Coral Reef Diversity And Association Animals On Biorock In The Waters Of Sepa Island, Seribu Islands, Dki Jakarta

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ABSTRACT

Biorock is an artificial reef technique developed to restore and rehabilitate damaged coral habitats. Biorock uses low-voltage electricity to accelerate and strengthen coral growth. The biorock method has been applied to several islands in the Seribu Islands National Park, including Sepa Island. The purpose of this research is to identify the diversity of coral reef species and associated biota that live in biorock structures in the waters of Sepa Island, Seribu. The implementation of this research uses survey methods and observations, at three research stations, namely, Domus Moscullis. Domus Pirimidis, and Domus Arkae Similis. Data collection in November 2021, using the purposive sampling method. Research parameters include genus composition, diversity index, uniformity index, and dominance index of the coral reef and associated biota, as well as water Physico-chemical parameters. The results of this research stated that the diversity of coral species in the biorock structure on Sepa Island was 184 individuals from 13 genera, mostly in the Pocillopora and Acropora. The reef fish community was 451 individuals from 21 families, dominated by the Pomacentridae family. In the biorock structure, macroalgae, turf algae, sponges, and tunicates are also found which are competitors for corals in obtaining space on the substrate and food. For the level of stability of the coral reef community, it has a moderate status with a moderate diversity index (1.179-1.577); low uniformity index (0.245-0.351), and low dominance index (0.250-0.425).

Keyword : *Biorock, coral reef, diversity, associated biota.*

1. INTRODUCTION

The current condition of coral reefs in Indonesia has suffered a lot of damage. High dependence on sources of marine power results in the utilization of excessive and destruction of coral reefs[1]. Reef-damaged corals in Indonesia continue to increase every year. The results of LIPI observations[2], the poor category reefs as much as 36.18%, the category is quite good as much as 34.3%, the good category as much as 22.96% and the category very good only 6.5%.

The Seribu Islands National Park Water Area, Jakarta, covering an area of 107,489 ha has not escaped similar problems. Based on data from the Indonesian Coral Reef Foundation [3], the percentage of live coral cover in 2011 was 39,35%, in 2013 it was 35.51% and in 2015 it was 32.23%. From this data, it can be seen that the condition of living corals has been damaged from year to year. This can be caused by tourist activities or other activities. If it is allowed to continue, then the degradation of coral reefs will be even more uncontrollable.s

Given the importance of the presence of coral reefs in the marine environment, it is necessary to have integrated biological resource management efforts, including coral reef rehabilitation which involves the ability of coral reefs to reproduce and defend themselves from the rate of degradation experienced by coral reefs in their environmental conditions. One of the methods that have been used for the rehabilitation of coral reefs is mineral accretion or biorock.

Biorock is a method of making artificial corals using the principle of electrolysis which uses an electrical voltage with low voltage. The biorock skeleton is introduced into seawater, causing the dissolved minerals in the seawater to be converted into lime solids or CaCO3 and Mg(OH)2 which have the same structure as the original coral reefs. The biorock method can accelerate the growth of transplanted corals and has artistic value because the structure can be shaped according to needs [4].

Sepa Island is one of the resort islands located in the tourist zone in the Seribu Islands region. Sepa Island in 2010 experienced a degradation of the percentage of coral closures by 35.70% to 17.00% in 2011. The coral fish diversity index on Sepa Island also decreased from 2010 by 2.40 to 2.01 in 2011. The degradation of the percentage of hard coral cover and the decrease in the abundance of coral fish are indicators of the need to hold a coral reef rehabilitation program using artificial corals in the area.

The placement of the Biorock Structure on Sepa Island, first carried out in 2016, was named Domus Mosculli, followed in 2017, was named Domus Pirimidis in April, and Domus Arkae Similis in October. The results of research conducted by Tefa [5] stated that the recruitment of corals attached to the biorock structure was 216 individuals from 13 coral genera and the genus Polycillopora, most of which was 76.39% of the total recruitment. Other biotas are also obtained that attach to the biorock structure, namely sponges, tunicate, macroalgae, and turf algae. Various types of reef fish are also found around the biorock structure of 12-14 families, and the family Pomacentridae is the group of fish with the largest composition. These results are similar to the research hail of Madduppa et al.[6] on the Bake Island of the Seribu Islands and Alif [7] in Pamuteran Village, Bali.

Looking at the results of the development of coral reef ecosystem biorock structure in Sepa Island, it is interesting for researchers to further examine the development of coral species diversity and its associatic biota in the same location, where the biorock structure is after ± 5 years from 2016-2020, namely at the Domus Mosculi, Domus Piridis and, Domus Arkae Similis. The existence of this research is expected to add information about the development of the biorock artificial reef process on Sepa Island, Seribu Islands.

2. MATERIALS AND METHODS

2.1 Research Location

The research activity was started by conducting an initial survey to find out the general condition of the research site on the coral reef biorock structure in the waters of Sepa Island, Seribu Regency, DKI Jakarta, which was carried out in January 2021. The survey results found that there were 6 biorock structures located in the waters of Sepa Island, which were named From the 6 biorock structures selected 3 biorock structures that were determined as observation stations or research stations, namely: Domus Mosculli, Domus Pirimidis, and Domus Arkae Similis (**Fig-1**).

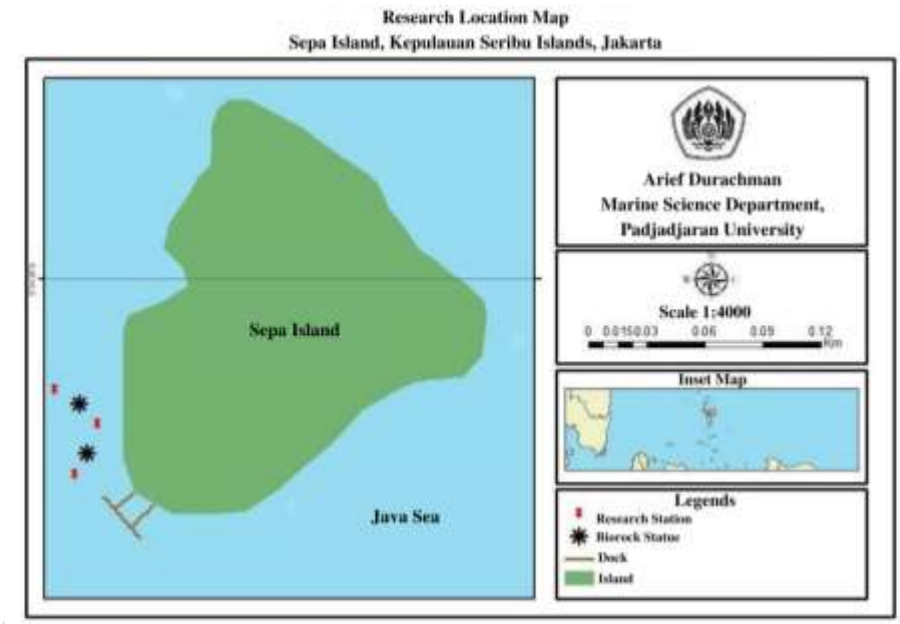

Fig- 1. Research Location Map

2.2 Data Retrieval

The implementation of this research uses survey methods and in-situ observation. Data collection in the field is carried out using the purposive sampling method. Observations were made of coral reefs that grow attached to biorock structures including their size, number, and genus of corals and the surrounding associated biota consisting of coral fish and other biotas (non Fish) attached to biorock structures, such as macroalgae, turf algae, sponges and others. For the collection of associated animal, data using the UVC (Under Water Visual –Census) method, data collection of water quality parameters (temperature, salinity, brightness, DO, pH, and current) was also carried out.

The research parameters are the size of coral diversity, the abundance of associated biota (reef fish and non-fish biota) and the quality of the waters. The data that have been obtained are then analyzed in a comparative description, which is to compares all research parameters from three research stations representing three different biorock structures located on Sepa Island, Seribu Islands, which are displayed in the form of tables and figures.

The determination of research stations and sampling points was selected based on aspects of coral reef representation, both biorock structure sites and association animals on the coast of Sepa Island, Seribu Islands, to describe the condition of coral reefs and the abundance.

2.3 Data Processing

Processing of associated animal data at the observation station using the Microsoft Excel program, and the association animal identification book[8]. The Microsoft Excel program is used to calculate the wealth of associations animal and indexes the community of animal associations (diversity, uniformity, and dominance).

2.4 Data Analysis

The physical-chemical parameters of the waters are compared with the standard value of seawater quality for marine life (coral reefs) as stated in the Annex to the Decree of the State Minister of the Environment Number 51 of 2004 concerning Seawater quality standards for marine life. This is done to determine the suitability of the water quality of the waters of Sepa Island with the optimal range for coral reef growth.

Data or indices of diversity, uniformity, and dominance of coral reefs and coral fish as a result of data processing, are then analyzed in a comparative descriptive manner, namely explaining all the data obtained from each research station and comparing them between three stations, to get an overview of the condition of artificial coral reefs, the structure of biorock and surrounding associated biota as well as the stability of coral reef communities and associated biota located at research sites in Sepa island waters.

3. RESULT AND DISCUSSION

3.1 Water Quality

The results of measuring chemical physics parameters compared to seawater quality standards for marine life (coral) listed in **Table-1** that show the quality of the waters at the Sepa Island research site, in general, still meets the quality standards for marine life, in this study for coral life, except for salinity parameters.

The temperature of the Sepa island waters at Stations I, II, and III, which were measured in the morning before making observations of the associated biota, was in the range of 28-30℃, following the water quality standards for corals. According to Nontji[9], the optimum temperature for coral reef growth ranges from 25-30 ℃. The condition of the waters where biorock coral reefs are located on Sepa Island can support the growth of coral reefs and associated biotas well[10].

Table-1. Water Quality Data of Research Sites on Sepa Island.

Parameter	Unit	Station			Quality Standards *
		I	II	III	
Temperature	℃	28	30	30	28 – 30
Brightness	m	3-6	8-10	8-9	$> 5\,m$
	(%)	100	100	100	
Salinity	%o (ppt)	35	35	35	33-34
pH		7,33	7,33	8	7 – 8,5
DO	Mg/l	11,6	9	12,3	> 5
Current	m/s	0,006	0.09	0,13	

*Standard based on Decree of the Minister of Environment of the Republic of Indonesia Number 51 Year 2004

The dissolved Oxygen (DO) content at the research site was in the range of 9-12.3 mg/l, with the largest value in the data collection value in the afternoon of 12.3 mg/l and the smallest occurring in the morning data collection, which was 9 mg/l which was likely caused by turbidity of the waters on Sepa Island. Meanwhile, light penetration from the results of measuring the brightness of the waters is fairly good and in accordance with quality standards with a brightness level of 100% and a visibility range of between 4-10 meters. The salinity of the waters on Sepa Island is about 35 ppt.

Data collection was carried out in November, including the transitional season when rainfall was still falling, so that high evaporation and low freshwater entry resulted in the high salinity of these waters. The speed of the current at the time of measurement looks calm. The results of measuring the speed of the current range from

0.006 – 0.17 m/s with an average current speed value of 0.075 m/s. An average water pH of 7.33 indicates neutral and alkaline-leaning water conditions[11].

3.2 Coral reef Diversity in Biorock Structures

The diversity of coral reefs at all observation stations shows that the structure on the biorock can provide a place for the attachment of coral planula larvae so that they can grow into coral reefs. The observations also found that coral reefs were attached and grown to ropes, iron frames, and anchors. This suggests that coral reef diversity has no specific medium or substrate to attach to.

3.3 Type Composition and Number of Coral Reef Individulas in Biorock

In **Table-2** it can be seen that the overall composition of the types (Genus) and coral reef individuals of the three stations are 13 genera, with 377 individuals. The highest number of individuals at Station III was 184 individuals from 9 genera, followed by Station I as many as 122 of the 8 genera, and Station II as many as 71 of the 8 genera.

Coral reefs of the Genus Pocillopora are the most common genus found in Station I and Station II. The genus pocillopora can live in shallow to deep waters, both in murky tidal inundation areas to clusters of clear small islands and in large undulating areas to calm waters[12].

The results of research conducted by Tefa[5], regarding coral recruitment in biorock architecture on Sepa Island, were obtained from the recruitment of corals of the genus Poccillopora is the most commonly encountered attached to the Biorock structure at all stations. This shows that corals of the genus Poccillipora can adapt to aquatic conditions where there is a biorock structure that is electrified by a weak electric current so that it can grow well on the biorock structure. Likewise, the results of research from Siahaan[13], on the recruitment of larvae in bioreeftek from coconut shells as a substrate for attachment, also found the genus Pocillipora. This is possible because around the site many coral reefs grow with the genus Poccilipora, the recruitment of corals attached to the biorock structure is the result of saplings from coral reefs living in the surrounding waters.

Table 2. Coral Reef Type Composition at Each Research Station

No.	Family	Genera	Station I (individual)	Station II (individual)	Station III (individual)
1.	Acroporidae	Acropora	30	24	71
2.	Acroporidae	Anacropora	-	6	26
3.	Acroporidae	Montipora	-	1	-
4.	Mussidae	Favia	1	1	1
5.	Mussidae	Favites	6	-	3
6.	Mussidae	Scolymia	-	-	1
7.	Merulinidae	Hydnophora	-	1	-
8.	Merulinidae	Pactygura	1	-	-

9.	Fungiidae	Fungia	-	-	1
10	Pocilloporidae	Pocillopora	73	28	42
11.	Pariitidae	Porites	4	5	9
12	Psammocoridae	Psammocora	6	5	30
13	Lobophyllidae	Symphillia	1	-	-
		Number of Genera	**8**	**8**	**9**
		Number of Individuals	**122**	**71**	**184**
		Period (months)	**60**	**54**	**48**

The results of this study show that it is not much different from the results of research conducted by Rudi et al.,[14] regarding the affinity of sticking coral larvae on the substrate. Most species of the genus Pocillopora have broading reproduction. The diversity of coral reefs in the biorock structure is the result of coral recruitment derived from surrounding coral broodstock that has broading reproduction.

When comparing the results of this research conducted in 2021 with the 2019 Tefa research[5], the number of pocillipora genus corals is highest at Stations I, II, and III compared to other types of corals. The results of this research are that the genus Pocillipora is dominant in Stations I and II, while for Station III there are more genera than Acropora. This is because the water conditions at Station III have a fairly fast current compared to the currents at Station I and Station II, so it is suitable for the genus Acropora to grow in these waters, besides that the genus Acropora tends to be a type of coral that grows quickly.

The rapid development of corals at station III can be due to a fairly calm aquatic environment, far from human activities compared to the environment of station I and station II adjacent to the ship base pier and there are development activities where ships carrying building materials are often passed. The quality of the waters at station III also supports coral growth.

According to Dianastuty et al.,[15] corals of the genus Acropora have high survival, high speed of life, and the ability to dominate empty coral reef ecosystem areas. The response of Acropora formosa corals to the presence of electric current in waters, as occurs in biorock structures, is to increase the survival and growth of coral reefs.

When viewed as a whole result from the three research stations, the composition of the hard coral species at the Sepa Island research site obtained corals of the genus Pocillopora and Acropora, which are the most growing genera attached to the Biorock structure on Sepa Island, respectively as much as 37.93% and 33.16% of the total number of coral reefs in the biorock structure (**Fig-2**). The existence of corals of the genus Pocillopora in addition to attaching to biorock structures is also on iron ropes such as anchor ropes and iron frames.

Fig- 2. Coral Reef Diversity on Sepa Island

This research is a continuation of the research that has been carried out by Tefa in 2019. Based on the results of this research and previous research [5] it can be seen the development of coral species that grow in biorock structures on Sepa Island (**Table-3**).

Table-3. Coral Development in Biorock Structure at Sepa Island Research Site

Station	Research Results	Biorock Age (Months)	Jenis Karang			Genus Dominant
			Family	Genera	Individual	
I- Domus Musculii	Tefa, 2019	19	9	12	147	Pocillopora
	Durachman 2021	**60**	**7**	**8**	**122**	**Pocillopora**
II- Domus Pirimidis	Tefa, 2019	11	2	2	65	Pocillopora
	Durachman 2021	**54**	**6**	**8**	**71**	**Pocillopora**
III-Domus Arkae Similis	Tefa, 2019	5	1	1	4	Pocillopora
	Durachman 2021	**48**	**6**	**9**	**184**	**Acropora**

It can be seen that overall coral reef communities growing on biorock structures are constantly developing, based on the increasing number of coral families, genera, and individuals, with different ages of biorock structures. This indicates that the structure of the biorock is quite good as well as the substrate on which it is attached to the recruitment of corals of various types of corals and is also supported by the quality of the waters.

Based on the results of observations of the water parameters of Sepa Island, the best water quality at station III was obtained compared to the station I and station II. The electricity flow in the biorock structure of station III is still flowing well compared to the station I and station II which can cause the coral substrate formation process to grow faster. This good quality of the waters greatly supports the survival and development of the coral reefs at station III.

In addition to being a hard substrate medium and wasting space for the attachment of coral larvae, biorock structures also using low-voltage electricity can provide accelerated growth of coral reefs 2-6 times the spleen compared to their natural growth rate. In addition to being able to provide faster growth of biorock structures, it also increases the survival rate of coral reefs by 15-60 times for an environment that is unfavorable to corals and makes shelter from large fish for small fish[16].

3.4 Diversity Index, Uniformity Index, and Coral Reef Dominance Index

The results of the analysis of the diversity index (H'), uniformity index (E), and dominance index (C) of growing coral reefs attached to the Biorock structure at three research stations on Sepa Island are listed in **Table-4**.

3.4.1 Diversity Index (H')

The results of the Analysis of the Shannon-Wiener Diversity Index (H'), the type of coral reef obtained from the three stations ranged from 1,179-1,577 with the highest value found at Station III. The value of the species diversity index (H') which is 1 < H'< 3 indicates that the diversity of coral reef species at the research station belongs to the categories of a medium, moderate spread, and medium community stability. If the diversity index is in the moderate category then the number of individuals in each community is in relatively good condition [17].

Table-4. Diversity Index of Uniformity and Dominance of Coral Reefs at Each Station

Biological Index	Station I	Station II	Station III
Diversity (H')	1,179	1,496	1,577
Uniformity (E)	0,245	0,351	0,302
Dominance (C)	0,425	0,287	0,250

3.4.2 Uniformity Index (E)

Based on the results of the analysis of the uniformity index (E) of coral reefs at the Sepa Island research site, the uniformity index values for the three research stations are not much different or relatively the same range from 0.245 - 0.352 (**Table-4**) were obtained. The uniformity index is in the range of 0 < E < 4, meaning that including low uniformity, the community is depressed. the uniformity index (E) in (**Table-4**) may be from low uniformity, communities are depressed so that they experience uniformity on low coral reefs.

3.4.3 Dominance Index (C)

Based on the results of the analysis of the dominance index (C) of coral reefs at the Sepa Island research site, the dominance index values for the three research stations were obtained in the range of 0.250 - 0.425 (**Table-4**). The uniformity index is in the range of 0 < C < 1, meaning that including low dominance, no genus is dominating.

3.5 Association Biota in Coral Reef Ecosystems

Coral fish and coral reef associations have a very close relationship, so the presence of coralfish in coral reef ecosystems will be very fragile if there is damage to coral reef ecosystems. Thus the type of reef fish can be used as a benchmark for a habitat conditions. For example, the presence of indicator fish of the family Chaetodontidae is an indicator of coral health. The number of indicator fish in water indicates a high level of coral fertility [18].

3.6 Composition and Abundance of Reef Fish

Based on the results of observations of reef fish communities at the research sites at the three stations as stated in Table 9, the number of reef fish found was 451 individuals, covering 21 families. The types of reef fish found in the three stations are 6 families, with the most number of the family Pomacentridae 209 heads, followed by the family Siganidae 78 heads, Caesionidae 68 heads, family Ephipidae 52 heads, Scaridae 17 heads, and

Carangidae 11 heads, while the other families are only found at one station. Reef fish from the family Pomacentridae occupies the highest number of 209 and are predominantly hatched on each station (**Figure 3**), or overall as much as 46% of the total reef fish community at the research station.

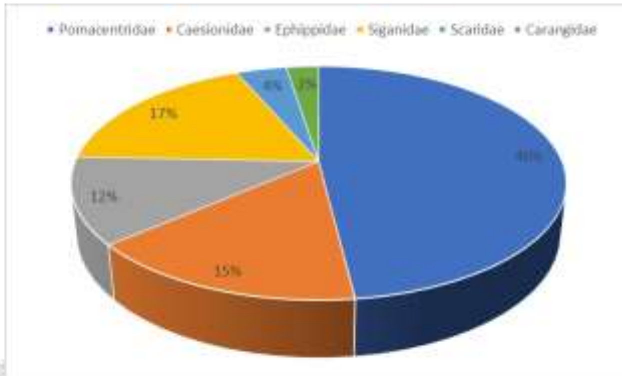

Fig- 3. Reef Fish Composition in Sepa Island

Based on the results of direct observations at each station, the types of reef fish found at the biorock structure research station site on Sepa Island, are quite diverse. The identification results obtained that the number of reef fish families found was quite varied between one station and another. This condition can be caused because the station has different biorock structure shapes, diversity of coral types, and different types of substrates, so it is believed that it can affect the abundance and diversity of coral fish, as nybakken stated [19] that one of the causes of the high diversity of species on coral reefs is the variation in their habitat because the ecosystem of coral reefs does not only consist of corals, but there are also sandy, rocky areas, and also diverse base shapes.

The total abundance of reef fish in the waters of Sepa Island found during the observation of morning, afternoon, and evening time is 451 ind/1440 m^2. This abundance value is classified as abundant based on the criteria for the abundance of reef fish according to The criteria for the abundance of reef fish according to CRITC-COREMAP LIPI[18] are: a) categories are very abundant (>50 heads), b) abundant (20-50 heads), c) less abundant (10-20 heads), rarely (5-10 heads), and d) very rarely (1-5 heads).

Based on data on the abundance of reef fish at each station, the highest abundance at Station- III was 108 ind/1440m^2, then Station I, and the lowest was 52 ind/1152m^2 at Station II (**Fig-4**).

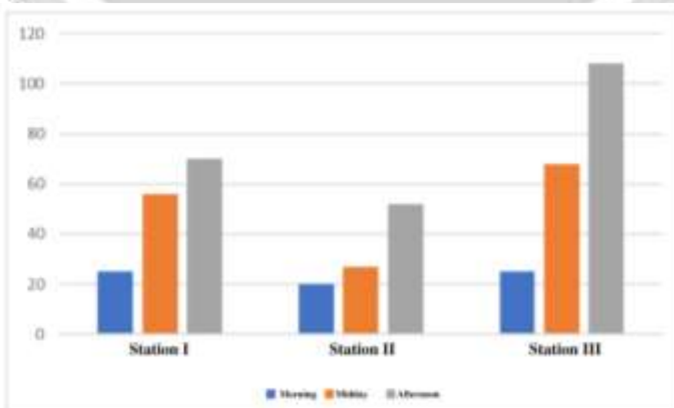

Fig- 4. Reef Fish Abundance (eng/1440 m2)

The highest abundance of major reef fish found around the biorock structure, at Station III, is a reef fish of the family Pomacentridae. The abundance of major fish in each region, striking its existence because of the types of fish that belong to the major fish group, is the largest group of fish inhabitants of coral reefs, and generally lives in large groups (schooling fish)[20].

3.7 Index of Diversity, Uniformity, and Dominance of reef Fish

Table-5. Index of Diversity, Uniformity and Dominance of Reef Fish

Biological Index	Station I	Station II	Station III
Diversity (H')	4,130	3.879	4,288
Uniformity (E)	0,823	0,844	0,809
Dominance (C)	0,853	0,986	0,983

3. 7. 1. Diversity Index

The results of the calculation of the reef fish uniformity index at three stations at the Biorock research site in the Sepa Island Waters (**Table 5**), obtained a diversity index ranging from 3,879 -4,288. The lowest value on station II and the highest value is in Station III. The reef fish community at Station II consists of 8 families, the same as at Station I, while at Station III it consists of 17 families. Nybakken[19] states that a high diversity value indicates a stable comfortable environment, while in a low category the diversity value indicates a stifling and changing environment.

3. 7. 2. Uniformity Index

The uniformity index (E) obtained at the research sites of Stations I, II, and III, is relatively the same, ranging from 0.809 – 0.844. The value of this index is between $0.6 < E < 1.0$, which means that uniformity is high and the community is stable.

3. 7. 3. Dominance Index

The dominance index (C) is used to see the degree of dominance of a particular group of biota, in this case, a particular family of reef fish. Based on the analysis of the reef fish dominance index at the three stations, an index value was obtsained that did not differ much between 0.853 – 0.986. Based on Shannon Wiener's dominance index category (C), it is included in the high dominance because it is close to the value of 1. Index value $0.75 < C < 1.0$ is high dominance.

This condition is due to the abundance of food sources for fish of the family Pomacentridae. The biorock structure becomes a substrate where algae are attached because the depth of the waters on Sepa island is quite shallow 4-10 m where light penetration reaches the bottom of the water (100%) so that the algae can carry out the photosynthetic process properly.

3. 7. Other Associated Biota

The results of observations made on associated biota on the biorock structure found various biota located in the biorock structure including types of bivalves (barnacles, tunicate, and kima) that have been integrated with the biorock structure. Other types of biota found attached to the biorock structure are sponges, turf algae, and macroalgae.

3. 7. 1. Competitors on Biorock Station I Structure

The station I has a wider macroalga and turf cover than Station II and Station III. This is because Station I has a lower depth, which is 4-5 meters, so it is more exposed to sunlight entering the sea surface compared to other stations. Green algae (phylum Chlorophyta) can carry out photosynthesis, which produces food and oxygen, which are a source of food for those animals living in the water. The extent of the coral cover is directly proportional to the depth of each in the structure and is also related to the intensity of sunlight received at the observation station[21]. The types of macroalgae that were successfully identified were: *Padina* sp, *Halimeda* sp, and *Lobophora variegate*.

3. 7. 2. Competitors on the Biorock Structure at Station II

Based on direct observations, overall competitors for corals in the biorock structure at Station II obtained macroalgae, turf algae, Sponges, and Tunicate. The most space competencies at Station II are sponge and tunicate biota compared to macroalgae and turf algae. The presence of macroalgae and turf algae in the biorock structure at Station II, is not as much as that obtained in the biorock of Station I, because Station II receives the least exposure to sunlight. The types of macroalgae located at Station II are Padina sp, and Lobophora variegate. The most common type of macroalgae is Lobophora varieagata, which attaches to the apex of the biorock structure at a depth of 3 –4 meters, the closest part to the surface and gets a supply of sunlight, while the macroalgae Padina sp is often found among transplant corals.

3. 7. 3. Competitors on the Biorock Structure at Station III

The results of direct observations on the biorock structure at Station III, which is shaped like a ship's platform, there are only a few macroalgae on the ship's part platform, and turf algae on the iron parts that have not received mineral accretion flow. The tunicate is found in only a few, from the species Atrolium robustum that fuse with corals. An iron that undergoes mineral accretion becomes a suitable substrate for the growth of Tunicate biota [15].

4. CONCLUSIONS

1. The diversity of coral species in the biorock structure on Sepa Island is 184 individuals from 13 genera, the most in the genus Pocillopora and Acropora. Moderate stability of communities with a moderate diversity index (1,179 - 1,577); low uniformity index (0.245-0.351) and low dominance index (0.250-0.425).
2. The uniformity of the associated biota on the biorock structure in Sepa Island consists of:
   - A reef fish community of 451 individuals from 21 families, family Pomacentridae.
   - Macroalgae, turf algae, sponges, and tunicate. is a competitor to corals in obtaining substrate and food space.

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