Coral Reef Health Index On Sangiang Island

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Abstract

The coral reef is massive deposits of calcium carbonate produced from coral animals that are symbiotic with zooxanthellae. One of the activities carried out as an effort to improve the sustainability of coral reefs is monitoring the health condition of coral reefs. The coral reef health index value is based on benthic components and fish components. The benthic component consists of variable life coral cover and the level of coral reef resilience determined based on macroalgae, rubble, and life coral. Fish component is the total biomass of target reef fish. The highest coral reef health index value is at value 10 and the lowest value is at value 1. This study aimed to determine the value of the health index on Sangiang Island. This research was conducted on 16-18 February 2019 on Sangiang Island on three dive stations are Legon Bajo, Legon Waru, and Tembuyung. Data collection of benthic components uses the Underwater Photo Transect (UPT) method and data collection of fish components uses the Underwater Visual Census (UVC) method. The results showed that the coral reef health index on Sangiang Island was at values 6 and 5, means the live coral cover on Sangiang Island was included in the high and medium category, and the level of coral reef resilience or recovery potential was included in the high category, while the total biomass of the target reef fish is still in the low category, only a few species of fish were found that belong to the target reef fish.

Keywords*: coral reefs, fish, health, resilience, Sangiang Island*

Introduction

Indonesia is the largest archipelagic country in the world consisting of 18,110 islands and an area of coral reefs in Indonesia about 18% of the world's coral reefs and has around 3000 species of reef fish (Suharsono, 2014). Coral reefs are massive deposits of calcium carbonate produced from coral animals with algae and other organisms, then produce calcium carbonate. Coral reef ecosystems very important for biotas as a shelter, a place to provide food, and reproduction (Cahyo, 2017). The coral reef ecosystem is also widely used by coastal communities for tourism purposes such as snorkeling or activities by fishermen (Prasetya *et al*., 2018).

The exploitation of marine resources, especially on coral reefs which is carried out excessively and is not environmentally friendly, will have a negative impact in the form of damage. According to Yusuf (2013), the damage to coral reefs in Indonesia is mostly caused by human activities. Damage to coral reefs can be caused by natural factors and human factors. Damage is caused by natural factors, for example, changes in seawater temperature, global climate change, typhoons, earthquakes, volcanic eruptions, predators, and diseases. Meanwhile, examples of damage caused by humans are capture fisheries that use explosives, toxic chemicals, and fishing gear that are not environmentally friendly (Maynard *et al*., 2008; Uar *et al*., 2016).

The Coral Reef Rehabilitation and Management Program (COREMAP) carried out by the Government of Indonesia to protect, rehabilitate and manage the use of coral reefs is expected to be able to improve coral sustainability and the welfare of coastal communities. One of the activities carried out by this program is monitoring coral reefs to describe the health condition of coral reefs. So far the parameter used is the percentage of live coral cover, where the higher the percentage of live coral cover the healthier the coral reefs. However, the reality is

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that when data collection is often found in locations with low life coral cover but high coral reef fish resources, and vice versa. So that the coral reef health index value is developed which is based on benthic components and fish components. The benthic component is stated based on live coral cover and the level of resilience or recovery potential, while the fish component is based on the total biomass of target reef fish (Giyanto *et al*., 2017).

Sangiang Island has been designated as a Nature Tourism Park Area through the Decree of the Minister of Forestry No. 55 of 1993. Geographically Sangiang Island is located at 5°56'00 "- 5°58'00" South Latitude and 105°49'30"-105°52'00" East Longitude, while administratively it is located in Cikoneng Village, Anyer District. Serang Regency, Banten Province. The tourism potential of Sangiang Island includes enjoying natural panorama (sunset and sunrise), panoramic views of mountains and hills, and has 23 strategic marine tourism spots that can be developed for diving, snorkeling, jet-ski, sailing, swimming, fishing, and sunbathing around the sea waters of Sangiang Island Nature Park. Sangiang Island Nature Park can be reached by sea/boat from Anyer in about 30 minutes. Research on coral reefs has been done a lot, but until now no one has been able to describe the health condition of coral reef ecosystems on Sangiang Island.

Material and Methods

Data collection was carried out at Sangiang Island. Data retrieval includes photos of coral reef conditions, recording of target reef fish, and water physics and chemistry parameters. Observations were made at three dive stations, namely Legon Bajo (5°56'48"-5°56'48" South Latitude and 105°51'40 "-105°51'41" East Longitude), Legon Waru (5°57'15 "-5°57'17" South Latitude and 105°51'43"-105° 51'45 "East Longitude), and Tembuyung (5°57'46"-5°57'46 "South Latitude and 105°51'54"-105° 51'55"E) (Figure 1).

The data collection for the coral reef health index in the waters of Sangiang Island consists of two components, namely the benthic component and the fish component. The benthic component is further divided into two, namely live hard coral cover and recovery potential or level of resilience, while the fish component is seen based on the target reef fish category stated by the total fish biomass variable (Giyanto *et al*., 2017).

Benthic component data was taken using an underwater camera, the Underwater Photo Transect (UPT) method was carried out 3 times for each station with a transect length of 20 m, data collection was taken at 1 m intervals and 5 m breaks for each

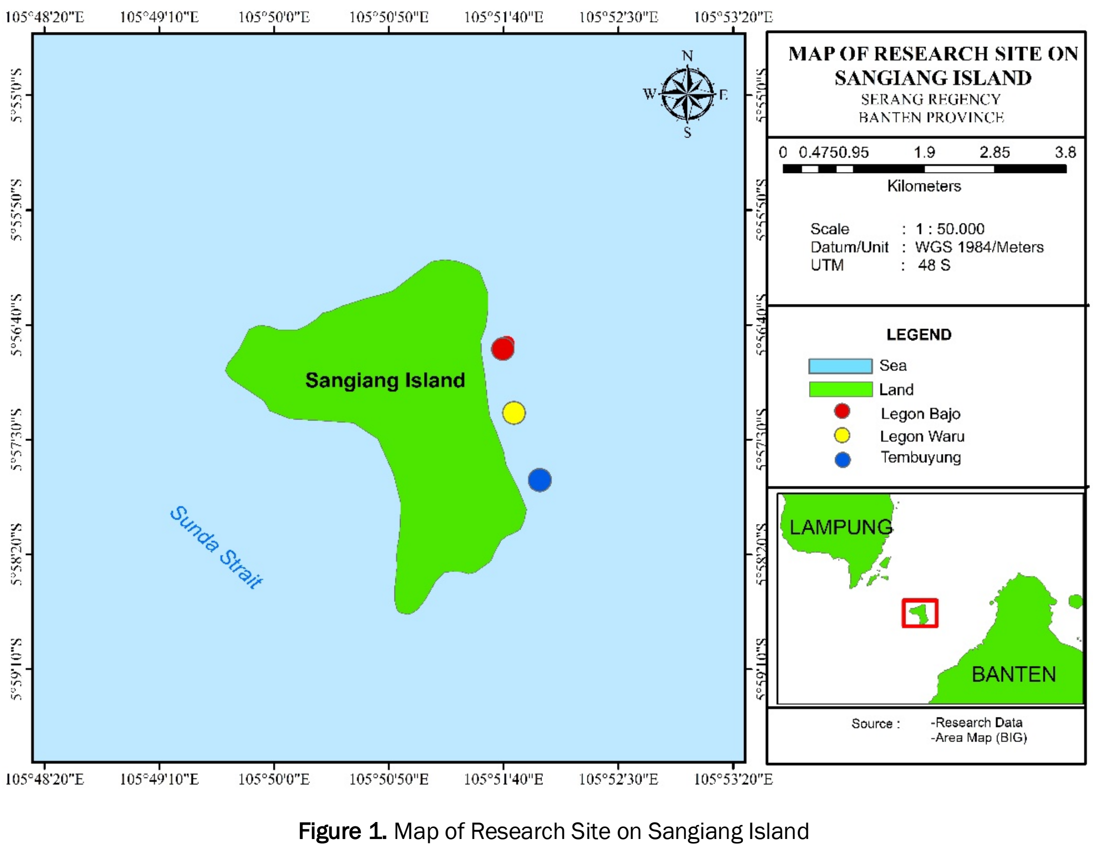

Figure 1. Map of Research Site on Sangiang Island

replication so that each station got a total of 60 photos of 3 replicates. Meanwhile, data collection for fish components used the Underwater Visual Sensus (UVC) method. The 50 m long transect is made parallel to the edge, with an observation limit of 2.5 m to the right and left of the transect line so that it covers an area of $250\mathrm{m}^2$.

Water quality measurements were carried out at the surface of each observation station. Parameters of temperature, salinity, pH, current velocity, brightness, dissolved oxygen (DO) were carried out in situ. Meanwhile, the parameters of nitrate and phosphate were carried out specifically where the water samples were taken using HDPE bottles then filtered and given H_2SO_4 then analyzed. Quality standards for good water characteristics for biota growth are stipulated by the Decree of the State Minister for Environment No 51 of 2004 which is presented in Table 1.

Data in the form of photos were analyzed using Coral Point Count software with excel Extensions (CPCe). The level of data analysis used is the intermediate level (intermediate) to determine all the percentage cover of biota and substrate categories based on English *et al*. (1997). Each photo is analyzed by selecting random point samples. The number of random points used is 30 for each photo (Giyanto *et al*. 2010). Based on the photo analysis process carried out on each photo frame carried out, it can be obtained that the percentage value of the category cover for each frame is calculated based on the following formula:

$$\text{Percentage cover of category} = \frac{amount\ of\ category\ points}{number\ of\ random\ dots} \times 100\%$$

The benthic components by the live coral cover variable are divided into three categories. See Table 2. The benthic component categories for the level of resilience or recovery potential, represented by variables of macroalgae cover, coral rubble cover, and live coral together (Table 3.).

Components of reef fish are expressed by the variable total biomass of target reef fish or economic value. The target reef fish are included in 7 families, namely Scaridae, Siganidae, and Acanthuridae, Serranidae, Lutjanidae, Lethrinidae, and Haemulidae. Identify fish used the book of Reef fish identification-Tropical Pacific (Allen *et al*., 2003). Fish biomass categories are divided into three categories which can be seen in Table 4.

The relationship between length and weight is the individual weight of the target fish (W in grams) equal to the species-specific index (a) multiplied by the estimated total length (L in cm) in the power of the species-specific index (b). Fish biomass is obtained from the following formula:

$$W = aL^b$$

Note : W = fish weight (grams); a and b = species-specific index following Froese and Paully (2014); L = estimated total length of fish (cm)

The coral reef health index values are in the range of values 1 to 10 can be seen in Table 5. Analysis of coral reef health and variations in the distribution of coral growth forms or coral lifeforms were analyzed using Correspondent Analysis (CA) (Bengen 2000) with the help of XLstat 2016 software, the research station was designated as matrix i (row) and matrix j (column) as percent lifeform cover coral and coral reef health variables.

Table 1. Quality Standard of Water Chemical Physical Conditions

Physics		Chemical	
Temperature (˚C)	28 – 30	Salinity (ppt)	33-44
Brightness (m)	>5	DO ($mg.L^{-1}$)	>5
		pH	7 - 8.5
		Nitrate ($mg.L^{-1}$)	0.008
		Phosphate ($mg.L^{-1}$)	0.015

Source: KEPMEN-LH No. 51 of 2004

Table 2. Life coral Cover Category

Category	Criteria
Low	Life coral Cover < 19%
Medium	19% ≤ Life coral Cover ≤ 35%
High	Life coral Cover > 35%

Source: Giyanto *et al*, 2017

Table 3. Categories of Resilience Level Factors or Potential For Recovery

Category	Criteria
Low	1. Macroalgae cover ≥ 3% 2. coral rubble cover > 60% or life coral cover ≤ 5%
High	1. Macroalgae cover < 3% 2. coral rubble cover < 60% or life coral cover ≥ 5%

Source: Giyanto *et al.* (2017)

The relationship of each matrix is obtained using the following formula:

$$d^2(\text{i}, \text{i}') = \frac{\sum(\frac{x_{ij}}{x_i} - \frac{x_{i'j'}}{x_{j'}})^2}{x_j}$$

Note : X_i = number of rows for all columns j; X_j = number of columns for all rows i

Result and Discussion

Water chemical physical conditions

Temperature is one of the most important water physical parameters for aquatic organisms. The temperature measurement results at each station ranged from 30-31°C. See Table 6. Legon Waru and Legon Bajo stations have the same temperature value, namely 30°C, while at Tembuyung Station the measured temperature is 31°C. According to KEPMEN-LH No. 51 of 2004 is vulnerable to a temperature value of 28-30°C which is the quality standard value of water so that the temperature at each observation station is still classified as normal for coral reef growth. Tropical countries have relatively constant temperatures, the occurrence of temperature changes of 1-3 can disrupt metabolic processes in corals (Muhlis 2011). Increasing temperature in water can increase viral pathogens and reduce the immunity of coral organisms (Furby *et al*., 2014).

The flow of currents that move in water is very important because it brings along food, oxygen, and microorganisms from other areas. Besides, the current velocity can clean and avoid excess suspended material deposition on coral bodies, sediment build-up can endanger coral growth and development (Muhlis 2011). The current velocity at Legon Bajo, Legon Waru, and Tembuyung stations is 0.16 $m.s^{-1}$, 0.06 $m.s^{-1}$, and 0.4 $m.s^{-1}$, respectively.

The brightness of the waters can be observed visually using a Secchi disk, the brightness values at Legon Waru and Tembuyung stations are still included in the water transparency quality standards according to KEPMEN-LH No. 51 of 2004 is above 5. Whereas at Legon Waru station the water transparency value is 4, the small brightness value at Legon Waru station can be seen because quite a lot of material has been found deposited on the body of the coral. Suspended solids in the waters have a positive correlation with turbidity (Effendi, 2003). The brightness factor is very important for coral growth because it affects the rate of photosynthesis in zooxanthellae which is symbiotic with coral animals (Riska *et al*., 2013).

The value of the degree of acidity or pH at all stations is 7.9. The pH value quality standard according to KEPMEN-LH No. 51 of 2004 is in the range 7-8.5. Activities carried out by phytoplankton and aquatic plants involving carbon dioxide can affect the acidity of the waters (Yuliani *et al*., 2016).

The salinity of the observed results is relatively homogeneous with a value of 30 ppt at each station. The low salinity measured during data collection can be caused by rainwater that fell at night before data collection. However, according to Haruddin *et al*. (2011), a salinity range of 25-30 is the optimal range for coral life. Tropical marine salinity has an average value of 35 and a salinity range of 34-36 living coral animals are fertile (Supriharyono, 2007). Salinity can be affected by the evaporation and rainfall processes that occur in the sea. The ups and downs of salinity levels can be caused by several natural factors including rainfall, freshwater input from land, and sun exposure. If there is a drastic change in salinity levels it can cause coral bleaching (Dedi *et al*., 2017).

The dissolved oxygen content or Dissolve Oxygen (DO) measurement results have a range from 6.9 - 7.1 $mg.L^{-1}$. The highest dissolved oxygen content was at Legon Bajo station with a value of 7.1 $mg.L^{-1}$ and the lowest was at Tembuyung station with a value of 6.9 $mg.L^{-1}$. The dissolved oxygen content in the waters of Sangiang Island tends to be uniform and good enough for the growth of marine life. Following KEPMEN-LH No. 51 of 2004, the dissolved oxygen content in Sangiang Island is still in the normal category for marine life. Photosynthesis carried out by phytoplankton can produce oxygen, so this is one of the factors that trigger high oxygen levels in the waters. The more oxygen levels in the waters, the better for the biota for its respiratory needs (Johan *et al*., 2017).

Phosphate and nitrate compounds are factors that determine how much nutrient levels are in the water. Phosphate content at Legon Bajo, Legon Wa

Table 4. Category Components of Fish Biomass

Category	Criteria
Low	Total biomass of target reef fish < 970 $kg.ha^{-1}$
Medium	970 $kg.ha^{-1}$ ≤ total biomass of target reef fish ≤ 1940 $kg.ha^{-1}$
High	Total biomass of target reef fish > 1940 $kg.ha^{-1}$

Source: Giyanto *et al*. *(*2017).

Table 5. Coral Reef Health Index Values

benthic components		fish component	
life coral cover category	resilience	total biomass of fish category	coral reef health index values
high	high	high	10
medium	high	high	9
high	high	medium	8
high	low	high	8
medium	high	medium	7
low	high	high	7
high	high	low	6
high	low	medium	6
medium	low	high	6
medium	high	low	5
low	high	medium	5
low	low	high	5
high	low	low	4
medium	low	medium	4
low	high	low	3
low	low	medium	3
medium	low	low	2
low	low	low	1

Source: Giyanto *et al*, 2017

Table 6. Physical Chemical Conditions of Sangiang Island Waters

Statiun	Temp (˚C)	Current velocity ($m.s^{-1}$)	Brightnes	pH	Salinity (ppm)	DO ($mg.L^{-1}$)	Phoshate ($mg.L^{-1}$)	Nitrate ($mg.L^{-1}$)
Legon Bajo	30	0.16	8	7.9	30	7.1	0.013	0.097
Legon Waru	30	0.06	4	7.9	30	7	0.018	0.116
Tembuyung	31	0.4	6	7.9	30	6.9	0.017	0.099

and Tembuyung stations are 0.013 $mg.L^{-1}$, 0.017 $mg.L^{-1}$, and 0.018 $mg.L^{-1}$, respectively. The nitrate content at Legon Bajo, Legon Waru, and Tembuyung stations were 0.097 $mg.L^{-1}$, 0.099 $mg.L^{-1}$, and 0.116 $mg.L^{-1}$, respectively. Increased levels of nitrate and phosphate can be caused by waste around the island and anthropogenic activities that cause an increase in the number of nutrients in the waters resulting in changes in water quality in coral reef ecosystems (Furby *et al*., 2014).

Percentage of benthic cover

The benthic component is stated based on live coral cover and the potential for recovery or level of resilience can be seen from the condition of live coral cover, macroalgae cover, and rubble or coral debris. The percentage of the results of the analysis of the cover of the biota and substrate categories using the Coral Point Count with Excel Extensions (CPCe) software is shown in Table 7 and the average percentage cover of benthic components is shown in Table 8.

Overall the results showed that the benthic component cover was not dominated by life corals. However, when compared, the average percentage of live coral cover with the average percentage of macroalgae or rubble at each station, the percentage of live coral cover still dominates except in Tembuyung station which is dominated by rubble.

The percentage of live coral cover at Legon Bajo station is 78.76%. This illustrates that the condition of coral reefs is still in the high category (Giyanto *et al*., 2017). The benthic component cover at

Tembuyung station is quite a lot of found algae in the form of smooth, less than 2cm in size which is called turf algae. Dense turf algae will complicate the potential for recovery in corals because they interfere with coral growth and attachment of coral larvae. Life coral cover at Legon Waru station shows an average percentage cover value of 37.16% so that the presence of coral reefs at this station is still in the high category (Giyanto *et al*., 2017). Unlike the Legon Bajo and Legon Waru Stations, at Tembuyung Station the percentage of rubble cover dominates compared to the live coral cover. The percentage of live coral cover is 24.06%, so this condition is in the moderate category (Giyanto *et al*., 2017). According to Yusri *et al*. (2017), live coral cover in the eastern part of Sangiang Island has an average percentage value of life coral cover of 18.33% with the percentage value of live coral cover in each location ranging from 2.50% to -37.50%. Life coral cover parameters are very important for the resilience of coral reefs because they are an indication of the quality and habitat of these waters (Abrar *et al*., 2012). Based on the category of Giyanto *et al*. (2017), the current condition of coral reefs in Sangiang Island is in the medium category and high category, so it shows that at this location the distribution of coral reefs is not evenly distributed. Seeing the condition of coral reefs in this category requires more attention considering the many roles of coral reefs in an ecosystem.

The ability of coral reefs to adapt or withstand any disturbance that can threaten their growth or development is called the level of resilience. Practically the level of resilience can also be interpreted by the level of potential recovery that coral reefs have to return to their original state when they received disturbances. Coral reef ecosystems that have a low level of resilience or recovery potential will occur if their macroalgae cover is more than 3% and rubble cover exceeds 60% and live coral cover is less than 5% (Giyanto *et al*., 2017). The recovery potential rate at the three stations can be

Table 7. Percentage of Cover for Biota and Substrate Categories on Sangiang Island Using CPCe Software with 3 replication (R)

Category	Legon Bajo Station (%)			Legon Waru Station (%)			Tembuyung Station (%)		
	R1	R2	R3	R1	R2	R3	R1	R2	R3
ACB	10.83	12.53	5.17	1.50	0.00	0.00	0.18	1.00	8.68
ACD	1.50	0.00	0.00	0.00	0.00	0.00	0.00	2.33	0.00
ACE	1.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CB	9.50	10.69	12.00	29.83	9.83	2.33	0.00	0.83	19.83
CE	0.00	0.00	0.00	0.00	0.17	0.00	3.50	0.67	0.00
CF	41.67	50.69	62.00	34.00	21.83	2.83	0.83	1.17	15.50
CM	5.83	5.69	6.17	0.33	0.50	2.67	0.33	1.33	1.50
CMR	0.00	0.00	0.33	1.33	1.83	0.83	0.33	0.00	0.00
CME	0.00	0.00	0.00	0.00	0.00	0.00	4.50	0.00	0.00
CS	0.50	0.00	0.00	0.00	1.67	0.00	1.00	2.83	5.83
SC	0.00	0.00	1.50	2.50	6.50	8.33	30.83	11.00	10.00
MA	0.00	0.00	0.17	0.00	0.00	0.17	0.00	0.18	0.33
TA	1.33	0.17	2.83	12.00	43.33	42.00	1.00	5.83	17.50
AA	0.00	0.00	0.00	3.50	0.00	3.50	0.00	0.00	0.00
OT	0.17	0.00	1.33	3.00	0.00	0.00	7.67	0.50	0.00
SP	0.00	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00
DCA	17.16	18.4	8.17	7.17	5.67	1.17	19.50	20.83	0.00
R	10.17	1.83	0.33	4.17	3.17	14.50	29.17	50.00	2.83
S	0.17	0.00	0.00	0.00	5.17	21.67	0.83	1.50	18.00
NC	0.00	0.00	0.00	0.17	0.33	0.00	0.33	0.00	0.00

Information: ACB = *Acropora Brancing*; ACD = *A. Digitate*; ACE = *A.Encrusting*; CB = *Coral Branching*; CE = *Coral Encrusting*; CF = *Foliose*; CM = *Coral Massive*; CME = *Coral Millepora*; CMR = *Coral Mushroom*; CS = *Coral Sub-massive*; SC = *Soft Coral*; MA = *Macroalgae*; TA = *Turf Algae*; AA = *Algae Assemblage*; OT = *Other*; SP = *Sponge*; DCA = *Dead Coral Algae*; R = *Rubble*; S = *Sand*; NC = *Non Coral*

Table 8. Average Percentage of Benthic Component Cover on Sangiang Island

Station	Life coral cover	Macroalgae cover	*Ruble cover*
Legon Bajo	78.76%	0.06 %	4.11 %
Legon Waru	37.16 %	0.06%	7.28 %
Tembuyung	24.06 %	0.17%	27.33%

said to be high because the percentage value of macroalgae cover is low or does not exceed 3%. According to Simarangkir (2015), although the percentage of macroalgae cover is small, every 0.5% change in macroalgae cover can affect the resilience of coral reefs.

The rubble or rubble at Tembuyung station has a fairly dominant percentage of cover compared to the live coral cover. The average percentage cover of coral debris analyzed at Tembuyung Station was 27.33%. The substrate which is dominated by coral fragments will easily be exposed to currents and waves back and forth so that coral fragments are not a good substrate for coral larvae to grow and develop (Giyanto *et al*., 2017). Coral fragments generally come from dead Acropora corals, damage can also be caused by human activities around the waters, for example, the release of anchors by fishermen which results in breaking coral branches (Manzanaris *et al*. 2018). Also, changes in environmental conditions that last for a long time such as global warming and climate can damage coral reefs, leaving only rubble (Ghiffar *et al*., 2017).

Reef fish component

Coral fish is an important part of maintaining the balance in the coral reef ecosystem because these animals are one of the biotas that inhabit coral reef ecosystems. Target reef fish are also known as economically important or consumption fish. It is hoped that a good coral reef ecosystem condition will increase the number of coral fish that live in the coral reef ecosystem. The target fish were observed based on 7 families determined by Giyanto *et al*. (2014), namely Serranidae, Lutjanidae, Haemulidae, Lethrinidae, Siganidae, Scaridae, and Acanthuridae.

Based on the results of the research shown in Table 11, the Acanthuridae family was found in all three stations, but the total number of fish found in each station was not more than two and the total biomass of target reef fish was calculated to be less than 970 kg.ha^{-1}. This shows that the target reef fish biomass at each station is in a low category (Giyanto *et al*., 2017). The low biomass of target reef fish especially in herbivorous fish such as Serranidae, Lutjanidae, Lethrinidae, and Haemulidae which is very little found can cause high algae growth and interfere with the attachment of coral larvae and coral growth, making the potential for coral recovery to be difficult. About 50-70% of carnivorous fish are found in coral reef ecosystems, 15-20% of herbivorous fish groups, and the rest are omnivorous fish groups. The existence of these fish groups depends on the health of the coral to grow and develop (Rembet *et al*., 2011). The absence of marine plants such as seagrass around the observation station is also thought to have caused very few target reef fish. According to Russ and Alcala (1989), the richness of target fish species from small fish predators such as Serranidae, Lutjanidae, and Lethrinidae is low due to intensive fishing activities. *Ctenochaetus striatus* can be found on coral reef flats or overgrown rocks at a depth of 3 to 30 meters, usually swimming alone and found in small groups (Randall and Clements 2001). According to Randall and Anderson (1993), Plectorhinchus vittatus is a fish that inhabitants of coral reefs. *Acanthurus lineatus*, a territorial species that is generally in a wavy zone leading to the high seas, this fish is almost constantly on the move. Including herbivorous fish that also eat crustaceans. *Siganus vulpinus* likes Acropora corals where these fish feed on algae growing at the base of dead coral branches, usually found swimming alone or in pairs (Woodland 1990).

Table 9. Target Reef Fish Biomass on Sangiang Island

Station	Family	Species	Length (cm)	Number (tail)	Total Biomass (kg.ha^{-1})
Lagon Bajo	*Acanthuridae*	*Ctenochaetus striatus*	20	1	11.37
	Haemulidae	*Plectorhinchus vittatus*	15	1	
Lagon Waru	*Acanthuridae*	*Ctenochaetus striatus*	25	2	35.36
Tembuyung	*Acanthuridae*	*Acanthurus lineatus*	25	1	19.29
	Siganidae	*Siganus vulpinus*	15	1	

Table 10. Health Index Value for Sangiang Island Coral Reefs

Station	Benthic component		Fish component	Coral reef health index values
	Life coral cover	Resilience	Fish biomass	
Legon Bajo	high	high	low	6
Legon Waru	high	high	low	6
Tembuyung	medium	high	low	5

Coral reef health index

The coral reef health index in Sangiang Island was obtained from the calculation of the average percentage of each benthic component and fish component. After obtaining the average results, they are categorized based on the criteria mentioned in table 4 to table 6 so that the coral reef health index value is known. The coral reef health index in Sangiang Island as shown in Table 12 is known to be at values 6 and 5.Based on COREMAP coral reef monitoring activities carried out in 32 locations and 366 stations that spread from west to east Indonesian waters, it is generally found that the coral reef health index Indonesian corals are at most values 5, 6 or 3.

Analysis of coral reef health and spatial distribution of coral lifeform

The results of the correspondence analysis between research stations and health variables were centered on the F1 and F2 axes with a range of 73.33% and 26.67%, respectively. Figure 2 shows that the coral reef health variables are divided into 3 groups. Life coral cover has the greatest cosine square value of 0.935. The coral reef health variable that has a big contribution to the F1 axis is a living coral cover which is closely related to the Legon Bajo station. Macroalgae and rubble covers have quadratic cosine values of 0.775 and 0.838 which are closely related to the Tembuyung station. The coral reef health variable that contributed greatly to the F2 axis was reef fish biomass with a cosine quadratic value of 0.717 which is closely related to the Legon Waru station. This can be seen from the largest reef fish biomass found at Legon Waru Station. This can be due to the physical and chemical conditions of the observed waters which are still included in normal conditions for coral reef growth so that the live coral cover found is quite high. The existence of coral transparency, which is one of the techniques for rehabilitation and restoration of coral reefs to multiply coral colonies by utilizing the asexual reproduction of fragmented corals found at Legon Bajo and Legon Waru Stations since 2017 is suspected of causing the live coral cover to be included in the high category. Tembuyung Station has a close correlation or relationship with macroalgae and rubble, where its presence is mostly found in this station.

The existence of rubble or coral fragments can be followed by the presence of macroalgae, macroalgae usually live attached to dead coral fragments. According to Dawson (1966), macroalgae contains calcite and aragonite which can form cement as an adhesive for dead coral fragments. The spatial distribution of coral lifeforms at the research station points was based on the results of the correspondent analysis centered on the F1 and F2 axes with variations of 59.32% and 19.09%, respectively (Figure 3.). Figure 3 shows the spatial distribution of coral lifeforms divided into three groups. The first group which was dominated by coral encrusting and coral millipore growth forms spread out at Tembuyung station in the first replication (TB1). The percentage of live coral cover at Tembuyung Station has the lowest value among other stations, making the form of encrusting coral growth

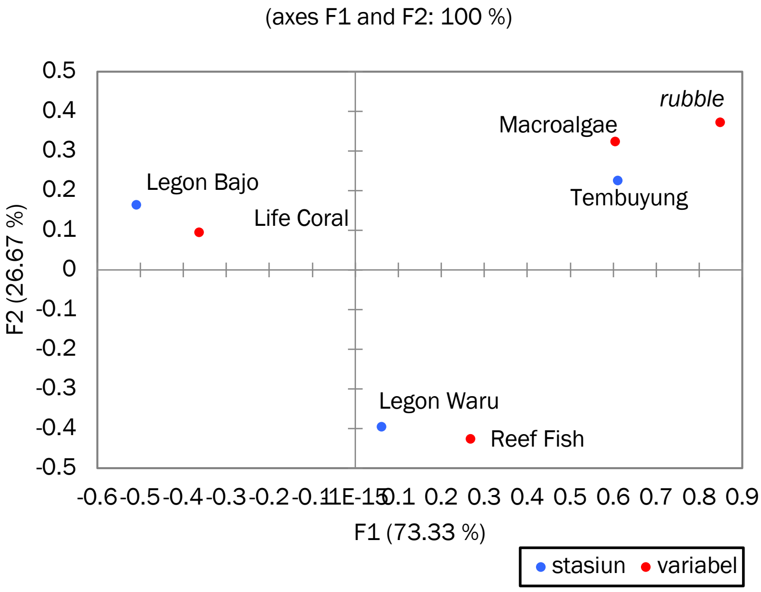

Figure 2. Correspondent Analysis of Coral Reef Health Index Variables

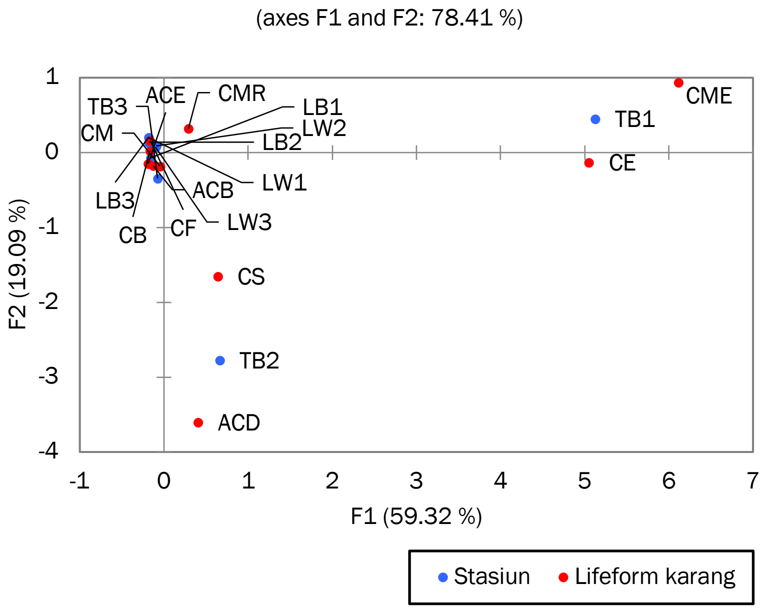

Figure 3. Correspondent Analysis of Coral Lifeform Distribution

dominating at that location, where the form of growth and distribution is low, usually attached to hard rock surfaces. Millepora coral species, although not included in the main reef formation, can produce limestone skeleton continuously and have a high growth rate and survival rate (Aziz, 2002). The second group consisting of submassive coral growth forms and coral digitate Acropora spread out at Tembuyung station in the second replication (TB2). According to Yusri *et al*. (2017) submassive coral growth forms a form of growth that is quite common because it is by the conditions of the waters which are rather wavy, where the eastern part of Sangiang Island during the eastern monsoon conditions the water can reach 2 meters. Sub-massive coral has relatively slow growth, but its sturdy and stable shape does not make this species easily damaged by strong waves. The third group classifies the dominant coral mushroom lifeforms at Legon Bajo station in the third test (LB3). Coral mushroom or often called mushroom coral is a species that can live in various kinds of substrates and live alone or solitary, the presence or absence of this coral species is not influenced by the condition of the coral reefs around it because its life does not depend on the underlying substrate. Legon Bajo Station where the most life coral cover is found, including fungal corals where this species can be found on the reef flats and the bottom of the water (Hoeksema, 2012).

Conclusion

The coral reef health index in Sangiang Island is at values 6 and 5. The health condition of coral reefs in Sangiang Island is based on life coral cover and high levels of coral resilience, however, low reef fish biomass will make it difficult for coral reefs to use space with macroalgae so that coral health can be interrupted. It is necessary to conduct ongoing research to determine the potential for the recovery of coral reefs on Sangiang Island. It is necessary to research seagrass to identify herbivorous fish.

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References

Abrar, M., Bachtiar, I. & Budiyanto, A. 2012. Struktur komunitas dan penyakit pada karang (Scleractinia) di perairan lembata, Nusa tenggara Timur. *Ilmu Kelautan: Indonesian Journal of Marine Sciences*. 17(2): 63-73. doi: 10.14710/ik.ijms.17.1.1-7

Allen, G., Steen, R., Humann, P.& DeLoach, N. 2003. Reef fish identification-Tropical Pacific. Start Standart Industries Pte Ltd. 442 p.

Aziz, A.M. 2002. Tingkat Kelangsungan Hidup, Laju Pertumbuhan Dan Rasio Pertumbuhan Beberapa Jenis Karang Batu Dan Karang Api Yang Ditransplantasikan Di Perairan Pulau Pari, Kepulauan Seribu, Jakarta. Skripsi. Fakultas

Perikanan dan Ilmu Kelautan: Institut Pertanian Bogor.

Bengen, D.G. 2000. Sinopsis teknik pengambilan contoh dan analisis data biofisik sumberdaya pesisir. Bogor: PKSPL-IPB.

Cahyo, F.D. 2017. Kondisi terumbu karang di perairan Teluk Lada Kabupaten Pandeglang Provinsi Banten. *Pros. Sem. Nas. Ekosistem Perairan Teluk Lada dan Pulau Tunda* 23-32. Aula Dinas Kelautan dan Perikanan Provinsi Banten, KP3B Serang.

Dawson, E.Y. 1966. Marine botany and introduction. Holt, Rinehart and Winston Inc. 7:271.

Dedi, Zamani, N.P. & Arifin, T. 2017. Hubungan parameter lingkungan terhadap gangguan kesehatan karang di Pulau Tunda-Banten. *J. Kelautan Nasional*. 11(2): 105-118. doi: 10.15578/jkn.v11i2.6112

Effendi, H. 2003. Telaah Kualitas Air Bagi Pengelolaan Sumber Daya Dan Lingkungan Perairan. Yogyakartaa (ID): Kanisius.

English, S.A., Wilkinson, C.R. & Baker, V.J. 1997. Survey Manual for Tropical Marine Resources. Townsville (AU): Australian Institute of Marine Science.

Furby, K.A., Apprill, A., Cernivo, J.M., Ossolonski, J.E. & Hughen, K.A. 2014. Incidence of lesions on fungiidae corals in the eastern red sea is related to water temperature and coastal pollution. *Mar. Environ. Res.,* 98: 29-38. doi: 10.1016 /j.marenvres.2014.04.002

Froese, R. & Pauly, D. 2014. FishBase. World Wide Web electronic publication.

Ghiffar, M.A., Irham, A., Harahap, S.A., Kurniawaty, N. & Astuty, S. 2017. Hubungan kondisi terumbu karang dengan kelimpahan ikan karang target di perairan Pulau Tinabo Besar, Taman Nasional Taka Bonerate, Sulawesi Selatan. *J. Spermonde*. 2(3): 17-24. doi: 10.20956 /jiks.v3i2.3002

Giyanto, Iskandar, B.H., Soedharma, D. & Suharsono. 2010. Effisiensi dan akurasi pada proses analisis foto bawah air untuk menilai kondisi terumbu karang. *Oseanologi dan Limnologi di Indonesia*. 36(1): 111-130.

Giyanto, Mannuputty, A.E.W., Abrar, M., Siringoringo, R.M., Suharti, S.R., Wibowo, K., Edrus, I. N., Arbi, U.Y., Cappenberg, H.A.W., Sihaloho, H.F., Tuti, Y. & Zulfianita, D. 2014. Panduan Monitoring Kesehatan Terumbu Karang. Jakarta (ID): LIPI Press.

Giyanto, Mumby, P., Dhewani, N., Abrar, M. & Iswari, M. Y. 2017. Indeks kesehatan terumbu karang Indonesia. Bogor (ID): Media Sains Nasional.

Haeruddin, A., Purwanto, E. & Budiastuti, S. 2011. Dampak kerusakan ekosistem terumbu karang terhadap hasil penangkapan ikan oleh nelayan secara tradisional di Pulau Siompu Kabupaten Buton Provinsi Sulawesi Tenggara. *J. Ekosains*. 3(3): 29-41.

Hoeksema, B.W., Meij, E.T.V.D. & Fransen, H.J.M., 2012. Mushroom coral as a habitat. *J. Mar. Biol. Assoc. UK.,* 92(4): 647-663. doi: 10.1017/S0025315411001445

Johan, O., Dillenia, I., Troa, R.A. & Triarso, E. 2017. Dampak pengangkatan artefak bawah laut terhadap kerusakan terumbu karang berdasarkan indicator tutupan substrat dan parameter lingkungan. *J. Kelautan Nasional*. 12(3): 141-150. doi: 10.15578/jkn.v12i2.6247

Kementerian Lingkungan Hidup. 2004. Keputusan Menteri Negara Lingkungan Hidup No 51 Tahun 2004 tentang Baku Mutu Air Laut. Kantor Kementerian Lingkugan Hidup dan Kehutanan. Jakarta.

Manzanaris, M.R., Rondonuwu, A.B. & Pratasik, S.B. 2018. Struktur komunitas dan kondisi terumbu karang di perairan Desa Poopoh Kecamatan Tombariri kabupaten Minahasa. *J. Ilmiah Platax*. 7(1): 9-19.

Maynard, J.A., Anthony, K.R.N., Afatta, S., Anggraini, L. F., Haryanti, D. & Ambariyanto, A. 2008. Rock anchoring in Karimun Jawa, Indonesia: Ecological impacts and management implications. *Pac. Conserv. Biol.*, 14(4): 242-243. doi: 10.1071/PC080242

Muhlis. 2011. Ekosistem terumbu karang dan kondisi oseanografi perairan Kawasan Wisata Bahari Lombok. *Berk. Penel. Hayati*. 16: 111-118.

Prasetya, J.D., Ambariyanto, A., Supriharjono. & Purwanti, F. 2018. Hierarchical Synthesis of Coastal Ecosystem Health Indicators at Karimunjawa National Marine Park. In IOP Conference Series: Earth and Environmental Science. 116(1): 012094. IOP Publishing. doi: 10.1088/1755-1315/116/1/012094

Randall, J.E. & Clements, K.D. 2001. Second revision of the surgeonfish genus *Ctenochaetus*

(Perciformes: Acanthuridae), with descriptions of two new species. *Indo-Pacifik Fish*. (32): 33pp

Randall, J.E. & Anderson, C. 1993. Annotated checklist of the epipelagic and shore fishes of the Maldives Islands. *Ichthyol. Bull. of the J.L.B. Smith Inst. of Ichthyol*. 59: 1-47.

Rembet, U.N.W.J., Boer, M., Bengen, D.G. & Fahrudin, A. 2011. Struktur komunitas ikan target di terumbu karang Pulau Hogow dan Putus-putus Sulawesi Utara. *J. Perikanan dan Kelautan Tropis*. 7(2): 60-65. doi: 10.35800/ jpkt.7.2.2011.179

Riska, Sadarun, B. & Haya, L.O.M.Y. 2013. Kelimpahan Drupella pada perairan terumbu karang di Pulau Belan-belan Besar Selat Tiworo Kabupaten Muna, Sulawesi Tenggara. *J. Mina Laut Indonesia*. 2(6): 69-80.

Russ, G.R. & Alcala, A.C. 1989. Effects of intense fishing pressure on an assemblage of coral reef fishes. *Mar. Ecol. Prog. Ser.* 56: 13–27. doi: 10.3354/meps056013

Simarangkir, O.R. 2015. Kajian Resiliensi Pasca Pemutihan Karang Sebagai Dasar Pengelolaan Teumbu Karang Berkelanjutan [Tesis]. Bogor (ID): Istitut Pertanian Bogor.

Suharsono. 2014. Biodiversitas Biota Laut Indonesia. Jakarta (ID): LIPI Press.

Supriharyono, M.S. 2007. Pengelolaan Ekosistem Terumbu Karang. Jakarta (ID): Djambatan.

Uar, N.D., Murti, S.H. & Hadisusanto, S. 2016. Kerusakan lingkungan akibat ativitas manusia pada ekosistem terumbu karang. *J. Majalah Geografi Indonesia,* 30(1): 88-95. doi: 10.22146/mgi.15626

Woodland, D.J. 1990. Revision of the fish family *Siganidae* with descriptions of two new species and comments on distribution and biology. *Indo-Pacific Fish.* 19: 136.

Yuliani, W., Ali, M.S. & Saputri, M. 2016. Pengelolaan ekosistem terumbu karang oleh masyarakat di Kawasan Lhokseudu Kecamatan Leupung Kabupaten Aceh Besar. *J. Ilmiah Mahasiswa Pendidikan Biologi*. 1(1): 1-9.

Yusri, S., Prastowo, S.W., Idris & Akhrari, H. 2017. Base Line Survey - Terumbu Karang P. Sangiang: Program Rehabilitasi Karang Tahap 1 (2016-2017). Jakarta (ID): Yayasan TERANGI.

Yusuf, M. 2013. Kondisi terumbu karang dan potensi ikan di perairan Taman Nasional Karimunjawa Kabupaten Jepara. *Bul. Oseano*. 2: 54-60.