Analysis of the fishing season pattern of mackerel scad (*Decapterus macarellus*) using purse seine fishing gear at the Belawan Ocean Fishing Port, North Sumatra Province

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**Abstract.** The fishery potential of mackerel scad (*Decapterus macarellus*) in the Malacca Strait has a high value. The fishermen at the Belawan Ocean Fishing Port mostly get the mackerel scad (*Decapterus macarellus*) in their fishing activity. This study aims to determine the pattern of fishing season for mackerel scad (*Decapterus macarellus*) at the Samudera Belawan Fishing Port. Secondary data analysis used the model Schaefer and the Fishing Season Index (FSI) for the last five years. The catching season is in January, March, May, June, August, and November. The peak season for mackerel scad (*Decapterus macarellus*) occurs in November (transitional season II) with an FSI value of 116.49% and the lowest in February (the west season) with an FSI value of 89.35%.

1. **Introduction**

Belawan Ocean Fishing Port is one of the largest fishing ports in North Sumatera and become the only type A fishing port in the East Coast of Sumatra [1]. Based on statistics from the Belawan Ocean Fishing Port in 2020, mackerel scad (*Decapterus macarellus*) is one of the pelagic fish that are most dominantly caught by purse seine fishing gear at the Belawan Ocean Fishing Port [2].

High demand and purchasing power of consumers in the fish market have an impact on fishermen who carry out large-scale fishing. This fishing activity is considered to endanger the mackerel scad (*Decapterus macarellus*) population in the waters, especially if it is carried out continuously. When this condition continues, the population of mackerel scad (*Decapterus macarellus*) in Belawan waters will decrease. Information on the fishing season for mackerel scad is needed to facilitate fishing operations using the purse seine fishing gear, because by knowing the fishing season pattern of mackerel scad, it is hoped that it will make it easier for fishermen to carry out fishing operations [3].

The pattern of the fishing season and the mackerel scad areas can be obtained by estimating the fishing season and purse seine fishing ground of mackerel scad (*Decapterus macarellus*) that landed at Belawan Ocean Fishing Port. The aim of this research is to determine the status of utilization and cultivation level and to estimate the fishing season pattern of mackerel scad (*Decapterus macarellus*) in the Belawan Ocean Fishing Port.
2. Materials and methods

2.1. Research location
This research was conducted from June to July 2020 at Belawan Ocean Fishing Port (figure 1). This research was a descriptive analysis using secondary data which included data from the Belawan Ocean Fishing Port from 2015 to 2019.

![Figure 1. The map of research location.](image)

2.2. Data
Secondary data analysis was conducted using the Schaefer model which was a CPUE regression analysis model for business size, to determine the maximum sustainable potential (MSY), optimal effort (Fopt), the level of utilization and cultivation of mackerel scad (*Decapterus macarellus*).

2.2.1. Estimating TPC and TPf: The estimation of utilization rate and effort rate was carried out to determine the percentage of management of mackerel scad (*Decapterus macarellus*) in the waters. The formulation of TPC and TPf are:

\[
TPC = \frac{Ci}{MSY} \times 100\%
\]  

(1)

where: TPC = level of utilization in year-i (%), Ci = fish catch in year-i (tons), MSY = maximum sustainable yield (tons/year)

\[
TPf = \frac{fs}{Fopt} \times 100\%
\]  

(2)

where: TPf = level of effort in year-i (%), Fopt = optimal fishing effort (trip), fs = catch effort in the period-i
2.2.2. **The total allowable catch (TAC).** TAC were determined by analyzing the surplus production using equation (3):

\[
TAC = 80\% \times MSY
\]

(3)

Where: TAC = amount of catch allowed (tons/year), MSY = maximum sustainable yield (tons/year)

2.2.3. **Analysis of fishing season pattern.** The fishing season pattern is analyzed using the time series data of the monthly catch data of mackerel scad (*Decapterus macarellus*) that caught by purse seine fishing gear in five years, then the method for analyzing the fishing season pattern is continued with the moving-averages calculation. The fishing season pattern can be known by following several steps, start from arranging CPUE series in five years, arranging the 12-months CPUE moving average (RGi), calculating the moving average of centralized CPUE in month-i (RGPi), calculating the average ratio of month-i (Rbi), making the average value in an i × j matrix that compiled for each month (starting from July of a certain year to June of the following year) and then calculating the total value of all average ratio and the pattern of the fishing season. All of those steps can be analyzed by using these formulas (in order):

\[
CPUE = n_i
\]

(4)

\[
RG_i = \frac{1}{12} \left( \sum_{j=i}^{i-6} CPUE_i \right)
\]

(5)

\[
RG_i = \frac{1}{2} \left( \sum_{j=i-1}^{i+1} RG_i \right)
\]

(6)

\[
R_{bi} = \frac{CPUE_i}{RG_i}
\]

(7)

\[
R_{bbi} = \frac{1}{2} \left( \sum_{j=i}^{i-1} R_{bbi} \right)
\]

(8)

\[
JRBB = \sum_{i=1}^{12} R_{bbi}
\]

(9)

\[
FK = \frac{1200}{JRBB}
\]

(10)

\[
FS_{ii} = R_{bbi} \times FK
\]

(11)

Where:

- \(n_i\) = CPUE in the order to-i
- \(i\) = 1, 2, 3, 4, …, 12
- \(FS_{ii}\) = index value of the fishing season in the i-month
- \(R_{bbi}\) = the average ratio for the i-month
- \(RG_i\) = 12-month moving average of the-i
- \(CPUE_i\) = CPUE order to-i
- \(RG_i\) = moving average CPUE centered month to-i
- \(R_{bi}\) = average ratio of the month to-i
- \(R_{bbi}\) Monthly = average ratio in the size matrix i × j
- \(j\) = 1, 2, 3, 4,…, n
- \(JRBB\) = total ratio of the average month
- \(R_{bbi}\) = average \(R_{bbi}\) for the month to-i
- \(FK\) = correction the factor value
Criteria for determining the fishing season is divided into three groups. The first one is when the FSI value > 100%, it is categorized into the fishing season (the peak season) and the second is when FSI value < 100%, it is categorized as a not fishing season (the medium season) and when the FSI value is < 50%, it is categorized as the low season.

3. Results and discussion

3.1. Production of mackerel scad (Decapterus macarellus)
Production data of mackerel scad (Decapterus macarellus) using purse seine fishing gear in 2015-2019 landed at the Belawan Ocean Fishing Port tends to fluctuate. The highest number of capture production from 2015-2019 was occurred in 2016 with amount to 10,048 tons, while the lowest capture production was occurred in 2018 with amount to 6,646 tons.

The decrease in the number of fishing effort carried out by fishermen is one of the impacts that causes the decrease in the amount of mackerel scad (Decapterus macarellus) production in 2018. The catch of fish is influenced by several factors such as the presence of fish, the number of fishing efforts, and the success rate of fishing operations [4].

3.2. Fishing effort for mackerel scad (Decapterus macarellus)
Fishing effort of the mackerel scad (Decapterus macarellus) was determined from fishermen that used purse seine as the fishing gear. The fishing effort using purse seine fishing gear in five years (2015-2019) landed at the Belawan Ocean Fishing Port can be seen in figure 2.

![Figure 2](image)

**Figure 2.** The chart of fluctuation in a fishing effort (trip) in five years from 2015-2019.

The effort to catch the mackerel scad (Decapterus macarellus) continues to experience a very drastic decline every year. The highest fishing effort was occurred in 2015 with 6,498 trips, while the lowest effort was occurred in 2019 with 3,154 trips. However, fishing effort in 2015 (6,498 trips) and 2016 (6,233 trips) were classified as high effort because both had exceeded the optimum value effort by 6,577 trips/year. The fishing effort that is too high can damage the amount of catch or the fish stock in the waters because of the imbalance between fishing effort and the condition of the available fish resources [5].
3.3. CPUE
The catch and effort of catching the mackerel scad (*Decapterus macarellus*) in five years from 2015-2019 have fluctuated so that the monthly CPUE value of the mackerel scad (*Decapterus macarellus*) for five years has also experienced fluctuation, it can be seen in figure 3.

Based on the value of CPUE, it fluctuated from 2015-2019. The highest CPUE value was occurred 2016 with 1.61 tons/trip and the lowest was occurred in 2017 with 1.24 tons/trip. The high and low CPUE values was occurred because during that period there have been additions and subtractions in both the use of fishing gear and fishing trips (effort). The highest increase in CPUE values occurred in 2018-2019 with 0.5 tons/trip. In 2017, the CPUE value experienced a depletion because the fishing effort in the previous year was very high so that the fish resources wa decreased. But in the following years, the CPUE value has increased, where there is a recovery of fish resources.

A quite drastic increase in fluctuation occurred in 2019, namely 2.18 tons/trip, in contrast to 2017 where it had the lowest CPUE value compared to other years, which was 1.24 tons/trip. This is because in 2017 the production of catches decreased compared to 2016, but the amount of fishing effort did not decrease drastically. When viewed between CPUE (tons/trip) and effort (trip), the more the effort value increases, the less CPUE will be, so that production will be decrease. This mean that CPUE is contrary to effort where wit each increase in effort value, the CPUE value will decrease [6].

Judging from the CPUE value which has increase every year, this explains that the Malacca Strait is experiencing under fishing catches. One of the effects of under fishing is not the optimal use of new input in the process of catching fish production [7].

3.4. TPC and TPF
The level of utilization and effort of mackerel scad (*Decapterus macarellus*) at the Belawan Ocean Fishing Port from 2015-2019 can be seen in figure 4.

The utilization rate in 2015, 2016, and 2019 has obtained of value exceeded 100%, meaning that in that year the number of fishing is high and has exceed the value of the sustainable potential which could threaten the sustainability of mackerel scad (*Decapterus macarellus*) in the waters. Uncontrolled exploitation of fish resources can indicate a decrease in fish catch. The utilization rate is the percentage of the number of fish caught against the estimated potential of the fish resource. If the proportion of the utilization rate is more than 100%, it is called an over-utilization rate [7].
Additional effort can be dangerous to resource extinction. In 2017, the value of the utilization rate was reduced to 77.68% with the cultivation level value increasing to 81.61%. That indicates a reduction in the number of mackerel scad (*Decapterus macarellus*) in the Belawan Ocean Fishing Port that is allowed annually is 6,871.88 tons/year. This calculation was value obtained from 80% of the total sustainable potential (MSY) of mackerel scad, if the amount of catch allowed exceeds 80%, it means that the catch has reached its sustainable potential value and it is not recommended to make additional fishing efforts.

The result was calculation of the allowable catch (TAC), which is 6,871.88 tons/year, which means that the number of fish catches of mackerel scad (*Decapterus macarellus*) in the Belawan Ocean Fishing Port that is allowed annually is 6,871.88 tons/year. This calculation was value obtained from 80% of the total sustainable potential (MSY) of mackerel scad (*Decapterus macarellus*), if the amount of catch allowed exceeds 80%, it means that the catch has reached its sustainable potential value and it is not recommended to make additional fishing efforts.

3.5. Fishing season pattern

**Table 1.** Mackerel scad (*Decapterus macarellus*) fishing season index in 2015-2019.

| Month     | FSI (%) | Fishing Season | Season in Indonesia |
|-----------|---------|----------------|---------------------|
| July      | 98.87   | Medium         | East                |
| August    | 107.12  | Peak           | East                |
| September | 97.57   | Moderate       | Transition II       |
| October   | 96.36   | Moderate       | Transition II       |
| November  | 116.49  | Peak           | Transition II       |
| December  | 95.05   | Medium         | West                |
| January   | 101.73  | Peak           | West                |
| February  | 89.35   | Medium         | West                |
| March     | 101.70  | Peak           | Transition I        |
| April     | 92.82   | Moderate       | Transition I        |
| May       | 101.89  | Peak           | Transition I        |
| June      | 101.05  | Peak           | East                |
The fishing season pattern is calculated based on data on the catch and fishing effort per month over a period of 5 years (2015-2019). Calculations are performed using time series analysis and the moving average method. The value of the fishing season index (FSI) of the mackerel scad (Decapterus macarellus) could be seen in table 1.

Based on table 1 above was shown estimated that the highest peak season for mackerel scad (Decapterus macarellus) occurred in November (the end of transition season II) with an FSI value of 116.49%. Meanwhile, the fishing season with the lowest value is estimated to occur in February (the west season) with an FSI value of 89.35% but it is still included in the medium fishing season.

It is best to catch the mackerel scad (Decapterus macarellus) during the peak season, namely the second transitional season in November compared to the west season in February. Because the fishermen also said that during the western season, the waters of the Malacca Strait tend to have big waves and strong winds, making fishes reluctant to be caught in fishing nets. Meanwhile, in the period of the second transitional season has sufficient environmental conditions to carry out fishing efforts by increasing fishing trips in this season, thus resulting in increased production and catching season index which indicates that this period is the peak season for catching the mackerel scad (Decapterus macarellus). Thus, the good season for catching a mackerel scad (Decapterus macarellus) in the Malacca Strait is January (the west season), March and May (the transitional season I), June and August (the east season) and November (the transitional season II).

4. Conclusions

This research concludes that TPC and TPF value of mackerel scad (Decapterus macarellus) at the Belawan Ocean Fishing Port is below 100% and is in the category of catch density or optimum. Allowed catches (TAC) for mackerel scad (Decapterus macarellus) is 6,871.88 tons/year. Based on the calculation of the Fishing Season Index (FSI) for the last five years, the mackerel scad (Decapterus macarellus) can be caught every year. The fishing season is January, March, May, June, August, and November with the peak fishing season in November, which is the second transitional season.

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