Macrozoobenthos Community Structure at Teluk Marunggai Beach, Nagari Sungai Nyalo, Pesisir Selatan District, West Sumatera Province

Panji Ahmad Ariaz[1*], Zulkifli[1], Efriyeldi[1]

[1]Department of Marine Sciences, Faculty of Fisheries and Marine, Universitas Riau, Pekanbaru 28293 Indonesia
*Panji.ahmad2371@student.unri.ac.id

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Abstract

Teluk Marunggai Beach, Nagari Sungai Nyalo, is one of the new tourist areas in Pesisir Selatan Regency which, over time, will begin to be in demand by tourists, which will have an impact on the life of the biota on the beach, one of which is macrozoobenthos. This research was conducted in March 2023 in the Intertidal Zone of Teluk Marunggai Beach, Sungai Nyalo Village, Koto Ampek Tarusan District, Pesisir Selatan Regency, West Sumatra Province. The purpose of this study was to determine the type and abundance of macrozoobenthos species in the coastal waters of Marunggai Bay and to determine the diversity, uniformity, dominance and distribution patterns of macrozoobenthos in the coastal waters of Marunggai Bay. The research method used is the survey method, where the sampling using the quadrant transect method is carried out at three stations. The research results found 40 species of macrozoobenthos. The most common species found at all stations were *Turbo cinereus* from the Turbinidae family and the Gastropod class. The macrozoobenthos abundance values obtained ranged from 6.44–6.67 ind/m^2. Species diversity index values ranged from 3.06–3.52, namely high. Uniformity index values ranged from 3.02 to 3.14, high uniformity, dominance index values ranged from 0.10 to 0.15; no species dominated, and the value of the distribution pattern ranged from 2.959 to 2.962 with a group distribution pattern.

1. Introduction

Nagari Sungai Nyalo is one of the new tourist areas in South Pesisir Regency. Geographically, Sungai Nyalo Village faces the Mentawai Islands Regency and the Indian Ocean, which can cause wave activity and affect the tides. The position of the coastal waters in Sungai Nyalo Village is relatively sheltered due to the presence of small islands around it, so the influence of wind causes waves to be reduced and makes the waters at Nyalo Beach classified as calm waters (Mukhtar et al., 2016). One of the beaches located in Sungai Nyalo Village is Teluk Marunggai Beach.

Geographically, the Teluk Marunggai beach area is located around the edge of the hills, forming a bay that is entirely obstructed by small islands in front of it and has relatively calm waves and white sand beaches. This beach can still be said to be natural, as can be seen from the minimal tourism activities that are still carried out. However, along with the development of information in the community, Marunggai Bay Beach will begin to be in demand by tourists, which will ultimately impact the life of biota on the beach, one of which is macrozoobenthos.

Macrozoobenthos is a water-bottom organism that lives on the surface (epifauna) or inside (infauna) of the water-bottom substrate.

Macrozoobenthos can be distinguished based on their movement: benthic animal groups whose lives settle on the bottom of the waters and benthic animals whose lives move. Benthic animals that live sedentary are often used as indicators of water conditions; natural factors that affect the presence and distribution of macrozoobenthos are current speed, bottom substrate, temperature, dissolved oxygen, pH, turbidity, suspended density, food, competition, predation relationships and disease (Pratiwi, 2017).

Organisms that live in waters, such as macrozoobenthos, are susceptible to changes in water quality where they live, which will affect their composition and abundance. This depends on their tolerance to environmental changes, so these organisms are often used as indicators of the pollution level of a body of water. In addition, macrozoobenthos are aquatic organisms that live at the bottom of the water with relatively slow and sedentary movement and relatively long life cycles so that these animals can respond to water quality conditions continuously (Setiawan, 2010).

A decrease in the abundance and composition of macrozoobenthos organisms can be used to indicate ecological disturbances that occur in a body of water (Oktarina & Syamsudin, 2015). The abundance and diversity of macrozoobenthos are highly dependent on tolerance and sensitivity to environmental conditions. The tolerance of benthic animals varies depending on the environment (Pelealu et al., 2018). So, calculating the structure of the macrozoobenthos community through indicators of abundance, diversity, uniformity, dominance, and distribution patterns of macrozoobenthos can quickly determine the ecological quality of waters for the life of these macrozoobenthos.

Research on the structure of macrozoobenthos communities in waters in various regions has been carried out, including Lestari (2015) in the mangrove forest area of Maligi Beach, West Pasaman Regency. Anggara et al. (2021) in Sambungo Village, Silaut District, Pesisir Selatan Regency, West Sumatra Province and Julians et al. (2023) in seagrass ecosystems in the waters of Nirwana Beach and Panjang Island waters in West Sumatra.

2. Methodology

2.1. Time and Place

This research was conducted in March 2023. The research location was in the intertidal zone of Marunggai Bay Beach, Nagari Sungai Nyalo, Koto Ampek Tarusan Subdistrict, Pesisir Selatan District, West Sumatra Province (Figure 1). Identification of macrozoobenthos samples and analysis of sediment samples were carried out at the Marine Biology and Marine Chemistry Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau.

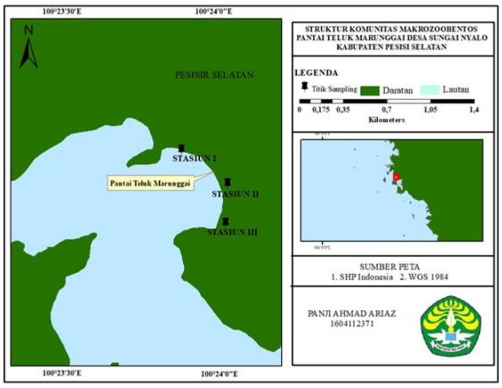

Figure 1. Research Location Map

2.2. Method

The method used in this study is a survey method, namely direct observation of the research area and sampling and measurement of water quality parameters in the field. Parameters to be measured include macrozoobenthos species, abundance, diversity, uniformity, dominance, distribution patterns, water temperature, salinity, acidity, total organic matter and sediment type. Furthermore, the samples were identified and analyzed at the Marine Biology Laboratory of the Department of Marine Science, Faculty of Fisheries and Marine Sciences, Universitas Riau.

2.3. Procedure

Before The research station was determined using the purposive sampling technique, the research sampling represented the characteristics of the environment in Teluk Marunggai Beach, Sungai Nyalo Village, Pesisir Selatan Regency, West Sumatra Province. Each research station is divided into three subzones: 1) upper intertidal zone, 2) middle intertidal zone, and 3) lower intertidal zone. Each research station has three transects with a distance of 30 m between transects; each transect consists of 3 plots with a quadratic plot size of 1 x 1 m^2 with a distance of 5 m between plots. Furthermore, measurements of water quality parameters, including temperature, pH, and salinity, were taken.

In this study, sediment samples were also taken to measure organic matter and sediment fraction. Sediment samples were taken using a 10 cm diameter pipe with a depth of 15 cm.

2.4. Data Analysis

Macrozoobenthos samples were brought to the laboratory, washed with fresh water, and then macrozoobenthos identified and grouped into trays labelled according to the station point. Samples were identified based on the shape obtained using the identification book (Carpenter & Niem, 1998).

2.4.1. Macrozoobenthos Abundance

According to Brower & Zar (1990), density is calculated using the following formula:

$$D = ni / A$$

Description:
Di = The abundance of the i-th individual species (ind/m^2)
ni = Number of individuals of the i-th species obtained
A = Plot area of the i-the species found (m^2)

2.4.2. Diversity Index

Macrozoobenthos species diversity index based on the Shannon Wienner formula (Kasry et al., 2012) with the following formula:

$$H' = -\sum_{i-1}^{s} pi\ (\ln pi)$$

Description:
H’ = Species diversity index
Pi = ni/N
Ni = Number of individuals of the i-th species
N = Total number of individuals
s = Number of species captured

2.4.3. Macrozoobenthos Diversity Index

The species uniformity index is calculated by the Shannon-Wiener formula (Fajri, 2013), namely:

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

Description:
E = Uniformity index
H' = Shannon-Wiener diversity index value
s = Number of species

2.4.4. Macrozoobenthos Dominance Index

The dominance index is used to determine the type of macrozoobenthos that dominates in an area, calculated using Simpson's formula (Kasry et al., 2012), namely:

$$C = \sum_{i=1}^{s} (ni/N)^2$$

Description:
C = Dominance index
ni = Number of individuals of each species
N = Total number of individuals of all species
s = Number of individuals captured

2.4.5. Macrozoobenthos Distribution Pattern

Macrozoobenthos distribution patterns were calculated using the Morisita index formula (Fajri, 2013) as follows:

$$Id = N\,\frac{\sum x^2 - \sum x}{(\sum x)^2 - \sum x}$$

Description:
Id = Morisita distribution index
N = Number of sampling plots
Σx = Number of individuals per plot
$\Sigma x2$ = The sum of squares of individual plots

2.4.6. Sediment Fraction and Total Organic Matter

Two methods were used to analyze the sediment fraction: the wet sieving method and the pipette method. The stratified sieve method was used to obtain Ø-1 - Ø4, while for the pipette method, a volumetric pipette was used to obtain Ø5 - Ø7. To analyze the type of sediment fraction (Rifardi, 2008).

The concentration of total organic matter in the sediment was carried out with a formula:

$$BOT = \frac{(Wt\text{-}C)\text{-}(Wa\text{-}C)}{Wt\text{-}C} \times 100\%$$

Description:
Wt = the total weight (crucible + sample) before burning,
Wa = total weight (crucible + sample) after burning
C = weight of the empty crucible

The data obtained in the form of calculations are presented in tables and graphs that are analyzed descriptively, statistics and then descriptively narrated. A one-way

ANOVA statistical test was conducted to determine the difference in macrozoobenthos abundance between stations and sub-zones.

3. Result and Discussion

3.1. Water Quality

Both physical and chemical water quality parameters are carried out to see whether the environment is still good. The measured water parameters include salinity, pH and temperature. The results of water quality measurements in Sungai Nyalo Village can be seen in Table 1.

The temperature at each research station is around 31-32 ºC, and this value is still within normal limits for the life of macrozoobenthos. Temperature plays an essential role in the metabolic process and photosynthesis rate of phytoplankton organisms, which are food for benthic animals. The results of temperature measurements in the waters of Marunggai Bay Beach still provide tolerance, and it can be said that the temperature at each research station is included in the optimum conditions for macrozoobenthos.

Table 1. Average Results of Marunggai Bay Beach Water Quality Measurements

No	Parameter	Unit	Station		
			I	II	III
1	Temperature	˚C	32	32	31
2	Salinity	ppt	34	34	35
3	pH	-	6	6	6

Table 2. Percentage of Sediment Fraction and Sediment Type

Station	Plot	Average Sedimen Fraction (%)			Sediment Type
		Gravel	Sand	Mud	
I	Lower	5.91	87.71	6.39	Sand
	Midle	48.01	47.66	4.33	Sandy gravel
	Upper	13.05	82.15	4.80	Sand
II	Lower	47.24	47.83	4.93	Gravelly sand
	Midle	76.60	16.91	6.49	Gravel
	Upper	83.66	4.22	12.11	Gravel
III	Lower	81.09	13.62	5.30	Gravel
	Midle	64.73	28.81	6.47	Sandy gravel
	Upper	70.11	24.98	4.92	Sandy gravel

According to Meisaroh et al. (2019), the ideal pH value for the life of aquatic organisms is not less than five and not more than 9 for survival and reproduction. So, it can be concluded that the pH value of the waters at the three research stations can still be tolerated for the life of macrozoobenthos. The research results on salinity measurements at each station in the intertidal zone of Marunggai Bay Beach waters obtained values ranging from 30-31 ppt, where the salinity is classified as favourable for macrozoobenthos life. According to Sinyo & Idris (2013), the range of salinity that can still support the life of aquatic organisms, especially macrozoobenthos fauna, is 27-34 ppt. Based on the measurement of water quality parameters, it can be concluded that the waters of Marunggai Bay Beach have a relatively normal quality of aquatic environment and support for the life and sustainability of macrozoobenthos.

3.2. Sediment Type

Sediment types at Marunggai Bay Beach vary in sand, gravelly sand, gravel, and sandy gravel. The highest percentage of gravel is found at station II upper sampling point with a value of 83.66%, the highest percentage of sand is found at station I lower sampling point with a value of 87.71% and the highest percentage of mud is found at station II upper sampling point with a value of 12.11% (Table 2).

3.3. Total Organic Matter in Sediments

The sediment organic matter content at each research station has a different percentage. The highest organic matter content is found at Station I of the Middle zone, with a percentage of 3.30%, while the lowest organic matter content is at Station II of the lower zone with a percentage of 1.55% (Table 3). Macrozoobenthos is closely related to the availability of organic matter in the substrate, because organic matter that is generally found in the bottom substrate is a source of nutrients for biota (Choirudin et al., 2014). Organic matter dramatically influences the abundance of macrozoobenthos, either directly or indirectly. However, high organic matter content is not always favorable for aquatic bottom organisms, because it can clog the respiratory apparatus (Ulfah et al., 2012).

Table 3. Mean Sediment Organic Matter

Point Sampling	Station		
	I	II	III
Lower	3,07	1,55	2,81
Middle	3,30	3,08	2,53
Upper	1,95	1,93	1,65
Average	2,78	2,18	2,33

In general, total sediment organic matter can come from land and waters that are deposited and accumulated on the substrate of the bottom of the waters. The deposition of total sediment organic matter in the form of material can be sourced from shell fragments and dead corals that are more abundant in nearshore areas and the high seas environment (Kohongia, 2002).

3.4. Macrozoobenthos Species and Abundance

The results of observations and identification of macrozoobenthos species in the intertidal zone of Marunggai Bay beach found macrozoobenthos from Malacostraca, Bivalvia and Gastropoda classes consisting of 25 families, 27 genus and 40 species, including *Ceonobita rugosus, Anadara antiquata, Barbatia foliata, B.fusca, Corbicula javanica, Crassostrea virginica, Gloripallium pallium, Marcia opima, Periglypta puerpera, Trisidos torta, Conus betulinus, C.coronatus, C.flavidus, C.quercinus, Cypraea annulus, C.carneola, C.depressa, C.erosa, C.leviathan, C.mauritiana, Cymatium Muricinum, C.parthenopeum, Engina mendicaria, Ellobium aurisjudae, Vexillum rugosum, Latirus philberti, L. polygonus, Mitra eremitarum, M. stictica, Monodonta canalifera, Nerita costata, Polinices lacteus, Pythia scarabaeus, Rhinoclavis sinensis, Strombus urceus, Tectus fenestratus, Trachycardium rugosum, Turbo cinereu, T. petholatus, Vanikoro cancellata*.

The most common macrozoobenthos species in all stations is *T.cinereus* from the Turbinidae family and the Gastropoda class. *T. cinereus* is equipped with a piece of shell that protects its soft organs from predators. *T. cinereus* snails usually occupy sandy and pebble beach habitats around coral reef areas with diverse topography and are rich in microalgae, moss, and organic matter found on the bottom substrate. *T. cinereus* can also be found in the coastal zone, which is not too steep or sloping and has a depth of less than 20 m. *T.cinereus* prefers healthy coral reef environments and clean, flowing waters up to the shore. Adult snails can be found attached to corals or rocks at 1-5 m depth to shallower waters in the intertidal zone (Hamzah, 2021).

The abundance of macrozoobenthos between stations in the waters of Marunggai Bay Beach obtained results of 6.44-6.67 ind/m^2. The highest abundance is found at Station II, which is 6.67 ind/m^2, while the lowest is found at Station III, which is 6.44 ind/m^2. The results of the calculation of macrozoobenthos abundance at each station in the intertidal zone of Marunggai Bay Beach can be seen in Table 4.

Table 4. Mean Abundance Macrozoobenthos at the Between Station

Station	Average ± std Deviation
I	6,56 ± 1,171
II	6,67 ± 1,155
III	6,44 ± 1,171
Average	6,56 ± 1,165

The abundance of macrozoobenthos between intertidal subzones in the waters of Marunggai Bay Beach obtained results of 6.33-6.67 ind/m^2. The highest abundance was found in the upper and middle zone with a value of 6.67 ind/m^2, while the lowest abundance was found in the lower zone with a value of 6.33 ind/m^2 (Table 5).

Table 5. Mean Abundance Macrozoobenthos at the Between Subzone

Subzone	Average ± std. Deviation
Upper	6,67 ± 2,028
Middle	6,67 ± 2,646
Lower	6,33 ± 1,667
Average	6,56 ± 2,113

The abundance of macrozoobenthos between stations in the waters of Marunggai Bay Beach obtained results of 6.44-6.67 ind/m^2. The highest abundance is found at Station II, which is 6.67 ind/m^2. This is thought to be caused by coconut vegetation and many coral fragments that macrozoobenthos can use as a shelter from the waves. Environmental factors are still classified as good, unpolluted, and far from the activities of the local community, and they are among the factors of high abundance at the station.

The abundance of macrozoobenthos at Stations I and III is relatively low compared to Station II, namely 6.54 ind/m^2 and 6.44 ind/m^2. This is thought to be because stations I and II are located in the tourist area of Marunggai Bay Beach, where human activities affect the area so that the habitat of macrozoobenthos is disturbed, but organic matter in the sediment at Stations I and III are 2.78% and 2.33% including high compared to station II (2.18%), this is because the type of substrate at the location of station II is more dominated by gravel. Based on the analysis of sediment fraction in Table 2, the sediment types that dominate Marunggai Bay Beach are gravel and sandy.

Gravel and sandy sediment types are generally nutrient-poor and vice versa, and finer substrates are rich in nutrients. Although organic matter at Stations I and III are high, the community's activities cause ecological pressure and affect the abundance of macrozoobenthos. The low abundance at stations I and III is also thought to be caused by human activities in utilizing the Marunggai Bay Beach area itself and pollutants that enter water bodies due to human activities (anthropogenic pollutants), such as domestic activities (households) in the Marunggai Bay Beach area and those from the mainland, waste from fishing boats and tourist boats, urban activities (urban) and industrial activities that occur on land, and this can interfere with the existence and survival of organisms in it.

According to Fachrul (2007), environmental factors significantly affect the community and abundance of macrozoobenthos. Habitat conditions and high human activity in the habitat strongly influence the existence of benthos (macrozoobenthos and bivalves). In addition, the abundance and distribution of macrozoobenthos are influenced by food availability, predation and competition. According to Werdiningsih (2007), high and low abundance values are also supported by the percentage of organic matter content in the waters. It is suspected that organic matter plays a vital role in providing food sources for macrozoobenthos organisms.

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

The value of the diversity index (H') of macrozoobenthos between stations at Marunggai Bay Beach was found to be 3.06-3.52, with the highest diversity index value found at Station I, namely 3.52 and the lowest diversity index value found at station III, namely 3.06. The value of the uniformity index (E) between stations obtained results 3.02-3.14, with the highest uniformity index value at Station II, namely 3.14 and the lowest uniformity index value at Station III, namely 3.02. The dominance index value (C) between stations is 0.10-0.15, with the highest at station III, 0.15, and the lowest at Station I, 0.10. The results of calculating the index value of diversity, uniformity and dominance of macrozoobenthos between stations at Marunggai Bay Beach can be seen in Table 6.

Table 6. Diversity Index, Uniformity Index, and Dominance

Observation Station	(H’)	(E)	(C)
I	3.52	3.12	0.10
II	3.38	3.14	0.11
III	3.06	3.06	0.15

Ecosystem environmental conditions are good if a high diversity and uniformity index is obtained and a low dominance index value is obtained. According to the results of research by Yuniarti (2012), the condition of the aquatic environment also affects the diversity, uniformity, and abundance of macrozoobenthos.

Diversity index (H') macrozoobenthos in the waters of Marunggai Bay Beach each station obtained values ranging from 3.06 to 3.52 (station I: 3.52; station II: 3.38 and station III: 3.06). The diversity index, according to Fachrul (2007), is a vegetation parameter that is very useful for comparing various communities, especially to study the influence of environmental or abiotic factors on a community or to determine the succession and stability of the community. Following the macrozoobenthos species diversity index, which states 1.0 ≤ H' < 3.0 indicates that the diversity criteria at Station I, station II, and Station III are included in the category of high diversity, the distribution of high numbers of individuals, high productivity, balanced ecosystem conditions, low ecological pressure and stability of the waters have been polluted low.

The community is said to have high species diversity if it is composed of many species with the same species abundance. Conversely, if the community is composed of a few species and only a few species are dominant, then the species diversity is low. In a community that has high diversity, there will be species interactions involving energy transfer (food webs), predation, competition and the division of niches that are theoretically more complex. One of the causes of the moderate macrozoobenthos diversity index at the study site is that there has been a capture by visiting tourists and some resident activities that reduce the quality of the number and type of macrozoobenthos.

The uniformity index (E) of macrozoobenthos in the waters of Marunggai Bay Beach in each station obtained values ranging from 3.02 to 3.14 (station I: 3.12; station II: 3.14 and station III: 3.02). Following the species uniformity index, which states 0.6 ≤ E ≤ 1.0, it can be concluded that the uniformity at Stations I, II, and III is in the high uniformity category. According to Sirante (2011), if the uniformity index is close to one, then the organisms in the community show uniformity. Otherwise if the uniformity index is close to zero, the organisms in the community are not uniform. Meanwhile, according to Hendri (2014), if the value of E is close to 1 (>0.5), it means that the uniformity of organisms in a water body is in balance. There is no competition for both place and food. The diversity and uniformity index value of biota in a body of water highly depends on the number of species in the community. The more species found, the greater the diversity and uniformity, although this value highly depends on the number of individuals of each species and vice versa. According to Purnama et al. (2011), aquatic ecosystems that have not experienced changes in environmental conditions will show an even number of individuals in almost all existing species. Conversely, in aquatic ecosystems that have experienced changes in environmental conditions, the distribution of the number of individuals is uneven because there are species that dominate.

The dominance index (C) of macrozoobenthos in the waters of Marunggai Bay Beach at each station obtained values ranging from 0.10 to 0.15 (Station I: 0.10; Station II: 0.11 and Station III: 0.15), it can be concluded that there is no dominating species at the study site. The dominance index describes a species' dominance pattern over other species in an ecosystem community (Mawazin, 2013). The higher the dominance index value of a species illustrates the pattern of control centred on certain species only or the community is more suitable for certain species. Otherwise, if the dominance index value is lower, it will illustrate that the pattern of species control in the community is relatively spread among each species (Olivia, 2019). In addition, the low dominance of species also indicates that there is no dominating species, which means that there is no significant competition for space, food or living space for these organisms (Hermanses, 2018).

3.6. Macrozoobenthos Distribution Pattern

Distribution patterns between observation stations obtained results 2.959-2.962 where Id> 1, which means the distribution pattern is clustered. Calculation of macrozoobenthos distribution patterns between stations can be seen in Table 7.

Table 7. Macrozoobenthos Distribution Pattern

Station	Id	Distribution pattern
I	2.961	Group
II	2.959	Group
III	2.962	Group

The distribution pattern (Id) of macrozoobenthos in the waters of Marunggai Bay Beach obtained consecutive results in Station I: 2.96, station II: 2.96, and station III: 2.96, it can be concluded that the distribution of macrozoobenthos in the waters of Marunggai Bay Beach is grouping. This follows the statement of Werdiningsih (2007) that the pattern with grouping distribution is a pattern of organisms or biota in a habitat that lives in groups in specific numbers. Meanwhile, according to Nontji (2007), macrozoobenthos can also be found in various environments, and their forms have adapted to the environment.

Several factors, including environmental conditions, sediment substrate type, feeding habits, and production methods, cause this grouping. Macrozoobenthos is one of the molluscs found in various substrates. This is thought to be because macrozoobenthos have higher adaptability than other classes in hard and soft substrates (Triwiyanto, 2015). According to Hidayati (2010), distribution patterns are caused by the instincts of individuals or species to find a suitable living environment for these species. Individuals in the environment will be able to live and grow if the environment where they grow is supportive.

Grouping distribution patterns are caused by factors limiting the existence of a population. The grouping of a species is caused by the tendency to defend themselves from predators and other unfavourable factors. Macrozoobenthos distribution pattern grouping because the types found in large numbers in each type dominate in an area. This grouping distribution has a tendency, like other species, to obtain food and has low mobility properties that make it difficult to move and spread. In addition, the grouping distribution pattern in macrozoobenthos is also thought to be due to the nature of macrozoobenthos itself, which tends to live in groups attached to one place so that interactions between species become more intensive and favourable in terms of reproduction, foraging, and survival and this limits certain species to spread uniformly or randomly.

4. Conclusion

Macrozoobenthos found in the coastal waters of Marunggai Bay consist of Malacostraca, Bivalvia and Gastropoda classes, which include 25 families, 27 genus and 40 species. The species found was Turbo cinereus of the family Turbinidae. The average abundance of macrozoobenthos at each station is classified as moderate. The diversity index value (H') of macrozoobenthos at each station is categorized as high. The value of the uniformity index (E) of macrozoobenthos at each station is high. There is no dominance (C) of macrozoobenthos at each station. Macrozoobenthos distribution patterns between observation stations are grouped.

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