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Diversity of Echinoderms in The Water of Dedap Island, Abang Island Sub-district, Batam City

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Abstract

Dedap Island is a group of small islands in the waters off the coast of Abang Island which is famous as a spot for anglers because of its clean location and abundance of marine life. This research is focused on identifying the diversity of Echinoderms in the waters surrounding Dedap Island, located in Abang Island sub-district, Batam City, Indonesia. Additionally, it examines the factors that influence the distribution and abundance of these species. The observation was conducted using line transect methods across various locations, leading to the identification of five species of Echinoderms: three from the class Holothuridae (sea cucumbers), one from the class Astroidea (starfish), and one from the class Echinoidea (sea urchins). The species Diadema setosum (sea urchin) emerged as the most dominant, with a total of 361 individuals recorded. The diversity index (H') for Echinoderms in Dedap Island was classified as low (0.40), and the evenness index (E) also indicated low values (0.25), suggesting an uneven distribution of individuals and dominance by certain species. Contributing factors to this low diversity include ecological pressures, unstable productivity, and substrate conditions primarily composed of sand.

Keywords: *Dedap Island; Diadema setosum; Diversity; Echinodermata*

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INTRODUCTION

Indonesia is a country that has a very high level of biodiversity and endemism because it has a total of 17,504 islands, the length of Indonesia's coast reaches 95,181 km with a sea area of 5.4 million km^2, and dominates the total territorial area of Indonesia of 7.1 million km^2 so that Indonesia becomes one of the mega biodiversity country (Muzammil et al., 2021), one of them is Dedap Island. Dedap Island is a

crucial fishing area for the local fishing community. Positioned at coordinates 0°29'31" N and 104°16'03" E, this uninhabited island is part of a cluster of small islands in the waters off Abang Island, Batam, Kepulauan Riau. Its strategic location in the southern region makes it a favorite spot for anglers, owing to its distance from industrial areas and the relatively clean waters that are abundant in various species of fish and other marine animals, including Arthropoda, Mollusca, Cnidaria, and Echinoderms.

Echinoderms is a group of invertebrate animals widely distributed across almost all marine ecosystems, particularly in the intertidal zone. Approximately 7,000 species of Echinoderms have been described from all oceans (Zhukova, 2023), comprising five classes: Echinoidea (sea urchins), Holothuroidea (sea cucumbers), Crinoidea (sea lilies and feather stars), Ophiuroidea (brittle stars), and Asteroidea (starfish). They represent the fourth most speciose marine taxon, following crustaceans, mollusck, and annelids (Sobczyk et al., 2023). These animals are characterized by rough protrusions resembling spines on their outer epidermis. Distinguishing features include an endoskeleton made of calcium carbonate, a water vascular system, pedicellariae shaped like pincers, papillae for respiration, and pentaradial symmetry in adulthood (Tala et al., 2021). Echinoderms are known for their ability to autotomise and regenerate damaged, severed, or lost body parts. All Echinoderms live in the oceans from coastal waters to depths of 6,000 meters (Tompolumiu et al.,, 2023). They associate with various substrates, such as sandy, muddy, seagrass, coral reefs, and mangroves; however, substrate type significantly affects biodiversity and abundance due to variations in food availability.

According to Lestari et al., (2020), the habitat of Echinoderms is also influenced by physical and chemical factors in their respective areas. This group of animals is known as beach cleaners due to their detritivorous feeding habits, utilizing organic material that other animals do not consume. Echinoidea (sea urchins), Asteroidea (starfish), and Ophiuroidea (brittle stars) serve to protect coral from excessive algal growth, while Holothuroidea and Echinoidea play roles in nutrient recycling (Erlangga et al., 2018). Additionally, these organisms are primarily nocturnal and tend to hide during the day.

Certain species of Echinoderms hold significant economic value in both food and medicinal fields. In some countries such as Japan, Korea, Hong Kong, China and European countries, sea cucumbers (Holothuria) and sea urchins (Echinoidea) have a higher demand. According to Hanifaturahmah et al., (2024), Indonesia is a largest producer of sea cucumber exports. High market demand causes biota capture not to pay attention to the size and age suitable for harvest, causing a significant population decline, such as on Drini beach, Yogyakarta (Mufida et al., 2023), the water of Ngle-Ngle small island (Nurafni et al., 2019), and the water of Letman, Maluku Utara (Silaban et al., 2022). Several species are also categorized as endangered by the IUCN (International Union for Conservation of Nature) 2023, such as *Apostichopus japonicus, Holothuria lessoni, Holothuria nobilis, Holothuria scabra, Holothuria whitmaei, Isostichopus fuscus, and Thelenota ananas* (Kudato et al.,2025).

Continuous exploitation can disrupt ecological interactions between species, resulting in reduced numbers and diversity. In addition, there has been no previous research on the diversity of Echinoderms on Dedap Island, so this study encourages

this study to assess the diversity of Echinoderms found on the island by determining the diversity index, evenness index, and dominance index. This finding is expected to provide insight into the community structure of Echinoderms in the waters of Dedap Island.

METHOD

Time and Place

This study was conducted in September 2024 on Dedap Island, which is located at coordinated 0°29'31" N and 104°16'03" E, Abang Island Sub-district, Batam City, Kepulauan Riau. The researchers faced challenges due to climate change entering the rainy season, so sampling was carried out at night 19.30 P.M – 03.00 A.M in the intertidal zone. The observed area featured sandy substrates along the beach, while the middle section leading to the sea was dominated by sand mixed with rocky coral.

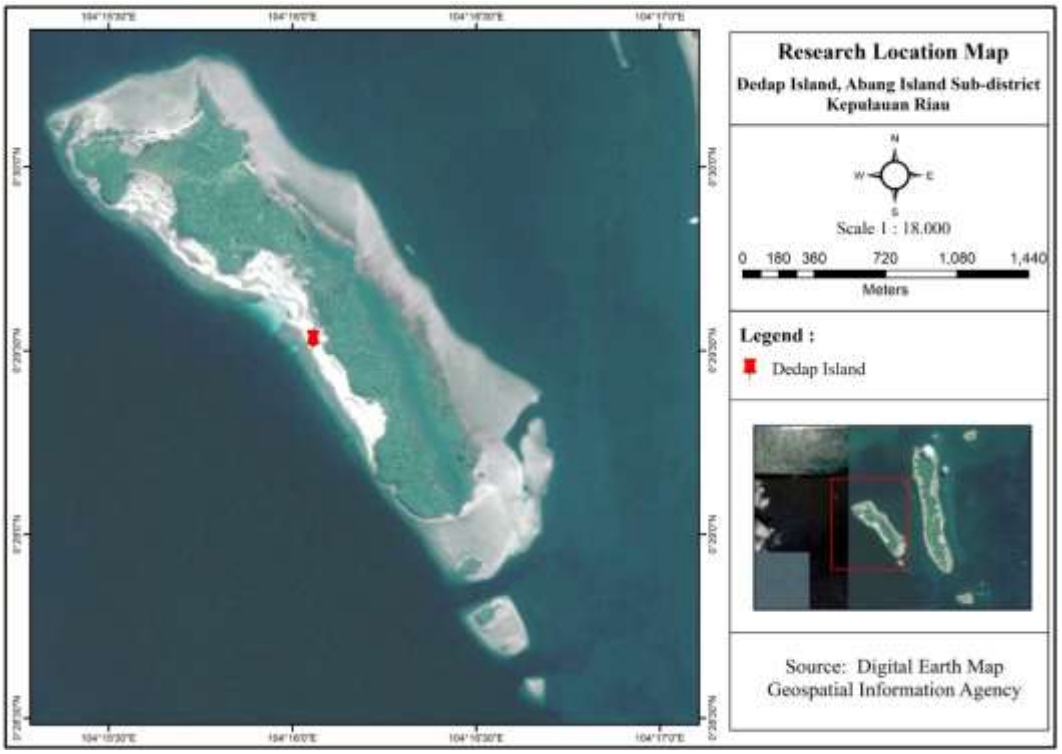

Figure 1. Research Location in The Water Of Dedap Island, Abang Island Sub-district, Kepulauan Riau

Instrument

Some of the main tools used in data collection include ropes used as a gauge in determining transect lines or research boundaries, refractometers used to measure salinity or dissolved salt levels, pH meters used to measure aquatic acid-base levels, DO meters used to measure dissolved oxygen levels in the water, thermometers to measure water temperature, and GPS as a determinant of the coordinate point of the

research location. In addition, other tools are also used in supporting sampling such as buckets, nets, gloves, cameras, stationery, and boats.

Procedure and Data collection

The research procedure begins by establishing a sampling point. After the location is determined, sampling is carried out by the straight line transect method using a rope pulled parallel or perpendicular for 50 meters from the lowest receding point towards the sea. The distance between the observation transects is 20 meters. The samples used as data sources are all types of phylum Echinoderms and the results of environmental parameter measurements. Sampling is carried out at low tide at night in the intertidal area by tracing the transect line towards the lowest low tide limit. The samples found were placed in a bucket to be identified. The researchers observed and recorded all types and individual counts of each species of Echinoderm found along the transect, as well as recorded aquatic environmental parameters that included temperature, salinity, pH, DO and base substrate. Each type of Echinoderm found, was identified by following the guidance from (Purcell et al., 2023; Arriesgado et al., 2022; and Norte et al., 2018).

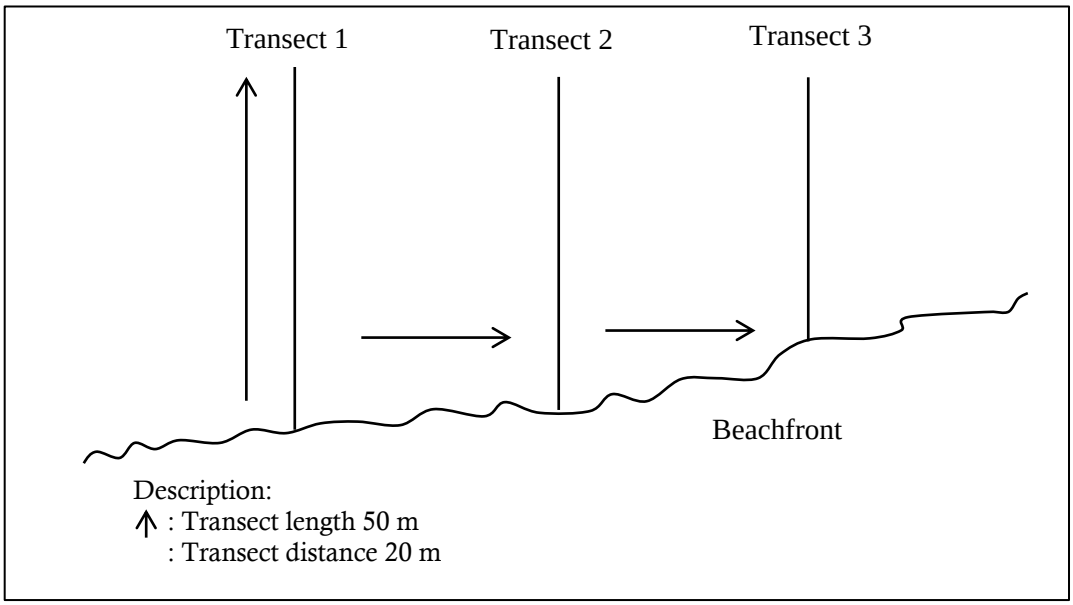

Figure 2. Sampling Method of Echinodermsurce (Putri & Potoboba, 2022)

Data Analysis

The collected data were analysed descriptively and quantitatively using the Shannon-Wiener diversity index (H'), Pielou evenness index (E), and Simpson dominance index (D). Additionally, water quality testing was carried out to determine the influence of environmental parameters on Echinoderms diversity.

The Shannon-Wiener diversity index

The Shannon-Wiener diversity index was calculated using the formula (Eman et al., 2021):

$$H' = -\sum_{i=1}^{s} \left[\frac{ni}{N}\right] In \left[\frac{ni}{N}\right] \quad \text{..... (1)}$$

Description:
H' = Diversity Index
S = Number of Species in the Sample
Ni = Number of Individuals in the Sample
N = Total Number of Individuals of All Species in the Sample

Table 1. Interpretation Based on the Diversity Indeks

No.	Diversity	Stability Criteria
1.	0<H'<1	Low (unstable)
2.	1<H'≤2	Moderate
3.	H'>2	High (stable)

Source: (Fitriyah et al., 2020)

The Evenness Index

The evenness index was calculated using the following formula (Nurafni et al., 2019):

$$E' = \frac{H'}{H'max} \quad \text{..... (2)}$$

Description:
E' = Evenness Index
H' = Diversity Index
H Max = Maximum Species Diversity
S = Number of Species in the Sample

Table 2. Interpretation Based on the Evenness Index

No.	Evenness	Stability Criteria
1.	E < 0,4	Low Evenness
2.	0,4 ≤ E ≤ 0,6	Moderate Evenness
3.	E > 0,6	High Evenness

Source: (Nurafni et al., 2019)

The dominance Index

The dominance index was calculated using the formula (Eman et al., 2021):

$$D = \Sigma\left(\frac{ni}{N}\right)^2 \quad \text{..... (2)}$$

Description:
D = Dominance Index
ni = Number of Individuals of species i
N = Total Number of Individuals

Table 3. Interpretation Based on the Dominance Index

No.	Dominance	Dominance Criteria
1.	0 <D < 0,50	Low Dominance
2.	0,50 <D< 0,75	Moderat Dominance
3.	0,75 <D< 1,00	High Dominance

Source: (Azwir et al., 2019)

RESULT AND DISCUSSION

The research was conducted in the waters of Dedap Island, Abang Island Sub-district, Batam City. This area is a small island situated to the south of Batam City, Kepulauan Riau. The region serves as a marine tourism site and features beautiful beaches, with well-preserved and natural coral reefs supporting a diverse range of marine life. Two substrate types were identified at the sampling location: sandy substrate along the beach and sandy substrate mixed with rocky coral further out to sea.

Echinoderms Species Diversity

From observations, five species of Echinoderms were identified on Dedap Island consisting of *Holothuria leucospilota*, *Holothuria scabra*, *Holothuria fuscocinerea* from the class Holothuridae, *Diadema Setosum* from the class Echinoidea, and *Culcita novaeguieneae* from the class Astroidea.

Holothuria leucospilota

Holothuria leucospilota known as the black sea cucumber, exhibits a dorsal black colour and a dark brown ventral side, with a long body size. This tentacle-less species is commonly found in shallow habitats. *Holothuria leucospilota* is a prevalent sea cucumber species capable of adapting to temperate climates. When handled, it contracts into a smaller size (Tuhumury et al., 2019). During the study, this sea cucumber was found on sandy substrates.

Holothuria scabra

Holothuria scabra or sand sea cucumber, displays yellow-grey or light brown colours with brown or grey spots on its back. It is considered to have higher economic value compared to other sea cucumber species. Typically, this sea cucumber is yellow or grey with transverse black stripes across its back.

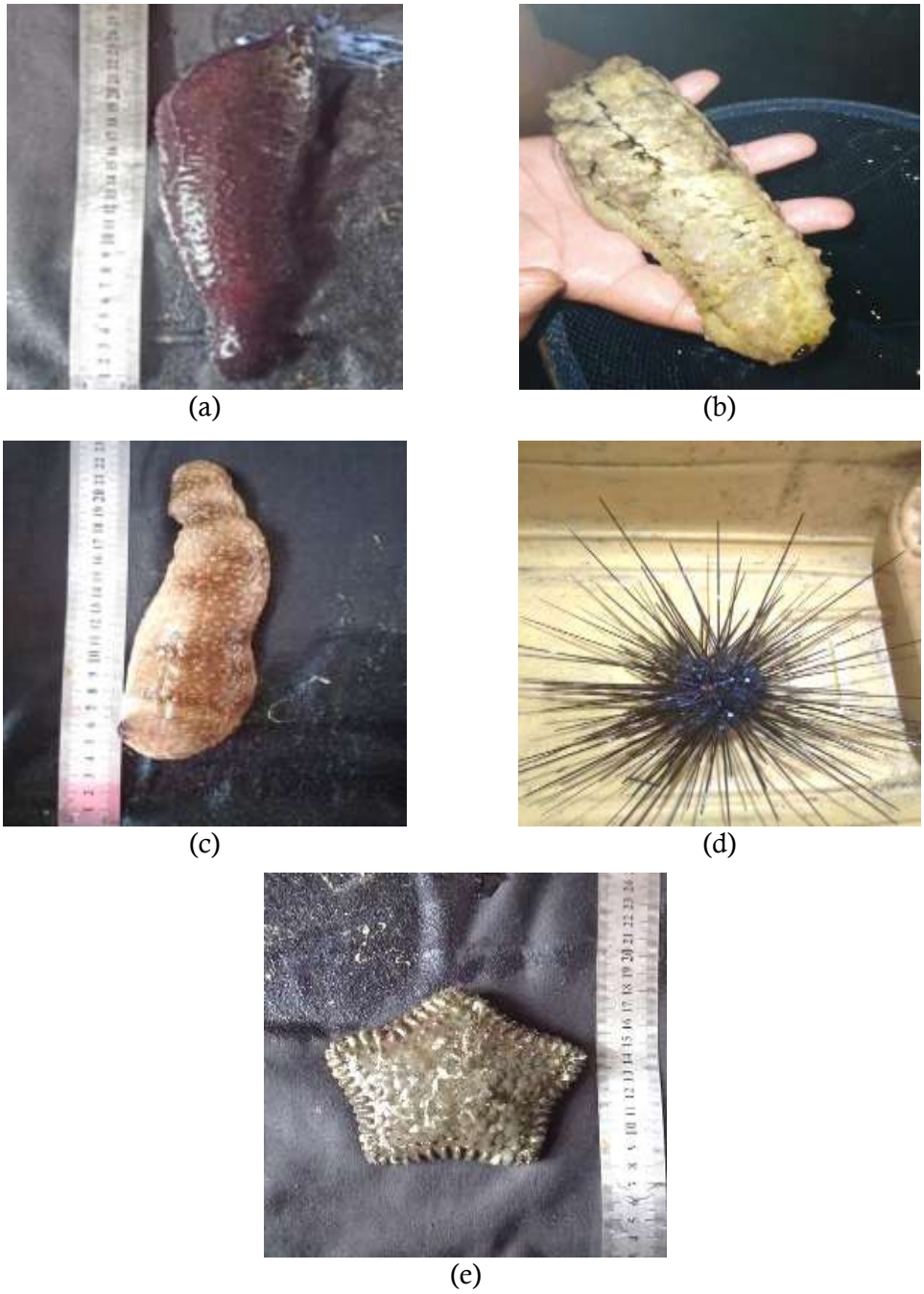

Figure 3. Echinoderms Species in the Waters of Dedap Island, *Holothuria leucospilota* (a), *Holothuria scabra* (b), *Holothuria fuscocinerea* (c), *Diadema Setosum* (d), and *Culcita novaeguieneae* (e).

Holothuria fuscocinerea

Holothuria fuscocinerea was the most frequently encountered sea cucumber during the study. It has a brown-grey dorsal color and darker brown stripes on its back. There are ring-like brown markings around the anus and near the base of the ventral podia. This sea cucumber lacks commercial value in Indonesia due to a general lack of public interest in its consumption, leading to its tendency to thrive in its habitat.

Diadema setosum

The sea urchin species *Diadema setosum* has a flattened, round shape, with a shell covered in long, sharp spines. Its body is predominantly black, with a purple ring around the mouth area. This species possesses tube feet between the spines that aid in movement. *Diadema setosum* from the class Echinoidea inhabits shallow sublittoral zones at depths ranging from 1 to 20 meters, but is most commonly found at depths of 4 to 6 meters (Vafidis et al., 2021). This sea urchin species lives in groups and prefers sandy habitats and shelter under coral colonies (Sese et al., 2018).

Culcita novaeguieneae

Culcita novaeguieneae is a starfish species characterised by short arms and a thick, swollen body. The tube feet on this starfish function as suction discs, enabling it to adhere to rocks and facilitate movement. This species is commonly referred to as the cushion star (Fatihah et al., 2023). According to Norte et al., (2018), this species exhibits color variations with patterns of yellowish-brown, orange-brown, yellow, and green spots. It typically lives solitarily in sandy environments covered with seagrass or coral reefs.

Table 4. Echinoderms Species Found on Dedap Island for 50 Meters

Class	Genus	Species	Transect			Total Individuals
			1	2	3	
Holothuroidea	Holothuria	*Holothuria leucospilota*	4	5	1	9
			0	2	0	2
		Holothuria scabra	2	0	24	26
		Holothuria fuscocinerea				
Echinoidea	Diadema	*Diadema Setosum*	81	145	135	361
Asteroidea	Culcita	*Culcita novaeguieneae*	0	1	0	1
Diversity (H)						**0,40**
Evenness (E)						**0,25**
Dominance (C)						**0,81**

Based on Table 4, *Holothuria fuscocinerea* was the most frequently encountered individual among the sea cucumber species, with a total of 26 individuals recorded. This species was found at the third transect. The gently sloping beach surface with rocky coral conditions provides a suitable habitat for fauna to seek shelter and forage. Additionally, *Holothuria fuscocinerea* is less favored by the public, while *Holothuria scabra* has high commercial value, because in addition to being used as a food ingredient, it also has ingredients such as saponins, chondroitin sulfate, collagen, amino acids, and phenols that are used in the pharmaceutical industry.

According to the IUCN Red List, *Holothuria scabra* is currently endangered due to overexploitation and environmental degradation. The low distribution of sea cucumbers at the study site is influenced by the sandy substrate conditions, leading to inadequate food availability. Sea cucumbers prefer habitats among seagrass and in

crevices of rocks (Husain & Lamangantjo, 2023). This is due to the fact that the distribution of Echinoderms fauna is primarily influenced by food availability and the feeding methods of each species (Sriwahjuningsih et al., 2020). The class Astroidea was the least frequently encountered in the observation area, with Asteroidea abundance typically found in dense seagrass and coral ecosystems. In addition, the Crinoidea and Ophiuroidea classes were not found during sampling because of the habit of these individuals lying on coral reefs to shelter from strong currents and the impact of waves. According to Yusron et al., (2016), Crinoidea usually lives in the tubir area so it is difficult to find.

Sea urchins were the most frequently encountered group of Echinoderms in each transect (Table 1). The central beach area leading to the sea was dominated by the sea urchin species *Diadema setosum* from the class Echinoidea. Previous research by Efendi et al., (2024) indicated that this species is commonly found in the waters surrounding Dedap Island. *Diadema setosum* is often encountered in coral, rocky areas, and sandy substrates covered with seagrass. Efendi et al., (2024) also noted that this species is typically observed around coral reefs and shallow rocky habitats (usually at depths of 1-6 m), where they hide in crevices and under cover during the day. Occasionally, they are found in large groups in adjacent sandy flats. Sea urchins inhabiting flat sandy areas, algal growth zones, and coral reefs typically live in large groups, whereas in coral areas, they may form smaller groups or live solitary in dead coral holes and coral debris.

Generally, sea urchins live in colonies for self-protection (Prasetyo et al., 2019), as they are highly vulnerable to predator threats. Additionally, microalgae of the Sargassum type are present in the areas approaching the sea, supporting sea urchin populations in their food acquisition. Microalgae are microscopic seaweeds that utilise sunlight for photosynthesis and provide nutrients to support marine life, including *Zooxanthellae* in coral reefs. However, excessive microalgal growth can impede sunlight penetration necessary for *Zooxanthellae,* thereby allowing sea urchins to regulate microalgal populations. The distribution of sea urchins in Dedap Island can be observed at depths of up to 4 meters above sea level.

Quantitative data indicate that the diversity index of Echinoderms in Dedap Island is classified as low (H’ = 0.40). This is evident from the criteria H’ = 0’<1. A high diversity index (H’) is indicative of numerous different species being found, while a low diversity index suggests that only a few species are present. The low species diversity index in Dedap Island aligns with research conducted by Frisca et al., (2020) at Melayu Beach, Rempang Island, Kepulauan Riau, which also falls into the low category with H’ = 0.08. This is attributed to the sandy substrate type and limited seagrass at Melayu Beach, as well as the locations that open for marine tourism. The same diversity index value (H'= 0.43) also occurred in the research of Triacha et al., (2021) on Cibuaya beach, West Java, at station three. Having a sandy and rocky coral substrate and the presence of human activities make the location low in diversity and only *Ophiocoma scolopendrina* species dominate.

The low level of Echinoderms diversity in Dedap Island can be attributed to: (1) Ecological pressures and unstable productivity, resulting in only certain species being able to thrive in the area. Factors influencing the high or low diversity of species at a location are often affected by environmental physical conditions

(Bahri et al., 2021). (2) Sandy substrate conditions lead to inadequate food availability, shelter, and breeding grounds for organisms. These factors are thought to have an effect on the distribution of echinoderms due to their impact on growth rate, metabolic activity, immune system, and their association with stress levels and reproductive success. High diversity levels are based on the abundance of species richness and evenness within a community.

Evenness Index

The evenness index value of Echinoderms found in Dedap Island falls into the low category (0.25). An evenness index is considered low if it has a value of ≤ 4. The low evenness index indicates that the distribution of Echinoderms individuals in Dedap Island is uneven, with certain species dominating specific areas. According to Suwartimah et al., (2017), a smaller evenness index among species in a community implies that the distribution of individual numbers across each species is unequal, suggesting that the community is dominated by one or a few particular species.

Dominance Index

The dominance index is used to identify specific Echinoderms species that dominate a habitat (Marnix & Katili, 2019). The analysis revealed that the dominance index value of Echinoderms at the research location is D = 0.81, which is categorized as high. A high dominance index indicates that among all species present, one species is significantly more abundant than the others. This suggests that within the entire observed biota community structure, there is one genus that significantly dominates others, and this area is indeed dominated by the species *Diadema setosum*. This species is capable of spreading across all marine zones and can outcompete other species.

Environmental Parameters

Water quality is a crucial factor influencing the growth and abundance of organisms. Good water quality supports various marine life to inhabit and survive. The water quality measurements at Dedap Island included temperature, pH, salinity, and dissolved oxygen (DO), as shown in the following table 5. Based on the water parameter measurements, the water temperature at Dedap Island was recorded at 27 °C. This aligns with previous research by Efendi et al., (2024) at the same location, which indicated a decrease in water temperature. This reduction is attributed to daytime rainfall, while sampling was conducted at night. Nevertheless, this temperature range remains ideal for Echinoderms life. In addition to temperature, water salinity significantly affects the biota living in the water. Salinity refers to the concentration of dissolved salts in water. The current salinity measurement is 32 °C.

The salinity at the research site has decreased compared to the study by Efendi et al., (2024) in the waters of Dedap Island. The decrease in water salinity is caused by the rainfall occurring during the day. The presence of a mixture of

seawater and freshwater is suspected to affect the salinity of the waters. Rainfall is also a factor influencing salinity (Husain & Lamangantjo, 2023). However, this salinity value is still considered good for marine biota.

Table 5. Measurements of Environmental Parameters in The Water of Dedap Island

No	Environmental Parameter	Quality Standards	Value
1	Temperature	28-30°C	27°C
2	Salinity	33-34 ‰	32‰
3	pH	7 - 8,5	8.4
4	DO	> 5 mg/L	9.1

pH or acidity level, is a water quality parameter that can influence aquatic productivity (Daud et al., 2023). The measurement results indicated that the water at Dedap Island has a pH of 8.4, which remains within the normal range for supporting Echinoderms life. The ideal pH value for aquatic organisms generally ranges between 7 and 8.5 (Angreni et al., 2017). The DO value of Dedap Island waters is 9.1 ppm. Through the Decree of the Minister of Environment No. 51 of 2004 that the value of dissolved oxygen or DO that supports marine life is in the range of >5 mg/L, so that the DO value at the research site still meets the standard. The clarity of the water at the research location is classified as very good, as the island is uninhabited, access to it is relatively expensive, and it is located far from industrial areas, allowing the beach with sandy substrate conditions to maintain its cleanliness. The beauty of the underwater biota is still visible from the surface of the sea at depths of 3 - 4 meters.

CONCLUSION

Based on the research conducted at Dedap Island, it can be concluded that the diversity of Echinoderms in this location is classified as low, with a diversity index (H') of 0.40. Five species of Echinoderms identified include 3 species from the class Holothuridae, one from the class Astroidea, and one from the class Echinoidea. The species *Diadema setosum* dominates the Echinoderms population at the research site, with a total of 361 individuals recorded, while sea cucumber species such as *Holothuria fuscocinerea* and *Holothuria scabra* had significantly lower numbers. The diversity and evenness indices of Echinoderms at the research location are both low, indicating an uneven distribution of individuals dominated by certain species. Factors influencing these conditions include ecological pressures, unstable productivity, and sandy substrate conditions, leading to inadequate food availability and shelter for Echinoderms.

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