Jurnal Ilmu Kelautan **P-ISSN: 2460-0156**
SPERMONDE (2026) 12(2): 72-78 **E-ISSN: 2614-5049**

SPATIAL-TEMPORAL ANALYSIS OF PREDICTED FISHING ZONES (ZPPI) IN RIAU WATERS USING R STUDIO COMPUTATIONS (2018–2023)

Putri Wangi Tri Rumelia[1], Romie Jhonnerie[2], Alit Hindri Yani[2], Nofrizal[2], Pani Meinaldi[3]

Submitted: August 1, 2026 Accepted: September 28, 2026

[1]Master's student in Marine Science at the Faculty of Fisheries and Marine Sciences, University of Riau.
[2]Master of Marine Science, Faculty of Fisheries and Marine Sciences, University of Riau.
[3]Educational Laboratory Coordinator, Faculty of Fisheries and Marine Sciences, University of Riau.
Corresponding Author:
*Putri Wangi Tri Rumelia
E-mail: putri.wangi6086@grad.unri.ac.id

ABSTRACT

Coastal fisheries in Riau Province, particularly in the regions surrounding Dumai and the Bengkalis Strait, continue to serve as a significant source of livelihood. However, local fishers predominantly depend on intuition rather than empirical data to identify fishing grounds, a practice that results in inefficient fuel use and reduced catch efficiency. This study conducted a spatial-temporal mapping of Fish Catch Prediction Zones (ZPPI) in Riau waters from 2018 to 2023, utilizing sea surface temperature (SST) and chlorophyll-a concentration data derived from Aqua MODIS Level 3 satellite imagery. The data, obtained from the NASA Ocean Color portal, featured a 4 km spatial resolution in NetCDF format. The entire data processing workflow, from extraction to thematic map visualization, was executed in R Studio using the sf, raster, and tmap packages, without reliance on additional software. The results indicate that ZPPI density consistently concentrated along the coast over the six-year period, with the highest point densities observed around Bengkalis, Sungai Pakning, and Dumai. Aggregation zones near Bengkalis Island and river mouths exhibited stability across the years, a pattern attributed to organic nutrient input from river runoff that supports high biological productivity. This spatial consistency provides fishers with a dependable basis for planning fishing routes and minimizing fuel expenses. Furthermore, the study demonstrates that R Studio can function as a comprehensive tool for the entire geospatial fisheries workflow, encompassing satellite data processing, statistical analysis, and cartographic output, thereby integrating tasks typically distributed across separate GIS, spreadsheet, and statistical software. These findings advocate for the use of long-term, satellite-derived environmental data as a practical foundation for fisheries management policy in Riau's coastal waters.

Keywords: Aqua MODIS, chlorophyll-a, Fish Catch Prediction Zone, R Studio, sea surface temperature.

INTRODUCTION

The fisheries sector serves as the economic foundation for coastal communities in Riau Province, particularly in the waters surrounding Dumai City, Rokan Hilir, and the Bengkalis Strait. Fishing locations at sea are inherently dynamic, shifting in response to alterations in aquatic environmental conditions (Fadillah et al., 2024). Despite this, most local fishermen continue to rely on intuition and traditional methods to identify fishing spots (Munthe, 2018). This reliance results in inefficient fishing operations and fuel wastage due to the uncertainty of catch locations.

The abundance of fish resources in a specific body of water is significantly influenced by the ocean's physical conditions, which constitute their habitat (Akhlak et al., 2015). Sea Surface Temperature (SST) and chlorophyll-a concentration are critical indicators of fish habitat presence. Chlorophyll-a reflects the fertility of the water body, as it is directly linked to the abundance of phytoplankton, the foundation of the marine food chain. The combination of temperatures conducive to metabolism and a high availability of natural food creates potential fish aggregation zones for exploitation (Akhlak et al., 2015).

From a bioecological perspective, the movement of fish schools is a natural response to their biological requirements. Fish typically migrate toward areas that provide protection and abundant food, including regions conducive to optimal metabolism and feeding activity (Karmila et al., 2024; Ridho et al., 2004). The presence of fish schools in a specific area is significantly influenced by the suitability of physical oceanographic parameters as their natural habitat. Periodic environmental changes necessitate that fish seek areas with more stable biophysical conditions to ensure their survival.

Among these oceanographic parameters, water temperature is pivotal in determining the distribution and behavior of fish in the ocean (Putra, 2012; Akhlak et al., 2015). Variations in water temperature directly impact fish metabolism, movement, and spawning success, with fish generally selecting water masses that offer a temperature range conducive to oxygen solubility for their respiratory systems (Ridho et al., 2004). Conversely, chlorophyll-a concentration serves as an index of water fertility, reflecting the

abundance of phytoplankton, which constitutes the foundation of the food chain (Mursyidin & Yuswardi, 2017). Elevated chlorophyll-a levels indicate biological productivity capable of attracting fish schools to congregate in a particular area. The combination of stable temperatures and abundant natural food sources ultimately creates potential fish aggregation zones for fishing activities.

Remote sensing technology, which involves acquiring information about an object or phenomenon without direct contact, facilitates large-scale and continuous monitoring of oceanographic parameters. The primary advantage of remote sensing data is its capacity to periodically record sea surface conditions over extended periods through time series data. This capability allows for a more comprehensive and efficient identification of oceanographic phenomena compared to direct field observations. NASA's Aqua MODIS satellite, equipped with sensors specifically designed to observe marine water dynamics, aims to collect information on the Earth's water cycle, including the identification of phytoplankton and sea surface temperature (Graham, 2005). The daily temporal resolution of Aqua MODIS imagery supports continuous monitoring of aquatic environmental variability (Zainuddin, 2009), and its application has demonstrated effectiveness in identifying potential fishing zones extensively, rapidly, and accurately (Zainuddin, 2009).

The substantial volume of satellite data, characterized by its time series nature, necessitates a computational system capable of efficient processing. R Studio, an integrated development environment for the R programming language, is tailored for statistical computing and has proven effective in processing large-scale geospatial data or big data (Latifah et al., 2022). Its ability to manage time series data enables researchers to extract historical information from complex datasets (Sarvina, 2017), and its programming workflow is robust for both numerical data analysis and integrated spatial visualization (Latifah et al., 2022). These features position R Studio as a tool with significant potential for accurately and scientifically presenting spatio-temporal fisheries information.

This study aims to identify and map Fish Catch Prediction Zones (FCPZs) in the waters of Riau by utilizing two oceanographic parameters: Sea Surface Temperature (SST) and chlorophyll-a concentration, both derived from Aqua MODIS satellite imagery. The data processing was confined to the annual period from 2018 to 2023 and was executed entirely using the R Studio computing system. The objective was to produce accurate, long-term, data-driven identifications of fishing locations to enhance the operational efficiency of fishermen in the Riau coastal region. This study was structured to address three primary questions: Firstly, how does the temporal distribution of ZPPI density in Riau waters appear during the 2018–2023 period when analyzed using R Studio? Secondly, what are the consistency patterns of fish aggregation zones in the Riau coastal region based on annual analysis? Lastly, to what extent is R Studio effective as a single tool for managing the entire workflow of geospatial fisheries data analysis? In alignment with these questions, the study seeks to analyze the temporal distribution of ZPPI density in Riau waters during the specified period, identify consistent patterns of fish aggregation zones in coastal areas to determine stable fishing locations, and evaluate the effectiveness of R Studio as a comprehensive software platform for executing the entire workflow of geospatial fisheries data analysis.

The findings of this study are anticipated to benefit multiple stakeholders. For fishermen, the long-term density data from 2018 to 2023 can provide a precise reference for determining navigation routes and fishing locations, thereby minimizing operational time and fuel expenses. For government agencies, particularly the Department of Marine Affairs and Fisheries, this extensive spatial and temporal data can form the basis for developing sustainable fisheries resource management policies in the Riau coastal region. Additionally, it can assist in mapping stable productive areas to optimize fishing zones. For academics, this study is expected to serve as a reference for developing more efficient, programming-based methodologies for estimating fishing grounds, while also offering insights into the effectiveness of statistical computations using R Studio in fisheries geospatial analysis.

In response to this need, a study titled “Spatial Temporal Analysis of Predicted Fishing Zones (ZPPI) in Riau Waters Using R Studio Computations (2018–2023)” was conducted. This study integrates Aqua MODIS satellite imagery data with the R Studio computational system to generate accurate and practical catch location maps for the management of Riau’s coastal fisheries.

MATERIALS AND METHODS

Time and Location of Research

The study was conducted between April and June 2026. Spatial data were acquired from Aqua MODIS Level 3 satellite imagery, which was downloaded from the official NASA Ocean Color website (oceancolor.gsfc.nasa.gov). All data processing and analysis were performed at the Fishing Ground Laboratory, Faculty of Fisheries and Marine Sciences, University of Riau.

Data and Data Sources

The study utilizes secondary data derived from Aqua MODIS Level 3 satellite imagery, specifically focusing on Sea Surface Temperature (SST) and chlorophyll-a concentration parameters. The observation period spans from 2018 to 2023. All images were officially acquired from the NASA Ocean Color website, with a spatial resolution of 4 km, and are available as Standard Mapped Images (SMI) in NetCDF (NC) file format. The six-year timeframe was selected to provide a comprehensive long-term analysis of the density and consistency patterns of fishing zones, facilitating temporal analysis beyond the scope of a single season or specific year.

Data Analysis Using R Studio

All phases of the analysis, encompassing data extraction to the final visualization, were conducted exclusively within the R Studio environment, without employing GIS or alternative statistical software. The workflow initiated with the loading of NetCDF formatted image files, utilizing spatial data processing libraries, specifically the sf and raster packages, which are adept at handling geospatial data structures and rasterization operations (Tennekes, 2018). The numerical data extracted from satellite imagery were subsequently managed and filtered to isolate SST and chlorophyll-a values in accordance with the fish habitat thresholds that served as the study's reference.

Time series data processing was executed for each year within the 2018–2023 range, resulting in the temporal distribution of potential fish locations for each observation period. From the outcomes of this statistical processing, the system generated coordinate points that conformed to the fish habitat criteria, which were subsequently visualized as annual thematic maps using the tmap package to illustrate the spatiotemporal intensity of Fish Catch Prediction Zones (ZPPI) (Tennekes, 2018). R Studio's capability to handle large-scale time series data facilitates the extraction of historical information from complex datasets (Sarvina, 2017), while also supporting numerical analysis and spatial visualization within a single integrated workflow (Latifah et al., 2022).

The ultimate result of this phase is an annual density map illustrating regions in Riau Waters that consistently functioned as fish aggregation zones over the six-year observation period. This map was subsequently subjected to descriptive analysis to discern distribution patterns and the consistency of fishing zones across different years. This analysis serves as a foundation for evaluating the stability of fishing locations based on long-term historical data.

RESULTS AND DISCUSSION

Spatial Density and Consistency of Fish Aggregation Zones (2018–2023)

The temporal distribution of fishing prediction zone (ZPPI) density in Riau waters from 2018 to 2023 exhibits dynamic spatial variation, predominantly concentrated in coastal areas annually. Utilizing the R Studio computational system, potential locations were identified through the processing of time series data, which revealed accumulations of high-density points around the waters of Rokan Hilir, Bengkalis, and Dumai. The visualization of these analytical results offers a macro-level overview of the distribution of coordinates that satisfy fish habitat criteria, based on the annual interaction of physical oceanographic parameters.

The consistent patterns of fish aggregation zones in the Riau coastal region suggest the presence of stable productive areas, particularly in waters adjacent to the Bengkalis Island mainland and river estuaries. This regularity in fishing locations is attributed to the substantial influx of organic nutrients from the mainland (river runoff) into coastal areas, thereby establishing optimal water fertility levels for fish aggregations. Information regarding these highly stable locations is essential for fishermen to optimize their catch while minimizing operational costs, as it provides certainty regarding fishing locations supported by long-term historical data. The series of annual ZPPI analysis results for the 2018–2023 period in Riau waters is illustrated in the following figures.

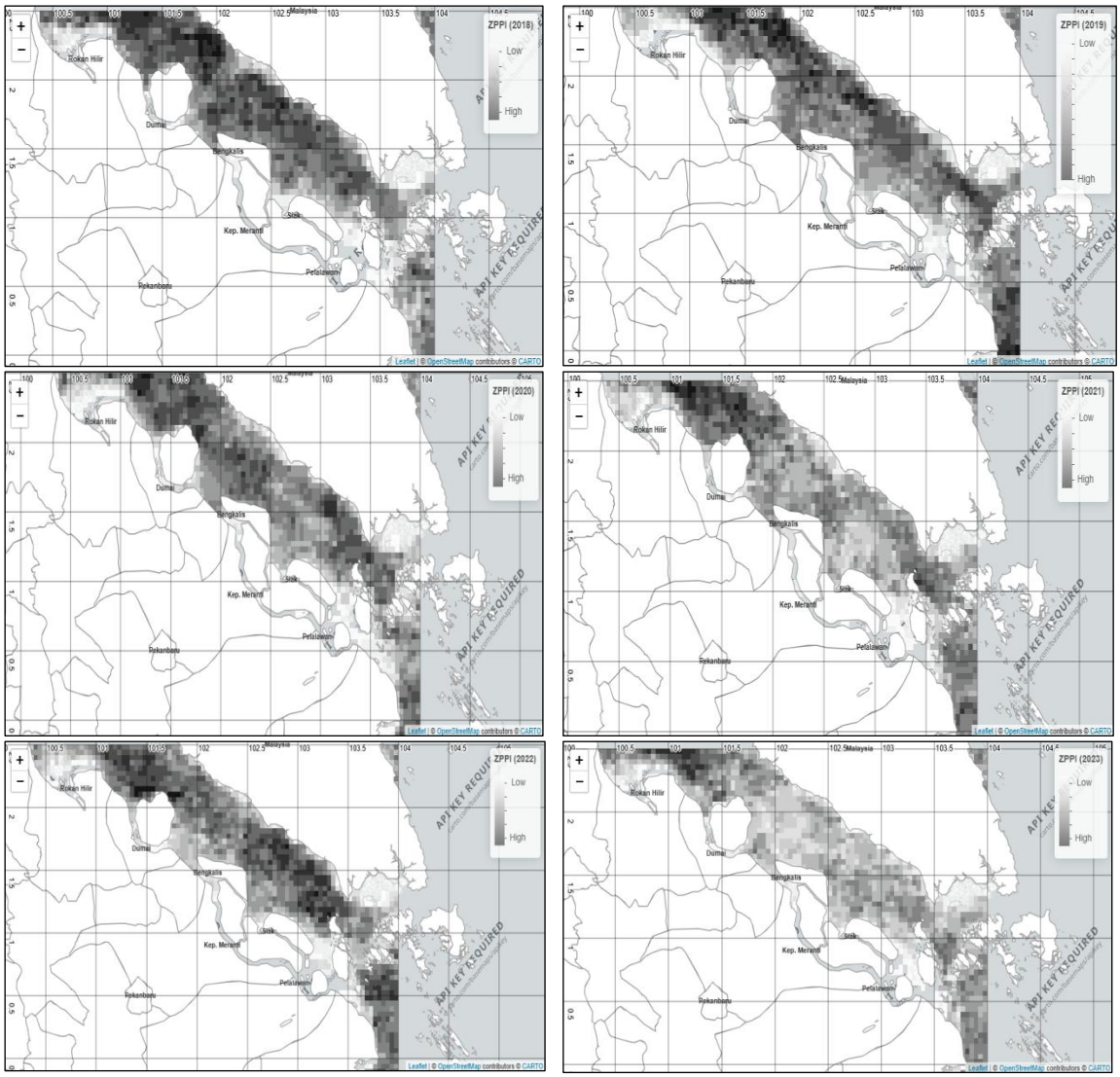


Figure 1. Map of the 2018–2023 ZPPI in Riau Waters

Annual map visualizations from 2018 to 2023 consistently demonstrate that the distribution of Fishing Prediction Zones (ZPPI) in Riau's waters is concentrated along coastal areas. The highest density of potential fishing points is identified in the waters surrounding Bengkalis, Sungai Pakning, and the city of Dumai. Notably, during 2018 and 2020, potential coordinates formed dense clusters closer to the mainland than the open sea. This pattern suggests stable habitat availability supporting marine life in the shallow waters along the Riau coastal corridor over the past six years.

The high density in this coastal area is corroborated by Syofyan et al. (2009), who noted that the coastal waters of Riau, particularly the Bengkalis Strait, provide a highly productive habitat for various fishery commodities. The concentration of potential fishing spots in this region is closely linked to chlorophyll-a indicators, which signify the abundance of natural food for fish schools (Fadillah et al., 2024). The R Studio computing system is advantageous for identifying a wide range of physical oceanographic parameters to determine effective fishing locations (Sarvina, 2017). Additionally, Aqua MODIS satellite imagery has proven accurate in providing spatiotemporal fisheries data in coastal waters (Munthe, 2018).

During the period from 2018 to 2023, the consistent patterns of fish aggregation zones in Riau waters indicate the presence of stable productive areas around the coast of Bengkalis Island and regions influenced by river estuaries. These clusters of potential coordinate points exhibit minimal geographical shifts annually, maintaining their positions near the coast. This stable aggregation pattern provides crucial guidance for local fishermen's fishing strategies by offering a high degree of certainty regarding catch

locations. It demonstrates that the biophysical interactions between the terrestrial and marine environments in this region have remained consistent throughout the observation period.

The stability of the aggregation zone in this coastal region is corroborated by research conducted by Jhonnerie et al. (2014), which indicates that the influx of organic nutrients from the mangrove ecosystems on the mainland of Bengkalis Island significantly enriches the surrounding waters through river runoff. Additionally, the physical characteristics of the waters north of Bengkalis, including a sea surface temperature range that is highly conducive to supporting the metabolic activity and survival of marine biota, further contribute to this stability (Wijayanto et al., 2017). The application of statistical computing technology to process this complex time series data enables researchers to identify locations with high coordinate accuracy for fishermen's operations (Sarvina, 2017). The effectiveness of R Studio as a singular tool in this geospatial analysis workflow is advantageous for comprehensively presenting spatiotemporal information (Latifah et al., 2022).

The Effectiveness of Using R Studio as a Single Tool for Geospatial Analysis

The exclusive utilization of the R Studio computing system in this study demonstrated significant efficacy in mapping the density of Fish Catch Prediction Zones (ZPPI) in Riau waters over the 2018–2023 period. The entire process, from the extraction of Aqua MODIS satellite data to the visualization of precise coordinates, was executed within a single integrated programming workflow, eliminating the need for supplementary software. The analysis results indicate that R Studio effectively presents information on the annual distribution of potential fishing points, consistently identified in the coastal areas of Bengkalis and Dumai.

The programming workflow in R Studio specifically initiates by loading NetCDF-formatted image files through a specialized spatial data processing library. This process is followed by the management of numeric data extracted from satellite imagery to filter Sea Surface Temperature (SST) and chlorophyll-a parameters according to the specified fish habitat thresholds. Through this statistical data processing, the system automatically generates precise coordinate points, which are subsequently visualized as interactive thematic maps, illustrating the spatiotemporal intensity of fishing zone density.

R Studio's functionality as an integrated development environment (IDE) significantly enhances data processing efficiency, being specifically tailored for statistical computing and big data management (Latifah et al., 2022). This software possesses robust capabilities for managing complex time series data, facilitating researchers in conducting comprehensive analyses of historical datasets. The support for various additional packages within the R system offers extensive opportunities for developing more efficient and precise analytical methodologies (Sarvina, 2017).

By employing specialized packages such as sf, raster, and tmap, R Studio can perform sophisticated spatial analyses and produce professional thematic map visualizations (Tennekes, 2018). These features allow for the accurate depiction of oceanographic phenomena, thereby generating geospatial information that is readily comprehensible to users (Latifah et al., 2022). The integration of workflows between statistical programming languages and geographic information systems within a single platform establishes a more advanced foundation for spatiotemporal analysis in identifying environmental variability (Munir et al., 2020).

The R Studio programming system demonstrated significant efficacy as a singular tool for executing the complete spatial analysis workflow in this study. Its functionalities extend beyond mere map creation, excelling in various data analyses, including the generation of statistical curves and graphs, tasks traditionally performed using Excel or SPSS. This versatility positions R Studio as a comprehensive analysis platform, facilitating the integration of tabular data processing and geospatial visualization within a unified and efficient computing environment (Sarvina, 2017).

CONCLUSION

The findings of this study reveal that the temporal distribution of Fish Catch Prediction Zone (ZPPI) density in Riau waters from 2018 to 2023 was consistently concentrated in coastal regions, particularly around the waters of Bengkalis, Dumai, and Rokan Hilir. The persistent pattern of fish aggregation zones suggests the existence of productive areas that maintain similar coordinates annually, especially in regions affected by nutrient inflows from river estuaries. This provides a stable level of certainty regarding catch locations for local fishermen's operations.

The R Studio computing system, employed as a singular tool, has proven highly effective in managing the entire workflow of geospatial fisheries data analysis. This includes the extraction of Aqua-MODIS satellite data and the visualization of thematic maps. The tool exhibits strong capabilities in processing complex time-series data and can independently perform various supporting statistical analyses, such as generating graphs and curves, without the need for additional software. This enhances efficiency and accuracy in identifying fish habitats.

Based on the results of this analysis, future developments should consider incorporating additional oceanographic variables, such as current velocity or salinity, and directly integrating field catch data to enhance the precision and validation of fish aggregation points. Support from government agencies, through the provision of GPS navigation equipment, is crucial to enable fishermen to effectively reach the precise coordinates generated by this R Studio computational system.

ACKNOWLEDGMENT

The author expresses profound gratitude to God Almighty for His mercy and grace, which facilitated the completion of this journal article. Sincere appreciation is extended to the author's parents for their prayers, love, and unwavering support throughout this endeavor. The author also acknowledges the invaluable contributions of course instructors Dr. Romie Jhonnerie, S.Pi., M.Sc, Dr. Ir. Hj. Alit Hindri Yani, M.Sc, and Prof. Dr. Nofrizal, S.Pi., M.Si, whose knowledge, guidance, advice, and motivation were instrumental during the course of study and the preparation of this article.

Furthermore, the author is grateful to colleagues at the Regional Fisheries Laboratory, Faculty of Fisheries and Marine Sciences, University of Riau, for their support, assistance, and camaraderie during the data processing phase. Appreciation is also extended to peers in the Master's Program in Marine Science, Class of 2025/2026, Odd Semester, for their encouragement, support, and motivation, which were crucial in completing this journal article.

REFERENCES

Akhlak, M.A., Supriharyono, & Hartoko, A. (2015). Hubungan Variabel Suhu Permukaan Laut, Klorofil-a dan Hasil Tangkapan Kapal Purse Seine yang Didaratkan di TPI Bajomulyo Juwana, Pati. *Management of Aquatic Resources Journal (MAQUARES)*, 4(4), 128-135.

Fadillah, A. N., Husaine, N. A. V., Nafisah, K. F., Apriyani, L., Hanifah, N., Rosalia, A. A., & Afni, D. N. (2024). Analisis daerah potensial penangkapan ikan tenggiri menggunakan citra satelit aqua MODIS di WPPNRI 711. *SEMAH Jurnal Pengelolaan Sumberdaya Perairan*, *8*(2), 159-167.

Graham, S., Parkinson, C., & Chahine, M. (2005). *The Water Cycle*. NASA Earth Observatory.

Jhonnerie, R., Siregar, V. P., Nababan, B., Prasetyo, L. B., & Wouthuyzen, S. (2014). Mangrove coverage change detection using landsat imageries based on hybrid classification in Kembung River, Bengkalis Island, Riau Province. *Jurnal Ilmu dan Teknologi Kelautan Tropis*, *6*(2).

Karmila, M., Yuliana, E., & Jalil. (2024). Kesesuaian Daerah Penangkapan Ikan di Taman Wisata Perairan (TWP) di Timur Pulau Bintan Provinsi Kepulauan Riau. *Jurnal Akuatiklestari*, 8(1), 57-65.

Latifah, L. L., Hudjimartsu, S. A., & Yanuarsyah, I. (2022). Analisis Daerah Rawan Kecelakaan Lalu Lintas Menggunakan Cluster Analysis Di Kota Bogor Berbasis Webgis. *Jurnal Ilmiah Teknologi Infomasi Terapan*, *8*(2).

Munir, S. (2022). *Urban air quality monitoring, mapping and modelling to determine the main drivers of air pollution* (Doctoral dissertation, University of Sheffield).

Munthe, S. R. (2018). *Pemetaan Zona Potensi Penangkapan Ikan dengan Menggunakan Citra Satelit Modis di Perairan Pesisir Banyuasin, Sumatera Selatan* (*thesis*). Universitas Sriwijaya.

Mursyidin & Yuswardi. (2017). *Pemanfaatan Data Satelit Untuk Perikanan*. Jakarta.

Putra, E. (2012). *Variabilitas Konsentrasi Klorofil-A Dan Suhu Permukaan Laut Dari Citra Satelit MODIS Serta Hubungannya Dengan Hasil Tangkapan Ikan Pelagis Di Perairan Laut Jawa (thesis).* Institut Pertanian Bogor.

Ridho, M. R., Kaswadji, R. F., Jaya, & Nurhakim, S. (2004). Distribusi Sumberdaya Ikan Demersal di Perairan Cina Selatan. *Jurnal Ilmu Perairan dan Perikanan Indonesia*, 9(2), 123-128.

Sarvina, Y. (2017). Pemanfaatan Software Open Source "R" Untuk Penelitian Agroklimat. *Informatika Pertanian*, 26(1), 23-30.

Syofyan, I., Jhonnerie, R., & Kasman, A. R. (2009). Aplikasi Sistem Informasi Geografis dalam Penentuan Daerah Pengoperasian Alat Tangkap Gombang di Perairan Selat Bengkalis. *Jurnal Perikanan dan Kelautan*, 14(2), 128-134.

Tennekes, M. (2018). tmap: Thematic Maps in R. *Journal of Statistical Software*, 84(6).

Wijayanto, D., Ghalib, M., & Nasution, S. (2017). *The Physical Oceanography Conditions of the Northern Waters of Bengkalis Island Riau Province* (Doctoral dissertation, Riau University).

Zainuddin, M. (2009). Estimasi Potensi Dan Pemetaan Daerah Potensial Penangkapan Ikan Pelagis Di Perairan Selayar Dengan Menggunakan Citra Satelit AQUA/MODIS. *Fakultas Ilmu Kelautan dan Perikanan*. UNHAS.