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# DYNAMICS OF SQUID FISHERIES BASED ON THE SUNGAILIAT NUSANTARA FISHING PORT, BANGKA BELITUNG PROVINCE

# DINAMIKA PERIKANAN CUMI-CUMI YANG BERBASIS DI PELABUHAN PERIKANAN NUSANTARA SUNGAILIAT, PROVINSI BANGKA BELITUNG

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## ABSTRACT

The Nusantara Fishing Port (NFP) in Sungailiat is one of the landing sites for squid catches, with production tending to decline in the 2017–2021 period. The decline in squid production is thought to be influenced by exploitation pressure, climate change, and marine tin mining activities. The sustainability of squid is threatened, given their high sensitivity to changes in water conditions. The study aims to describe squid fishing gear at Sungailiat NFP and analyze the ecological dynamics of squid fisheries in the waters of Bangka Belitung during the period 2017–2021. Fishing unit data were obtained through observation and interviews with fishermen, while oceanographic data were obtained from remote sensing imagery. Data analysis included descriptive analysis, CPUE analysis, fishing season index analysis, and temporal analysis. The results showed that the main fishing gear used for squid in the Sungailiat NFP was handline, dominated by fishing boats ≤ 5 GT. The average CPUE value was higher in the east monsoon season than in the west monsoon season. The peak fishing season occurred from August to November. Chlorophyll-a distribution was higher during the eastern season, sea surface temperature was relatively warm during the eastern season until the transition, and salinity was within the optimal range (± 31.5–33.0 PSU). The interaction between oceanographic factors and the fishing season affects the dynamics of squid catches in the waters of Bangka Belitung.

Keywords: catch per unit effort, fishing season, oceanographic parameters, squid, temporal distribution

## ABSTRAK

Pelabuhan Perikanan Nusantara (PPN) Sungailiat sebagai salah satu lokasi pendaratan hasil tangkapan cumi-cumi dengan produksi cenderung menurun pada periode 2017–2021. Penurunan produksi cumi-cumi diduga dipengaruhi oleh tekanan eksploitasi, perubahan iklim, dan aktivitas penambangan timah laut. Keberlanjutan cumi-cumi dapat terancam mengingat tingginya sensitivitas cumi-cumi terhadap perubahan kondisi perairan. Penelitian bertujuan mendeskripsikan alat penangkapan cumi-cumi di PPN Sungailiat dan menganalisis dinamika ekologi perikanan cumi-cumi di perairan Bangka Belitung periode 2017–2021. Data unit penangkapan diperoleh melalui observasi dan wawancara nelayan, sedangkan data oseanografi diperoleh dari citra penginderaan jauh (*remote sensing*). Analisis data meliputi analisis deskriptif, analisis CPUE, analisis indeks musim penangkapan, dan analisis temporal. Hasil penelitian menunjukkan bahwa alat tangkap utama cumi-cumi di PPN Sungailiat adalah pancing ulur yang didominasi kapal berukuran ≤ 5 GT. Rata-rata nilai CPUE lebih tinggi pada musim timur dibandingkan musim barat. Musim puncak penangkapan terjadi pada bulan Agustus–November. Distribusi klorofil-a lebih tinggi saat musim timur, suhu permukaan laut relatif hangat pada musim timur hingga peralihan, dan salinitas berada pada kisaran optimal (± 31,5–33,0 PSU). Interaksi antara faktor oseanografi dan musim penangkapan memengaruhi dinamika hasil tangkapan cumi-cumi di perairan Bangka Belitung.

Kata kunci: cumi-cumi, CPUE, distribusi temporal, musim penangkapan, parameter oseanografi

## INTRODUCTION

Squid (*Loligo* sp.) ranks sixth as a leading export commodity in the Bangka Belitung Islands Province (Wiadnyana *et al.* 2022). The export value of Bangka squid increased by around 14.7% to reach 330 million USD during 2019–2021 (Marine and Fisheries Service of the Bangka Belitung Islands Province 2022). Until the end of 2025, squid will remain one of Bangka Belitung's leading fishery export commodities, alongside whiteleg shrimp, giant catfish, grey eel-catfish, and yellowtail (Tribunnews Bangka 2025). The export volume of frozen squid reached 89.5 tons in August 2025 (Bangka Belitung Province Fish Quarantine Office 2025), and this commodity still has high economic value as a fishery export commodity in Bangka Belitung.

The export value of Bangka squid indeed shows an increasing trend. However, there are indications of a declining squid population in the waters of Bangka (Marine and Fisheries Service of the Bangka Belitung Islands Province 2022). This condition can occur because an increase in export value does not always reflect the condition of the resource stock, but is also influenced by market price dynamics. This is reflected in the increase in the average export price of Bangka squid during the period 2019–2021, from around USD 4.02/kg to USD 5.17/kg (Data Portal of the Ministry of Marine Affairs and Fisheries 2025).

One of the landing locations for squid catches in Bangka Belitung waters is the Sungailiat Nusantara Fisheries Port (NFP). Squid production landed at the Sungailiat NFP over the five years (2017–2021) exhibited a dynamic pattern. Squid production increased from 2017 to 2019, then declined in 2020, and then showed an upward trend again in 2021 (Sungailiat NFP operational data for 2016–2021). The highest average squid production was in 2017, at 30,609 kg, while the lowest average production was in 2019, at around 12,827 kg.

Currently, although Bangka squid is known as a superior commodity, several studies have shown that squid populations in Bangka waters are declining due to exploitation pressure, climate change, and offshore tin mining activities (Kurniawan *et al.* 2014; Oktariza *et al.* 2014; Bidayani and Kurniawan 2020; Rema *et al.* 2025). Waste (tailings) from offshore tin mining activities has the potential to directly or indirectly put pressure on water quality. Dynamic changes in aquatic environmental conditions can affect the distribution and abundance of squid.

Squid are highly sensitive to changes in oceanographic parameters such as sea surface temperature, salinity, and aquatic productivity (Alabia *et al.* 2016; Yu *et al.* 2018; Marcout *et al.* 2024; Feng *et al.* 2025). Information on the interactions of oceanographic parameter variability is essential for understanding squid responses to environmental change. Kim *et al.* (2025) emphasized that research incorporating a broader range of environmental variables could increase ecological relevance to support future squid fishery management.

Research on squid fishery dynamics integrated with comprehensive oceanographic parameter variations is still limited. Previous studies have focused solely on fishing seasons (Rosalina *et al.* 2011; Febrianto *et al.* 2017; Rema *et al.* 2025), while others have focused on squid stock sizes and production (Oktariza *et al.* 2014; Oktariza *et al.* 2016). Therefore, the research aims to (1) describe the squid fishing gear used by fishermen in Sungailiat NFP and (2) analyze the ecological dynamics of squid fisheries in Bangka Belitung waters for the 2017–2021 period through monthly catch per unit effort (CPUE) analysis, calculation of the fishing season index (FSI), and temporal analysis of water oceanographic parameters. The research results are expected to be useful for the government in developing better strategies or policies to realize more sustainable squid fisheries.

## METHODS

### Time and location

The research was located at Sungailiat Nusantara Fishing Port (NFP), Bangka Regency, Bangka Belitung Province (Figure 1), and was conducted in October–December 2025. The research was conducted in two stages, namely, Stage 1, which is primary data collection to describe squid fishing gear located at Sungailiat NFP, and Stage 2, which is data processing to analyze the dynamics of aquatic ecology in the waters of Bangka Belitung.

### Data collection and processing procedures

Data on fishing gear types, specifications, and operating methods were used to describe the squid fishing units in Sungailiat Fishing Port. Data were collected through observation and interviews with fishermen landing squid catches in Sungailiat Fishing Port. Respondents were selected using an accidental sampling method (sampling based on fishermen's availability and willingness at the time of the study). A total of 30 squid fishermen were interviewed.

Data used to analyze the ecological dynamics of squid fisheries included squid production and fishing effort in Sungailiat Fishing Port (2017–2021) from Sungailiat Fishing Port operational documents, as well as oceanographic parameter data (chlorophyll-a concentration, sea surface temperature (SST), and salinity) for the 2017–2021 period obtained through remote sensing.

Squid production and fishing effort data were tabulated annually and monthly as the basis for calculating CPUE analysis and FSI calculations. Oceanographic parameter data were obtained from the Marine Copernicus website (data.marine.copernicus.eu/) with a spatial resolution of 0.25°×0.25°. The territorial waters encompass the entire territorial waters of Bangka Belitung Province with boundaries at 104°50’ to 109°30’ East Longitude and 0°50’ to 4°10’ South Latitude. Files were downloaded in file format (.nc) according to the territorial waters boundaries. The files (.nc) were then processed using SeaDAS 8.3.0 software to extract oceanographic parameter values in the study area. The processing process included the stage of cutting the area and converting the data to text format (.txt). The extracted data were then processed using Microsoft Excel to remove invalid values (Not a Number/NaN). The output of oceanographic parameter data is presented in the form of a monthly temporal distribution boxplot graph to illustrate the seasonal variations of chlorophyll-a, SST, and salinity in the research area.

**Data analysis**

*Describe the squid fishing unit*

Descriptive analysis was used to explain the squid fishing unit at Sungailiat NFP. Information is presented in narrative form, images, and graphs.

*Analyzing monthly CPUE dynamics and seasonal patterns of squid fishing*

CPUE analysis and the moving average method were used to determine the squid fishing season index in Sungailiat NFP (Wiyono 2001; Wijayanti et al. 2021).

$$CPUE = \frac{Catch}{Effort}$$

Description:
*CPUE* = Catch per unit effort (kg/trip)
*Catch* = Total catch (kg)
*Effort* = Total fishing effort (trip)

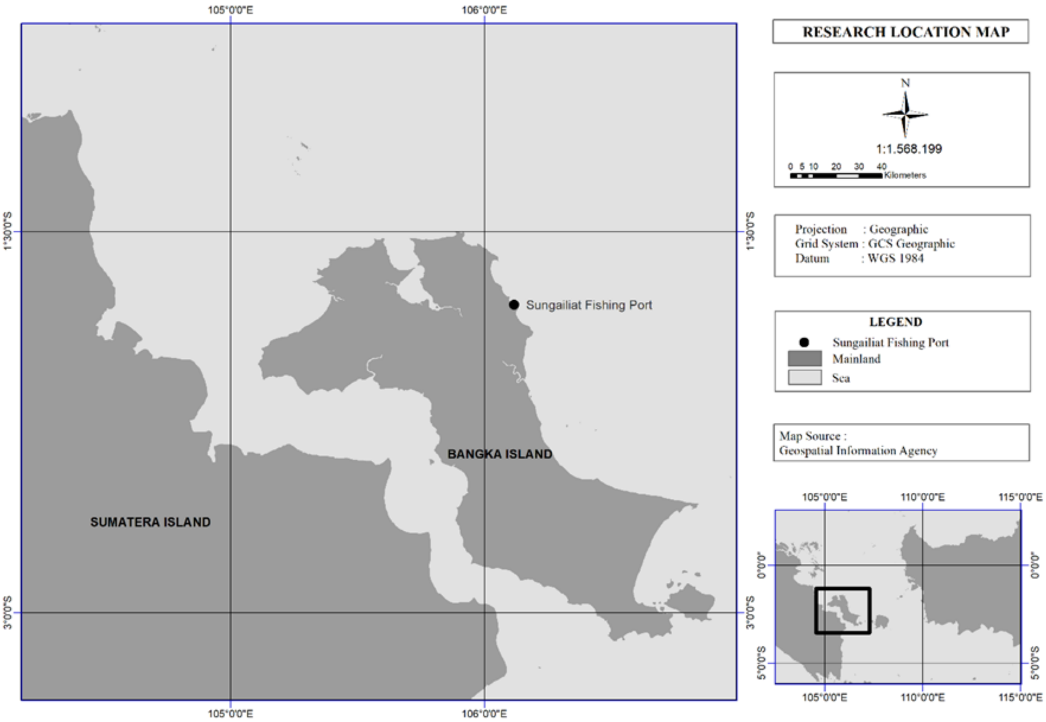


Figure 1. Research location at Sungailiat Nusantara Fishing Port, Bangka Regency, Bangka Belitung Province.

*Fishing season index*

a. Compile a series of CPUEi from January 2017 to December 2021

$$Ni = CPUEi$$

$i$ = Month sequence (1, 2, 3, ..., 60)
*Ni* = CPUE sequence-$i$

b. Compile a moving average (MA) of CPUE for 12 months

$$MA_i = \frac{1}{12}\left[\sum_{i=1-6}^{i+5} CPUE_i\right]$$

*MAi* = 12-month moving average sequence-$i$
*CPUEi* = CPUE sequence-$i$
$i$ = 7, 8, ..., n–5

c. Constructing a centered CPUE moving average (MAC)

$$MAC_i = \frac{1}{2}\left[\sum_{i=i}^{i=1} MA_i\right]$$

*MACi* = Moving average of centered CPUE sequence-$i$
*MAi* = Moving average of 12-month sequence-$i$

d. Monthly Average ratio (MAR)

$$MAR = \frac{CPUE_i}{MAC_i}$$

*MAR* = Average ratio of the i-th month
*CPUEi* = CPUE sequence-$i$
$i$ = 7, 8, ..., n–5

e. Monthly average ratio amount (ARSM)

$$ARSM = \left(\sum_{j-1}^{12} ARSM_i\right)$$

*ARSM* = Average ratio of the month
*ARSMi* = Average MAR *ij* for the month to-$i$
$i$ = 1, 2, 3, ..., 12

f. Total of the month average ratio (TMAR)

$$TMAR = \sum_{i=1}^{12} ARMS_i$$

*TMAR* = Total month average ratio
*ARMSi* = Average ratio for sequence month-$i$
$i$ = 1, 2, ..., 12

g. Calculating the correction factor

$$CF = \frac{1200}{TMAR}$$

*CF* = Correction factor value
*TMAR* = Total Monthly Average Ratio

h. Fishing season index /FSI

$$FSIi = ARSMi \times CF$$

*FSIi* = Monthly fishing season index-$i$
*ARSMi* = Average ratio for monthly to-$i$
$i$ = 1,2,3, ..., 12

According to Batubara *et al.* (2022), the fishing season can be categorized into three seasons: the lean season, the moderate season, and the peak season (Table 1).

*Temporal distribution analysis of oceanographic parameters*

Temporal distribution analysis used monthly boxplots to illustrate variations in chlorophyll-a concentration, SST, and salinity during the period 2017–2021. The boxplots present the median, lower quartile (Q1), upper quartile (Q3), minimum and maximum values, and outliers for each oceanographic parameter.

## RESULTS AND DISCUSSION

### Squid fishing gear

Handlines were the dominant fishing gear used by fishermen in Sungailiat NFP to catch squid. The number of handlines was recorded as the highest compared to other fishing gear during the 2016–2021 period, based on operational data from Sungailiat NFP (Figure 2). Tampubolon *et al.* (2022) and Wiadnyana *et al.* (2022) reported that handlines are a common fishing gear used by fishermen in Bangka waters to catch squid. Fishermen's preference for handlines is related to their relatively simple and easy-to-operate characteristics. Shadiqin *et al.* (2019) and Noor *et al.* (2020) stated that handlines are inexpensive, have a simple construction, and are easy to operate.

The characteristics of handline are in line with the characteristics of the fishing boat in Sungailiat NFP, which is generally dominated by fishing boats under 5 GT (Figure 3). The fishing boats under 5 GT accounted for almost 87.06% of the total number of fishing boats above 5 GT during the 2005–2021 period. The choice of handline is considered appropriate for the needs of small-scale fishermen, as they require simple and easy-to-operate fishing gear.

Table 1. Fishing season categories based on fishing season index (FSI) values.

| FSI Values | Categories/Seasons |
|---|---|
| <50% | Lean season |
| 50% ≤ FSI < 100% | Medium season |
| ≥ 100% | Peak season |

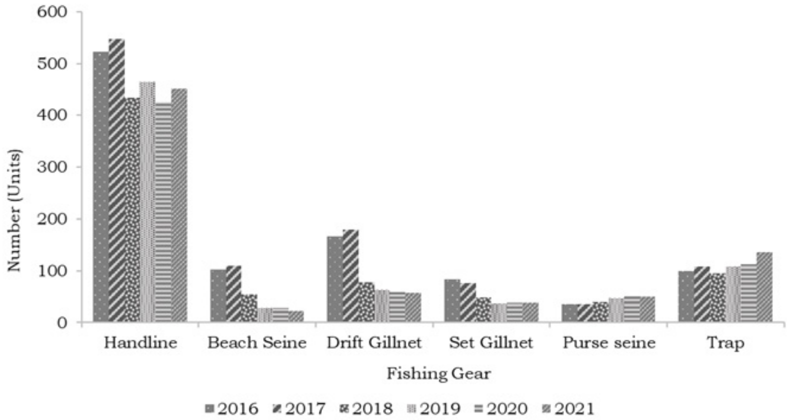


Figure 2. Distribution of types and number of fishing gear in Sungailiat NFP for the period 2016–2021.

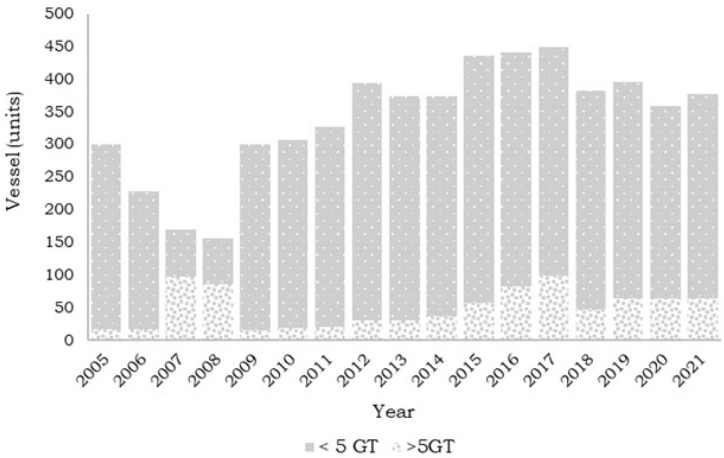


Figure 3. Distribution of the number of fishing boats measuring < 5 GT and > 5 GT at Sungailiat NFP.

An illustration of the handline construction used by fishermen at Sungailiat Fishing Port is presented in Figure 4. The handline construction consists of a plastic reel, main line, swivel, sinker, and float. The reel is used to wind the main line. The main line serves as the attachment point for the swivel, sinker, and hook. The sinker is made of iron and tin. The swivel prevents tangles in the line during the reeling process, thus preventing fishing activities from being hampered (Andela *et al.* 2021).

Handline fishing operations are relatively simple. One reel of line typically contains 3–5 hooks and is held directly by the fisherman from the boat. The line is then lowered into the water, and the fisherman waits for the line's response. If the line vibrates or moves, it is immediately pulled aboard (Andela *et al.* 2021).

Puspito (2009) and Luasunaung and Reppie (2016) explain that there are two methods of handline fishing: with bait and without bait. Based on interviews, fishermen in the Sungailiat NFP predominantly use artificial bait (Figure 5). Reza *et al.* (2019) also confirmed that fishermen in Bangka waters prefer using artificial bait because it is cheaper than natural bait. The artificial bait used by fishermen in the Sungailiat Fishing Village is known as ”candak”. The ”candak” comes in various shapes, such as bottles (oval), shrimp, and fish.

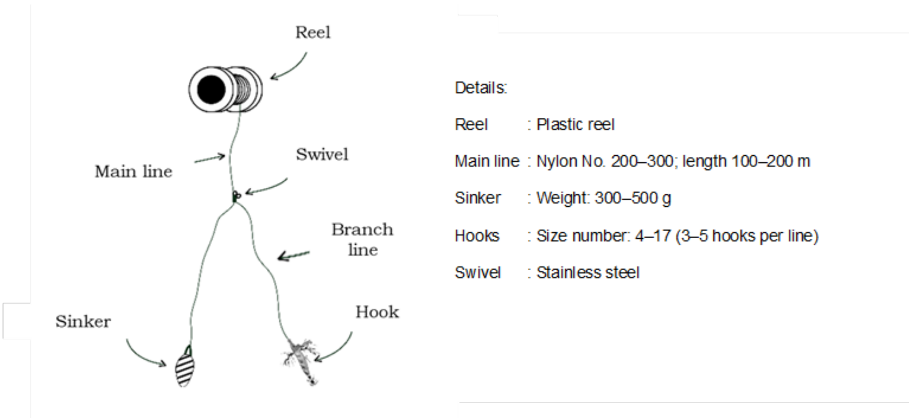


Figure 4. Squid handline construction for fishermen at Sungailiat NFP (Source: Primary data from field documentation, illustrated by the author).

Figure 5. Artificial bait used by fishermen from Sungailiat Nusantara Fishing Port.

## Monthly CPUE dynamics and seasonal fishing patterns

*CPUE Dynamics*

Squid CPUE based at Sungailiat NFP was relatively low at the beginning of the year (January–March), then increased mid-year (April–October), and then decreased again towards the end of the year (November–December) (Figure 6). The lowest average CPUE value was in 2019 (7.36 kg/trip), while the highest average monthly CPUE was in 2021 (22.28 kg/trip). Low CPUE values indicate a low squid fishing success rate. Conversely, an increase in CPUE values mid-year (April–October) indicates more favorable water conditions for squid fishing activities, thus increasing the chance of catching squid. Hasmawati (2015) reported that the east monsoon is the season for squid egg attachment, thus increasing fishing productivity after spawning.

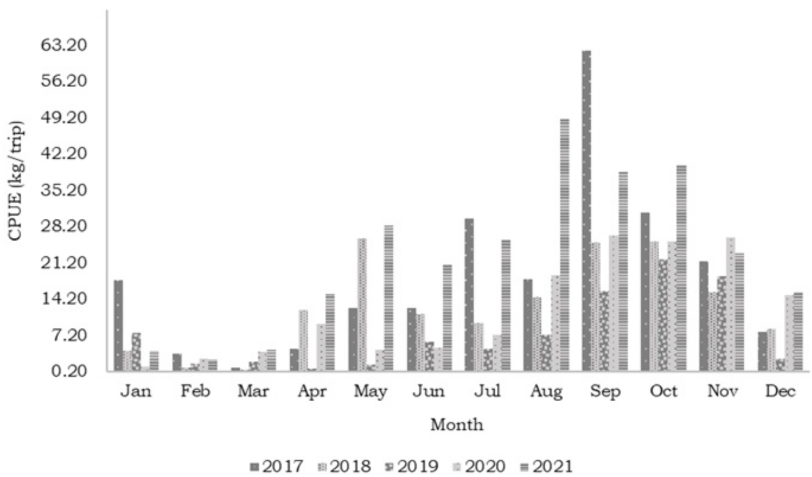


Figure 6. Monthly CPUE values of squid (Loligo spp.) in Sungailiat NFP for the period 2017–2021.

*Fishing season patterns*

The monthly CPUE variation consistently aligns with the squid FSI (fishing season index) pattern. The squid fishing season runs from August to November, with FSI values exceeding 100% (Figure 7). Meanwhile, the lean squid fishing season occurs from December to July (with FSI values below 100%). The highest FSI value was found in September (246.21%), followed by October (220.34%) and November (180.69%). A drastic decline in FSI values began in December (72.87%). The lowest FSI value was found in February (11.20%).

The results of this study are consistent with several previous studies related to the squid fishing season in Bangka waters. Rosalina *et al.* (2011) stated that the squid fishing season occurs in November. Research conducted by Prasetyo *et al.* (2014) found that the squid fishing season in the Karimata Strait (eastern part of Bangka Island waters) occurs during the second transition season to the west season (September–December). Febrianto *et al.* (2017) stated that the peak squid season in the waters outside the tin mining area of South Bangka Regency occurs during the second transition season (September–November), with the highest peak in November. Wiadnyana *et al.* (2022), stated that the peak squid fishing season occurs twice a year, namely during the first transition season (April–June) and the second transition season or the west season (October–November). A similar finding was also reported by Rema *et al.* (2025), that the highest FSI value was 230.78% (November), and the lowest was 23.16% (March).

**Temporal distribution of chlorophyll-a, sea surface temperature, and salinity in Bangka Belitung waters**

*Chlorophyll-a*

The temporal distribution of chlorophyll-a concentrations in Bangka waters from 2017 to 2021 is presented in Figure 8. Average chlorophyll-a concentrations ranged from 0.15 mg/m$^3$ to 0.35 mg/m$^3$. The highest chlorophyll-a concentrations occurred in mid-year (July–September), while the lowest values occurred in March–May (Figure 8). The highest chlorophyll-a concentration was in August (0.35 mg/m$^3$), while the lowest chlorophyll-a value was in April (0.15 mg/m$^3$).

The distribution of chlorophyll-a does not directly impact the presence of squid, but it does impact the squid food chain. This is because squid do not utilize chlorophyll-a directly. Suwarso *et al.* (2019) explained that increasing chlorophyll-a concentrations will increase migration activity and food availability for squid. The dominant upwelling process during the second transition season and the east monsoon brings nutrients from the lower layers to the surface, stimulating the growth of phytoplankton, the ocean's food producers. Nutrient-rich waters will increase productivity, thus increasing squid catches.

*Sea surface temperature (SST)*

The temporal distribution of SST in Bangka waters from 2017 to 2021 shows a dynamic pattern (Figure 9). The SST range is 27.5–32.5 °C. Research conducted by Wiadnyana *et al.* (2022) found that mature squid gonads in Bangka waters were found at temperatures of 30.16–30.78 °C. Furthermore, Prasetyo *et al.* (2014) found that squid in Bangka waters can be found at SSTs ranging from 21 to 32.1 °C.

The lowest temperature occurs in February and the highest in November. SST decreases during the west monsoon (December, January, and February) and then increases during the first transitional season (March, April, and May). SST increases continue at the start of the east monsoon (June), then decrease slightly in the following months (July and August). Entering the second transition season, SST continues to decline in September but increases again in October and November, then decreases again when entering the west season. Based on research results from Triharyuni and Puspasari (2012) and Kusumawardani *et al.* (2019), the squid spawning season occurs when there is an increase in water temperature. The results of the analysis of seasonal patterns show that the peak squid fishing season occurs from the east season to the second transition season, which means it has warm temperatures.

*Salinity*

The temporal distribution of salinity in Bangka waters from 2017 to 2021 ranged from ± 31.5 to 33.0 PSU (Figure 10). This finding aligns with the research of Wiadnyana *et al.* (2022), which found mature squid gonads in Bangka waters generally within the range of 31 to 31.4 PSU. Putri and Suciaty (2010), Hasmawati (2015), Aras and Hasmawati (2016), and Pirmansa *et al.* (2020) also reported that squid can survive in waters with salinity values of 28 to 32 PSU.

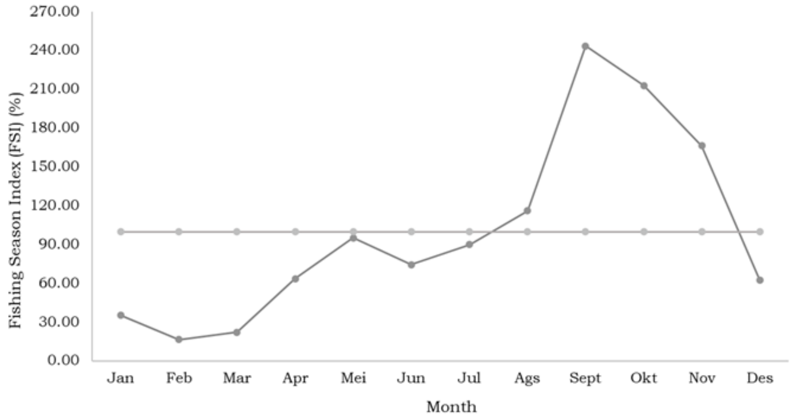


Figure 7. Squid fishing season index in Bangka waters.

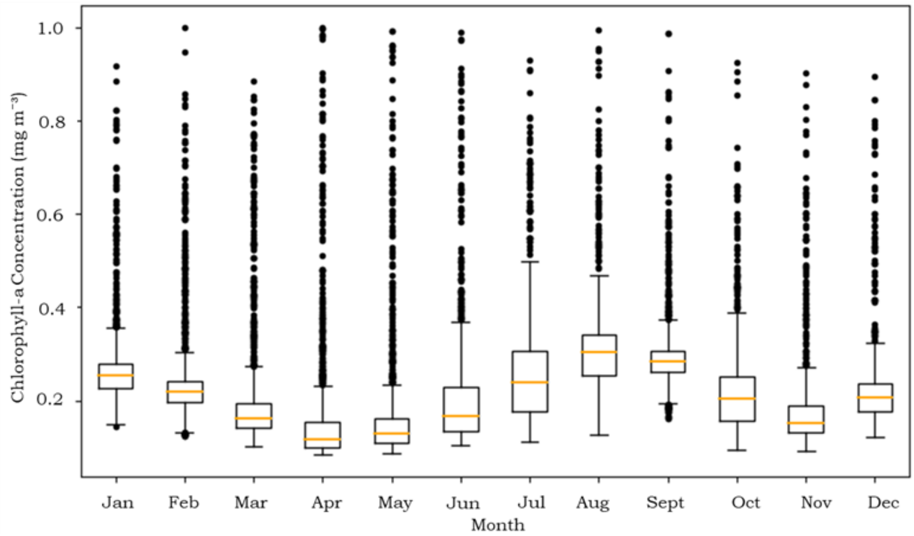


Figure 8. Temporal distribution of chlorophyll-a concentration (mg/m³) in Bangka Belitung waters in 2017–2021.

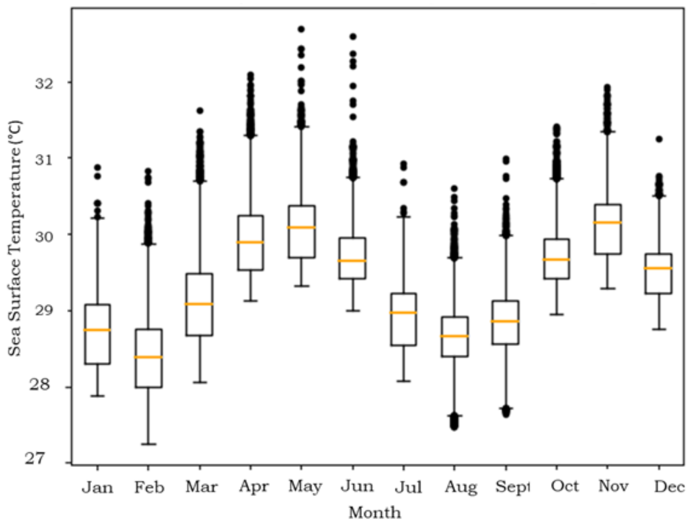


Figure 9. Temporal distribution of sea surface temperature in Bangka Belitung waters, 2017–2021.

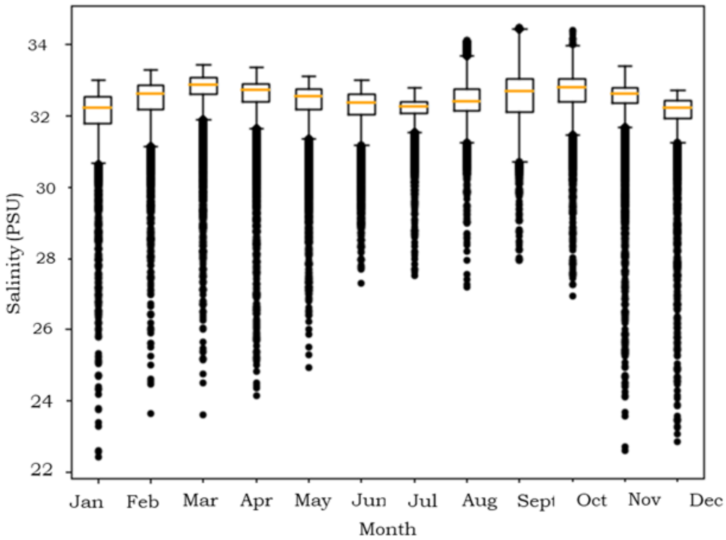


Figure 10. Temporal distribution of salinity in Bangka Belitung waters, 2017–2021.

The lowest salinity was found in January and December (around 32.2 PSU). The highest salinity was found in September, with values of 32.8 to 33.0 PSU (Figure 10). Variations in salinity changes in waters are influenced by various factors, including river flow and monsoon systems. During the west monsoon, increased rainfall and river flow lead to a decrease in salinity. Conversely, during the east monsoon, salinity is relatively higher due to reduced freshwater input from river flows (Yuliardi *et al.* 2024).

Salinity plays a crucial role in the survival of marine organisms, including squid. Arizqi *et al.* (2026) stated that extreme changes in salinity levels can lead to fish mortality. Aras and Hasmawati (2016) found that salinity affects squid survival because squid are stenohaline and can only tolerate certain salinity limits. Suitable salinity conditions also influence the success of egg hatching and larval survival.

**The relationship between oceanographic parameters of waters with CPUE dynamics and seasonal patterns of squid fishing**

The relationship between oceanographic parameters (sea surface temperature-SST and chlorophyll-a) is presented in Figure 11. Increases in chlorophyll-a concentration are directly proportional to increases in CPUE. As chlorophyll-a concentrations increase in June–September, with relatively dynamic surface temperature conditions, CPUE increases. This aligns with research findings showing that the optimal squid fishing season occurs from the end of the east monsoon to the beginning of the transitional season, when chlorophyll-a is relatively high and temperatures begin to rise again. Conversely, at the beginning of the year, with low chlorophyll-a and relatively lower temperatures, squid CPUE is at its minimum.

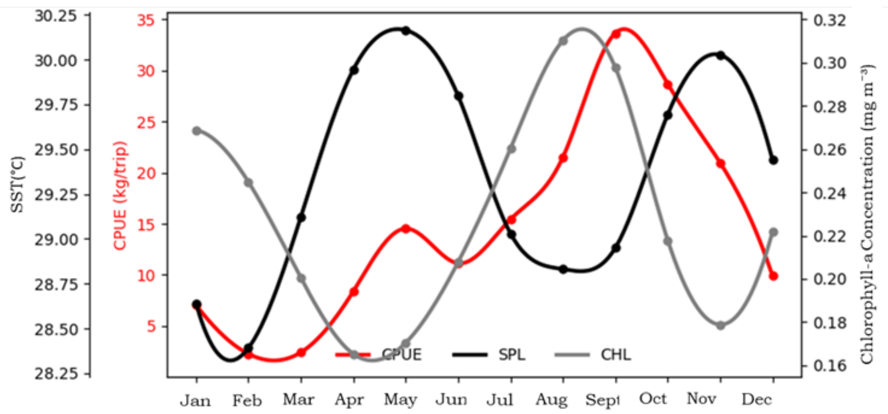


Figure 11. Temporal correlation diagram of sea surface temperature (°C) and chlorophyll-a (mg/m³) against squid CPUE.

The interaction of SST and chlorophyll-a plays a role in determining the seasonal dynamics of squid catches. Research conducted by Febrianto *et al.* (2017) and Puspitasari and Fahrudin (2019) explained that sea surface temperatures tend to be warmer during the east monsoon, in line with increased primary productivity that supports the growth of plankton, the squid's natural food source. This condition impacts squid productivity in the waters. Conversely, during the west monsoon and transitional seasons, squid catches tend to decline. Changes in temperature and unstable ocean currents can cause squid to migrate to other areas more suitable for their biological activity (Febrianto *et al.* 2017).

## CONCLUSION

Squid fisheries in Sungailiat NFP are dominated by the use of handlines and fishing boats with a size of ≤ 5 GT. CPUE dynamics show that the average CPUE for squid catches is higher during the east monsoon than the west monsoon. The peak fishing season occurred from August to November, while the lean season occurred from December to March. Chlorophyll-a distribution increased mid-year, sea surface temperatures were relatively warm from the east monsoon to the transitional season, and salinity was within the optimal range for squid habitat. Increases in CPUE tend to occur after increases in chlorophyll-a and under relatively stable temperature and salinity conditions, indicating that the interaction between oceanographic factors and seasonal patterns plays a significant role in determining the dynamics of squid catches in Bangka Belitung waters.

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