Study of sea surface temperature and chlorophyll-a influence on the quantity of fish caught in the waters of Sadeng, Yogyakarta, Indonesia

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Abstract. Oceanographic factors can be an indicator in determining the potential of fishing areas. The sampling technique of Sea Surface Temperature (SST) and chlorophyll-a data in this study was carried out directly (in-situ) and using satellite image data that can be downloaded from NASA Ocean Color to obtain SST and chlorophyll-a data. The purpose of this study was to analyze the effect of SST and chlorophyll-a on the quantity of purse seine catches, based on multiple correlation tests and multiple linear regression analysis. Species of fish caught during the study included: yellowfin tuna *(Thunnus albacares),* skipjack tuna *(Katsuwonus pelamis),* dolphin fish *(Coryphaena hippurus),* starry triggerfish *(Abalistes stellaris)*, rainbow runner *(Elagatis bipinnulata),* scad mackerel *(Decapterus russelli)* and squid *(Loligo).* The SST was measured in-situ. In the waters of Sadeng, Yogyakarta, the SST is relatively homogeneous, ranging from 27 to 30.3°C. Data verification is carried out ex-situ, with the aim of testing the level of accuracy. Satellite image data was processed for as many as 26 sampling points. The relative error was of 5.63%. Correlation test results between SST variables, chlorophyll-a and catches in the waters of Sadeng, Yogyakarta were performed for the period April to May 2022. The analysis of the effect of SST and chlorophyll-a showed that SST had a weak effect, while chlorophyll-a had a significant effect on the catches), as indicated by their level of significance of 0.556 (>0.05) and 0.041 (<0.05), respectively. Meanwhile, if the test was carried out on the combination of SST and chlorophyll-a, the result would have a significance of 0.056, which means that the SST and chlorophyll-a variables together strongly influence the catch.
Key Words: Geographic Information System (GIS), satellite imagery, oceanography, MODIS.

Introduction. Sadeng waters which are included in FMA 573 have the potential as habitat for economically important fish such as skipjack tuna *(Katsuwonus pelamis)*, bigeye tuna *(Thunnus obesus),* yellowfin tuna *(Thunnus albacares),* mackerel tuna *(Euthynnus affinis),* mackerel scad *(Decapterus russelli)* and sardin *(Sardinella lemuru)* (Nikijuluw 2008; Wijopriono 2012; Wahyuningrum et al 2012; Jayawiguna et al 2019). Skipjack tuna *(Katsuwonus pelamis)* is the second largest commodity in the area (Anggraeni et al 2015; Ma'mun et al 2017). Its geographical condition favors Indonesia's biodiversity (Kusmana & Hikmat 2015). Hendiarti et al (2004) explained that Sea Surface Temperature (SST) can affect the metabolism and reproduction of organisms in the sea. The distribution of SST is very important to know because it can provide information about the front, upwelling, currents, weather/climate and fishing ground (Abidin et al 2020). Sidik et al (2015) and Azizah et al (2020) explained that the influence of SST on the growth of phytoplankton will indirectly affect the concentration of chlorophyll-a in waters. According to Alfajri et al (2017), the Aqua satellite created by NASA functions as an observation satellite in the marine field. The Aqua-Modis satellite can measure various types of water parameters, one of which is SST in the waters. Oceanographic factors that are often associated with catches are SST and chlorophyll-a (Hastuti et al 2021).

Based on the discussion above and given the lack of research on SST and chlorophyll-a influence on the catch number in Sadeng waters, the study researched if there is a relationship between these variables. The results of this research are expected to help fishermen to determine fishing areas, based on oceanographic parameters.

Material and Method

Description of the study sites. The research was conducted from March 18 to May 30 2022, by participating in activities of fishing by purse seine operating in the Indian Ocean. The research locations are as shown in Figure 1 below:

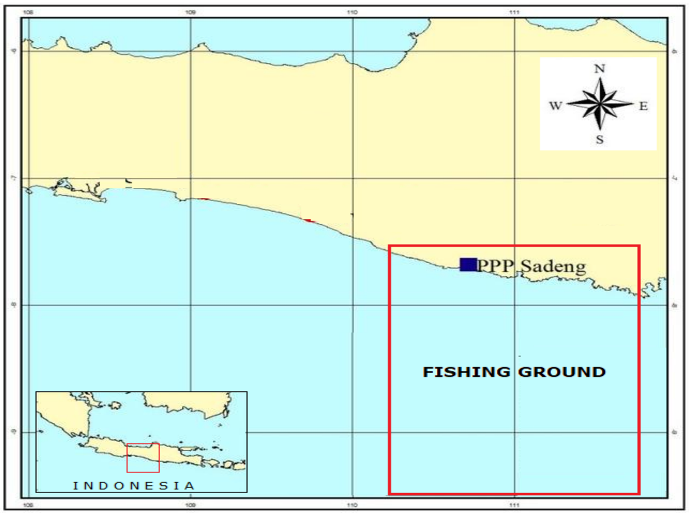


Figure 1. Map of fishing ground.

Method of collecting data. Data collection is done by collecting primary data and secondary data. Primary data concerned the fishing area position, the in-situ SST measured directly and the number of catches calculated for each trip. The secondary data were chlorophyll-a and SST images obtained by level 3 Aqua MODIS satellite imagery. Materials and tools used include: purse seine, GPS, compass, digital thermometer, software (.Excel, Seadas 7.5.3, Arcmap 10.8, SPSS), Camera, Chlorophyll-a Image, SST Image.

Data processing method. In processing MODIS data, SeaDas software was used. The results obtained are Aqua MODIS images at level 3, which produce SST values in degrees Celsius (°C) and chlorophyll-a (mg m^{-3}). Due to the relatively wider area, the projection system used is the Geographic Coordinate System (GCS) with the WGS84 datum. The processing of chlorophyll-a and SST values contained in the Aqua MODIS image map was carried out using the SeaDAS software. Data were filtered with Microsoft Excel, and a map of the distribution of chlorophyll-a and SST was made, using the IDW (Inverse Distance Weighted) analysis & the contouring menu, by interpolation, a simple deterministic method based on the surrounding points (Nurman 2010).

Data analysis method. Associative research methods were used with a quantitative approach to observe certain populations or samples (Sugiyono 2010). Analysis of the effect of SST and chlorophyll-a on the catch was tested by several methods including a verification test of satellite imagery data (ex-situ) and direct measuring (in-situ) data, a classical assumption test, and multiple linear regression analysis.

Results and Discussion

Catch production.
1. Catches number on the 1st trip: The 1st trip was held on 1 to 8 April 2022 by setting 9 times the gear, with the overall catch consisting of *T. albacares* (2,552 kg), *K. pelamis*

(3,023 kg), *D. russelli* (2,837 kg), *C. hippurus* (105 kg), *E. affinis* (337 kg) and *A. stellaris* (2,332 kg), with a total of 11,186 kg. The catches were dominated by *K. pelamis*.

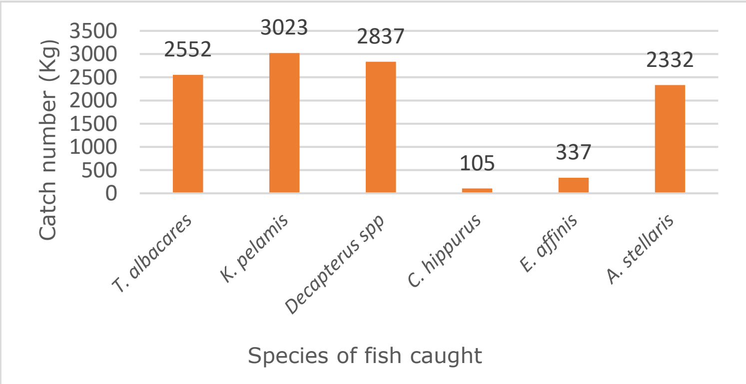


Figure 2. The number of catches on the 1st trip.

2. The number of catches of the 2nd trip: The 2nd trip was held on 10 to 16 April 2022 with 7 days of fishing operations or 7 settings. The catches of the 2nd trip consisted of *T. albacares* (2,002 kg), *K. pelamis* (5,237 kg), *D. russelli* (402 kg), *C. hippurus* (150 kg), *E. affinis* (644 kg), *A. stellaris* (38 kg), with a total of 8,473 kg. The catches on the 2nd trip were dominated by *T. albacares, K. pelamis,* and *D. russelli.*

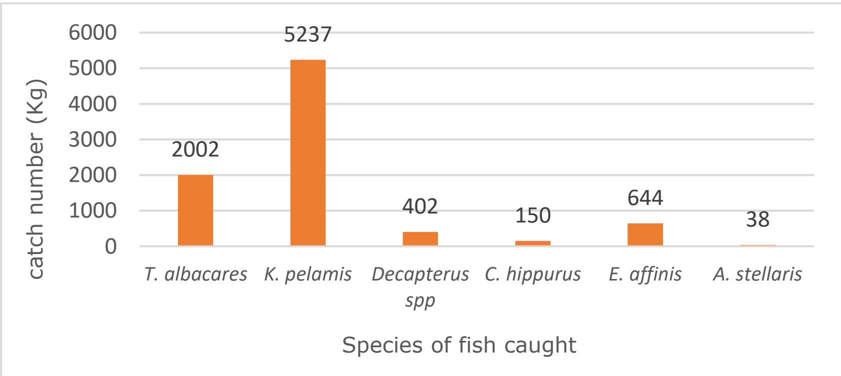


Figure 3. The number of catches on the 2nd trip.

3. The number of catches of the 3rd trip: The 3rd trip was held on 09 to 18 May 2022 with 10 days of catching and 10 settings. The catches on this trip were dominated by *K. pelamis*. The composition of the catch was: *T. albacares* (3,503 kg), *K. pelamis* (10,378 kg), *D. russelli* (5,866 kg), *C. hippurus* (143 kg), *Loligo* (497 kg), *E. bipinnulata* (154 kg), with a total of 20,541 kg.

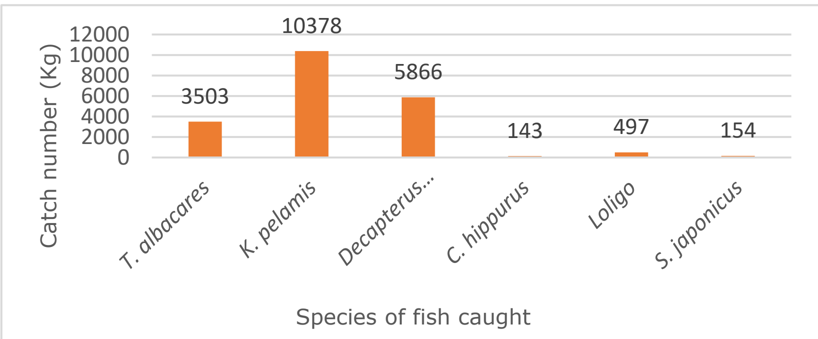


Figure 4. The catch of the 3rd trip.

Catch composition. In 3 trips with 26 catches, the catch was 40,200 kg. *K. pelamis* dominated with as much as 18,638 kg and an average of 716 kg per setting, the 2nd highest catch was *D. russelli* with as much as 9,105 kg and an average of 350 kg per setting, and the 3rd was *T. albacares* with as much as 8,057 kg and an average per setting of 309 kg. Meanwhile, the lowest catches were *C. hippurus* with 398 kg and *E. bipinnulata* with 154 kg and an average of 15.3 kg and 5.9 kg, respectively, for each setting. Table 1 shows the composition of the catching trips:

Table 1

Fish composition and catch number

Species	*Catch number (Kg)*			*Total*	*Average*	*Percentage (%)*
	Trip 1	*Trip 2*	*Trip 3*			
T. albacares	2,552	2,002	3,503	8,057	309	20
K. pelamis	3,023	5,237	10,378	18,638	716	46.3
D. russelli	2,837	402	5,866	9,105	350	22.6
C. hippurus	105	150	143	398	15.30	1
A. stellaris	2,332	38	0	2,370	91.15	5.9
E. affinis	337	644	0	981	37.73	2.5
E. bipinnulata	0	0	154	154	5.92	0.4
Loligo	0	0	497	497	19.11	1.3

The diagram in Figure 6 synthesizes the composition of the fish species caught.

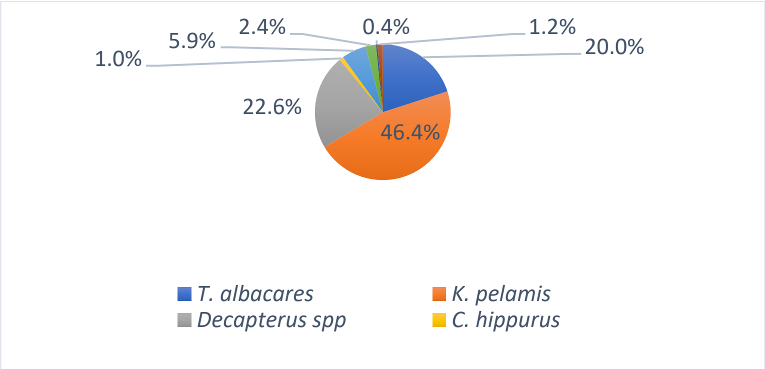


Figure 6. The composition of the caught fish species.

Distribution of Sea Surface Temperature (SST).

1. Distribution of SST in April 2022 for the 1st trip: The distribution of SST was observed to be stable, this can be seen from the 9 sampling points that were obtained during the 1st trip in April. Table 2 shows in-situ and ex-situ SST distribution values measured from 01 to 08 April 2022:

Table 2

The distribution of SST in Sadeng waters in April 2022, on the 1st trip

Date	*Position*		*SST (°C)*	
	Latitude (S)	*Longitude (T)*	*In-situ*	*Ex-situ*
01/04/2022	08°42'14''	110°31'22''	27.0	31.7
02/04/2022	08°46'05''	110°33'36''	28.1	31.3
03/04/2022	08°51'00''	110°35'12''	28.0	31.3
03/04/2022	08°49'07''	110°36'05''	28.5	31.4
04/04/2022	08°52'07''	110°36'10''	29.0	31.5
05/04/2022	08°41'47''	110°33'00''	27.1	31.5
06/04/2022	08°38'05''	110°51'51''	26.7	31.2
07/04/2022	08°47'00''	110°34'00''	29.2	31.1
08/04/2022	08°43'12''	110°33'26''	30.1	31.7
Average			28.1	31.4

Zulkhasyni (2015) stated that in general high SST occurs in the west season to the transition season, where the west season starts in September and ends in February, every year. The *K. pelamis* was caught at a temperature range of 29 to 30°C from November to March (Nugraha et al 2020). According to Yeka et al (2022), the potential area for catching *K. pelamis* has a close relationship with the environmental parameters, especially the chlorophyll-a, whose optimum ranges from 0.12 to 0.22 mg m^{-3}. SST in-situ of Sadeng waters in April 2022 ranged from 26.7 to 30.1°C. The highest SST occurred in April 8 2022, reaching 30.1°C, while the lowest temperature occurred on April 6, 2022, reaching 26.7°C. The average in-situ SST in April 2022 on the first trip was 28.1°C and the average ex-situ temperature was 31.4°C, as illustrated in Figure 6.

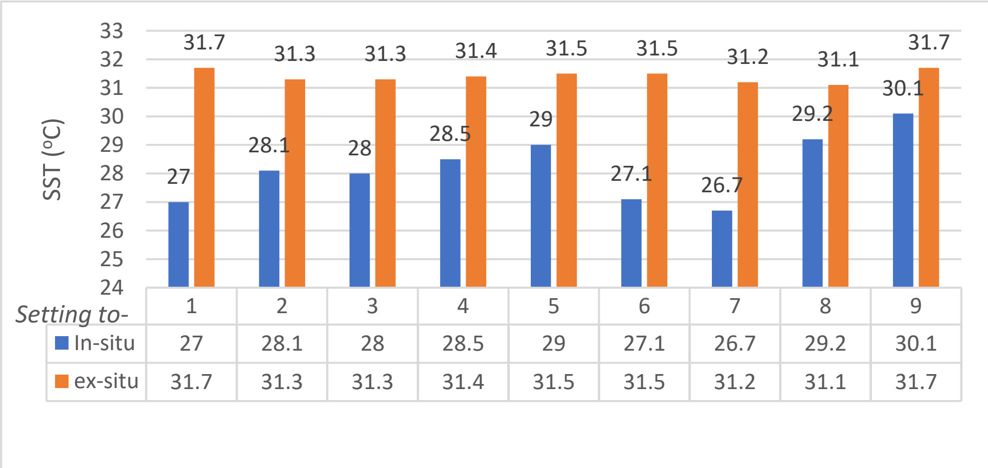


Figure 6. SST distribution in the 1st trip.

The highest number of catches occurred at the setting 9, with a total of 2,121 kg, at a high SST, reaching 30.1°C, while the least catch occurred at the setting 1, with a total catch of 345 kg, at a lower SST, of 27°C. This shows that in April 2022 if the SST value is high, the number of catches will be high and vice versa if the SST is low, the number of catches will also be low. The comparison of SST with the number of catches in April 2022 can be seen in Figure 7 below:

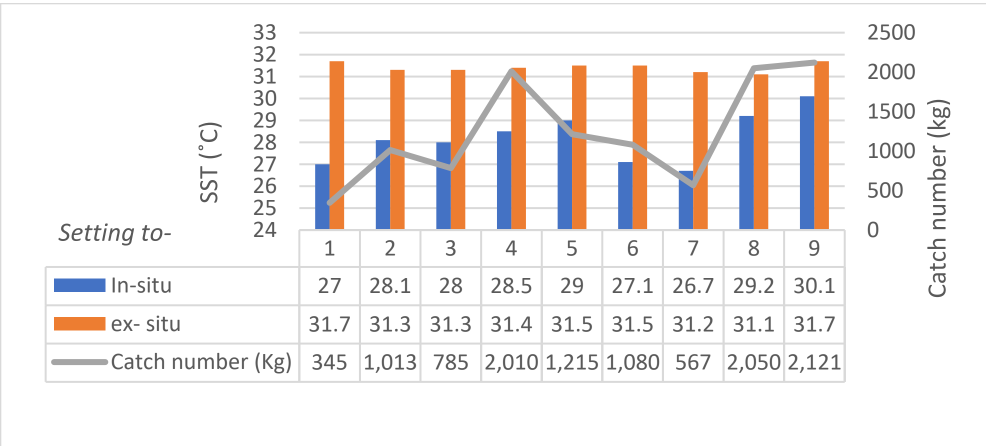


Figure 7. Comparison of SST with catch number in April 2022 on the 1st trip.

2. Distribution of the SST in April 2022 for the 2nd trip: This month, the SST data collection method was carried out in-situ and ex-situ at 7 points of the fishing ground, as observed in Table 3.

Table 3

The distribution of SST in Sadeng waters in April 2022 on the 2nd trip

Date	*Position*		*SST (°C)*	
	Latitude (S)	*Longitude (E)*	*In-situ*	*Ex-situ*
10/04/2022	08°36'38"	110°38'20"	30.2	31.7
11/04/2022	08°37'44"	110°29'54"	29.7	29.9
12/04/2022	08°35'20"	110°34'19"	27.5	30.1
13/04/2022	09°05'52"	110°09'27"	29.8	30.1
14/04/2022	08°32'25"	110°35'24"	28.5	30.1
15/04/2022	08°30'37"	110°38'14"	30.1	30.3
16/04/2022	08°30'25"	110°32'43"	28.3	29.4
	Average		29.1	30.2

Based on the data above, it can be seen that for all 7 sampling points, the SST distribution in April 2022 looks stable, ranging from 27.5 to 30.2°C. The highest temperature increase occurred on 10th of April 2022, reaching 30.2°C, while the lowest temperature occurred on April 12th of 2022, with a temperature reaching 27.5°C. The in-situ average in April 2022, on the 2nd trip, was 29.1°C and the ex-situ average was 30.2°C.

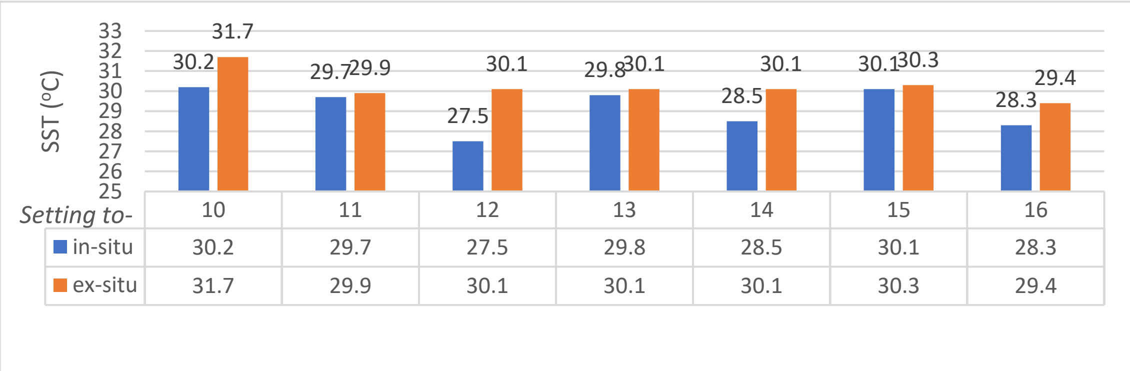


Figure 8. SST distribution on the 2nd trip.

In Figure 9, the comparison of the SST value with the catch in April 2022 shows that the highest of catch number occurred in the 12th setting, with as much as 2,053 kg, at an SST value reaching 27.5°C. Meanwhile, the smallest number of catches occurred in the 11th setting, with as much as 566 kg and an SST reaching 29.7°C. This shows that in April 2022, if the SST is high then the catch decreases and conversely, if the SST is low then the catch number is high, inversely proportional to the 1st trip.

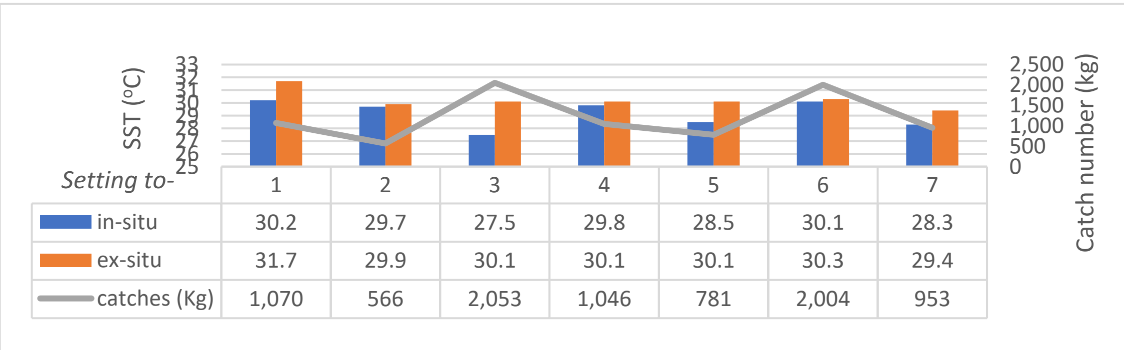


Figure 9. Comparison of the SST value and the catch quantity in April 2022, on the 2nd trip.

3. Distribution of the SST in May 2022, for the 3rd trip: In May 2022 the sampling point method was carried out directly on the satellite imagery, 10 times, as shown in Table 4:

Table 4

The distribution of SST in Sadeng waters in May 2022, on the 3rd trip

Date	*Position*		*SST (°C)*	
	Latitude (S)	*Longitude (E)*	*In-situ*	*Ex-situ*
09/05/2022	08°28'50"	110°08'51"	28.2	30.3
10/05/2022	08°44'19"	110°25'58"	29.1	29.7
11/05/2022	08°46'04"	110°54'56"	30.2	29.6
12/05/2022	09°09'10"	110°16'09"	30.3	30.3
13/05/2022	09°41'15"	109°59'03"	28.6	29.5
14/05/2022	09°27'33"	109°54'56"	27.7	28.8
15/05/2022	08°57'29"	110°06'22"	28.3	29.1
16/05/2022	08°46'14"	110°37'47"	27.7	30.1
17/05/2022	08°43'39"	110°46'36"	27.6	30.2
18/05/2022	08°33'23"	110°34'50"	28.3	28.5
	Average		28.6	29.6

Based on Table 4 and Figure 10, SST fluctuations occurred in May 2022. The SST distribution was stable, ranging from 27.6 to 30.3°C. The highest SST occurred on 12 May 2022, reaching 30.3°C, while the lowest SST, of 27.6°C, occurred on 17 May 2022. The average SST in-situ in May, on the 3rd trip, was 28.6°C and the ex-situ average was 29.6°C.

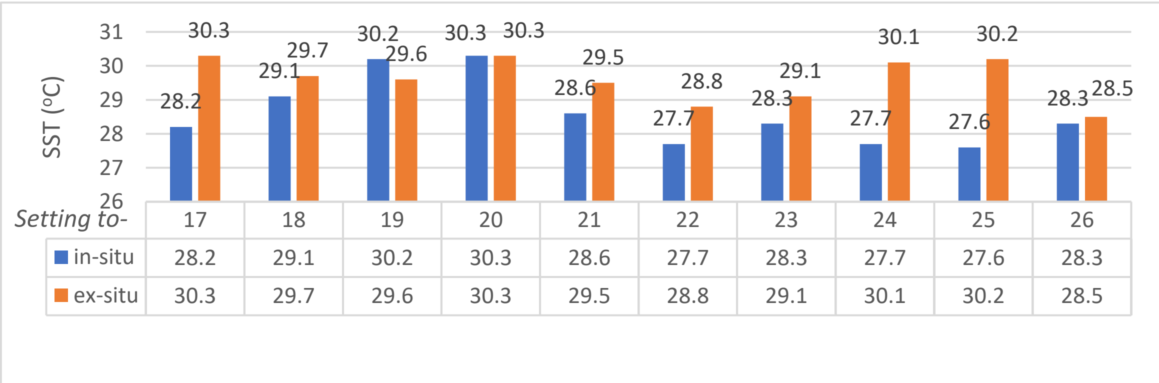


Figure 10. SST distribution in the 3rd trip.

In Figure 11, the comparison of SST with the highest catches number in May 2022, occurred at the setting 23, with a total of 5,045 kg, at a high SST value of 28.3°C. The lowest catches number on the 3rd trip occurred at the 25th setting, with a total of 641 kg and a SST reaching 27.6°C. Based on the previous findings, it can be concluded that in May 2022 if the SST is high, the catches number is high and if the SST is low, the catches number is low too.

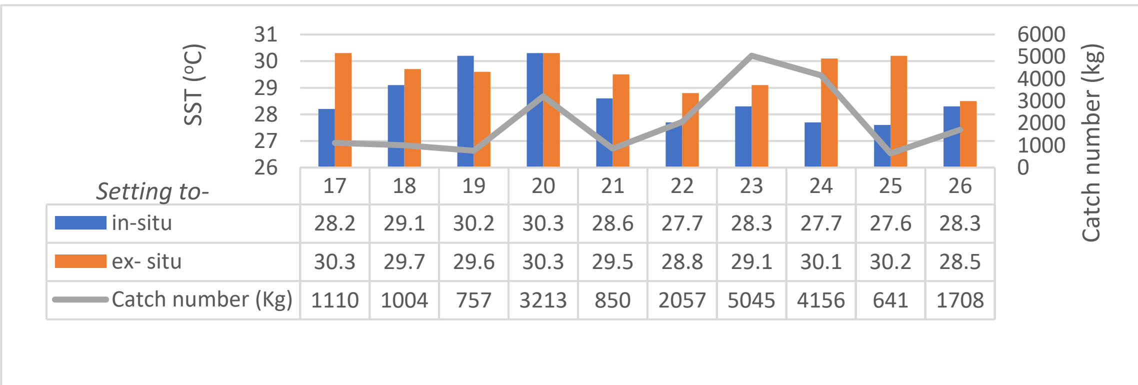


Figure 11. Comparison of SST with the catches number in May 2022 on the 3rd trip.

Chlorophyll-a concentration. One of the waters fertility factors is the availability of chlorophyll-a in the waters. According to Nufus et al (2017), the fertility level of coastal waters can be assessed from the biological and chemical characteristics, especially from the availability of essential nutrients. Based on the Table 5, the concentration of chlorophyll-a in Sadeng waters tends to experience fluctuations.

Table 5

Concentration of chlorophyll-a in Sadeng waters in 2017 to 2021

Period (Month/year)	*Chlorophyll-a (mg m^{-3})*				
	2017	*2018*	*2019*	*2020*	*2021*
April	0.38	0.33	0.58	0.28	0.39
May	0.40	0.73	0.76	0.34	0.41

The highest value of chlorophyll-a, 0.76 mg m^{-3}, occurred in May 2019, while the lowest value occurred in April 2020, with a value of 0.28 mg m^{-3}, as observed in Figure 12. The high and low values of chlorophyll-a are influenced by the nutrients content in the waters, which is also closely related to the abundance of phytoplankton. If the nutrients in the waters are abundant, the chlorophyll-a value will also be high. In addition, other factors that can affect the level of chlorophyll-a in waters are the temperature and salinity.

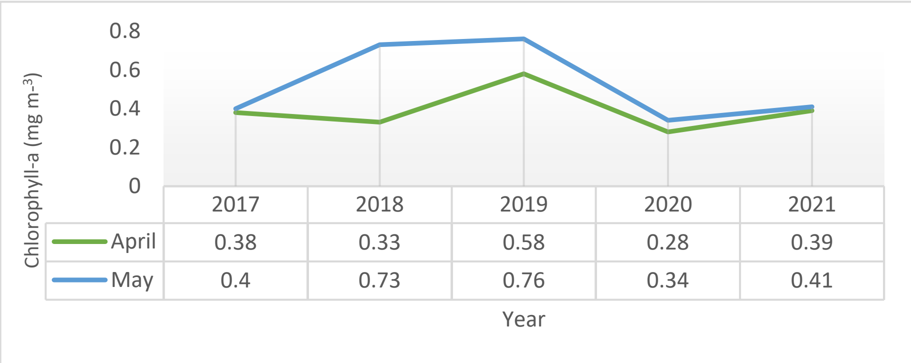


Figure 12. Chlorophyll-a concentration in 2017–2021.

1. Concentration of chlorophyll-a in April 2022, on the 1st trip: The distribution of chlorophyll-a concentration in April seemed to fluctuate. This can be seen from the 9 sampling points obtained from the NASA Ocean Color level 3, with a daily period, as it can be seen in Table 6.

Table 6

The concentration of chlorophyll-a in Sadeng waters in April 2022 for the 1st trip

Date	*Position*		*Chlorophyll-a (mg m^{-3})*	*Catch number (kg)*
	Latitude (S)	*Longitude (E)*		
01/04/2022	08°42'14''	110°31'22''	0.13	345
02/04/2022	08°46'05''	110°33'36''	0.15	1,013
03/04/2022	08°51'00''	110°35'12''	0.15	785
03/04/2022	08°49'07''	110°36'05''	0.12	2,010
04/04/2022	08°52'07''	110°36'10''	0.15	1,215
05/04/2022	08°41'47''	110°33'00''	0.14	1,080
06/04/2022	08°38'05''	110°51'51''	0.14	567
07/04/2022	08°47'00''	110°34'00''	0.15	2,050
08/04/2022	08°43'12''	110°33'26''	0.13	2,121
	Average		0.14	1,242

Based on Table 6 above, at the 9 sampling points observed during this trip, the highest increase in the value of chlorophyll-a occurred on 1st April 2022 with a concentration value of 0.15 mg m^{-3}. Meanwhile, the lowest chlorophyll-a value occurred on April 3rd 2022, with a chlorophyll-a concentration value of 0.12 mg m^{-3}. The average concentration of chlorophyll-a on the 1st of April trip was 0.14 mg m^{-3}.

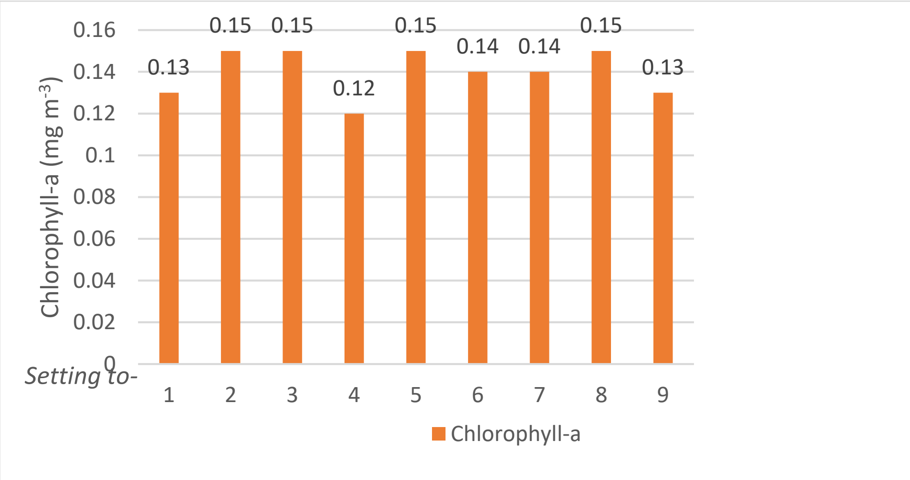


Figure 13. Chlorophyll-a concentration in April 2022, on the 1st trip.

In Figure 14 the comparison of the value of chlorophyll-a and the catches number in April 2022 shows that the highest catches number occurred in the 8th setting, with a total of 2,050 kg, at a high concentration of chlorophyll-a, of 0.15 mg m^{-3}. Meanwhile, the smallest catch number on the 1st trip occurred in the first setting, with the amount of 345 kg where the chlorophyll-a concentration value reached 0.13 mg m^{-3}. It can be concluded that in April 2022, if the concentration of chlorophyll-a is high then the catches number is high. Conversely, if the chlorophyll-a is low then the catches number is also low.

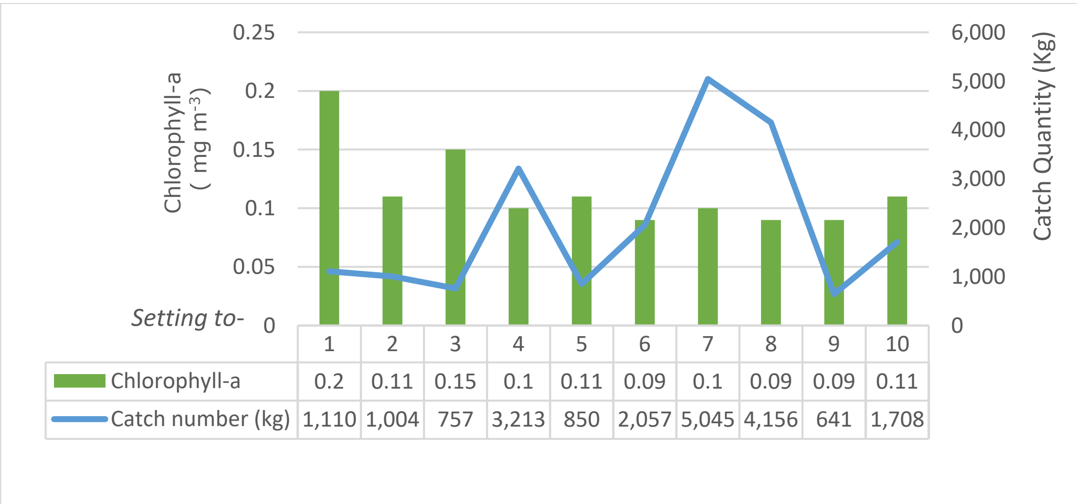


Figure 14. Comparison graph of chlorophyll-a value with the catches quantity on the 1st April 2022 trip.

1. Concentration of chlorophyll-a in Sadeng waters in April 2022 on the second trip: In April 2022, we considered 7 sampling points during the fishing operations; data were obtained from the NASA Ocean Color satellite (NASA 2007). The detailed chlorophyll-a concentration values can be seen in Table 7:

Table 7
The concentration of chlorophyll-a in Sadeng waters in April 2022, for the second trip

Date	*Position*		*Chlorophyll-a*	*Catches*
	Latitude (S)	*Longitude (T)*	*(mg m^{-3})*	*number (kg)*
10/04/2022	08°36'38"	110°38'20"	0.11	1,070
11/04/2022	08°37'44"	110°29'54"	0.12	566
12/04/2022	08°35'20"	110°34'19"	0.11	2,053
13/04/2022	09°05'52"	110°09'27"	0.12	1,046
14/04/2022	08°32'25"	110°35'24"	0.10	781
15/04/2022	08°30'37"	110°38'14"	0.11	2,004
16/04/2022	08°30'25"	110°32'43"	0.09	953
	Average		0.10	1,210

Figure 15 is a graph of the results of the 7 sampling points taken during the 2nd trip:

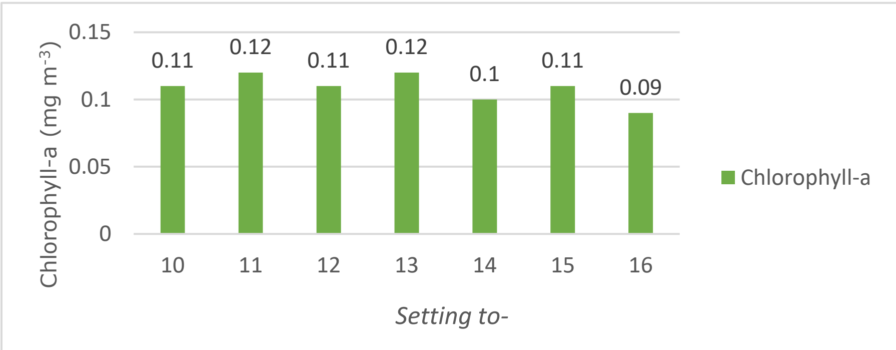


Figure 15. Chlorophyll-a value in April 2022, on the 2nd trip.

Based on the data above, it can be seen that from 7 sampling points taken during this trip, the highest increase in the value of chlorophyll-a occurred on April 13th 2022, with a concentration value of 0.12 mg m^{-3}. Meanwhile, the lowest chlorophyll-a value occurred on April 16th 2022, with a chlorophyll-a concentration value of 0.09 mg m^{-3}. The average concentration of chlorophyll-a in April, at the 1st fishing operation trip, was of 0.10 mg m^{-3}.

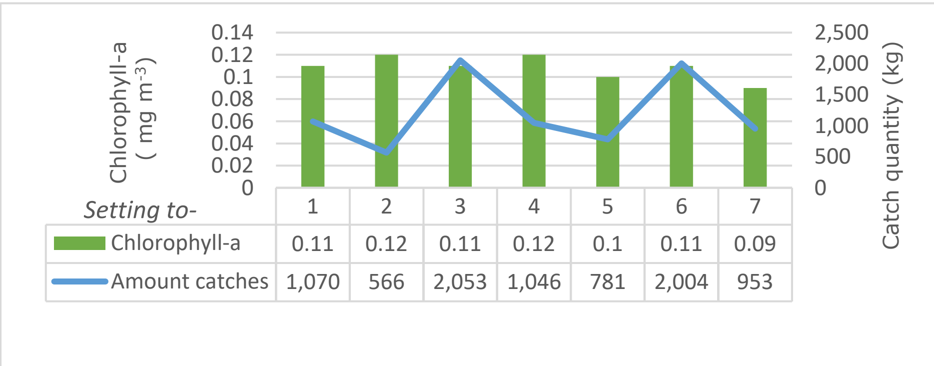


Figure 16. Comparison of the value of chlorophyll-a with the catches quantity, on the 2nd April 2022 trip.

In Figure 16, the comparison of the value of chlorophyll-a and the catch number in April 2022 shows that the highest catch number occurred at the 15th setting, with a total of 2,053 kg, inversely proportional to the chlorophyll-a concentration (0.11 mg m^{-3}, the lowest value). The smallest catch on the 2nd fishing operation trip occurred at the 11th setting, with the amount of 566 kg, when the value of chlorophyll-a concentration was the highest (0.12 mg m^{-3}). From the findings above, it can be concluded that in April the catch quantities are inversely proportional to the values of chlorophyll-a concentrations.

1. Concentration of chlorophyll-a in Sadeng waters in May 2022 on the third trip: The concentration of chlorophyll-a in May 2022 was observed to be stable, ranging from 0.09 to 0.15 mg m^{-3}. In May 2022, 10 sample points were taken using the satellite imagery obtained from NASA Ocean Color. The concentration of chlorophyll-a in Sadeng waters in May 2022 is presented in Table 8.

Table 8

The concentration of chlorophyll-a in Sadeng waters in May 2020, for the 3rd trip

Date	*Position*		*Chlorophyll-a (mg m^{-3})*	*Catch number (kg)*
	Latitude (S)	*Longitude (T)*		
09/05/2022	08°28'50''	110°08'51''	0.20	1,110
10/05/2022	08°44'19''	110°25'58''	0.11	1,004
11/05/2022	08°46'04''	110°54'56''	0.15	757
12/05/2022	09°09'10''	110°16'09''	0.10	3,213
13/05/2022	09°41'15''	109°59'03''	0.11	850
14/05/2022	09°27'33''	109°54'56''	0.09	2,057
15/05/2022	08°57'29''	110°06'22''	0.10	5,045
16/05/2022	08°46'14''	110°37'47''	0.09	4,156
17/05/2022	08°43'39''	110°46'36''	0.09	641
18/05/2022	08°33'23''	110°34'50''	0.11	1,708
Average			0.11	2,054

The data was synthesized in Figure 17:

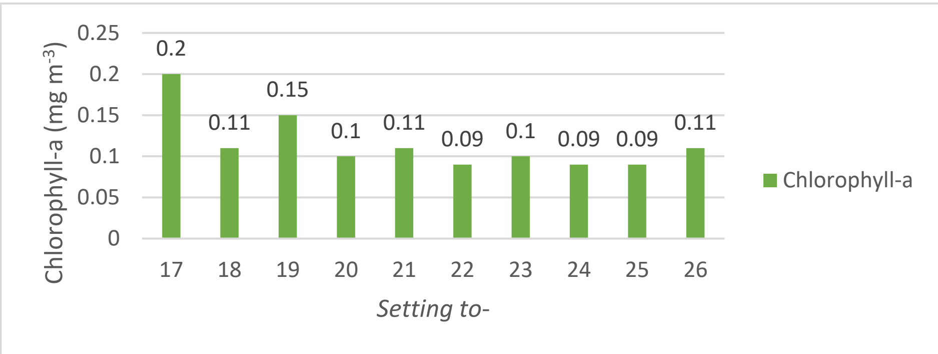
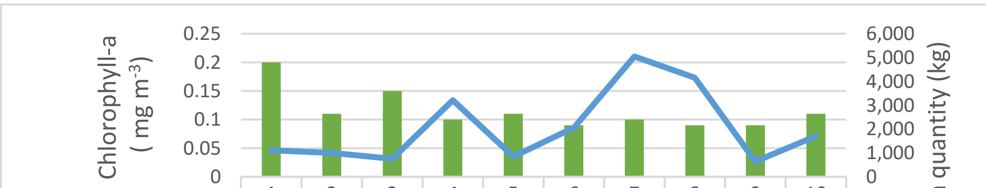


Figure 17. Chlorophyll-a concentration in May 2022, on the 3rd trip.

In Table 8 and Figure 17, it can be observed that the concentration of chlorophyll-a fluctuates in May. The highest chlorophyll-a value occurred on 11th of May 2022, of 0.15 mg m^{-3}, while the lowest chlorophyll-a value occurred on 14th, 16th, and 17th of May 2022, of 0.09 mg m^{-3}. The average concentration of chlorophyll-a in April 2022, on the fourth fishing operation trip, was 0.11 mg m^{-3}.



Setting to-	1	2	3	4	5	6	7	8	9	10
Chlorophyll-a	0.2	0.11	0.15	0.1	0.11	0.09	0.1	0.09	0.09	0.11
Catch number	1,110	1,004	757	3,213	850	2,057	5,045	4,156	641	1,708

Figure 18. Comparison of chlorophyll-a concentration with the catching quantity in May 2022.

In Figure 18, the comparison of the value of chlorophyll-a and the catching quantity in May 2022 shows that the highest quantity of catches occurred at the setting 23, with a total of 5,045 kg, at a high concentration of chlorophyll-a, with a value of 0.10 mg m^{-3}. Meanwhile, the smallest catch number on the 1st fishing operation trip occurred at the 25th setting, with a total of 641 kg where the chlorophyll-a concentration value reached 0.09. Based on the previous findings, it can be concluded that in May, if the concentration of chlorophyll-a is high then the catch number is high or conversely, if the chlorophyll-a is low then the catch number is also low.

SST data is obtained based on the analysis of MODIS images. The data is then verified against the measurements. The verification results are shown in Table 9:

Table 9

Verification of in-situ SST data with satellite imagery

No. setting	*Data in-situ*	*Data ex-situ*	*Value of error (%)*
1	27.0	28.28	4.92
2	28.1	28.28	0.69
3	28.0	28.29	1.12
4	28.5	26.78	6.69
5	29.0	27.42	6.08
6	27.1	27.39	1.12
7	26.7	28.18	5.69
8	29.2	25.7	13.46
9	30.1	26.98	12.00
10	30.2	28.28	7.38
11	29.7	26.08	13.92
12	27.5	26.21	4.96
13	29.8	27.66	8.23
14	28.5	27.53	3.73
15	30.1	28.04	7.92
16	28.3	27.56	2.85
17	28.2	27.11	4.19
18	29.1	28.4	2.69
19	30.2	28.32	7.23
20	30.3	27.41	11.12
21	28.6	26.13	9.50
22	27.7	28.86	4.46
23	28.3	28.33	0.12
24	27.7	28.56	3.31
25	27.6	27.01	2.27
26	28.3	28.48	0.69
Mean relatives error	28.61	27.59	5.63

According to Fadika et al (2014), data verification is done by calculating the MRE. In-situ SST data verification against the Aqua MODIS satellite image data, at 26 sampling points, shows that the average relative error value is 5.63%. This value is included in the correct category, where the resulting value is no more than 30%. Jaelani et al (2013) stated that values with an average relative error of less than 30% in image data processing can be used for further analysis. Based on the previous statement, it can be concluded that the SST satellite image data can be further analyzed because it has an accuracy of 91.89%. According to Simanjuntak et al (2012), among the factors that cause errors in the satellite image datais a reading error at the time of observation.

Analysis of the effect of SST and chlorophyll-a on the total catch.

1. Normality test

The normality test is part of the data analysis requirements. It is a classical assumption test: before performing a statistical analysis to test the hypothesis, a regression analysis is used to determine whether the residual values are normally distributed or not. The residual is normally distributed if the significance is more than 0.05 (Gunawan 2020).

In Table 10, the test results, obtained with the SPSS software, can be seen. The asymptotic normality obtained had the significance value (sig.)0.200 (>0.05), so the residual values can be considered as normally distributed.

Table 10

Normality test

One-Sample Kolmogorov-Smirnov Test		
		Unstandardized residual
N		26
Normal parameters[a,b]	Mean	.0000000
	Std. deviation	1016.50300169
Most extreme differences	Absolute	.108
	Positive	.108
	Negative	-.071
Test statistic		.108
Asymp. Sig. (2-fish)		.200[c,d]

[a] Test distribution is Normal; [b] Calculated from data; [c] Lilliefors Significance Correction; [d] This is a lower bound of the true significance.

The basis for decision making in the K - S Normality test is as follows:
- If the significance value (sig.) >0.05 then the data is normally distributed. On the contrary,
- If the significance value (sig.) <0.05, then the data is not normally distributed.

2. Linearity test

In Table 11 of the SST - catches relationship's Deviation from Linearity, the significance value (sig.) obtained is 0.868, greater than 0.05. So it can be concluded that there is a significant linear relationship between the SST variable (X) and the number of catches (Y).

Table 11

Linearity test of the catch number with SST

ANOVA Table							
			Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Catches * SST	Between groups	(Combined)	21329060.787	19	1122582.147	0.539	0.858
		Linearity	1812590.669	1	1812590.669	0.870	0.387
		Deviation from linearity	19516470.118	18	1084248.340	0.521	0.868
	Within groups		12497302.667	6	2082883.778		
	Total		33826363.454	25			

In Table 12 of the chlorophyll-a catches relationship's Deviation from Linearity, the significance value is 0.889, greater than 0.05. So it can be concluded that there is a significant linear relationship between the chlorophyll-a variable (X) and the catch number (Y).

Table 12

Linearity test of total catch with chlorophyll-a

ANOVA table							
			Sum of squares	*df*	*Mean square*	*F*	*Sig.*
Catches * Chlorophyll-a	Between groups	(Combined)	10614882.479	7	1516411.783	1.176	0.364
		Linearity	7753006.461	1	7753006.461	6.012	0.025
		Deviation from linearity	2861876.018	6	476979.336	0.370	0.889
	Within groups		23211480.975	18	1289526.721		
	Total		33826363.454	25			

The basis for decision making in the linearity test by comparing the significance value is as follows:

- If the value of Deviation from Linearity sig.>0.05, then there is a significant linear relationship between the independent variable and the dependent variable.
- If the value of Deviation from linearity sig.<0.05, then there is no significant linear relationship between the independent variable and the dependent variable.

3. Multicollinearity test

The multicollinearity test was used to test whether the regression model found a correlation between the independent variables. If a correlation exists, then there is a multicollinearity (multico) problem (Gunawan 2020). Multicollinearity is detected by examining the Variance Inflation Factor (VIF) value and tolerance, with reference to certain conditions: if the VIF value is less than 10 and the tolerance is more than 0.1, it is considered that there is no multicollinearity (Gunawan 2020).

In Table 13 it is shown that the value of the collinearity tolerance of the two variables is 0.90, more than 0.10, and the VIF statistic value of 1.11 is less than 10.

Table 13

Multicollinearity test

Coefficients[a]								
Model		*Unstandardized coefficients*		*Standardized coefficients*	*t*	*Sig.*	*Collinearity statistics*	
		B	*Std. err.*	*Beta*			*Tolerance*	*VIF*
1	(Constant)	2421.912	998.784		2.425	0.024		
	SST	1.219	2.630	0.089	0.464	0.647	0.900	1.111
	Chlorophyll-a	-117.383	50.033	-0.451	-2.346	0.028	0.900	1.111

[a] Dependent variable: Cathes.

So it can be concluded that the data above does not occur multicollinearity between independent variables. The basis for making decisions on the multicollinearity test with tolerance is as follows:

- If the tolerance value is greater than 0.10, it means that there is no multicollinearity in the regression model.
- If the tolerance value is less than 0.10, it means that there is multicollinearity in the regression model.

4. Heteroscedasticity test

The heteroscedasticity test aims to test whether in the regression model there is an inequality of variance from one observation to another. A good regression model is one without heteroscedasticity or with homoscedasticity (Gunawan 2020). Based on Table 14, it can be observed that the significance value (sig.) for the SST variable (X_1) is 0.811, while the significance value (sig.) for the chlorophyll-a variable (X_2) is 0.089.

Table 14

Heteroscedasticity test

Coefficients[a]						
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2825.294	3687.361		0.766	0.452
	SST	-30.753	126.844	-0.048	-0.242	0.811
	Chlorophyll-a	-9494.419	5333.793	-0.354	-1.780	0.089

[a] Dependent variable: Cathes.

Because the significance value of the two variables above is greater than 0.05, according to the basis for decision making in the Glejser test, it can be concluded that there is no symptom of heteroscedasticity. The basis for decision making in the heteroscedasticity test, using the Glejser conditions, is as follows:

- If the significance value (Sig.) is greater than 0.05, then the conclusion is that there is no heteroscedasticity symptom in the regression model.
- On the other hand, if the significance value (sig.) is less than 0.05, the conclusion is that heteroscedasticity is occurring.

5. Multiple linear regression

This analysis is used to measure the magnitude of the influence between the independent and dependent variables. There are several eligibility requirements that must be met when regression analysis is used, namely: the number of samples used must be the same, the number of independent variables is 1, the residual value must be normally distributed, there is a linear relationship, there are no symptoms of heteroscedasticity.

Based on Table 15, it is explained that the correlation coefficient (R) of 0.471 between the variables sea surface temperature and chlorophyll-a with the catch means that there is a very strong positive relationship between SST and chlorophyll-a with the fish catch.

Table 15

Model summary

Model summary				
Model	R	R Square	Adjusted R square	Std. error of the estimate
	.471[a]	0.221	0.154	1036.89027

[a] Predictors: (Constant), Chlorophyll-a, SST.

Meanwhile, the R square coefficient obtained is 0.221 or 22%, meaning that the independent variables (SST and chlorophyll-a) affect the Y variable (catch) by 22% while the rest of the catch is influenced by other variables. Based on Table 16, it is observed that the coefficient test of the SST variable produces $t_{count} < t_{table}$ (0.598<2.069) and the significance value obtained is 0.556 (Sig>0.05) so that SST only weakly affects the catch.

Table 16

t_{test}

Coefficients[a]						
Model		Unstandardized coefficients		Standardized coefficients	t	Sig.
		B	Std. error	Beta		
1	(Constant)	2262.186	977.214		2.315	0.030
	SST	1.539	2.573	0.116	0.598	0.556
	Chlorophyll-a	-106.246	48,953	-0.421	-2.170	0.041

[a] Dependent variable: Cathes.

Meanwhile, by testing the coefficient of chlorophyll-a variable, it was found that $t_{count}>t_{table}$ (2.170>2.069), with a significance value of 0.041 (Sig<0.05) so that it is known thatchlorophyll-a has a strong influence on the catch.

$$Y = 2262.186 + 1.539\ X_1 - 106.246\ X_2$$

The above equation describes the effect of changing the values of the independent variables, in the regression algorithm. The interpretation is as follows:

a. The intercept (2262.186) in this regression model represents the mean value of the catch (the response variable) when SST and chlorophyll-a (predictor variables) are equal to zero.
b. Every increase of 1^0 in SST (X_1) results in an increase of 1.539 in the catch (Y).
c. Every 1 mg m^{-3} increase in chlorophyll-a (X_2) results in a decrease of 106.246 in the catch (Y) since the chlorophyll has a negative regression coefficient with the catches.

In Table 17, able it can be observed that $F_{count}<F_{table}$ (3.271<3.40), while the significance value obtained is 0.056 (Sig>0.05), so it can be concluded that there is an influence between the combined SST and chlorophyll-a variables on the catch quantities.

Table 17

Significance test (f_{test})

		ANOVA[a]				
Model		*Sum of squares*	*df*	*Mean square*	*F*	*Sig.*
1	Regression	7034292.282	2	3517146.141	3.271	.056[b]
	Residual	24728253.103	23	1075141.439		
	Total	31762545.385	25			

[a] Dependent variable: Catch number; [b] Predictors: (Constant), Chlorophyll-a, SST.

Conclusions. The results of the significance test showed that SST had a partial influence on the catch number, while chlorophyll-a had a significant effect on the catch quantity. Meanwhile, if the test was carried out simultaneously, the results would obtaine a significance of 0.056, which means that the combined SST and chlorophyll-a have an influence on the catch quantities.

Conflict of interest. The authors declare no conflict of interest.

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