Ecological Study and Habitat Characteristics of Sea Cucumbers (Holothuroidea) in Kamal and Socah Waters, Bangkalan Regency, Madura, Indonesia

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Abstract. Sea cucumbers are economically valuable commodities in Bangkalan waters and play a crucial ecological role in marine ecosystems. Understanding their habitat characteristics and ecological health is essential for sustainable management and conservation. This study aims to assess the ecological health and habitat characteristics of sea cucumbers in Kamal and Socah waters of Bangkalan Regency, Madura, Indonesia. Sea cucumbers were collected using hand collection methods during low tide. Water quality and substrate conditions at the collection sites were evaluated to ensure suitability for sea cucumbers. The study identified four sea cucumber species: Phyllophorus sp., Phyllophorella spiculata, Acaudina leucoprocta, and Colochirus quadrangularis. Diversity indices were low (<1), with Kamal ranging from 0.2 to 0.86 and Socah from 0 to 0.87. Dominance values were medium to high (0.5-1), except in Socah area 5 where dominance was low (0.48). Phyllophorus sp. was the most dominant species, comprising 58% of the total biota in both locations. The low diversity and varying dominance of sea cucumber species are attributed to the sandy sediment and suitable water quality in both locations. These findings highlight the need for continued monitoring and management to ensure the sustainability of sea cucumber populations in Bangkalan waters.

1 Introduction

East Java is one of the regions with the largest sea cucumber production in Indonesia. Based on Indonesia Ministry of Maritime Affairs and Fisheries, sea cucumber production from East Java on 2021 reach 1439.2 tons (35%) from total Indonesia's sea cucumber production. Numerous sea cucumber species, including *Holothuria arta* [1], H. *impatiens*, *Stichopus horrens*, H. *hilla*, H. *leucospilota*, and H. *verrucosa* [2], *Paracaudina australis* [3], *Phyllophorus* sp. [4], *Stichopus variegatus* [5], *Colochirus quadrangularis*, and *Acaudina molpadiodes* [6], can be found in the waters off the coast of East Java.

Sea cucumbers are marine animal with leathery-skinned echinoderms belonging to the class Holothuroidea. Living on the ocean floor, they contribute to the marine ecosystem's ecology by recycling nutrients and dissolving organic materials and debris. It also high economic value commodity because of they benefit for human. Sea cucumber are widespread throughout the world, including in Madura Island. On Madura island we can found some species of sea cucumber in Bangkalan waters [2] [3]. Bangkalan is one of 4 districts on Madura Island, where several sub-districts are coastal areas. It make this area has quite high potential for fishery resources. Sea cucumbers are one of the maritime fisheries that account for 85% of Bangkalan's total fish production, according to data. In Socah (Bangkalan), the annual haul of sea cucumbers was as high as 25,46 Quintal. [7] notes that in Socah territory, the communities turn teripang into a *kerupuk* (a type of crispy, fried snack originating from Indonesia) or referred to as "crackers", which is subsequently marketed to certain areas inside Madura as well as outside of it, like Surabaya.

The issue is that although sea cucumbers are being caught in large quantities [8], there is still a lack of knowledge on the identification of individual species and certain characteristics of their habitats. So, the research is needed to understanding the ecological and habitat condition that preferred by sea cucumber. The result of this study can give some information for more study and sea cucumber sustainable management.

2 Material and methods

2.1 Time and study location

This study was carried on Kamal and Socah Waters, Bangkalan Regency, Madura Island. There are 4 areas in Kamal waters and 5 areas in Socah waters for sampling (sea cucumber and sediment) and measurement water quality (Figure 1). This research was held on August-September 2023.

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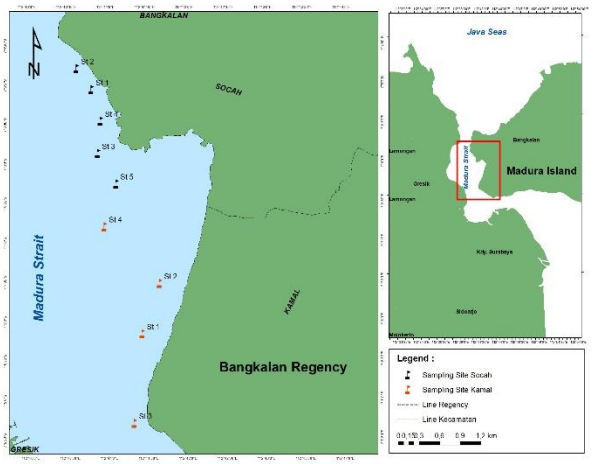

Fig. 1. Study sites at Kamal (blue sign) and Socah (red sign) waters, Bangkalan, Madura Island.

2.2 Data collection

A boat, a water quality tester, a camera, an Ekman grab, traditional fishing gear, and bucket samples were used in this study. Sea cucumber sampling was carried out by fisherman using hand collect method with traditional tools called *krengkeng/bi' rombi'* (traditional tool made of iron and shaped like a hook at the end, with a wooden handle) when the water low.

The water physical-chemical parameters were also determined in this research using *in situ* analysis using a water quality checker, such as salinity, DO, pH, and temperature. Sediment samples were taken using an Ekman grab on each sampling area, and the grain size of the sediment was measured by sequential sediment-sieving using an analytical sieve shaker. This allowed for the evaluation of the relative abundance (% dry weight) of the following size fractions by [9] and then grouped according to the Shepard triangle.

2.3 Data analysis

The species found in the study area were analysed descriptively. Diversity and dominance indexes are the community structure components examined in this study.

2.3.1 Species diversity

The Shannon-Wiener diversity index (H') was used to analyse the sea cucumber species [10]:

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

Where pi means the number of individuals in species-i. H'<1.0 denotes low diversity, 1≤H'<3 denotes intermediate diversity, and H'≥3 denotes high diversity in the diversity index.

2.3.2 Dominance index

Sea cucumber dominance index was calculated using the following Simpson's Dominance Index calculation [11]:

$$D = \sum (pi)^2 \quad (2)$$

0<D<0.5 indicates low dominance, 0.5<D<0.7 indicates moderate dominance, and 0.75<D<1.0 indicates extreme dominance according to the Dominance Index criteria.

3 Results and discussion

3.1 Species diversity, number, and composition of sea cucumber

In this research that conducted in Kamal and Socah waters we found 4 species of sea cucumber that consist of Phyllophoridae, Caudinidae, and Cucumariidae (Table 1). There are fewer species found in this study than those found by [12] who found five species in the waters. This is thought to be caused by differences in time and sampling methods. The discovered species differs from the sea cucumber species previously found by [13] in the northern waters of Bangkalan which had different habitat condition. Specifically, the discovered species belongs to the families Stichopodidae and Holothuroiidae that tends to live on seagrass meadow .

Table 1. Species diversity of Holothuroidea in Socah and Kamal waters.

Class	Family	Species
Holothuroidae	Phyllophoridae	*Phyllophorella spiculata*
		Phyllophorus sp.
	Caudinidae	*Acaudina leucoprocta*
	Cucumariidae	*Colochirus quadrangularis*

The Holothuroid found in this research have different characteristics, both in shape, color, and texture. Descriptions of each species are presented in Table 2.

During this research, 134 individuals from Kamal waters and 151 persons from Socah waters had their remains discovered (Table 3). The species A. leucoprocta (Fig 5), Phyllophorus sp (Fig 2). and Phylophorella spiculata (Fig 3) are found in both Kamal and Socah waters, while the species *Colochirus quadrangularis* (Fig 4) is found only in Socah. The species that is most frequently found is *Phyllophorus* sp., which is found in 72% of Kamal and 45% of Socah. In contrast, the species that is least commonly known is *Phylophorella spiculata*, which is found in just 8% of Kamal and 10% of Socah.

Table 2. Description of sea cucumbers in Socah and Kamal waters.

No	Species and Description
1	 **Fig. 2** *Phyllophorus sp.*
	Local name: *Terung lokal* It is often referred to as sea ball cucumber because of its spherical body. It found in different colours include white, beige, brownish, and even orange and have thick body-skin. Papulae, or small filaments, and tube feet cover the entire body equally. It has a table-type spicula, which is a circle-shaped spicule with holes in the middle [12]
2	 **Fig. 3** *Phyllophorella spiculata* [14]
	Scientific name: **Local name**: *Terung gimbul* Imperfect round shape, all throughout their body are papillae, which are tiny protrusions. It has a smooth and muffled texture on its body. Spicula of this kind has a nail-like shape [12]
3	 **Fig. 4** *Colochirus quadrangularis* [14]
	Local name: *Terung merah* Shape of body quadrangular with smooth and leathery body surface in the dorsal interambulacral area. Four rows of spiky and hard papillae arranged in a line at the two corners of the dorso-lateral and ventrolateral areas. The background colour was reddish yellow especially at the ambulacra area in the dorsal. Tentacles were yellow with reddish endings at the tip [15]
4	 **Fig. 5** *Acaudina leucoprocta*
	Local name: *Blonyo* The body wall is slimy and smooth. So, it is called smooth sea cucumber. Spots of brown, orange, or brown-black pigment widely spaced on the body wall.

Table 3. The number of sea cucumbers found in Kamal and Socah waters, Bangkalan, Madura Island.

Species	Kamal (ind)				Socah (ind)				
	1	2	3	4	1	2	3	4	5
AL	-	7	-	19	-	-	12	28	-
PHY	47	13	36	1	20	4	5	1	38
CQ	-	-	-	-	22	-	-	-	6
PS	8	-	3	-	-	-	-	-	15

*AL: *Acaudina leucoprocta*
PHY*: Phyllophorus sp.*
CQ: *Colochirus quadrangularis*
PS: *Phyllophorella spiculata*

A variety of ecological and environmental conditions can influence the type of sea cucumber, or holothuria, that is found in a body of water. Qualitative and compositional aspects of the substrate, environmental parameters, food sulies and nutrition, water depth, human activity effects, and biogeographical factors are some of the primary determinants of a species' survival.

3.2 Diversity and dominance index

The species diversity index, which is determined by species richness and individual equality within species, is typically used to monitor the state of the ecosystem or ecological stability [16]. Table 4 displays the results of the calculation of the diversity and dominance index. Dominance value that closed to 1 indicates there is one or more species were dominate other species. According to the outcome, sea cucumbers in Kamal and Socah waters have Shannon-Wiener (H') diversity index that belongs into the low category since H'<1 (0-0.87). The low diversity observed at both locations may indicate limited habitat variability or ecological stressors that could impact the overall health and resilience of the sea cucumber populations.

Table 4. Value of species diversity index.

Location	Area	Diversity (H')		Dominance Value (D)	
Kamal	1	0.41	Low	0.75	High
	2	0.86		0.5	Medium
	3	0.27		0.86	High
	4	0.2		0.91	High
Socah	1	0.69	Low	0.5	Medium
	2	0		1	High
	3	0.61		0.58	Medium
	4	0.15		0.93	High
	5	0.87		0.48	Low

The low diversity category in this research also followed by the medium-high category of dominance index. The dominant index in the entire area ranges between 0.5-1 that belongs to the medium-high category, except for station 5-Socah that have a low

dominance index with a value of 0.48. From Table 3 we can assume that the most dominant sea cucumber in this research belong to Phyllophorus sp. as these species found at all the sampling area in quite numbers.

Various factors, including habitat type, availability of food, geographic location, sampling time, and method, might affect the fluctuation of the diversity and dominance index [3]. In this research the most likely factor that causing the dominance of the Phyllophorus sp. is the habitat type. This sea-ball cucumber prefers to live in the soft sediment type which has more fine and coarse sand sediment and less silt [5]. On the other hand, *Colochirus quadrangularis* was found in the lowest number. This could be chance because this thorny sea cucumber prefers to live in habitat containing seagrass. In the Merambong shoal, it was discovered that the species C. *quardangularis* was closely related to the seagrass *Enhalus acoroides* [15].

3.3 Habitat characteristic

3.3.1 Water quality

According to [17], the average value of the physical and chemical variables was generally still within the range of quality standards that suort marine life. One of the most important parameters determining sea cucumber survival is salinity level [18]. During the research, the salinity ranged from 20 to 32 (Table 5), and this variation of salinity was caused by sampling time and the distance from the land. However, the water salinity during sampling showed conditions that were still suitable for sea cucumber life.

The metabolic system, growth [19], feeding behaviour, and survival of sea cucumbers were all greatly impacted by temperature [20]. Table 4 also showed that temperature in Bangkalan waters during this research ranged between 29.3-30.6°C and suitable for sea cucumbers species on that area [21]. Similar to [4], this narrow varied of temperature will not affect to the metabolic activity of sea cucumber. But, the increase of water temperature must be concern because [22] state when the water temperature reaches more than 30°C, it can cause large scale death of sea cucumbers.

Table 5. Water quality of Kamal and Socah waters.

Parameter	Location		Quality Standart*
	Socah	Kamal	
Salinity (t)	26	26	33-34
Water Temperature (^{0}C)	30.05	29.9	28-32
pH	7.9	7.6	7-8.5
Dissolved Oxygen (mg/L)	6.33	6.55	>5
Water transparency (%)	60	55	NA
Water Depth (cm)	94.4	103.4	NA

*Quality standard based on [17]; NA: data not available

Every study location had an average dissolved oxygen level that was within the quality standard range, which is greater than 5 m. The average of pH is ranged 7.6-7.8 and this condition is still suitable to suort sea cucumber to grow [23].

3.3.2 Sediment texture

The substrate of the watershed has a crucial role in the survival of the marine and coastal biota, particularly in the case of sea cucumbers and other benthic organisms that live at the bottom of the water. The presence of sea cucumber species in a given area is influenced by the composition of the sediment grains, as mentioned in [24], since sea cucumbers can be found in a variety of habitat features [25]. The results of the analysis of the percentage of sediment fractions in Kamal and Socah waters are presented in Table 6.

Table 6. Percentage of sediment fraction.

Location	Area	Gravel (%)	Sand (%)	Mud (%)
Kamal	1	7.57	83.8	8.63
	2	9.59	77	13.41
	3	12.24	87.7	0.05
	4	20.55	79.38	0.07
Socah	1	14.7	85.3	0
	2	12.23	87.47	0.3
	3	28.36	71.25	0.39
	4	7.99	87.6	4.41
	5	8.61	90.07	1.33

The sediment texture in both location (Kamal and Socah waters) were dominated with sand fraction. This is the sediment's texture condition that led to the discovery of the four species in the area. [4] and [26] also found that sand type of sediment are preferred by several types of sea cucumbers such as, *Phyllophorus* sp., *Colochirus quadrangularis*, because some species was usually buried in sandy areas [27].

[28] suggested that sea cucumber development may be suorted by sand-type materials. According to [29] research, a higher percentage of sand in sea cucumbers' natural environments has a good effect on their survival. This indicates that the sediments in the waters of Socah and Kamal are ideal for suorting the life of sea cucumbers.

Overall, the study highlights that the water quality and sediment type in Kamal and Socah are conducive to suorting sea cucumber populations, with Phyllophorus sp. showing significant dominance. This information is crucial for understanding the ecological dynamics of these marine habitats.

4 Conclusion

Water quality in the two locations is similar, and is still suitable for marine biota, including sea cucumbers. In

this research we found 4 species of sea cucumbers including *Phyllophorus* sp. (*terung lokal*), *Phyllophorella spiculata* (*terung gimbul*), *Acaudina leucoprocta* (*blonyo*), and *Colochirus quadrangularis* (*terung merah*). Diversity level were low at both location and dominated by *Phyllophorus* sp. (*terung lokal*). *Phyllophorus* sp. was dominate than other spesiec due to the habitat condition such as water quality and sediment type. The water quality on Kamal and Socah is suitable for sea cucumber and the sediment type is sand.

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