Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 29(6): 305 – 315 (2025)
www.ejabf.journals.ekb.eg

Temporal Pattern in Scads (*Decapterus* spp.) Catches from Java Sea at Bajomulyo Coastal Fishing Port

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ARTICLE INFO

Article History:
Received: July 20, 2025
Accepted: Oct. 7, 2025
Online: Nov. 9, 2025

Keywords:
Fishing season index,
Java Sea,
Purse seine,
Scads

ABSTRACT

The dynamics of the scad fishing season at the Bajomulyo Coastal Fishing Port from the Java Sea fishing ground were investigated using catch and oceanographic data from 2020 to 2024. Scads production data showed significant fluctuations, potentially due to variations in oceanographic conditions, fish stock availability, fishing effort, and external factors. Sea surface temperature (SST) ranged from 28°C to 31°C, while chlorophyll-a concentrations varied between 0.204 and 0.7mg/ m³. Correlation analysis revealed a significant negative relationship between chlorophyll-a and scads production (r= -0.949, *P*-value< 0.05), suggesting a time lag between phytoplankton abundance and scads abundance. SST showed a weak correlation with scads production (r= 0.312, *P*-value> 0.05), with higher catches observed at temperatures between 29°C and 30°C, matching the optimal living temperature for scads. The fishing season index (FSI) indicated that the most intense scads fishing activities occurred from August to December, with FSI values exceeding 100% (> 1). These findings provide insights into the influence of oceanographic factors on the scads fishing season and support the development of sustainable fisheries management strategies along the northern coast of Central Java.

INTRODUCTION

Pati Regency is located on the northern coast of Central Java. It is known for its significant marine and fishery potential, which contributes considerably to the region's gross regional domestic product (GRDP). A large portion of the coastal population depends on fishing activities for their livelihoods, particularly the use of purse seines **(Wijayanto *et al*., 2018)**. Purse seines are a type of fishing gear used to encircle schools of pelagic fish **(Budiarti *et al*., 2015)**. The scad fish (*Decapterus* spp.) are the fish target of the purse seine that landed at Bajomulyo Coastal Fishing Port (Bajomulyo CFP), around 36% **(Sari & Wibowo, 2023)**.

However, the waters of the Java Sea are currently experiencing overexploitation, which has led to declining fish stocks **(Jaya *et al*., 2017)**. This situation is aggravated by the inefficient use of production inputs by fishermen, resulting in technical inefficiencies in fishing operations **(Suharno & Widayati, 2015)**. Consequently, fishermen tend to increase fishing efforts to maintain their income, which can negatively affect the biological, social, and economic sustainability of fisheries **(Wiyono, 2012; Madau *et al.*, 2018)**.

This study aims to analyze the influence of oceanographic variations, specifically chlorophyll-a and sea surface temperature, on the seasonal catch patterns of scads in the Java Sea. Given these challenges, effective fisheries management strategies are urgently needed to ensure sustainable purse seine fishing. A key component of this strategy is the measurement of fishing season to improve technical efficiency. Field data analysis is expected to provide insights and recommendations to support the sustainability of purse seine fisheries along the northern coast of Central Java.

MATERIALS AND METHODS

The data of scads production (tons), fishing effort (trips), sea surface temperature (℃), and chlorophyll-a concentration (gr/m^3) in the Java Sea for five year period (from 2020 to 2024) were used in this study. The scads production and fishing effort were obtained from catch statistical data of the Bajomulyo CFP. Meanwhile, the sea surface temperature (SST) and chlorophyll-a (CHL) concentration were obtained from remote sensing data of the MODIS satellite, http://oceancolor.gsfc.nasa.gov/. Data analysis was carried out by calculating the catch per unit effort and the fishing season index (FSI) **(Fadhilah & Dewinta, 2021; Pratama *et al.*, 2025)**. Further data analysis to estimate the average SST and CHL concentration was conducted using MODIS satellite imagery data **(Sachoemar *et al.*, 2012)**.

FSI values were used to determine the fishing season. According to **Nurdin and Panggabean (2017)**, FSI values were derived using the following mathematical procedure:

a. Calculation of CPUE series

   CPUE = n_i

   Where:
   $i = 1,2,3, \ldots , n$
   ni = the i-th order

b. Calculating the 12-month moving average of CPUE (RG)

   $RG_i = \frac{1}{12}\sum_{i=i-6}^{i+5} CPUE_i$

   Where:
   RGi = the 12-month moving average at the i-th position
   $CPUEi$ = the CPUE at the i-th position
   $i = 7,8, \ldots , n-5$

c. Calculating the centered moving average of CPUE (*RGP*)

$RGP_i = \frac{1}{2}\sum_{i=1}^{i=1} RG_i$

Where:
RGPi = the centered moving average of CPUE at the *i*-th position
RGi = the 12-month moving average at the *i*-th position
i = 7,8, ... , n-5

d. Calculating the ratio of average for each month (*Rb*)

$Rb_i = \frac{CPUE_i}{RGP_i}$

Where:
Rbi = the ratio of average for the *i*-th month
CPUEi = the CPUE at the i-th position
RGPi = the centered moving average of CPUE at the *i*-th position

e. Arranging the values of Rbi into an i x j matrix as Rbij, then calculating the average for each month, starting from Januari 2020 to December 2024

f. Calculating Total Monthly Average Ratio (JRRB)

$JRRB_i = \sum_{i=1}^{12} RRB_i$

Where:
JRRBi = the total monthly average ratio
RBBi = is the monthly average ratio for the *i*-th month
i = 1,2, ... , 12

g. The total monthly average JRBB ratio was 1200. However, because of various influencing factors, it may deviate from this value. To address this issue, the monthly average ratio must be adjusted using a correction factor known as the correction factor (FK). The correction factor was calculated as follows:

$FK = \frac{1200}{JRRB}$

Where:
FK = the correction factor value
JRRB = the total monthly average ratio

h. The formula to calculate the fishing season index (FSI) was as follows:

$IMP_i = RRB_i \times FK$

Where:
FSIi = the fishing season index for the *i*-th month

RRBi = the monthly average ratio
FK = the correction factor value
i = 1,2, ... , 12

The classification of FSI values into seasonal categories was based on the FSI index table formulated by **Wiyono (2001)** and **Ihsan *et al*. (2014)**.

Table 1. FSI index categories

FSI value	Season category
< 1 (<100%)	Not a fishing season
1 (=100%)	Normal
> 1 (>100%)	fishing season

The relationship between oceanographic variations and scads fishery production was analyzed using Pearson correlation. This method produces a coefficient that indicates the strength of the association between two variables, assuming that the relationship is linear **(Sekaran, 2010)**. If the obtained *P*-value was less than 0.05, it signified a strong and significant positive relationship between the two variables. In this study, the guideline for interpreting the correlation coefficient values refers to the formulations proposed by **Sugiyono (2010)** and **Pratama *et al*. (2025)**.

Table 2. The interpretation of correlation coefficient values

R- value	Interpretation
0.00-1.199	Very weak
0.20-0.399	Weak
0.40-0.599	Moderate
0.60-0.799	Strong
0.80-1.000	Very strong

RESULTS

Scads production of purse seine landed at Bajomulyo CFP

Production data for scads landed by purse seine fishing gear at the Bajomulyo CFP from January 2020 to December 2024 show significant fluctuations in production from year to year (Fig. 1). These fluctuations may be caused by several factors, including oceanographic conditions, fish stock availability, fishing effort intensity, and external factors, such as fisheries management policies and climate change. Production peaked in early 2020. However, a subsequent decline indicates high fishing pressure or changes in the spatial distribution of the fish stocks.

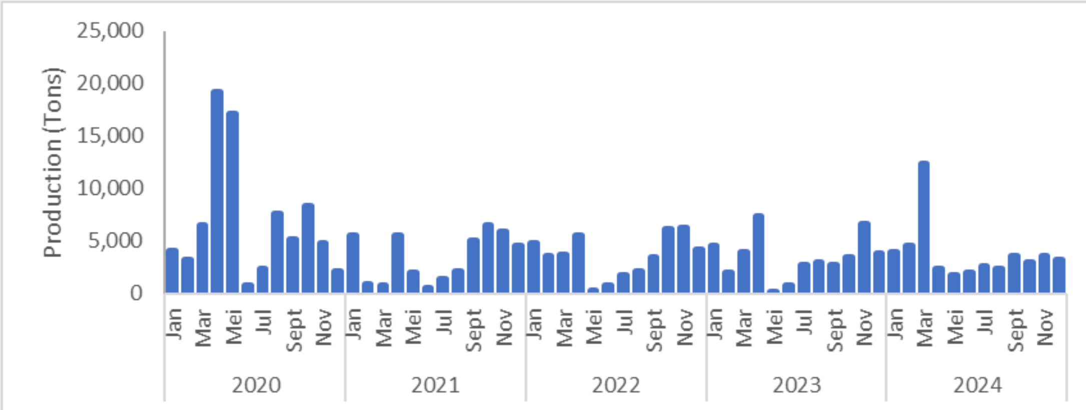

Fig. 1. Scad productions at Bajomulyo CFP (Fishing Ground: Java Sea) year 2020-2024.

Relationship between sea surface temperature (SST) variations and scads production

The distribution of sea surface temperatures from 2020 to 2024 in the Java Sea was approximately 29°C (Fig. 2). The average SST annually was recorded at 29.81°C (2020), 29.51°C (2021), 29.79°C (2022), 29.42°C (2023), and 29.92°C (2024). The highest value occurred in April 2024 at 31.12°C and the lowest occurred in August 2023 (28.18°C). The relationship between SST and scad production at the Bajomulyo CFP is illustrated through a correlation test in Fig. (2). The correlation between sea surface temperature and scad production from 2020 to 2024 was 0.312 (P-value< 0.05). This means that the production of scads landed at Bajomulyo (fishing ground Java Sea) is influenced by sea surface temperature with a low correlation level.

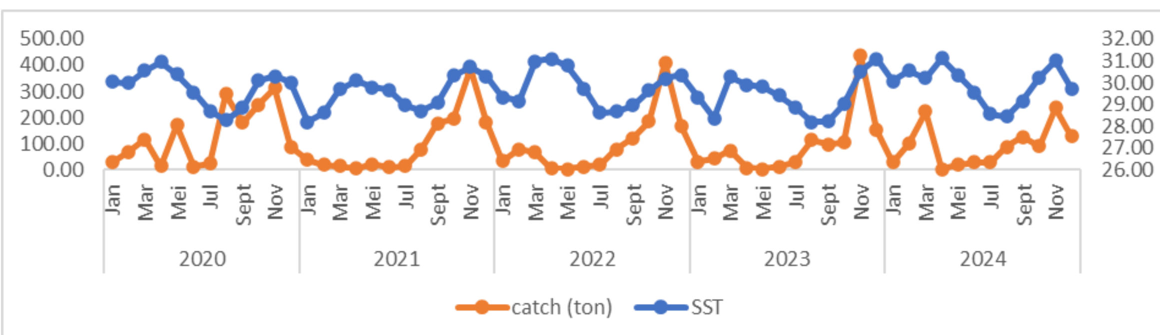

Fig. 2. The relationship between scad production and sea surface temperature in Bajomulyo CFP (Fishing Ground: Java Sea)

Relationship between chlorophyll-a (CHL) variation and scads production

The average chlorophyll-a concentrations (CHL) for the same period was 0.321, 0.320, 0.291, 0.329, and 0.401mg/ m^3, respectively. December 2023 had the lowest chlorophyll-a level; during the 2020-2024 period the lowest level was reached, namely 0.204mg/ m³, whereas in April 2024, the highest chlorophyll-a level was reached, namely 0.699mg/ m³. The correlation value between chlorophyll-a and scads production from 2020 to 2024 was -0.949 (*P*-value > 0.05), which indicates a powerful and significant negative relationship between chlorophyll-a and scads production.

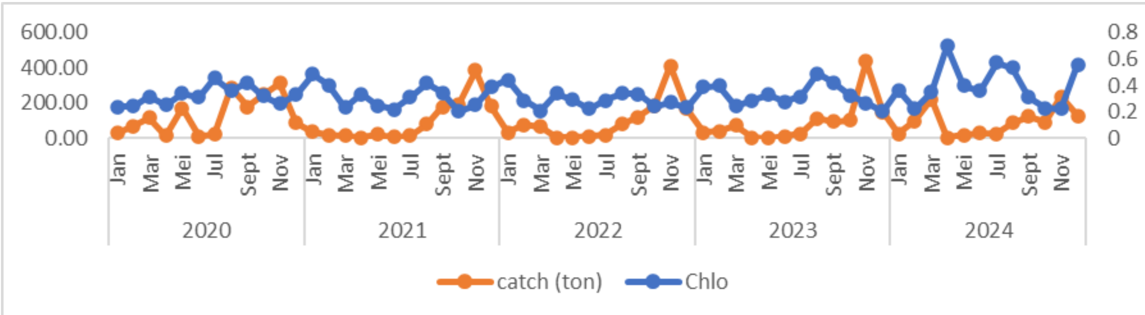

Fig. 3. The relationship between scad production and chlorophyll-a concentrations in Bajomulyo CFP (Fishing Ground: Java Sea)

Scads fishing season

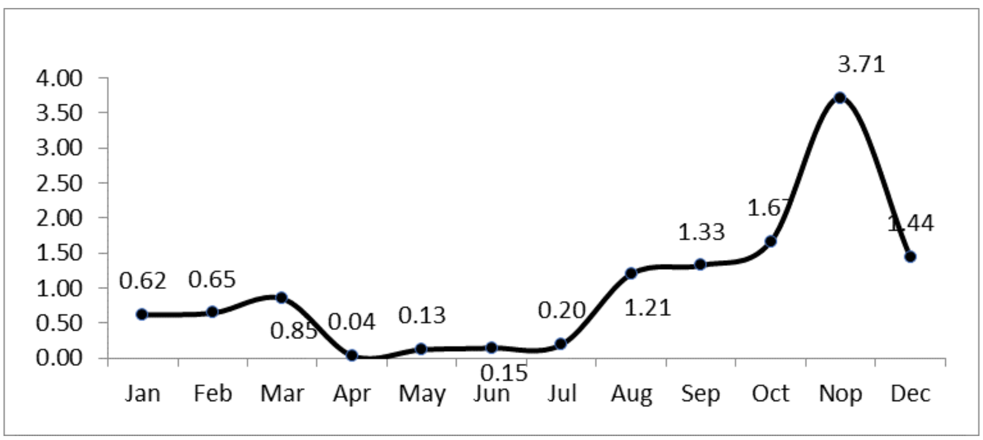

Fig. 4. Scads fishing season index value 2020-2024 in Bajomulyo CFP (Fishing Ground: Java Sea)

The fishing season pattern was illustrated using the fishing season index (FSI) obtained. The seasonal index for scads was greater than 100% during August (1.21), September (1.33), October (1.67), November (3.71), and December (1.44). The fishing season index (FSI) for scads that landed at Bajomulyo values greater than 100% (> 1) were obtained from August to December. This indicates that a fishing season occurred during these months. In other months, the FSI value was less than 100% (< 1), with the lowest FSI value occurring in April, indicating that these months were not the fishing season in the sea.

DISCUSSION

The fishing potential index (FPI) was used as an indicator to determine the optimal timing for fishing activities **(Syahrir *et al*., 2010)**. However, there is a dynamic seasonal fishing pattern that often changes and is not uniform across different waters. This variability is caused by differences in ecosystem characteristics, including the abundance of fish resources related to oceanographic factors, technical specifications of fishing gear and vessels, and intensity of fishing efforts **(Wijayanti *et al*., 2021)**. Oceanographic parameters influence fish life patterns. Oceanographic conditions, especially sea surface temperature and chlorophyll-a content **(Ningsih *et al*. 2021)**, affect the distribution of fish in habitats and represent an indicator of potential fishing grounds and fishing seasons **(Nurani *et al*., 2022)**.

Table 3. Results of the correlation analysis of CHL and SPL on scads production at Bajomulyo CFP (Fishing Ground: Java Sea)

	Scads Production	
CHL	*Pearson correlation (r)*	-0,949
	P-value	0,000
SST	*Pearson correlation (r)*	0,312
	P-value	0,015

Based on the temporal distribution of chlorophyll-a concentrations from 2020 to 2024, there is a pattern in which chlorophyll-a concentrations increase from July. This increase in chlorophyll-a concentration was influenced by the increasing intensity of upwelling in the water. During upwelling, fish populations tend to increase because nutrients from the seabed are brought to the surface, increasing the concentration of phytoplankton, which is the primary food source in these waters **(Tambaru *et al*., 2024)**. Scad fish feed on zooplankton and small fish, and do not directly consume phytoplankton, which is indicated by the presence of chlorophyll-a. Based on this, there will be a time lag between the abundance of chlorophyll-a and the abundance of scad fish **(Siswantoputri *et al*., 2024)**. This time lag is believed to be the factor that causes the scad fishing season to begin in August, even though chlorophyll-a concentrations start to rise in July. This was confirmed by Pearson correlation analysis, which yielded a negative value with a significant *P*-value, indicating that chlorophyll-a concentration has a significant effect on scad fish production (Table 3). In addition, **Ningsih *et al*. (2025)** stated that the Chl-a concentrations above 0.2mg/ m³ indicates the presence of sufficient phytoplankton and the related food web to support commercially viable fisheries operations. This is consistent with the research findings, which indicate that the average of Chl-a concentrations in the Java Sea ranged from 0.204 to 0.699mg/ m³.

It is worthnoting that. sea surface temperature (SST) affects fish catch because it plays a role in the metabolism and reproduction of marine organisms. Scad is remarkably sensitive to changes in temperature, with optimal living temperatures ranging between 29 and 31°C **(Bubun & Mahmud, 2016)**. The correlation between sea surface temperature and *Decapterus* production at Bajomulyo CFP showed a direct pattern, where *Decapterus* catches increased with rising SST (Fig. 3). This condition also correlates with the peak of the *Decapterus* season from to 2020-2024, which occurs in November (Fig. 5). More *Decapterus* species are caught at temperatures of 29– 30°C, matching their natural habitat in warm waters. This species tends to migrate if the water temperature is unsuitable because it is sensitive to temperature changes. These results are consistent with those of **Arleston *et al*. (2016)**, who stated that increases in SST are followed by increased scad catches.

The relation between oceanographic dynamics and scads (*Decapterus* spp.) abundance reflects the linkage between environmental variability and fishing seasonality. Understanding these temporal patterns is fundamental for optimizing fishing operations, as aligning fishing efforts with favorable environmental conditions can improve catch efficiency and reduce operational costs for fishers **(Ridwan *et al*., 2022)**. Moreover, integrating environmental indicators into fisheries planning supports scads fish sustainability by implementing limited fishing effort during less productive seasons (FSI < 1). Therefore, scads fishing activities in the Java Sea would be more efficient if they are adjusted to periods when the FSI > 1, while also considering the time lag observed between scads production and chlorophyll-a concentration as indicated by the research findings (Table 3). Therefore, sustainable management strategies for scads fisheries in Java Sea can be achieved.

CONCLUSION

Sea surface temperatures fluctuated between 28 and 31°C from 2020 to 2024 in the Java Sea. The chlorophyll-a concentrations also fluctuated during the same period, ranging from 0.204 to 0.7 mg/m³. The results of the correlation analysis indicated a significant negative relationship between Chl-a and scad fish production (r = -0.949, *P*-value < 0.05). In contrast, sea surface temperature showed a weak correlation with scad fish production (r = 0.312, *P*-value > 0.05). Scad fishing activities at the Bajomulyo Coastal Fishing Port (Fishing ground Java Sea) were most intense between August and December, with the fishing season index (FSI) exceeding 100% (FSI > 1) during that period. The management strategy for scads (*Decapterus* spp.) fisheries in the Java Sea is recommended to implement limited fishing effort during less productive seasons (FSI < 1) to ensure the sustainability of scads fish.

ACKNOWLEDGMENT

The authors thank the Faculty of Fisheries and Marine Science, Universitas Diponegoro, Indonesia and the staff of Bajomulyo Coastal Fishing Port for providing support to this research.

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