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Analysis of Seasonal Patterns of Mackerel (*Scomberomorus* sp.) in Belawan Samudera Fishery Port

Vanesa Marsela Katarina Hutahaean[1], Ester Restiana Endang Gelis[1*], Lisna Lisna[1], Bs Monica Arfiana[1], Dwinda Pangentasari[1], Afriani Harahap[2]

[1]Fishery Resources Utilization Study Program, Faculty of Animal Science, University of Jambi Jambi-Muara Bulian Road, KM15, Mendalo Darat, Jambi, 36361, Indonesia
[2]Animal Husbandry Study Program, Faculty of Animal Science, University of Jambi Jambi-Muara Bulian Road, KM15, Mendalo Darat, Jambi, 36361, Indonesia

Correspondence:
esterrestiana@unja.ac.id

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ABSTRACT

Mackerel (*Scomberomorus* sp.) is a large pelagic fish from the Scombridae family that lives in schools and is migratory. This commodity has high economic value and is one of the important catches landed at the Belawan Ocean Fisheries Port (PPS), WPPNRI 571. However, mackerel production shows fluctuations from year to year. This study aims to analyse the catch and seasonal patterns of mackerel fishing at the Belawan PPS. The study was conducted in January-February 2026 using a quantitative descriptive survey method utilising secondary data from the Belawan PPS fisheries logbook for 2021-2025. The analysis included calculating Catch Per Unit Effort (CPUE), standardising fishing gear using the Fishing Power Index (FPI), estimating Maximum Sustainable Yield (MSY) and optimum effort using the Schaefer model, calculating the Total Allowable Catch (TAC), utilisation levels, and fishing seasonal patterns using the average percentage method based on time series. The results showed an average annual production of mackerel fish of 34,048 tonnes. The highest CPUE value occurred in 2021 at 0.55 tonnes/trip and the lowest in 2025 at 0.03 tonnes/trip. The MSY value obtained was 150,957 tonnes/year with an optimum effort of 1,401.702 trips and a TAC of 120,765 tonnes/year. The average utilisation rate of 23% indicates that the resource is still underfished. The peak fishing season occurs in May, July, October, and November, while the lean season occurs in February, March, April, August, and December. The results indicate that mackerel resources in the Belawan PPS still have the potential for sustainable utilisation.

INTRODUCTION

Belawan Ocean Fishing Port in North Sumatra Province is located between the East Coast of Sumatra and the Strait of Malacca (WPP RI 571), and is within the Indonesian Exclusive Economic Zone (ZEEI), making it one of the strategic ports in the western region of Indonesia as well as an entry point for economic activities in the Asian region (Siahaan *et al.*, 2016). This port plays a vital role as a landing, distribution, and post-catch handling center for fishery products. Some of the fish species landed at this port include tuna, mackerel, mackerel, and Spanish mackerel. Based on 2020 data statistics, Spanish mackerel (*Scomberomorus* sp.) is one of the large pelagic commodities with high economic value (Yusniati *et al*., 2023).

Based on statistical data from the Ministry of Maritime Affairs and Fisheries (KKP), the production of mackerel in 2017 was 1,227.554 tons. This condition indicates overfishing, according to (Zunit & Zora, 2023). Overfishing is a method of excessive fishing which will have an impact on a drastic and continuous decline in fish populations which will eventually lead to extinction which can have an impact on reducing the number of mackerel in the waters because it is above the MSY value. Meanwhile, in 2012, 2013, 2014, 2015, 2016, 2018, 2019, 2020 and 2021, mackerel fishing efforts experienced underfishing where the utilization of mackerel fish resources has not been carried out optimally even though the availability of resources still exists. because production is still below the MSY value of 1,211.63 tons/year (Yusniati *et al*., 2023).

In addition, the 2024 Belawan Ocean Fishing Port Logbook Data states that the production of mackerel obtained in 2022-2024 experienced fluctuations, with the total production of mackerel amounting to 202,39 tons, 57,04 tons and 87,68 tons. Mackerel production in 2017 was the highest production, this is because the fishing effort in that year was also the highest compared to other years. Based on (Suryana *et al*., 2018) fishing effort plays an important role in obtaining catches in an exploitation activity. (Mayu *et al*., 2018) also added that the high production amount is due to the tendency of fishing effort. If exploitation takes place intensively without providing opportunities for adult fish to reproduce, then a decline in stocks is inevitable (Mahmud & Bubun, 2015).

The fishing season pattern was analyzed using the Fishing Season Index (IMP) to determine the peak season period for mackerel fishing in one year. The criteria for determining the IMP are: "it's the fishing season (the right season for fishing) if the IMP value is above the monthly average IMP value, and "not the right season for fishing" if the IMP value is below the monthly average IMP value (Haluan, 2001 in Imron *et al*., 2021). Based on the IMP value, the fishing season pattern indicates that the mackerel season occurs in March (137,065), April (134,264), October (110,654), and November (122,662). During this period, the mackerel catch is estimated to peak, especially in March (Situmorang *et al*., 2018).

Based on this, landing data at the Belawan Ocean Fishing Port is routinely collected. However, data to observe catch results and fishing season patterns is still limited. Therefore, specific research is needed to analyze the catch results and fishing season patterns of mackerel at the Belawan Ocean Fishing Port. This study aims to determine the catch analysis. and seasonal patterns of mackerel fish at the Belawan Ocean Fisheries Port and become the basis for processing to be more focused and sustainable.

METHODS

This research was conducted at the Belawan Ocean Fisheries Port located at Jalan Gabion, Belawan City, Medan, North Sumatra Province from January 12, 2026 to February 5, 2026. The primary data comes from the Belawan Ocean Fishing Port's annual report for 2021-2025, covering mackerel production, fishing locations, catch per unit of fishing gear, and fishing gear types. Supporting materials were obtained from relevant government agencies and various literature such as textbooks, scientific journals, and relevant previous research. The tools used in this study included a computer or similar device with Microsoft Excel and

Microsoft Word for data processing, stationery for recording information during data collection, and a digital camera for documenting the research objects, such as mackerel and the fishing gear used.

This study employed a survey method with a quantitative descriptive approach. According to Sugiyono (2017), the survey method is used to collect data from a specific region or population, which is then analyzed to draw conclusions. The quantitative descriptive approach was chosen because this study aims to describe a condition based on statistically processed numerical data (Sugiyono, 2017). The data used consisted of secondary data in the form of annual catch and fishing effort data for the 2021-2025 period obtained from fisheries logbooks, relevant agencies, and supporting literature such as textbooks, scientific journals, and previous research.

The research process began with a site survey, followed by secondary data collection in the form of fishing logbooks obtained from the Belawan Fisheries and Fisheries Management Center (PPS) for the 2021-2025 period. These logbooks served as the primary source for the research analysis. After data collection, several interrelated analysis stages were conducted. The first stage was a Catch Per Unit Effort (CPUE) analysis to determine the productivity level of mackerel fishing based on the catch per unit of fishing effort. Next, fishing gear standardization was conducted to equalize the fishing power of various types of fishing gear used, allowing objective comparisons of the data obtained. The results of the CPUE analysis and gear standardization were then used in a Maximum Sustainable Yield (MSY) analysis using the Schaefer Model. This analysis aims to estimate the maximum potential catch that can be sustainably utilized without compromising the sustainability of fish resources. Based on the MSY analysis, a utilization level analysis was conducted to determine the extent to which mackerel resources have been utilized compared to their sustainable potential. In addition, the obtained CPUE data was also used to analyze fishing season patterns. This analysis aimed to identify peak, moderate, and lean seasons for mackerel fishing during the study period. This information is crucial for determining the most effective fishing times. All analysis results, including CPUE analysis, gear standardization, MSY, utilization rates, and fishing season patterns, were then integrated and presented in the results and discussion section. The final stage of the research was the preparation of conclusions, which summarize the main findings related to catch conditions, utilization levels of mackerel resources, and fishing season patterns at the Belawan Ocean Fishing Port.

Data Analysis

CPUE

Catch per unit effort (CPUE) analysis is used to assess fish catches by comparing the catch (catch) in kilograms with the fishermen's fishing effort (effort) in trips (Hilborn & Walters, 2013).

$$\text{CPUE} = \frac{\text{Catch}}{\text{effort}}$$

Where:

Catch (C) = Total mackerel catch (kg)
Effort (E) = Total fishing effort (trip)
CPUE = Catch per fishing effort (kg/trip)

Fishing Gear Standardization

Standardization is carried out by determining the fishing gear with the highest CPUE value as the standard (FPI = 1). According to Sparre & Venema (1999) in Febriani *et al*. (2014), the equation used to calculate fishing gear standardization is as follows:

$$\text{CPUEr} = \frac{\text{Catch r}}{\text{Effort r}}$$
$$\text{CPUEs} = \frac{\text{Catch s}}{\text{Effort s}}$$
$$\text{FPIi} = \frac{\text{CPUEs}}{\text{CPUEr}}$$

Where:
CPUEr = Total catch per effort of fishing gear r to be standardized (tons/trip)
CPUEs = Total catch per effort of fishing gear s to be standardized (tons/trip)
FPIi = Fishing Power Index of fishing gear i (standardized and standard fishing gear)

According to Tangke (2010), the total standard effort is calculated using the following equation:

$$\text{E} = \sum_{\text{i}=1}^{1} \text{fpi} \times \text{Ei}$$

Where:
E = Total effort of standardized fishing gear and standard fishing gear (trip)
Ei = Effort of standardized fishing gear and standard fishing gear (trip)

Schaefer Model

The Schaefer model is used to describe the catch per unit effort (y/f) as a function of the fishing effort (f). This is done through a linear model introduced by Schaefer. According to Sparre *et al*. (1988) in Mallawa *et al*. (2010), the Scheafer model is as follows: The relationship between Y (catch) and f (fishing effort) is:

$$\text{y} = \text{af} + \text{b(f)}^2$$

The optimum effort value (f optimum) is:

$$\text{fopt} = -\frac{\text{a}}{2\text{b}}$$

Maximum Sustainable Potential Value (MSY) is:

$$\text{MSY} = -\frac{\text{a}^2}{4\text{b}}$$

Where:
Y = Total catch per unit of fishing effort (tons/trip)
a = Intercept
b = Slope
f = Fishing effort (trip) in period i
fopt = Optimal fishing effort (trip)
MSY = Maximum sustainable potential value (tons/year)

Total Allowable Catch/TAC

The Total Allowable Catch/TAC can be calculated based on FAO data from 2002 (Anugrahini, 2011) using the following formula:

TAC = 80% x MSY

Where:
TAC = Allowable Catch
MSY = Maximum Sustainable Yield

Utilization Rate

The utilization rate is calculated by comparing the annual catch (Ci) to the allowable catch (TAC = 80% MSY), using the Dahuri 2001 formula in (Harjanti *et al*., 2012).

Utilization Rate = Ci/TAC x 100%

Where:
Ci = Total annual catch

TAC = Allowable catch, which is 80% of the MSY value.

The overall level of fish resource utilization appears to be dominated by overfishing at around 49%, followed by fully exploited conditions at around 37% and moderate conditions at 14% (Suman, 2016).

Fishing Seasonal Patterns

The analysis of fishing seasonal patterns uses the Average Percentage Method, which is based on Time Series Analysis by Spiegel (1961). The procedure is as follows Purwasmita (1993):

1. Calculate the catch per unit of effort (CPUE) per month (Ui) and the average monthly CPUE for the year (U).

$$\overline{U} = \frac{1}{m}\sum_{i=1}^{m} Ui \text{ .... (1)}$$

Where:
$\overline{U}$ = Average monthly CPUE in a year (tons/trip)
Ui = CPUE per month (tons/trip)
m = 12 (number of months in a year)

2. Calculate U_P, which is the ratio of Ui to $\overline{U}$ expressed as a percentage:

$$U_P = \frac{Ui}{U} \text{ x } 100\% \text{ .... (2)}$$

3. Next is calculated:

$$IM_{i=\frac{i}{t}} \sum_{i=1}^{1} Up = \text{ .... (3)}$$

Where:
IMi = Seasonal Index i
t = Number of years of data

4. If the IMi amount is not 1200% (12 months x 100%), then an adjustment is required.

$$IMS_{i=} \underline{1200} \sum_{i=1}^{m} IMi \text{ .... (4)}$$

Where:
IMSi = Adjusted Seasonal Index i

5. If there is an extreme value in Up in the calculation, then the Up value is not used in the Seasonal Index (IM) calculation, what is used is the median (Md) of the IM. If the total Md value is not 1200%, then the following adjustments need to be made:

$$IMMds_{i=} \frac{1200}{\sum_{i=1}^{m} \text{x } md_i}$$

Where:
IMMdSi = Seasonal Index with Median adjusted to i.

6. The criteria for determining a fish season is if the season index is more than 1 (more than 100%) or above average, and not a season if the season index is less than 1 (less than 100%). If IM = 1 (100%), this value is the same as the average monthly price so it can be said to be in normal or balanced conditions (Haluan, 2001 in Imron *et al*., 2021).

Subsequently, the fishing season (IMP) criteria are determined based on IMP value ranges: ➢ IMP> 100%: peak season. ➢ 50% ≤ IMP ≤ 100%: moderate season. ➢ IMP < 50%: lean season (Anam *et al*., 2026).

RESULTS

Mackerel Catch Results 2021-2025

The estimation of the potential of mackerel resources at the Belawan Ocean Fishing Port uses data from mackerel catches and fishing efforts conducted over a five-year period, from

2021 to 2025, as shown in the table below.

Table 1. Mackerel Catches at the Belawan Ocean Fishing Port in 2021-2025

Year	Fishing Gear		Total (Ton)
	Purse Seine	JHIB	
2021	30,905	12,85	43,755
2022	45,481	1,815	47,296
2023	10,767	1,295	12,062
2024	11,956	14,33	26,286
2025	8,198	32,641	40,839
Total	107,307	62,931	
Average	21,4614	12,5862	34,048

Based on the table, the Spanish mackerel catch in 2021 was 43,755 tons, increasing to 47,296 tons in 2022. This then decreased to 12,062 tons in 2023. In 2024 and 2025, catches increased by 26,286 tons and 40,839 tons, respectively, with an average catch of 34,0476 tons.

Standardization of Capture Efforts

The fishing gear used to catch Spanish mackerel (*Scomberomorus* sp.) at the Belawan Ocean Fishing Port consists of two types: purse seines and bagged fish nets (JHIB). To calculate the Catch Per Unit Effort (CPUE) value, standardization of fishing gear is necessary. This ensures accurate comparison of production data from each gear and provides accurate analysis. The following table shows the production of the fishing gear used:

Table 2. Fishing Gear Productivity and Fishing Power Index (FPI)

Year	Fishing Gear		Total
	Purse Seine	JHIB	
2021	0.312	0.857	1.169
2022	0.323	0.454	0.776
2023	0.207	0.108	0.315
2024	0.078	0.020	0.098
2025	0.037	0.023	0.060
Average	0.191	0.292	0.484
FPI	0.655	1	

The FPI calculation results show that the JHIB FPI value is 1, Purse Seine = 0.655. The FPI value of 1 on the JHIB fishing gear indicates that this fishing gear can be used as a standard fishing gear, while other fishing gears show that the proportion of their fishing ability is relative to the JHIB fishing gear. Thus, it can be concluded that the smaller the FPI value on a fishing gear, the smaller the relative fishing ability of the gear compared to the standard fishing gear.

Catch Unit Per Effort (CPUE)

Table 3. Calculation of CPUE Value of Spanish Mackerel Fish 2021-2025

Year	Catch Results (Ton)	Standard Effort (Trip)	CPUE (Ton/Trip)
2021	43,755	79,811	0.55
2022	47,296	96,306	0.49
2023	12,062	46,042	0.26
2024	26,286	819,162	0.03
2025	40,839	1,542.333	0.03

Year	Catch Results (Ton)	Standard Effort (Trip)	CPUE (Ton/Trip)
Total	170,238	516,731	1.36
Average			0.272

Based on Table 3, the CPUE value shows a continuous downward trend from 2021 to 2025. The highest CPUE value occurred in 2021, at 0.55 tons/trip, meaning each fishing trip yielded an average of 0.272 tons of mackerel. Conversely, the lowest CPUE value was recorded in 2025, at 0.03 tons/trip. This significant decline in CPUE indicates that although the number of fishing trips has increased year after year, the catch per trip has actually decreased. This can be interpreted as meaning that the availability of mackerel in the waters is decreasing along with the increasing intensity of fishing efforts.

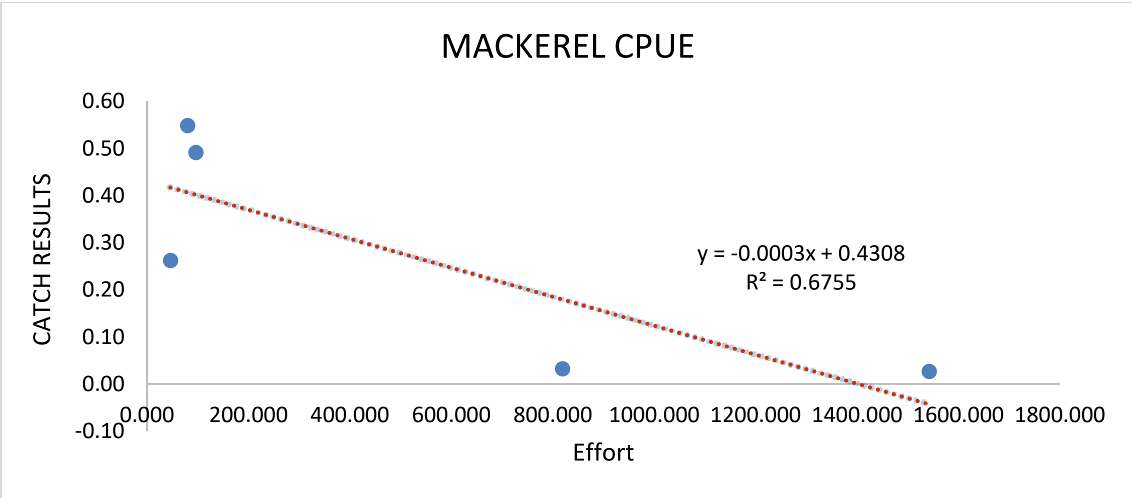

Figure 1. Mackerel CPUE

The results of the analysis of the relationship between fishing effort and CPUE value of mackerel fish produced a linear regression equation y = -0.0003x + 0.4308 with an R^2 value of 0.6755, which means that 67,55% of the change in CPUE value during the research period was influenced by changes in the amount of fishing effort, while the rest was influenced by other factors outside the model.

Maximum Suistainable Yield (MSY)

Maximum Suistainable Yield (MSY) is the optimum sustainable condition of the catch produced in a fishery.

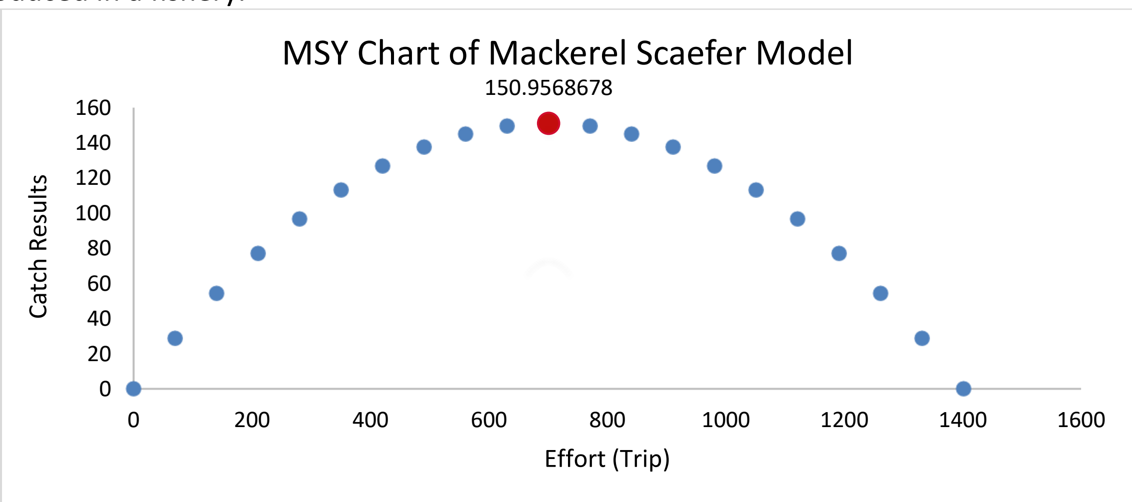

Figure 2. Maximum Suistainable Yield

With optimal efforts of 1,401.702 trips, the maximum sustainable yield (MSY) of mackerel at the Belawan Ocean Fisheries Port over the past five years was 150,957 tons.

Total Allowable Catch (TAC)

The Total Allowable Catch (TAC) is the maximum catch limit that can be taken from a body of water to maintain fish stocks and prevent overfishing. In Indonesia, the TAC is set at 80% of the MSY value in accordance with Decree of the Minister of Maritime Affairs and Fisheries Number 19 of 2022 concerning the Estimation of Fish Resource Potential, Total Allowable Fish Catch, and the Level of Fish Resource Utilization in the Fisheries Management Area of the Republic of Indonesia.

Table 4. Permissible Catch of Mackerel at Belawan Ocean Fishing Port

Year	Catch Results (Ton)	MSY (Ton)	Fopt (Trip)	TAC (Ton/year)
2021	43,755			
2022	47,296			
2023	12,062	150,957	700,851	120,765
2024	26,286			
2025	40,839			
Total	170,238			
Average	34,048			

Based on the table above, the MSY value for mackerel at the Belawan Ocean Fishing Port was 150,957 tons/year with an optimum effort (F opt) of 700,851 trips. Based on this MSY value, the Total Allowable Catch (TAC) was set at 120,765 tons/year. The total catch from 2021-2025 reached 170,238 tons, with an average of 34,048 tons per year.

Utilization Rate

Based on the table, the MSY value obtained is 150,957 tons/year with an optimal effort of 1,619 trips. The utilization rate data for the five years (2021-2025) is as follows:

Table 5. Utilization Level

Year	Catch Results (Ton)	Msy (Ton)	Utilization Rate	Information
2021	43,755		29%	low
2022	47,296		31%	low
2023	12,062	150,957	8%	low
2024	26,286		17%	low
2025	40,839		27%	low
Total	170,238		113%	
Average			23%	

The average utilization rate of mackerel during 2021-2025 was 23% per year. This figure is derived from the average annual utilization rates of 29% (2021), 31% (2022), 8% (2023), 17% (2024), and 27% (2025), resulting in an average of 112%/5 = 23% per year.

Seasonal Fishing Pattern of Spanish Mackerel (*Scomberomorus* sp.).

The seasonal pattern of mackerel fish landed at the Belawan Ocean Fishing Port was determined using monthly catch and fishing effort data for a five-year period, from 2021 to 2025. This study used the Average Percentage Method, a method of time series analysis. The seasonal pattern of fishing is strongly influenced by weather and climate conditions in a region. The seasonal index (IM) for mackerel fishing was calculated using the seasonal pattern formula shown in Table 6.

Table 6. Index (IM) Values for Mackerel Fish at the Belawan Fishing Port

No	Month	Seasonally Adjusted Index (%)	Season Category
1	January	101.67%	Peak Season
2	February	42.64%	Lean Season
3	March	49.62%	Lean Season
4	April	59.38%	Moderate Season
5	May	169.93%	Peak Season
6	June	106.93%	Peak Season
7	July	150.24%	Peak Season
8	August	77.39%	Moderate Season
9	September	106.33%	Peak Season
10	October	137.92%	Peak Season
11	November	141.82%	Peak Season
12	December	56.15%	Moderate Season

At the Belawan Ocean Fishing Port, a Seasonal Index (IM) value exceeding 100% indicates that the month is within the fishing season, while a value below 100% indicates that the month is not. The seasonal fishing months are January, May, June, July, September, October, and November. Meanwhile, February, March, April, August, and December are not recorded as seasonal for mackerel fishing.

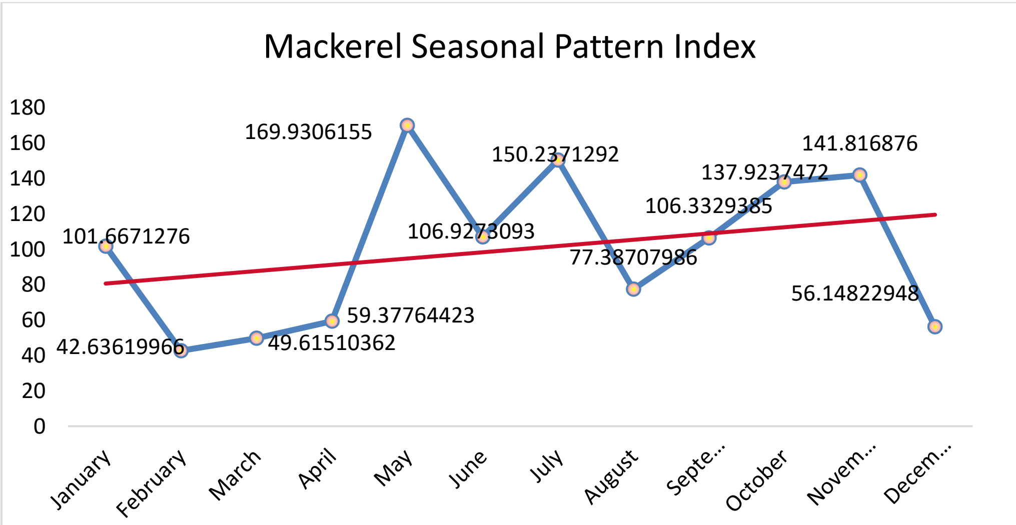

Figure 3. Seasonal Pattern Index of Mackerel Fish

The seasonal pattern of mackerel fishing is inextricably linked to the fish's migration behavior. When mackerel migrate through or temporarily reside in the waters of the Belawan Fishery Authority (WPP NRI 571), the peak fishing season occurs. Conversely, when mackerel migrate to other waters, following prey or environmental conditions, catches will drop drastically, even if fishermen continue to sail.

DISCUSSION

Mackerel Catch Results 2021-2025

Based on the table, the catch of mackerel in 2021 was 43,755 tons, increasing to 47,296 tons in 2022. This then decreased to 12,062 tons in 2023. In 2024 and 2025, catches increased by 26,286 tons and 40,839 tons, respectively, with an average catch of 34,0476 tons. Fluctuating catches are influenced by several factors, including the number of fishing attempts, the availability of fish, and the success rate of fishing operations (Nugraha, 2012).

Furthermore, changes in catches can also be influenced by weather and fishing season. This research aligns with Sparre & Venema (1999), who stated that increasing fishing effort over a period can increase catches, but if done continuously, it can lead to a decline in fish stocks.

Standardization of Capture Efforts

Standardizing fishing gear is a crucial step in streamlining fishing efforts. This process involves designating one unit of fishing gear as the standard, chosen based on the dominant species of fish caught (Lelono, 2012).

The FPI calculation results show that the JHIB FPI value is 1, Purse Seine = 0.655. The FPI value of 1 on the JHIB fishing gear indicates that this fishing gear can be used as a standard fishing gear, while other fishing gears show that the proportion of their fishing ability is relative to the JHIB fishing gear. Thus, it can be concluded that the smaller the FPI value on a fishing gear, the smaller the relative fishing ability of the tool compared to the standard fishing gear. This is in line with the opinion of Putra *et al*. (2012), standard fishing gear is a fishing gear that has the highest average productivity level compared to other fishing gear, and has a fishing ability value or Fishing Power Index (FPI) of 1.

Catch Unit Per Effort (CPUE)

Based on Table 3, the CPUE value shows a continuous downward trend from 2021 to 2025. The highest CPUE value occurred in 2021, at 0.55 tons/trip, meaning each fishing trip yielded an average of 0.272 tons of mackerel. Conversely, the lowest CPUE value was recorded in 2025, at 0.03 tons/trip. This significant decline in CPUE indicates that although the number of fishing trips has increased year by year, the catch per trip has actually decreased. This could mean that the availability of mackerel in the waters is decreasing along with the increasing intensity of fishing effort. According to Susanto (2006), in the initial stages of fishing activities, there is an increase in CPUE values due to increased fishing effort. However, over time, the CPUE value will decrease as fish resources begin to decline.

The analysis of the relationship between fishing effort and CPUE for mackerel yielded a linear regression equation of $y = -0.0003x + 0.4308$ with an R^2 value of 0.6755. This means that 67,55% of the change in CPUE during the study period was influenced by changes in fishing effort, while the remainder was influenced by factors outside the model. This equation yields a = 0.4308 and b = -0.0003. A negative b value is a prerequisite for the validity of the Schaefer Model, as it indicates that any increase in fishing effort will decrease the CPUE. Conversely, if the b value is positive, the analysis of potential and optimum effort need not be continued (Wahyudi, 2010). The negative b value indicates that the more fishermen go out to sea, the fewer mackerel are caught per fishing trip. This is a general indication of waters beginning to experience pressure due to high fishing intensity, as explained by Putri *et al*. (2019) that changes in fish production are influenced by fishing efforts, availability of fish stocks, and oceanographic conditions of the waters.

Maximum Suistainable Yield (MSY)

Maximum Sustainable Yield (MSY) is the optimum sustainable yield of a fishery's catch. One necessary step is to conduct a stock assessment to determine the sustainable yield potential (MSY), optimal efforts, and fish utilization levels to ensure fish resources remain sustainable and available in the future without harming their populations (Juniko *et al*., 2018).

Based on the figure, with an optimal effort of 1,401.702 trips, the maximum sustainable yield (MSY) of mackerel at the Belawan Ocean Fishing Port over the past five years was 150,957 tons. If fishing effort exceeds the optimal effort, the catch value will decrease (Simbolon *et al*., 2011). The Schaefer model excels in its simplicity, as it utilizes a linear relationship between CPUE and effort. This model is suitable for directly generating MSY and optimum effort values, has proven valid, and is internationally recognized.

Effect Total Allowable Catch (TTC)

Based on the table above, the MSY value of mackerel fish in the Belawan Ocean Fishing Port was obtained at 150,957 tons/year with an optimum effort (F opt) of 700,851 trips. From this MSY value, the Allowable Catch (TAC) was set at 120,765 tons/year. The total catch during 2021-2025 reached 170,238 tons with an average of 34,048 tons per year. When comparing the average actual catch with the set TAC value, it is clear that the utilization of mackerel fish in these waters is still in a condition that needs attention so as not to exceed the permitted limit. According to Dahuri (2001) in Harjanti *et al*. (2012), the TAC is set at 80% of the MSY value as a safe limit so that fish resources remain sustainable and do not experience overfishing.

Utilization Rate

This utilization rate is considered low, or underfishing. This indicates that the actual catch is still far below the MSY value, meaning that the mackerel resources at the Belawan Ocean Fishing Port are not being optimally utilized. The sharpest decline occurred in 2023 (8%), likely influenced by seasonal factors, weather, or reduced fishing effort that year. After 2023, production gradually recovered in 2024 (17%) and 2025 (27%).

With an average of 23%, mackerel utilization at the Belawan Ocean Fishing Port falls into the underfishing category, indicating there is still room to increase fishing effort without threatening stock sustainability. According to Aminah (2011), the decline in catches could be caused by a decline in population size due to previously high fishing effort. Therefore, although the current situation remains underfished, it is important to maintain control to prevent overexploitation in the future.

Seasonal Fishing Pattern of Spanish Mackerel (*Scomberomorus* sp.)

Based on the analysis using the average percentage method, the seasonal pattern of mackerel fishing at the Belawan Ocean Fishing Port for the 2021-2025 period shows that the fishing season is divided into three categories: the peak season with an IMP value above 100%, the moderate season with an IMP value between 50-100%, and the lean season with an IMP value below 50% (Rizki, 2025).

The peak season is the period when fish availability in the waters is most abundant and fishermen's catches are at their highest. The Fishing Season Index (IMP) is used to assess fishing productivity, with the peak season occurring when the IMP value is above 100%. The presence of mackerel influences its abundance in a given body of water. Mackerel is a migratory fish species, so its movements depend on the availability of small pelagic fish, which are its food source (Situmorang *et al*., 2018).

The moderate season is a transitional period during which catches are still quite good but have not yet reached their optimal levels. An IMP value below 100 indicates a moderate season, where catches are still considered normal but have not yet reached their peak. In the moderate season, catches are still considered good, although not at their optimal levels, and this pattern is commonly found in the transitional months between seasons (Nurhayati *et al*., 2018).

The lean season is a period when fish catches are very low and sea conditions are unfavorable for fishing. The onset of the lean season is characterized by strong winds, large waves, and heavy rain, which prevent fishermen from fishing at sea, thus directly impacting the economic conditions of the community, especially fishermen. The lean season for pelagic fish in Indonesian waters generally lasts from December to April, in line with the dominance of the westerly monsoon, which creates unfavorable sea conditions for fishing (Ilhamdi *et al*., 2016). The low IMP value in August is also suspected to be related to the transition from the east monsoon to the transitional season, which causes groups of mackerel to move to other waters.

CONCLUSION

Based on the research results, it can be concluded that the average production of mackerel at the Belawan Ocean Fishing Port during 2021-2025 is 34,048 tons/year. Furthermore, the average utilization rate of mackerel is 23% per year, indicating that the waters are still underfished and that mackerel resources still have the potential for increased utilization. Peak fishing seasons occur in May (IM 169,93%), July (IM 150,24%), November (IM 141,82%), and October (IM 137,92%), while the lean season occurs in February, March, April, August, and December due to the influence of the west monsoon and mackerel migration patterns.

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