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Analysis of Chlorophyll-a Distribution in Determining the Fishing District of (*Euthynnus affinis*) Using Satellite Images in North Sumatera Sea Flows

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ABSTRACT

The North Sumatra Sea waters are one of the potential areas for tuna (*Euthynnus affinis*) fisheries. However, fishermen's determination of fishing grounds still relies on traditional methods, such as observing seabirds and water color changes, which are often inaccurate. This study aims to determine chlorophyll-A distribution, the accuracy of tuna fishing areas, and the relationship between chlorophyll-A and catch using satellite imagery. This research is beneficial because it is helpful reference material for the fishing industry and the community regarding the relationship between chlorophyll-a and fishing grounds. This research was conducted from April 05 to April 29, 2024, using Aqua Modis satellite image data. The research method used was a survey method that was analyzed descriptively. The results obtained during the study showed that the highest chlorophyll-a concentration occurred in the period April 22 to April 29, 2024, with an average value of 8.71 mg/m3, and the lowest occurred in the period April 06 to April 13, 2024, with an average value of 4.83 mg/m3. Determination of the estimated fishing grounds for tuna (Euthynnus affinis) with overlay technique by shading the chlorophyll-a criteria area >0.1 mg/m^3. The accuracy level of the estimation of tuna fishing grounds has an average accuracy of 52%. Chlorophyll-a and catches in North Sumatra Sea Waters have a very strong relationship with an R-value of 0.99.

Keywords: Chlorophyll-a Image, Tuna, Catch Rate

1. INTRODUCTION

The utilization of marine biological resources, especially fisheries, in various parts of Indonesia is still uneven. In some water areas, there are still great opportunities for development and utilization, while in others, it has reached a condition of dense capture or overfishing. The lack of integrated management of potential marine fisheries resources causes this condition. One is the unavailability of data and information on the potential fisheries resources in Indonesia. The North Sumatra Sea waters have a lot of fishery potential, including many catches with high economic value, such as tuna (*Euthynnus affinis*). Tuna is a marine biological resource with a high economic potential, meaning that this fish is one of the fishery products targeted by fishermen. Tuna has the advantage of high protein content and is rich in omega 3, so tuna is a species that is quite widely studied.

Currently, the insight of fishermen in determining fishing grounds is still a fundamental obstacle because fishermen only see signs such as birds flying over the waters or changes in water color, so the catch of fish obtained is not optimal. In the current era of digitalization, the determination of fishing grounds can be done using technology. The determination of fishing grounds can be known through the primary productivity of these waters because the higher the potential of fishery resources can be known from the high primary productivity of these waters. The primary productivity of water is closely related to the abundance of phytoplankton. The presence of phytoplankton can be detected from the level of chlorophyll-a concentration in these waters.

Chlorophyll-a is one of the parameters used as an information system and wind direction to predict the occurrence of upwelling and fishing ground areas (Rahman & Kunarso, 2022). This is because chlorophyll-a indicates the distribution and abundance of phytoplankton. Therefore, it can be used as an approach to water fertility and food availability, a characteristic of fishing grounds (Aufar et al., 2021). Chlorophyll-a can be measured from two methods. The first is the in-situ method, which is to do it directly; this method requires a lot of money and time, and the second method uses satellite imagery that can analyze an object without having to interact directly with the object being studied. Remote sensing techniques can explore large areas but are challenging to reach by conventional means quickly (Hamuna et al., 2015). With satellites, monitoring all oceans in Indonesia can cover an unlimited area and time and cost because this technology can monitor a large area in a short time (Kumaat et al., 2018). One of the remote sensing techniques is using geographic information systems.

Geographic Information System (GIS) is a system designed to work with substantial data sources (Prastowo et al., 2020). GIS is a reliable medium for presenting remote sensing (RS) data as helpful information for various purposes for many parties (Mutsakov, 2020). One geographic information system (GIS) instrument that can be used for chlorophyll-a measurements is the aqua modis satellite.

Aqua MODIS satellite image is a remote sensing image with many benefits in various fields, such as forestry, agriculture, meteorology, climatology, fisheries, and marine. Aqua MODIS satellite images illustrate chlorophyll-a patterns and can be used to estimate fishing grounds. Aqua Modis Level 3 and 4 satellite images are one of the products developed for monitoring water quality parameters, one of which is chlorophyll-a.

Based on the background of the problems that the author has stated, this research was conducted to examine the guidelines for determining fishing areas using satellite imagery and whether chlorophyll-a images that have been used as fishing area maps can be used as a guide for deciding fishing areas in North Sumatra Sea Waters.

2. RESEARCH METHOD

Time and Place

This research was conducted in the North Sumatra Sea Waters from April 06 to April 29, 2024.

Method

The method used in this research is a survey method that is analyzed descriptively. The survey method is a research method that collects data following the actual data, which is compiled, processed, and analyzed to provide an overview of the existing problems.

Procedures

The data used to analyze chlorophyll-A concentrations came from Aqua MODIS images with a spatial resolution of 1 km and a temporal of 8 days from April 06 to April 29, 2024. Data is downloaded through the Oceancolor website. The 2019 digital map of Indonesia from the Geospatial Information Agency is another data used as a base map. Image data collection procedures are carried out with the first stage of downloading image data. Image data is obtained through the site https://oceancolor.gsfc.nasa.gov/. The data menu was selected to download the data, and level 3&4 was selected. Next, the chlorophyll-a product was chosen for a period of 8 days, starting from April 06 to April 29, 2024. Then select the mapped data type and press download.

Determination of Area of Interest (AoI)

The AoI is a way to demarcate the study area under study. The downloaded image data is presented on a global scale. To obtain valuable information on the North Sumatra Sea Waters, the global data must be zoomed in and then cropped using the SeaDAS application. After cropping, the data is stored in a text document format, which will then be sorted using the MS Excel application.

Data Filtering

After determining the AoI, sort the data using the MS Excel application. This stage aims to filter out erroneous data (errors) from the AoI determination results how to filter data by deleting data that has NaN information.

Processing of Chlorophyll-a Values

The filtered chlorophyll-a image value data was inputted into the ArcMAP 10.3 application. After the data is inputted, the distribution map is made by selecting the 3D Analyst Tool menu and Raster Interpolation. Then, the chlorophyll-a value data is presented in the form of a map, which displays the distribution of chlorophyll-a.

3. RESULT AND DISCUSSION

Chlorophyll-A Distribution Patterns in North Sumatra Marine Waters

Fertile waters contain high chlorophyll-a concentrations because chlorophyll-a indicates fertility in a body of water. Chlorophyll-A concentrations are also strongly influenced by currents in these waters. Using satellite image data, namely chlorophyll-A, is very important because it has proven a productive fishing area.

The distribution of chlorophyll-a in the North Sumatra Sea was analyzed using satellite image data. The analysis of chlorophyll-a distribution was conducted using Ocean Color Aqua MODIS level-3 data at a spatial resolution of 4 km for 8 days from April 06 to April 29, 2024. The results of image data processing are presented in Figures 3-5.

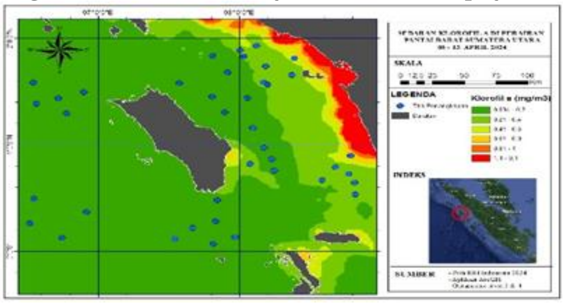

Figure 3. Distribution of chlorophyll-a (mg/m^3) April 06-13, 2024

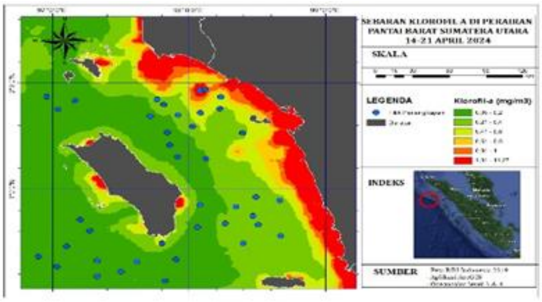

Figure 4. Distribution of chlorophyll-a (mg/m^3) April 14-21, 2024.

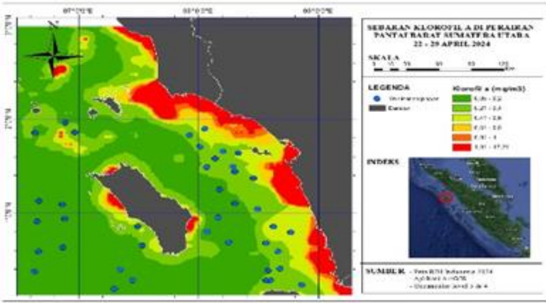

Figure 5. Distribution of chlorophyll-a (mg/m^3) April 21-29, 2024

The image analysis results show that chlorophyll-A in the North Sumatra Sea Waters has an uneven distribution of chlorophyll-A. The distribution of chlorophyll-a is primarily found in the eastern waters of Nias Island, with chlorophyll-a concentration values ranging from 0.03-0.2 mg/m^3 and the least from 0.81-1 mg/m^3. High chlorophyll-a concentrations are generally found in coastal waters, while chlorophyll-a concentrations in the high seas are relatively low. This is due to the availability of nutrients, which are run-off products from the land, so phytoplankton in these waters can carry out the photosynthesis process optimally (Triadi et al., 2015). The value of chlorophyll-a concentration from satellite image analysis can be seen in Table 1.

Table 1. Temporal chlorophyll-a concentration

No	Time (2024)	Concentration Chlorophyll-a (mg/m^3)		
		Minimum	Maximum	Average
1.	06 – 13 April	0,03	9,63	4,83
2.	14 – 21 April	0,04	11,59	5,81
3.	22 – 29 April	0,04	17,38	8,71

Source: Ocean Color Satellite Imagery Data

The concentration of chlorophyll-a from April 06 to April 29, 2024 increased. The highest concentration occurred from April 22 to 29, with an average value of 8.71 mg/m^{3,} and the lowest occurred from April 06 to 13, 2024, with an average of 4.83 mg/m^3. The distribution of chlorophyll-a concentration tends to be inhomogeneous and has different values in each pixel. This is thought to be due to environmental influences such as temperature, currents, and the amount of nutrients entering the waters that make chlorophyll -a concentrations fluctuate.

The Level of Accuracy of Fishing Areas for Tuna Based on Chlorophyll-A Distribution

The suspicion of tuna fishing areas was

analyzed using the overlay technique utilizing the chlorophyll-a map that had been explored previously with the criteria of areas that have chlorophyll-a concentrations of 0.1-0.35 mg/m^3 (Tangke et al., 2015).

Areas with these criteria are shaded, and a map of the alleged mackerel fishing grounds is obtained. Furthermore, the accuracy level of the mackerel fishing area was tested by combining the map of the suspected mackerel fishing area analysis results with the fishing point data. The results of the study of the alleged mackerel fishing grounds can be seen in Table 2.

Table 2. Accuracy value of fishing area for tuna

No	Time (April 2024)	Catch Point		
		alleged	Total	%
1.	06 – 13	25	40	62,5
2.	14 – 21	21	40	52,5
3.	22 – 29	16	40	40
Total		62	120	52

The analysis of the alleged fishing grounds for tuna showed that the fishing points from April 06 to April 29, 2024, had an average percentage accuracy of 52%. Estimated fishing areas with the highest accuracy level occur in the period 06 - 13 April and 22 - 29 April 2024 with an accuracy value of 62.5%, while the lowest estimated fishing occurs in the period 22 - 29 April 2024 with an accuracy value of 40%. This is likely due to the time lag in the food chain (Aryawati et al., 2018), so the increase in phytoplankton in the waters does not directly impact the increase in the number of fish in the seas. The accuracy of fishing areas is influenced by several factors, namely oceanographic conditions such as water temperature, salinity, ocean currents, and depth, which affect the presence of tuna.

Relationship between Chlorophyll-a Distribution and Fish Catches

Tuna is a pelagic fish that feeds on small fish, crustaceans, and squid (Wardani, 2021). Although this fish is not a plankton eater, in the food chain, tuna is also influenced by phytoplankton, although it is not directly related to the food chain where phytoplankton are producers.

Fish catches are directly proportional to the value of chlorophyll-a concentration found in a body of water. This means the fish catch will also be high if the chlorophyll-a concentration is high in a water area. Conversely, the catch will be low if the chlorophyll-a concentration is low in a water body. Arta et al. (2015) said that high chlorophyll-a concentrations are closely related to food availability for fish. As we know, small and large fish will move to find fertile areas to get food. The relationship between chlorophyll-A distribution and the catch of tuna can be seen in Table 3.

Table 3. Chlorophyll-a data with tuna catches

No	Time (2024)	Chlorophyll-a (mg/m^3)	Catch (kg)
1.	06 – 13	4,83	38.500
2.	14 – 21	5,81	43.000
3.	22 – 29	8,71	62.500

Source: PT Horizon catch data year 2024

Table 3 shows that when the chlorophyll-a concentration is high at an average of 8.71 mg/m^3, the tuna production volume increases with a catch of 62,500 kg. Vice versa, tuna production is also low when the chlorophyll-a concentration is low at an average of 4.83 mg/m^3, with a catch of 38,500 kg. The correlation of chlorophyll-a to the catch of tuna in Table 4.

Table 4. Chlorophyll-a correlation with the catch of tuna

	Chlorophyll-a (mg/m^3)	Catch (kg)
Chlorophyll-a (mg/m^3)	1	
Catch (kg)	0.99	1

The results of the correlation analysis show that chlorophyll-a influences tuna. The correlation test results are positive, indicating a high correlation between chlorophyll-a and the mackerel catch. The relationship between the two parameters to the mackerel catch is included in the very strong category with an R-value of 0.99. This is in line with the research of Munthe et al. (2018) that areas with very high chlorophyll-a levels are high in nutrients so that marine biota, especially pelagic fish such as tuna, gather in these areas.

4. CONCLUSION

Based on the results obtained in the research, it can be concluded that chlorophyll-a in the North Sumatra Sea Waters is unevenly distributed. The distribution of chlorophyll-a is primarily found in the eastern waters of Nias Island, where the value of chlorophyll-a concentration ranges from 0.03 - 0.2 mg/m^3 and the least ranges from 0.81 - 1 mg/m3. The analysis of the alleged fishing grounds for tuna (Euthynnus affinis) showed that the fishing points from April 06 to April 29, 2024, had an average percentage accuracy of 52%. Chlorophyll-a with catches in North Sumatra Sea Waters has a very strong relationship with an R-value of 0.99.

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