The biomass, abundance, and distribution pattern of starfish *Asterias* sp. (Echinodermata: Asteroidea) in East Coast of Surabaya

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**Abstract.** This study aims to determine the biomass, density, and distribution patterns of *Asterias* sp. Samples were collected from three locations such as Wonokromo, Dadapan and Juanda, each divided into 3 zones. In each zone, samples were taken as many as 5 repetitions using swept area method. Temporarily, the highest biomass of starfish was 2.95 gr/m\textsuperscript{2} in Dadapan Zone on January. Spatially, biomass of starfish was found in Dadapan Zone (3.35 gr/m\textsuperscript{2}). Similarly, the high density was also found in Dadapan Zone on January (9 ind/10 m\textsuperscript{2}). In general, the distribution pattern of starfish in East Coast Surabaya through spatial and temporal showed that the pattern of starfish was grouping distribution (Id value> 1) for Dadapan and Juanda, and uniform for Wonokromo. Oceanographic condition, antropogenic activity, and water quality in East Cost of Surabaya become important things which is affected the biomass, density and distribution pattern of starfish. The knowledge of starfish biomass and density is very important given that this biota has ecological value as a balancing ecosystem in the waters.

1. **Introduction**

The east coast of Surabaya is close to Sidoarjo Regency, is an industrial development area of the city of Surabaya. These industries can potentially cause pollution from industrial waste disposal through rivers and finally to the waters of the east coast of Surabaya. According to Pourvali *et al.* [1], echinoderms are one of the oldest and most important groups of marine organisms which play an important role in marine ecology. Asteroidea is a class of the Echinoderm and are commonly found in shallow waters with a depth of 10 meters. These animals are commonly found in tropical coral reefs, rocky shores, tidal pools, mud and sand, kelp forests, seagrass meadows and the deep-sea floor down to at least 6,000 m. Starfish are biota that are sensitive to marine pollution and considered to be a bioindicator for marine ecosystems [1,2]. *Asterias* sp. is one genus of the Asteroideaclass. This species is usually found by fishermen during their shellfish fishing activities in the east coast of Surabaya. According to Shah [3], *Asterias* are known by the name of starfish. There are about 150 species of *Asterias*, all of which have different geographic distributions. The habitat of the *Asterias* is exclusively...
marine, bottom dwelling or benthonic, inhabiting various types of sea floors, mainly in the littoral zones where they are cruising or concealed.

The knowledge of starfish biomass and abundance is very important given that this biota has the ecological value of balancing the ecosystem in the waters. There is not much publication and information about the biomass, abundance and distribution patterns of starfish, especially in the east coast of Surabaya. International research on Asterias sp. has been conducted by others such as Anger et al. [4] and Dalgic et al. [5] concerning in-situ investigations on the echinoderm Asterias rubens as a predator of soft-bottom communities in the western Baltic Sea. In addition, other studies of Asterias vulgaris and A. forbesi in several heterogeneous environments were carried out by Menge [6]. Other studies on the abundance and distribution patterns of Asteroidea include Freeman et al. [7] regarding Astropecten irregularis in the coastal waters of North Wales and also research on Oreaster reticulatus in St. Croix, U. S. Virgin Islands by Scheibling [8]. Research on Asterias sp. is still minimal in Indonesia. The research conducted so far has been more focused on Echinodermata in general as conducted by Aziz [2] and Supono and Arbi [9] in Pari Island. Therefore, this particular research is important as basic information on the ecology aspect of this biota and how environmental factors affect them. Here we report on the biomass, abundance, and pattern of spatial distribution of Asterias sp. populations, where the species has not been commercially harvested and its habitat remains largely impacted by human activities, but has a function in balancing the ecosystem.

2. Methodology
The study on starfish (Asterias sp.) was conducted in the east coast of Surabaya between January and March 2017. Samples were collected from three zones namely Wonokromo, Dadapan, and Juanda where each location was divided into three sites (figure 1) as five repetitions. Samples were collected using the swept area method [10] by using a local fishing tool names garit for 1 minute at the speed of about 3 km/hour for each repetition. Samples were preserved in a cold state. The number and biomass of starfish from each repetition were measured.

Figure 1. Map locations of the research.
3. Data Analysis

3.1. Biomass and abundance

The density (individual / m²) and biomass (kg / m²) of starfish were calculated based on the swept area method, based on the relationship between the speed of the fraction, the duration of the pull, the length of the garit and the length of the opening of the garit mouth. Stock density was mathematically calculated by using the following formula [10]:

Track distance: 
\[ D = V \cdot t \]  

Information:
\( D = \) track distance
\( V = \) The speed of the pull of a garit (km / h)
\( t = \) Length of withdrawal (hours)

Sweep area determination: 
\[ a = D \cdot h \]  

Information:
\( a = \) Sweep area (m²)
\( h = \) Length of garit (m)
\( D = \) Distance of the covered sweep path

Density / biomass was calculated using the formula
\[ Q = \frac{Cw}{ef} \]

Information:
\( Q = \) Density per sweep area (ind / m²) or biomass (kg / m²)
\( Cw = \) The catch per sweep area
\( a = \) Area of sweep (m²)
\( ef = \) Factor of breakthrough

3.2. Distribution pattern

To find out the distribution pattern of starfish, the method of Morisita distribution pattern [11] was used. The formula for its calculation is as follows:

\[ Id = \frac{n \cdot \sum X_i^2 - N}{N \cdot (N-1)} \]

Information:
\( Id = \) Morisita distribution index
\( n = \) Number of sampling plots
\( N = \) Total number of individuals gained
\( X_i = \) Number of individuals in the i sampling sequence

The results from the Morisita index are grouped as follows:
\( Id < 1: \) Distribution patterns are uniform
\( Id = 1: \) Individual distribution patterns are random
\( Id > 1: \) Individual distribution patterns are grouping

To test whether the distribution pattern is significantly different between the three zone, the Chisquarestatistical test [12] was subsequently carried out.
4. Results
The latest results show that the highest biomass of starfish was 2.95 tons/km$^2$ in the Dadapan Zone in January. Spatially, the highest biomass of starfish was found in the Dadapan Zone (figure 2). Similarly, the highest density was also found in the Dadapan Zone in January (9.3 ind/10 m$^2$) and the Dadapan zone generally had the highest density compared to the other locations (figure 3). In general, the distribution pattern of starfish in the east coast of Surabaya through spatial and temporal testing showed that the patterns of starfish was found to be as a clumped distribution for Dadapan and Juanda (Id value > 1) and uniform distribution for Wonokromo (id value < 1) (table 1).

![Figure 2. Biomass of Asterias sp. in East coast of Surabaya.](image)

![Figure 3. Biomass of Asterias sp. in East coast of Surabaya.](image)

**Table 1.** Distribution pattern of Asterias sp. in East Coast of Surabaya.

| Zone      | Id value | Distribution pattern         |
|-----------|----------|------------------------------|
| Wonokromo | 0.06     | Uniform distribution         |
| Dadapan   | 3.15     | Clumped distribution         |
| Juanda    | 9.13     | Clumped distribution         |
Environmental factors can affect the biomass, abundance, and distribution patterns of *Asterias* sp., such as oceanography conditions and water quality. Based on information from the Indonesian Agency for Meteorology, Climatology and Geophysics in Perak I [13], in general the value of the current velocity, wind velocity, and wave heights at the three zones observed in January was lower than February and March (figure 4). The water quality of the east coast of Surabaya is shown in table 2. Based on BOD value, all three zones have exceeded the quality standard of 20 mg/L [14]. Dadapan had the highest BOD value among the three zones. Based on the dissimilarity index, Wonokromo and Juanda had similar water quality characteristics (figure 5).

**Table 2.** Water Quality of East Coast of Surabaya.

| Parameters  | Units | Wonokromo     | Dadapan       | Juanda       |
|------------|-------|---------------|---------------|--------------|
| Temperature| ºC    | 28.67 ± 0.58  | 29.33 ± 1.53  | 30.00 ± 0    |
| Salinity   | ppt   | 31.67 ± 4.93  | 30.67 ± 1.15  | 30.00 ± 1.00 |
| pH         | -     | 8.13 ± 0.12   | 8.17 ± 0.15   | 6.77 ± 5.95  |
| Transparency| Cm  | 56.67 ± 15.28 | 55.00 ± 21.79 | 96.67 ± 25.17 |
| DO         | mg/l  | 5.00 ± 0      | 4.50 ± 0.87   | 7.33 ± 2.31  |
| TSS        | mg/l  | 32.67 ± 16.92 | 11.83 ± 6.25  | 15.83 ± 9.8  |
| BOD        | mg/l  | 27.60 ± 15.65 | 39.26 ± 10.01 | 35.10 ± 14.26 |
5. Discussion
Information on biota distribution helps to preserve species and also provides basic information for ecological studies [15]. In general, the high biomass and abundance in January especially in Dadapan was due to the low levels of oceanographic conditions which include wind velocity, current velocity and wave height (figure 4). This indicated that there was no high dispersion of starfish in that zone. The Wonokromo and Juanda zones almost had the same biomass and density. This is in accordance with the water quality habitat conditions that possess a high degree of similarity (figure 5). While the Dadapan zone has a lower level of similarity. The high biomass and abundance of starfish in Dadapan was indicated by the presence of organic material which can be seen from the high BOD value. This is because Dadapan has more than one river flowing into its waters indicating high organic material entering it. This is in contrast to Wonokromo and Juanda which only has one river flowing into them. This indicates that Dadapan has a richer food source compared to the other zones. According to Helm et al. [16] the presence of aquatic animals is strongly influenced by abiotic factors (eg temperature, salinity, dissolved oxygen and substrate) as well as biotic factors (eg food, predation and competition). All or a combination of several environmental variables can affect the growth and distribution of species.

The distribution pattern of Asterias sp. for Dadapan and Juanda are grouping, while it tends to be uniform for Wonokromo. This is also related to the type of substrate and availability of food in the living locations as well their adaptability. The grouping of macrozoobentos in certain places is suspected to be due to the movement of the slow macrobenthos [17]. The grouping distribution pattern is the most common form of dispersal in the ecosystem. This is because individuals in the population tend to form groups of various sizes. The grouping distribution occurs as a result of a response to the habitat locally [18]. The pattern of distribution in groups is due to the strategy of groups of individuals in response to changes in weather and seasons, as well as changes in habitat and the reproduction process [19]. The distribution of a population occurs due to habitat selection, predation and competition against other species, as well as both physical and chemical environmental factors [20]. Predation or competition is characterized by the presence of other species and also influences the distribution of species as they compete for space, food and other factors [21].
6. Conclusion
This research shows that the highest biomass and abundance of starfish was found in January. Spatially, *Asterias* sp. are commonly found in Dadapan. The oceanographic conditions, anthropogenic activity and water quality of the east coast of Surabaya are important factors that affect the biomass, density and distribution patterns of the starfish *Asterias* sp.

7. Reference
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