Mapping of Sea Surface Temperature and its Correlation with Salinity Concentration in The Coastal Beach of Bangkalan Madura District

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Abstract. Sea surface temperature is one of the parameters that plays a role in the quality of aquatic ecosystems in the sea, especially in shallow marine waters. Other parameters that play a role in determining the quality of the soil on the coast are salinity concentrations, which defines the mineral content of salts that are in the structure of soil widely used for farming or for ponds. This study aims to obtain a correlation of salinity to changes in temporal sea surface temperature for 2 consecutive years on the coastal areas of Bangkalan Madura district as a case study. The method used in this study was mapping with remote sensing using Terra Modis satellite imagery for 2018 and 2019. The acquisition of SST data used the ATBD algorithm and field data while for salinity field data were used. The study found that the magnitude of the SST values during the temporal analysis was not too much different in 2018 and 2019, only for correlations with salinity, the statistically calculated error rate of 5% showed that there were sufficient differences with the SST changes that occurred during a year. The conclusion is that there was a significant correlation of the amount of salinity concentration with changes in sea surface temperature that occurred during the year of observation and this requires serious handling so that high salinity in coastal areas do not seep into the land which would have a negative impact on coastal communities.

Keywords: Salinity, Sea surface temperature, Seawater infiltration, Terra Modis

1. Introduction
Sea surface temperature plays an important role in the quality of shallow marine aquatic ecosystems, where changes that occur at sea surface temperature (SST) will have an impact on the ecosystem in the area. As an example of changes that occur on the coast where the sea depth is relatively not deep, even a change of one degree will affect the lives of marine fish, and fish populations in shallow sea areas will change a little bit. Changes that occur can be either positive or negative depending on the value of changes in SST that previously occurred. A temperature change of 1 degree may not affect humans or mammals living on the high seas, but this does not apply to small fish that are part of the capture fisheries ecosystem that is needed by fishermen to be taken as one of the dominant food ingredients in coastal areas. Changes in sea surface temperature cannot be avoided, it happens every time there is an incident where sea surface temperatures experience a significant increase or decrease. The problem now is how the pattern of change
occurs and how much impact can be caused from these changes. Changes that occur can take place daily, weekly and even yearly. Variations in sea surface temperature over time require to be consistently and continuously observed. For that we need a method that can observe changes that occur temporally and can reach large areas. Remote sensing technology is one of the most possible alternatives to record and map changes in temporal and effective sea surface temperature. Remote sensing has the ability to obtain data in the same area of a certain time interval, and to get this picture one of the most widely used satellite images is Aqua MODIS and Terra MODIS (Maritorena, Fanton D’andon, Mangin, & Siegel, 2010; Wibisana, Sukojo, & Lasminto, 2018).

Research on sea surface temperatures has been carried out by many researchers, both related to parameters of ecosystem changes such as salinity concentration (Hunter, 1998; Jin et al., 2017; Stuyfzand, 2017), sea surface temperature (Nieto & Melin, 2017; Reynolds & Smith, 1994; Ruiz-Ochoa, Beier, Bernal, & Barton, 2012; Tu, Pan, & Hao, 2015), or chlorophyll-a concentration (Dennison et al., 2005; Houborg, Soegaard, & Boegh, 2007; Sirjacobs et al., 2011; Wibisana, Zainab, & Handajani, 2016), along with the development of sensors and the compilation of algorithms related to the optimization of mathematical models which were also growing.

This study aims to get an idea of the correlation between sea surface temperature and the salinity concentration values where the two of them have major interferences on the water ecosystem. Salinity concentration is one of the parameters to determine whether an aquatic ecosystem is dependent on sea surface temperature or not interconnected.

2. Materials and methods

2.1 Research location

The research was done on the coast of Bangkalan Madura district at coordinates 7°9’49.88 “LS to 7°9’57.99” LS and 112°51’40.48 “BT to 112°50’59.64” as seen in Figure 1. The location geographically borders with the Madura Strait in the south and Modung Kwanyar Highway in the north coast. The east borders with Sampang and west with the Suramadu Bridge. The coastline is of a short distance from the Modung Kwanyar highway, only about 50 meters apart. The beach is muddy and partially covered with rocks, the coast towards the Suramadu bridge is covered with mangroves while the coast to the east looks arid with steep coastal conditions and also covered with rocks. The waves on the Kwanyar coast are not large, and the beaches are classified as shallow beaches with 3-5 meters of depth at a distance of 100 meters from the coastline.

Figure 1. Research location at Coast of Kwanyar Bangkalan distric of Madura
2.2 Retrieval of SST from Seawater
To measure the sea surface temperature, a digital thermometer was used. Measurements were made at the designated coordinate points with a fishing boat. First, the thermometer was fired at the surface of the sea water and after some delay, a stable number was obtained. Then, the values were recorded with the corresponding coordinate values. Data were taken as many as 20 times in several places with a distance of approximately 200 meters between each point.

2.3 Salinity Data
Salinity was measured by taking 1 liter of seawater into a bottle container and then bringing it to the laboratory and measuring its salinity using a method such as Jurgen (jurgen, 2010). Salinity value is expressed as part per million (ppt) or in units (o / oo)

2.4 Retrieval of Satellite Images
The satellite image used in this study was from Aqua Modis and it was obtained from the website https://modis.gsfc.nasa.gov. The file downloaded for the year 2018 was A2018035061000.L2_LAC_SST.nc and for the year 2019 it was A2019054061000.L2_LAC_SST.nc. The span of the obtained image was 1 km. The satellite imagery obtained had to be cropped first according to the research area before being rearranged with the existing projections.

3. Results and Discussion
The results of extracting sea surface temperature values from Aqua Modis satellite images are shown in Table 1, where the SST values obtained were for 2018 and 2019, the algorithm used for the SST value was the ATBD algorithm, and the last column lists the temperature values for field measurements directly at the corresponding coordinate point.

| Data Point | Longitude | Latitude | SST 2019 | SST 2018 | SST insitu (°C) |
|------------|-----------|----------|----------|----------|-----------------|
| 1          | 113.04156 | -7.22458 | 33.103   | 31.603   | 32              |
| 2          | 113.02496 | -7.21440 | 33.905   | 25.175   | 31              |
| 3          | 113.00440 | -7.21449 | 31.990   | 28.735   | 31              |
| 4          | 112.98384 | -7.21458 | 29.690   | 25.560   | 30              |
| 5          | 112.96324 | -7.20440 | 30.385   | 31.620   | 30              |
| 6          | 112.94369 | -7.20449 | 28.185   | 30.310   | 28              |
| 7          | 112.92213 | -7.20458 | 27.345   | 29.625   | 28              |
| 8          | 112.91190 | -7.21488 | 28.953   | 28.580   | 28              |
| 9          | 112.89134 | -7.21497 | 32.020   | 28.310   | 31              |
| 10         | 112.88106 | -7.21501 | 31.345   | 29.315   | 31              |
| 11         | 112.88110 | -7.22527 | 32.020   | 29.590   | 30              |
| 12         | 112.90166 | -7.22519 | 32.195   | 29.300   | 30              |
| 13         | 112.92222 | -7.22510 | 31.555   | 27.970   | 29              |
| 14         | 112.94377 | -7.22501 | 31.915   | 25.170   | 30              |
| 15         | 112.96153 | -7.22493 | 11.915   | 27.720   | 30              |
| 16         | 112.97361 | -7.22488 | 31.890   | 29.070   | 28              |
| 17         | 112.99421 | -7.23506 | 22.055   | 25.345   | 32              |
| 18         | 113.01477 | -7.23497 | 22.035   | 25.995   | 30              |
| 19         | 113.02505 | -7.23493 | 31.985   | 28.530   | 30              |
| 20         | 113.04560 | -7.23483 | 31.770   | 28.645   | 29              |
From Table 1, the SST values were then depicted into a graph to see a comparison between the 2019 and 2018 SST as well as the SST obtained in the field (in situ). The comparison graph can be seen in Figure 2.

![Simulation graph of SST values along with the appropriate coordinate samples](image)

**Figure 2.** Simulation graph of SST values along with the appropriate coordinate samples

In Figure 2 it can be seen that SST 2019 had a relatively higher values among the others, especially from the 10th data collection point to the 20th. This was because the data from the 11th to 20th sampling locations were carried out at a distance of 200 meters from the coastline, while the first data up to the 10th location were taken at a distance of 100 meters from the coastline, so that the water turbidity at sample 1 up to 10 is suspected to be higher compared to samples 11 to 20.

Furthermore, the research was continued by testing the range of distances when sampling data as well as the time taken for reflecting data compared to the insitu SST. The calculation was done by calculating the Analysis of Variance (ANOVA) method to see whether there was a difference between the distance of data retrieval and the time of data collection. And the results are shown in Table 2, where in the ANOVA table the F distribution was obtained and compared with the F table value in the table marked as Fcrit.

| Source of Variation | SS      | df | MS       | F       | P-value | F crit |
|---------------------|---------|----|----------|---------|---------|--------|
| Rows                | 463100  | 19 | 2.4374   | 0.9417  | 0.5417  | 1.8673 |
| Columns             | 776031  | 2  | 38.8016  | 14.9920 | 1.59E-03| 3.2448 |
| Error               | 983498  | 38 | 2.5682   |         |         |        |
| Total               | 2222630 | 59 |          |         |         |        |

Table 2 shows that the F value for the row is 0.9417, while for F crit it is 1.8673 so it can be said that the F count is smaller than F table. For this fact, the null hypothesis was rejected and the hypothesis of the opponent was accepted.
The comparison of correlation between the values of SST 2018, SST 2019 and SST insitu are shown in Table 3, where it is shown that there was a good correlation between SST 2019 and SST insitu, thus the two set of data were then further used for the seawater salinity correlation test.

Table 3. Correlation of SST in 2018, 2019 and SST insitu

|             | sst 2019 | sst 2018 | sst insitu (°C) |
|-------------|----------|----------|-----------------|
| sst 2019    | 1        |          |                 |
| sst 2018    | -0.3661  | 1        |                 |
| sst insitu (°C) | 0.6804  | -0.1765 | 1               |

From Table 4, it can be seen that the correlation between the SST value and internal salinity was not too significant, where the greatest correlation in Table 4 was of the SST 2019 relationship.
with internal salinity, whereas with SST there was a relatively smaller value of 0.3895, so it can be said that the temperature recorded from direct measurement in the field did not show a causal relationship with the salinity of sea water.

**Figure 4.** Frequency histogram of Salinity at Bangkalan Madura coast with Exponent algorithm

**Figure 5.** Frequency histogram of Salinity at Bangkalan Madura coast with power algorithm
Figure 6. Thematic map of Salinity at Bangkalan Madura coast with linear algorithm

From Figure 9 it can be seen that for coastal areas in Bangkalan Regency, the distribution of salinity concentration was in the range of 17.5 to 35, indicating that there were relatively few anomalies from the salinity that were dissolved in coastal waters which seeped into the beach and infiltrated until it reached farmland in residential areas in the coastal area of Bangkalan.

Figure 7. Thematic map of Salinity at Bangkalan Madura coast with exponent algorithm
Figure 7 is a exponent algorithm of the salinity distribution conditions on Bangkalan Coast and Madura Strait. It can be seen that the distribution of salinity using the exponent algorithm was in the range of 27.07 to 29.87 (o/oo). The following is an explanation of the high range. The algorithm was modified into using the mathematical models of exponential functions, then as already calculated using scatter diagrams and regression analysis, the R correlation value was only around 60%, and this percentage was still smaller than the algorithm with linear mathematical models of logarithmic, only for processing with the "Math band" obtained for the past 5 years the use of logarithmic mathematical models were not going well, only valid for the year in which field data was taken, but when forecasting the distribution of salinity concentration for 5 years, discrepancies were shown between linear and exponential models.

Figure 8. Thematic map of Salinity at Bangkalan Madura coast with logarithmic algorithm

4. Conclusions
Aqua Modis satellite imagery has the temporal ability to provide reflectance data for visible light wavelengths from 400 nm to 700 nm, so algorithm analysis for optimum mathematical models of salinity distribution can be processed properly and results can be developed to generate more complex algorithms. Salinity can be analyzed in digital processes from satellite imagery utilizing reflectance data by finding a correlation with temporal sea surface temperature. It was found that the 2019 SST values provided the results of a mathematical model that had an R2 correlation value higher than that for 2018 data. Whereas the right wavelength and channel type to obtain the optimum mathematical model was obtained at a wavelength of 667 nm, namely the wavelength of the canal red on fashionable aqua satellite imagery. The algorithm used in this study to obtain the value of SST was the ATBD algorithm in addition to obtaining field data for the validation process.

The results indicated low correlation between the concentration of salinity and SST, where the value of the correlation with SST in 2019 only contributed a percentage of 53.78%, while the correlation with the SST insitu was even lower at only 38.95%.

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Acknowledgment
The author would like to thank the party of UPN Veteran East Java LPPM who has provided research funding so that it can run well and on time, as well as Dani, Agus and Hendra who have helped to collect sample data in the field.