Spatial and temporal variation of sea surface temperature and chlorophyll-a on the mackerel fish (*Scomberomorus commerson*) distribution using Aqua Modis satellite in naukerjerai district, merauke regency

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Abstract. Remote sensing is a technique that can be applied for observing oceanographic parameters such as content of sea surface temperature and chlorophyll-a. The study aims to analyze the parameters of Sea Surface Temperature and Chlorophyll-a by using Aqua Modis Satellite to see the spatial and temporal distribution of the two parameters on the distribution of CPUE of Mackerel (*Scomberomorus commerson*). Conducted for 2 months from May-June 2019 this study was held in the waters area of Naukenjerai District, Merauke Regency. The results showed the concentration of sea surface temperature in May was warmer in the range of 26.56 – 28.42 °C compared to June, where the temperature was cooler in the range of 25.43 – 26.94 °C. Meanwhile the concentration of chlorophyll-a in May was seen to be low around 0.3-1.73 mg/m³ which compared to June the concentration was relatively high around 1.45-2.36 mg/m³. The highest distribution of CPUE of Mackerel was found in June, which was 89 kg and the lowest CPUE Mackerel in May was around 22 kg. Therefore in June there is a great potential for capturing Mackerel.

Keywords: Sea Surface Temperature, Chlorophyll-a, Aqua Modis Satellite, CPUE Mackerel

1. Introduction

Naukenjerai District waters is a potential coastal area in the fisheries sector, especially in terms of fish and shrimp fishings, one of the fish resources that have economic value is Narrow-Barred Spanish Mackerel [1]. It shows the increasing efforts of fishing mackerel. According to [2] Increased exploitation of fish resources was due to the demand for fish resources.

According to [3] the mackerel (*Scomberomorus commerson*) is a group of large pelagic fish, where mackerel species like shallow habitats on the continental shelf mainly associated with the presence of coral reef substrates to the depths of 10-70 m. [4] state that the mackerel is poikilotherm. That is to say that the mackerel’s body temperature is following sea temperatures, and mackerel tends to be caught in the sea with temperatures of 25°C - 30°C and chlorophyll-a concentrations of 0.03 - 1.1 mg / m³. This
is in line with [5], the spread of large pelagic fish, including the mackerel is influenced by aquatic environments that are suitable to body conditions and tend to migrate to fertile sea.

According to [3] A fertile aquatic environment for Mackerel fishing can be supported by chlorophyll-a content and sea surface temperature, which have a relatively strong correlation with mackerel. [6] state that the determination of the fishing location can be conducted using remote sensing technology by detecting chlorophyll-a content and sea surface temperature via the Aqua MODIS satellite.

Remote sensing is a technique that can be applied for observing oceanographic parameters such as chlorophyll-a and SPL content, both spatially and temporally. Therefore, it is necessary to conduct further study related to the oceanographic parameters in the sea, one of them is by analyzing the parameters of sea surface temperature and chlorophyll-a by using Geographic Information System (GIS) to see the spatial and temporal distribution of the two parameters to the fishing of mackerel and the distribution of mackerel’s CPUE (Scomberomorus commerson).

2. Research Method

This research was conducted over 2 (two) months, from May to June 2019 in the sea of the Naukenjerai District, Merauke Regency at the coordinates of 140°25'40.00"EL and 8°43'55.16" SL.

![Figure 1. Map of Research Location](image)

The tools and materials used in this research can be seen in Table 1 and Table 2.

| No. | Tool                  | Usability                                      |
|-----|-----------------------|------------------------------------------------|
| 1   | Ship                  | Used for transportation                        |
| 2   | Gillnet               | Used as the tool to fish mackerel              |
| 3   | GPS                   | Used to see coordinates                        |
| 5   | WinSCP Software       | Used as the tool to download MODIS image level-3|
| 6   | SeaDas 7.3.1 Software | Used as the tool to transform chlorophyll-a and sea surface temperature data |
| 7   | ArcMap 10.2           | Used as the tool to make chlorophyll-a and sea surface temperature distribution map. |
Table 2. Materials

| No | Materials                                                                                                                                 |
|----|------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Chlorophyll-a and sea surface temperature data from Aqua MODIS satellite imagery in May - June 2019                                          |
| 2  | Coordinate data on the position of the Mackerel fishing area from the log book or GPS of the fisherman’s fishing boat.                       |
| 3  | Data on the result of Mackerel fishing conducted with the fishermen’s fishing boat in the sea of the Naukenjerai District in May - June 2019 |

Data on the result of Mackerel fishing conducted with the fishermen’s fishing boat in the sea of the Naukenjerai District in May - June 2019. Data processing used to analyze oceanographic parameter data (chlorophyll-a and Sea Surface Temperature) and the mackerel’s fishing position requires time series data on coordinates of fishing areas and the result of the mackerel’s fishing in the sea of the Naukenjerai District in 2 months from May - June 2019. Data processing consists of several stages, as follows:

1) Converting the coordinates of the fishing area into the programming software to be composited with the results of chlorophyll-a and daily sea surface temperature so that it will produce chlorophyll-a and daily sea surface temperature values in accordance with the fishing area.

2) Gridding (geostatistics) the coordinate of mackerel CPUE distribution using software (ArcMap 10.2). The gridding process (geostatistics) is the process of transforming data at coordinate points into spatial layers [7].

3) Chlorophyll-a and sea surface temperature distribution data are spatially processed using software (SeaDAS 7.3.1) then overlaid with mackerel CPUE according to the coordinates fishing area.

4) The process of analyzing mackerel CPUE using software (Microsoft Excel 2013) for the creation of a graph that shows the fluctuation pattern of daily and monthly mackerel CPUE.

5) The process of inserting metadata or layout so that the output can be complete information both spatially and temporally on the distribution of the mackerel [7].

3. Research Result

3.1. Distribution of Sea Surface Temperature

Based on the results of data processing, the value of sea surface temperature in May-June 2019 in the sea of the Naukenjerai District is obtained, the map of sea surface temperature distribution in the sea of the Naukenjerai District is presented in (Figure 2).
Figure 2. Map of Sea-Surface Temperature distribution in May-June 2019 in the sea of the Naukenjerai District

In (Figure 2), we can see the concentration of Sea Surface Temperature in May 2019, ranging between 26.56 - 28.42 °C, which means that it experienced warmer temperatures compared to June 2019, which experienced colder temperatures in the range of 25.43 - 26.94 °C. Sea surface temperature conditions are relatively high in May because the end of transitional season 1 occurred in that month. In that season, the average rainfall is quite low, and the wind direction is erratic. [8] stated that March and May are categorized as the transition 1 season or the early year monsoon transition. In this transitional season, the sun moves across the equator so that the winds weaken, have an erratic direction and move at speeds ranging between 2-4 m/s.

According to [9] December to May experience high temperatures and keep increasing until it reaches its peak in February or March annually. June to November experience low temperatures annually, where the temperature in the sea of the Bali Strait decreases every month until it reaches its lowest in August / September annually. This is in line with [12’], which states that an increase in sea surface temperature occurred from December to May and reaches its peak in February/March.

Sea surface temperature is relatively low in June because at the end of monsoon season occurred in that month, wherein that season is the rainy season brought by the wind. This is in line with the statement of [6] the decline in sea surface temperature from June to August is allegedly due to the strengthening of southeast monsoon which blows from southeast to northwest causing Ekman Transport so that a vacancy will occur that results in rising water (upwelling) from below to the surface layer.

The result of sea surface temperature distribution observation as the effect of currents show the pattern of the east to west movement. In general, the distribution pattern of SPL in the sea of the Naukenjerai District indicates that there was a temperature difference between May and June. In May, the temperature in the sea of Naukenjerai District was around 26.56 - 28.42 °C. In June, the temperature tends to be colder around 25.43 - 26.98 °C. [3] stated that the optimum temperature of the Mackerel is in the range of 24.6 °C - 28.4 °C. Sea surface temperature profile shows a tendency to decrease in temperature from May to June 2019. Cold sea surface temperature found in some areas may be due to the effect of upwelling. This assumption is based on the results of research by [10], which states that the upwelling often occurs and that upwelling can result in a decrease in Sea Surface Temperature.
[11] stated that pelagic fishing areas in the Indian Ocean are around the upwelling area in the west season and front area in the east season. The movement of monsoon winds causes variations in sea surface temperature in the southern sea of Java, upon entering the west season (west monsoon) the mass of water from the Andaman Sea enters the southern sea of Java and pushes the mass of water towards the east following the movement of wind and current direction. Whereas in the east season (southeast monsoon), winds, and currents in the south of Java moving from Australia bring a relatively colder mass of water to the west [12]. The increasing speed intensity of the southeast monsoon wind will increase in upwelling intensity [10]. Transitional season 1 (March-May) and transition 2 (September-November) are the stages of changes of monsoon. Thus, in May, which is still in the transitional season 1, the temperature is still warm and in June, the east season gets colder because it is still affected by erratic wind and current.

[13] Merauke is located in a season zone area where there is a distinct difference between the rainy season and the dry season. The indication of this season can be seen with the movement of dominant wind or monsoon. There are two monsoons in Indonesia, the eastern monsoon and the western monsoon. The location of the Merauke City that is close to the Australian continent also gives its weather characteristic, especially in the period of east monsoon, where the wind direction is mostly from east to south. The characteristics of the east monsoon wind are drier (tends to be cold), so that the growth of rain clouds in Merauke city is usually decreased. East monsoon in the city of Merauke usually occurs around May to November.

3.2. Chlorophyll-a Distribution

Based on the results of data processing, the value of chlorophyll-a concentration in May-June in the sea of the Naukenjerai District can be seen in (Figure 3) below.

![Figure 3. Map of chlorophyll-a distribution in May-June 2019 in the sea of the Naukenjerai District](image-url)

Based on the results of data processing, different values of chlorophyll-a concentration between May and June 2019 in the sea of the Naukenjerai District were obtained, chlorophyll-a concentrations in May is ranging between 0.3 to 1.73 mg/m$^3$ (Figure 3) which means it has a low chlorophyll-a content. Chlorophyll-a is low in May because transitional season 1 occurred in that month, where the wind and current movement are erratic. [14] stated that the minimum value of chlorophyll-a
concentration occurs in the transitional season 1 when the amount of rainfall is also minimum. According to Putra [6], in the dry season, especially in the transitional season, the amount of rainfall is relatively little so that nutrients carried by the river into the Java Sea are few. Broadly speaking, the intensity of rainfall can cause the concentration of chlorophyll-a in the sea to decrease dramatically (transitional season) because the materials or nutrients that enter the sea through the river are reduced due to the reduced discharge of water flowing in the river to the sea.

Chlorophyll-a concentration in June 2019 in the sea of the Naukenjerai District was relative with values ranging between 1.45 - 2.36 mg/m$^3$. The concentration of chlorophyll-a is relatively high because there is an east season in which the season with a relatively calm wind condition and low rainfall in June. From the distribution of chlorophyll-a concentrations in the Indonesian sea, it was found that the highest chlorophyll-a concentration was found in the east monsoon wind when there was upwelling in several seas, especially the eastern seas [15].

According to [14], the increase of wind speed in coastal areas can increase the vertical mass of water, which increases the fertility of the water because of the mixing of water masses from the seabed, which is rich in nutrients and ultimately increases the chlorophyll-a content on the surface. [16] shows that the distribution of chlorophyll-a concentrations strongly depends on sea surface temperature where the colder sea surface temperature, the more chlorophyll-a contained inside it. This is related to the upwelling process, which can be identified by colder sea surface temperatures compared to the surrounding area.

The observation of chlorophyll-a content distribution shows the pattern of movement from east to west, where in general, the distribution pattern of chlorophyll-a content in the waters of the Naukenjerai District forms a divergent pattern that is the source of high chlorophyll-a in front of the River Estuary. Chlorophyll-a in the sea of the Naukenjerai District shows that in May and June, the range of chlorophyll-a content was between 0.3-2.36 mg/m$^3$. [3] stated that the optimum range of chlorophyll-a for Mackerel habitat is in the range of 0.30 - 8.04 mg/m$^3$. It can be concluded that the chlorophyll-a content at the Mackerel fishing point from May to June was relatively high. This is explained [17] nutrient increase in shallow seas is closely related to the influence of river flow and the process of upward base water stirring by the effects of tides and waves, nutrients from land have a positive effect on phytoplankton growth which will affect chlorophyll-a concentration.

According to [6] The high concentration of chlorophyll-a in the coastal area is due to the accumulation of nutrients carried by the river flow into the sea waters in the coastal area, especially on the southern. The period of the transitional season is very short, only a few days with erratic direction and intensity of the wind. This will affect the distribution of oceanographic parameters such as chlorophyll-a and SPL when the distribution tends to be non-uniform compared to other seasons [18]. According to [19], The high concentration of chlorophyll-a in the east season period (June - August) was suspected caused by a strong enough current to carry chlorophyll-a from the coast to the offshore sea resulting in a pattern of high chlorophyll-a concentrations distribution from the southwest coast of Papua beginning to be seen extending in all directions.

[20] Higher southeast monsoon wind speeds will result in higher intensity of upwelling processes as well as higher advection of sea surface temperature so that the SPL range is lower. The high intensity of upwelling that occurs also increases the level of surface nutrients, thus triggering faster growth of phytoplankton, and increase the concentration of chlorophyll-a. [21] stated that the presence of chlorophyll-a is a product of a high water productivity process, where it is influenced by adequate nutrient elements.

Chlorophyll is a green pigment in plants, algae, and photosynthetic bacteria. This pigment plays a role in the photosynthesis process in plants by absorbing and converting light energy into chemical energy [12]. A good ecosystem must be able to support life in it. One measure of the quality of an
ecosystem is the implementation of the production process or primary productivity, which requires the existence of light for its sustainability. The higher the value of productivity, the greater the support for the lives of the inhabitants. Conversely, low primary productivity indicates low carrying capacity. Primary productivity can be defined as the rate of solar radiation energy storage through photosynthesis activities carried out by primary producers who can utilize inorganic substances and convert them into organic matter [22]

3.3. Mackerel CPUE Distribution

The result of the Narrow-Barred Spanish Mackerel fishing during the research period in May - June 2019 in the sea of the Naukenjerai District, Merauke Regency with a total of 13 fishing trips, the most occurred in June was 89 kg with 7 fishing attempts, while in May the result of the fishing was 22 kg with 6 fishing attempts, the highest result of fishing occurred on June 30, 2019 with 23 kg. The result of mackerel fishing can be seen in (Figure 4) below:

![Figure 4. Graph of The Mackerel Production in the Period of May - June 2019](image)

Based on (Figure 4) the highest CPUE distribution of Mackerel was found in June with 89 kg, and the lowest occurred in May with 22 kg. Changes in monthly CPUE are influenced by several factors. In June, SPL and chlorophyll-a were found, which is preferred or following the mackerel’s habitat. Thus, the result of mackerel fishing is increasing. [23] said that CPUE fluctuations are influenced by various factors, including differences in fishing efforts, monthly weather conditions, availability of food sources, and oceanographic conditions that affect the life and presence of pelagic in the fishing area.

4. Conclusion

Spatial and temporal variations in sea surface temperature and chlorophyll-a to the distribution of narrow-barred Spanish mackerel fish (Scomberomorus commerson) show that sea surface temperature concentrations in May range between 26.56 - 28.42 °C which means it experienced warmer temperatures compared to June which experienced colder temperatures around 25.43 - 26.94 °C while the chlorophyll-a concentration in May was seen to be low around 0.3 - 1.73 mg / m$^3$ compared to June 2019 where chlorophyll-a was relatively high with a range of values between 1.45 - 2.36 mg / m$^3$. The highest distribution of the mackerel CPUE was found in June with 89 kg and the lowest mackerel CPUE in May with 22 kg. Thus, it is very potential to fish Mackerel in June.
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