BIODIDAKTIKA: Jurnal Biologi dan Pembelajarannya, Vol.20, No.2, 2025, pp. 166-181
e-ISSN 2527-4562. DOI. 10.62870/biodidaktika.v20i2.31705

Diversity of Echinoderms on the Coast of Kuala Langsa

Submitted 19 March 2025, Revised 29 July 2025, Accepted 31 July 2025

Jihan Nabila Tasya[1], Indriaty Indriaty [2], Sri Jayanthi[3*]

[1,2,3]Department of Biology Education, Faculty of Teacher Training and Education, Universitas Samudra, Langsa City, Aceh, Indonesia

Corresponding Email: *srijayanthi@unsam.ac.id

Abstract

Kuala Langsa is one of the coastal areas in Aceh known for its high biodiversity, including animals from the phylum Echinodermata. This study aims to identify Echinodermata species and analyze their populations about the physical and chemical environmental factors of the coastal waters. The research was conducted using a quantitative descriptive method in December 2024 along the coast of Kuala Langsa, Langsa City, with sampling carried out at three transects during low tide. The results showed that five species of Echinodermata from three classes were found. The diversity index was 2.190, indicating a moderate category; the evenness index was 0.830, classified as stable; and the dominance index was 0.358, indicating a low level of dominance. The highest abundance was recorded for Holothuria scabra, while Astropecten cingulatus had the lowest abundance and frequency of occurrence (66.7%). The other four species had a frequency of 100%. The highest similarity index (1) was found between Station II and Station III, while the lowest (0.88) was found between Station I and II and between Station I and Station III. Environmental parameters at the study site showed a temperature range of 29–33°C, pH ranging from 7.2 to 8.5, and salinity ranging from 20–27%. These findings provide important baseline data to support future biodiversity monitoring and highlight the ecological significance of the Kuala Langsa coastal ecosystem.

Keywords: Diversity, Echinoderms, Kuala Langsa, Biodiversity, Coastal Ecology

INTRODUCTION

Indonesia, as the largest archipelagic country in the world, has a highly diverse aquatic ecosystem (Arthaz, 2015). Indonesia's marine biodiversity includes various types of flora and fauna that inhabit coral reefs, seagrass beds, and mangrove ecosystems, which serve as habitats for a wide range of marine species (Putra et al., 2021). One of the regions that stands out for its rich aquatic ecosystems is the coastal area of Kuala Langsa in Aceh, which is renowned for its pristine and well-preserved coastal environment (Apriyanti et al., 2024). According to Tasya et al. (2024), Kuala Langsa is considered one of the biodiversity-rich coastal areas in Aceh Province, Indonesia.

One of the essential components of this diversity is animals from the phylum Echinodermata. These animals are divided into five classes: Asteroidea (sea stars), Echinoidea (sea urchins), Ophiuroidea (brittle stars), Holothuroidea (sea cucumbers), and Crinoidea (feather stars) (Hickman et al., 2017; Nurafni & Sibua, 2019). Based on interview results, fishermen in Kuala Langsa have caught and sold echinoderm animals such as sea cucumbers, which serve as one of their sources of livelihood. These echinoderms are often found in intertidal zones or tidal areas, with habitats greatly influenced by environmental conditions such as water quality and sea depth (Lubis, 2022).

Echinodermata are invertebrate animals that have spines or protrusions on the outer surface of their bodies (Suryanti, 2019). Echinoderms play an important role both ecologically and economically. Ecologically, they are key components in marine food webs, functioning as predators (Asteroidea), herbivores (Echinoidea), and detritivores (Ophiuroidea, Holothuroidea, and Crinoidea) (Hickman et al., 2017). Economically, certain classes of Echinoderms, such as Echinoidea and Holothuroidea, have long been cultivated due to their high economic value (Tala et al., 2021). Additionally, Echinoderms can serve as bioindicators of water quality, particularly in assessing heavy metal pollution from elements such as cadmium, copper, lead, zinc, and nickel (Arifin, 2023). The abundance and diversity of Echinoderms are also significantly influenced by physicochemical environmental factors such as temperature, water pH, salinity, and dissolved oxygen (DO) levels (Salmanu & Arini, 2019).

Research has shown that Echinodermata are widely distributed across various tropical and subtropical marine regions, including the waters of Southeast Asia, the Pacific, and the Indian Ocean (Siti et al., 2021). In Aceh, several studies have been conducted, particularly in Aceh Besar, where species such as *Diadema setosum*, *Protoreaster nodosus*, and *Holothuroidea scabra* are commonly found (Azwir et al., 2019; Syafrijal et al., 2019). This may be due to Aceh's relatively pristine and well-preserved marine ecosystems (Tari et al., 2020). However, to date, no study has specifically examined the diversity of Echinodermata along the coast of Kuala Langsa.

Based on this background. Therefore, this study aims to identify echinoderm species and analyze their population structure about environmental factors in the Kuala Langsa coastal area. This research is expected to make a significant contribution to the understanding of marine biodiversity in the region and provide essential data for conservation efforts and the sustainable management of marine resources.

METHOD

Research Location and Time

This research was conducted in Kuala Langsa Village, West Langsa District, Langsa City, Aceh Province, in December 2024. The research location map is shown in Figure 1.

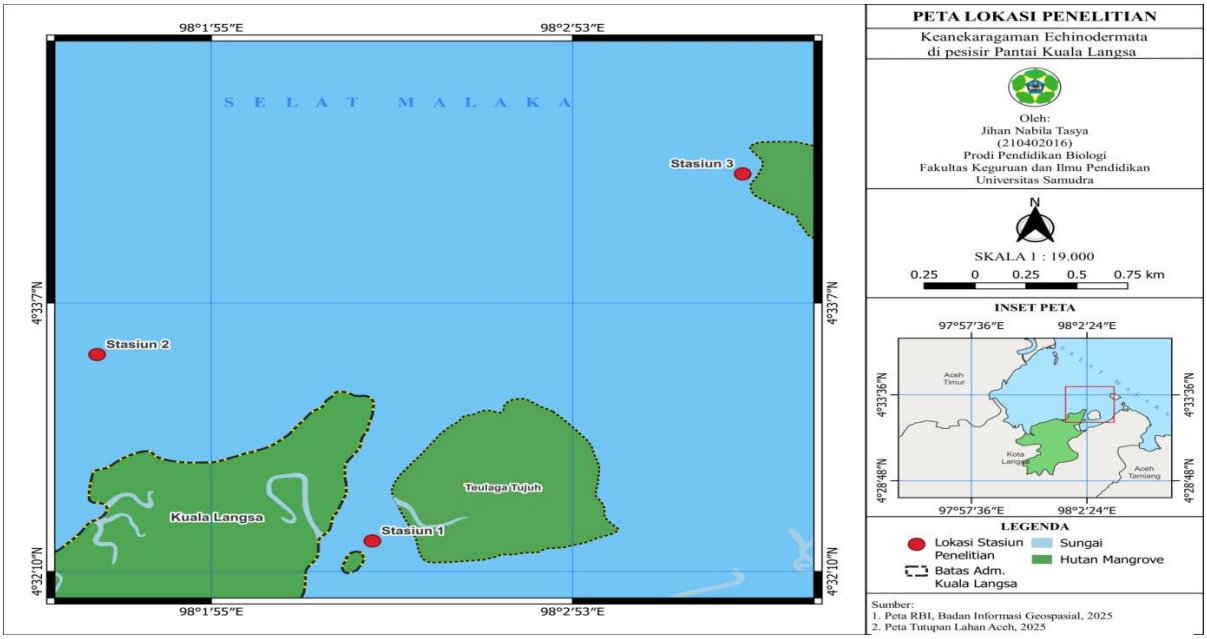


Figure 1. Research Location Map

Research Methodology

The type of research used is quantitative descriptive research, which aims to systematically and accurately describe the details of a phenomenon. The sample data collection was conducted through direct observation. The parameters measured in this study include diversity index analysis, abundance, evenness index, frequency of occurrence, dominance, and similarity index. Additionally, the study examines how environmental factors such as salinity, water temperature, and pH influence this diversity. The researcher selected the study locations using purposive sampling, establishing three research stations at different locations:

a. Station I is located at coordinates 4.537822°N – 98.039132°E.
b. Station II is located at coordinates 4.548929°N – 98.026941°E.
c. Station III is located at coordinates 4.559695°N – 98.055533°E.

Notably, all research locations experience tidal fluctuations.

Research Procedure

The procedures and steps in this study are as follows:

Determination of Observation Stations

Based on interviews with fishermen in Kuala Langsa, it was found that Echinodermata species are present in the area. To confirm this, the researchers surveyed Kuala Langsa Beach, Langsa Barat District, Langsa City, Aceh Province. Following this, the researchers prepared the necessary tools and materials for the study. The research sampling locations were divided into three different stations, based on the presence and environmental conditions of the coastal waters in the Kuala Langsa area. Station 1 is located at coordinates 4.537822°N –

98.039132°E, station 2 at 4.548929°N – 98.026941°E, and station 3 at 4.559695°N – 98.055533°E.

Sampling Technique

Sampling of Echinodermata was carried out using the cruise method at three different stations. Each station consisted of three transects. The transect lines were drawn perpendicular from the sea toward the land for a distance of 50 meters during low tide. Each transect had an area of 200 square meters, with a distance of 10 meters between transects. Data collection was repeated three times at each station using the same method (Al Faroby et al., 2021). The layout of the research transects is shown in Figure 2.

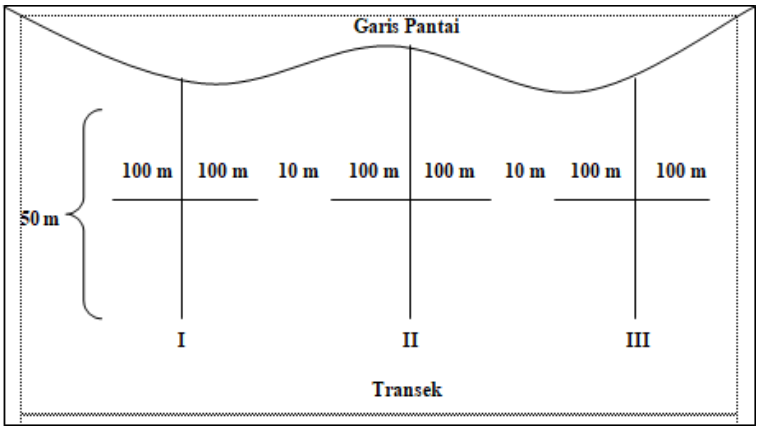


Figure 2. Research Transect

Sampling was conducted in two stages: during low tide and high tide. During low tide, samples were collected using the hand collecting method, while during high tide, tools such as nets were used to collect samples in the water. The collected samples were then rinsed with distilled water, placed in labeled plastic containers, and brought back for identification using identification books (Suryanti, 2019; Sidauruk, 2024) and reference journals related to Echinodermata diversity research. At each station, physical factors (such as water temperature) and chemical factors (such as water pH and salinity) were measured, and the results were recorded using writing instruments.

Data Analysis

The data analysis used in this study includes both qualitative and quantitative methods. The qualitative method involves identifying Echinodermata species using identification books (Suryanti, 2019; Sidauruk, 2024) and reference journals from previous studies. The quantitative analysis is conducted to calculate the diversity index, abundance, evenness index, frequency of occurrence, dominance, and similarity index of Echinodermata, as well as to analyze the relationship between physicochemical environmental factors and the diversity of Echinodermata, using the following formulas:

Diversity Index

The diversity index of Echinodermata is analyzed using the Shannon-Wiener formula (Wang et al., 2015; Kambey et al., 2015) as follows:

$$\mathbf{H' = -\sum \left(\frac{ni}{N}\right) In \left(\frac{ni}{N}\right)}$$

$$\mathbf{= -\sum pi\ In\ pi}$$

Description:

H' : Species diversity index

ni : Number of individuals of species i

Pi : Proportion of individuals of species i (ni) to the total individuals (N)

N : Total number of individuals of all species

ni/N : Proportion of species i to the total number of individuals

Criteria:

H' < 1 : Low diversity

1 < H' < 3 : Moderate diversity

H' > 3 : High diversity

Evenness Index

The evenness index of echinoderm species is analyzed using the Evenness formula (Firmaningrum et al., 2021):

$$\mathbf{E = \frac{H'}{Hmaks}}$$

Description:

E = Evenness index

H' = Diversity index

H max = Maximum diversity (Log_2 S)

Criteria:

0.0 < E ≤ 0.50 → Suppressed evenness

0.50 < E ≤ 0.75 → Unstable evenness

0.75 < E ≤ 1.00 → Stable evenness

Dominance

The dominance index of echinoderms is analyzed using Simpson's Dominance formula (Firmaningrum et al., 2021):

$$\mathbf{D = \sum \frac{(ni)2}{N}}$$

Description:

D = Dominance Index

Ni = Total number of individuals

N = Total number of individuals

Criteria:

$0 < D \leq 0.50 \rightarrow$ Low dominance

$0.50 < D \leq 0.75 \rightarrow$ Medium dominance

$0.75 < D \leq 1.00 \rightarrow$ High dominance

Abundance Index

The abundance index refers to the number of individuals for each species. Abundance is also defined as the number of individuals per unit area or per unit volume, using the formula provided by He & Gaston (2000) as follows:

$$\mathbf{K} = \frac{\boldsymbol{ni}}{\boldsymbol{A}}$$

Description:

K = Abundance of the i-th species (ind/m²)

ni = Number of individuals of the i-th species (individuals)

A = Quadrant area (m)

The relative abundance index is analyzed using the following formula (Kambey et al., 2015):

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

Description:

KR = Relative abundance

ni = Number of individuals of species *i*

N = Total number of individuals

Frequency of occurrence (FK)

The frequency of occurrence (FK) can be calculated using the formula (Márquez-Farias & Castillo-Geniz, 1998):

$$\mathbf{FK} = \frac{\boldsymbol{The\ number\ of\ stations\ where\ the\ species\ was\ found}}{\boldsymbol{Number\ of\ stations}} \mathbf{x\ 100\%}$$

Criteria:

0-25% Very rare attendance frequency

25-50% Rare attendance frequency

50-75% Common attendance frequency

>75% Very common attendance frequency

Similarity Index

The similarity index is a measure of species similarity, calculated using the following formula:

$$IS = \frac{2C}{A+B}$$

Description:

A = Number of species found at station a

B = Number of species found at station b

C = Number of species found at both stations a & b

Criteria:

Is < 50% → Low similarity

Is > 50% → High similarity

RESULTS AND DISCUSSION

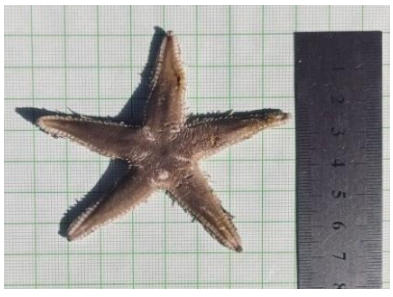
Identification Results of Echinoderm Species Found on the Coast of Kuala Langsa

Based on the results of the research conducted, the types of echinoderms found along the coastal area of Kuala Langsa at the research stations are presented in Table 1.

Table 1. Echinoderms Found Along the Coastal Area of Kuala Langsa

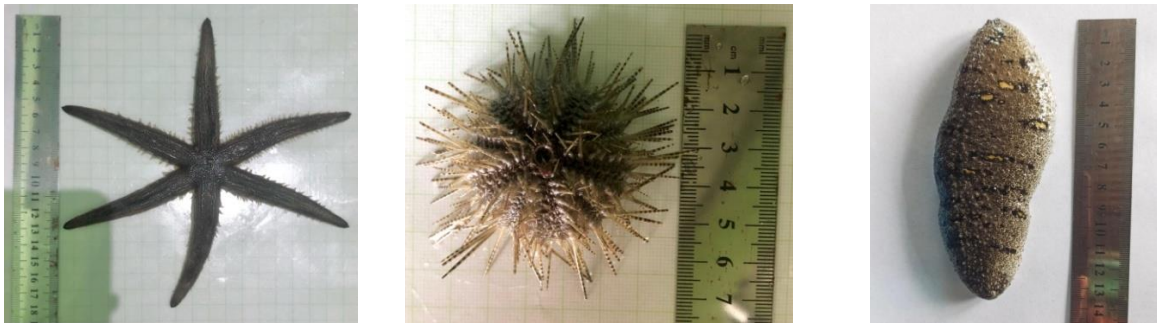
Species	Station			Total Individuals
	I	II	III	
1) *Astropecten indicus*	2	5	2	9
2) *Astropecten cingulatus*	0	4	3	7
3) *Luidia savignyi*	2	6	2	10
4) *Echinothrix calamaris*	4	10	6	20
5) *Holothuria scabra*	7	36	12	55
Number of Individuals	15	61	25	101

Based on the data in Table 1, the overview of species found on the coast of Kuala Langsa is shown in Figure 3.



(a)

(b)



(c) (d) (e)

Figure 3. a. *Astropecten indicus*, b. *Astropecten cingulatus*, c. *Luidia savignyi*, d. *Echinothrix calamaris*, e. *Holothuria scabra*

Diversity Index, Evenness Index, Dominance Index, Abundance Index, Frequency of Occurrence, and Similarity Index of Echinoderms on the Coastal Area of Kuala Langsa

The diversity, evenness, and dominance indices of Echinodermata along the coast of Kuala Langsa at the research stations can be seen in Table 2.

Table 2. Diversity, Evenness, and Dominance Indices at the Research Stations

Ecological Index	Station		
	I	II	III
Diversity	1.245	1.219	1.353
Evenness	0.898	0.758	0.841
Dominance	0.324	0.395	0.315

Abundance Index and Frequency of Occurrence of Echinoderms on the Coastal Area of Kuala Langsa at the research stations can be seen in Table 3.

Table 3. Abundance Index and Frequency of Occurrence at Research Stations

Species Name	Abundance Index									FR
	Ni (Ind/m^2)			Ki			Kr (%)			
	I	II	III	I	II	III	I	II	III	
Astropecten indicus	2	5	2	0,00006	0,00016	0,00006	0,12	0,08	0,075	100%
Astropecten cingulatus	0	4	3	0	0,00013	0,0001	0	0,065	0,125	66,7%
Luidia savignyi	2	6	2	0,00006	0,0002	0,00006	0,12	0,1	0,075	100%
Echinothrix calamaris	4	10	6	0,00013	0,00033	0,0002	0,26	0,165	0,25	100%
Holothuria scabra	7	36	12	0,00023	0,0012	0,0004	0,46	0,6	0,5	100%
Total Individuals	15	61	25	0,0005	0,0020	0,0008	100	100	100	

The similarity index of echinoderms on the coast of Kuala Langsa at the research stations can be seen in Table 4.

Table 4. Similarity Index at Research Stations

Stations	I	II	III
I	X	0.88	0.88
II	X	X	1
III	X	X	X

Physical and Chemical Environmental Measurements at the Research Station

The results of physical and chemical environmental measurements at the research station, based on the measured parameters, can be seen in Table 5.

Table 5. Results of Environmental Parameter Measurements at the Research Station

Parameters	Research Station		
	I	II	III
Water temperature (℃)	29-32	30-33	29-32
pH	7.5-8,2	7.2-8,5	7.3-8,2
Salinity (°/%)	20-27	20-25	20-26

Based on the results of the research conducted along the coast of Kuala Langsa, members of the phylum Echinodermata were found, consisting of 3 classes, 4 orders, 4 families, 4 genera, and 5 species. The three classes identified were Asteroidea, Echinoidea, and Holothuroidea. The class Asteroidea included 3 species *Astropecten indicus, Astropecten cingulatus, and Luidia savignyi*. In the class Echinoidea, 1 species was found *Echinothrix calamaris*, and in the class Holothuroidea, 1 species was identified *Holothuria scabra*. The species consistently found at all research stations were *Astropecten indicus, Luidia savignyi, Echinothrix calamaris, and Holothuria scabra*. The most commonly found species was *Holothuria scabra*.

The highest diversity index value of echinoderms was found at Station III, with a diversity index of H' = 1.353, which falls into the moderate category. This indicates that the echinoderm community at this station is fairly diverse and relatively stable. The higher diversity is attributed to relatively stable environmental parameters, with environmental conditions still within the optimal range for echinoderms, thus allowing more species to survive (Pakpahan et al., 2020). Meanwhile, the lowest echinoderm species diversity was found at Station II, with a diversity index of H' = 1.219, which also falls into the moderate category. This is due to the uneven distribution of different species at the study site and a tendency for one species to dominate the population (Ariyanto, 2016). This is in line with the opinion of Melvia (2017), who stated that in addition to the number of species, the distribution of individuals of each species is also a factor influencing the diversity value. The uneven number of individuals within a species is associated with various adaptive patterns, such as the availability of different types of substrates, food, and environmental conditions

(Mufida et al., 2023). The echinoderm diversity index values at all observation stations fall into the moderate category, with a Shannon-Wiener index (H') value of 2.190. This value indicates that the echinoderm community at the study site consists of several fairly diverse species, although the number of individuals is not entirely evenly distributed (Simatupang et al., 2017). This condition is supported by relatively stable environmental factors, such as water temperatures ranging between 29–33°C, pH levels between 7.2–8.5, and salinity ranging from 20–27 ppt. These factors are considered optimal for supporting marine life, particularly echinoderms. According to Febrianti et al., (2022), waters with balanced temperature and pH provide favorable conditions for the metabolic processes and survival of organisms, thereby increasing the number and diversity of species found.

The highest evenness index of echinoderms was found at Station I, with a value of 0.898, indicating that the species found at this research station were evenly distributed, with no species significantly dominating. The high evenness at Station I can be associated with stable water pH (7.5–8.2) and relatively constant temperatures (29–32°C), which provide nearly equal opportunities for various species to thrive (Ramadini, 2019). In contrast, the lowest evenness index was found at Station II, with a value of 0.758. This indicates that species distribution at this station was less uniform, most likely due to the dominance of a particular species, such as *Holothuria scabra*, which was found in greater numbers compared to other species. Additionally, more fluctuating environmental conditions may have led to lower survivability for some species, resulting in a less even distribution. This is also supported by the statement from Armita et al. (2021), which notes that an evenness index approaching 0 indicates low evenness due to species dominance, while a value approaching 1 indicates high evenness, where no single species dominates, and the number of individuals per species is evenly distributed. The overall evenness index (E) across all observation stations was 0.830, indicating that the distribution of individuals among species was fairly uniform and stable. This means that most species had relatively equal chances of survival, without any particular species being overly dominant (Supriatna, 2018). High evenness generally reflects environmental conditions that support a wide range of species and minimal ecological pressures, such as pollution or drastic habitat changes (Puspitasari et al., 2016). According to Ainalyaqin & Abida (2024), one factor supporting this high evenness is the stability of water temperature and pH, especially at Stations I and III, where environmental parameter ranges were not highly variable.

The calculated dominance index (C) for the entire area was 0.358, which falls into the low category, indicating that no single species strongly dominates the community. The

highest dominance index value was found at research station II, which was 0.395. This is due to the presence of a dominant species, *Holothuria scabra*, at this station, as evidenced by the species abundance index showing Holothuria scabra had the highest abundance. Meanwhile, the lowest dominance index values were recorded at station I, 0.324, and station III, 0.315. These low dominance index values indicate that no echinoderm species dominated at these research stations (Toruan & Soewarlan, 2024).

The results of the overall calculation of species abundance index and relative abundance for each species showed that the highest abundance was found in the species *Holothuria scabra*, with an abundance value of 0.0012 ind/m² and a relative abundance of 0.6%. This is because sea cucumbers generally live in groups in the wild, although some may be solitary. *Holothuria scabra* in particular tends to live in groups of 3–5 individuals (Suryanti, 2019). This is supported by research from Nisa (2021), which states that *Holothuria scabra* (sandfish sea cucumber) is commonly found in sandy and muddy habitats in shallow, sheltered waters, as these environments provide abundant food and favorable conditions for growth. Meanwhile, the species with the lowest abundance was *Astropecten cingulatus*, with a value of 0 ind/m² and a relative abundance of 0%. This is because *Astropecten cingulatus* is rarely found due to its hidden habitat on sandy or muddy sea bottoms, as well as its habit of burying itself in sediment to hide, making it difficult to detect (Clark & Rowe, 1971). Additionally, the relatively small body size of *Astropecten cingulatus* makes it easier for the species to conceal itself in sediment and avoid predators.

The calculation results of the frequency of occurrence at the study site are relatively stable. Four out of five species had a frequency of occurrence of 100%, indicating that they were consistently found at all three research stations. Only Astropecten cingulatus had a lower frequency of occurrence, at 66.7%, suggesting that this species was not found at all stations. This may be related to the species' more limited habitat preferences or certain environmental factors that are less favorable to its presence at one of the locations.

The results of the similarity index calculation show that the highest value was obtained between Station II and Station III, which was 1. This value indicates a very high similarity in species composition between the two stations, both in terms of species types and the number of individuals of each species. This suggests that the environmental conditions at both stations are relatively similar, thereby supporting the presence of the same species (Sulis, 2017). Meanwhile, the lowest similarity index values were found between Station I and Station II, as well as between Station I and Station III, with each having a value of 0.88. Although still considered high, this value indicates some differences in species composition between the

stations (Bando et al., 2016). According to Yasir (2017), these differences may be caused by variations in environmental conditions such as pH and salinity, as well as potential differences in substrate conditions or local disturbances at the stations that affect the distribution and presence of species. Therefore, the closer the similarity index value is to 1, the more similar the species composition between the two compared locations. Conversely, the closer the index value is to 0, the more different the species composition between those locations (Nisa et al., 2024).

The presence of *Holothuria scabra* at the study site carries important implications for conservation efforts, given that this species holds high economic value and is vulnerable to overexploitation. If its utilization is not properly managed, it could lead to a significant decline in population. The high similarity in species composition among stations also indicates that the habitats in this area are interconnected and support the presence of similar species, including *Holothuria scabra*. This reinforces the importance of habitat protection and the sustainable management of biological resources. As a follow-up measure, annual monitoring of species occurrence is needed to observe population trends over time. In addition, research on population genetics is also essential to understand the level of genetic variation and connectivity among populations, which can serve as a basis for long-term conservation efforts. Education for local fishermen also needs to be strengthened so that they can better understand the importance of preserving economically valuable species such as H. scabra and adopt more sustainable harvesting practices.

CONCLUSION

Based on the results of the study on the Diversity of Echinodermata on the Coast of Kuala Langsa, the following conclusions can be drawn:

1. The Echinodermata species identified in this study consisted of five species: *Astropecten indicus, Astropecten cingulatus, Luidia savignyi, Echinothrix calamaris,* and *Holothuria scabra*.
2. The Echinodermata diversity index recorded at the study site was 2.190, which falls into the moderate category. The evenness index across all stations was 0.830, indicating a stable distribution. The dominance index was 0.358, which is categorized as low. *Holothuria scabra* showed the highest abundance index, while *Astropecten cingulatus* had the lowest. The frequency of occurrence for *Astropecten cingulatus* was the lowest at 66.7%, while the remaining four species had a frequency of 100%. The highest similarity

index was recorded between stations II and III at 1, while the lowest was between station I and stations II and III at 0.88.

3. Environmental parameters at the study site showed temperature ranging from 29–33°C, pH from 7.2–8.5, and salinity from 20–27‰.
4. These findings indicate that the coastal area of Kuala Langsa supports a moderately diverse and stable Echinodermata community, with low species dominance and relatively high species occurrence. Such ecological characteristics suggest that the area has the potential to be developed as a conservation zone or an ecotourism destination, especially for marine biodiversity education and sustainable resource use.

SUGGESTIONS

The recommendations for future research on echinoderm diversity are as follows:

1. The results of this study are expected to be used as a reference in teaching and in other research related to echinoderms.
2. The researcher also hopes that further studies on the diversity of echinoderm species can be conducted with a broader sampling area.

REFERENCES

Ainalyaqin, M. I., & Abida, I. W. (2024). Korelasi Kandungan Oksigen Terlarut dan pH terhadap Keanekaragaman Plankton di Sungai Kalidami Kota Surabaya. *Environmental Pollution Journal*, *4*(1), 895-905.

Al Faroby, W., Supratman, O., & Syari, I. A. (2021). Analisis Kepadatan Teripang Hitam (Holothuria atra) Di Kawasan Intertidal Perairan Tuing Kabupaten Bangka: Density Analysis of Black Sea Cucumbers (Holothuria atra) in the Tuing Intertidal Waters, Bangka Regency. *Akuatik: Jurnal Sumberdaya Perairan*, *15*(1), 1-7.

Apriyanti, D., Suciaty, E., Simamora, M. S., & Purba, R. H. (2024). Keanekaragaman Gastropoda Berdasarkan Karakteristik Habitat pada Ekosistem Mangrove Kota Langsa. *Jurnal Jeumpa*, *11*(1), 53-62. https://doi.org/10.33059/jj.v11i1.8896

Arifin, F. U. (2023). Studi Keanekaragaman Filum Echinodermata di Pantai Karapyak Kabupaten Pangandaran Sebagai Bahan Ajar Biologi (*Doctoral Dissertation*, Universitas Siliwangi).

Ariyanto, T. P. (2016). Keanekaragaman dan kelimpahan echinodermata di pulau barrang lompo kecamatan ujung tanah kota makassar. *Skripsi. Universitas Islam Negeri Alauddin Makassar*.

Armita, D., Al Amanah, H., & Amrullah, S. H. (2021). Struktur Komunitas Makrozoobentos pada Saluran Mata Air Langlang dengan Vegetasi Riparian yang Berbeda di Desa

Ngenep, Kabupaten Malang, Jawa Timur. *Teknosains: Media Informasi Sains dan Teknologi*, *15*(2), 181-189. https://doi.org/10.24252/teknosains.v15i2.19520

Arthaz, C. P. (2015). Hubungan Kelimpahan Bulu Babi (*Sea urchin*) dengan Bahan Organik Substrat Dasar Perairan di Pantai Krakal, Yogyakarta. *Management Of Aquatic Resources Journal (MAQUARES)*, *4*(3), 148-155.

Azwir, A., Musriadi, M., & Saputra, S. (2019). Keragaman Jenis Echinodermata Berdasarkan Zona Litoral di Pantai Pasir Putih Ujong Batee Kabupaten Aceh Besar Provinsi Aceh. BIOEDUKASI: *Jurnal Pendidikan Biologi,* 10(2), 149-156. https://doi.org/10.24127/bioedukasi.v10i2.2482

Bando, A. H., Siahaan, R., & Langoy, M. D. (2016). Keanekaragaman Vegetasi Riparian di Sungai Tewalen, Minahasa Selatan-Sulawesi Utara. *Jurnal Ilmiah Sains*, 7-11. https://doi.org/10.35799/jis.16.1.2016.12197

Clark, A. M., & Rowe, F. W. E. (1971). Monograph of shallow-water Indo-West Pacific echinoderms. London: Trustees of the British Museum.

Firmaningrum, N. F., Sari, L. A., Pursetyo, K. T., Zein, A., Idris, M. H., & Cahyoko, Y. (2021, March). Biodiversity studies of echinoderms in Sedati waters, Sidoarjo District, East Java Province. In *IOP Conference Series: Earth and Environmental Science* (Vol. 718, No. 1, p. 012089). IOP Publishing.

Febrianti, D., Harisandy, M. D., Nadhira, C. A., & Syahputra, M. R. (2022). Keanekaragaman dan Identifikasi Morfometrik Jenis Ikan Hasil Tangkapan Nelayan di TPI Kuala Langsa. *Jurnal Jeumpa*, *9*(2), 758-766. https://doi.org/10.33059/jj.v9i2.6325

He, F., & Gaston, K. J. (2000). Estimating species abundance from occurrence. *The American Naturalist*, *156*(5), 553-559.

Hickman, C. P., Keen, S. L., Eisenhour, D. J., Larson, A., & I'Anson, H. (2017). *Integrated Principles of Zoology* (*Seventeenth*). Mcgraw-Hill Education.

Kambey, A. G., Rembet, U. N. W. J., & Wantasen, A. S. (2015). Komunitas Echinodermata Di Daerah Intertidal Perairan Pantai Mokupa Kecamatan Tombariri Kabupaten Minahasa. *Jurnal Ilmiah Platax*, *3*(1), 10-15.

Lubis, N. F. (2022). Studi Keanekaragaman Kelas Holothuridea (Teripang) di Pulau Berhala sebagai Bahan Modul Bio Marine (Doctoral Dissertation, Fakultas Keguruan dan Ilmu Pendidikan, Universitas Islam Sumatera Utara).

Márquez-Farias, J. F., & Castillo-Geniz, J. L. (1998). Fishery biology and demography of the Atlantic sharpnose shark, Rhizoprionodon terraenovae, in the southern Gulf of Mexico. *Fisheries Research*, *39*(2), 183-198.

Melvia, M. (2017). Pengaruh Penggunaan Ampas Kopi sebagai Media Tanam terhadap Pertumbuhan dan Produktivitas Jamur Tiram *Pleurotus sp* (*Doctoral dissertation*, Universitas Hasanuddin).

Mufida, I., Pertiwi, M. P., & Rostikawati, R. T. (2023). Diversity of Echinoderms in Drini Beach Gunung Kidul, Yogyakarta. *Jurnal Ilmu Dasar*, *24*(1), 19-30.

Nisa, R. N (2021). Diversitas Echinoidea (Bulu Babi) pada Zona Intertidal.

Nisa, Z., Pramayudi, N., & Hasnah, H. (2024). Komparasi Keanekaragaman Arthropoda Permukaan Tanah pada Dua Lokasi Ekosistem Tembakau yang Berbeda di Kabupaten Aceh Besar. *Jurnal Ilmiah Mahasiswa Pertanian*, *9*(2), 321-338.

Nurafni, N., & Sibua, I. (2019). Keanekaragaman Echinodermata di Perairan Pulau Ngele Ngele Kecil, Kabupaten Pulau Morotai. *Jurnal Ilmu Kelautan Kepulauan*, *2*(2), 74-83. https://doi.org/10.33387/jikk.v2i2.1427

Pakpahan, H. L., Irwani, I., & Widowati, I. (2020). Komposisi dan Kelimpahan Ophiuroidea dan Echinoidea di Perairan Pantai Pok Tunggal, Gunung Kidul, Yogyakarta. *Journal of Marine Research*, *9*(2), 109-118. https://doi.org/10.14710/jmr.v9i2.26101

Puspitasari, A. T. T., Amron, A., & Alisyahbana, S. (2016). Struktur Komunitas Karang Berdasarkan Karakteristik Perairan di Taman Wisata Perairan (TWP) Kepulauan Anambas. *Omni-Akuatika, 12*(1). https://doi.org/10.20884/1.oa.2016.12.1.30

Putra, R. W., Firmansyah, R. M., Wagianto, W., Gunansyah, G., & Kamal, E. (2021). Study of Management of Indonesian Coastal and Marine Seas (Review: Benoa Bay Reclamation). Acta *Aquatica: Aquatic Sciences Journal, 8*(3), 174-179. https://doi.org/10.29103/aa.v8i3.5522

Ramadini, L. (2019). Keanekaragaman Makrozoobentos sebagai Bioindikator Kualitas Air di Sungai Way Kedamaian Bandar Lampung (*Doctoral Dissertation*, UIN Raden Intan Lampung).

Sidauruk, D. J. (2024). Identifikasi dan Karakterisasi Bivalvia di Kecamatan Pantai Cermin Serdang Bedagai sebagai Pengembangan Bahan Ajar Berupa Buku Monograf. (*Doctoral dissertation*, Fakultas Keguruan & Ilmu Pendidikan, Universitas ISlam Sumatera Utara).

Salmanu, S. I., & Arini, I. (2019). Hubungan Faktor Fisik Lingkungan terhadap Keanekaragaman dan Dominansi Echinodermata di Zona Intertidal Sekitar Dermaga Desa Hila Pulau Romang Kabupaten Maluku Barat Daya. *BIOSEL (Biology Science and Education): Jurnal Penelitian Science dan Pendidikan*, *8*(2), 183-189. https://doi.org/10.33477/bs.v8i2.1147

Simatupang, M. Y. C., Sarong, M. A., & Ulfah, M. (2017). Keanekaragaman Echinodermata dan Kondisi Lingkungan Perairan Dangkal Pulau Pandang Kabupaten Batu Bara Provinsi Sumatera Utara (*Doctoral Dissertation*, Syiah Kuala University).

Siti, M., Dita, A., & Baterun, K. (2021). *Potensi Produk Olahan Hasil Perikanan Laut Nelayan Kenjeran Surabaya*. Surabaya: Lentera Optima Pustaka.

Sulis, S. (2017). Komposisi dan Struktur Komunitas Zooplankton pada Kedalaman yang Berbeda di Danau Diatas Kabupaten Solok Sumatera Barat (*Doctoral Dissertation*, Universitas Andalas).

Supriatna, J. (2018). *Konservasi Biodiversitas: Teori dan Praktik di Indonesia*. Yayasan Pustaka Obor Indonesia.

Suryanti, S. (2019). *Buku Ajar Bioekologi Phylum Echinodermata*. Departemen Sumberdaya Akuatik Fakultas Perikanan dan Ilmu Kelautan Universitas Diponegoro

Syafrijal, S., Mukarramah, N., & Ahadi, R. (2019). Indeks Keanekaragaman Echinodermata di Perairan Pantai Desa Deudap Pulo Aceh Aceh Besar. In *Prosiding Seminar Nasional Biologi, Teknologi dan Kependidikan* (Vol. 6, No. 1).

Tala, W. S., Kusrini, K., & Jumiati, J. (2021). Struktur Komunitas Echinodermata pada Berbagai Tipe Habitat di Daerah Intertidal Pantai Lakeba, Kota Baubau Sulawesi Tenggara. *Jurnal Kelautan Tropis, 24*(3), 333-342. https://doi.org/10.14710/jkt.v24i3.11610

Tari, K., Iswahyudi, I., & Siregar, D. S. (2020). Kesesuaian Kawasan untuk Pengembangan Ekowisata Hutan Mangrove Kuala Langsa. *Jurnal Belantara*, *3*(2), 173-185. https://doi.org/10.29303/jbl.v3i2.567

Tasya, J. N., Annisa, M. N., Situmorang, P. B., & Muthmainnah, D. (2024). Identifikasi Jenis Udang Hasil Tangkapan Nelayan di Kawasan Pesisir Kuala Langsa Provinsi Aceh. *Jurnal Jeumpa*, *11*(1), 44-52. https://doi.org/10.33059/jj.v11i1.8971

Toruan, L. N. L., & Soewarlan, L. C. (2024). Keanekaragaman Echinodermata Pada Ekosistem Lamun Di Teluk Kupang NTT. *Metamorfosa: Journal of Biological Sciences*, *11*(01), 50-62.

Wang, Z., Wang, H., Fan, S., Xin, M., & Sun, X. (2021). Community structure and diversity of macrobenthos in Jiaozhou Bay. *Marine Pollution Bulletin*, *171*, 112781.

Yasir, A. A. (2017). Struktur Komunitas Makrozoobenthos Pada Lokasi Dengan Aktivitas Berbeda Di Perairan Sungai Tallo Kota Makassar. *Skripsi Departemen Ilmu Kelautan Fakultas Ilmu Kelautan Dan Perikanan Universitas Hasanuddin Makassar*.