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Condition of Coral Reef and Reef Fishes in Dofa Village, Sula Island Regency

Alimuddin[1*], Nurul Chayati[1], Tedy Murtejo[1], La Ode M. Gunawan Giu[2], Ria Fitri[3]

*Corresponding author e-mail: alimuddin@uika-bogor.ac.id

[1]Study Program of Civil Engineering – Faculty of Engineering and Science – Ibn Khaldun University
[2] Study Program of Marine Science – Faculty of Fisheries and Marine Science – Halu Oleo University
[3] Study Program of Industrial Chemical Technology – Faculty of Chemical Engineering – Polytechnic State of Ujung Panjang

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Abstract

Coral reefs are unique among ocean associations or communities that are entirely formed by biological activity. This study aims to determine the condition of coral refs and reef fishes in Dofa Village, West Mangoli District, Sula Islands, 2018. Collecting coral data used the Line Intercept Transect (LIT) method, and reef fishes data collection used the visual census method. Water parameters measured are temperature, salinity, degree of acidity (pH), brightness and current velocity. Based on observations, the water temperature ranges from 29.33 °C - 29.9 °C. The salinity of the waters ranges from 29.67 ‰ – 34 ‰. The degree of acidity is 7.5 which supports the life of coral reef. The water brightness level is 65 % - 100 %. The current velocity ranges from 0.02 m/s to 0.05 m/s. The condition of the coral reef ecosystem based on the percentage of hard coral cover ranged from 21.02 % - 33.7 % with low to medium category. The coral mortality index at the study location was small where at station 1 it was 0.487, station 2 was 0.335 and station 3 was 0.205, meaning that there was no significant change for live coral reefs. The abundance of reef fishes ranged from 0.52 ind/m2 - 1.22 ind/m2 which was dominated by the Pomacentridae and Labridae families where the two families were groups of fish that used coral reefs as habitat for feeding ground. The index value of reef fishes diversity in the coral reef ecosystem at all stations ranged from 0.58 to 3.60 where the diversity index value was in the low to medium category. The uniformity index is included in the medium category with values ranging from 0.58 to 0.63 which illustrates that the difference in the number of individuals for each species is not too significant. The dominance index of reef fishes at the observation station is very small, ranging from 0.03 - 0.07 which indicates that the dominance of the species is very low, so that the condition of the reef fish community is relatively stable.

Keywords: Coral Reef, Reef Fishes, Coverage Percentage, Community Structure, Dofa Village

1. Introduction

Indonesia, with its vast marine area and an estimated 60,000 km2 of coral reefs, makes this country very rich in biodiversity (Mahmudi, 2003). Coral reefs are unique among ocean associations or communities that are entirely formed by biological activity (Nybakken, 1992). Coral reefs have a very important value and meaning both from a socio-economic and cultural perspective, because almost a third of Indonesia's population lives in coastal areas and depends on their livelihood from shallow marine fisheries (Suharsono, 1996).

Good condition of the coral reef ecosystem for tourists, especially divers, is a nice view. Maritime tourism is one of the main factors supporting the

economy of an archipelago country like Indonesia which also has a tropical climate with sandy beaches and clear water with very beautiful and charming coral reefs. Based on research conducted by the Research and Development Center for Oceanology-LIPI, it is stated that almost 43% of coral reefs in Indonesia have been severely damaged, while only 6.5 % are still in good condition (Moosa and Suharsono, 1997). Given the importance of the functions and benefits of coral reef ecosystems that are widespread in Indonesian waters, it is necessary to have sufficient scientific data and information to support efforts to manage and utilize this potential appropriately.

Damage to coral reefs will continue with the presence of various pressures from the mainland (Baum et al. 2015). High pollution intensity and high sedimentation inputs have resulted in continuous damage to coral reefs with the main effect of the damage seen in the coral reefs of small islands located near the mainland. Damage to coral reefs can also be caused by natural disasters (Lubis et al, 2018). Damage can also be caused by temperature fluctuations or sedimentation from one of the many interconnected coastal and terrestrial oceans (Kausarian et al. 2016; Lubis et al, 2017).

Coral reef ecosystems can repair and improve itself from damage if given the needed protection, however, recovery takes a long time. Therefore, coral reefs that have naturally maintained themselves in nature need to be preserved (Lubis, 2018).

Coral reefs are heavily influenced by human activities through pollution and habitat loss throughout Indonesia (Burke et al. 2011), and rising sea levels or rising ocean temperatures due to global changes. In Indonesia, marine communities have been affected by increased eutrophication and sedimentation rates as shown in Jakarta Bay. As a result of increased sedimentation, nutrient loading, and chemical contamination, coral reefs are damaged. Furthermore, degraded reefs can affect coral reef fish communities because of their strong relationship (Madduppa et al. 2013).

Coral reefs are an important massive deposit of calcium carbonate produced by corals (Phylum Cnidaria, class Anthozoa, order Madreporaria/ Scleractinia) with a little addition of calcareous algae and other organisms that secrete calcium carbonate ($CaCO_3$) (Nybakken, 1992). Coral reefs get their food in two ways: first, by using their tentacles to catch plankton and secondly through small algae (zooxanthellae) that live in coral tissue. Several types of zooxanthellae can live in one type of coral, usually they are found in large numbers in each polyp, live in symbiosis, provide color to polyps, energy from photosynthesis and 90 % of the polyp's carbon requirement. Zooxanthellae receive essential nutrients from corals and provide as much as 95 % of their photosynthesis (energy and nutrients) to corals (Supriharyono, 2007).

Coral is a collection of millions of polyps that produce limestone ($CaCO_3$). Most of the corals are small animals called polyps that live in colonies and make the reefs. Each polyp has an outer framework called a coralite. A coralite generally has septa that resemble bulkheads. Coral polyps consist of intestines called mesenteric filaments, tentacles that have nematotic cells (stingers) that function to immobilize their enemies. The body of the coral polyp consists of two layers, namely ectoderm and endoderm. Between the two layers there is a jelly-like tissue called mesoglea. In the endoderm layer of the body, the polyp lives in symbiosis with the one-celled algae zooxanthellae (Samsul Rizal, 2016).

Condition of coral reefs and the diversity of reef fishes species are two things that cannot be separated from one another. One of the indicators of environmental damage to coral reefs is also characterized by the decreasing diversity of fish species (Badrudin et al., 2003), which means that good and bad conditions of coral reefs and their environment will determine the abundance of reef fishes that inhabit these ecosystems. Sale (1991) states that there are three forms of interaction between reef fishes and coral reefs. The first interaction is the direct interaction between coral structures and as a shelter for small fish. Second, there is a relationship between the food chain or the process of eating and eating such as reef fishes and sessile biota, including algae. Third, there is a role for coral structure and the feeding pattern of plankton-eaters and carnivores associated with corals (Alimuddin, 2008).

The Central Indo-Pacific region of the Philippine Islands and Indonesia has the largest number of fish species and their numbers are diminishing in all directions away from this center. In Indonesia, there are at least 11 main families contributing to fishery production, namely Caesionidae, Holocentridae, Serranidae, Scaridae, Siganidae, Lethrinidae, Priacanthidae, Labridae, Lutjanidae, and Haemulidae (Djamali and Mubarak, 1998) and Ancanthuridae (Hutomo, 1986). One of the reasons for the high diversity of species on coral reefs is due to the variety of habitats on the reef.

Damage to coral reef ecosystems must be addressed through comprehensive control. This overall control is a coral reef environmental management strategy that includes sustainable exploitation, protection and prevention of pollution and degradation caused by human activities (Suharsono, 1996). For the smooth running of the process, first it is necessary to know the status and condition of coral reef resources by conducting survey and direct observation in the field.

2. Methods

2.1. Time and Location of Reseacrh

The research was conducted in November 2018 in the coastal area of Dofa Village, Sula Islands. The research location map is presented in Figure 1.

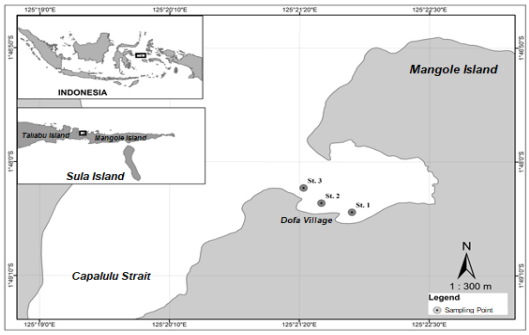

Fig 1. Research Location

2.2. Tools and Materials of Research

Tools used in this research are SCUBA diving equipment, slates, pencils, roll meters, GPS, underwater cameras, ships, thermometers, refractometers, floating droudge, stopwatches, secchi disc, DO meters, and pH meters. Materials used is sea water to measure water parameters consisting of water physical and chemical factors that have an important role in the distribution pattern of coral reefs in a water zone.

2.3. Data Collection

Collecting coral reef data using the Line Intercept Transect (LIT) method along 50 m using a roll meter. Transect installation is placed parallel to the coastline and following the contour. The diver follows the transect and records the transition of the reef offending the transect in centimeters and records the code for its life form.

Collecting reef fishes data using a visual census method along 50 m. The limit of fish data observation is 2.5 m to the left and to the right so that the area of observations obtained at each station is 250 m^2. The recording of this reef fish data is to identify the fish species found and their numbers (English et al., 1994).

2.4. Data Analysis

2.4.1. Percentage of Hard Coral Coverage

According to English et al. (1994), to assess existing coral reefs, the percentage of live coral coverage can be formulated:

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

Information:
L : Percentage of coral reef coverage (%)
Li : Length category lifeform i
N : Transect length

Based on the Decree of the Minister of Environment No. 4 of 2001 concerning the Standard Criteria for Coral Reef Damage, the range of percentage levels of coral reef coverage is presented in table 1 below.

Table 1. Range of Percentage Levels of Coral Reef Coverage

Persentage of Coverage (%)	Range
0 – 24.9	Bad
25 – 49.9	Middle
50 – 74.9	Good
75 - 100	Very good

Source: Decree of the Minister of Environment No. 4 of 2001

Coral Reef Mortality Index

Coral reef mortality index shows the magnitude of changes in live coral to dead coral. Coral reef mortality index (IMK) by calculating:

$$IMK = \frac{\text{Percentage of death coral coverage}}{\text{Percentage of coverage (dead coral + live coral)}}$$

Coral reef mortality index value that is close to zero indicates that there is no significant change for live coral, while a value close to one indicates that there has been a significant change from live coral to dead coral. Percentage of dead coral coverage consisted of dead coral, dead coral with algae and rubble.

2.4.2. Abundance of Reef Fishes

According to Odum (1993), abundance of reef fishes is the number of individuals per unit area or volume, with the following formula:

$$N_i = \frac{\sum n_i}{A}$$

Information:
Ni : Abundance (ind/m^2)
Σni : The number of individuals earned per station
A : Number of sampling area (m^2)

2.4.3. Diversity Index (H'), Uniformity Index (E) and Dominance Index (C)

Diversity is a community level characteristic based on its biological organization. Diversity index (H') is used to determine the diversity of the population of organisms so that it is easy to analyze information on the number of individuals of each fish species in a community (Odum, 1993). A community is said to have high species diversity if the community is composed of many species with the same or nearly the same species abundance. To determine this diversity, the Shannon-Wiener (Odum, 1993) diversity index (H ') is used with the formula:

$$H' = -\sum_{i=1}^{s} P_i \ln P_i$$

Information :
H' : Diversity index
Pi : ni/N
Pi : The ratio between the number of individuals of the species i with the total number of individuals
s : Number of reef fishes species

The range of Shannon-Wiener diversity index values for reef fishes are:
H' < 2.30 : low diversity

2.30 < H' < 6.90 : middle diversity
H' > 6.90 : high diversity

Uniformity is the individual composition of each species found in a community. The uniformity index (E) describes the size of the number of individuals between species in a fish community. If the distribution of individuals between species is more evenly distributed, the balance of the ecosystem will increase. The formula for the uniformity index according to Odum (1993) is as follows:

$$E = \frac{H'}{H'max}$$

Where, H` max = ln S
Information :
E : Uniformity index
H ' : Diversity index
H 'max : The equilibrium of species in maximum equilibrium
S : Number of species

Where the uniformity index ranges from 0-1, provided that:
E> 0.6 : High uniformity
0.6 ≥ E ≥ 0.4 : Middle uniformity
E <0.4 : Low uniformity

The range used for the uniformity index and diversity index, if the value obtained is small, then the ecosystem has a tendency to be dominated by certain species and if the value obtained is large, the ecosystem is in a relatively stable condition, namely the number of individuals for each species is relatively the same. The uniformity index value ranges from 0-1.

Dominance index is the number of individuals per species that are relatively the same in an ecosystem. The sufficiently large dominance of a species will lead to stressed conditions of the ecosystem or community. To see whether there is dominance or not, it can be seen from the Simpson dominance index value (Odum, 1993):

$$C = \sum_{i=1}^{s} p_i^{\,2} = \sum_{i=1}^{s} \left[\frac{n_i}{N} \right]^2$$

Information:
C : Dominance index
Ni : Number of individuals of the i species
N : The total number of individuals of all species
S : Number of species

The range of dominance index values is as follows:

C <0.30 : low dominance
0.30 <C <0.60 : middle dominance
C> 0.60 : high dominance

Dominance index values ranged from 0-1. A small dominance index value means there is no dominance by a species in the community. A large dominance index value means that there is dominance in a community by one species (Odum, 1993).

3. Discussion Results

3.1. Condition of water physical and chemical parameters

Growth and development of coral reefs is influenced by the condition of the surrounding waters. Based on observations of physical and chemical parameters in the field, it is known that in general it is still within the range to support the growth and development of coral reefs. Several physical and chemical parameters at each observation station are presented in table 2 below.

Table 2. Some physical and chemical parameters at each observation station

Station	Coordinate	Salinity (‰)	DO (mg/l)	pH	Temperature (°C)	Current Speed (m/dtk)	Brightness (%)
1	S 01º 48' 19,9" E 125º 24' 24,3"	25	7.77	6.58	29.3	0.1	65
2	S 01º 48' 22,9" E 125º 21' 33,1"	30	7.68	6.65	29.8	0.1	100
3	S 01º 48' 20,7" E 125º 21' 47,0"	30	7.57	6.62	29.9	0.1	100

The results of measurements at all locations, the salinity at the surface measured in situ is 30 ‰. The effect of salinity on corals varies greatly depending on the conditions of sea water and local natural influences such as river water input, storms, rain.

The results of DO and pH measurements carried out in situ at each station ranged from 7.57 - 7.77 mg/l for DO and 6.58 - 6.65 for pH. This indicates that the DO and pH values at the research location are good enough for coral reef formation.

The results of temperature observations carried out in situ at each station ranged from 29.33 to 29.9 ˚C. From the observations it is known that the temperature range obtained is a temperature that is good enough for the formation of coral reefs.

The water brightness level is 65 – 100 %. This means that light penetration is sufficient to reach the bottom of the waters where the research location is 3 meters. This condition indicates the availability of sufficient sunlight intensity so that photosynthesis carried out by zooxanthellae can take place optimally which directly supports coral growth (Suharsono, 1996).

The amount of current velocity will affect the growth of coral biota, because the strong currents will affect the supply of oxygen and nutrients in sea water needed by coral biota. The size of the current will also affect the amount of sediment in coral colonies (Nybakken, 1992). The results of the surface current velocity observations made at each station are 0.1 m/s.

3.2. Persentage of Hard Coral Coverage

The percentage of hard coral cover at the observation station ranged from 21.02 - 33.7 %. Based on the Decree of the Minister of Environment No. 4 of 2001, the condition of coral reefs at the research location was in the bad to moderate category with the lowest percentage of hard coral cover found at observation station 1 while the highest was at observation station 3. The percentage of hard coral coverage is presented in Figure 2 below.

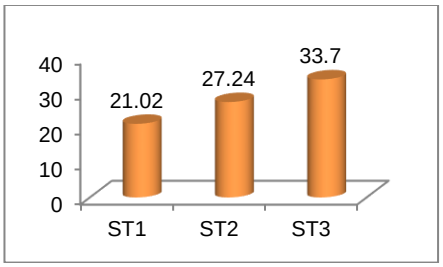

Fig 2. Hard Coral Coverage

3.3. Coral Reef Mortality Index

Roral reef mortality index which shows the magnitude of the change in live coral to dead coral in the study location is small, where at station 1 it is 0.487, station 2 is 0.335 and station 3 is 0.205. This means that the value of the coral mortality index indicates that there is no significant change for live corals. The coral mortality index is presented in Figure 3 below.

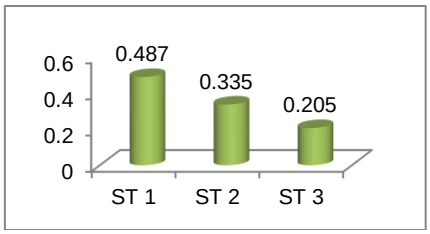

Fig 3. Coral Reef Mortality Index Value

3.4. Condition of Reef Fish Community

The number of reef fish families found at the three observation stations ranged from 2 to 10 families consisting of 19 - 42 species. Pomacentridae and Labridae are relatively dominant families. The high species of these two families is thought to be due to the fact that many invertebrates, which are a source of food for them, are found at station 1. Coral reefs are a habitat for various kinds of marine life such as crustaceans, snails, shellfish and echinoderms. Coral reefs also function as habitat and foraging places for various types of reef fishes. The composition of the number of families and species of reef fishes found at the three observation stations is presented in Figure 4 below.

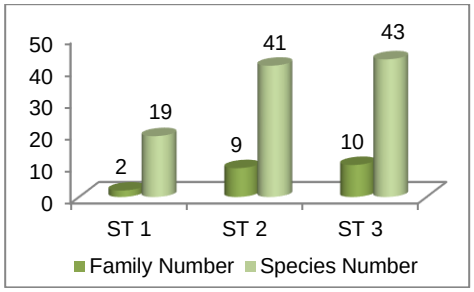

Fig 4. Composition of Number of Families and Species of Reef Fishes

The total abundance of reef fishes found at the three observation stations ranged from 0.52 ind/m^2 - 1.22 ind/m^2. The highest reef fishes abundance is dominated by the Pomacentridae and Labridae families where the two families are fish groups that use coral reefs as habitat for foraging. The abundance of reef fishes is presented in Figure 5 below.

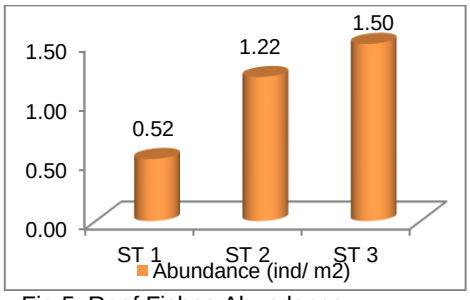

Fig 5. Reef Fishes Abundance

3.5. Structure of Reef Fishes Community

The community structure is used to see the condition of the relationship between groups of reef fishes species and to determine the stability of the ecosystem. This can be seen through the diversity index (H '), uniformity (E), and dominance (C).

The index value of reef fishes diversity in the coral reef ecosystem at all stations ranged from 0.58 to 3.60 where the diversity index value was in the low to medium category. The uniformity index is in the medium category with values ranging from 0.58 to 0.63. This shows that in general the difference in the number of individuals for each species is not too significant when compared to the diversity of species that are in the low to moderate range. This information shows that the reef fish community at the observation station is relatively stable because the fluctuation of environmental pressure on the survival of reef fish is not too large. The dominance index of reef fish at the observation station is very small, which is close to zero (ranging from 0.03 - 0.07), indicating that the dominance of the species is very low, so that the reef fishes community conditions are relatively stable. The structure of the reef fishes community is presented in Figure 6 below.

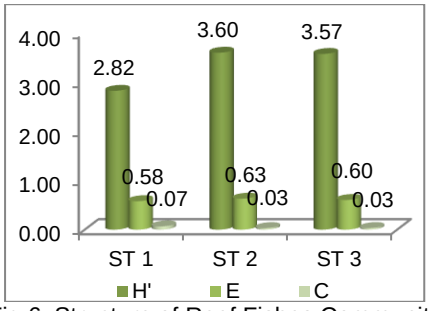

Fig 6. Structure of Reef Fishes Community

4. Conclusions

Conclusion this research are condition of the coral reef ecosystem based on the percentage of hard coral cover ranged from poor to moderate condition. Coral mortality index is small, meaning that there is no significant change for live corals. Abundance of reef fishes are dominated by the Pomacentridae and Labridae families. Index value of reef fishes diversity in coral reef ecosystems is in the low to medium category, the uniformity index is in the medium category while the reef fish dominance index is very small.

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