Abundance and Morphometric Characteristics of the Sea Urchin *Diadema setosum* in Seagrass Beds of Malahing Village Waters, Bontang City, East Kalimantan, Indonesia

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ABSTRACT

Seagrass meadows are vital coastal ecosystems that support biodiversity and ecological balance, particularly in Bontang City, East Kalimantan. This study investigated the ecological relationship between seagrass meadows and the sea urchin ***Diadema setosum*** *through field sampling conducted from October 2024 to February 2025 in Malahing Village. Data collection included seagrass density, physicochemical water parameters, sediment composition, and sea urchin abundance and morphometrics. Results showed that substrates were dominated by sandy textures (average 89.2%), suitable for sea urchin habitats. Seagrass density varied among species, with Enhalus acoroides dominating northern stations and Thalassia hemprichii thriving in eastern and southern stations. The total abundance of D. setosum reached 480 ind/m^2, with the highest density at the eastern station. Morphometric analysis revealed negatively allometric growth, where test diameter increased faster than body weight. Correlation analysis indicated a strong positive relationship between D. setosum abundance and T. hemprichii density ($r = +0.896$), but a weak negative correlation with E. acoroides ($r = -0.712$). These findings highlight the species-specific interactions between sea urchins and seagrass, emphasizing the role of T. hemprichii in supporting sea urchin populations and the importance of mixed seagrass beds in maintaining coastal ecosystem health.*

INTRODUCTION

Seagrass meadows are one of the most important coastal ecosystems, thriving in the shallow waters of Bontang City. Seagrasses are flowering plants (Angiosperms) that differ from marine algae because they possess rhizomes, leaves, flowers, and fruits (Sjafrie et al., 2018). These meadows play a crucial role in maintaining marine ecosystem balance by providing food, shelter, and habitat for a wide variety of aquatic organisms (Faiqoh et al., 2017). The dense structure of seagrass vegetation makes it a key ecosystem supporting coastal biodiversity.

Among the biota closely associated with seagrass ecosystems are sea urchins (*Echinoidea*). The dense vegetation cover of seagrass meadows offers sea urchins essential resources for feeding, spawning, and protection from predators (Supono & Arbi, 2010 in Firmandana et al., 2014). Sea urchins are commonly found in seagrass habitats with hard substrates composed of sand mixed with coral fragments (Drahman, 2020). Morphologically, they are characterized by a rounded body encased in a calcareous shell covered with movable spines, which may be long and sharp or short and blunt (Anwar, 2020). Their presence in seagrass meadows reflects not only habitat suitability but also the ecological dynamics of coastal communities.

The close relationship between seagrass meadows and sea urchins highlights the importance of ecological studies that examine their interactions. Seagrass provides substrate and shelter, while sea urchins contribute to energy flow and community structure within marine ecosystems. Therefore, this study aims to analyze the ecological relationship between seagrass meadows and sea urchins in the waters of Bontang City, focusing on their distribution, habitat preferences, and ecological roles as indicators of coastal ecosystem health.

METHODOLOGY

Study Area

This research on the abundance and morphometric characteristics of Diadema setosum in seagrass ecosystems was conducted from October 2024 to February 2025 in the coastal waters of Malahing Village, Bontang City, East Kalimantan, Indonesia (Figure 1). Field sampling included sea urchins, seagrass, physicochemical water parameters, and sediment.

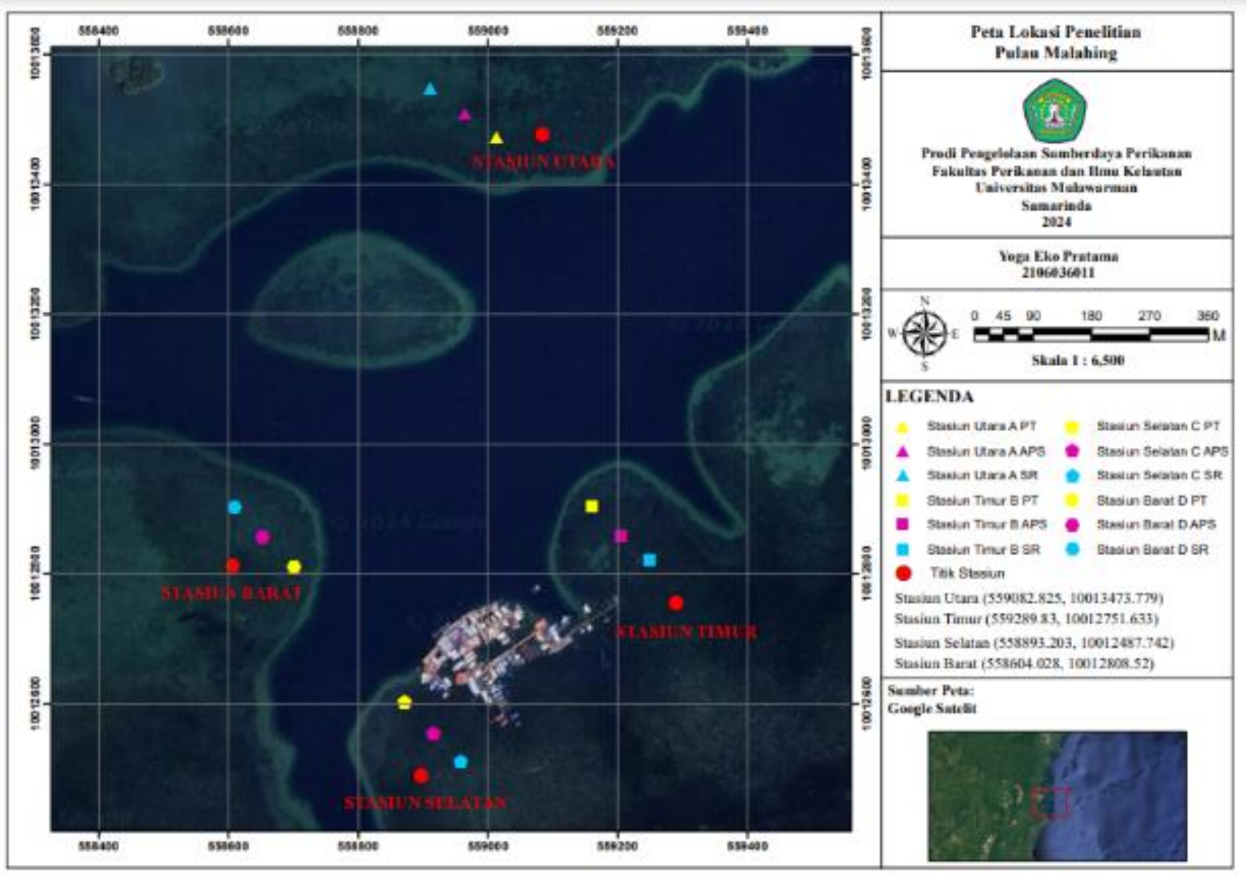

Figure 1. Map of the Study Area

Research Method

The study was conducted at four sampling stations, namely northern, eastern, southern, and western stations. Each station consisted of three transect lines. The distance between sub-stations was 25 m, with each transect line having a length of 50 m.

Research Procedures

Sampling Procedure

Seagrass and *Diadema setosum* were collected using 50 × 50 cm quadrats placed according to the occurrence of seagrass within each quadrat frame.

Measurement of Physicochemical Parameters

Water samples and in situ measurements of physicochemical parameters were conducted over three sampling periods with 15-day intervals. Turbidity, nitrate, and phosphate analyses were performed in the laboratory.

Sediment Sampling

Sediment samples were collected using a PVC pipe inserted vertically into the seabed to a depth of 10 cm. Sediments entering the pipe were extracted with the assistance of a shovel, then transferred into labeled plastic bags corresponding to each sampling station.

Abundance of *Diadema setosum*

Abundance was calculated using the following formula (Rahma & Fitriani, 2006):

$$D_1 = \frac{ni}{A}$$

Where:

Di = Abundance of species i
ni = Number of individuals of species i
A = Sampling plot area

Species Density

Species density refers to the number of individuals (or shoots) per unit area. Seagrass density at each station was calculated using the following formula (Fachrul, 2007):

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

Where:

Ki = Species density (individuals/m²)
ni = Total number of individuals
A = Sampled area (m²)

Relative Density

Relative density is the proportion of individuals of a species compared to the total number of individuals of all species. It was calculated using the following equation (Tuwo, 2011):

$$KR = \frac{ni}{N} \text{ x } 100\%$$

Where:

KR = Relative density (%)
ni = Number of individuals of species *i*
N = Total number of individuals of all species

Relationship Between *Diadema setosum* Abundance and Seagrass Beds

The relationship between the abundance of *Diadema setosum* and seagrass density was analyzed using Pearson Product Moment correlation analysis (Riduwan, 2003). Pearson correlation is a bivariate parametric statistical method used to measure the relationship between two variables. Two variables are considered associated when changes in one variable influence changes in the other (Priosambodo, 2015).

The correlation coefficient is calculated using the following formula:

$$r_{xy} = \frac{n\sum XY - \sum X \sum Y}{\sqrt{n\sum X^2 - (\sum X)^2}\sqrt{n\sum Y^2 - (\sum Y)^2}}$$

Where:

r = Correlation coefficient between variables X and Y
n = Number of observations
X = Value of variable X
Y = Value of variable Y

According to Abdullah and Susanto (2015), the correlation coefficient (r) ranges from -1 to 1 and is interpreted as follows:

r = -1: perfect negative correlation between X and Y
r = 0: no or very weak correlation between X and Y
r = 1: perfect positive correlation between X and Y

RESULT AND DISCUSSION

Bottom Substrate Characteristics

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

Table 1. Analysis of Bottom Substrate

No	Parameter	Unit	Station 1	Station 2	Station 3	Station 4
1	pH	%	9.4	9.01	9.03	8.73
2	Organic Carbon	%	0.47	0.42	0.44	0.43
3	Very Coarse Sand	%	12.35	13.71	13.34	10.8
4	Coarse Sand	%	23.44	22.83	26.03	27.25
5	Medium Sand	%	24.96	22.46	21.08	25.06
6	Fine Sand	%	17.14	20.93	18.34	19.22
7	Very Fine Sand	%	11.63	9.9	10.64	8.55
8	Total Sand	%	89.52	89.83	89.43	90.88
9	Clay	%	2.32	2.73	3.73	1.61

10	Silt	%	8.16	7.44	6.84	7.51
11	Texture	-	Sand	Sand	Sand	Sand

Based on Table 2, the substrate conditions across all four sampling stations were dominated by sandy textures, with total sand content ranging from 89.43% to 90.88% and an average of 89.2%. The sediment characteristics in the study area are suitable for sea urchin habitats, as stated by Juliawan et al. (2017), who reported that sea urchins can be found in various substrates, including live coral, dead coral, rocky substrates, sandy substrates, and seagrass-associated habitats.

Seagrass Species Density and Relative Density

Based on Figure 2, *Enhalus acoroides* exhibited the highest density at the northern station, averaging 213 shoots/m², while the lowest density was observed at the southern station with an average of 102 shoots/m². For *Thalassia hemprichii*, the highest density was recorded at the eastern station with an average of 207 shoots/m², whereas the lowest density occurred at the northern station with an average of 50 shoots/m².

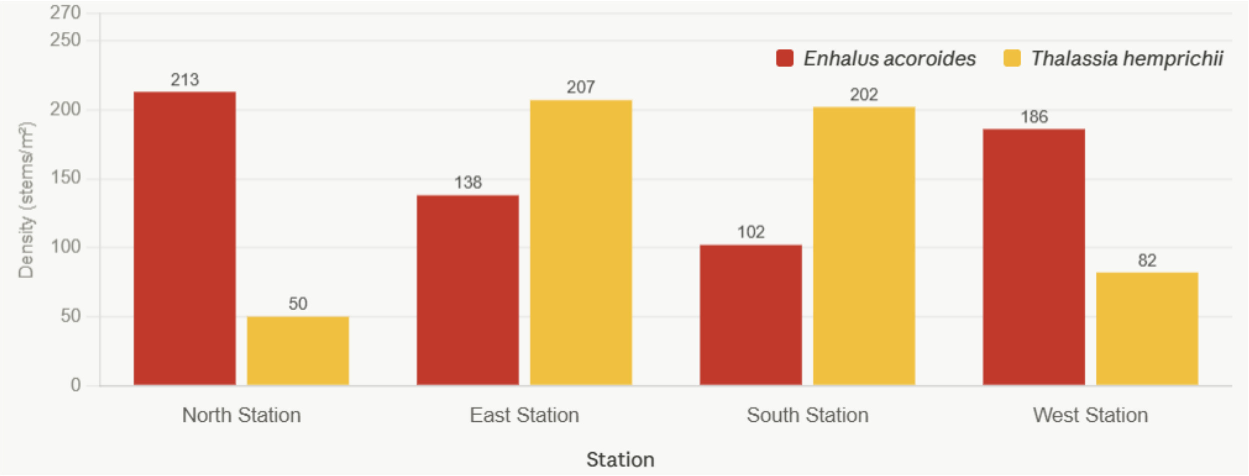

Figure 2. Species Density

The high density of *E. acoroides* at the northern station is influenced by several environmental factors, particularly substrate type. All sampling stations were characterized by sandy substrates, which are more suitable for the growth of *E. acoroides*. According to Hartati et al. (2012), seagrass density is influenced by several factors, including species type, substrate conditions, seasonality, tidal dynamics, wave energy, organic matter content in sediments, and other environmental variables.

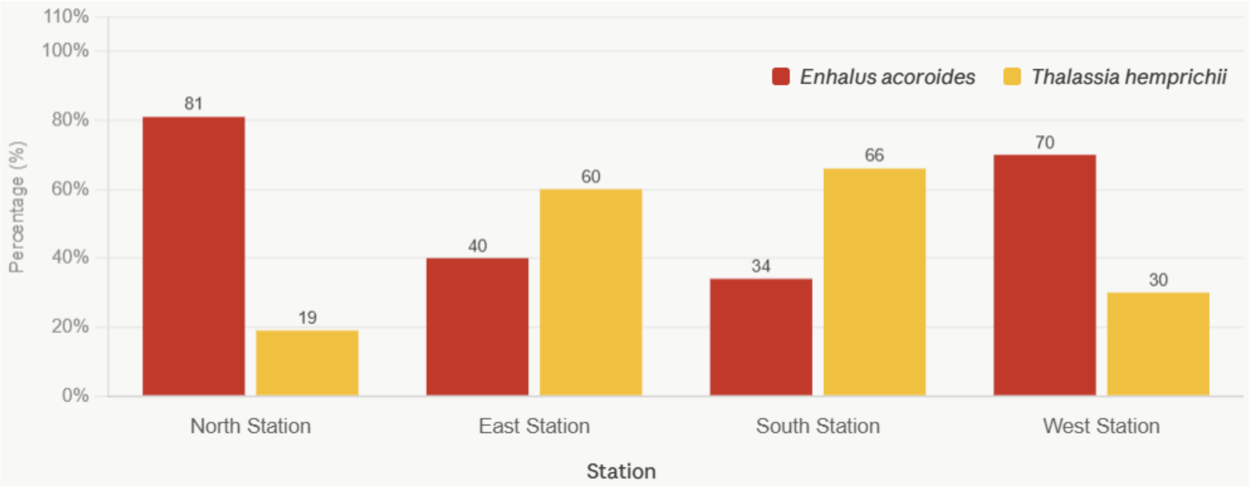

Figure 3. Relative Density

Based on the relative density results, *Enhalus acoroides* at the northern station showed the highest relative density, with an average of 81%. At the eastern station, relative density ranged from 37–45% with an average of 40%, while at the southern station it ranged from 33–35% with an average of 34%. At the western station, relative density ranged from 69–70% with an average of 70%.

The lowest relative density was observed in *Thalassia hemprichii* at the northern station (average 19%). At the eastern station, relative density ranged from 55–63% with an average of 60%, while at the southern station it ranged from 65–67%. At the western station, it ranged from 30–31% with an average of 30%.

This pattern is related to the ecological advantages of *E. acoroides*, which is capable of growing and adapting across various substrate types and efficiently absorbing organic matter from muddy sand, medium and coarse sand, and coral fragments. This is supported by its extensive, robust, and fibrous rhizome system, which is larger and stronger compared to other species (Nainggolan, 2011; Sinaga, 2016).

Abundance of *Diadema setosum*

Based on the results of this study conducted in the coastal waters of Malahing Village, Bontang City, East Kalimantan, the total abundance of *Diadema setosum* was 480 ind/m². The highest abundance was recorded at the eastern station with 176 ind/m², while the lowest abundance was observed at the northern station with 76 ind/m². This variation is influenced by seagrass distribution and substrate conditions in the study area.

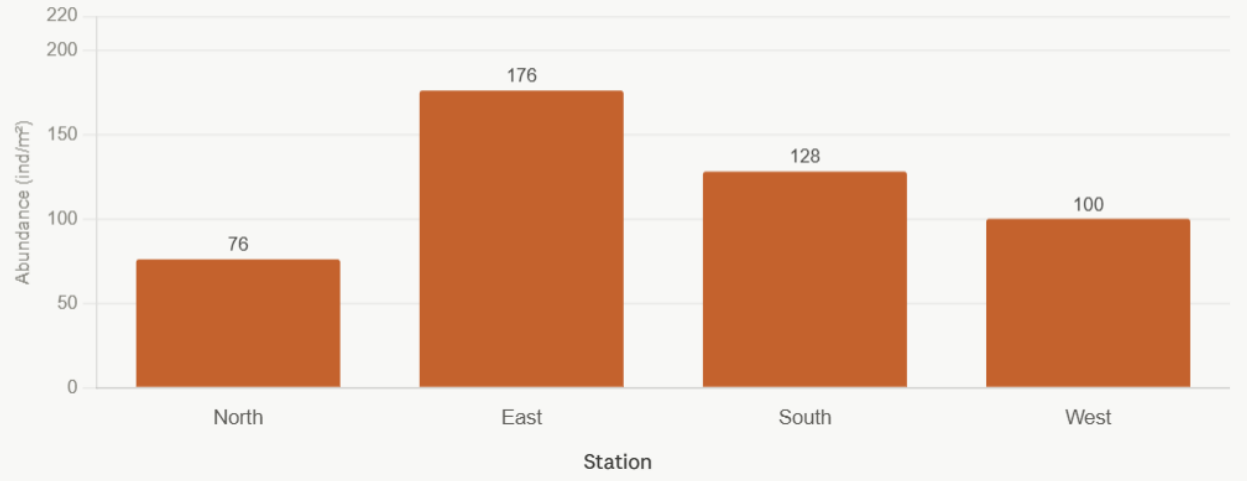

Figure 4. Abundance of *Diadema setosum*

Sea urchins are commonly found in mixed seagrass ecosystems. *D. setosum* can thrive in seagrass beds with hard substrates composed of sand mixed with coral fragments (Drahman, 2020). Another important environmental factor affecting sea urchin abundance is salinity. In this study, salinity ranged from 29.4 to 31.7‰, which is suitable for sea urchin survival. According to Darsono (1983) in Noviana et al. (2019), sea urchins can tolerate salinity levels ranging from 26 to 32 ppt.

Morphometric Characteristics of Diadema setosum

Based on morphometric measurements of *D. setosum* across all stations, values varied among sampling locations.

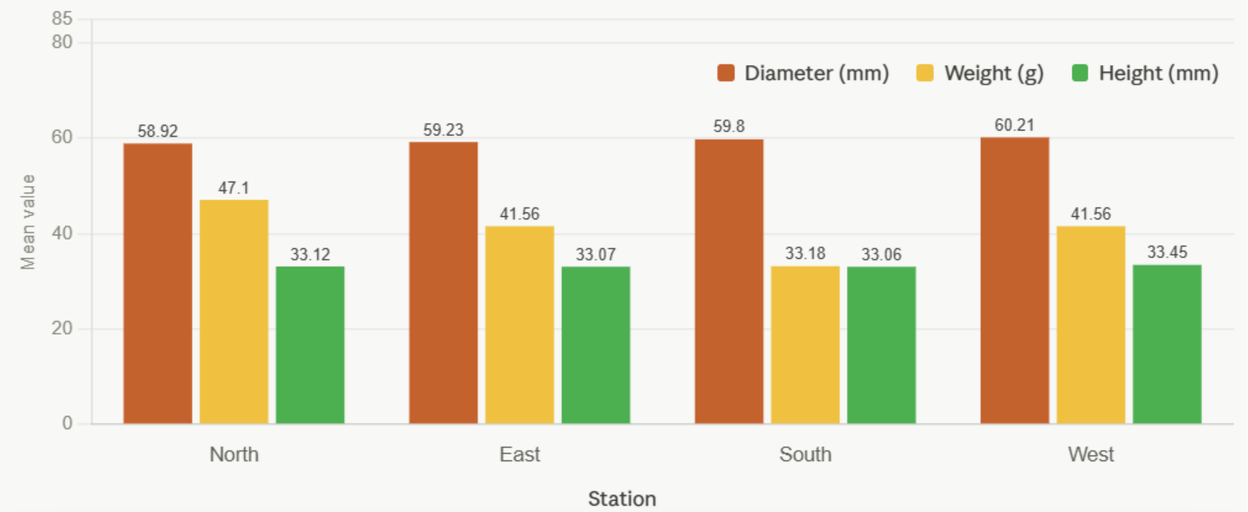

Figure 5. Morphometrics of *Diadema setosum*

At the northern station, the mean height was 33.12 mm, mean diameter was 58.92 mm, and mean weight was 37.1 g. At the eastern station, the mean height was 33.07 mm, mean diameter was 59.23 mm, and mean weight was 37.56 g. At the southern station, the mean height was 33.06 mm, mean diameter was

59.8 mm, and mean weight was 38.18 g. At the western station, the mean height was 33.45 mm, mean diameter was 60.21 mm, and mean weight was 38.56 g.

The diameter-to-weight ratio differed among stations, with values of 1:0.63 (northern and eastern stations) and 1:0.64 (western and southern stations). The growth pattern of *D. setosum* across all stations was negatively allometric, indicating that test diameter increases faster than body weight. Tjendanawangi (2010) stated that the body weight of sea urchins in natural habitats is closely related to substrate type.

Relationship between *Diadema setosum* Abundance and Seagrass Beds

The correlation analysis results showed varying relationships between *Diadema setosum* abundance and seagrass species density in the study area. A weak negative correlation was observed between *D. setosum* abundance and *Enhalus acoroides* density (r = -0.712), with a coefficient of determination of 50.69%. This indicates a weak inverse relationship between the two variables.

Table 2. Relationship Between *Diadema setosum* Abundance and Seagrass Density

Variable	Seagrass Density (shoots/m²)	*Enhalus acoroides*	*Thalassia hemprichii*
Diadema setosum (individuals/m²)	r = +0.983	r = −0.712	r = +0.896

The relationship between *Diadema setosum* abundance and seagrass density shows contrasting correlation patterns among seagrass components. The positive correlation between *D. setosum* and total seagrass density (r = +0.983) and with *Thalassia hemprichii* (r = +0.896) indicates that higher seagrass cover, particularly *T. hemprichii*, is associated with increased abundance of this sea urchin. This pattern suggests that *D. setosum* benefits from structurally complex seagrass beds, which may provide shelter from predators, stabilize sediments, and enhance food availability through epiphytic algae growing on seagrass blades. In contrast, the negative correlation with *Enhalus acoroides* (r = −0.712) implies that areas dominated by this large, thick-leaved seagrass species tend to support lower densities of *D. setosum*. This may be due to the dense canopy and coarse leaf structure of *E. acoroides*, which can reduce habitat suitability or limit access to epiphytic resources compared to more open or mixed seagrass stands. Additionally, differences in sediment characteristics and hydrodynamic conditions associated with *E. acoroides* beds may further influence sea urchin distribution. Overall, these results indicate that *D. setosum* responds not only to overall seagrass abundance but also to species-specific habitat structure within the seagrass community. This suggests that the abundance of *D. setosum* is strongly influenced by seagrass density, particularly *T. hemprichii*, which provides suitable habitat conditions for growth and development. Sea urchins are commonly associated with mixed seagrass beds. This condition occurs because sea urchins depend on various seagrass genera such as *Thalassia*, *Syringodium*, *Thalassodendron*, and *Cymodocea*, which typically grow in hard substrates composed of sand and coral fragments (Drahman, 2020).

CONCLUSION

The study demonstrated that seagrass meadows in Malahing Village provide essential habitats for *Diadema setosum*, with sandy substrates and suitable salinity ranges supporting their survival and growth. The variation in seagrass density across stations influenced sea urchin abundance, highlighting the ecological significance of substrate type and seagrass composition in shaping benthic community structures.

The positive correlation between *D. setosum* abundance and *Thalassia hemprichii* density underscores the importance of structurally diverse seagrass beds in sustaining sea urchin populations. In contrast, the negative correlation with *Enhalus acoroides* suggests that dense canopies of this species may limit habitat suitability. These findings indicate that sea urchins respond not only to overall seagrass cover but also to species-specific traits that influence food availability, shelter, and sediment stability.

Overall, the research highlights the ecological role of *D. setosum* as an indicator species for coastal ecosystem health. The strong association with mixed seagrass beds emphasizes the need for conservation strategies that maintain seagrass diversity and habitat complexity. Protecting seagrass ecosystems, particularly those dominated by *T. hemprichii*, is crucial for sustaining sea urchin populations and ensuring the resilience of coastal biodiversity in Bontang City

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