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Species Composition and Abundance of Zooplankton at Different Depths in the Waters of Teluk Makmur Subdistrict, Dumai City

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ABSTRACT

Teluk Makmur in Dumai City is a coastal area experiencing ecological pressure due to human activities, such as tourism and industry. Changes in water quality in this region may affect the structure of the zooplankton community, which plays a crucial role in the food chain. This study aims to determine the species and abundance of zooplankton at various depths and stations. The research was conducted in November 2024 at Koneng Beach, Marina Beach, and Puak Beach. At each station, samples were collected at three depths (1 m, 3 m, and 5 m) using survey and purposive sampling techniques. Water quality parameters such as temperature, salinity, DO, pH, transparency, current, nitrate, and phosphate were also measured. Identification revealed five zooplankton species from the class Hexanauplia: *Acartia* sp., *Calanus* sp., *Temora turbinata*, *Oithona* sp., and *Nauplius* sp. The highest abundance was recorded at a depth of 5 m (41,542 ind/l), while the lowest abundance was found at depths of 1 m and 3 m (0 ind/l). Based on stations, the highest abundance was observed at Station I (27,694.67 ind/l) and the lowest at Station II (8,308.33 ind/l). One-way ANOVA test results showed no significant difference in zooplankton abundance either between depths or between stations ($p > 0.05$).

Keywords: Zooplankton, Abundance, Zooplankton Species, Teluk Makmur

1. INTRODUCTION

Plankton are microscopic organisms with limited mobility, generally drifting with water currents. Plankton is classified into two main groups: phytoplankton, which function as primary producers, and zooplankton, which act as the first-level consumers in the food chain (Chusna et al., 2024). Zooplankton acts as a link between phytoplankton and higher trophic-level organisms. This aligns with the statement by Amri et al. (2020), who emphasized that the presence of zooplankton significantly influences the ecological stability of aquatic environments and the continuity of the food chain.

Marine zooplankton comprises a diverse array of organisms, including copepods, small jellyfish, and fish larvae. These organisms play an essential role in the trophic system of marine waters and can also serve as bioindicators for assessing the quality of the aquatic environment. Samiaji (2021) stated that the composition and abundance of zooplankton can reflect the condition of the waters in which they live.

One of the coastal areas with significant potential but facing ecological pressures is Teluk Makmur, a subdistrict located in Medang Kampai District, Dumai City, Riau Province. In addition to its aquatic ecosystem, Teluk Makmur is also known for its tourism appeal, with sites such as Marina Beach and Koneng Beach frequently visited for recreation, photography, and sports activities (Saputri & Nurjannah, 2024). Unfortunately, increasing human activities, such as the development of beach facilities and waste disposal, have triggered environmental degradation in these waters. The resulting changes in water quality are a concern, as they may affect biodiversity, including zooplankton communities that are highly sensitive to shifts in environmental conditions.

Previous studies have shown that the species composition and abundance of zooplankton can be early indicators of ecological stress. This study focuses on zooplankton rather than phytoplankton because zooplankton exhibit diel vertical migration, making them more relevant for analysis across different water depths. This movement allows zooplankton to be present throughout the water column, from the surface layer to specific depths. However, to date, no similar research has been conducted in the waters of Teluk Makmur despite the urgent need for such data to assess the overall condition of the ecosystem.

Therefore, this study was conducted to gather data on the types of zooplankton present and their abundance at various depths and stations in the waters of Teluk Makmur Subdistrict.

2. RESEARCH METHOD

Time and Place

This research was conducted in November 2024 in the waters of Teluk Makmur Subdistrict, Dumai City. The samples were subsequently analysed at the Marine Biology Laboratory, Department of Marine Science, Faculty of Fisheries and Marine Science, Universitas Riau.

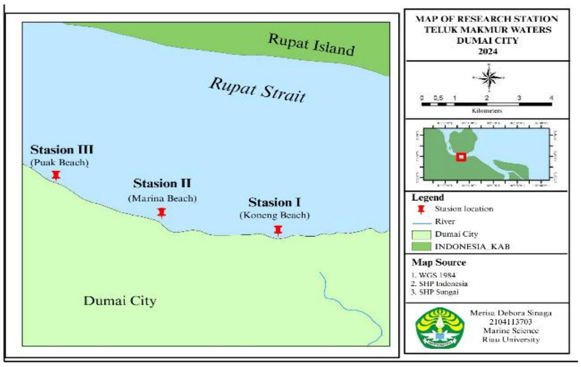


Figure 1. Map of the research station

Method

Sampling stations were determined using a purposive sampling technique and were divided into three groups. Station I is located at Koneng Beach, approximately 300 m from the shoreline, near an estuary. Station II is located at Marina Beach, approximately 300 m from the shore, in a well-known tourist area. Station III is situated in the Puak area, approximately 300 meters from the shoreline, and is considered to have minimal human activity, thereby making it ecologically more stable.

Procedures

Sampling Point Determination Based on Depth

Zooplankton sampling was conducted using a stratified sampling method. Samples were taken from three water layers: the surface layer at a depth of 1 m, the middle layer (between the surface and bottom) at a depth of 3 m, and the bottom layer at a depth of 5 m. Sampling at these depth points was carried out in the same manner and at the same depths at all three stations.

Zooplankton Sampling

Zooplankton samples were collected at 09:00 AM local time, during high tide and before the sun became too intense. The samples were taken vertically using a 10-litre Van Dorn water sampler at three different depths. The collected water was transferred into a bucket and filtered using a No. 25 plankton net, resulting in a concentrate of approximately 125 ml. This concentrate was then moved into a labelled sample bottle and preserved by adding 3–4 drops of 4% Lugol's solution. The samples were stored in an ice box and transported to the laboratory for further analysis.

Water Quality Measurement

The environmental parameters measured included temperature, transparency, current velocity, pH (DO), salinity, nitrate, and phosphate. These parameters were measured at all three sampling stations.

Zooplankton Sample Identification

Zooplankton samples collected from the field were observed in the laboratory using a microscope and identified based on the identification guides by Yamaji (1984); Davis (1995). Observations were conducted using an Olympus CX21 microscope at a magnification of 10 × 10, employing the field-of-view method, with each observation encompassing 12 fields of view (Nurrachmi et al., 2021).

Zooplankton Abundance Calculation

According to APHA (2005), zooplankton abundance is calculated using the following formula:

$$N = \frac{O_i}{O_p} \times \frac{V_r}{V_o} \times \frac{1}{V_s} \times \frac{n}{p}$$

Information:

N	:	Zooplankton abundance (ind/L)
O_i	:	Area of the cover glass (625 mm²)
O_p	:	Area of the microscope field of view (1.306 mm²)
Vr	:	Volume of sample in the bottle (125 ml)
Vo	:	Volume of sample under the cover glass (0.06 ml)
Vs	:	Volume of water filtered (10 L)
n	:	Total number of zooplankton observed in all fields of view (ind)
p	:	Number of fields of view observed (12 fields)

Relative Abundance of Zooplankton

Relative abundance (RA) refers to the

proportion of individuals of species *i* compared to the total number of individuals of all species, expressed as a percentage. The calculation follows the formulation by Odum (1971):

$$KR = \frac{\text{ni}}{\text{N}}\ x\ 100$$

Information:

KR : Relative abundance (%)
ni : Abundance of a specific species (ind/l)
N : Total abundance of all species (ind/l)

Data Analysis

The collected data were presented in tables and graphs, and then analyzed descriptively to interpret the prevailing water conditions. A one-way ANOVA statistical test was performed to determine differences in zooplankton abundance between stations and across different depths..

3. RESULT AND DISCUSSION

Water Quality

This study was conducted in Teluk Makmur Subdistrict, Medang Kampai District, Dumai City, Riau Province. Geographically, Teluk Makmur is located at coordinates 1˚36'50.4" North Latitude and 101˚31'4.8" East Longitude (Figure 1).

Teluk Makmur has a flat topography, with soil types dominated by organic peat. Sandy clay is also commonly found along the coastline, extending 2–3 km inland. The subdistrict features several coastal destinations, including Koneng Beach, Marina Beach, and Puak Beach. Additionally, it is home to a Malay tourism village facing directly toward Rupat Island and the Malacca Strait (Kausarian, 2019).

During sampling, the weather conditions were slightly overcast, and it had rained earlier in the morning. The beach environment was relatively calm, with few visitors, allowing sampling activities to be carried out without significant disturbance. Based on water quality measurements, the results of water quality parameters in the waters of Teluk Makmur are presented in Table 1.

Table 1. Results of water quality measurements in Teluk Makmur

Stasion	Depth	Parameter							
		Temperature (°C)	Salinity (ppt)	DO (mg/L)	pH	Brightness (cm)	Current (m/s)	Nitrate (mg/L)	Phospate (mg/L)
I	1	28.4	18	6.7	5.91	75	0.123	0.053	0.131
	3	29.2	25	10.6	6.2	-	-	0.073	0.126
	5	25	24	10.5	7.36	-	-	0.052	0.103
II	1	29.6	23	6.5	7.36	135	0.303	0.040	0.140
	3	25	23	6.2	7.2	-	-	0.055	0.102
	5	29.5	24	7.3	7.28	-	-	0.072	0.126
III	1	29	29	5.9	6.9	78	0.186	0.044	0.099
	3	29	29	5.7	7.3	-	-	0.065	0.116
	5	30	30	5.7	6.9	-	-	0.070	0.102

Table 2. Zooplankton species found in the waters of Teluk Makmur

Class	Station	I			II			III		
	Depth (m) / Species	1	3	5	1	3	5	1	3	5
Hexanauplia	*Calanus* sp.	*				*				*
	Acartia sp.			*			*			*
	Oithona sp.	*	*	*				*		
	Temora turbinata			*			*			
	Nauplius sp.		*							*
Total		2	2	3	0	1	2	1	0	3

Identified Zooplankton Species

Based on the identification results, the zooplankton found in the waters of Teluk Makmur consisted of several species belonging to the class Hexanauplia. Four. In contrast, sed as holoplankton, namely *Acartia* sp., *Calanus* sp., *T. turbinata*, and *Oithona* sp., while one species, Nauplius sp., was categorized as meroplankton.

The zooplankton species found in the waters of Teluk Makmur belong to the class Hexanauplia. The dominance of *Hexanauplia* zooplankton is presumed to be related to their strong adaptability, which enables them to survive and thrive under various aquatic conditions (Witariningsih et al., 2020). *Oithona* sp. was the most abundant species found in the waters of Teluk Makmur, with a relative abundance of 31.57%. The high number of individuals of this species is attributed to its wide distribution and frequent occurrence in tropical regions, both in freshwater and marine environments, as well as in tidal areas and bottom sediments (Novianto & Efendy, 2020). Moreover, *Oithona* sp has a short life cycle (14–16 days) and a high reproductive capacity (Table 2).

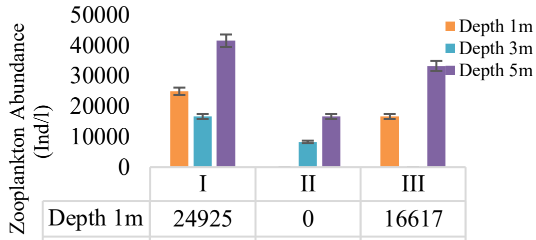
Nauplius sp. was the least abundant species, with a relative abundance of 10.52%. *Nauplius* sp. is the larval stage of copepods and is categorised as meroplankton (Handayani & Patria, 2010). Several abiotic factors, such as light intensity and water current, may influence. *Nauplius* sp has low abundance in Teluk Makmur waters. In addition, biotic factors not observed in this study, such as predation, may also influence zooplankton distribution by reducing population numbers (Jimmy et al., 2023).

Based on Table 2, *Oithona* sp and *Calanus* sp. were found at all depth levels. This may be attributed to the suitability of environmental conditions, particularly water temperature, at each depth for the optimal growth of *Oithona* sp, which thrives at 25–30°C (Isnan et al., 2021). Although both species were present across all depths, *Calanus* sp. showed a broader distribution. Unlike *Oithona* sp, *Calanus* sp is a cosmopolitan species (Razai et al., 2018) and thus can be found across all sampling stations.

While *Oithona* sp and *Calanus* sp were found at every depth, *Acartia* sp and *T. turbinata* were only recorded at a depth of 5 m. According to a study by Elijonnahdi et al. (2012), T. turbinata inhabit deeper waters, specifically at depths of 8–9 m during morning and evening hours. This behaviour is likely due to the species' tendency to avoid sunlight, making it rarely observed in surface layers that are still influenced by the sunlight.

Zooplankton Abundance Based on Depth

The observed zooplankton abundance in the waters of Teluk Makmur varied across different depths, ranging from 0 to 41,542 ind/l. The abundance values by depth are illustrated in Figure 2.



	I	II	III
Depth 1m	24925	0	16617
Depth 3m	16617	8308	0
Depth 5m	41542	16617	33233

Figure 2. Zooplankton abundance based on depth

As shown in Figure 2, the highest zooplankton abundance was recorded at a depth of 5 m across all stations, with the maximum value reaching 41,542 ind/l. The high abundance of zooplankton at 5 m is likely due to their negative phototactic behaviour, meaning they tend to avoid sunlight. In addition, zooplankton often move away from light to reduce predation risk (Wati et al., 2019). Another contributing factor is current velocity. Waters with stronger currents tend to have lower zooplankton abundance, while areas with weaker currents support higher abundance. Nusratina et al. (2023) stated that current velocity is generally more substantial near the surface and decreases with depth. As currents weaken closer to the seabed, zooplankton abundance at 5 m tends to be higher than at depths of 1 and 3 m.

At a depth of 1 m, zooplankton abundance ranged between 0 and 24,925 ind/l, indicating that environmental conditions at this depth may be less favourable for zooplankton. According to Table 1, the current velocity and water transparency at 1 m depth in Station II were relatively high compared to Stations I and III. High current velocity and water clarity can negatively impact the abundance of zooplankton. In areas with strong water currents, zooplankton abundance tends to be lower, whereas in areas with slower currents, zooplankton abundance is generally higher (Yuliana & Ahmad, 2017).

At a depth of 3 m, zooplankton abundance significantly declines at certain stations. Station I recorded an abundance of 16,617 ind/l, while Station II showed 8,308 ind/l. However, no zooplankton were found at Station III at this depth (0 ind/l). This distribution pattern is likely influenced by oxygen limitation at this depth. The DO level at 3 m in Station III was relatively low compared to the other stations. Oxygen is an essential macronutrient required for the survival, physiological processes, and metabolism of aquatic organisms. A decline in DO concentration can affect zooplankton abundance and may lead to hypoxic conditions if it drops to a critical threshold (Mubarak et al., 2010).

Zooplankton Abundance Based on Station

Zooplankton abundance by station is presented in Figure 3.

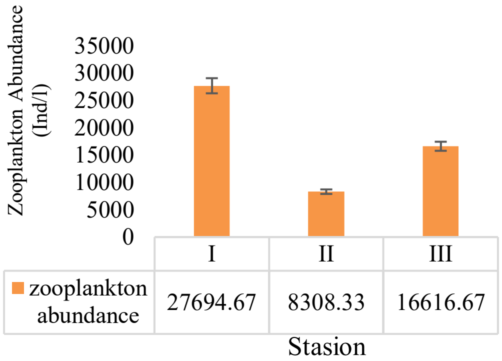


Figure 3. Zooplankton abundance based on the station

According to Figure 3, the highest zooplankton abundance was recorded at Station I, with a value of 27,694.67 ind/l. This high abundance at Station I can be attributed to its proximity to an estuary. Estuarine areas often receive nutrient input from terrestrial sources carried by river flow, which enhances nutrient availability. Increased nutrient levels can boost phytoplankton productivity, which serves as the primary food source for zooplankton (Nurfadilah & Lukman, 2020). Additionally, the relatively lower current velocity at Station I compared to the other stations may also support a higher zooplankton abundance, as water currents influence zooplankton movement.

The second-highest zooplankton abundance was observed at Station III, with a value of 16,616.67 ind/l. This Station is located in an area with minimal human activity. Aquatic environments with less anthropogenic disturbance tend to have more stable water quality parameters, essential for supporting aquatic ecosystems (Hamuna et al., 2018).

Water quality param such as temperature (ranging from 29–30°C), salinity (20–23 ppt), pH (6.9–7.3), and DO (5.7–5.9 mg/l) are still considered suitable and within acceptable limits to support zooplankton survival, based on the Indonesian Government Regulation No. 22 of 2021 on Marine Water Quality Standards for marine biota. Station II exhibited the lowest zooplankton abundance, with a value of 8,308.33 ind/l. This low abundance may be attributed to Station II's location in a tourist area. Tourism activities can disturb the environment and lead to declining water quality (Jimmy et al., 2023). In addition, water transparency and current velocity were relatively higher at Station II compared to the other stations, which likely influenced the lower zooplankton abundance observed at this Station.

The differences in zooplankton abundance among stations were not statistically significant. This may be due to the relatively short distance between sampling stations, which results in similar environmental characteristics. This finding is consistent with a study by Pangestika & Insafitri (2020), which stated that environmental homogeneity over short spatial distances may lead to insignificant differences in zooplankton abundance.

Compared to previous studies, the number of zooplankton species found in the waters of Teluk Makmur tended to be lower. This may be attributed to several environmental and technical factors that are less supportive of zooplankton diversity. One possible reason is the unfavourable weather conditions before the sampling took place. It rained from the night until early morning, and during the morning sampling, the sky was still cloudy. These weather conditions may have influenced the activity and vertical distribution of zooplankton, as some species are sensitive to changes in light intensity and temperature (Patty et al., 2020).

4. CONCLUSION

The zooplankton species found in the waters of Teluk Makmur Village consisted of *Acartia* sp, *Calanus* sp, *T. turbinata*, *Oithona* sp, and *Nauplius* sp. *Oithona* sp and *Calanus* sp were found at all depths, while *Acartia* sp and *T. turbinata* were only found at a depth of 5 m. The highest zooplankton abundance based on depth was recorded at 5 m in Station I, whereas the lowest abundances were observed at 1 m in Station II and 3 m in Station III. Based on the sampling stations, the highest zooplankton abundance was found at Station I, while the lowest was recorded at Station II.

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