodon vagabundus	0.16±0.14	0.05±0.08
Chaetodon trifacialis	0.23±0.35	0.06±0.09

Fish species	MPA	NMPA
Chaetodn lunula	0.02±0.05	0±0
Chaetodon unimaculatus	0.02±0.05	0.01±0.04
Chaetodon rafflesi	0.14±0.22	0±0
Chaetodon mellanutos	0.04±0.07	0±0
Chaetodon citrinellus	0.04±0.07	0.00±0.02
Chaetodon auriga	0.00±0.02	0±0
Chaetodo reticulatus	0.00±0.02	0±0
Forcipiger longirostris	0.04±0.07	0±0
Heniochus varius	0.16±0.15	0.15±0.17

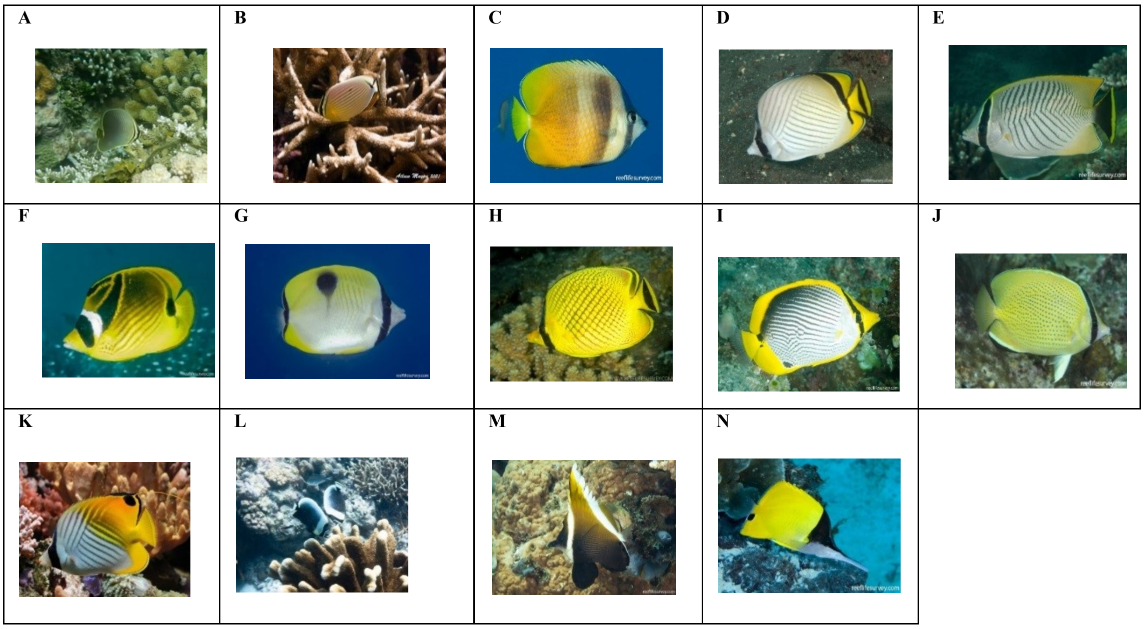

Figure 6. *Photos of butterflyfish species found in Guimputlan Marine Sanctaury and adjacent fished area.*

Some of these photos were reprinted with authors or photographers cited beside the species. **A** *Chaetodon baronessa*, **B** *Chaetodon lunulatus* (A.P. Maypa 2021), **C** *Chaetodon kleinii* (J. Kurtz 2014), **D** *Chaetodon vagabundus* (I.Shaw), **E** *Chaetodon trifacialis* (I. Shaw), **F** *Chaetodon lunula* (I. Shaw), **G** *Chaetodon unimaculatus* (R. Smith), **H** *Chaetodon rafflesi* (I. Shaw), **I** *Chaetodon melannotus* (I. Shaw), **J** *Chaetodon citrinellus* (R. Smith), **K** *Chaetodon Auriga* (D. Polack), **L** *Chaetodon reticulatus* (A.P. Maypa), **M** *Heniochus varius* (I. Shaw), **N** *Forcipiger longirostris* (R. Smith).

As previously mentioned, total butterflyfish density vs %LHC were tested for correlation both in the MPA and in the adjacent fished area. This revealed no significant results (Figure 7). In the MPA although there is a suggestion of a linear association pattern between the two variables, the non-significance result is maybe due to the presence of influential low points. Thus, more replicates are most likely needed.

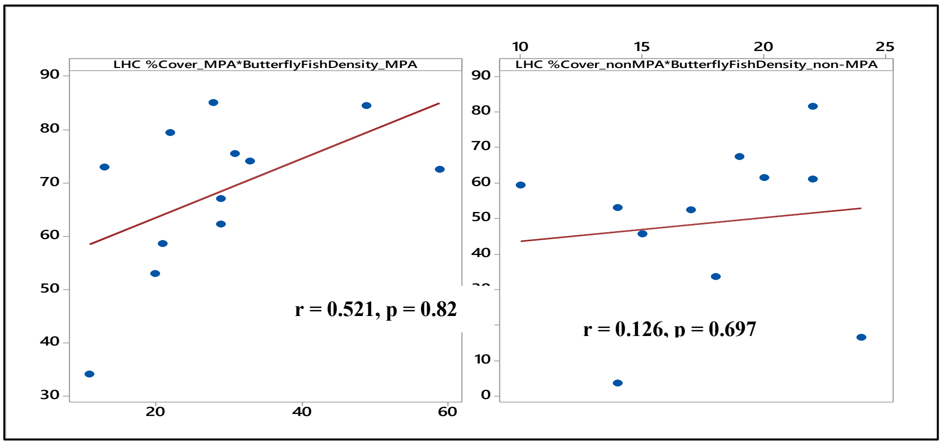

Figure 7. *Scatterplot of the butterflyfish density vs live hard coral cover with a line fit showing the correlation coefficient (r) and p-value.*

Further, we tested for the density of corallivore obligates vs %LHC. A moderate positive linear relationship resulted in the MPA (r = 0.622; p= 0.031) (Fig. 9). No significant correlation resulted in the fished area (r = -0.78; p = 0.58). Based on this result, it was confirmed that the density of obligate corallivore butterflyfish can indicate coral reef health in Brgy. Guimputlan Marine Protected Area. However, fishing will likely affect this pattern. This also shows the importance of protection to show natural population densities of reef fishes, in this case of Chaetodontidae.

The interactions between corals and corallivorous fish were crucial in influencing the local environment's health and overall reef degradation, according to Andrews and Kownacki (2021). Because butterflyfish are found all over the world, they were a good indicator species for estimating the decrease of overall fish populations on coral reefs. Globally, 20% of coral reefs have already been devastated, with the remaining 50% risking extinction in the near future. In recent years, anthropogenic factors such as boat traffic and fish harvesting have proven to be particularly damaging to coral health. Coral bleaching, for example, puts additional stress on corals, causing parts of otherwise connected reefs to die, fragmenting reef growth and limiting the continuity of shelter for reef fish.

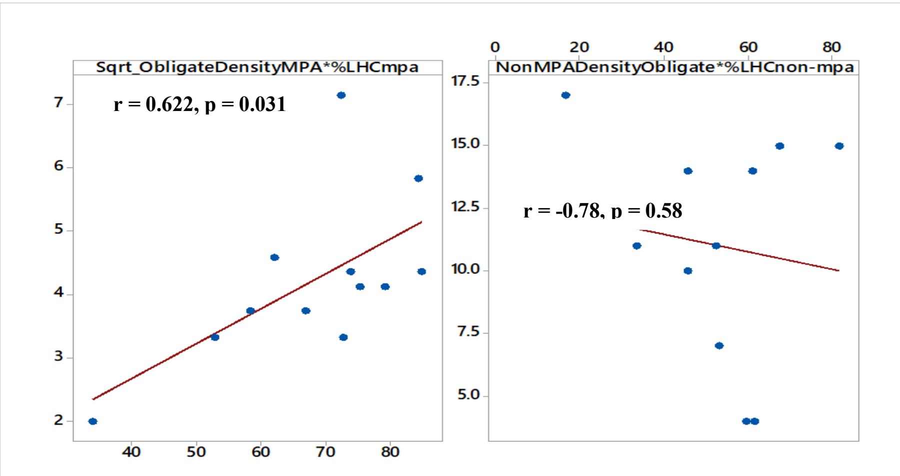

Figure 8. *Scatterplot of the obligate butterflyfish density vs live hard coral cover with a line fit showing the correlation coefficient (r) and p-value*

Conclusions

The total butterflyfish density (28.75%) was higher compared to the density (17.5%) of butterflyfish found outside the Marine Protected Area (MPA) of Brgy. Guimputlan, Dapitan City. The results highlight the importance of the MPA in terms of effectiveness and protection of fish assemblages in Brgy. Guimputlan. The study confirmed that the feeding habit of butterflyfish species shows a significant correlation with live hard coral among the non-corallivores fishes. Positive correlation between obligates butterflyfish density and percent live hard coral cover inside Marine Protected Area. However, like most other studies they also found a positive correlation between butterflyfish diversity and distribution.

Coral condition drives the abundance and species composition of butterflyfish. For instance, coral death due to anthropogenic disturbances and sedimentation or crown of thorns infestations this likely reduces the number of fish species and individuals linked with a reef. As the reef's structure is degraded by physical processes, its numbers should continue to drop. In addition, the density of butterflyfish (Chaetodontidae) was extremely vulnerable to environmental disturbances to their benthic habitats, and reductions in the cover of live branching corals in particular. We should strive to eliminate these anthropogenic disturbances to help our reef recover from natural disturbances.

Based on the result of the study, the researcher suggests that more replicates of the sample size should be done. The local government and other stakeholders must undertake greater monitoring and implementation of marine reserves. They should conduct further information, education and communication (IEC) to spread wide awareness to the residents in order for them to understand the importance and benefits of Marine Protected Areas (MPA) or Marine Sanctuaries. Building systems of marine reserves that are interconnected and large enough to be essentially self-sustaining, and incorporating each habitat type in numerous reserves to offer buffers against changing environmental and societal influences.

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