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ANALYSIS OF UTILIZATION CHLOROPHYLL-A CONCENTRATION DATA FROM REMOTE SENSING IMAGERY TO SUPPORT MARITIME SECURITY OPERATIONS (*CASE STUDIES IN THE ARAFURA SEA*)

Okol Sri Suharyo, Nawanto Budi Sukoco, Johar Setiadi, Eko Kurniawan

Indonesia Naval Technology College, STTAL, Surabaya Indonesia

ABSTRACT

Indonesia is the largest archipelago in the world with a vast ocean area and the richness of the fish. It allows the occurrence of crime at sea, for example, is a crime of theft of fish and other marine resources. Indonesia in the regard Indonesian Navy confronted with various obstacles, among others, the limitation of the number of patrol boats that are not proportional to the extent of waters that should be on the cover as well as the limitations of the available budget for operational activities in the framework of the implementation of law enforcement operations related crime at sea. With the limitation of that than required effectiveness and efficiency in operations to crime at sea can still be implemented and the richness of the sea remains awake.The utilization of remote sensing satellite technology capable of delivering information quickly with a broad scope. This research use the MODIS Aqua Image data Level 2 to detect the distributions of chlorophyll-a concentration which is an indicator of the fertility of the waters of an area the area is closely connected with the fisheries through the implementations process of bottom-up areas with transparent high fertility rate is an area that's prone to fish theft crime occurred. From the result of the data processing MODIS-Aqua Satellite image pattern time and location of the concentration of chlorophyll-a and verified by VMS data indicate that there is a close relationship where a times and areas with a high concentration of chlorophyll observed a lot of fishing activity, so it is used in this research can be used as supporting data in determining the direction and timing of the operation in particular operations against crimes the theft of fish, finally the marine security operations could become more effective and efficient and success can be further improved.

Keywords: *Sea area, chlorophyll-a, effective and efficient.*

1. INTRODUCTION

Indonesia is one of the largest archipelagic countries in the world, with a vast ocean area and has the largest marine wealth and biodiversity in the world with coastal ecosystems and extraordinary fish wealth. With the vast ocean area that Indonesia has, it is very possible for crimes to steal marine products, especially fish. Every year foreign vessels that steal marine products from Indonesian waters reach 1,000 ships spread across Natuna, Arafuru, Sulawesi Sea and other areas.

Law enforcement operations related to the prosecution of crimes in the sea are in dire need of high costs so optimization in operations is very necessary, logistical support, especially fuel issues play a very important role in the operation of KRI elements, therefore the availability of fuel greatly affects the amount of operating time, the sustainability of the KRI at sea, and the speed of the KRI (economical speed, maximum roaming). Given that the potential for a crime occurring in Arafuru waters can occur at any time, it also requires security at all times or every day or 360 days in a year, all of which have not been carried out due to these limitations.

To address and deal with these limitations, it is necessary to have a new method / technology-based technique, one of which is the use of remote sensing technology. With remote sensing, a fast, accurate and wide range of data and information can be obtained which can support more well-planned security operations so that the movement of the KRI becomes more effective and directed, which ultimately uses logistics in this case the fuel becomes more efficient. From this remote sensing satellite image, data/information can be obtained which will be processed and processed in such a way as to produce data in the form of information on chlorophyll-a concentration values in an area of water which can then be linked to patterns and movement plans in marine security operations.

Chlorophyll-a is one of the most dominant pigments found in phytoplankton and plays a role in the process of photosynthesis. Marine ecosystems on the earth depend almost entirely on the photosynthetic activity of marine plants during the photosynthesis process, phytoplankton produces acids that are useful for fish. Phytoplankton acts as a primary producer or early producer in the food chain in the waters. Furthermore, phytoplankton will be eaten by early eaters (primary consumers) and subsequent eaters. In general, small pelagic fish are at the primary consumer level, namely plankton eaters. The level of water fertility (aquatic productivity) can also be indicated by the concentration of chlorophyll found in these waters so that it becomes an attraction for the types of fish that are plankton feeders.

By knowing the information on the first foundation of this food chain, information on areas suspected of having much fish can be known, then it can be predicted in areas or areas where there will be much fishing, both by our fishermen and illegal fishing criminals. By knowing the information on areas or areas that are suspected of having many fishers, the information can be used as a consideration in determining the time and location of the movement of patrol vessels so that the operation will become more effective and efficient with reliable information.

Today, the distribution of chlorophyll-a content can be detected using Terra (EOS AM) and Aqua (EOS PM) satellites with the sensor of the Moderate Resolution Imaging Spectroradiometer (MODIS). The distribution of the chlorophyll content can then be implemented to determine the fishing area.

Seeing the magnitude of the likelihood of marine crime, especially against fishing theft in Indonesian waters in general and especially in Arafuru waters, and along with the rapid development of technology in the field of remote sensing, it is necessary to maximize the use of advanced technology with the availability of regional information fishing area. These fishing areas in certain positions can become vulnerable areas. By knowing the information on areas prone to crime, especially against illegal fishing, it is hoped that the director of operations will be more directed. The success of each operation also increases so that directly or indirectly contributes more to the reduction or loss of crime against existing and state-owned marine resources. Thus, state losses, damage to marine ecosystems can be minimized and at the same time can eliminate potential threats to state sovereignty. Therefore, research on the Utilization of Chlorophyll-A Concentration Data from Remote Sensing Images to Support Marine Security Operations.

2. MATRIAL AND METHOD

2.1 Problems

Arafura waters are a vast area and have the potential to occur in many cases of marine resource theft and illegal fishing, as evidenced by the presence of these perpetrators who were caught by Navy patrols while operating in these waters. The limitation of the number of patrol boats and the extent of the water area that must be covered and the amount of budget needed for existing vessel operations is an obstacle that must be faced, so that good and accurate planning is needed so that security operations must be carried out and targets of success must be achieved. Satellite remote sensing technology can provide good and accurate information with wide coverage so that the information can be supporting data in the implementation of marine security operations so that operations can be carried out effectively and efficiently and success can be further improved.

The EOS Aqua satellite with the MODIS Sensor (Moderate Resolution Imaging Spectroradiometer) can measure almost all parameters of land, sea, and air so that its usefulness is very wide. Starting from the plant index, soil moisture, aerosol levels in the air, sea surface temperature, and chlorophyll content of the sea**.**

With the advances in technology about satellites, how far can it be utilized and applied as a form of accurate, up to date and reliable information to support the Indonesian Navy in its functions and duties, namely sea security operations, then further research is needed on how far the Indonesian technology is Aqua-MODIS satellite imagery can provide accurate and reliable information so that it can be significantly used to combat crimes that occur at sea.

2.2 Boundary of Problems

To sharpen and direct this paper, this paper is limited to research on chlorophyll-a concentration from Aqua satellite image data with MODIS sensor by carrying out daily image data processing from MODIS level 2 data from January 2008 to December 2012 (image data 5 years). The researcher carried out MODIS Level 2 image processing using Wim Soft software. The results of processing and calculation are in the form of a distribution pattern of chlorophyll-a concentration in the area of the research area. The distribution pattern of chlorophyll-a concentrations in this area is an indicator of fertility that exists at a particular time and location which can then be implemented to determine the zone and time potential for fishing which is also a zone and time prone to crime at sea.

2.3 Data Processing Method

The data used is image data from Aqua-MODIS satellite level 2 with a spatial resolution of 1000 m. Initial data is downloaded from NASA's website. MODELS satellite data level 2 has been corrected geometric and radiometric in the HDF file (Hierarchical Data Format) format and has a chlorophyll-a concentration value in units of mg / m^3.

Level 2 daily image data from January 2008 to December 2012 is then further processed to produce more informative data. The processing uses WimSoft software. Daily data is processed into monthly average data. Furthermore, the monthly average for these 5 years can be identified. This monthly variation of daily data for 5 (five) years is the information on the pattern of time and location of chlorophyll-a concentration distribution in the study area and is the final result of processing in this study.

The stages in digitally processing data from Aqua-MODIS satellite image data to get the results in the form of a time pattern and location of chlorophyll-a concentration. MODIS imagery from Aqua satellite results from recording by NASA ordered by e-mail to http://oceancolor.gsfc.nasa.gov according to the data of the date, month and year of recording desired. The order e-mail that has been sent is verified and prepared in the requested daily data. Then, NASA provides a website address where the requested data can be downloaded.

a. From the website address provided, the download process can only be downloaded. Image data that has been obtained in the HDF file format is then extracted and divided into monthly data every year.

b. The next process is sorting data/files to separate the recording data that is feasible (good) with data that is not a feasible process (bad). Process improper data is corrupt data that occurs during the download procession, so this data cannot be processed further. This process uses the command prompt program that has been installed and is compatible with the Wim Soft program.

c. The data that has been selected becomes data that can be processed further then digitally cropped and corrected for the geometric position according to the research area.

d. The next process is the making of a monthly average profile, which averages daily data into monthly data digitally annually.

e. The next process is to create processing zones with menus found in the Wim Soft program. The research area is divided into several zones. This is intended to know the pattern of each zone.

f. At the next stage, the monthly profile together with the predetermined zones is processed in one processing process with Wim soft software and produces information on the concentration of each zone in the form of a table. From this table, then produce a graphical display showing the chlorophyll-a concentration values and time patterns that vary according to the zone in the study area.

g. Variations in values that form the time pattern and location of chlorophyll-a concentration distribution in zones in this area of research which is then analyzed further.

3. RESULTS AND DISCUSSION

Monthly variations for 5 years of chlorophyll-a concentration as an indicator of aquatic fertility and fishing potential have been processed and analyzed. This analysis aims to determine the pattern of the increase in chlorophyll-a concentration in general at the study site.

This is intended to determine the potential time for fishing. The potential for high fishing will be related to the rampant crime in the sea, for example, fishing theft, because the perpetrators of crimemay also use almost the same technology.

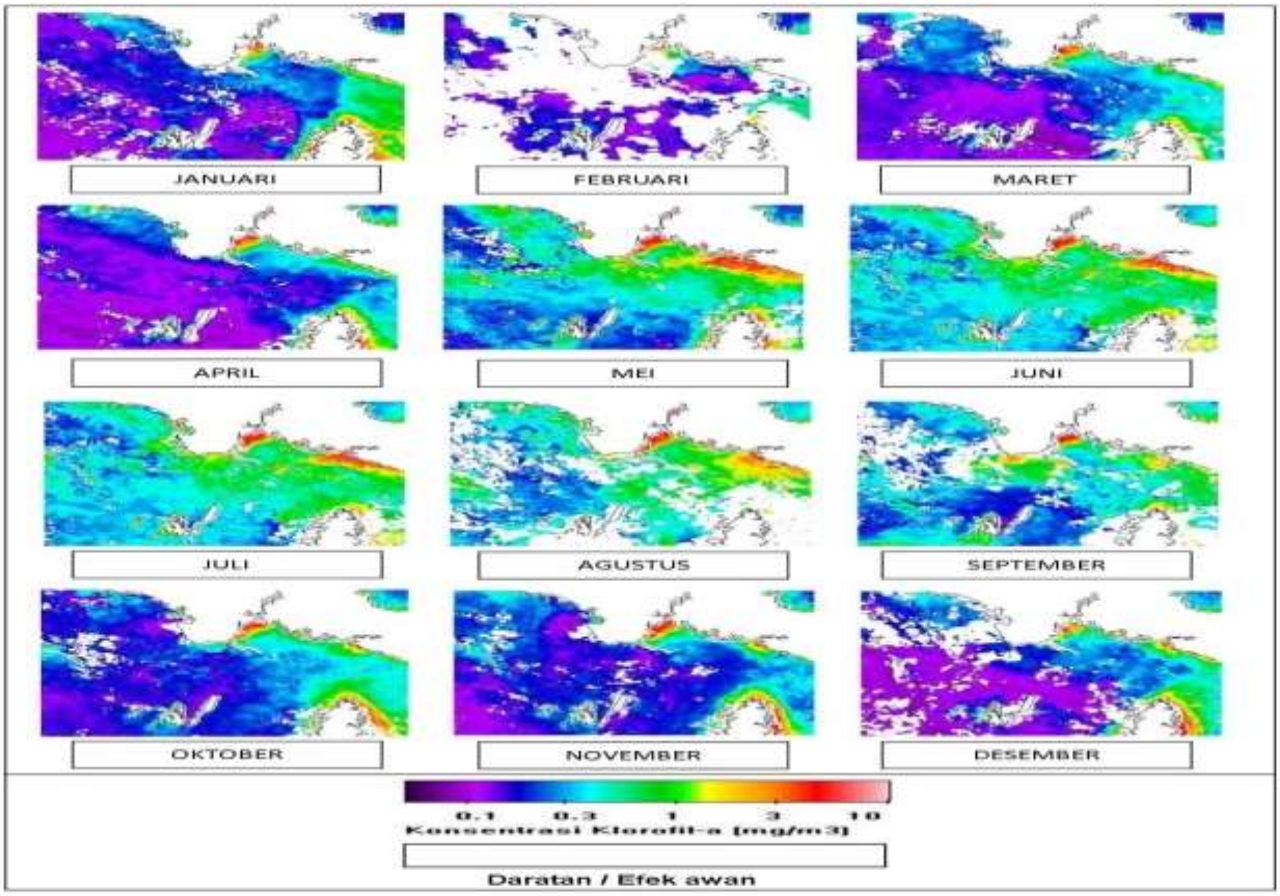
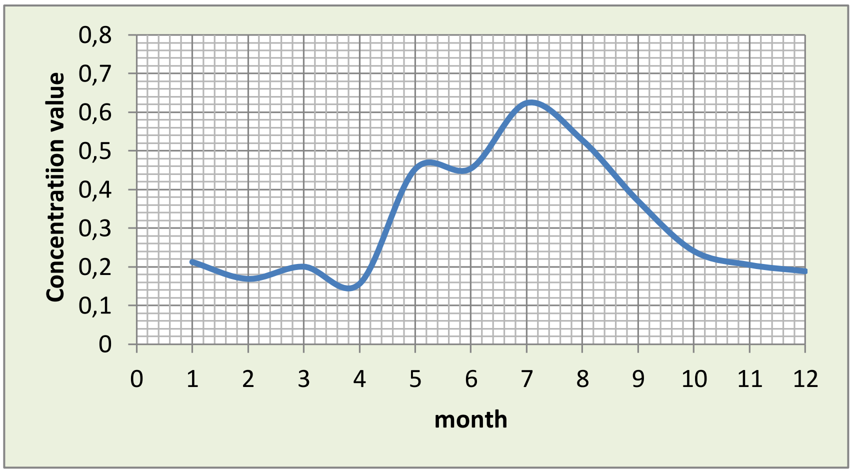


Fig.1 Chlorophyll Concentration Image 2008

Table1. Concentration values for 2008

MONTH	Concentration Value (mg / m³)
1	0.212635
2	0.168904
3	0.200489
4	0.155912
5	0.453031
6	0.454552
7	0.623957
8	0.527752
9	0.370208
10	0.240659
11	0.205073
12	0.188649

Chart 1. Chlorophyll-a Concentration in 2008



Information on the distribution of monthly chlorophyll concentrations at the study sites in 2008 can be seen in Figure 4.1 and Figure 4.2. The average chlorophyll-a variation for 5 years ranges from 0.156 mg / m3 - 0.624 mg / m3. The value of the chlorophyll-a concentration of 0.156 mg / m3 is in the low range, where this concentration is usually possessed by oceanic waters in tropical waters which are low in nutrients (nutrients).

The value of chlorophyll-a concentration in August to September tends to decrease by 0.158 mg / m3. The decreasing tendency of chlorophyll-a concentration values continued until December 2008. In red images near the shoreline which indicates that coastal influences are more dominant than in the middle of the sea

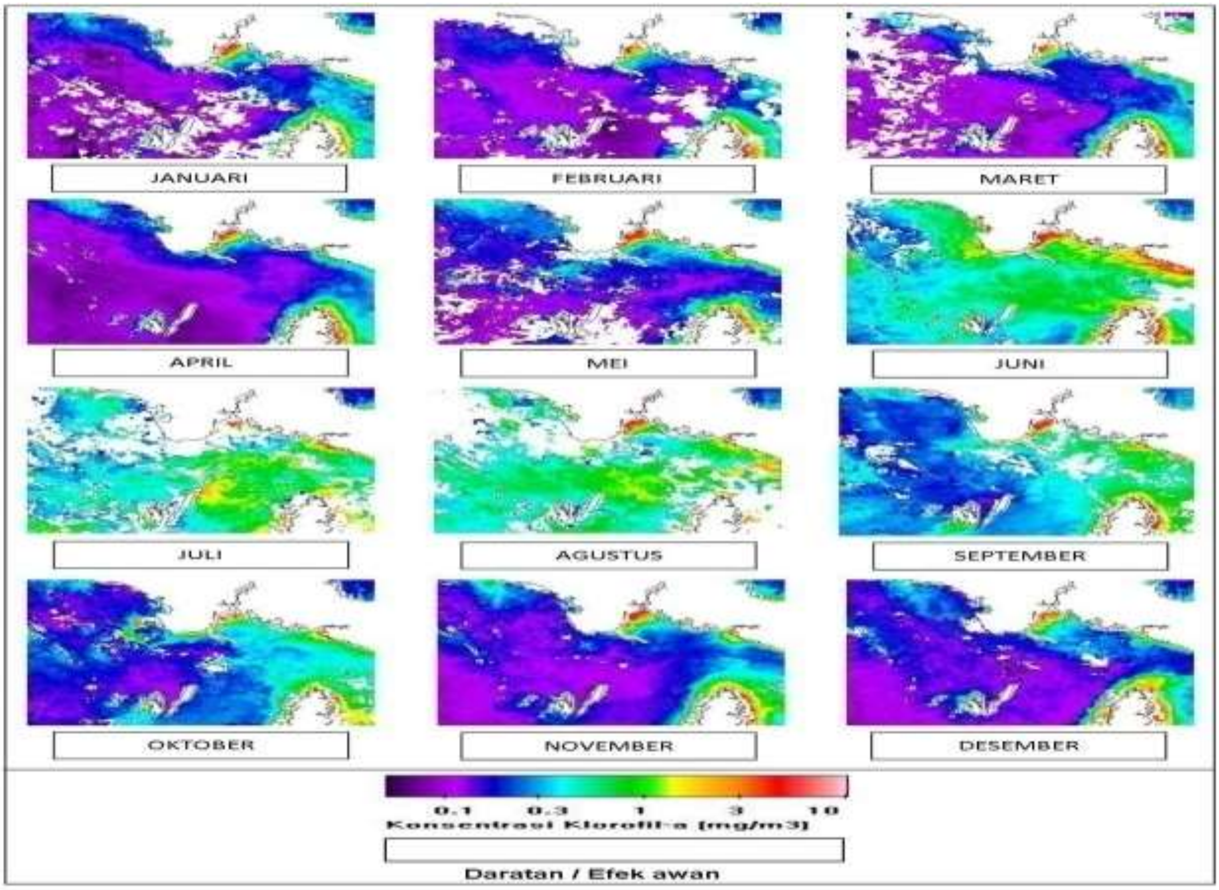
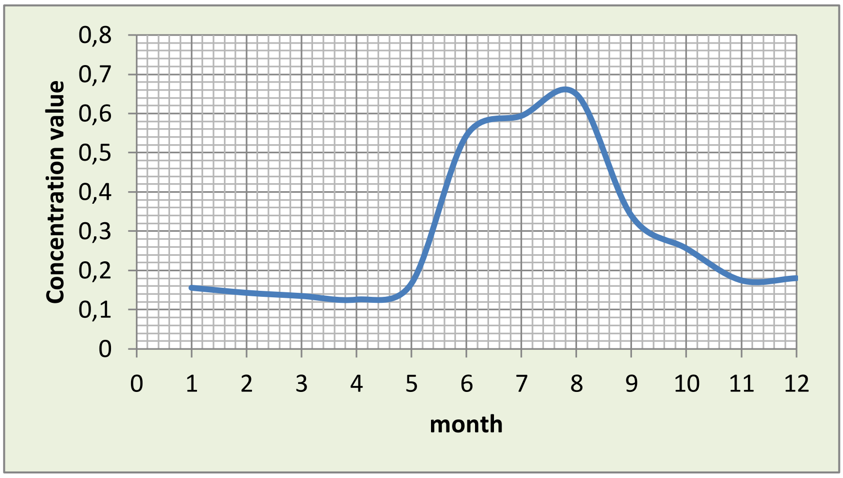


Fig.2 Chlolrophyll-a Consentration image 2012

Table 2. Concentration for 2012

MONTH	Concentration Value (mg / m³)
1	0.155851
2	0.143068
3	0.135025
4	0.125788
5	0.166644
6	0.543563
7	0.59408
8	0.649272
9	0.339736
10	0.256158
11	0.174705
12	0.180353

Chart 2. Chlorophyll-a Concentration in 2012



The chlorophyll-a concentration in January was 0.156 mg / m3 and continued to decline in February-April. In April-May, the chlorophyll-a concentration rose to 0.167 mg / m3, but in June-August, chlorophyll-a concentrations tended to increase, which ranged from 0.544 mg / m3 to 0.649 mg / m3. In August-September, the chlorophyll-a concentration decreased by 0.31 mg / m3 and continued to decline until December.

The highest chlorophyll-a concentration value occurred in August, which was 0.649 mg / m3. In April, it was a condition where the chlorophyll-a concentration was lower than the other months in 2012, which reached 0.126 mg / m3.

3.1 Chlorophyll-a Concentration in 2008 – 2012

In general, in the research area, chlorophyll-a concentrations are high in June - September and coincide with East Moonsons (June-August).

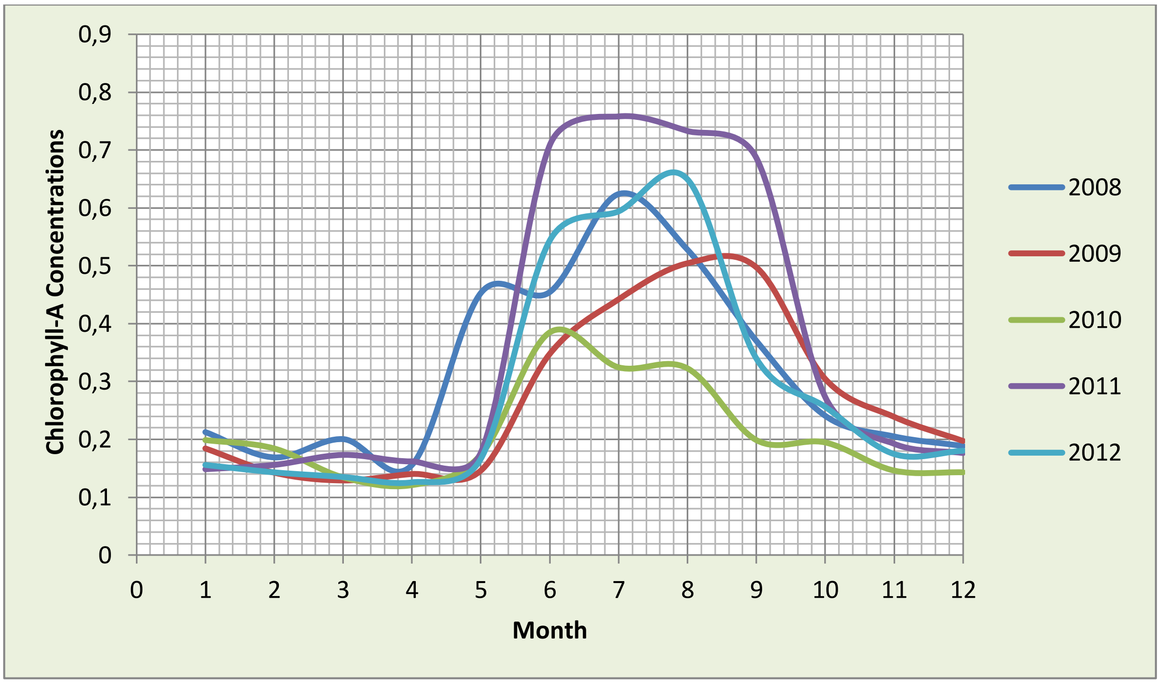


Fig.3 Chlorophyll-a Concentration in 2008 – 2012

In general Indonesian waters, the circulation of the mass of water is very dependent on the presence of the Monsoon climate. Wirtky (1961) said that Indonesian waters in June-September experienced Southeast Moonsons (East Season). In December-March the Northwest Moonsons (West Season) occurs.

This season phenomenon results in changes in the pattern of surface currents in Indonesian waters, wherein the east season the current moves westward. The direction of the current that moves west while the east side island, makes the water become water shortage due to the mass of water moving westward. It is this vacuum of water that causes an increase in the mass of water from below, commonly referred to as upwelling. This is what causes changes in the condition of the water. including variations in sea surface temperature and salinity, as well as vertical and horizontal patterns of distribution of nutrients (nitrate, phosphate, and silicate), which of course also affects primary productivity in the area.

As with Indonesian waters in general, Arafuru Waters also experience changes caused by the current season. The phenomenon of upwelling and Arlindo is an example where the temperature and salinity variations caused are very significant. Upwelling phenomena in eastern Indonesia waters mostly occur in the east monsoon, so that the eastern Indonesian sea carbon concentration is higher in the eastern season than in the western season (http://aisyahuda.blogspot.com).

Arafura waters are dynamic waters, besides being influenced by monsoons also by input of water masses from waters off eastern Indonesia. The difference in water level between the tropical western part of the Pacific Ocean and the Indian Ocean and the presence of straits that are open to the Indian Ocean allows the flow of the Arus Lintas Indonesia (Arlindo) water mass that carries organic material from In addition to the process of upwelling and stirring by the wind, the intake of nutrients can occur from the river and land. River water carries organic material as a nutrient source and will have a higher rainy season. However, this effect only occurs near the coast and does not spread to the open sea. From a monthly analysis every year, from 2008-2012, the pattern of increasing chlorophyll-a concentrations has a similar tendency, starting from May to September. Chlorophyll-a concentration values began to rise in May and were already high in June, except in 2008, concentrations began to rise in April and were already high in May. This year the increase occurred one month earlier. Then the chlorophyll-a concentration declined again in October, except in 2010, the concentration of chlorophyll-a began to decline in September, this can be seen in Figure 3

Related to the analysis of the timing of the pattern of increasing fishing potential, which will be associated with KAMLA operating time, the results mentioned above can be used as a reference. In general, at the study location, the recommended time for marine security operations in June, July, August, and September, because the increase in chlorophyll-a concentration occurred in that month, occurred in all years during 2008-2012. But it should be noted that there is a possibility of shifting the beginning and end of the time the concentration of chlorophyll-a increases. As happened in 2008 where the increase in chlorophyll-a concentration had begun from April and ended faster as it did in 2010 which was already low in September.

Statistically, this anomaly occurs in only 1 year for 5 years, so in general, the recommended time can be used for future times. Although it can be used for predicting the following year, the factors that influence the existence of the anomaly must continue to be studied. In general, Indonesian waters are affected by global phenomena, namely El Nino, IOD (Indian Ocean Dipole) and Arlindo. Specifically, at the research location, it will also be influenced by factors locally.

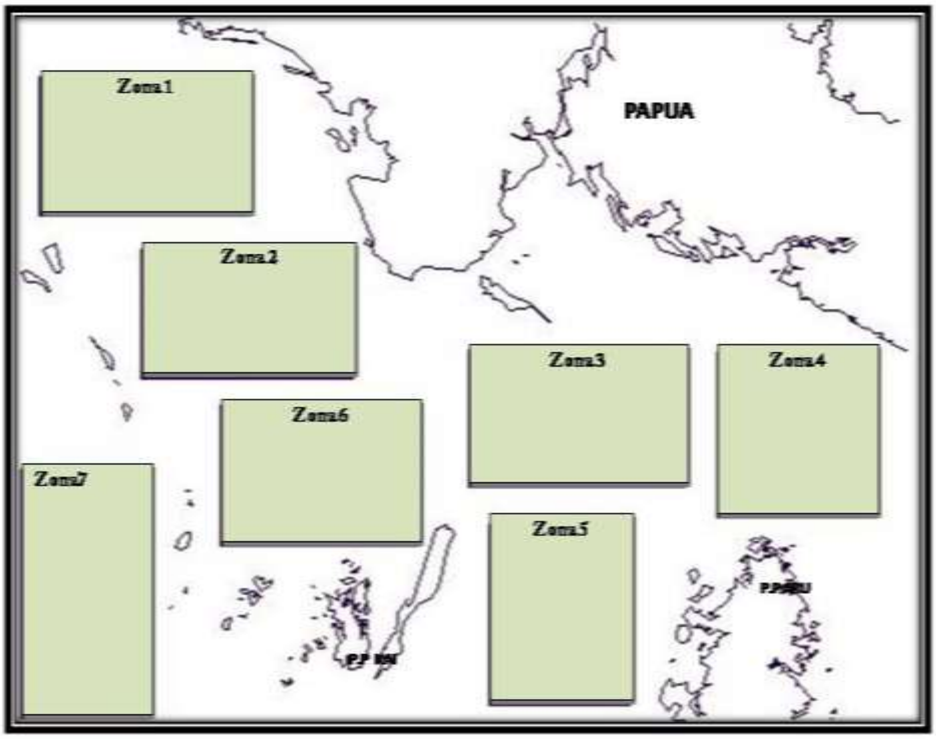


Fig.4 Chlorophyll-a Concentration in Research Zoning

To determine the character of the distribution of monthly chlorophyll-a concentrations in the study area, the research area is divided into observation and calculation zones as shown in figure 4. Zone division is done to determine the differences in monthly trends between zones in 1 (one) research area. In between these zones have different characters from other zones, then the action/handling in that area should ideally be different from the other zones.

For example in terms of setting a schedule/time of operation on the application of information on the distribution pattern of chlorophyll-a concentration as supporting information for planning sea security operations.

The study area was divided into 7 (seven) zones representing all areas of research in Arafuru waters. This study did not address the waters near the coast so that the zones that were made were far from the coast. This is done to examine areas prone to fishing theft which generally occur in the middle of the sea. In addition, the waters near the coast are more dominated by land or coastal influences, so it is possible to overestimate the algorithm for estimating the chlorophyll-a concentration calculation. The turbidity factor of the waters around the coast is an example of the influence of the land or coast.

3.2 Chlorophyll-a Concentration in Different Zones

From the results of the 5 (five) year image data processing in 7 (seven) zones representing throughout the research area, that is, in Arafuru waters it is shown in the form of pictures, tables, and graphs. It can be seen that the distribution value of the average chlorophyll-a concentration from zones 1-7 varies, which is between 0.096 mg / m3-0.976 mg / m3. Temporal distribution patterns occur in May-October and high averages in June, July, and August, which range between 0.339-0.976 mg / m^3.

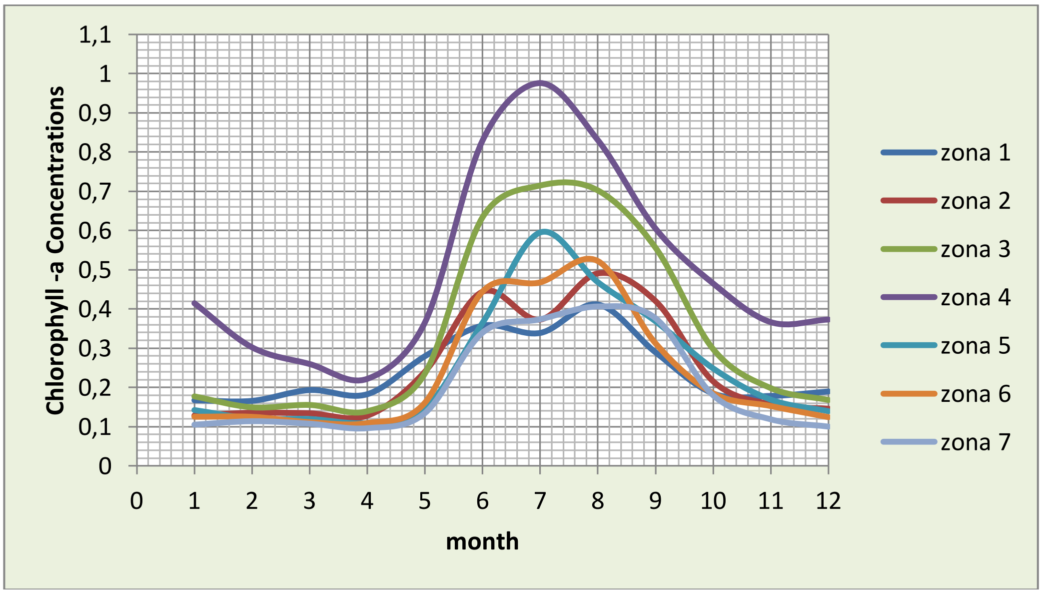


Fig.5 Chlorophyll-a Concentration in Zonas

The distribution pattern of chlorophyll-a concentration is seen spatially per zone, from zone 1 to zone 7 the concentration increase movement is slightly different, namely in zone 1 and zone 2. In zone 1 and 2, the tendency to increase the value of the average starts to rise in April and low starting in October or the concentration raising movement is faster (overtaking) than the other zones (zones 3-7) whose new pattern starts in May.

In its implementation, this can be an indication that the likelihood of fishing will be many at the same time but in particular, there are still differences in certain zones, for example in zones 1 and 2 that are different from zones 4 to zone 7. Where is the zone 1 and 2 the concentration increase pattern is earlier and lower faster than zone 3 to zone 7, so that zones that have different characters in the application need different treatments or steps in planning KAMLA By looking at the variation in chlorophyll-a concentration values over the past 5 years, it can be predicted that the pattern of distribution of concentration in subsequent years will not change much from the pattern that is already known, but other factors that influence changes in the next pattern are also very important. , for example, due to the existence of climate phenomena and global warmings such as the El Nino phenomenon, La Nina or Dipole Mode, and regional climate phenomena such as the circulation of the Asian-Australian Monsoon.

3.3 Verification Using VMS Data

From verification between the results of processing chlorophyll-a concentration image data from 2008-2012 with P2SDKP-KKP VMS monitoring data from 2011-2012, it can be concluded that temporally there is a close link between the chlorophyll-a concentration pattern and the vessel propensity activity fish catcher operating. The pattern of chlorophyll-a concentration whose value rises starting in May and high in June-August is similar to the tendency of fishing vessels to enter the area and operate in those months.

From the results of monitoring, VMS states that the activities of many fishing vessels occur in May-August (attachments A and B). This is in accordance with the results of chlorophyll-a concentration processing which states that in those months the concentration of chlorophyll-a is high. When the value of low chlorophyll-a concentration, ie from January to April and October-December, is closely related to the minimum activity of vessels operating in that month in the research zone (attachments A and B). This shows that there is a correlation between the time the value of chlorophyll concentration is high and the number of fishing vessels carrying out fishing activities with the same tendency. In the research area, areas that have high chlorophyll-a concentration values are zones 3, 4, 5, and 6. However zones 3 and 4 are WPP Arafuru 2 areas, which require that the Arafuru WPP 2 area is only for ships- ships with shrimp / non-ship trawlers with fishing trawlers. So that it is likely that fishing vessels that have VMS transmitters are monitored no one operates in the zone, even though the chlorophyll-a concentration is high. This spatial linkage is shown in zones 5 and 6, wherein zones 5 and 6 the chlorophyll-a concentration value is higher than other zones related to VMS monitoring data which shows that in zones 5 and 6 there are many activities of ships observed. fishcatcher compared to other zones which have low chlorophyll

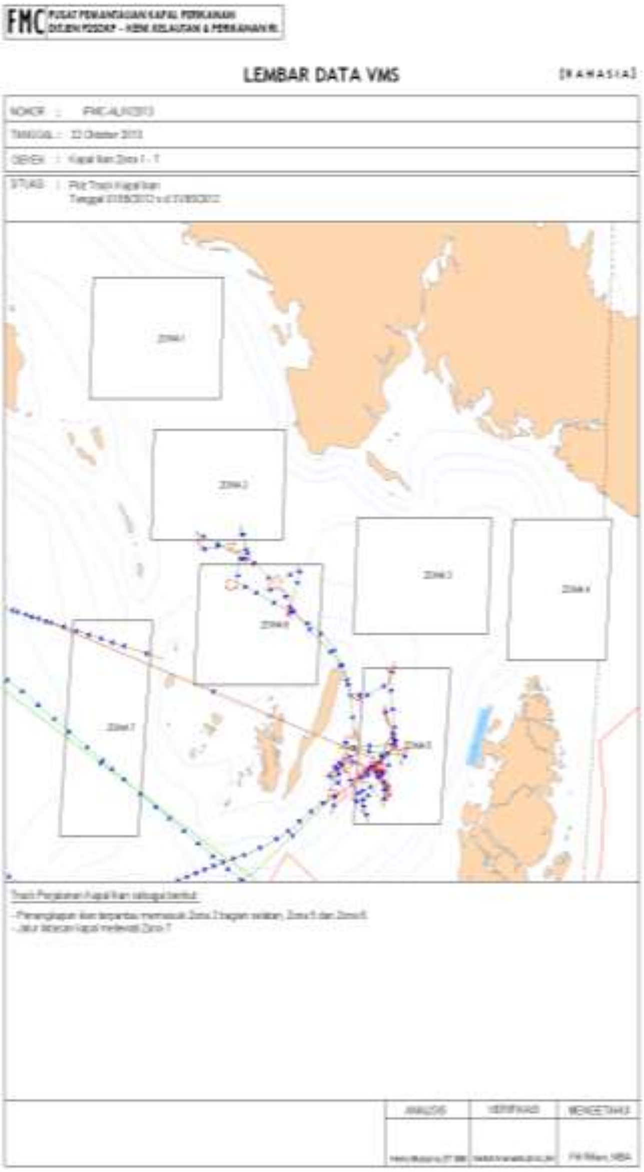


Fig.6 VMS data May 2012

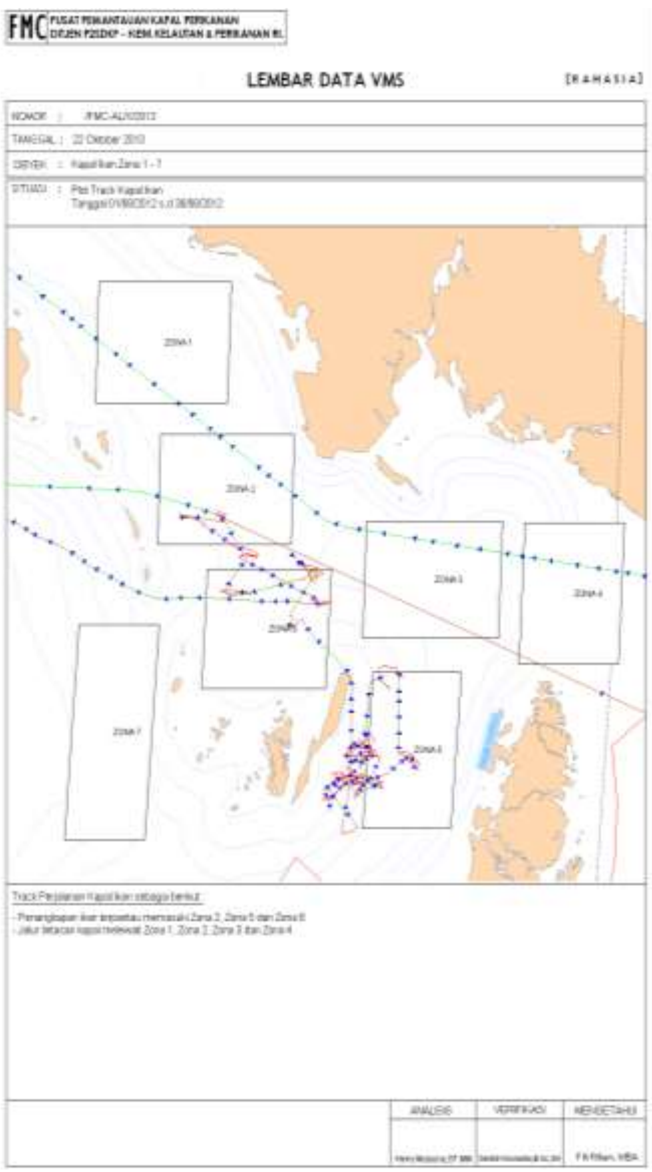


Fig.7 VMS data June 2012

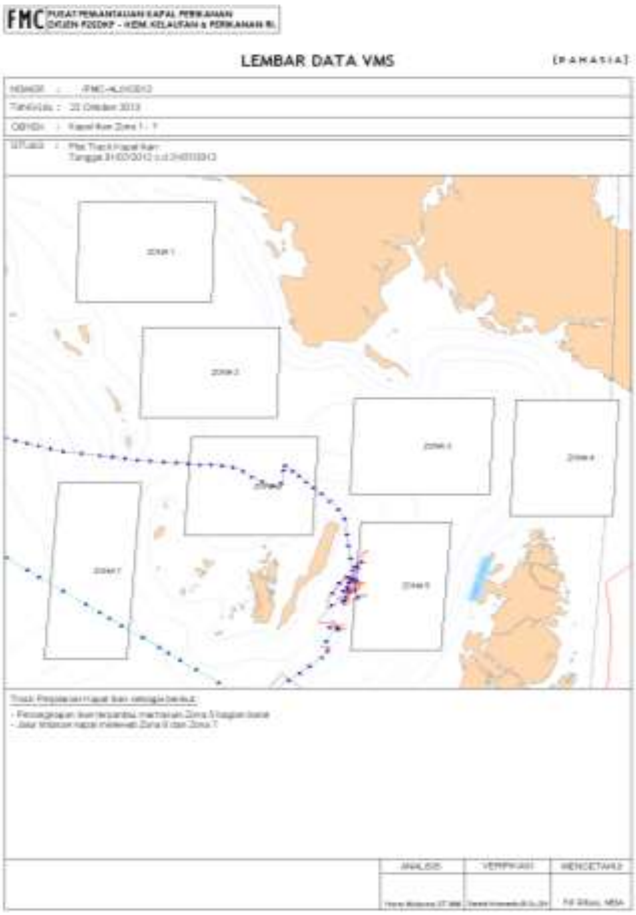


Fig.8 VMS data July 2012

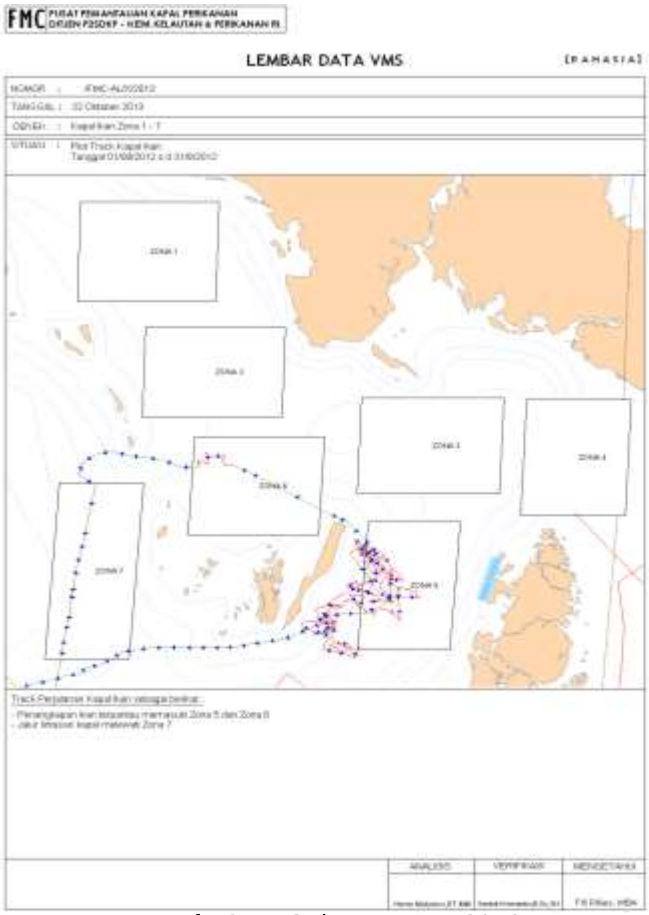


Fig.9 VMS data August 2012

4. CONCLUSION

Based on the results of Aqua-MODIS satellite image data processing in 2008-2012, it generally shows that the pattern according to time (temporal) in the area of increasing chlorophyll-a concentration occurred in May, high in June, July, August and low again in September. Specifically when viewed per zone, from the 7 observation zones there are zones whose predecessor is more elevated, namely zones 1 and 2, zones 1 and 2 the raising pattern starts in April or is 1 month faster than the other zones, even though the mean height it is still relatively the same as other zones, namely June, July, and August. The pattern according to the location (spatial) from zones 1 to 7, the highest average concentration values are in zone 3 and zone 4.

Based on the verification between data from image processing in the form of time patterns and chlorophyll-a concentration locations with VMS data in the form of time and location of activities of fishing vessels operating in the area of research indicates a close relationship between the two data, Chlorophyll-concentration pattern a whose value rises starting in May and the height of June-August, is the same as the tendency of fishing vessels to enter the area and operate in those months (Figure 4.34 p. 65 and Appendix A & B) so that in the application of time pattern information and the location of the chlorophyll-a concentration is suitable for end user and operational purposes.

The results of the study in this study are information on the pattern of time and location of chlorophyll-a concentration which is zone information that has the potential for fishing as well as a zone of potential violations/crime. This information can be used as supporting data in determining the timing and direction/sector of the ideal sea security operation so that in its implementation operations become more effective and efficient armed with information that can be relied upon for accuracy.

5. ACKNOWLEDGMENTS

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