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Original Article

Spatial Distribution of Macrozoobenthos in Relation to Oceanographic Parameters in the Marine Waters Surrounding Tunda Island

Novia Ramadhani[1], Nur'aini Dwi Anra[1], Lingga Diva Puspita[1], Syifa Fauzia[1], Samuel Silaban[1], Raflian Khansa Dipura[1], Ode Alam Minsaris[1], Tirta Samudera Ramadhani[1], Joy Elisabeth Silaban[1], Keelan Squire[2]

[1] Department of Marine Information Systems, Universitas Pendidikan Indonesia, Indonesia;
[2] University of Portsmouth, Portsmouth, United Kingdom

*Corresponding Email: (novia.ramadhani@upi.edu)

ABSTRACT
This study explores the spatial distribution of macrozoobenthos in relation to oceanographic parameters in the waters surrounding Pulau Tunda, Banten. A combination of remote sensing data namely sea surface temperature (SST), salinity, chlorophyll-a concentration, and bathymetry was utilized alongside direct field sampling at three designated stations. Oceanographic data were extracted from Landsat 8 imagery and GEBCO bathymetric sources, processed using ArcGIS Pro and Global Mapper. The Shannon-Wiener and Simpson indices were applied to assess biodiversity and species dominance. Results reveal that areas exhibiting SST between 28–31°C, moderate salinity levels (31–32 ppt), and high chlorophyll-a concentrations tend to support moderately diverse and stable benthic communities, predominantly composed of gastropods. The findings highlight the utility of remote sensing for habitat prediction and emphasize the ecological potential of Pulau Tunda's coastal waters.

KEYWORDS
Macrozoobenthos; Oceanography; Tunda Island.

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INTRODUCTION

Indonesia is known as the largest archipelagic country in the world, with a total water area of 6.32 million km^2 or around 63% of its total land area (Marine Affairs and Fisheries, 2024). Indonesia's coastal and marine ecosystems have enormous potential, including high biodiversity and environmental services that are important for the socio-economic sustainability of coastal communities (Huffard et al., 2012). One of the marine areas that has been relatively unexplored scientifically is Tunda Island, a small island in Serang Regency, Banten. This island has unique oceanographic characteristics, including variations in temperature, salinity, dissolved oxygen, depth, and substrate types that may influence the distribution of benthic organisms.

One important component of the benthic ecosystem is macrozoobenthos, which are organisms that live on the bottom of water bodies (*epifauna*) or within the substrate of water bodies (*infauna*) that are larger than 1 mm in size, both sessile and slow-moving (Azis, 2023). Macrozoobenthos not only plays a role as part of the food chain, but is also widely used as a bioindicator to assess water quality due to its relatively long-term presence (Azimah et al., 2021). Variations in the abundance and composition of macrozoobenthos are known to be greatly influenced by oceanographic parameters such as temperature, pH, salinity, and depth found in estuarine areas (Kinasih et al., 2015). For example, extreme temperatures can disrupt the metabolism of benthic organisms, while high salinity fluctuations can limit the types of species that can survive.

The use of remote sensing technology is one effective approach for estimating oceanographic conditions spatially. Parameters such as sea surface temperature (SST) distribution, salinity, and turbidity levels can be measured using ocean sensors installed on satellites that cross water areas (Nagi et al., 2023). Several studies have utilized macrozoobenthos to evaluate ecosystems, such as Retnaningdyah et al. (2022), for example, who used macrozoobenthos communities as indicators of mangrove ecosystem quality in East Java. Rosdatina et al. (2019) also demonstrated the effectiveness of macrozoobenthos as an indicator of pollution on Penyengat Island, while Barus et al. (2019) linked organic content in sediments to the abundance of benthic organisms in South Sumatra. On the other hand, Wijayanti et al. (2022) found that physical structures such as coral reef cover also influence the distribution of macrozoobenthos on Buton Island.

Analysis of these parameters enables efficient preliminary predictions to be made regarding the distribution of potential habitats for macrozoobenthos. This approach has also been proven successful in mapping other coastal ecosystem potentials, such as modeling the benthic habitat biodiversity index in Karimunjawa using *Landsat* and Sentinel-2 on seagrass and coral reefs, with a high degree of accuracy (Wicaksono, 2024). Hartoni et al. (2022) utilized an object-based classification approach with the *Support Vector Machine* (SVM) algorithm in the Thousand Islands, while Munawaroh et al. (2021) developed a classification approach without training data using the *IsoData* and *K-Means* algorithms. Other *machine learning* methods, such as *Random Forest,* have been applied in the classification of seabed substrates (Hafizt et al., 2017).

Most previous studies have focused on mapping habitats such as seagrass, coral reefs, and mangroves, and have been conducted mainly in central and eastern Indonesia. To date, no studies have specifically integrated oceanographic parameters from satellite imagery with field data on macrozoobenthos in the western coastal region of Indonesia, particularly on Tunda Island. In addition, the direct relationship between sea surface temperature, salinity, and turbidity levels obtained from remote sensing and the actual distribution of macrozoobenthos has not been widely explored. Therefore, this study offers a new approach by combining remote sensing data and field surveys simultaneously to identify the spatial distribution of macrozoobenthos in the waters of Tunda Island.

The novelty of this study lies in the location of the study, which has not been widely explored scientifically, as well as the methodological approach that combines spatial analysis of oceanographic parameters with empirical validation of benthic organism composition. These findings are expected to contribute to coastal communities, especially in marine resource conservation planning and improving sustainable fisheries management. In addition, the results of this study have the potential to become the basis for environmental education and advocacy, and can be used by stakeholders as a reference in efficient habitat quality monitoring based on spatial technology and remote sensing (Wanchana & Sayan,2018)).

In general, research in island areas has a number of advantages over coastal areas in the context of oceanography and benthic ecology studies. Small islands often offer environmental conditions that are more isolated from direct anthropogenic influences such as domestic waste, industrial pollution, and freshwater runoff, which are commonly found in coastal areas. The island environment also tends to have substrate variation, shallow depths, and more stable oceanographic parameters, making it a suitable study location for evaluating the direct relationship between physical water conditions and the distribution of benthic organisms such as macrozoobenthos (Hartati et al.,2024) . In addition, archipelagic regions can serve as relatively closed coastal ecosystem models, allowing for more measurable mapping of species distribution without much interference from complex external factors. In ecological studies, this is very useful for gaining a more accurate understanding of the response of organism communities to environmental changes.

METHOD

Research Location

This research was conducted in the waters around Tunda Island, located in Serang Regency, Banten Province. The research period ran from March to May 2025 and included the stages of secondary data collection, sampling, data processing, analysis, and report preparation. The research location was divided into three stations, as shown in Figure 1. Station 1 was located at coordinates -5.807328° S and 106.269725° E, on the eastern side of Tunda Island. Station 2 is located in the south-central part, precisely at coordinates -5.815330° S and 106.275078° E. Meanwhile, Station 3 is located on the southwest side of the island, at coordinates -5.816589° S and 106.288767° E. These three stations were chosen because they were considered to represent the variation in environmental conditions relevant to the study of macrozoobenthos communities in the southern waters of Tunda Island.

The selection of Tunda Island as a research location was based on its unique oceanographic characteristics and minimal intensive anthropogenic activity compared to coastal areas on the mainland. As a relatively isolated small island, this region offers more stable and representative environmental conditions for evaluating the relationship between physical oceanographic parameters and macrozoobenthos communities. In addition, scientific data on the ecological conditions of Tunda Island's waters are still very limited, so this study can fill the information gap on the western coast of Indonesia.

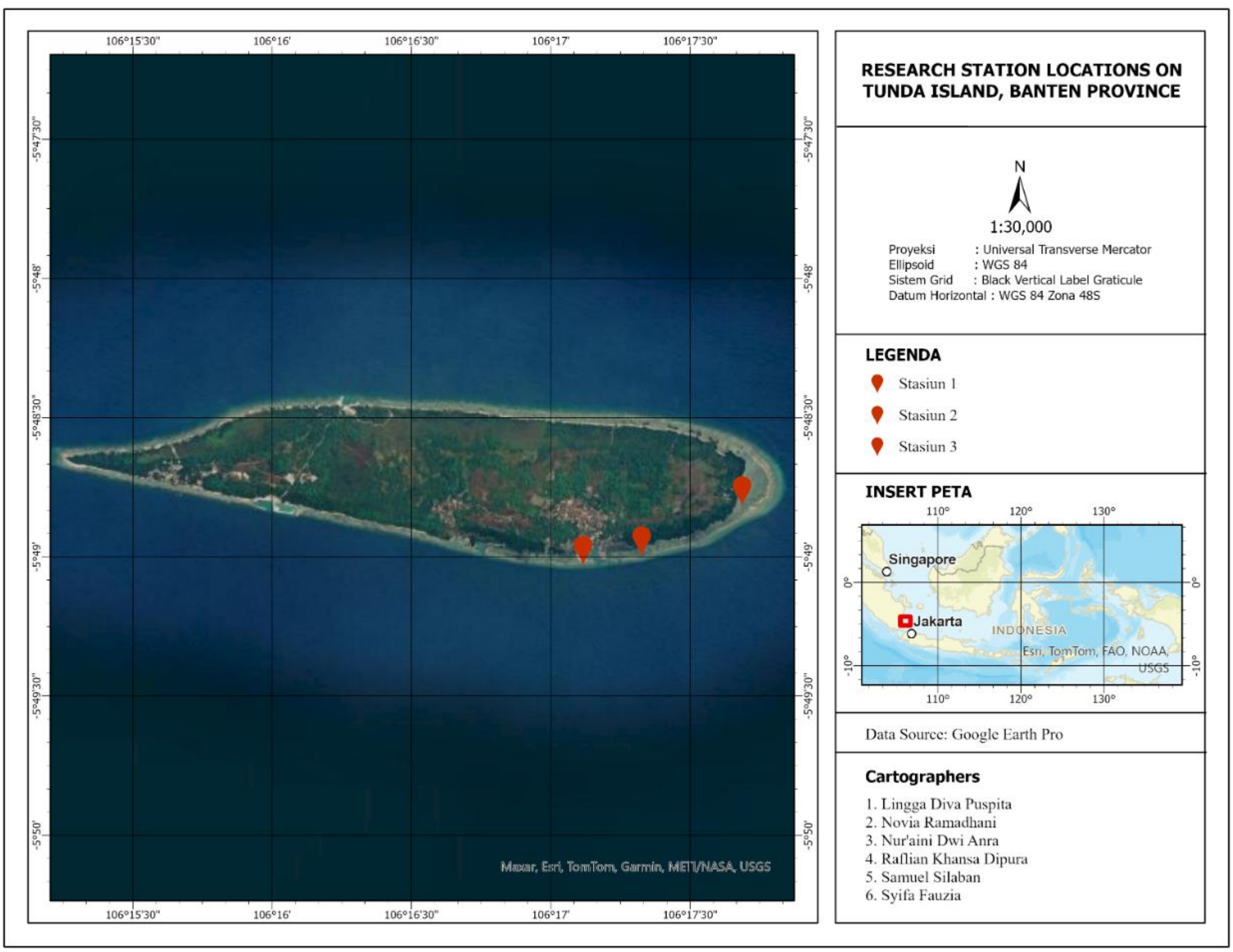

Figure 1. Research Location Map

Research Approach

This study is a quantitative descriptive study with a spatial approach. This study aims to detect and map the potential distribution of macrozoobenthos in the waters of Tunda Island based on oceanographic parameters, namely sea surface temperature (SST), salinity, chlorophyll-a, and water depth (bathymetry). The analysis was conducted using secondary data in the form of satellite imagery and bathymetry data to predict potential locations for macrozoobenthos before conducting a direct field survey. The results of this analysis will be used to determine the most relevant observation locations or stations, with reference to the suitability of water environmental parameters with the optimum range of macrozoobenthos habitats as described in previous literature (Nurzanah, 2019).

Research Procedure

This research procedure was carried out in two main stages, namely: (1) secondary data analysis to determine the potential distribution zone of macrozoobenthos, and (2) field verification based on the prediction results. The first stage began with the collection of secondary data in the form of sea surface temperature (SST) and chlorophyll-a from Landsat 8 images downloaded via *USGS Earth Explorer,* bathymetry data from *GEBCO,* and salinity data from *the World Ocean Atlas (NOAA)*. All data were then processed through preprocessing stages such as radiometric correction, image cropping, and coordinate system reprojection to match the study area using *ArcGIS Pro* and *Global Mapper* software.

Once the data is ready, oceanographic parameters such as SST, chlorophyll-a, salinity, and sea depth are extracted using relevant algorithms or index approaches from the literature. These parameters are then visualized in the form of thematic maps using *ArcGIS Pro* and *Surfer* to see their spatial distribution. Based on the visualization results, an analysis was conducted to identify potential macrozoobenthos distribution zones by considering optimal environmental conditions, namely temperatures between 28–31°C, high chlorophyll-a concentrations, stable salinity, and water depths of less than 20 meters.

Figure 2. Research Procedure Flowchart

The next stage is field verification based on the mapped potential zones. Sampling points are determined based on the results of previous spatial analysis. Macrozoobenthos sampling is carried out at selected locations using *purposive sampling*, which is the determination of locations based on appropriate ecological considerations (Angelia et al., 2019).

Each station consists of three substations located 25 meters apart. At each substation, a 50-meter transect is drawn perpendicular from the shoreline towards the sea. Along this transect, six plots are created with a distance of 10 meters between each plot, resulting in a total of 18 observation points at each station and 54 observation points for the entire location.

During sampling, environmental parameters such as temperature, salinity, pH, and water brightness were also recorded directly (*in situ*) for the purpose of validating secondary data. The macrozoobenthos samples obtained were then identified morphologically both in the field and in the laboratory to determine their composition and distribution. The results of this stage were used to evaluate the accuracy of the prediction zones that had been created and to enrich understanding of the distribution of macrozoobenthos in the waters of Tunda Island.

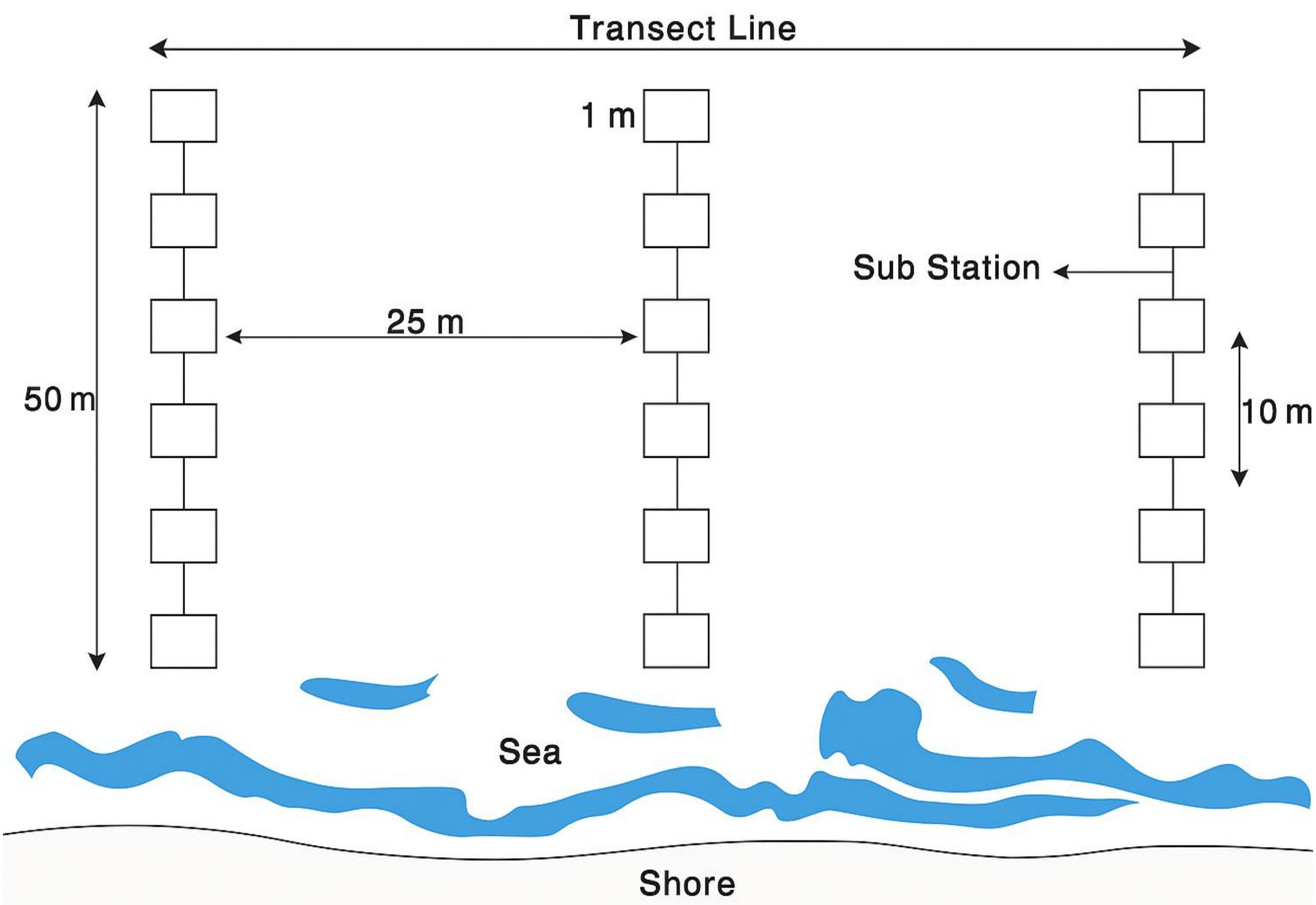

Figure 3. Determination of *Line Transect* Placement at each station
Source: Angelia et al., 2019

Data Collection Instruments

The instruments used in this study are divided into two categories, namely *software* and secondary data, as well as field tools used for sampling. These instruments were selected based on their suitability for spatial analysis and ecological data collection in the field. The tools used in this study of macrozoobenthos distribution analysis based on oceanographic parameters in remote sensing can be seen in the following table of tools and materials:

Table 1. *Software* and Secondary Data Used

No.	Software/Data	Purpose
1	*ArcGIS Pro*	Spatial mapping
2	*Global Mapper*	Bathymetric processing
3	*Surfer*	Contour visualization
4	*Landsat 8*	Temperature, salinity, and chlorophyll data
5	*Excel*	Data calculation and tabulation

The tools used in this field research on macrozoobenthos distribution analysis for sampling can be seen in the following table of tools and material.

Table 2. Tools for sampling and their uses

No	Name of Equipment	Purpose
1	*GPS/Avenza Maps* Application	To determine the geographical location of the research
2	pH meter	Determining the acidity level (pH)
3	Writing instruments	Used to record data obtained in the field
4	*Mesh Size* 1.0 mm Sieve	Used to filter the substrate
5	Camera/Mobile Phone	Sample image capture
6	Shovel	Used to collect benthos and substrate samples
7	*Tape* measure	Used to measure the distance between sampling points
8	Thermometer	Used to measure water temperature
9	*Secchi disc*	Used to measure water turbidity/depth
10	*Salinometer*	Used to measure salinity
11	Water Sample Bottle	Used to collect SST data
12	Gloves	Used to protect hands
13	Laptop	Used for processing data

Data Analysis

Data analysis in this study was conducted through several main stages, starting from bathymetric data processing to oceanographic parameter mapping. Bathymetric data was obtained from the BATNAS website in raster format and processed using *Global Mapper* software to produce visualizations of sea depth contours around the study area, namely the waters of Tunda Island. Next, *Landsat 8 Level-2* satellite images downloaded from the *USGS Earth Explorer* portal were processed using *ArcGIS Pro*. This process included radiometric and atmospheric corrections to ensure more accurate earth surface reflectance values.

After the corrections were made, sea surface temperature values were extracted based on the thermal channel, and chlorophyll-a values were calculated based on the spectral ratio of certain optical channels.

Diversity Index

Diversity indicates the richness of species in a community and the balance in the distribution of numbers per individual (Bahri et al.,2020). This index is calculated using the Shannon-Wienner equation (Brower & Zar,1977).

$$H' = \sum (ni / N) \ln(ni / N)$$

Description, H’: Shannon-Wienner species diversity index; Ni = Importance value of each species (number of individuals per species); N: Total importance value (total number of all individuals). The assessment criteria for the Shannon-Wienner species diversity index are grouped into the following three assessment criteria:

Table 3. Assessment criteria for the diversity index

H' < 1	Low diversity
1 < H’ < 3	Moderate diversity
H’ > 3	High diversity

Source: Brower & Zar, 1977

Dominance Index

Species dominance is calculated by calculating the Simpson Dominance Index. The formula is as follows:

$$C = \sum (ni / Ntotal)^2$$

Explanation: C is the dominance index, Ni is the number of individuals of each species, and N is the total number of individuals of all species. Odum's dominance index assessment criteria are grouped into the following three assessment criteria:

Table 4. Dominance Index Criteria

0 < C < 0.3	Low dominance
0.3 < C < 0.6	Moderate dominance
0.6 < C < 1	High dominance

Source: Odum, 1998

RESULTS AND DISCUSSION

Results

The results of the extraction process are visualized in the form of color raster maps depicting the distribution of oceanographic parameters, namely sea surface temperature (SST), chlorophyll-a, and salinity. These maps show the spatial variation of each parameter around Tunda Island, where temperatures tend to be higher in the outer regions of the island and high chlorophyll-a values are distributed around the coastline. *The layout* of the oceanographic parameter results can be seen in Figure 4, which presents a sea surface temperature map, Figure 5, which presents a chlorophyll-a map, Figure 6, which presents a salinity map from satellite imagery in May 2024, and Figure 7, which presents bathymetric mapping.

The sea surface temperature map in Figure 4 shows that the SST range in the study area is between 28°C and 31.8°C. This value is still within the tolerance limit of tropical marine organisms. Based on the Decree of the Minister of Environment No. 51 of 2004, the maximum recommended temperature for marine water quality is 32°C, so the temperature conditions in this area are still supportive of benthic life such as macrozoobenthos.

Figure 5 shows that the highest concentration of chlorophyll-a appears to be around the coastal zone, indicating a high level of primary productivity. This may be due to nutrient runoff from land or *upwelling* processes in the surrounding waters. Chlorophyll-a, as an indicator of phytoplankton abundance, has a direct relationship with the availability of organic matter, which is the main food source for the macrozoobenthos community.

The map in Figure 6 shows relatively stable salinity values ranging from 31 to 32 ppt. Although negative anomalies were found, which were likely due to data errors, in general the salinity level was still close to the optimal range for macrozoobenthos habitats (around 33–34 ppt), so it could still be categorized as suitable for the habitat. Salinity stability is very important for benthic organisms because it is related to osmotic balance and metabolism. Figures 4, 5, and 6 show spatial mapping of oceanographic parameters such as chlorophyll-a, sea surface temperature (SST), and salinity around the island.

These three parameters play an important role in determining the potential distribution of macrozoobenthos because they greatly affect the quality of the aquatic habitat. The oceanographic parameters shown indicate that the coastal waters of the island provide favorable conditions for the presence of macrozoobenthos. The combination of high productivity, stable warm temperatures, and near-optimal salinity creates a potential habitat, although further field data validation is still needed to strengthen the interpretation.

Figure 7 shows a bathymetric map of the waters around Tunda Island based on data from BATNAS. This map depicts sea depth using isobath contours, where light blue indicates shallow waters (0 to -15 meters), while dark blue indicates deep waters (>90 meters).

Shallow areas dominate around the island, forming a coastal zone that is ideal for macrozoobenthos habitats because it has a sandy or muddy bottom, sufficient lighting, and relatively calm currents. In contrast, the deeper waters are located further from the island and have different physical characteristics, such as stronger currents and a less stable bottom, making them less suitable for most macrozoobenthos.

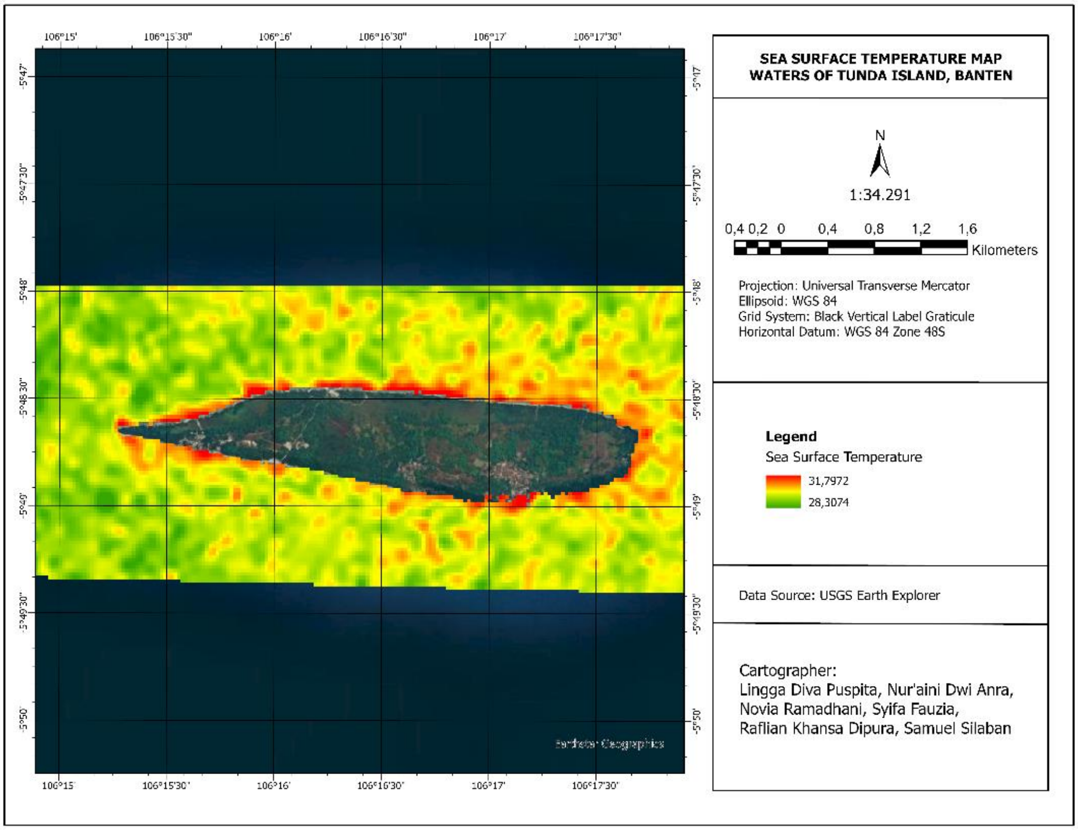

Figure 4. Sea Surface Temperature of Tunda Island Waters

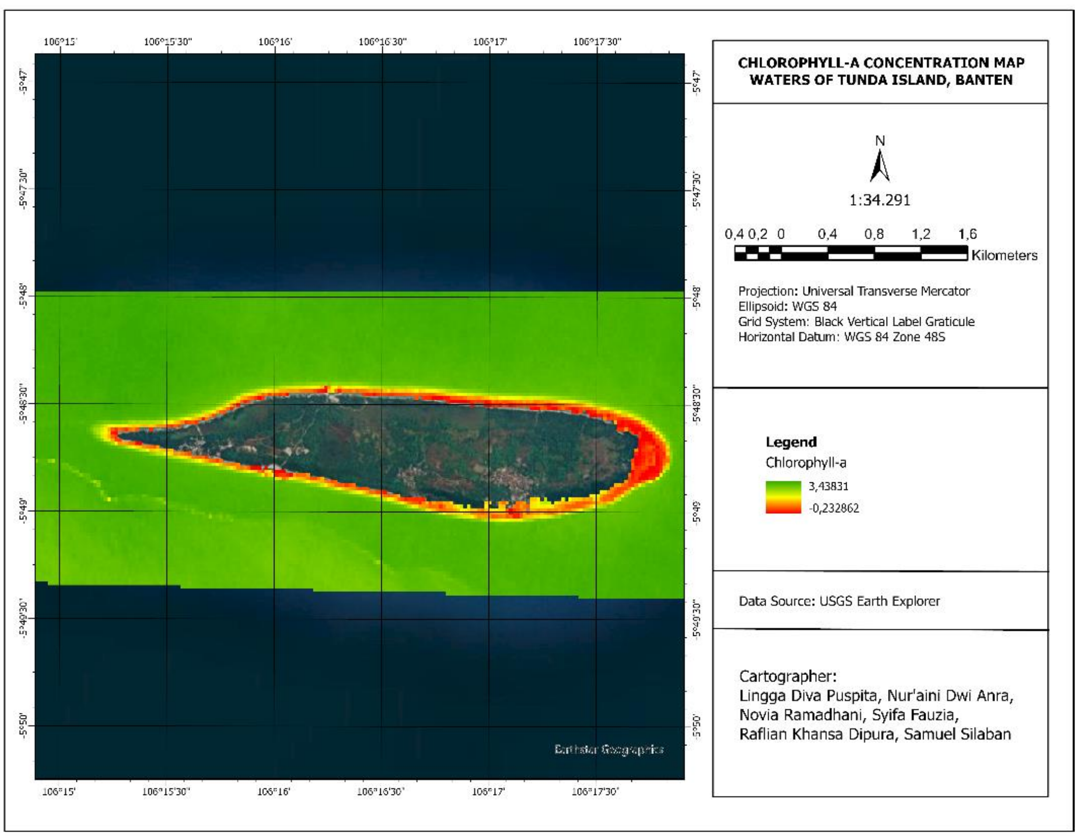

Figure 5. Chlorophyll-a in the Waters of Tunda Island

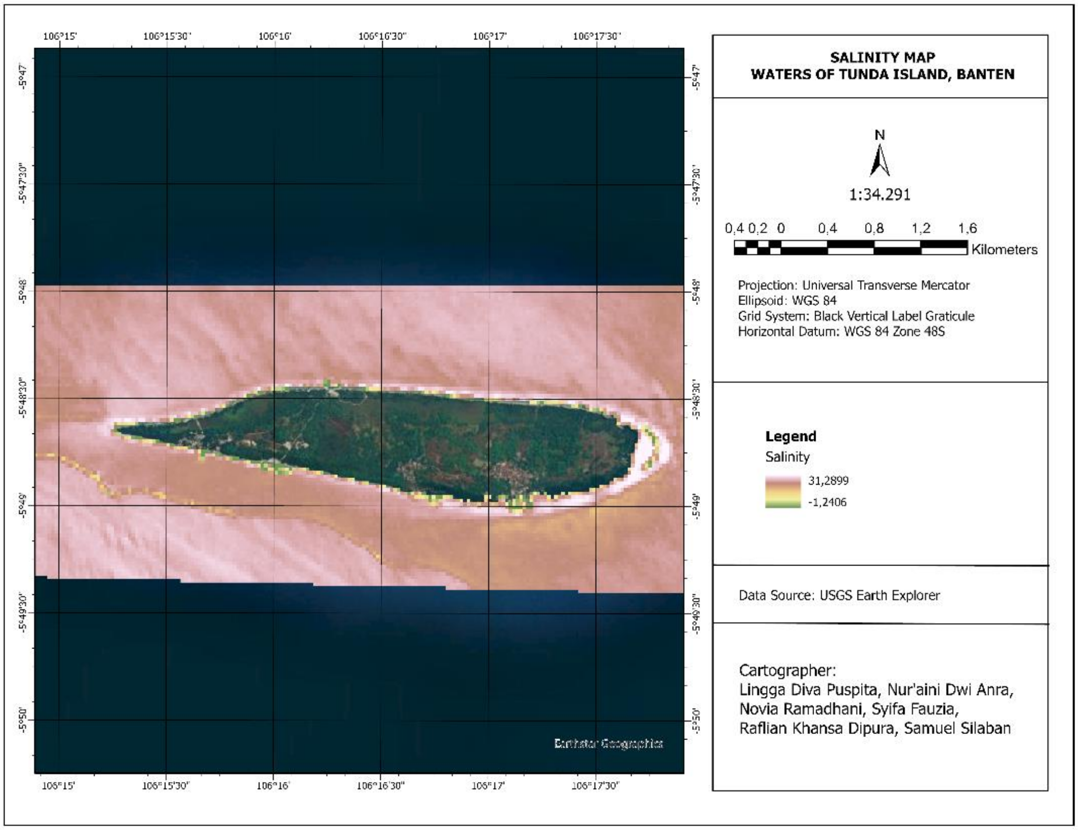

Figure 6. Salinity of Tunda Island Waters

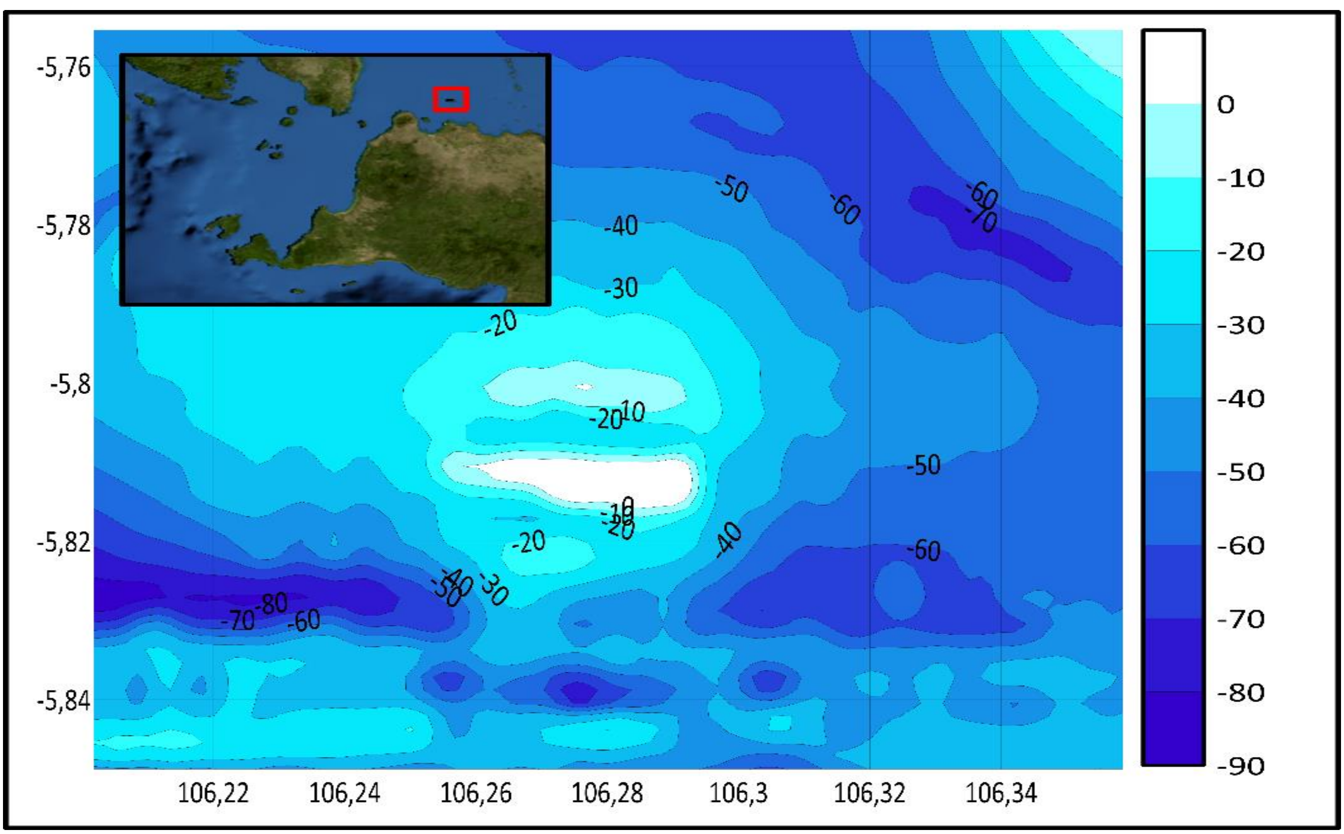

Figure 7. Bathymetric Map of Tunda Island Waters

Discussion

Field validation was conducted through direct measurements at three observation stations determined based on the results of spatial analysis of oceanographic parameters (chlorophyll-a, temperature, salinity) and bathymetric conditions. The three station points were selected to represent the coastal environmental variation of Tunda Island, covering shallow to moderately deep zones, as well as differences in substrate characteristics. Measurements of temperature, pH, salinity, and depth at each station are presented in Table 6 below:

Table 6. Water Quality Parameters at Each Station

Station	Temperature (°C)	pH	Salinity (ppt)	Depth (cm)
1	30	6.05	28	10
2	30	7.12	32	50
3	30	7.12	32	120

Source: Researcher, 2025

The sea water temperature at the three observation stations was the same, namely 30°C. This temperature tended to be stable because the measurements were likely taken at similar times and weather conditions were relatively uniform at the three locations. This is in line with Raymond's (1980) opinion that the ideal temperature for the growth of organisms in tropical waters is in the range of 25 s to 32°C. Meanwhile, according to Sukarno (1988), macrozoobenthos can still tolerate temperatures between 25 and 36°C. Although there was no temperature variation between stations, 30°C is still within the normal range for tropical waters and is capable of supporting marine organisms.

The pH range at the observation site ranged from 6.05 to 7.12. Station 1 had the lowest pH of 6.05, indicating slightly acidic conditions. Meanwhile, stations 2 and 3 had the same pH of 7.12, which is close to neutral. A pH value below 7 may indicate the influence of biological activity, organic matter degradation, or the entry of acidic waste. A neutral to slightly acidic pH can affect the balance of the ecosystem, especially sensitive organisms such as plankton and macrozoobenthos. The ideal pH value for aquatic organisms is generally between 7 and 8.5 (Minister of Environment,2004).

Salinity on Tunda Island ranges from 28 to 32 ‰. Station 1 has the lowest salinity (28 ‰), while stations 2 and 3 have the highest salinity (32 ‰). These differences may be due to the influence of tides, local rainfall, or the presence of habitats such as mangroves and seagrass beds. In general, higher salinity reflects high evaporation rates or minimal dilution by freshwater. The salinity range considered suitable for macrozoobenthos life is between 15-45 ppt (Mudjiman, 1981). A salinity of 32 ‰ is considered normal for seawater, while 28 ‰ indicates the possibility of freshwater input from land or rainfall.

The water depth at the observation sites varied from 10 cm to 120 cm. Station 1 had the shallowest depth (10 cm), while station 3 had the deepest depth (120 cm). Shallow waters such as those at station 1 tend to have greater fluctuations in temperature and pH, and can be an important habitat for various types of benthic organisms. Meanwhile, deeper waters such as those at station 3 can provide a more stable environment and support higher biodiversity, depending on other water quality parameters.

The results of the research conducted at the three observation stations show the presence of various macrozoobenthos species living in the waters of Tunda Island. These species reflect the diversity of the benthic community spread across the research area, and some of them can be seen in Figure 8.

Based on the results of macrozoobenthos observations found on Tunda Island, a total of 19 species were successfully identified. The most dominant species based on the number of individuals *were Terebralia sulcata* and *Telescopium telescopium*, each with 6 individuals, followed by *Cerithidea obtusa* with 5 individuals. Meanwhile, several other species were only found once, such as *Scylla tranquebarica, Thais hippocastanum,* and *Mancinella tuberosa*. This high species diversity indicates that the aquatic environment around Tunda Island provides a supportive habitat for various types of macrozoobenthos. The diverse substrate conditions and relatively shallow water depth are likely the main factors supporting the existence and distribution of these benthic organisms (Juwita, 2017).

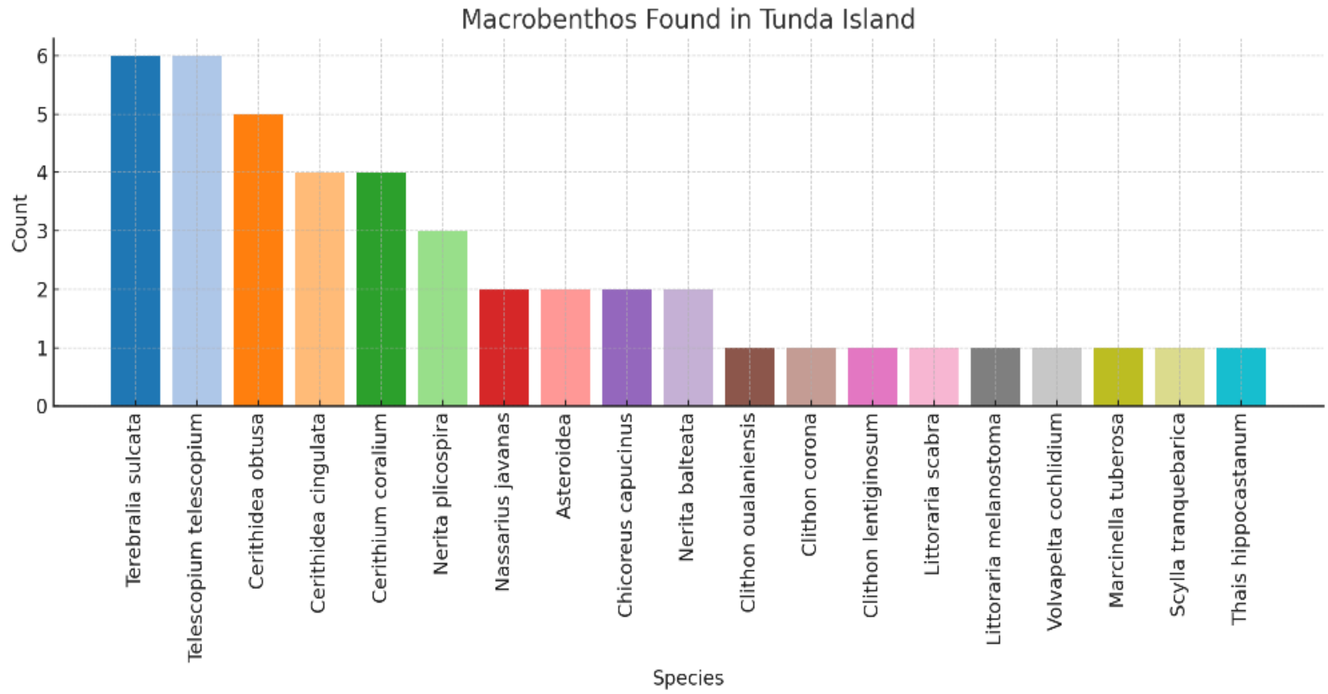

Figure 8. Macrozoobenthos Species Graph in Tunda Island
Source: Researchers, 2025

Analysis of macrozoobenthos diversity data (H')

Measurements of the diversity index values at each station are presented in Table 7. Based on the results of macrozoobenthos species identification and Shannon-Wiener diversity index (H') calculations, there is a clear variation in diversity levels between observation stations.

Table 7. Diversity Index Values

Diversity Index Values			
Station 1	Station 2	Station 3	Average
2.6549	0.2301	0.9759	1.2869

Source: Researcher, 2025

Station 1, with a dominant substrate of sand, has a diversity index value of 1.33 ind/m^2, which is classified as moderate. This value indicates a relatively balanced macrozoobenthos community, supported by the presence of 6 species out of a total of 17 species found across all stations. These conditions indicate a well-preserved ecosystem with habitats that sufficiently support optimal species diversity (Angelia et al., 2019).

Stations 2 and 3, which are dominated by rebel substrates, show lower diversity index values, namely 0.97 ind/m^2 and 0.89 ind/m^2, respectively, which are categorized as low. Station 2 contained 14 species, including 12 species *of Gastropoda* and several species from the classes *Bivalvia* and *Crustacea,* while station 3 had 11 species dominated by *Gastropoda* and *Crustacea*. These low index values indicate the dominance of certain species and higher ecological pressure. Environmental degradation factors, such as physical and chemical pollution detected at stations 2 and 3, likely contributed to reduced habitat complexity and a decline in the abundance of sensitive species (Angelia et al., 2019).

The decline in diversity at both stations is likely influenced by suboptimal substrate conditions, low dissolved oxygen, and disturbance from anthropogenic activities around the site. This type of environmental pressure causes the macrozoobenthos communities at stations 2 and 3 to be dominated by environmentally resistant species with shorter lifespans and capable of consuming organic material, while species with low tolerance experience a decline in numbers (Dong et al., 2021).

Overall, the average diversity index value for the three stations was 1.06 ind/m^2, indicating an ecosystem with moderate to low diversity. The variation in these index values reflects differences in environmental quality and ecological pressures experienced by the macrozoobenthos communities at each station, which are greatly influenced by substrate type, physical conditions of the water, and human disturbance around the study area (Juwita, 2017).

Analysis of macrozoobenthos dominance (C) data

Measurements of the dominance index values at each station are presented in Table 8.

Table 8. Dominance Index Values

Dominance Index Values			
Station 1	Station 2	Station 3	Average
0.0849	0.0665	0.0124	0.0546

Source: Researcher, 2025

The Dominance Index (C) obtained from field research shows a value of 0.0849 at Station 1, 0.0665 at Station 2, and 0.0124 at Station 3. Based on commonly used categories, this dominance index value falls into the low category (Odum,1998), as it is below the threshold of 0.3. This low dominance index value indicates that no single species dominates the macrozoobenthos community at the three stations. This relatively low dominance value indicates ecosystem stability, where species are evenly distributed without significant domination by one or a few species (Hafidzah et al., 2025). The dominance index can be used to assess the balance of individuals between species and also indicates species richness in the community.

Field observations show that the macrozoobenthos community is dominated by the class *Gastropoda*, especially the species *Terebralia sulcata* and *Telescopium telescopium*, which are found in abundance on sandy substrates at Station 1 and on rocky substrates at Stations 2 and 3. The class *Gastropoda* is known to have high tolerance to environmental changes and is able to survive in various substrate conditions (Nento et al., 2013). In addition, *Gastropoda* are often used as pollution indicators because of their ability to accumulate pollutants without dying. These organisms move slowly, live at the bottom of the water, act as detritivores, and can absorb contaminants into their body tissues to levels exceeding those in the surrounding environment (Nadia, 2023).

Based on this low dominance index value, it can be concluded that the macrozoobenthos community in the waters of Tunda Island is still in a relatively stable condition and there is no excessive dominance by certain species, indicating good habitat quality and supporting biodiversity.

CONCLUSION

The distribution of macrozoobenthos in the waters of Tunda Island is significantly influenced by oceanographic characteristics, including temperature, salinity, chlorophyll-a, and water depth. Spatial analysis shows that areas with temperatures between 28–31°C, near-stable salinity (31–32 ppt), and high chlorophyll-a levels have the potential to be the main habitat for macrozoobenthos. The presence of 19 species with moderate to low diversity and low dominance levels reflects the relative stability of the coastal ecosystem at the study site. Macrozoobenthos communities in areas with sandy substrates tend to be more diverse than those in areas dominated by coarse substrates. In addition, higher environmental pressures at several observation stations are important indicators in assessing the ecological conditions of coastal areas. These findings underscore the importance of oceanographic monitoring and the use of remote sensing data as an efficient approach to spatially mapping benthic organism habitats.

The results of this study indicate that the use of remote sensing data and oceanographic analysis is effective for spatially identifying potential macrozoobenthos habitats. These findings can benefit coastal zone management, particularly in supporting benthic habitat conservation policies, ecosystem protection zoning planning, and sustainable marine environmental health monitoring. The spatial information generated can be used as a basis for determining areas for the protection or restoration of benthic habitats that support the sustainability of coastal biological resources.

Based on these findings, it can be concluded that the use of remote sensing data and oceanographic analysis is effective in identifying potential macrozoobenthos habitats. However, this study has limitations in terms of the limited number of observation stations, which means that it does not fully represent the entire habitat variation in the waters of Tunda Island. In addition, the spatial and temporal resolution of the satellite data used, particularly for salinity and chlorophyll-a parameters, also has limitations in providing a detailed picture of environmental conditions. This study was also conducted in only one season, so it was not able to describe the temporal dynamics of macrozoobenthos distribution. Therefore, further research is recommended to expand the coverage of stations, use multitemporal high-resolution imagery data, and integrate statistical or *machine learning* approaches for spatial modeling. The addition of other environmental variables such as organic matter content and dissolved oxygen is also important to provide a more comprehensive picture of the habitat and abundance of macrozoobenthos.

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