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CHLOROPHYL-A DISTRIBUTION AND SEA SURFACE TEMPERATURE USING MODIS AQUA IMAGE DATA IN BONE BAY WATERS

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ABSTRACT

One of the parameters determining productivity in the sea is chlorophyll-a. The fertility level of chlorophyll-a is closely related to the concentration of chlorophyll-a. The higher the concentration of chlorophyll-a, the higher the water fertility level, conversely, if chlorophyll-a is low, the water fertility level will also be low. One factor influencing growth rate and chlorophyll-a production is temperature. This research aimed to determine the distribution of chlorophyll-a and sea surface temperature based on season in 2022 in the waters of Bone Bay using quantitative descriptive method and geographic information analysis (GIS) procedure in the form of analysis of Aqua MODIS remote sensing image data. The research results showed that the highest distribution of chlorophyll-a occurred in the east season with a concentration of 0.06-2.04 mg/m³, while the lowest distribution of chlorophyll-a occurred in the west season with a concentration of 0.07-1.76 mg/m³. Meanwhile, the highest intensity sea surface temperature distribution occurred in the west season, which was 28.76-37.09 °C and the lowest sea surface temperature distribution fell in the east season, which was 27.13-33.62 °C. Spatial temperature variability and sea surface chlorophyll-a can be used as information about potential areas for fishing grounds.

***Key words**: chlorophyll-a distribution, sea surface temperature, Bone Bay, Aqua MODIS*

INTRODUCTION

Bone Bay is located in South Sulawesi Province and Southeast Sulawesi Province (to the east). South Sulawesi Province, Bone Bay directly borders the waters of Bone, Sinjai, Wajo, Luwu, Palopo, North Luwu and East Luwu regencies. Meanwhile, the parts of Southeast Sulawesi Province that directly border the waters of Bone Bay are Bombana Regency and Kolaka Regency. To the south, the waters of Bone Bay border the Flores Sea. Bone Bay is where the Cenrana River flows. Geographically, the Cenrana River is where a large number of rivers in South Sulawesi flow into Bone Bay (Tampubolon *et al.*, 2016).

The productivity of Bone Bay waters refers to the ability of the aquatic ecosystem to produce biomass or biological resources, especially in terms of the growth of marine organisms such as phytoplankton, zooplankton, fish and other marine organisms. One parameter that really determines marine primary productivity is chlorophyll. Bahri *et al.* (2017) said that the fertility level of waters is very dependent on the concentration of chlorophyll-a. If the concentration of chlorophyll-a is higher, the fertility level of the waters will also be higher, and conversely, if the concentration of chlorophyll-a in the waters is low, the fertility level of the waters will also be low.

Sea surface temperature can influence the growth and production of chlorophyll-a. Suitable and stable temperature conditions can support optimal growth of chlorophyll-a (Rosalina *et al.,* 2023b). Sea surface temperature is one of the important parameters in oceanography. The surface temperature of the Indonesian water layer is in the range of 26 °C – 30 °C; the thermocline layer is in the range of 9 °C – 26 °C; and the deepest layer is in the range of 2 °C – 8 °C.

The stands for SST distribution can be used as an indicator of upwelling, namely the increase in sea water mass from the deep layers to the surface layers, so that the SST in the waters concerned is cooler than the surrounding waters (Muhaemin, 2022; Rosalina *et al.,* 2023a).

Information regarding the spatial variability of sea surface temperature and chlorophyll-a can be used as a source of information regarding the management and utilization of fisheries resources without having to directly analyze chlorophyll-a and sea surface temperature in the area (Rosalina *et al.,* 2023c). Observations using remote sensing methods and modis aqua image data will make it easier to study large areas in a short time. One of the benefits is providing information about potential areas for fishing grounds.

MATERIALS AND METHOD

This research was carried out from August to October 2023 in the waters of Bone Bay. Data processing was carried out at the Hasanuddin University (UNHAS) Inderaja Laboratory. The data collection location can be seen in (**Figure 1**) and the work procedure can be seen in (**Figure 2**).

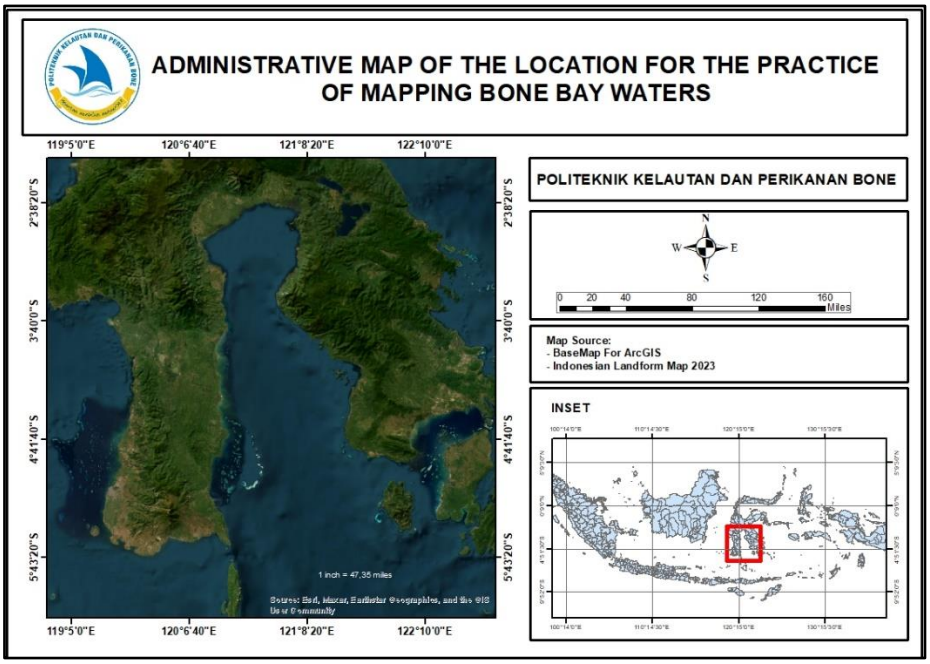

Figure 1. Research location

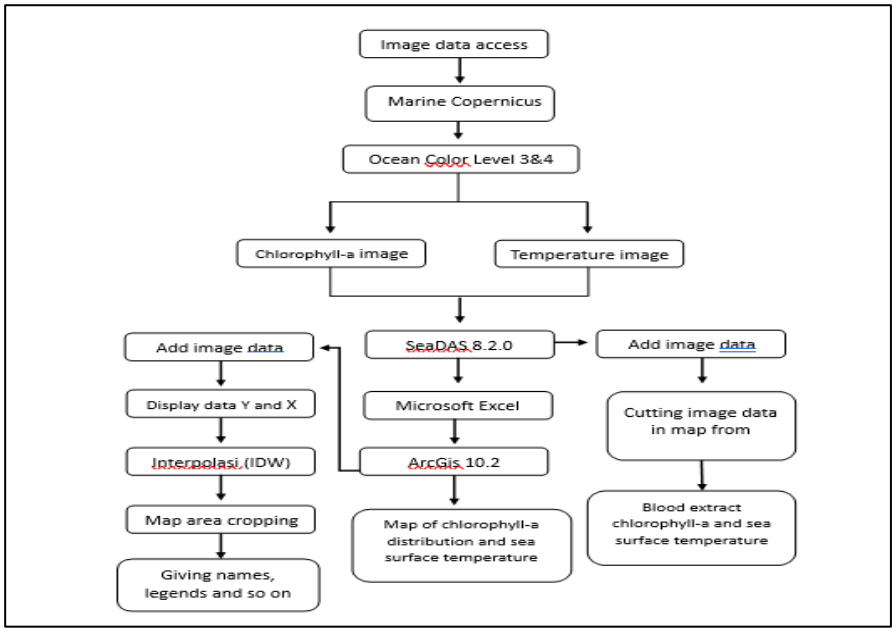

Figure 2. Work stages

It can be seen **Figure 2** of the data management stages or procedures in field work practice II, which starts with downloading image data on the Ocean Color level 3 and 4 web page then selecting chlorophyll-a and temperature data, after that determining the coordinate points on the Copernicus marine website according to the desired location. In the seadas 8.20 application we extract data according to the coordinate points that we have obtained, after that in the Microsoft excel software application sorts the data and deletes error data (NaN) for chlorophyll image data. Then open ArcGIS 10.2 SOFTWARE To Interpolate Data, Create Layouts and import map features.

RESULT AND DISCUSSION

Distribution of Chlorophyll-A

The results of Aqua Modis satellite image analysis of chlorophyll-a in Bone Bay in 2022 were displayed in a diagram processed from the average chlorophyll-a per season. The average distribution of chlorophyll-a in the West Season was 0.25 mg/m³. This value increased in Transition Season I, namely 0.28 mg/m³. Furthermore, the increase occurred again in the East Season, namely 0.39 mg/m³. Transition Season II was a period of decreasing amounts of chlorophyll-a, namely 0.30 mg/m³ (**Figure 3**).

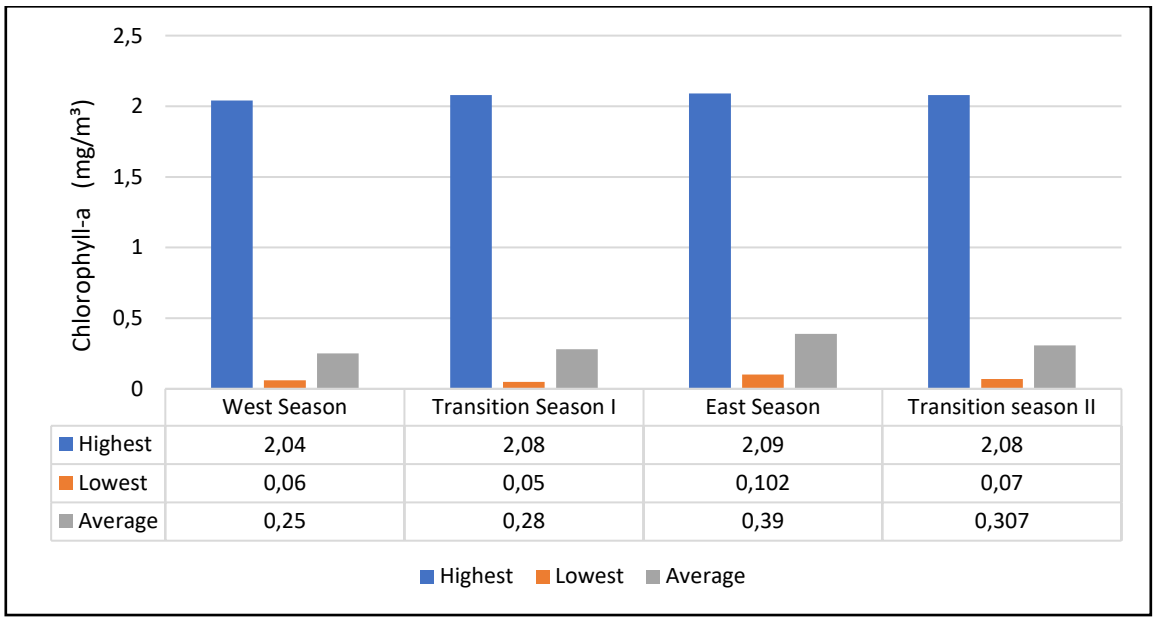

Figure 3. Chlorophyll-a

Aqua Modis image interpolation results produced a distribution of chlorophyll-a concentrations in Bone Bay during the period January – December 2022 in the range of 0.05 – 2.09 mg/m³. The distribution of chlorophyll-a values in 2022 experienced the highest peak in the East Season (June, July, August), namely around 0.39 – 2.09 mg/m³. This likely occurred due to the upwelling process which brought nutrients to the sea surface. According to Purwanti *et al.* (2017), in the east season the high speed of the southeast monsoon winds causes the mass of water to rise more intensively, so that nutrients in the waters increase. This condition is different from the western season (December, January, February) where the lowest decrease in chlorophyll-a concentration occurred, where the decrease was in the range of 0.06 – 2.04 mg/m³. Low chlorophyll-a concentrations occurred because the high intensity of sunlight caused sea surface temperatures to warm and decreased chlorophyll-a concentrations. According to Sihombing *et al.* (2013), decreasing wind speed in January and uncertain wind direction are the changes at the beginning of the year.

Chlorophyll-a is one of the parameters that really determines marine primary productivity. The high and low concentrations of chlorophyll-a are closely related to the oceanographic conditions of a body of water. Several physical and chemical parameters that influence the distribution of chlorophyll-a are light and nutrients found in waters which cause variations in primary productivity in several waters. The level of water fertility can be seen from the concentration of chlorophyll-a in the water. If the chlorophyll-a in the water is high then the fertility level of the water is also high, conversely if the concentration of chlorophyll-a in the water is low then the fertility level of the water is also low (Gunawan *et al.*, 2019).

According to Alqadri *et al.* (2022), less fertile waters have a chlorophyll-a concentration level of <1 mg/m³, waters with a chlorophyll-a concentration of 1-15 mg/m³ are included in waters with moderate fertility, fertile waters have a chlorophyll-a concentration of 15-30 mg/m³, and waters with concentration of >30 mg/m³ are included in the very fertile category. The high and low levels of chlorophyll-a content are closely related to the supply of nutrients originating from land. Chlorophyll-a content is found more in the surface layer which is close to land. The deeper the sea area, the lower the chlorophyll-a content because land supplies a lot of nutrients into the waters. This is in accordance with the statement of Nugraheni *et al.* (2022) that the chlorophyll-a concentration value in open sea waters is low because there is no direct input of nutrients from land. The further towards the sea an area is, the lower the chlorophyll concentration in that area. According to Suprapto *et al.* (2014), river flows carrying a continuous supply of inorganic and organic materials can stimulate the consolidation process of bottom sediments in coastal areas as a source of nutrients, so that these flows can stimulate the availability of concentrations of nutrient elements in water pools. Therefore, the waters through which rivers pass have higher levels of chlorophyll-a compared to the open sea.

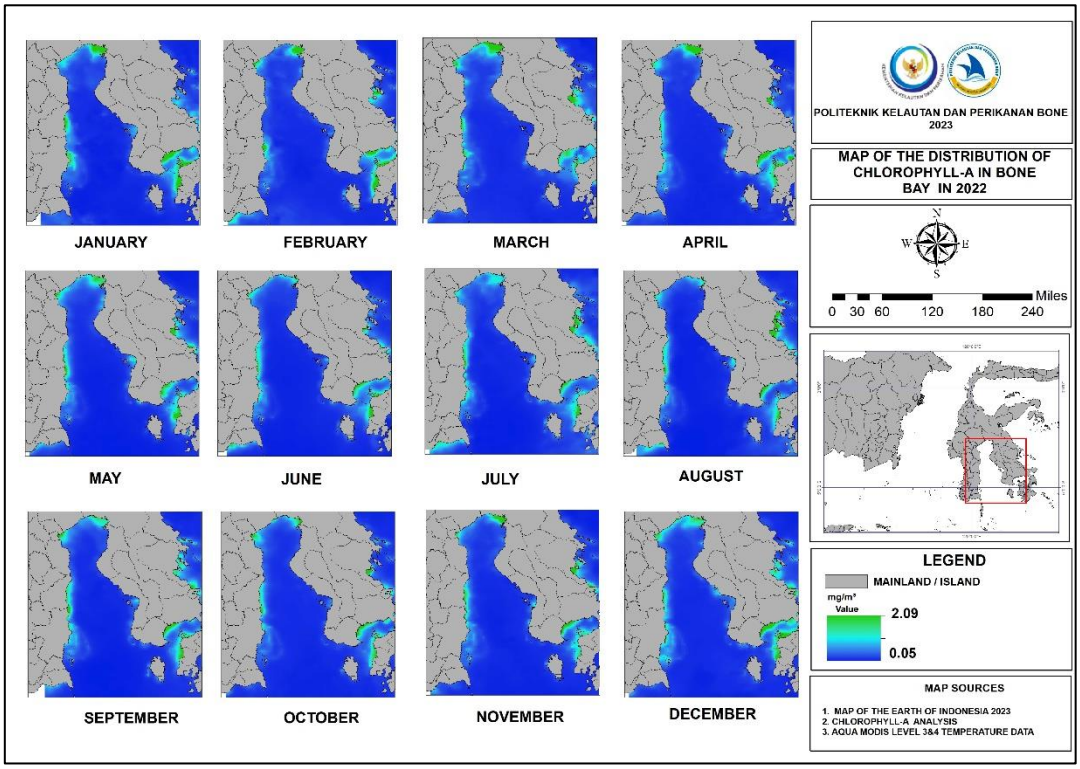

Figure 4. Distribution of chlorophyll-a in 2022

In the western season (December, January, February), the concentrations of chlorophyll-a were in the range of 0.06 – 2.04 mg/m³. The highest concentrations of chlorophyll-a were found in Luwu, Palopo and Bone Regencies. In the west season, the wind blew harder so this increased the mixing of water masses causing nutrients to rise to the surface. According to Yoga *et al.* (2014), the increase in wind speed occurring in the west season vertically increases the fertility of the waters, due to the mixing of water masses from the seabed which are rich in nutrients. As a result, this phenomenon will increase the concentration of chlorophyll-a on the surface. According to Hatta (2016), turbulent water masses on the surface are usually caused by wind. This phenomenon causes mixing of the upper water layer with the lower water layer. This mixing process causes nutrients to be lifted to the surface layer. High nutrients supported by sufficient light intensity will stimulate better phytoplankton growth.

Entering the first transition season (March, April, May), chlorophyll-a concentrations were in the range of 0.05–2.08 mg/m³ where the highest chlorophyll-a concentrations occurred in East Luwu, North Luwu, Palopo, Wajo and Bone Regencies. The increase in chlorophyll-a concentration probably occurred because geographically Bone Bay was where rivers flew. This is what caused high nutrient content

to enter the waters of Bone Bay. According to Marlian *et al.* (2015), the large horizontal distribution of chlorophyll-a in estuarine and river waters is waters containing a lot of nutrients, both nitrate and orthophosphate. Relatively higher levels of nutrients in both waters stimulated the horizontal distribution of chlorophyll-a significantly. According to Suprapto *et al.* (2014), river flows that carry a continuous supply of inorganic and organic materials can stimulate the process of consolidation of bottom sediments in coastal areas. These components act as nutrients and form the physical structure of coastal water sediments. The continuous euphotic zone causes physical, chemical and microbiological contact, so that this phenomenon can increase the availability of nutrient concentrations in the water pool.

Entering the east season (June, July, August), the concentrations of chlorophyll-a were in the range of 0.10 – 2.09 mg/m³ where the highest concentrations of chlorophyll-a were in the waters of East Luwu, Luwu and Palopo Regencies. The increase in concentration occurred because during the east monsoon the upwelling process existed. In this case, the accumulated nutrients would be lifted and provide nutrients for plankton, so that the concentration of chlorophyll-a increased. The high level of chlorophyll-a in the east season probably occurs due to the entry of high light intensity into the waters which is needed by phytoplankton to carry out photosynthesis (Marendy *et al.*, 2017). According to Safitri (2014), the winds occurring during the east season bring quite strong waves and increase the intensity of upwelling. This process increases the solubility of nutrients into the water, which is a supporting factor in increasing chlorophyll-a concentrations.

Entering Transition Season II (September, October, November), chlorophyll-a concentrations decreased with the concentrations in the range of 0.07 – 2.08 mg/m³. The highest concentrations were in the waters of East Luwu, Palopo and Wajo Regencies. In November, winds originating from mainland Australia carried little water vapor so rainfall was low. Factors causing an increase in cholorophyll-a are the increasing of nutrients and the intensity of sunlight entering the water. According to Ayuningsih *et al.* (2014), low concentrations of chlorophyll-a occur due to a lack of nutrients entering from the mainland to the coast. The presence of anthropogenic activities, ports, settlements and industry are the factors causing low chlorophyll-a concentrations. The resulting waste is directly carried by the river and flows into the bay.

Distribution of Sea Surface Temperature

The results of Aqua Modis satellite image analysis of sea surface temperatures in Bone Bay in 2022 were displayed in a diagram processed from the average temperature per season. It is known that the highest average SST occurred in the West Season, namely 31.13 °C. Meanwhile, the lowest average SST fell in the East Monsoon, namely 29.41 °C. The study of the SPL value can be further observed in **Figure 5**.

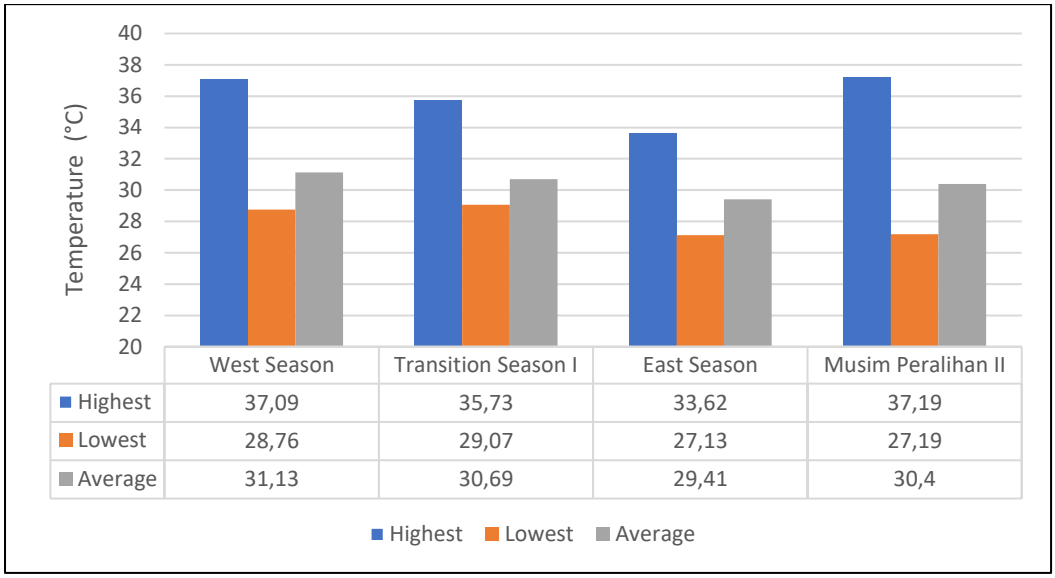

Figure 5. Sea Surface Temperature

The results of Aqua Modis image interpolation produced the SST distribution in Bone Bay during the period January – December 2022 which were in the range of 27.13 – 33.76°C. The distribution of SST values in 2022 experienced the highest peak temperature in the West Season (December, January, February), namely around 28.76 – 37.09 °C. This condition occurred because in December the intensity of sunlight was relatively high and the wind came from the Banda Sea. This statement is in accordance with the findings of Lubis *et al.* (2018) stating that currents originating from the Banda Sea move westward through the Flores Sea and carry masses of warm water. This condition was different from the eastern season (June, July, August) where the lowest temperature dropped to 27.13 – 33.62 °C. This low SST value occurred because the current flowing from the south was very strong. According to Azizah & Wibisana (2020), in the east monsoon there is horizontal mixing of mass water.

Sea air temperature varies from day to day, especially sea surface temperature. Temperature can change daily, nocturnally, lunarly, seasonally or annually. Many situations can affect the condition of marine waters. According to Yusuf *et al.* (2022), sea surface temperature and upwelling are the warm layer because this layer receives relatively higher solar radiation during the day which causes wind movement. The top layer of the surface up to a depth of 50-70 meters will experience agitation, so that the layer can reach a homogeneous temperature of 28 °C. Sea surface temperature (SST) is the most important water quality parameter in the ocean, especially coastal areas. Sea surface temperatures can change at any time according to the natural conditions that influence these waters. One of the factors that influences this is the monsoon winds (Azizah & Wibisana 2020).

Generally, Indonesia's sea surface temperature are in the range of 20-30 °C. From the results of data processing, the highest SST occurs near land compared to the open sea. According to Patty *et al.* (2020), higher SST usually occurs near the coast compared to the open sea. This is because the movement of fresh water masses from river flows more easily enters the waters near the coast. This movement of water masses can generate heat because friction between water molecules occurs in this process, so that the sea water temperature in nearshore waters is warmer than the water masses in offshore waters (Figure 6).

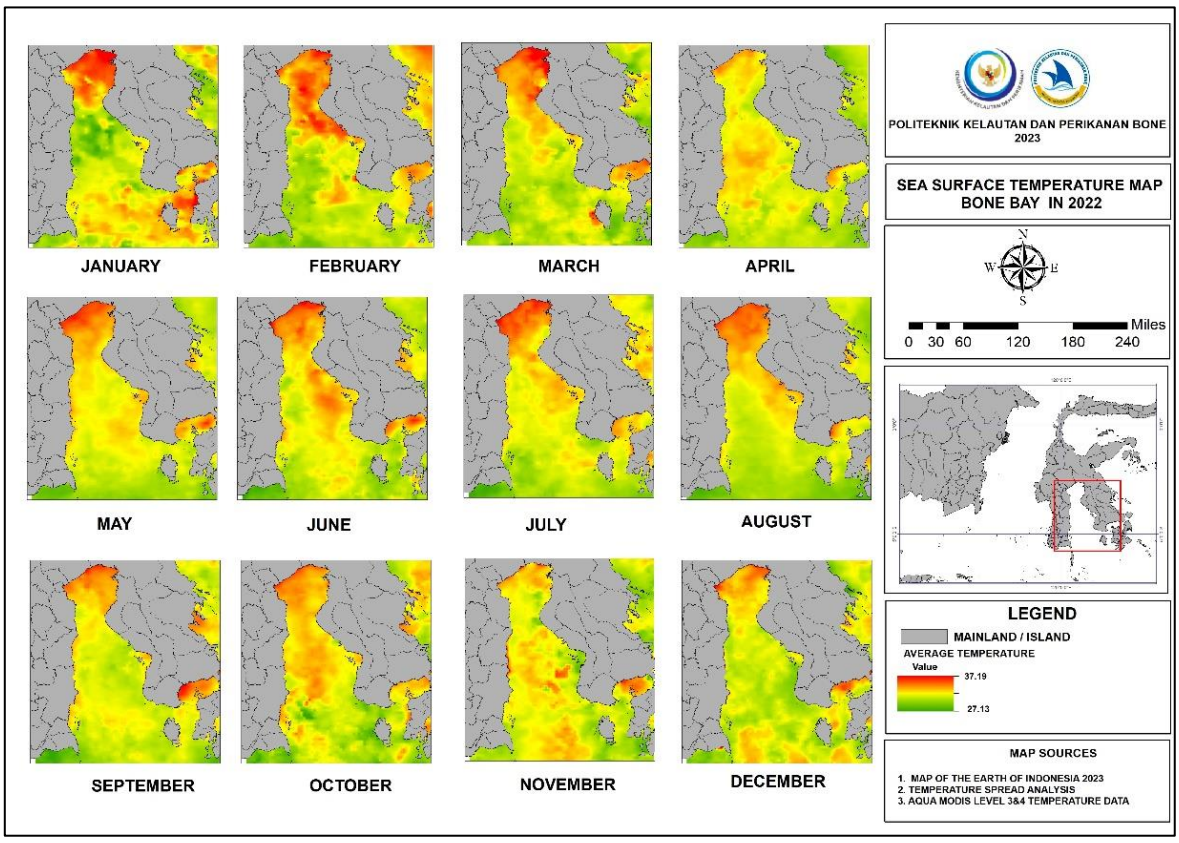

Figure 6. Distribution of sea surface temperatures in 2022.

The distribution of surface temperatures in the west season (December, January, February) is in the range of 28.76 – 37.09 °C. The temperature in the waters of Bone Bay during the west season was relatively variable, indicated by the red color which had a high temperature. The high temperatures in the western season were likely to happen due to the high intensity of sunlight, rainfall, humidity and wind speed. This is in accordance with the statement of Alfajari *et al.* (2017) saying that the high and low sea surface temperatures are influenced by the intensity of sunlight. According to Tanto & Riswanto (2022), warmer SST occurs in the west season because winds originating from mainland Australia bring high air pressure to Indonesia. This causes the southern part of the earth to be warmer.

The distribution of surface temperatures in Transition Season I (March, April, May) were in the range of 29.07 – 35.73°C. The highest temperatures occurred in East Luwu, North Luwu and Palopo districts. The depth of Bone Bay reaches 2000 meters towards the sea offshore (south). Areas along the west, north and east coasts are classified as shallow areas because these areas have a depth of 50-2000 meters. Bone Bay is included in the category of closed waters so that it influences temperature differences horizontally and vertically in certain circumstances (Safitri, 2014). Apart from the depth factor, Bone Bay is also thought to be the estuary area of the Cenrana River due to the mass movement of fresh water from the river flowing into these waters. This induces heat generation, so that sea temperatures become warmer (Sidabutar et al., 2019).

The distribution of surface temperatures in the east season (June, July, August) was in the range of 27.13 – 33.62°C. The decrease in SST was likely to happen due to the strengthening of the southeast monsoon which blew strongly from southeast to northwest and caused sea surface emptiness. This caused water to rise from the bottom to the surface (upwelling). This condition is in accordance with the statement by Yuniarti *et al.* (2013) saying that continuously blowing winds cause the formation of empty space and pressure gradients on the coast. As a result, the existence of this pressure gradient causes the water mass to strive towards balance, so that this phenomenon increases the intensity of upwelling bringing low temperature water masses from the lower layers to the surface. In addition, the intensity of sunlight decreases and affects SST. It is known that during the east monsoon the sea surface temperature is not minimum. This happens because water takes time to release heat (Fadika et al., 2014).

The distribution of surface temperatures in Transition Season II was in the range of 27.19 – 37.19°C. The apparent movement of the sun caused differences in air pressure in the northern and southern hemispheres. Indonesia is located on the equator, which is the area where air movement passes. This happens because of the difference in air pressure in the two hemispheres (monsoon winds). Monsoon winds alternately pass through Indonesia throughout the year with a 6 month period, namely April to September and October to March. Wind movements will affect the characteristics of sea water masses. One of them is a change in the direction of surface currents. Strong wind movements influence the mixing of water masses in the upper layer and homogenize the temperature distribution (Rifai *et al.*, 2020). According to Swara *et al.* (2021), one of the factors causing sea surface temperatures to decrease is the intensity of the southeast monsoon wind speed. The intensity of wind speed increases the intensity of upwelling, where increasing the intensity of upwelling will increase the flow of water from the bottom layer to the surface. Furthermore, according to Kunarso *et al.* (2015), the decrease in SST also occurs due to the advection process, namely the process of transferring heat from waters to the atmosphere through wind media.

CONCLUSION ANS SUGGESTION

The highest distribution of chlorophyll-a concentrations in the waters of Bone Bay occurred in the East season which took place in the waters of East Luwu, Luwu and Palopo Regencies with concentrations of 0.06 – 2.04 mg/m³. The lowest distribution of chlorophyll-a concentrations occurred in the west season which took place in Luwu, Palopo and Bone Regencies with concentrations of 0.07 – 1.76 mg/m³. The highest sea surface temperature distribution occurred in the west season in the waters of Luwu, East Luwu, North Luwu, Kolaka and North Kolaka Regencies with concentrations of 28.76 -37.09 °C. The lowest sea surface temperature distribution fell in the east season which took place in the waters of Palopo, Luwu, East Luwu and North Luwu Regencies with concentrations of 27.13-33.62 °C. Spatial temperature variability and sea surface chlorophyll-a can be used as information about potential areas for fishing grounds

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