The Diversity and Abundance of Sea Cucumbers in the Batam Waters, Riau Islands

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Abstract

The exploitation of sea cucumbers in Indonesia has reportedly increased by 66% in the last two decades. This figure is considered the upper limit for sustainable exploitation. The waters of Batam, Riau Islands, are known as one of the sea cucumber producers. However, no current status report exists on the diversity and abundance of sea cucumbers in Batam waters. This study aimed to determine the species diversity and abundance of sea cucumbers in Batam Waters. Sampling was carried out quantitatively in August 2023 using the quadratic transect method at three locations: Abang Island, Ngenang, and Temoyong waters. About three transect lines were placed at each station, drawn perpendicular from the coastline towards the sea with a length of 50 m. The distance between transect lines was 50 m, and a 5x5 m plot was placed at each. Sampling was carried out to a depth of up to 1 m, on a substrate ranging from sand to muddy sand. The results showed that there were six types of sea cucumbers, namely *Stichopus nactivagus, Stichopus hermanni, Stichopus monotuberculatus, Holothuria scabra, Holothuria impatiens,* and *Holothuria leucospila*. Species diversity across three locations ranged from 0.214 to 0.314. The abundance of species on Abang, Ngenang, and Temoyong Islands ranged from 0.073 to 0.100 individuals/m^2. The low diversity and abundance indicate high environmental pressure from anthropogenic activities on sea cucumber populations in Batam, Riau Islands.

Keywords: gamat, *Holothuria sp, Stichopus sp*

INTRODUCTION

Batam is the largest city located in the Kepulauan Riau Province. It consists of several large islands, namely Batam, Rempang, and Galang, as well as other smaller islands in the Singapore and Malacca Straits. Some of these small islands include Abang Island in the south, Temoyong Island in the southwest, and Ngenang Island in the north. As an archipelago, Batam waters are rich in marine biodiversity, including sea cucumbers.

Sea cucumbers are one of the most significant marine invertebrate resources, providing livelihoods and income for many coastal communities throughout the Indo-Pacific region (Asha and Muthiah, 2008), including in the waters around Batam. In general, sea cucumbers are mainly collected for export as a dried product known as *beached-mer*, a delicacy in most Asian countries. High demand and increasing market value drive intensive exploitation of this resource (Purcell *et al*., 2013).

Sea cucumbers are scattered throughout the sea, from the West to the East of Indonesia, and from shallow areas to the deep sea. The distribution also cuts across the sea, such as coral habitats, seagrass beds, rocky, sandy-muddy habitats, and sandy plains (Setyastuti *et al*., 2019; Wirawati *et al*., 2021).

The characteristic properties include an elongated, soft body. At one end of the body, sea cucumbers have organs mostly elongated and

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flexible (tentacles) around the mouth, which serve to catch prey. Movement is usually performed by pseudo-feet to form a tube (podia) on the side of the abdomen (ventral). Most species are suspension or deposit feeders, feeding mainly on sediment and organic matter, which is then excreted (Atkinson and Sink, 2018).

Sea cucumbers are benthic invertebrates that feed on marine sediments, such as microorganisms, dirt, and detritus, leading to a recycling role in coastal marine ecosystems (Kalthoumi *et al*., 2023). Furthermore, sea cucumbers live in shallow waters, usually less than 20 m deep, in protected areas with high nutrient content, and can adapt to various habitats, including muddy, sandy, rocky, coral, seagrass beds, and areas with algal growth. At low tide, this species comes out in a half-submerged position (Manuputty and Noya, 2019).

Apart from the ecological function, sea cucumbers are also used for consumption and medicine. Around 56 species have been consumed in Indonesia and traded in dried or frozen form. Based on data from the Indonesian Institute of Sciences (LIPI), all belong to *the Aspidochirotida (Holothuroidea)* order. However, Indonesian waters have more than 400 species of sea cucumbers. Other orders include *Dendrochirotida, Apodida*, *Molpadida, Dactylochirotida, and Elasipodida*. In addition, sea cucumbers have been used as medicine for a long time. Traditional medicine is regarded as a tonic used to treat damage to the kidneys, reproductive organs, and digestive tract (Setyastuti *et al*., 2019).

Studies have shown that Indonesian sea cucumbers, such as *Stichopus, T. ananas, T. canax, H. fuscogilva, H. leucospilota, H. atra, H. scabra,* and *A. Mauritiana*, are edible, possess medicinal effects, and exhibit low toxicity (Elfidasari *et al*., 2012). They also provide animal protein with a dry weight of 43% and are classified as highly nutritious (Elfidasari *et al*., 2012). Nearly 80% of the collagen in sea cucumbers can promote cell regeneration for ulcer healing (Pangestuti and Arifin, 2018) and serve as a wound-healing and anti-inflammatory agent (Gianto *et al*., 2018). Additionally, their secondary metabolites are reported to reduce free radicals and may help prevent degenerative diseases (Avigail *et al*., 2019).

The numerous benefits of sea cucumbers have driven increased market demand, particularly in the pharmaceutical industry. This activity directly reduces species diversity in coastal waters. This fishery commodity is also not managed well due to very limited local policies, raising concerns over sustainability (Brown *et al*., 2010). Currently, not only are economically valuable species caught, but also cheap species, which were not initially a concern. This underscores the need for conservation efforts to reduce excessive fishing.

Studies on the community and abundance of sea cucumbers mainly focus on eastern Indonesia (Papua, Maluku, and Makassar) (Setyastuti, 2016; Pattinasarany & Manuputty, 2018; Manuputty & Noya, 2019; Luhulima *et al*., 2020; Silaban *et al*., 2022) and Java (Karimunjawa, Jepara, and Seribu Island) (Elfidasari *et al., 2012;* Ristina *et al.*, 2018; Avigail *et al*., 2019). Meanwhile, studies conducted over the last five years in Western Indonesia are limited. Several studies related to the ecological status of sea cucumbers in this area were reported by Armi *et al.* (2022) and Marni *et al.* ((2020) for Pesisir Laut waters, Aceh, and Bintan waters, Riau Island provinces, respectively. The types, abundance, and diversity of sea cucumbers in Batam waters have never been reported. Therefore, this study aimed to determine the species diversity and abundance of sea cucumbers in the Batam waters, represented by three locations: Abang, Temoyong, and Ngenang islands. The results will provide baseline data on the current status of sea cucumbers in the intertidal zone of Batam waters, including species, diversity, and abundance. It can also be used as a basis for information on water management and the potential of sea cucumbers in the pharmaceutical industry.

MATERIALS AND METHOD

This study was carried out in August 2023. The locations were randomly selected in the intertidal waters of Abang (0º31’2.37” N; 104º15’4.68” E), Ngenang (0º58’59.28” N; 104º12’9.76” E), and Temoyong Island (0º53’53.30” N; 104º0’13.24” E), Batam City. The sampling location is shown in Figure 1.

This study was conducted quantitatively using the quadratic transect method at predetermined locations. Three transect lines were placed, each drawn perpendicularly from the coastline towards the sea with a length of 50 meters, referring to Ndun *et al*. (2021) with modification. The distance between transect lines was 50 meters, and on each line, a 5 x 5 meter plot was placed. Observations were made at the lowest low tide or before low tide. In each transect plot

(plot), a census of individual sea cucumbers was carried out and then collected. One individual from each species was collected, preserved in 70% formalin, and sent to the laboratory for identification. The water condition data collected directly (in situ) from the field includes physico-chemical parameters, namely water temperature, salinity, degree of acidity (pH), and dissolved oxygen (DO).

Morphological observations were carried out traditionally. According to Kalthoumi *et al*. (2023), the conventional method involved observing size, color, and shape. Determination of the species was carried out with the guidance of the General Guideline for Identification of Sea Cucumber Populations, Directorate of Conservation and Marine Biodiversity, Directorate General of Marine Spatial Management, Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia (Sadili *et al*., 2015) and (Setyastuti *et al*., 2019). The abundance of species was calculated using the Odum formula (Ulum *et al.*, 2012):

$$D_i = \frac{n_i}{A}$$

Note: Di = species abundance; ni = total number of individuals of type i; A = total area of sampling area

The diversity of sea cucumber species at each station was determined using the Shannon-Wiener diversity index formula (Ristina *et al.,* 2018) with the equation:

$$H' = -\sum_{ni=1}^{s} P_i \, lnP_i$$

Note: H' = Shannon-Wienner diversity index; Pi = ni/N (Proportion of type–i); ni = total number of individuals of type i; N = total number of individuals of all types

The criteria for the level of species diversity are as follows (Ristina *et al*. 2018; Ramses *et al.*, 2020): H' > 3.0, shows very high diversity; ≤ H' ≤ 3.0, shows moderate diversity; H'< 1.0 shows low diversity

RESULT AND DISCUSSION

Six species were obtained from two different genera, and the collected samples are shown in Table 1. These species include *S. nactivagus*, locally known as gamat, *S. hermanni* (gamat batu), *S. monotuberculatus* (mentonan), *H. scabra* (nabi-nabi), *H. impatiens* (kulong), and *H. leucospila* (butoh keling). Purcell *et al.* (2012) stated that from a morphological point of view, comprising the color and shape of bodies, *Holothuria* species are almost similar and vary according to the environment. Visible differences are evident directly from the shape, color, and pattern.

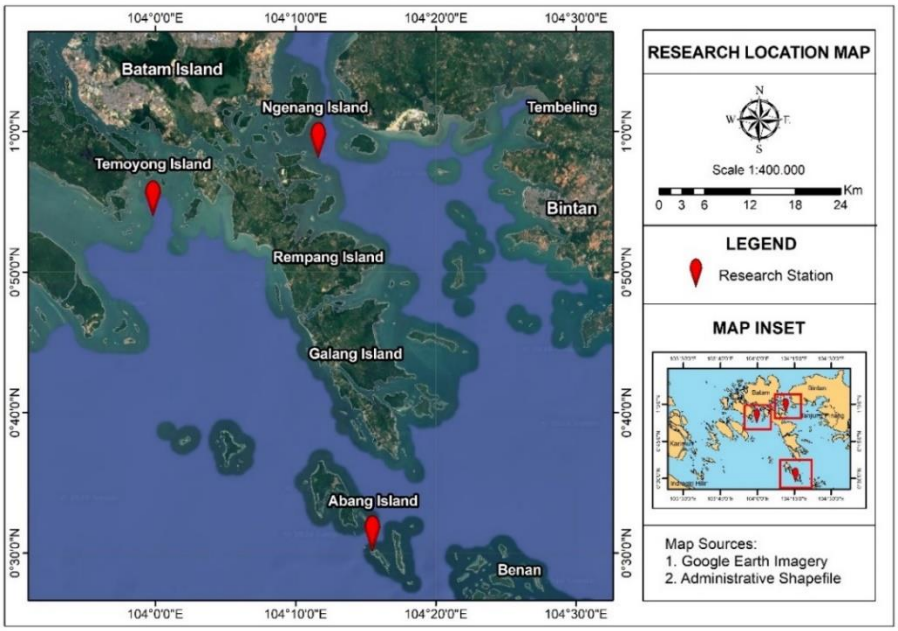

Figure 1. Sampling location of sea cucumbers in the Abang, Ngenang, and Temoyong Islands, Indonesia

The sea cucumbers found at the sampling location belong to two families, i.e, *Stichopodidae* and *Holothuriidae*. The *Stichopodidae* family has a rectangular or trapezoidal body shape, a surface with prominent papillae and tube feet, gonads with two tube-like branches, no Cuverian organs, and numerous stem-shaped, C-shaped, and S-shaped spicules (Hartati *et al*., 2021; Wirawati and Purwati, 2016). Meanwhile, the *Holothuriidae* family has a basic, elongated, round body shape with a flat ventral surface. The body surface is generally covered with papillae, has a single tube-like gonad, and button-shaped ossicles (Akashah *et al*., 2021).

S. noctivagus, also known as gamat, has a rectangular body shape, hard, stiff, and flat on the stomach. Woo *et al*. (2015) reported that the body is rectangular in cross-section with four distinct sides, smooth, firm, and hard, showing a thick integument. It is dark blue underwater and almost black outside. Large, long papillae on the dorsolateral edge extend from the tentacle collar towards the anus in two rows. There are similar papillae on the ventrolateral edge, but in one row. The tip of the papilla is yellow to ocher. Tube feet and small interambulacra are present, while the central ambulacrum is wider than the others. On the ventral side of the mouth, there are 20 peltate tentacles and an anus. Spicules are present with dorsal body walls, with tables, C-shaped, and S-shaped rods.

S.hermanni is locally known as gamat batu. The body color ranges from light mustard-yellow to orangey-brown, brown, or olive green. Furthermore, the color is lighter ventrally, with numerous dark brown to black dots spread across the body. Two double rows of bigger wart-like papillae are flanked by fine dark rings. Podia are abundant ventrally. The body is a bit elongated and squarish in cross-section. The ventral mouth has 8-16 thick green tentacles, while the anus is a terminal condition in which there are no teeth or surrounding papillae (Purcell *et al*., 2012). According to Woo *et al.* (2015), *S. herrmanni* papillae are significantly smaller and less prominent than *S. monotuberculatus*. The size and number of rosette spicules in *S. herrmanni* varied greatly. It can be distinguished from other congeners by the presence of pseudo-tables in the dorsal body.

H. scabra, locally known as nabi-nabi, has a long, round body cross-section. The ventral side tends to be flat, and the anus hole is round. The body color is greenish-white. Murphy *et al.* (2010) state that the shape is elongated and cylindrical along the oral–aboral axis. The mouth and anus are opposite at the ends of the axis. Specifically, the mouth is anterior, while the anus is posterior. Around the mouth, some tentacles can be extended and retracted quickly. Tentacles are modified tube feet that function to capture food. Some studies reported that sand sea cucumbers have a maximum length of 40 cm and weigh about 1500-2000 grams (Manuputty, 2019). Furthermore, *H. scabra* is found in areas with coarse sand substrate; the body is often covered with fine sand. This species is the most common black sea cucumber in Indonesian intertidal waters (Setyastuti, 2016).

H. leucospilota, locally known as butoh keling, is usually found in sandy areas of coral reefs. This species is tolerant of prolonged exposure to air and may be found near the coast. Harith *et al.* (2018) stated that morphologically, *H. leucospilota* has a uniform black body color. It has a soft body and smooth protrusions. This species has shield-shaped tentacles. *H. impatiens* (kulong) has a round body cross-section, the ventral side tends to be flat, and the anus is round. The body is greyish-brown, soft, and thin. The types of spicules found on the dorsal side are table and button, according to Kalthoumi *et al.* (2023). Furthermore, *H. impatiens* has dark transverse stripes in varying shades of brown. Small samples may reach 5.7 cm in length, with a cylindrical, vermiform body, thin integument, a soft body wall, and white to yellowish papillae.

Abundance describes the number of species per unit area of observation. Table 2 shows the abundance of sea cucumbers found at each location in Abang, Ngenang, and Temoyong Island waters. Based on Table 2, the abundance of sea cucumbers ranges from 0.003 ind/m^2 to 0.09 ind/m^2. The highest abundance was found on Abang Island, namely *H. leucospilota*, at 0.09 ind/m^2. This species was found in a seagrass zone with a muddy sand substrate and fertile corals. Purcell *et al.* (2012) stated that the suitable habitat for *H. leucospilota* is rich seagrass beds, muddy sand substrate with coral debris, and rock crevices with algae suitable habitat for this species. The abundance of this species on Abang Island can be related to its low economic value. Cañada *et al.* (2020) state that this condition may have prevented the species from fishing pressure, thereby allowing breeding in the area.

The second highest abundance was *S. noctivagus*, with 0.050 ind/m^2 on Ngenang Island and 0.053 ind/m^2 on Temoyong Island. This species has been used in a traditional medicinal ointment product known locally as 'gamat oil'. Furthermore, the species with the lowest abundance were *H. scabra* and *H. impatiens*. Both types have low abundances due to the relatively high price and inclusion in the main category (Silaban *et al*., 2022). Considering this species is caught widely, only a few were found at the sampling location. The abundance of sea cucumbers in the Batam Sea varied from 30-900 ind/ha. This figure is higher than Tanjung Keramat, Bintan waters, which range from 4-46 ind/ha (Marni *et al*., 2020); Ambon, Maluku waters, at 10-55 ind/ha (Luhulima *et al.*, 2020); and Tanjung Benoa, Bali waters, at 34-104 ind/ha (Suryaningsih *et al.*, 2020).

The diversity index of sea cucumbers found in three sampling locations is shown in Table 3. Overall, the diversity index of sea cucumbers at all locations is in the low category with a value of (H') < 1. This result is similar to those of Marni *et al*. (2020) and Suryaningsih *et al.* (2020) for Tanjung Keramat and Tanjung Benoa waters with diversity index ranges of 0.500 - 0.550 and 0.140 - 0.370, respectively. Furthermore, these three locations have lower values compared to the West Simeulue water, as reported by Armi *et al.* (2022), with a diversity index range of 1.890 – 2.023.

The diversity index can be influenced by various factors, including the number of species collected, the presence of many species found in abundance, substrate homogeneity, and ecological conditions (Sukmiwati *et al*., 2012). The low diversity index at all sampling locations may be related to the condition of the waters that connect

Table 1. Six species of sea cucumbers were found at sampling locations

Samples	Latin name	Local name	Number of samples found		
			Abang island	Ngenang island	Temoyong island
	*Stichopus nactivagus*	Gamat	-	15	16
	*Stichopus hermanni*	Gamat batu	3	-	-
	*Stichopus monotuber-culatus*	Mentonan	-	1	1
	*Holothuria scabra*	Nabi-nabi	-	3	7
	*Holothuria leucospilota*	Butoh keling	27	1	4
	*Holothuria impatiens*	Kulong	-	1	-

directly to the open sea. Therefore, waters are directly associated with coral reefs and have a coarse sand substrate due to the presence of several dead coral fragments.

As stated by Ramses *et al*. (2020) Low diversity can also indicate extreme environmental pressure from anthropogenic activities such as poaching, reclamation, transportation, shipyard activities, and domestic activities that generate pollutants. Some pollutants in Batam waters include organic waste, heavy metals (Amelia *et al*., 2019; Ismarti, 2024) oil spills, and oil sludge from transportation and shipyard activities (Cantika, 2020; Arviana, *et al*., 2025).

Water quality affects survival and can be a limiting factor in the distribution of marine biota (Hamuna *et al.*, 2018; Tanjung *et al*., 2019). The physicochemical parameters of water measured in this study included DO, temperature, salinity, and pH. The data is shown in Table 4.

Water temperature is a very important factor in the life of marine organisms. The temperature at all locations was the same, namely 31°C, which is the appropriate value for sea cucumbers (Mazlan and Hashim, 2015). According to Sulardiono *et al*. (2017) The water temperature for sea cucumbers ranges from 26 °C to 33 °C. The Minister of Environment Decree No. 51, 2004, also states that the optimal temperature range for marine life is 28-32°C. Elfidasari *et al.* (2012) stated that sea cucumbers can survive at temperatures of 25-35 °C. Higher temperatures will cause the body to be inactive, even though the tentacles can still move.

Salinity is an important factor hindering the spread of sea cucumbers. Most species live in the normal seawater salinity range of 30–34‰, but some may survive up to 37‰ (Elfidasari *et al*., 2012; Sadili *et al*., 2015). Salinity is the concentration of dissolved salts in seawater and affects osmotic pressure. Low salinity levels will cause cell lysis, leading to death (Elfidasari *et al*., 2012). Abang, Ngenang, and Temoyong Island had salinities of 29.33, 30, and 31‰, respectively. Based on the results, the salinity is ideal for sea cucumbers to survive and grow optimally. Armi *et al.* (2022) stated that the ideal habitat for sea cucumbers is seawater with a 29-33% salinity.

Acidity is an indicator of water quality. It plays an essential role in the lives of aquatic organisms. Water quality is considered good when the pH>7. Meanwhile, the pH value is influenced by biological activity, photosynthesis, temperature, and oxygen content. Changes in pH may alter the balance of carbon dioxide, bicarbonate, and carbonate in water. The pH of the water at Abang, Ngenang, and Temoyong Island was 8.01, 6.30, and 7.29, respectively. The suitable pH for sea cucumbers ranges from 6.5 to 8.4 (Sulardiono *et al*., 2017).

Table 2. Species abundance of sea cucumbers

Species	Species abundance (individuals/m^2)		
	Abang island	Ngenang island	Temoyong island
S. noctivagus	0	0.050	0.053
S. hermanni	0.010	0.000	0.000
S. monotuberculatus	0	0.010	0.023
H. scabra	0	0.003	0.003
H. leucospilota	0.090	0.007	0.013
H. impatiens	0	0.003	0.000

Table 3. Diversity index of sea cucumbers

No	Sampling location	H'	Criteria
1	Abang island	0.263	Low diversity
2	Ngenang island	0.214	Low diversity
3	Temoyong island	0.314	Low diversity

Table 4. Physicochemical parameters of water in the sampling locations

Location	Temperature (°C)	Salinity (‰)	pH	DO (mg/l)
Abang Island	31.57±0.12	29.33±1.15	8.01±0.60	6.20±0.22
Ngenang Island	31.47±0.12	30.00±0.00	6.30±0.00	7.00±3.36
Temoyong Island	31.40±0.36	31.00±1.00	7.29±0.20	7.40±0.28

*The measurement was performed in triplicate

DO in water determines the level of water quality. Oxygen in water is required by living beings, or marine biota, for respiration and oxidation. Moreover, the presence of oxygen in marine waters functions as an oxidant for chemical compounds. The highest oxygen content originates from free air and phytoplankton or green plants containing chlorophyll (Sukmiwati *et al.*, 2012). The DO values at the study location were 6.20, 7.00, and 7.40 for Abang, Ngenang, and Temoyong islands, respectively. These values are in the optimum range for the life of sea cucumbers (4-8 ppm), as stated by Elfidasari *et al.* (2012). According to Sulardiono *et al.* (2017) The tolerant DO levels for sea cucumber growth range from 4 to 9 ppm. This implies that DO in waters is available in sufficient quantities for the respiration and metabolism of sea cucumbers. Furthermore, the Minister of Environment No. 51 Decree of 2004 states that the optimal range of DO for sea biota is 5.30-7.67 mg/l. The physicochemical parameters indicated that the water quality on Abang, Ngenang, and Temoyong islands in Batam City was good for the growth and development of sea cucumbers.

CONCLUSION

Six sea cucumbers were found in three water locations: Abang, Ngenang, and Temoyong Islands. These include *S. noctivagus* (gamat), *S. hermanni* (gamat batu), *S. monotuberculatus* (mentonan), *H. scabra* (nabi-nabi), *H. impatiens* (kulong), and *H. leucospilota* (butoh keling), which belongs to the class *Holothuroidea*. Based on the results, *H. leucospilota* had the largest abundance on Abang Island, with 0.090 ind/m^2, followed by *S. noctivagus* with 0.050 ind/m^2. Species diversity across three locations ranged from 0.214 to 0.314. Overall, the diversity and abundance of sea cucumbers at the study locations were relatively low, which can be related to the extreme environmental pressure on Batam waters.

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