Analysis of Fish Catches of Fishermen in the Southern Waters of Java Island in 2018 and 2020 Based on Chlorophyll-A Fertility and Sea Surface Temperature

Al Fauzi Novianto, Hamim Zaky Hadibasyir(✉), and Afif Ari Wibowo

Faculty of Geography, Universitas Muhammadiyah Surakarta, Surakarta 57162, Central Java, Indonesia
hamim.zaky.h@ums.ac.id

Abstract. The decline in fish catches in 2018–2020 becomes a problem experienced by fishermen in the southern waters of Java island. This affects fishermen whose livelihoods are from marine products. From these problems, the purpose of the research is to analyze the fishermen's catches in the southern waters of Java island in 2018 and 2020 based on chlorophyll-a fertility and sea surface temperature (SST), and supported by upwelling phenomena and determination of Potential Fishing Zones. The method used is secondary data analysis taken from MODIS Level 3 imagery to visualize water conditions. The concentration of chlorophyll-a in the eastern season of 2018 had an average of 0.4–0.6 mg/m^3 with a sea surface temperature of 25.9–27.8 °C. In 2020, there was a decrease by an average of 0.3–0.4 mg/m^3 with a sea surface temperature of 26.7–28.3 °C. This is proved by all significance values of paired t-test less than 0.005. That is, there is a significant difference between both periods. In 2018, the widest strong upwelling was in July with an area of 13,0723.94 km^2. In 2020, it occurred in June with an area of 41,515.86 km^2. The most potential fishing zones of 2018 were in August as many as 254 points and in 2020 in July 154 points. High chlorophyll-a with low sea surface temperature levels, strong upwelling areas, and dominant potential fishing zones are mostly found in areas proximate to the coast compared to those further away from the coast.

Keywords: Fishermen · Chlorophyll-a · Sea surface temperature

1 Introduction

Indonesia covers a sea area of about 5.9 million km^2 and is a resource-rich country. This allows Indonesian to have biodiversity and animals in each region (Putra et al., 2017). The high level of marine resources owned by Indonesia opens a greater opportunity to produce abundant fishery productivity for fishermen, including on the southern coast of Java island. The southern waters of Java island are from the tip of Banten province to the edge of East Java province in a straight line to the south as far as 200 miles or

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enter the Exclusive Economic Zone (EEZ). The southern waters of Java island have abundant marine resources (Kunarso et al., 2011), which should provide an opportunity for fishermen to catch fish to get the maximum yield. However, from 2018 to 2020, fish catches in the southern waters of Java island decreased.

Coastal waters will certainly have a direct impact, especially on people who work as fishermen with a high number of fishermen catching fish in several provinces of Java. The southern coastal region of Java is a transitional area of land and ocean, such conditions will ensue in the coastal region being a location for economic activities among communities on the coast. This activity is fishing that utilizes the land and waters (Pinto, 2016). Economic activity is carried out to improve the welfare of coastal communities, with dependence on environmental conditions and natural resources in the vicinity, which cannot be separated from the Marine phenomena that are quite influential to these activities when the economy of marine products in the fishing port area and the market price is unstable due to the erratic fishing results by fishermen catch fish, therefore the activity of marine phenomena is very crucial on the economic activity of Fisheries. Some of the effects of the fish distribution in the sea are high and low chlorophyll-a and suitable sea surface temperatures for clustering fish in certain areas, therefore mapping using remote sensing assistance is needed especially with a large area coverage (Danardono et al., 2022).

Information can be used for fishermen to catch fish, by studying the effect of marine phenomena, especially chlorophyll-a and sea surface temperature, therefore the fishermen, especially those on the southern coast of Java, can choose the proper time and location to fish so that the results obtained will be optimal (Khalfianur et al., 2017). Additionally, the safety of anglers can also be guaranteed by avoiding certain distances and depths by adjusting the strength of their boats. Sea conditions are very influential in the process of fishing operations. Often when bad weather fishermen cannot go to sea to catch fish, this is certainly enough to inhibit fishermen's livelihoods.

The decline in fish catches in the southern waters of Java island was observed in 2018–2020 consisting of Banten province, West Java, Central Java, East Java, and the Special Region of Yogyakarta. In 2018, the production volume was 1,225,150. 05 tons; in 2019 it decreased to 1,170,386. 06 tons; and in 2020 it experience decreasing to 1,128,209. 26 tons (Kementerian Kelautan dan Perikanan, 2020). This phenomenon is a serious problem that should be addressed because this problem is rather alarming if it persists for the lives of people on the southern coast of Java island whose livelihood source depends on the sea (Yoga et al., 2014).

The yield of fishermen on the south coast of Java island affects the water condition in that area. Unbefitting waters with the fish habitat precipitate the fish to move farther from the fishing location (J.Ch et al., 2018) and the uncertain condition of the waters hinders fishermen when sailing if they are left uninformed and cannot maximize the catch at the right time (Yoga et al., 2014).The oceanography state of the southern sea of the island of Java is modified by the monsoon system. In the western season (December–February), there is a downwelling phenomenon, while in the eastern season (June–August) an upwelling phenomenon may occur in the southern ocean of Java island. The eastern season reaches its peak in August (Surinati & Wijaya, 2017), because, in the Western season, the movement of currents on the surface moves towards the direction of

t. Compared to the distribution of sea surface temperature (SST), the lower the mass of water in the southern waters, the more inland, and the higher the sea surface temperature is (SST). As a result, there has been no correlation between the distribution of sea surface temperature (SST) with the direction of the surface current movement in the Western season (Ningrum et al., 2022).

The relationship between the upwelling phenomenon and the distribution of fish catch is quite influential since the upwelling phenomenon brings masses on the seabed to the surface, including chlorophyll - a. These nutrients are carried to the surface during vertical currents (Anggraeni et al., 2017), hence the location will eventually induce zooplankton and fish when rising from the seabed to higher sea levels, namely the surface (Triadi et al., 2015). The upwelling phenomenon can be used as one of the fertility cues of the waters due to the high concentration of chlorophyll-a in the ocean (Demena et al., 2017). This certainly places the upwelling phenomenon prominent on the fishermen's productivity, including in the southern waters of Java island (Makmur, 2010). By utilizing remote sensing, data and information can be attained with a wide scope and in a short time, including for the potential fishing zone (PFZ). Phenomena can be identified using remote sensing technology to predict discrepancies that occur by examining changes in lower sea surface temperatures and high levels of chlorophyll-a concentrations (Silubun et al., 2015). The chlorophyll-a concentration levels above 0.2 mg/m^3 indicate sufficient plankton, and the location can maintain the survival of fish (Tangke & Sitkun, 2013). Satellite data used for upwelling area estimation is AQUA MODIS satellite image data to analyze the sea surface temperature (SST) and chlorophyll-a concentration (Rahman et al., 2019).

The satellite image used can be used to monitor and study the sea surface temperature (SST) and the distribution of chlorophyll-a concentration since it has a thermal band (Anjas Swara et al., 2021) and a fairly high temporal resolution. Therefore, the dynamic changes of sea surface temperature (SST) can be identified on an ongoing basis (Munthe et al., 2018). Information regarding the level of spatial variability of sea surface temperature (SST) and the degree of chlorophyll-a distribution in the field of Marine Fisheries has a significant role as a means and information in determining the extent of fishing zones. Spatial variability data processing of sea surface temperature (SST) using satellite images can be used to simplify, improve efficiency, and save costs because it can analyze the study area with a wide coverage (Kurnianingsih et al., 2017), and overall when compared with data collection in the site. A body of water is inseparable from the conditions and variations of its oceanographic parameters. Therefore, it is expected that complete and accurate information on the oceanographic characteristics of the waters will be important for the implementation of sustainable management of aquatic resources in the future (Gaol & Sadhotomo, 2007). The existence of a potential fishing zone (PFZ) facilitates the process of utilizing fishery resources (Purwanto et al., 2021) and images of chlorophyll-a distribution and sea surface temperature (SST) can be detected using a combination of remote sensing technologies (Haryana et al., 2013), with geographic information technology (GIS) through remote sensing and the provision of information relevant to potential fishing zones (PFZ) both spatially and temporarily (Munthe et al., 2018).

The significance of this study is to compare and verify the condition of the water body in 2018 and 2020 by using remote sensing (Fikriyah, Anggani, et al., 2022), to determine the state of the water body by visualizing oceanographic parameters as needed (Fikriyah, Hasbi, et al., 2022) and monitor potential fishing zones - whether the decline in fish catches is due to the phenomenon of high or low upwelling - and the existence of potential fishing zones (PFZ) in 2018 and 2020. The purpose of this study was to (a) Analyze chlorophyll-a distribution and sea surface temperature (SST) for the determination of upwelling areas and potential fishing zones (PFZ) in the eastern season of the southern waters of Java island in 2018 and 2020; (b) study fish catches by anglers in the southern waters of Java island in 2018 and 2020 based on chlorophyll-a fertility and sea surface temperature (SST).

2 Method

2.1 Scope of Study

The region of Java Island is geographically located between the 7º50′10″–7º56′41″ South Latitude and 113º4′10″–113º48′26″ East Longitude. The geographical condition of Java Island according to the map is divided into six provinces. Based on geography, Java island is bordered by the North: Java Sea, the south: Indian Ocean, the east: Bali Strait, and the West: Sunda Strait. Java island has 6 provinces, namely, Banten province, Jakarta, West Java, Central Java, East Java, and Yogyakarta. Research areas are displayed in Fig. 1.

It is located in the southern waters of Java island, which has the boundaries of the research area as follows. North: the southern coast from the tip of Banten province to the

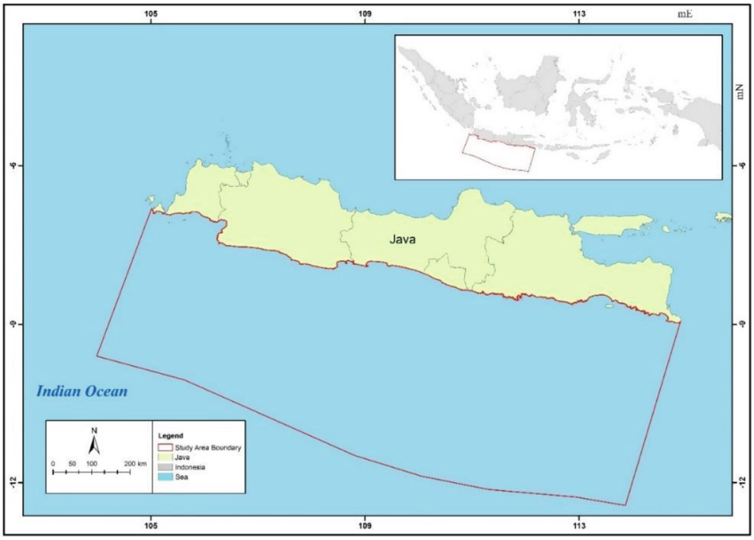


Fig. 1. Scope of study

Table 1. Research Data

Data	Source
Data on fishermen catching fish and catches	Statistics from the Ministry of Maritime Affairs and Fisheries (KKP)
Chlorophyll-a	Aqua Modis Level 3 Satellite Image
Sea surface temperature (SST)	Aqua Modis Level 3 Satellite Image
Digital sea depth data	Digital sea depth data Digital Elevation Model (DEM) and National Bathymetry
Digital Map of Indonesian Sea Boundaries	Ina-Geoportal
Digital Map of Indonesian	Ina-Geoportal

tip of East Java province; east and west boundaries: the drawing of vertical lines from both ends of the island to the outer boundary of the Exclusive Economic Zone (EEZ), which is a maritime boundary 200 miles (321.8 km) from the shore; and south of the outer boundary of the Exclusive Economic Zone (EEZ).

2.2 Data Source

The Data used are data on the number of fishermen and fish catches from Banten province, West Java, Central Java, East Java, and Yogyakarta in 2018–2020 that experienced decreasing sea surface temperature data, and chlorophyll-a image data from satellite images with a resolution of 4 km in the eastern season (June–August) in 2018 and 2020. Data on sea surface temperature and chlorophyll-a obtained from web https://oceancolor.gsfc.nasa.gov/ (NASA, 2022). Both data are useful to model the distribution of chlorophyll-a and sea surface temperature to support the estimation of upwelling areas and fishing potential zones. Table 1 shows the data used in the study.

2.3 Data Processing

Data from the Aqua Modis Level 3 satellite obtained chlorophyll-a data and sea surface temperature (SST). The two image datasets are useful for modeling chlorophyll-a distribution, sea surface temperature (SST), upwelling area estimation, and potential fishing zones. It was done through a series of processing that can be freely accessed through the ocean-color web (NASA, 2022).

Image Registration and Data Filter

Chlorophyll-a image registration and sea surface temperature are useful to adjust the coordinate system on both images in order to match the coordinate system of the research area exported in the form of file tif. Data information is extracted by using the SeaDAS application to retrieve attribute data from images, then using Export Mask Pixel and saving it as GeoTIFF. This can be advantageous for retrieving data in text form.doc and within the specified coverage area. Data selection using Microsoft Excel for processing and filtering of unused chlorophyll-a and sea surface temperature (SST) and (Nan) data can be omitted for effortless classification when creating maps.

Inverse Distance Weighting (IDW) and intersection
The advantage of the IDW interpolation method is the characteristics can be controlled by limiting the input points used in the interpolation process on chlorophyll-a and sea surface temperature (SST) data. Intersect is used to combine two intersecting sets of spatial data; the attributes contained in these two themes will also be integrated with the new shapefile.

Estimation of Upwelling and Potential Fishing Zones (PFZ)
Estimation was measured using chlorophyll-a overlay and sea surface temperature as it combines the contours of the sea surface temperature image and the contours of the chlorophyll-a distribution image. Intersect is used to unite two intersecting spatial datasets, only those features found in the extent of both themes will be omitted. The attributes on these two themes will also be mixed with a new shapefile used at the intersection of chlorophyll-a contour lines and sea surface temperature which will be the point of the potential fishing zone. At the ArcGIS 10.8 stage, the layout of chlorophyll-a distribution maps and sea surface temperature made from basic materials and based on X and y coordinate contour inputs, upwelling 3 was classified based on upwelling intensity criteria. The mapping of potential fishing zones is based on the assembly between chlorophyll-a contour lines and sea surface temperatures that have undergone the IDW (inverse distance weighting) and intersect processes.

2.4 Upwelling Criteria

Classification of upwelling criteria according to (Kunarso et al., 2011) using indicators of sea surface temperature (SST) and chlorophyll-a. This classification falls into three categories, namely weak upwelling intensity, moderate intensity upwelling, and strong upwelling intensity. The details are provided in Table 2.

2.5 Data Analysis

Descriptive analysis is the fishermen's economy through coastal life, especially the size of the catch, supported by data chlorophyll-a and sea surface temperature of a more suitable ecosystem for fertility level of the waters, as well as data on the catch yields according to the sea weather during the activity. Paired T-test was used on two paired

Table 2. Upwelling Criteria

Sea surface temperature	Chlorophyll-a	Upwelling Criteria
27.5–28.5	<0.5	weak upwelling intensity
26–27.5	≥ 0.5	medium upwelling intensity
≤ 26	≥ 0.5	strong upwelling intensity

datasets to determine the significant differences in spatial conditions in the southern waters of Java island. The paired (dependent) T-test is a parametric test, and it is to see if a mean difference between chlorophyll-a in the eastern season of 2018 and 2020 and sea surface temperature in the eastern season of 2018 and 2020 can be found. The basis of the normality test is if the significance > 0.05 then the residual value is normally distributed and if the value is 0.05 then, the residual value is not normally distributed. The basis for decision-making (paired sample t-test) is if the value of Sig. (2-tailed) attains 0.05, then there is a significant difference between the results of the data (parameters used) in 2018 and 2020 and the Sig. value (2-tailed deer > 0.05).

3 Results and Discussion

3.1 Distribution of Chlorophyll-a

There was a difference in chlorophyll-a in the eastern season (June–August) between 2018 and 2020 due to an increase in chlorophyll-a > 0.5 mg/mm^3 across the southern coast of Java and monthly chlorophyll-a variability that occurred from June to August was found increasing (Kunarso et al., 2011). Judging from the results of the monthly changes of MODIS images in two years, the comparison of chlorophyll-a in the eastern season was more dominant in 2018 than in 2020, as shown in Fig. 2.

The 2018 eastern season in the south of Java island contained chlorophyll-a on average 0.4–0.6 mg/m^3, with the lowest chlorophyll-a value of 0.1 mg/m^3 and the highest value of 8.4 mg/m^3. Compared to the eastern season of 2020 which had an average of 0.3–0.4 mg/m^3, the lowest chlorophyll-a value was 0.08, and the highest value was 6.7 mg/m^3. This happened due to the increasing chlorophyll-a on the surface that caused the distribution, in which the upwelling phenomenon occurred (Putra et al., 2017). This chlorophyll-a content can be used to analyze a phenomenon in a marine region. The high concentration of chlorophyll-a was found in the waters closer to the coast, while the value of chlorophyll-a declined towards the open sea, such circumstance is a result of the availability of nutrients upheaved to the surface (Triadi et al., 2015).

3.2 Distribution of Sea Surface Temperature (SST)

Surface winds are one of the important elements that greatly affect the dynamics of ocean waters and play a role in temperature changes, one of which is sea surface temperature (Fikriyah, Anggani, et al., 2022). The dynamics of sea surface temperature (SST) in the southern waters of Java island has an average sea surface temperature of 25.9–27.8 °C in the eastern season of 2018 with the highest score of 35.2 °C and lowest 23 °C, whereas the average sea surface temperature in the eastern season of 2020 is 26.7–28.3 °C with a high score of 35.8 °C and lowest 24 °C. Sea surface temperature (SST) is lower when the area experiences upwelling phenomena due to the lifting of water from the seabed with low temperature to the surface with higher temperature, therefore sea surface temperature (SST) is an indicator of upwelling phenomena as it is also a benchmark for the intensity of upwelling in the water body (Hadiman et al., 2016). The rise and fall trend of average sea surface temperature and chlorophyll-a concentration in the eastern season of 2018 and 2020 is shown in Fig. 3.

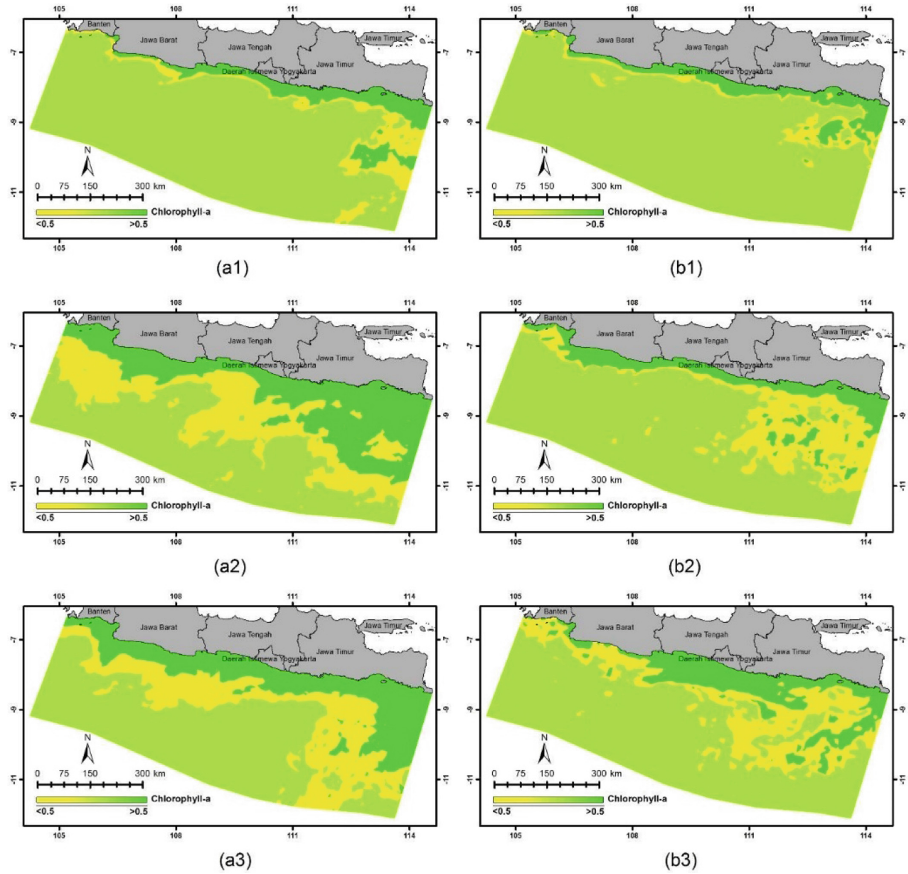


Fig. 2. Chlorophyll-a in the 2018 Eastern Season (a1, a2, a3) and in 2020 (b1, b2, b3)

Figure 4 shows a decrease in initial sea surface temperature (SST) and an increase in chlorophyll-a based on monthly averages during the eastern season in 2018 and 2020. In 2018, the highest chlorophyll-a levels occurred in July with a value of 0.62 mg/m^3 and a temperature of 26.19 °C. Meanwhile, in 2020, the highest chlorophyll-a levels occurred in August with a value of 0.49 mg/m^3, and the lower the sea surface temperature level, the higher the chlorophyll-a concentration content is. Another impact is the upwelling process in the area (Hadiman et al., 2016).

3.3 Upwelling Area

Table 3 shows that in 2018 in the eastern season, the strongest upwelling category was observed in July, with an area of 13,0723.94 km^2 and in 2020 it occurred in June with a strong upwelling area of 41,515.86 km^2. The area of strong upwelling in 2018 is wider than in 2020, which means marine phenomena had diminishing fish catches because seas are different and the distribution of upwelling was stronger in 2018. This prompted the fish catches in 2020 to decrease due to poor water conditions.

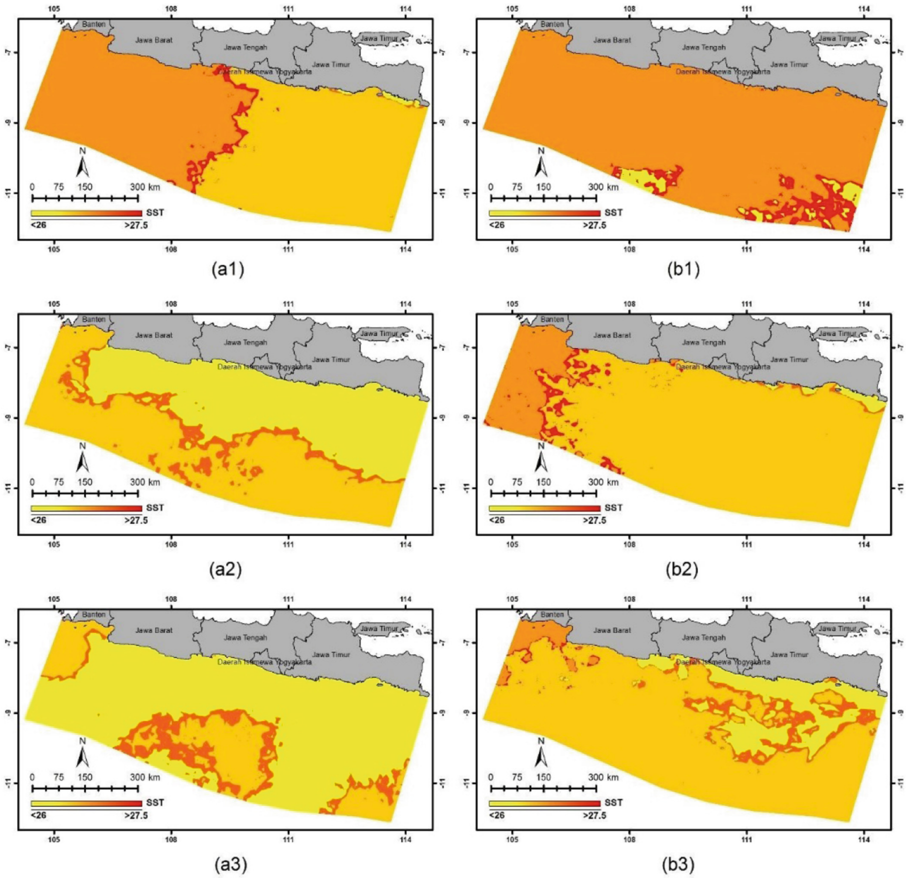
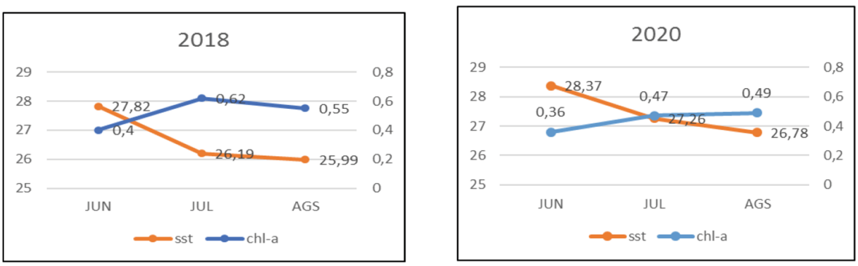


Fig. 3. Sea surface temperatures in the Eastern seasons 2018 (a1, a2, a3) and 2020 (b1, b2, b3)



(a) (b)

Fig. 4. Graph of sea surface temperature and chlorophyll-a (a) 2018 and (b) 2020

Table 3. Upwelling Area

Month	Upwelling Criteria	Area km^2	
		2018	2020
June	Weak	167057.62	320494.79
	Medium	37791.01	72.52
	Strong	1877.98	41515.86
July	Weak	226252.59	50836.49
	Medium	16483.15	61368.99
	Strong	130723.94	5072.49
August	Weak	248125.12	10297.05
	Medium	9263.31	51139.36
	Strong	116086.42	37394.30

Strong or weak upwelling is based on the high and low sea surface temperature and chlorophyll-a in the ocean. Strong upwelling occurs when the chlorophyll-a value is > 0.5 mg/m^3 and sea surface temperature is < 26 °C, and weak upwelling is when chlorophyll-a value is < 0.5 mg/m^3 and temperature is above 27.5 °C. The intensity of upwelling with strong criteria began to increase in June to July and decreased in August, while during the eastern season in 2020, upwelling that falls into the strong criteria was below those in 2018 despite strong upwelling. However, weak upwelling was more dominant. Table 3 shows 2018 when the eastern season's strongest upwelling occurred in July with an area of 130,723.94 km^2 and the year 2020 took place in June with a strong upwelling area of 41,515.86 km^2, as presented in Fig. 5. Strong upwelling occurred more vastly in 2018 compared to 2020, which implies the phenomenon of the sea with declining fish catch results. It is because of the different ocean conditions, and the distribution of strong upwelling in 2018, and it is the reason fish catch results in 2020 decreased due to less favorable water conditions.

3.4 Potential Fishing Zones

A good fishing area should have good suitability of water conditions, of course, for organisms in the area and has a high fertility (Saraswati et al., 2019). If there is a high concentration of chlorophyll-a, then the area is feasible for a fishing zone. For fishing, including water conditions as per sea surface temperature factors, the establishment of potential fishing zones by combining sea surface temperature contours and chlorophyll-a makes the location estimation process more facile (Marpaung et al., 2017). The potential fishing zone (PFZ) in 2018 and 2020 during the eastern season is displayed in Fig. 6.

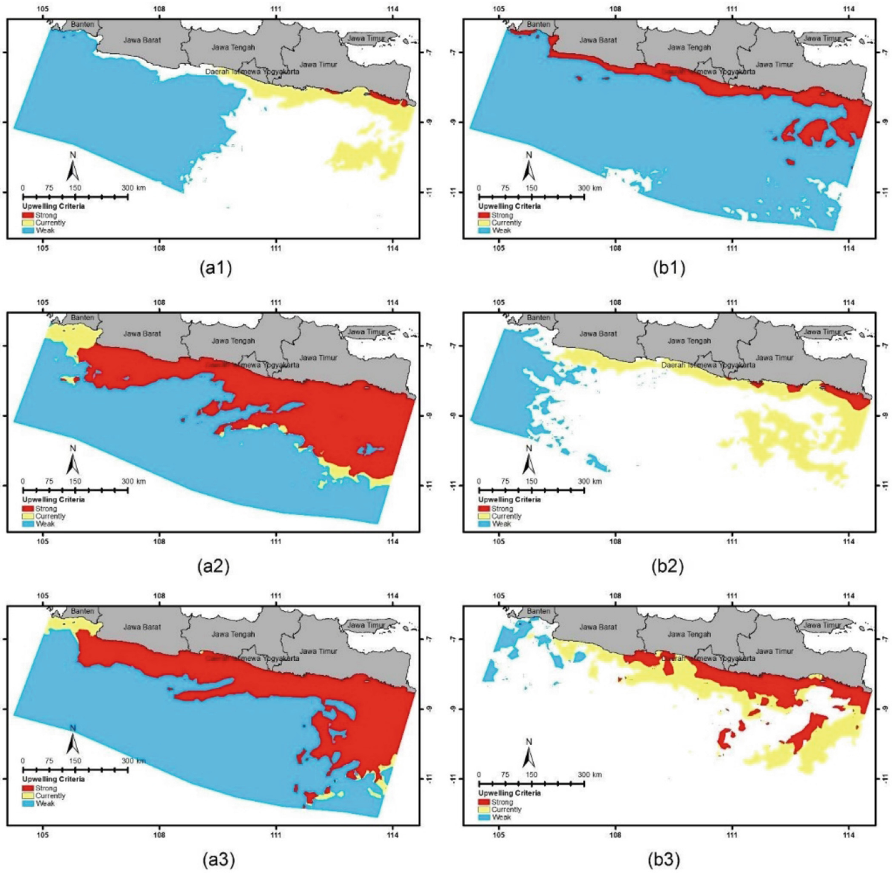


Fig. 5. Upwelling during the 2018 Eastern Season (a1, a2, a3) and 2020 (b1, b2, b3)

In the eastern season of 2018, the most points were pinpointed August with a number of 254, while the eastern season in 2020 occurred in July with a value of 154. It is mostly dominated by areas close to the coast. This is an opportunity to develop coastal areas (Martono, 2018), about 50 km from this land according to research (Martono, 2017), which reveals a zone of fertile and abundant potential fishing along the coast.

Based on Table 4 in the entire month of the eastern season in 2018, the number of points in the potential fishing zone was more noticeable compared to 2020. The distribution of fish potential zone model processing follows the availability of chlorophyll - a and the suitability of sea surface temperature levels that experience movement from winds and currents creates potential fishing zones that also encounter movement in the waters.

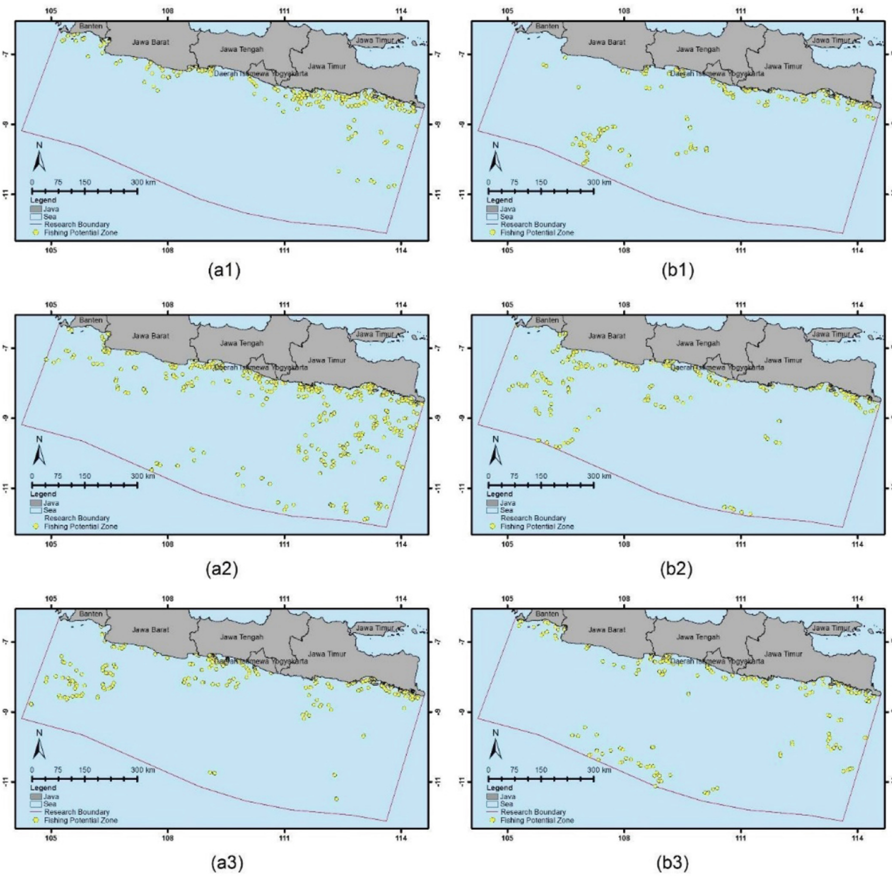


Fig. 6. Fishing Potential Zone of East season in 2018 (a1, a2, a3) and 2020 (b1, b2, b3)

Table 4. Potential Fishing Zone of Eastern Season

Month	2018	2020
June	163	121
July	182	154
August	254	135

3.5 Significant Paired T-test

Sea surface temperature and chlorophyll-a are dynamically interrelated because the main parameter to analyze the ocean that decreases fish catch directly affect coastal communities. When the fishery productivity plummets, the price of fish will rise and vice versa, despite experiencing the same oceanographic circumstances to different degrees. In the eastern season of 2020, the monthly average for chlorophyll-a concentration and sea surface temperature was no higher than in 2018 and there was a dominant distribution in areas closer to the coast. Therefore, it is possible to have significant differences between chlorophyll-a during the eastern season in 2018 and 2020 and between sea surface temperatures in 2018 and 2020. This significant difference was determined by running significant t-tests with the same variables at different times, the results are shown in Table 5.

The significant paired T-test in Table 5 demonstrates the significant value of chlorophyll – a in the eastern season (June–August 2018 and 2020), which was 0.000 in June and July, 0.007 in August, and the value was 0.05. In other words, there was a significant difference between the two years at the time of the eastern season. The eastern season in 2018 and 2020 for the significance value of sea surface temperature in June-August also had the value of 0.000 and this value was 0.05, so a significant difference was identified.

Table 6 describes the number of fishermen from 2018 to 2020 and for Table 7 shows the total amount of fish caught from that year, anglers are great in size on Java island, especially those that water in the South. Anglers in the south of Java island from 2018–2020 in each province have increased. This should result in increased fishing results, not the otherwise. It is because more fishermen and sailing fishing vessels get satisfying yields as well. However, productivity in 2018 – 2020 declined. This is due to the unfavorable water state in 2020 compared to 2018, with low chlorophyll-a and high sea surface temperatures (SST).

Table 5. Significant Paired T-test

	Month		
Chlorophyll-a 2018 dan 2020	June	July	August
Sig. (2-tailed)	0.000	0.000	0.007
Amount (N)	120	120	120
Sea Surface Temperature 2018 dan 2020	June	July	August
Sig. (2-tailed)	0.000	0.000	0.000
Amount (N)	120	120	120

Table 6. Number of Fishermen

Province	**2018**	**2019**	**2020**
Banten	33,258	42,711	43,294
Special Region of Yogyakarta	1,891	3,733	4,317
West Java	33,555	61,022	40,625
Central Java	42,942	108,164	171,515
East Java	144,024	213,495	212,379
Total	**255,670**	**429,125**	**472,130**

Source: (Kementerian Kelautan dan Perikanan, 2020)

Table 7. The Productivity of Fish Catches

Year	Amount (tons)
2018	1225150.05
2019	1170386.06
2020	1128209.26

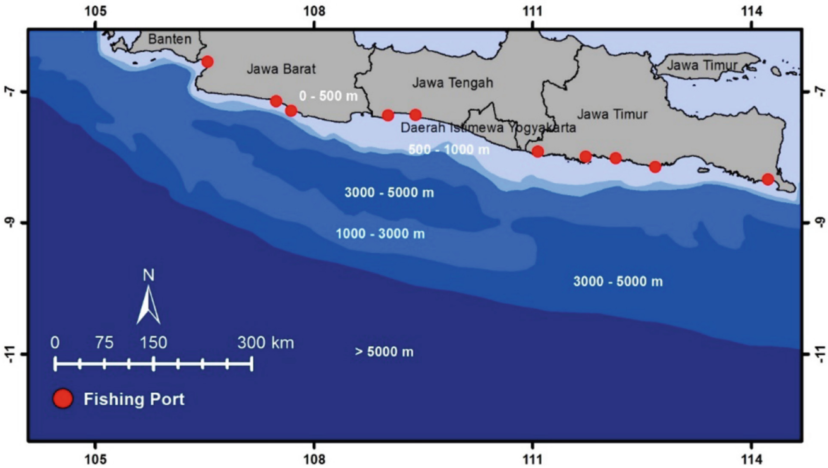


Fig. 7. Map of Fishing Ports and Sea Depths

The depth of the sea is useful for fishermen in case to find the biome vegetation and potential along the southern water body of Java island. Because at certain sea depths, there is much information that can be utilized, such as increasing economic potential and marine information. The phenomenon for fishermen and local governments. The sea depth at the end of the exclusive economic zone reaching 6 km from the water level is shown in Fig. 7. Some fishing ports located on the south coast of Java island are Nusantara Fishing Port, Samudera Cilacap Fishing Port, Cilauteureun Fishing Port, Rancabuaya Fishing Port, Pantai Logending Kebumen Fishing Port, Pantai Tamperan Fishing Port, Nusantara Prigi Fishing Port, Tambakrejo Fishing Port, Pantai Pondok Dadap Fishing Port, and Grajagan Fishing Port.

4 Conclusions

Coastal areas are utilized by the surrounding community to rely their livelihood on. The fewer fishing results have a direct impact on the fishermen's income, which is due to the less favorable sea conditions in 2020 compared to 2018. Low chlorophyll-a and high temperatures make the water area ominous for fish. High chlorophyll-a, low sea surface temperatures, strong upwelling areas, and many potential fishing zones (PFZ) are dominant in areas proximate to the coast compared to water conditions that are farther from the coast. It suggests better utilization of potential fishing in areas close to the coast at a distance of about 50 km from the shore. The upwelling phenomenon identified from chlorophyll-a and sea surface temperatures on the southern coast of Java island developed in the coastal part and spread afar when reaching the high sea in the eastern season of 2018 and 2020.

There was a phenomenon of upwelling with high chlorophyll-a in the region. The difference with the eastern season in 2020 decreased by an average of 0.3–0.4 mg/m^3 and the lowest chlorophyll-a value of 0.08. The highest value of 6.7 mg/m^3 with 2 mean chlorophyll-a sea surface temperatures and sea temperatures in the 2018 and 2020 eastern seasons also showed significant differences between the two years. Significant paired tests yielded values of less than 0.005, suggesting a significant difference between the two periods. The largest strong upwelling area in 2020 occurred in June with an area of 41,515.86 km^2. In the eastern season of 2018, the most points were pinpointed August with a number of 254, while the eastern season in 2020 occurred in July with a value of 154. of chlorophyll-a distribution and sea surface temperatures during the Eastern monsoon upwelling period. In 2018, there were stronger and more potential fishing zones than in 2020. In this study, all data were obtained from remote sensing technology, namely MODIS images mainly used to obtain data on sea surface temperature and chlorophyll-a. Hence, in the future, other researchers are needed to obtain a more accurate upwelling distribution using additional parameters such as wind and currents.

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