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Observation of the Third Year, the Use of Artificial Reefs Made from Bamboo, on the Malalayang Beach in Manado, North Sulawesi, Indonesia

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Abstract: ***Efforts of securing, maintaining, and preparing the sustainability of reef fish stock were conducted in the coastal waters of MalalayangDua, Manado, North Sulawesi, using coral reef condition rehabilitation-based management concept of community's fisheries zone, artificial reef made of bamboo or "BambooReef", as an innovative development of alternative artificial reef model. BambooReef can only stand in 2-3 years, andwhen the BambooReef modul is decomposed, the coral transplanted will fall to the sea bottom. The fish occupying the module will have new habitat, increase fish biomass, and create fish stocking area for surrounding waters. BambooReef was placed around natural coral reefs at the depth of 5 - 7 M. Data collected covered occurrence and preference of reef fish (number of species and density). Results found 28 species consisting of mayor species group (18species), 3 indicator species, and7 target species, with 181 individuals and density of 11.3125 ind.sq.m^{-1}or113,125 ind.ha^{-1}after 3 years of placement. Twenty-eight genera of coral fishes found were not in the range of optimal size for fisheries. However, this study reflects that bambooreef placement has opened an opportunity for new habitat creation for several genera of reef fishes.***

Keywords: artificial reef, coral transplant, coral rehabilitation, demersal fish,BambooReefmodul.

1. Introduction

In general, coral reefs have ecological, production, socio-economic, and socio-cultural functions. It also has major roles as habitat, feeding ground, nursery ground, and spawning ground for various marine biota in the coral reefs, including demersal fishes (Kusen et al. 2016**)** and fish abundance (Prasetiawan, 2017). Therefore, coral reef ecosystems support an incredibly diverse community of fish species (Ehrenfeucht, 2014).Coral reef ecosystem utilization, especially from production and social economic functions, can result in significant impact on habitat degradation. The impact of environmentally unfriendly practices can cause physical and biological damages of the coral reefs. Nevertheless, human activities have highly contributed to physical damage of the reefs, such as ship anchors over coral reefs, coral removals for house development, unfriendly fishing practices, excessive human traffic, and water pollution.

Artificial reefs can sustain large and diverse communities of fish and can be used as a tool to promote the biodiversity of fish communities. Fishes utilizing the artificial reefs in a number of ways. For instance, larval fishes may settle out on the reef and use it for shelter. Some fishes will use the reef for habitat and actually reside in the artificial reef while others will stay some distance from the reef and just use it for orientation. Reef can be also used as a foraging site for some fishes or a spawning site for the others (Polovina, 1985).

Artificial reefs have a great deal of potential as a tool in conservation efforts.Coral pieces are usually transplanted to improve damaged coral habitats, and then lead to fish community development(Cabaitan et al 2008, dela Cruz et al 2014). Structurally complex artificial reefs create a more suitable habitat for fish communities than structurally simple artificial reefs (Ehrenfeucht, 2014).Variable patterns in abundance may be influenced by a combination of environmental conditions, other biological processes like competition, and sampling effort (Streich et al 2017).The artificial reefs colonized with various species have potentials to remove organic compounds from fish farm effluents. (Angel, 2002). It has also an ability to strengthen an economy from its contribution to aquaculture, tourism and science. Artificial reefs have attracted sports fishermen, SCUBA divers, snorkelers and even surfers (artificial-reefs-study.blogspot.com/2015/11/the-disadvantages-of-artificial-reefs.html). Scientists can also benefit as these artificial reefs are convenient for scientific study and can even be used to rehabilitate rare coral for conservation. Artificial reefs also offer protection to the coastline.

Although artificial reefs can increase regional fish production,reef construction may also have deleterious effects on reef fish populations, such as increased fishing effort and catch rates, increased access to previously unexploited stock segments that leads to stock overexploitation, and increased probability of over exploitation due to concentration on previously exploited segments of the stock. There is also no convincing evidence that reef fishes are limited by insufficient quantities of hard-bottom habitat.

The purpose of these artificial reefs and other reef restoration efforts are to establish a better environment for coral and fish recruitment. The development of an artificial reef can cause problems since many kinds of toxic chemicals-containing materials are used that can pollute the ocean and harm the marine life. Artificial reefs may also damage the food chain, depleting other organisms that these species feed on. The structures may also affect ecosystem function by increasing the disease frequency in fish and invertebrates.Therefore, potential positive and negative aspects of reef construction need to be carefully considered prior to the addition of new reefs to marine environments (Grossman et al 1997).

The application of community-based rehabilitation concept using bamboo-made reef modul called *BambooReef*, as an alternative artificial reef.Bamboo has traditionally been a basic material to make fish raft, and has long life in the water. One of the preservation techniques, according toSulistyowati (1996) is soaking it in the water.This result would give new solution in fisheries, particularly fish stock supply around the artificial reef of*BambooReef*. This method is expected to be able to give good contribution to fish stock availability for surrounding waters as new fishing ground for local fishermen's income development. Fisheries sector is highly important as source of livelihoodand economy of the fishermen communities (Unsworth et al 2007; Ramadhan et al 2016).This study aims to identify the fish preference in inhabiting the *BambooReef*and to know the durability of BambooReefin the water.

2. Method

Bambooreef was laid around the coral reef in MalalayangDua, Malalayang district, Manado, North Sulawesi (Figure 1).The study was carried out in 3 phases, artificial reef development, placement, and fish monitoring. Bambooreef is a bamboo-materialized reef in prismatic shape with a dimension of 200 cm long, 200 cm wide, and 50 cm high (Figure 2).

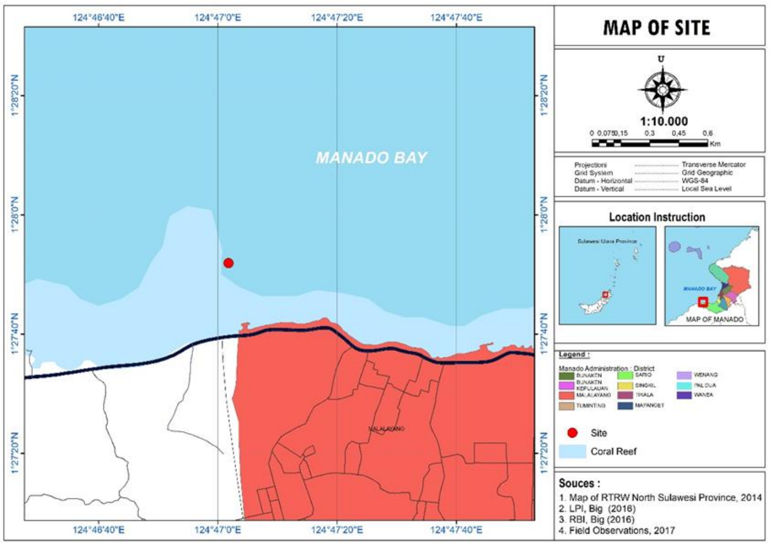

Figure 1: Study site

Each field of the reef was added with 10 cm wide-bamboo sticks placed in parallel position, and the middle parts were left empty space to let fish go in and out the modul (Figure 2). Coral transplants were tied on the holed bamboo sticks. Bambooreef was placed in 2015 on the sandy bottom at the depth of about 6 M near coral reef ecosystem. This site was selected to ensure that the local environment could support the coral transplants to survive because of being in suitable water conditions.

Figure 2: Bambooreef

Observations focused on fishes inhabiting around the bambooreefs, particularly species and numberof individuals. These observations were done for 3 years on the 6th month, 9th month, 12th month after the placement, and the third year, respectively. Local coral percent cover was also assessed using Line Intercept Transect (LIT) method, and coral reef condition was classified using Yap & Gomez (1984) category.

3. Results and Discussion

Coastal waters of Malalayang Dua is surrounded by coral reef ecosystems with slant topography. This coral reef area is reef fish fishing zone. Qualitative survey using manta board showed that general coral reef conditions ranged from poor to good enough, and the most were poor condition.Line Intercept Transect (LIT) data sampling found thatthe study area had moderate coral condition with 27% of live corals.According to Yap & Gomez (1984), hard coral cover of75-100%is categorized as very good condition, 50-74.9 % as good, 25 – 49.9 % as good enough, and 0-24.9 % as poor.Our observations revealed that in MalalayangDua waters, dead corals had higher percent cover than live corals,Hard coral cover of 27 % in this area indicates that the coral reef has good enough condition andneeds restoration andconservation efforts.

Placement of artificial reef "Bambooreef". The observations done since the 6^{th} month to the third year exhibited that the coral transplants have grown and the bambooreef was occupied by various algae and other benthic organisms, so that the artificial reef has been used as habitat by coral-eating(Kambey&Lohoo, 2017).Figure4 shows that the bambooreefhas attract many fish species as alternative habitat.It is supported by the surrounding coral reef environment in supplying coral fishes. The development of coral transplants becomes also an indicator that the site selection for thebambooreefplacement becomes crucial consideration, particularly distance from natural coral colonies where the coral transplants were taken from. Nevertheless, coral species and size of coral transplanted fragments, and other factors influencing reef recovery over time including cause of reef degradation and coral mortality need to be understood (Garrison & Ward, 2011).

b

Figure 4: Artificial reef "Bambooreef"in the first year. Source: field photo

Bambooreefis an organic material-based reef and has relatively short durability in the water. This study found that the bambooreefcould last in about 3 years, the growing coral transplants fell and live on the sandy sea bottomafter 3 years of observation (Figure 5), while corals need hard substrate to grow well. It is related with sedimentation rate, in which high sedimentation could threaten the survivorship of the transplanted corals. Our field observations in MalalayangDua showed that there were many pieces of branching corals growing also on the sandy bottom.

Figure 5: Bambooreefafter 3 years of placement.

Fourney&Figueiredo (2017) who studied the survival of *Poritesastreoides* found that Increased water temperature and anthropogenic sedimentation could cause mortality of coral recruit, but high concentration of natural (coarse) sediment was not detrimental to coral recruits, and even benefitted them. It could result from that anthropogenic sedimentation yields high water turbidity influencing the survival of the coral recruits. Perez III et al (2014), however, found that the major impact of the sediment was on successful settlement rather than on mortality, and larval substrate selection behavior was the primary factor.MalalayangDua waters is a very potential marine environment to select as coral recruitment site because it has appropriate water quality requirements for corals to live in.

Based on Living Environmental Minister's Decree numbered 51/2004 concerning standard quality for aquatic biota, Malalayang Dua waters has very supporting water quality to marine life. Water temperature, salinity, pH.and turbidity to marine life, particularly coral growth. It means that these water quality ranges could still be tolerated by corals to live and develop.

Changes in salinity that come from terrestrial freshwater inputs (Faxneld et al 2010; Williamson et al., 2011).MalalayangDua waters is also flown with small river nearby. The placement site of the bambooreef was about 1 km distance from the stream. It gets very little and highly temporary effect from the river.Water salinity range (Table 2) found in the present study reflects normal conditions for coastal waters.Nybakken (1992) stated that coastal waters is a dynamic environment with low salinity variations. Marine organisms living in this area tend to tolerate salinity changes up to 15 ‰.

Water acidity can be formulated as neutral if pH = 7 is neutral, acid if < 7, alkaline if pH > 7. Acidic or base pH will hazard the plankton. During the study, water pH in the study sites ranged from 7.04 to 7.21. According to Living Environmental Minister's Decree numbered 51/2004 concerning standard quality for aquatic biota, the optimum pH ranges from 7 to 8.5. It indicates that water conditions are still very normal because there was only very low effect of organic matters from the terrestrial area. There is a small river at the distance of about 1 km from the study site. Ocean acidification, caused by increased concentrations of atmospheric CO_2, lowers saltwater pH and impedes the ability of corals to assimilate $CaCO_3$ to form their skeleton (Andersson et al 2009).

Dissolved oxygen is needed by all living organisms for respiration, metabolism, and growth, beside oxidation in aerobic process. Dissolved oxygen in the water is produced through photosynthesis of the aquatic plants (seagrasses, algae, phytoplankton) and water surface and atmosphere interaction.

Water turbidity in MalalayangDua ranged from 2 NTU to 3 NTU (Table 2). This range is relatively lower than that of seawater quality standard for living organisms, < 5.It is related with the amount of sunlight intensity needed to support the photosynthesis of the zooxanthellae. Thus, clear coastal waters is such an important seawater condition to help continuous symbiotic interaction between corals and zooxanthellae to build the reefs. This condition occurs in MalalayangDua waters even though increased water turbidity could happen when excessive number of materials from terrestrial area could come in bad rainy season.

Such an aquatic environmental condition could support the coral to grow well, even though it still needs long time to reach natural reef conditions for coral transplants,benthic organisms**,** such as limpetsand algae, or fish occupancy after six-month period. Our finding revealed that the Bambooreef could only sustain in 3 years, but the organisms living there, such as corals transplanted, have grown and become new coral habitat.

Coral fish distribution in the artificial reef. Artificial reefBambooReefcannot be coral fish producer, but locality for fishes migrating from surrounding natural coral reefs. According to Smith et al. (2015), the fish come from the adjacent coral reefs, but how the process occurs is still unclear. Nevertheless, there are still arguments whether the artificial reef produces new fish or only attract fish biomass from surrounding waters.15 species were obtained, where the highest number of species was included in the major species group (13 species), followed by 1 species of indicator species, and 1 species target species, with 137 individuals, Kambey&Lohoo (2017).There were 28 species of coral fishes found around the bambooreef, consisting of mayor speciesgroup (18species), 3 species of indicator fish, 7 species of target fish, with a total number of 181 individuals (Table 1). They were not, in general, categorized as having minimumsize for fisheries. Thus, this artificial reef placement has provided new habitat for coral fish that come the bambooreef(Figure 4), and in the next future, this is expected to be a potential fishing ground for the local fishermen.

Fish occurrence in the Bambooreef revealed that the highest density was found in *Pomacentrusamboinensis* Bleeker, 1868, 1.0625 ind.sq,M^{-1} and the lowest *Parupeneusmultifasciatus(Quoy&Gaimard 1825), Siganusfuscescens (Houttuyn 1782)* and *Myripristismurdjan (Forsskål 1775)*, 0.125 ind/m^2. It indicates that fish occurrence is dependent upon food availability in the artificial reef, modul shape as shelter and habitat, since the higher the availability of space and food for the fish is, the more fish species will occur.Based on the fish presence, the highest number of species was found in major species, 18 species, followed with target species, 7 species, and then indicator species, 3 species.

Moreover,low fish diversity (H' = 1.251) found in the modul area could result from that the coral transplants have not reached suitable condition for coral fish habitat yet.Better coral growth will attract more fish species to come and stay there (Suharsono, 1999).

Table 1: Coral fishes found at the third year

No	Fish species		Sd	D
	Indicator Species			
1	Chaetodonvagabundus Linnaeus, 1758	7	0.71	0.438
2	*Chaetodontrifascialis (Quoy&Gaimard 1825)*	5	3.5	0.313
3	*Chaetodonkleinii* Bloch 1790	5	3.5	0.313
	Major Species			
4	Amblyglyphidodon curacao (Bloch, 1787)	12	1.4	0.75
5	Aulostomuschinensis (Linnaeus, 1766)	8	0	0.5
6	Pomacentrusamboinensis Bleeker, 1868	17	0.7	1.063
7	Dascyllustrimaculatum (Rüppell, 1829)	12	2.1	0.75
8	Abudefduf bengalensis Bloch, 1787	8	0	0.5
9	Centriscusscutatus Linnaeus, 1758	9	0.7	0.563
10	Centropygetibicen (Cuvier, 1831)	11	1.4	0.688
11	Centropygevroliki (Bleeker, 1853)	16	1.4	1
12	Chromisamboiensis (Bleeker, 1871)	8	2.1	0.5
13	*Chromisweberi* Fowler & Bean, 1928	9	2.8	0.563
14	Pomacentrus moluccensisBleeker, 1853	5	0.7	0.313
15	*Pseudodaxmollucanus* (Valenciennes, 1840)	7	1.4	0.438
16	Thallasomalunare (Linnaeus, 1758)	4	0.7	0.25
17	Neopomacentruscyanomos (Bleeker 1856)	3	2.1	0.188
18	*Dascyllusreticulatus (Richardson 1846)*	3	2.1	0.188
19	*Halichoerestrimaculatus* (Quoy&Gaimard 1834)	2	1.4	0.125
20	*Atule mate* (Cuvier, 1833)	4	1.4	0.25
21	Halichoeresbivittatus (Bloch 1791)	3	2.1	0.188
	Target Species			
22	*Parupeneuscyclostomus (Lacepède 1801).*	5	3.5	0.313
23	*Parupeneusmultifasciatus(Quoy&Gaimard 1825)*	2	1.4	0.125
24	*Scolopsisciliata (Lacepède 1802)*	3	2.1	0.188
25	*Siganusfuscescens (Houttuyn 1782)*	2	1.4	0.125
26	*Myripristismurdjan (Forsskål 1775)*	2	1.4	0.125
27	*Scolopsisbilineata (Bloch 1793)*	4	2.8	0.25
28	*Acanthurusauranticavus (Randall 1956)*	5	3.5	0.313
		181		

Table 1demonstrates that in general, major species outnumber other species groups and represent 18species, while target species and indicator species represent only 7 and 3 species, respectively. Number of individuals are also found to be higher in major species than other species groups. Major species usually come first as temporary residents and stay around the modul, but will leave the modul when divers come. Field observations showed that when the coral transplants grew well, the number of major species and individuals got higher. The indicator species (Chaetodontidae) come when the coral transplants show good growth. The presence of this species group reflects good coral reef condition, because this group is highly dependent upon the live corals. They come for feeding between coral branches. Target species come after other groups have stayed around the modul. Nevertheless, this species group is temporary visitor moving in and out the bambooreef, but then goes back to the nearby natural coral reefs.

BambooReef placement in MalalayangDuawaters has indicated an opportunity to have a model of fish house(habitat, feeding ground, spawning ground, and nursery ground), is beneficial for fish stockingand supports the coastal waters with damaged coral reefs and can be developed to reserve fish stock for surrounding waters. However, fast decomposition of organic material-based modul, such as bamboo, becomes another constraint to maintain the fish population around from modul destruction. Therefore, material selection of the modul should be considered to ensure the survivorship of the coral transplants that the conservation effort through this program could succeed.

4. Conclusion

Corals transplanted on the artificial bambooreef could grow well, have become habitat for sessile animals, such as limpets and algae, and attracted a variety of fish species to live there. Increase in number of fish occurrence from 1th, to the 3rd year could result from fish migration activities in adjacent reefs. Number of reef/coral demersal fish occurrence in the bambooreef was 15 species (137 ind.) at the 1th year, while there were 28 fish species (181 ind.) recorded at the 3rd year. Fish species diversity (H') = 1.2510 with the highest density of 1,0625 ind.sq.m-1. This condition reflected that the artificial reef of bamboo (BambooReef) has become part of demersal fish supplying process, at least in this study, with a density of 11.3125 ind.sq.m-1 or 113,125 ind.ha-1. Organic material-based modul will not be a good alternative for artificial reef development due to low durability in the water. Therefore, the conservation efforts through this program is more selective in order to maximize the survival of the coral transplants and the fish population around the modul.

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