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The Impact of Aquatic Productivity on Fishermen's Catches in Kawasi and Soligi Villages on Obi Island, South Halmahera

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Abstract

This study examines the seasonal association between aquatic productivity, fishermen's catch, and income in the waters of Obi Island, South Halmahera Regency, Indonesia. Aquatic productivity was represented by chlorophyll a concentration and sea surface temperature (SST) derived from Aqua MODIS satellite imagery for the period 2022–2023. Satellite data were processed to describe variability across the east and west monsoons and the two transitional seasons. Fisheries data, including catch volume, fishing frequency, and income, were collected through surveys of active fishermen in Soligi and Kawasi Villages using a purposive sampling approach. All datasets were analysed descriptively to examine the correspondence between seasonal oceanographic conditions and fishing performance. The results show that chlorophyll a concentrations ranged from 0.01 to 1.50 mg/m³, with higher values during the east monsoon (May–June) and lower values during transitional season I (July–September). Sea surface temperature varied between 25.0 and 31.0 °C, with relatively lower temperatures observed during transitional season I. Periods characterised by higher chlorophyll-a concentrations were accompanied by increased fishing activity, during which catches reached approximately 100–500 kg per trip per month, whereas lower chlorophyll-a conditions were associated with reduced catches of about 10–50 kg per trip per month. The average monthly income of fishermen in Soligi Village is IDR 10,677,845, while in Kawasi Village, where fishermen earn IDR 11,948,611 per trip and average 12 trips per month, their monthly income reaches IDR 143,383,332.

1. Introduction

The waters surrounding Obi Island can be characterised as a productive marine environment that supports pelagic fisheries and multiple life stages of fish. Numerous studies have shown that large pelagic species, such as tunas and billfishes, tend to concentrate spawning activities in areas and seasons with high plankton productivity, as favourable feeding conditions enhance larval survival and growth. In tropical regions, pelagic fishes may spawn throughout the year across broadly productive waters, responding to intermittent productivity pulses driven by physical processes such as vertical mixing and monsoonal circulation (Buenafe *et al.*, 2025). Shallow coastal habitats adjacent to productive offshore waters, including seagrass meadows and other structured environments, also serve as important feeding and nursery areas for fish larvae and juveniles, where primary productivity and oxygen availability are closely linked to early-life-stage abundance (Ngisiange *et al.*, 2024). Consequently, productive coastal and estuarine zones often serve simultaneously as feeding, spawning, and nursery grounds, supporting high fish biomass and a large proportion of immature or spawning individuals (Hashiguti *et al.*, 2025). Because early life stages are particularly sensitive to environmental conditions, the quality and extent of nursery habitats strongly Influence population size, recruitment success, and fisheries yield, while habitat degradation can reduce stock productivity and resilience to fishing pressure (Champagnat *et al.*, 2024; Walker-Milne *et al.*, 2025).

Chlorophyll a is widely applied as an indicator of phytoplankton biomass and a proxy for identifying potential fishing grounds, particularly when derived from satellite observations (Shahvaran *et al.*, 2024; Ginanjar *et al.*, 2025). In marine systems adjacent to Indonesia, elevated chlorophyll a concentrations combined with favourable sea surface temperatures reliably indicate productive pelagic fishing areas, with strong seasonal variability driven by monsoonal circulation and upwelling (Nurmila *et al.*, 2023). In North Maluku waters, which are administratively and ecologically part of the Fisheries Management Area of the Republic of Indonesia (WPPNRI) 715 and include Obi Island, higher mid-year chlorophyll-a levels are associated with enhanced primary productivity and increased fish availability. In contrast, climate variability such as negative phases of the Indian Ocean Dipole can weaken upwelling and suppress productivity (Pratama *et al.*, 2025). Previous studies in North Maluku and other small-island and coastal systems demonstrate the usefulness of chlorophyll a and related oceanographic indicators for identifying productive fishing grounds, but also highlight the vulnerability of small-scale island fisheries to water-quality degradation, environmental change, and limited adaptive capacity. Despite the strategic role of WPPNRI 715 in supporting pelagic fisheries and local livelihoods, empirical studies that integrate satellite-based productivity indicators with fisheries catch and fishermen's income at the local scale remain limited. Therefore, this study aims to examine the seasonal association between aquatic productivity, fishing activities, and fishermen's income in the waters of Obi Island, providing evidence to support adaptive and context-specific fisheries management within WPPNRI 715.

Despite this well-established ecological understanding and the recognised usefulness of chlorophyll a and sea surface temperature as indicators of productive fishing grounds, empirical evidence linking seasonal variability in aquatic productivity to realised fishing outcomes and fishermen's income remains limited, particularly in remote island systems such as Obi Island. Previous studies have largely focused on biological responses or physical oceanographic processes, with comparatively little integration of satellite-derived productivity indicators and socio-economic data at the local scale. In small, isolated island waters, fishing activities are strongly constrained by limited fishing ranges, high dependence on seasonal environmental conditions, and the restricted adaptive capacity of fishing communities. However, the extent to which seasonal changes in chlorophyll a concentration and sea surface temperature correspond to variations in fishing activity, catch levels, and fishermen's income has not been sufficiently documented. Therefore, this study aims to examine the seasonal association among aquatic productivity, fishing activities, and fishermen's income in the waters of Obi Island, providing evidence to support adaptive, context-specific fisheries management within WPPNRI 715.

2. Material and methods

2.1 Research Location and Time

This research was conducted in Soligi Village and Kawasi Village, located on Obi Island, South Halmahera Regency, North Maluku Province. These two locations were selected based on their characteristics as centres of pelagic fishing activity and their proximity to mining industrial areas. The research lasted one year, from October 2022 to September 2023, thus encompassing seasonal variations in local waters. A map of the research locations is shown in Figure 1.

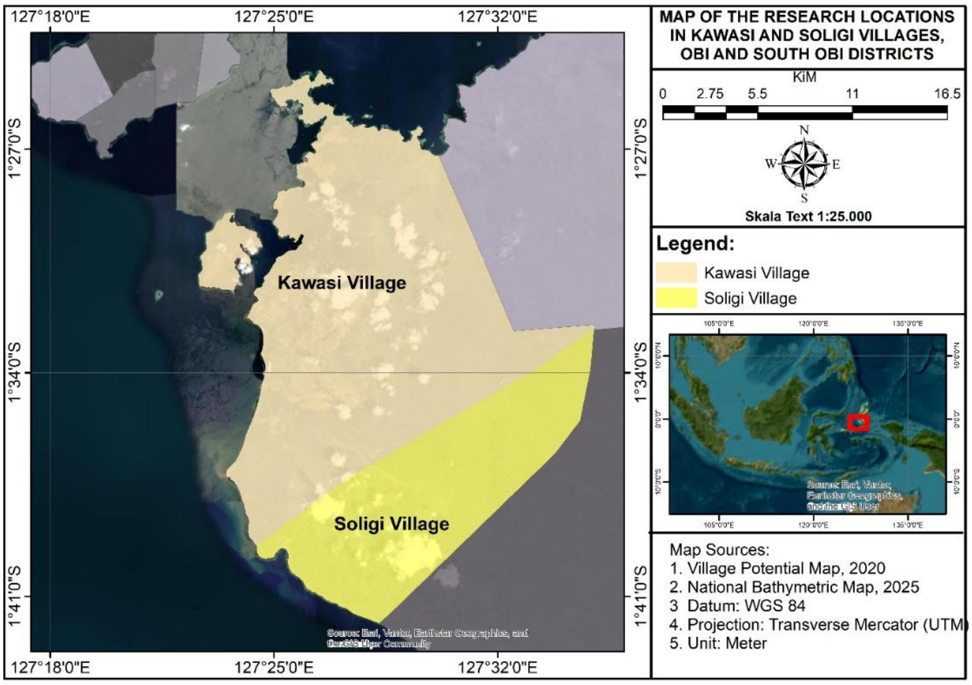

Figure 1. Map of Research Locations in Soligi and Kawasi Villages, Obi Island, South Halmahera Regency

2.2 Sampling Techniques

Data collection is carried out through two main approaches:

2.3 Oceanographic Data

Spatial and temporal variations in chlorophyll a concentration and sea surface temperature (SST) were derived from Aqua MODIS satellite imagery using standard remote sensing approaches. Monthly composite products were employed to minimise cloud contamination and to represent seasonal conditions during the 2022–2023 period. Chlorophyll a data were obtained from the MODIS ocean colour product at approximately 4 km spatial resolution. In comparison, SST data were extracted from the MODIS thermal infrared product with a spatial resolution of 4 km. The satellite datasets had undergone standard atmospheric correction, radiometric calibration, and geometric correction as part of the MODIS Level-3 processing chain. Cloud-affected pixels were excluded using quality control flags provided within the MODIS products. Chlorophyll a concentrations were estimated using the OC3 algorithm, widely applied in open and coastal waters, whereas SST was derived using the standard MODIS split-window algorithm. These satellite-derived variables were analysed to characterise seasonal variability in aquatic productivity and thermal conditions in the waters surrounding Obi Island (Park *et al.*, 2022).

1. Fisheries Socio-Economic Data

Fisheries socio-economic data were collected through structured surveys conducted in Soligi and Kawasi Villages. Respondents were selected using a purposive sampling approach targeting active small-scale fishermen who were directly involved in fishing activities during the study period. Selection criteria included: (1) regular engagement in fishing operations, (2) active fishing during the 2022–2023 seasons, and (3) willingness to provide information on catch volume, fishing frequency, fishing areas, and income. A total of n = 20 fishermen were surveyed in Soligi Village and n = 20 fishermen in Kawasi Village. The sample size represents a substantial proportion of the active fishing households in each village and was considered adequate to capture seasonal variability in fishing activities and income patterns (Mulyasari *et al.*, 2023; Suryana and Nurezka, 2023).

To enable comparison with satellite-derived productivity indicators, fisheries data were aggregated seasonally into the east monsoon, west monsoon, and two transitional seasons. Catch and income data were averaged for each season to match the temporal resolution of monthly composite Aqua MODIS chlorophyll a and sea surface temperature datasets. Spatially, reported fishing locations were confined to nearshore and offshore waters surrounding Obi Island, consistent with the spatial extent of the MODIS data. Satellite-derived chlorophyll a and SST values were extracted for the waters adjacent to each village fishing area and analysed at a seasonal scale, assuming minimal time-lag between changes in aquatic productivity and fishing outcomes. This approach enabled an integrated assessment of seasonal associations between oceanographic conditions, fishing activity, and fishermen's income (Li *et al.*, 2024; Putri *et al.*, 2024).

2.4 Data analysis

Oceanographic data, including chlorophyll a concentration and sea surface temperature (SST), were analysed to describe seasonal, spatial, and temporal variability in the waters surrounding Obi Island. Monthly satellite-derived values were first organised and aggregated into seasonal means for the east monsoon, west monsoon, and the two transitional seasons. Fisheries survey data, including catch volume, fishing frequency, and fishermen's income, were compiled, coded, and tabulated using Microsoft Excel (Ahmed *et al.*, 2024; Pratama *et al.*, 2025).

Descriptive statistical analyses were conducted in Microsoft Excel to summarise patterns in aquatic productivity, fishing activity, and income, including calculation of means, ranges, and seasonal averages. To quantitatively assess the relationships between oceanographic conditions and fisheries outcomes, correlation analyses were performed using Excel's built-in statistical functions. Pearson correlation coefficients were calculated to evaluate the strength and direction of associations between seasonal chlorophyll a concentration, SST, catch volume, and fishermen's income, assuming approximately linear relationships among variables. When data distributions deviated from normality, correlation results were interpreted cautiously and used to indicate general associations rather than strict statistical inference (Ajrin and Heliani, 2025).

Correlation analyses were conducted at the seasonal scale to ensure temporal consistency between satellite-derived productivity indicators and fisheries data. The analyses aimed to quantify the degree of association between environmental variability and fishing outcomes, rather than to establish causal relationships. The use of Microsoft Excel was considered appropriate for the scope of this study, as it provides reliable tools for descriptive and correlation-based statistical analyses commonly applied in fisheries and environmental studies. Statistical significance was evaluated at a 95% confidence level ($\alpha = 0.05$) (Ahkam and Tarya, 2023).

3. Results

3.1 Seasonal Variability of Aquatic Productivity

Chlorophyll a concentrations in the waters surrounding Obi Island showed clear seasonal variability, ranging from 0.01 to 1.50 mg/m³ across the study period. Seasonal interpretation is based on average ranges, while higher values represent localised spatial extremes. During the east monsoon (May–June), chlorophyll a exhibited higher seasonal averages (0.18–0.78 mg/m³), coinciding with the peak fishing season and indicating enhanced primary productivity. In contrast, Transitional Season I (July–September) was characterised by lower average concentrations (0.01–0.50 mg/m³), despite occasional spatial hotspots. Spatial distribution maps (Figures 2 and 3) illustrate an expansion of productive zones during the east monsoon and a contraction during transitional periods, highlighting strong seasonal control on productivity, Table 1.

The distribution map of chlorophyll a content in the waters around Obi Island is shown in Figures 2 and 3.

3.2 Surface Temperature

Sea surface temperature (SST) ranged from 25.0 to 31.0 °C and also varied seasonally. Lower SSTs occurred during Transitional Season I (25.0–29.5 °C), while relatively higher and more stable temperatures were observed during the east monsoon (27.5–31.0 °C). Compared with chlorophyll a, SST exhibited weaker spatial gradients (Figures 4 and 5), suggesting that SST primarily modulates rather than directly drives seasonal productivity patterns in the study area (Table 2).

Table 1. Average Value of Chlorophyll-a Content in the Waters of Obi Island and its Surroundings in 4 Seasonal Conditions

Season	Month	Chlorophyll-a content (mg/m^3)
East (Peak)	May – June	0.18 – 0.78
Transitional Season I (Normal)	July – September	0.01 – 1.50
West (Lean)	December – January	0.18 – 0.52
Transitional Season II (Normal)	March – April	0.12 – 0.66

(Source: Chlorophyll-a content data from Aqua MODIS Satellite Imagery in 2023, processed)

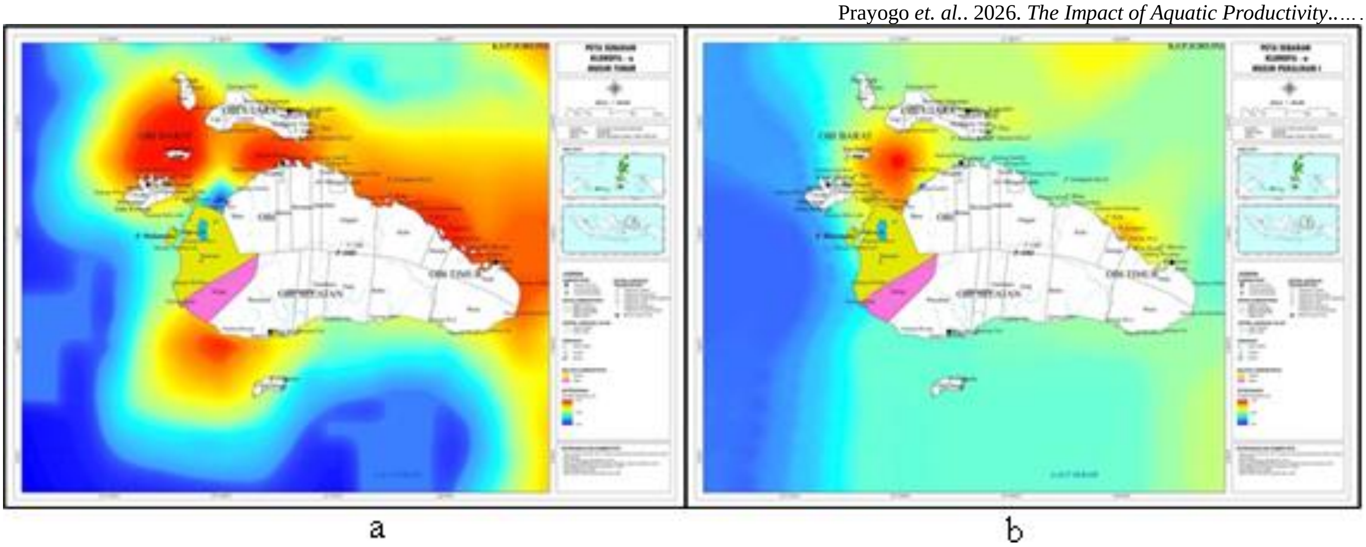

Figure 2. Map of the Distribution of Chlorophyll-a Content in the Waters of Obi Island and its Surroundings (a. East Season, May – June and b. Transitional Season I, July – September)

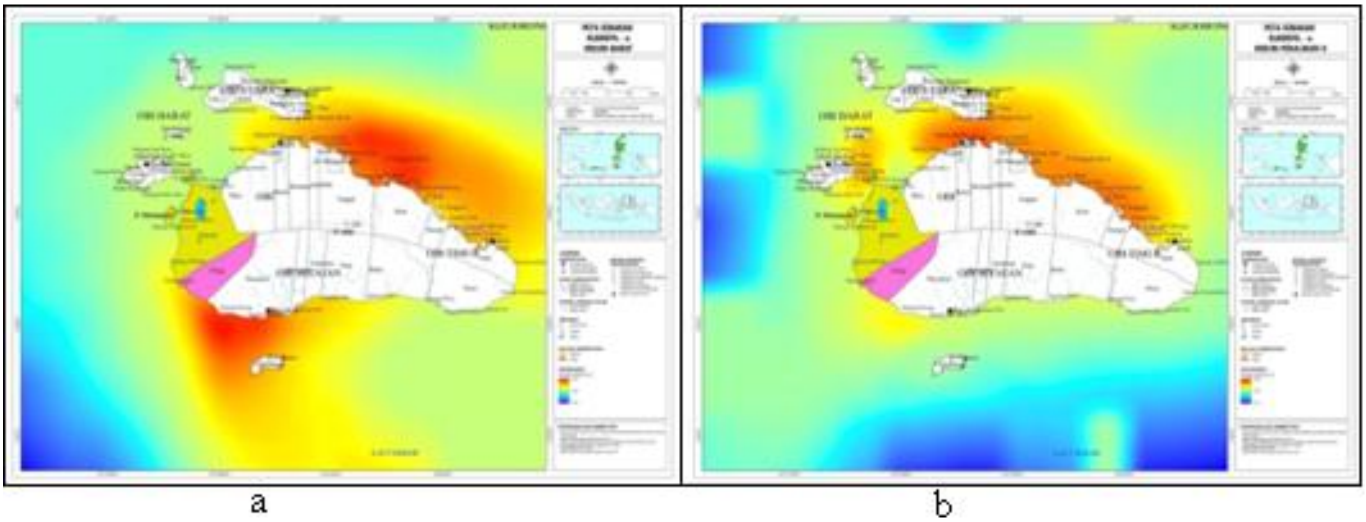

Figure 3. Map of the Distribution of Chlorophyll-a Content in the Waters of Obi Island and its Surroundings (a. West Season, December – January and b. Transitional Season II, March – April)

Table 2. Average Value of Sea Surface Temperature (SST) Distribution in the Waters of Obi Island and its Surroundings in 4 Seasonal Conditions

Season	Month	Sea Surface Temperature (ºC)
East (Peak)	May – June	27.5 – 31.0
Transitional Season I (Normal)	July – September	25.0 – 29.5
West (Lean)	December – January	28.5 – 30.0
Transitional Season II (Normal)	March – April	29.0 – 30.8

(Source: 2021 Aqua MODIS Satellite Imagery SPL distribution data, processed)

Figures 4 and 5 show the spatial distribution of sea surface temperature in this region.

3.3 Catch and Income Patterns

Fishing activity and catch volumes varied consistently with seasonal productivity. During the east monsoon, catches increased to approximately 100–500 kg per trip per month, whereas during the west monsoon (December–January), catches declined to around 10–50 kg per trip per month. Correlation analysis conducted at the seasonal scale showed a moderate positive association between chlorophyll a concentration and catch volume. At the same time, SST showed a weaker, generally To ensure comparability, fishermen's income was standardised on a monthly basis. Average monthly income in Soligi Village was IDR 10,677,845, while higher incomes in Kawasi Village were associated with higher fish prices and direct market access. Fishermen using fish aggregating devices (FADs) consistently recorded higher catches and incomes than those without FADs; however, these differences are interpreted descriptively as indicative patterns rather than statistically tested effects (Table 3).

The survey results show that fishermen in Soligi and Kawasi Villages catch fish on average 12 times in 1 (one) month, with the highest production amount being fish aggregating device fishermen, namely 12 tons/month, while the production of fishermen without fish aggregating device is 3 tons/month for fishermen in Soligi Village and 84 kg/month for fishermen in Kawasi. The highest income of fish aggregating device fishermen is Rp. 11,948.61/month or Rp. 143,383,333/year in Kawasi Village, while the highest income of fishermen without a fish aggregating device in Soligi Village is Rp. 4,000,000.00/month or

48,000,000.00/year. The income of these fishermen depends on the marketing of their catch; fish from fishermen in Soligi Village are sold through collectors in Kawasi Village at a price of Rp. 16,000/kg, while fishermen in Kawasi Village sell directly to local markets or to companies in Kawasi Village at a price of Rp. 30,000 /kg.

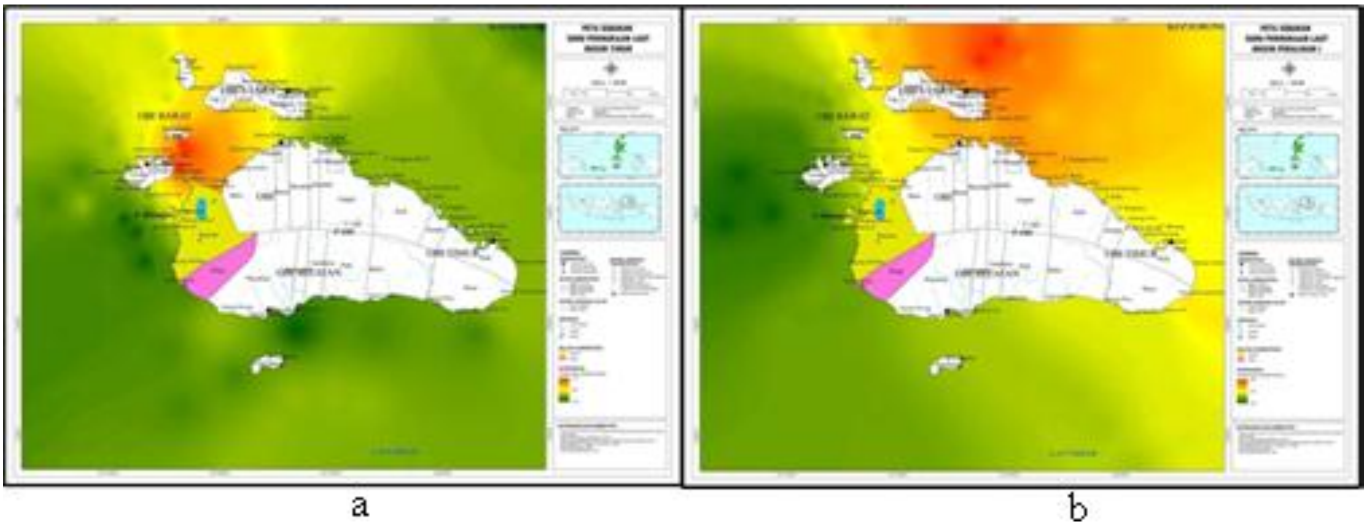

Figure 4. Map of Sea Surface Temperature Distribution in the Waters of Obi Island and its Surroundings (a. East Season May – June and b. Transitional Season I July – September)

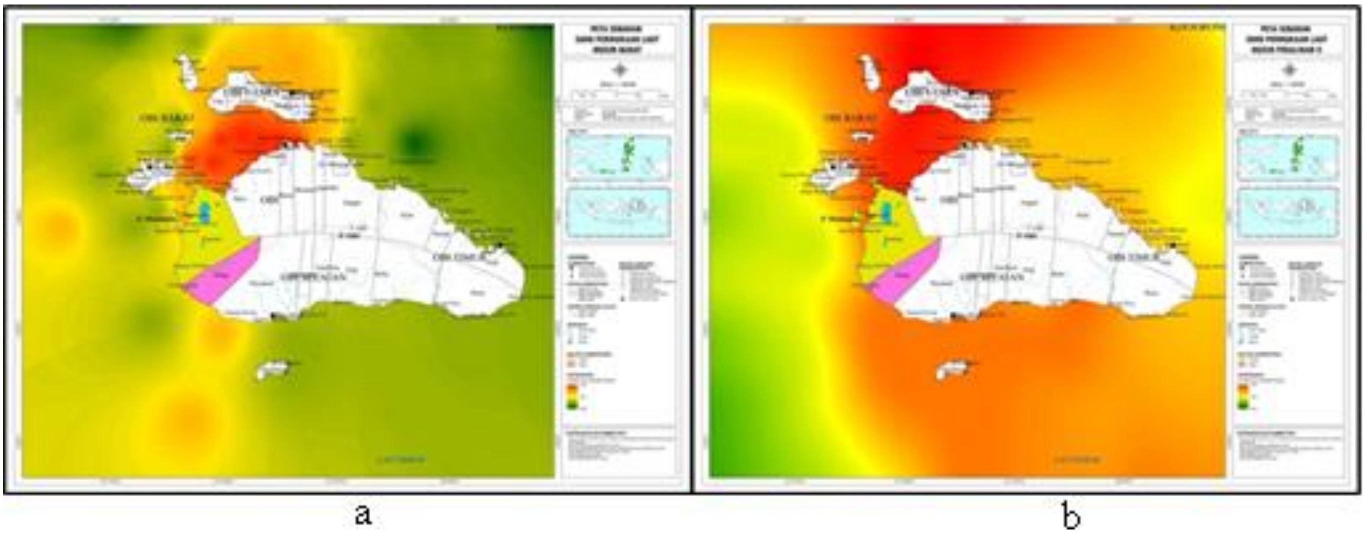

Figure 5. Map of Sea Surface Temperature Distribution in the Waters of Obi Island and its Surroundings (a. West Season December – January and b. Transitional Season March – April)

4. Discussion

This study demonstrates that seasonal variability in aquatic productivity around Obi Island, as indicated by chlorophyll a concentration and sea surface temperature (SST), is closely associated with observed fishing activity and catch dynamics. However, the strength and expression of this association are shaped by local environmental and socio-economic conditions. The observed chlorophyll a ranges during the east monsoon (0.18–0.78 mg/m³) are comparable to values reported for productive pelagic fishing grounds in other parts of Halmahera and eastern Indonesian waters, where optimal catches commonly occur within moderate chlorophyll a concentrations rather than at extreme values. This pattern is consistent with previous studies that identify favourable fishing conditions at intermediate productivity levels, reflecting efficient energy transfer through the food web rather than short-lived phytoplankton blooms (Kemarau *et al.*, 2025; Pratama *et al.*, 2025).

Compared with earlier studies in North Maluku, the seasonal peak in productivity observed during May–June on Obi Island aligns with monsoon-driven mixing processes. However, the spatial extent of high chlorophyll a concentrations appears more localised. This suggests that local hydrographic conditions, coastal configuration, and nearshore habitat characteristics may modulate the broader monsoonal signal, resulting in spatially heterogeneous productivity patterns. Sea surface temperature exhibited a narrower seasonal range and weaker spatial gradients than chlorophyll a, supporting its role as a secondary, modulating factor rather than a direct driver of fish availability in the study area (Kim *et al.*, 2023; Shampa *et al.*, 2024; Anil *et al.*, 2025; Lestari *et al.*, 2025; Pratama *et al.*, 2025).

In contrast to chlorophyll a, sea surface temperature exhibited a narrower seasonal range and weaker spatial gradients, indicating a relatively smooth seasonal response to regional atmospheric forcing. This divergence supports the interpretation that SST acts primarily as a modulating environmental condition. In contrast, chlorophyll a more directly reflects localised physical and biogeochemical processes such as mixing intensity, nearshore inputs, and habitat structure. Comparable satellite-based analyses in other coastal systems have shown that chlorophyll a displays pronounced spatial heterogeneity even when SST varies more uniformly, reinforcing the differential sensitivity of these variables to local versus regional drivers (Kim *et al.*, 2023; Anil *et al.*, 2025).

Temporal lag effects between phytoplankton productivity and fish availability are recognised as an important ecological mechanism. While this study did not explicitly model time-lagged responses, the seasonal aggregation of data suggests that increased catches during the east monsoon likely reflect productivity enhancement occurring in the preceding weeks to months. The alignment between seasonal increases in chlorophyll a and peak fishing activity implies that lag effects operate within the same seasonal window. However, finer temporal resolution would be required to quantify these dynamics more precisely (Setiawan *et al.*, 2024; Mooney *et al.*, 2025; Pratama *et al.*, 2025).

From a socio-economic perspective, the results indicate that environmental variability directly translates into economic opportunities and vulnerabilities for fishing communities (Rahim *et al.*, 2025; Sudhakaran and Varsha, 2025). Higher productivity during the east monsoon corresponds with increased catches and improved income, whereas reduced productivity during the west monsoon coincides with substantially lower catches. However, income differences between Soligi and Kawasi Villages cannot be attributed solely to environmental factors. Market access, fish prices, and the use of fish aggregating devices (FADs) play a critical role in mediating the conversion of environmental productivity into economic benefits. This highlights the uneven capacity of fishing households to buffer seasonal downturns and underscores the importance of considering socio-economic structures alongside environmental drivers (Quezada-Escalona *et al.*, 2025).

In addition, access to fishing assets, including boats, gear, storage facilities, credit, and technologies such as fish aggregating devices (FADs), strongly influences income levels and the ability to engage in more market-oriented fishing activities (Kapapa *et al.*, 2024). Households with limited physical and financial capital are less able to benefit from periods of high productivity, even when fish resources are locally abundant (Xu *et al.*, 2023). Local price structures, buyer power, and value-chain arrangements further mediate the distribution of resource value, often constraining the share of benefits captured by small-scale fishers (Quezada-Escalona *et al.*, 2025). Together, these factors highlight that fisheries productivity alone does not determine livelihood outcomes; rather, the interaction between environmental variability and socio-economic structures shapes resilience and vulnerability in small island fishing communities.

Although not directly analysed, anthropogenic pressures such as nickel mining activities represent an additional factor that may interact with productivity patterns and fisheries sustainability around Obi Island. Mining-related sedimentation and changes in water quality can affect nearshore habitats and the early life stages of fish, which are closely linked to local productivity dynamics. The presence of such pressures reinforces the need for integrated monitoring that combines satellite-based productivity indicators with fisheries and environmental assessments to support precautionary and adaptive management (Canete *et al.*, 2024; Pagano *et al.*, 2024).

In the context of Obi Island, the coexistence of productive fishing grounds and mining activities highlights the potential for cumulative impacts on fisheries resources and fisher livelihoods. This reinforces the need for integrated and precautionary monitoring frameworks that combine satellite-based productivity indicators with fisheries and water-quality assessments, enabling adaptive management responses that account for both environmental variability and anthropogenic pressures.

Overall, the findings suggest that while chlorophyll a and SST provide valuable indicators of seasonal fishing potential, fisheries outcomes in Obi Island waters are ultimately shaped by the interaction of environmental variability, fishing practices, and socio-economic conditions. Integrating these dimensions is essential for developing management strategies that enhance resilience and sustain livelihoods in small island fisheries (Al, 2025; Ginanjar *et al.*, 2025).

5. Conclusions

This study shows that seasonal variability in satellite-derived chlorophyll-a and sea surface temperature (SST) is consistently associated with fishing activity and fishermen’s income in the waters of Obi Island. Higher aquatic productivity during May–June coincides with increased catches and improved income, while lower productivity in December–January aligns with reduced fishing outcomes, indicating a clear seasonal correspondence between environmental conditions and fisheries performance without implying direct causality. Importantly, income differences between Soligi and Kawasi Villages cannot be explained by environmental variability alone, but reflect socio-economic factors such as market access, fishing strategies, infrastructure, and gear use that mediate how productivity is converted into economic benefits. The novelty of this study lies in integrating satellite-based productivity indicators with local fisheries and income data in a remote small-island setting within WPPNRI 715, where such empirical evidence remains limited. These findings support the use of seasonal oceanographic information to inform adaptive fisheries management, seasonal planning, and livelihood support strategies, emphasizing the need to combine environmental monitoring with socio-economic considerations to strengthen fisheries governance and community resilience in Obi Island waters.

Ethics approval

No permits were required.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Author contributions

W.P. and M.S. contributed to conceptualization, data collection, data curation, investigation, and original draft preparation. A.S. and F.R.G.S. contributed to funding acquisition, resources, and supervision. S.S. and M.J.A. contributed to validation, visualization, and scientific supervision. All authors reviewed and approved the final manuscript.

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Declaration of competing Interest

None

References

Ahkam, M. F., & Tarya, A. 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*. 10.59188/devotion.v4i12.646

Ahmed, A., Dhar, B., Hasan, M., & Mahboob, M. 2024. Spatiotemporal variability of sea surface temperature and its relationship with salinity, chlorophyll-a concentration and bathymetry in Bangladesh. *Ecology Journal*. 10.59619/ej.6.2.6

Ajrin, H. A., & Heliani, L. 2025. Correlation Analysis of Chlorophyll-a and Sea Surface Temperature with Fish Production in Baron Beach Gunungkidul Using Remote Sensing Technology. *Engineering Headway*. 27: 496-516. 10.4028/p-carjq3

Al, N. E. 2025. Spatio-Temporal Correlation of Sea Surface Temperature and Chlorophyll-a with East Seasonal Upwelling in the Bali Strait Using Aqua-MODIS Data. *Egyptian Journal of Aquatic Biology and Fisheries*. 10.21608/ejabf.2025.427220.6649

Anil, P., Madhu, N., Sajeev, R., Kumar, T. G., Sudheesh, P., & Mohammed, P. H. 2025. Implications of coastal upwelling and mud banks on the structuring of phytoplankton communities in the nearshore waters of Alappuzha, southwest coast of India. *The Science of the total environment.* 967: 178731. 10.1016/j.scitotenv.2025.178731

Buenafe, K., Neubert, S., Scales, K., Dunn, D., Everett, J., Flower, J., Suthers, I., Granados-Dieseldorff, P., Dabalà, A., Esturas, K. J., Mercer, J., & Richardson, A. 2025. Near-global spawning strategies of large pelagic fish. *Nature Communications.* 16. 10.1038/s41467-025-63106-w

Canete, P. R. M. P., Silor, D. A., & Arellano, R. 2024. Impact of Mining of Marine Gastropods Habitat: Basis for Information Education Communication(IEC) for Environmental Sustainability. *International Journal For Multidisciplinary Research*. 10.36948/ijfmr.2024.v06i03.21004

Champagnat, J., Rivot, E., & Le Pape, O. 2024. The response of marine fish population productivity to juvenile habitat modifications depends upon life histories. *Fish and Fisheries*. 10.1111/faf.12821

Ginanjar, M. A., Wahyudi, A., & Alfaris, L. 2025. Examining The Interrelationship Among Chlorophyll-A Distribution, Sea Surface Temperature Patterns, and Fishing Ground in Southern Java Sea. *Indo-MathEdu Intellectuals Journal*. 10.54373/imeij.v6i1.2626

Hashiguti, D., Jardim, A., Cunha, É. J. S., Souza, T. D. S., & Frédou, T. 2025. Ichthyofauna From An Amazonian Island: Diversity, Reproduction, And Feeding Aspects. *Oecologia Australis*. 10.4257/oeco.2025.2902.03

Kapapa, L., Onyango, P., Bwanthondi, P., & Mfilinge, P. 2024. The vulnerability of fisheries-based livelihoods to climate variability and change in coastal small pelagic fishing communities in Tanzania. *Marine Policy*. 10.1016/j.marpol.2024.106344

Kemarau, R., Eboy, O. V., Sakawi, Z., Suab, S., & Noor, N. 2025. Satellite-Observed Monthly Variability of Sea Surface Chlorophyll-a Concentration: A Case Study in East Malaysia. *Journal of Engineering and Technological Sciences*. 10.5614/j.eng.technol.sci.2025.57.1.1

Kim, H.-C., Son, S., Jo, C. O., Kim, Y. H., Park, M.-C., Park, Y. G., & Ryu, J. 2023. Spatio-temporal structures of satellite-derived water quality indicators along the Korean South Coast. *Environment international.* 178: 108083. 10.1016/j.envint.2023.108083

Lestari, D. F., Salsabila, A., Octaviandini, N., Cakasana, N., Pasaribu, R., Prayogo, W., Sujatno, R. D. H., Hutami, P. R., Setyabud, P., & Ahadyatulakbar, F. 2025. Phytoplankton communities in different season in the coastal area of Kawasi, the western part of Obi Island, North Maluku, Indonesia. *BIO Web of Conferences*. 10.1051/bioconf/202516804010

Li, J., Xing, Q., Li, X., Arif, M., & Li, J. 2024. Monitoring Off-Shore Fishing in the Northern Indian Ocean Based on Satellite Automatic Identification System and Remote Sensing Data. *Sensors (Basel, Switzerland).* 24. 10.3390/s24030781

Mooney, B., Gårdmark, A., Faithfull, C., Van Dorst, R., & Huss, M. 2025. Warmer Lakes Support Phytoplankton Over Fish. *Global Change Biology.* 31. 10.1111/gcb.70288

Mulyasari, G., Trisusilo, A., Windirah, N., Djarot, I., & Putra, A. 2023. Assessing Perceptions and Adaptation Responses to Climate Change among Small-Scale Fishery on the Northern Coastal of Bengkulu, Indonesia. *The Scientific World Journal.* 2023. 10.1155/2023/8770267

Ngisiange, N., Tarimo, B., Daudi, L., Mwangi, S., Malesa, F., George, R., Kyewalyanga, M., Gullström, M., Osore, M., Mwaluma, J., & Winder, M. 2024. Seasonal fish larvae abundance and composition in seagrass habitats of coastal East Africa. *Scientific Reports.* 14. 10.1038/s41598-024-62012-3

Nurmila, W. O., Asmadin, Mustafa, A., Saenuddin, Sadarun, B., Indrayani, & Ogbonna, D. 2023. Analysis of Chlorophyll-A Distribution And Sea Surface Temperature for Estimation of Skipjack Fishing Grounds (Katsuwonus Pelamis) Based on Different Seasons in South Buton Waters. *Coastal and Marine Journal*. 10.61548/cmj.v1i2.17

Pagano, M., Rodier, M., Laval, M., Varillon, D., Guilloux, L., Dupouy, C., Devenon, J., & Chevalier, C. 2024. Zooplankton in Kone Lagoon (New Caledonia): Natural variability versus mining effects. *Marine pollution bulletin.* 210: 117302. 10.1016/j.marpolbul.2024.117302

Park, K.-A., Park, J.-E., & Kang, C.-K. 2022. Satellite-Observed Chlorophyll-a Concentration Variability in the East Sea (Japan Sea): Seasonal Cycle, Long-Term Trend, and Response to Climate Index. 9. 10.3389/fmars.2022.807570

Pratama, G. B., Aisyah, & Muhyun, A. A. 2025. Impact of Oceanographic Variability on Chlorophyll-a Concentration and Sea Surface Temperature in North Maluku Waters and its Influence on Fish Abundance. *Asian Journal of Fisheries and Aquatic Research*. 10.9734/ajfar/2025/v27i2876

Putri, D., Yulius, Y., Rosalia, A. A., Arifin, T., Putra, A., Heriati, A., Prihantono, J., Purbani, D., Salim, H., Hartati, S. T., Ramdhan, M., Wahyono, A., & Rahmania, R. 2024. Influence Of Sea Surface Temperature And Chlorophyll-A On Mackerel

Productivity In Banten Bay, Indonesia: Analysis Using Aqua Modis Data (2014–2023). *Geographia Technica*. 10.21163/gt_2025.201.05

Quezada-Escalona, F., Tommasi, D., Kaplan, I., Hernvann, P.-Y., Frawley, T., Garcia, D., Ibaibarriaga, L., Sanchez-Maroño, S., De Moor, C., Beckensteiner, J., Schueller, A., Feijó, D., Ciorciaro, D., Kurota, H., Oliveros-Ramos, R., Wildermuth, R., Mroch, R., Wise, L., Baker, M., Hansen, C., Hemed, S. A., Brochier, T., Stohs, S., Enciso-Enciso, C., & Jacobsen, N. 2025. Socio-economic impacts and responses of the fishing industry and fishery managers to changes in small pelagic fish distribution and abundance. *Reviews in Fish Biology and Fisheries.* 35: 1063-1093. 10.1007/s11160-025-09949-4

Rahim, A., Malik, A., & Hastuti, D. 2025. Impact of Extreme Weather Events Due to Climate Change on Household Economic Change and Adaptation Decisions of Small-scale Fishers in Coastal Areas. *Turkish Journal of Fisheries and Aquatic Sciences*. 10.4194/trjfas26937

Setiawan, H., Dwi, M., & Manessa, M. 2024. Study on Spatio-temporal Distribution of Chlorophyll-a on Pelagic Catch Productivity in Muara Bendera, West Java, Indonesia. *Jurnal Ilmiah Perikanan dan Kelautan*. 10.20473/jipk.v16i2.55940

Shahvaran, A. R., Pour, H., & Cappellen, P. 2024. Comparative Evaluation of Semi-Empirical Approaches to Retrieve Satellite-Derived Chlorophyll-a Concentrations from Nearshore and Offshore Waters of a Large Lake (Lake Ontario). *Remote. Sens.* 16: 1595. 10.3390/rs16091595

Shampa, M. T. A., Ahmed, M. K., Chowdhury, K., Islam, M. A., Hasan, M., Rahman, M. S., & Islam, M. S. 2024. Spatial and seasonal variability of chlorophyll-a, total suspended matter, and colored dissolved organic matter in the Sundarban mangrove forest using earth observation and field data. *Heliyon.* 10. 10.1016/j.heliyon.2024.e38789

Sudhakaran, B. V., & Varsha. 2025. Climate Change Vulnerabilities on Livelihood of Fishing and allied Communities of Southwest Coast of India: A Case Study of Azheekkal Fishing Village, Kerala, India. *International Journal of Ecology and Environmental Sciences*. 10.55863/ijees.2025.0710

Suryana, A., & Nurezka, K. 2023. Economic Mapping of Small-Scale Fishers in Dadap Village, Juntinyuat District, Indramayu Regency, Indonesia. *Asian Journal of Fisheries and Aquatic Research*. 10.9734/ajfar/2023/v25i3667

Walker-Milne, N., Elliott, S., Wright, P., & Bailey, D. 2025. Seascape ecology of juvenile gadoid nursery areas. *Royal Society Open Science.* 12. 10.1098/rsos.250705

Xu, Z., Qayum, M., Afzal, J., & Aslam, M. 2023. Availability and access to Livelihood capital assets for development of sustainable Livelihood strategies of fishermen: A case study of Manchar Lake Pakistan. *Heliyon.* 9. 10.1016/j.heliyon.2023.e22549