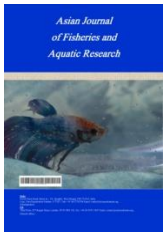

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Status of Coral Reefs in Lagonoy Gulf, Eastern Bicol, Philippines with Emphasis on Marine Protected Areas

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Status of coral reef health of 8 Marine Protected Areas (MPA), 6 adjacent MPA reefs and 5 regular reefs of Lagonoy Gulf were assessed from December 2017 to August 2018 and compared with previous gulf-wide assessment results in 1994 and 2004. Underwater photo transect (UPT) method was utilized to collect benthic lifeform information and coral point count with excel extensions (CPCe) was used to analyzed benthic data. Results showed that present live coral cover in MPAs are low with 26% as compared to adjacent MPA reef areas (30%) and regular reef stations (33%). A downtrend was noted from 1993 – 2004 with 10% decline of MPA reefs while from 2004 to 2018 decrease was almost 20% and from 1993 to 2018 an average fall of 25% was detected. Overall, Lagonoy Gulf reef health is declining and can be attributed to both natural and fisheries activities, as evidenced by almost 20 typhoons affecting the Region per year with a super typhoon at least every 5-10 years and the heavy dependence of fishing communities on reef fishes respectively. However, non-MPA reefs decline was observed to very minimal as compared for both MPA and adjacent MPA reefs ranging from 1% to 6%. With this, MPA management schemes should be revisited and amended to improve and strengthen MPA governance, direction and strategies.

Keywords: Live coral cover; coral status; reef assessment; reef health.

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1. INTRODUCTION

Lagonoy Gulf is one of the major fishing grounds in the Philippines and is located along the east coast of Bicol Region. More than 60% of the fishes caught in the gulf are reef attached species [1,2] which are extracted from the 16,616 hectares reef area that are extensive from Rapu-rapu Island to Tiwi in Albay, stretching to narrow strips and patches to Camarines Sur in Atulayan Bay and Caramoan Peninsula, towards northeast to San Andres and Bato in Catanduanes [3,4].

The first major reef assessment in the gulf was conducted in 1993 – the Resource and Ecological Assessment - primarily to have a baseline information and determine status of the reefs [3], and in 2004, the Resource and Social Assessment [4] was implemented as a follow-up assessment to determine impacts of the previous reef assessment. However, there were also several small and site-specific studies conducted in the area, like the Bicol Fish Biodiversity Program implemented by Bicol University College of Fisheries (1997 – 2002), Tiwi Reef Assessment (1980's, 1990's, 2002 and 2016), CRMP of Malinao Albay (2002), Uson-Buang-Pongco-Bonga (Bacacay, Albay) coral reef survey (2001), San Miguel Island Coastal Resource Management Project [4,5,6]. There were also survey sites established in the gulf during the National Reef Assessment conducted by De La Salle University in 2016 in Rapu-rapu and Bacacay in Albay, San Andres and Virac in Catanduanes and Caramoan in Camarines Sur [7].

In most cases, output of these assessments was the establishment of Marine Protected Areas (MPA), as such in 1994, the Agojo Point Marine Fish Sanctuary and Reserve, Atulayan Fish Sanctuary and the Gaba Bay Fish Sanctuary were first established in the gulf, then it was followed by Tabaco City (in San Miguel Island), then by Bacacay (2001) then by Tiwi and Malinao [4,5,6]. As of this date, at least 15 MPAs are established in the Gulf and are mostly managed by local government unit (LGU), however, around 8 have reef assessment records. One of the main reasons for the establishment of MPA was that fishery in the gulf is mainly reef fisheries, so to protect this declining reef fishery, MPA was the popular mode of management [4].

Average percent live coral cover in 1994 was 44% but had decline 4% in 2004, while dead corals increased by 2% in 2004 from 22% in 1993 [3,4]. With time gap from 2004 to 2018, a need to determine the present status of these reefs should be done. This paper discussed the present status (2018) of coral reefs in Lagonoy Gulf taking notes the inside versus outside of MPAs and versus a regular reef.

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 areas 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.

Fifteen sampling stations were established in the Gulf of which 8 were MPAs and 7 were regular reef (Fig. 1). Since adjacent MPA reefs were also assessed except for Agojo MPA and Malinao MPA since the outside reef do not qualify to the criteria set for coral reef survey, a total of 21 sampling sites were established, that is, MPA-inside = 8, MPA-out = 6 and regular reef = 8.

2.2 Data Collection

Underwater photo transect (UPT) method [8], using Canon G1X camera and GoPro™ Hero 3 was utilized to collect benthic lifeform information. Photos were taken every meter at an angle perpendicular to the substrate with a 50cm x50cm metal frame with a distance of 75cm from the substrate using a 50m transect line. A total of four to six 50m transects within an area of 50m x 50m were established in each sampling site. Benthic lifeform cover data were analyzed using the Coral Point Count with Excel Extensions (CPCe) [9]. Data collection was done from December 2017 – August 2018.

Furthermore an interview and focus group discussion with 10 random fishermen in each site with more than 10 years experience in fishing was conducted to elicit possible reasons or observations for the decline of status of reefs in the area.

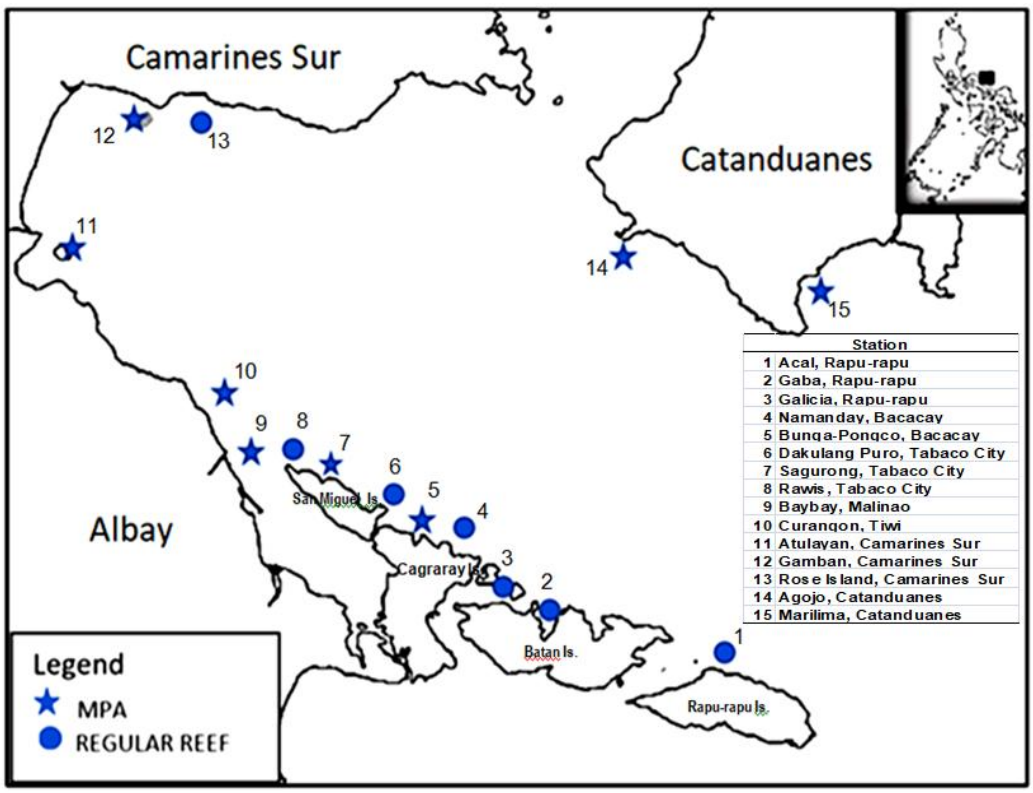

Fig. 1. Map of Lagonoy Gulf showing coral reef sampling sites

2.3 Statistical Analysis

Descriptive statistics was used to compare percentage cover among benthic categories between and among sampling stations. Analysis of Variance to determine differences among and between sampling stations were all done using PAST ver. 3 [10].

3. RESULTS AND DISCUSSION

3.1 Results

From 1993 to 2018 there were three major coral reef surveys in the Gulf namely; Resource and Ecological Assessment in 1993 [3], this was followed by the Resource and Social Assessment in 2004 [4], and the latest was 2018 [this study], - the Current Status and Resilience of coral reefs of Lagonoy Gulf. These three coral reef surveys were the main sources coral reef health data for the Gulf. In 1993, only 10 sites were assessed and an additional three MPA sites were added in the 2004 reef survey making it 13 sites. It will be noted that in 1993, MPAs have relatively higher live coral cover as compared to non-MPA sites, being one of the criteria in the establishment of MPAs. However, in 2004, of the10 sites, 6 sites showed decline of their live coral cover (LCC), while two indicated increase and one remained the same. Rosa Island recorded the highest percent decline of almost 61% followed by Tiwi with 42% decline, Bacacay MPA and Dakulang Puro with 24% and 21% decline respectively, while Atulayan MPA and Rawis declined with 17% and 14% respectively. On the other hand, highest increase was observed in Gaba with 41%, followed by Namanday with 39% increase then by Agojo MPA in 34% increase while Acal Point had a very minimal increase of 2%. In 2018, a total 21 stations were surveyed, that is, 8 MPAs, 6 outside MPAs and 7 non-MPAs. Results showed that LCC of the Gulf declined from 1993 to 2018 which can be observed by the absence of reef areas with more than 50% LCC cover (Fig. 2).

It was noted that from 2004 to 2018 MPAs have the largest decline like Marilima MPA where live coral cover (LCC) decline recorded to as high as 90% and was followed by 60% decline by SMI MPA then by Agojo, Malinao and Atulayan MPAs with 58%, 56% and 41% respectively. Of the 13 stations, only 2 stations registered increase in LCC coral cover but were very minimal such as in Rawis and Dakulang Puro with only 0.30% and 0.28% increase for almost 25 years (Fig. 2).

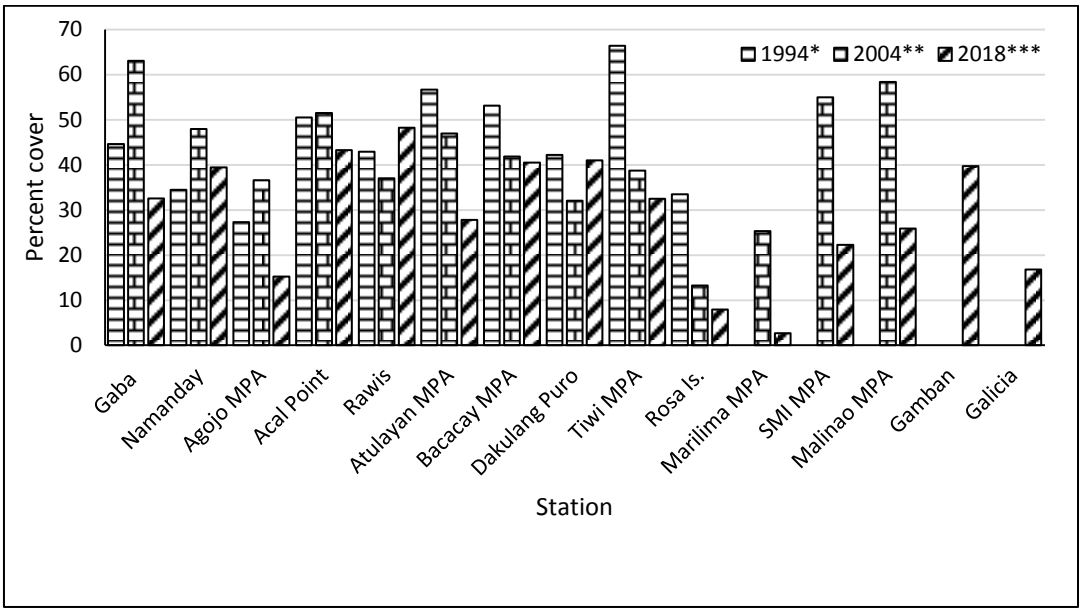

Fig. 2. Comparison of the percent hard coral cover between 1994 [3], 2004 [4], 2018

** 1994 data from REA project, ICLARM-BUCF [3]; ** 2004 data from RSA project, BUTC [4], *** this project*

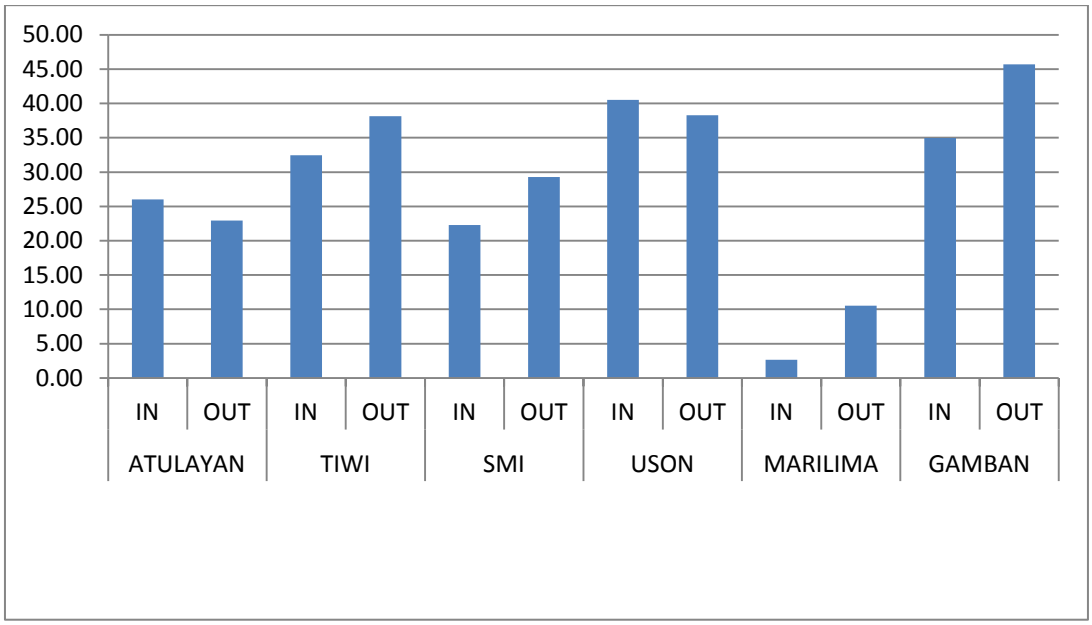

Fig. 3. Comparison of the mean hard coral cover between in and out of MPAs. Lines on bars represent standard error

Comparing inside and outside of MPA, it was generally observed that inside MPA has lower LCC as compared to the adjacent reefs. Four out of six MPAs have lower LCC inside versus its outside counterpart (Fig. 3).

3.2 Discussion

Within the ten years span (1994-2004) most of the MPAs have declined drastically like Tiwi, Bacacay and Atulayan MPAs as compared to non MPA reefs like Dakulang Puro and Rawis [3,4]. Although there were several destructive typhoons that hit Bicol Region area from 1993 to 2004 that have direct impact on coral reefs like typhoons Rosing, Iliang and Loleng with maximum wind speeds from 155km/h to 215km/h that also brought heavy rains, anthropogenic impacts due to illegal fishing and unsustainable upland practices resulting to siltation have

contributed much to the destruction of coral reefs in the Gulf [3,4]. This is what happened to Rose Island that had the dramatic decline due to the proliferation of blast and cyanide fishers surrounding the Island [4]. Take note also of the impact of 1998 widespread El Nino in the Philippines [11]. Surprisingly, there were increases in some areas despite decline in most areas in the Gulf, and noticeable are increases in areas with strict implementation and community support like Agojo MPA and Gaba Reef Area and areas with very high-water current and high energy waves such as Namanday Reef with around 20%, more than 10%, and around 10% respectively. It was observed that during the implementation of the Fishery Resource Management Program (FRMP) in the Philippines in the 90's, Agojo MPA and Gaba Reef Areas have very strict implementation and have proven to be effective because even there were natural calamities that hit the area, the recovery is fast and have improved which was also the same observation by Weeks et al. [12] and Selig and Bruno [13] in the importance of effective law implementation, and social support in form of co-management [14,15]. While for Namanday Reef Area, the high energy waves and strong water current are the contributing factors why illegal fishers (i.e., blast fishers) avoided the area.

Overall observation showed that for almost 25 years (1994-20018),majority of coral reef sites in Lagonoy Gulf had declined with highest percent in Rosa Island (76%), followed by Tiwi and Atulayan MPAs with 51% each, then by Agojo MPA with 44% while Gaba, Bacacay MPA and Acal Point have 27%, 24% and 14% respectively. Dakulang Puro had a very minimal decline of 3% while Rawis and Namanday were the sites that showed increased by 12% and 14% respectively. The declining state of reef areas in Lagonoy Gulf is also similar with the nationwide observation by Licuanan et al. [7], where there were increases in the number of poor (0-25% LCC) and fair categories (25-50% LCC) and decreases in good (50-75%LCC) and no more excellent (75-100%LCC). Overall observation on the present status of reef health of Lagonoy revealed no more reef sites have LCC above 50% or with "good coral cover" as described by Gomez et al. [16].

The general climatic condition in Lagonoy Gulf is classified as type II (Corona's classification) which means that the area has no dry period at all throughout the year, with a pronounced wet season from November to February [17]. This means that freshwater input is continuous throughout the year? which is not good for coral reefs [18]. However, observation of the reefs in the entire gulf showed that reefs that are fringing the mainland have low coral cover as compared reefs away from mainland or reefs found in islands (i.e., Rapu-rapu Island to San Miguel Island). Proximity of the reefs to river systems of mainland like Marilima and Agojo MPAs in Catanduanes have been observed to have high impact on the live coral cover especially during the first and last quarters of the year where precipitation is high (see Fig. 3). This would explain the presence of more coral reefs on the southern part of the Gulf (Albay side) as compared to the opposite section (Camarines to Catanduanes side).

On the other hand, interviews and focus group discussions results showed that two to three decades ago, coral reefs were mostly in good condition, but the proliferation of illegal fishing method in addition to changes in LGU implementation strategies (e.g., changes in LGU leadership) had targeted MPAs as fishing areas leaving adjacent areas better than inside MPA. Furthermore, personal communication with former MPA managers and elders showed that changes in the local chief executives resulted also to changes in the MPA management like, funding, manpower, support activities and others. Usually when there are changes in the political leadership more often the succeeding chief executive do not support the projects of the previous administration.

Although there were no baseline data available for the comparison between adjacent MPA reefs and inside MPAs, it is needless to say that inside MPAs have higher LCC as compared to adjacent reefs since top criterion in establishing MPAs is good LCC and one of its objectives is to increase LCC after years of establishment. Therefore, it is expected that after 15-25 years, MPAs should have higher LCC [13,19,20]. This can be the reason for the present situation that reefs inside MPAs do not differ from that of the outside reefs ($p = 0.289$), which means that the management effort in maintaining the MPAs are not effective and efficient since reef status outside the MPA – that is without restriction or management is just the same with those that with restrictions or management strategies.

4. CONCLUSION

This assessment of status of coral reefs of Lagonoy Gulf showed that the reefs are

functional as exemplified by the heavy dependence of fishers but are under threat by natural and anthropogenic factors as exhibited by its steady decline for 25 years. Remarkably noticeable were the live coral mean cover of adjacent MPA reefs that were higher than inside MPA and regular reefs have higher HC mean cover than MPAs. This would mean that MPA management strategies are not effective in improving coral reef live coral cover. This result sheds light on the importance on the crafting or revising new strategies e.g., legislations, organizational structure and financial and community support, on how to improve and strengthen management.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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