Determination of fishing season mackerel (*Rastrelliger kanagurta*) in The Waters of Belawan, Sumatera Utara

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Abstract. Mackerel (*Rastrelliger kanagurta*) is a small pelagic fish resource with high potential and economic value. This fish is one of the principal species landed at the Belawan Ocean Fishing Port. To maintain the resource sustainability, every fishing activities must be carried out wisely. This research aimed to determine the pattern of the fishing season for mackerel landed at the Belawan Ocean Fishing Port. The research method used survey method for primary and secondary data collection. Primary data was obtained from interviews and direct data collection from the field. Secondary data were obtained from the time series fisheries statistics of the Belawan Ocean Fishing Port from 2015-2019. The results showed that the highest fishing season for mackerel (*Rastrelliger kanagurta*) occurred in November (the end of the second transitional season) with fishing season index value of 127.56%. Meanwhile, the fishing season with the lowest value is estimated to occurred in July (the east season) with the Fishing Season Index value of 77.40% but it is still included in the medium fishing season.

1. Introduction

Mackerel (*Rastrelliger kanagurta*) is categorized into small pelagic groups that scattered in Indonesian waters and classified as an important economic commodity. Geographically, the distribution of mackerel is very wide, compared the Indo-Pacific region from the waters of South Africa to around the Solomon Islands. The spread of mackerel is based on space and time which is closely related to feeding or spawning process [1].

The waters of the Belawan Sea, especially in the eastern part of North Sumatera Province, are one of the potential fishing areas for mackerel. The fisheries statistics of Fishing Port Belawan between 2015-2019 shows that the average annual production of mackerel caught is 3,067.58 tons/year (Fishing Port of Belawan, year 2015-2019). The main fishing gears used by fishermen to catch mackerel (*Rastrelliger kanagurta*) in Sumatera Utara are purse seines and pole and line.

Fish resources is categorized as renewable resources if managed wisely, so that the benefits can be enjoyed [2]. Therefore, the utilization of the potential of mackerel fish resources must be carried out in a controlled manner, so that the preservation of mackerel fish resources can be maintained for optimum productivity. These are because resources that are quite abundant have no meaning from an economic side if there is no serious and systematic effort to provide sustainable benefits.

The results of this analysis are expected to provide information on how much potential fish resources have been utilized. In addition, this information is used to determine how many fishing attempts have been achieved. Meanwhile, the moving average method is used to determine the value
of the fishing season index (FSI). Furthermore, the FSI values were used to analyze fishing season patterns. The results of the analysis are expected to provide information about the right time to carry out fishing operations, because of that were use of fish resources remains under control.

2. Materials and methods
The method were used in this research is quantitative descriptive. The data used are secondary data from statistical data fishery fishing season pattern Bloating and holistic research methods with surplus production models [3] and the method of moving average.

2.1. Analysis data
The data analysis in this study was used to estimate the potential and the pattern of the fishing season for mackerel that consists of several adjusted analyzes.

2.2.1 Catch per Unit of Effort (CPUE). The CPUE calculation aims to determine the value of the catch rate for mackerel fishing effort based on dividing the total catch with the effort [4].

\[
CPUE = \frac{C_i}{F_i} \quad (1)
\]

Where:
- \( C_i \): catch-i (kg)
- \( F_i \): catch effort-i (trip) and
- \( CPUE \): catch of the fishing effort-i (kg/trip)

2.2.2 Estimation of the level of utilization and level of effort. The formula for the utilization rate is[5]:

\[
TPc = \frac{C_i}{MSY} \times 100\% \quad (2)
\]

Where:
- \( TPc \): Utilization rate in years to-i (%)
- \( C_i \): Catch of year to-i (ton)
- \( MSY \): Maximum Sustainable Yield (ton)

The equation for the level of effort is:

\[
TPf = \frac{f_i}{f_{opt}} \times 100\% \quad (3)
\]

Where:
- \( TPf \): Level of effort in years-i (%)
- \( f_i \): effort standard in years-i (trip)
- \( f_{opt} \): Optimum fishing effort (ton/year)

2.2.3 Fishing season. The determination of fishing season was used the average percentage method based on the [6] Times Series Analysis. The procedure is as follows calculate the value of the catch per catching effort (CPUE = Catch per Unit of Effort = U) per month (Ui) and the monthly average CPUE in a year (\( \bar{U} \)).

\[
\bar{U} = \frac{1}{m} + \sum_{i=1}^{m} U_i \quad (4)
\]

Where:
Calculate $U_p$ namely in the ratio of $U_i$ to $\bar{U}$ expressed in percent:

$$U_p = \frac{U_i}{\bar{U}} \times 100\%$$  \hspace{1cm} (5)

Then calculated:

$$S_{i} = \frac{1}{t} + \sum_{i=1}^{m} U_{p_{i}}$$  \hspace{1cm} (6)

Where:

$S_{i}$: Season Index-$i$

$t$: Number of years of data

If the amount of $S_{i}$ is not 1200% (12 months x 100%), then an adjustment is required using the following formula:

$$F_{S_{i}} = \frac{1200}{\sum_{i=1}^{m} |I_{i}| \times S_{i}}$$  \hspace{1cm} (7)

Where:

$F_{S_{i}}$ = Fishing Season Index to $i$

3. **Results and discussion**

3.1. **Catch per unit of effort (CPUE)**

The catch of mackerel for five years from 2015-2019 has fluctuated, so that the monthly CPUE value of mackerel for five years has also fluctuated and shown in figure 1.

![Figure 1. Chart of CPUE.](image-url)
Based on the graph in figure 1, it shown that the development of fishing effort and the catch by the fishing purse seine gear in 2015-2019 fluctuated every month on annual basis. The highest CPUE value for mackerel occurred in November 2019, amounting to 1,716.86 kg/trip. While the lowest occurred in November 2016 amounting to 71.19 kg/trip.

3.2. Fishing effort
The effort of catch each fishing gear in the last 5 years (2015-2019) landed in Belawan Ocean Fishing Port there is shown in figure 2.

![Figure 2. Fluctuations in fishing effort.](image)

The effort catch using fishing purse seine gear has decreased the amount of effort every year. Based on the graphic data was shown in figure 2, the highest value effort was in 2015 of 6,498 trips/year. The value effort was lowest in 2019 with value of 3,154 trips/year. Meanwhile, fishing effort using fishing gear has fluctuated in the number of trips each year. As shown in Figure 2, the number of fishing attempts in 2015 was of 1,807 trips/year, then the number of fishing attempts in 2016 increased to 2,074 trips/year. In 2017, the number of attempts to recapture decreased to 1,813 trips/year. The highest number of fishing attempts occurred in 2019 with of 4,078 trips/year and the lowest in 2015 at 1,807 trips/year. This fishing effort data continues to fluctuate every year due to the influence of the number of vessels operating at the sea to catch fish. Estimation of Level of Utilization and Level of Effort of mackerel (*Rastrelliger kanagurta*) in the Belawan Ocean Fisheries Port from 2015-2019 is shown in figure 3.

![Figure 3. Percentage of level of utilization and level of effort.](image)
Based on figure 3, the value of the utilization rate of mackerel (*Rastrelliger kanagurta*) in the last 5 years has fluctuated. In 2015 the value of the utilization rate was 72.62% with an effort level of 176.24%. Whereas in 2016 the utilization rate of mackerel (*Rastrelliger kanagurta*) decreased to 47.71% with the cultivation rate decreasing to 169.06% and from 2017 to 2019 the value of utilization and cultivation rates continued to fluctuate each year.

Conditions for the level of use of puffed fish in 2015-2019 are included in the category, except in 2019 the utilization status was in over exploited category. Fully exploited condition, where the number of catches of fish resource groups per year was obtained value range of 80-100%, the estimated potential set [7]. With this status, the development of the mackerel fishery must be carried out carefully in order to avoid being over exploited in the following year. This can be done for example by reducing fishing effort (trip). However, reducing fishing effort by the number of efforts per year must be done gradually in order to hamper the fishermen's economy. Besides that, it also takes into account the size of the ship according to the capability of the existing facilities.

### 3.3. Determination of the fishing season

Determination of the fishing season pattern of mackerel (*Rastrelliger kanagurta*) in the waters of the Malacca Strait was calculated based on data of catches and fishing effort per month within a period of 5 years (2015-2019). Calculations are performed using time series analysis (time series data) and the method moving average. The fishing season index (FSI) value of mackerel (*Rastrelliger kanagurta*) was shown in table 1.

| Month   | FSI (%) | Fishing Season | Season in Indonesia |
|---------|---------|----------------|---------------------|
| July    | 77.40   | Medium         | East                |
| August  | 84.68   | Medium         | East                |
| September | 101.28 | Peak           | Transition II       |
| October | 106.74  | Peak           | Transition II       |
| November| 127.56  | Peak           | Transition II       |
| December| 87.56   | Medium         | West                |
| January | 103.13  | Peak           | West                |
| February| 90.89   | Medium         | West                |
| March   | 99.53   | Medium         | Transition I        |
| April   | 100.23  | Peak           | Transition I        |
| May     | 109.96  | Peak           | Transition I        |
| June    | 111.04  | Peak           | East                |

Based on table 1, the results was calculation of the fishing season index value (FSI), it can be estimated that the peak season of fishing for mackerel when viewed from the FSI value that more than 100% occurs in September, October, November, January, April, May and June. The moderate season for mackerel fishing with an FSI value of more than 50% occurs in July, August, December, February and March. According to [8] the criteria for determining the fishing season, if the FSI is more than 100%, the peak season is catching, if the less than 50%, it means we said the dry season. If the value of 50-100% range, there is a moderate season.

The peak of the highest fishing season for mackerel (*Rastrelliger kanagurta*) occurred in November (end of the second transition season) with an FSI value of 127.56%. While the fishing season with the lowest value is estimated to occur in July (East season) with an FSI value of 77.40% but it is still included in the moderate fishing season. The FSI value shows that the good season for
catching mackerel (Rastrelliger kanagurta) in Belawan waters it was on April to May (transitional season I), June (the east season), September to November (transitional season II) because it has more mackerel production than other months and is included in the peak fishing season. Furthermore, according to [9] a good month to conduct fishing operations is a month that has a catching index that was above 100% because it was considered very potential for fishing operations. The fishing season index graph can be seen in figure 4.

![Fishing Season Index (FSI)](image)

**Figure 4. Fishing Season Index (FSI).**

The pattern of tuna fishing season in Belawan waters is not the same as the fishing season for mackerel in other areas. It can be seen from the very close relationship between very sharp fluctuations and total production caused by changes in environmental changes in these waters. The similarity with the patterns between seasons in a year to the next year is not known, it is depending on whether there are environmental influences on these waters. Besides, there are factors that also influence the amount of mackerel production such as the migration patterns of fish in Belawan waters. However, to obtain more certain information, further research about the mackerel migration patterns and times of fish migration is needed.

4. **Conclusions**

The fishing season for mackerel landed at the Belawan Ocean Fishing Port can caught all year round. The fishing season on April, May June, September, October and November. The season is catching puffed fish December, February, March, July and August. The peak season for catching with the highest catch is in November (known as transition II season).

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