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ANALYSIS OF WATERS PHYSICAL CONDITION IN SMALL PELAGIC FISHING LOCATION (CASE STUDY AT FISHERIES MANAGEMENT AREA (FMA) 715)

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ABSTRACT

The aim of research is to study the physical conditions at the small pelagic fishing locations relation with the ideal criteria for small pelagic fish habitat. In this research, physical parameters consist of temperature and chlorophyll-a will be analyzed according to conditions at the actual small pelagic fishing location in FMA 715 throughout 2018. The actual small pelagic fishing location is obtained from the fishing logbook data which is validated with the Vessel Monitoring System (VMS) data using Kernel Density Interpolation. Sea surface temperature (SST) and chlorophyll-a information at small pelagic fishing locations are extracted through MODIS Imagery. Small pelagic fish species at the fishing location are caught for Shortfin Scad, Trevally, Yellowstrip Scad, and Shadow Trevally. The results showed that the surface temperature at the small pelagic fishing location in FMA 715 is 21.56 - 31.75 °C and chlorophyll-a concentration is 0.08 - 1.33 mg/m^3. It can be concluded that the physical conditions at the small pelagic fishing location are not always in accordance with the ideal habitat conditions. The conditions of sea surface temperature and chlorophyll-a that are close to the ideal conditions for small pelagic fish habitat are in the East Season.

KEYWORDS *Sea surface temperature, Chlorophyll-a, Small pelagic fish, FMA 715, Remote sensing*

INTRODUCTION

Indonesia's marine and fisheries resources are also undoubtedly abundant. With its geographical location along the equator, Indonesia receives sunlight almost all year round, thus affecting the growth pattern of chlorophyll which is part of the food chain in the waters. Indonesian waters are a meeting place between warm and cold currents that produce water temperatures that are suitable for the habitat of several types of fish (Yulianto, 2018). Indonesia's marine and fisheries sector has great potential for income, so its role in meeting world food needs is worthy of being considered (MMAF, 2017). According to FAO (2016), capture fisheries

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production in Indonesia in 2014 ranked 2nd in the world after China (14.81 million tons), with a total production of 6.02 million tons. Fisheries production increased by 6.10 million tons in 2016 (FAO, 2018). Based on the Decree of the Minister of Marine Affairs and Fisheries Number 50/KEPMEN-KP/2017, the potential for fish resources in Indonesia is 12.54 million tons per year and the largest potential is small pelagic fish of 4.88 million tons.

Small pelagic fish are fast-swimming fish, have a torpedo-like body shape and their migration range is worldwide by migrating in groups or schooling (Kusuma, 2016). Pelagic fish groups are the fish resources that are most widely caught by small fishermen to upper-middle fishermen. The location of catching small pelagic fish certainly cannot be separated from the habitat and environment where the fish are looking for food (Aryaguna, 2017). Each factual location for catching small pelagic fish has varying physical conditions of the waters. Pelagic fish have a high dependence on the environment (Mallawa, 2006).

According to Susilo et al. (2015), temperature is one of the oceanographic parameters that greatly influences fish life because each type of fish has an optimum temperature range for its life. Aryaguna (2017) in his research revealed that the habitat of small pelagic fish is influenced by surface temperature, chlorophyll-a, and salinity factors. The location of small pelagic fish capture is also influenced by physical parameters of the waters, including surface temperature, chlorophyll-a, and upwelling and thermal front events (Bayudin, 2018). In general, small pelagic fish are captured according to their aquatic habitat. However, there are certain conditions where small pelagic fish are caught in waters that do not match the criteria for the fish's habitat. Therefore, it is necessary to further study whether the physical conditions of the waters at the factual location of small pelagic fish capture are in accordance with the criteria for small pelagic fish habitat which have been used as references for compiling fishing area zoning.

The remote sensing approach is considered appropriate for studying and monitoring Indonesia's vast waters and abundant fishery resources. One of the remote sensing satellite images to obtain information on physical parameters of waters in the form of surface temperature and chlorophyll-a is MODIS Imagery. MODIS (Moderate Resolution Imaging Spectrometer) is one of the sensors installed on the Terra and Aqua satellites. The Terra satellite crosses the equator at 10:30 am and is designed to record images of the earth during the day, while the Aqua satellite crosses the equator at 1:30 pm, and is also designed to obtain information on the earth's surface at night (Danoedoro, 2012). Thus, in one day the MODIS sensor can present information on the earth's surface four times.

To see the relationship between the physical parameters of the waters at the factual location of small pelagic fishing with the physical parameters of the waters that are the habitat of small pelagic fish, multitemporal data is needed to determine the pattern of the relationship. MODIS Imagery offers earth surface recording data with high temporal resolution. This study attempts to see the relationship pattern between the physical parameters of the waters at the factual location of small pelagic fish capture with the physical parameters of the waters that are the habitat of small pelagic fish for a period of 1 (one) year. The utilization and processing of MODIS Imagery is expected to produce physical parameters of the waters at the capture location, especially in Fisheries Management Area 715 which has the potential as fertile waters.

The purpose of this study was to determine the condition of the physical parameters of the waters at the location of small pelagic fish capture in relation to the criteria for ideal small pelagic fish habitat. The physical parameters of the waters at the fishing location are useful for modeling the zoning of potential fishing. Synchronization of the criteria for small pelagic fish habitat with the physical parameters of the waters at the fishing location is expected to increase the accuracy of further research so that the utilization of fishery resources becomes more optimal.

RESEARCH METHOD

This study was conducted using the spatial analysis method of remote sensing imagery. The remote sensing imagery used was MODIS Imagery. The software used for data processing was: SeaDAS 7.5.3, QGIS 3.10.1, ENVI 5.1, ArcGIS 10.7, and Microsoft Office. The data used in this study were spatial data of Fisheries Management Area (FMA) 715, fishing log book data of FMA 715 in 2018, VMS data of fishing vessels in FMA 715 in 2018, and MODIS Imagery recorded in 2018. Fishing log book data and FMA 715 data were obtained from the Directorate General of Capture Fisheries, Ministry of Marine Affairs and Fisheries (MMAF). While VMS data of fishing vessels were obtained from the Directorate General of Marine and Fisheries Resources Surveillance, MMAF. MODIS Imagery were downloaded via the website https://oceancolor.gsfc.nasa.gov/ to be analyzed for sea surface temperature and chlorophyll-a information.

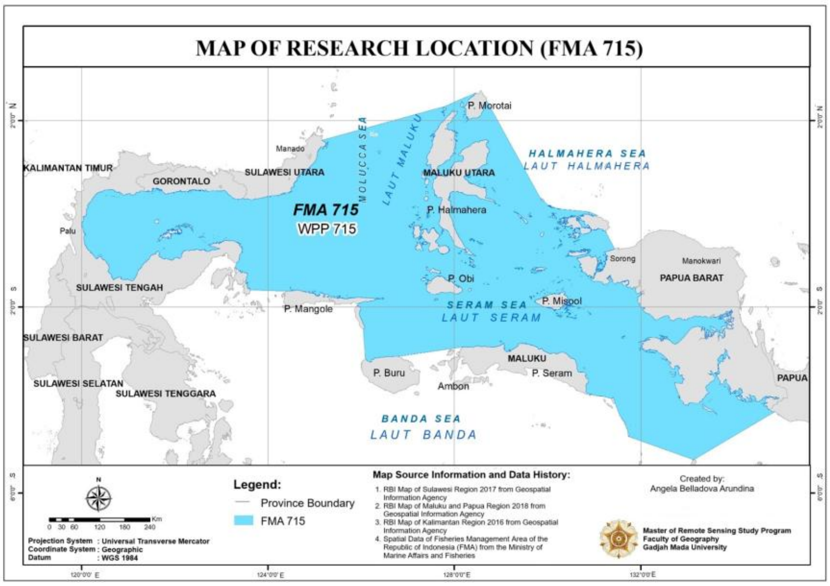


Figure 1. Map of Research Location

The study area location is FMA 715 which includes Tomini Bay, Molluca Sea, Halmahera Sea, Seram Sea, and Berau Bay with boundaries of 2.59^{o} N - 5.29^{o} S and 120^{o} E - 134.97^{o} E as shown in Figure 1. FMA 715 has high pelagic fisheries resource potential. This study was conducted by integrating factual data on pelagic fishing from fishing log books, real-time VMS data from fishing vessels, and

MODIS data at small pelagic fishing locations. The process stages in this research are:

1. Plotting of Small Pelagic Fishing Locations

Factually, small pelagic fishing locations can be known from the fishing log book data filled in by the ship's captain according to the format stated in the Regulation of the Minister of Maritime Affairs and Fisheries Number 48/PERMEN-KP/2014 concerning Fishing Log Books. The fishing log book data collected is limited to the small pelagic fishing locations in FMA 715. The results of processing the fishing log book are the coordinates (x, y) of the small pelagic fishing locations in vector data format.

2. Small Pelagic Fishing Data Validation

Each fishing vessel route and tracking can be known from the Vessel Monitoring System data. Fishing vessels certainly use various fishing gear. By using various fishing gear, it will form different patterns, directions, and routes. The coordinates of small pelagic fishing locations are combined with VMS data to improve the accuracy of factual fishing locations (Bastardie et al., 2010).

In filling out the fishing log book, sometimes the coordinates of the ship's position when fishing are not the same as the data written in the log book. Therefore, factual information on small pelagic fishing requires additional information, namely regarding the position, direction, distance, and speed of the ship in real time. This information is contained in the VMS data of fishing vessels that reflect the activities carried out by the ship, for example when the speed approaches 0 knots/hour within a certain time, the ship is indicated to be fishing (Yulianto, 2018). The VMS data processing process includes: VMS data cleaning, data repair, ship tracking analysis with transmitters, and data filtering.

Validation is done by overlaying the small pelagic fishing location with the fishing vessel coverage area. Validation of small pelagic fishing location data with fishing vessel VMS data is calculated over a monthly period by comparing the small pelagic fishing location points that are included in the vessel's fishing area. This vessel's fishing area is simulated by spatial interpolation using Kernel Density. By carrying out this validation calculation, it is expected to minimize errors in small pelagic fishing location data that will be analyzed further.

3. MODIS Data Processing

The advantage of MODIS Imagery is that it can be obtained for free from the satellite directly or downloaded from the internet. With a sweep width of 2,330 km, MODIS is able to cover the entire surface of the earth in one or two days, and presents it in 36 spectral bands, ranging from 0.46 to 14.38 µm. MODIS also provides information that varies, from 250 m to 1 km (Danoedoro, 2012). Khakhim (2013) and Insanu et al. (2013) in their research explained that to extract sea surface temperature information on MODIS Imagery, bands 20, 31, and 32 were used. MODIS Imagery of bands 20, 31, and 32 were first converted into radiance values to brightness temperatures, using the Planck equation:

Tb = c2/(Vi*ln(1+c1/(Vi5* R))).. (1)

Description:

Tb= Water Brightness Temperature (^oK)
c1= Radiation Constant (1.1910659x108) [W m-2 sr-1(μ m-1)-4]
c2= Radiation Constant (1.438833x104) [K μ m]
Vi= Central Wavelength (See Table 1)
R = Radiance Value of Channels 20, 31, and 32

After obtaining the brightness temperature value on bands/channels 20, 31, and 32 are then inputted into the algorithm developed by Brown and Minnet (1999) in ATBD (Algorithm Technical Background Document) 25, namely:

SST=k1+k2*(Tb31-273)+k3*(Tb31-Tb32)*(Tb20-273)+k4*(Tb31-Tb32)* (1/cosθ-1).. (2)

Description:
SST = Sea Surface Temperature (^oC)
Tb20 = Water Clarity Temperature of Channel 20 (^oC)
Tb31 = Water Clarity Temperature of Channel 31 (^oC)
Tb32 = Water Clarity Temperature of Channel 32 (^oC)
k1, k2, k3, k4 = Sea Surface Temperature Coefficient (See Table 1)
θ = Zenith Sensor Radiance Value

Table 1. SST Coefficient Values on MODIS Satellites (Terra and Aqua)

Satelit	**k1**	**k2**	**k3**	**k4**
Terra (day)	1,052	0,984	0,130	1,860
Terra (night)	1,886	0,938	0,128	1,094
Aqua (day)	1,152	0,960	0,151	2,021
Aqua (night)	2,133	0,926	0,125	1,198

Source: Brown and Minnet (1999)

According to the channel specifications on MODIS Imagery, the concentration of chlorophyll-a in waters can be detected using bands 8 to 11. Prasasti et al. (2005) in Khakhim (2013) stated that the OCV-V2 algorithm is a formula that can be used to determine chlorophyll-a with results that are closest to the actual chlorophyll distribution pattern. The OCV-V2 formula can be seen in the following equation (3):

OCV-V2: Chlorine = 10 (a0 + a1 * R + a2 * R^2 + a3 * R^3)+a4……………… (3)

Description:
R = log (channel 10/channel 11)
a0 = 0.2974; a1= -2.2429; a2= -2.2429; a3= -0.0077; a4= -0.0929

MODIS level 2 data used is sampled at least 1 image in each 8-day phase of image recording. Image selection is based on the purposive sampling method according to the research objectives and research location. The selected MODIS imagery records most of the research area (FMA 715). If within a period of 1 8-day phase there is no image scene that can represent 1 recording date with a recording location coverage of >50% then within a period of 1 8-day phase, >1 MODIS Imagery can be selected. MODIS level 2 data still needs to be subjected to simple geometric correction in the form of image reprojection. Image reprojection is carried out with the help of SeaDas software provided by NASA to process MODIS Imagery.

4. Determination Small Pelagic Fish Habitat Criteria

The small pelagic fish habitat criteria used in this study were quoted from research conducted by Yulianto (2018). Generally, small pelagic fish are found at depths of 0-200 m with chlorophyll content of 0.5-2.0 mg/m^3 and sea surface temperatures between 20-29 ^{o}C as stated in Table 2.

Table 2. Habitat Criteria for Small Pelagic Fish

Parameter	Value
Sea Surface Temperature	20 – 29 ^{o}C
Chlorophyll-a Content	0.5 – 2.0 mg/m^3
Depth	0 – 200 m

Source: (Hendiarti, 2005 and EoL, 2016 in Yulianto (2018))

Physical parameters of waters at small pelagic fishing locations are not always ideal water conditions for small pelagic fish habitat. Each fish has its ideal habitat criteria in this case the parameters used are based on sea surface temperature and chlorophyll-a. To carry out a comparative analysis of the characteristics of sea surface temperature and chlorophyll-a parameters, the analysis was grouped based on the small pelagic fishing season. In this research, the analysis was carried out based on 4 (four) fishing seasons, namely West Season, Transition Season 1, East Season and Transition Season 2. The division of fishing seasons and months, namely: West season (December, January and February); transition season 1 (March, April and May); east season (June, July and August); and transition season 2 (September, October and November).

RESULT AND DISCUSSION

Fishing log book data in Fisheries Management Area (FMA) 715 includes information on the catch of fishing vessels that have a SIPI (Fishing Permit). There are 65 types of fish caught throughout 2018 in FMA 715. Small pelagic fish in FMA 715 are limited to the types of Indian Mackerel, Short Mackerel, Trevally, Greater Amberjack, African Pompano, Bluespotted Trevally, Shadow Trevally, Scad, Japanese Scad, Redtail Scad, Indian Scad, Shortfin Scad, Mackerel Scad, Blackfin Scad, Oxeye Scad, Yellowstripe Scad, Rainbow Runner, Talang Queenfish, Goldstripe Sardinella, and Commerson's Anchovy. The factual small pelagic fishing locations in FMA 715 were obtained from the results of plotting the coordinates contained in the fishing log book represented in the map in Figure 2.

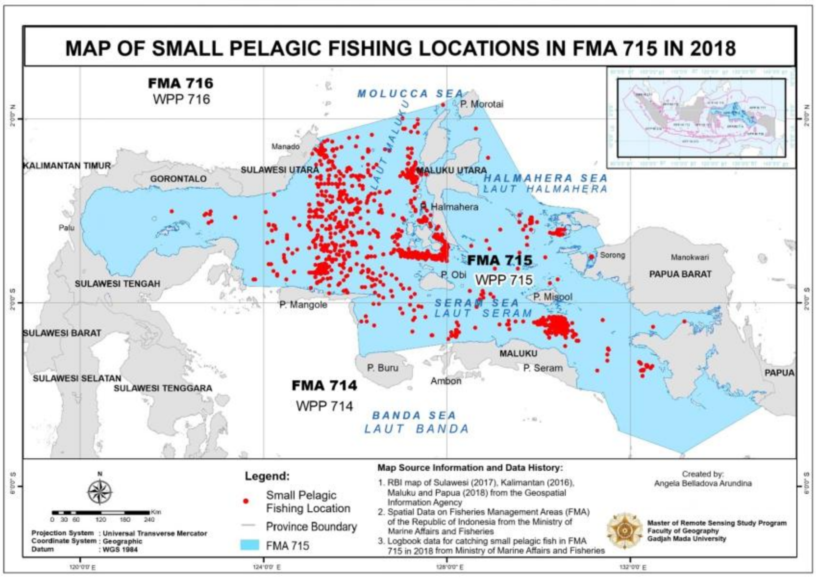


Figure 2. Map of Small Pelagic Fishing Locations in FMA 715 in 2018

Based on the plotting of the distribution of small pelagic fishing locations throughout 2018, it can be seen that locations with high pelagic fishing densities are around the Maluku Sea and Seram Sea. Meanwhile, the density of small pelagic fishing in Tomini Bay and Halmahera Sea is low-moderate. To increase the validity of factual pelagic fishing location data, VMS data from fishing vessels is needed. The complete results of the plotting of VMS data from fishing vessels during 2018 are presented in Figure 3.

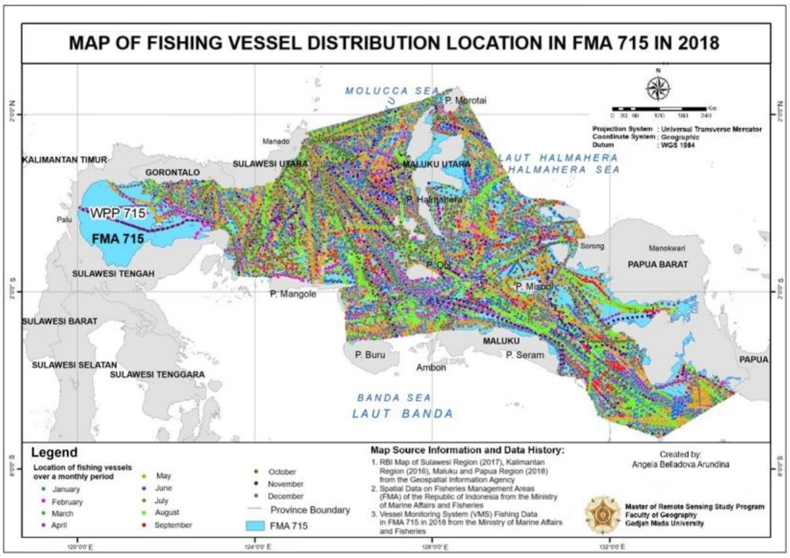


Figure 3. Map of Fishing Vessel Distribution Locations in FMA 715 in 2018

Based on the calculation results, it is known that the average validity of fishing log book data by fishing area vessels is 88.6%. Of the 3,115 small pelagic fishing locations, 2,760 small pelagic fishing locations are included in vessel fishing areas. Thus, the distribution of pelagic fishing location points that will be used in further analysis is 2760 points. Point data for small pelagic fishing locations that are not included in fishing vessels' fishing areas are not used for further analysis.

The results of the validation process obtained factual small pelagic fishing locations that met the criteria because they were in accordance with the position of the fishing vessel and the speed when carrying out fishing activities. The MODIS data processing process to produce sea surface temperature and chlorophyll-a data. The results of MODIS Imagery data processing, namely SST and chlorophyll-a information, were then overlaid with the location (x, y) of small pelagic fishing from fishing log book data during 2018, especially in WPP 715. The limitations of MODIS Imagery are that recording is not always in the same scene area every day. SST and chlorophyll-a data processing in the study area was only carried out on certain dates so that the types of small pelagic fish that were successfully identified were limited to kuwe fish, long pectoralf kuweh, layang deles, and yellow scad.

Meanwhile, the location and time of catching other small pelagic fish could not be identified. Data analysis was conducted based on fishing seasons, namely West Season (January, February, and December), Transition Season 1 (March, April, and May), East Season (June, July, and August), and Transition Season 2 (September, October, and November).

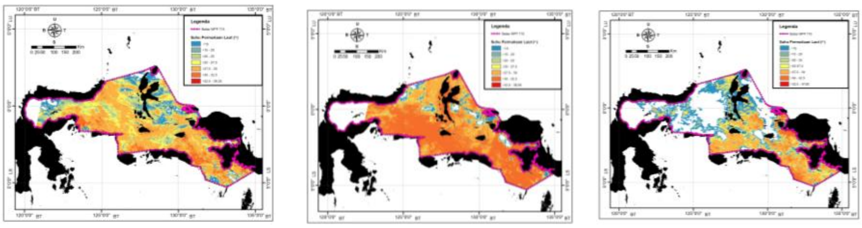
Table 3. Sea Surface Temperature (SST) and Chlorophyll-a Conditions at Small Pelagic Fishing Locations in the West Season (January, February, and December)

Fishing Date			Fishing Location		Types of Fish	Scientific Name of Fish	SST (ºC)	Chlorophyll-a (mg/m^3)
Day	Month	Year	Longitude (X)	Latitude (Y)				
3	January	2018	127.3167	-0.9500	Shadow Trevally	*Carangoides dinema*	29.92	0.17
10	January	2018	126.8500	-0.8500	Shadow Trevally	*Carangoides dinema*	28.25	0.14
10	January	2018	130.2333	-2.6000	Shadow Trevally	*Carangoides dinema*	29.31	0.16
10	January	2018	130.5500	-2.6667	Shadow Trevally	*Carangoides dinema*	29.53	0.15
10	January	2018	130.1000	-2.4667	Shadow Trevally	*Carangoides dinema*	29.71	0.16
10	January	2018	124.6333	-0.9333	Shortfin Scad	*Decapterus macrosoma*	30.11	0.16
10	January	2018	125.2500	-0.7500	Yellowstrip Scad	*Caranx leptolepis*	29.48	0.16
31	January	2018	125.7333	-0.0333	Shadow Trevally	*Carangoides dinema*	30.35	0.11
7	February	2018	126.6167	-0.9500	Shadow Trevally	*Carangoides dinema*	28.02	0.16
20	February	2018	127.0167	-0.4500	Shadow Trevally	*Carangoides dinema*	29.74	0.22
20	February	2018	130.3667	-2.3167	Shadow Trevally	*Carangoides dinema*	29.91	0.13
20	February	2018	127.8000	-1.0000	Shadow Trevally	*Carangoides dinema*	30.29	0.21
20	February	2018	127.5500	-0.1833	Shadow Trevally	*Carangoides dinema*	30.36	0.20
20	February	2018	130.1500	-2.5000	Shadow Trevally	*Carangoides dinema*	30.47	0.14
20	February	2018	132.3500	-3.3667	Shadow Trevally	*Carangoides dinema*	30.90	0.34
20	February	2018	125.5167	-0.0667	Shortfin Scad	*Decapterus macrosoma*	30.51	0.14
12	December	2018	130.4333	-2.6333	Shadow Trevally	*Carangoides dinema*	29.46	0.19
12	December	2018	130.4333	-2.5000	Shadow Trevally	*Carangoides dinema*	29.97	0.22
12	December	2018	130.6500	-2.6167	Shadow Trevally	*Carangoides dinema*	30.01	0.19
24	December	2018	127.0667	-0.2000	Shortfin Scad	*Decapterus macrosoma*	29.44	0.29

Source: data analysis and processing

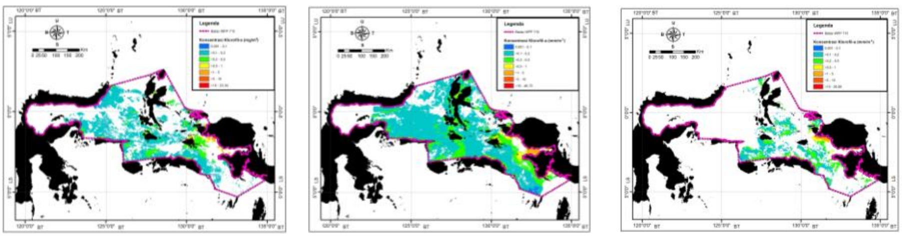
Through MODIS Image data extraction, information on sea surface temperature and chlorophyll-a around WPP 715 was obtained. MODIS imagery has a high temporal resolution so that it can monitor large water areas in a daily time span. Overlaying the coordinates of small pelagic fishing locations on the sea surface temperature (SST) and chlorophyll-a maps in the west season produces information on the date, location, type of fish, SST and chlorophyll-a as contained in Table 3. The results of information extraction from MODIS Imagery obtained the results, namely the average sea surface temperature in the fishing area is 29.76

oC and the average chlorophyll-a concentration is 0.18 mg/m^3. The lowest sea surface temperature at the small pelagic fishing location in the west season is 28.02 ^{o}C and the highest is 30.90 ^{o}C. The complete distribution of sea surface temperature (SST) in the west season can be seen in Figure 4.



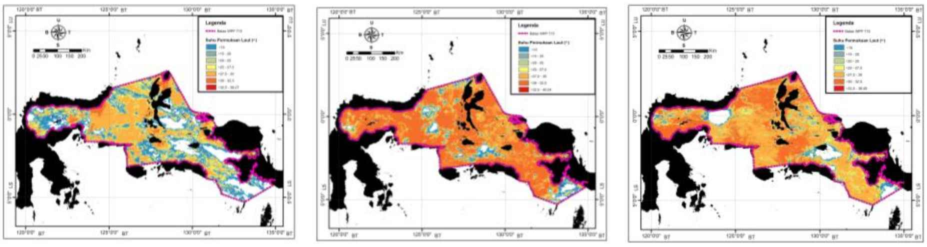
(a) SST January 10, 2018, (b) SST February 20, 2018 (c) SST December 12, 2018
Figure 4. Sea Surface Temperature in the West Season

The lowest chlorophyll-a concentration at the small pelagic fishing location in the west season was 0.11 mg/m^3 and the highest was 0.34 mg/m^3. The complete distribution of chlorophyll-a in the waters in the West Season can be seen in Figure 5. The highest chlorophyll-a concentration at the small pelagic fishing location in the West season is still below the small pelagic fish habitat criteria, which is between 0.5-2.0 mg/m^3. This shows that the small pelagic fishing location is not always an area with physical parameters in accordance with the habitat of the fish. In addition, with the rather low chlorophyll-a content in the West Season, it can certainly affect the limited number of fishermen's catches.



(a) Chlorophyll-a 10 Jan. 2018, (b) Chlorophyll-a 20 Feb. 2018, (c) SST 12 December 2018
Figure 5. Chlorophyll-a Concentration in the West Season

In Transition Season 1 (March, April, May), the average distribution of Sea Surface Temperature (SST) is in the range of 20 – 32.5 oC. Plotting the coordinates of the small pelagic fishing location was carried out on the sea surface temperature map so that complete information was obtained, which is presented in Table 4. The lowest sea surface temperature at the small pelagic fishing location in transition season 1 was 21.96o C and the highest was 31.75o C. The complete distribution of sea surface temperature (SST) in transition season 2 can be seen in Figure 6.



(a) SST March 13, 2018, (b) SST April 21, 2018, (c) SST May 23, 2018

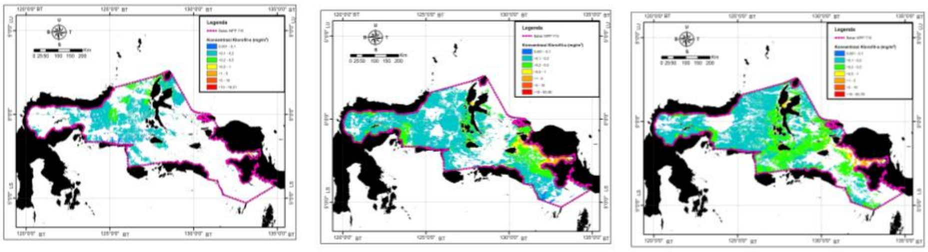
Figure 6. Sea Surface Temperature in Transition Season 1

Table 4. Conditions of Sea Surface Temperature (SST) and Chlorophyll-a at the Small Pelagic Fishing Location in Transition Season 1 (March, April, and May)

Fishing Date			Fishing Location		Types of Fish	Scientific Name of Fish	SST (ºC)	Chlorophyll-a (mg/m^3)
Day	Month	Year	Longitude (X)	Latitude (Y)				
13	March	2018	130.2333	-2.6000	Shadow Trevally	*Carangoides dinema*	24.70	0.15
13	March	2018	127.9500	-0.9500	Shadow Trevally	*Carangoides dinema*	31.28	0.13
13	March	2018	125.6000	-0.3667	Shortfin Scad	*Decapterus macrosoma*	29.22	0.15
20	March	2018	127.2000	0.7333	Shadow Trevally	*Carangoides dinema*	27.55	0.16
20	March	2018	126.0167	1.4000	Yellowstrip Scad	*Caranx leptolepis*	28.55	0.18
24	March	2018	127.5333	-1.0667	Shadow Trevally	*Carangoides dinema*	30.23	0.19
24	March	2018	125.9333	-0.5333	Shortfin Scad	*Decapterus macrosoma*	30.40	0.14
5	April	2018	132.3667	-3.3667	Shadow Trevally	*Carangoides dinema*	30.02	0.15
5	April	2018	127.3167	0.0167	Shortfin Scad	*Decapterus macrosoma*	26.65	0.18
14	April	2018	127.5167	0.0667	Trevally	*Caranx spp*	31.20	0.16
14	April	2018	132.3667	-3.3667	Shadow Trevally	*Carangoides dinema*	31.75	0.16
14	April	2018	127.2833	-0.9333	Shortfin Scad	*Decapterus macrosoma*	29.87	0.11
21	April	2018	127.3000	-0.9500	Shadow Trevally	*Carangoides dinema*	29.96	0.28
21	April	2018	127.2167	0.8833	Shortfin Scad	*Decapterus macrosoma*	30.11	0.15
21	April	2018	125.2500	-1.3333	Yellowstrip Scad	*Caranx leptolepis*	30.06	0.10
23	April	2018	125.0333	-0.0167	Shadow Trevally	*Carangoides dinema*	30.22	0.11
23	April	2018	127.2500	0.8000	Shortfin Scad	*Decapterus macrosoma*	25.56	0.15
28	April	2018	125.2833	1.3000	Shortfin Scad	*Decapterus macrosoma*	29.18	0.25
7	May	2018	125.8667	1.5833	Shadow Trevally	*Carangoides dinema*	29.61	0.18
7	May	2018	125.2500	-1.3333	Shortfin Scad	*Decapterus macrosoma*	30.83	0.13
16	May	2018	125.1833	-0.5333	Shadow Trevally	*Carangoides dinema*	21.96	0.13
16	May	2018	131.1667	-1.0000	Shadow Trevally	*Carangoides dinema*	30.86	0.53
16	May	2018	125.6000	-0.3667	Shortfin Scad	*Decapterus macrosoma*	29.90	0.13
23	May	2018	127.1667	-0.9833	Shadow Trevally	*Carangoides dinema*	29.65	0.28
23	May	2018	127.2833	-2.1667	Shortfin Scad	*Decapterus macrosoma*	29.66	0.43
25	May	2018	129.6667	-0.4167	Shadow Trevally	*Carangoides dinema*	28.87	0.55
25	May	2018	127.2333	1.3500	Shortfin Scad	*Decapterus macrosoma*	30.64	0.20

Source: data analysis and processing

The results of chlorophyll-a information extraction in Transition Season 1 are visualized in the distribution map contained in Figure 7. The concentration of chlorophyll-a has increased compared to the West Season. May is the month with the highest distribution of chlorophyll-a concentration in Transition Season 1. The lowest chlorophyll-a concentration at the small pelagic fishing location in Transition Season 1 is 0.10 mg/m^3 and the highest is 0.55 mg/m^3. It is estimated that the quantity of fishermen's fish catches in Transition Season 1 will be greater in May compared to March and April. (a) Chlorophyll-a March 13, 2018, (b) Chlorophyll-a April 21, 2018, (c) Chlorophyll-a May 23, 2018



(a) Chlorophyll-a 13 Maret 2018, (b) Chlorophyll-a 21 April 2018, (c) Chlorophyll-a 23 Mei 2018

Figure 7. Chlorophyll-a Concentration in Transition Season 1

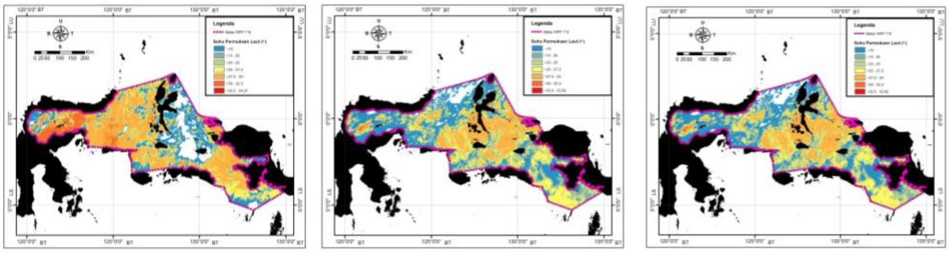
The distribution of Sea Surface Temperature (SST) at the small pelagic fishing location in the eastern season is the lowest 25.73 ºC and the highest 31.23 ºC. Plotting the coordinates of the small pelagic fishing location was carried out on the SST and chlorophyll-a maps so that complete information was obtained which is presented in Table 5.

Table 5. Conditions of Sea Surface Temperature (SST) and Chlorophyll-a at the Small Pelagic Fishing Location in the Eastern Season (June, July, August)

Fishing Date			Fishing Location		Types of Fish	Scientific Name of Fish	SST (ºC)	Chlorophyll-a (mg/m^3)
Day	Month	Year	Longitude (X)	Latitude (Y)				
17	June	2018	131.1500	-1.0167	Shadow Trevally	*Carangoides dinema*	29.52	1.33
24	Juni	2018	127.4667	-0.9333	Shadow Trevally	*Carangoides dinema*	28.41	0.44
24	Juni	2018	127.9500	-0.9833	Shadow Trevally	*Carangoides dinema*	28.75	0.58
24	Juni	2018	127.4167	0.8167	Shortfin Scad	*Decapterus macrosoma*	29.72	0.24
26	Juni	2018	130.7500	-2.7333	Shadow Trevally	*Carangoides dinema*	26.53	0.24
26	Juni	2018	127.3333	0.7000	Shortfin Scad	*Decapterus macrosoma*	29.24	0.30
26	Juni	2018	127.2500	0.7333	Shortfin Scad	*Decapterus macrosoma*	29.53	0.17
10	Juli	2018	125.1667	-1.5833	Yellowstrip Scad	*Caranx leptolepis*	25.73	0.33
12	Juli	2018	129.6667	-0.4167	Shadow Trevally	*Carangoides dinema*	28.22	0.36
12	Juli	2018	127.6833	-1.0333	Shadow Trevally	*Carangoides dinema*	29.05	0.29
12	Juli	2018	127.4667	-0.2500	Shortfin Scad	*Decapterus macrosoma*	29.47	0.18
26	Juli	2018	127.0333	-0.1667	Shadow Trevally	*Carangoides dinema*	28.71	0.43
26	Juli	2018	127.2333	0.7000	Shortfin Scad	*Decapterus macrosoma*	28.79	0.18
31	Juli	2018	128.0167	-0.7833	Shortfin Scad	*Decapterus macrosoma*	28.73	0.50
4	August	2018	125.1833	-0.5333	Shadow Trevally	*Carangoides dinema*	29.06	0.31
11	August	2018	127.8333	-1.0000	Shadow Trevally	*Carangoides dinema*	30.36	1.14
11	August	2018	125.2500	-0.7500	Shortfin Scad	*Decapterus macrosoma*	28.66	0.34
20	August	2018	131.4000	-2.3833	Shadow Trevally	*Carangoides dinema*	27.82	0.40
20	August	2018	128.1000	-2.6500	Shadow Trevally	*Carangoides dinema*	28.37	0.36
20	August	2018	127.4667	-0.9667	Shadow Trevally	*Carangoides dinema*	30.17	0.21
20	August	2018	125.3167	-1.2000	Shortfin Scad	*Decapterus macrosoma*	26.36	0.15
27	August	2018	130.2333	-2.6000	Shadow Trevally	*Carangoides dinema*	26.66	0.23
27	August	2018	127.2833	-0.9667	Shadow Trevally	*Carangoides dinema*	28.52	0.32
29	August	2018	128.6500	-2.1000	Shadow Trevally	*Carangoides dinema*	29.08	0.19
29	August	2018	125.5500	1.1833	Shadow Trevally	*Carangoides dinema*	29.22	0.16
29	August	2018	126.1667	-1.3167	Shortfin Scad	*Decapterus macrosoma*	28.07	0.23
29	August	2018	127.5000	-0.1667	Shortfin Scad	*Decapterus macrosoma*	31.23	0.17

Source: data analysis and processing

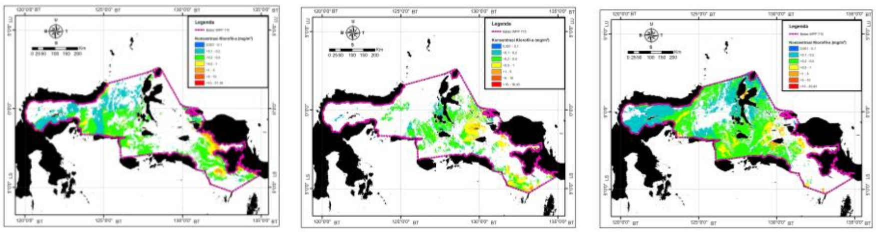
The complete distribution of SST in the eastern season can be seen in Figure 8 which shows moderate to warm temperatures. Most of the small pelagic fishing locations in the eastern season range between 20-29 ºC. SST in the small pelagic fishing area in the Eastern Season shows that the location is close to the criteria for small pelagic fish habitat. (a) SST 17 June 2018, (b) SST 12 July 2018, (c) SST 20 August 2018



(a) SST June 17, 2018 (b) SST July 12, 2018 (c) SST August 20, 2018

Figure 8. Sea Surface Temperature in the East Season

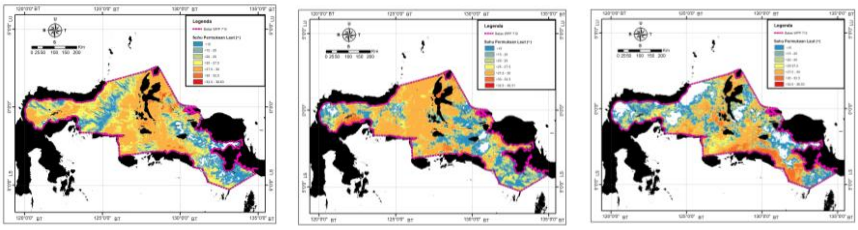
The results of the extraction of chlorophyll-a information in the East Season are visualized in the distribution map in Figure 9. The concentration of chlorophyll-a increased compared to the West Season and Transition Season 1. The lowest concentration of chlorophyll-a was at the small pelagic fishing location, namely 0.16 mg/m^3 and the highest was 1.33 mg/m^3 as contained in Table 5. With a fairly even and abundant distribution of chlorophyll in WPP 715 in the east season, fishermen can certainly get abundant fish catches in June, July, and August.



(a) Chlorophyll-a June 17, 2018, (b) Chlorophyll-a July 12, 2018, (c) Chlorophyll-a August 20, 2018

Figure 9. Chlorophyll-a Concentration in the East Season

In Transition Season 2 (September, October, and November), the average Sea Surface Temperature (SST) distribution is in the range of 20-32.5 ^{o}C. Plotting the coordinates of the small pelagic fishing location was carried out on the sea surface temperature and chlorophyll-a concentration map so that complete information was obtained which is presented in Table 6. The lowest sea surface temperature at the small pelagic fishing location in transition season 2 was 21.56 ^{o}C and the highest was 31.75 ^{o}C. The complete distribution of sea surface temperature (SST) in transition season 2 can be seen in Figure 10. For information on chlorophyll-a concentration in transition season 2, it is visualized as contained in Figure 11.



(a) SST Sept 14, 2018, (b) SST October 7, 2018, (c) SST November 8, 2018)

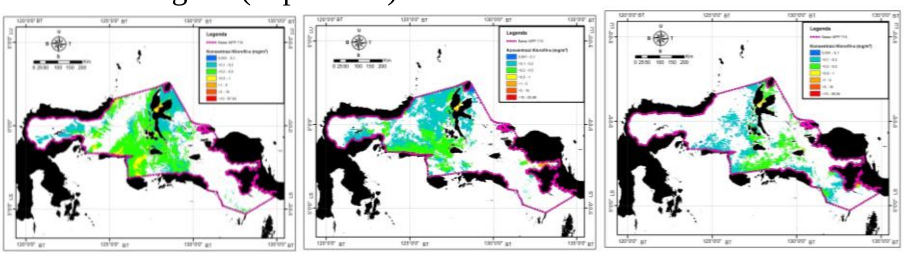
Figure 10. Sea Surface Temperature in Transition Season 2

Table 6. Conditions of Sea Surface Temperature (SST) and Chlorophyll-a at Small Pelagic Fishing Locations in Transition Season 2 (September, October, November)

Fishing Date			Fishing Location		Types of Fish	Scientific Name of Fish	SST (°C)	Chlorophyll-a (mg/m^3)
Day	Month	Year	Longitude (X)	Latitude (Y)				
14	Sept	2018	127.3333	-0.9667	Shadow Trevally	Carangoides dinema	28.18	0.40
14	Sept	2018	127.9833	-0.8333	Shadow Trevally	*Decapterus macrosoma*	29.64	0.25
21	Sept	2018	127.3167	-0.9000	Shadow Trevally	*Carangoides dinema*	28.47	0.25
21	Sept	2018	125.0000	-0.1333	Shortfin Scad	*Decapterus macrosoma*	27.57	0.77
28	Sept	2018	127.2833	0.7500	Shadow Trevally	*Carangoides dinema*	28.17	0.22
30	Sept	2018	130.3333	-0.5000	Shadow Trevally	*Carangoides dinema*	26.31	0.30
30	Sept	2018	125.2500	1.2167	Shortfin Scad	*Decapterus macrosoma*	28.42	0.40
5	Oct	2018	125.2833	0.1333	Shortfin Scad	*Decapterus macrosoma*	28.78	0.24
5	Oct	2018	125.2333	0.1333	Yellowstrip Scad	*Caranx leptolepis*	28.86	0.24
7	Oct	2018	127.8833	-1.0000	Shadow Trevally	*Carangoides dinema*	28.93	0.27
7	Oct	2018	125.6667	-0.2500	Shortfin Scad	*Decapterus macrosoma*	25.92	0.21
7	Oct	2018	125.2167	1.2333	Yellowstrip Scad	*Caranx leptolepis*	28.55	0.16
14	Oct	2018	126.9000	-1.4833	Shadow Trevally	*Carangoides dinema*	30.16	0.28
14	Oct	2018	125.2667	1.0000	Shortfin Scad	*Decapterus macrosoma*	29.28	0.12
19	Oct	2018	129.9000	-2.4333	Shadow Trevally	*Carangoides dinema*	30.11	0.11
19	Oct	2018	126.3000	-1.3000	Shortfin Scad	*Decapterus macrosoma*	30.17	0.18
30	Oct	2018	128.2167	-2.6000	Shadow Trevally	*Carangoides dinema*	30.40	0.31
30	Oct	2018	125.3167	-1.1667	Shortfin Scad	*Decapterus macrosoma*	29.32	0.14
3	Nov	2018	131.1667	-1.0000	Shadow Trevally	*Carangoides dinema*	29.80	0.40
3	Nov	2018	127.0500	1.7833	Shortfin Scad	*Decapterus macrosoma*	29.40	0.15
3	Nov	2018	127.0500	1.7833	Yellowstrip Scad	*Selaroides leptolepis*	29.41	0.15
6	Nov	2018	130.2333	-2.7667	Shadow Trevally	*Carangoides dinema*	30.21	0.08
8	Nov	2018	130.3500	-2.6333	Shadow Trevally	*Carangoides dinema*	31.11	0.16
8	Nov	2018	125.7333	0.2000	Shortfin Scad	*Decapterus macrosoma*	28.04	0.14
8	Nov	2018	126.3500	0.3667	Yellowstrip Scad	*Caranx leptolepis*	30.04	0.12
11	Nov	2018	125.4333	-1.6333	Shadow Trevally	*Carangoides dinema*	29.65	0.14
15	Nov	2018	129.8333	-0.2500	Shadow Trevally	*Carangoides dinema*	21.56	0.18

Source: data analysis and processing

Judging from the visualization results of the distribution of chlorophyll-a, there was a decrease in chlorophyll-a in the transition season 2 compared to the eastern season. The distribution of chlorophyll-a concentrations in September, October, and November decreased compared to August. At the small pelagic fishing location, the lowest chlorophyll concentration was 0.08 mg/m^3 (November) and the highest was 0.77 mg/m^3 (September).



(a) Chlorophyll-a 14 Sept 14, 2018, (b) Chlorophyll-a Oktober 7, 2018, (c) Chlorophyll-a November 8, 2018

Figure 11. Chlorophyll-a Concentration in Transition Season 2

To determine the sea surface temperature (SST) conditions during the fishing season (west season, transition season 1, east season, and transition season 2), the lowest and highest temperature ranges for each type of small pelagic fish (kuwe fish, long pectoral kuweh fish, deles scad, and yellow scad) are visualized as shown in Figure 12 in the form of a graph of SST conditions during the small pelagic fishing season.

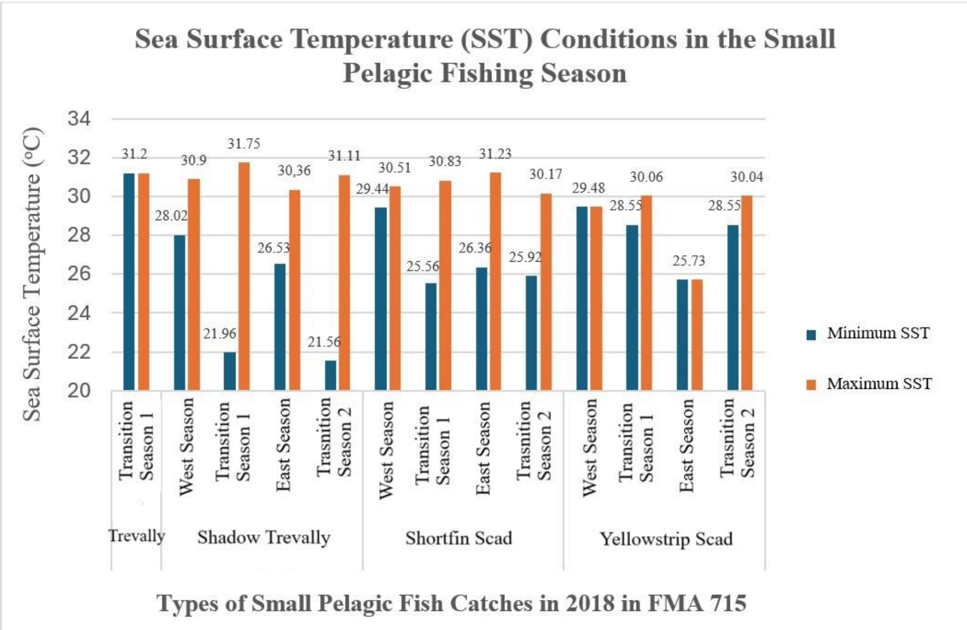


Figure 12. Graph of SST Conditions During the Small Pelagic Fishing Season (Source: Data Analysis and Processing)

By looking at the graph in Figure 12, the sea surface temperature during the transition season at the small pelagic fishing location varies greatly in temperature. This temperature variation is influenced partly by the west season and partly by the east season so that there is a significant difference between the minimum and maximum temperatures of the sea surface. Therefore, in this transition season, small pelagic fish are not in their ideal habitat conditions. However, when viewed in general, the highest SST in each season at the small pelagic fishing location is more than 30 ^{o}C which indicates that some small pelagic fish are caught not in their ideal habitat conditions because in theory the ideal habitat conditions are at SST 20-29 ^{o}C.

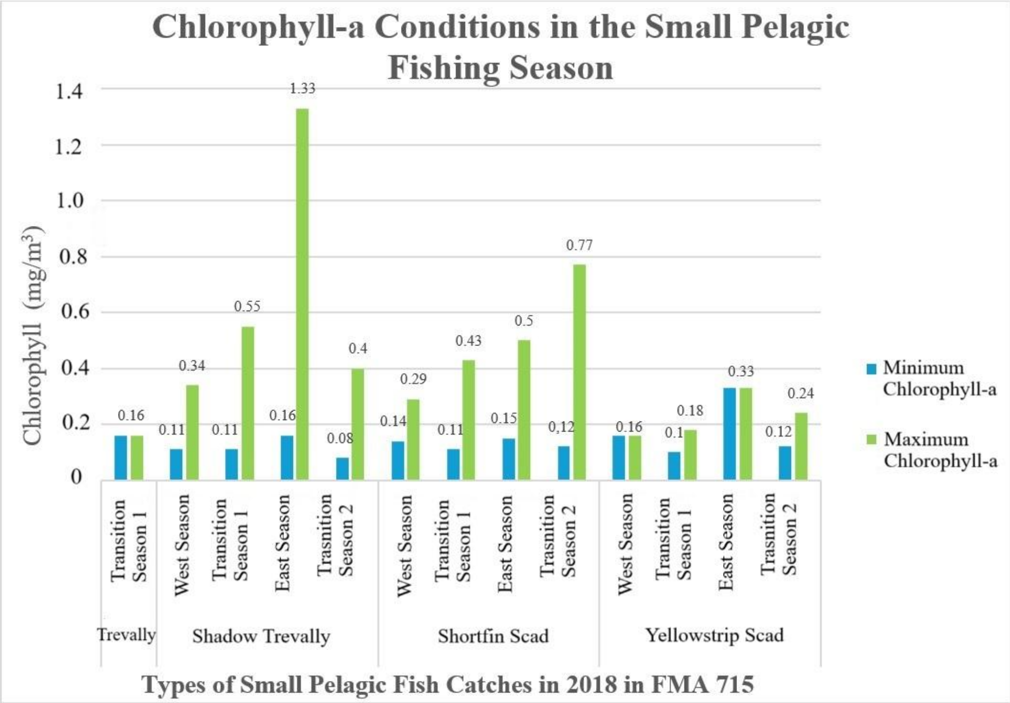


Figure 13. Graph of Chlorophyll-a Conditions in the Small Pelagic Fishing Season (Source: Data Analysis and Processing)

The abundance of chlorophyll-a in the waters becomes nutrition and food for small pelagic fish. The chlorophyll-a content at the small pelagic fishing location in each fishing season is presented in Figure 13. Each small pelagic fishing location has a chlorophyll-a concentration that varies each season. The east season is the season and transition season to the season with abundant chlorophyll-a in the waters.

Based on the theory used to predict the location of small pelagic fish capture, the ideal chlorophyll-a concentration for the habitat of small pelagic fish is 0.5 - 2 mg/m^3. Looking at the results of this study, several types of small pelagic fish caught were not in the ideal chlorophyll-a conditions for the habitat of the fish, for example in kuweh and yellow scad. The location of the capture of pectoralf long kuweh and deles scad in the west season also showed chlorophyll-a conditions in the waters that were not ideal for the habitat of small pelagic fish. Therefore, experts / researchers in the future can review the parameter values of the zoning potential for small pelagic fish capture. There are certain conditions where small pelagic fish adapt to waters that are less than ideal for their habitat.

This study is expected to be useful for researchers and/or experts in compiling potential fishing areas, especially for small pelagic fish species. For traditional fishermen who depend on marine products for their livelihood, it is expected to be more productive in catching fish, especially small pelagic fish in the east season. In addition, in the transition season 1 and transition season 2, either 1 month before and/or 1 month after the east season, it is also good for fishermen to catch fish.

CONCLUSION

The factual location of small pelagic fish in FMA 715 with high density is around the Molluca Sea and Seram Sea. The sea surface temperature at the small pelagic fishing location is between 21.56-31.75 ºC. The concentration of chlorophyll-a in the waters at the small pelagic fishing location ranges from 0.08-1.33 mg/m^3. These results indicate that the factual location of small pelagic fishing has SST and chlorophyll-a concentrations that are not ideal conditions/criteria for their habitat. The conditions of sea surface temperature and chlorophyll-a that are close to the ideal conditions of small pelagic fish habitat are in the East Season.

The recommendation from this study is to review the concept of fishing area forecast modeling by considering the water conditions at the factual fishing location. The development of this research in the future can be carried out more perfectly if daily SST and chlorophyll-a concentration data are available complete with additional information on other supporting physical parameters of the waters. Research development can also be carried out at other locations in Indonesian waters.

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