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Community Structure of Herbivore Reef Fishes in Lagonoy Gulf, Eastern Philippines

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Abstract

Reef herbivory is a critical ecological process that can control community structure in a reef and can determine recovery potential; therefore, herbivores are an important input in coral reef resiliency. In Lagonoy Gulf, herbivorous reef fishes were surveyed from 22 sampling stations with 93 transects of which 149 species belonging to 14 families were recorded. Although no differences between stations were detected among their biomasses, sizes, abundance and number of species; clustering of stations showed significant differences between clusters. Functional grouping suggests that almost all reefs experienced overfishing as average biomasses were relatively low, with grazers weighing only 112 kg ha^{-1}, scrapers with 56 kg ha^{-1}, browsers 14 kg ha^{-1}, and territorial damselfish 70 kg ha^{-1}. Marine Protected Areas (MPA) were noted to have no impact on reefs' herbivore community structure since it was almost similar with outside-MPAs and non-MPAs, but then, MPAs have higher overall values than the two other areas. Generally, presence of herbivore fishes in Lagonoy Gulf is a good indicator of the reef's potential recovery before and after a disturbance event. Furthermore, the diverse herbivore population of the Gulf enhances functional redundancy.

Keywords: marine protected areas, algal herbivory, herbivore functional group, Bicol.

1. Introduction

Reef herbivory is one of the main components in reef resiliency (Hughes et al. 2003, 2007; Mumby 2006; Burkepile and Hay 2006) and is one of the indicators used to determine potential recovery of reef ecosystem before and after a disaster (McClanahan, et al., 2001; Green and Bellwood, 2009; Hughes, 2007, Heenan and Williams, 2013). Usually, algal growth is rapid after a disaster in that can result to mass coral mortality such as ENSO and typhoons (Burkepile and Hay 2006). However, herbivore fishes balance coral-algal competition for space in reef ecosystem by grazing, browsing, scraping and excavating actions to seaweeds attached to the reef (Green and Bellwood, 2009), thereby maintaining algal biomass and providing settlement areas for juvenile corals (Green and Bellwood, 2009, Mumby 2006, Heenan and Williams, 2013).

Reef herbivores such as fishes and sea urchins can consume large number of seaweeds up to 90% of its daily production and can keep up a grazing area and preventing establishment of algal community (Mumby 2006; Heenan and Williams, 2013; Burkepile and Hay 2006; Albert et al., 2016). Several experiments on algal-fish herbivory have shown relationships between biomasses of fish and seaweeds (Heenan et al., 2016; Burkepile and Hay 2006; Edwards et al., 2013; Green and Bellwood, 2009).

Green and Bellwood (2009) described four functional groups of herbivorous reef fishes based on their different roles in coral reef resiliency such as: (i) Scrapers/small excavators, (ii) Large excavators/bioeroders, (iii) Grazers/detritivores, and (iv) Browsers. On the other hand, Edwards et al., (2013) devised similar grouping, however, they segregated territorial damselfishes making it their 4th functional group: (i) Scraper/excavators, (ii) Grazer/detritivores, (iii) Browsers and (iv) Territorial damselfishes.

With the declining state of coral reef in the Philippines (Licuanan et al., 2017) even with the establishments of Marine Protected Areas (MPAs), the condition of reef fishes is directly and indirectly affected (Maypa et al., 2012; Maliao et al., 2009; Alcala et al., 2005; White et al., 2000). In Lagonoy Gulf, Soliman et al., (2008), noted that fish catch composition from 1994 to 2004 had significantly change from predominantly carnivore to herbivore and planktivore, while David et al., (2005) observed slight decline in live coral cover from 1994 to 2004. With Lagonoy Gulf being on the typhoon path with an average of 18-20 typhoons year^{-1} and with 1 major typhoon every 3-5years, determining recovery potential of reefs is critical since it is a major source livelihood of 15 coastal communities with almost 16,000 registered fishers (BFAR, 2017).

With this, determining the recovery potential or resilience of a reef ecosystem utilizing herbivorous reef fish community structure data is essential to provide science-based management measures to improve reef's services.

2. Methodology

2.1 Study area

It is located in the eastern coast of Southern Luzon, Philippines (Fig. 1). It is approximately 3,070 km^2 of which 166 km^2 is the reef area. Most of the reef area are located in Albay from Rapu-rapu Island to San Miguel Island while narrow strips and patches are found in Camarines Sur from Atulayan to Rose Island going to northeast from Caramoan to the Island province of Catanduanes.

Sixteen sampling stations were established in the Gulf of which 8 were MPAs and eight were regular reef (Fig 1). Since adjacent MPA reefs (outside-MPA) were also assessed except for Agojo MPA and Malinao MPA since the outside reef do not qualify to the criteria set for coral

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reef survey, a total of 22 sampling sites were established, that is, MPA-inside = eight, MPA-out = six and regular reef = eight.

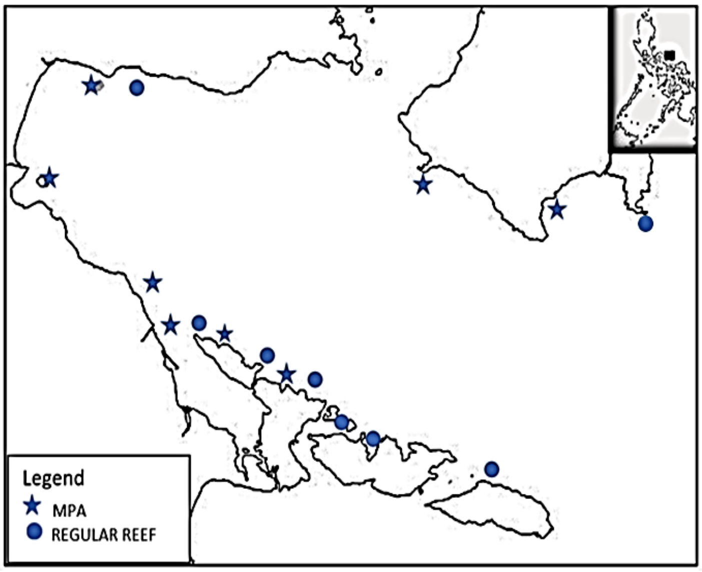

Figure 1. Distribution of coral reef assessment sites in Lagonoy Gulf, showing MPA stations and regular reef stations.

2.2 Herbivore fish survey

Fish visual census was used to survey herbivorous reef fishes. This was done by using the belt transect (50m × 5m) method. Four to five replicate belt transects were established haphazardly at each station. All targeted fish herbivores that appeared inside the belt area were recorded, counted and their total body length (TL) estimated to the nearest centimeter. The most important reef fish herbivore families are the Acanthuridae (surgeonfishes and unicornfishes), Pomacentridae (damselfishes), Scaridae (parrotfishes), and Siganidae (rabbitfishes). However other species that contribute to herbivory on the reef were also considered. Like *Chaetodon* sp., some genus of Tetraodontidae is 20-60% herbivore. Some Pomacentrus were also considered since they farm algae, which can be used to define resiliency (Edwards et al., 2013; Green and Bellwood, 2009). Functional grouping of all observed species was done following Edwards et al., (2013) and Green and Bellwood (2009).

2.3 Data analysis

Biomass of the herbivores was computed using the length (L) and weight (W) relationship of fishes in the formula:

$$W=aL^b \tag{1}$$

Where: W = weight of the fish in grams (g); L = total length (TL) of the fish in cm; and a and b are constants calculated for each species or genus (Kulbicki et al., 1993, Kulbicki et al., 2005).

Indicators of community diversity such as fish abundance, sizes, species richness (number of species), were used to compare among sites using Analysis of Variance (ANOVA). Multivariate analysis of data such as clustering, ANOSIM, SIMPER was done using PAST

4.01 (Hammer et al., 2001). Since there were zeros (0's) or no data/observation in some cases, data transformation was carried out using the *log(y+1)* to stabilize variance and if possible, bring normality to data (wikipedia.org/wiki/Data transformation).

3. Result

Twenty-two sampling stations with 94 transects were surveyed for herbivorous reef fish in Lagonoy Gulf. Of the 22 stations, eight were MPAs, six = outside MPAs and eight = nonMPAs. The survey recorded 149 herbivorous fish species belonging to 14 families (Table 1). Pomacentrids has the highest representative species of 68 species followed by scarids with 22 species, the third was acanthurids with 21 species, then by chaetodontids with eight species, then by pomacanthids with seven, while siganids and tetraodontids have the same number of species with six. The rest families have representative species of one and two. Acanthuridae, Pomacentridae, Scaridae, Pomacanthidae and Siganidae were found in almost all stations, while Chaetodontidae and Tetraodontidae were found in 15 stations, on one hand, Blenniidae and Ephippidae were only observed in seven and six stations respectively and the rest were only recorded in two or three stations. Most speciose stations were Sagurong Outside, Marilima MPA and Rawis with 64, 62 and 60 species respectively. Dakulang Puro, Tiwi MPA, Malinao MPA, Agojo MPA and Namanday have 54 to 50 species observed, while Bato, and Tiwi MPA have 48 species each. Gamban Outside and Bacacay MPA had recorded 45 and 40 species respectively. The rest of the stations have species tally ranging from 32 to 25 with Rose Island registered the lowest with only 20 herbivore fish species (Table 2).

In terms of biomass, Rawis registered the highest with 516.64 kg ha^{-1}, followed by Sagurong Outside, Marilima MPA, Namanday and Marilima Out with 403.27 kg ha^{-1}, 340.21 kg ha^{-1}, 327.22 kg ha^{-1}, and 302.39 kg ha^{-1} respectively. This was followed by four MPA stations namely Bacacay, Malinao, Agojo and Atulayan with biomasses ranging from 269 kg ha^{-1} to 243 kg ha^{-1}. While Gamban Out, Acal, Tiwi MPA, Gaba, Bato Dakulang Puro, Tiwi Out, Bacacay Out, Sagurong MPA, Rose Island and Galicia recorded biomasses from 222 to 112 kg ha^{-1}. Gamban MPA and Atulayan Out were the stations that registered the lowest biomasses with 63 and 54 kg ha^{-1} respectively (Table 3). Pomacentrids ranked 1st in terms of average biomass of all families observed in the Gulf with 69 kg ha^{-1}, this was followed by acanthurids with 54 kg ha^{-1}, and scarids landed on 3rd place with 48 kg ha^{-1}.

With regards to density of herbivorous fishes, Tiwi Out listed the densest station with 7912 ind. ha^{-1}, this was followed by stations in Catanduanes - Marilima MPA and Bato with 6120 and 5503 ind. ha^{-1} respectively, then by Rawis with 4093 ind. ha^{-1}, Malinao MPA – 3663 ind. ha^{-1}, Gaba with 3176 ind. ha^{-1}, Gamban Out 3054 ind. ha^{-1}, the rest ranged from 2907 ind. ha^{-1} to 1807 ind. ha^{-1} (Table 3). Pomacentrids recorded the densest fish family with 471 ind. ha^{-1}, however this time, siganids ranked 2nd with 403 ind. ha^{-1}, and the 3rd was scarids with 399 ind. ha^{-1}, the acanthurids and pomacanthids recorded with almost 388 ind. ha^{-1}, while tetraodontids and chaetodontids have only 352 and 295 ind. ha^{-1} respectively.

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Table 1. Observed number of species per family of herbivore fishes in Lagonoy Gulf

Family	Number of species
Acanthuridae	21
Balistidae	2
Blenniidae	2
Chaetodontidae	8
Aphippidae	2
Gobiidae	1
Lutjanidae	2
Monacanthidae	1
Plotosidae	1
Pomacanthidae	7
Pomacentridae	68
Scaridae	22
Siganidae	6
Tetraodontidae	6
Total	149

For the sizes of the observed herbivore fishes, Acal and Agojo MPA recorded the largest surgeonfish measuring almost 11cm (TL), while both sites in Atulayan, Bato, Dakulang Puro, Gaba and Galicia have surgeonfishes measuring almost 10cm each. Rest of the stations have surgeonfish measurements range from 9cm to 7cm with Bacacay MPA and Outside MPA recording the smallest with 6.5cm and 5cm respectively. For the parrotfishes, all stations have almost similar sizes with maximum average size of 11cm and smallest average size of 9.38cm. For rabbitfishes, maximum average size of 12cm was recorded in Acal and the smallest average size of 6cm was found in Tiwi, mean average size of rabbitfishes in the Gulf was 9cm. The damselfishes which are basically small bodied fishes, range of measurement is from 7cm to 4cm with mean size of 5.7cm. Acal, Agojo MPA and Atulayan MPA were the sites that recorded the largest damselfish while Bacacay (both in MPA and Outside-MPA) measured the smallest with 4.33cm and 4.08cm respectively. Angelfishes on the other hand, has size range of 9.75cm to 4cm with Acal having the largest observed angelfish and the smallest in Bacacay MPA, average size of this family in Gulf is 7cm. For the butterflyfishes, observed measurements ranged from 11.5cm to 6.33cm with an average size of 9.17cm with Acal and Agojo MPA having the largest observation of 11.5cm and 11cm respectively while Rawis and Namanday have the smallest record of 6.33 and 6.5 respectively (Table 3).

Analysis of Similarities (ANOSIM) showed four clusters of stations using the presence-absence data (figure 2), and further analysis using the Similarity Percentage (SIMPER) of the species composition per cluster revealed that for cluster 1 vs cluster 2, *Siganus corallinus* has the highest percentage contribution of 2.14%. It was observed that *S. corallinus* was not found in all eight stations in cluster 2 but is present in all five stations in cluster 1. The 2nd highest source of difference was *Canthigaster amboinensis* that has percentage contribution of 1.88%. *C. ambionensis* was found in all stations in cluster 1 but was

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only present in 1 out of 8 stations in cluster 2. For clusters 1 and 3 - *Hipposcarus longiceps* and *Scarus globiceps*; *Chromis retrofasciata* and *Centropyge bicolor* have the highest percent contribution with 1.917% each. In clusters 1 and 4, *Chromis analis* was the main difference where it was absent in cluster 1, and was observed only in all stations in cluster 4.

Table 2. Observed number of species of herbivore fishes in Lagonoy Gulf

Station	Total
Sagurong Outside	64
Marilima MPA	62
Rawis	61
Dakulang Puro	54
Tiwi MPA	52
Malinao MPA	51
Agojo MPA	50
Namanday	50
Bato	48
Tiwi Outside	48
Gamban Outside	45
Bacacay MPA	40
Gaba	32
Marilima Outside	32
Sagurong MPA	32
Atulayan MPA	31
Acal	30
Bacacay Outside	30
Gamban MPA	30
Galicia	26
Atulayan Outside	25
Rose	20

Table 3. Average abundance, biomass and sizes of observed herbivore reef fishes in Lagonoy Gulf.

Station	Abundance (ind ha^{-1})	Biomass (kg ha^{-1})	Size (cm)
Acal	2170.5	219.75	7.67
Agojo	2520.0	263.41	7.88
Atul	2409.5	242.67	8.03
Atul Out	2453.3	53.69	6.40
Bato	5503.3	269.32	7.98
Dak Pur	2709.3	162.94	7.53
Gaba	3175.8	196.7	7.29
Galicia	2616.7	187.15	6.35
Gamban In	1806.7	196.76	7.66
Gamban Out	3054.0	112.53	7.08
Malinao	3663.4	62.69	5.97
Marilima	6119.8	222.31	7.36
Marilima_Out	2282.6	264.28	7.22
Naman	2738.2	340.21	8.00
Rawis	4093.0	302.39	8.94
Rose	2780.0	327.22	8.00
Sag In	2690.8	516.64	8.26
Sag Out	2907.1	115.13	7.50
Tiwi	2347.1	121.26	6.97
Tiwi Out	7912.1	403.27	7.25
Uson In	2895.3	202.39	6.83
Uson Out	2290.7	183.17	6.81

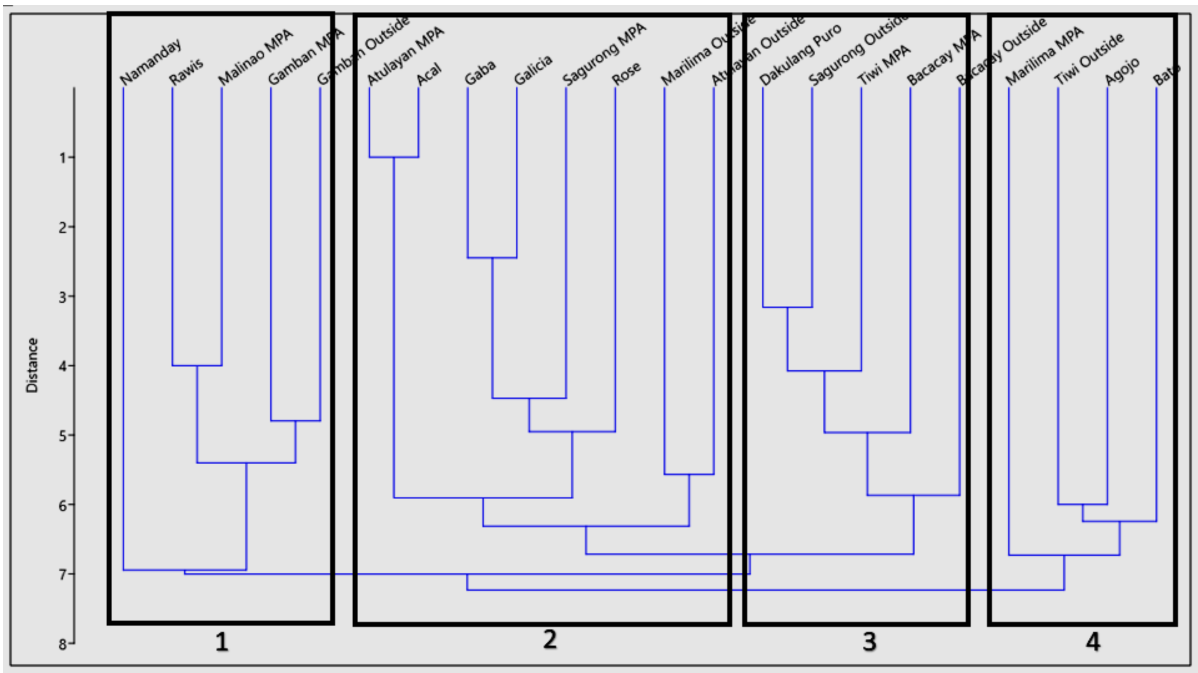

Figure 2. Four clusters of herbivore reef fish stations based on presence/absence data using the classical routine, UPGMA algorithm and Euclidean similarity index.

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In clusters 2 and 3, *Chromis amboinensis, Chlorurus sordidus,* and *Siganus corallinus* were the sources of difference, where all three species were only found in cluster 3, with contribution percentage of 2.198% each. Comparing clusters 2 and 4, *Chromis analis* contributed 1.97% of the difference between the two clusters, while *Siganus vulpinus* and *Acanthurus lineatus* contributed 1.724% which means that these two species were only recorded in one out of eight stations in cluster 2 while were present in all four stations in cluster 4. For cluster 3 vs cluster 4, *Pomacentrus sp., Acanthurus lineatus, Chaetodon octofasciatus, Centropyge bicolor* and *Hipposcarus longiceps* were the species that were found to be different between the 2 clusters that contributed 8.88% of the difference.

The functional groupings of herbivore reef fishes (Table 4) showed that in terms of biomass, grazers outweighed the other groups with an average weight of 112kg ha^{-1}, with Namanday weighing 235 kg ha^{-1}, while the lowest was Gamban MPA with 8.41kg ha^{-1}. The grazers are represented by acanthurids, siganids and pomacanthids. The scrapers on the other hand have an average total weight of 56 kg ha^{-1}, with Rawis being the highest with 133 kg ha^{-1}, and Galicia the lowest with 4.5 kg ha^{-1}. Scrapers on coral reef are the scarids. The browsers which are represented by the batfishes (Ephippidae) in this study, which was only observed in 7 out of 22 stations, recorded the lowest biomass among the functional groups, with Rawis the highest weighing 42 kg ha^{-1} and the lowest was Namanday with 6 kg ha^{-1}. Mean total biomass of this group was 13.55 kg ha^{-1}. Territorial damselfishes which are represented by its own family – Pomacentridae, has an average total weight of 70 kg ha^{-1}, with Sagurong Out the highest with 158 kg ha^{-1} and the was lowest Atulayan Out with 11.48 kg ha^{-1}. However, in terms of abundance (ind./ha.), the damselfishes were the highest with an average abundance of 472 ind. ha^{-1}, with 684 ind. ha^{-1} while the lowest is Bato with 249 ind. ha^{-1}. Grazers and Scrapers have almost the same abundance of 402 and 400 ind. ha^{-1} respectively. And the browsers only have 84 ind. ha^{-1} with Malinao MPA the highest recording 400 ind. ha^{-1} and the lowest were Tiwi and Atulayan MPA tallying to 160 ind. ha^{-1} (Table 4). But, with regards to sizes (TL in cm) of the observed fishes, scraper and browsers have very similar average observed sizes of 10cm while the grazers have an average of 8.47cm with max average observed TL of 9.62cm and lowest being 5.55cm. And for the damselfishes which are basically small bodied fishes has an average observed TL of 5.70cm with biggest average size of 7cm and small average size of 4cm (Table 4).

Clustering of stations based on whether it is an MPA, outside-MPA or non-MPA using presence-absence of species showed no significant differences among the clusters. However, it showed that MPAs has more observed species as compared to Outside MPA and non-MPA with 349, 243 and 321 species respectively.

4. Discussion

Community structure and/or pattern of abundance and diversity are wholly or partly defined by the ecological condition/s (Verberk, 2011; Bell 2001). In this sense, the range and abundance distribution of species, the variation and increase of diversity among sites can be described and interpreted based on the patterns of ecological parameters or processes (Bell 2001), that can in turn be used to determine potential recovery of reef ecosystem (Edwards et al., 2013; Green and Bellwood, 2009).

Observed species count of herbivore fishes in Lagonoy Gulf was significantly different between families however no significant differences was found between stations. This shows that representative species observed in each family were not the same, which is basically true for Pomacentrids, Acanthurids and Scarids which are among the speciose reef fish families. However, comparison between stations would reveal similarity of species present in each. This can indicate similarities of environmental conditions present in every station (Verberk, 2011). This is consistent with the concept of abundance and range of species diversity discussed by Bell (2001). Accordingly, Bell (2001), expressed that the community structure arises through sorting process such that the distribution of organisms is a product of the unique combinations of adaptations – such as functional role in coral-algal herbivory (Edwards et al., 2013; Green and Bellwood, 2009), and further argue that species will tend to be aggregated due to the similarity of growth conditions in nearby sites.

This is the same with biomasses of these observed fishes, significant difference was detected between families however no significant differences was found between stations. The main factor that has significant weight for the differences among families in terms of biomass are abundance and length (TL), it should be recalled that biomass was derived from length and abundance estimates and their corresponding *a* and *b* values (Edwards et al., 2013; Green and Bellwood, 2009). In this case, most pomacentrids and acanthurids have schooling characteristics while scarids are usually large species. With this, it was expected that abundance in terms of number of individuals would be significantly different for families due to the schooling effect of some families and their being diverse. However, about stations, no significant differences were noted which implies that number of individual species observed is almost the same in each station. Similar for the observed sizes, comparisons between families were significant due to their differences in growth characteristics or geometric morphometry; nonetheless, stations were not significant from each other.

However, ANOSIM and SIMPER based on presence-absence data revealed that species found in clusters of stations are significantly different from each other. This would suggest that although no differences were detected comparing abundance, sizes, biomass, and number of species between stations using ANOVA, the Similarity Profile of herbivore reef fish species showed that clustering of stations were apparent (figure 2). Pairwise comparisons of the clusters showed that clusters 1, 2, 3 and 4 (figure 2) have distinct dissimilarity in terms of species composition - cluster 1 vs cluster 2. This may further suggest that the reef may have favourable conditions for specific herbivores (Nyström, 2006), such as habitat variables, utilization and diversity (Verberk, 2011; Jennings et al., 1996; Connor and McCoy, 1979) fishing intensity (Wilson et al., 2012).

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Table 4. Average biomass, abundance and sizes of reef fishes according to functional groups.

Station	Browsers			Grazers			Scrapers			Territorial damselfishes		
	Biomass (kg ha^{-1})	Abund. (ind ha^{-1})	Sizes (cm)	Biomass (kg ha^{-1})	Abund (ind ha^{-1})	Sizes (cm)	Biomass (kg ha^{-1})	Abund (ind ha^{-1})	Sizes (cm)	Biomass (kg ha^{-1})	Abund (ind ha^{-1})	Sizes (cm)
Acal				95.91	400.00	8.78	36.36	368.00	10.00	87.48	642.50	6.31
Agojo MPA				146.29	286.00	9.40	29.74	250.00	9.38	87.31	609.09	5.95
Atulayan MPA	6.42	160.00	10.00	94.77	431.11	8.78	43.74	392.00	10.20	97.22	587.50	6.81
Atulayan Out				38.34	252.31	6.77	30.49	373.33	11.00	11.48	400.00	4.33
Bacacay MPA				119.53	506.67	9.62	95.06	232.00	10.57	72.23	249.09	6.00
Bacacay Out				44.35	426.67	8.29	85.92	434.29	10.63	59.67	501.71	5.53
Bato				164.45	458.46	8.33	30.44	600.00	10.80	28.31	452.50	5.50
Dakulang Puro				59.77	408.89	7.67	74.98	240.00	10.71	78.94	470.00	5.03
Gaba				151.48	196.36	9.31	34.76	306.67	10.00	54.64	313.33	5.88
Galicia				78.60	293.33	8.67	4.54	213.33	10.00	47.38	684.00	6.00
Gamban MPA	5.87	400.00	9.00	8.41	385.45	5.55	36.01	470.00	10.00	11.59	452.00	4.08
Gamban Out	12.79	200.00	11.00	81.25	442.67	8.00	28.66	166.67	10.67	98.31	407.69	5.60
Malinao MPA	16.05	240.00	10.00	118.89	416.47	7.91	73.58	697.78	9.88	55.31	286.67	5.25
Marilima MPA				182.28	464.00	8.27	25.57	497.14	11.00	132.26	494.55	7.00
Marilima Out				171.79	433.85	9.00	127.85	500.00	10.11	20.75	523.48	7.00
Namanday	5.73	320.00	10.00	234.94	405.71	9.25	98.13	573.33	11.00	78.35	460.00	5.82
Rawis	41.60	360.00	11.00	228.16	428.57	8.81	132.57	570.00	11.00	113.25	464.76	6.22
Rose				49.95	485.71	8.57	28.54	450.00	9.67	36.30	463.81	6.10
Sagurong MPA				61.98	541.05	9.43	50.24	113.33	9.50	62.40	577.39	5.67
Sagurong Out				147.74	312.00	9.21	97.12	354.29	10.50	158.31	401.38	5.98
Tiwi MPA	6.42	160.00	10.00	97.71	452.31	8.67	52.77	560.00	10.71	71.59	486.00	4.83
Tiwi Out				95.93	434.29	7.89	15.99	440.00	10.67	71.25	450.67	4.91

Functional groupings (table 4) of herbivore reef fishes would indicate that the Gulf had experience impacts from heavy fishing pressures. This can be deduced from the sizes, abundance and biomass of these fishes (Heenan and Williams, 2013, Heenan et al., 2016, Green and Bellwood 2009). Green and Bellwood (2009) stressed the importance of large (>1kg ind.$^{-1}$) excavators and "army" of scrapers and grazers to maintain or improve resiliency of a reef. In this study, absence of excavators (large parrotfishes) and major target species in the reefs such as large serranids, lethrinids and lutjanids, haemulids, suggest overfishing. Furthermore, abundance of territorial damselfishes (pomacentrids) strongly indicate less predators are present (Edwards et al., 2013). Scrapers/small excavators and grazers/detritivores have a critical function in restraining coral-algal shifts by constant removal of epilithic algal turfs thereby limiting the establishment and growth of macroalgae. Furthermore, they provide areas to facilitate settlement and growth of coralline algae and corals. (Green and Bellwood 2009, Heenan and Williams, 2013, Heenan et al., 2016).

MPAs have been observed to be not effective in reef fish protection as ANOVA results showed no difference on herbivore reef fish biomasses between MPAs, outside-MPAs and non-MPAs. The clustering of stations as shown in figure 2, may also support this finding of no distinct pattern of herbivore distribution in the Gulf. While many advocated that MPAs can increase fish yields (Alcala et al., 2005; Maypa 2012; Mellin 2016), several areas have demonstrated otherwise, such as those findings cited by Maypa et al., (2012) and Mellin (2016). Several arguments can be inferred based on the results, (1) it could be that MPAs were established after the area had suffered high fishing pressures (Mellin 2016), wherein several literatures have agreed that it would take at least 35 to 60 years for fished to heavily fished (depleted) reefs respectively to recover (MacNeil et al., 2015). MacNeil et al., (2015) contested that MPAs established in the past 10-20 years, need many more years to attain potential recovery. (2) Level or degree of management is low or struggling (Maypa et al., 2010), and (3) lack support both from local community and government (Maypa et al., 2010; Camargo et al., 2009; Jameson et al., 2002).

5. Conclusion

Presence of herbivore fishes in reef ecosystems of Lagonoy Gulf is a good indicator of its recovery potentials before and after a disturbance event. The relatively diverse herbivore population provides resiliency on reef ecosystem of the Gulf by enhancing redundancy on similar functional group, where the loss of any one species during or after a disaster can be more likely to be replaced by actions of another (Nyström, 2006) However, these herbivorous fishes are under pressure due to fishing especially scarids, siganids and acanthurids. Since the major target (carnivore) fishes have been declining, these herbivores are now targeted and had contributed much to the decline of large excavators and browsers which are important part of algal-coral competition process. The similarities of herbivore reef fish community structure prove the similarities of the reef habitats and possibly connectivity in the Gulf. However, it was observed that MPAs were not ecologically functioning, because herbivore fish community structures were similar with those in Outside-MPAs and non-MPAs. It was inferred in this study that MPAs are either on a recovery or experiencing human encroachments and low community and LGU support.

It is recommended that management strategies of MPAs should be revisited to include studies on resiliency and to update mechanisms and activities to improve MPA resiliency.

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