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Analysis of Sea Surface Temperature Changes and Its Impact on the Coastal Ecosystem of Saugi Island, Pangkep Regency

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Abstract

Sea surface temperature (SST) is a key parameter in the study of marine ecosystems, which plays an important role in determining the biological and physical dynamics of waters. This study analyzes changes in sea surface temperature in Saugi Island and its impact on coastal ecosystems. Using spatial analysis methods through remote sensing using Aqua Modis satellite imagery, sea surface temperature data were collected from August to September 2024. The results show that sea surface temperatures vary between 30°C and 36°C, with an average reaching 31.3°C. This increase in temperature has the potential to affect the metabolism and reproduction of marine organisms, as well as worsen the condition of coastal ecosystems due to seawater acidification and salinity fluctuations. This study aims to provide insight into the dynamics of sea temperature changes and the need for mitigation measures to protect ecosystems and improve the sustainability of coastal communities. This study is expected to be the basis for developing strategies in dealing with changes in sea surface temperature that have an impact on coastal ecosystems with mitigation efforts of the temperature monitoring network and eco wave initiative.

Keywords: *Climate change, pH of seawater, Salinity, Sea surface temperature, Seawater quality*

INTRODUCTION

Climate change is a long-term transformation in temperature and weather patterns, which includes significant variations in temperature, changes in rainfall patterns, and other weather phenomena, and has a profound impact on the environment and life on Earth, with one of the main indicators being rising sea surface temperatures (Ainurrohmah & Sudarti, 2022). The ocean serves as the main energy sink for trapped heat due to greenhouse gases, absorbing up to 90% of the total additional heat, resulting in large increases in sea air temperatures and potentially affecting marine ecosystems and overall climate change (Huang *et al*., 2022). This increase in temperature not only has a limited impact on marine biota, but also has the potential to change global weather patterns, increase

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sea levels, and disrupt the balance of the ecosystem as a whole, which can affect various aspects of the environment on earth (Varabih & Fitri, 2024; Nasrul *et al*., 2025).

Temperature is an environmental parameter that measures the level of heat in a certain area, both on land and in the ocean (Maru *et al*., 2015, 2023; Prihartini Kahar *et al*., 2024). Sea surface temperature (SST) has a very vital role in the life of marine organisms, because this temperature influences various aspects, such as metabolic activity and the reproductive processes of existing species. Apart from that, SST also functions as an important indicator in assessing water quality, which has a direct impact on marine ecosystems. For mapping sea surface temperatures, satellite technology is used effectively. In this research, data from the AQUA MODIS satellite was used. Continuously changing sea surface conditions require remote sensing data from Aqua MODIS and Quickscat imagery to provide temporal information. Aqua MODIS has a wavelength range that is designed to be quite narrow, so it is able to produce more accurate remote sensing data and has advanced capabilities to connect the entire earth's surface every one to two days (Kurnianingsih *et al*., 2017). With this capability, research can provide accurate and up-to-date information on changes in sea surface temperature, which is very important for understanding the dynamics of marine ecosystems and their impact on life in the ocean. The data obtained can also be used to support conservation efforts and sustainable management of marine resources (Nasrul *et al*., 2025). Saugi Island is part of a group of small islands that are part of the Spermonde archipelago. This island functions as the administrative center for the village of Mattiro Baji, which is located in the Labakkang District area (Qaiyimah *et al*., 2024). This village has significant potential, especially in the marine fisheries and marine tourism sectors. Most of the population works as fishermen, who rely on the sea as their main source of livelihood. They look for fish using various types of tools and facilities available, such as nets, fishing rods, rods, as well as tools for catching crabs and other types of fisheries. In this way, village communities strive to meet their daily needs and support household life. This potential not only contributes to the local economy, but also offers opportunities for sustainable tourism development in the area (Remmang *et al*., 2020).

Based on climate model projections, sea water temperatures are expected to continue to increase along with the global warming trend, which could have serious consequences for marine biota and human life (Cheng *et al*., 2019). The increase in temperature which coincides with the increase in ocean acidity levels due to excessive absorption of CO_2 puts great pressure on marine ecosystems. This is characterized by changes in acidity levels and fluctuations in salinity. This ocean acidification process has detrimental impacts, especially for marine organisms that have calcium carbonate-based shell structures, such as coral reefs. Coral reefs are a vital element in maintaining the balance of coastal ecosystems (Andrade *et al*., 2024). Therefore, these changes have the potential to disrupt not only the survival of these organisms, but also the entire ecosystem that depends on them. This research aims to explore the pattern of sea surface temperature changes that occur on Saugi Island and analyze its impact on ecosystems in coastal areas. By increasing understanding of the dynamics of this change, it is hoped that effective mitigation and adaptation measures can be formulated to overcome the impacts that arise, while ensuring the preservation of the ecosystem and the survival of local communities. In its implementation, this study will integrate various relevant current references, thereby providing a more comprehensive perspective on this problem, especially those related to the implications of climate change in coastal areas. With this approach, research is expected to make a significant contribution to environmental protection efforts and improve the quality of life of local communities.

METODOLOGY

This research was located on Saugi Island, Mattiro Baji Village, Liukang Tupabbiring Utara District, Pangkajene and Islands Regency, South Sulawesi. This research was carried out on 10-13 October 2023. Geographically, Saugi Island is located at coordinates between 4º46'00.42" South

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Latitude and 119º27'46.54" West Latitude. The following is a map of the research location. The research location can be seen in Figure 1.

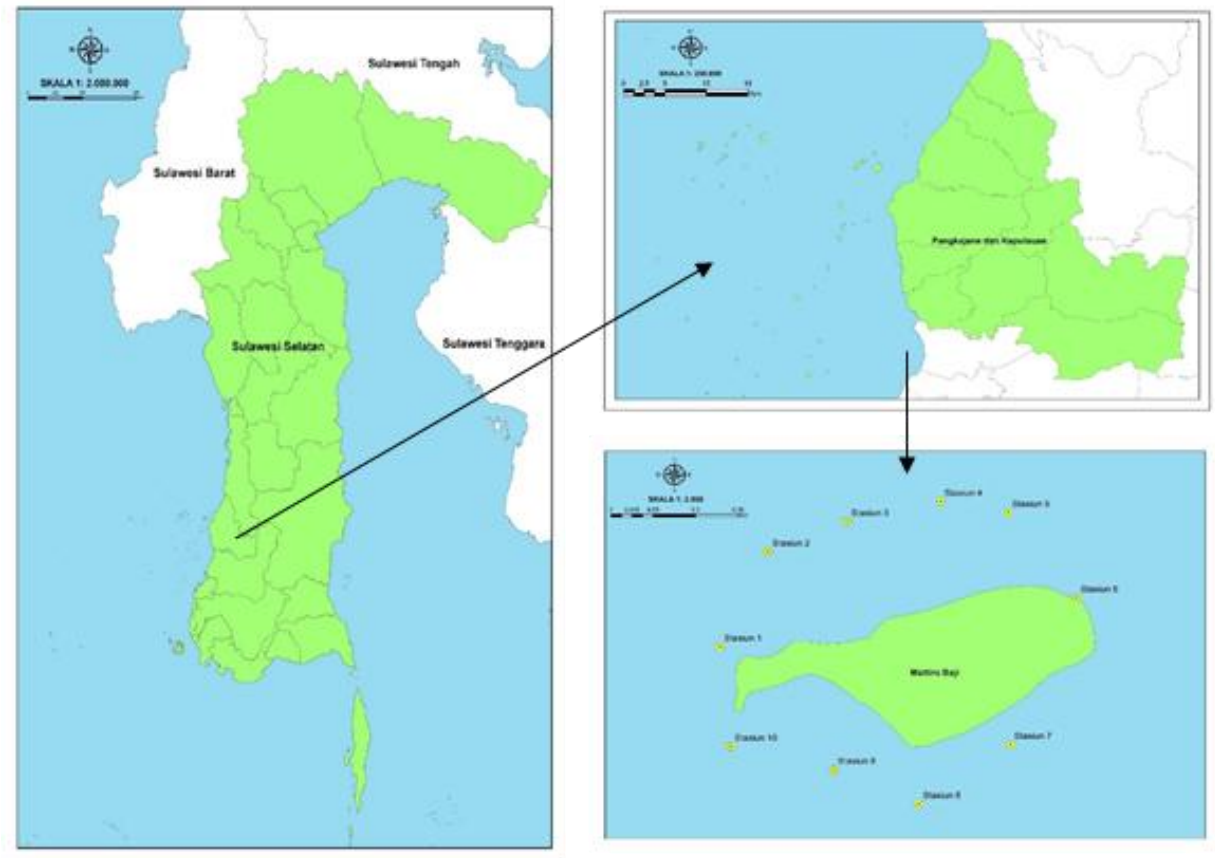

Figure 1. Research Location Map.

In this research, the method used is remote sensing spatial analysis using the Aqua Modis SPL Level 3 satellite image sensor for the period August-September 2024. The research method used is spatial analysis. Spatial analysis is a set of methods for finding and describing levels/patterns of a spatial phenomenon, so that it can be better understood (Budiman, 2016).

In this research, selecting data sources is an important aspect in conducting analysis. The data used in this research consists of two, namely primary data and secondary data.

a. The primary data used in this research comes from observations and measurements in the field. Primary data is information obtained directly through observation at the research location to obtain accurate and reliable data. This data collection is carried out by interviewing sources or respondents who are research subjects or parties who are used as sources to obtain the necessary information and information. Apart from the interview method, primary data can also be obtained through direct observation in the field (Sawo *et al*., 2021). The data obtained is sea surface and air temperature data, salinity, dissolved oxygen levels, and the degree of acidity (pH) of sea water.
b. Secondary data is a type of additional data that is not obtained from primary sources, but has been previously obtained through other sources. This means that the data user does not directly experience the phenomenon being researched, but gets the information from other primary sources (Jabnabillah *et al*., 2023). The secondary data used in this research is Aqua Modis SPL Level 3 satellite image sensor data for the period August-September 2024 using spatial analysis. This data was obtained via the Nasa Ocean Color website. Apart from that, the secondary data used also comes from scientific journals and other reading sources.

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Remote sensing data analysis requires reference data such as thematic maps, statistical data and field data. Users can use this information to assist in the decision-making process in developing the area. The entire process starting from data collection, data analysis to data use is called a remote sensing system. The data obtained is then carried out by a cropping process using SeaDas software, then the data is processed in Microsoft Excel 2007 after which the krigging process is carried out in Arcgis software. The research flow is detailed in Figure 2.

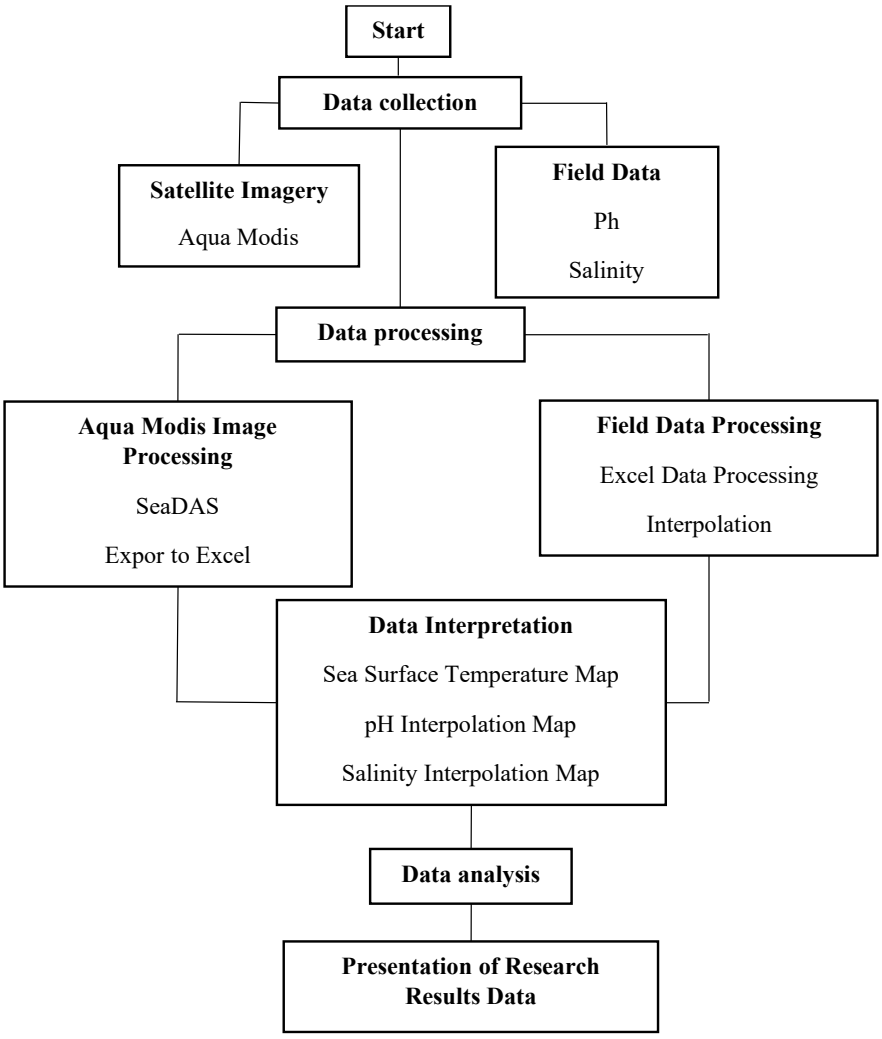

Figure 2. Flowchart of Research.

RESULTS

Based on the analysis carried out through the use of sig using remote sensing images of Aqua Modis and field observations, two results were obtained, as follows:

1. Results of Aqua MODIS SPL Level 3 Satellite Image Analysis

In this research, we used image data obtained from the Aqua MODIS SPL Level 3 satellite image sensor for the period August-September 2024. The following is a map of sea surface temperature on Saugi Island obtained:

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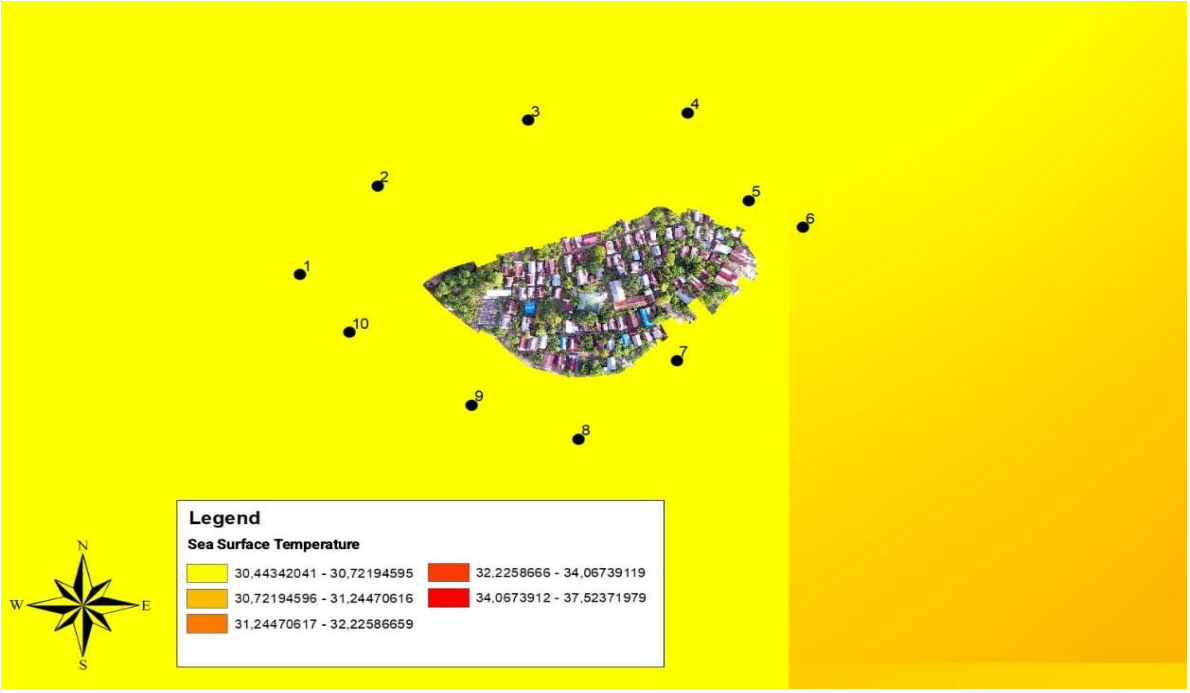

Figure 3. Map of Sea Surface Temperature Distribution on Saugi Island, Pangkep Regency.

Based on Figure 2 above, the Sea Surface Temperature Map on Saugi Island shows the classification of five temperature categories, namely 30°C, 31°C, 32°C, 35°C, 36°C and 37°C. From this map, it can be seen that the area around Saugi Island is dominated by sea surface temperatures reaching 30°C. This temperature reflects relatively cool conditions and can support a healthy marine ecosystem. Furthermore, a temperature of 31°C was identified around Mattiro Baji Village, indicating the existence of temperature variations in the region. These slightly higher temperatures may have an impact on fishing activity and marine life in the area, and could provide important information for fishermen and marine resource managers. Additionally, higher temperature classifications, such as 32°C, 35°C, and 36°C, indicate specific areas that may experience warming, which could impact marine habitats and water quality.

2. Analysis of Data from Field Measurements

In this research, field data was obtained through observations and measurements on Saugi Island. Water pH is measured using a universal indicator, and the measurement results indicate the level of acidity or alkalinity of the water which can affect the life of marine biota. Salinity is measured with a hand refractometer, which provides information about the salt concentration in water, important for understanding the dynamics of aquatic ecosystems. In addition, salinity and pH maps were created using the interpolation method to describe the spatial distribution of these parameters in a clearer and more detailed manner. The following is a salinity map and Ph map obtained on Saugi Island:

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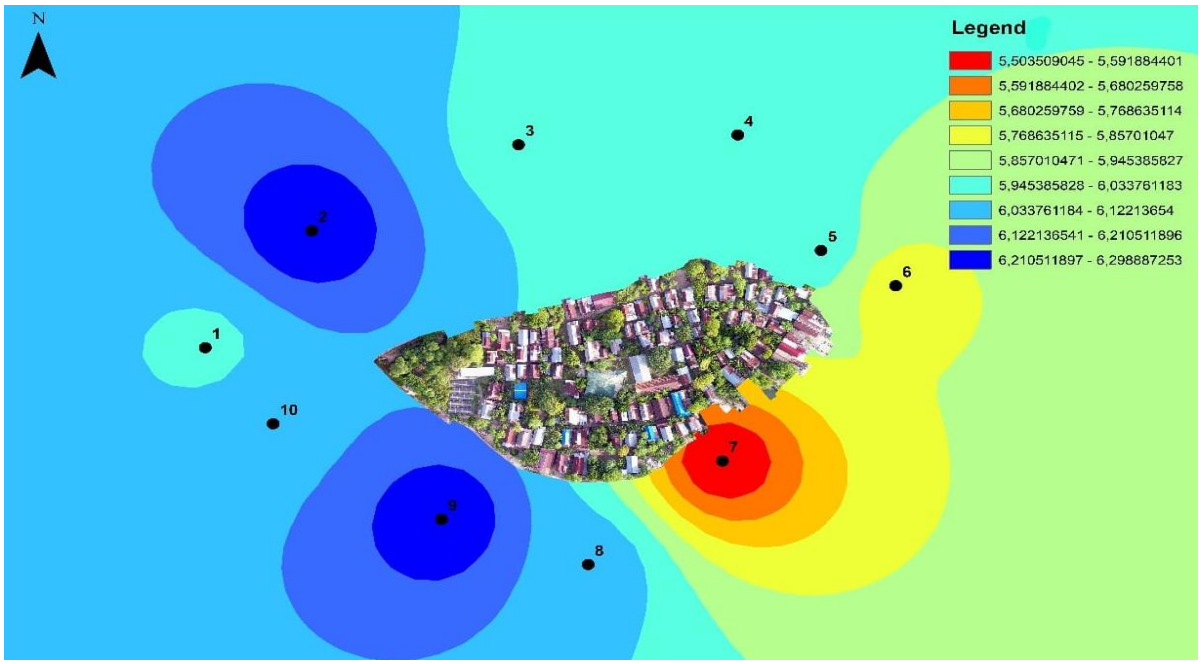

Figure 4. pH Map (Degree of Acidity) of Saugi Island.

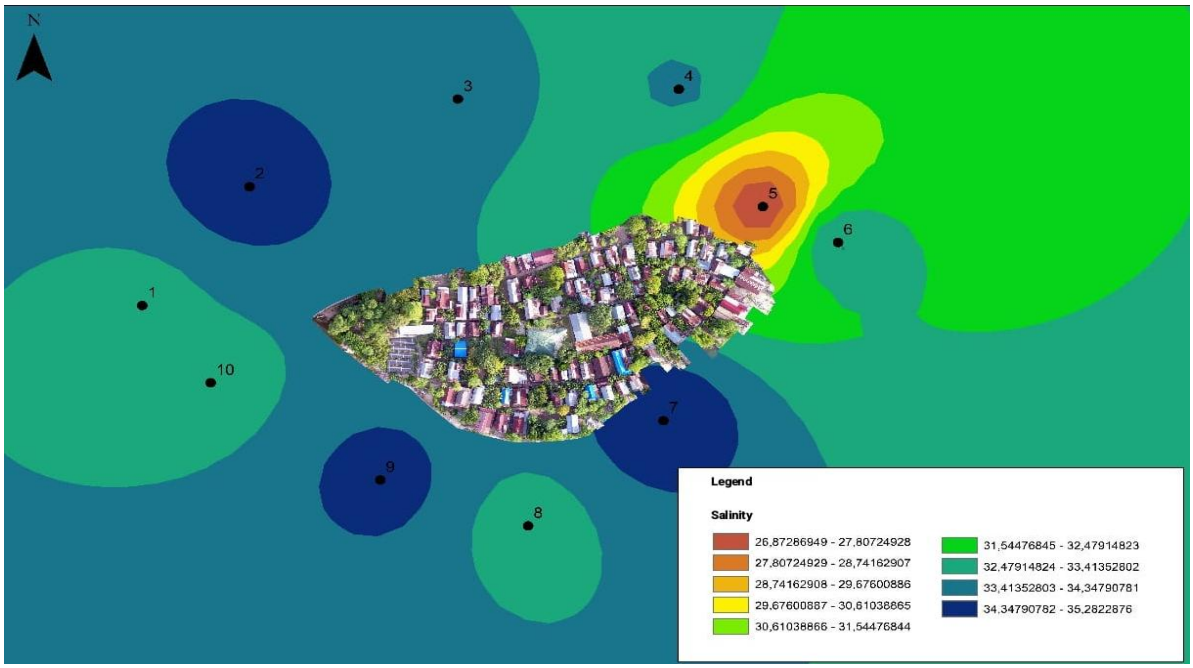

Figure 5. Saugi Island Salinity Map

Salinity and pH measurements were carried out on Saugi Island to understand the condition of the aquatic environment. The salinity measurement results show an average salinity level of 33.2, with a minimum value of 26.8 measured at the fifth station and a maximum value of 35.3 at the seventh station. High salinity can indicate the influence of deeper sea water or other factors such as high evaporation. Meanwhile, the average pH value obtained is 6, which indicates acidic conditions. This pH condition can affect the survival of various species, especially those that are sensitive to changes in acidity. Knowledge about salinity and pH is very important, because it can affect the health of the marine ecosystem and the biota in the waters of Saugi Island.

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DISCUSSION

Based on the results obtained in Figure 3, carried out using the Aqua-Modis image sensor. Traditional sea surface temperature measurements using instruments on ships or buoys are limited to certain areas and are unable to provide global data. Therefore, remote sensing is a necessary solution to obtain wider data. Each system has advantages and disadvantages regarding accuracy and the influence of cloud cover. The average temperature in Indonesian waters is estimated to be between 26-31°C with an accuracy of above 90%. The data processing process includes geometric and radiometric corrections to ensure measurement accuracy. The use of certain algorithms in data processing is also described to increase the accuracy of temperature estimates. Sea surface temperatures have a significant impact on marine ecosystems, including organism metabolism and other biological activities. Mapping the distribution of temperatures is also important for understanding phenomena such as upwelling, climate change and the dynamics of ocean currents (Tanto, 2020).

Methods for measuring surface temperature correlation using aquamodic and primary imagery involve the use of infrared image data taken from satellites or aircraft. To explain the method for measuring surface temperature correlation using aquamodic and primary images, we need to understand several basic concepts. This image can be used to calculate surface temperature with relatively high accuracy. Infrared image data and radiometric data can be synchronized to calculate surface emissivity and surface temperature. Surface temperature is a very important parameter and influences directly or indirectly the life of biota in the waters. This often affects environmental phenomena such as organisms in aquatic ecosystems which have an impact on the amount of oxygen in the water (Azizah, 2017). The distribution of sea surface temperature (SST) values around Saugi Island during a one month period ranging from August-September 2024 ranges between (30-36ºC) . Saugi Island is dominated by sea surface temperatures reaching 30ºC. Then a temperature of 31ºC for Mattiro Baji village can be seen in Figure 3. Meanwhile, for field data, the sea water temperature obtained was an average of 31.3°C with the highest temperature at station 3 and station 4 reaching 32°C. This temperature range is still within the normal level that is often found in tropical waters. Based on the quality standards of Kep.Men.LH. No. 51 of 2004 for marine biota, namely between 28-32ºC, with conditions varying at any time (day, night and season). This means that the sea surface temperature on Saugi Island can still support the life of organisms around the island and also shows that there is no significant increase in temperature. Every biological and physiological activity in an aquatic ecosystem is greatly influenced by temperature so that every increase in temperature greatly influences the rate of metabolism in organisms (Azizah, 2017).

Salinity is an important factor for the distribution of marine organisms and turbidity can hinder physical processes and biological productivity. Salinity is a term for the salinity or salt content of sea water. Sea water consists of 89% chloride salts and 11% other elements (Kusminah *et al*., 2023). Salinity is often defined as the total amount of dissolved substances (expressed in grams) in 1 kg of seawater. The salinity measurement results obtained at the location showed that the average salinity level was 33.2, with a minimum value of 26.8 measured at the fifth station and a maximum value of 35.3 at the seventh station. In Figures 4 and 5, the surface temperature map shows the distribution of salinity where the salinity value around the coast is lower than the salinity in the open sea. This is caused by the influence of river water mixing with sea water, causing salinity in areas near land to be lower. The measured salinity fluctuations reached 1.5%, indicating significant variations in salinity distribution at the location. According to Nasrul *et al*., (2025) stated that surface salinity to a depth of 10 meters in the waters of Sulawesi and its surroundings ranges from 33.7-33.8%. The low salinity in these waters indicates influence from land, such as mixing with fresh water from river flows. This shows that the interaction between sea water and fresh water can influence the salinity characteristics in the region.

Marine waters are categorized as either acidic (pH>7) or alkaline. Based on the data, the pH of seawater in the Saugi Island waters has an average pH of 6, which means that this value is classified as low, especially when compared with the normal pH value of the waters. According to Susana (2009) in

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Patty *et al*., (2020), the pH value that falls into the normal category in waters is in the range 8.0-8.3 and a pH value that is different from the standard is an indicator of disturbance in the waters. Variations in the degree of acidity (pH) of sea water can be used as an indicator of sea water quality. Good sea water is usually alkaline with a pH>7. Several factors that can cause low pH values in these waters can include oxidation factors, rainfall, influences from land such as water masses from around river mouths. From Figures 4 and 5, it can be seen that the differences in seawater pH values at each observation station in the surface layer of water and waters near the bottom are relatively the same (homogeneous), this is usually influenced by the nature of seawater which has a pH that is generally relatively stable with a narrow range of values, and is usually influenced by its capacity as a buffer with the influence of factors such as CO_2 conditions at the surface of seawater and the presence of bicarbonate and carbonate salts contained in it (Patty et al., 2020, 2021; Ding *et al*., 2024).

Water quality is the main benchmark for the sustainability of coastal ecosystems, especially on Saugi Island, including physical, chemical and biological water parameters. Among the applicable environmental parameters, namely temperature, pH and salinity, are the most important key parameters for controlling biological components of the ecosystem (Qaiyimah *et al*., 2024; Nasrul *et al*., 2025). In addition, temperature, salinity, and pH together are known to directly influence the physico-chemistry of seawater, as well as the buffering capacity and CO_2 enhancement in estuarine systems (Nikinmaa, 2013). Changes in temperature, pH and salinity that exceed quality standards will have a negative impact on the distribution patterns of biota, especially benthic organisms (Nasrul *et al*., 2025). Changes in temperature, salinity and pH have an influence on species dynamics in estuaries (Nasrul *et al*., 2024; Nasrul *et al*., 2024). Temperature, pH and salinity interact with each other and influence marine ecosystems. Sea surface temperature affects the metabolism of organisms, where higher temperatures can increase metabolic rates and reduce oxygen solubility. pH serves as an indicator of water quality; Low values can indicate pollution and impact the health of organisms, which have narrow pH tolerances. Salinity, which reflects the concentration of dissolved salts, influences water density and circulation, and interacts with pH and temperature. Overall, changes in one parameter can trigger chain effects that affect ecosystem balance and water quality. temperature, salinity, and pH together are known to directly influence the physico-chemistry of seawater, as well as the buffering and CO_2 enhancement capacity in water systems. Changes in temperature, pH, salinity and TDS that exceed quality standards will have a negative impact on biota distribution patterns, especially benthic organisms and have an influence on species dynamics in estuaries (Yolanda *et al*., 2023).

This research found that sea surface temperatures on Saugi Island ranged from 30°C to 36°C, with an average of 31.3°C. This increase in temperature has the potential to affect the metabolism and reproduction of marine organisms. Temperature is a very important factor for the life of organisms in the ocean, because temperature greatly influences both metabolic activity and the development of marine organisms. This situation is caused by the same type of tank, depth and observation time, thus the effect is almost the same in receiving and maintaining temperature. In each treatment there tends to be an increase in temperature. This is in accordance with Nita *et al*., (2017) statement that daily and annual temperature variations are the result of solar radiation and evaporation. In addition, these conditions can cause ocean acidification and salinity fluctuations, which negatively affect coastal ecosystems, especially sensitive species such as coral reefs. Coastal ecosystems are connected to the sea and receive freshwater input from land. The scope of regulation of coastal areas and small islands in this context is the transitional area of land and sea ecosystems which is influenced by land and sea areas, towards land covering administrative areas and towards sea as far as 12 miles of a country's jurisdictional boundaries. The impact of changes in water quality, especially temperature, pH and salinity, on coastal economies is very significant. Changes in the physical and chemical parameters of water can disrupt the distribution patterns of marine biota, especially benthic organisms, which are important resources for coastal communities that depend on fishing and aquaculture. Therefore, sustainable management and

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appropriate policies are needed to protect water quality for the welfare of the coastal economy (Köller *et al*., 2006).

Based on the results of research that has been carried out, the mitigation efforts that we can offer relate to two types of important initiatives: the temperature monitoring network and the eco wave initiative. The temperature monitoring network is a system that uses advanced sensors and monitoring tools to measure sea surface temperatures in real-time. This technology includes the use of satellite-based sensors and buoys that can provide accurate data on temperature fluctuations, salinity and water quality. The collected data not only helps in understanding the impact of temperature changes on coastal ecosystems, but also supports better decision making in marine resource management, such as determining the timing and location of fishing and protecting habitats. This is directly proportional to previous research by Rozikin *et al*., (2023), namely an arduino uno-based sea surface temperature measuring device named automatic sea water surface temperature measurement (AUTOSWASTEM). Where from previous research the DS18B20 sensor has been widely used to monitor temperatures in pools and room temperatures, so researchers took the initiative to develop the DS18B20 sensor which is used as a temperature measuring tool on sea water surfaces based on the Arduino IDE. To integrate this technology in a temperature monitoring network, to increase accuracy and efficiency in monitoring sea surface temperatures which contributes to the sustainable management of coastal ecosystems.

Meanwhile, the eco wave initiative is a program that focuses on protecting and sustaining coastal ecosystems through various strategies. The use of coastal areas for human activities continues to increase every year, giving rise to environmental problems (Qaiyimah *et al*., 2024; Nasrul *et al*., 2024; Nasrul *et al*., 2025). The large number of tourists influences the spread of plastic waste. Widayatama *et al*., (2023), the rapid development of tourism contains various risks, among others. Pollution, pollution and waste problems. Garbage is one of the main causes of environmental damage in coastal areas. The effects of pollution on aquatic organisms if this waste pollution is not immediately handled in the best possible way, there is a risk that coastal and marine resources will deteriorate (Harefa *et al*., 2022). This initiative includes the restoration of natural habitats, such as coral reefs and mangrove forests, which serve as coastline protection and homes for various species. Apart from that, this program also emphasizes the importance of public education to increase awareness about the impacts of climate change and the application of green technology for managing marine resources. This is related to what is explained in the 1997 environmental law which states that an ecosystem is a unified cultural system that is so complete and comprehensive that all environmental elements influence each other. These environmental factors can also be called biotic and abiotic elements, both living things and non-living things. Everything in the environment is organized as a group that cannot stand alone, but must communicate and influence each other, so that they cannot be separated from each other. The coastal area of Cermini Beach has the strength of natural resources and the unique beauty of white sand which makes this beach beautiful and a suitable tourist destination, apart from the rubbish pollution around the beach. The beach environment and weakens the environmental quality of the mirror beach. This requires regulation and police protection. One of these protection efforts is the enforcement of sanctions for all violations of Article 19 of Regional Regulation 10/2010. Sanctions are given as punishment for violations of the law that harm the surrounding community (Harefa *et al*., 2022). By involving various stakeholders, the Eco Wave Initiative aims to address environmental challenges and increase the resilience of coastal communities to climate change (Nasrul, *et al*., 2024).

CONCLUSSION

This study shows that sea surface temperatures (SST) around Saugi Island range between 30°C and 36°C, with an average of 31.3°C based on Aqua MODIS satellite data from August to September 2024. Spatially, the central area near Mattiro Baji Village recorded slightly higher temperatures (31-32°C), while the outer regions remained relatively cooler, around 30°C. This pattern reflects localized

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warming, which appears more dominant than seasonal or annual variations. The rise in SST has the potential to affect the metabolism and reproductive cycles of marine organisms, as well as trigger changes in pH and salinity levels. Field measurements indicate an average salinity of 33.2 PSU and a pH of approximately 6, which is acidic and may negatively impact marine life and the stability of coastal ecosystems. Thus, although the observed SST remains within the tolerance limits of tropical marine organisms, it signals early signs of environmental stress in coastal waters. These findings highlight the importance of continuous monitoring and further research on the interactions between temperature, salinity, and acidity in maintaining the health of marine ecosystems.

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