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Diversity of Coral Reefs in Badul Island Waters, Ujung Kulon, Indonesia

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Abstract

Indonesia is a maritime nation with abundance the uniqueness of marine diversity, especially coral reefs. There are so many island in Indonesia with the diversity of coral reefs, such as Badul Island, part of Seribu Island. The study was conducted at Western part of Badul Island waters to identify biodiversity of coral reefs, located at Ujung Kulon district, West Java. Variable observed were biodiversity and level of mortality related to environmental condition surrounding location of study. Sampling method used was line intercept transect method (LIT method) in 75 m lenghth. There were 3 sampling sites with 25 m distance straight to the sea with 3 replication. The results showed that the average of coral cover which was still alive was 72,53% with mortality index was 0,265. Neverthelles, diversity index of coral showed at moderate level, with low level condition of domination index.

Key Words: Coral reef, diversity, mortality index, Badul Island.

Introduction

Indonesia with a vast sea area has the number of islands that reach about 17.508 with estimated coral reefs area of about 60,000 km^2. Marine and coastal ecosystems in Indonesia are vary widely recorded. These ecosystems sustain the lives of so many species. So, it has to be conserve from destruction, especially coral reef ecosystem[1]. Ecosystem of coral reef can be found at Badul Island. Badul Island is a small white sandy island with the beauty underwater ecosystems. This is located at Ujung Kulon National Park, West Java, which has 33 species of coral reefs[2]. Badul Island serves as a buffer for the marine protected areas.

Coral reef ecosystem has an important role that provide a significant contribution to protect coastal ecosystem from negative anthropogenic impacts. The ecological function of coral reefs are: as place to breed, spawn, nurse, and feed for other marine organisms; and as protector of severe wave action. Other uses of coral reefs are for fisheries, educational and tourism place, besides for coral and sand mining. Those will be as destuctive activities for sustainable of coral reefs if it is exploited without high responsibility of users and sustained efforts to conserve this ecosystem.

There are many activities regarding to the utilization of living marine resources at Ujung Kulon National Park, including the Badul Island, Panaitan Island, Peucang Island and Handeuleum Island. Those activities are fishing, water sport (like diving and snorkling) and also for bussiness needs (such as exploring reefs and marine organisms). There are so many impacts of these which tend to disrupt the living organisms under the area. Moreover, the use of explosives/bombs are still running to get ornamental fish, lobster and other marine organisms which could damage the coral reefs ecosystem. Thus, this study needed to conduct to analyze diversity of coral reef ecosystems at Badul Island waters with coverage of living coral measurement related to mortality index.

Material and Methods

Research Station: The research station was located at Western side of Badul Island (6°30'-6°52'S, 102°02'-105°37'E) Ujung Kulon National Park and it was graphically represented in figure 1. This study site was chosen as abundance of coral reefs found and also represented the condition of coral reef ecosystems in the waters of Badul Island.

Water Quality Measurement: Water quality was analyzed by measuring some physical and chemical parameters, those were depth, temperature, brightness, salinity, pH at each research station at depth of 3 and 10 meters. This measurement is very common for assessing the quality of water, salt water and freshwater such as in lake[3] and pond[4]. This parameters were measured both in situ and in laboratory.

Observations of Coral Reefs: It was used LIT (*Line Intercept Transect*) method to collect data which was made of 3 transects. The length of transect was each 25 m with 5 m interval between each transect, so it was about 85 meters lenght of line toward the sea. Observation was conducted at two depths, which were at 3 and 10 meters depth, with 3 replications. The depth of 3 m represented shallow waters while the 10 m depth for a relatively deepest water. It is assumed where corals can grow well at both depth as reported at Weh island, Aceh[5].

Figure-1
Site Study: Badul Island at Ujung Kulon National Park (wwf.or.id)

Installation of transects was placed parallel to the coastline, strong stretching and follow the contour. Transects were placed on the top of coral colonies. Observation was conducted in the morning or afternoon depending on weather at study site. The lifeform of reefs was collected once in every sampling stations where the reefs were found beneath the transects. Unknown coral colonies were recorded using water resistant camera to which was identified further. One colony was considered as an individual of reefs. If a colony is as the same species, it is separated by one or several parts of the dead, and every part of lifeform was considered as a separate section. If two or more colonies grew on the other colonies, they were still counted as a separate colony.

Data Analysis: Percentage of coral reef coverage was calculated using the following formula[6]:

$$L = \frac{Li}{N} \times 100\%$$

L = Percentage of coral coverage (%), Li = length of lifeform type I, N = Length of transect

Coral mortality index was used to determine the death of coral and calculated using the formula below[7]:

$$CMI = = \frac{DC+R}{LC+DC+R}$$

CMI = mortality index, LC = coverage of live coral, DC = coverage of dead coral (DC + DCA), R = rubble (fault rocks)

Coral mortality index values near zero indicates no significant changes for live coral, while the value of 1 shows that there is a change of live to dead coral. The percentage of dead coral coverage consists of DC (*coral death*), DCA (*death coral with algae*), and fracture of rocks (*rubble*). Biodiversity indices of Shannon-Wiener are one of variables used to determined community structure of coral reefs. Moreover, uniformity and dominance index were also calculated.

Result and Discussions

Water Quality: Water quality in western part of Badul island was still within the normal range for supporting the growth and development of live coral. The results of physical and chemical parameters are shown in table 1.

The temperature and brightness of waters in Badul island showed the optimal condition for coral growth, while the optimal temperature was at 25-30^{o}C[8]. In addition, the water flow at the sampling site was relatively stable at 0.3 m/s. This is caused by the location of Badul Island in the open area. A stable water flow can support the survival of corals, in terms of providing oxygen and nutrients needed by the coral reefs for growing up. This condition indicated the low movement of waves and also low sedimentation, and it resulted in high clarity of water. This was supported by study of Hoitink[9] which stated that the waves in Banten Bay act only in uppermost, few meters of the reef slopes which could result in low sediment. Furthermore, the current could decrease the amount of sediment in coral colonies and it cleaned the coral polyps[8]. Thus, corals can grow well where the brightness is one of the important factors for zooxanthellae in terms of photosynthesis process.

The salinity and pH value in the two depths of sampling sites were in the normal range. According to Connel and Gillanders[10], coral animals can grow well in salinity level of 32-35‰. Effects of salinity on the coral reefs were greatly vary depending on the condition of the sea water and the influence of a local nature such as the input of river water[9], storm, rain[11] and also seasonal fluctuation[4]. While range of pH for corals growth was 8 to 8.50[12].

Diversity of Coral Reefs: Based on observations, there were coral reefs in the western side Badul Island which were piled up

each other, adjacent to the mainland and bounded by the waters that were not too deep. The component of coral reef ecosystems found in the observation station was biotic and non-biotic components. Biotic components consist of acropora, non-acropora and other fauna. Non-biotic components consist of dead coral, sand and rock fracture (rubble).

Condition of coral reefs in the western part of Badul Island was still in good condition, in terms of the percentage of live coral cover was recorded as the average of 60.13% -84.93% and it is shown in table 2. The greater the percentage of live coral cover, the better condition of the coral reefs.

The condition of coral reefs at depth of 3 m was in the category of good and percentage of coral coverage was between 50-74.9%, while at depth of 10 m was in very good condition with 75-100% percentage of coverage[13]. The higher percentage of live coral cover in depth 10 m than 3 m was also reported by Supriharyono[14]. The percentage of coral coverage at each observation station is shown in figure 2.

Table-1
Physics Parameters at Study Site in Bandul Island Waters

Parameters	Remarks	
	Depth of 3 m	**Depth of 10 m**
Temperature (^{o}C)	30	29,5
Brightness (m)	3,00	7,2
Salinity (‰)	32	32,5
pH	7,98	8,01
Coordinate	S 06^{o}18'10.1" E 105^{o}50'38.2"	
Speed (m/s) & flow direction	0,3 m/s East	

Table-2
The Percentage of Live Coral Coverage

Depth							
3 meter				**10 meter**			
Plot 1	**Plot 2**	**Plot 3**	**average**	**Plot 1**	**Plot 2**	**Plot 3**	**average**
59.6%	67.2%	53.6%	60.13%	91.6%	71.6%	91.6%	84.93%

Note: Average of live coral coverage at 3 m and 10 m depth = 72,53 % (Good Category)

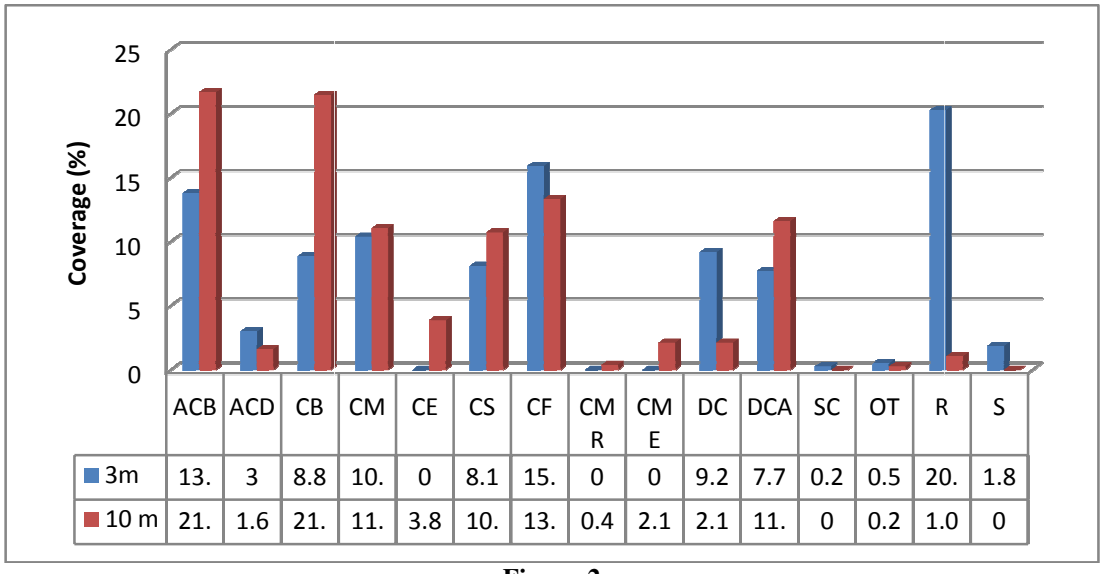

Figure-2
Percentage of Coral Coverage at A Depth of 3 m and 10 m. Note: ACB (Acropora Branching), CMR (Mushroom Coral), ACD (Acropora Digitate), CME (Fire Coral), CB (Branching Coral), DC (Dead Coral), CM (Massive Coral), DCA (Dead Coral Algae), CE (Encrusting Coral), SC (Soft Coral), CS (Submassive Coral), OT (Other Fauna), CF (Foliose Coral), R (Rubble), S (Sand)

Non-acropora species of corals dominated coral types at each observation station, which were 43.33% (3 m depth) and 61,66% (10 m depth) of coral coverage. They were branching coral (CB), massive coral (CM), submassive corals (CS) and coral foliose (CF). Study by Supriharyono[14] also found that massive coral, sub-massive coral, foliose coral and encrusting coral dominated reefs at Riau Island, in depth of 3 m and 10 m. It shows that most of them grew under highly sun dependent, where there had been high sunlight penetration at shallow water of Badul Island, especially at western side. This also proved that the waves were not too strong and good for reefs life. Moreover, these kind of corals are very difficult to mine because of hardness and less economics. These corals are widely used by miners as a stepping stone when they do mining, because it has a solid structure and strong[15].

Acropora species of corals were only cover 16.8%-22.67% of the reefs at each depth, which were dominated by acropora branching coral (ACB). This was due to the form of branching corals have rapid growth compared with other forms of corals[14,16]. According to Nontji[17] and Veron[18], branching corals can be found in the area of the reef slope on the sheltered or semi-open site in Indonesian Archipelago.

At depth of 10 m, mushroom corals (CMR) were found, eventhough in a small number of 0.4% coverage, but it was not found at depth of 3 m. This type of corals lives solitary on the reef slope and it can also survive on rather turbid waters[18]. It was also found Millepora coral (CME), known as fire coral in this depth. These types of corals are usually found near the slopes of the reef and it can be very dominant. This corals are dangerous because it can cause skin burning when are touched[19].

At 3 m depth, it was found avertebrates such as starfish and sea urchins from the Echinodermata phylum, but it was not at depth of 10 m. This is due to the use of coral reef for food and shelter by most of the organisms in sea water. At shallow water, sunlight highly penetrates into water so there has been abundant food as a resulf of photosynthesis process.

The amount of non-biotic components at 3 m depth was fairly high which was about 22.14% compared to 10 m depth, only 1%. This is caused by the anchor of fishermen which intentionally damaged coral reefs at shallow water than deep water. In addition, high-speed boat cause high current which could be destroy susceptible coral of ACB. This showed by lower percentage of ACB coverage at depth of 3 m than 10 m. Corals damages cause by bombs or achors had already been happened in the past as reported by Edinger et al.[20].

Anthropogenic activities give significantly impact to the growth of organisms living in aquatic ecosystem[3,4,21]. The impacts that may affect the coral reefs are numerous since the past[7,17,21] until now[20,22,23,24]. Marine tourism may have high impact to coral reefs condition. Most of tourists like doing water sport like diving, snorkling or swimming in this area. Their activities are tend to damage coral reefs unless there are good supervision for them. According to Brander et al.[23] human activities in sea water will be bad for coral reefs preservation. In Badul Island, tourism activities were relatively low so that percentage of dead coral cover was also as low as 23,1% in depth 10 m. This is due to less human activities carried out at deep water than shallow water. At a depth of 3 m, high coral fracture reached 20.27%, due to high wave and destructive fisheries in shallow water. Although destructive fisheries result in coral damage in some reefs, but majority coral conditions were still good with average of live coral cover was about 72.53%.

Generally, coral species found in depth of 3 m were less than depth of 10 m. At 3 m depth, it was found *Acropora, Seriatopora, Porites, Stylophora, Montipora, Turbinaria, Favites, Leptoseris* and *Echinopora*. While, at depth of 10 m those were *Acropora, Seriatopora, Porites, Echinopora, Goniastrea, Turbinaria, Montipora, Fungia, Millepora, Leptoseris, Alveopora, Stylophora* and *Favites*.

Coral Mortality Index (CMI): The value of CMI both at 3 and 10 m depth was less than 1. This is meant that the rate of coral mortality in the observation station was considered low. It was proved by high average of live coral cover in both studied depth which were about 72,53% in average. This showed good condition of coral reefs in Badul Island. Thus, it is clear that less mortality will impact to high live corals which was supported with good water quality surrounding the ecosystem, indeed.

The value of CMI at 3 m depth was higher than at 10 m depth. This was in accordance with the percentage of coral coverage data where the value of abiotic components and dead coral at a 3 m depth was quite higher compared to the depth of 10 m. Human activities also affect the coral mortality. In shallow waters, there are higher human activities than deep waters. Human activities often take place in shallow water, such as swimming, snorkeling and diving. These activities often have a negative impact on the survival of coral reefs such as fracture of lifeform and also death due to trampled. It was also reported by Fava et al.[24] that human activities had been resulting in increasing amount of coral rubble at Bunaken Marine Park. It was different from coral reefs destruction at Fiji and Cook Island which was dominantly caused by agroindustry activities[22].

Coral Reef Community Structure: Regarding to describe the community structure of coral reefs, it is needed to analyze the diversity (H'), uniformity (E) and dominance (C) index at each observation station. Data of diversity (H'), uniformity (E) and dominance (C) index of coral reefs are shown in table 3.

Table-3
Index of Diversity (H'), Uniformity (E) and Dominance (C) at 3 m and 10 m Depth

Index	Depth					
	3 m			10 m		
	Plot 1	Plot 2	Plot 3	Plot 1	Plot 2	Plot 3
H'	2,179	2,155	2,078	2,270	2,456	1,962
E	0,950	0,877	0,948	0,877	0,954	0,854
C	0,120	0,129	0,141	0,133	0,09	0,183

It was found that diversity index of coral species is moderate (2.00 <H'<3.00). Uniformity index at depth of 3 m and 10 m was high and had a stable community structure (E>0.6). This resulted in low value of dominance index (C≤0.5), where there was not found a dominant species of corals at both depth.

Moderate category of diversity index and low level for dominance were caused by a wide range of differences in coverage percentage in a certain type of coral reefs in Badul Island. The diversity index of corals in Badul Island was better than in Abang Island, Batam which was as low as 0,16-0,68[25]. It proved that Badul Island has a good coral reefs condition and this has to be conserved sustainably.

Conclusion

Coral reefs in the water of western part of Badul Island was in good condition with 72.53% of live coral coverage and the very low value of coral mortality index was about 0.26. Thus, it can be concluded that Badul Island still had a good water quality and suitable for coral reefs life. This should be maintained continously and sustainably.

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