Relationship of Temperature and Chlorophyll-a with Distribution of Yellowstripe Scad (*Selaroides leptolepis*) in East Coastal Waters of North Sumatra

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Authors’ contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The east coast of North Sumatra is part of the Malacca Strait, a highly utilized fishing area. One of the commodities that can be harvested is the Yellowstripe Scad (*Selaroides leptolepis*). Through oceanography parameters, specifically temperature and chlorophyll-a concentrations, it is possible to determine optimal fishing grounds which can be used as guidelines. One of the satellites that can detect sea surface temperature (SST) and chlorophyll-a concentrations is Aqua (EOS PM), which is equipped with a Moderate Resolution Imaging Spectroradiometer (MODIS) sensor. Data on the Yellowstripe Scad (*Selaroides leptolepis*) were obtained from the Belawan Ocean Fishing Port (OFP). Based on the analysis of MODIS images from the Aqua satellite, the sea surface temperature of the east coastal waters of North Sumatra in 2012 - 2016 ranged from 29°C – 32°C with chlorophyll-a concentrations ranging from 0.19 – 5.26 mg/m³. The largest harvest occurred during the west monsoon with a value of 143.46 tons and the lowest was during the east monsoon with a value of 139.87 tons. Yellowstripe Scad harvest has a negative correlation with the sea surface temperature with a correlation value of -0.365. Chlorophyll-a concentrations and harvest amount have a positive correlation value of 0.660. Yellowstripe Scad is predicted to yield the largest harvest during the west monsoon (December-February) between the Asahan and Labuhanbatu Regencies at coordinates 2.68°N - 2.74°N and 100.37°E - 100.44°E.

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1. INTRODUCTION

1.1 Background

The east coast of North Sumatra is part of the Malacca Strait which is a highly utilized fishing area. One of the commodities that can be harvested is the Yellowstripe Scad (Selaroides leptolepis), a small pelagic fish. Pelagic fish has a large harvesting potential in the east coastal waters of North Sumatra, which enables further development while still maintaining sustainability.

From 2012 - 2016, the average Yellowstripe Scad harvest at the Belawan fishing port has increased each year. In 2012, harvest yielded 1,642.44 tons of Yellowstripe Scad and increased to 1,778.51 tons in 2016. This increase is assumed to be related to the increase in the number of fishing vessels operating on the east coast of North Sumatra. However, this amount is still below the sustainable potential of Yellowstripe Scad in the coastal waters of North Sumatra, which is approximately 3,500 tons/year [1].

The nonoptimal harvest of Yellowstripe Scad in the east coast of North Sumatra is due to the fact that fishermen have to actively search for potential fishing grounds. Its dynamic, constantly moving nature negatively impact harvests and operational costs. A fishing ground is an area to conduct fishing activities where fish usually gather. Fishermen determine these areas by spotting nearby birds [2].

Data regarding the spatial variability of temperature and surface-level chlorophyll-a concentrations can be used to facilitate resource management and utilization, namely as a basis for predicting and determining potential fishing grounds [3]. This can then be used as a guide for fishery purposes through spread information to Vessel Monitoring System (VMS) of fishermen fishing boat.

Sea surface temperature and chlorophyll-a concentrations can be measured directly (insitu) and indirectly, namely through remote sensing using satellites. Remote sensing is an efficient method to determine the distribution of sea surface temperature and chlorophyll-a concentrations. This data is crucial in determining the optimum temperature and chlorophyll-a concentrations preferred by fish, which in turn can be used to predict fishing grounds [4].

One of the satellites that can detect sea surface temperature and chlorophyll-a concentrations is the Aqua (EOS PM) satellite which is equipped with a Moderate Resolution Imaging Spectroradiometer (MODIS) sensor. Data from the MODIS can determine the distribution of sea surface temperature and chlorophyll-a concentrations in the east coastal waters of North Sumatra. This data can be linked to Yellowstripe Scad harvest data to determine the distribution and potential fishing grounds, which can help fishermen save operational costs and increase their catch. Therefore, fishermen need no longer actively look for fish, but rather simply catch them.

1.2 Research Purposes

1. Determining the distribution of sea surface temperature and chlorophyll-a concentrations in the east coastal waters of North Sumatra.
2. Analyzing the relationship between sea surface temperature and chlorophyll-a concentrations with the distribution of Yellowstripe Scad in the east coastal waters of North Sumatra.
3. Determining Yellowstripe Scad fishing grounds in the east coastal waters of North Sumatra.

2. RESEARCH MATERIALS AND METHODS

2.1 Time and Place of Research

This research was conducted from March to May 2017 in the east coast of North Sumatra which is geographically located at coordinates 2°21’15”N - 4°21’15”N and 98°13’45”E - 101°21’15”E. This area is a fishing ground for fishermen of the Belawan Ocean Fishing Port. The location of research is shallow water of coastal waters of North Sumatera.

2.2 Research Tools and Materials

There were several tools used in this research, namely a camera to take pictures of
YellowstripeScadas physical evidence, a Global Positioning System (GPS) to determine the coordinates of YellowstripeScad fishing grounds, writing tools to record research results, a laptop to analyze data, SeaDAS 7.2 using a Windows operating system to obtain chlorophyll-a concentration values and SST in ASCII form from MODIS images, WinRAR 3.42 to extract MODIS level 3 images of chlorophyll concentrations and monthly SST with a 4 km resolution, Surfer-8 to display the spatial distribution of SST and chlorophyll-a, ArcGis 10.2.2 to determine YellowstripeScad fishing grounds, and Microsoft Excel to analyze the relationship between sea surface temperature and chlorophyll-a concentrations with harvest amount.

The materials used include sea surface temperature and chlorophyll-a concentration data obtained from the MODIS (Moderate Resolution Imaging Spectroradiometer) Aqua satellite imagery. The image data used is the 2012 - 2016 monthly average level 3 image obtained from http://www.oceancolor.gsfc.nasa.gov and the 2012 - 2016 Yellowstripe Scad harvest data obtained from the Belawan Ocean Fishing Port (OFP).

2.3 Data Collection Method

2.3.1 Harvest data

Harvest data were analyzed using Microsoft Excel and presented in tables and graphs. Harvest obtained during the study is included to analyze harvest based on the distribution scale of the fishing ground (spatial) and the time of harvest (temporal). The data used is statistical data from the Belawan Ocean Fishing Port from January 2012 to December 2016 in the fishing grounds of the east coast of North Sumatra.

2.3.2 Satellite image processing

MODIS Aqua satellite image data is processed to obtain the chlorophyll-a concentration and SST values. The level-3 MODIS images were downloaded in the form of compressed digital data in the Hierarchical Data Format (HDF) which has been radiometric and atmospheric corrected. The data was then extracted using WinRAR 3.42 and processed using SeaWIFS Data Analysis System (SeaDAS) 7.2 with a Windows operating system. The images were then cropped based on the research area. The output is converted into the American Standard Code for Information Interchange (ASCII) which includes longitude, latitude, and estimation values for chlorophyll-a concentration and SST.

The spatial distribution of chlorophyll-a concentrations and SST were displayed using Surfer 8 and ArcGIS 10.2.2, then converted into the JPG format.

2.3.3 Relationship between sea surface temperature and chlorophyll-a concentration with yellowstripe scad harvest

SST and chlorophyll-a concentrations obtained from image processing are then compared with Yellowstripe Scad harvest. The relationship between SST and chlorophyll-a with harvest amount was analyzed using SPSS (Statistical Product and Service Solution) 18 and converted to graphs using Microsoft Excel. The catch of Yellowstripe Scad is obtained from fishing port Belawan every month and year of 2014 to 2016.

3. RESULTS AND DISCUSSION

3.1 Distribution of Sea Surface Temperature in the East Coastal Waters of North Sumatera

Based on the analysis of 2012-2016 MODIS Aqua images, the distribution of sea surface temperature in the eastern coastal waters of North Sumatra is a relatively constant 30°C. The yellow color indicates a sea surface temperature of 29°C. The red color indicates a relatively warm temperature of 31°C, indicating that the value of the surface temperature distribution has increased. The distribution of the seasonal average sea can be seen in Fig. 1.

Based on Fig. 1, the distribution pattern of the average sea surface temperature of the eastern coastal waters of North Sumatra during the 2012 -2016 western monsoon shows a value of 30.02 °C. The average temperature is obtained by conversion of satellite image to Sea Surface Temperature (SST), where the water mass is displayed mostly in yellow. Compared to other monsoons, the west monsoon shows the lowest sea surface temperature.
In the first transitional monsoon, the distribution of sea surface temperature is 30.87 °C, indicated by the water mass being shown mostly in red. Compared to other monsoons, it has the highest sea surface temperature. During the east monsoon, the sea surface temperature on the east coast of North Sumatra is relatively warm, around 30.80 °C. The second transitional monsoon shows a sea surface temperature distribution pattern of around 30.39 °C.

Based on Table 1, the monthly average sea surface temperature on the east coast of North Sumatra in 2012 - 2016 ranges from 29.26 - 31.56 °C. According to Saeri [5] the average temperature of the Malacca Strait in 2013 was 23-35 ° Celsius, with a relative humidity of 65-75%.

The distribution of sea surface temperature on the east coast of North Sumatra has the highest value of 30.87 °C during the first transitional monsoon and the lowest during the west monsoon with a value of 30.02 °C. The high sea surface temperature during the first transitional monsoon is caused by the lack of water movement across the Malacca Strait due to the loss of west monsoon influence and the magnitude of the east monsoon influence. This in turn causes the influence of meteorological factors, such as temperature and sunlight intensity, to increase SST in the Malacca Strait. This is in accordance with the research of Habibie and Nuraini [6] which shows that when the sun is in the Northern Hemisphere the atmosphere tended to be warmer, followed by a rise in SST. The SST during this month is highest in parts of the Malacca Strait, reaching 30.5°C, while the surrounding areas, namely along the east and west coast of Sumatra, covering Padang to Aceh, have a temperature of 30°C.

3.2 Distribution of Chlorophyll-a Concentration in the East Coastal Waters of North Sumatra

The results of the MODIS Aqua satellite image analysis show that the distribution value of chlorophyll-a in the east coast of North Sumatra in 2012 - 2016 ranges between 1.49 - 3.73 mg/m³. Chlorophyll-a concentrations fluctuate every month; greener water indicates increased concentrations. The seasonal average distribution of chlorophyll-a in 2012 - 2016 can be seen in Fig. 2.
The highest chlorophyll-a concentration was detected during the west monsoon which occurs in December - February with a distribution value of 3.61 mg/m³, while the lowest was during the east monsoon with a distribution value of 2.09 mg/m³. Chlorophyll-a concentrations on the east coast of Sumatra tend to be high during the west monsoon; Arinardi [7] states that during the west monsoon, surface-level chlorophyll-a concentrations of > 0.50 mg/m³ was always found along the east coast of Sumatra. This is also supported by research conducted by Adnan [8], which states that the high concentration of chlorophyll-a in February during the west monsoon is due to the fact the average rainfall is quite high in January and February, causing a supply of nutrients to arrive from the mainland through rivers.

Table 1. 2012 – 2016 Monthly Average Sea Surface Temperature (°C)

| Month    | 2012 | 2013 | 2014 | 2015 | 2016 |
|----------|------|------|------|------|------|
| January  | 30.13| 30.01| 29.26| 30.06| 30.40|
| February | 29.98| 29.69| 29.79| 30.75| 30.89|
| March    | 30.66| 30.74| 30.49| 30.79| 31.56|
| April    | 30.70| 31.28| 30.79| 30.79| 31.26|
| May      | 30.79| 31.34| 31.20| 30.57| 31.39|
| June     | 30.54| 30.95| 30.79| 30.72| 30.97|
| July     | 30.23| 30.61| 30.32| 30.27| 31.21|
| August   | 30.42| 30.59| 30.15| 30.64| 31.33|
| September| 30.35| 30.33| 30.14| 29.91| 30.78|
| October  | 30.52| 30.09| 30.26| 30.42| 29.91|
| November | 29.95| 29.80| 30.50| 30.19| 29.82|

Fig. 2. 2012 - 2016 Average Distribution of Chlorophyll-a during (a) West Monsoon (b) First Transitional Monsoon (c) East Monsoon (d) Second Transitional Monsoon
During the first transitional monsoon and the east monsoon, chlorophyll-a concentrations decrease. The coastal areas of Sumatra and Peninsular Malaysia experience low tides as the sea surface temperatures of these two monsoons are relatively high, causing a lack of nutrients and minerals from land. Utari [9] stated that the east monsoon is marked by the occurrence of high air pressure over Australia and low air pressure over Asia, which causes the wind to move from east to west.

Based on the analysis of MODIS Aqua images, chlorophyll-a concentrations during the 2012-2016 western monsoons showed a value of 3.61 mg/m³. The west monsoon has the highest chlorophyll-a concentrations compared to other monsoons, which is indicated by the water mass being displayed mostly in green.

In the first transitional monsoon, chlorophyll-a concentrations on the east coast of North Sumatra seem to decrease, as indicated by a decrease of the green representation of water mass. The lowest chlorophyll-a concentrations were detected during the east monsoon, with a value of 2.09 mg/m³. This is increased again during the second transitional monsoon to 2.56 mg/m³. For monthly values, the highest concentrations were detected in February 2016 (west monsoon) and the lowest was in June 2013 (east monsoon) (see Table 2).

In general, the increase in chlorophyll-a occurs during the second transitional monsoon (September-November) and reaches its peak during the west monsoon (December-February) with a range of 3.09-3.73 mg/m³. The lowest chlorophyll-a concentrations were found during the east monsoon (June-August) with a range of 1.49-2.14 mg/m³.

### 3.3 Yellowstripe Scad Harvest on the East Coast of North Sumatra

Yellowstripe Scad is one of the pelagic fish that is most often brought to the Belawan OFP. Its independence on monsoon has caused the Yellowstripe Scad to become one of the most dominant fish in the area. It is usually caught using gillnets. The total harvest of Yellowstripe Scad can be seen in Table 3.

From 2012-2016, harvest fluctuated every month, with the highest occurring mostly in February, March, and April and the lowest in May, July, and December. The highest harvest volume of 229.05 tons occurred in March 2014 while the lowest was 101.36 tons which occurred in July 2014.

Based on statistical data from the Belawan Ocean Fishing Port (2016), Yellowstripe Scad (Selaroides leptolepis) is one of the main commodities of the warm waters of the East Coast of Sumatra. According to Syakila [10], Yellowstripe Scad is commonly found in the east coastal waters with a temperature range of 27-30°C throughout the year.

### Table 2. 2012 – 2016 Monthly Average Chlorophyll-a Concentrations (mg/m³)

| Month    | Year 2012 | Year 2013 | Year 2014 | Year 2015 | Year 2016 |
|----------|-----------|-----------|-----------|-----------|-----------|
| January  | 2.93      | 2.50      | 2.00      | 2.55      | 2.26      |
| February | 2.99      | 3.09      | 3.36      | 2.45      | 3.73      |
| March    | 2.96      | 2.85      | 2.52      | 2.63      | 2.37      |
| April    | 2.36      | 2.06      | 1.82      | 2.02      | 2.34      |
| May      | 2.14      | 1.93      | 2.02      | 2.45      | 2.37      |
| June     | 2.24      | 1.49      | 2.45      | 2.31      | 2.09      |
| July     | 2.53      | 1.88      | 2.45      | 2.63      | 1.79      |
| August   | 2.17      | 1.55      | 2.05      | 1.98      | 2.22      |
| September| 2.29      | 1.99      | 1.94      | 2.22      | 1.65      |
| October  | 3.29      | 2.87      | 3.16      | 3.15      | 1.72      |
| November | 3.24      | 2.70      | 2.77      | 2.67      | 1.70      |
| December | 3.18      | 2.45      | 3.05      | 2.99      | 1.88      |
The highest average harvest of Yellowstripe Scad on the East Coast of North Sumatra occurred in January with a volume of 166.31 tons and the lowest was in December with a volume of 123.58 tons. The low volume in December is thought to be caused by frequent rainfall, making it difficult for fishermen to catch fish. This is supported by Septiana’s research [11] which states that there has been a significant decrease in the catch during the last 10 years from June to December. High sea surface temperatures, low chlorophyll-a concentrations, high waves that reach 2.4 m, frequent rainfall followed by strong winds, and erratic weather are assumed to be the factors that prevent fishermen from sailing. The highest rainfall occurred in November and December and the lowest in July and August.

### 3.4 Relationship between Sea Surface Temperature, Chlorophyll-a and Harvest

In general, harvest volume on the east coast of North Sumatra increases when sea surface temperatures decrease which can be seen during the second transitional monsoon and the west monsoon. The opposite can be observed during the east monsoon, where harvest volume decreases as sea surface temperature increases. The highest Yellowstripe Scad harvest volume occurred during a sea surface temperature of 29.79 °C.

Yellowstripe Scad harvest shows a monthly fluctuating pattern where the decrease in sea surface temperature is almost evenly followed by an increase in harvest. During the west monsoon where the sea surface temperature reaches 30.02 °C, 143.46 tons of Yellowstripe Scad were successfully harvested, which is the same amount as in the second transitional monsoon. Meanwhile, during the first transitional monsoon where sea surface temperatures are high, harvest decreases. This is thought to be caused by the limited adaptability of Yellowstripe Scads. Brill [12] stated that adaptability, which is influenced by individual weight and environmental temperature, is an equilibrium value, which means that if there is a significant increase in the sea surface temperature, small fish are likely to look for other areas with preferable temperatures.

The relationship between chlorophyll-a and Yellowstripe Scad harvest can be seen in the tendency of large harvests during high chlorophyll-a concentrations and vice versa. This is in accordance with the research of Septiana [11] which states that when the chlorophyll-a concentration is relatively low, Yellowstripe Scad harvest is also low. When the chlorophyll-a concentration in Lampung Bay increased, harvest volume also increased. This is also supported by Panjaitan’s research [13] which shows that upwelling during an east monsoon causes an abundance of phytoplankton which is feed for pelagic fish.

In coastal areas, chlorophyll-a concentrations during a west monsoon tend to be high, indicating an abundance of phytoplankton as fish feed [14]. The large quantity of phytoplankton is assumed to be caused by nutritional supply from land to sea. According to Satriuddin et al. [15] high chlorophyll-a concentrations, especially in coastal areas, indicate a sufficient plankton

#### Table 3. 2012-2016 Monthly Harvest of Yellowstripe Scad in the East Coast of North Sumatera

| Month     | Total Harvest (Tonnes) | Average |
|-----------|------------------------|---------|
|           | 2012       | 2013       | 2014       | 2015       | 2016       |
| January   | 153.66     | 136.34     | 197.28     | 168.10     | 176.17     | 166.31     |
| February  | 143.23     | 125.67     | 150.27     | 181.05     | 172.34     | 154.51     |
| March     | 117.70     | 115.29     | 229.05     | 152.00     | 160.90     | 154.98     |
| April     | 129.24     | 172.40     | 132.15     | 144.69     | 146.49     | 144.99     |
| May       | 115.47     | 163.07     | 113.20     | 148.98     | 145.00     | 135.14     |
| June      | 139.64     | 135.92     | 109.34     | 148.90     | 140.00     | 134.76     |
| July      | 140.47     | 114.84     | 101.36     | 159.21     | 143.00     | 131.77     |
| August    | 140.04     | 145.01     | 117.22     | 157.07     | 150.28     | 141.92     |
| September | 155.87     | 142.03     | 167.89     | 119.70     | 147.00     | 144.49     |
| October   | 131.83     | 145.64     | 146.07     | 135.22     | 144.43     | 140.63     |
| November  | 150.49     | 144.29     | 133.66     | 122.70     | 129.70     | 134.16     |
| December  | 124.82     | 123.15     | 130.20     | 116.56     | 123.20     | 123.58     |
| Total     | 1,642.44   | 1,663.68   | 1,727.67   | 1,754.18   | 1,778.51   |

The data show that Yellowstripe Scad harvest is affected by the sea surface temperature. The highest harvest occurred during warm sea surface temperatures, while the lowest harvest occurred during cold sea surface temperatures.
supply to maintain the sustainability of economically important small pelagic fish.

In certain conditions, the harvest volume of Yellowstripe Scad decreases during an increase in chlorophyll-a distribution, such as in September 2014 and August 2015. This is assumed to occur due to time lag in the food chain, meaning that an increase in phytoplankton does not have an immediate impact on the number of Yellowstripe Scad. This is in accordance with Tangke et al., [4] stating that chlorophyll concentrations do not immediately affect the number of fish in the area. There is a delay or time where chlorophyll is first consumed by herbivorous organisms, for example, zooplankton or small (juvenile) crustaceans, and then consumed by organisms in the trophic level above it.

When the sea surface temperature is normal, the chlorophyll-a concentration will also be normal. However, if the sea surface temperature is high, the chlorophyll concentration will below which means that these two variables are negatively related. This is because high temperatures increase the intensity of the light received. This is in accordance with Nybakken [16] stating that high light intensity will damage chlorophyll, causing the photosynthesis process to be disrupted and not run well. Likewise, the photosynthesis process will also not run well if the light intensity is very low, as there is an insufficient amount of light to carry out the photosynthesis process. The maximum temperature for phytoplankton to photosynthesize is 30°C, showing that phytoplankton is distributed in a temperature gradient from 5 - 30°C.

Based on the results of the Pearson correlation analysis, it is known that harvest has a negative correlation with sea surface temperature and a positive correlation with chlorophyll-a concentrations. According to Panjaian [13] chlorophyll-a concentrations significantly affect harvest in the waters of the Bali Strait as this indicates fertile water conditions, thus an abundance of plankton as fish food. The high level of surface nutrients during upwelling in the east monsoon will increase phytoplankton concentrations. Phytoplankton resides in the lowest level of the food chain in the ocean and is a source of food for zooplankton and small fish.

In general, Yellowstripe Scad harvest in the east coastal waters of North Sumatra is directly proportional with chlorophyll-a concentrations. The largest harvest and chlorophyll-a concentrations were found during the west monsoon, decreased during the first transitional monsoon and the east monsoon, and increased again during the second transitional monsoon. The largest harvest of Yellowstripe Scad was conducted during a chlorophyll-a concentration of 2.52 mg/m³.

3.5 Correlation of Yellowstripe Scad Harvest with SST and Chlorophyll-a

The relationship between Yellowstripe Scad harvest with sea surface temperature and chlorophyll-a was analyzed using the Pearson correlation from SPSS 18. Yellowstripe Scad harvest was used as the dependent variable while sea surface temperature and Chlorophyll-a were the independent variables with a significance value of <0.05.

The results show that Yellowstripe Scad harvest and sea surface temperature has a negative (-) or opposite correlation with a value of -0.365. This means that if the sea surface temperature increases, Yellowstripe Scad harvest will decrease and vice versa.

Chlorophyll-a and Yellowstripe Scad harvest have a positive correlation value (+) of 0.660 which indicates that chlorophyll-a and harvest have a strong and unidirectional relationship. This means that if the chlorophyll-a content in the water increases, Yellowstripe Scad harvest will also increase and vice versa.

3.6 Estimating Yellowstripe Scad Fishing Grounds

Fishing grounds were predicted by overlaying the results of the analysis of sea surface temperature and chlorophyll-a in 2012 - 2016, then determined according to the distribution of chlorophyll-a and temperature in the east coastal waters of North Sumatra. According to Adnan [8] potential fishing grounds are areas with high chlorophyll-a concentrations with optimal temperatures for fish distribution.

During west monsoons, the fishing grounds are located in the east coastal waters of the Asahan district to the Labuhanbatu district. The largest Yellowstripe Scad harvest is predicted to occur during this monsoon. The map of predicted Yellowstripe Scad fishing grounds during west monsoons can be seen in Fig. 3.
Based on Fig. 4, the Yellowstripe Scad fishing grounds which are predicted to produce the largest harvest are in Asahan to Labuhanbatu districts at coordinates 2.68°N- 2.74°N and 100.37°E-100.44°E during a west monsoon. The distribution of chlorophyll-a concentrations in this area is quite high, namely in the range of 4.5-8.5 mg/m³ with temperatures in the range of 29-30 °C. This is in accordance with Adnan’s [8] research, stating that during west and east monsoons, potential fishing grounds are scattered in various places in East Kalimantan waters and the distribution of fishing areas is wider expanding to the offshore. This is because during monsoons, chlorophyll-a concentrations tend to be higher and SST tends to be lower. High chlorophyll-a concentrations are closely related to the availability of fish feeds. It is commonly known that fish, both small and large, will move in search of fertile areas for feeds.

Yellowstripe Scad Fishing Grounds during the first transitional monsoon are in the coastal waters of the Asahan district. It is predicted that the smallest Yellowstripe Scad harvest will occur during this monsoon, due to low chlorophyll-a concentrations. The sea surface temperature during this monsoon is also too warm for Yellowstripe Scads. Presumably, these conditions are not suitable for Yellowstripe Scads. This is also supported by Fausan [17] stating that the fluctuation of harvest in a fishing ground is determined by oceanographic conditions such as sea surface temperature, chlorophyll-a concentrations, and other parameters. Fishing grounds during the first transitional monsoon can be seen in Fig. 4.

Yellowstripe Scad fishing grounds during east monsoons are the same as during west monsoons, namely in the east coastal waters of the Asahan district to the Labuhanbatu district. However, there are fewer fishing grounds during the east monsoon.

During east monsoons, the Yellowstripe Scad fishing grounds are relocated in the coastal waters from Asahan to Labuhanbatu districts. Fishing grounds change each monsoon, as they are not only affected by SST and the distribution of chlorophyll-a, but also by wind patterns. Indonesia itself is influenced by monsoons, namely the west and east monsoons. According to Hadi [18] the Indonesian archipelago is located between Asia and Australia. The differing seasons of these continents cause monsoons to blow over them, bringing a rotation of rainy and dry seasons to the Indonesian archipelago. Yellowstripe Scad fishing grounds during east monsoons can be seen in Fig. 5.

![Fig. 3. Yellowstripe scad fishing grounds during West Monsoons](image_url)
Fig. 4. Yellowstripe scad fishing grounds during the first Transitional Monsoon

Yellowstripe Scad Fishing Grounds during the second transitional monsoon is located almost evenly along the east coast, namely small areas in each district located from Langkat to Labuhanbatu districts. Yellowstripe Scad Fishing Grounds during the second transitional monsoon can be seen in Fig. 6.

During the second transitional monsoon, the Yellowstripe Scad fishing grounds are located along the eastern coastal waters of North Sumatera, from Langkat to Labuhanbatu districts. During this period, fishing grounds are located in almost all waters of North Sumatra [19-20] albeit only in coastal areas. This is in line with the statement of Adnan [8] stating that fishing grounds during each monsoon are mostly located in coastal areas and near river estuaries. This is because the fertility rate in coastal areas and near river estuaries tends to be higher than offshore.

Fig. 5. Yellowstripe scad fishing grounds during East Monsoons

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4. CONCLUSIONS AND SUGGESTION

4.1 Conclusions

1. Distribution of the sea surface temperature in the eastern coastal waters of North Sumatra in 2012 - 2016 ranges from 29.26 - 31.56°C, as analyzed from MODIS Aqua images. The highest SST distribution was during the first transitional monsoon with an average value of 30.87°C and the lowest was during the west monsoon with an average value of 30.02°C. Chlorophyll-a concentrations in the east coastal waters of North Sumatra in 2012 - 2016 ranged from 1.49 to 3.73 mg/m³. The lowest chlorophyll-a concentrations were found during the east monsoon with a value of 2.09 mg/m³ and the highest was during the west monsoon at 3.61 mg/m³.

2. Sea surface temperature (SST) has a negative correlation with Yellowstripe Scad harvest with a correlation value of -0.365. Chlorophyll-a and harvest yield a positive correlation value of 0.660.

3. The Yellowstripe Scad fishing grounds predicted to provide the largest harvest are between Asahan and Labuhanbatu districts (2.68°N - 2.74°N and 100.37°E - 100.44°E) during the west monsoon (December-February).

4.2 Suggestion

This research should use a larger variety of harvest data to obtain varied results, and harvest data can hope fully be obtained directly from fishing vessels to avoid the possibility of changes or errors. In addition, it is necessary to add wind data to observe the pattern of wind distribution for each monsoon.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

COMPETING INTERESTS

Authors have declared that no competing interests exist.
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