Plankton Community Structure in Seagrass Beds at Selangan Hamlet, Bontang City, East Kalimantan

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ABSTRACT

Plankton is an organism that lives floating in the water whose movement is influenced by the current. The presence of plankton in a water body can be used as a bioindicator because it has a high level of sensitivity and is also influenced by changes in water conditions. Changes in water conditions can be caused by human activities. The purpose of this study was to determine the structure of the plankton community in seagrass beds in the waters of Selangan Hamlet. This research was conducted in November-December 2019 in Selangan Hamlet, Bontang City, East Kalimantan. Data analysis includes abundance, diversity index, uniformity index and dominance index. The results showed that the composition of plankton species found in the waters of Selangan Hamlet at 4 stations with conditions at high tide and low tide obtained 13 plankton classes namely *Cyanophyceae*, *Bacillariophyceae*, *Oligotrichea*, *Dinophyceae*, *Foraminifera*, *Chlorophyceae*, *Trebouxiophyceae*, *Conjugatophyceae*, *Hexanauplia*, *Crustaceae*, *Gastropoda*, *Tubulinea*, and *Euglenoidea* consisting of 47 plankton species. Plankton abundance ranged from 893-2,514 ind/L. The structure of the plankton community in the waters of Selangan Hamlet has a Diversity Index (H') value in the medium category with a range of values of 2.28-2.99, Diversity Index (E) category of stable plankton communities with a range of values of 0.82-0.95, and Dominance Index (C) category there is no dominant genus at each research station with a range of values of 0.06-0.14.

INTRODUCTION

Plankton is an important type of biota that plays a significant role in aquatic ecosystems. Plankton consists of microscopic organisms that float in the water or have very limited swimming ability, and their movement is always influenced by water currents (Nybakken, 1992). Plankton is divided into two major groups: phytoplankton and zooplankton. Phytoplankton are plankton that can perform photosynthesis and are therefore referred to as primary producers. Phytoplankton serve as natural food for aquatic organisms, including zooplankton and small fish, whereas zooplankton are the first consumers in aquatic ecosystems that feed on primary producers, namely phytoplankton (Nontji, 2008). The abundance of zooplankton in a body of water can indicate the availability of food as well as the environmental carrying capacity that supports the life of aquatic organisms. Thus, changes in a water region can be detected by observing changes in zooplankton abundance (Nybakken, 1992).

Considering the important role of plankton in maintaining the balance of aquatic ecosystems, particularly marine ecosystems in the waters of Selangan Hamlet, the author is interested in conducting research on the plankton community structure in the seagrass beds of Selangan Hamlet waters.

METHODOLOGY

Research Location

The determination of sampling stations was based on the purposive sampling method, meaning the selection of locations was made with specific considerations (Sugiyono, 2016). The research area was divided into four stations, located to the north, south, east, and west of Selangan Hamlet.

1. Station A (North) : Around the Long Pier
2. Station B (East) : A ship traffic route
3. Station C (South) : Around the mangrove ecosystem
4. Station D (West) : Around the fishing gear area (Belat)

Each station was sampled three times at 15-day intervals, with sampling conducted during both high and low tides. Supporting data for this research was collected through measurements of water quality parameters. These measurements are presented in Table 1.

Table 1. Water Quality Parameters

No.	Parameter	Unit	Measurement Tool/Method	Location
1.	Temperature	^{o}C	Thermometer	*Insitu*
2.	Current Speed	m/s	Current ball	*Insitu*
3.	Clarity	cm	*Sechi disk*	*Insitu*
4.	Turbidity	NTU	Turbidimeter	*Exsitu*
5.	pH	-	pH meter	*Exsitu*
6.	Salinity	ppt	Refractometer	*Exsitu*
7.	Dissolved Oxygen	mg/L	Titration	*Exsitu*
8.	Nitrate	mg/L	Spectrofotometer	*Exsitu*
9.	Phosphate	mg/L	Spectrofotometer	*Exsitu*

Plankton sampling was carried out using the filtration method, by collecting 100 liters of seawater and filtering it down to 50 ml using a plankton net. The sample was then preserved with 4 drops of Lugol's solution, sealed, labeled, and stored in a cool box for plankton identification at the Water Quality Laboratory, Faculty of Fisheries and Marine Science, Mulawarman University.

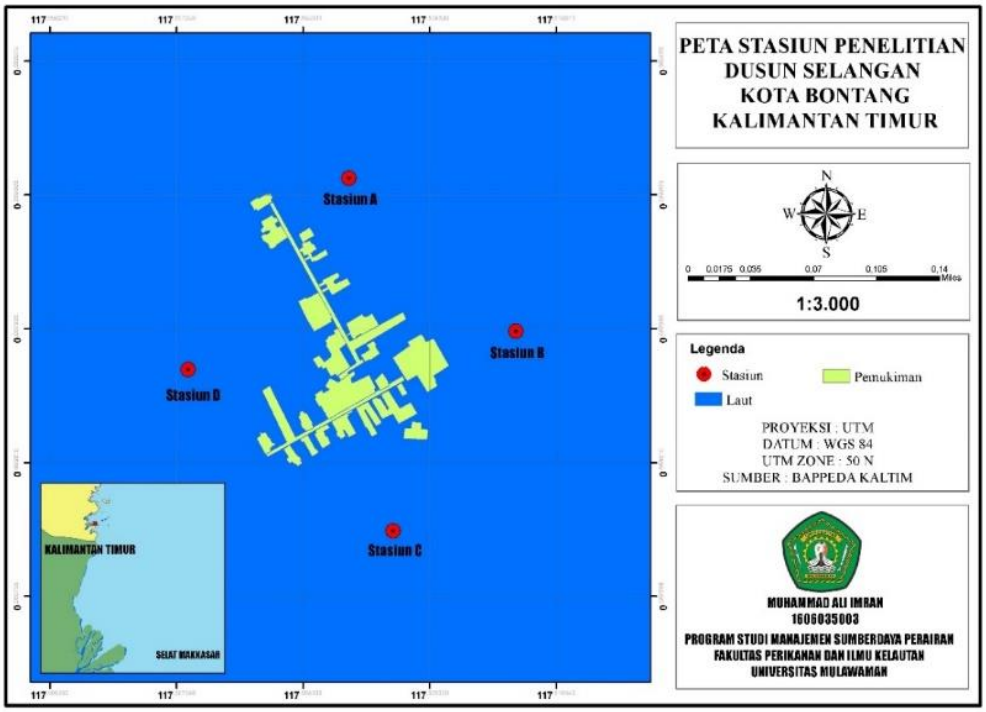

Figure 1. Study area map

Data Analysis

Plankton Abundance

Plankton abundance is expressed quantitatively in cells per liter. The Sachlan (1972) formula used is:

$$F = \frac{A}{B} x \frac{C}{D} x \frac{1}{E} xN$$

Explanation:

F = Number of individuals per liter
A = Cover glass area (20x20 mm²)
B = Field of view area (3.14 x 0.92 mm²)
C = Filtered sample volume (50 ml)
D = Examined sample volume (0.3 ml)
E = Filtered sample volume (100 liters)
N = Number of organisms found

Diversity Index

The diversity index mathematically represents the population of organisms to simplify the analysis of the number of individuals of each species in a community. It uses the Shannon-Wiener equation (Krebs, 1989):

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

Explanation:

H' = Shannon-Wiener diversity index
pi = ni/N (proportion of the i-th species)
ni = Number of individuals of the i-th species
N = Total number of individuals

Evenness Index

The evenness index is used to determine the degree of similarity in the distribution of individuals among genera in a community. The equation from Krebs (1978) is:

$$E = \frac{H'}{\ln S}$$

Explanation:

E = Evenness index
H' = Diversity index
ln S = Number of species

Dominance Index

According to Odum (1996) in Faza (2012), the formula for calculating the dominance index is:

$$C = \Sigma(\frac{ni}{N})^2$$

Explanation:

C = Dominance index
ni = Number of individuals of the i-th species
N = Total number of individuals

Principal Component Analysis (PCA)

According to Legendre & Legendre (1983), the formula for PCA calculation is:

$$d^2_{(I,I')} \sum_{j=1}^{p} (\frac{X_{ij}}{X_{i'}} - X_{i'j})$$

Explanation:

d = Euclidean distance
I, I' = Two stations in the rows
j = Physico-chemical parameter in the columns, varying from 1 to p

Correspondence Analysis (CA)

According to Legendre & Legendre (1983), the formula for CA calculation is: Explanation:

$$d^2_{(I,I')} \sum_{j=1}^{p} (\frac{X_{ij}}{X_{i'}} - X_{i'j})$$

d_2 = Chi-squared distance
i, i = Two stations in the rows
Xi = Total of row i for all columns
Xj = Total of column j for all rows

RESULT AND DISCUSSION

Plankton Species found in the waters of Selangan Hamlet at four stations, during both high and low tides, included 13 classes of plankton: Bacillariophyceae, Chlorophyceae, Conjugatophyceae, Crustaceae, Cyanophyceae, Dinophyceae, Euglenoidea, Foraminifera, Gastropoda, Hexanauplia, Oligotrichea, Trebouxiophyceae, and Tubulinea, comprising 47 species in total. Phytoplankton species identified include: *Achnanthes sp.*, *Amphidinium sp.*, *Amphora sp.*, *Bacillaria sp.*, *Biddulphia sinensis*, *Ceratium sp.*, *Chaetoceros sp.*, *Climacosphenia sp.*, *Coscinodiscus sp.*, *Cyclotella sp.*, *Cymbella sp.*, *Dinophysis caudata*, *Ditylum sol*, *Foraminifera sp.*, *Fragilaria sp.*, *Gymnodinium sp.*, *Gyrosigma sp.*, *Lyngbya martensiana*, *Melosira sp.*, *Meridion sp.*, *Navicula sp.*, *Nitzschia sp.*, *Oedogonium sp.*, *Oscillatoria sp.*, *Pinnularia sp.*, *Pleurosigma sp.*, *Prorocentrum sp.*, *Protoperidinium sp.*, *Skeletonema sp.*, *Spirogyra sp.*, *Stichococcus sp.*, *Synedra sp.*, *Thalassionema sp.*, *Thalassiosira sp.*, *Thalassiothrix sp.*, *Tintinnopsis sp.*, and *Trichodesmium sp.* Zooplankton species identified include: *Acartia sp.*, *Arcella vulgaris*, *Calanus sp.*, *Euglena sp.*, *Eurytemora pacifica*, *Nauplius sp.*, *Oithona davisae*, *Tigriopus japonicus*, *Trachelomonas sp.*, and *Veliger* larvae.

Table 1. The Abundance of Plankton Found in the Waters of Selangan Hamlet

Value	North St.		East St.		South St.		West St.	
	High	Low	High	Low	High	Low	High	Low
Range (Ind/L)	364 – 702	1014 – 1430	1274 -2002	858 – 1066	1560 – 2288	2158 - 3796	1170 - 1872	1456 - 2210
Average	572	1213	1655	962	1959	3068	1491	1872

Based on the analysis and calculations from all stations, the highest plankton abundance was recorded at the South Station during low tide, with 3,068 individuals/liter. The lowest plankton abundance was observed at the North Station during low tide, with 572 individuals/liter. The species with the highest abundance was *Amphora sp.*, with 6,084 individuals/liter, while the species with the lowest abundance was *Dinophysis caudata*, with 26 individuals/liter.

Amphora sp. is a species of benthic diatoms belonging to the Order Pennales. According to Bold and Wynne (1985), species from the Order Pennales typically dominate benthic habitats, while those from the Order Centrales are more common in the water column. This explains the high abundance of *Amphora sp.* during low tide. *Dinophysis caudata* is a species of marine phytoplankton from the class Dinophyceae, and its distribution is found nearly worldwide in both temperate and tropical climates. According to Reguera et al. (2012), *Dinophysis caudata* is one of 12 species capable of producing toxins known as Dinophysistoxins (DTXs) and Okadaic Acid (OA). These toxins can cause Diarrhetic Shellfish Poisoning (DSP) in humans when consumed through contaminated shellfish.

Table 2. Plankton Diversity, Evenness, and Dominance Indexes at High Tide

Index	Northern Station		Eastern Station		Southern Station		Western Station	
	Range	Average	Range	Average	Range	Average	Range	Average
H'	2,07-2,64	2,285	2,51-2,70	2,597	2,89-3,12	2,993	2,84-2,99	2,937
E	0,94-0,98	0,957	0,87-0,93	0,904	0,92-0,92	0,921	0,93-0,94	0,933

C	0,08-0,14	0,114	0,08-0,10	0,091	0,06-0,07	0,062	0,06-0,07	0,064

Note: H' = Diversity, E = Evenness, C = Dominance

Based on the results above, it can be concluded that the plankton community structure during high tide has the following characteristics:

- The **Plankton Diversity Index (H')** falls into the **Moderate** category [1<H′<3][1 < H' < 3][1<H′<3].
- The **Plankton Evenness Index (E)** falls into the category of a **Stable** plankton community [0.75≤E≤1][0.75 ≤ E ≤ 1][0.75≤E≤1].
- The **Plankton Dominance Index (C)** falls into the category where **no genus dominates** [0<C≤0.5][0 < C ≤ 0.5][0<C≤0.5].

Table 3. Plankton Diversity, Evenness, and Dominance Indexes at Low Tide.

Index	**Northern Station**		**Eastern Station**		**Southern Station**		**Western Station**	
	Range	Average	Range	Average	Range	Average	Range	Average
H'	2,40-2,49	2,451	2,21-2,39	2,330	2,61-2,78	2,715	2,35-2,51	2,444
E	0,93-0,94	0,937	0,86-0,88	0,876	0,81-0,85	0,824	0,83-0,85	0,836
C	0,09-0,10	0,099	0,13-0,14	0,135	0,11-0,12	0,117	0,13-0,16	0,141

Based on the results above, it can be concluded that the plankton community structure during low tide has the following characteristics:

- The **Plankton Diversity Index (H')** falls into the **Moderate** category [1<H′<3][1 < H' < 3][1<H′<3].
- The **Plankton Evenness Index (E)** falls into the category of a **Stable** plankton community [0.75≤E≤1][0.75 ≤ E ≤ 1][0.75≤E≤1].
- The **Plankton Dominance Index (C)** falls into the category where **no genus dominates** [0<C≤0.5][0 < C ≤ 0.5][0<C≤0.5].

Table 4. Physical-Chemical Water Parameter Measurements During High and Low Tides.

Parameter	Northern Station		Eastern Station		Southern Station		Western Station		PP No. 22 of 2021
	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide	High Tide	Low Tide	
Current Speed	7	4	6	4	6	4	5	5	cm/s
Temperature	29,9	30,0	29,6	29,3	30,3	28,9	30,4	28,2	28-30 °C
Clarity	1,47	0,31	1,32	0,37	1,19	0,43	1,07	0,55	> 3 m
Turbidity	0,33	11,71	0,15	0,81	0,61	2,82	0,00	5,22	5 NTU
pH	8,00	8,59	8,05	8,19	8,02	8,26	8,02	8,26	7–8,5
DO (Dissolved Oxygen)	5,00	4,02	4,66	4,49	4,44	4,66	3,95	4,80	>5 mg/L
Salinity	34,67	34,67	34,33	34,00	34,00	34,00	34,00	33,67	33-34 ‰

Nitrate	0,392	0,266	0,189	0,320	0,292	0,227	0,406	0,264	0,06 mg/L
Phosphate	0,017	0,013	0,033	0,020	0,019	0,019	0,015	0,012	0,015 mg/L

The results of water quality measurements in the waters of Dusun Selangan show that the current speed in the waters ranges between 4-7 cm/s, which falls into the very slow category. This is based on Mason's (1981) statement, which classifies water currents as very fast (>100 cm/s), fast (20-100 cm/s), moderate (25-50 cm/s), slow (10-25 cm/s), and very slow (<10 cm/s). The water temperature ranges from 28.2-30.4°C, which is still within the seawater quality standard range. Water clarity ranges between 0.31-1.47 m, which is also within the seawater quality standards. Turbidity at two stations exceeded the seawater quality standards during low tide, with 11.71 NTU at the North Station and 5.22 NTU at the West Station. The water pH ranged from 8.00-8.59, still within the seawater quality standards. Dissolved oxygen (DO) in the waters ranged from 3.95-5.00 mg/l, which is considered good for plankton life. This aligns with Sunarti's (2002) statement that plankton can thrive at DO concentrations above 3 mg/l. Water salinity ranged from 33.67-34.67‰, a level still tolerable for plankton life, in line with Isnansetyo & Kurniastuty's (1995) statement that optimal salinity for plankton is 20-35‰. Nitrate levels ranged from 0.189-0.406 mg/l, which is still tolerable for plankton life. This agrees with Mackentum's (1969) statement that nitrate levels below 0.144 mg/l are limiting for plankton growth, with optimal levels between 3.9-15.5 mg/l. However, according to Government Regulation No. 22 of 2021 regarding seawater quality standards, the nitrate levels in the waters of Dusun Selangan have exceeded the standard limits. Phosphate levels ranged from 0.012-0.033 mg/l, which also exceeded the seawater quality standards. Phosphate is often considered a limiting factor for phytoplankton growth in natural waters if it is below 0.004 ppm, while levels above 1.0 ppm can lead to blooms (Mackentum, 1969).

Distribution of Physical-Chemical Characteristics of Waters

The results of the Principal Component Analysis (PCA) are used to describe the correlation between water quality parameter variables (current speed, temperature, clarity, turbidity, pH, DO, salinity, nitrate, and phosphate) and habitats (stations) in the form of graphs under high tide and low tide conditions. The PCA analysis results for the waters of Dusun Selangan can be seen in Figures 2 and 3.

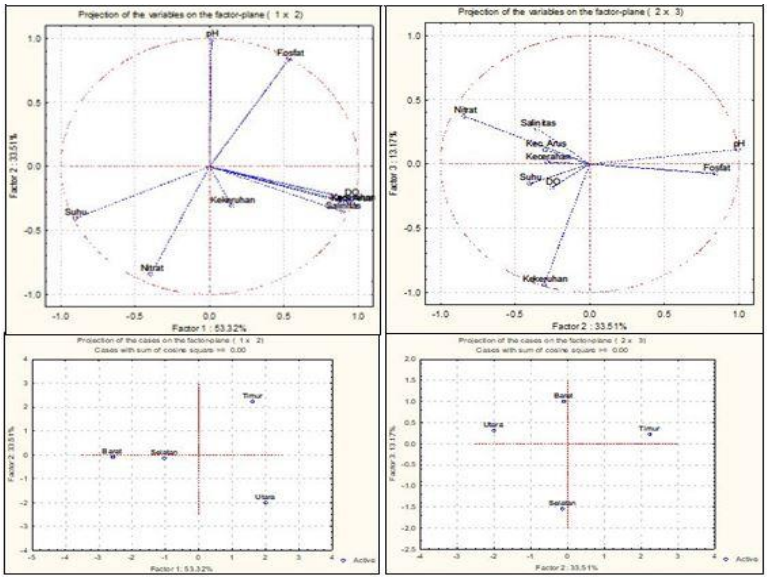

Figure 2. Results of the PCA analysis of the physical-chemical characteristics of the water during high tide in the waters of Dusun Selangan.

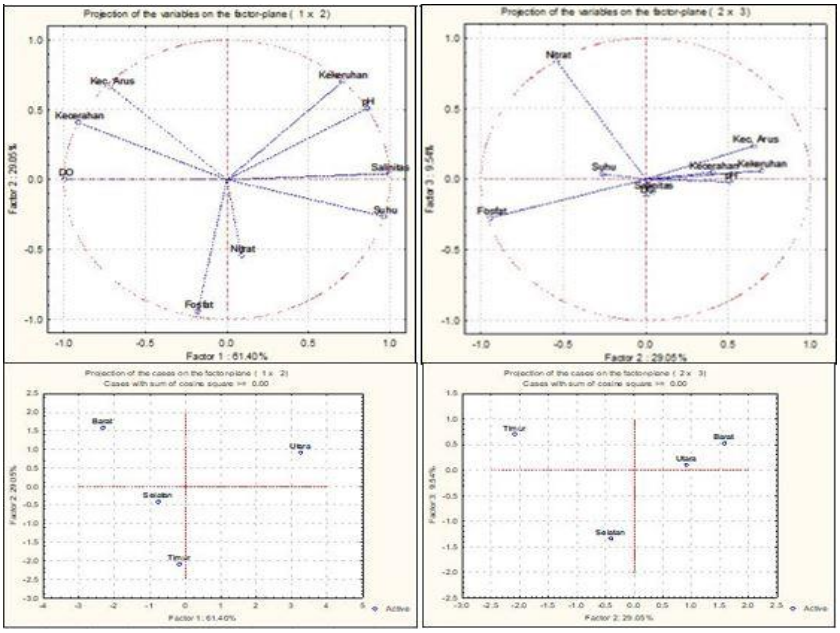

Figure 3. Results of the PCA analysis of the physical-chemical characteristics of the water during low tide in the waters of Dusun Selangan.

Distribution of Plankton Communities with Habitat Characteristics

Principal Component Analysis (PCA) and Correspondence Analysis (CA) during high tide in the waters of Dusun Selangan reveal the following:

- **North Station:** Characterized by high nitrate levels and closely associated with the distribution of plankton species such as *Arcella vulgaris*, *Climacosphenia sp.*, *Cymbella sp.*, *Euglena sp.*, and *Meridion sp.*
- **East Station:** Characterized by high pH and phosphate levels and closely associated with the distribution of plankton species such as *Amphora sp.*, *Calanus sp.*, *Coscinodiscus sp.*, *Dinophysis caudata*, *Ditylum sol*, *Nitzschia sp.*, and *Tintinnopsis sp.*
- **West Station:** Characterized by high temperature and closely associated with the distribution of plankton species such as *Acartia sp.*, *Amphidinium sp.*, *Foraminifera sp.*, *Nauplius*, *Navicula sp.*, *Oithona davisae*, *Prorocentrum sp.*, *Stichococcus sp.*, *Trachelomonas sp.*, and *Veliger larva*
- **South Station:** Characterized by high turbidity and closely associated with the distribution of plankton species such as *Cyclotella sp.*, *Gymnodinium sp.*, *Melosira sp.*, *Oedogonium sp.*, *Protoperidinium sp.*, *Spyrogira sp.*, *Thalassiosira sp.*, *Thalassiothrix sp.*, and *Trichodesmium sp.*

During low tide, PCA and CA reveal the following:

- **North Station:** Characterized by high temperature, pH, and salinity and closely associated with the distribution of plankton species such as *Bacillaria sp.*, *Calanus sp.*, *Ditylum sol*, *Navicula sp.*, *Pinnularia sp.*, *Protoperidinium sp.*, *Stichococcus sp.*, *Synedra sp.*, *Thalassiosira sp.*, and *Tintinnopsis sp.*
- **East Station:** Characterized by high phosphate levels and closely associated with the distribution of plankton species such as *Coscinodiscus sp.*, *Meridion sp.*, and *Nitzschia sp.*
- **West Station:** Characterized by high clarity and dissolved oxygen (DO) and closely associated with the distribution of plankton species such as *Achnanthes sp.*, *Arcella vulgaris*, *Climacosphenia sp.*, *Fragilaria sp.*, *Melosira sp.*, *Pleurosigma sp.*, and *Thalassionema sp.*
- **South Station:** Characterized by low nitrate levels and closely associated with the distribution of plankton species such as *Ceratium sp.*, *Eurytemora pacifica*, *Oithona davisae*, *Oscillatoria sp.*, *Tigriopus japonicus*, *Trichodesmium sp.*, and *Veliger larva.*

CONCLUSION

Plankton species found in the waters of Dusun Selangan include the following for phytoplankton: *Achnanthes* sp., *Amphidinium* sp., *Amphora* sp., *Bacillaria* sp., *Biddulphia sinensis*, *Ceratium* sp., *Chaetoceros* sp., *Climacosphenia* sp., *Coscinodiscus* sp., *Cyclotella* sp., *Cymbella* sp., *Dinophysis caudata*, *Ditylum sol*, *Foraminifera* sp., *Fragilaria* sp., *Gymnodinium* sp., *Gyrosigma* sp., *Lyngbya martensiana*, *Melosira* sp., *Meridion* sp., *Navicula* sp., *Nitzschia* sp., *Oedogonium* sp., *Oscillatoria* sp., *Pinnularia* sp., *Pleurosigma* sp., *Prorocentrum* sp., *Protoperidinium* sp., *Skeletonema* sp., *Spirogyra* sp., *Stichococcus* sp., *Synedra* sp., *Thalassionema* sp., *Thalassiosira* sp., *Thalassiothrix* sp.,*Tintinnopsis* sp., *dan Trichodesmium* sp. Zooplankton species obtained include *Acartia* sp., *Arcella vulgaris*, *Calanus* sp., *Euglena* sp., *Eurytemora pacifica*, *Nauplius* sp., *Oithona davisae*, *Tigriopus japonicus*, *Trachelomonas* sp., and *Veliger larva.*

The structure of the plankton community in the waters of Dusun Selangan has a Diversity Index (H') in the moderate category, a Uniformity Index (E) indicating a stable plankton community, and a Dominance Index (C) indicating that no genus dominates at each research station. Plankton abundance during low tide (858-3,796 ind/L) is higher than during high tide (364-2,288 ind/L). The highest plankton abundance is found at the Southern Station, while the lowest is at the Northern Station. The species with the highest abundance is Amphora sp., with 6,084 individuals per liter, while the species with the lowest abundance is Dinophysis caudata, with 26 individuals per liter.

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