RSF Conference Proceeding Series: Business, Management and Social Science, Vol. 5 No. 2 (2025) https://doi.org/10.31098/bmss.v5i2.937

Check for updates

Research Paper

Seasonal Dynamics and Production Risk of Hairtail at Sadeng Fishing Port, Indonesia (2019-2024)

Zulfa Nur Auliatun Nissa', Aura Dhamira*, Maulana Yudinugroho, Ayu Kumala Sari

Universitas Pembangunan Nasional Veteran Yogyakarta, Indonesia

Received : September 15, 2025	Revised : September 23, 2025	Accepted : September 26, 2025	Online : October 15, 2025

Abstract

This study examines the production dynamics and risk level of hairtail at Sadeng Fishing Port from 2019 to 2024. As one of the most economically important commodities, hairtail significantly contributes to local livelihoods, particularly among smallholder fishermen. However, its production is subject to seasonal fluctuations and environmental variabilities. Monthly catch data were analyzed to capture the patterns of hairtail production, while the coefficient of variation was used to measure the production risk. The result shows that the catches peaked typically during January-March, with the highest production occurring in January 2023, and a complete absence of production was recorded in August during multiple years. The production risk shows a slightly negative trend, though the slope is minimal. The value notably fluctuates with higher levels of risk, which coincidentally happen in years influenced by climatic anomalies such as El Niño and La Niña. These findings suggest that both environmental and human-related factors jointly shape the variability of hairtail production. Understanding these dynamics is crucial to reducing the vulnerability of fishing communities and enhancing resilience under conditions of climate uncertainty.

Keywords *Climate Change, Hairtail, Production Risk, Sadeng Fishing Port*

INTRODUCTION

Climate change has emerged as one of the most significant global challenges, with profound implications for marine ecosystems and fisheries. The Intergovernmental Panel on Climate Change (IPCC, 2021) reported that the global mean surface temperature from 2011 to 2020 was 1.09°C higher (likely range: 0.95–1.20°C) than during the pre-industrial period (1850–1900). Rising temperatures, sea level changes, and shifts in wind patterns are increasingly altering the dynamics of capture fisheries worldwide, both biologically and socioeconomically. El Niño and La Niña irregularities increase these hazards. ENSO cycles change plankton production and upwelling systems, affecting fish availability and seasonal harvest (Bertrand et al., 2023).

Such uncertainty disproportionately affects small-scale coastal fisheries, which rely heavily on seasonal patterns. These mechanisms demonstrate that climate change poses a threat to the socioeconomic resilience and ecological sustainability of fisheries-dependent communities. These climate-induced variations in fisheries production demonstrate that fishing communities face a significant threat from climate change. In economic terms, risk refers to the situation where the probability distribution of possible outcomes is known, whereas uncertainty occurs when outcomes cannot be predicted or assigned probabilities (Debertin, 2012). Seasonal catch fluctuations and monsoon-related sea conditions pose common dangers to small-scale fishermen. The timing and extent of El Niño and La Niña occurrences are unpredictable, making it challenging to estimate their effects on fish stocks and fishing operations.

Corresponding author's email: aura.dhamira@upnyk.ac.id

Sadeng Fishing Port in Gunungkidul, Yogyakarta, Indonesia, stands out as the largest marine capture fisheries hub in the province. Gunungkidul district produced a total of 3,713 tonnes in 2020, the most of any DIY sub-regency, according to the BPS Provinsi D.I.Yogyakarta (2024). About 4,583 tonnes, or 48.7% of DIY's marine harvest, came from Sadeng Fishing Port alone within Gunungkidul (Putera et al., 2022). Furthermore, according to species-specific statistics, *Katsuwonus pelamis* (skipjack tuna) output rose sharply from 306 tons in 2016 to about 1,396 tons in 2020 (Hutajulu et al., 2023), underscoring both its economic importance and potential vulnerability to climatic variability. Despite this significance, fishing activities at Sadeng are dominated by small-scale fleets (<5 GT), which remain highly exposed to climate-induced production risks.

While studies have examined the biological and socioeconomic effects of climate change on fisheries globally, limited attention has been paid to localized assessments of production risk in Indonesian small-scale fisheries, especially hairtail. Understanding production fluctuations at ports such as Sadeng is crucial for strengthening the resilience of coastal communities. Accordingly, the objective of this study is to measure and analyze production risks in the capture fisheries sector at Sadeng Fishing Port by assessing the annual fluctuations of the risks.

LITERATURE REVIEW

The global rise in air temperatures has a direct impact on marine systems, affecting sea surface temperatures (SSTs), sea levels, and wind patterns. For example, in Indonesia, average monthly temperatures remain relatively stable at 25–26°C, but rainfall shows significant seasonal variation, with monsoonal cycles heavily influenced by El Niño and La Niña events (World Bank Climate Change Knowledge, 2021). Sea level rise is a key indication of climate change in Indonesian waterways. Monthly mean sea level anomalies in the Indonesian Exclusive Economic Zone range from +30 mm in August to approximately +95 mm in December, according to 1993–2025 satellite records. Between –130 mm (November) and +226 mm (December), extreme values vary due to interannual variability and large-scale climate causes. Normal variations range from 55 to 80 mm, indicating that sea level change in the region is dynamic. High anomalies occur at year-end (November–December) and low anomalies in mid-year (July–September). Elevated sea levels threaten Indonesia's coastal areas with erosion, tidal flooding, saltwater intrusion, and destruction of marine and fishery habitats. In a changing climate, fisheries and coastal management must adapt to protect lives and ecosystems (Figure 1) (World Bank Group, 2025).

In addition to changes in sea level, the sea surface temperature (SST) in Indonesian waters, especially in the Java Sea, has shown a rising trend. From 2011 to 2021, the sea surface temperature increased by approximately 0.31°C, rising from 28.82°C in 2011 to 29.13°C in 2021. Seasonal variations are clearly observed, with the peak SST recorded in March–May (29.4–30.4°C) and the minimum in August–September (27.4–29.3°C). The observed fluctuations are significantly affected by global climate phenomena. For instance, El Niño events, such as those in 2015, led to a decrease in SST, while La Niña episodes occurring in 2016–2017 and 2020–2021 resulted in elevated SST values (Ahmad et al., 2019; Simanjorang et al., 2018; Dewi et al., 2020). Atmospheric conditions demonstrate considerable variability. The Global Wind Atlas (2023) indicates that the average wind speed in Indonesia at a height of 100 m varies from 3.5 to 5.0 m/s, exhibiting significant spatial differences that influence wave height. The dynamics of seasonal winds in tropical areas significantly influence ocean circulation, the distribution of nutrients, and the abundance of fish in coastal ecosystems.

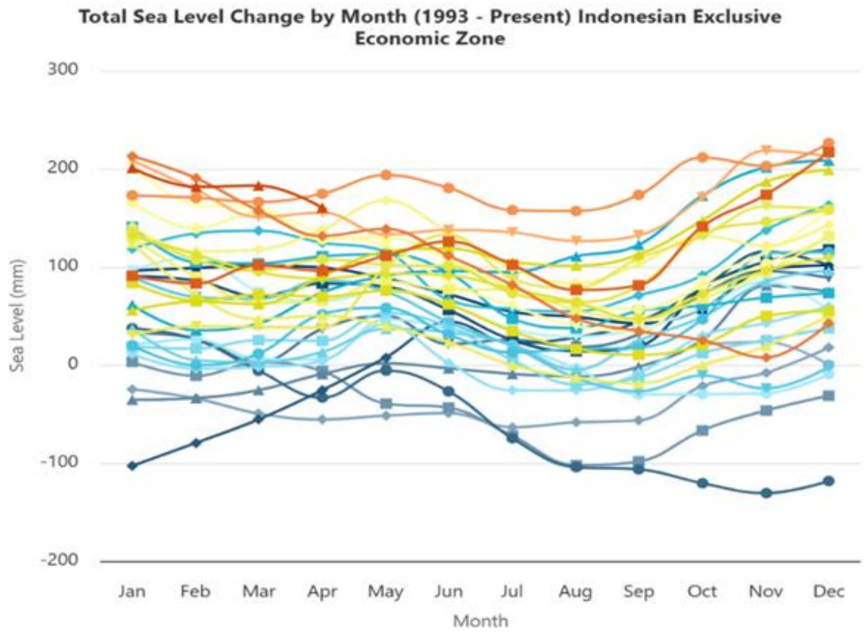

Figure 1. Total sea level change by month (1993–present) in the Indonesian Exclusive Economic Zone, showing both seasonal cycle and interannual variability

Source: World Bank Group (2025)

Global studies show that rising SST alters fish distribution, migration, and spawning grounds, reducing potential catch in tropical regions (Cheung et al., 2021; Free et al., 2019). Thermal anomalies increase metabolic stress, impair recruitment, and heighten disease vulnerability (Barange et al., 2018). Additionally, sea level rise contributes to coastal erosion, salinity intrusion, and habitat loss in estuaries and mangroves, while ocean acidification disrupts the calcification of organisms and marine food webs (Islam et al., 2014). Climate extremes, such as storms and cyclones associated with changing wind patterns, damage fishing infrastructure, restrict access to fishing grounds, and increase operational costs, particularly for small-scale fishers. ENSO events modify plankton production and upwelling systems, thereby shaping seasonal fish availability (Bertrand et al., 2023).

From an economic perspective, risk occurs when probabilities of outcomes are known, while uncertainty arises when outcomes cannot be predicted (Debertin, 2012). For capture fisheries, seasonal catch variations and monsoon-related sea conditions represent predictable risks, whereas the timing and intensity of El Niño and La Niña events remain uncertain. Small-scale fishers are disproportionately affected due to limited adaptive capacity and reliance on seasonal patterns.

RESEARCH METHOD

This study focuses on hairtail production at Sadeng Fishing Port from 2019 to 2024. The clustered monthly data of hairtail production is presented to identify temporal variations, highlighting the months with the highest and lowest levels of production. To measure production risk, the Coefficient of Variation (CV) method is applied. The CV is defined as the ratio between the standard deviation (σ) and the mean (μ) of production, expressed as follows:

$$CV = \frac{\sigma}{\mu} \quad (1)$$

Where CV represents the coefficient of variation or production risk, σ denotes the standard deviation of production, and μ indicates the average production during the observation period. The interpretation follows the principle that a higher CV value reflects a greater level of production risk (i.e., higher instability). In comparison, a lower CV value indicates more stable production and lower risk (Debertin, 2012). To identify the trend of production risk, annual CV values will be calculated based on monthly production data. These annual CV values will then be visualized using a line chart to illustrate the fluctuation in production risk across all capture fisheries at Sadeng over the six-year period (2019–2024).

FINDINGS AND DISCUSSION

The production data of hairtail in Sadeng Fishing Port from 2019 to 2024 shows a pattern that can be linked to several factors, including environmental and human-related factors. Hairtail is one of the most commercially important species; it contributes to the local economy, making it essential to understand not only the volume of catches but also the risks associated with production fluctuations. By examining monthly production data and calculating the coefficient of variation, this study highlights how variability differs across time, providing insights into potential drivers of risk such as climate anomalies, fishing practices, and resource availability.

Seasonal and Interannual Patterns of Hairtail Production

We clustered the monthly data on hairtail production in Sadeng Beach from 2019 to 2024 to identify production patterns, as shown in Figure 2. The data show a clear seasonal pattern, with the highest production generally occurring around January to March. The most apparent anomaly was observed in January 2023, when production peaked at 140,756 kg, almost double the maximum production in January 2022, which was 74,044 kg. This surge may be attributed to favorable oceanographic conditions associated with the transition from La Niña to neutral ENSO. According to Badan Meteorologi Klimatologi dan Geofisika (2023), the ENSO index indicated a weak La Niña condition and was predicted to shift to a neutral ENSO condition starting in March.

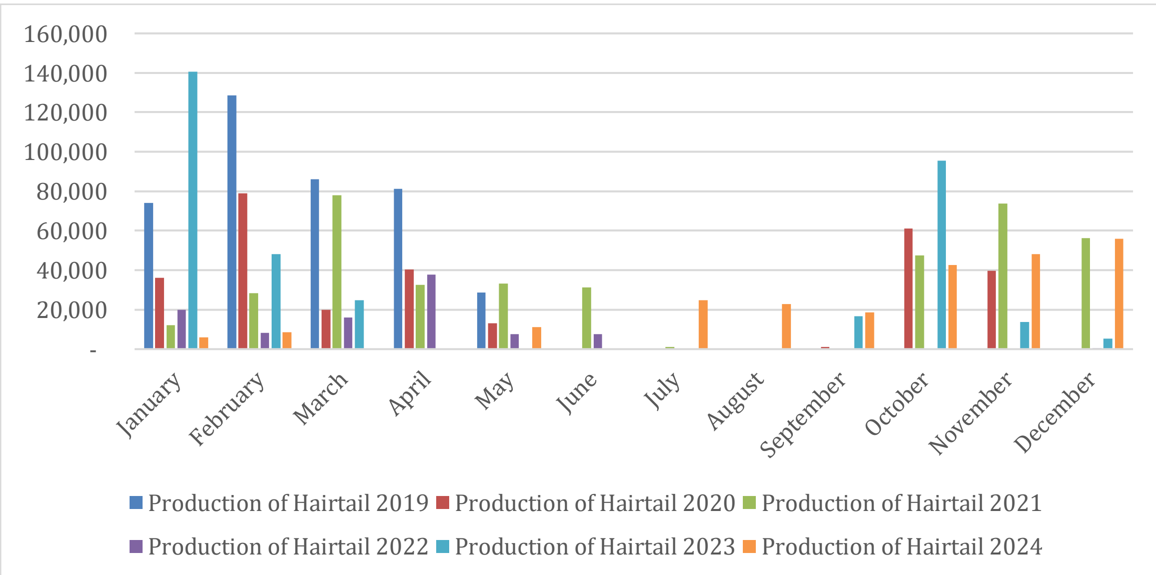

Figure 2. Clustered monthly production of hairtail (2019–2024) in Sadeng Beach
Source: Sadeng Fishing Port (2025)

The IOD index indicated a neutral IOD condition that was predicted to remain neutral until July 2023. In addition to increased fishing effort at the beginning of the year. According to fishermen in Sadeng, small-scale fishers generally base their decision to go to sea on prevailing weather conditions, venturing out when the conditions are deemed safe and favorable. This reliance on weather patterns is primarily due to the limited capacity and technological constraints of small vessels, which make them highly vulnerable to rough seas, strong winds, and unpredictable climatic events. As a result, periods of adverse weather not only restrict fishing activity but also directly reduce the volume of landings, since fewer trips are made to sea. Consequently, climatic factors exert a dual influence, shaping both the operational decisions of fishers and the overall level of catch production observed in local fisheries.

The hairtail production consistently declined during the mid-year period (around May-September), which coincides with the southeast monsoon when rough seas and strong winds often limit fishing activities. Based on the findings of Prihatiningsih et al. (2025), the spawning season of hairtail in the southern waters of Java typically occurs around July-August. This reproductive cycle is closely linked to environmental conditions, including sea surface temperatures, monsoonal wind patterns, and nutrient availability, which create favorable habitats for spawning. The seasonal nature of this process helps explain the decline in catch volumes during mid-year months, as the species allocates more energy toward reproduction and may migrate to specific spawning grounds that are less accessible to local fisheries.

A smaller secondary peak was seen during the October-November period, suggesting an additional fishing season linked to the onset of the rainy period. Wijopriono and Akbar (2017) reported a positive correlation between hairtail catch and precipitation. Increased rainfall contributes to the dilution and reduction of salinity levels in coastal waters, creating favorable conditions that enhance the abundance of hairtail and, consequently, increase catch production. This relationship is particularly relevant to the Sadeng region, where the monsoonal cycle has a strong influence on rainfall patterns. Overall, the findings indicate that Sadeng's hairtail fishery is strongly seasonal but subject to substantial interannual variability.

Risk Dynamics in Hairtail Production

To further evaluate the uncertainty of production outcomes, the coefficient of variation (CV) was applied as a measure of risk (Figure 3). The CV values show substantial interannual fluctuations. In 2019, risk was relatively high (around 1.35) before declining to its lowest level in 2021 (0.79), indicating relatively stable production conditions. It then increased in 2022-2023, peaking at 1.50 in 2023, coinciding with the unusually high production in January, followed by sharp declines in subsequent months. In 2024, the CV dropped below 1.0, indicating relatively lower production variability.

The trend line indicates a slightly negative long-term trend in production risk over the six-year period, although the slope is minimal and therefore statistically less pronounced. This suggests that while the overall direction suggests a gradual reduction in production risk, the dominant characteristic of hairtail production in Sadeng remains its high variability across seasons and years. Such volatility likely reflects the combined influence of multiple interacting factors.

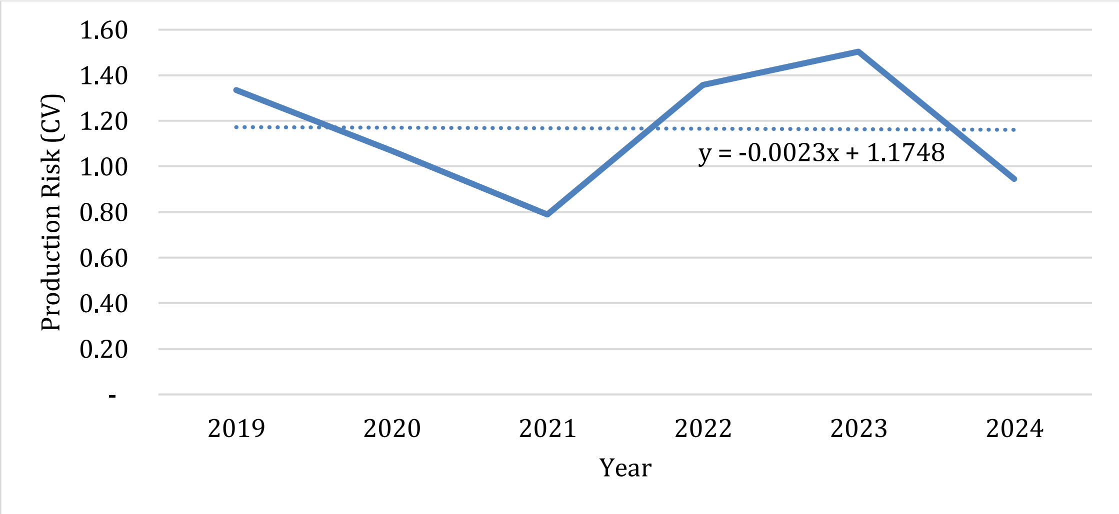

Figure 3. Hairtail's Risk Production Trend in Sadeng Beach, 2019-2024
Source: Secondary Data Analysis (2025)

Climate anomalies, including El Niño and La Niña events, contribute to shifts in sea surface temperature, precipitation, and current patterns (Firmansyah et al., 2022; Dewi et al., 2020) that directly affect hairtail abundance and distribution. In addition, the influence of monsoonal weather cycles determines both the availability of suitable fishing days and the biological processes, such as spawning and migration. Beyond environmental drivers, fluctuations in fishing efforts shaped by operational capacity, market demand, and fuel costs further amplify the observed instability. These dynamics create a system where risk persists despite a marginal downward trend, underscoring the need for adaptive strategies that can address both environmental uncertainty and socioeconomic pressures.

CONCLUSIONS

This study highlights the dynamic of hairtail production in Sadeng Fishing Port, emphasizing the combined effect of environmental variability and socio-economic factors. The result demonstrates clear seasonal patterns, with production peaks during the early months of the year and a complete absence around August. This study also found that the production risk fluctuates over time, which tends to intensify during years influenced by climate anomalies such as El Niño and La Niña.

While this study provides insight into production dynamics and risk, further investigation is still needed to strengthen the understanding of underlying mechanisms. Future studies should integrate oceanographic and biological data to establish stronger causal links between climate variability and hairtail availability. The socioeconomics dimension also needed to be incorporated to provide a more comprehensive picture of the risk faced by fishing communities.

REFERENCES

Ahmad, A. L., Syamsuddin, M. L., Purba, N. P., & Sunarto. (2019). Thermal front condition through El Nino and Indonesian throughflow phase in southern sea of East Java and Bali on the east monsoon. *IOP Conference Series: Earth and Environmental Science*, *303*(1). https://doi.org/10.1088/1755-1315/303/1/012002.

Badan Meteorologi Klimatologi dan Geofisika. (2023). *Analisis dinamika atmosfer-laut; analisis & prediksi curah hujan: update dasarian II Januari 2023*.

Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, K. L., & Funge-Smith, S. (2018). Impact of climate change on inland and ocean fisheries and aquaculture. In *Food and Agriculture Organization of the United Nations*. FAO Fisheries and Aquaculture Technical Paper. https://doi.org/10.1079/9781800624870.0006.

Bertrand, A., Lengaigne, M., Takahashi, K., Avadi, A., Poulain, F., & Harrod, C. (2023). *El Niño Southern Oscillation (ENSO) Effects on Fisheries and Aquaculture.* FAO.

BPS Provinsi D.I.Yogyakarta. (2024). *Production of fish capture by regency/municipality in DI Yogyakarta Province, 2017–2022 (tons)*. BPS Provinsi D.I. Yogyakarta. https://yogyakarta.bps.go.id/en/statistics-table/1/MTc0IzE=/production-of-fish-capture-by-regency-municipality-and-type-of---captures-in-di-yogyakarta-province--2017-2022--ton-.html.

Cheung, W. W. L., Frölicher, T. L., Lam, V. W. Y., Oyinlola, M. A., Reygondeau, G., Rashid Sumaila, U., Tai, T. C., Teh, L. C. L., & Wabnitz, C. C. C. (2021). Marine high temperature extremes amplify the impacts of climate change on fish and fisheries. *Science Advances*, *7*(40), 1–16. https://doi.org/10.1126/sciadv.abh0895

Dewi, Y. W., Wirasatriya, A., Nugroho Sugianto, D., Helmi, M., Marwoto, J., & Maslukah, L. (2020). Effect of ENSO and IOD on the Variability of Sea Surface Temperature (SST) in Java Sea. *IOP Conference Series: Earth and Environmental Science*, *530*(1). https://doi.org/10.1088/1755-1315/530/1/012007.

Debertin, D. L. (2012). *Agricultural Production Economics* (2nd Ed.). Macmilan Publishing Company.

Firmansyah, A. J., Nurjani, E., & Sekaranom, A. B. (2022). Effects of the El Niño-Southern Oscillation (ENSO) on rainfall anomalies in Central Java, Indonesia. *Arabian Journal of Geosciences*, *15*(24). https://doi.org/10.1007/s12517-022-11016-2

Free, C. M., Thorson, J. T., Pinsky, M. L., Oken, K. L., Wiedenmann, J., & Jensen, O. P. (2019). Impacts of historical warming on marine fisheries production. *Science*, *363*(6430), 979–983. https://doi.org/10.1126/science.aax5721.

Global Wind Atlas. (2023). *Global Solar Atlas.* https://globalwindatlas.info/en/area/Indonesia.

Hutajulu, J., Annur, M. Y., Nugraha, E., Mualim, R., Yusrizal, Hermawan, M., Kusumo, T., Dewi, P., Nurlaela, E., & Putra, G. N. (2023). Study on Katsuwonus pelamis fishing business at Sadeng Fishery Port, Yogyakarta, Indonesia. *AACL Bioflux*, *16*(1), 328–341.

IPCC. (2021). Climate Change 2021: The physical science basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. In *Cambridge University Press*.

Islam, M. M., Sallu, S., Hubacek, K., & Paavola, J. (2014). Limits and barriers to adaptation to climate variability and change in Bangladeshi coastal fishing communities. *Marine Policy*, *43*, 208–216. https://doi.org/10.1016/j.marpol.2013.06.007.

Prihatiningsih, P., Tirtadanu, T., Taufik, M., Rosmiati, R., Nurdin, E., Panggabean, A. S., Kembaren, D. D., Nurulludin, N., Chodrijah, U., Mahulette, R. T., & Nugraha, B. (2025). Unveiling the status of Trichiurus lepturus (Actinopterygii, Scombriformes, Trichiuridae) stocks in the southern Java waters, Indonesia: A biological and length-based assessment approach. *Acta Ichthyologica et Piscatoria*, *55*, 31–43. https://doi.org/10.3897/aiep.55.138745.

Putera, I. G. S. A., Suadi, S., & Budhiyanti, S. A. (2022). User's Satisfaction Levels Toward Sadeng Coastal Fishing Port Service at Gunungkidul Regency. *Marine Fisheries: Journal of Marine Fisheries Technology and Management*, *13*(2), 149–160. https://doi.org/10.29244/jmf.v13i2.41020.

Simanjorang, J. E., Pranowo, W. S., Sari, L. P., Purba, N. P., & Syamsuddin, M. L. (2018). Building up the database of the Level-2 Java Sea Ecoregion based on physical oceanographic parameters. *IOP Conference Series: Earth and Environmental Science*, *176*(1). https://doi.org/10.1088/1755-1315/176/1/012009.

Wijopriono, & Akbar, M. A. (2017). Kelimpahan stok ikan layur (Trichiurus spp.) dan faktor lingkungan yang mempengaruhinya di perairan Palabuhanratu, Jawa Barat. *Jurnal Penelitian Perikanan Indonesia*, *23*(1), 29–36.

World Bank Climate Change Knowledge. (2021). *Climate data: Indonesia Histrorical*. World Bank Group. https://climateknowledgeportal.worldbank.org/country/indonesia/climate-data-historical.

World Bank Group. (2025). *Sea Level Rise in Indonesia*. Climate Change Knowledge Portal.