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The Relationship between Sediment Grain Size and Bivalve Abundance in Nirwana Beach Waters, Padang City, West Sumatra

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ABSTRACT

Bivalves are benthic organisms that act as bioindicators of ecosystem balance. One of the main factors affecting bivalve abundance is sediment condition. Nirvana Beach is both a tourist area and a harbor for traditional fishing boats. These activities have the potential to change sediment characteristics, which in turn can affect habitat stability, nutrient availability, and various biological processes that support bivalve life. This study aims to determine sediment grain size, bivalve abundance, and the relationship between the two. Sediment and bivalve sampling were conducted using a purposive sampling method at three observation stations. Results showed two main sediment types, gravel and sand gravel, with gravel dominating at all stations. Sediment size was classified as granule and very coarse sand, with mean size values ranging from -2.66 to -1. Bivalve abundance was highest at station II (4.6 ind/m²) and lowest at station I (3.2 ind/m²). Regression analysis showed a very strong relationship between sediment grain size and bivalve abundance. This confirms that sediment characteristics play a role in determining bivalve abundance at Nirvana Beach.

Keywords: Abundance, Bivalves, Nirwana Beach, Sediment.

1. INTRODUCTION

Nirwana Beach is situated in Lubuk Begalung District, Padang City, West Sumatra, with a 3-km coastline. This area is managed as both a tourist destination and a traditional fishing port. The beach has a large tidal area, and the tidal zone of this beach has different substrates inhabited by various types of biota. This beach is one of the ecosystems rich in biodiversity and plays a crucial role in maintaining environmental balance. One group of organisms that plays a significant role in the coastal ecosystem and is highly valuable as macrozoobenthos is the Bivalvia category (Sitompul, 2020).

Bivalvia are a group of mollusks that live on the seabed with soft substrates, such as sand and mud. The main characteristics of bivalves are paired shells with strong muscles and a shovel-shaped foot (Samson et al., 2020). Bivalves are animals that can be used as bioindicators of ecosystem balance. The availability of organic matter in sediments can influence the variation in the abundance of organism’s present (Razid et al., 2021). The main factor influencing the distribution of bivalves in the intertidal zone is sediment conditions. When sediment changes, bivalve life is also affected. Sediment grain size can influence bivalve habitat stability, nutrient availability, and other biological processes such as burial and the ability of bivalves to survive predators (Yanti et al., 2022).

Ecologically, the abundance of bivalves can indicate the health of coastal ecosystems. Bivalves are highly sensitive to environmental changes, including pollution, temperature fluctuations, salinity variations, and alterations in sediment characteristics (Supriyantini et al., 2017). Economically, bivalves are also a vital resource, particularly for the fishing and aquaculture industries. Bivalves play a crucial role in the food chain, serving as a nutrient source for marine predators, including fish and birds.

The relationship between sediment grain size and bivalve abundance is highly relevant. Several factors influencing the abundance of this biota include sediment grain size and organic matter content, as bivalves are bioindicators of aquatic ecosystems. Some species inhabit muddy substrates, where fine sediments typically contain more organic matter (Sitorus, 2008), while others prefer sandy or rocky substrates.

Bivalves also absorb nutrients from

organic particles in the sediment, and water quality factors such as temperature, salinity, and oxygen levels also influence bivalve abundance (Geodefroo et al., 2023). High organic matter content can support larger bivalve populations. Therefore, this study aims to analyze sediment grain size, identify bivalve abundance, and evaluate the relationship between sediment grain size and bivalve abundance in the waters of Nirwana Beach, Padang City, West Sumatra.

2. RESEARCH METHOD

Time and Place

This research was conducted at Nirwana Beach, Padang, West Sumatra, in February 2025. Sediment grain size analysis was carried out at the Physical Oceanography Laboratory, and bivalve identification was conducted at the Marine Biology Laboratory, Department of Marine Science, Faculty of Fisheries and Marine, Universitas Riau.

Method

The method used in this study was a survey method, which involved direct sampling in the field at Nirwana Beach in Padang City, West Sumatra Province. The samples obtained in the field were then analyzed at the Physical Oceanography Laboratory and Marine Biology Laboratory of the Faculty of Fisheries and Marine Sciences, University of Riau.

The sampling points were determined using purposive sampling, a sampling technique that considers specific criteria. Based on the considerations made, the research area was divided into 3 (three) stations, each with 5 (five) sampling points, with each point covering a 1x1m² quadrant. Station I is the port activity area. Station II is the tourist activity area. Station III is the shellfish fishing activity area.

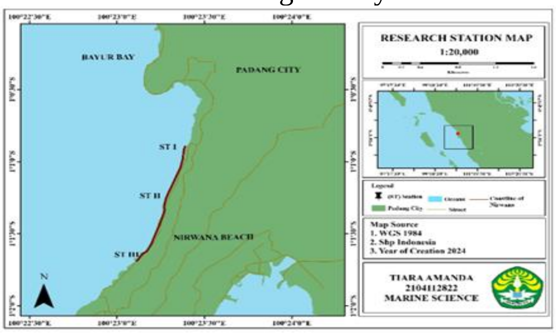

Figure 1. Research station map

Procedures

Sediment Grain Size Analysis

Sediment samples were classified based on sediment fraction size using the Wenworth scale. Next, statistical calculations were performed to determine the mean size. The mean size values are shown in Table 3. The determination of sediment fraction types is presented in tabular form and then analyzed descriptively concerning relevant literature. The mean size values were obtained using the formula (Fork & Ward, as cited in Rifardi, 2012).

$$Mz = \frac{Ø16 + Ø50 + Ø84}{3}.$$

Table 1. Mean sediment size price assessment

No	Classification	Mean / Ø (*phi*)
1	Boulder	(-8)
2	Cobble	(-8) – (-6)
3	Pabble	(-6) – (-2)
4	Granule	(-2) – (-1)
5	Very Coarse Sand	-1 - 0
6	Coarse Sand	0 – 1
7	Medium Sand	1 – 2
8	Fine Sand	2 – 3
9	Very Fine Sand	3 – 4
10	Silt	4 – 8
11	Clay	8 – 16

Source: Rifardi (2008)

Analysis of Bivalve Abundance

Bivalve abundance is calculated by determining the percentage of each different species obtained during identification, which is done by dividing the number of individuals per species by the total number of individuals, using the formula (Odum *in* Adli et al., 2016):

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

Description:

K : Abundance of species i (individuals/m^2)
Ni : Number of individuals of species i obtained
A : Area of the quadrant plot (m^2)

Relationship between Sediment Grain Size and Bivalve Abundance

A simple linear regression test was conducted to test the hypothesis of a relationship between sediment grain size and bivalve abundance. Based on the formula referred to by Sugiyono (2013), the mathematical model is as follows:

$$Y = a + bx$$

Description:

Y : Abundance of bivalves
X : Sediment grain size
a and b : Constants

3. RESULT AND DISCUSSION

Sediment Fractions in Nirwana Beach Waters

Based on the analysis of sediment samples in Nirwana Beach waters, the percentage of sediment fractions in Nirwana Beach waters was determined. The types obtained were gravel and sand gravel. The calculation of sediment fractions is presented in Table 2.

Table 2. Sediment fractions and types in the waters of Nirwana Beach

Station	Sampling Point	Sediment Fraction (%)			Sediment Types
		Gravel	Sand	Mud	
I	1	90,16	8,61	1,23	Gravel
	2	80,13	17,47	2,40	Gravel
	3	86,97	12,77	0,25	Gravel
	4	80,79	17,30	1,91	Gravel
	5	94,65	5,35	0,00	Gravel
II	1	89,76	8,57	1,67	Gravel
	2	79,28	20,72	0,00	Gravel
	3	76,68	22,39	0,93	Sandy Gravel
	4	84,25	15,02	0,73	Gravel
	5	79,48	20,02	0,50	Gravel
III	1	87,88	12,12	0,00	Gravel
	2	95,64	4,10	0,26	Gravel
	3	98,28	1,49	0,23	Gravel
	4	98,60	1,40	0,00	Gravel
	5	86,25	13,51	0,25	Gravel

The sediment analysis results indicate two types, namely gravel and sand-gravel. At Station I, the sediment type is predominantly gravel, with the highest percentage at sampling point 5 at 94.65%. At Station II, the sediment is predominantly gravel, with the highest percentage observed at sampling point 1, at 89.76%. Additionally, there is one type of sandy gravel, comprising 76.68% of the sediment. While at Station III, gravel is the dominant material, with the highest percentage at sampling point 4, at 98.60%.

Sediment Diameter in Nirwana Beach Waters

The results of sediment grain size calculations in Nirwana Beach waters, based on the mean size, are presented in Table 3.

Table 3. Sediment diameter values in the waters of Nirwana Beach

Station	Sampling Point	Sediment Size Ø	Name of Grains
I	1	-2,33	Granule
	2	-2,23	Granule
	3	-2,66	Granule
	4	-1,2	Very coarse sand
	5	-1,6	Very coarse sand
II	1	-2,33	Granule
	2	-2,56	Granule
	3	-1	Very coarse sand
	4	-2,66	Granule
	5	-2,53	Granule
III	1	-2	Granule
	2	-1,93	Very coarse sand
	3	-2,66	Granule
	4	-2,26	Granule
	5	-2,6	Granule

The results of the mean size calculation indicate two types, namely granules and very coarse sand. The highest mean size value is located at station II sampling point 3, which is -

1, and the lowest at station I sampling point 3, which is -2.66.

Based on the flow velocity values at the study site, which range from 0.48 to 0.55 m/s, the flow is classified as fast. Water current velocity can be categorized into four categories: slow current (0–0.25 m/s), moderate current (0.25–0.50 m/s), fast current (0.50–1 m/s), and very fast current (over 1 m/s) (Lubis et al., 2022). The relatively strong current velocity in the waters off Nirwana Beach is sufficient to deposit and retain coarse sediments on the seabed. This aligns with the statement by Nurainie et al. (2020), who noted that coarse-textured sediment particles are generally found in areas with relatively high current velocities, as the high energy levels allow larger particles to remain deposited. Conversely, fine-textured sediments are more dominant in areas with low current speeds, where fine particles can settle more easily.

In addition, sediment grain size is closely related to the source of the sediment. Nirwana Beach, which faces the Indian Ocean directly, indicates that the sediment is likely to originate from the sea, undergo a transportation process, and finally settle at the observation site. According to Gemilang et al. (2017), sediment grain size tends to become finer toward the mainland or near river mouths and mangrove areas, while grain size facing the open sea and far from river mouths is coarser. This finding aligns with the conditions at the study site, where the dominance of particle size reinforces the hypothesis that open-ocean dynamics and minimal influence from the land strongly influence sediment characteristics.

Abundance of Bivalves

The results of observations on bivalve species obtained in the waters of Nirwana Beach are presented in Table 4.

Table 4. Bivalve species found in the waters of Nirwana Beach

Family	Genus	Species
Arcidae	Anadara	*Anadara antiquata*
Mactridae	Mactra	*Mactra chinensis*
Veneridae	Gafrarium	*Gafrarium pectinatum*
Psammobiidae	Asaphis	*Asaphis violascens*
Donacidae	Donax	*Donax faba*
Veneridae	Meretrix	*Meretric lyrata*
Veneridae	Tapes	*Tapes literatus*
Veneridae	Gafrarium	*Gafrarium tumidum*
Mesodesmatidae	Atactodea	*Atactodea striata*

Table 5. Number of bivalve individuals in the waters of Nirwana Beach

Species	Station			Number of Individuals
	I	II	III	
Anadara antiquata	2	1	-	3
Mactra chinensis	1	3	1	5
Gafrarium pectinatum	8	2	-	10
Asaphis violascens	3	-	-	3
Donax faba	-	2	1	3
Meretric lyrata	2	1	1	4
Tapes literatus	-	6	-	6
Gafrarium tumidum	-	-	4	4
Atactodea striata	-	-	3	3
Amount	16	15	10	41

Observations of bivalve mollusks in the waters off Nirwana Beach revealed the presence of 7 families (Arcidae, Mactridae, Veneridae, Psammobiidae, Donacidae, Mesodesmatidae) and nine genera (Anadara, Mactra, Gafrarium, Asaphis, Donax, Meretrix, Tapes, Gafrarium, Atactodea), and nine species (*Anadara antiquata, Mactra chinensis, Gafrarium pectinatum, Asaphis violascens, Donax faba, Meretrix lyrata, Tapes literatus, Gafrarium tumidum, Atactodea striata*) (Table 5).

Environmental quality parameters that

have the potential to affect the growth and development of bivalves themselves. The growth and development of an organism are influenced by temperature, which directly or indirectly affects the life of aquatic organisms. The water temperature at Nirwana Beach ranges from 30-32°C. The optimal temperature range for bivalves to metabolize efficiently is between 25°C and 35°C (Bening & Purnomo, 2019), so the temperature at Nirwana Beach meets the criteria for an optimal temperature for the development and reproduction of bivalves. Water temperature can influence the activities of all aquatic biota, such as metabolism, thereby affecting the growth and development of biota in their habitat (Farid et al., 2023). In addition to water quality parameters, organic matter also influences the abundance, growth, and development of bivalves themselves.

Organic matter in water serves as an indicator of water quality and acts as a nutrient source for organisms living in the ecosystem. Station III, located in the oyster fishing area, has the highest organic matter content at 2.06%. Station II, which features a sandy gravel substrate and is situated in a tourist area, had an organic matter content of 1.42%. Meanwhile, Station I has the lowest organic matter content, at 0.81%.

Table 6. Organic matter content of sediments

Station	Organic Content of Sediment (%)					Average (%)
	1	2	3	4	5	
I	0,71	1,22	0,98	0,66	0,46	0,80
II	1,55	1,37	1,70	1,16	1,34	1,42
III	2,15	2,36	2,23	1,59	1,99	2,06

The organic matter content in sediments is classified into five classes based on its percentage, namely very high (>35%), high (17–35%), moderate (7–17%), low (3.5–7%), and very low (<3.5%) (Simanjuntak et al., 2020). Based on the measurement results, the average organic matter content at each observation station ranged from 0.81% to 2.06%.

This value indicates that the organic matter content at the study site is very low. This is further reinforced by the sediment fraction results at the study site, which are dominated by gravel. Gravel substrates tend to have low capacity to accumulate organic matter, contributing to the low organic matter content in this area. As a result, the availability of food sources for bivalves is also limited. This finding aligns with the results of Yuliana et al. (2020), who reported that smaller sediment particles have a greater ability to trap organic matter compared to larger sediment particles. The relatively low abundance of bivalves is due to the low organic matter content in the gravel fraction. This condition has an impact on the low abundance of bivalves at the study site, considering that the organic matter content in the gravel fraction is very low. This statement is also supported by Kinasih et al. (2015), who stated that, in general, mud sediments are richer in nutrients than sand and gravel sediments.

Relationship Between Sediment Grain Size and Bivalve Abundance

The results of simple linear regression analysis showed a coefficient of determination (R^2) of 0.893, meaning that 89.3% of the variation in bivalve abundance could be explained by sediment grain size. The remaining 10.7% is influenced by other factors such as organic matter content, interspecies interactions, and human activities around the site.

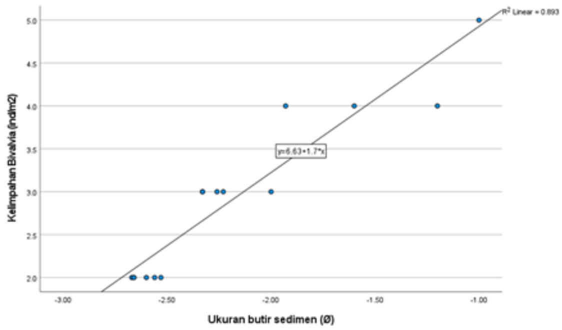

Figure 3. Relationship between bivalve abundance and sediment grain size

The correlation coefficient (r) of 0.945 indicates that the relationship between sediment grain size and bivalve abundance is powerful. The larger the value (Ø), which means the finer the sediment particle size, the greater the tendency for bivalve abundance to increase. The finer the sediment size, the greater the potential for food supply, which can contribute to an increase in bivalve abundance in the area. This positive relationship is visible in the graph, where the regression line slopes upward with the equation y=6.63+1.7x, indicating that an increase follows an increase in the Ø value in the number of bivalves.

Although bivalves are still found in the study area, their abundance is relatively low. However, some bivalve species possess the ability to adapt to less-than-ideal substrate types. One example is Anadara antiquata, which is known to prefer areas with more sand on the seabed and can live not only on muddy sand substrates (Samson & Kasale, 2020). This ecological adaptation allows bivalves to survive even when sediment conditions are not entirely favorable.

4. CONCLUSION

Based on the results of research conducted in the waters of Nirwana Beach, it can be concluded that the sediment grain size in the waters of Nirwana Beach falls into the granule and very coarse sand categories. The abundance of bivalves in the waters of Nirwana Beach ranges from 3.2 to 4.6 individuals per square meter. The relationship between sediment grain size and bivalve abundance in the waters of Nirwana Beach is powerful.

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