Comparison of the Abundance of Macrozoobenthos in Areas Affected and Unaffected by Reclamation in Pesisir Selatan District

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Article Info

Received
10 March 2025

Accepted
15 May 2025

Keywords:
Beach reclamation, Macrozoobenthos, Mandeh Tourism

Abstract

This study aims to identify differences in macrozoobenthos abundance in areas affected and unaffected by reclamation around the Mandeh Tourism Area. This study was conducted in February–March 2023, using a survey method and sampling with the transect method. This study's results indicate that the water's condition in the Mandeh Tourism Area is still within the limits of the water quality standards and is quite good for the survival of macrozoobenthos. Macrozoobenthos found in Mandeh Tourism Area consisted of 12 families, namely *Arcidae*, *Asterinidae*, *Cardiidae*, *Ellobiidae*, *Nassariidae*, *Neritidae*, *Potamididae*, *Siphonariidae*, *Trochidae*, *Turbinidae*, *Vanikoridae* and *Veneridae*. A mixture of sand and gravel dominates the sediment type in the Mandeh Tourism Area. The total organic matter content of the sediments ranged from 3.65 to 3.90% (low). The density value of macrozoobenthos individuals in areas affected by reclamation is 5.89 ind/m^2 with the highest relative density, *Terebralia sulcata* (26%), in areas unaffected by reclamation the average density of individuals is estimated at 10, 57 ind/m^2 with abundance the highest relative is the type *Pythia scarabaeus* (23%).

1. Introduction

Reclamation is an activity carried out to increase the benefits of land resources from an ecological and socio-economic point of view by backfilling, drying or draining land (Wurjanto 2016). The primary purpose of land reclamation activities is to make damaged or useless wetlands better and more usable. However, coastal reclamation also has a major negative impact, which can harm the surrounding environment and increase water pollution. Industrial or residential areas around the land reclamation area can increase pollution, and so on. One of the consequences of applying land reclamation that does not comply with environmental principles is a decrease in the quality of the waters along the coastline.

Indonesia's coastal areas and small islands are increasingly being drained to meet economic growth needs and rising sea levels. One reclaimed area is the Mandeh tourism area in Pesisir Selatan Regency, West Sumatra province. Reclamation activities carried out in the tourist area of Mandeh are carried out to increase the attractiveness and satisfaction of visitors, such as the construction of hotels on the shoreline as accommodation for tourists. One of the reclamation activities carried out is dumping around the mangrove ecosystem. Stockpiling can affect the life of biota in these waters, especially biota that live on the bottom of the seas, such as macrozoobenthos.

Extraction activities and infrastructure development have a major negative impact that will cause the death of aquatic biota, especially those with less rapid mobility, such as plankton and benthos (Husna et al. 2012). Macrozoobenthos is an aquatic biota that makes the bottom of the water a habitat, so the substrate's composition and particle size significantly influence the abundance and diversity of macrozoobenthos animals. Coastal reclamation can also cause changes in the composition and abundance of biota, such as macrozoobenthos living in the reclaimed aquatic environment (Puspasari et al., 2018). Changes in the abundance of macrozoobenthos may occur due to the influence of the ability of these organisms to adapt to their environment (Dewi & Widyorini, 2014).

This description indicates that the reclamation activities in the Mandeh Tourism Area have influenced the presence and abundance of macrozoobenthos found there. Therefore, it is necessary to investigate the relative abundance of macrozoobenthos in areas affected and unaffected by reclamation, so that there are apparent differences regarding the effects of reclamation activities in the Mandeh Tourism Area.

2. Methodology

2.1. Time, Place, and Materials

This survey was conducted in February-March 2023, sampling in the Mandeh Tourism Area, West Sumatra Province. The sampling stations have been determined based on a targeted sampling technique. Two stations were chosen for this study: in areas that have been reclaimed and those that have not.

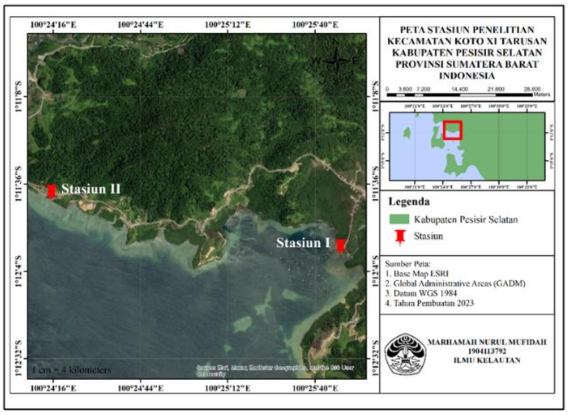

Figure 1. Map of the research station

2.2. Method

The data collection was performed when the seawater was going through the lowest ebb tide to obtain a larger sampling area and facilitate the sampling of macrozoobenthos. The sampling technique was performed using the transect method, where each transect was given three quadrant plots. Sampling in the plot was done by direct collection and sieving, dredging the sediment with a shovel and then sieving with a sieve to separate the sample from the substrate.

2.3. Procedures

In addition to macrozoobenthos samples, this study measured water quality: temperature with a thermometer, salinity with a hand refractometer, pH with a pH indicator, and brightness with a secchi disk. Analysis of Water Quality Data Using Quality Standards Government Ordinance of the Republic of Indonesia No. 22 of 2021 on the Implementation of Environmental Protection and Management.

Table 1. Seawater Quality Standards for Marine Biota

Parameters	Government Ordinance No. 22 of 2021
Salinity (ppt)	33 - 34
pH	7 - 8,5
Brightness (m)	> 3
Temperature (°C)	28 - 32

In addition, sediment samples were also taken to analyze the type of sediment and the total organic matter content of the sediment. The obtained data were quantitatively analyzed using the following formulas:

Individual Abundance

Individual abundance was calculated using the formula of Brower et al. (1990).

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

Information:
D = Individual abundance (ind/m^2)
ni = Number of individuals of type i
A = Area of sampled area (m^2)

Relative Abundance

Relative abundance can be calculated using the Odum (1971) formula.

$$KR = \frac{ni}{N} \times 100\%$$

Information:
KR = relative abundance
ni = number of individuals of each species
N = number of all individuals

Analysis of Sediment Fractions and Type

In the analysis of the sediment fraction in the laboratory, the aforementioned method was followed (Rifardi, 2008), namely, grain size analysis of the sand and gravel fraction using the wet sieve method, because the sludge fraction was analyzed using the pipette method. The results of calculations of the particle size content in the form of gravel, sand and silt in surface sediments are classified according to the Sheppard diagram to determine the sediment type.

Total Organic Matter Content of Sediment

The sediment's total organic matter content was analysed using the Loss on Ignition (LOI) method (Prasetia et al., 2019). The organic matter content is calculated using the formula (Mucha et al., 2003):

$$\text{BOT } (\%) = \frac{a-c}{a-b} \text{ x } 100\%$$

Information:

a = total weight (cup + sample) after drying at 105 ^{0}C,

b = cup weight, and

c = weight of beaker + sample after combustion at 550 ^{0}C

The results of the calculation of the total organic matter content were then analyzed based on criteria for organic matter content in sediments according to Reynolds (1971).

Table 2. Criteria for organic matter content according to Reynolds (1971)

% Organic Matter	Information
> 35	Very high
17 – 35	High
7 – 17	Moderate
3,5 – 7	Low
< 3,5	Very Low

3. Result and Discussion

Water Quality Parameters

Based on the results of measurements of water quality parameters in the areas affected and unaffected by reclamation, it can be concluded that the salinity, pH, brightness and temperature of the water in the two regions are still within the quality standards of the Government Ordinance of the Republic of Indonesia No. 22 of 2021 on the Implementation of Environmental Protection and Management. The results of measuring water quality parameters can be seen in Table 3.

Table 3. Water Quality Parameters at Research Station

Parameters	Affected by Reclamation	Unaffected by Reclamation
Salinity (ppt)	18	29,67
pH	7	7
Brightness (%)	100	100
Temperature (°C)	29	31

The temperature measurement results show a value that is still within the limits of the quality standard. The temperature measurement was carried out before noon in cloudy, sunny weather. According to Nurlinda et al. (2019), a good temperature range for the growth of macrozoobenthos is 25-32 °C. Based on the temperature measurements that have been made, it can be said that the wetlands in the areas affected and unaffected by reclamation have temperatures that are still within normal ranges according to seawater quality standards and are still within normal limits to support macrozoobenthos to live.

Brightness level measurement in affected and unrecovered areas is 100%. In both places, when observed directly, the water still appears clear. According to Kurniawan (2013), the clarity value measured by a secchi disc has an average value of 90%, which means that the water clarity is still in line with quality standards and the water is still classified as good water. Based on seawater quality standards, the clarity obtained in degraded and unexploited areas is classified as suitable for macrozoobenthos survival.

Measurement of the pH value in the degraded and non-mined areas yielded a result of 7. This value indicates that the pH of the waters in the two study areas is still within the norm for the survival of macrozoobenthos. The pH value obtained is quite good as it is in the normal seawater pH range for biota. Most aquatic biota are sensitive to pH changes and like pH values ranging from 7.0 to 8.5 (Effendi, 2003).

One of the parameters that can change due to reclamation is salinization. Changes in salinity can affect the life of marine biota in the environment, where the brackish area (where fresh and seawater meet) is an ideal place to live for some marine biota, as it is rich in nutrients from river currents. During reclamation, the brackish water area can change and shift (Shen et al., 2018). The results of salinity measurements in reclaimed regions are low, with a value of 18 ppt. This value is below the seawater quality standard for biota life. The low salinity is because it is a coastal reclamation area, which is filled with quite large rocks around the area and is also not far from the mouth of the river, through which boats are used as a means of tourist transport. According to Izzah & Roziaty (2016), a good salinity range for macrozoobenthic life is in the range of 15 – 45 ppt, because macrozoobenthos such as annelids, gastropods and bivalves can be found in waters with low or high salinity.

Sediments Type

The analysis of sediment types in areas affected and unaffected by reclamation showed that the predominant sediment types were sand and gravel. Sand is very dominant, and the condition of the beach being reclaimed makes the sand content very high (Meynita et al., 2017). The weight percentage of the sediment fraction and type per station can be seen in Table 4.

Table 4. Percentage of Sediment Fraction and Sediment Type

Station	Transect	% Sediment Fraction			Sediment Type
		Gravel	Sand	Mud	
Affected by Reclamation	1	26,96	52,1	20,94	Sandy gravel
	2	24,43	53,48	22,09	Sand Gravel Mud
	3	24,44	50,21	25,35	Sand Mud Gravel
Unaffected by Reclamation	1	73,56	26,34	0,10	Gravel sand
	2	56,48	43,36	0,17	Gravel sand
	3	55,59	44,36	0,05	Gravel sand

Sediment Total Organic Matter Content

The high or low organic matter content in sediments has a major effect on the population of basal organisms (Abdunnur, 2002). Low organic matter content will affect the diversity of macrozoobenthos animals in their environment. An abundance of benthic organisms often supports sediments rich in organic matter. Based on the criteria for organic matter content in sediments according to Reynolds (1971), the analysis results of the organic matter content of sediments in areas affected and unaffected by reclamation are classified as low. The value of the total organic matter content of the sediment can be seen in Table 5.

Table 5. Total Organic Matter Content of Sediments

Station	Transect			Average (%)
	1	2	3	
Affected by Reclamation	4,35	3,64	3,7	3,90 ± 0,32
Unaffected by Reclamation	3,07	3,82	4,07	3,65 ± 0,42

Species of Macrozoobenthos

The species of macrozoobenthos found in degraded and non-reclaimed areas originate from the molluscs and Echinodermata phyla, consisting of 3 (three) classes, 12 families, 15 genera and 19 species. Macrozoobenthos from the gastropod class were found more frequently than the bivalve class. Macrozoobenthos found in areas affected by reclamation consists of the molluscs and Echinodermata. Of the Mollusca phylum, there are six species of Gastropoda class and two species of Bivalvia, while of the Echinodermata phylum, only one species of Asteroidea class. Macrozoobenthos found in degraded and non-reclaimed areas can be seen in Table 6.

The dominant species in the reclamation affected area is *Terebralia sulcata*. According to Dharma (1988), *T. sulcata* is a gastropod commonly inhabiting mangrove forests that can be found as epifauna and arboreal fauna, so it has a wide distribution. This type of animal lives on muddy beach bottoms and is a unique species in the mangrove ecosystem. It can be found on rocks and mangrove trunks in the reclamation area. *T. sulcata* is one of the native mangrove snails that can adapt well to environmental changes. This species has a thick and strong shell, which allows it to adapt to different environmental conditions. Based on the environmental conditions, reclaimed land is one of the factors contributing to the many species of *T. sulcata* found. This aligns with Lasalu et al. (2015) stating that only animals with a high tolerance for extreme changes and physical factors can survive and thrive in their habitat.

Table 6. Species of Macrozoobenthos

Class	Family	Genus	Species	Affected by Reclamation	Unaffected by Reclamation
Gastropoda	Potamididae	Telescopium	*T. telescopium*	√	-
		Terebralia	*T. sulcata*	√	-
			T. palustris	√	-
	Neritidae	Nerita	*N. textilis*	√	-
			N. histrio	√	-
			N. plicata	√	√
			N. balteata	-	√
	Siphonariidae	Siphonaria	*S. zelandica*	-	√
	Trochidae	Monodonta	*M. australis*	-	√
	Vanikoridae	Vanikoro	*V. cancellata*	-	√
	Ellobiidae	Pythia	*P. scarabaeus*	-	√
	Nassariidae	Nassarius	*N. mutabilis*	-	√
	Turbinidae	Turbo	*T. bruneus*	-	√
Asteroidea	Asterinidae	Parvulastra	*P. exigua*	√	-
Bivalvia	Arcidae	Barbatia	*B.amygdalum-tostum*	-	√
	Veneridae	Chionopsis	*C. pulicaria*	√	-
		Periglypta	*P. reticulata*	-	√
		Dosinia	*D. histrio*	-	√
	Cardiidae	Dallocardia	*D. muricata*	-	√

Information: √ = Present; - = Not present

In areas affected by reclamation, macrozoobenthos of the gastropod class are more common. This is in agreement with the statement of Ramadhan et al. (2023), macrozoobenthos found in the land reclamation area in the Mandeh Tourism Area consists only of the gastropod and bivalve classes which are in the form of shells only because the substrate is in the area smells rotten due to a mixture of land reclamation materials and land repotting that results in low organic matter in the area. Only 2 (two) species were found in the bivalve class macrozoobenthos, and this happened because bivalves are biota that cannot move and cannot adapt to the impact of coastal reclamation in that area. Based on the environmental conditions and components of the reclamation material, this is a supportive factor for finding more gastropods compared to macrozoobenthos of other classes, especially in areas affected by reclamation.

Only eight species of macrozoobenthos from the Mollusc phylum were found in areas unaffected by reclamation, consisting of 8 species of gastropods and four species of bivalves. Gastropods are a group with a wide variety of species due to their ability to adapt to different habitats and ecosystems. The most common gastropod found in areas unaffected by reclamation is *Phytia scarabaeus* from the family Ellobiidae. *P. scarabaeus* is a gastropod species generally found in coastal environments, especially near mangrove forests. It can also live on medium, sandy, and muddy substrates (Kinasih, 2018). Mangrove forests are still common in the coastal areas of the Pesisir Selatan district, and this is a factor that causes the dominance of the *P. scarabaeus* species.

Abundance of Macrozoobenthos

The abundance of individuals in areas affected by Prohibition is lower than in areas unaffected by Prohibition. Tables and graphs of the abundance of individual macrozoobenthos can be seen in Table 7.

Table 7. Species Abundance of Macrozoobenthos

Station	Abundance ± Std. dev
Affected by reclamation	5,89 ± 0,42
Unaffected by reclamation	10,57 ± 0,57

It is believed that the low abundance value of macrozoobenthos in areas affected by reclamation is due to stockpiling, which can make the ecosystem unstable so that only macrozoobenthos with high adaptability can survive. In addition, the study site is close to human settlements, and there is a lot of household waste, fishing boats, and tourists, which can affect the abundance of macrozoobenthos due to high ecological pressure.

The graph above shows that the calculation results for the abundance of macrozoobenthos have different values between the stations. The high value of macrozoobenthos abundance in areas unaffected by reclamation is believed to be because the area is quite far from human settlement, and mangrove ecosystems are still found in that area. In addition, the high density of macrozoobenthos in areas unaffected by reclamation is influenced by good water quality. Optimal water conditions and a pristine environment will impact the quality of life of macrozoobenthos. Various types of macrozoobenthos have also been found in areas that have not been reclaimed. This indicates that the area unaffected by reclamation is still in good condition for macrozoobenthos life.

Differences in macrozoobenthos abundance between stations were caused by different types of substrate, where in areas affected by extraction, the substrate was a mixture of gravel, silt and sand. In contrast, the substrate was dominated by gravel and sand in areas unaffected by extraction. The bottom water substrate will determine the macrozoobenthos animals' density and species composition. Tasabramo et al. (2013) state that the sand substrate is the most preferred habitat for macrozoobenthos animals. According to Atmaja (2011), the bottom substrate, which consists of coarse muddy sand, will generally be inhabited by more macrozoobenthic animals compared to the bottom of the waters, which consists of mud flats. This is because coarse, muddy sand sediments are more stable and allow gas exchange and the exchange of food or nutrients.

Based on the results of the data analysis performed, it can be concluded that the reclamation development in the Mandeh Tourism Area mathematically influences the abundance of macrozoobenthos in the area. In addition, the reclamations carried out have impacted the diversity of macrozoobenthos living in the reclaimed area. This is in line with previous research conducted by Dewi & Widyorini (2014), which found that the diversity of macrozoobenthos in regions affected by reclamation has been included in the low category due to changes in environmental conditions, especially substrate conditions.

Relative Abundance of Macrozoobenthos

Based on Figure 2, it can be seen that the highest relative density of macrozoobenthos in regions affected by reclamation is the species *T. sulcata*.

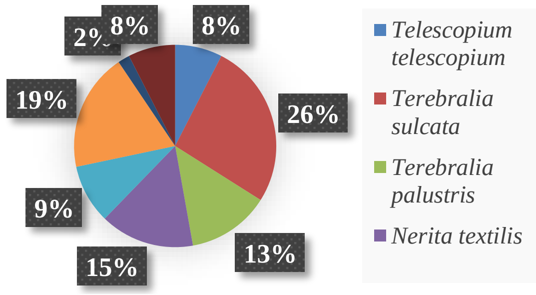

Figure 2. Scheme of Relative Density (%) of Macrozoobenthos in Areas Affected by Reclamation

The *T. sulcata* is a species of gastropod. According to Alwi et al. (2020), gastropods have a hard shell and mobile properties that are more active, allowing them to survive compared to other classes. In addition, gastropods have a reasonably large pattern of adaptation to changes in environmental factors. Therefore, *T. sulcata* has the highest relative abundance of macrozoobenthos in the reclamation-affected area because it is a species that has greater adaptability and tolerance to its environment in the reclamation area. The lowest relative abundance in the reclamation-affected area was *P. exigua*, which was 2%. The macrozoobenthos of the *P. exigua* species found in areas affected by reclamation has a low relative density value, which is believed to be due to the environmental conditions in the reclamation area with salinity below seawater quality standards and is classified as low, which is 18 ppt. The salinity value is well below the tolerance value for starfish salinity, which is 30-34 ppt.

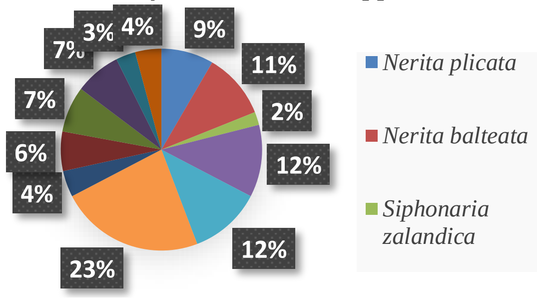

Figure 3. Scheme of Relative Density (%) of Macrozoobenthos in Areas Unaffected by Reclamation

The highest relative density in areas unaffected by reclamation is the *Phytia scarabaeus*, which is 23% (Figure 3). *P. scarabaeus* lives in habitats with medium to moderately muddy substrates near mangrove forests (Kinasih, 2018). This is consistent with the environmental conditions in areas unaffected by reclamation, with a sandy gravel substrate and surrounded by mangrove plants, so the *P. scarabaeus* species are abundant. The lowest relative density in areas unaffected by reclamation was *Dosinia histrio*, at 3%. Macrozoobenthos type *D. histrio* belongs to the class of bivalves. Bivalvia are sand-burrowing organisms that are difficult to find in large numbers.

4. Conclusion

Based on the survey results, the waters in the tourist area of Mandeh are classified as suitable for macrozoobenthos life. The macrozoobenthos originated from the Echinodermata tribe, namely the Asteroidea class, and the Mollusc tribe, which consists of the Gastropod and Bivalve classes. The found macrozoobenthos consisted of 12 families, namely *Arcidae, Asterinidae, Cardiidae, Ellobiidae, Nassariidae, Neritidae, Potamididae, Siphonariidae, Trochidae, Turbinidae, Vanikoridae* and *Veneridae*.

The abundance value of macrozoobenthic species in areas affected by reclamation was 5.89 ind/m^{2,} with the highest relative density, *Terebralia sulcata* (26%). In areas unaffected by reclamation, the species abundance was 10.57 ind/m^2, with the highest relative density, namely type *Pythia scarabaeus* (23%).

References

[PP] Peraturan Pemerintah Nomor 22 Tahun 2021 tentang pelaksanaan perlindungan dan pengelolaan lingkungan hidup.

Abdunnur, A. (2002). Analisis Model Brocken Stick terhadap Distribusi Kelimpahan Spesies dan Ekotipologi Komunitas Makrozoobenthos di Perairan Pesisir Tanjung Sembilan Kalimantan Timur. *Jurnal Ilmiah Mahakam*, 1(2).

Alwi, D., Muhammad, S., & Herat, H. (2020). Keanekaragaman dan Kelimpahan Makrozoobenthos pada Ekosistem Mangrove Desa Daruba Pantai Kabupaten Pulau Morotai. *Jurnal Enggano*, *5*(1): 64-77.

Atmaja, J.L. (2011). *Studi Kelimpahan Hewan Makrobenthos pada Daerah Intertidal di Pantai Bandengan Jepara*. Fakultas Perikanan dan Ilmu Kelautan, Universitas Diponegoro, Semarang.

Brower, J., Jerrold, Z., & Ende, C.V. (1990). *Field and Laboratory Methods for Genera Zoology*. (3rd ed). United States of America: W.M.C. Brown Publishers

Departemen Kelautan dan Perikanan Kabupaten Pesisir Selatan. (2012). *Pengembangan Sumberdaya Kelautan dan Perikanan Pesisir Selatan*. Painan.

Dewi, T.S., & Widyorini, N. (2014). Kelimpahan Hewan Makrobenthos pada Daerah yang Terkena Reklamasi dan Tidak Terkena Reklamasi di Pantai Marina, Semarang. *Management of Aquatic Resources Journal (MAQUARES)*, *3*(2): 50-57.

Dharma, B. (1998). *Siput dan Kerang Indonesia*. PT. Sarana Graha. Jakarta.

Effendi, H. (2003). *Telaah Kualitas Air Bagi Pengelolaan Sumberdaya dan Lingkungan Perairan*. Kanisius. Yogyakarta.

Fuadi, K., & Yoswaty, D. (2016). Kajian Potensi Ekowisata Bahari Kenagarian Mandeh Kecamatan Koto XI Terusan Kabupaten Pesisir Selatan Provinsi Sumatera Barat. *Jurnal Online Mahasiswa (JOM) Bidang Perikanan dan Ilmu Kelautan*, *3*(2): 1-12.

Husna, N., Alibasyah, M.R., & Indra, I. (2012). Dampak Ekologi, Sosial dan Ekonomi Masyarakat Akibat Reklamasi Pantai Tapaktuan Aceh Selatan. *Jurnal*

Manajemen Sumberdaya Lahan, 1(2): 171-178.

Izzah, N.A., & Roziaty, E. (2016). Keanekaragaman Makrozoobentos di Pesisir Pantai Desa Panggung Kecamatan Kedung Kabupaten Jepara. *Bioeksperimen: Jurnal Penelitian Biologi*. 2(2): 140- 148.

Kinasih, A.G. (2018). Studi Hubungan Struktur Komunitas Makrozoobenthos dengan Kualitas Perairan di Rumah Mangrove Wonorejo, Surabaya. *Prosiding Seminar Nasional Kelautan dan Perikanan. Tunjungan-Surabaya*.

Kurniawan, K. (2013). *Analisis Kualitas Air dilihat dari Total Suspended Solid (TSS) di Perairan Pulau Pahawang Lampung*. *Jurnal Praktek Laut*. Universitas Sriwijaya.

Lasalu, N., Sahami, F.M., & Kasim, F. (2015). Komposisi dan Keanekaragaman Gastropoda Ekosistem Mangrove di Wilayah Pesisir Teluk Tomini sekitar Desa Tabulo Selatan Kecamatan Mananggu Kabupaten Boalemo Provinsi Gorontalo. *The Nike Journal*, *3*(1).

Meynita, D., Muskananfola, M., & Sedjati, S. (2017). Hubungan Tekstur Sedimen dan Kandungan Bahan Organik dengan Kelimpahan Makrozoobentos di Muara Sungai Silandak, Semarang. *Management of Aquatic Resources Journal (MAQUARES)*, *5*(4): 363-370.

Mucha, A.P., Vasconcelos, M.T.S.D., & Bordalo, A.A. (2003). Macrobenthic Community in the Douro Estuary: Relation with Trace Metals and Natural Sediment Characteristics. *Environmental Pollution.*

Nurlinda, S., Kasim, M., & Nur, A.I. (2019). Struktur Komunitas Ikan Karang pada Terumbu Karang Buatan di Perairan Desa Tanjung Tiram Kecamatan Moramo Utara Kabupaten Konawe Selatan. *Jurnal Manajemen Sumber Daya Perairan*, 4(1): 75–82.

Odum, E.P. (1971). *Dasar-Dasar Ekologi*. Diterjemahkan oleh: T. Samingan dan B. Srigandono. Fundamentals of ecology. Gadjah Mada University Press.

Prasetia, M.N., Suprihayono, S., & Frida, P. (2019). Hubungan Kandungan Bahan Organik dengan Kelimpahan dan Keanekaragaman Gastropoda pada Kawasan Wisata Mangrove Desa Bedono Demak. *Journal of Maquares,* 8(2): 87-92.

Puspasari, R., Hartati, S.T., & Anggawangsa, R.F. (2018). Analisis Dampak Reklamasi terhadap Lingkungan dan Perikanan di Teluk Jakarta. *Jurnal Kebijakan Perikanan Indonesia*, *9*(2): 85-94.

Ramadhan, R., Tanjung, A., & Elizal, E. (2023). The Impact on Coastal Reclamation on the Existence of Macrozoobenthos in the Nagari Mandeh Water Area, Pesisir Selatan District, West Sumatra. *Asian Journal of Aquatic Sciences*, *6*(1): 76-83.

Reynold, S.C. (1971). *A Manual of Introductory Soil Science and Simple Soil Analysis Methods.* South Pacific, Noumea, New Caledonia.

Rifardi, R. (2008). *Tekstur Sedimen, Sampling dan Analisis.* UNRI Press. Pekanbaru.

Shen, Y., Jia, H., Li, C., & Tang, J. (2018). Numerical Simulation of Saltwater Intrusion and Storm Surge Effects of Reclamation in Pearl River Estuary, China. *Applied Ocean Research*, *79*: 101-112.

Tasabaramo, I.A., Ambo-Rappe, R., & Amran, M.A. (2013). Keberadaan Makrozoobentos Hubungannya dengan Penutupan Lamun di Perairan Pulau Bonebatang, Makassar. *Jurnal Ilmu Kelautan dan Perikanan, 23*(1): 21-28.

Wurjanto, A. (2016). *Reklamasi Teluk Jakarta: Peran Ilmu dan Pengetahuan Teknik Kelautan*. Disampaikan dalam Diskusi Forum Guru Besar ITB tentang Reklamasi Teluk Jakarta, Balai Pertemuan Ilmiah ITB Bandung.