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MONITORING OF THE FISHING SEASON PATTERN OF ANCHOVY (*Stolephorus* spp.) BASED ON OCEANOGRAPHIC CONDITION IN BONE GULF, INDONESIA

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ABSTRACT

Anchovy (*Stolephorus* spp.) is one of the small pelagic fish resources that plays an important role in supporting capture fisheries and the economy of coastal communities. Anchovy production in the waters of the Gulf of Bone shows fluctuations influenced by seasonal factors; therefore, information on fishing season patterns is needed to improve the efficiency and sustainability of fish resource utilization. This study aims to analyze the fishing season pattern of anchovy based on Catch Per Unit Effort (CPUE) values and the Fishing Season Index (FSI). This study used monthly anchovy catch production and fishing effort data obtained from the Lonrae Fish Landing Base, Bone Regency, South Sulawesi, from January 2020 to December 2024, consisting of 60 monthly observations. SST and chlorophyll-a data derived from Aqua MODIS satellite imagery were used as supporting oceanographic data. The analysis was carried out using a time-series method with moving average approach to obtain monhtly FSI values. The results showed that the anchovy fishing season occured in two main phases, namely February – April with an FSI value of 122.62%, while the second and highest peak occured in October with an FSI value of 75.65%. This fishing season pattern is related to monsoon dynamics and the oceanographyc conditions of the Gulf of Bone waters. The resulting fishing season information can be used as a basis for planning fidhing operation and supporting sustainable anchovy fishieris management.

Keywords: anchovy, chlorophyll-a, CPUE, fishing season index, Gulf of Bone, sea surface temperature.

INTRODUCTION

Anchovy (*Stolephorus* spp.) is one of the small pelagic fish species with high economic value and an important role in supporting capture fisheries activities in Indonesia's coastal waters (Aditya et al., 2017; Arifin et al., 2020; Karuwal, 2019). Anchovy is widely consumed by coastal communities and is also used as raw material for fishery-based products. However, the availability of anchovy in nature fluctuates throughout the year because its abundance and distribution are strongly influenced by seasonal and environmental conditions, including monsoon dynamics, sea surface temperature, chlorophyll-a concentration, and primary productivity (Karuwal, 2019; Safruddin & Zainuddin, 2018; Safruddin et al., 2017)).

The Gulf of Bone is one the important marine areas in Sulawesi that supports small

pelagic fisheries, including anchovy fisheries. Scientifically, the Gulf of Bone is important because it is a semi-enclosed marine area influenced by monsoon-driven oceanographic variability and coastal processes. These conditions affect sea surface temperature, chlorophyll-a concentration, primary productivity, and the distribution of small pelagic fish. Therefore, the Gulf of Bone provides an important natural setting for studying the relationship between seasonal oceanographic variability and anchovy fishing season patterns.

Anchovy fishing activities in the Gulf of Bone are carried out almost throughout the year. However, the catch obtained by fishers is not always stable. Differences in catch production and fishing effort indicate that anchovy availability may follow a seasonal pattern. Without accurate information on fishing seasons, fishers may conduct fishing operations during less productive periods, resulting in low fishing efficiency and higher operational costs. Therefore, information on fishing season patterns is needed to support more effective and sustainable fishing activities.

The estimation of fish fishing seasons is one of the important approaches in capture fisheries management. Fishing season analysis can be carried out using catch per unit effort (CPUE) data, which reflects the relative abundance of fish resources in relation to fishing effort. One of the commonly used methods is the Fishing Season Index (FSI), which is able to describe peak season periods, fishing seasons, and lean seasons based on time-series data. This information is very useful as a basis for decision-making in planning fishing time that is more effective and sustainable (Gulland, 1983; Paendong et al., 2014; Prihantoko & Boesono, 2019).

Several Previous studies have examined anchovy fishing seasons in several Indonesian waters and the relationship between anchovy catches and oceanographic parameters such as sea surface temperature and chlorophyll-a. Other studies have also discussed small pelagic fisheries and potential fishing grounds in the Gulf of Bone (Safruddin et al., 2017; Safruddin & Zainuddin, 2018; Rumpa et al., 2021). However, specific information on the monthly fishing season pattern of anchovy in the Gulf of Bone based on recent multi-year CPUE data remains limited. In addition, the integration of CPUE-based Fishing Season Index analysis with SST and chlorophyll-a interpretation to explain peak and lean fishing seasons in this area has not been widely reported.

The novelty of this study lies in the use

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of five-year monthly time-series data from 2020 to 2024 to identify anchovy fishing season patterns in the Gulf of Bone using CPUE and FSI analyses, supported by the interpretation of SST and chlorophyll-a variability. Therefore, this study aimed to determine monthly anchovy fishing season patterns using CPUE and FSI analyses and to interpret their relationship with SST and chlorophyll-a variability in the Gulf of Bone waters. The results of this study are expected to provide scientific information and practical guidance for fishers, fisheries managers, and related stakeholders in supporting more efficient and sustainable anchovy fisheries management.

MATERIALS AND METHODS

Study Area and Research period

This study was conducted in the Gulf of Bone waters, with anchovy landing data obtained from the Lonrae Fish Landing Base, Bone Regency, South Sulawesi. Field observation and supporting data collection were conducted from September to December 2024. However, the fshery data analyzed in this study covered a five year period from January 2020 to December 2024. Thus this study used monthly time-series dat consisting of 60 monthly observation. (Figure 1).

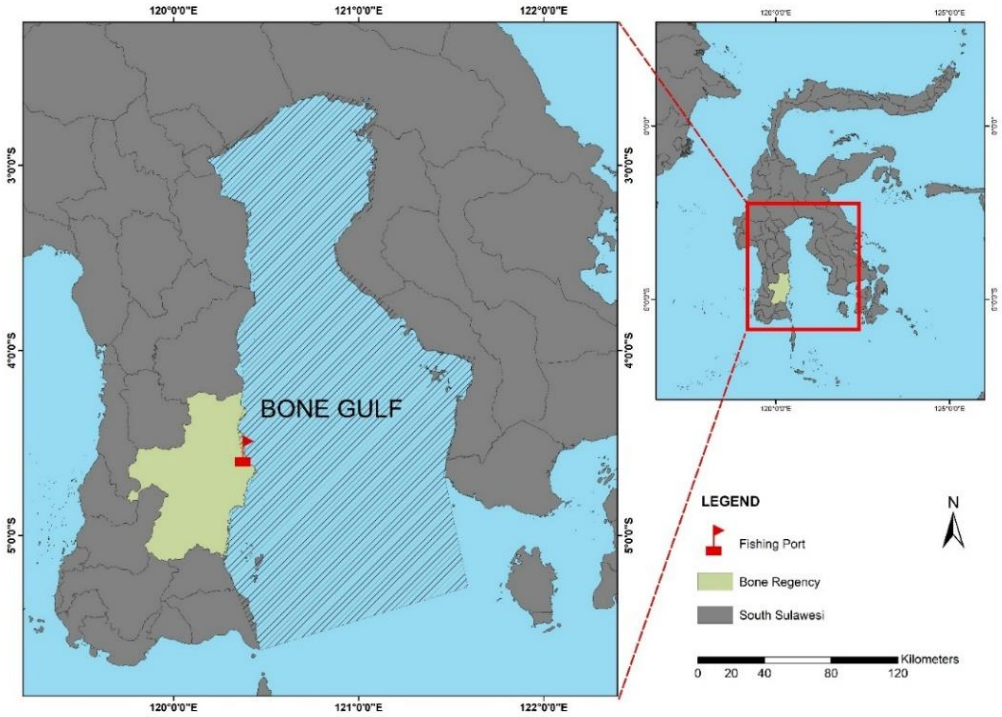

Figure 1. Map of the Study Area

Fishery Data Collection

The data used in this study consisted of

primary and secondary data. Secondary data included monthly anchovy (*Stolephorus* spp.) catch production and fishing effort data recorded at the Lonrae Fish Landing Base during the 2020–2024 period. Fishing effort was expressed as the number of fishing trips per month. Primary data were collected through interviews with fishers around the Lonrae Fish Landing Base to obtain supporting information related to fishing activities, fishing grounds, and seasonal catch conditions.

Satellite Data Imagery Collection

Oceanographic data were used as supporting data to interpret the anchovy fishing season pattern. Sea surface temperature (SST) and chlorophyll-a concentration data were obtained from Aqua MODIS satellite imagery through the OceanColor data portal. The data were processed as monthly composite data with a spatial resolution of approximately 1 km. SST and chlorophyll-a distributions were analyzed to describe oceanographic conditions during peak and lean fishing seasons. These parameters were selected because SST influences fish distribution and physiological activity, while chlorophyll-a represents phytoplankton abundance and primary productivity, which are related to food availability for small pelagic fish

CPUE Analysis

Catch Per Unit Effort (CPUE) analysis was used to describe the productivity of anchovy catches relative to fishing effort (Gulland, 1983). CPUE values were calculated for each month during the study period using the following. Equation:

$$CPUE_i = \frac{C_i}{F_i}$$

Where $CPUE_i$ is the catch per unit effort in the *i*-th month (kg/trip), C_i is the total anchovy catch (kg), and F_i is the number of fishing trips in the *i*-th month. The monthly CPUE values were then used as the basis for the fishing season analysis.

Fishing Season Index (FSI) Analysis

The Fishing Season Index (FSI) was used to determine the monthly fishing season pattern of anchovy. The analysis was conducted using a time-series approach based on monthly CPUE data. A moving average method was applied to reduce random fluctuations and obtain a more stable seasonal pattern.

The general steps of the FSI analysis were as follows. First, monthly CPUE values were arranged sequentially from January 2020 to December 2024. Second, moving average values were calculated to smooth the CPUE time series. Third, centered moving average values were obtained to represent the trend

component. Fourth, the ratio between monthly CPUE and centered moving average was calculated to obtain seasonal values. Fifth, seasonal values for the same month across the study years were averaged. Finally, the values were adjusted so that the annual average index equaled 100%.

The Fishing Season Indeks was calculated using the following equation:

$$FSIi \frac{CPUEi}{CMAi} \times 100$$

Where FSIi is the fishing season index in month I, CPUEi is the monthly catch per unit effort, and CMAi is the centered moving average value in month i. Month FSI values greater than 100 % were categorized as fishing seasona periods, while months with FSI values below 100 % were categorised as learn or off-season periods.

RESULTS AND DISCUSSION

Catch per Unit Effort (CPUE) Pattern of Anchovy

The CPUE analysis showed that anchovy (*Stolephorus* spp.) catches in the Gulf of Bone varied among months during the 2020–2024 period. CPUE tended to increase at the beginning of the year, particularly from February to April. After this period, CPUE gradually decreased from May to August. CPUE then increased again from September and reached its highest level in October, before declining toward the end of the year. This pattern indicates that anchovy fishing productivity in the Gulf of Bone is seasonal and not evenly distributed throughout the year.

The increase in CPUE during February–April and September–November suggests that these periods provide more favorable conditions for anchovy aggregation and availability in the fishing ground. In contrast, the decline in CPUE during June–August indicates a less productive period for anchovy fishing. Similar seasonal fluctuations in anchovy catch productivity have been reported in other Indonesian waters, where catch variation was associated with changes in environmental conditions such as SST, chlorophyll-a concentration, and seasonal oceanographic dynamics (Arifin et al., 2020; Prihantoko & Boesono, 2019; Hastuti et al., 2021). Therefore, the CPUE pattern observed in this study supports the view that small pelagic fisheries are strongly influenced by seasonal environmental variability. The monthly CPUE pattern is presented in Figure 2.

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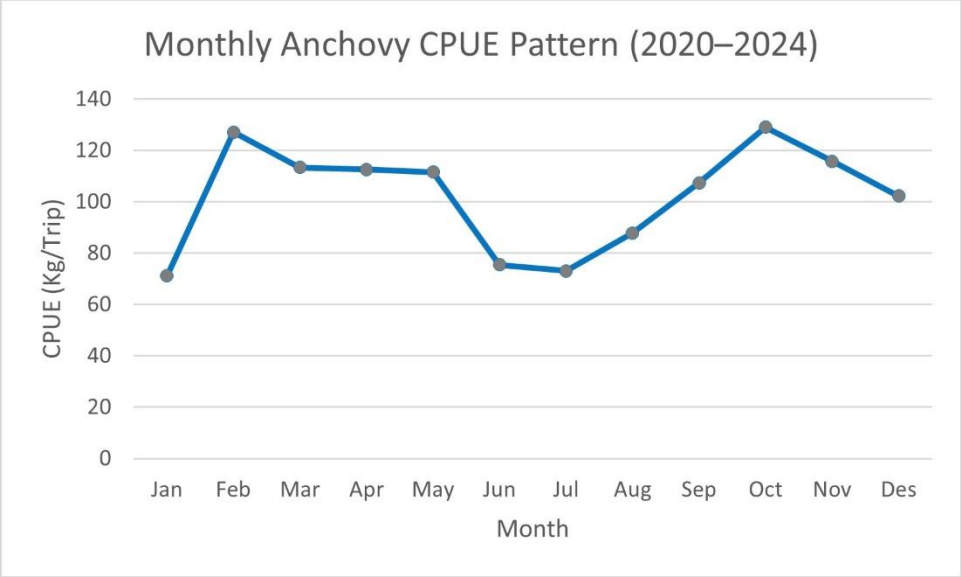

Figure 2. Catch per Unit Effort

Fishing Season Index (FSI) of Anchovy

Based on the Fishing Season Index analysis, the FSI values of anchovy in the Gulf of Bone ranged from 75.65% to 125.65%. Months with FSI values greater than 100% were categorized as fishing season periods, while months with FSI values below 100% were categorized as lean seasons. The analysis identified two main anchovy fishing season periods. The first fishing season occurred from February to April, with a peak in April at an FSI value of 122.62%. The second fishing season occurred from September to November, with the highest peak in October at an FSI value of 125.65%. The lowest FSI value occurred in July at 75.65%, indicating the main lean season.

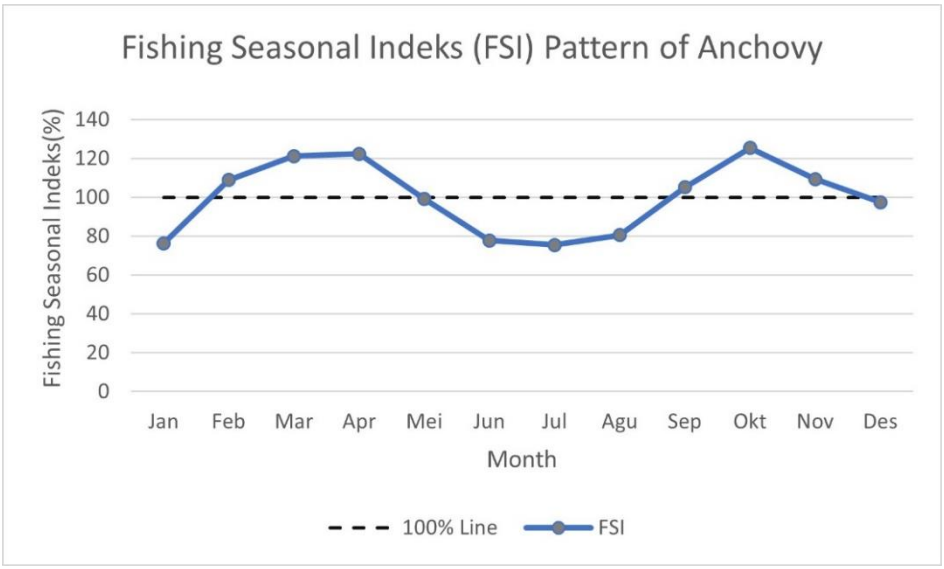

Figure 3. Fishing Seasonal Indeks

This seasonal pattern shows that anchovy availability in the Gulf of Bone is influenced by temporal environmental dynamics. The occurrence of two fishing season peaks suggests that anchovy may respond to transitional or favorable oceanographic conditions during specific months. The higher FSI value in October indicates that this month represents the most productive period for anchovy fishing during the study period. This information is important for fishers because fishing activities can be prioritized during high-index months to improve catch efficiency and reduce operational costs during less productive periods.

Compared with previous studies, the results of this study are consistent with the general pattern that anchovy and other small pelagic fish show seasonal catch fluctuations. Arifin et al. (2020) reported that anchovy fishing season patterns in Madura waters were influenced by fishing effort and seasonal conditions. Prihantoko and Boesono (2019) also showed that anchovy fishing season varies by month in coastal waters and is related to fishing ground dynamics. However, the specific peak months found in the Gulf of Bone differ from those in other regions, indicating that anchovy seasonality is strongly controlled by local oceanographic characteristics.

Oceanographic Conditions

Oceanographic conditions provide supporting information for interpreting the anchovy fishing season pattern. During the peak fishing season in October 2024, SST in the Gulf of Bone ranged from 28.4 to 34.7 °C, while chlorophyll-a concentration ranged from 0.15 to 1.9 mg/m^3. Relatively suitable SST and sufficient chlorophyll-a concentration may support biological productivity and food availability in the waters. Chlorophyll-a is an indicator of phytoplankton abundance, which forms the base of the marine food web and supports zooplankton availability as food for anchovy

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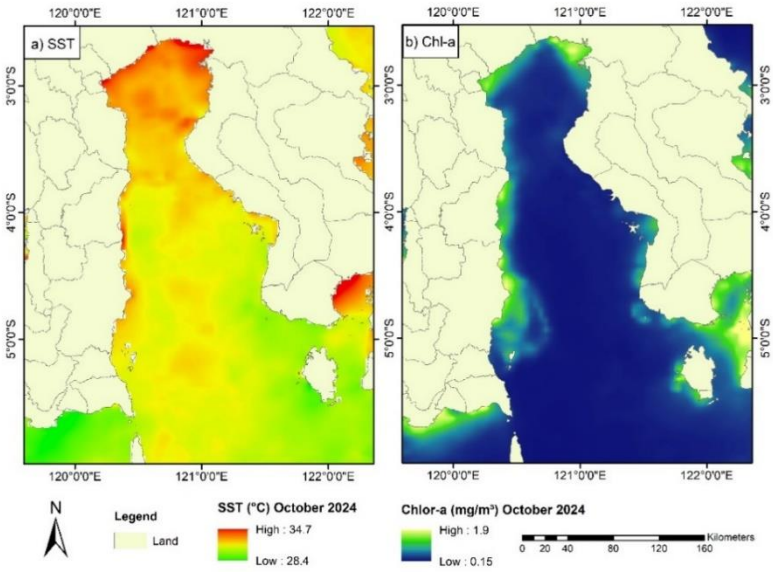

Figure 4. Oceanographic Conditions During the Peak Anchovy Fishing Season in 2024

The high FSI value in October coincided with relatively higher chlorophyll-a concentrations in coastal areas and several parts of the Gulf of Bone. This condition suggests that increased primary productivity may contribute to higher anchovy abundance or aggregation in fishing areas. Previous studies have also shown that anchovy catch distribution is associated with SST and chlorophyll-a variability (Firmansyah et al., 2023; Hastuti et al., 2021; Kristiyani et al., 2020; Sari et al., 2019). Therefore, the high CPUE and FSI values during the peak fishing season in this study may be linked to favorable oceanographic conditions that support anchovy feeding and aggregation.

During the June–August period, FSI values were below 100%, with the lowest value occurring in July. This period may reflect less favorable environmental conditions for anchovy availability in the fishing ground. Changes in SST, chlorophyll-a concentration, water mass movement, and monsoon-driven circulation may influence the distribution of anchovy and reduce catchability. This finding emphasizes the importance of integrating fishery data and satellite-derived oceanographic information to better understand the seasonal dynamics of anchovy fisheries in the Gulf of Bone.

Overall, the results indicate that the anchovy fishing season in the Gulf of Bone occurs in two main periods, with the highest fishing season in October. The relationship between FSI, SST, and chlorophyll-a suggests that anchovy fishing productivity is not only

affected by fishing effort but also by environmental conditions. These findings can be used to support fishing operation planning, especially by directing fishing activities to productive months and reducing fishing effort during lean months.

CONCLUSION

The anchovy (*Stolephorus* spp.) fishing season in the Gulf of Bone showed a clear monthly pattern based on CPUE and FSI analyses during the 2020–2024 period. The FSI values ranged from 75.65% to 125.65%. The fishing season occurred in two main periods, namely February–April and September–November. The first peak occurred in April with an FSI value of 122.62%, while the second and highest peak occurred in October with an FSI value of 125.65%. The lean season occurred in July, indicated by the lowest FSI value of 75.65%. The peak fishing season was associated with relatively suitable SST and higher chlorophyll-a concentration, indicating favorable environmental conditions for anchovy availability. These results provide practical guidance for fishers to plan fishing operations during productive months and support fisheries managers in developing seasonal management strategies for sustainable anchovy fisheries in the Gulf of Bone.

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