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Diversity of Sea Cucumbers (Holothuroidea) in the Waters of Sarang Island and the Nenek Strait, Batam, Riau Islands, Indonesia

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Abstract

Background: *Sea cucumbers (Holothuroidea) are key benthic organisms that contribute to coastal ecosystem stability through bioturbation, organic matter decomposition, and their role in marine food webs. However, despite their ecological and economic importance, information on the diversity and community structure of sea cucumbers in the waters of Batam City, remains limited. This study aimed to analyze the diversity of sea cucumbers in the waters of Sarang Island and the Nenek Strait, as a basis for evaluating ecological conditions and supporting sustainable marine resource management.* **Methodology:** *Sampling was conducted in the intertidal zone using the sweeping method during nighttime to accommodate the nocturnal activity of sea cucumbers, using two transects at each sampling station. Species identification was based on morphological and visual characteristics, while environmental parameters such as temperature, pH, salinity, dissolved oxygen, water transparency, and current velocity were measured in situ.* **Findings:** *Five sea cucumber species were identified, namely Stichopus herrmanni, Holothuria leucospilota, H.scabra, Bohadschia aegyptia, and H. fuscopunctata. Community structure was then analyzed using the Shannon–Wiener diversity index (H'), evenness index (E), and Simpson's dominance index (C). At Sarang Island, 25 individuals representing five species were recorded, with Actinopyga mauritiana dominating 64% of the population, resulting in moderate diversity (H' = 0.576), low evenness (E = 0.358), and high dominance (C = 0.453). In the Nenek Strait, 22 individuals from three species were identified, showing moderate diversity (H' = 1.059), high evenness (E = 0.964), and low dominance (C = 0.360), actinopyga mauritiana dominated 64% of the population, likely due to its higher tolerance to local environmental conditions and its preference for sandy–muddy substrates commonly found in the study area, indicating a more balanced community structure.* **Contributions:** *These findings highlight spatial variation in sea cucumber communities related to habitat characteristics and ecological pressure, contributing baseline scientific data on the diversity and community structure of Holothuroidea in Batam coastal waters.*

Keywords: *Biodiversity; Sea cucumbers; Holothuroidea; Ecological indices; Community structure*

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INTRODUCTION

Coastal ecosystems around the world are experiencing increasing pressure from human activities, climate change, and habitat degradation, which threaten marine biodiversity and ecosystem stability. Understanding the diversity and community structure of marine organisms has therefore become an important focus in ecological studies to support sustainable coastal management. The waters surrounding Sarang Island constitute a cluster of small islands located adjacent to the highly congested international shipping lane of the Philip Strait. The geographical characteristics of this region are defined by shallow coastal waters that support diverse and productive coastal ecosystems, including coral reefs, seagrass meadows, and mangrove forests. These ecosystems play a crucial role in sustaining local biodiversity and maintaining ecological stability within the coastal environment (Ramses et al., 2019).

Indonesia's tropical coastal waters are recognized as one of the world's regions with the highest levels of marine biodiversity, encompassing key benthic communities such as sea cucumbers (class Holothuroidea). Sea cucumbers play an essential ecological role as deposit feeders and sediment bioturbators, contributing to nutrient cycling and the maintenance of seabed structure (MacTavish et al., 2012). In addition to their ecological importance, several species possess high economic value in international markets and are therefore intensively exploited through capture fisheries and aquaculture. Numerous studies have indicated that commercial harvesting pressure and environmental changes have affected the distribution and abundance of sea cucumbers across various regions of Indonesia. Consequently, a quantitative understanding of their diversity and abundance is critical to support sustainable management and conservation strategies (Winanto et al., 2024).

Regional studies in Indonesia have revealed distinct spatial habitat patterns that influence sea cucumber species composition across seagrass ecosystems, coral reefs, and sandy substrates. Holothuria scabra is widely recognized to inhabit seagrass ecosystems and sandy–muddy substrates, where the availability of organic matter supports its deposit-feeding behavior (Namukose et al., 2016). In contrast, species of the genus Stichopus are frequently found in coral reef habitats characterized by complex substrates and high food availability, while Actinopyga species tend to inhabit coral rubble and rocky substrates with moderate water movement. These patterns indicate that sea cucumber distribution is strongly influenced by habitat characteristics, local environmental conditions, and anthropogenic pressures. In Indonesian coastal waters, the diversity and distribution of several commercially important sea cucumber species, such as Holothuria scabra, Stichopus herrmanni, and Actinopyga spp., have been widely documented, particularly within seagrass beds and coral reef ecosystems (Boli et al., 2026; Helmiyani et al., 2024; Setyastuti et al., 2024). These studies have provided valuable information regarding species composition and habitat preferences in several regions. However, quantitative data on the diversity and community structure of sea cucumbers in certain coastal areas, including the waters of Sarang Island and the Nenek Strait in Batam City, remain limited. Therefore, systematic surveys and population monitoring are necessary to generate

reliable baseline data to support effective management and conservation of sea cucumber resources (Oedjoe & Eoh, 2015).

Sea cucumbers are echinoderms belonging to the phylum Echinodermata that play significant ecological and economic roles. Intensive exploitation practices, often conducted without consideration of species identity or size, have led to substantial declines in natural populations. In addition, coral reef exploitation and degradation, which reduce habitat quality and overall resource availability, threaten large portions of coastal areas and may further accelerate the decline of sea cucumber populations. The potential extinction of certain sea cucumber species poses a serious risk of losing valuable genetic resources in the natural environment. Therefore, the implementation of conservation measures and the development of sea cucumber aquaculture are essential to offset excessive exploitation and ensure long-term sustainability (Médard & Ohl, 2019). Data regarding the overall status of sea cucumber fisheries in Indonesia remain limited and insufficiently documented, while the harvesting and utilization of sea cucumbers have continued to increase over time. Furthermore, the absence of specific regulations governing the capture and trade of sea cucumbers from natural waters constitutes a major challenge for effective fisheries management. This lack of regulatory framework has become a critical issue in efforts to achieve sustainable management of sea cucumber fisheries in Indonesia (Handayani et al., 2017).

Although several islands within the Riau Archipelago and adjacent regions have been the subject of benthic ecological research, empirical data on the abundance and diversity of sea cucumbers in the waters of Sarang Island and the Nenek Strait (Batam City) remain scarce or insufficiently documented. This knowledge gap limits the ability to assess local conservation status and to develop evidence-based management recommendations. Accordingly, this study aims to inventory Holothuroidea species present in the study area, quantify their relative abundance, and analyze spatial distribution patterns in relation to habitat conditions in the waters of Sarang Island and the Nenek Strait (Setyastuti et al., 2024). Emphasized that quantitative field surveys and biometric data are essential for supporting sustainable marine resource management. Therefore, the findings of this study are expected to provide a scientific foundation for local management and conservation strategies for sea cucumbers in the Batam region.

In tropical coastal ecosystems, ecological parameters such as species diversity, abundance, and community structure are commonly used to evaluate the population status and environmental conditions of sea cucumbers (Holothuroidea), which are highly sensitive to habitat characteristics and environmental disturbances. Studies conducted in the waters of Sarang Island and surrounding areas of Batam reported that mollusk populations generally exhibit allometric growth patterns, with condition factor values indicating that local environmental conditions remain supportive of normal growth and physiological stability (Dinata et al., 2025). Similar findings from Batam coastal waters further confirm that variations in morphometric traits and length–weight relationships are closely associated with habitat quality, substrate type, and water physicochemical parameters, providing essential baseline data for sustainable management and conservation planning (Hasibuan et al., 2025). In addition, biometric studies in Indonesian

coastal ecosystems emphasize that integrating morphometric data, length–weight relationships, and condition indices is crucial for evaluating population health and supporting fisheries and aquaculture development strategies in small-island environments (Ramses et al., 2019).

Therefore, this study aims to identify the species composition, analyze the diversity and community structure, and evaluate the spatial distribution of sea cucumbers (Holothuroidea) in the waters of Sarang Island and the Nenek Strait, Batam City. The results of this study are expected to provide baseline ecological data on sea cucumber diversity and community structure in the region, which can contribute to scientific understanding and support future conservation and management strategies for sea cucumber resources in Batam coastal waters.

METHODS

This study was conducted from August to October 2024 in the waters of Sarang Island and the Nenek Strait, Batam City. Two sampling stations were established: Station I at Sarang Island (N = 1°07′31.253″; E = 102°50′39.63″) and Station II at the Nenek Strait (N = 1°07′31.253″; E = 102°50′39.63″) Sampling was carried out in the intertidal zone using the sweeping method during nighttime. At each station, three transects were established parallel to the shoreline. Each transect measured 50 m in length and 5 m in width, covering a sampling area of 250 m² per transect. Thus, the total sampling area at each station was 750 m².

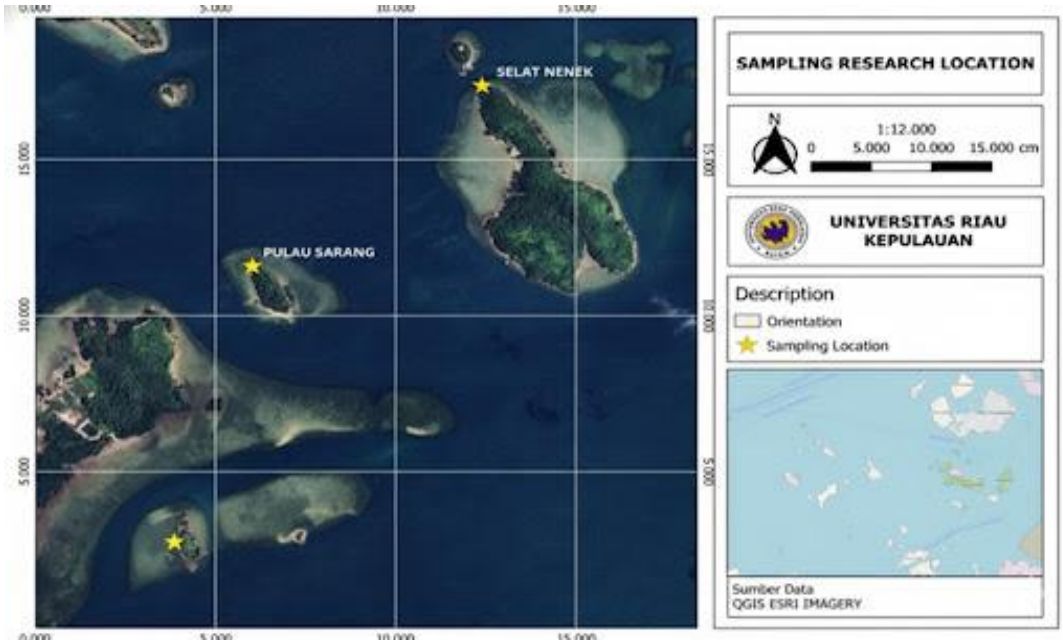

Figure 1. Research Location Map

Sampling was conducted three times at each station with a two-week interval between sampling events. During each survey, all sea cucumbers encountered within the

transect area were collected and recorded. Species identification was performed based on morphological and visual characteristics. Environmental parameters including water temperature, pH, salinity, dissolved oxygen (DO), water clarity, and current velocity were measured in situ at each station during the sampling period.

Tools and Materials

Data collection and water quality measurements in this study employed a range of instruments, including a measuring tape, snorkeling equipment, stationery, an underwater camera, a GPS device for coordinate determination, a camera, and sample bags. Water quality measurements were conducted using a thermometer, refractometer, dissolved oxygen (DO) meter, pH meter, Secchi disk, total dissolved solids (TDS) meter, and a float for current velocity estimation. All water quality parameters were measured in situ. Remote underwater survey tools such as towed mini-ROVs and high-resolution video systems have been shown to significantly increase the spatial coverage and efficiency of benthic community sampling compared with traditional diver-based methods, while providing geo-referenced imagery that supports quantitative analysis (Raoult et al., 2025). Advances in marine water sampling technology emphasize the importance of deploying appropriate devices — including pressure-retaining and passive samplers to collect high-quality in-situ water samples with minimal disturbance, ensuring integrity of physicochemical measurements across varying depths and conditions (Wang et al., 2024).

Sampling Procedure

The field equipment used in this study was adapted to the sweeping method applied in the intertidal zone. Species identification was carried out based on morphological and visual characteristics. These procedures were employed as the basis for determining sampling points along each transect, as commonly applied in Holothuroidea survey studies within coastal ecosystems (Setiawan et al., 2025). For species identification, in addition to morphological observations, a visual documentation approach using an underwater camera was employed, consistent with practices applied in studies of sea cucumber species composition in Raja Ampat (Handayani et al., 2017).

The observation process involved surveying an area extending 20 meters forward, with a 5-meter sweep to the left and a 5-meter sweep to the right at each transect. Each station was surveyed in two replicates, with a distance of 20 meters between replicates. These procedures were implemented to ensure the accuracy and reliability of the data obtained. The sampling locations were selected based on specific considerations to achieve optimal representation of the study area.

Water Quality Measurement

Environmental quality measurements were conducted to assess factors influencing Holothuroidea abundance. The parameters measured included water temperature, pH, turbidity (TDS), dissolved oxygen (DO) concentration, water transparency, and current velocity. Recent marine water quality assessment studies emphasize the simultaneous

measurement of key physico-chemical parameters including temperature, salinity, pH, dissolved oxygen, and turbidity to comprehensively evaluate coastal water conditions and identify environmental stressors affecting aquatic ecosystems (Suhartawan & Daawia, 2025). The obtained values were subsequently compared with marine water quality standards for biota, as stipulated in the Regulation of the State Minister for the Environment of the Republic of Indonesia No. 51 of 2004. In situ measurement of physical and chemical water quality properties using multiparameter instruments provides real-time and high-resolution data essential for tracking spatial variations and temporal dynamics of coastal seawater quality (González-Guirald et al., 2024).

DATA ANALYSIS

Diversity

The Shannon–Wiener diversity index (H') was used to describe the level of species diversity within the community. The value of H' is influenced by the number of species (S) and the relative abundance of each species (p_i). Higher H' values indicate a more diverse and stable community, whereas lower H' values suggest strong dominance by one or a few species.

$$H' = -\sum_{i=1}^{s} pi \ln (pi) \quad \text{..... (1)}$$

The Shannon–Wiener index is widely applied in sea cucumber ecological studies because it effectively represents variation in species composition and community stability within coastal ecosystems (Pinasthi et al., 2024).

Evenness Index (E)

The evenness index (E) was used to assess the degree of uniformity in the distribution of individuals among species within a community. Values of E range from 0 to 1, where values approaching 1 indicate a more even community with no strongly dominant species, while values approaching 0 indicate dominance by a single species (Cerabolini et al., 2009).

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

Pielou's evenness index (E) is widely used to evaluate the uniformity of sea cucumber communities in coastal ecosystems characterized by variability in species abundance and distribution (Ardiannanto et al., 2014).

Simpson's Dominance Index (C)

The Simpson dominance index (C) was used to determine the degree of species dominance within a community. Values of C range from 0 to 1, where values approaching 1 indicate high dominance by one or several species, while values approaching 0 indicate the absence of dominant species and a more balanced community structure. The greater the value of p_i (relative abundance), the greater the contribution of that species to the

overall dominance index. The Simpson dominance index is widely applied in sea cucumber studies to assess the extent to which particular species dominate benthic communities in coastal regions (Moom et al., 2021).

RESULT

Inventory of Sea Cucumber Species

Observations conducted at both research stations within the seagrass ecosystem waters of Sarang Island recorded a total of five sea cucumber species (Figure 2). Three species were identified in the seagrass ecosystem of the Nenek Strait Island, namely *Stichopus herrmanni*, *H. scabra*, and *H. leucospilota*. In contrast, five species were recorded at Sarang Island, including *Holothuria scabra*, *H. leucospilota*, *H. fuscopunctata, Stichopus herrmanni*, and *Bohadschia aegyptia*. Based on these findings, the species composition of sea cucumbers in the waters of Sarang Island and the Nenek Strait is presented in Figure 1.

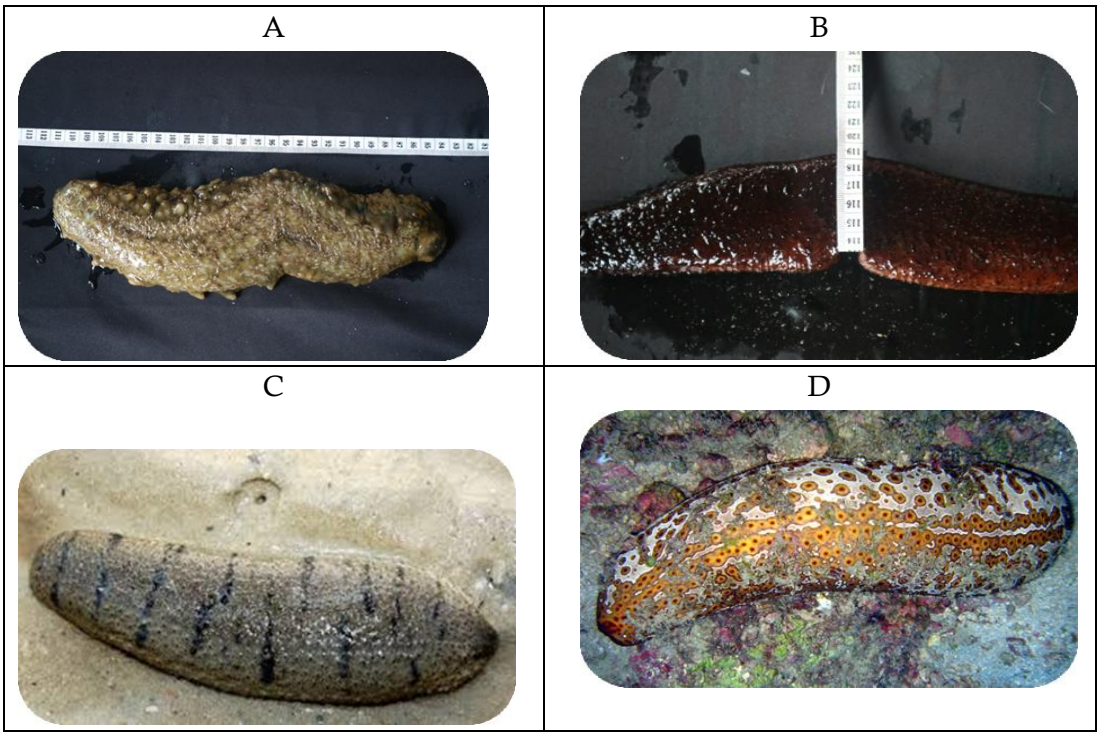

Figure 2. Species of sea cucumbers

Diversity

The Shannon–Wiener diversity index (H') was calculated for both study sites, namely Sarang Island and the Nenek Strait, based on relative abundance data. The H' value at Sarang Island was 1.059, whereas the H' value at the Nenek Strait was 0.576. This difference indicates that sea cucumber species diversity at the Nenek Strait is higher than at Sarang Island. The lower H' value at Sarang Island suggests that the sea cucumber community at this site is dominated by a single species, *Stichopus herrmanni* (gamat sea cucumber), which accounted for approximately 64% of the relative abundance. Such

strong single-species dominance reduces overall diversity, even when the total number of individuals is relatively high. In contrast, the higher H' value at the Nenek Strait reflects a more diverse sea cucumber community with a more even distribution of individuals among species. The absence of extreme dominance by any single species contributes to increased diversity, indicating a more ecologically stable community structure at the Nenek Strait.

Table 1. The species of sea cucumbers found on Sarang Island and Selat Nenek Island

No	Sea Cucumber Species	Sarang Island	Selat Nenek Island	Total
1	*Stichopus herrmanni*	16	10	26
2	*Holothuria leucospilota*,	4	7	11
3	*Holothuria scabra*	3	5	8
4	*Bohadschia aegus*	1	-	1
5	*Holothuria fuscopunctata*	1	-	1
Total		25	22	47

Table 2. Results of sea cucumber diversity on Sarang Island and Selat Nenek Island

No	Research Location	Amount of Species (S)	Individuals (N)	H' Value
1	Sarang Island	5	25	1.059
2	Nenek Strait	3	22	0.576

Evenness Index (E)

The evenness index (E) was calculated for the two study sites, Sarang Island and the Nenek Strait. The results indicate that the evenness value at Sarang Island was 0.358, which is categorized as low. This value suggests an uneven distribution of individuals among sea cucumber genera at this site, with dominance by a single species, namely the gamat sea cucumber, which exhibited a substantially higher relative abundance than the other species. In contrast, the evenness value at the Nenek Strait was 0.964, classified as high. This result indicates a more uniform distribution of individuals among sea cucumber species at this location. The absence of excessive dominance by any single species contributes to a more balanced and stable community structure. The difference in evenness values between the two sites indicates that Sarang Island supports a less evenly structured community, whereas the Nenek Strait harbors a more homogeneous, proportionally distributed sea cucumber community.

Table 3 Results of sea cucumber uniformity on Sarang Island and Selat Nenek Island

Research Location	Number of Species (S)	H' Value	ln(S) Value	Evenness Value (E)
Sarang Island	5	1.059	1.609	0.358
Nenek Strait	3	0.576	1.099	0.964

Simpson's Dominance Index (C)

The Simpson dominance index (C) was used to describe the degree of dominance exerted by particular species within the sea cucumber community at each study site. Based on the calculations, the dominance value at Sarang Island was 0.453, indicating a relatively high level of dominance. This value reflects that the sea cucumber community at Sarang Island is dominated by a single species, namely the gamat sea cucumber, which accounted for approximately 64% of the total relative abundance. Such strong dominance elevates the dominance index and results in a less balanced community structure.

In contrast, the dominance value at the Nenek Strait was 0.360, which is lower than that observed at Sarang Island. This lower value indicates the absence of excessive dominance by any single species. The distribution of individuals among the three species recorded in the Nenek Strait was relatively more even compared to Sarang Island, resulting in a lower dominance index. The difference in C values between the two sites reflects ecologically distinct community conditions: Sarang Island exhibits a more strongly dominated community structure, whereas the Nenek Strait supports a more balanced community, suggesting habitat conditions that may be more stable or less influenced by environmental stressors.

Table 4. Simpson's Dominance Index (C)

Research Location	Number of Species (S)	Dominance Value (C)
Sarang Island	5	0.453
Nenek Strait	3	0.360

Water Quality

Water quality can significantly influence the survival of marine biota, and can also act as a limiting factor for the distribution of marine organisms (Hamuna et al., 2018). The physical and chemical parameters of the water measured in this study included water temperature, salinity, and pH.

Temperature

Water temperature is one of the most critical factors influencing the survival and biological processes of aquatic organisms. The average water temperature recorded at the study sites was 30.33 °C, which slightly exceeded the recommended water quality standard of 28–30 °C. Such temperatures may affect oxygen solubility and biological activity in marine environments but remain within the suitable range for sea cucumber habitation. Excessively high seawater temperatures can hinder the growth and development of sea cucumbers (Baransano et al., 2019). Optimal seawater temperatures for sea cucumber life generally range from 20 to 31 °C.

Salinity

Salinity represents the concentration of dissolved salts in seawater and plays a crucial role in regulating osmotic pressure. The average salinity recorded at the study sites was 28.66‰, reflecting relatively balanced estuarine conditions. This range is considered suitable for the survival and optimal growth of sea cucumbers (Baransano et al., 2019). Seawater salinity in Indonesian marine waters generally ranges from 25–32‰ and may reach 30–35‰ in areas with low rainfall.

pH (Acidity Level)

Water pH is an important chemical parameter for assessing aquatic environmental stability (Lestari, 2021). The average seawater pH recorded at the study sites was 8.65, indicating alkaline conditions. According to the Decree of the Minister of Environment of the Republic of Indonesia No. 51 of 2004, the standard pH range for marine waters supporting biota is 7.5–8.5. Although the measured pH slightly exceeded this standard, the conditions remain generally supportive of sea cucumber development. Nevertheless, such values warrant attention to maintain ecosystem stability and to prevent potential environmental degradation.

Table 5. Water Quality and Substrate Condition Measurements

No	Parameters	Location Sampling
1	Temperature	30.33 ° C
2	Salinity	28.66 ppm
3	Ph	8.65
4	Depth	10-15 m
5	Current Speed	2.386 m/s
6	Substrate	Dominant sand, mud

DISSCUSSION

Diversity

Sea cucumber diversity at the study sites was analyzed using the Shannon–Wiener diversity index (H'), which accounts for both species richness and the relative abundance of each species within the community. The diversity index is an important parameter for evaluating ecosystem stability and the level of environmental pressure acting on benthic communities. Based on the analysis, sea cucumber diversity values ranged from low to moderate, indicating that the community structure has not yet reached full ecological stability. Low H' values generally reflect the presence of ecological pressures such as habitat degradation, anthropogenic activities, and excessive resource exploitation. As benthic organisms with limited mobility, sea cucumbers are highly dependent on substrate conditions and water quality; consequently, environmental changes directly affect their species composition and abundance (Bethanya et al., 2025). Communities with low

diversity tend to be more vulnerable to disturbances than those with higher levels of diversity.

In studies of subtidal benthic assemblages, seasonal surveys have revealed that spatial and temporal variability in species composition and community diversity is strongly influenced by habitat structure and environmental fluctuations, underscoring the importance of sampling across multiple time points to capture true diversity patterns (Xu et al., 2023). Quantitative assessments of benthic macrofaunal communities in recovering coastal systems show that taxonomic and functional diversity metrics often exhibit divergent responses to environmental changes, indicating that multiple diversity indices should be considered for comprehensive benthic biodiversity evaluations (Shi et al., 2022).

Moderate sea cucumber diversity indicates that the ecosystem can still support several species; however, the distribution of individuals among species remains suboptimal. Who stated that diversity values are strongly influenced by habitat complexity and the level of environmental disturbance (O'Keeffe, 2004). In coastal ecosystems under ecological pressure, benthic biodiversity tends to decline and become dominated by species with high environmental tolerance (Sudarmo et al., 2023). Based on the study results, the Shannon–Wiener diversity index (H') differed between the two research sites, Sarang Island and the Nenek Strait. Calculations based on relative abundance data showed that the H' value at Sarang Island was 0.576, while the H' value at the Nenek Strait was 1.059. The higher diversity observed at the Nenek Strait is likely associated with lower wave exposure and greater surface complexity compared to Sarang Island, which provides more favorable microhabitats for sea cucumber assemblages.

Uniformity

The evenness index (E) was used to describe the degree of uniformity in the distribution of individuals among species within the community. The calculated evenness values for sea cucumbers ranged from moderate to low, indicating an uneven distribution of individuals among species, with certain species exhibiting substantially higher abundances than others. Communities with low evenness values reflect less stable environmental conditions or the presence of selective pressures that allow only certain species to adapt successfully. Such conditions are commonly observed in disturbed coastal ecosystems, including those subjected to intensive harvesting of marine organisms and changes in water quality.

Iskandar et al., (2023) Explained that stable ecosystems generally exhibit high evenness because each species has a relatively equal opportunity to thrive. Therefore, the sea cucumber evenness values obtained in this study indicate that the community is under moderate ecological pressure, highlighting the need for sustainable management measures and habitat protection. The evenness index (E) was calculated for the two study sites, Sarang Island and the Nenek Strait. The analysis showed that the evenness value at Sarang Island was 0.358, which is considered low. This value indicates an uneven distribution of individuals among sea cucumber genera at this site, with dominance by a single species,

namely the gamat sea cucumber, which exhibited a substantially higher relative abundance than the other species. In contrast, the evenness value at the Nenek Strait was 0.964, placing it in the high category. High Pielou's evenness values in benthic community studies have been linked to more balanced species abundances across sampling stations, indicating that no single species dominates and reflecting a more stable community structure under less disturbed environmental conditions (Shi et al., 2022).

This value indicates that the distribution of individuals among sea cucumber species in the Nenek Strait is more even. The absence of excessive dominance by any single species results in a more stable and balanced community structure at this site. The difference in evenness values between the two locations demonstrates that Sarang Island supports a less evenly structured community, whereas the Nenek Strait harbors a more homogeneous sea cucumber community with a more proportional distribution of individuals.

Simpson's Dominance Index (C)

The Simpson dominance index (C) was used to assess species dominance within the community. The dominance values obtained in this study ranged from low to moderate, indicating that no single species completely dominated the sea cucumber community, although a tendency toward dominance by certain species was observed. Dominance index values approaching zero indicate a relatively balanced and diverse community, whereas values approaching one reflect strong dominance by one or several species (Simpson, 1949). Moderate dominance suggests that the sea cucumber community remains in a reasonably stable condition, although environmental pressures are influencing community structure.

Species dominance is often associated with adaptive capacity to environmental conditions and resource availability (Baransano et al., 2019). Sea cucumber species that exhibit high tolerance to environmental fluctuations and strong adaptive abilities tend to show higher abundances. Moom et al., (2021) also reported that sea cucumber dominance in coastal ecosystems is influenced by habitat conditions, food availability, and harvesting pressure. The Simpson dominance index (C) was used to describe the degree of dominance exerted by particular species within the sea cucumber community at each study site. Based on the calculations, the dominance value at Sarang Island was 0.453, indicating a relatively high level of dominance. This value reflects that the sea cucumber community at Sarang Island is dominated by a single species, namely the gamat sea cucumber, which accounted for approximately 64% of the total relative abundance. Such dominance increases the dominance index and results in a less balanced community structure. In contrast, the dominance value at the Nenek Strait was 0.360, which is lower than that observed at Sarang Island.

In marine fish community assessments, Simpson's dominance index has been used to quantify the relative contribution of abundant species, where higher dominance values indicate that one or a few species disproportionately contribute to total abundance, thus implying lower overall community diversity and potential ecological imbalance

(Cömert et al., 2025). Studies of coastal benthic ecosystems have shown that Simpson's dominance values tend to increase in assemblages where environmental stressors or disturbance regimes favor a few opportunistic species, reflecting reduced evenness and potentially compromised ecosystem function under degraded conditions (Rivadeneira & Nielsen, 2022).

This value indicates that no single species dominates the community excessively at the Nenek Strait. The distribution of individuals among the three recorded species is relatively even compared with that observed at Sarang Island, resulting in a lower dominance index. The difference in C values between the two sites reflects ecologically distinct community conditions. Sarang Island exhibits a more strongly dominated community structure, whereas the Nenek Strait supports a more balanced community, suggesting habitat conditions that may be more stable or less influenced by specific environmental stressors.

Environmental Quality Parameters

Based on the measurements of marine water quality parameters, it can be concluded that the water conditions at the Sarang Island observation station largely meet the marine water quality standards for marine biota as stipulated in the Decree of the Minister of Environment of the Republic of Indonesia No. 51 of 2004. The dissolved oxygen (DO) concentration at Sarang Island was 8.4 mg/L, which is well above the minimum threshold of 5 mg/L, indicating highly favorable conditions for supporting marine life. Seawater temperature at the research station ranged from 30 - 31 °C, with minimal variation and remaining within the allowable maximum fluctuation of ±2 °C from natural conditions, which generally does not disrupt the balance of the marine ecosystem. Slightly lower temperatures may affect biological activity, as the optimal temperature for sea cucumber activity is reported to be around 31 °C (Rodríguez-Forero et al., 2024).

However, the Total Dissolved Solids (TDS) values recorded at Sarang Island were relatively high, reaching 73,400 mg/L. Elevated TDS levels can reduce water clarity and light penetration, potentially affecting primary productivity within marine ecosystems. In addition, pH values ranged around 8.65, indicating slightly higher alkalinity than the recommended normal range of 7.5–8.5. Such conditions may result from biological processes or anthropogenic activities that influence the chemical stability of seawater. A near-neutral to slightly alkaline pH range of 8.5–8.8 is considered to create relatively stable environmental conditions that support the survival of various marine species (Samdin et al., 2024). Salinity values at Sarang Island ranged around 28‰, remaining within the maximum allowable variation of 5% from the seasonal average. This condition indicates relatively stable salinity levels that are conducive to the survival of marine biota. The current velocity at Sarang Island averaged 0.68 m s, a rate that supports the effective circulation of nutrients and oxygen, which is essential for ecosystem sustainability. Such current speeds enhance nutrient distribution, promote even resource availability, and help

prevent the dominance of a single species, thereby maintaining ecological balance (Martín et al., 2020).

However, water transparency was relatively low, ranging from 2 to 3 meters. This low transparency suggests a high concentration of suspended particles or elevated biological activity, such as plankton abundance, which limits light penetration in these waters. Overall, the marine water quality in Sarang Island waters remains relatively good, as indicated by key parameters such as dissolved oxygen, temperature, and salinity. However, attention should be given to the relatively high TDS values and the slightly elevated pH, as these conditions may potentially affect the stability of the marine ecosystem if not properly managed. Regular monitoring is therefore necessary to ensure that seawater quality continues to support the sustainability of marine biota, particularly in light of potential impacts from anthropogenic activities.

CONCLUSION

The sea cucumber population at Sarang Island comprised 25 individuals across five species, with Holothuria sp. (gamat sea cucumber) dominating 64% of the total. The diversity index at this site was categorized as moderate (H' = 1.059), evenness was low (E = 0.358), and dominance was relatively high (C = 0.453), indicating single-species dominance and an imbalanced community structure. In contrast, the waters of the Nenek Strait recorded 22 individuals across three species, with a diversity index (H' = 0.576) in the moderate category, evenness close to one (E = 0.964) in the high category, and a dominance index (C = 0.360) in the low category, reflecting a more stable and balanced community. These differences indicate that, although Sarang Island has a higher diversity index, its community structure is less stable due to uneven species distribution and strong dominance by a single species. Conversely, the Nenek Strait shows a more ecologically balanced condition, where individuals are distributed more evenly among species, suggesting more favorable or less disturbed habitat conditions. This finding emphasizes that diversity index values alone are not sufficient to represent ecosystem stability without considering evenness and dominance components. These variations are likely related to differences in habitat characteristics and levels of ecological pressure between the two locations. This study provides baseline biodiversity data on sea cucumbers (Holothuroidea) in Batam coastal waters, which can serve as a scientific reference for future ecological monitoring, conservation planning, and sustainable management of marine resources in the region..

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