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THE EFFECT OF SUBSTRATE VARIATION ON THE STRUCTURE OF MACROBENTHIC COMMUNITIES IN THE SEAGRASS BEDS OF TARAHAN ISLAND

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ABSTRACT

This study aims to analyze the impact of different substrate types on the composition and diversity of macrobenthic communities in the seagrass beds of Tarahan Island. Research on macrobenthic diversity in seagrass habitats in the waters of Tarahan Island highlights the important role of substrate variation in shaping benthic community structure. Comparisons between two stations with different substrate characteristics show that the dominance of seagrass and sand cover at Station 1 creates a more heterogeneous and stable environment, thereby supporting higher abundance and diversity of macrobenthos compared to Station 2, which is dominated by macroalgae and coral/rock. Gastropods emerged as the most dominant group, utilizing the complexity of seagrass habitats as a source of food, protection, and microhabitats. Additionally, Bivalvia and Malacostraca were more abundant in sandy-seagrass habitats, while Holothuroidea were only found in limited numbers on stable organic-sand substrates. Variations in community composition between stations underscore the importance of seagrass beds as hotspots of benthic biodiversity in coastal areas. These findings underscore the urgency of protecting and managing seagrass beds sustainably to maintain benthic ecosystem stability and support biodiversity in the coastal areas of Tarahan Island.

INTRODUCTION

Tarahan Island, located in the waters of Cilegon, Bojonegara, Banten on the western side of Java Island, is a small uninhabited island with an important ecological role in the coastal region. The island serves as a habitat for marine biodiversity and influences the dynamics of the surrounding aquatic ecosystem. As a transition zone between land and sea, this small island reflects the health of the marine environment through the interaction of biological and physical processes. This study focuses on identifying and analyzing essential ecosystem components such as seabed substrate characteristics, macroalgae diversity and abundance, and macrobenthic community structure, which are expected to provide new information and support biodiversity conservation efforts on Tarahan Island and its surroundings.

The seabed substrate refers to the material that forms the seabed or the bottom of the water where benthic organisms live and reproduce. The composition of the substrate itself is one of the abiotic factors that can influence the distribution, abundance, and structure of organism communities in a water body. The substrate itself can vary from soft materials such as sand, mud, and a mixture of both (Taqwa et al., 2014).

The type of substrate greatly determines the availability of habitat and resources for various other marine organisms. For example, rocky and coral substrates often serve as ideal habitats for macroalgae and various invertebrate species. Meanwhile, soft substrates such as sand and mud provide habitats for organisms that live within the sediment and those that live on the sediment surface, which can adapt to such conditions (Levinton, 2001).

Macroalgae, also known as seaweed, are a group of multicellular algae that are macroscopic in size and live in marine and freshwater environments. They play an important role as primary producers that provide the main source of energy for the benthic food chain. Additionally, macroalgae play a vital role in biogeochemical cycles, particularly in oxygen production and carbon dioxide absorption through photosynthesis (Kordi, 2010). On the other hand, macrobenthos are invertebrate organisms that live on the seafloor and are large enough to be easily observed directly. Macrobenthos plays a crucial role in nutrient cycles, the decomposition of organic matter, and serves as a food source for higher trophic level organisms. Due to their limited mobility and slow response to environmental changes, the structure of macrobenthos communities—including species composition, abundance, and diversity—is often used as an effective indicator to assess environmental quality impacted by human activities.

Macroalgae play a crucial role in coastal ecosystems as primary producers, habitat providers, and indicators of environmental health. In tropical waters such as Tarahan Island, macroalgae diversity is influenced by complex interactions between physico-chemical parameters (temperature, salinity, pH) and substrate characteristics (sand, coral, seagrass). Research on Pelapis Island, Kayong Utara Regency, identified 17 macroalgae species from three main classes (Chlorophyta, Phaeophyceae, Rhodophyta), with Halimeda macroloba and Sargassum duplicatum dominating on sandy-coral substrate 1. Similar findings in the waters of Tiwoho, North Sulawesi, showed Turbinaria ornata as the dominant species in rocky intertidal zones, confirming the adaptation of macroalgae to substrate variations (Lestrari et al., 2023).

This study aims to obtain comprehensive empirical data on the ecological conditions of the waters around Tarahan Island, Cilegon, through the identification of the water substrate to understand the physical habitat, analysis of the diversity and abundance of macroalgae as indicators of primary productivity, and evaluation of the structure of the macrobenthic community to assess environmental quality and anthropogenic pressure. Additionally, this study examines the relationship between abiotic and biotic factors to provide a comprehensive picture of ecosystem dynamics. The results of this study are expected to serve as a scientific basis for formulating management and conservation efforts for the Tarahan Island ecosystem in the future, particularly given the lack of previous ecological assessments in this area (Putro et al., 2024; Atmaja et al., 2024). Similar approaches have proven effective in other Indonesian coastal regions in identifying key drivers of benthic ecosystem dynamics and informing sustainable habitat management strategies (Sugianti & Mujiyanto, 2020).

METHOD

Research Location and Time

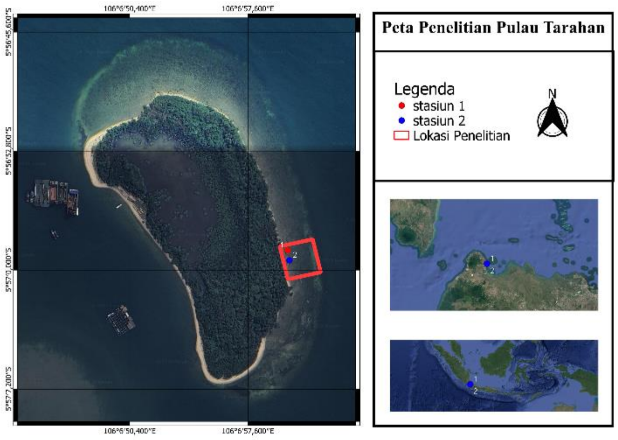

Figure 1. Map of Tarahan Island

This research was conducted on April 26, 2025, in the northern part of Tarahan Island, Bojonegara District, Serang Regency, Banten. The coordinates of the eastern part of Tarahan Island are 50°56′56″ S, 106°06′56″ E. The research activities included the collection of macrozoobenthos data as well as physical and chemical water parameter data, conducted directly on Tarahan Island using survey methods and transect sampling techniques. Data collection was carried out at 2 stations, with 10 plots at each station.

The map shows the research location on Tarahan Island, Serang Regency, Banten Province, Indonesia. This study was conducted using a spatial approach with satellite imagery marked by geographic coordinates (latitude and longitude). The map displays two observation points (stations): Station 1 (marked with a red dot) and Station 2 (marked with a blue dot).

Both stations are located on the northeast side of Tarahan Island and are within the area bounded by the red square line as the main research location. This area was chosen because it has a unique coastal ecosystem potential, such as coral reefs, seagrass beds, and mangroves, which were identified from satellite images and field observations. The area marked with a red box indicates the boundaries of the research area that is the focus of observation or sampling (Rahmawati, 2020).

Sample Collection

Each station is located in the intertidal zone or tidal zone and is conducted when the water is receding. Each station has a 10-meter transect line perpendicular to the coastline. There are 11 plots on each transect line. Macrozoobenthos sampling is conducted using a 50cm x 50cm transect. Sampling is repeated 11 times at each plot. The macrozoobenthos species found within the plot are placed into a ziplock bag and separated by station.

Species Identification

In this study conducted on Tarahan Island, the identification of macrobenthos in the bottom substrate in the eastern part was carried out to distinguish the species found in the macrobenthos collected from the bottom substrate of the water, specifically at the Biotechnology Laboratory on the campus of Sultan Ageng Tirtaya University. The identification was based on different characteristics, starting from morphology. To obtain and identify the species found, the Web WoRMS database and scientific journals were utilized.

RESULT

Habitat Characteristics

Table 1. Average percentage of substrate coverage at each station

ST	MA	SG	S	R	C
1	8,18	53,18	22,27	13,18	3,18
2	19,91	20,68	10,91	8,64	9

The table above shows the average percentage of coverage of various types of substrates at two observation stations. At Station 1, seagrass (SG) dominates with 53.18%, followed by sand (SA) at 22.27%, and coral fragments (R) at 13.18%. Meanwhile, macroalgae (MA) and coral/rock (C) are relatively low, at 8.182% and 3.18%, respectively. In contrast, Station 2 shows an increase in macroalgae coverage to 19.91% and coral/rock to 9.55%, but seagrass coverage has decreased dramatically to 20.68%. The percentages of sand and coral fragments at Station 2 were also lower than at Station 1, at 10.91% and 8.636%, respectively. These data indicate significant variations in substrate composition between the two stations, particularly in terms of seagrass, macroalgae, and coral/rock components.

Macrobenthic Wealth

Tabel 2. Macrobenthic Wealth

Class	Species	St 1	St 2
Gastropoda	*Monodonta canalifera*	✓	✓
Gastropoda	*Canarium sp*	✓	✓
Gastropoda	*Aquatile sp*		✓
Gastropoda	*Semiricinula fusca*	✓	✓
Gastropoda	*Littorea sp*	✓	✓
Gastropoda	*Lunella smaragda*	✓	✓
Gastropoda	*Mutabile sp*	✓	
Gastropoda	*Bolma rugosa*	✓	✓
Gastropoda	*Monetaria annulus*	✓	
Gastropoda	*Cardium sp*	✓	✓
Bivalvia	*Pholas dactylus*	✓	✓
Bivalvia	*Fulvia mutica*	✓	
Bivalvia	*Pleurobranchaea*	✓	
Malacostraca	*Charybdis sp*		✓
Malacostraca	*Euplax dagohoyi*	✓	
Holothuroidea	*Holothuria atra*	✓	

The table above presents data on the abundance of macrobenthic species found at two observation stations, covering several major classes such as Gastropoda, Bivalvia, Malacostraca, and Holothuroidea. Most of the identified species belong to the Gastropoda class, such as *Monodonta canalifera*, *Canarium sp*, and *Littorea sp*, which are distributed across both stations. Additionally, there are species from the Bivalvia class such as *Pholas dactylus* and *Fulvia mutica*, as well as Malacostraca such as *Charybdis sp* and *Euplax dagohovi*, and one Holothuroidea species, *Holothuria atra*. The distribution of species indicates that some species are only found at one station, while others are found at both stations, reflecting variations in the composition of the macrobenthic community between locations.

Abundance of Macrobenthos

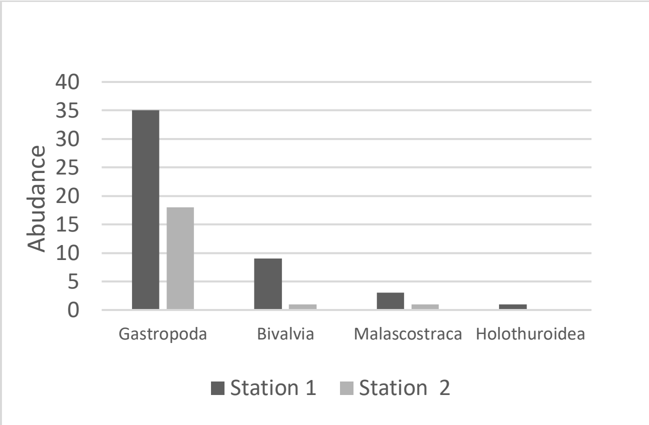

Figure 1. Comparison of Macrobenthos Abundance Based on Class at Two Observation Stations

Figure 1 shows the abundance of four classes of macrobenthos at two observation stations, namely Gastropoda, Bivalvia, Malacostraca, and Holothuroidea. Gastropoda is the most dominant class at both stations, with the highest number of individuals at Station 1 (around 35 individuals) and lower at Station 2 (around 20 individuals). Bivalvia and Malacostraca were also more abundant at Station 1 than at Station 2, although their numbers were far fewer than those of Gastropoda. Meanwhile, Holothuroidea were only found in very small numbers at Station 1 and were not detected at Station 2. These data indicate that Station 1 has a higher abundance of macrobenthos compared to Station 2, with a clear dominance by the Gastropoda class.

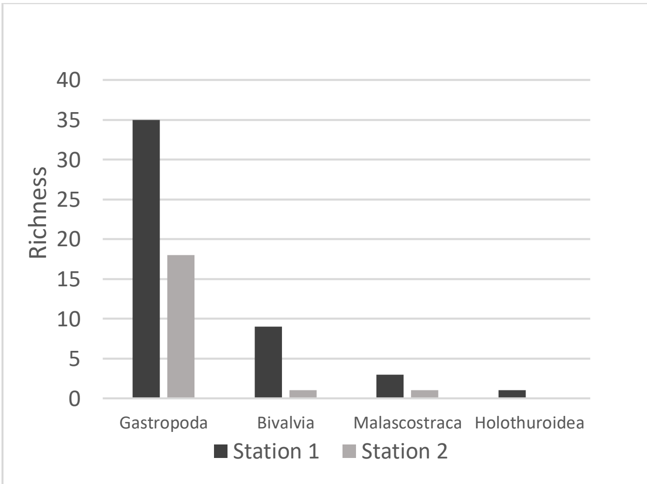

Figure 2. Comparison of Macrobenthos Abundance at Two Observation Stations

Figure 2 shows the level of macrobenthos richness at two observation stations. It can be seen that Station 1 has a higher level of abundance, with a value of around 10, compared to Station 2, which is only around 8. This data indicates that Station 1 has a more diverse macrobenthic community than Station 2, which may reflect more favorable environmental conditions for various types of macrobenthos at Station 1.

DICUSSION

Macrobenthic Biodiversity and Habitat Characteristics

Substrate composition is the main determinant of macrobenthos distribution. At Station 1 on Tarahan Island, the dominance of seagrass (53.18%) and sand (22.27%) creates a heterogeneous environment that supports the abundance of Gastropoda such as Monodonta canalifera and Littorea sp. Seagrass substrate provides complex microhabitats through its root system and leaves, which stabilize sediments, while also serving as a source of organic matter through the decomposition of detritus (Nurhia et al., 2021). Conversely, at Station 2, with an increase in macroalgae (19.91%) and coral/rock (9.55%), there was a 30.7% decrease in macrobenthic diversity compared to Station 1. This aligns with findings (Nybakken, 1992) stating that rocky substrates tend to have lower organic matter content, making them suitable only for certain species like Charybdis sp. that can adapt.

Gastropods showed the highest dominance at Station 1 because seagrass cover reached 53.18%, creating an optimal habitat for this group. The seagrasses *Enhalus acoroides* and *Thalassia hemprichii* provide a complex substrate supporting 10 Gastropoda species (*Monodonta canalifera, Canarium sp, Aquatile sp, Semiricuktula fusca, Littorea sp, Lunella smaragda, Muirhile sp, Bolma rugosa, Monetaria annulus, and Cardium sp*). Research at Nirwana Beach shows that seagrass ecosystems with a pH of 8 and salinity of 33.3‰ support 16 species of Gastropoda with a diversity index H' = 2.193-2.370 (Sari et al., 2019). This mechanism occurs because seagrass acts as: (1) a provider of microhabitats through epifauna attached to leaves and rhizomes, (2) a food source in the form of detritus and microalgae, and (3) shelter from predators and hydrodynamics. A study in Bahoi Village demonstrated that a seagrass bed spanning 16.50 hectares supports 26 gastropod species (11 families) with a maximum density of 1.10 ind/m^2 and a diversity index H' = 2.51 (Hutabarat et al., 2021). The structural complexity of seagrass at Station 1 also reduces interspecific competition, allowing the coexistence of species with different ecological niches, such as *Littorea sp*. (herbivores) and *Cardium sp*. (filter feeders).

Bivalves (*Pholas dactylus*, *Fulvia mutica, Peurobranchus*) dominated Station 1 because the sand substrate (22.27%) stabilized by seagrass facilitated burrowing activity. Research in Bali Barat National Park shows a significant correlation ($p<0.05$) between seagrass cover and bivalve density, with Pinna bicolor reaching a density of 50% at 50.46% seagrass cover (Ayu et al., 2024). The sandy-seagrass substrate at Station 1 provides optimal conditions for bivalves because: (1) sediment stability reduces the risk of burial, (2) high organic matter content from seagrass detritus, and (3) slow currents that facilitate filtration. A study at Puding Beach demonstrated that *Gafrarium tumidium* dominates areas with *Halodule uninervis* (141 ind/m) and *Enhalus acoroides* (7 ind/m) due to the seagrass roots' ability to bind organic sediment (Febrina et al., 2018). In contrast to Station 2, the increase in macroalgae (19.91%) and coral (9%) created a hard substrate unsuitable for burrowing Bivalvia, so only Fulvia mutica, which is adaptive to mixed substrates, was found.

Malacostraca (*Charybdis sp, Euplax dagohovi*) showed a preference for Station 1 due to the complexity of the seagrass habitat, which provides refugia and food sources. Research on the Paraguaná Peninsula shows that the density of *Thalassia testudinum* at 1,511.48 stems/m^2 with high LAI supports a diverse Decapoda community through increased structural complexity (Marino et al., 2018). Seagrass serves as a nursery ground for juvenile Malacostraca because: (1) protection from predators through camouflage, (2) availability of zooplankton and detritus, and (3) microhabitat stability. Studies show that El Supí, with vegetation cover of 87–100% and the presence of flowering *Thalassia testudinum*, has higher Decapoda abundance than *Adícora* (69–97%) (Marino et al., 2018). At Station 2, a decrease in seagrass cover (20.68%) and increased anthropogenic activity caused habitat fragmentation, reducing the effectiveness of refugia for Malacostraca.

Holothuroidea (*Holothuria atra*) is exclusively found at Station 1 due to its preference for stable organic-sand substrates. Research at Mertasari Beach shows that *Holothuria atra* reaches an abundance of 0.1 ind/m^2 in areas with *Enhalus acoroides* (93.77 ind/m^2) because the wide leaf morphology provides protection from excessive light intensity (Made et al., 2021). The sandy-seagrass substrate at Station 1 is optimal for *H. atra* because: (1) high detritus content as a food source, (2) sediment stability for burrowing activity, and (3) stable physico-chemical parameters (pH 8.5–8.8). Studies show that dense seagrass conditions enhance water fertility through the abundance of microorganisms (plankton, detritus, foraminifera) that serve as the primary food source for sea cucumbers (Made et al., 2021). The absence of H. atra at Station 2 is related to the substrate dominated by macroalgae and coral, which are unsuitable for deposit feeding and burrowing activities.

The distribution pattern of macrobenthos on Tarahan Island reflects the importance of habitat heterogeneity in supporting species diversity. Station 1, with high seagrass cover, serves as a biodiversity hotspot, while Station 2 has undergone degradation due to changes in substrate composition and anthropogenic pressure. Conservation strategies should focus on: (1) protecting seagrass beds as key habitats, (2) monitoring sediment quality and substrate coverage, and (3) managing anthropogenic activities that affect the stability of the benthic ecosystem. Research indicates that seagrass rehabilitation can significantly increase macrobenthos abundance, emphasizing the urgency of ecosystem-based management in the waters around Tarahan Island.

CONCLUSSION

Research on macrobenthic diversity in the seagrass habitat of Tarahan Island shows that Station 1, which is dominated by seagrass and sand cover, has higher macrobenthic diversity and abundance than Station 2, which is dominated by macroalgae and coral/rocks. Gastropods are the most dominant group at both stations, particularly at Station 1, as seagrass structures provide optimal habitat and food sources. Variations in substrate composition significantly influence the distribution and structure of the macrobenthic community, with seagrass-dominated habitats acting as biodiversity hotspots. The ecological implications of these findings emphasize the importance of seagrass bed conservation and the management of human activities to maintain the stability and diversity of the benthic ecosystem in Tarahan Island.

REFERENCES

Ayu, S., Putri, M., Ambaranatha, I. W. M., & Darmadi, N. M. (2024). DEPIK Community structure of bivalve on seagrass ecosystems in the West Bali National Park area. 13(April), 78–84. https://doi.org/10.13170/depik.13.1.33903

Chang, C. F., & Tseng, C. K. (2010). "Marine Macroalgae as a Biological Resource in Coastal Ecosystems." Journal of Applied Phycology, 22(5), 789–797.

Dewi, A. K., et al. (2025). "Diversity of Macroalgae in the Coastal Waters of Gunung Payung, Bali." Jurnal Akuakultur dan Fisiologi Hewan, 10(1), 45–56.

Febrina, M., Adi, W., & Febrianto, A. (2018). BANGKA SELATAN Bivalve Abundance at the Seagrass Ecology of Puding Beach , South Bangka Regency. 64–75.

Filbee-Dexter, K., & Scheibling, R. E. (2014). "Detrital Subsidies and Nutrient Cycling in Coastal Macroalgal Beds." Marine Ecology Progress Series, 515, 1–17.

Hillman, K., et al. (1995). "Seagrass and Macroalgae Communities in Coastal Ecosystems: Structure, Function, and Environmental Influences." Marine Ecology Progress Series, 123, 201–213.

Kordi, K. M. G. H., 2010. Kiat Sukses Budidaya Rumput Laut dan di Tambak. penerbit ANDI. Yogyakarta

Lestrari, F. putri, Juliono, F., Ramadhani, H., Hafidz, M., Halim, S., Hidayat, S., Raynaldo, A., & Marista, E. (2023). Inventory of Macroalgae Species in the Coastal Waters of Pelapis Island, Kayong Utara Regency. Jurnal Laut Khatulistiwa, 6(2), 2614–8005. http://jurnal.untan.ac.id/index.php/lk

Made, N., Morina, S., Riyantini, I., & Mulyani, Y. (2021). Abudance Of Sea Cucumber (Holothuroidea) in Seagrass Density In The Waters Of The Coast of Mertasari , Subdistrict Of Denpasar , Bali. 9(4), 128–139.

Marino, J., Mendoza, M. D., & L, B. L.-S. (2018). Composition and Abundance of Decapod Crutaceans in Mixed Seagrass Meadows in the paraguana peninsula, Venezuela. 1–10. https://doi.org/10.1590/1678-4766e2018004

Masduki, A., et al. (2024). "Structure and Distribution of Macrobenthos Community in Code River, Yogyakarta, Indonesia." Indonesian Journal of Aquatic and Marine Science, 2(2), 77–88.

Nurhia, ., Ira, ., & Rahmadani, . (2021). Kelimpahan Dan Pola Sebaran Makrozoobenthos Di Perairan Desa Ollo Selatan Kabupaten Wakatobi. Jurnal Sapa Laut (Jurnal Ilmu Kelautan), 6(1), 49. https://doi.org/10.33772/jsl.v6i1.17556

Nybakken J.W., 1992. Biologi laut suatu pendekatan ekologi.Gramedia. Jakarta

Pamungkas, E. R., et al. (2025). "Marine Macroalgae Biodiversity in the Pangandaran Coastal Area, Indonesia." Egyptian Journal of Aquatic Biology & Fisheries, 29(1), 1–18.

Sangaji, M. (2021). "Macroalgae Abundance and Cover as Ecological Indicators of Coral Reef Management in the Waters of Katapang Village, West Seram Regency, Maluku Province." International Journal of Science and Engineering, 12(2), 121–130.

Setyorini, D., et al. (2021). "Macroalgae Community Structure and Diversity in Peh Pulo Beach, Blitar, East Java." Hayat: Journal of Biosciences, 8(1), 13–23.

Suryanti, N., et al. (2024). "Macroalgae Diversity and Environmental Parameters in the Coastal Waters of Kendari Bay, Southeast Sulawesi." Jurnal Ilmu Kelautan, 29(1), 67–76.

Taqwa, R. N., Muskananfola, M. R., Program, R., Manajemen, S., Perairan, S., Perikanan, J., Perikanan, F., & Kelautan, I. (2014). Di Muara Sungai Sayung Kabupaten Demak. Diponegoro Journal of Maquares, 3(1), 125–133. http://ejournal-s1.undip.ac.id/index.php/maquares