GIS-based spatio-temporal analysis on Yellow Fin Tuna catch in Eastern Indian Ocean off Sumatera

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Abstract. Spatio-temporal analysis of yellow fin tuna fishing activity could give us new perception and perspective on studying this fisheries resource exploration. This study was carried out in Eastern Indian Ocean off Sumatera. Fishing data were collected between 2014 until 2018 from the hand line fishermen’s daily logbooks accessed from Bungus fishing port. Data were organized into a database and structured on a geographical reference to allow GIS-Based analysis. We performed raster calculator analysis and spatial statistical analysis to understand spatiotemporal distribution behaviour and fishing activity also employed the generalized additive model to understand the habitat preferences. The result of GIS-based analysis shows the dynamics of catch, effort and catch per unit effort distribution patterns, underlining the annual differences of geographical distribution and fishing pattern. The most concentrated fishing activity monitored in 2014 while the more dispersed fishing activity monitored in 2017. The geographic orientation of spatial distribution monitored at range between 72.90 degrees until 176.15 degrees. GIS provide an important and powerful tool to analyse fishing information to help decision makers in the EIO off Sumatera on Tuna management.

1. Introduction
Yellowfin Tuna (YFT) is one of the potential export fish commodity from Eastern Indian Ocean off Sumatera (EIO off Sumatera) that support national fishing productivity of Indonesia. According to Directorate General Capture Fisheries (DGCF) of Indonesia, Yellowfin tuna has the highest percentage of tuna production with 72% from total, followed by bigeye tuna (21%), albacore (6%) and southern Bluefin Tuna (1%) [1]. Yellowfin tuna can be found all over the world Ocean including Atlantic, Indian, and Pacific Ocean. In Indonesia yellowfin tuna are scattered in the eastern Indian Ocean which includes western waters of Sumatra, southern waters of Java, southern waters of Bali and also found in Banda, Maluku, Halmahera, Arafuru, and Sulawesi Sea [2].

The facts related to tuna resources in Indian Ocean are summarized in the report of the 20th Session of the IOTC Working Party on Tropical Tunas. Referring to the report, the exploitation of yellowfin tuna in the Indian Ocean has reached 93.8% which is classified as over-exploitation [3]. EIO off Sumatera contributed to this high exploitation of tuna. Yellowfin tuna is known as highly migratory species and distributed over very large oceanic extent [2]. Therefore, spatial information on tuna fishing activities, especially yellow fin tuna is needed to support monitoring activities that lead to sustainable management of tuna resources.
It is widely recognized that pressures and demands on fisheries resources are often excessive, and that actions should be taken in order to minimize negative impacts on the fisheries resources [4]. In supporting sustainable tuna resource management programs, a scheme that is practical, flexible and easy to understand is necessary. Information on fishing activities spatially is very important. The facts, there are many problems in the process of providing this information, such as the unavailability of high-quality tuna fishing data, expensive observation activities, and the accuracy of the analytical method. We need an approach that is simple, practical, and easy to understand both analytically and technically. GIS approach with some spatial analysis methods could be the solution of these problems.

This study illustrates the use of GIS and spatial analysis techniques to aid the fisheries management system. GIS technology was recognized as a powerful tool to achieve this purpose in support of an informed management decision system [5]. Geographic information system technology is specifically designed to visualize, manipulate, manage, and analyse various reference data to determine relationships, linkages, patterns, and trends, which may not be directly proven by the existing data sources [6].

Development of tools in GIS, such as spatial statistical analysis methods, make it easier for the researcher to study and understand marine and fisheries resources in the spatiotemporal domains [7]. Many studies have utilized the GIS in fisheries science and fishing fleets monitoring in the management aspects [7][8][5][9] including marine area and fisheries planning [10], modelling the relationship of environmental parameters and fish distribution [14][12][13][11].

The aim of this paper is to perform the application of GIS to analyse the spatiotemporal patterns of the yellow fin tuna fishing catch and activities in the Eastern Indian Ocean off Sumatera and to analyse yellow fin tuna habitat preference. The proposed of this GIS-based analysis can add new information about the important of yellow fin tuna fishing distribution and help decision makers in managing tuna resources sustainably in Indonesia.

2. Material and methods

2.1. Study area
The study area (Figure. 1) is located in the Eastern Indian Ocean off Sumatera (EIO off Sumatera) includes the Strait of Mentawai and the offshore Mentawai Island. Based on the Fish Management Area that also known as Wilayah Pengelolaan Perikanan (WPP), EIO off Sumatera identified as Fish Management Area no. 572 (WPP RI 572) and also included in Indian Ocean Tuna Commission (IOTC) competence area. These areas represent potential fishing ground of the yellowfin tuna fishery.

![Figure 1. The study area of Eastern Indian Ocean off Sumatera (EIO off Sumatera).](./image.png)
2.2. Data collection and GIS data-warehouse

Data were collected between 2012 and 2014 from daily hand line fishermen’s logbooks and organized into a spatial database. The raw database includes many information on fishing activities, but not all those information included in the spatial database. The spatial database only includes information on fishing coordinate (x and y), day, month, year, fishing catch (N and kg), and fishing trip (days at sea). In order to help the data processing and analysis, all data were structured on a same geographical reference to allow an easy practical spatial modelling through the GIS tools.

The spatial data and their attributes were processed under GIS platform. The GIS data-warehouse for spatiotemporal analysis on YFT fishing catches, as shown in Figure 2.

- Data collection and storage (A): input and storage fishing data to spatial geodatabase and handling the results obtained from GIS-based analysis.
- Data management (B): The data exploration and aggregation able to: (i) check and detect outliers; (ii) perform query and selections according to simple defined criteria (by attribute, location, etc.); (iv) convert and export the results of data analysis.
- Spatiotemporal analysis (C): in this step we perform two analyses, e.g. measuring of geographic distributions and time-series spatial analysis of YFT fishing catch.
- Outputs (D): at this subsystem we showing the result (table, graph and maps)

![GIS data warehousing flow chart](image)

**Figure 2.** GIS data warehousing flow chart.

2.3. Fishing catch and effort analysis

The GIS-based analysis of fishing catch and effort was carried out using the technical approach described in Figure 3, in order to analyse spatiotemporal distribution of YFT fishing pressure in the study area. Catch (kg) and Effort (days at sea) point data were rasterized by executed the point to raster tools with cell assignment method “sum” and cell size “4 km”. The reason on using “4 km” as the cell size was because “1 km” cell size produced too small appearance and visually unclear during layout process. So, to get better understanding on fishing activity pattern we decided to use “4 km” as our base cell size. Then we performed the raster calculator with “/” as the algebra operator to calculate the CPUE. The value was estimated as the sum of kg and days of all catch points, within a grid having a resolution of 4 km. The estimation of CPUE used the catch (kg) data only, because it is representative enough for estimate the spatiotemporal distribution of YFT’s catch. Fishing pressure maps on total catch (kg) trip, (days at sea) and Catch Per Unit Effort (CPUE), in term of kg per 4 km², days per 4 km², and kg days⁻¹ per 4 km² and were produced for the period 2014 until 2014. The equations of this technical approach define clearly at Table 1.
2.4. Measuring geographic distribution of YFT catch

The calculation of the geographical distribution was carried out using the GIS-based model to determine 4 spatial indicators, namely central tendency, spatial dispersion, directional dispersion, and directional trends [6]. The spatial tendencies were calculated using the "mean center tool" which is the geographical center distribution of the YFT catch data, or the average x and y coordinates of the total YFT catch coordinates in the study area. Changes in the central tendency reflect variations in the distribution of YFT fishing activity both spatially and temporally [4].

The spatial dispersion was calculated using a "standard distance tool" representing the degree to which spatial fishing activity are spatially concentrated or distributed around the central tendency. The spatial dispersion maps will be represented by circles with a radius equal to 95% of the total fishing activities data point as input in the study area. The radius value of the circle was assumed to be the concentration level of the spatial distribution. The greater of the circle radius value, the more dispersed the fishing activity or vice versa [4]. To give clear brief related to spatial indicator used in this study it shows at figure bellow.

Directional dispersion and directional trend were calculated using the "standard deviational ellipses tool". The directional distribution calculated the standard distance from the direction of the x and y coordinates distributions that were represented by oval visualization containing 95% of the total data input. Thus, the extent of the fishing activity distribution in an area was determined. On the other hand, directional trends state the direction degree of the distribution data input. The directional trends are representations of extending clockwise axis rotation starting at mid-day point. In general, the description of the spatial indicators used in this study is shown in Table 1.
Table 1. Spatial indicators used in this study.

| Spatial indicators       | Equations                                                                 | Spatial scale | Time scale | Ecological explanation                                      |
|--------------------------|----------------------------------------------------------------------------|---------------|------------|-------------------------------------------------------------|
| Central tendency         | $\bar{R} = \frac{\sum_{i=1}^{n} x_i}{n}$                               | Global        | Annual     | Centre of the fishing fleet concentration                   |
| Spatial dispersion        | $SD = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}$                | Global        | Annual     | Spatial dispersion of fishing fleets                         |
| Directional dispersion    | $SDx = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}}$              | Global        | Annual     | Directional distribution of $x$ axis                         |
|                          | $SDy = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n}}$              | Global        | Annual     | Directional distribution of $y$ axis                         |
| Directional trend         | $\tan \theta = \frac{A + B}{C}$                                        | Global        | Annual     | Directional tendency of fishing fleets spatial distribution  |
| Catch per unit effort     | $CPUE = \frac{\sum_{i=1}^{n} (\text{N or kg})}{\sum_{i=1}^{n} \text{(days at sea)}}$ per 4 km$^2$ | Global        | Annual     | Fishing catch (N or kg), effort (days and CPUE analysis per 4 km$^2$) |

Source: [4]

Central tendency was average of total $x$ (longitude) and $y$ (latitude) coordinates in the study area. Spatial dispersion was the result of standard deviation ($SD$) of total $x$ and $y$ coordinates over study area, while the directional dispersion was standard deviation over $x$ ($SDx$) coordinates and standard deviation over $y$ ($SDy$) coordinates that represent of standard distance over the direction of $x$ and $y$ coordinates. Directional trends were the calculation of degree A, B, and C. Clear brief of this equation explained as follow:

$$A = \left( \Sigma_{i=1}^{n} x_i^2 - \Sigma_{i=1}^{n} y_i^2 \right)$$
$$B = \sqrt{\left( \Sigma_{i=1}^{n} x_i - \bar{x} \right)^2 + \left( \Sigma_{i=1}^{n} y_i - \bar{y} \right)^2}$$
$$C = 2 \Sigma_{i=1}^{n} x_i y_i$$

(1)

$\bar{x}_i$ and $\bar{y}_i$ are the deviations for the x-y coordinates from the mean centre calculation.

2.5. Environment variables relationship

In this study, we performed generalized additive model (GAM) to understand of yellow fin tuna habitat preferences. GAMs were constructed in the R program (version 3.5.2) using the mgcv packages to calculate the response of predictor variables namely SST, SSH, SSS, MLD, CHL and bathymetry, the model’s form shown in equation bellow.

$$g(u_i) = \alpha_0 + s1(x1_i) + s2(x2_i) + s3(x3_i) + ... + sn(xni)$$

(2)

Where $g$ is the link function, $u_i$ is the expected value of dependent variables, $\alpha_0$ is the model constant, and $sn$ is smoothing function for each of the model covariates $x_n$ [15][16]. GAM is a semi-parametric model of multiple regressions with not too requiring normality of data distribution. This method is nonlinear and can be used to reduce the weakness of using the assumption of a normal distribution in the observed environmental parameters and not finding a linear relationship between two variables.

3. Result

3.1. Fishing catch and effort analysis

Overall 6,320 or 238,562 kg yellow fin tuna were caught during 74,089 days of fishing effort at EIO off Sumatera during 2014 until 2018. Fishing season was every month in a year, some oceanographic
parameter and climate event sometime disturb fishing activity in EIO off Sumatera. Figure 5.A shows the variation of fishing activity data during 2014 until 2018 and highlighted the fluctuation of fishing activity at the study area. Fishing catch per year (N) shows the approximately same variation during 2014 until 2018, smallest data variation found at 2015 with value range between 1 until 3 fish. Fishing catch per year (kilograms) shows more various data variation at the study area, the smallest variation fishing activity data found consistently at 2015 while the highest variation happened at 2014 and became fluctuated during 2016 until 2018. The highest days at sea (trip) found at 2015 that inversely proportional with fishing catch per year that consistently smallest, this is indication of hard fishing season at the study area. Smallest variation on days at sea (trip) was 2017 that related to the highest CPUE per year that also happened at 2017. While, the smallest variation of CPUE found at 2016.

Mean value of fishing activity per year (Figure 5.B) shows us more various behaviour than fishing activity data variations. Starting with mean catch (N) reached more than 3 and decrease in 2015 to < 3 and continuously increase in 2016 to 2018, highest and smallest mean value of catch (N) found at 2017 and 2015 respectively. More dynamic fluctuation found at mean catch (kilograms) per year that randomly increase and decrease during 2014 to 2018, highest and smallest value of mean catch (kilograms) per year found at 2014 and 2018 respectively. Smallest mean days at sea (trip) found at 2017 while the highest mean days at sea happened at 2015, the smallest mean days at sea and highest mean catch will clearly explained the highest mean CPUE also found at 2017. From this data variation we can underlined and simply explained that 2017 was the most productive fishing year during 2014 until 2018.

The annual fishing activity maps in figure 4 shows the variability of catches, total effort, and catch per unit effort (CPUE) in 4 km spatial resolution. It should be at 1 km spatial resolution but the area of interest extension were too large, so we decide to determine the spatial resolution as 4 km2 (cell size). 4 km2 resolution is to make sure that the spatial visualization was representative and well analysed. The value of catches sum per 4 km2 were various during 2014 and 2019, we classified the fishing activities by 5 class with same threshold each class on each year. The map shows us clearly that fishing activities at the EIO off Sumatera has dynamic fluctuation during 5 years range. 2014, 2017 and 2018 monitored as the productive fishing year because of total catch (kg) has dominantly class more than 350 spatially. Highest class scattered densely at those years on catch, effort and CPUE. 2015 and 2016 monitored as the hard fishing year because small class were dominant spatially. Environment parameters were the main role on this high fluctuation of YFT fishing activity at the study area.

Figure 5. (A)Tuna fishing activity data variation; (B) Mean value and standard error of Yellow Tuna fishing activities.
Figure 6 shows us that tuna fishing activity especially yellow fin tuna at EIO off Sumatera highly dynamic according to high value fluctuation on catches, days at sea, and CPUE. The pattern rasterization of catches, days at sea and CPUE are almost identical, dominant distribution location is in Mentawai strait and in the off west coast of Sipora Island. From Figure 4 it can be seen that the maximum catch value per 4 km² experienced a positive trend during 2014 to 2019. This explains that the activity of tuna fishing in the EIO off Sumatra is always increasing. Based on the PPS Bungus explanation is because high rate of conversion of fishing vessels long line to hand line over the past 5 years. Because of the hand line fishing techniques using lights and operating at night, the dominant catch is YFT which tends to be close to the surface at night. Figure 6 also shows that the hand line traditional potential fishing zones (PFZs) is spatially unchanged and tends to be in an identical pattern, this is because the fishermen are still using conventional methods in determining the fishing area.

Figure 6. Spatial distribution of catches (kg per 4 km²), total effort (days at sea per 4 km²), and CPUE (kg day⁻¹ per 4 km²), between 2014 and 2018, obtained by fishing catch and effort analysis.
3.2. Measuring annual geographic distribution

Figure 7 shows the distribution of YFT catches (red dots) from 2014 until 2018 with spatial indicators such as spatial dispersion (circle), directional dispersion $x$ and $y$ (ellipse) and directional trends. The 2017 fishing season monitored widest distribution of YFT in EIO off Sumatera, whereas during 2014, 2015, 2016 and 2018 they were more concentrated in strait of Mentawai and off the west coast of Siberut and Sipora Island. In 2014 were monitored that fishing activity only in small area mainly including the strait of Mentawai. During 2014 to 2018 the main distribution area monitored in the strait of Mentawai and in the off west coast of Siberut and Sipora Island. This geographic distribution shows that annual spatial distribution of YFT in EIO off Sumatera has dynamic pattern even just in two dominant area in study area.

Figure 7. Annual maps of YFT catches (red dots) distribution from 2014 to 2018. Spatial dispersion (circle), directional dispersion and trends (ellipses), spatial tendency (mean centre).

Table 2 show the annual values of spatial indicators (spatial dispersion, directional dispersion, directional trends). Annual geographic distribution calculation result that spatial dispersion has value in range 67.24 – 148.43, directional dispersion $x$ in range between 84.52 – 111.09 and directional dispersion $y$ has value between 43.58 – 191.38 range. The directional trend of distribution of annual
catches showed a geographical orientation ranging between 72.90° – 176.15°. The highest value of spatial dispersion is in 2017 indicated a wider distribution of YFT catches in the study area, whereas the distribution became more compact in the 2014. The smallest value of directional dispersion x and y monitored in 2014, while the highest value found in 2015 and 2017 respectively.

Table 2. Value of YFT fishing annual geographic distribution.

| Year | Spatial dispersion (km) | Directional dispersion x (km) | Directional dispersion y (km) | Directional trends (degrees) |
|------|------------------------|-------------------------------|-----------------------------|----------------------------|
| 2014 | 67.24                  | 84.52                         | 43.58                       | 168.31                     |
| 2015 | 90.30                  | 111.09                        | 62.99                       | 176.15                     |
| 2016 | 86.88                  | 94.73                         | 78.24                       | 117.45                     |
| 2017 | 148.43                 | 86.22                         | 191.38                      | 75.85                      |
| 2018 | 100.13                 | 89.04                         | 110.11                      | 72.90                      |

The central tendency of the annual YFT catches distribution or fishing activities from 2014 to 2018 is shown in Figure 7. The annual central tendency on the YFT catches was more spatially centred. It could be seen that the points are accumulated in a certain area, it explained that the traditional fishing zone of hand line is constantly centred and shifted less along the study area. From figure 5 of mean centre we can understand that YFT fishing activity was only concentrated at 90°E - 100°E and 1°S - 2°S (Figure 5 of mean centre). This was also clearly confirmed by the results of other spatial indicator estimations. The annual YFT fishing data showed not much pattern variations of geographical distribution. The spatial pattern and estimation results represented the actual YFT fishing activities behaved in term of spatial and temporal at the EIO off Sumatera.

The geographic distribution calculation shows us in term of spatial and temporal variations that hand line fishing activities are less dynamic. The best assumption on this case is because the hand line fishermen still practiced a conventional way to determine their potential fishing zone. Natural sign like birds, floating’s, group information, extreme oceanographic condition such as wave, wind and current are the main factor that hand line fishermen used to make decision where they will start setting, all of it clearly shown in the figure 7 and table 2.

3.3. Environment variables relationship

The relationship between oceanographic variables with YFT statistically is shown in Figure 6. The x axis shows the value of the explanatory variable, and the y axis indicates the contribution of the explanatory variable to the results of YFT catches (CPUE). The thick lines show the right functional statistically, while the dashed lines show a confidence interval of 95% for each explanatory variable. The horizontal lines became the limits of high or low of relationship between YFT and oceanographic variables. When the GAM function is dropped on the zero horizontal line, this shows that no relationship between parameters. High relationship justified when the functional line cross the horizontal line in the positive area or vice versa. From figure 8 we can explain that all variables have optimum range value of YFT habitat preferences, optimum means high relationship.

The optimal range of SST monitored at range around 29°C – 29.5°C, normal range for Tropical Ocean like EIO off Sumatera. The SSH optimum preferences for YFT showed at range between 0.87 – 0.95 m that represent the lowest value in study area. Minimum value also found at salinity value, YFT optimum preferences monitored in range between 33.4 – 33.78 psu. MLD monitored has 2 differences optimum range, because there are 2 peak crossing the limit line, the values are around 20 m and 60 m of mix layer depth. Small value of Chlorophyll-a concentration showed as the optimum preferences of YFT, the value in range between 0.15 – 0.25 mg m-3. We also highlighted how the fishing activities data response over the bathymetry within the study area. EIO off Sumatera has really typical high slope topography and deep ocean floor, the value of YFT preferences over the bathymetry are in range between 500 – 4000 m depth event the spatial distribution of fishing activities only in strait and off the coast area.
4. Discussion
The result of this study highlighted of GIS’s potential in supporting spatial and temporal analysis on fishing data. The application of GIS on spatiotemporal analysis is allowed an easier interpretation upon big dataset in term spatially and temporally. In this outcomes we can say that GIS based analysis can be considered as a powerful method which clearly more understandable both practically and analytically. The GIS approach has been widely applied in marine and fisheries study by authors such as [4] in terms of monitoring of sword fishing activities and CPUE analysis; fisheries management planning [17]; fish pelagic distribution modelling [17][18] and the relationship between environmental parameters and fish distribution [20]. The GIS enables more dynamic and efficient management (fisheries and marine spatial) of data with the methods that are flexible regarding storage and processing [4]. The GIS-based analysis proved that it could be an alternative approach for marine and fisheries resources management. GIS application in this study allowed proper fishing data management i.e. catch coordinates, fishing catch, days at sea, total hook eye, CPUE, environment parameters and even biological data. GIS also allowed an efficient and flexible on pre-processing data, data storage, processing data, visual analysis, even more provide easier technique to editing, preparing and visualizing the thematic map [4]. GIS based analysis provide better understanding on visual analysis of catches and CPUE in the EIO off Sumatera, showing us the spatiotemporal variability of hand line fishing activity within study area. Analysing on YFT CPUE possible to understand the distribution pattern behaviour that change annually in term of fishing activities. Temporally we can say that fishing activity within study area are very dynamic according to the catches value, days at sea and CPUE per 4 km2 during 2014 to 2018. But either not in spatially, the variability are not significantly change over 5 years data, tend to be concentrated at certain very productive area which are Mentawai strait and off the west coast of Siberut and Sipora Island.

The results are consistent with [19] that studied the pelagic fish, the Mentawai Straits is the most productive area in the EIO off Sumatera in term of fishing activity. [21] result showed not different fact, highest spatial distribution of fishing activity in this case is YFT also dominantly around Mentawai Strait. It was reasonable because Mentawai Strait is save protected area and strategic fishing ground in the EIO off Sumatera, close to the fishing base, close to the temporary accommodation base, and well covered from high wave of Indian Ocean. Mentawai Strait also being traditional fishing ground for some fishing gears i.e. purse seine, long line, and boat lift net, so it is undeniable that Mentawai strait and area

Figure 8. Component smooth function of variables relationship with CPUE as representation of YFT habitat preferences.
around the Siberut, Sipora, North and South Pagai Island is the highest densities area in term of fishing activities.

Annual geographic distribution of YFT catches shows varies pattern, more dispersed distribution monitored in the 2017 and the most centred distribution found in 2014. [4] explained that skill of fishermen, oceanographic parameter, season, distance to fishing base, and vessel conditions are the main factor that influenced the spatial distribution of fishing activity. The species monitoring information especially an important of strategic commodity is really important to support of fisheries and marine management [17]. Many studies have utilized the GIS in fisheries science and fishing fleets monitoring in the management aspects [7][8][5][9] including marine area and fisheries planning [10], modelling the relationship of environmental parameters and fish distribution [14][12][13][11]. All those authors highlighted the potential GIS platform on supporting fisheries and marine science study.

The results of this study found that optimal range of SST monitored around 29oC – 29.5oC, SSH at range between 0.87 – 0.95 m, SSS in range between 33.4 – 33.78 psu, MLD are around 20 m and 60 m and chlorophyll concentration value in range between 0.15 – 0.25 mg m-3. This result are consistent with the previous results conducted by [21] for SST and salinity that found optimum range of SST are 29.3°C – 29.4°C, salinity in range between 34.0 – 34.1 psu and SSH in range between 0.49 – 0.50 cm that inconsistent with our study. Our SSH result tend to be over estimate than the previous study that found the SSH value in small range, indicated upwelling in study area. Our study indicated that SSH range value may have time lag with the CPUE that caused bigger range in this study. This results also consistent with [22] study which states that the temperature preferences of YFT in around 30°C. That statement is supported by [23] which explained that YFT spend most of their time in waters with temperature between 21 – 30°C.

[22] and [21] states that SST is the most important variable as habitat preference for YFT species. Changes in water temperature directly affect to the fish species, when temperature decrease below normal or optimal it causes a decrease in movements and feeding activities and inhibit the process of spawning [24]. Furthermore, [22] Explained from GAM estimation result that MLD appeared slightly more important than SSH. This is in agreement with some others study that found MLD to be more important than SSH for YFT. MLD represents the mixing layer that how much further deep the water temperatures are significantly same with the surface temperature. In this case MLD has optimum preference are 20 and 60 m that slightly small, it because in this study we are using hand line fishing data that setting in night time. [23] Explained YFT species night time vertical distribution are usually and often in the first 20 m layer.

[25] mentioned that SSH has positive relationship with hook rate temporally. SSH indicates upwelling energy forming in the waters that become productive area for the development of aquatic productivity, which increase food sources for fish. In the end, every variable mentioned is related to each other except that there is a difference timing in influencing fishing activities, in this case represented as CPUE. The information of habitat preferences could be really important in term of determining PFZs in this case is YFT species. Non linear statistical analysis gave us more understanding how environment variables, ocean dynamics, and natural condition work over activity of fishing. The habitat references information can be new reference for all stakeholders related to help on decision making in term of exploration or even more conservation. Combination on non linear statistical analysis and simple practical GIS Based analysis can be proper alternative approach to understand the spatiotemporal distribution of YFT in the EIO off Sumatera.

5. Conclusion
GIS system highlights the potential easier practical analysis on spatiotemporal pattern of yellow fin tuna fishing activities. GIS platform has more adaptable tools for spatial statistical analysis and underlined the new way on visualized the fishing spatial database statistically. Combining on the spatial statistical analysis and conventional statistical analysis can add new friendly practical approach on analysing spatiotemporal pattern on yellow fin tuna fishing activity in eastern Indian Ocean off Sumatera. Also, statistical analysis can give us a better understanding on yellow fin tuna habitat preferences and relationship of yellow fin tuna species with some of environment parameters.
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