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Original research article

The Macrozoobenthos Community Structure on Artificial Reef at Penyusuk Marine, Bangka Regency

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ABSTRACT

Macrozoobenthos are all types of sedentary organisms or move freely whose habitat's in the bottom substrate of waters with a body size of more than equal to 0.5 mm. Benthos have a very important role in waters where macrozoobenthos communities must remain balanced so that aquatic ecosystems are balanced. This study aims to determine the type of macrozoobenthos, the abundance of macrozoobenthos and the structure of macrozoobenthos communities on artificial reefs in Penyusuk Marine, Bangka Regency which was sunk by PT. Arta Cipta Langgeng. Data collection will be carried out in May 2023 at an artificial reef in Penyusuk Marine, Bangka Regency. The determination of the research location point was carried out by purposive sampling and macrozoobenthos data collection using road sampling techniques and free hand picking methods. Measurement of environmental parameters was carried out in situ and ex situ as well as data analysis using Principal Component Analysis (PCA). The results of the study found 32 types of macrozoobenthos with a total of 2,745 individuals found at the three observation stations. The abundance obtained ranged from 46,04 ind/m2 – 49,01 ind/m2. The diversity value ranges from 0,60 – 0,87 so that was categorized as low, the uniformity value ranges from 0,19 – 0,27 as low was categorized and the dominance value ranges from 0,72 – 0,82 was high categorized.

Introduction

Coral reefs are ecosystems that have high biodiversity and have an important role in coastal waters and tropical seas (Sahatepy et al., 2021). Ecologically, this ecosystem functions as feeding ground, spawning ground and nursery ground (Putra et al., 2019). Human and natural activities can cause damage to this ecosystem, making some marine life their habitat.

Making artificial reefs is an alternative strategy to minimize damage that occurs in coral reef ecosystems. Artificial reefs can improve coral reef ecosystems by providing new habitats and substrate layers for feeding areas for marine life such as fish and

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macrozoobentos (Director General of P3K, 2004). Makrozoobenthos is a marine organism whose nature is sedentary and moves freely whose habitat is on the boto substrate of waters with a body size of ≥ 0.5 mm (Desmawati et al., 2019).

Makrozoobenthos play an important role in the food chain and have an important role so that the macrozoobentos community must remain balanced so that the aquatic ecosystem is also balanced (Nurlinda et al., 2019). This is because, macrozoobenthos communities can be an indicator of water quality. Penyusuk waters are one of the waters that have artificial reef. This structure was sunk by PT. Artha Cipta Langgeng in May 2022 with an artificial reef cube arranged in stages.

Penyusuk waters are located in Romodong Indah Village, Belinyu District, Bangka Regency. In this location there are human activities so that it is quite influential in the occurrence of damage to coral reef ecosystems. Therefore, the need for management for resource sustainability so that the food chain is well maintained. Based on the description above, this research is needed to determine the success rate of artificial reef in supporting ecosystems in the waters and to provide information about the structure of macrozoobenthos communities in artificial reef.

Materials and Methods

Time and Place of Research

This research will be carried out in May 2023 on artificial reefs sunk by PT. Artha Cipta Langgeng in Penyusuk Waters, Kabupeten Bangka. Taking the physical parameters of aquatic chemistry is carried out in situ and ex situ. Substrate samples were analyzed at the Aquatic Resources Management laboratory, Faculty of Agriculture, Fisheries and Biology, Bangka Belitung University, and Total Suspended Solid samples and Biological Oxygen Demand samples were analyzed at the laboratory of the Bangka Belitung Islands Provincial Health Office. The map of the research location can be seen in Figure 1.

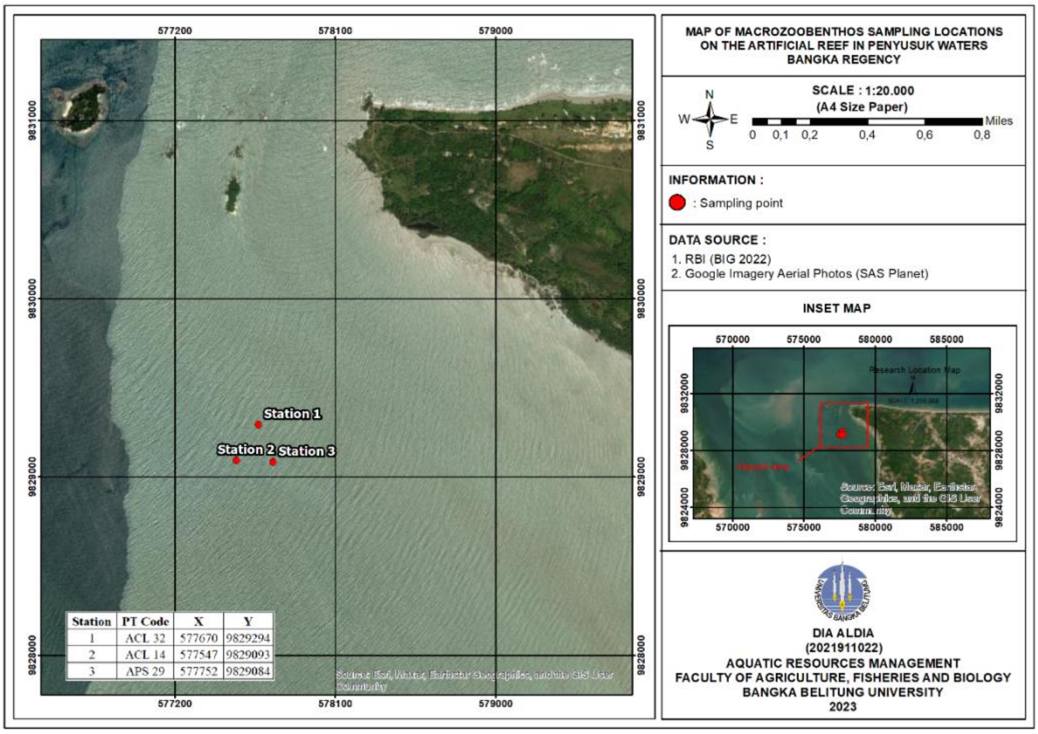

Figure 1. Research location at Penyusuk Marine, Bangka Regency

Tools and Materials

The tools and materials used are stationery, 70% alcohol, sample bottles, benthos identification books, underwater cameras, DO meters, GPS, hand refractometers, kite currents, pH paper, plastic samples, scuba sets, secchi disks, and thermometers.

Data Collection Method

The method used in determining the location of the study is using the purposive sampling method. This method is used by researchers to determine the location of research by considering certain aspects (Fachrul, 2007). The research location point consists of 3 stations with a distance between stations of about ±500 meters. The three stations were selected according to the artificial reef derived by PT. Artha Cipta Langgeng. Consists of 50 artificial reefs with cube shapes arranged in tiers at each station. The number of first levels consists of 25 pieces, the second level is 15 pieces and the third level is 10 pieces with a length of each rib 50 cm and a thickness of 8 cm (Secondary Data PT. Artha Cipta Langgeng, 2022). An illustration of the shape of an artificial reef can be seen in Figure 2.

Data collection of macrozoobentos using the method of extraction techniques and collecting freely by documenting the biota found (Bookhout, 1996). Exploration is done by exploring the artificial reef area and then taking documentation and counting the number of each individual found. Samples of each type of individual were taken as samples to be identified in the laboratory of the Aquatic Resources Management Study Program, Faculty of Agriculture, Fisheries and Biology, Bangka Belitung University. The identification process is carried out visually by looking at its morphology. Identification refers to the identification books of Colin and Arneson (1997), Allen and Steene (1998), FAO Species (1998), Poore (2004), Dharma (2005), then confirmed it in WoRMS (World Register of Marine Species).

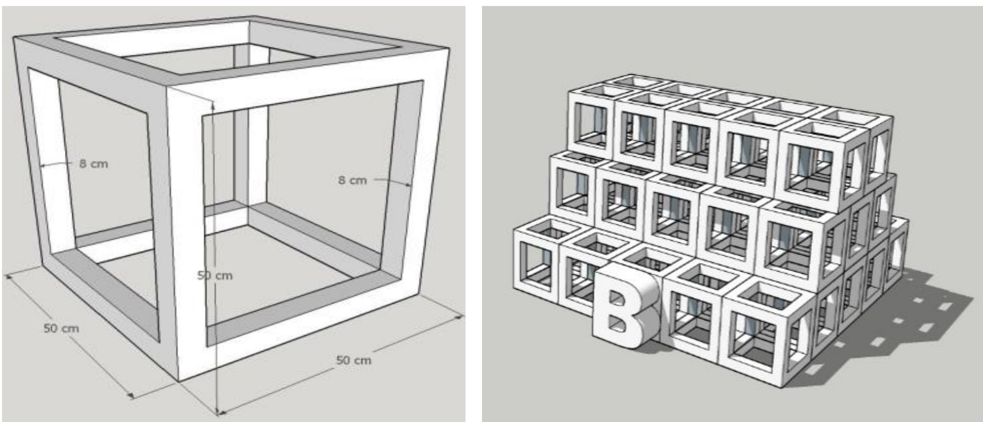

Figure 2. Artificial Reef Form PT. Artha Cipta Langgeng

Data Analysis
Abundance

Data analysis to calculate the abundance of macrozoobentos refers to the calculation of the formula according to (Brower et al., 1998) as follows:

$$Di = \frac{ni}{A}$$

Description:
Di : Abundance of individuals of the I species
ni : Number of individuals of the I species (ind)
A : Area of observation area (m2)

Diversity Index

The macrozoobenthos diversity index can be calculated using the Shannon-Wienner diversity index according to (Brower et al., 1998) as follows:

$$H' = -\sum_{i=1}^{n}(Pi\ Ln\ Pi)$$

Description:
H': Shannon-Wienner Index
Pi : Number of individuals of i-th type (ni) divided by total number of individuals of all types (ni/N)
ni : Number of individuals of i-th species
N : Total number of individuals

The range of diversity index values refers to Fachrul (2007) as follows:
H<1,0 : Low diversity
1,0<H<3,0 : Medium diversity
H>3,0 : High diversity

Uniformity Index

The uniformity index of macrozoobenthos can be calculated using the formula according to (Krebs, 1989) as follows:

$$E = \frac{H'}{Ln\ S}$$

Description:
E: Uniformity index
H': Shannon-Weinner diversity index
S: Number of all types

The uniformity index values range from 0-1 with the category of the range according to (Krebs, 1989) as follows:
E<0,4: Low uniformity
0,4<E<0,6: Medium uniformity
E>0,6: High uniformity

Dominance Index

The macrozoobenthos dominance index can be calculated using the Simpson dominance index formula referring to (Fachrul, 2007) as follows:

$$D = \sum_{i=1}^{s} Pi^2$$

Description:
D: Dominance index
Pi: Number of individuals of the I-th type (ni) divided by the total number of individuals of all types (ni/N)

There are criteria for dominance index values that refer to (Odum, 1993) as follows:
0 < D < 0,3: Low dominance
0,3 < D < 0,6: Medium dominance
0,6 < D < 1: High dominance

Relationship of Macrozoobenthos Abundance with Environmental Parameters

The relationship of macrozoobenthos abundance with environmental parameters was analyzed using Principal Component Analysis (PCA) using the XLSTAT 2015 application. This analysis aims to provide maximum information on a matrix of data into a descriptive graphic form (Bengen, 2000). The data used were data on the abundance of macrozoobenthos and environmental parameters obtained at the time of the study.

Result and Discussion

Types and Abundance of Macrozoobentos

There are 32 types of macrozoobentos with a total of 2,745 individuals spread across three observation stations. Consists of several phyla including phylum Mollusca, Arthropods, Echinoderms, and Annelids which come from 8 classes namely Gastropoda, Bivalvia, Malacostraca, Pycnogonida, Echinoidea, Polychaeta, Crinoidea, and Thecostraca. Macrozoobentos with the most common types come from the phylum Mollusca, namely the classes Gastropoda and Bivalves. According to Nurlinda et al., (2019) that macrozoobenthos species from the phylum Mollusca can live in various types of substrates such as reef debris, dead coral sheets and rocks (Table 1).

The abundance of macrozoobenthos at all three stations ranged from 46,04 ind/m2 – 49,01 ind/m2. The highest abundance value is located at station 2 which is 49,04 ind/m2. There are physical chemical factors of waters such as salinity, potential of hydrogen (pH), sand substrate, dissolved oxygen (DO) and brightness that affect the abundance of macrozoobentos at station 2 better than other stations. While the lowest abundance value is located at station 3 with a value of 46.04 ind/m2. Environmental parameters are one of the causes of the low abundance of macrozoobenthos at this station. The environmental parameters that affect station 3 are Total Suspended Solid (TSS), Total Organic Matter (TOM), Biological Oxygen Demand (BOD), current speed and depth.

Macrozoobenthos Community Structure

The highest diversity value (H') is located at station 2 (0.87) and the lowest is located at station 3 (0.60). The highest uniformity value (E) is located at station 2 (0.27) and the lowest is located at station 3 (0.19) while the highest dominance value (D) is located at station 3 (0.82) and the lowest is located at station 2 (0.72) (Figure 3).

The diversity value at the three stations ranged from 0,60 - 0,87 so it was categorized as low diversity. The uneven distribution of individuals of each type and the presence of dominant species make the value of diversity tend to be low. In addition, the condition of the waters is also one of the indices that can determine the high and low diversity of a species. This is reinforced by the statement of Meisaroh et al., (2019) that environmental factors can also affect the diversity of a biota.

The uniformity value obtained ranges from 0,19 - 0,27 so that this value is included in the low uniformity category. This is thought to be because the number of macrozoobenthos species found is small and individuals spread relatively unevenly so that communities are slightly disturbed and cause low uniformity. Based on the statement of Sofiyani et al., (2021), the low uniformity value occurs because the number of individuals of each type is uneven and there tends to be a type that dominates.

Table 1. Types and Abundance of Macrozoobentos

Class	Types of Makrozoobenthos	Station		
		1 (Ind/m^2)	2 (Ind/m^2)	3 (Ind/m^2)
Gastropoda	*Laevistrombus canarium*	0,365	0,521	0,104
	Nassarius crematus	0,469	0,104	0,208
	Bufonaria crumena	0,573	0,781	0,417
	Purpuradusta minoridens	-	0,052	0,365
	Monodonta labio	0,104	0,521	-
	Umbonium vestiarium	0,521	0,365	0,104
	Turbo bruneus	0,208	-	0,104
	Tectus pyramis	0,313	0,104	0,208
Gastropoda	*Vexillum lyratum*	0,104	0,208	0,365
	Rhinoclavis aspera	0,469	0,625	0,313
	Phalium bandatum	0,104	0,104	0,052
	Turritella terebra	0,208	0,104	-
	Goniobranchus preciosus	0,104	0,208	0,208
	Coryphellina rubrolineata	0,208	0,625	0,104
	Varicospira kooli	-	0,208	-
Bivalvia	*Mactra violacea*	0,469	0,260	0,104
	Circe scripta	0,156	-	0,156
	Marcia hiantina	0,104	0,313	0,052
	Callista erycina	0,208	0,365	0,104
	Decatopecten amiculum	0,052	0,208	-
	Placuna ephippium	0,104	-	-
	Hyotissa hyotis	0,365	0,573	0,208
Malacostraca	*Portunus pelagicus*	0,104	-	-
	Ozius deplanatus	0,104	0,208	0,052
	Schizophrys aspera	-	0,156	0,104
	Etisus splendidus	0,156	-	0,052
	Ashtoret lunaris	0,052	0,104	-
Pycnogonida	*Austrodecus glaciale*	-	-	0,156
Echinoidea	*Diadema setosum*	0,208	0,104	0,208
Polychaeta	*Nereis* sp.	0,104	-	0,208
Crinoidea	*Cenometra bella*	0,313	0,521	0,417
Thecostraca	*Tetraclita* sp.	41,667	41,667	41,667
	Total	47,92	49,01	46,04

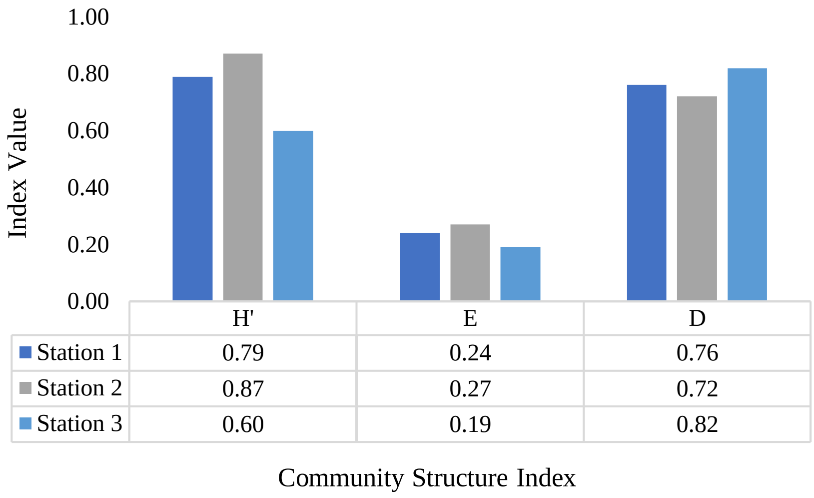

Figure 3. Macrozoobenthos Community Structure Diagram

The dominance value obtained at the three stations ranged from 0,72 - 0,82 so that it was categorized as a high dominance value. This suggests that there is a type of macrozoobentos that dominates at all three study stations, which tends to cause the population to become unbalanced. According to Meisaroh et al., (2019) a high dominance value occurs when the number of macrozoobentos types obtained is low and there is one type of macrozoobentos whose number of individuals is high and dominates. In this study, the type of Tetraclita sp. was found. Or usually called barnacles that attach firmly permanently to the artificial reef. This breed multiplies hermaphroditely, so its presence increases very quickly. In addition, this biota has a very high resistance to extreme environmental changes. This is reinforced by Okta (2022) barnacles are able to survive drastic changes in temperature, salinity, pH and fluctuating current speeds. Therefore, this is what makes the type of Tetraclita sp. Or these barnacles can dominate in all three observation stations.

Environmental Parameter Measurement

Environmental parameters measured include temperature, salinity, current speed, brightness, depth, potential of hydrogen (pH), dissolved oxygen (DO), Biological Oxygen Demand (BOD), Total Suspended Solid (TSS), substrate and Total Organic Material (TOM).

Water temperature measurements at all three research stations ranged from 31 °C - 32 °C. The difference in values between stations 1, 2 and 3 is not very significant. Usually, the temperature in the waters is relatively stable and not too drastic changes (Putriningtias et al., 2021). According to the Presidential Regulation of the Republic of Indonesia Number 22 of 2021 concerning the Implementation of Environmental Protection and Management, the temperature value for marine life ranges from 28 °C - 30 °C and is allowed to change to 2 °C from the natural temperature. In line with Widyastuti's statement (2013), macrozoobentos can also live with water temperatures ranging from 25 °C - 36 °C. Based on this statement, the value obtained is still within normal temperature limits for marine life.

The salinity value of the waters obtained at station 1 is 30 ppm, at station 2 it is 35 ppm and at station 3 it is 30 ppm. Salinity can be affected by weather conditions, tides and nature. The significant difference in values between station 1 and station 3 with station 2 is due to the difference in time and day of data collection. Makrozoobenthos can tolerate salinity for life with a range between 33 - 34 ppm and is allowed to change up to 5 ppm according to the average seasonal salinity (Presidential Decree Number 22, 2021). This is also reinforced by the statement of Angelia et al., (2019) macrozoobentos can tolerate salinity in a water with a range between 15 ppm - 45 ppm. Therefore, the value obtained is still in good condition for marine life (Tabel 3).

Table 3. Environmental Parameter Measurement

Parameters	Unit	Station			Quality Standards *
		1	2	3	
Temperature	°C	32	31	31	natural: 28-30
Salinity	ppm	30	35	30	natural: 33-34
Current speed	m/s	0,50	0,51	0,51	-
Brightness	%	38,46	40,57	29,27	> 5
Depth	m	3,9	5,3	4,8	-
Potential of Hydrogen	-	7,3	7,4	7,3	7- 8,5
DO	mg/l	5,9	6,1	5,6	>5
BOD	mg/l	23	21,8	34,5	20
TSS	mg/l	12	20,2	38,5	20
Substrate	%	Sand (98,01) Dust (0,02) Clay (1,98)	Sand (99,04) Dust (0,02) Clay (0,95)	Sand (95,79) Dust (0,01) Clay (4,21)	- - -
TOM	%	3,45	6,25	7,2	-

Description:
Natural = Normal conditions in nature, varying according to time and season
(*) = Presidential Regulation of the Republic of Indonesia Number 22 of 2021 (Annex VIII) concerning the Implementation of Environmental Protection and Management for the Designation of Sea Water Quality Standards.

Current velocity measurements at all three research stations ranged from 0,50 m/s – 0,51 m/s. There was no significant difference in values between the three observation stations. According to Aprisanti et al., (2013) the current speed of 0,50 - 1 m/s falls into the category of fast current. Based on the results of the study, macrozoobentos can still be found so that the current velocity value obtained can still tolerate macrozoobentos life at the research site.

The brightness value of the waters obtained at station 1 is 38,46%, at station 2 it is 40,57%, and at station 3 it is 29,27%. Time differences and weather conditions when data is collected can cause differences in the brightness values obtained. This is reinforced by the statement of Fadilla et al., (2021) the brightness value of waters can be influenced by weather factors, measurement time, plankton, microorganisms and total suspended solid (TSS) content. According to Presidential Regulation Number 22 (2021), macrozoobentos can live at a water brightness level above 5%. Based on this, the brightness value obtained is still within normal limits for macrozoobenthos life.

The depth of water obtained at the three stations ranged from 3,9 – 5,3 meters so that these waters were included in the category of shallow water. The difference in depth of each station can be caused by differences in retrieval time, tides and the shape of the seabed surface. According to Putriningtias et al., (2021) the depth of different waters is influenced by the topography of the location and the tidal cycle in each time period.

The potential value of hydrogen (pH) waters found at the three points of the study location ranged from 7,3 - 7,4. There was no significant difference in scores at the three research stations. Based on Presidential Regulation Number 22 of 2021, macrozoobentos can live in waters that have pH values ranging from 7 – 8,5. This statement is also reinforced by Izzah and Roziaty (2016) macrozoobentos such as waters that have pH values ranging from 7 - 8,5. Marine organisms such as seawater whose acidity (pH) is close to neutral or 7 because it can maximize the decomposition process in waters (Roem et al., 2016). Therefore, the potential value of hydrogen (pH) obtained is still within normal limits for macrozoobenthos life.

The concentration of dissolved oxygen (DO) obtained at the three study stations ranged from 5,6 mg/l – 6,1 mg/l. The value of dissolved oxygen (DO) obtained does not differ too much. The difference in values is due to differences in time and weather conditions when collecting data. In addition, the entry of organic matter from land carried by rainwater into the sea can also be one of the causes of dissolved oxygen (DO) to be low. This is supported by Patty's statement (2015) low dissolved oxygen (DO) content due to the presence of organic materials that enter the waters so that it requires a lot of oxygen to decompose it. According to Presidential Regulation Number 22 (2021), waters with dissolved oxygen (DO) concentrations above 5 mg/l become normal habitats for marine biota, including macrozoobenthos. This is also reinforced by the statement of Angelia et al., (2019) that dissolved oxygen concentrations (DO) above 5 mg/l are good for marine life. Based on this statement, the value of dissolved oxygen (DO) obtained is in the good category for marine life.

The concentration of Biological Oxygen Demand (BOD) at station 1 is 23 mg/l, station 2 is 21,8 mg/l, and station 3 is 34,5 mg/l. There is a very significant change in value between station 3 and other stations. The activity of bacteria in the process of decomposition of organic and inorganic matter can cause the content of Biological Oxygen Demand (BOD) to be high in the waters. The more organic matter that will be decomposed, the more dissolved oxygen will be needed so that it can cause dissolved oxygen to decrease and Biological Oxygen Demand (BOD) to increase. This is supported by Daroini and Arisandi's (2020) statement that a low concentration of dissolved oxygen (DO) in a water indicates that a high concentration of Biological Oxygen Demand (BOD). According to Presidential Regulation Number 22 (2021), the concentration of Biological Oxygen Demand (BOD) which is good for marine life is 20 mg/l. The value obtained is still quite possible to tolerate the life of macrozoobenthos biota because biota is still found at the research site.

The Total Suspended Solid (TSS) value obtained at station 1 is 12 mg/l, station 2 is 20,2 mg/l, and station 3 is 38,5 mg/l. The difference in values is very significant at the three stations due to data collection carried out at different times and weather conditions. Based on the statement of Saiful et al., (2020) the content of Total Suspended Solid (TSS) can spread in coastal waters because it is influenced by several factors such as wind, rainfall, waves, currents and tides. Data collection at station 3 was carried out after the rain, causing the Total Suspended Solid (TSS) content at this station to be higher. When it rains, particles and organic matter from the land will be carried to the coast to the sea. In addition, waves and currents also stir particles on the bottom of the water to the surface of the sea, making the Total Suspended Solid (TSS) content at station 3 higher. The activity of the imping river that empties into the Penyusuk Waters also allows for the influence of high Total Suspended Solids (TSS). According to Presidential Regulation Number 22 (2021) that the ideal total suspended solid (TSS) content for marine life is 20 mg/l. When viewed based on quality standards (Presidential Decree Number 22, 2021) at stations 1 and 2, the Total Suspended Solid (TSS) content value obtained is still relatively good, while the Total Suspended Solid (TSS) value obtained at station 3 has exceeded the normal threshold, but the macrozoobentos found can still tolerate their life.

The substrate value obtained at station 1 is 98,01%, at station 2 it is 99,04%, and station 3 is 95,79%. The type of substrate obtained is the type of sand. The existence of this type of substrate is greatly influenced by the speed of the water current. This is supported by the statement of Hartini et al., (2012) strong current speeds can cause the substrate type to be dominated by the sand substrate type while the weak current causes the susbtrate type to be dominated by mud or clay substrate types. Macrozoobenthos of the mollusk phylum are particularly fond of sandy aquatic substrates because they can make it easier to obtain a supply of nutrients and water. According to Tritama (2021), the sand substrate has air pores, allowing an intensive mixing process with water on it and making the dissolved oxygen (DO) content relatively larger.

Total organic matter (TOM) values at all three stations ranged from 3,45% - 7,2%. The lowest total organic matter (TOM) content was found at station 1, which was 3.45%. This can occur if there is little organic material entering from land and the supply of organic material from the sea to the coast is low (Nugroho et al., 2020). At station 3, the highest total organic matter (TOM) content was 7.2%. One of the causes of the high total organic matter (TOM) at this station is due to data collection carried out after the rain, making particles and organic matter from land carried to the sea. According to Sari et al., (2014) the appropriate amount of total organic matter (TOM) will be useful for waters and excess amounts will make waters disturbed, for example can cause silting and decreased water quality. Macrozoobentos found at the three research stations are quite diverse so that the organic matter content obtained is still quite good in supporting macrozoobenthos life.

Relationship of Macrozoobenthos Abundance with Environmental Parameters

There are five environmental parameters that are most related to the abundance of macrozoobentos in artificial reef PT. Artha Cipta Langgeng in Penyusuk Waters, Bangka Regency are salinity, potential of hydrogen (pH), dissolved oxygen (DO), sand substrate and brightness (Figure 4).

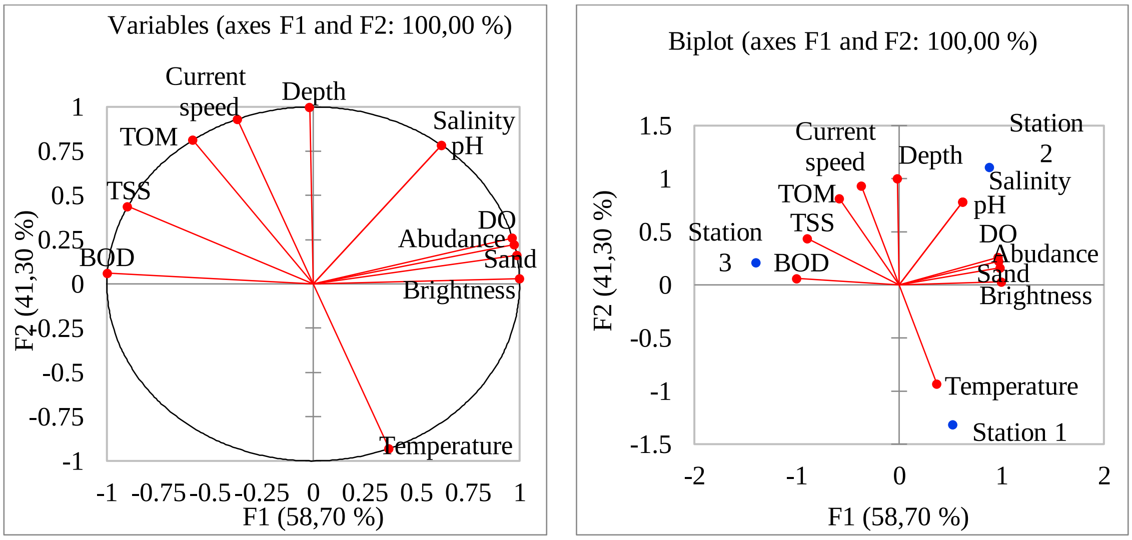

Figure 4. Relationship of Macrozoobenthos Abundance with Environmental Parameters

The potential of hydrogen (pH) can affect survival and growth for macrozoobenthos (Sofiyani et al., 2021). Most marine organisms are very sensitive to changes in the degree of acidity (pH) of the waters. Based on the analysis that has been done, a strong correlation relationship was formed between the potential of hydrogen (pH) and the abundance of macrozoobentos where the correlation value obtained was 0,780. This is in accordance with Sugiyono's statement (2010) the correlation value between 0,60 – 0,799 is categorized as having a strong correlation level. The correlation value obtained is positive and unidirectional so that the value of the potential of hydrogen (pH) has a high influence on the abundance of macrozoobenthos at this study location.

Dissolved oxygen (DO) in a body of water can affect macrozoobentos life in the form of the number and type of macrozoobentos (Widhiandari et al., 2021). The oxygen content in waters is produced through the process of photosynthesis and diffusion of oxygen by aquatic plants. Based on the results of the analysis, dissolved oxygen (DO) formed a very strong correlation relationship with the abundance of macrozoobentos with a correlation value obtained of 0,999. According to Sugiyono (2010) the correlation value between 0,80 – 1 is categorized as having a very strong correlation level. The correlation value obtained is positive and unidirectional so that dissolved oxygen (DO) parameters have a very high influence on the number and type of macrozoobenthos. This certainly makes the abundance of macrozoobentos at the research site also high.

The texture of the substrate becomes a habitat for marine life such as macrozoobenthos. According to Angelia et al., (2019) substrate texture can affect the structure of aquatic macrozoobenthos communities. The sand substrate type is highly preferred by macrozoobenthos biota of the gastropod class. This is in line with the statement of Angelia et al., (2019) the gastropod class can live quite widely on various types of substrates such as rocky, sandy, and muddy substrates. Based on the results of the analysis, the texture of the sand substrate formed a very strong correlation relationship with the abundance of macrozoobentos with a correlation value obtained of 0,998. Based on Sugiyono's statement (2010), the correlation value between 0,80 – 1 is categorized as having a very strong correlation level. The correlation value obtained is positive and in line with the abundance of macrozoobentos so that the texture of the substrate has a very high influence on the abundance of macrozoobentos at this location.

The depth of the waters is one of the limiting factors for macrozoobenthos life. According to Sofiyani et al., (2021) the depth of waters can affect the abundance of aquatic macrozoobenthos species. There are only certain types of macrozobentos that can adapt to deep waters (Nurlinda et al., 2019). Based on the results of the analysis, the depth parameter has a weak correlation relationship with the abundance of macrozoobenthos where the correlation value formed is 0,206. According to Sugiyono (2010) the correlation value between 0,20 – 0,399 is categorized as having a weak correlation level. This shows a positive and unidirectional correlation value so that the depth of the waters has a sufficient influence on the abundance of macrozoobenthos found at the study site.

Temperature can affect metabolic activities, biota survival such as movement and distribution in waters (Sofiyani et al., 2021). The temperature value must remain stable in order to properly support the existence of macrozoobenthos. Based on the results of the analysis, there is a very weak correlation between temperature and macrozoobenthos abundance where the correlation value obtained is 0,152. Along with Sugiyono's statement (2010), the correlation value between 0,00 – 0,199 is categorized as having a very weak correlation level. However, the correlation value obtained remains positive and unidirectional, making temperature parameters still have a sufficient influence on the survival and abundance of macrozoobenthos at this location.

Current speed plays an important role in macrozoobenthos life because it can affect macrozoobenthos communities (Sofiyani et al., 2021). The current will affect the type of substrate for benthos living and other environmental parameters. In addition, current speed plays a role in oxygen solubility, carbon dioxide removal and food supply.

Makrozoobenthos do not like strong current speeds because these organisms will be difficult to attach to their susbtrates. According to Nurlinda et al., (2019) waters with calm current speeds will support macrozoobenthos life because of their inherent nature of life. Based on the results of the analysis, the current speed has no correlation relationship with the abundance of macrozoobenthos where a correlation value of -0,152 is obtained. According to Angelia et al., (2019) if the correlation value obtained is negative, it means that the correlation is not unidirectional, then the value has no effect. This certainly shows that the current speed has no influence on the abundance of macrozoobenthos at the study site because the abundance of macrozoobenthos will decrease with the increase in current speed.

Biological Oxygen Demand (BOD) can affect the number, type, species composition and mortality of macrozoobenthos in waters (Maula, 2018). According to Daroini and Arisandi, (2020) a high concentration value of Biological Oxygen Demand (BOD) will cause organisms in waters to die due to lack of dissolved oxygen (DO). Based on the results of the analysis, the Biological Oxygen Demand (BOD) parameter has no correlation relationship with the abundance of macrozoobentos where the correlation value obtained is -0,959. According to Angelia et al., (2019) if the correlation value obtained is negative, it means that the correlation is not unidirectional, then the value has no effect. Therefore, it can be stated that Biological Oxygen Demand (BOD) has no influence on the abundance of macrozoobenthos found at this location.

Total Suspended Solids (TSS) can affect the growth of macrozoobenthos in waters (Saiful et al., 2020). In addition, it can affect the brightness of the waters where the incoming light will be blocked by particles floating in the water body. Based on the results of the analysis, the Total Suspended Solid (TSS) parameter has no correlation relationship to the abundance of macrozoobenthos where the correlation value formed is -0,779. According to Angelia et al., (2019) if the correlation value obtained is negative, it means that the correlation is not unidirectional, then the value has no effect. Therefore, the content of Total Suspended Solids (TSS) does not affect the abundance of macrozoobenthos at this location.

Total organic matter (TOM) is a content contained in the substrate that can affect the development and different types of macrozoobentos in waters (Gazali et al., 2015). This is because each type of macrozoobentos has a different level of tolerance to organic matter in susbtrate. It is known that the texture of the substrate obtained is a sand substrate. The shape and nature of the sand substrate is coarse and fragmentary so that it tends to only be able to bind a little organic matter content (TOM) (Hawari et al., 2014). Based on the results of the analysis, total organic matter (TOM) has no correlation to the abundance of macrozoobenthos where the correlation value obtained is -0,388. According to Angelia et al., (2019) if the correlation value obtained is negative, it means that the correlation is not unidirectional, then the value has no effect. This suggests that total organic matter (TOM) had no influence on the abundance of macrozoobenthos found at the study site.

The abundance of macrozoobenthos seen from its distribution at all three stations based on environmental parameters can be seen in (Figure 6.) where at station 1 the influencing parameter is temperature. At station 2 the influencing parameters are sand substrate, dissolved oxygen (DO), potential of hydrogen (pH), salinity, and brightness. While at station 3 the parameters that affect are Biological Ogygen Demand (BOD), Total Suspended Solids (TSS), Total Organic Matter (TOM), current speed and depth. Based on this, it shows that the three stations have different characteristics and the environmental parameters that affect the abundance of macrozoobenthos are also different. This makes the three research stations have nothing in common.

Continuous Management Efforts for Makrozoobenthos

Makrozoobenthos is one of the diversity of biological resources whose existence can act as ecosystem stability, economic resources and germplasm sources (Wahyuningsih et al., 2022). One example of the role of benthos as an economic source is by utilizing it as a source of food and its shells as handicrafts. Continuous and excessive utilization will result in the presence of macrozoobenthos in an ecosystem can experience population decline and extinction. This will certainly have an impact on the balance of the ecosystem in these waters.

In this study found several types of benthos whose presence can potentially be a food source such as *Laevistrombus canarium, Mactra vioaleca, Circe scripta, Marcia hyantina, Callista erycina, Decatopecten amiculum, Placuna ephippium, Hyotissa hyotis* and *Portunus pelagicus*. Therefore, in order for the biota to be maintained, it is necessary to make sustainable management efforts. One form of macrozoobentos management efforts that can be developed is by providing habitat restocking and creating macrozoobenthos conservation areas.

Conclusion

There were 32 types of macrozoobentos obtained with a total of 2,745 individuals spread across three observation stations. The highest abundance value is located at station 2 which is 49,01 ind/m2 and the lowest abundance value is 46,04 ind/m2. Diversity values ranged from 0,60 – 0,87 (low category), uniformity values ranged from 0,19 – 0,27 (low category), and dominance values ranged from 0,72 – 0,82 (high category).

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