Grouper : Jurnal Ilmiah Perikanan
Vol. 16 No. 1 (2025) pp. 189-203
pISSN: 2086-8480 | eISSN: 2716-2702
Journal Homepage: https://grouper.unisla.ac.id/index.php/grouper

Study on The Distribution of Longtail Tuna (*Thunnus Tonggol*) Catch Based on Chlorophyll-A Using Aqua Modis Imagery in West Sumatera

Muhammad Farhan Al Iqromi[1], Afriani Harahap[2], Septy Heltria[1*], Farhan Ramdhani[1], Ester Restiana Endang Gelis[1], Hutwan Syarifuddin[2]

[1]Department of fisheries, Faculty of animal science, Universitas Jambi, Indonesia
[2]Department of Animal science, Faculty of animal science, Universitas Jambi, Indonesia

*Correspondence Author: septyheltria@unja.ac.id

Submitted: 28 October 2024 Revised: 21 April 2025 Accepted: 28 April 2025

Keywords:
CPUE;
Cholorophyll-a;
Longtail tuna;
Regression

ABSTRACT

The longtail tuna (*Thunnus tonggol*) is one of the highest-producing fishery commodities in the waters of West Sumatra. Its abundance is influenced by oceanographic conditions, particularly indicated by chlorophyll-a concentration as a marker of water productivity. This study aims to examine the distribution of chlorophyll-a in relation to the catch of longtail tuna (*Thunnus tonggol*) using Aqua MODIS imagery in the waters of West Sumatra. The method used in this research is observational, involving data collection on chlorophyll-a distribution and logbook records. Chlorophyll-a data was obtained from the Ocean Color website, and logbook data for 2018–2022 was sourced from the Bungus Oceanic Fisheries Port (PPS). The results show that chlorophyll-a distribution in the waters of West Sumatra fluctuated between 2018 and 2022, with an average range of 0.15 mg/m^3 to 0.33 mg/m^3. A simple linear regression analysis showed a significant F-value of 0.0045, which is smaller than α (0.05), indicating that the regression equation is valid. This suggests that the distribution of chlorophyll-a has a significant effect on the longtail tuna catch in the waters of West Sumatra. The average annual CPUE (Catch Per Unit Effort) of longtail tuna was 0.44 tons/trip, with an average catch over the 2018–2022 period of 18.38 tons and an average of 41 trips per year.

INTRODUCTION

The production of longtail tuna (*Thunnus tonggol*) ranks fourth among other fish species, with the highest production recorded at 1,380.04 tons in 2020 in the waters of West Sumatra (PPS Bungus, 2020). This is further supported by research from Nurlaela et al. (2021), which identified three primary catch species, particularly from boat lift net vessels: Euthynnus affinis, Thunnus albacares, and Decapterus macrosoma landed at the Bungus Oceanic Fisheries Port (PPS). Boat lift nets are one of the fishing gears used for catching longtail tuna. According to Rumpa et al. (2021), the gross tonnage (GT) capacity of these vessels varies from 21 to 30 GT.

Longtail tuna generally feed on small fish, anchovies, crustaceans such as crab larvae, stomatopods, and squid (Collette and Nauen, 1983; Froese and Pauly, 2010). The abundance of longtail tuna in a particular water body is often indicated by a high concentration of chlorophyll-a, as this suggests an abundance of plankton, which is a key food source. Phytoplankton-rich areas will attract zooplankton and other organisms that are the primary prey of pelagic fish, making regions with high chlorophyll-a concentrations potential hotspots for pelagic fish harvesting.

The potential of fish catch distribution in relation to chlorophyll-a concentrations can be analyzed using remote sensing technology, particularly with Aqua MODIS satellite imagery, which offers high resolution. Ulqodri and Aryawaty (2013) highlighted that Aqua MODIS is widely utilized by researchers in remote sensing studies. Determining fishing grounds can be achieved by predicting fish-catching areas using a combination of physical and biological approaches, such as identifying oceanographic parameters in a body of water. Phytoplankton-rich regions serve as feeding grounds for small fish, which are consumed by the larger fish (Kuswanto et al., 2017).

Based on the above considerations, this study aims to: (1) Analyze the influence of chlorophyll-a distribution on longtail tuna (*Thunnus tonggol*) catches in the waters of West Sumatra; (2) Examine the annual fluctuations in chlorophyll-a distribution in relation to longtail tuna (*Thunnus tonggol*) catches based on the fishing season during 2018–2022; and (3) Assess the abundance of longtail tuna (*Thunnus tonggol*) resources in the waters of West Sumatra.

LITERATURE REVIEW

Chlorophyll-a is an important indicator in aquatic ecosystems as it reflects primary productivity, which plays a role in determining the abundance of pelagic fish, including longtail tuna (*Thunnus tonggol*). Chlorophyll-a concentration shows a significant relationship with fish catch results, where an increase in chlorophyll-a levels may indicate a high availability of phytoplankton as a food source.

In addition, seasonal fluctuations in fish distribution are influenced by environmental conditions such as salinity, temperature, and chlorophyll-a concentration. Previous studies have shown that seasonal changes can affect the migration patterns and abundance of pelagic fish. In the waters of West Sumatra, factors such as rainfall and upwelling also contribute to changes in chlorophyll-a concentration and fish catch results (Siregar et al, 2018; Priatna and Natsir, 2007). This is important to analyze in the context of longtail tuna catch distribution, which may experience significant variations during seasonal periods.

The utilization of satellite technology in monitoring marine environmental parameters, including chlorophyll-a, has proven effective in estimating fish presence and enhancing the understanding of marine ecosystem dynamics. According to Cassot et al. (2011), remote sensing can be used to predict fish distribution based on variations in chlorophyll-a concentration and sea surface temperature. Research by Ahkam and Tarya (2023) demonstrated that combining satellite data with ecological models can improve the accuracy of pelagic fish population estimates, making it an important tool in fisheries management. Additionally, a study by Asri et al. (2024) suggested that the use of satellite technology can provide broader and more accurate data for monitoring environmental conditions that influence fish distribution.

METHOD

This research was conducted at the Bungus Ocean Fishing Port, West Sumatra by collecting data on gray tuna (*Thunnus tonggol*) based on 5 years of data starting from 2018 - 2022. The research location map is in Figure 1.

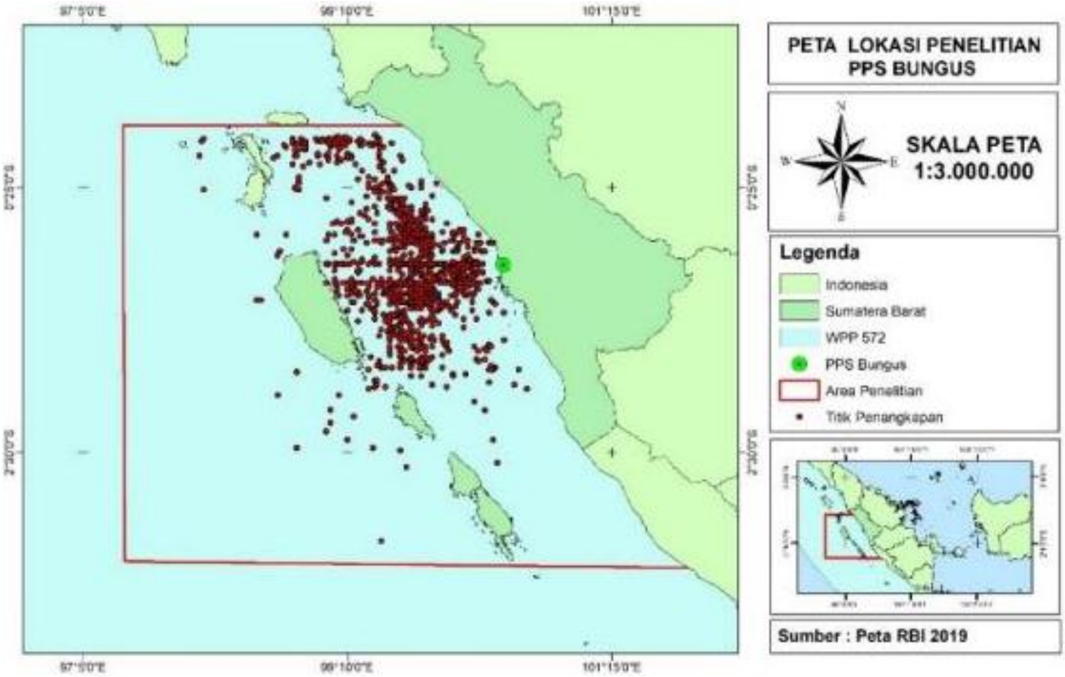

Figure 1. Research Map location

This study employed an observational method with two primary data types: chlorophyll-a distribution data and fishing logbook data. Chlorophyll-a data was obtained from the Ocean Color Web (https://oceancolor.gsfc.nasa.gov/l3/), which provides satellite imagery for analyzing the distribution of chlorophyll-a in marine environments. Meanwhile, logbook data was sourced from the archives of the Bungus Oceanic Fisheries Port (PPS), containing detailed records of fishing activities. The integration of these two data sets aims to understand the relationship between chlorophyll-a distribution and longtail tuna catch distribution.

In this study, several observational parameters were used as the basis for data collection and result analysis. These parameters include:

Table 1. Observational parameters used in the study

Parameter	unit	Instrumen	Resolution	Type file	Keterangan
Klorofil-a	mg/m^3	Aqua-MODIS	4 km x 4 km	nc.	Measurement of Chlorophyll-a Concentration Distribution

CPUE Analysis

The Catch Per Unit Effort (CPUE) analysis was conducted to assess the abundance of longtail tuna (*Thunnus tonggol*) resources based on the processing of catch data and fishing effort over a 5-year period, from 2018 to 2022, using data obtained from the Bungus Oceanic Fisheries Port (PPS). According to Widodo (1998), the CPUE analysis is formulated as follows:

$$\text{CPUE} = \frac{C_i}{F_i} \quad (1)$$

Information:

Catch (Ci) = Total catch in the i-th fishing effort (tons)
Effort (Fi) = Total fishing effort in the i-th trip (trips)
CPUE = Amount of catch per unit of fishing effort in the i-th trip (tons/trip)

Simple Linear Regression Analysis

Simple linear regression was used to analyze the effect of chlorophyll-a distribution on longtail tuna (*Thunnus tonggol*) catches. The regression analysis yields an F-value and a coefficient of determination (R^2). The regression equation is used to evaluate the causal relationship between production factors and the resulting output (Soekartawi, 2003). The simple linear regression equation can be written as follows (Kuswanto and Syamsuddin, 2017):

$$Y = a + bx \quad (2)$$

Information:

Y = Longtail tuna catch (tons)

a = Constant

b = Chlorophyll-a coefficient

x = Chlorophyll-a concentration (mg/m^3)

RESULT AND DISCUSSION

Chlorophyll-a Distribution during the West Monsoon Season

Figure 2 shows the chlorophyll-a distribution during the west monsoon season from 2018 to 2022. In the west monsoon season (December–February) of 2018, no longtail tuna (*Thunnus tonggol*) fishing occurred in the waters of West

Sumatra. In 2019, there were 287 fishing points with an average chlorophyll-a distribution ranging between 0.19 mg/m^3 and 0.23 mg/m^3. Subsequently, chlorophyll-a distribution increased in 2020, with an average range of 0.20 mg/m^3 to 0.93 mg/m^3, and 322 fishing points. In 2021, the chlorophyll-a distribution during the west monsoon season decreased, with only 17 fishing points recorded, and an average distribution ranging between 0.13 mg/m^3 and 2.26 mg/m^3. In 2022, chlorophyll-a distribution further decreased, with an average range of 0.19 mg/m^3 to 0.22 mg/m^3, and 20 longtail tuna fishing points were identified. The fluctuation of corrophyll-a distribution in this study appear to influence the number of fishing trips and indirectly influence CPUE. Ramdhani et al (2024) stated that chlorophyll abundance has a positive correlation to CPUE indicated by the increasing numbers of the chlorophyll will be followed by the increase in CPUE.

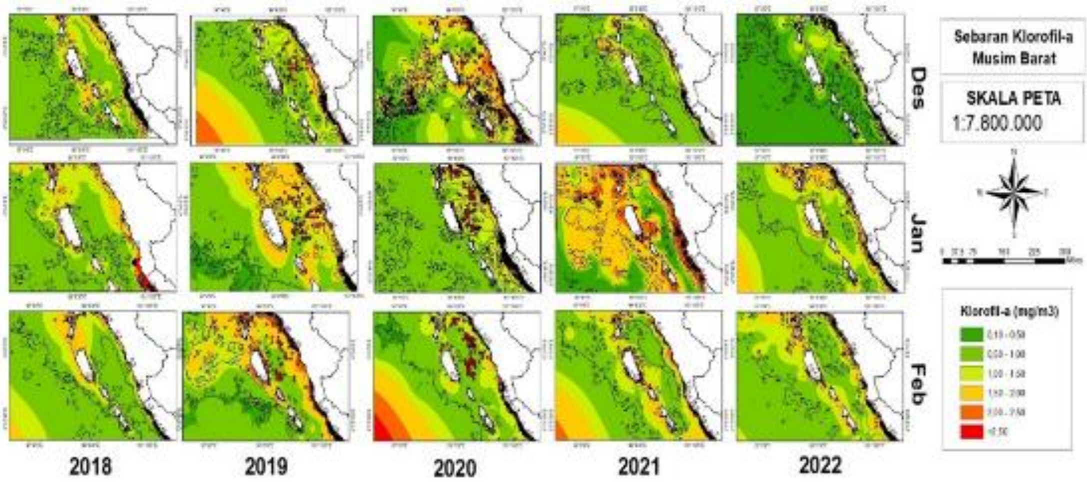

Figure 2. Chlorophyll-a Distribution during the West Monsoon Season (2018–2022)

The Meteorology, Climatology, and Geophysics Agency (BMKG, 2018) reported that heavy rainfall, exceeding 300 mm per month, occurred in December 2018 along the west coast of Sumatra, including West Sumatra. This indicates that during the west monsoon season, high rainfall frequently occurs. Chlorophyll-a concentration during the west monsoon season is the highest compared to other seasons, particularly in coastal and estuarine areas (Heltria et al., 2024). Additionally, variations in chlorophyll-a levels in a water body are influenced by river runoff into the sea (Auricht et al., 2022). In addition, chlorophyll-a concentrations in the waters of West Sumatra are influenced by the Indian Ocean Dipole (IOD) phenomenon, which induces upwelling as a result of negative sea surface temperature (SST) anomalies (Dipo et al., 2011). The occurrence of upwelling is indicated by a decrease in SST values and an increase in water fertility, as reflected by elevated chlorophyll-a concentrations (Natalia et al., 2015).

Chlorophyll-a Distribution during Transitional Season I (2018–2022)

Figure 3 shows the chlorophyll-a distribution during Transitional Season I (March–May) from 2018 to 2022, with varying levels each year. In Transitional Season I (March–May) of 2018, there were 81 fishing points, with an average chlorophyll-a distribution ranging between 0.15 mg/m^3 and 0.26 mg/m^3. In 2019, the chlorophyll-a distribution during Transitional Season I decreased, with an average range of 0.14 mg/m^3 to 0.19 mg/m^3, and 171 longtail tuna (*Thunnus tonggol*) fishing points were recorded.

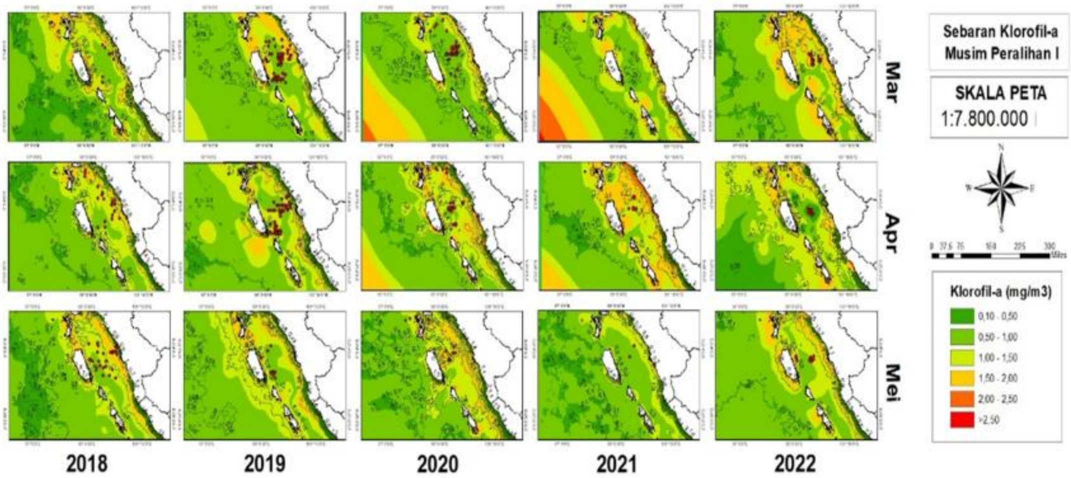

Figure 3. Chlorophyll-a Distribution during Transitional Season I (2018–2022)

In Transitional Season I (March–May) of 2020, chlorophyll-a distribution increased again, with 84 longtail tuna (*Thunnus tonggol*) fishing points recorded and an average chlorophyll-a distribution ranging between 0.14 mg/m^3 and 0.37 mg/m^3. Subsequently, in 2021, there were only 9 fishing points for longtail tuna, with an average chlorophyll-a distribution ranging between 0.16 mg/m^3 and 0.18 mg/m^3. By 2022, during Transitional Season I, chlorophyll-a distribution began to rise again, with an average range of 0.11 mg/m^3 to 0.20 mg/m^3.

The number of fishing points during Transitional Season I was recorded as lower compared to the West Monsoon season. This condition may contribute to lower chlorophyll-a levels during the transition from the West Monsoon to Transitional Season I. This pattern is primarily attributed to increased rainfall during the West Monsoon, which enhances nutrient-rich river runoff into coastal areas, thereby stimulating phytoplankton growth.

For instance, research along the western coast of South Sulawesi identified two zones with elevated chlorophyll-a levels during the rainy season, with peaks in January and April. These increases are linked to river runoff transporting nutrients and organic matter into coastal waters, promoting phytoplankton proliferation

(Wirasatriya et al., 2021).

Similarly, a study in Jakarta Bay, Musi Estuary, and Rokan Estuary found that chlorophyll-a concentrations are significantly influenced by rainfall and climate phenomena. The research highlighted that nutrient transport via rivers, driven by rainfall patterns, plays a crucial role in determining chlorophyll-a levels in these estuarine environments (Sudrajat, et al., 2024). Additionally, observations along the west-south coast of Nanggroe Aceh Darussalam revealed higher chlorophyll-a concentrations during the West Monsoon. This increase is attributed to elevated rainfall leading to greater nutrient input from terrestrial sources into coastal waters (Arafat and Siregar, 2021).

These findings align with Siregar's (2018) assertion that intensified rainfall during the West Monsoon enhances nutrient runoff from land to sea, thereby increasing chlorophyll-a concentrations in coastal regions. Consequently, the West Monsoon season exhibits higher chlorophyll-a distribution compared to Transitional Season I.

Chlorophyll-a Distribution during the East Monsoon Season (2018–2022)

Based on data obtained during the East Monsoon season (June–August) in 2018, as shown in Figure 4, there were 73 fishing points for longtail tuna, with an average chlorophyll-a distribution ranging between 0.22 mg/m^3 and 0.32 mg/m^3. In 2019, chlorophyll-a distribution decreased, with an average range of 0.22 mg/m^3 to 0.29 mg/m^3. In 2020, chlorophyll-a levels were significantly lower compared to the previous year, with an average distribution ranging between 0.16 mg/m^3 and 0.23 mg/m^3, and 150 fishing points recorded for longtail tuna. In 2021, chlorophyll-a distribution increased again, with 133 fishing points and an average range of 0.19 mg/m^3 to 0.28 mg/m^3. By 2022, there were 12 fishing points recorded in August, with an average chlorophyll-a distribution of approximately 0.12 mg/m^3. This is inversely proportional to studiy that chlorophyll-a concentrations in Indonesian waters exhibit seasonal patterns, often peaking during the East Monsoon due to upwelling processes that bring nutrient-rich waters to the surface. For instance, research along the southern coast of the Lesser Sunda Islands has shown that strong offshore Ekman mass transport during the southeast monsoon enhances upwelling, leading to increased chlorophyll-a concentrations (Simanjuntak and Lin, 2022).

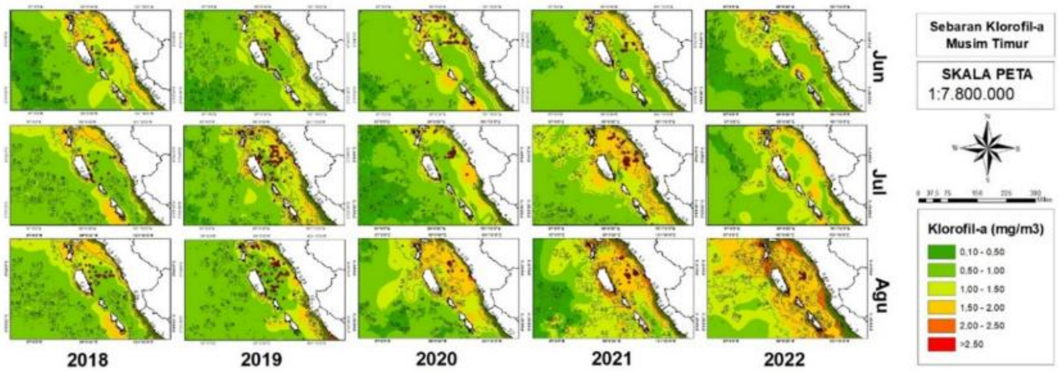

Figure 4. Chlorophyll-a Distribution during the East Monsoon Season (2018–2022)

The low chlorophyll-a distribution during the East Monsoon season compared to previous fishing seasons can be attributed to several factors, including weather, sunlight, and human activities. Siregar (2018) stated that chlorophyll-a distribution during the East Monsoon is influenced by low rainfall and high sunlight intensity, which can affect chlorophyll-a distribution patterns in the waters. High rainfall significantly increases nutrient runoff from land to water bodies (Arta et al., 2015). During heavy rainfall events, rainwater carries various nutrients, such as nitrogen and phosphorus, from the soil and agricultural areas into the aquatic system, including rivers and eventually to the estuary. This process leads to increased nutrient accumulation in estuarine waters, which can subsequently impact the aquatic ecosystem, such as accelerating phytoplankton growth and potentially triggering eutrophication if left unchecked. Sari et al. (2022) stated that during the east monsoon (June–August), intensified coastal upwelling along the western coast of Sumatra enhances nutrient availability, leading to increased chlorophyll-a concentrations. Conversely, during the northwest monsoon, reduced upwelling results in lower chlorophyll-a levels.

Chlorophyll-a Distribution during Transitional Season II (2018–2022)

In Transitional Season II (September–November), there were 186 fishing points recorded, with an average chlorophyll-a distribution ranging between 0.19 mg/m^3 and 0.26 mg/m^3. Chlorophyll-a distribution increased in 2019, with an average range of 0.32 mg/m^3 to 0.92 mg/m^3 and 298 fishing points. In 2020, chlorophyll-a distribution during Transitional Season II experienced a significant decrease, with an average range of 0.21 mg/m^3 to 0.23 mg/m^3 and 43 fishing points recorded. In 2021, chlorophyll-a distribution began to increase again, with 70 fishing points and an average range of 0.17 mg/m^3 to 0.26 mg/m^3. By 2022, chlorophyll-a distribution decreased again, with 39 fishing points and an average range of 0.13 mg/m^3 to 0.18 mg/m^3.

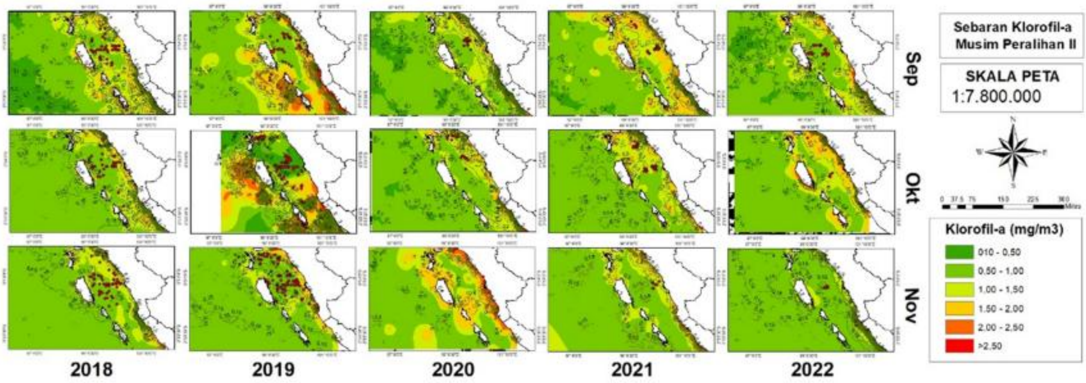

Figure 5. Chlorophyll-a Distribution during Transitional Season II (2018–2022)

The variation in chlorophyll-a distribution during Transitional Season II is influenced by light factors. Light plays a crucial role in determining chlorophyll-a distribution in the ocean through the photosynthesis process of phytoplankton, which ultimately affects chlorophyll-a concentration in the waters during the transitional season. Siregar (2018) indicated that chlorophyll-a distribution during Transitional Season II is influenced not only by light factors but also by the conditions of the preceding season, namely the East Monsoon, and the preparation for the upcoming West Monsoon. The East Monsoon, typically characterized by strong winds and upwelling, can enhance nutrient content in the waters, supporting phytoplankton growth before entering Transitional Season II. Conversely, the forthcoming West Monsoon brings changes in wind patterns, currents, and water temperature, which also impact chlorophyll-a distribution patterns. These seasonal changes create a complex environmental dynamic where light and season interact, influencing chlorophyll-a distribution in marine waters during this transitional period.

Chlorophyll-a Fluctuations from 2018 to 2022

Figure 6 illustrates the chlorophyll-a distribution in the waters of West Sumatra from 2018 to 2022 based on data obtained from the Bungus Oceanic Fisheries Port (PPS), which indicates year-to-year fluctuations. This variability is influenced by seasonal monsoon patterns and large-scale climate phenomena such as the Indian Ocean Dipole (IOD) and El Niño–Southern Oscillation (ENSO) (Sari et al., 2022).

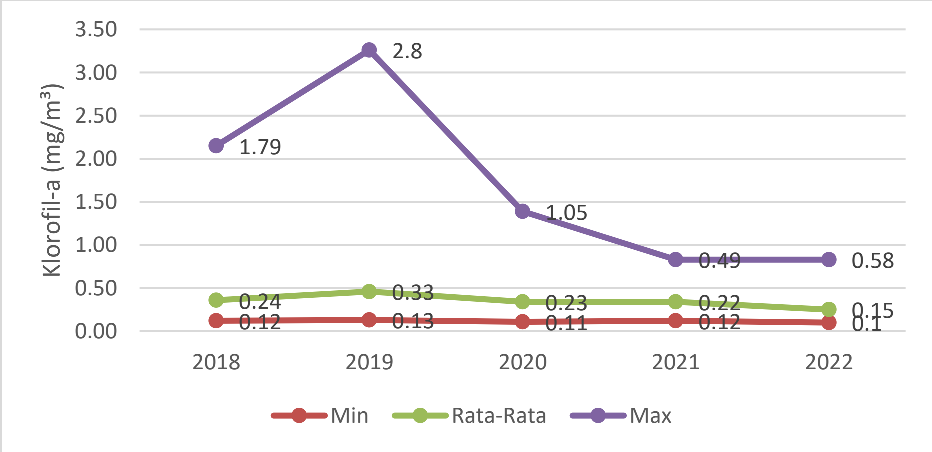

Figure 6. Chlorophyll-a Distribution Graph (2018–2022)

The highest average chlorophyll-a distribution occurred in 2018, measuring 0.33 mg/m^3, while the lowest was recorded in 2022 at 0.15 mg/m^3. Figure 6 indicates that the highest chlorophyll-a value ever recorded was in 2019, at 2.8 mg/m^3, which occurred during Transitional Season II, specifically in November 2019. Conversely, the lowest chlorophyll-a concentration was observed in 2022, at 0.1 mg/m^3, occurring during Transitional Season I in April 2022. The average chlorophyll-a distribution in the waters of West Sumatra indicates a low concentration, with an average chlorophyll-a level of 0.28 mg/m^3 over the period from 2018 to 2022.

The chlorophyll-a levels in West Sumatra from 2018 to 2022 fall into the mesotrophic category. Research conducted by Seegers et al. (2018) classified trophic regions based on chlorophyll-a concentration into three categories: eutrophic (chlorophyll-a > 1 mg/m^3), mesotrophic (0.1 mg/m^3 < chlorophyll-a ≤ 1 mg/m^3), and oligotrophic (chlorophyll-a ≤ 0.1 mg/m^3). This indicates that chlorophyll-a content in the waters of West Sumatra experiences fluctuations each year. The variable chlorophyll-a distribution is attributed to water mass exchange (upwelling).

Seasonal water mass exchange significantly influences the abundance and distribution of pelagic fish in a water body. This process brings nutrients to the surface through upwelling, supporting plankton growth as the primary food source for pelagic fish. During seasons with active water mass exchange, food availability increases, leading to a rise in pelagic fish populations. Conversely, during seasons with minimal water exchange, fish abundance decreases or they migrate to more productive areas. Therefore, the migration patterns and abundance of pelagic fish are directly influenced by the seasonal dynamics of oceanographic factors in the waters (Pratama et al, 2022).

Longtail Tuna Catch Results

The decline in the number of longtail tuna (*Thunnus tonggol*) fishing trips shown in Figure 7 for the years 2021 and 2022 indicates a lack of optimal fishing activity during these two years. The number of trips recorded in 2021 was 212, while it decreased to 104 trips in 2022. This decline is attributed to several periods of no fishing activity, such as in March 2021 and from June to July 2022. The reduction in the frequency of fishing trips directly affects the catch results, as the less time spent fishing correlates to a lower opportunity for increasing the catch quantity.

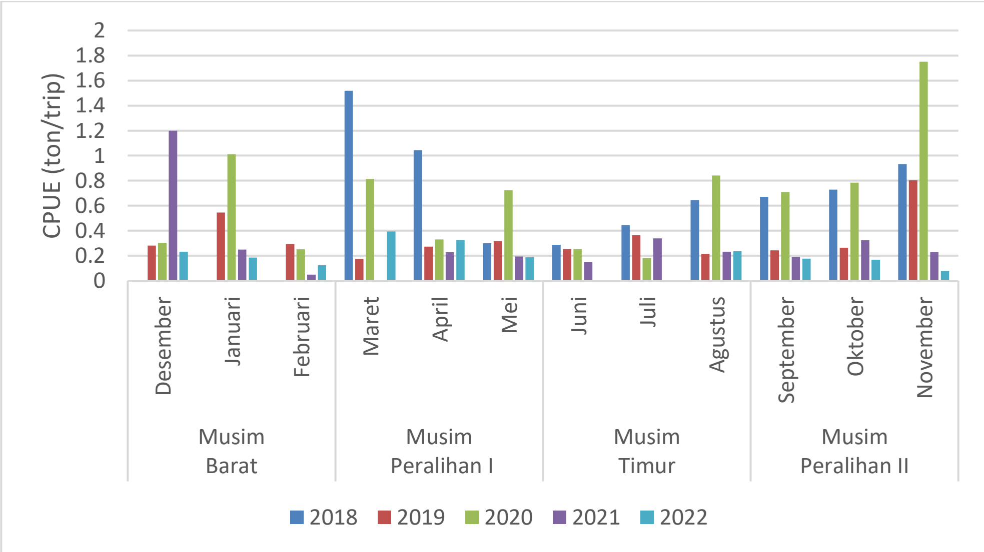

Figure 7. CPUE Results for Longtail Tuna (2018–2022)

The average CPUE (Catch Per Unit Effort) obtained over two consecutive years shows a declining trend in the productivity of longtail tuna fishing. In 2021, the CPUE was recorded at 0.24 tons per trip, whereas in 2022, it decreased to 0.22 tons per trip. This decline indicates that although fishing efforts continued, the catch per unit of effort decreased, reflecting suboptimal utilization of fishery resources.

This reduction in CPUE can be interpreted as a sign that the abundance of fish available in the waters is not being maximally exploited, either due to high natural mortality rates or because of the potential for these fish to be captured by foreign fishermen. Tanjaya (2015) explains that suboptimal utilization can lead to significant losses, both ecologically and economically, thus necessitating better management strategies to prevent sharper declines in the future.

Relationship Between Chlorophyll-a and Catch Results

Based on the calculations performed using Microsoft Excel, the results of the regression analysis are presented in Table 2.

Table 2. Results of Simple Regression Analysis and F-test

Variabel	coefisien
Multiple R	0,561619468
R Square	0,315416427
Fhitung	0,01234
Ftabel	4,45

The regression results displayed in Table 2 illustrate the extent of the influence of chlorophyll-a as an independent variable on the catch of longtail tuna (*Thunnus tonggol*) in the waters of West Sumatra. With a correlation coefficient (R) of 0.56, it can be concluded that there is a moderate relationship between the chlorophyll-a variable and the catch of longtail tuna, whereby 56% of the variation in catch results can be explained by changes in chlorophyll-a levels. Although this relationship is relatively strong, it indicates that chlorophyll-a is not the only factor affecting catch results; other factors also need to be considered. Meanwhile, the coefficient of determination (R^2) of 0.31 shows that approximately 31% of the variation in longtail tuna catch is directly influenced by chlorophyll-a levels, while the remaining 69% is attributed to other variables such as environmental factors, weather, fishing effort, and other oceanographic conditions. Arta et al. (2023) also reported a similar finding, demonstrating a moderately strong correlation between chlorophyll-a concentration and the catch of longtail tuna (*Thunnus tonggol*), with a coefficient of determination (R^2) of 34.9%.

Furthermore, the results of the F-test analysis presented in Table 3 reinforce the conclusion that chlorophyll-a has a significant impact on longtail tuna catch results. With an F-value of 7.83, which is greater than the F-table value of 4.45, and a significant F-value of 0.012, which is smaller than the confidence level α (0.05), it can be concluded that chlorophyll-a plays an important role in determining variations in longtail tuna catch. This means that changes in chlorophyll-a levels in the waters can significantly affect the availability of longtail tuna, possibly related to the availability of plankton as food in the area. These results suggest that monitoring chlorophyll-a distribution could serve as a useful indicator in fisheries management and in predicting future catch results. This is also supported by Munthe et al. (2018), who stated that areas with high chlorophyll-a concentrations are typically nutrient-rich zones, attracting a high abundance of marine biota, particularly pelagic fish such as longtail tuna. Conversely, a decrease in chlorophyll-a concentration may lead to a decline in longtail tuna production (Nurwani & Yusrudin, 2023)

CONCLUSION

Based on the research conducted, it is established that the distribution of chlorophyll-a affects the catch of longtail tuna (*Thunnus tonggol*) in the waters of West Sumatra, using Aqua MODIS imagery. It can be concluded that chlorophyll-a distribution has a significant impact on the catch of longtail tuna in the region. The average annual CPUE for longtail tuna was recorded at 0.44 tons per trip, with an average total catch of 18.38 tons over the period from 2018 to 2022, and an average of 41 trips.

REFERENCES

Ahkam M.F., Tarya. (2023). Estimation of The Potential of Large Pelagic Fish Fisheries Using Satellite Data in The Banda and Arafura Seas. Devotion: *Journal of Research and Community Service*. 4(12):2338 -2352.

Arafat, H., & Siregar, V. P. (2021). Spatial and Temporal Variation of Chlorophyll-a and Sea Surface Temperature along West-South Coast in Nanggroe Aceh Darussalam. *Coastal and Ocean Journal* (COJ), 5(2), 92-102.

Arta F.H., Mubarak M., & Nasution S. (2015). Sebaran Klorofil-a di Perairan Pantai Padang dan Pariaman Provinsi Sumatera Barat Menggunakan Citra Satelit Aqua Modis. *Jurnal Ilmu Lingkungan* 10(2): 128-137.

Arta F.H., Afriani F., Pasaribu M. 2023. Hubungan parameter klorofil-a dengan hasil tangkapan ikan tongkol krai (auxis thazard) di perairan laut sibolga dan tapanuli Tengah. *Jurnal Penelitian Terapan Perikanan dan Kelautan*. 5(2): 10-13.

Asri H., Agustina., Kamaruddin., Utami, W., Putri, N.A., 2024. Utilization of Aqua MODIS Satellite Imagery for Predicting Potential Pelagic Fish Fishing Areas in the Waters of Pasangkayu Regency. *Jurnal ilmiah wahana laut lestari*. 2(1): 8-21.

Auricht HC, Luke M, Mosley ML, Ken C. 2022. Mapping the Long-term Influence of River Discharge on Coastal Ocean Chlorophyll-a. J. *Remote Sensing in Ecology and Conservation*. 8(5): 629-643.

Badan Meteorologi Klimatologi dan Geofisika (BMKG). (2018). Analisis Dinamika Atmosfer-Laut; Analisis dan Prediksi Hujan Dasarian I Desember 2018. https://www.bmkg.go.id/berita [diakses 23 Desember 2023].

Collete B.B, & Nauen C.E. (1983). FAO Special Catalogue. Vol. 2 Scombrids of the world an annotated and illustrated catalogue of tunas, mackerels, bonitos, and related species known to date. *FAO Fisheries Synopsis* 125 (2): 92-93.

Cassot. E., S. Bonhommeau., G. Reygondeau., K. Nieto., J.J. Polovina., M.Huret., N.K. Dulvy, & H. Demarcq. (2011). Satellite remote sensing for an ecosystem approach to fisheries management. *ICES Journal of Marine Science*, 68(4):651-666. doi: 10.1093/icesjms/fsq195

Dipo P, Nurjaya IW, Syamsudin S. 2011. Karakteristik Oseanografi Fisik di Perairan Samudera Hindia Timur pada Saat Fenomena Indian

Ocean Dipole (IOD) Fase Positif Tahun 1994/1995, 1997/1998, dan 2006/2007. *J. Ilmu dan Teknologi Kelautan Tropis*. 3(2): 71-84.

Froese R, & Pauly D.E. (2020). FishBase, version 02/2020. www.fishbase.org, Accessed at 26-08-2020.

Heltria S., Noferdiman., Gelis E.R.E., Ramdhani F., Yuliardi A.Y. 2024. suitability of spatial-temporal habitat of yellowfin tuna (*thunnus albacares*) using maximum entropy model in west sumatra. *Marine Fisheries: Journal of Marine Fisheries Technology and Management*. 5(2): 147-158.

Kuswanto T.D., Syamsuddin M.L., & Sunarto. (2017). Hubungan suhu permukaan laut dan klorofil-a terhadap hasil tangkapan ikan tongkol di teluk lampung. *Jurnal Perikanan Kelautan*, 8(2): 90-102

Munthe MG, YV Jaya dan RD Putra. 2018. Pemetaan zona potensial penangkapan ikan berdasarkan citra satelit aqua/terra MODIS di Perairan Selatan Pulau Jawa. *Dinamika Maritim*. 7(1): 39-42.

Nontji A. (1993). Laut nusantara. Jakarta (ID): Djambatan. 368 hal

Nurlaela E., Al Magribi A., Husein E.S., Yuniarty T., Aini S., Sari I.P., Maulita M. (2021). Komposisi Hasil Tangkapan Ikan Pada Km Puspa Sari 03 Di Perairan Sumatera Barat. *Buletin Jalanidhitah Sarva Jivitam* 3(2):53-62.

Nurwany H.M., Yusrudin. 2023. Hubungan suhu permukaan laut dan klorofil-a terhadap hasil tangkap ikan tongkol (euthynnus affinis) di teluk rembang. *AGROPRO*. 1(2): 38-45.

PPS Bungus. (2020). Laporan Tahunan 2020 Pelabuhan Perikanan Samudera Bungus.

Pratama G.B., Nurani T.J., Mustaruddin., Herdiyeni Y. (2022). Hubungan parameter oseanografi perairan terhadap pola musim ikan pelagis di perairan palabuhanratu. *Jurnal Teknologi Perikanan dan Kelautan*. 13(1): 67-78.

Prahasta E. (2004). Sistem Informasi Geografis: ArcView Lanjut Pemrograman Bahasa Script Avenue. *Informatika*, Bandung.

Ramdhani, F., Heltria, S., Gelis, E. R. E., Magwa, R. J., Noferdiman, N., Putra, M. G. A., & Halim, M. (2024). Exploitation rates and oceanographic characteristics of anchovy fishing grounds in FMA-572 West Sumatra. *Depik*, 13(2), 328-337.

Rumpa A., Hermawan., Maskur M., Yusuf A. (2021). Pemetaan Zona Daerah Penangkapan Ikan Dengan Bagan Perahu Cungkil Berdasarkan Time Series Pada Perairan Teluk Bone. *Jurnal Airaha*, 10(01):56-67.

Sari, Q. W., Siswanto, E., Utari, P. A., Saputra, O. F., Lestiana, H., Holidi, ... & Iskandar, I. (2022). Seasonal driven mechanism of the surface chlorophyll-a distribution along the Western Coast of Sumatra. *Journal of Ecological Engineering*, 23(11), 254-260.

Seegers B.N., Stumpf R.P., Schaeffer B.A., Loftin K.A., Werdell J. (2018). Performance metric for the assessment of satellite data products : an ocean case study. *Journal Optics Express* 26(6): 1-19.

Simanjuntak, F., & Lin, T. H. (2022). Monsoon effects on chlorophyll-a, sea surface temperature, and ekman dynamics variability along the southern coast of lesser Sunda islands and its relation to ENSO and IOD based on satellite observations. *Remote Sensing*, 14(7), 1682.

Siregar E.S.Y., Suriyanti S.V., Agus S.A. (2018). Analisis Daerah Penangkapan Ikan Tuna Sirip Kuning Thunnus Albacares Di Perairan Sumatera Barat Berdasarkan Model Gam. *Jurnal Ilmu dan Teknologi Kelautan Tropis* 10(2): 501-516. *https://doi.org/10.29244/jitkt.v10i2.21908*

Soekartawi. (2003). Teori Ekonomi Produksi Dengan Pokok Bahasan Analisis Fungsi Cobb-Douglas. PT. Raja Grafindo Persada. Jakarta.

Sudradjat, A., Muntalif, B. S., Marasabessy, N., Mulyadi, F., & Firdaus, M. I. (2024). Relationship between chlorophyll-a, rainfall, and climate phenomena in tropical archipelagic estuarine waters. *Heliyon*, 10(4).

Tanjaya E. (2015). Potensi Pemanfaatan Sumberdaya Ikan Tongkol (Auxis Thazard) Di Perairan Kabupaten Maluku Tenggara. *Jurnal Amanisal* 4(10):32-37.

Ulqodry T.Z., Aryawaty R. (2013). Pola sebaran konsentrasi klorofil-a di Selat Bangka dengan menggunakan citra aqua-modis. *Maspari Journal: Marine Science Research* 5(1): 22-33.

Widodo J. (1998). Sistematika, Biologi dan Perikanan Tenggiri (*Scomberomorus Scombridae*) di Indonesia. *Pewarta Oseana*. Vol XIV No.4. Semarang: Balai Penelitian Perikanan Laut. Jakarta. Hal 145 - 150.

Wirasatriya, A., Susanto, R. D., Setiawan, J. D., Ramdani, F., Iskandar, I., Jalil, A. R., ... & Maslukah, L. (2021). High chlorophyll-a areas along the western coast of south sulawesi-indonesia during the rainy season revealed by satellite data. *Remote Sensing*, 13(23), 4833.