

Species and Density of Starfish (*Asteroidea*) in Seagrass Ecosystems at Pengudang Village, Bintan Regency, Kepulauan Riau

Jenis dan Kepadatan Bintang Laut (Asteroidea) di Ekosistem Padang Lamun Desa Pengudang Kabupaten Bintan, Kepulauan Riau

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Abstract

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Sea stars, members of the Echinodermata phylum, are closely associated with seagrass beds and play a role in the food chain. High seagrass cover supports a variety of biota, including sea stars. This study aims to determine the types and density of starfish (*Asteroidea*) in the seagrass ecosystem of Pengudang Village, Bintan Regency, Kepulauan Riau Province. This research was conducted in September 2024 in Pengudang Village, Bintan Regency, Kepulauan Riau Province. Starfish sampling and observation were conducted at three station points, with each station having three transect lines. Each transect contained ten observation plots measuring 1×1 m. Two species of starfish were found during the study in Pengudang village: *Archaster typicus* (73 individuals) and *Protoreaster nodosus* (14 individuals). The density of starfish found during research in Pengudang Village ranged from 700 to 13,700 individuals per hectare. Water quality conditions during the study were classified as good for supporting starfish life, with temperatures ranging from 29.7 to 31.3°C, current speeds from 0.055 to 0.076 m/s, salinity from 29.9 to 31.6 ppt, and dissolved oxygen from 6.82 to 7.66 mg/L.

Keywords: Species, Density, *Asteroidea*, Pengudang Village

Abstrak

Bintang laut sebagai anggota Echinodermata, berasosiasi erat dengan padang lamun dan berperan dalam rantai makanan. Tutupan lamun yang tinggi mendukung kehadiran berbagai biota, termasuk bintang laut. Penelitian ini bertujuan untuk mengetahui Jenis dan Kepadatan Bintang Laut (*Asteroidea*) di Ekosistem Padang Lamun Desa Pengudang Kabupaten Bintan Provinsi Kepulauan Riau. Penelitian ini dilakukan pada bulan September 2024 di Desa Pengudang Kabupaten Bintan Provinsi Kepulauan Riau. Pengambilan dan pengamatan sampel bintang laut dilakukan di tiga titik stasiun dengan masing-masing stasiun terdapat tiga line transek. Pada masing-masing transek terdapat sepuluh plot pengamatan yang berukuran 1×1 m. Jenis bintang laut yang ditemukan selama penelitian di Desa Pengudang sebanyak 2 jenis yang terdiri dari *Archaster typicus* (73 individu) dan *Protoreaster nodosus* (14 individu). Nilai kepadatan bintang laut yang ditemukan selama penelitian di Desa Pengudang berkisar 700 – 13.700 ind/ha. Kondisi kualitas perairan selama penelitian berada pada kategori baik untuk mendukung kehidupan bintang laut, dengan nilai suhu 29,7-31,3°C, nilai kecepatan arus 0,055-0,076 m/s, nilai salinitas 29,9-31,6 ppt, dan nilai oksigen terlarut 6,82-7,66 mg/L.

Kata kunci: Jenis, Kepadatan, *Asteroidea*, Desa Pengudang

1. Introduction

Sea stars, members of the Echinodermata phylum, are closely associated with seagrass beds and play a role in the food chain. High seagrass cover supports the presence of various biota, including sea stars, for feeding, living, spawning, and sheltering from predators (Supono & Arbi in Alfatmadina et al., 2019). Seagrass beds have high biological productivity and play a very important role in the ecological functions of coastal environments. Ecologically, seagrass beds serve as nurseries, feeding grounds for small fish, turtles, porcupinefish, and other biota, and as shelters for various types of marine biota (Jalaludin et al., 2020).

Pengudang Village is a seagrass conservation area. Sentinel-2A imagery shows that the area of seagrass beds decreased from 8.43 ha in 2018 to 7.30 ha in 2020, with an accuracy of 80%. This decline was caused by image reduction, oil spills, and community activities (Putra et al., 2023). Oil spills during the northern winter (December–February) often occur when ships dump waste during high waves and strong winds. This was followed by rampant development on the east coast of Bintan, including Pengudang, triggered by the 2005–2025 spatial policy that designated this area as a tourist destination. The impact was a decline in water quality due to sedimentation and turbidity, which reduced seagrass growth and energy potential (Sjafrie, 2018).

Preliminary research by the UNESA PKM-RE Team shows that starfish have the potential to serve as bioindicators of heavy metal lead due to industrial waste. Starfish meet the criteria for bioindicators because they move slowly, have soft tissue, feed on organic matter from the seabed, are easily identified, and are capable of accumulating pollutants. Research on heavy metal lead (Pb) Biomonitoring on Spermonde Island, Makassar, using Starfish as Bioindicators by Amalia & Ramang (2014) states that *Protoreaster nodosus* shows tolerance to Pb at levels of 2.6080-2.8876 ppm. This level does not cause any damage to this species of starfish. This makes *Protoreaster nodosus* one of the animals that can play a role in combating pollution and serve as a bioindicator of heavy metal pollution in water.

Considering the role of starfish in seagrass ecosystems and the lack of research on their presence, research on the species and density of starfish (*Asteroidea*) in the seagrass ecosystem of Pengudang Village, Bintan Regency, Kepulauan Riau Province, is needed. The results of this research can be used as a basis for information on the management of aquatic biota resources, especially starfish in the phylum Echinodermata.

2. Material and Method

2.1. Time and Place

This research was conducted in September 2024 in the coastal waters of Pengudang Village, Bintan Regency, Kepulauan Riau Province.

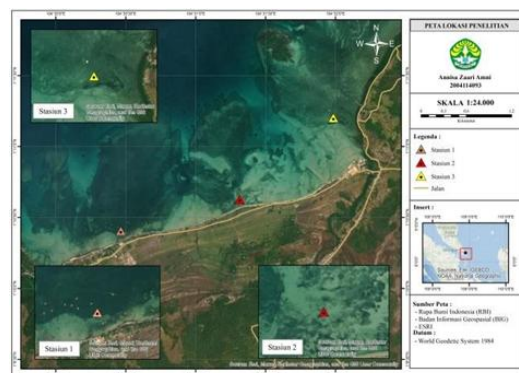


Figure 1. Research Location Map

2.2. Methods

The method used in this study was a survey, with the waters of Pengudang Village, Bintan Regency, Kepulauan Riau Province, as the research location. The required data were primary and secondary. Primary data included starfish diversity and water quality data. Secondary data were topographical information on the area obtained from relevant local government agencies.

2.3. Procedures

2.3.1. Determination of Station Location

The determination of starfish observation stations was carried out using the purposive sampling method, namely selecting stations based on various considerations of the conditions and circumstances of the research area, which were expected to represent the occurrence of starfish in the seagrass ecosystem of Pengudang Village waters. The area of the seagrass ecosystem in Pengudang Village is approximately 7.30 ha.

Station 1 : An area surrounded by resorts and rivers and located at coordinates 1°11'13.1" N and 104°31'53.6" E.

- Station 2 : An area where floating fishing platforms are located, located at coordinates 1°10'43.2" N and 104°31'12.8" E.
- Station 3 : A densely populated residential area in Pengudang Village. Located at coordinates 01°10'28.8" N and 104°30'11.2" E

2.3.2 Sampling of Starfish

Starfish sampling is described by Binambuni et al. (2019). Sampling was conducted once at each station where seagrass was first found using the quadrat transect method. There were three transects in each station, each 100 meters apart. At each transect, a straight line 100 m long was drawn towards the sea using a tape measure. In each transect, there were ten 1x1 m² plots with a distance of 10 m between plots. This sampling process was carried out at the lowest ebb of the tide. The starfish species found will be photographed for documentation and identified by observing the morphological characteristics of the underside (oral) and upper side (aboral) of the starfish, referring to identification books (Brusca & Brusca, 1990), starfish morphological identification guides (Rusyana, 2011), and several previous research journals on *Astroidea*.

2.4. Data Analysis

2.4.1. Starfish Density

The density of starfish will be calculated using a modified formula (Odum in Nurafni et al., 2019):

$$K = \frac{Ni}{A} \times 10.000$$

Explanation:

- K = Species density (ind/m²)
- A = Area sampled (ha)
- Ni = Total number of species (individuals)
- 10.000 = Conversion value for sampling area

2.4.2. Species Frequency

Analysis of the frequency of starfish species found at the observation site (Odum in Anwar et al., 2018) was conducted using the following formula: $Fi = \frac{Pi}{\sum P}$

Explanation:

- Fi = Species Frequency
- $\sum P$ = Total number of observation plots
- Pi = Number of plots where species i was found

Relative frequency analysis is a comparison between the frequency of a type (Fi) and the sum of the frequencies of all types ($\sum Fi$) (Odum in Anwar et al., 2018) and is calculated using the following formula:

$$RFi = \left[\frac{Fi}{\sum fi} \right] \times 100\%$$

Explanation:

- Rfi = Relative frequency
- $\sum fi$ = Total frequency
- Fi = Frequency of type I

3. Result and Discussion

3.1. Characteristics of Starfish Types

During the study, two types of starfish were found at the research site, namely *Archaster typicus* and *Protoreaster nodosus*. The *Archaster typicus* starfish is gray with brown spots, has five arms 3-4 cm long, a body length of 8-10 cm, a body diameter of 4-5 cm, and a distinctive feature of small spines on each arm in the oral region. The *Protoreaster nodosus* species is pink in color, with 5 arms measuring 6.5-9 cm, a body length of 15-26 cm, a body diameter of 7.5-13.5 cm, and blunt black spines on the aboral side. The types of starfish found at the research site can be identified using the starfish (*Astroidea*) identification guide (Rusyana, 2011). The results of the observations are shown in Table 1.

Table 1. Characteristics of Starfish Species at the Research Site

| No. | Name | Color | Number of Arms | Arm Length (cm) | Body Length (cm) | Diameter (cm) | Oral and Aboral Surface |
|-----|-----------------------------|-------------------------|----------------|-----------------|------------------|---------------|------------------------------------------------------|
| 1. | <i>Archaster typicus</i> | Gray with brown stripes | 5 | 3 - 4 | 8 - 10 | 4 - 5 | Has small spines on each arm in the oral region |
| 2. | <i>Protoreaster nodosus</i> | Pinkish white. | 5 | 6.5 – 9 | 15 - 26 | 7.5 – 13.5 | Has blunt black spines (spicules) on the aboral side |

The starfish species *Archaster typicus* and *Protoreaster nodosus* can adapt and are well-suited to the habitat conditions at the research site, which are seagrass beds, enabling their survival. Another study on starfish species

was conducted on Pucung Island, Malang Rapat Village, Bintan Regency, by Irawan (2014), which found four species (*Culcita novaeguineae*, *Archaster typicus*, *Protoreaster nodosus*, and *Nardoa tuberculata*). The starfish species *Nardoa tuberculata* and *Culcita novaeguineae* were not found at the research site, as these species do not live in seagrass beds. These species tend to live in dense coral reef areas as their feeding habitat.

Archaster typicus is a member of the Archasteridae family. This species is gray in color with brown stripes on its aboral surface. It has five arms and a flat body, with the mouth on the oral side and the anus on the aboral side. It also has small spines encircling each arm (Suwartimah et al., 2017). The key to identifying this species lies in the spatula-shaped spines on each infero-marginal plate and the tweezers-shaped pedicellariae on the ventral side (Clark & Rowe, 1971). The spines help remove sand that sticks to their bodies (Syafira et al., 2022). *Archaster typicus* has an aboral side with a madreporite for water circulation and an anus, while the oral side has a mouth and ambulacral openings (Triana et al., 2015). The starfish species *Archaster typicus* exhibits pairing between males and females during the spawning season (Yunita et al., 2020).

This species of starfish tends to live in groups when found, but some individuals are also found alone, quite far from their group. This species is found in seagrass beds, but some individuals bury themselves in the sand between the seagrass stalks. Neno et al. (2019) stated that *Archaster typicus* efficiently consumes several foods in the form of detritus, like other types of starfish, and lives mostly in sand. This species is nocturnally active and can move large amounts of sand into the substrate in search of food.



Figure 2. *Archaster typicus*

Protoreaster nodosus is often referred to as the horned starfish due to its distinctive horn-like protrusions on its dorsal side (Anwar et al., 2018). This is consistent with the explanation by Clark & Rowe (1971) that there are horn-like protrusions in the carinal area. The body shape of this starfish is radially symmetrical, with the mouth located on the oral side, the madreporite located on the aboral side, and the anus located on the aboral side. *Protoreaster nodosus* moves using ambulacral tubes located on the aboral side of the tube feet (Fitriansyah, 2018).

This species is found in seagrass beds quite far from the coast. It lives hidden under the cover of seagrass branches, tends not to live in groups, and is only occasionally seen in proximity to other individuals. Ernawati et al. (2019) stated that *Protoreaster nodosus* is a species of the class Asteroidea that prefers specific microhabitats such as seagrass beds. Seagrass habitats are used by *Protoreaster nodosus* as places to shelter and forage. The types of food consumed by *Protoreaster nodosus* in seagrass areas include decaying seagrass leaves, microbes, macroalgae, and detritus.



Figure 3. *Protoreaster nodosus*

3.2. Starfish Density

The total number of starfish species found in the seagrass ecosystem of Pengudang Village ranged from 12 to 48 individuals. Details of the range of species numbers obtained are presented in Table 2.

| No. | Species | Station 1 | Station 2 | Station 3 | Amount |
|-----|-----------------------------|-------------|-----------|-----------|--------|
| | | Individuals | | | |
| 1. | <i>Archaster typicus</i> | 22 | 10 | 41 | 73 |
| 2. | <i>Protoreaster nodosus</i> | 5 | 2 | 7 | 14 |
| | Amount | 27 | 12 | 48 | 87 |

Based on the number of starfish observed at the research site, the density ranged from 0.07 to 1.37 ind/m². These values were converted to a larger unit of area, namely hectares (ha), in order to obtain integer density values.

The density values for both species ranged from 4,000 to 16,000 ind/ha. Details of the density range values are shown in Table 3.

Table 3. Density of Starfish

| No. | Species | Station 1 | Station 2 | Station 3 |
|-----|-----------------------------|------------------|-----------|-----------|
| | | Density (ind/ha) | | |
| 1. | <i>Archaster typicus</i> | 7.300 | 3.300 | 13.700 |
| 2. | <i>Protoreaster nodosus</i> | 1.700 | 700 | 2.300 |
| | Amount | 9.000 | 4.000 | 16.000 |

The density of starfish among the three stations in the seagrass ecosystem of Pengudang Village was highest at station 3, with a density of 13,700 individuals per hectare of the species *Archaster typicus*, while the lowest density was at station 2, with a density of 700 ind/ha of the species *Protoreaster nodosus*. Many factors cause the high and low density values of starfish. Station 2 has two main factors causing low density, namely the activity of floating kelong crossing the seagrass beds to enter the kelong stopping area on the coast and high rainfall during the west monsoon season, which causes a decrease in salinity. Kusri & Azhar (2023) state that human activities, such as the construction of docks, sand mining, and chemical fishing, also influence the presence of starfish in the intertidal zone. Salinity is an important factor in the distribution, abundance, and diversity of marine biota. Changes in salinity can affect organisms in two ways. First, when heavy rainfall occurs in tidal areas, salinity levels decrease. Second, salinity increases when evaporation is very high during the day (Nybakken in Husein, 2023).

The water quality parameters measured to support the life of the two types of starfish found during the study showed that the temperature ranged from 29.7 to 31.3°C, the current velocity ranged from 0.055 to 0.076 m/s, the salinity ranged from 29.9 to 31.6 ppt, and dissolved oxygen values ranged from 6.82 to 7.66 mg/L. The parameter values measured during this study were close to the water quality parameter values from a study on starfish in the waters of Busak Island, Buol Regency, Central Sulawesi by Mappetahang et al. (2018), which stated that three types of starfish (*Archaster typicus*, *Protoreaster nodosus*, and *Linckia laevigata*) were found during this study, with the measured quality parameters being temperature with values ranging from 28.5-30.9°C, pH with values ranging from 6.5-7.7, and salinity ranging from 29.5-30.8 ppt.

The life of both types of starfish in the seagrass ecosystem of Pengudang Village is influenced by the condition of the seagrass that serves as their habitat in the waters of Pengudang Village. The condition of seagrass beds in Pengudang Village was studied in the research paper titled "Blue Carbon Reserves in Seagrass Ecosystems" by Maemunah et al. (2022). This study stated that the seagrass ecosystem in Pengudang Village has five types of seagrass, namely *Enhalus acoroides* with a value of 747 stands/m² (13.54%), *Cymodocea rotundata* with a value of 396 stands/m² (4.62%), *Syringodium isoetifolium* with a value of 221 stands/m² (2.61%), and *Thalassia hemprichii* with a value of 2,024 stands/m² (33.03%).

Research on the association of starfish in seagrass ecosystems has also been conducted in the waters of Samuh Beach, Nusa Dua, Bali by Vindia et al. (2019). This study reported that the Echinodermata species found in this study numbered 13, 2 of which were *Archaster typicus* and *Protoreaster nodosus*. The seagrass density at all stations in the waters of Samuh Beach ranged from 156-246 stands/m², and the seagrass species composition in the waters of Samuh Beach consisted of 5 seagrass species, namely *Enhalus acoroides*, *Halophila ovalis*, *Cymodocea serrulata*, *Thalassodendron ciliatum*, and *Syringodium isoetifolium*.

3.3. Frequency of Species and Relative

The results of the calculation of the frequency value of starfish species at each station in the waters of Pengudang Village are 0.062-0.533, as shown in Table 4.

Table 4. Starfish Frequency

| No. | Species | Species Frequency | | |
|-----|-----------------------------|-------------------|-----------|-----------|
| | | Station 1 | Station 2 | Station 3 |
| 1. | <i>Archaster typicus</i> | 0.333 | 0.200 | 0.533 |
| 2. | <i>Protoreaster nodosus</i> | 0.167 | 0.067 | 0.167 |
| | Amount | 0.500 | 0.267 | 0.700 |

Table 5. Relative Frequency of Starfish

| No. | Species | Relative frequency (%) | | |
|-----|-----------------------------|------------------------|-----------|-----------|
| | | Station 1 | Station 2 | Station 3 |
| 1. | <i>Archaster typicus</i> | 66.6 | 74.9 | 76.1 |
| 2. | <i>Protoreaster nodosus</i> | 33.4 | 25.1 | 23.9 |

ratio between the frequency of species *i* and the total frequency for all species (Bengen in Babo et al., 2020). The frequency of starfish among the three stations in the seagrass ecosystem of Pengudang Village was highest at Station 3, at 0.700, while the lowest frequency was at Station 2, at 0.267. The frequency value at Station 2 indicates

a low chance of finding one individual of the species in one observation plot, whereas the frequency value at Station 3 indicates a higher chance of finding one individual of the species in one observation plot. Based on the number of starfish observed at the research site, the starfish frequency value ranged from 0.267 to 0.700 (Table 5). This value was converted to a percentage to obtain the relative frequency value in order to determine whether the starfish frequency found was high or low.

Frequency classification is based on [Indriyanto in Hidayat et al. \(2018\)](#), consists of five classes, namely: class A (1-20%) very low, class B (21-40%) low, class C (41-60%) moderate, class D (61-80%) high, and class E (81-100%) very high. The relative frequency of starfish species in Pengudang Village was highest at Station 3, where *Archaster typicus* accounted for 76.1%. Similarly, the lowest relative frequency was observed at Station 3 for the *Protoreaster nodosus* species, at 23.9%. The *Protoreaster nodosus* species was found in small numbers during the observation period, compared with *Archaster typicus*. Given that it does not live in groups and was not found in many of the predetermined observation plots, this species was difficult to find.

3.4. Water Quality and Starfish Management at the Research Site

Water quality is one of the determinants of the condition or suitability of an aquatic ecosystem that forms part of a starfish's habitat. The water quality parameters measured during the study showed temperature values ranging from 29.7 to 31.3°C, current velocity values ranging from 0.055 to 0.076 m/s, salinity values ranging from 29.9 to 31.6 ppt, and dissolved oxygen values ranging from 6.82 to 7.66 mg/L. The results of water quality measurements in the seagrass ecosystem of Pengudang Village can be seen in Table 6

Table 6. Water Quality

| No. | Parameters | Location | | |
|-----|-------------------------|---------------|---------------|---------------|
| | | Station 1 | Station 2 | Station 3 |
| 1. | Temperature (°C) | 29.7 – 30.1 | 30.0 – 31.3 | 31.2 – 30.8 |
| 2. | Flow Velocity (m/s) | 0.067 – 0.076 | 0.059 – 0.066 | 0.055 – 0.059 |
| 3. | Salinity (ppm) | 30.0 – 31.3 | 29.9 – 30.1 | 31.6 – 30.7 |
| 4. | Dissolved oxygen (mg/L) | 7.66 – 7.38 | 7.13 – 6.87 | 6.82 – 6.34 |

The temperature of a body of water is one of the parameters that directly affects the life of marine organisms ([Hamuna et al., 2015](#)). The temperature measurements at the research site were within the normal range, as can also be seen in the study by [Alfatmadina et al. \(2019\)](#), which states that a seawater temperature of 28-29°C is still within the normal range for starfish survival. [Zainuri et al. \(2023\)](#) argue that several factors, such as weather conditions, the location of the sampling point, and the time of sampling, can influence the high and low temperatures in the measurement results.

The flow is the movement of a water mass influenced by wind, water density, and pressure differences, resulting in the transport of water materials from the surface and the water column ([Prayogo, 2021](#)). Measurements of flow velocity in the waters of Pengudang Village showed figures of 0.055-0.076 m/s. The flow velocity is influenced by tidal conditions, which prevent starfish from remaining stationary on their substrate because they tend to move slowly and are not always able to hold onto the seagrass leaves. Starfish try to move when the flow is fast to areas with enough sand to bury themselves. [Modek et al. \(2022\)](#) stated that a flow velocity of 0.02-0.15 m/s is still suitable for starfish life.

Salinity is one of the parameters used to determine water quality, both in surface water and groundwater. Salinity is the level of saltiness or dissolved salt content in water in grams per liter of seawater ([Hasrianti & Nurasia, 2016](#)). Measurements of salinity levels in the waters of Pengudang Village ranged from 29.9 to 31.6 ppm. These salinity levels are still considered normal for starfish survival. Starfish can survive within a tolerance range of 30-34 ppt ([Aziz in Setyowati et al., 2017](#)). The results of dissolved oxygen level measurements at the research site were obtained at station 1 with a value of 7.66-7.38 mg/L, station 2 with a value of 7.13-6.87 mg/L, and station 3 with a value of 6.82-6.34 mg/L. The differences in values between station are influenced by the time of water sampling: it begins in the morning, when light intensity is high, and continues until late afternoon, when it begins to decrease. The dissolved oxygen values obtained during the study were still in the category of being good for supporting starfish life. Based on the Decree of the Minister of Environment (2004), dissolved oxygen (DO) that is good for marine life is more than 5 mg/L.

Based on the information and observations obtained during the research, starfish living in the coastal waters of Pengudang Village are not managed in accordance with regulations issued by ministries or other government agencies. This is because the community and fishermen in Pengudang Village do not utilize starfish to meet their daily needs. Starfish in Pengudang Village are used only for recreational purposes by tourists, as research objects, and as learning objects for school and university students. This does not disturb or reduce the starfish population at the research site. Another study on seagrass ecosystems in the waters of Pengudang Village was conducted by [Jemi et al. \(2022\)](#). This study reported that seagrass cover at the Pengudang station was 65.20%, categorized as dense seagrass. Based on the determination of seagrass status under the Minister of Environment Decree No. 200 of 2004, seagrass in Pengudang waters is classified as rich/healthy, with a coverage of $\geq 59.90\%$. The findings of this study are reinforced by the findings of a study on Pixel-Based Benthic Habitat Mapping using Spot-7 Images

in the Waters of Pengudang Village, Bintan Regency (Kartika et al., 2025). This study reports that seagrass habitats increased significantly from 25 ha (2016) to 46 ha (2022). This improvement was driven by conservation and protection efforts, such as community and local government awareness-raising to preserve and protect the seagrass ecosystem in the waters of Pengudang Village (Kurniawati et al., 2025).

4. Conclusions

Starfish (*Asteroidea*) in the seagrass ecosystem of Pengudang Village consist of the species *Archaster typicus* and *Protoreaster nodosus*, with densities ranging from 700 to 13,700 ind/ha and relative frequencies ranging from 23.9 to 76.1%. The water quality conditions during the study were in the good category for supporting starfish life, with temperatures ranging from 29.7 to 31.3°C, current speeds ranging from 0.055 to 0.076 m/s, salinity ranging from 29.9 to 31.6 ppt, and dissolved oxygen ranging from 6.82 to 7.66 mg/L. This study is recommended to be continued with more in-depth research on starfish, such as analyzing starfish organs to understand their function and, subsequently, determine the composition of starfish bodies. This is because several types of starfish are currently known to have potential applications in the medical field.

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