Fishing Ground Mapping of Demersal Fish in The Riau Islands Province Waters Related to the Oceanographic Factors

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Abstract. Research on the potential fishing ground for demersal fishing is a way to determine the areas that have the potential for fishing activities. Potential fishing ground mapping can be done by observing the dynamics of oceanographic parameters. The use of satellite imagery helps in providing oceanographic data in order to study the variability of oceanographic parameter. The aim of the study was to analyse the relationship between oceanographic parameter and demersal fish catch in order to validate potential fishing grounds for demersal fish. This research has been conducted in the waters of the Riau islands. Field observations and data collection including surveys of fishing grounds and identification of fish catches were carried out during March to August 2020. To support the analysis, Aqua-Modis Level-3 satellite data was used to observe the oceanographic variations. The data used in the analysis consisted of fishing grounds coordinate information, catches, sea surface temperature, chlorophyll-a, water depth, and salinity. The results showed that during the period 2010-2020, oceanographic dynamics did not experience significant changes or tended to be stable. Most of the research areas indicated appropriate categories for fishing activities based on the research parameters analysis. The correlation of the research parameters described a significant effect on fishing activities.

1. Introduction
The development of satellite remote sensing technology in ocean monitoring allows the development of various analytical models in the study of marine fisheries. Oceanographic satellite produces values for several oceanographic parameters essential that can be important in assessing habitat dynamics, including fishing areas. Oceanographic factors obtained from the satellite imagery are generally used in estimating the habitat of pelagic fish, assuming the recording results show the surface area of the waters. Several studies and developments have been carried out map the potential distribution of demersal fish habitat, which will later be used as a map of their fishing grounds.

Demersal fish generally spend the day at the bottom of the water and spread out in the water column; this is done to avoid the concentration of phytoplankton, which releases toxic substances
during the day. The bottom substrate significantly affects the abundance of demersal fish populations [1]. The seabed substrate is a habitat for demersal fish. Some fish prefer coral reefs to live, but some fish prefer sand or mud as their habitat. Various types of benthos on the sand or mud substrate that various types of benthos live in it [2].

Temperature, salinity, brightness, and depth affect the presence of certain types of demersal fish, while on the density of demersal fish biomass, these effects are minor. The effect of temperature, salinity, brightness, and depth on demersal fish biomass is not independent but affects demersal fish biomass density. Demersal fish crocodiles are not based on the influence of temperature, salinity, or food but for spawning [3]. Chlorophyll is one of the parameters that determine primary productivity in the sea. The distribution of chlorophyll-a in the sea varies geographically and based on water depth. These variations are caused by differences in the intensity of sunlight and the concentration of nutrients in the waters. Nutrient concentrations are low and variable at sea level, and their concentrations increase with increasing depth [4].

The purpose of this study was to analyze the relationship between oceanographic parameter and demersal fish catch in the waters of the Riau islands. The result of the study will validate potential fishing grounds for demersal fish by comparing the effect of oceanographic parameter on fish catch.

2. Methods

2.1 Dataset
The research has been conducted in the Riau islands waters. Field data observations including catch data and identification of fishing point of demersal fish were carried out during March to August 2020. Aqua-MODIS Level-3 satellite data was used to observe the oceanographic variations as well as the national bathymetry data applied for the depth. The parameters used include sea surface temperature, chlorophyll, salinity, and depth in a seasonal format for ten years (2010-2020). Furthermore, data on fishing points were collected through field surveys, interviews, and tabulations from the annual report of the Directorate General of Marine and Fisheries Resources Surveillance in Batam. The analyses were performed in SPSS 22.

2.2 Oceanographic Parameters
2.2.1 Sea Surface Temperature (SST)
The SST data used in this study was obtained from the Aqua-MODIS satellite data which was downloaded from the oceancolor.gsfc.nasa.gov page. The SST data in seasonal applied Level-3 data with a resolution of 4 km. The SST value was obtained through the initial calculation equation as follows:

\[
dBT = BT_{39} - BT_{40}
\]  

(1)

where:
\(dBT\) is the brightness of the color temperature, \(BT_{39}\) is the brightness temperature at 3.959 m, in degree Celsius, and \(BT_{40}\) is the brightness temperature at 4.050 m in degree Celsius.

Furthermore, the SST value can be found by the equation:

\[
ssT_4 = a_0 + a_1 \times BT_{39} + a_2 \times dBT + a_3 \times 1/\mu - 1
\]  

(2)

where \(\mu\) is the angular level of the Zenith sensor. The values \(a_0, a_1, a_2,\) and \(a_3\) have been determined by the Rosenstiel School of Marine and Atmospheric Science (RSMAS) according to the brightness level of sea surface temperatures obtained by the Aqua-MODIS satellite.
2.2.2 Chlorophyll-a
The chlorophyll-a data used in this study came from the Aqua-MODIS satellite downloaded from the website oceancolor.gsfc.nasa.gov using the Aqua-MODIS Chlorophyll Concentration sensor, seasonal using Level-3 imagery with a resolution of 4 km using the following algorithm equation:

\[
\log_{10}(\text{Chlorophyll-a}) = a_0 + \sum_{i=1}^{4} a_i \log_{10} \left( \frac{R_{rs} \left( \lambda_{\text{blue}} \right)}{R_{rs} \left( \lambda_{\text{green}} \right)} \right)
\]

(3)

\(R_{rs}\) has a wavelength between 440 and 670nm. In this study, blue and green \(R_{rs}\) have wavelengths of 443 and 488, while values at \(a_0 = 547\) and \(ai = 0.2424\).

2.2.3 Depth
The water depth data in this study comes from the http://tides.big.go.id/DEMNAS/BATNAS.php page. The algorithm formulated by [5] is an algorithm for transforming satellite image values to produce the relative depth of seawater. This algorithm requires three input images which are formulated as follows:

\[
\begin{bmatrix}
Y_1 \\
Y_2 \\
Y_3
\end{bmatrix} =
\begin{bmatrix}
\cos(r) \cos(s) & \sin(r) \cos(s) & \sin(s) \\
-\sin(r) & \cos(r) & 0 \\
-\cos(r) \sin(s) & -\sin(r) \sin(s) & \cos(s)
\end{bmatrix}
\begin{bmatrix}
X_1 \\
X_2 \\
X_3
\end{bmatrix}
……(4)
\]

Where:

\(X_1\) : first image, \(X_2\) : second image, \(X_3\) : third image
\(Y_1\) : main transformation result, \(Y_2\) and \(Y_3\): side transformation results
\(r\) and \(s\) : angle direction of rotation

The above equation can be described in the form of a 3x3 matrix multiplication as follows:

\(Y_1 = X_1 \cos(r) \cos(s) + X_2 \sin(r) \cos(s) + X_3 \sin(s)\)
\(Y_2 = -X_1 \sin(r) + X_2 \cos(r)\)
\(Y_3 = -X_1 \cos(r) \sin(s) - X_2 \sin(r) \sin(s) + X_3 \cos(s)\).

2.3 Catch
Catch data consists of geographic coordinates of fishing grounds, types of fishing gear, and fish catch composition. Catch data was collected through fishing activities and the fisheries annual report. Meanwhile, the previous catch data was obtained from the recapitulation of fish catch data recorded at the fishing port. Catch analysis was carried out through Cath per Unit Effort (CpUE) analysis.

3. Result and Discussion

3.1 Fish Catch and Fishing Ground
Catch data collected from the Kijang fishing port in Bintan Regency Indonesia which was focused on the demersal fish. This catch was obtained from the Fisheries Management Area (FMA) 711. Based on the Directorate General of Marine and Fisheries Resources Surveillance statistics report for January-August 2020, the composition of demersal fish in the FMA 711 was dominated by kaci fish: 313.617 tons, anggoli: 250,048 tons, grouper: 218,165 tons, snapper: 208,269 tons and bigeye: 5,135 tons. The fishing gear used in the FMA 711 area consists of trap, gill net, hand line, purse seine and lift net. Meanwhile, to catch demersal fish, many fishermen applied traps and gill nets. Due to the water conditions that were not too deep, such as the waters of Java and Sulawesi, demersal fish and reef fish were often caught using gill nets, purse seines and lift net. However, the majority of fishing vessels in FMA 711 were dominated by traps and gill nets.

Map on Figure 1 describes the main fishing ground of demersal fish that are usually carried out by local fishermen. The distribution of fishing points that illustrated on the map were collected using participatory mapping in the fishing activity in the waters of the Riau islands during April-August 2020.
Figure 1. Fishing operation position during April-August 2020

Based on the fishing activities in the location as shown on the map in Figure 1, it can be illustrated that the highest fish catches during April was found in the coordinate of 107°1’ East longitude and 3°8’ North longitude, with 1,291 kg catches of demersal fish. During May, the highest fish catches was found in the 107°3’ East longitude and 2°7’ North longitude with 1,363 kg of demersal fish catches, June in the 106°7’ East longitude and 3°4’ North latitude with 1,368 kg of demersal fish catches, July in the 106°1’ East longitude and 3°5’ North longitude with 1,369 kg of demersal, and on August in the coordinate of 106°1’ East longitude and 3°5’ North longitude with the catch of 1,371 kg demersal fish. The result illustrated that the variability of fish catch based on the distribution of fishing ground was not so significant. The fishing points were the common area for local fishermen in applying fishing activity. The catch difference as described could be due to the effect of oceanographic

The research by [6] stated that the distribution of most of the fish species was associated with temperature. In general, a warm water fish fauna dominated by Gadidae and Scorpaenidae. Many species also showed an association with depth and/or salinity. Study by [7] held that there was no effect on the occurrence of organisms has been found to be related to a recent increase in salinity, but other study result that there was an indication that an increased salinity might potentially affect several species [6]. In light of expected climatic changes and increased economic development in the region, this mapping may serve as a basis for future monitoring of important components of the marine ecosystem in this area

Moreover, the lowest fishing monthly was on April at coordinates of 106°3’ East longitude and 0°2’ North longitude with 430 kg of demersal fish catches. The lowest fishing for May was detected on 106°5’ East longitude and 0°3’ North longitude with 446 kg of demersal fish catches, June at 106°5’ East longitude and 1°8’ North latitude with 576 kg of demersal fish catch, July at the coordinate 107°1’ East longitude and 0°3’ North longitude with 375 kg of demersal fish catch and August was at 107°6’ East longitude and 0°3’ North longitude with 789 kg of demersal fish catch.

3.2 The Effect of SST on Catches
Based on study results, the SST range in the waters of the Riau Islands was 30°C - 31.4°C. Figure 2 describes the relationship between SST and catch, while the analysis result of SST effect on catches is presented in Table 1. During the period of April to August 2020, the highest SST was around 31.3 - 31.4 °C and the lowest was 30.1 - 30.5 °C. The catch tends to be high in the SST range of 30.5°C with the highest catch value in August (168,801 kg) and the lowest fish catch in June (111,705 kg).
### Table 1. Statistical analysis of SST on fish catches

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|---|----------|-------------------|-----------------------------|
| 1     | .356a | .126 | .017 | 827.64060 |

a. Predictors: (Constant), SST

| Model | Sum of Squares  | df | Mean Square  | F | Sig. |
|-------|-----------------|----|--------------|---|------|
| 1     | Regression      | 1  | 793473.174   | 1.158 | .313b |
|       | Residual        | 8  | 684988.966   |               |      |
|       | Total           | 9  | 6273384.900  |               |      |

a. Dependent Variable: Catch
b. Predictors: (Constant), SST

c. **Coefficients**

| Model | B     | Std. Error | Beta | t    | Sig.       | 95.0% Confidence Interval for B |
|-------|-------|------------|------|------|------------|---------------------------------|
|       |       |            |      |      | Lower Bound | Upper Bound                     |
|       |       |            |      |      | (Constant) | -91429.698                       | 17133.821                      |
| 1     | 93703.441 |         | 1.025       | .335 | 304540.702 | 117133.821                      |
| SST   | 3199.464  | 2972.712 | .356               | .313 | -3655.623 | 10054.550                      |

a. Dependent Variable: Catch

The analysis shows the magnitude of the coefficient of determination R square was 0.126. This shows that independent variables such as SST can explain the dependent variable (catch) of 12.6% while the remaining 87.4% was influenced by other factors. Table 1 shows that the calculated F value is 1.158 with F count < F table 2.58. Based on the basis of decision making on the F test, it can be concluded that H₀ was accepted and H₁ was rejected, meaning that SST has no effect on catch. The results of this analysis are in accordance with previous studies where demersal fish were found in the SST range of 27-30°C [8].

#### 3.3 The Effect of Chlorophyll on Catches

The range of chlorophyll in the waters of Riau Islands was 0.17 mg.m⁻³ - 0.26 mg.m⁻³. The catch tends to be high in the chlorophyll range of 0.26 mg.m⁻³ with the highest catch value was in August with a
total catch of 168,801 kg. (Figure 3). The analysis result of chlorophyll effect on catches is presented in Table 2.

![Figure 3. Graph of chlorophyll and catch](image)

**Table 2.** Statistical analysis of chlorophyll on fish catches

| Model | R     | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-------|----------|-------------------|---------------------------|
| 1     | .826a | .683     | .643              | 498.79923                 |

a. Predictors: (Constant), chlorophyll

| Model | Sum of Squares | df | Mean Square | F     | Sig.  |
|-------|----------------|----|-------------|-------|-------|
| 1     | 4282979.549    | 1  | 4282979.549 | 17.215| .003b |
| Residual | 1990405.351  | 8  | 248800.669  |       |       |
| Total  | 6273384.900   | 9  |             |       |       |

a. Dependent Variable: Catch
b. Predictors: (Constant), chlorophyll

| Model | Unstandardized Coefficients | Standardized Coefficients | 95.0% Confidence Interval for B |
|-------|-----------------------------|---------------------------|--------------------------------|
|       | B              | Std. Error | Beta  | t   | Sig.  | Lower Bound | Upper Bound |
| 1     | (Constant) | 6050.908 | 361.812 | 16.724 | .000 | 5216.567 | 6885.249 |
|       | chlorophyll | -6565.288 | 1582.365 | -.826 | -4.149 | .003 | -10214.227 | -2916.349 |

a. Dependent Variable: Catch

The analysis shows the magnitude of the coefficient of determination R square was 0.683. This shows that the chlorophyll variable has an effect on the catch of 68.3%, while 31.7% is influenced by other factors. There is complex relationship between fish and environmental conditions and affects to the fish distribution, migration, aggregation, spawning and food supply, and fish behaviour [9]. Table 2 shows the calculated F value was 17.215. Due to the F arithmetic > F table 2.58, so according to the basis for decision making in the F test, it can be concluded that $H_0$ is rejected and $H_1$ is accepted, meaning that chlorophyll affects the catches. The results of this study are also in accordance with previous studies which stated that demersal fish were found in the chlorophyll range of 0.09-0.20 mg.m$^{-3}$ [9].
3.4 The Effect of Depth on Catches

Depth range in the waters of the Riau Islands was 63.8 - 65.8m. Figure 4 shows that the catch tends to be high in the depth range of 65.3 - 65.8 m, with the highest catch was in August (168,801 kg). The statistical analysis related to the effect of depth on catches as illustrated in Table 3.

![Figure 4. Graph of depth and catch](image)

**Table 3.** Statistical analysis of depth on fish catches

| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|---|----------|-------------------|---------------------------|
| 1     | .803<sup>a</sup> | .645     | .601              | 527.66190                 |
| a. Predictors: (Constant), Depth |

**ANOVA<sup>b</sup>**

| Model   | Sum of Squares | df  | Mean Square | F     | Sig.  |
|---------|----------------|-----|-------------|-------|-------|
| 1       | Regression     | 1   | 4045968.237 | 14.532| .005  |
|         | Residual       | 8   | 278427.083  |       |       |
|         | Total          | 9   | 6273384.900 |       |       |

<sup>a</sup> Dependent Variable: Catch  
<sup>b</sup> Predictors: (Constant), Depth

**Coefficients<sup>a</sup>**

| Model   | Unstandardized Coefficients | Standardized Coefficients | 95.0% Confidence Interval for B |
|---------|-----------------------------|---------------------------|--------------------------------|
|         | B Std. Error Beta t Sig.    |                           | Lower Bound Upper Bound        |
| 1       | (Constant) 1872.583 760.222 | .803 3.812 .005       | 119.508 3625.659               |
|         | Depth         40.199 10.545 | .803 3.812 .005       | 15.881 64.517                  |

<sup>a</sup> Dependent Variable: Catch

The analysis shows the magnitude of the coefficient of determination R square was 0.645. The results of the analysis show that the depth variable can explain the catch variable by 64.5%, while the remaining 35.5% is influenced by other factors. Depth is known to affect many factors on reef ecosystems includes fish communities. It is also influencing the coral reef communities due to light attenuation, water temperature variability, and resource availability [10][11]. Table 3 shows that the calculated F value was 14,532, F arithmetic > F table 2.58 and it can be concluded that H<sub>0</sub> is rejected.
and $H_1$ is accepted, meaning that depth affects the catch. The previous research was described that demersal fish were found at a depth of 60 - 80 m [12].

4. Conclusion
Oceanographic variability in the waters of Riau Islands includes FMA 711 did not experience significant changes throughout the year. Changes in the value of oceanographic parameters such as SST, chlorophyll, and depth tend to decrease each season and year. In general, oceanographic parameters have a significant influence on the catch of demersal fish. Demersal fish were caught in almost every range of SST. The annual distribution of fishing grounds in the study area did not show a significant difference. The potential fishing ground of demersal fish can also be analysed using the oceanographic parameters. It shows that high frequency of fishing activities occurs in the southern season (June-August) of transition-2. The study is important as a starting point in providing catch data in relation with their fishing ground and oceanographic parameters. This can be used as an important information for sustainable fisheries management.

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References
[1] Laevastu, Muraay T and Hayes L 1981 Fisheries Oceanography and Ecology (England: Fishing News Book Ltd. Farnham-Surrey)
[2] Wibisono M S 2005 Pengantar Ilmu Kelautan (Jakarta: Penerbit PT. Gramedia Widiasarana)
[3] Effendy M 2009 Jurnal Kelautan 2(1)
[4] Brown M R, Jeffrey S W, Volkman J K and Dunstan G A 1997 Aquaculture 151 1–4
[5] Van Hengel W and Spitzer D D 1991 International Journal of Remote Sensing 12 703-712
[6] Byrkjedal I and Høines A 2007 Sea Polar Research 26(2) 135-151
[7] Ingvaldsen R, Loeng H, Ådlandsvik B and Stiansen J E 2006 særnummer 1 20–23
[8] Ningsih R K and Syah A F 2020 Jurnal Trunojoyo 1(1) 2723-7583
[9] Setyohadi D, Zakiyah U, Sambah A B and Wijaya A 2021 Fishes 6(8) 1-9
[10]Gattuso J, Gentili B, Duarte C, Kleypas J, Middelburg J and Antoine D 2006 Biogeosciences Discussions 3(4) 895–959
[11] Goldstein E, D’Alessandro E, Reed J and Sponaugle S 2016 Ecosphere 7(11)
[12] Iwan 2018 Pemetaan daerah penangkapan ikan demersal di perairan Tarakan Kalimantan Utara (Makassar: Program Studi Pemanfaatan Sumberdaya Perikanan Departemen Perikanan FIKP UNHAS)