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MAPPING OF SEA SURFACE TEMPERATURE DISTRIBUTION, CHLOROPHYL-A CONCENTRATION AND POTENTIAL ZONE OF LARGE PELAGIC FISHING IN THE EAST MONSOON IN THE BANDA SEA, 2019

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ABSTRACT
Important parameters of water quality are sea surface temperature and chlorophyll-a concentration. The Banda Sea is famous for its fertile waters and rich in marine products, but not all of its areas have fertile waters, therefore it is necessary to map the distribution of temperature and chlorophyll-a in the Banda Sea. The objective of this fieldwork was to analyze the distribution of sea surface temperature and chlorophyll-a concentrations in the Banda Sea during the eastern monsoon (June, July, August) 2019 and identify potential fishing areas for large pelagic fish in 2019. The highest temperature distribution is in June and the lowest temperature value is in August. The highest chlorophyll-a concentration was in July and the lowest chlorophyll-a concentration was in June. For the potential zone for catching large pelagic fish in the Banda Sea, in the east monsoon it is in the northern part of the area observed or in June. This usually occurs due to current movements that affect the distribution of sea surface temperature and chlorophyll-a concentration in the waters.

KEY WORDS
Banda Sea, catching potensial zone, chlorophyoll-a, sea surface temperature.

Indonesia, whose entire territory is surrounded by the sea, has a rich potential for marine biological resources, but so far their management and use have not been implemented optimally. The increasing use of natural resources needs to be balanced with continuous monitoring of water quality conditions. Important parameters of water quality are sea surface temperature and chlorophyll-a concentration (Muskananfola et al., 2021).

The Banda Sea is a sea located in the Maluku Island, at central Maluku. Indonesia has an area of about 470,000 km^2, of which the deepest part reaches 5800 m. The Banda Sea is part of Indonesian waters, in the northern part of which there are some islands, namely Buru, Sula, Ambon and Seram. In the south, there are Wetar Island, Babar Island, Alor Island, Timor Island, Tanimbar Island. In the east, there is Aru Island, and in the west, there is Wakatobi Island. The Banda Sea is located between 03°10 - 8°30 S, 125° 30’ E - 132° 30’ E (Tadjuddah, 2016). The Banda Sea is famous for its fertile waters and rich marine products. However, not all areas have fertile areas. Therefore, it is necessary to map the distribution of temperature and chlorophyll-a in the Banda Sea.

Along with the rapid development of remote sensing technology, many researchers are conducting studies more efficiently. Aqua MODIS (Moderate Resolution Imaging Spectroradiometer) satellite imagery is one of the remote sensing images having many uses

in various fields, such as forestry, agriculture, meteorology, climatology, fisheries, and marine. The purpose of this study was to analyze the distribution of sea surface temperature and chlorophyll concentration in the Banda Sea during the east monsoon and determine the potential zones for catching large pelagic fish.

METHODS OF RESEARCH

The research was carried out from September to November 2022 at the Computer Laboratory of the Faculty of Maritime Affairs and Fisheries, Hasanuddin University, Makassar, with the location of the image being taken in the Banda Sea (Figure 1).

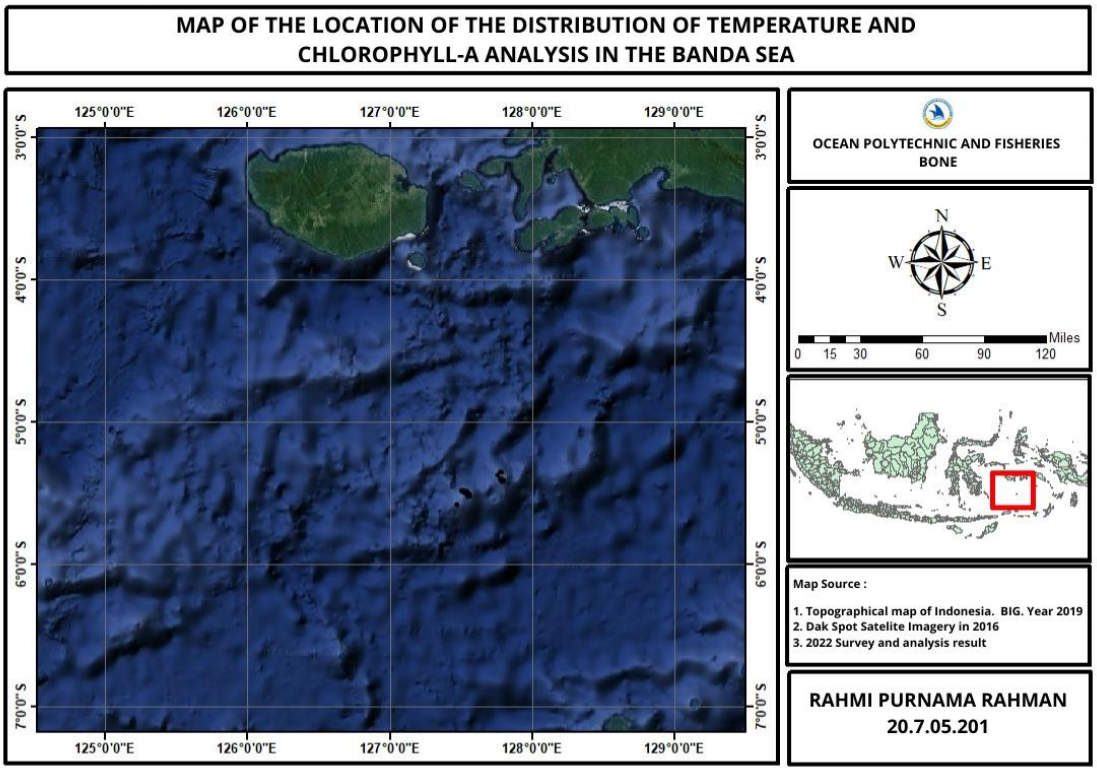

Figure 1 – Locations for Image Sampling in the Banda Sea

The image data used in this study was the Aqua MODIS satellite image data, in the form of monthly chlorophyll-a images and level-3 Standard Mapped Image (SMI) Sea Surface Temperature. The images used had a time span from June, July to August 2019 with a spatial resolution of 4 km. Aqua MODIS image data were downloaded free of charge from the official Nasa Ocean Color website, namely https://oceancolor.gsfc.nasa.gov/.

The downloaded MODIS images were in the form of chlorophyll-a images and sea surface temperature images. Furthermore, information was extracted from each image data using Seadas 8.2.0 software, which began with image cropping (cropping). Image cropping was adjusted to the research study area, namely the Banda Sea waters which produced tabulated data on the values of chlorophyll-a distribution, sea surface temperature for each pixel, and their coordinates in text document (.txt) format. Then, the data were converted into excel format using Microsoft Excel 2010. In spatial analysis, both in vector and raster formats, the required data covered the entire study area. Therefore, the interpolation process needed to be carried out to gain the value in the blank area (blank pixels) by utilizing the ArcGIS software version 10.7.1. Interpolation in this study used the IDW (Inverse Distance Weighted) model. From the interpolation process, a characteristic map of each image would be obtained. Next, the last process is layouts creation, which played the role of displaying the distribution map of chlorophyll-a and the distribution map of sea surface temperature in the waters of the Banda Sea from June, July to August 2019.

RESULTS AND DISCUSSION

Based on Figure 3, it can be seen that sea surface temperatures in the waters of the Banda Sea in July 2019 ranged from 24.4 °C to 31.45 °C. The lowest temperature ranged from 24.4 °C to 26.9 °C and the highest temperature ranged from 28.39 °C to 31.42 °C. The temperature distribution map above shows that the temperature distribution in the eastern Banda Sea was cooler than other areas and the high temperature distribution was spread in the north and west of the Banda Sea. Sea surface temperature is also affected by the time of day, air circulation, cloud cover and currents, and the depth of water bodies (Cheng et al., 2023).

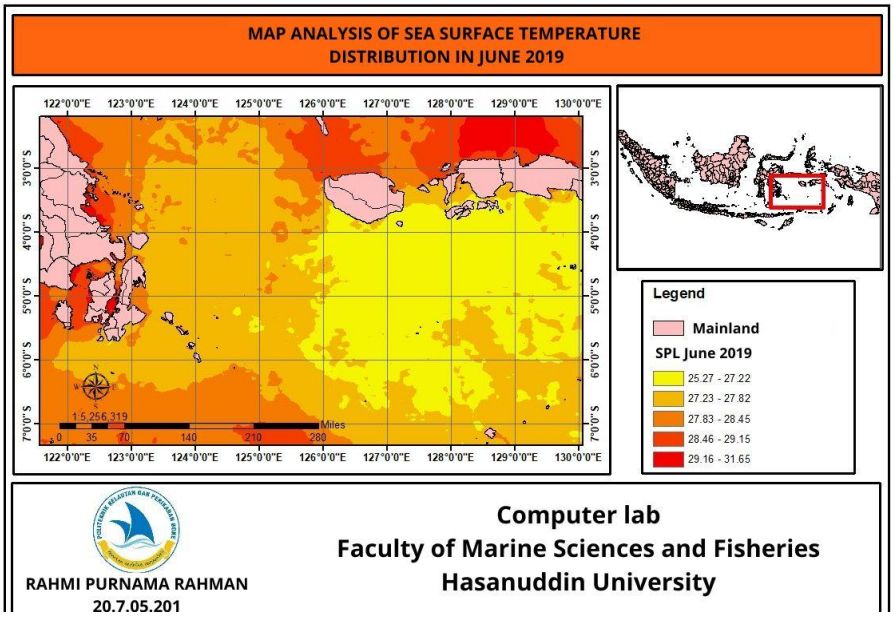

Figure 2 – Distribution of sea surface temperatures in June 2019

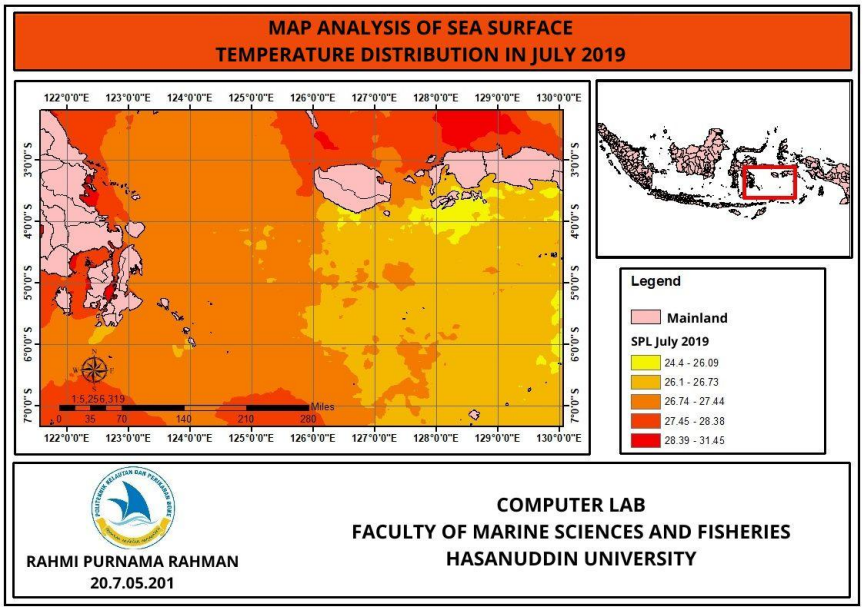

Figure 3 – Distribution of sea surface temperatures in July 2019

Based on Figure 4, it can be seen that sea surface temperature values ranged from 24.82 °C to 31.12 °C. The sea surface temperature in August in the Banda Sea was very cold with temperatures ranged from 24.82 °C to 25.98 °C. This is presumably because there

is still a strong influence from the previous monsoon or it occurs at the beginning of each monsoon, namely the transition monsoon II where the wind changes are erratic (Iskandar et al., 2021).

Sea surface temperature is an important factor influencing life in the oceans, where sea surface temperature is one of the parameters that needs to be measured in monitoring water conditions. According to Makwana et al (2021), temperature affects metabolic activity and the reproduction of organisms in the waters and temperature acts as an oceanographic parameter characterizing the mass of water in the ocean (which is related to the state of the seawater layer beneath it). Therefore, temperature can be used to determine upwelling, fishing potential and temperature changes occurring in the oceans. High temperatures can increase metabolic processes, so that the use of dissolved oxygen increases and the accumulation of pollutants also rises. High metabolism can cause death in marine life.

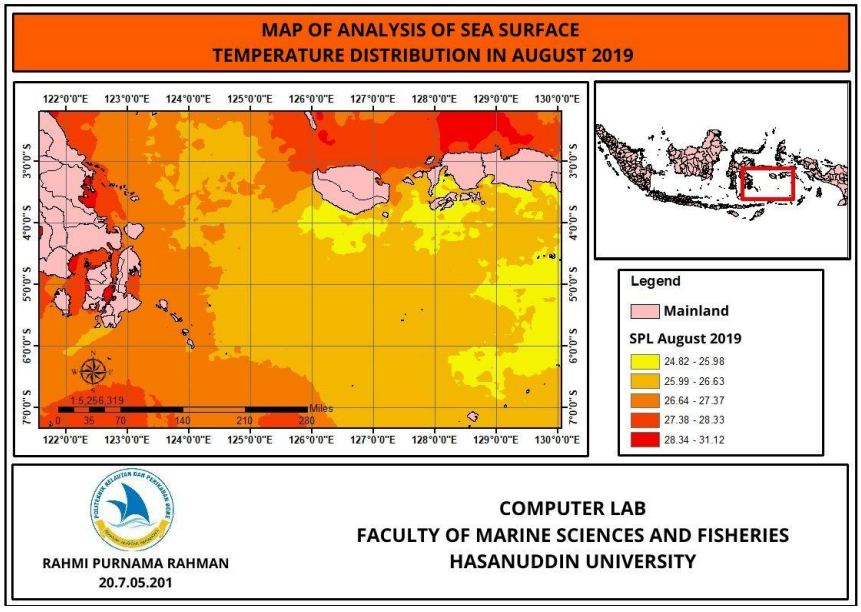

Figure 4 – Distribution of sea surface temperatures in August 2019

Sea surface temperature is a factor in research studies in the marine field because it is one of the factors affecting life in the sea, such as phytoplankton, zooplankton, small fish and large fish. Information about sea surface temperature can also be a factor affecting global climate. This is caused by changes in surface temperature which will influence the distribution of fish in the sea.

Along with the dynamics of human activities and natural phenomena, sea surface temperature values change every year. One example of a natural phenomenon causing changes in sea surface temperature is the monsoon. The monsoon period used based on the monsoon winds is divided into 4 monsoons, namely the west monsoon, transition monsoon 1, east monsoon, and transition monsoon 2. Westerly monsoon period from December to February, the first transition period from March to May, the winter monsoon period from June to August, and the second transition period from September until November.

The circulation system of water bodies in the Banda Sea is influenced by Arus Lintas Indonesia (Arlindo). Arlindo is a navigation system in Indonesian waters where currents carry water from the Pacific Ocean to the Indian Ocean. Arlindo occurs due to the pressure difference between the Pacific and Indian Oceans. Mass circulation in the Banda Sea is also affected by the Arus Munsoon (Armund) of Indonesia. The Armundo is an ocean current whose direction and speed belongs to Monson. The circulation of water bodies through Arlindo and Armundo in the Banda Sea makes these waters more fertile.

The southeastern winds during the east monsoon (June-August) push a lot of water masses from the Banda Sea and its surroundings to the west through the Flores Sea and

into the Java Sea. As a result, in the Banda Sea and its surroundings there is a deficit of water on the surface which must be replaced from below, and this increase in water is called upwelling (Sukresno & Kasa, 2012).

The existence of fish in Indonesian waters is dynamic, always changing/moving along with the movement of environmental conditions. This is because the fish will naturally choose the appropriate habitat. Furthermore, these habitats are strongly influenced by oceanographic conditions or parameters, such as sea surface temperature, salinity, marine chlorophyll concentration, ocean waves, weather, etc which affects the dynamics or motion of seawater, both horizontally and vertically (Fauziyah et al., 2022).

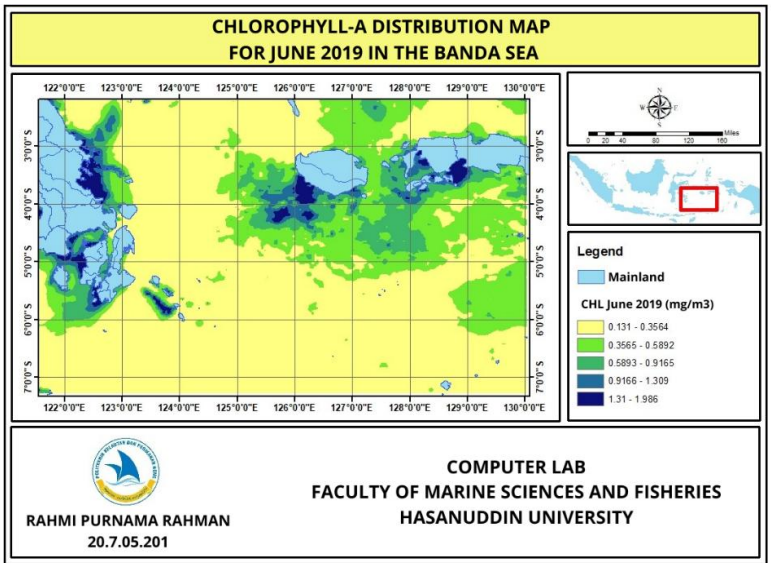

Figure 5 – Distribution of chlorophyll-a in June

Based on Figure 5, it can be seen that the distribution of chlorophyll-a concentrations in the Banda Sea in June 2019 ranged from 0.131 to 1.986 mg.m^{-3}. The picture above shows that the distribution of chlorophyll-a was most abundant in waters close to land. The high concentration of chlorophyll is one of the factors caused by the high intensity of sunlight, which causes chlorophyll blooms to form around the surface. This phenomenon is also reinforced by Loisel et al., 2017 explaining that the oceanographic conditions of the waters greatly affect the level of chlorophyll concentration on the surface.

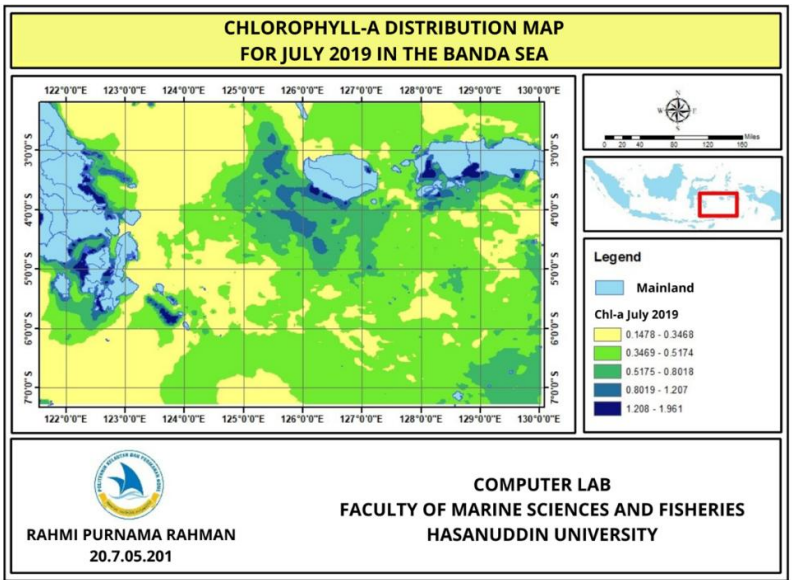

Figure 6 – Distribution of chlorophyll-a in July

Based on Figure 6, it can be seen that the distribution of chlorophyll-a concentrations in the Banda Sea in July 2019 ranged from 0.1478 to 1.961 mg.m-3. This causes a quantity of nutrient-rich water to rise to the surface. This condition can also cause high concentrations of chlorophyll-a at sea level and spread to most areas of the Banda Sea. The concentration of chlorophyll-a in water is highly dependent on the presence of nutrients and the intensity of sunlight. If nutrients and sunlight intensity are high, then the concentration of chlorophyll-a will be high and vice versa (Ghaemi et al., 2021).

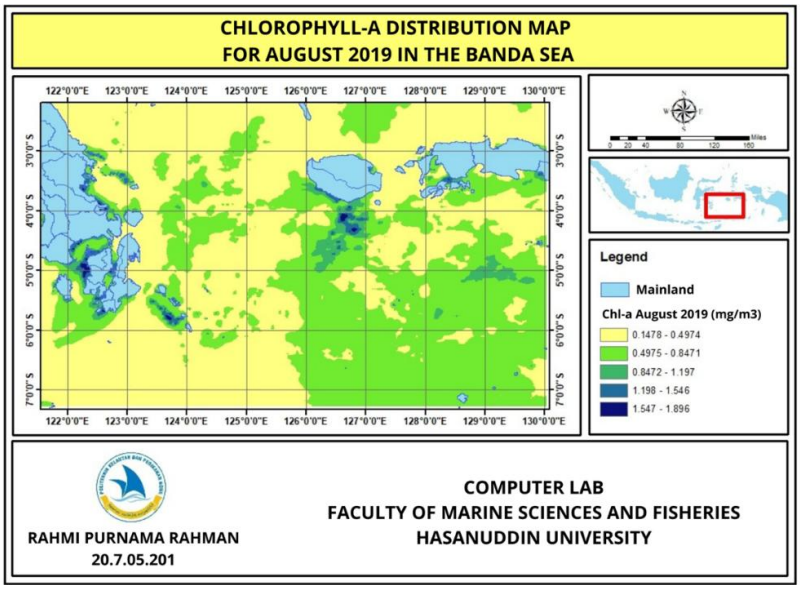

Figure 7 – Distribution of chlorophyll-a in August

Based on Figure 7, it can be seen that the distribution of chlorophyll-a concentrations in the Banda Sea in August 2019 ranged from 0.1478 to 1.896 mg.m^{-3}. This was caused by the movement of the currents carrying a mass of water rich in nutrients to the waters of the Banda Sea. High concentrations of chlorophyll-a are related to the impact of rainfall, river flow, stirring of the bottom of the waters, as well as the process of raising water in a rather deep layer of seawater towards the surface layer of seawater (upwelling). Wahyudi et al., (2023) stated that this upwelling process results in high levels of nutrients in the surface waters which triggers the rapid development of phytoplankton, so that the concentration of chlorophyll-a becomes higher.

According to Ryu et al., 2023, the body of phytoplankton contains a green leaf substance, namely chlorophyll-a. This substance acts as the most important pigment because chlorophyll-a has a function to carry out the process of photosynthesis. Phytoplankton is referred to as primary producers which have the ability to convert inorganic substances into organic ones.

Chlorophyll-a are one of the parameters that greatly determines primary productivity in the sea. Wang et al. (2021) said that the oceanographic conditions of waters are closely related to the high and low distribution of chlorophyll-a concentrations. The level of sunlight intensity and nutrients in the waters is one of the physical and chemical parameters of the waters that can affect the distribution of chlorophyll-a. These parameters are the cause of variations in the primary productivity of several places in the sea. Wang et al. (2021) explained that one of the parameters that greatly determines the level of water fertility is chlorophyll-a. Oceanographic conditions of a body of water are closely related to the distribution and level of chlorophyll-a concentrations. Several physical and chemical parameters that affect the distribution of chlorophyll-a are light intensity and nutrients present in the waters which cause variations in primary productivity in several waters. The level of water fertility is very dependent on the concentration of chlorophyll-a which can be seen from the high concentration of chlorophyll-a in the waters. If the chlorophyll-a of the water is high,

then the fertility level of the water will be high. Conversely, if the chlorophyll-a of a water is low, then the fertility level of the water will be low (Sholva, 2013).

Parameters of the level of fertility of a waters can be shown by the concentration of chlorophyll-a contained in the waters. This can be an attraction for pelagic fish which are plankton feeders. Hunt el at (2021) stated that when photosynthesis occurs, phytoplankton acts as the first producer in the food chain in the waters.

The high presence of large pelagic fish in high chlorophyll locations occurred due to food chain processes. Phytoplankton which contained chlorophyll was a food source for small pelagic fish. Phytoplankton would indirectly invite the presence of large pelagic fish (Kumaat, 2018).

Fishing potential zone (fishing ground) is a location where many fish congregate and are caught. Figure 8 shows (in yellow) the potential areas for catching large pelagic fish in the east monsoon, to be precise in June 2019.

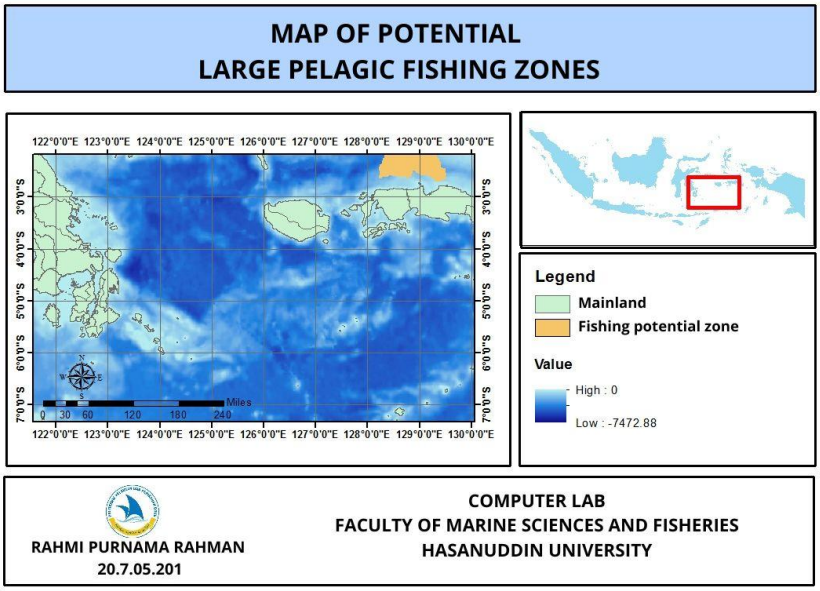

Figure 8 – Map of catching potential zone of large pelagic

Figure 8 shows the position of the fishing grounds which were in the northern part of the observed area in June, whereas in July and August there were no areas suitable for catching large pelagic fish. This is most likely caused by the movement of the currents which affected the distribution of sea surface temperature and the concentration of chlorophyll-a in these waters.

Satellites cannot directly see the presence of fish, but satellites can detect sea surface temperature and chlorophyll in the waters. Both of these elements are very important to provide information about the presence of fish in the sea. Fish have their own habitat characteristics. They live in waters with a certain temperature (not too hot and not too cold). As with other living things, fish certainly need food in locations that contain lots of food. Plankton is fish food. To live, plankton also need food in the form of chlorophyll. Where there is chlorophyll there is plankton, which means there are also fish. Information regarding sea surface temperature and chlorophyll are combined and then this information becomes an indication of its presence (Jasmin, 2012).

The relationship between oceanographic conditions, sea surface temperature and chlorophyll-a and potential fishing grounds has a descriptive relationship, where sea surface temperature and chlorophyll-a are independent variables and scores of potential fishing areas is the dependent variable. According to (Precioso et al. 2022), the distribution and abundance of biological resources in the water cannot be separated from the conditions and changes of oceanographic parameters.

The potential fishing area is influenced by oceanographic parameters such as sea surface temperature and chlorophyll-a in the waters. The identification of fishing areas can be detected by looking for oceanographic indicators affecting fishing areas within a body of water (Meeanan et al. 2023). When mapping potential zones, the temperature range used to detect the range of large pelagic fish is from 29.5°C to 31.5°C, while the optimal concentration of chlorophyll green-a ranges from 0.15 mg/m3 to 0.35 mg/m3 (Zhao et al. 2023).

The identification of potential spots was performed by examining the contours of the chlorophyll-a distribution and the relative sea surface temperature. The meeting point between sea-surface-temperature contigs and chlorophyll-a distribution is probably a good large-sea fishing area (Moutopoulos et al. 2019).

CONCLUSION

The distribution of sea surface temperature in June ranges from 25.27°C to 31.65°C; Sea surface temperature distribution in July ranges from 24.4°C to 31.45°C; meanwhile, sea surface temperature distribution in August ranges from 26.61°C to 31.12°C. During this winter monsoon (June, July and August) in the Banda Sea in 2019, the highest temperature distribution occurred in June, with the lowest temperature value occurring in August. concentrations of chlorophyll-a in the Banda Sea in June ranged from 0.13 to 1.98 mg.m-3; the distribution of chlorophyll-a concentrations in July ranged from 0.14 to 1.96 mg.m-3; and the distribution of chlorophyll-a concentrations in August 2019 ranged from 0.14 to 1.89 mg.m-3. During this eastern monsoon (June, July and August) in the Banda Sea in 2019, the highest concentrations of chlorophyll-a distribution occurred in July, while the lowest concentrations of chlorophyll-a occurred in June. The area with great potential for floating fishing in the Banda Sea during the winter monsoon season is in the northern part of the area observed in June, while in July and August there is not suitable for catching large floating fish.

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