Characteristics of the Distribution Pattern and Density of *Enhalus acoroides* in the Waters of Malahing Village, Bontang City, East Kalimantan, Indonesia

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ABSTRACT

Enhalus acoroides is one of the most widely distributed seagrass species in the coastal waters of Bontang, East Kalimantan, Indonesia. This study aimed to determine the distribution pattern characteristics and density of Enhalus acoroides in the waters of Malahing Village, Bontang City, East Kalimantan. The research was conducted from October 2024 to February 2025. Seagrass vegetation data were analyzed using species density, relative density, species frequency, relative frequency, species coverage, relative coverage, and the Important Value Index (IVI). The distribution pattern of seagrass was assessed using the Morisita Dispersion Index (MDI), while environmental factors influencing the distribution pattern were described and presented in observational tables. Sampling was carried out using 50 × 50 cm quadrats along transects at each station with three replications. The results revealed the presence of two seagrass species in the waters of Malahing Village, namely Enhalus acoroides and Thalassia hemprichii, with E. acoroides being the dominant species. Seagrass density across the four sampling stations ranged from 92 to 216 shoots m⁻². The Morisita Dispersion Index (MDI) analysis indicated that Enhalus acoroides exhibited a uniform distribution pattern, as evidenced by an index value of Id < 1.

INTRODUCTION

Malahing waters represent one of the remaining seagrass ecosystems in East Kalimantan Province. According to data from the Environmental Agency of Bontang City (2018), the seagrass beds in this region cover approximately 3,865.6 hectares. The vastness of this ecosystem highlights the ecological importance of Bontang's coastal waters as a natural habitat that sustains marine biodiversity and environmental balance. Beyond its ecological role, the seagrass ecosystem provides substantial economic benefits to local communities. Previous studies estimated that the economic value of seagrass beds in Bontang City could reach more than 7 trillion rupiah annually (Oktawati et al., 2018). These benefits include supporting capture fisheries, coastal tourism, and other ecosystem services that contribute directly to the livelihoods and welfare of coastal populations.

Seagrass beds play a crucial role in enhancing the productivity of coastal waters (Cucio et al., 2016). Several species have been identified in Bontang waters, including *Enhalus acoroides*, *Halophila ovalis*, *Halophila minor*, and *Thalassia hemprichii* (Budiarsa et al., 2015). Among these, *Enhalus acoroides* often dominates due to its ability to thrive on substrates ranging from muddy sand to coral-covered mud (Sakey et al., 2015). Its morphological characteristics—long smooth leaves, thick rhizomes, and large leafy flowers—make it more resilient and adaptive compared to other species.

Given the ecological significance and dominance of *Enhalus acoroides* in Bontang's coastal ecosystem, a deeper investigation into its distribution and density is essential. Therefore, this study aims to analyze the spatial distribution patterns and density levels of *Enhalus acoroides* in Malahing waters, Bontang City, East Kalimantan. The findings are expected to serve as a scientific basis for sustainable management and conservation strategies of coastal ecosystems.

METHODOLOGY

Research Location

This study was conducted from October 2024 to February 2025 in the coastal waters of Malahing Village, Bontang City, East Kalimantan, Indonesia (Figure 1). Field activities included seagrass sampling, measurement of physicochemical water parameters, and substrate collection.

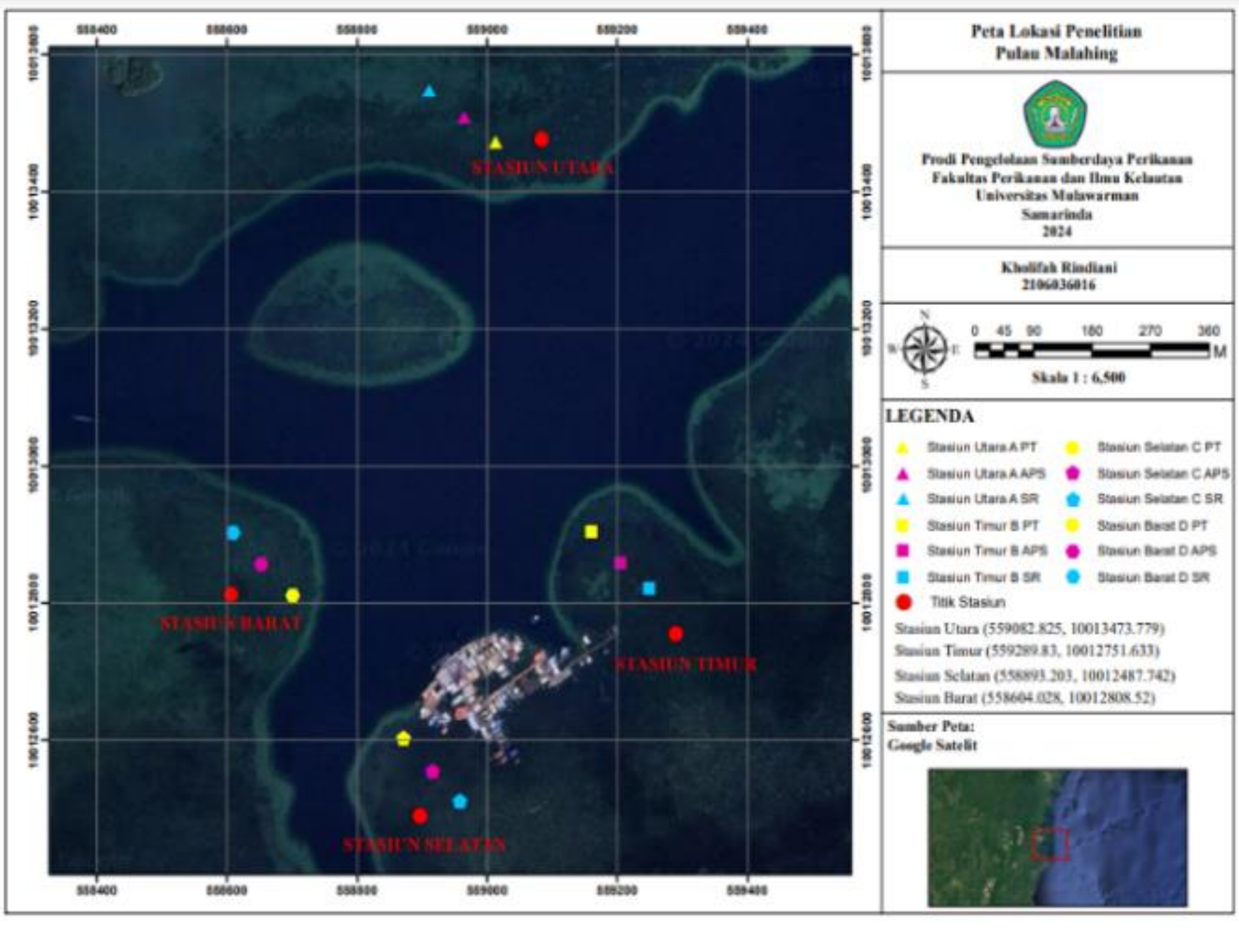

Figure 1. Study Area Map

Research Method

The study was carried out at four sampling stations representing the northern, eastern, southern, and western parts of the study area. Each station consisted of three transect lines. The distance between adjacent sub-stations for seagrass sampling was 25 m.

Research Procedures

Seagrass Sampling

Seagrass sampling was conducted using 50 × 50 cm quadrats placed along transects according to the occurrence of seagrass within each quadrat frame. The density of *Enhalus acoroides* shoots was determined based on their distribution within each sub-station using the quadrat method. All *E. acoroides* shoots found within the quadrat were counted. A seagrass shoot was defined as a cluster of leaves sharing a common basal attachment. Shoot abundance was determined through direct visual observation following the method described by Hartati et al. (2012).

Seagrass Density and Relative Density

Species density refers to the number of seagrass shoots per unit area. The density of *E. acoroides* was calculated according to Baratakusuma (2013) using the following formula:

$$K_i = \frac{N_i}{A}$$

Where:

Ki = Species density (shoots m^{-2})
Ni = Number of shoots of species i
A = Quadrat area (m^2)

Relative density was calculated as the proportion of individuals of a species relative to the total number of individuals of all species (Tuwo, 2011, cited in Septian, Azizah, & Apriadi, 2016):

$$KR = \frac{Ni \times 100}{\sum n}$$

Where:

KR = Relative density (%)
Ni = Number of individuals of species i (shoots m^{-2})
Σn = Total number of individuals of all species (shoots m^{-2})

Frequency and Relative Frequency

Species frequency represents the proportion of sampling quadrats in which a particular seagrass species occurs relative to the total number of quadrats examined. Species frequency was calculated using the following equation (Tuwo, 2011, cited in Septian, Azizah, & Apriadi, 2016):

$$FJi = \frac{Pi}{\sum P}$$

Where:

FJi = Frequency of species i
Pi = Number of quadrats containing species i
ΣP = Total number of quadrats observed

Relative frequency was calculated as:

$$FR = \frac{Fi}{\sum F}$$

Where:

FR = Relative frequency (%)
Fi = Frequency of species i
ΣF = Sum of frequencies of all species

Cover and Relative Cover

Species cover refers to the proportion of the substrate area covered by a particular seagrass species relative to the total seagrass-covered area. Species cover was calculated using the following equation (Tuwo, 2011, cited in Septian, Azizah, & Apriadi, 2016):

$$\mathrm{PJ} = \frac{ai}{A}$$

Where:
PJ = Cover of species i (% m^{-2})
ai = Total cover area of species i (%)
A = Total seagrass-covered area (m^2)

Relative cover was calculated as:

$$\mathrm{PR} = \frac{Pi}{P}$$

Where:
PR = Relative cover (%)
Pi = Cover of species i (% m^{-2})
P = Total cover of all seagrass species (% m^{-2})

According to the Decree of the Indonesian Minister of Environment No. 200 of 2004 regarding seagrass ecosystem assessment criteria, seagrass cover ≥60% is classified as rich or healthy, 30–59.9% as moderately rich or moderately healthy, and ≤29.9% as poor or degraded.

Important Value Index

The Important Value Index (IVI) was used to evaluate the overall ecological significance of each seagrass species within the community. The IVI was calculated using the following formula (Kordi, 2011, cited in Septian, Azizah, & Apriadi, 2016):

$$\mathrm{INP} = \mathrm{FR} + \mathrm{KR} + \mathrm{PR}$$

Where:
IVI = Important Value Index
FR = Relative frequency
KR = Relative density
PR = Relative cover

Distribution Pattern Analysis

The distribution pattern of seagrass species was determined using the Morisita Dispersion Index (Subur, 2014):

$$Id = \frac{n\Sigma_{i=1}^{S} x2 - N}{\mathrm{N}\,(\mathrm{N}-1)}$$

Where:
Id = Morisita Dispersion Index
n = Number of sampling plots

N = Total number of individuals in all plots
xi^2 = Squared number of individuals in each plot

The distribution pattern was interpreted according to the following criteria:

Id = 1 : Random distribution
Id < 1 : Uniform (regular) distribution
Id > 1 : Clumped (aggregated) distribution

RESULT AND DISCUSSION

Characteristics of the Bottom Substrate

The results of physicochemical parameter measurements in the coastal waters of Malahing Village, Bontang City are presented in Table 1.

Table 1. Analysis of Bottom Substrate

Parameter	Unit	Station I	Station II	Station III	Station IV	Mean
pH	-	9.4	9.01	9.03	8.73	9.04
Organic matter	%	0.47	0.42	0.44	0.43	0.44
Very coarse sand	%	12.35	13.71	13.34	10.8	12.55
Coarse sand	%	23.44	22.83	26.03	27.25	24.89
Medium sand	%	24.96	22.46	21.08	25.06	23.39
Fine sand	%	17.14	20.93	18.34	19.22	18.91
Very fine sand	%	11.63	9.9	10.64	8.55	10.18
Total sand	%	89.52	89.83	89.43	90.88	89.92
Clay	%	2.32	2.73	3.73	1.61	2.6
Silt	%	8.16	7.44	6.84	7.51	7.49
Sediment texture	-	Sandy	Sandy	Sandy	Sandy	Sandy

The substrate characteristics across the four sampling stations showed that pH values ranged from approximately 8.73 to 9.04, while organic matter content ranged from 0.42% to 0.47%. Sediment composition was dominated by sandy fractions, including very coarse sand (10.8–13.71%), coarse sand (22.83–27.25%), medium sand (21.08–25.06%), fine sand (17.14–20.93%), and very fine sand (8.55–11.63%). Total sand content was consistently high across all stations, ranging from 89.2% to 90.88%. Clay content was low (1.61–3.73%), while silt content ranged from 6.84% to 8.16%. Overall, the sediment texture across all stations was classified as sandy.

Based on Table 2, the substrate conditions in all stations are categorized as seagrass beds dominated by sandy sediments. According to Hidayat et al. (2019), suitable seagrass habitats are generally characterized by muddy substrates mixed with sand. However, field observations indicate that the substrate in Malahing waters is predominantly sandy. Sandy substrates are less favorable for seagrass growth; therefore, only two seagrass species were found in the study area.

Density and Relative Density

Seagrass density ranged from 92 to 216 shoots/m². The highest density of *Enhalus acoroides* was observed at the northern station, followed by the western station. The high density at the northern station is associated with the presence of mangrove ecosystems, which function as sources of detritus, sediment traps, and nutrients. These materials are transported to seagrass beds by water currents, thereby supporting seagrass growth.

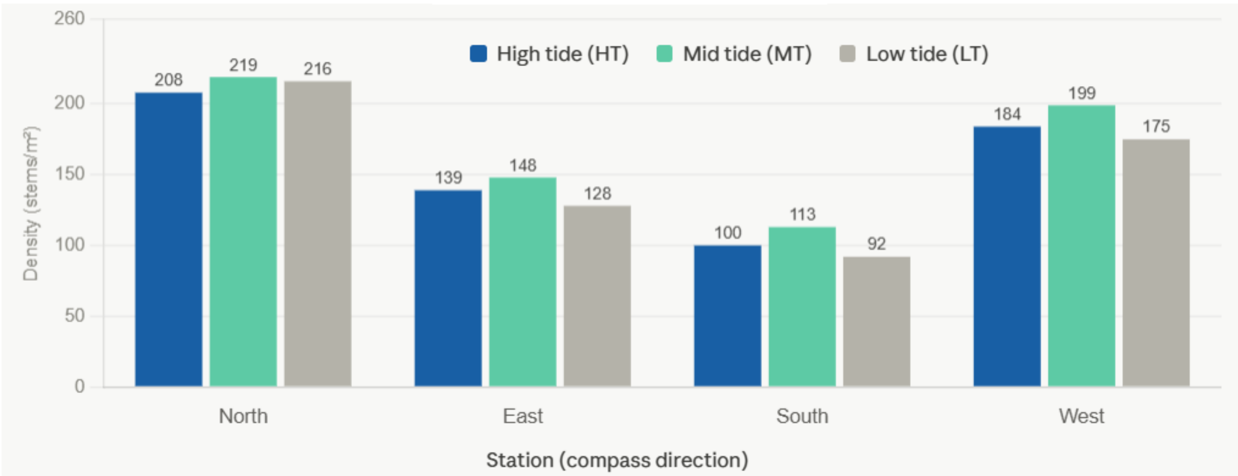

Figure 2. Density of *E. acoroides*

In contrast, the lowest density was recorded at the southern station, which exhibited lower water clarity, pH, and dissolved oxygen (DO). These conditions limit light penetration to the seabed, thereby inhibiting photosynthesis and growth of seagrass. The relative density of *E. acoroides* was highest at the northern station, with an average value of 81%. The lowest relative density was recorded at the southern station, with an average value of 34%.

Frequency and Relative Frequency

The highest frequency was observed at the northern station, with an average value of 65%, while the lowest frequency occurred at the southern station (43%). This variation is influenced by the ecological advantages of *E. acoroides*, which possesses a strong and extensive rhizome system with fibrous roots. This adaptation enables the species to thrive across various substrate types and efficiently absorb organic matter from sediments, including muddy sand, medium sand, coarse sand, and coral fragments (Nainggolan, 2011; Sinaga, 2016).

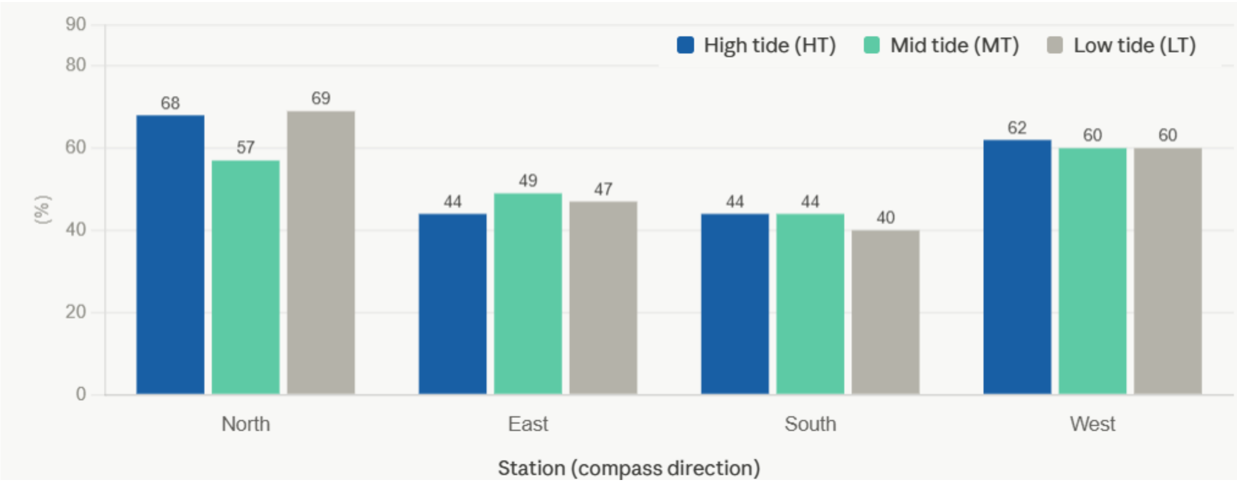

Figure 3. Relative Frequency of *E. acoroides*

Relative frequency analysis showed that the northern station had the highest value (65%), while the southern station recorded the lowest value (43%). The morphological characteristics of the leaves of *E. acoroides* also contribute to its ability to survive in turbid environmental conditions (Sinaga, 2016).

Cover and Relative Cover

Seagrass cover of *E. acoroides* across all stations was below the national quality standard. The cover values were less than 29.9%, indicating a “poor” or “degraded” category. This condition is associated with the low diversity and abundance of seagrass species in the study area. Nevertheless, the leaf morphology of *E. acoroides* allows it to provide substrate coverage despite limited species richness.

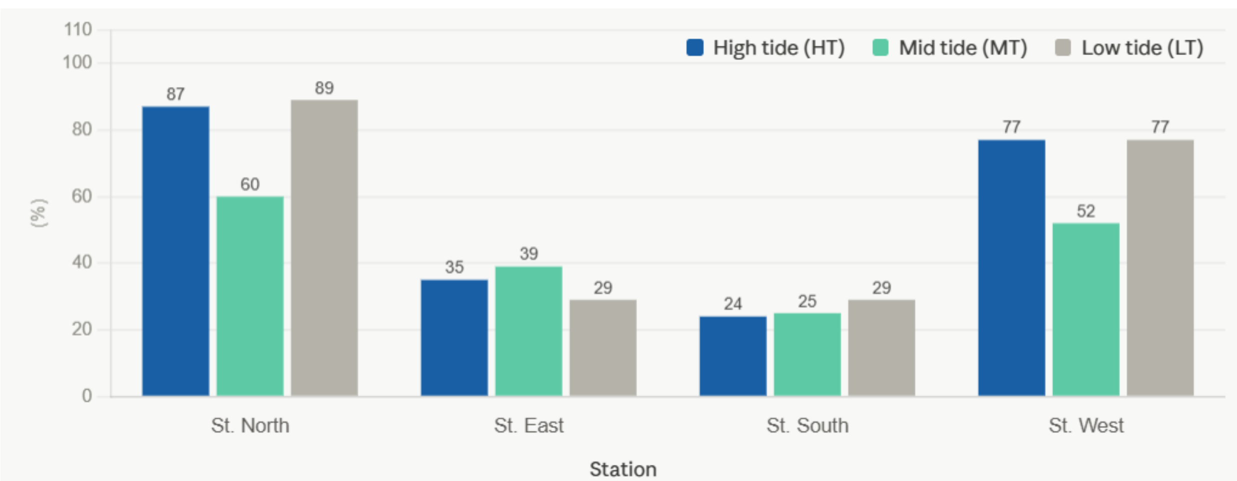

Figure 4. Relative Cover of *E. acoroides*

Relative cover values across all stations also remained below the established threshold (<29.9%), classifying the seagrass ecosystem as poor in condition. This is influenced by the limited number of seagrass species present, particularly those capable of forming extensive leaf coverage such as *E. acoroides*.

Important Value Index and Distribution Pattern of E. acoroides

The highest IVI was recorded at the northern station, with an average value of 369%, while the lowest IVI occurred at the southern station, with an average value of 140%. The IVI is also influenced by substrate conditions, as all stations were dominated by sandy sediments, which still support the growth of *E. acoroides*.

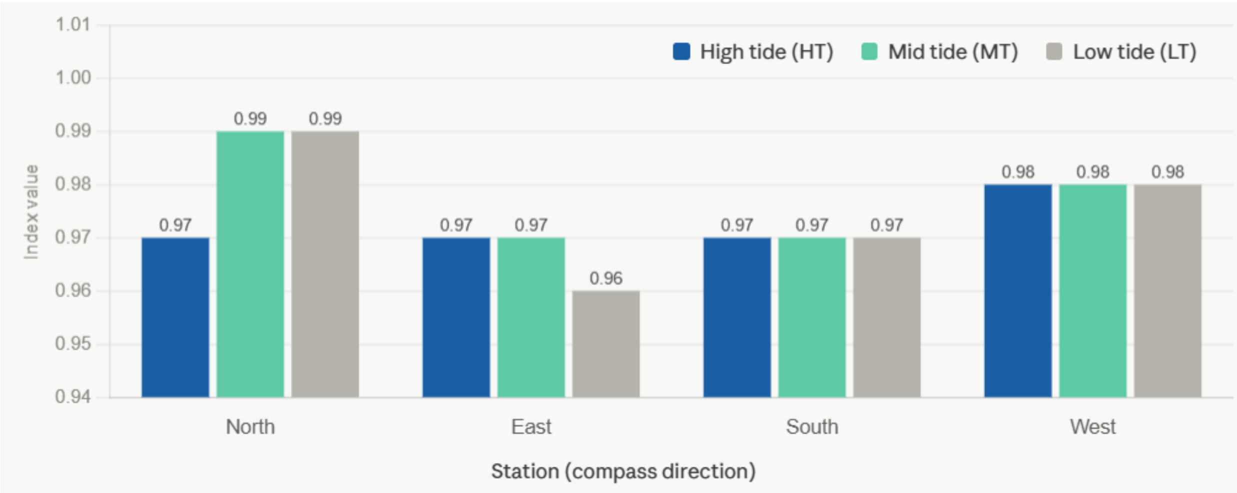

Figure 5. Distribution Pattern of *E. acoroides*

The Morisita Dispersion Index values for *E. acoroides* ranged from 0.96 to 0.99 across all stations. Since all values were less than 1 (Id < 1), the distribution pattern of *E. acoroides* is classified as uniform (regular), indicating that the distance between individual shoots tends to be relatively equal.

This uniform distribution pattern is influenced by habitat suitability, environmental conditions, and supporting physicochemical parameters that favor seagrass growth. It also suggests competition among individuals for space under similar environmental conditions.

Overall, the waters of Malahing Village, Bontang City, East Kalimantan exhibit a uniform seagrass distribution pattern. According to Crawley (1986) in Feryatun et al. (2012), a uniform distribution indicates that individuals are spaced at relatively equal distances from one another. Differences in climatic conditions and nutrient availability can produce significant variations in organism distribution (Rizky, 2018). This pattern is associated with the tendency of organisms to occupy habitats that best suit their ecological requirements.

CONCLUSION

The substrate characteristics of Malahing Village waters are dominated by sandy fractions with low organic matter, pH values around 9, and minimal clay and silt content. Such conditions are less favorable for diverse seagrass communities, as seagrass generally thrives in muddy-sand substrates. Consequently, only limited species were found, with ***Enhalus acoroides*** emerging as the dominant species capable of adapting to sandy environments.

The ecological performance of *E. acoroides* varied across stations, with the northern station showing the highest density, frequency, and IVI due to its proximity to mangrove ecosystems that supply nutrients and stabilize sediments. In contrast, the southern station exhibited the lowest values, influenced by reduced water clarity, lower pH, and dissolved oxygen, which limit photosynthesis and growth. Overall, seagrass cover remained below national standards, indicating a degraded ecosystem with poor resilience.

Despite these limitations, *E. acoroides* demonstrated adaptive traits such as strong rhizomes, fibrous roots, and leaf morphology that allow survival in sandy and turbid conditions. Its uniform distribution pattern reflects competition for space under similar environmental conditions. These findings highlight the importance of mangrove–seagrass connectivity and suggest that improving substrate quality and water clarity could enhance seagrass diversity and ecosystem health in Malahing waters.

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