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Community structure of sea cucumber (Echinodermata: Holothuroidea) resources in the Kepulauan Seribu National Park, Indonesia

NAZWA AYUNDA HELMIYANI[1,♥], SURYANTI SURYANTI[2], FRIDA PURWANTI[2]

[1]Graduate Program of Coastal Resource Management, Faculty of Fisheries and Marine Sciences, Universitas Diponegoro. Jl. Prof. Jacub Rais, Tembalang, Semarang 50275, Central Java, Indonesia. ♥email: Nazwaayunda922@gmail.com

[2]Department of Aquatic Resource, Faculty of Fisheries and Marine Sciences, Universitas Diponegoro. Jl. Prof. Jacub Rais, Tembalang, Semarang 50275, Central Java, Indonesia

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Abstract. *Helmiyani NA, Suryanti S, Purwanti F. 2024. Community structure of sea cucumber (Echinodermata: Holothuroidea) resources in the Kepulauan Seribu National Park, Indonesia. Biodiversitas 25: 344-354.* Kepulauan Seribu National Park has several types of commercial sea cucumbers (Echinodermata: Holothuroidea). Many local and foreign communities take sea cucumbers from nature without paying attention to habitat conditions. This phenomenon causes a decrease in the availability of sea cucumbers. This research was carried out to help stabilize the sea cucumber ecosystem and its availability to be considered for its sustainability. This research was conducted in May-June 2023, at Kelapa Dua Island and Panjang Kecil Island in the Kepulauan Seribu National Park, Jakarta, Indonesia. Sampling was carried out using the field observation method, where the location points were determined by adjusting where the sea cucumber habitat was located. Sampling points were carried out on two islands, each island was assigned 4 station points, with the total number of stations on both islands being 8 station points. Sampling was carried out using perpendicular transect lines, divided into 3 zones. The data analyzed includes the Index of Diversity, Evenness, Dominance and Density. Based on the results 12 species were obtained from both islands, with the genera *Holothuria*, *Stichopus*, *Bohadschia, Actinopyga*, and *Synapta*. The highest density is at station 3 Kelapa Dua Island, with a density value of 0.57 (ind/m^2), and the lowest density is at station 1 Panjang Kecil Island with a value of 0.14 (ind/m^2). The results show a moderate diversity value, a low Dominance value, and a small evenness value, while the water quality result value can be said to be good because it has a value according to the survival quality standards for sea cucumbers in marine waters.

Keywords: Diversity, ecology, sea cucumber

INTRODUCTION

The Kepulauan Seribu National Park (TNKpS) boasts abundant natural resources, including a variety of animals from the Echinodermata phylum. However, many of these species are often captured for their commercial value. It is important to note that any capture or removal of animals from the park is strictly prohibited. Sea cucumbers are marine invertebrates that have been hunted for their benefits as deposit feeders (Fredianto et al. 2019) and in the biopharmaceutical field where they have been used in certain treatments (Soltani and Baharara 2019). Sea cucumbers play a crucial role as a natural recycling system in the ocean by feeding on waste on the seabed and dead organic matter (Purcell et al. 2013).

Indonesia has a high production of sea cucumbers, which have entered both local and global markets (Setyastuti et al. 2019). Sea cucumbers have potential as a traditional food and medicinal ingredient due to their high nutritional content (Sukmiwati et al. 2022). The Kepulauan Seribu National Park (TNKpS) is an administrative region divided into several zones according to their respective functions. Island Kelapa Dua and Panjang Kecil Island are islands within the utilization zone, and many people utilize the resources available on each island. The Kepulauan Seribu are a potential producer of sea cucumbers in Indonesia. Various commercially valuable sea cucumber species have been utilized as a source of income for the community, especially fishermen (Yuniarga et al. 2021).

Cultivation in the Kepulauan Seribu National Park has not been successful due to a lack of knowledge and access to manage it, resulting in a decline in its availability in nature. However, information on the availability of sea cucumbers in Indonesia, especially in the Thousand Islands National Park, is still limited to certain areas of the islands. There is no annual production data available to identify the availability status in nature. Meanwhile, local fishermen continue to catch using snorkeling methods every day. Excessive fishing is also carried out by fishermen from outside the island, namely fishermen from Madura Island (Purcell et al. 2013).

In general, fishermen are experiencing the impact of the current exploitation, as it is becoming increasingly difficult to find and collect sea cucumbers. Diving is necessary to catch more, and this has been the case for the past few decades. In general, fishermen feel that collecting sea cucumbers has become more difficult, requiring deeper dives than in previous decades. From a global perspective,

the sea cucumber fishery in Indonesia has been overexploited (Toral-Granda et al. 2008; Purcell 2014). The exact amount of natural sea cucumber stock in Indonesia cannot be accurately determined due to the lack of data (Setyastuti et al. 2018). Overuse and damage to fishing resource habitats are two main factors contributing to the decline of fisheries worldwide, which is also happening in several Indonesian waters. Some types of fisheries resources, such as sea cucumbers, have experienced chronic overfishing phenomena that cannot recover naturally (Bell et al. 2018; Taurusman et al. 2018).

Sea cucumbers are frequently caught using fishing gear that does not meet safety standards. Unscrupulous fishermen use compressors to catch them, which not only threatens the exploitation of sea cucumbers but also damages other ecosystems and associated biota. The most commercially valuable sea cucumber species is the white sand sea cucumber (*Holothuria scabra*), which is becoming increasingly scarce local and off-island fishermen should focus on finding gama sea cucumbers of the genus *Stichopus* sp. Monitoring and research are conducted to determine the availability of sea cucumbers in the Kepulauan Seribu National Park. This data will be used to support management plans for the sustainable use of sea cucumber resources in the future. Additionally, it is important to understand the structure of the sea cucumber community, its density, and the ecological conditions of its habitat to ensure the survival and sustainability of sea cucumbers. Research on sea cucumber diversity has only been studied in certain areas of Indonesia. Meanwhile, free capture and exploitation of sea cucumber species with high economic value continue to occur (Siddiq et al. 2016).

MATERIALS AND METHODS

Data collection

This research was carried out in May-July 2023, in the National Park Management Section (SPTN) Area 1, Kelapa Dua Island and Panjang Kecil Island, North Kepulauan Seribu National Park, Jakarta Province, Indonesia (Figure 1.) Kepulauan Seribu National Park (TNKpS) has rich natural resources quite abundant, lots of commercial flora and fauna, one of which is sea cucumbers, and also a variety of biota and plants are protected. The research location taken has seagrass beds as a living habitat for sea cucumbers.

Sea cucumber sampling was carried out on two islands, Kelapa Dua Island and Panjang Kecil Island, provided that each island consisted of 4 stations, with a total of 8 stations from 2 islands. The coordinates of the observation site can be seen in (Table 1). The sampling method used is a direct observation method, where sampling points are determined based on the sea cucumber habitat (COREMAP 2016). (Manaputty and Noya 2019) The sampling method was carried out using perpendicular transects from the shoreline to the center for 100 meters, each station consisting of 3 transects, with an interval between them of 15 meters. Sampling of sea cucumbers was carried out using the line transect method with Reef Check modification for sampling megabenthos animals. This study used a transect length of 100 meters for sea cucumbers. Each research location was placed 100 m transect. The quadrant transect used was 1x1 m in size which was placed on the right and left of the transect line with a distance of 9m quadrant transect intervals, at each line transect was repeated until the 10th point. The number of transect lines at each station repeated 3 times with the same method of 100 m transect length. Thus the total area of sea cucumber sampling conducted was 3 x (2 m^2 x 10) = 60 m^2. The research sampling design can be seen in (Figure 2.).

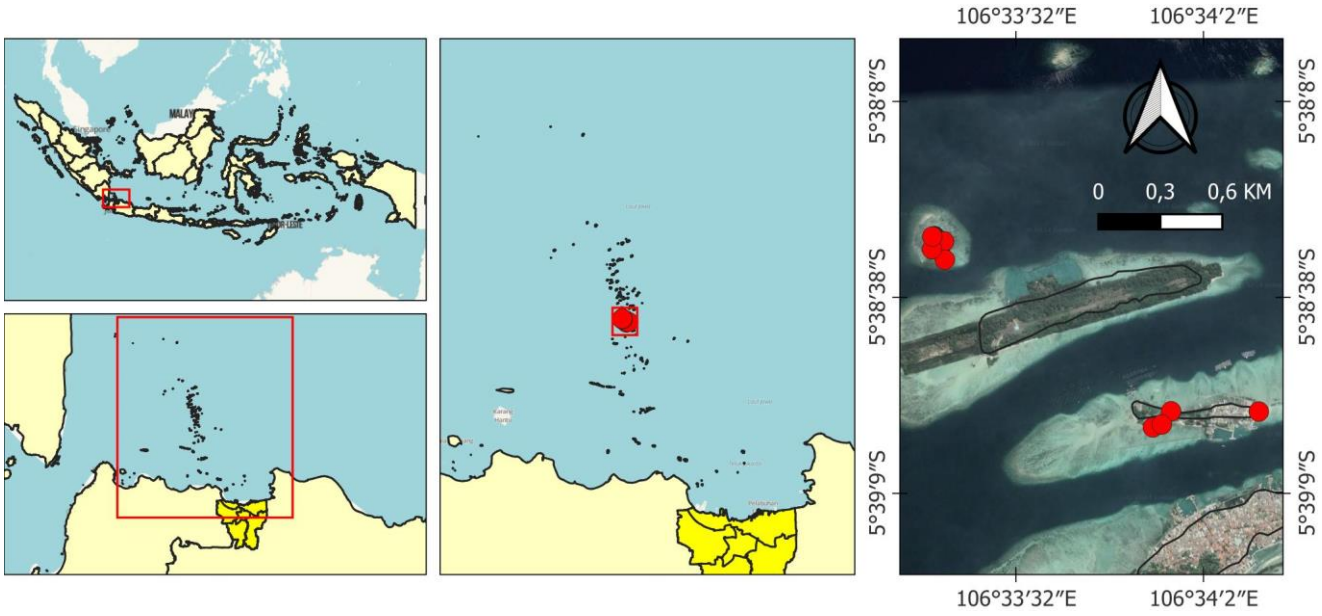

Figure 1. Research station in Kelapa Dua Island and Panjang Kecil Island, in the Kepulauan Seribu National Park, Jakarta, Indonesia

Table 1. Sampling coordinate of the study in the Kepulauan Seribu National Park, Jakarta, Indonesia

Name of island	Station	Depth (m)	Habitat	Coordinate point
Kelapa Dua	ST 1	1-3	Seagrass	5°38'56.19"S 106°33'56.83"E
	ST 2	1-3	Seagrass & coral reefs	5°38'58.70"S 106°33'53.95"E
	ST 3	1-3	Seagrass, coral reefs, algae	5°38'58.25"S 106°33'55.36"E
	ST 4	1-3	Seagrass & coral reefs	5°38'56.25"S 106°34'10.64"E
Panjang Kecil	ST 1	1-3	Seagrass	5°38'29.65"S 106°33'21.11"E
	ST 2	1-3	Seagrass, coral reefs, brown algae	5°38'32.52"S 106°33'21.22"E
	ST 3	1-3	Coral reefs & seagrass	5°38'30.86"S 106°33'19.20"E
	ST 4	1-3	Coral reefs	5°38'28.90"S 106°33'19.26"E

Sampling was carried out in areas with the availability of seagrass cover and also coral reefs based on the habitat favored by sea cucumbers. Sampling was carried out at night at 18.00-24.00 WIB. Sampling was carried out at a depth of 1-3 meters. Sampling carried out at night is the right choice to obtain a density of sea cucumbers, which is expected to be abundant, because sea cucumbers are nocturnal animals that are more active and easily reveal themselves at night. The data obtained was then documented based on transects, with each transect recording the type, association and type of substrate visually (Manaputty and Noya 2019). Ecological parameters of water quality measured during the study include temperature, pH, dissolved oxygen, and salinity. Temperature measurements were carried out with procedures in accordance with the literature (Machzar et al. 2018). pH measurements, salinity measurements were carried out with provisions according to (Siltri et al. 2015), DO waters were measured using a DO meter with guidance from (Rovita 2012). Which was measured after each sampling of sea cucumber resources, which is measured every time sampling of sea cucumber resources is carried out. Water quality measurements were carried out in situ and repeated 3 times at each observation station using the Horiba WQM Oceanography tool.

Data analysis

Dominance index

To calculate Simpson's dominance index (D) use the following calculation:

$$C = \sum_{i=1}^{s} (Pi)^2$$

The dominance index value ranges from 0-1. The dominance category is based on the Simpson Dominance Index value (D): (i) 0.00-0.50 = No Dominance Species, (ii) 0.51-1.00 = Dominance Species.

Diversity Index of Shannon-Wienner (H')

The diversity Index of species were calculated by using the following formula, according to Shannon-Winner, (1963):

$$H' = -\Sigma \, pi \ln pi$$

Categories of high and low diversity of sea cucumber species can be seen in (Table 2).

Evenness of species

Evenness can be said to be a balance, namely the composition of individuals of each species contained in a community. Pielou's evenness (J) is calculated using the following formula:

$$E = H'/Hmax$$

J is Pielou's evenness index (J), H' is the diversity index, ln(s) is the maximum species diversity. The criteria for the uniformity index are as follows; J value <0.4: small population evenness, value 0.4<J<0.6; medium population evenness, J value >0.6; large population evenness.

Density

Species density is the number of individuals per unit area, the density of each species at each station is calculated using the following formula (Aulia et al. 2021):

$$D = ni/A$$

D is the species density value, ni is the total number of individuals of the species, and A is the area sampled.

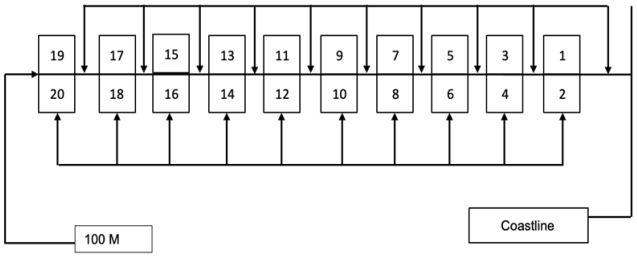

Figure 2. Transect station design for sea cucumbers

Table 2. Criteria of diversity (Krebs 1999) in (Muzaki et al. 2019)

Criteria	Value of H'
High diversity	H'>3
Moderate diversity	1≤H'≤3
Low Diversity	1<H'

Sea cucumber density distribution based on habitat characteristics

Spatial analysis of habitat characteristics was carried out using Arc GIS 10.8 application, data processing was carried out by combining sampling coordinates with sea cucumber density data at each station. The merging of bands in the Landsat 9 image data was carried out to distinguish habitat characteristics such as seagrass, coral reefs, and sand at the field sampling point, then the thematic map was given a legend attribute, cardinal direction, and scale, as well as instructions on where the research was conducted, and also the density value was displayed at each sampling point station.

RESULT AND DISCUSSION

Identification of sea cucumbers

Based on the results of research that has been carried out, there are 12 types of sea cucumbers found in Kelapa Dua Island and Panjang Kecil Island. The sea cucumbers found on Kelapa Dua Island are, *(Synapta* maculata, (b) *Stichopus horrens*, (c) *H. leucospilota*, (d) *Bohadschia marmorata*, (e) *H. edulis*, (f) *Stichopus herrmanni*, (g) *H. atra*, (h) *H. (Stauropora) fuscocinerea*, (i) *Actinopyga miliaris*, (j) *Stichopus vastus*, (k) *Bohadschia similis*, (l) *Bohadschia vitiensis*), (The sea cucumbers obtained can be seen and have been presented in (Table 3), and location found can be seen in (Table 4).

Black sea cucumber (*Holothuria atra*) has the highest abundance on Kelapa Dua Island and Panjang Kecil Island, this is obtained because there are factors that cause this to happen because the selling value of black sea cucumber is low. Fishermen and the community rarely take this type of sea cucumber so that its existence is easily found and very abundant compared to the type of sea cucumber that has high economic value. The people of the Kepulauan Seribu National Park search for sea cucumbers with a time ratio of every day, the search is carried out every day at the start of the evening, because they believe that it is easier to find sea cucumbers at night, this fact is reinforced by research that sea cucumbers are nocturnal animals (Purcell et al. 2023), in addition to their nocturnal nature, sea cucumbers can also be found in the light of day, but the percentage is small and tends to be difficult, because sea cucumbers take refuge in coral reef ecosystems (Purcell et al. 2023) in (Gray et al. 2023). Remote locations in Indonesia have been used as used as fishing grounds because cucumber because cucumber fishermen have to scour the places to find the target species that the market wants. Species the market wants. What the market wants. Whether the market wants it or not Whether the market wants it or not, fishermen are basically inclined to catch all kinds of sea cucumbers in various sizes that occur in nature (Conand and Tuwo 1996; Purwati et al. 2010; Setyastuti 2013).

Water quality

Sampling water quality can be seen and presented in (Table 5). Pulau Kelapa Dua is part of the utilization zone of the Kepulauan Seribu National Park. Pulau Kelapa Dua is part of the utilization zone of the Kepulauan Seribu National Park. It is used as a residential area and for educational tourism. The density of sea cucumbers on the island has decreased in recent years. The relatively high pH value of 8.68 may be due to the influence of household waste at station 4. In reality, Station 4's field is often used as a docking spot for small boats used by fishermen, which can lead to contamination from boat fuel and household waste due to the high population density in the area. This is further supported by the density value of sea cucumbers at Station 4, which is categorized as the lowest density compared to other stations with a value of 0.30 ind/m2. This is further supported by the density value of sea cucumbers at Station 4, which is categorized as the lowest density compared to other stations with a value of 0.30 ind/m^2. It can be seen that the water quality parameter values in Pulau Kelapa Dua have an average water quality value that still complies with the standard quality requirements. This is because most of the water areas are still considered clean. Therefore, the obtained results for salinity, density, temperature, pH, and water DO are still good for the survival of sea cucumbers. According to Padang et al. (2015), sea cucumbers can survive and adapt to a temperature range of 24-30°C. The average temperature range at Pulau Panjang Kecil station is 28.67°C. The Department of Marine and Fisheries states that seawater pH is a major buffer that has the property of being able to accommodate bases and acids, which stabilizes seawater pH. Sea cucumbers can survive in a pH range of 6.5-8.5. Dissolved oxygen has an optimal range of 4-8 ppm for sea cucumber growth. Research indicates that station 4 has a dissolved oxygen level of 8.68 ppm, which exceeds the standard quality value. The water quality at stations 1, 2, and 3 also meets the standard quality requirements for sea cucumber habitat.

The water quality of Pulau Panjang Kecil has salinity, temperature, pH, and DO values that are still within the standard limits for the survival of sea cucumbers. It can be observed that the highest salinity value is found at station 1, while the highest values at each station are found at stations 2 and 4, with a value of 28-29‰. The lowest average salinity is found at station 1, which is 27-28‰. The importance of dissolved oxygen (DO) should also be considered as a crucial factor in supporting the survival of sea cucumbers in their habitat. The DO value in Pulau Panjang Kecil can be categorized as good, with each research station having an average value of 5.00-5.21 mg/L. Pulau Panjang Kecil has relatively good water quality as it is an uninhabited island, indicating that the water has not been contaminated by waste that could disrupt its quality. Therefore, various types of biota, including stingrays, octopuses, and other echinoderms such as starfish and sea urchins, are associated with sea cucumbers.

Table 3. Photographic list of sea cucumbers found in Kelapa Dua Island and Panjang Kecil Island, Kepulauan Seribu National Park, Jakarta, Indonesia

Sea cucumbers	Description of sea cucumbers
	Scientific name: *Bohadschia similis* (Semper, 1868) Documentation by: Research results International name: Brownspotted sandfish Found in fine sand habitats & seagrass beds
	Scientific name: *Stichopus horrens* (Selenka, 1867) Documentation by: Research results Found in coral reef habitats
	Scientific name: *H. (Stauropora) fuscosinerea* (Jaeger, 1833) Documentation by: Research results Found in crusted sand & brown algae
	Scientific name: *Stichopus vastus* (Sluiter, 1887) Documentation by: Research results Found in coral sand habitats
	Scientific name: *Synapta maculata* (Selenka, 1867) Documentation by: Research results Found in seagrass habitats
	Scientific name: *Actinopyga miliaris* (Quoy and Gaimard, 1834) Documentation by: Research results Found in crusted sand
	Scientific name: *Holothuria (Halodeima) edulis* (Lesson, 1830) Documentation by: Setyastuti 2014 Found in seagrass and fine sand habitats
	Scientific name: *Stichopus Hermanni* (Semper, 1868) Documentation by: U.Y. Arbi Found in coral reef habitats
	Scientific name: *Bohadschia vitiensis* (Semper, 1868) Documentation by: Setyastuti et al. 2019 Found in fine sand & seagrass cover habitats
	Scientific name: *Bohadschia marmorata* (Jaeger, 1833) Documentation by: Setyastuti et al. 2019 Found in the sand of coral fragments
	Scientific name: *H. leucospilota* (Brandt, 1835) Documentation by: Setyastuti et al. 2019 Found in seagrass habitats
	Scientific name: *Holothuria atra* (Jaeger, 1833) Documentation by: Research results International name: Lollyfish Found in sand and seagrass habitats

Table 4. Sea cucumbers found in Kelapa Dua Island and Panjang Kecil Island, Kepulauan Seribu National Park, Jakarta, Indonesia

Type of sea cucumbers	Name of islands	
	Kelapa dua	Panjang kecil
Holothuria atra	+	+
Holothuria edulis	+	+
Holothuria (Stauropora) fuscocinerea	+	-
Bohadschia similis	+	-
Bohadschia marmorata	+	-
Synapta maculata	+	+
Bohadschia vitiensis	+	+
Stichopus herrmannii	+	-
Stichopus horrens	+	-
Stichopus vastus	+	-
Holothuria leucospilota	-	+
Actinopyga miliaris	-	+

Note**: (+) =** Found, (-) = Not found

Diversity (H'), Evenness (J), and Dominance (D)

Kelapa Dua Island and Panjang Kecil Island have different Ecological Indices, seen in Tables 5 and 6. Kelapa Dua Island has the highest diversity index found at (station 4) with a value range of (2.01), and the lowest value is found at (station 3) with a range of (1.81), this value shows a moderate value with the provisions of the limit value of diversity which is worth 1<H´<3 (Muzaki et al. 2019). The Evenness Index on Kelapa Dua Island is classified as high where the highest value is only (0.94) which is found at (station 4), and the lowest value is (0.88) at (station 1), classified as moderate. Based on the state of the environment, the dominance index on Kelapa Dua Island is low because it is below 0<C≤0.5, where the lowest value is at station 4 with a value of 0.14, and the lowest value is at station 3 0.18.

The ecological index value for sea cucumbers in the waters of Kelapa Dua Island shows a 10 species of sea cucumbers have been obtained including, *Holothuria atra, Holothuria edulis, Holothuria (Stauropora) fuscocinerea, Bohadschia similis, Bohadschia marmorata, Synapta maculata, Bohadschia vitiensis, Stichopus herrmannii, Stichopus horrens, Stichopus vastus*. Based on these results in accordance with the statement (Sulardiono and Hendrarto 2014) that sea cucumbers tend to have a preference for choosing the type of macro habitat. Panjang Kecil Island has fine sandy waters and tends to be rocky around its area, and has seagrass beds around the waters of Panjang Kecil Island, the value of the Index of small long island is low, seen from the highest diversity value is found (station 1) of (1.49) which is still classified as moderate because it is above 1, and less than 3, and the lowest value is found at (station 4) worth (0.42). Evenness of species on Panjang Kecil Island has the highest value (0.93) found at (station 1) with a high evenness value above 0.6.

Sea cucumber density of each species can be seen in Figures 3 and 4. The *H. atra* sea cucumber species was found in all sampling stations on Kelapa Dua Island. The highest density of *H. atra* sea cucumbers was recorded at stations 1 and 3, with a density value of 0.13 individuals per square meter. The lowest density value of *H. atra* was recorded at station 2, with a density of 0.02 individuals per square meter. Teripang *H. edulis* and *H. fuscocinerea* were found in all observation stations in Kelapa Dua Island. The highest density of *H. edulis* was recorded in station 2 with a density value of 0.07 ind/m^2, while the lowest density was recorded in station 3 with a value of 0.03 ind/m2. The highest density of *H. fuscocinerea* was found in station 3 with a density value of 0.13 ind/m^2, while the lowest density was found in station 1 with a value of 0.02 ind/m^2.

Table 5. Water quality of Kelapa Dua Island and Panjang Kecil Island, Kepulauan Seribu National Park, Jakarta, Indonesia

Name of island	Station	Salinity (‰)	Temperature (°C)	pH	DO (mg/L)
Kelapa Dua	ST 1	28-29.99	28-29	7.8-8	4.44-4.51
	ST 2	27-29	28-29	7.8-8	4.54-5.12
	ST 3	29-30	29-30	7.8-8.14	4.44-5.12
	ST 4	29-30	28-29	8.14-8.68	5.12-5.21
Panjang Kecil	ST 1	27-28	28.7-28.12	7.55-7.89	5.11-5.31
	ST 2	28-29	28-29	7.66-8	5-5.01
	ST 3	27-29	27-29	7.89-8	5.02-5.21
	ST 4	28-29	28-29	7.78-8	5.11-5.14

Table 6. Ecological index of sea cucumbers in Kelapa Dua Island and Panjang Kecil Island, Kepulauan Seribu National Park, Jakarta, Indonesia

Name of Island	Station	H'	J	D
Kelapa Dua	ST 1	1.94 (Moderate)	0.88 (High)	0.17 (Low)
	ST 2	1.95 (Moderate)	0.94 (High)	0.16 (Low)
	ST 3	1.81 (Moderate)	0.93 (High)	**0.18 (Low)**
	ST 4	**2.01 (Moderate)**	**0.96 (High)**	0.14 (Low)
Panjang Kecil	ST 1	**1.49 (Moderate**)	**0.93 (High)**	0.25 (Low)
	ST 2	0.84 (Moderate)	0.51 (Moderate)	0.63 (Moderate)
	ST 3	0.84 (Moderate)	0.60 (High)	0.62 (Moderate)
	ST 4	0.42 (Moderate)	0.30 (Low)	**0.85 (High)**

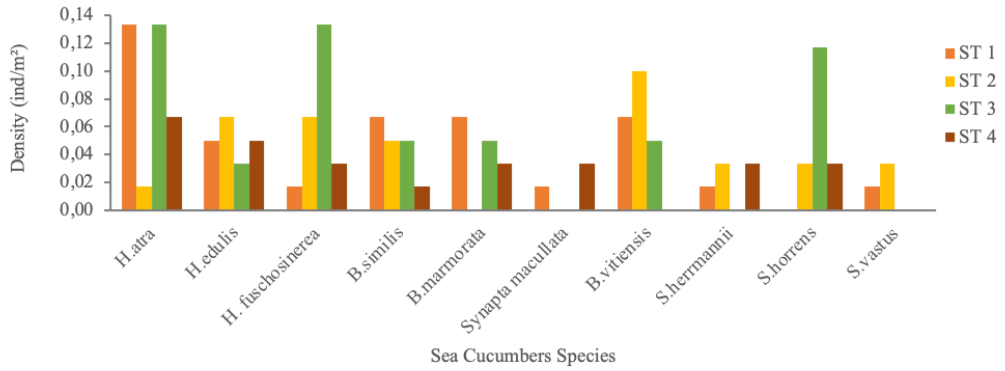

Figure 3. Density of sea cucumbers species in the waters of Kelapa Dua Island, Kepulauan Seribu National Park, Jakarta, Indonesia

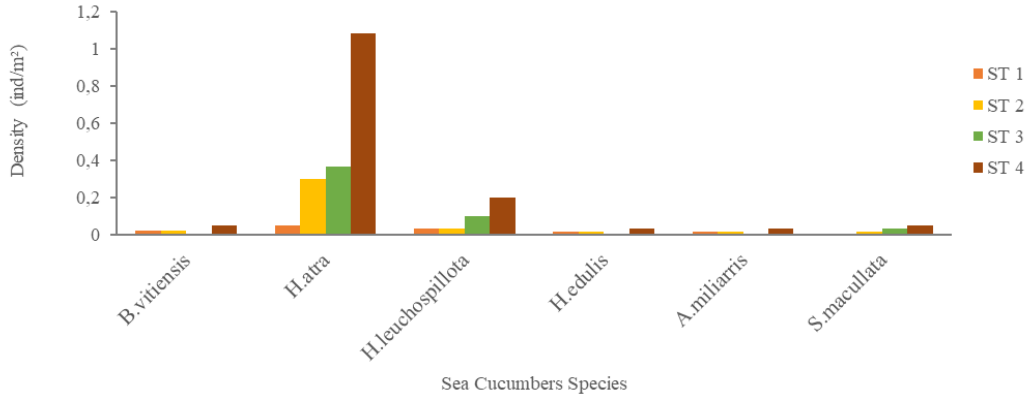

Figure 4. Density of sea cucumbers species in the waters of Panjang Kecil Island, Kepulauan Seribu National Park, Jakarta, Indonesia

The highest density of *B. similis* was recorded at station 1 with a density of 0.07 ind/m^2, while the lowest density was found at station 4 with a density of 0.02 ind/m^2. *B. marmorata* was found at stations 1, 3, and 4, with the highest density of 0.07 ind/m^2 and the lowest density of 0.03 ind/m^2 both recorded at station 4. The *Synapta maculata* sea cucumber species was only found at stations 1 and 4, with the highest density value recorded at station 4 (0.03 ind/m^2). *Bohadschia vitiensis* was found at stations 1, 2, and 3, with the highest density value recorded at station 2 (0.10 ind/m^2) and the lowest density value recorded at station 3 (0.05 ind/m^2). *Stichopus herrmanni* was found at stations 1, 2, and 4, with the highest density values at stations 2 and 4, at 0.30 ind/m^2. S. horrens was found at stations 2, 3, and 4, with the highest density value at station 3, at 0.12 ind/m^2. S. vastus was only found at stations 1 and 2, with the highest density value at station 2, at 0.03 ind/m^2.

Sampling of sea cucumbers in their natural habitat on Panjang Kecil Island yielded six species. The research results indicate that species *B. vitiensis* was found at stations 1, 2, and 4, with the highest density at station 4 (0.05 ind/m^2) and the lowest at stations 1 and 2, with a density of 0.02 ind/m^2. Teripang *H. atra* has the highest density value compared to all species of sea cucumbers found in Panjang Kecil Island, with a density value of 1.08 ind/m^2. *H. leucospilota* was found in all observation stations with the highest density value at station 4, which was 0.20 ind/m^2, and the lowest value was found at stations 1 and 2, which were 0.03 ind/m^2. *H.edulis* was only found at stations 1, 2, and 4, with the highest density value of 0.03 ind/m^2 at station 4. *S.maculata* was found at stations 2, 3, and 4, with the highest value of 0.03 ind/m^2 at station 4.

Spatial distribution of sea cucumber density and type of habitat

Sea cucumber density and habitat characteristics on Kelapa Dua Island can be seen in Figures 5 and 6. Sea cucumber density and habitat characteristics on Panjang Kecil Island can be seen in Figures 7 and 8.

There are 10 different types of sea cucumbers found on Pulau Kelapa Dua, with varying densities. The highest density was found in the H. Atra species, located at stations 2 and 4, while the lowest density was found in the Stichopus vastus species. At stations 1 and 2, there are fish and shrimp ponds that often use sea cucumbers as deposit feeders. The biota that live within the substrate are also affected. Teripang plays various roles in its association with other biota. It acts as a deposit feeder that processes the substrate of the water where other fishery resources

live, which are then used as a source of food in the form of larvae, eggs, and juveniles for other marine organisms (Purcell et al. 2009; Purcell et al. 2016).

The absence of regulations regarding the limitation of harvesting has allowed sea cucumbers in the Kepulauan Seribu National Park area to be freely harvested and utilized both economically and ecologically. The overall density of sea cucumbers on Kelapa Dua Island was highest at station 3 with a density value of 0.57 (ind/m^2), and lowest at station 4 with a value of 0.30 (ind/m^2). Incontrast to Kelapa Dua Island, Pulau Panjang Kecil is a small island located in the management section of National Park Region 1. The density of sea cucumbers on Pulau Panjang Kecil is also influenced by its ecological conditions, as sea cucumbers prefer seagrass and coral reefs as their habitat.

The preference of sea cucumbers for a certain coral cover in a coral reef ecosystem is believed to be related to the natural food prepared by each type of substrate in the ecosystem. Living (biotic) and non-living (abiotic) substrates are clearly different, and this phenomenon will cause differences in the distribution and density of sea cucumbers (Sulardiono and Hendrarto 2014). This island is one of the destinations for fishermen in search of sea cucumbers. The overall density graph and individual density/table show that Pulau Panjang Kecil has a density value that tends to be uneven compared to Pulau Kelapa Dua. The current conditions are stronger compared to Pulau Kelapa Dua, making it difficult to find a stable sampling station. The overall density graph and individual density/table show that Pulau Panjang Kecil has a density value that tends to be uneven compared to Pulau Kelapa Dua. The highest individual density on Pulau Panjang Kecil is the same as on Pulau Kelapa Dua. The research shows that the highest density is found in the individual species of sea cucumber (*H. Atra*) at (station 3) with a value of (0.50 ind/m^2). The lowest individual density values are found in two species of sea cucumber, namely (*H. edulis* and *Actinopyga miliaris*). The density of sea cucumbers in the Thousand Islands National Park is declining due to uncontrolled and unrestricted fishing by fishermen and the local community.

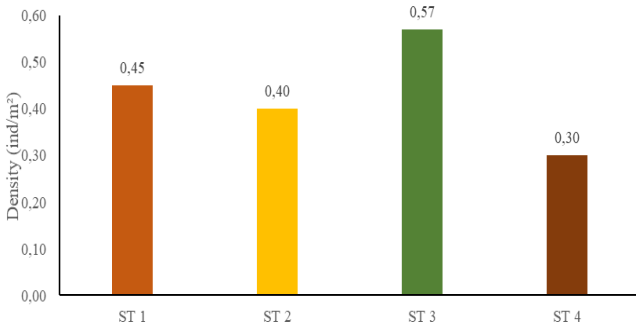

Figure 5. Observation station density of Kelapa Dua Island, Kepulauan Seribu National Park, Jakarta, Indonesia

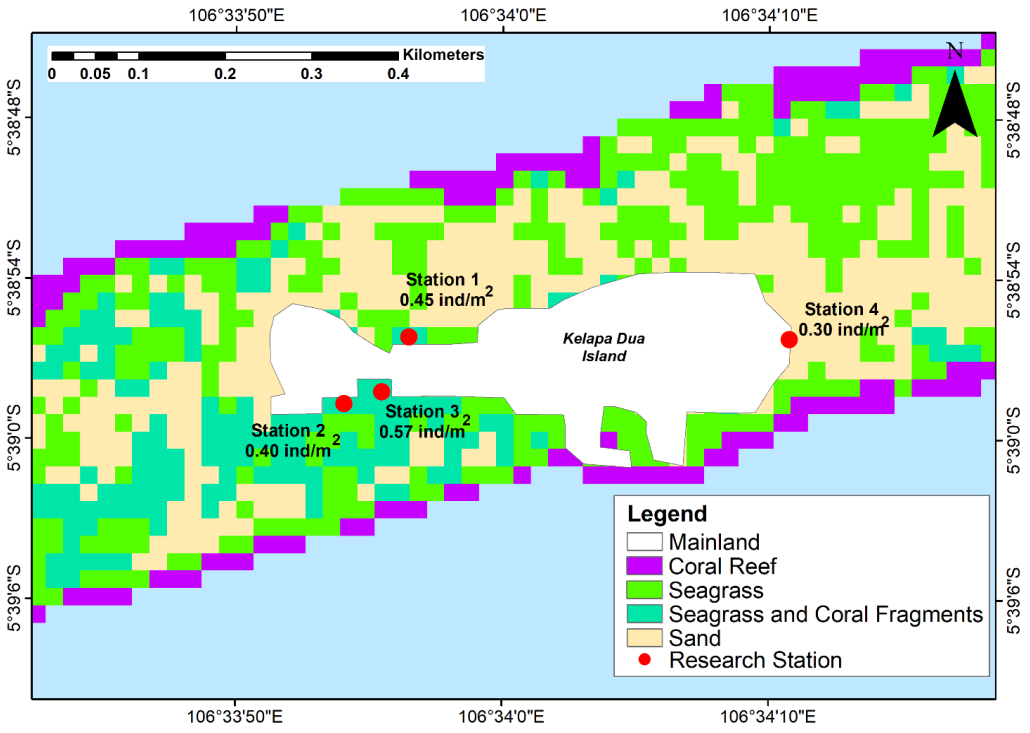

Figure 6. Spatial map of sea cucumber density based on habitat in Kelapa Dua Island, Kepulauan Seribu National Park, Jakarta, Indonesia

The decline in commercially valuable species is caused by various factors. Therefore, their abundance is easily found compared to other species with high economic value. The black sea cucumber (*Holothuria atra*) is the most abundant species found in Pulau Kelapa Dua and Pulau Panjang Kecil. This is due to the low commercial value of black sea cucumbers, which are rarely harvested by fishermen and the community. According to (Sosiawan and Mustalafin 2022), the sea cucumber resources in Pulau Kelapa Dua and Pulau Panjang Kecil in 2019 were found to have more sea cucumber species compared to the study conducted in 2023. The community of Taman Nasional Kepulauan Seribu searched for sea cucumbers every day, with a specific time ratio, during the evening. Because they believe that sea cucumbers are more easily found at night, this is supported by research that shows sea cucumbers are nocturnal animals (Purcell et al. 2023). Although sea cucumbers can also be found during the day, the percentage is small and they tend to be difficult to find because they hide in coral reef ecosystems (Purcell et al. 2023) according to (Gray et al. 2023). Many fishermen prefer to catch sea cucumbers with high economic value. The high economic value of sea cucumbers has led to an increase in their capture, and it is feared that this will lead to a consistent decline in their availability over time.

Substrate types and aquatic ecological associations also affect the survival rate of sea cucumbers (Harahap et al. 2022). Kelapa Dua Island found 3 types of seagrasses, namely, *Cymodocea rotundata*, *Thalassia hemprichii*, *Halophila ovalis*, it can be said that seagrass cover on Kelapa Dua island is quite good, so it becomes a place to live other biota, especially sea cucumbers (Nazihah et al. 2022). According to researchers, sea cucumbers like clear and clean waters with a salinity of 30-33‰, bottom waters that have a fine texture and are associated with protective plants, where these conditions can protect them from the waves of the sea, sometimes their lives are surrounded by algae and detritus.

The results showed that the habitat of sea cucumbers on Kelapa Dua island has a habitat or place of life that most of the area is filled with fine sand with seagrass beds, sea cucumbers are coral reef ecosystems (Elfidasari et al. 2012). Sediment types, environmental stability factors, food chains, competition between organisms can also be factors that affect species diversity. Kelapa Dua Island has a variety of substrate types, at station 1 most of the substrate is sandy, with occasional coral fragments and seagrass beds that are quite extensive in the island waters.

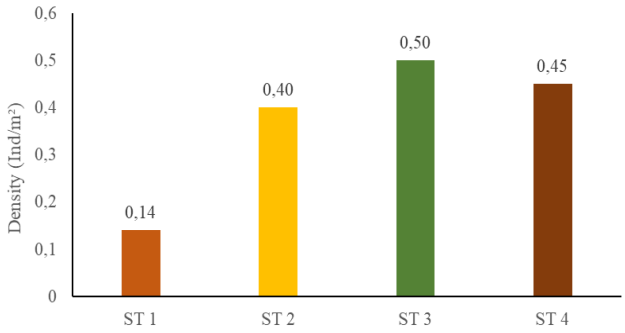

Figure 7. Observation station density of Panjang Kecil Island, Kepulauan Seribu National Park, Jakarta, Indonesia

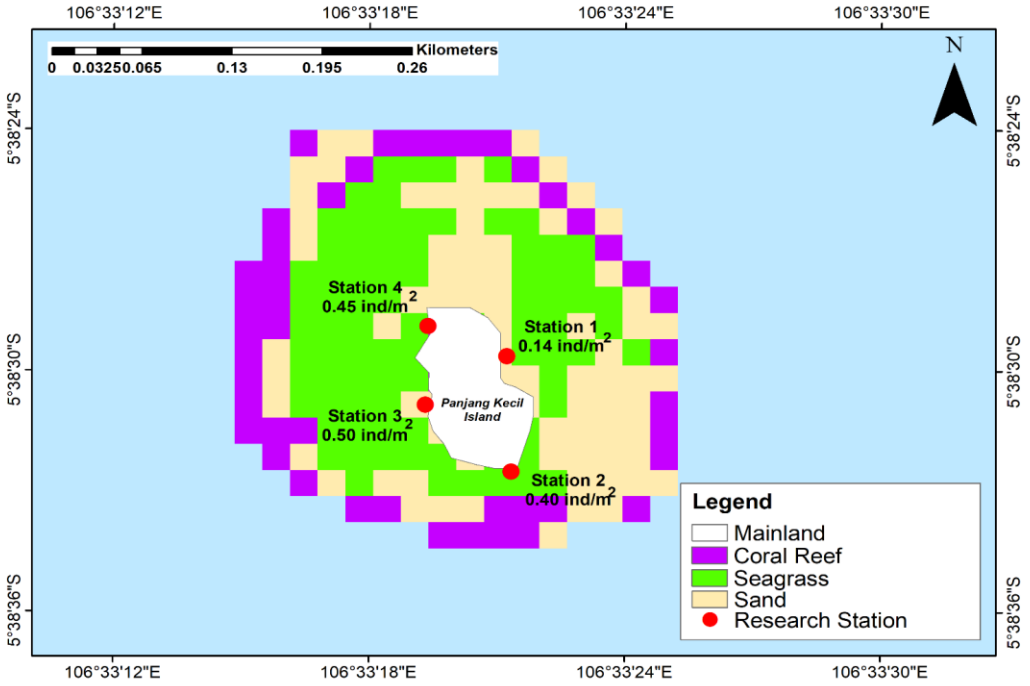

Figure 8. Spatial map of sea cucumber density based on habitat in Panjang Kecil Island, Kepulauan Seribu National Park, Jakarta, Indonesia

Panjang Kecil Island also has seagrass ecosystems that function as a support for coastal waters that are greatly affected by processes that occur at sea and on land. Many organisms are ecologically and biologically very influenced and dependent on the existence of seagrass ecosystems. The function of seagrass ecosystems in coastal areas works as a primary producer and serves as a stabilizer of the seabed as a biota habitat (as a spawning ground, nurturing and foraging for marine biota, can protect a beach from erosion because it can absorb waves and trap sediment, from erosion because it functions as a wave absorber and traps sediment. Sea cucumbers in the location are dominated by *H. atra* and *H. edulis*, tending not to be diverse, because the sea cucumber in the location is dominated by *H. atra*.

According to local fishermen, other types of sea cucumbers such as the genus Stichopus which have high commercial value in this location, are sought after and hunted by local and outside communities, which are caught on a large scale, the surrounding community believes that uninhabited islands tend to have more fishery resources, without regard to their ecological conditions, this happens because of the lack of knowledge and human resources that tend to be still low, While in fact the location of residential islands that have better seagrass beds and cover has abundant availability in it, but this can also be threatened because based on the results of the national seminar (Sosiawan and Mustalafin 2022) explained a significant difference with the results of the current study, where the ratio of the number of species found and the total number of sea cucumbers found is decreasing from year to year.

In conclusion, the results of research has been carried out, there are 12 species of sea cucumbers found in Kelapa Dua Island and Panjang Kecil Island. The sea cucumbers found on Kelapa Dua Island are, *Synapta maculata*, *Stichopus horrens*, *H. leucospilota*, *Bohadschia marmorata*, *H. edulis*, *Stichopus herrmanni*, *H. atra, H. (Stauropora) fuscocinerea, Actinopyga miliaris, Stichopus vastus*, *Bohadschia similis*, *Bohadschia vitiensis.* The results of this study indicate that the ecological index of sea cucumbers especially in terms of density on Kelapa Dua Island is worth (0.57 ind/m^2) at station 3 with the highest category among stations 1, 2, and 4 on Kelapa Dua Island. Panjang Kecil Island has the highest density value found at (station 3) with a density value of (0,50 ind/m^2). The ecological index on Kelapa Dua Island and Small Long Island has an average value of low and medium diversity, while the value of the evenness index is high on Small Long Island, the evenness index is high because it is dominated by the type of sea cucumber that is rarely caught for sale, namely the type (*H. atra*), so that its availability in nature is still very easy to find. Spatial data shows a picture of a location that is still quite good for sea cucumber habitat, with water quality values still in accordance with quality standards, except at locations that have been contaminated with household waste such as one of the stations on Kelapa Dua Island, which has been contaminated so that it causes the pH value to rise, and is less optimal for sea cucumber growth, although some species can still be found at the station, such as the example of sea cucumber genus *Bohadschia similis*. The results showed a decrease in sea cucumber community structure in Kelapa Dua Island and Panjang Kecil Island, from previous studies, which can be said, the need for management and supervision of fishermen and communities who play a role in the utilization process, which does not yet have special regulations in the Kepulauan Seribu National Park Waters. The community needs socialization related to information about the cultivation and management of sea cucumbers to support the sustainability and availability in nature, so that a balanced resource production and utilization can be created.

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