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MORPHOMETRIC COMPARISON OF SEAGRASS ENHALUS ACOROIDES AT TUKAK BEACH AND TANJUNG KERASAK BEACH SOUTH BANGKA REGENCY

Perbandingan Morfometrik Lamun *Enhalus Acoroides* Di Pantai Tukak Dan Pantai Tanjung Kerasak Kabupaten Bangka Selatan

Rizka Ramadhayanti[1], Umroh[1*], Eva Utami[1]

[1]Marine Science, Faculty of Agriculture, Fisheries and Marine Sciences, Bangka Belitung University

Balunijuk, Merawang District, Bangka Regency, Postal Code 33172

[*]Corresponding author: umrohumroh784@gmail.com

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ABSTRACT

Variations in water quality and substrate characteristics between Tukak Beach and Tanjung Kerasak Beach are presumed to influence the morphometric traits of *Enhalus acoroides* growing in these areas. Based on previous studies, there is a need for more comprehensive investigation in the South Bangka region, particularly focusing on Tukak Beach and Tanjung Kerasak Beach as the main study sites. This research aims to identify morphometric differences in *Enhalus acoroides* between the two locations, as well as to analyze the relationship between these morphological characteristics and the respective water quality parameters. The fieldwork was conducted in January 2024, with sampling carried out at Tukak Beach and Tanjung Kerasak Beach. Data were collected from six sampling stations, yielding a total of 360 morphometric samples of *Enhalus acoroides*. The results revealed notable differences in morphological measurements of *Enhalus acoroides* between the two study areas. At Tukak Beach, analysis of water quality indicated a significant correlation between dissolved oxygen (DO) levels and leaf length of *Enhalus acoroides*. Meanwhile, findings from Tanjung Kerasak Beach suggested that the local water quality exhibited a moderate level of correlation with the morphometric traits of the same species.

Keywords: Morphometric, *Enhalus acoroides*, Tukak Beach, and Tanjung Kerasak Beach.

ABSTRAK

Perbedaan dalam kualitas perairan serta karakteristik substrat antara Pantai Tukak dan Pantai Tanjung Kerasak diduga dapat memengaruhi morfometrik lamun *Enhalus acoroides* yang tumbuh di wilayah tersebut. Mengacu pada hasil penelitian sebelumnya, dibutuhkan eksplorasi lebih lanjut secara mendalam di wilayah Bangka Selatan, terutama di Pantai Tukak dan Pantai Tanjung Kerasak sebagai lokasi utama penelitian ini bertujuan mengidentifikasi variasi morfometrik lamun *Enhalus acoroides* antara kedua lokasi penelitian tersebut, serta melakukan analisis keterkaitan antara morfometrik lamun tersebut dengan kondisi kualitas perairan di lokasi tersebut. Kegiatan penelitian ini dilaksanakan selama bulan Januari tahun 2024, dengan lokasi pelaksanaan studi bertempat di Pantai Tukak dan Pantai Tanjung Kerasak. Pengambilan data dilakukan di enam titik stasiun, dengan jumlah total 360 sampel morfometrik lamun *Enhalus acoroides* yang berhasil dikumpulkan. Hasil penelitian mengindikasikan bahwa terdapat perbedaan ukuran morfologi pada lamun *Enhalus acoroides* diantara kedua Lokasi penelitian tersebut. Hasil analisis kondisi kualitas perairan Pantai Tukak menunjukkan adanya korelasi yang signifikan antara parameter DO (oksigen terlarut) dan panjang daun lamun *Enhalus acoroides*. Sementara itu, hasil analisis yang dilakukan di kawasan Pantai Tanjung Kerasak menunjukkan bahwa kualitas perairan di wilayah tersebut berada dalam kondisi yang memiliki korelasi dalam tingkat sedang terhadap morfometrik lamun dari spesies *Enhalus acoroides.*

Kata Kunci: Morfometrik, *Enhalus acoroides*, Pantai Tukak dan Pantai Tanjung Kerasak.

INTRODUCTION

The Tukak and Tanjung Kerasak Beach areas can be considered two distinct coastal locations that are habitats for various seagrass species, one of which is frequently encountered, Enhalus acoroides (Supratman & Adi, 2018). The reduction in seagrass area in the Tukak and Tanjung Kerasak Beach areas is likely related to the impacts of anthropogenic activities in the surrounding areas, including tourism, fishing activities at the port, and illegal tin mining (Sari, 2019). These activities have the potential to alter aquatic environmental conditions, ultimately impacting the growth and health of seagrass in the area (Safitri et al., 2024).

Seagrasses are able to respond to changes in their surrounding environment by adapting their shape plasticity (Ramili, 2019). The transformation of seagrass shape is evident in variations in morphometric characteristics, including leaf dimensions (length, width, and number of leaves), as well as rhizome and root dimensions. Seagrasses with larger stem diameters tend to grow more slowly and produce smaller shoot morphologies. When the nutrient content in the substrate is low, seagrass roots will grow longer to expand their nutrient absorption range and maintain the balance of their root system. When nutrient concentrations in the water are higher than in the substrate, seagrass leaves are able to optimally absorb nutrients, resulting in changes in leaf size and an increase in the number of veins (Tuapattinaya et al., 2021).

Data obtained from previous analyses indicate that the morphometric characteristics of the seagrass Enhalus acoroides vary from island to island, both in terms of size and morphometric characteristics. Differences in water quality and substrate characteristics at Tukak Beach and Tanjung Kerasak Beach are believed to influence the morphometrics of the seagrass Enhalus acoroides growing in those areas. Based on existing research results, further, more in-depth research is crucial, conducted in the South Bangka region, with a specific focus on Tukak Beach and Tanjung Kerasak Beach. The main objective of this research was to identify the morphological variations of the seagrass species Enhalus acoroides found in the Tukak Beach and Tanjung Kerasak Beach areas, as well as to analyze the correlation between the morphometrics of the presence of the seagrass and the condition of the surrounding water quality in both locations.

RESEARCH METHODS

Place and Time

This research was conducted in January 2024 at Tukak Beach and Tanjung Kerasak Beach, South Bangka Regency. Parameters measured in this study included temperature, salinity, acidity (pH), and dissolved oxygen content. Furthermore, sediment sampling was carried out directly from the research site to analyze substrate texture. The Aquatic Resources Management Laboratory, Faculty of Agriculture, Fisheries, and Biology, Bangka Belitung University, served as the site for sediment texture analysis. Meanwhile, nitrate and phosphate measurements were conducted at the Global Quality Analytical (GQA) Laboratory in Bogor.

Tools and Materials

The equipment used during the research activities included Personal Protective Equipment (PPE), basic diving equipment, Global Positioning System (GPS) devices, rolling tape measures, 50 × 50 cm square transects, permanent transects, Newtop worksheets, stationery, seagrass species identification books, underwater cameras, black containers, zipped plastic bags, label paper, cooler boxes, iron stakes, thermometers, refractometers, pH meters, Dissolved Oxygen (DO) meters, sediment sampling tools (core samplers), shovels, and rulers. The materials used in this research included seawater, waterbed substrates, seagrass plants, concentrated sulfuric acid solution, distilled water (aquades), and laboratory tissue.

Determination of Research Location Points

The determination of the research location points was carried out through a purposive sampling approach based on certain considerations (Sugiyono, 2016). Sample data collection was carried out at the selected location points. The determination of the research location was carried out based on differences in the water conditions inhabited by Enhalus acoroides seagrass with varying types of substrate. Six observation points were determined, and the coordinates of each location were measured using GPS as a reference position.

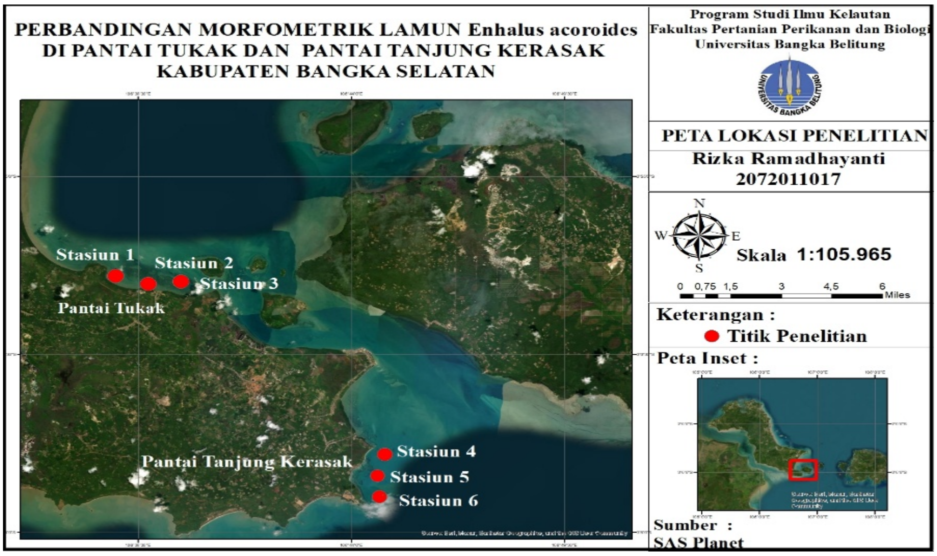

Figure 1. Research Location Point

Techniques for Collecting Information on the Area Covered by Seagrass

The technique applied is using a quadratic transect. Determination of transect data collection begins at a distance of 5 meters to 10 meters starting from the starting point where the seagrass was found. Transects were made using a roll meter with a length of 100 meters. Each research location Three transects were used in this study, with a length of 100 meters per transect and a distance between transects of 50 meters. The measurement tool in the form of a box (quadratic frame) measuring 50x50 cm was placed on the right side of the transect at the 0 meter position, with an interval between quadratic frames of 10 meters, so that the number of quadratic frames used in each transect was 11 e. Seagrass cover data collection was carried out according to the method of Rahmawati et al. (2017), namely by assessing how much part of each small box is covered by seagrass contained in the quadratic frame.

Seagrass Morphometric Sample Collection Procedure

Enhalus acoroides samples were collected when the water level reached its lowest point during low tide. This seagrass sample collection method, the quadratic transect method, was used to collect data on seagrass distribution, in accordance with the procedure described by Rahmawati et al., (2017). Samples were taken by digging up the roots of Enhalus acoroides and their substrate, totaling 20 stands at each research station point. A total of 360 stands were collected, including roots, stems (rhizomes), and leaves. After collection, the roots, stems, and leaves of the samples were cleaned of any remaining substrate and then stored in tightly closed, labeled plastic bags. After that, seawater was added to the plastic to maintain sample freshness and prevent wilting, according to the procedure of Aryanti et al., (2021).

Quantitative Morphometric Measurement Methodology of Seagrass Enhalus acoroides

Morphometric measurements of the seagrass Enhalus acoroides were conducted at the Aquatic Resources Management Laboratory, Bangka Belitung University. Data were collected using calipers with an accuracy of millimeters (mm). Observed parameters included leaf length and width, the length and diameter of the underground stem (rhizome), and root length (Amale et al., 2016).

Water Quality Parameter Measurement

Water quality parameter measurements were conducted directly at the research location (in situ) with three repetitions at each sampling point. Before using the instrument to measure physical and chemical parameters, calibration should be performed first to ensure the accuracy of the data obtained.

Substrate Granule Characterization Method

Substrate sampling was carried out to a depth of 10 cm. The collected substrate was then stored in a tightly closed plastic bag. After being labeled, the samples were stored in a cool box. The next steps refer to Helfinalis (2016) and were carried out at the Water Resources Management Laboratory of Bangka Belitung University.

Study of Substrate Granule Characteristics

Substrate grain characteristics were determined through a pipette sampling procedure according to the Holme and McIntyre (1984) procedure cited in Sihombing et al., (2021). This process was carried out in laboratory facilities located at the Aquatic Resources Management Study Program, Bangka Belitung University.

Nitrate Content Study (NO3)

Nitrate concentration measurements were conducted at the Global Quality Analytical (GQA) Laboratory in Bogor. The analysis process followed SNI 6989.79:2011 guidelines, using a cadmium reduction technique and reading the results using a UV-Vis spectrophotometer.

Phosphate Content Study (PO4)

Phosphate levels were measured at the Global Quality Analytical (GQA) Laboratory in Bogor, in accordance with SNI 06-6989.31-2005 standards, using the ascorbic acid method and a spectrophotometer.

Data Processing Method

1. **Seagrass Cover**

$$\text{Average seagrass cover per location/island (\%)} = \frac{\text{Average seagrass cover at a location or island}}{\text{Number of existing stations}}$$

2. **Seagrass Morphology Measurement**

Morphological measurement data are presented in tabular form and analyzed using descriptive statistical methods. This analysis aims to obtain minimum, maximum, and average values from samples collected at the research site. Descriptive data processing and analysis were performed using Microsoft Excel to facilitate the presentation of results in tabular format (Aryanti et al., 2021).

$$\text{Average} = \frac{X1+X2+X3+Xn}{n}$$

Information:
Xn: total accumulation of all data values.
n : the total amount of data collected or measured.

3. **Statistical Methods**

Statistical analysis was performed using SPSS (Statistical Package for the Social Sciences) version 23 software. This software was used to run the Kruskal-Wallis test, followed by the Pairwise Comparison test and Spearman correlation analysis. The Kruskal-Wallis test is a non-parametric method that functions to test differences between groups with the aim of comparing seagrass morphological data from various research locations through mean testing and hypothesis verification (Jamco & Balami, 2022). Furthermore, the Spearman correlation test was applied to evaluate the relationship between morphometric parameters of the seagrass Enhalus acoroides and water quality conditions at the study location.

RESULT

Table 1. Morphometric measurement data of Enhalus acoroides in the Tukak Beach and Tanjung Kerasak Beach areas

Tukak Beach					
Morphology	Unit	Amount	Min	Max	Average
Leaf Length	Mm	180	216	488	411
Leaf Width	Mm	180	7	12	10
Rhizome Length	Mm	180	80	140	112
Rhizome Width	Mm	180	8	13	10
Root Length	Mm	180	54	173	112
Tanjung Kerasak Beach					
Morphology	Unit	Amount	Min	Max	Average
Leaf Length	Mm	180	105	326	206
Leaf Width	Mm	180	4	8	6,1
Rhizome Length	Mm	180	98	147	123
Rhizome Width	Mm	180	9	12	11
Root Length	Mm	180	40	210	126

Table 2. Correlation between Enhalus acoroides Morphometrics and Water Quality at Tukak Beach

Correlation Variables		SPSS Spearman Correlation Analysis	
Seagrass Morphometrics *Enhalus acoroides*	Water Quality	Correlation	Information
Leaf Length	Temperature	0,579	Currently
	Salinity	0,623	Strong
	pH	0,670	Strong
	DO	0,815	Very strong
	Current Speed	0,632	Strong
	Nitrate	0,791	Strong
	Phosphate	0,791	Strong
	Sand	-0,158	Very weak
	Clay	0,791	Strong
	Dust	-0,632	Strong
Leaf Width	Temperature	0,555	Currently
	Salinity	0,676	Strong
	pH	0,652	Strong
	DO	0,763	Strong
	Current Speed	0,676	Strong
	Nitrate	0,784	Strong
	Phosphate	0,784	Strong
	Sand	-0,108	Very weak
	Clay	0,784	Strong
	Dust	-0,676	Strong
Rhizome Length	Temperature	0,236	Weak
	Salinity	0,133	Very Weak
	pH	0,342	Weak
	DO	0,441	Moderate
	Current Speed	0,133	Weak
	Nitrate	0,425	Moderate
	Phosphate	0,425	Moderate
	Sand	-0,292	Weak
	Clay	0,425	Moderate
	Dust	-0,133	Very Weak
Rhizome Width	Temperature	0,622	Strong
	Salinity	0,261	Weak
	pH	0,342	Weak
	DO	0,698	Strong
	Current Speed	0,622	Strong
	Nitrate	0,351	Weak
	Phosphate	0,351	Weak
	Sand	0,270	Weak

	Clay	0,351	Weak
	Dust	-0,622	Weak
Root Length	Temperature	0,500	Moderate
	Salinity	0,476	Moderate
	pH	0,562	Moderate
	DO	0,654	Strong
	Current Speed	0,476	Moderate
	Nitrate	0,556	Moderate
	Phosphate	0,556	Moderate
	Sand	-0,079	Very Weak
	Clay	0,556	Moderate
	Dust	-0,476	Moderate

Water quality in the Tukak Coast area shows a correlation with the morphometric characteristics of the seagrass Enhalus acoroides. One environmental parameter, namely dissolved oxygen (DO) levels, has a very strong correlation with the length of Enhalus acoroides leaves, indicated by the correlation coefficient obtained of r = 0.815. Based on the Spearman correlation test data which is in the range of 0.800 to 1.000, it can be concluded that there is a very close relationship between DO concentration and the growth of seagrass leaf length. This finding indicates that increasing DO levels in the aquatic environment tends to be followed by an increase in the length of Enhalus acoroides leaves. This can be explained by the important role of dissolved oxygen in supporting the metabolic activities of marine plants, especially in the processes of photosynthesis and respiration, which contribute directly to the development of leaf tissue.

Table 3. Morphometric Correlation of Enhalus acoroides with Water Quality at Tanjung Kerasak Beach

Correlation Variables		SPSS Spearman Correlation Analysis	
Morphometrics of Seagrass Enhalus acoroides	Water Quality	Correlation	Keterangan
Leaf Length	Temperature	0,382	Weak
	Salinity	0,319	Weak
	pH	0,558	Moderate
	DO	0,325	Weak
	Current Speed	0,558	Moderate
	Nitrate	0,399	Weak
	Phosphate	0,399	Weak
	Sand	0,558	Moderate
	Clay	-0,558	Moderate
	Dust	-0,558	Moderate
	Temperature	0,319	Weak
	Salinity	0,558	Currently
	pH	0,558	Currently
	DO	0,185	Weak

Leaf Width	Current Speed	0,324	Weak
	Nitrate	0,243	Weak
	Phosphate	0,243	Weak
	Sand	0,324	Weak
	Clay	-0,324	Weak
	Dust	-0,324	Weak
Rhizome Length	Temperature	0,440	Moderate
	Salinity	0,160	Very Weak
	pH	0,160	Very Weak
	DO	0,292	Weak
	Current Speed	0,160	Very Weak
	Nitrate	0,480	Moderate
	Phosphate	0,480	Moderate
	Sand	-0,160	Very Weak
	Clay	0,160	Very Weak
	Dust	0,160	Very Weak
Rhizome Width	Temperature	0,459	Moderate
	Salinity	0,460	Moderate
	pH	0,460	Moderate
	DO	0,369	Weak
	Current Speed	0,460	Moderate
	Nitrate	0,433	Moderate
	Phosphate	0,433	Moderate
	Sand	0,460	Moderate
	Clay	-0,460	Moderate
	Dust	0,460	Moderate
Root Length	Temperature	0,472	Moderate
	Salinity	0,406	Moderate
	pH	0,406	Moderate
	DO	0,339	Weak
	Current Speed	0,406	Moderate
	Nitrate	0,243	Weak
	Phosphate	0,243	Weak
	Sand	0,406	Moderate
	Clay	-0,406	Moderate
	Dust	-0,406	Moderate

Water quality conditions in the Tanjung Kerasak Coast area show a correlation with the morphometric parameters of the seagrass Enhalus acoroides. Several environmental factors, including temperature, salinity, pH, current velocity, nitrate and phosphate concentrations, and substrate texture characteristics such as sand, clay, and silt, show a moderate correlation with the seagrass morphometrics. Correlation coefficients ranged from r=0.406 to 0.588, which corresponds to the moderate correlation category based on the Spearman's statistical test, ranging from 0.400 to 0.599. Thus, it can be concluded that these water quality parameters have a significant correlation with the morphometric variables of Enhalus acoroides, although not as strong as the correlation with the previously mentioned DO parameter.

Table 14. Percentage of Seagrass Growth Area on Tukak and Tanjung Kerasak Coasts

Research Point	Station	Seagrass Cover (%)	Coverage Percentage (%)	Category	Seagrass Status *
Tukak Beach	1	35,98%	26-50%	Moderate	Unhealthy
Tukak Beach	2	30,49%	26-50%	Moderate	Unhealthy
Tukak Beach	3	32,57%	26-50%	Moderate	Unhealthy
Tanjung Kerasak Beach	1	24,43%	0-25%	Rare	Poor**
Tanjung Kerasak Beach	2	23,10%	0-25%	Rare	Poor**
Tanjung Kerasak Beach	3	23,67%	0-25%	Rare	Poor**

* Seagrass Status Decree of the Minister of Environment No. 200 of 2004
** Poor Seagrass Cover

Table 5. Water Quality Parameters

Parameter	Tukak 1	Tukak 2	Tukak 3	Kerasak 1	Kerasak 2	Kerasak 3	Quality standards *
Temperature °C	28,2	28,1	29	29,1	30,1	29	28-30
Salinity (ppt)	31	30	32	33	32	30	33-34
pH	7,6	7,2	7,3	7,2	7,1	6,8	7-8,5
DO (mg/L)	8,3	7,5	8,3	6,4	6,7	5,5	>5
Current Velocity (m/s)	0,023	0,022	0,028	0,080	0,071	0,070	
Nitrate (mg/L)	0,061	0,035	0,06	0,05	0,07	0,02	0,06
Phosphate (mg/L)	0,016	0,012	0,015	0,017	0,030	0,014	0,015

* Quality Standards (PP RI No. 22 of 2021)

Table 6. Substrate Texture

Location	Sediment Texture Percentage (%)			Sediment Types
	Sand	Clay	Dust	
Tukak 1	70,90	26,40	2,74	Sandy Loam
Tukak 2	75,83	18,72	5,45	Sandy Loam
Tukak 3	76,62	20,80	2,58	Sandy Loam
Average	74,45	21,97	3,59	
Tanjung Kerasak 1	85,91	12,78	1,32	Clayy Sand
Tanjung Kerasak 2	84,20	13,60	2,80	Clayy Sand
Tanjung Kerasak 3	81,32	14,49	4,19	Clayy Sand
Average	83,81	13,62	2,77	

DISCUSSION

The results of the study revealed differences in the morphometric characteristics of the seagrass Enhalus acoroides at each observation station. Differences occurred in the upper morphometric parameters, such as leaf length and width. The average order of seagrass leaf length and width at the study site was that leaves at Tukak 1 station were larger than those at Tukak 3, Tukak 2, Kerasak 1, Kerasak 2, and Kerasak 3 stations. This condition is likely related to the Tukak 1 location point being located in an area adjacent to a mangrove forest, thus creating a more stable and calm surrounding environment. The current at Tukak Beach, which has a speed ranging from 0.022 to 0.028 m/s, is relatively slow, also supported by the sloping coastal topography, thus creating calm water conditions and impacting substrate characteristics. In accordance with the explanation of Gultom et al., (2018), that slow currents facilitate the deposition of small particles such as clay and mud on the waterbed. According to research by Sari et al. (2023), the presence of dense seagrass can reduce current and wave speed, resulting in calmer waters. This is in line with Kaparang et al.'s (2023) statement, which states that waters with calm currents tend to experience sediment deposition, particularly organic sediment, which plays a crucial role in supporting seagrass growth. This condition is one of the factors that encourages seagrass growth, leading to a more dominant increase in leaf length and width.

Tukak Beach and Tanjung Kerasak Beach exhibited variations in seagrass rhizome length. Among the observed stations, the rhizomes at Kerasak 3 showed the greatest length compared to Kerasak 1, Kerasak 2, Tukak 1, Tukak 3, and Tukak 2. The results showed that the shortest rhizomes were found at Tukak 2, which has a muddy substrate texture, while the longest rhizomes were found on the coral rubble substrate, due to the larger sediment particle size found in the coral rubble substrate. The aquatic environment at both stations remained within the limits that allow seagrass growth. This finding supports the results of a study by Wangkanusa et al., (2017) at Tongkeina Beach, Manado, which stated that seagrass growing on muddy substrates tends to have shorter rhizomes than seagrass on sand or coral rubble substrates. Sand and coral rubble substrates have coarse grains with high and uniform porosity, which are generally less stable due to their porous texture compared to fine substrates. Seagrass needs to strengthen its roots and rhizomes with a longer growth process to survive in these conditions.

The order of rhizome width at Kerasak Station, from largest to smallest, is Kerasak 3, then Kerasak 2, Kerasak 1, Tukak 2, Tukak 3, and finally Tukak 1. Seagrasses with larger rhizome diameters tend to experience slower growth rates compared to those with narrower rhizomes. Substrates with lower fertility levels, especially due to low nutrient content, cause rhizomes to grow wider. This is supported by Tuapattinaya et al., (2021) who stated that wide-diameter rhizomes indicate slow growth due to low nutrients in the substrate. The larger rhizome width of Enhalus acoroides at Tanjung Kerasak Beach compared to Tukak Beach is due to the need for seagrass to demonstrate better stability when located on coarse-grained substrates. Coarse-textured substrates require rhizomes with strong structures so that the seagrass can attach well and is not easily carried away by currents or high waves. This aligns with Ramili's (2019) statement that large-diameter rhizomes are crucial for maintaining seagrass stability and resilience on coarse substrates.

At Kerasak 2 station, the longest roots were found, followed by Kerasak 3, Kerasak 1, Tukak 3, Tukak 2, and Tukak 1. The main factor in this difference is the coarser sediment grain size, requiring seagrass to strengthen its roots to anchor firmly in the substrate. Sediment texture plays a significant role in the development of seagrass root systems. Furthermore, the moderate ocean current speeds in the Tanjung Kerasak Coastal area encourage Enhalus acoroides to grow longer roots as an adaptation to environmental factors. This research aligns with the findings of Wangkanusa et al. (2017), which showed that coarser substrates require longer roots to firmly grip the substrate and withstand the effects of currents and waves. Furthermore, Putri et al. (2017) stated that relatively short roots indicate a high nutrient content in the substrate, indicating fertile water conditions, which prevent roots from growing long because nutrients are readily available from the substrate.Correlation between Morphometrics of the Seagrass Enhalus acoroides and Water Quality Conditions at Tukak Beach and Tanjung Kerasak Beach

The water quality level at Tukak Beach showed a significant relationship with the morphometric parameters of the seagrass Enhalus acoroides. One significant water quality parameter, dissolved oxygen (DO), showed a highly significant relationship with the leaf length of the seagrass Enhalus acoroides at Tukak Beach, with a correlation coefficient of $r = 0.815$. Based on the results of the Spearman correlation test in this analysis, correlation values ranged from 0.800 to 1.000, thus concluding that DO content has a significant and positive relationship with seagrass leaf length. This can be explained because dissolved oxygen plays a crucial role in the photosynthesis process, which causes increased leaf growth, allowing seagrass leaves to grow longer. Conversely, low DO levels have the potential to inhibit the photosynthesis process, which negatively impacts seagrass morphometrics. This finding is in line with Zurba's (2018) statement that decreased dissolved oxygen (DO) levels can inhibit the photosynthesis process in seagrass, which then has an impact on decreasing the primary productivity of the seagrass. On the other hand, the condition of water quality at Tanjung Kerasak Beach also shows a sufficient relationship with the morphometrics of the seagrass Enhalus acoroides. Several water quality parameters, including temperature, salinity, pH, current velocity, and nutrient content such as nitrate and phosphate, in addition, the characteristics of the substrate texture including the composition of sand, clay, and silt also contribute to this. The water quality shows a moderate level of correlation with the morphometrics of seagrass at that location with correlation coefficient values ranging from 0.406 to 0.588. Based on the results of the Spearman correlation test with a value range between 0.400 and 0.599, it can be concluded that these environmental factors have a fairly close, although not strong, relationship with the morphometric development of Enhalus acoroides in these waters.

The high seagrass area in the Tukak Beach area compared to Tanjung Kerasak Beach is thought to be influenced by the relatively flat topography. This causes currents to move at slower speeds, as well as its location being far from human (anthropogenic) activity. This remote location results in the water in this area being relatively clear. This water clarity allows sunlight to penetrate to the bottom, providing sufficient light for the seagrass to photosynthesize optimally. Furthermore, the environmental conditions at this station are relatively good and support optimal seagrass growth. The sandy loam substrate at Station 1 is also a contributing factor, as this type of substrate is preferred by seagrass, resulting in higher seagrass cover in this area than at other stations. This finding aligns with the research of Saputra et al. (2024), which states that high seagrass cover is closely related to maintained water quality, adequate nutrient availability, and the suitability of the substrate and salinity levels for seagrass growth. The condition of the seagrass growth area found in the Tanjung Kerasak Beach area at stations 4, 5, and 6 was categorized as damaged due to anthropogenic activities that can damage the seagrass ecosystem in these locations. Human activities, or anthropogenic activities, can put significant pressure on seagrass ecosystems, particularly through coastal development, unsustainable fishing practices, and offshore tin mining. This finding is supported by research by Ningtasya et al. (2020), which revealed that the low level of seagrass cover in the Tanjung Kerasak Beach area is closely related to these activities. This is due to the location's presence of fishing boat channels, tourism, and tin mining activities. This is in accordance with Sari et al.'s (2017) statement that the damage and degradation of seagrass ecosystems, particularly in South Bangka, is caused by offshore tin mining activities, which reduce seagrass density and cover.

The results showed that water temperatures at Tukak Beach at the three observation points were relatively similar, ranging from 28.1°C to 29°C. Meanwhile, at Tanjung Kerasak Beach, temperatures were recorded slightly higher, ranging from 29°C to 30.1°C. Leidonald et al. (2022) stated that fluctuations in water temperature are highly dependent on various factors, including the intensity of sunlight penetrating the water, the survey time, altitude, and rainfall levels. Despite temperature differences between locations, the temperatures measured in this study were still within optimal limits to support the growth of marine biota, such as seagrass.

Based on the research results, salinity levels in the Tukak Beach and Tanjung Kerasak Beach areas ranged from 30 to 33 ppt. Salinity at Tukak Beach tended to be lower, possibly due to sampling being conducted during the rainy season, which affected water salinity levels. Nevertheless, these salinity values still meet water quality standards for supporting seagrass survival.

Based on the data obtained, pH values in the Tukak Beach and Tanjung Kerasak Beach areas were recorded in the range of 6.8 to 7.6. The results of pH measurements at the research sites indicate that the water acidity level tends to be uniform across all observation points. Although the pH value at station 6 on Tanjung Kerasak Beach was recorded slightly below the quality standard, this condition is still considered supportive of aquatic productivity and capable of supporting the life of marine organisms, including seagrass. This statement aligns with the opinion of Faturohman and Nurruhwati (2016), who stated that waters with a pH between 6.5 and 7.5 are still considered productive, while waters with a pH of 7.5 to 8.5 have a high level of productivity. Conversely, a pH value below 5.5 or above 8.5 indicates less productive waters.

Dissolved oxygen (DO) levels in the waters at the research sites ranged from 5.5 to 8.3 mg/L. Based on Government Regulation of the Republic of Indonesia Number 22 of 2021, DO levels at these two locations still meet the standards required to support seagrass growth, which is above the minimum threshold of 5 mg/L.

The results of the study showed that the current speed at Tukak Beach ranged from 0.022 to 0.028 m/s, while at Tanjung Kerasak Beach it was higher, ranging from 0.070 to 0.080 m/s. The relatively low current speed at Tukak Beach is due to the beach's gently sloping topography, which tends to cause calm water flow.

Nitrate levels measured at both locations, Tukak Beach and Tanjung Kerasak Beach, ranged from 0.02 to 0.061 mg/L. The nitrate levels at Tukak Beach are considered optimal for seagrass growth, while at Tanjung Kerasak Beach, although slightly lower, are still sufficient to support seagrass growth. This statement aligns with the opinion of Abidin and John (2018), who stated that a nitrate concentration of 0.02 mg/L is still sufficient to sustain seagrass survival due to the oligotrophic aquatic environment.

Meanwhile, phosphate levels at both locations ranged from 0.012 to 0.030 mg/L. The highest levels were found at station 5 at Tanjung Kerasak Beach, which is located close to the shrimp pond waste disposal zone. Mastur et al., (2015) stated that excessively high phosphate levels can disrupt the photosynthesis process of seagrass, negatively impacting its health.

Analysis of the substrate types at the research site revealed a diverse texture, containing a mix of sand, mud, and clay with varying compositions. At Tukak Beach, fine sediments dominate the substrate, influenced by the enclosed waters and the presence of mangrove forests. Meanwhile, the sediment at Tanjung Kerasak Beach tends to be clayey sand, due to nearby mining activities, which results in a texture that is predominantly sand mixed with mud.

CONCLUSION

1. The morphometrics of the seagrass Enhalus acoroides showed differences between the two research locations. Tukak Beach had a larger average leaf size, with a length of about 411 mm and a width of 10 mm, compared to Tanjung Kerasak Beach, where the average leaf length reached 206 mm and a width of about 6.1 mm, smaller than the size at Tukak Beach. Conversely, the length and width of the rhizome at Tanjung Kerasak Beach were larger, with a length of 123 mm and a width of 11 mm, while at Tukak Beach they were only 112 mm and 10 mm, respectively. In addition, the root length at Tanjung Kerasak Beach was also superior with an average of 126 mm, compared to Tukak Beach which was around 112 mm.
2. The relationship between water quality conditions and morphometric aspects of Enhalus acoroides seagrass in the Tukak Beach area shows that dissolved oxygen (DO) levels have a very strong correlation with seagrass leaf length, with a correlation coefficient of r = 0.815. In contrast, at Tanjung Kerasak Beach, the relationship between water quality and morphometric parameters of Enhalus acoroides seagrass shows a correlation in the moderate range, with correlation values ranging from r = 0.406 to 0.588.

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