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Application of Generalized Additive Model for Identification of Potential Fishing Zones Using Aqua and Terra MODIS Imagery Data

Bandi Sasmito [1] , Nurhadi Bashit[2*] , Bella Riskyta Arinda[3], Abdi Sukmono[4]

[1,2,3,4] Department of Geodetic Engineering – Engineering Faculty – Diponegoro University, Jl. Prof Sudarto, SH, Tembalang, Semarang, Indonesia

* Corresponding author's email: nurhadi.bashit@live.undip.ac.id

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Abstract

Remote sensing applications can identify fishing zones to increase the efficiency and effectiveness of fishing operations by fishermen. Identification of fishing zones needs to be studied regarding the relationship between fish catches and oceanographic parameters using the Generalized Additive Model (GAM) in the Java Sea. GAM analysis was carried out using fish catch data as response variables and oceanographic parameters such as sea surface temperature (SST) and chlorophyll-a image processing results from MODIS, SSS from CMES, and Depth data as predictor variables. The selection of the best model is determined by the highest percentage of CDE and lowest AIC. GAM modeling results show that 60.3% of fish catches in the Java Sea are influenced by oceanographic factors and 39.7% by other factors. The oceanographic parameter that has the most influence on fish catches is the concentration of chlorophyll-a. GAM modeling results show that fish in the Java Sea tend to be found in seas that have chlorophyll-a concentrations of 0.2 mg/m3 – 0.5 mg/m3, SST 280C – 310C, salinity 31.8 PSU – 33 PSU, and a depth of 20 PSU. m. – 50 meters. The results of the most potential fishing zones were found on June 3, 2021, which spread the most in the sea around Pulau Laut, in the southern part of the island of Borneo, and in the north on the island of Madura.

Keywords: Generalized Additive Model (GAM), Java Sea, MODIS, potential fishing zone

1. Introduction

The Java Sea has a fishery resources utilization rate that has reached 130%. It indicates that fishery resources in the Java Sea are fully exploited or overexploited (Triarso, 2012). The Java Sea covers several areas in the northern part of the island of Java which consists of several districts/cities in the province of Central Java. Central Java Province tends to decrease in marine fishery production which is sold at Fish Auction Places (TPI) from 2018 to 2020. Central Java Province in 2019 recorded a depleting in marine fishery production from 2018 by 5.66% (BPS Jawa Tengah, 2019). The depleting in fishery production in Central Java Province occurred in the first trimester and second trimester of 2020. The depleting in fishery production results in each quarter was 29.08% in the first trimester of 2020 and 5.70% in the second trimester of 2020 (BPS Jawa Tengah, 2020).

Depleting in fishery production was due to high waves and the difficulty of fishermen in fulfilling fuel needs. High waves cause fishermen to be unable to carry out fishing activities. The current method of determining potential fishing ground is still traditional, based on the experience of fishermen, so this results in a waste of time, energy, and operational costs for fuel so that it supports conditions of uncertain and suboptimal catches (Suhartono et al., 2013).

This condition has been brought into attention for a method that can make easier for fishermen to determine the location of fishing grounds, so that fishing activities will be more effective and efficient, namely by presenting information on indicators that affect the presence of fish which are strongly influenced by oceanographic conditions (Rivai et al., 2017).

Determination of potential fishing zones can be identified using a scientific approach based on the relationship and suitability of oceanographic variables between sea surface temperature (SST) and chlorophyll-a concentrations to determine the location of fish presence. Remote sensing technology has currently gained increasing importance in providing oceanographic condition information and monitoring oceanographic environment (Solanki et al., 2017).

Various studies have been conducted to predict potential fishing areas. Several studies have produced a relationship between the location of fish presence and environmental oceanographic parameters. This study aims to obtain potential fishing zones so as to determine the location of the fish. Fishery resources and their oceanographic parameters generally have a non-linear relationship (Valavanis et al., 2008).

Generalized Additive Model (GAM) approach method can be used to study the relationship between the abundance of fishery resources and the dynamics of oceanographic environmental parameters. Generalized Additive Model or (GAM) is a semi-parametric generalization model of multiple linear regression with features that do not require the normality of the data distribution (Zuur et al., 2009). In this case, the model approach can solve the non-linear correlation between the response and prediction variables. The GAM method can predict the abundance of species objectively based on ecology in a wide geographic area and is one of the most appropriate methods of modeling fish habitats because this model accommodates non-linear relationships (Valavanis et al., 2008). The application of the GAM Model predicting the distribution of catfish and squid scattered in the northern Arabian Sea obtained good model results for predicting fish potential with deviations of 26% for catfish and 28% for squid (Solanki et al., 2017).

Integration of remote sensing application, GIS, and GAM approach have been applied in several research to identify potential fishing zones with good accuracy (Nurdin et al., 2017; Safruddin et al., 2014; Wibawa and Arief, 2017; Y.Siregar et al., 2018). The study aims to determine relationship between oceanographic parameters with fish catches and to identify potential fishing zones based on GAM model in the Java Sea.

2. Materials and Methods

2.1 Data

This study uses some data to support the implementation of the research. This study uses four oceanographic parameters to study the relationship between fish catch data and oceanographic parameters including sea surface temperature (SST), chlorophyll-a concentration, salinity, and depth, which can be seen in Table 1.

Table 1. Data Requirement

Types of Data	Source
Image of Aqua and Terra MODIS Level-1B	NASA's OceanColor Web
Daily Sea Surface Salinity (SSS) Data (GlobalOcean 1/12° Physics Analysis And Forecast Updated Daily)	Copernicus Marine Service (CMEMS)
Fishing Data	Field Survey (GPS Handheld)
BATNAS (National Bathymetry)	Geospatial Information Agency

2.1 Study Area

The research area is in the Java Sea, from 03^{0}00' N – 06^{0}34' N and 110^0 East Longitude – 117^{0}E which can be seen in Figure 1. The Java Sea is delimited by the coast of Sumatra, Java, and Kalimantan. The study location is included in the Fishiries Management Area of the Republic of Indonesia 712 (WPP RI-712). The Java Sea climate influenced by seasonal monsoon cycle that occur annualy in this area includes the rainy monsoon (occurs between mid December and March) and the dry monsoon (occurs from June to September).

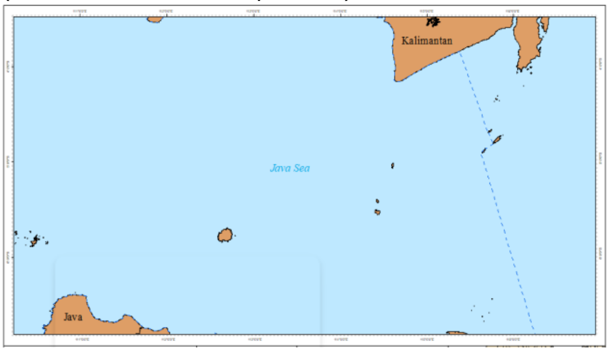


Figure. 1. Study area

In general, the steps of this research will be shown in Figure 2.

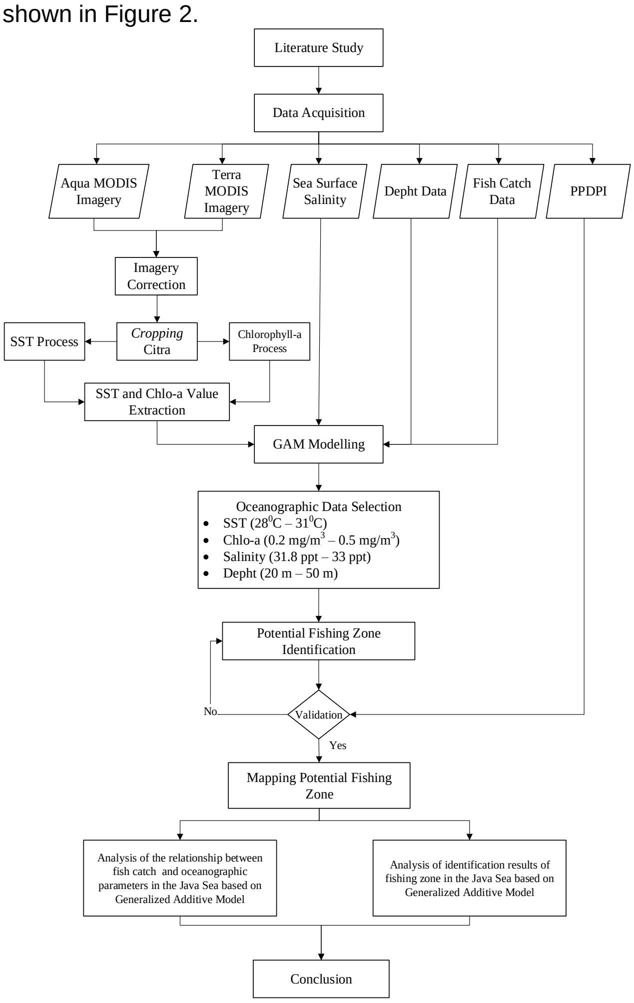


Figure 2. Study flowchart

2.2 Fishery Data

Fish daily catch data obtained from field survei around the Java Sea throughout March 2021 – June 2021. This study obtained data on fishing locations in the form of latitude and longitude as well as catch weight (kg) at each location. The catch data were divided into two category based on vessel size used for fish catch operation: (1) Jepara dataset; which obatained from area around Panjang Island, Jepara Regency using 15-GT vessel (2) Pati dataset; which obtained from area fishing base Juwana, Pati Regency using 70-GT vessel. Data on the type of fishing vessel and the time the fishermen sailed can be seen in Table 2.

Table 2. Ranges of dates fishing activity

Dates	Vessel Size	Fishing Base	Points
March 29th	15-GT	Jepara	41
March 27th – April 25th	70-GT	Pati	30
May 27th – June 25th	70-GT	Pati	30

2.3 Remotely Sensed Environmental Data

This study obtained data on sea surface temperature (SST) and chlorophyll-a from L1B MODIS satellite image data (daily data) with a spatial resolution of 1 kilometer. The data were downloaded from NASA GSFCS Distributed Active Archieve Center (DAAC) website (https://ladsweb.modaps.eosdis.nasa.gov/).

The MODIS data were processed to imagery with SST and cholorphyll-a data using ENVI 5.1. The algorithm applied to obtain the SST data was calculated from Minnet (2001) algorithm. Meanwhile, the algorithm applied to obtain the chlorophyll-a data was calculate from the OC3M algorithm.

This study also utilizes daily sea surface salinity (SSS) data sourced from the 1/12° Global Ocean Physics Analysis and Forecast. The SSS data in this study was sourced from downloading data from the Copernicus Marine Environment Monitoring Service (CMEMS) website (https://resources.marine.copernicus.eu/products). The SSS data were processed using ODV and ArcGIS 10.4.

The depth data were obtained from National Bathimetry (BATNAS) data with 6-arcsecond. The BATNAS data were downloaded from https://tanahair.indonesia.go.id/demnas/#/batnas. The depth data were processed using ArcGIS 10.4.

2.4 Generalized Additive Model (GAM)

GAM has an additive function to determine the relationship between the mean of the response variable and the smoothing function of the predictor variable. GAM can resolve the relationship between non-linear and non-monic of the response variable and predictor variable (Hastie and Tibshirani, 1990 in Shaari and Mustapha, 2018). A model of the GAM function shown in Eqn.1:

$$Y_i = \alpha + s(x_i) + \varepsilon \quad (1)$$

Where Y is the link function, i is the expected vakye of dependent variable, α is the model constant, s(.) is a smoothing function for each of the model covariates x_i, and ε random error term (Wood, 2006).

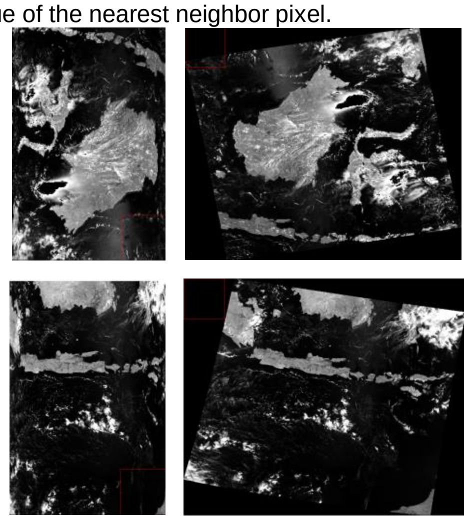
GAM is a semi-parametric and non-parametric regression technique model to determine the relationship between fish catch as a response variable and oceanographic parameters as a predictor variable. GAM uses the R software which is the gam function of the mgcv package.

The model is formed from simple objects using one parameter, such as sea surface temperature (SST), then adding other parameters. In this case, the best model can be selected based on a stepwise procedure. Akaike Information Criterion (AIC), Cumulative Deviance Explained (CDE), and the significance of the predictor terms in selecting the best model. The model is selected based on the installed model with the lowest AIC value and the highest CDE percentage.

3. Results and Discussion

3.1 Image Processing Results

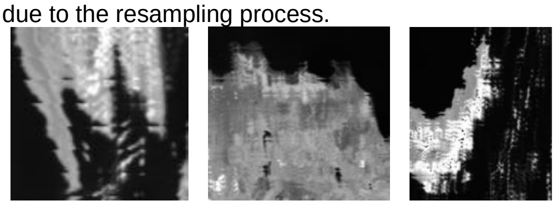
The MODIS Level 1B product already has a planimetric coordinate system (flat) but does not yet have the correct map coordinates. Information related to the projection system on the product before being corrected does not exist, while the corrected image already has a projection system. The image was improved after image correction was done by eliminating the duplication of lines that are no longer visible. This happened because the line duplication in the image is corrected by means of a mathematical transformation from the old image before being corrected to the new image. This fix was done with the formation of new pixels. The gray point in the new (corrected) pixel was formed by switching the gray value of the nearest neighbor pixel.



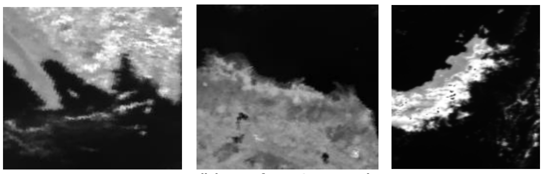
(a) Before (b) After

Figure 3. Image comparison before and after correction

Information related to the projection system on the product before being corrected does not exist, while the corrected image already has a projection system. This is because in the correction process there is a process of determining the projection system on the image. The difference in the MODIS Level 1B image before and after the geometric correction process is shown in Figure 3 (a) shows an uncorrected image, the image still does not have the correct map coordinates. Figure 3 (a) shows the inverted image position. This is because the recording of the Aqua image is done ascending from south to north. Figure 3 (b) already has the correct map coordinates. The image also changes direction due to the resampling process.



(a) Before correction



(b) After Correction

Figure 4. Image comparison before and after bowtie correction

The image has been improved marked by the disappearance of duplicate lines that are no longer visible. This happens because the image containing the line duplication is corrected by means of a mathematical transformation from the old image before being corrected to the new image. This fix is done with the formation of new pixels. The gray point in the new (corrected) pixel is formed by shifting the gray value of the nearest neighbor pixel.

The results of SPL and chlorophyll-a processing from the Aqua and Terra MODIS images shown in Figure 5 and Figure 6 indicate that the data recording process using remote sensing sensors was influenced by the presence of clouds. The presence of clouds causes an image to be not optimal in displaying information on the earth's surface. The research was carried out at a time with relatively high rainfall intensity or called the wet month, causing the image to lose quite a lot of information.

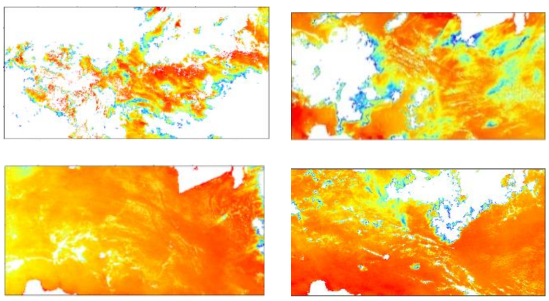


Figure 5. SST Image Processing Results

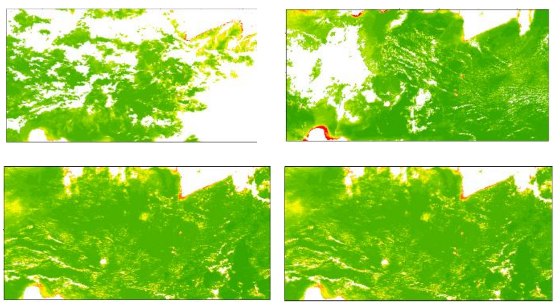


Figure 6. Chlorophyll-a Image Processing Results

3.1 Fish Catch Data Distribution

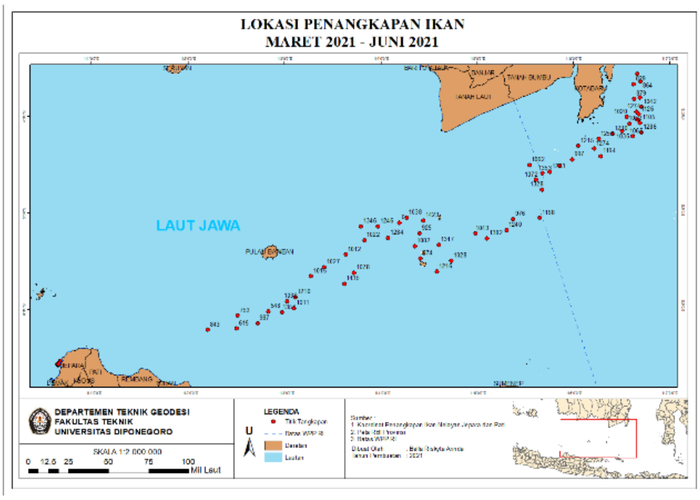
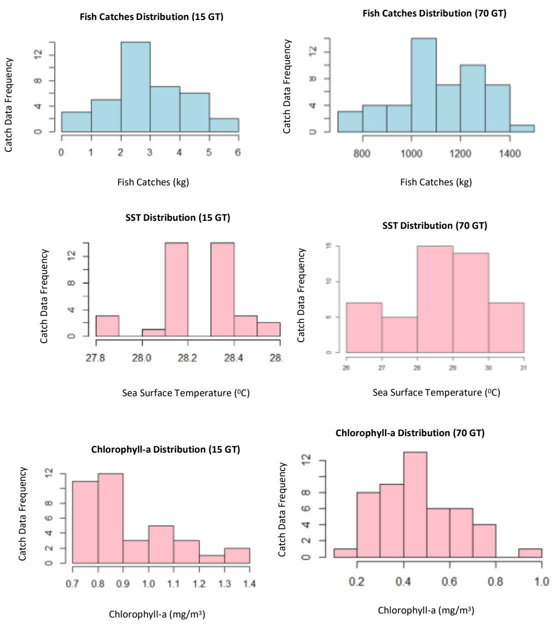


Figure 7. Catch Fish Location Distribution

Total catch fish weight from 3 trips is 66,0323 kg. The first trip was in the sea around Panjang Island, Jepara Regency with a total catch of 160,3 kg using 15 GT.The second and third trips were in the sea of the East Java Sea to parts of the Makassar Strait with a fishing base location in Pati Regency using a 70 GT vessel. Total catch fish weight on second trip is 32,229 kg. Total catch fish weight on third trip is 33,343 kg.

3.2 Variability of Oceanographic Parameters

Visualization of data with histograms was carried out for all variables, both in the Jepara location dataset and in the Pati location dataset. Histogram visualization is done to see the frequency distribution of data values. Histogram that showed distribution of data values shown in Fig 8.



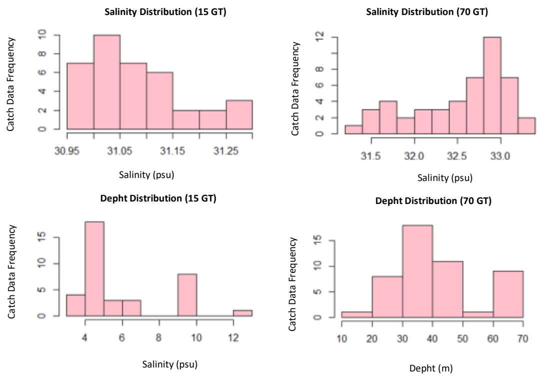


Figure. 8. Histogram showing frequency fish catches distribution, satellite-derived variables; (SST, Chlorophyll-a, Salinity and Depht)

Fig 8. shows distribution of data values. The number on horizontal axis represents variable values and the number on the vertical line represents the frequency or number of fish catch points carried out in this study.

3.3 Generalized Additive Model (GAM) Results

Determination of potential fishing zone needs to start with the relationship between oceanographic parameters and fish catches in the area using the GAM method. GAM uses several parameter criteria to analyze the relationship between fish catches and oceanographic parameters.

Table 3. The results of the GAM model combination of the location parameters of Jepara

Model	Variable	AIC	CDE (%)
GAM 1	SST	127,7886	7,11
GAM 2	Chl-a	127,5322	20,8
GAM 3	Salinity	128,6344	2,99
GAM 4	SST Chl-a	127,1812	18,5
GAM 5	SST Salinity	126,3337	26,3
GAM 6	Chl-a Salinity	187,2003	27
GAM 7	SST Chl-a Salinity	127,1766	32,5

Table 4. The results of the GAM model combination of the location parameters of Pati

Model	Variable	AIC	CDE (%)
GAM01	SST	649,4945	28
GAM02	Chl-a	646,9048	29,1
GAM03	Salinity	657,6166	16,33
GAM04	Depht	658,8166	13,5
GAM05	SST Chl-a	639,5454	42,7
GAM06	SST Salinity	645,0655	40
GAM07	SST Depht	648,3898	34,1
GAM08	Chl-a Salinity	638,8359	44,9
GAM09	Chl-a Depht	654,8671	37
GAM10	Salinity Depht	654,8671	25,9
GAM11	SST Chl-a Salinity	630,8253	56,2
GAM12	SST Chl-a Depht	638,1425	46,8
GAM13	SST Salinity Depht	644,4535	30,8
GAM14	Chl-a Salinity Depht	644,4535	43,7
GAM15	SST Chl-a Salinity Depht	629,9443	58,7

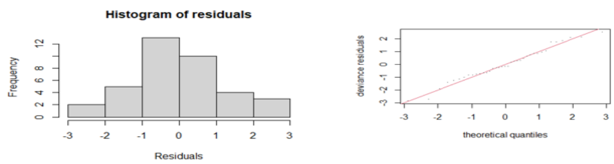
Fish catch prediction results are influenced by each parameter with different effects. Each individual parameter is assessed for the first time in identifying the model that will affect the fish catch. Parameters are determined based on the deviation described and AIC. The best parameter combination was selected based on reduction of Akaike's Information Criterion (AIC) and increase in cumulative deviance explained (CDE) (Mugo et. al., 2010). Table 3 and Table 4 show the CDE precentage and AIC value for each individual parameter.

From the CDE of each parameter on the Table 3 and Table 4, were found that for fish in Jepara, sequence influence of parameters was Chlorophyll-a > SST > and for fish in Pati, Chlorophyll-a > SST > Salinity > Depht. We observe a dominant influence of cholorophyll-a in fish weight catch followed by other parameters.

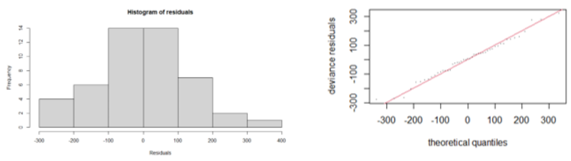
The single-parameter model in the table is made based on one predictor variable, and two-parameter models are made from a combination of two predictor variables, as well as a three-parameter model of three predictor variables, up to a four-parameter model of all variables.

The best model of Jepara dataset is shown in the GAM7 model with the smallest AIC value of 127,1766 and has the largest CDE of 32,5%. The GAM7 model is the result of a combination of three oceanographic parameters, namely sea surface temperature (SST), chlorophyll-a and salinity. The best model of Pati dataset is shown in the GAM15 with the smallest AIC value of 629,9443 and has the largest CDE of 58,7%. The GAM15 model is the result of a combination of all the oceanographic parameters, namely sea surface temperature (SST), chlorophyll-a, salinity, and depth. This shows that the best combination of the GAM model to reveal the presence of fish is the combination of all parameters in this study.

The best model that has been selected is carried out a diagnostic test to determine the feasibility of the model. Diagnostic tests are performed by looking at the residual plots generated by each model.



(a) Jepara dataset



(b) Pati dataset

Figure 9. Residual plots of (a) Jepara dataset, (b) Pati dataset

The residual plots in Figure 9. shows the shape of the histogram plot and the normal quantile-quantile (Q-Q) plot. The Q-Q plots generated from the two models show that there is a suitable distribution used in the model or is already ideal. This can be seen from the sample which is almost straight (1:1) with theoretical quantiles. Q-Q plots are useful in assessing the relationship of the sample to the theoretical quartiles (Wood, 2006).

3.4 Relationship between Fish Catches and Oceanographic Parameters

The GAM model formed from oceanographic parameter data and fish catch data for the Jepara location is shown in Table 5 shows through the p-value that all parameters, including sea surface temperature, chlorophyll-a, and salinity have a significant effect on fish catches at the study site. This is indicated by the p-value for each oceanographic parameter which has a value lower than 0,05 (p-value <0,05). Chlorophyll-a has the smallest p-value compared to other oceanographic parameters of 0,00038, while other parameters have lower significance values. Likewise for the selected model in the Pati dataset. Chlorophyll-a has the smallest p-value compared to other oceanographic parameters of 0,000079, while other parameters have lower significance values.

Table 5. GAM analysis (ANOVA) between location variables in Jepara

	F	p-value
s(SPL)	5.312	0.0098 **
s(Klorofil.a)	19.044	0.00038***
s(Salinitas)	3.875	0.01645 *
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

Table 6. GAM analysis (ANOVA) between location variables in

	F	p-value
s(SPL)	5.312	0.0115 *
s(Klorofil.a)	19.044	7.9e-05 ***
s(Salinitas)	3.875	0.0198 *
s(Kedalaman)	2.331	0.1877
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1		

The adjusted R-square value in the model generated from the variable shows how much the percentage of catch is affected by oceanographic parameters (Situmorang, 2010). The adjusted R-square value in the model generated from the Jepara location variable is 0,465 and from the Pati location variable is 0,603. The value of 0,465 indicates that the fish catch in the Jepara location was influenced by oceanographic parameters chlorophyll-a, sea surface temperature, and salinity of 46,5% and 53,5% is influenced by other factors. While the value of 0,603 indicates that the catch of fish was influenced by oceanographic parameters chlorophyll-a, sea surface temperature, salinity, and depth of 60,3% and 39,7% is influenced by other factors.

Each parameter has a different effect on fish catches. Based on the AIC, CDE, and p-value values, it shows that the most influential oceanographic parameters, respectively, are chlorophyll-a, sea surface temperature, and salinity. In Pati dataset model, depth has the weakest effect among other parameters. Both models show that the concentration of chlorophyll-a has a greater influence than other oceanographic parameters used in this study on fish catches at the study site. The existence of fish is influenced by the number of food sources in the ocean. The presence of fish will depend on the abundance of biomass from living things that occupy a trophic level below the trophic level of fish when connected to the food chain (Susilo et al., 2015).

The greater influence of chlorophyll-a concentration on fish catches is thought to be because the fish catches in this study are closer to areas with high productivity. The fishing locations in this study was classified as moderate to high due to several factors, such as the number of rivers that flowed into the vicinity of the study site and the onset of the dry season in June which was a factor that could support the high effect of chlorophyll-a concentrations on fish abundance.

Sea surface temperature was the second most influential oceanographic parameter on the abundance of fish catches in this study. These results indicate that sea surface temperature is a good indicator for determining fishing grounds. The high influence of sea surface temperature is related to changes in environmental factors (physical and biological) and has a considerable influence on migration patterns and fish growth.

GAM modeling produces a distribution plot of research data for each oceanographic parameter. GAM plots can be used to interpret the individual effects of each variable on fish catches. The horizontal axis represents the value of each predictor variable (oceanographic parameter). The quotation lines on the horizontal axis indicate the value of each parameter at the fishing point. The number on the vertical axis is the contribution of the smoothing function to the value of the data being tested. The black line shows the function in the model (fitted function), while the blue shade between these lines represents the 95% confidence interval limit. A narrow confidence limit indicates higher relevance and a wide confidence limit indicates a low distribution relevance range (Solanki et al., 2017).

The results of the validation of the GAM model through fish catch data and fish catch prediction data produced by each model show p-value > 0,05, namely for the Jepara location model 0,4111 and for the Pati location model 0,9548. A p-value of more than 0,05 means that H_0 is accepted or means that there is no significant difference between predictive data on fish catches and observational data on fish catches.

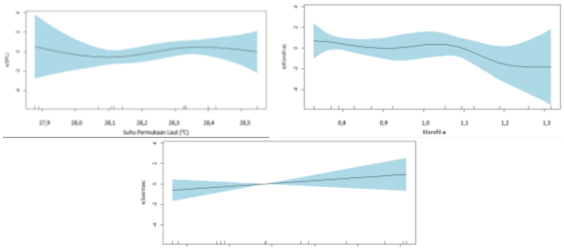


Figure 10. Residual plots of (a) Jepara dataset, (b) Pati dataset

The plot of sea surface temperature in Figure 10. shows a line that tends to be positive with a slight increase (curvature). The GAM plot of sea surface temperature shows that the sea surface temperature with abundant fish yields in this study is in the range of 28,1^{0}C – 28,4^{0}C. This indicates that the temperature in this range is the optimum temperature for fish around the location.

The chlorophyll-a plot in Figure 10 shows that fish tend to be caught in the concentration range of 0,7mg/m^3 – 0,9 mg/m^3. Fish catch increased as the concentration value increased in this range and showed a decrease in fish catch at the next larger value. This means that the range of values from 0,7 mg/m^3 – 0,9 mg/m^3 is the optimum concentration for the abundance of fish in the sea around Panjang Island, Jepara Regency.

The salinity plot in Figure 10 shows a positive linear line to the right which means that the higher the salinity value, the higher the fish catch. The results shown on the GAM plot show the fish catches that are often obtained in sea that have a salinity value of 30,95 psu – 31,15 psu.

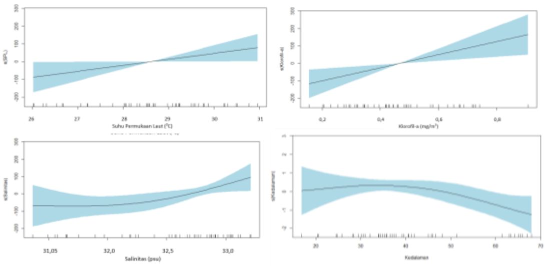


Figure 11. Residual plots of (a) Jepara dataset, (b) Pati dataset

The chlorophyll-a plot in Figure 11 shows a linear line in the positive direction with a fairly large increase. The catch of fish in this study area increased with the increase in the value of chlorophyll-a. The GAM plot of chlorophyll-a shows that fish tend to be caught in the concentration range of 0,2 mg/m^3 – 0,5 mg/m^3. The catch of fish in this study area increased with the increase in the value of the concentration of chlorophyll-a. Fish catch increased with increasing concentration values in this range.

The sea surface temperature plot in Figure 11 shows a linear line in the positive direction with not too large an increase. The catch of fish in this research location increases with the increase in the value of sea surface temperature. The GAM plot of sea surface temperature shows that the sea surface temperature with abundant fish yields in this study is in the temperature range of 28^{0}C – 31^{0}C. This indicates that the temperature in this range is the optimum temperature for fish at the research site.

The salinity plot in Figure 11 shows a positive line to the right with a very low curvature which means that the higher the salinity value, the higher the fish catch. The results shown on the GAM plot show the catch of fish that is often obtained in sea that have a salinity value of 31,8 psu - 33 psu. The depth plot in 5 shows the amount of fish caught in sea with a depth of 20 m – 50 m. The depth plot shows an increase in fish catch as depth increases in this range, but decreases at greater depths. This indicates that sea with a depth of 20 m – 50 m are the optimum sea for the presence of fish.

3.5 Fishing Zone Identification Results

Optimum conditions for the presence of fish are used to predict potential fishing zones in the study area by overlaying all oceanographic parameters. The process of overlaying oceanographic parameters resulted in 39 of the 60 days of observation. This is due to the lack of image quality of Aqua and Terra MODIS which is covered by clouds on certain days. The results of the identification of potential fishing zones show the distribution of different potential fish zones for different days.

The results of the identification of potential fishing zones in March (Figure 12) show that not many potential fishing zones are found in the Java Sea. This is presumably due to the lack of information from the imagery used for identification due to high cloud cover and sea conditions that are not yet optimal for the presence of fish.

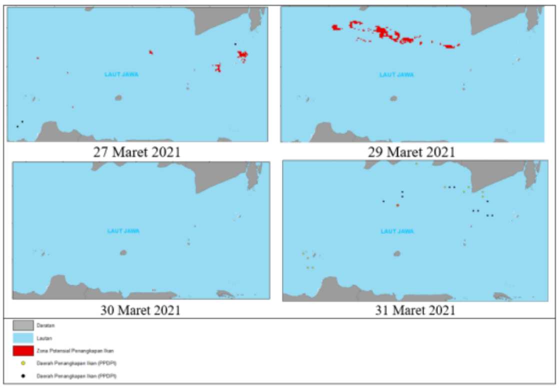


Figure 12. Potential fishing zones March 2021

Potential fishing zones on March 27 found as many as 70 grids of potential fishing zones or an area of 630 km^2 found around Matasiri Island.

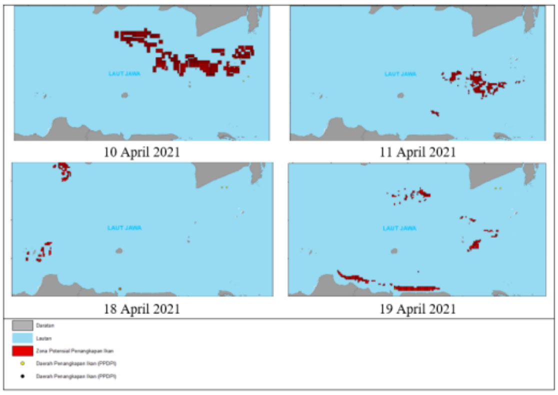


Figure 13. Potential fishing zones April 2021

The identification results in April, May and June showed that there were more potential zones than in March. This indicates that in these months there are more sea conditions that support the presence of fish in the Java Sea. Potential fishing zones in April (Figure 13) were found at most on April 10, 2021 to 14,391 km^2 located at $112^0$20' east longitude – $116^0$15' east longitude and $4^0$05' latitude – $4^0$55' latitude or a distance of approximately 37 nautical miles from the Kalimantan.

Potential fishing zones are almost always found in the sea between Masalembu and Matasiri Island. Potential fishing zones in April tend to be found in sea closer to the island of Borneo, but on April 19, 2021 – April 25, 2021, potential fishing zones are also found in north sea of the island of Java.

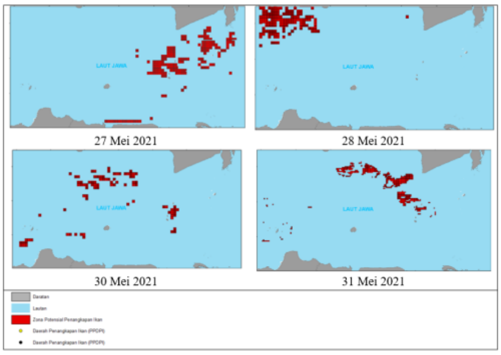


Figure 14. Potential fishing zones Mei 2021

The potential fishing zone in May (Figure 14) was found on 27 May 2021 to 12,177 km^2 located in the southern part of the island of Kalimantan, namely at $113^0$50' east longitude - $116^0$20' east longitude and 405' south longitude - $5^0$20' South Latitude and in the northern part of Madura Island, namely $112^0$40' East Longitude – $113^0$40' East Longitude and $6^0$45' South Latitude –$6^0$50' South Latitude.

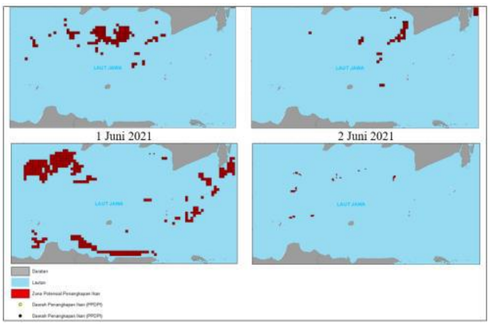


Figure 15. Potential fishing zones June 2021

Potential fishing zone in June (Figure 15) found at most on 3 June up to 25,191 km2 located in the southern part of the island Kalimantan is at $110^0$00' east longitude – $111^0$50' east longitude and $3^0$35'LS – $4^0$35' LS, in the southeastern part of Pulau Laut $116^0$05' east longitude– $116^0$35' East Longitude and $3^0$45' South Latitude – $4^0$20' South Latitude, northern sea Java Island and the northern sea of the eastern part of Java Island and Madura Island.

The results of the identification of potential fishing zones on This research is compared with the Regional Forecast Map Fishing (PPDPI) which contains points coordinates of the location of fish potential areas and areas fish catching. This PPDPI was published by Institute For Marine Research And Observation (BROL). PPDPI election as comparison data because PPDPI hasup to 87.2% accuracy in predicting potential areas fishing (Sukresno and Kusuma, 2021).

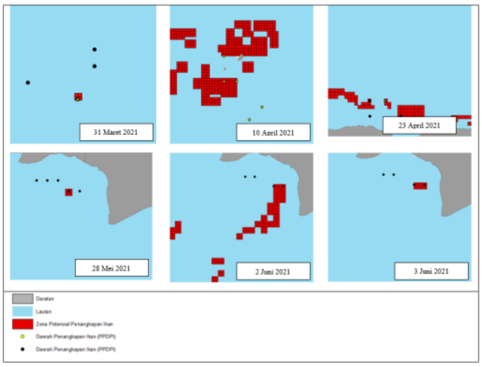


Figure 16. Comparison of potential zone identification results
fishing with PPDPI

Comparison results of potential fishing zones with potential areas and fishing areas presented in the Regional Forecast Map Fishing shows some results the same capture zone. As for the equation that between the two, namely the similarity of data usage MODIS and the use of GAM analysis methods. Differences that occur in the results of the comparison of zones fishing is suspected due to differences in use of oceanographic parameters in the model, level satellite image data used and method of determination sea surface temperature conditions.

4. Conclusion

GAM Model was applied to examine the relationship between fish catch and oceanographic parameters in the Java Sea. The fish catch of Java Sea at Jepara observation 46,3% influenced by oceanographic parameters, namely chlorophyll-a, SST, and salinity, while 53,5% influenced by other factors. The fish catch of Java Sea at Pati observation 60,3% influenced by oceanographic parameters, namely chlorophyll-a, SST, salinity, and depht while 39,7% influenced by other factors. Both GAM analysis results show chlorophyll-a has the greatest influence on fish catches in the Java Sea. The GAM model analysis indicated high distribution of fish related to Chlo-a, SST, Salinity, and depht in the range of 0,2mg/m3 – 0,5 mg/m3 , 28⁰C – 31⁰C 31,8 psu – 33 psu, and 20 m – 50 m. The results of the identification of daily potential fishing zones in the Java Sea from March 2021 to June 2021 show results with varying numbers and different spatial distributions according to optimum oceanographic conditions. The most potential fishing zones were identified on June 3rd , 2021 with a total zone of 25,191 km^2 distributed mostly in the southern sea of Laut Island, South Kalimantan (116⁰05' E – 116⁰35' E and 03⁰45 S – 04⁰20'S).

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