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EFFECT OF EL NINO SOUTHERN OSCILLATION (ENSO) ON SKIPJACK CATCH (Katsuwonus pelamis) IN PELABUHAN RATU, SUKABUMI

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Abstract

This study aims to assess the temperature variability and chlorophyll-a at the time of the ENSO phenomenon and Skipjack's catch results. The data used are data on sea surface temperature, chlorophyll-a from 2009 to 2015 obtained from Aqua MODIS satellites and data of catches of skipjack from 2009 to 2015 obtained from PPN Pelabuhan Ratu. This study uses a descriptive method that is carried out with a spatial and temporal analysis method approach. The results showed the temperature at the Elino phase became colder and during the La-Nina phase the temperature became warmer, and the average yield of the catch during the El-Nino phase was 39,806 kg, when the La-Nina phenomenon was 53,799 kg , whereas during normal conditions it is 52,712 kg.

Keywords: El Nino Southern Oscillation, Skipjack, Sea Surface Temperature, Chlorophyll-a

INTRODUCTION

The South Java Sea, which is part of the Eastern Indian Ocean, is unique because of its geographical location which is influenced by water masses originating from the Western Indian Ocean and water masses originating from the Pacific Ocean (Amri, 2013). The waters of Pelabuhan Ratu, located in the Southern Waters of West Java, are one of the potential fishing areas in Indonesia. These waters are influenced by several ocean-atmosphere phenomena, such as El Niño Southern Oscilation (ENSO), Indian Oscillation Dipole (IOD) and monsoon wind movement patterns (Susanto et al. 2001). P Pelabuhan Ratu is the most active fish landing place in West Java. Fish catches landed at PPN Pelabuhan Ratu consist of various types of pelagic fish, both large pelagic fish and small pelagic fish. One of the dominant catches landed at PPN Pelabuhan Ratu is Cakalang fish/Skipjack tuna (Ayu, 2015).

In Indonesia, climate change greatly affects the waters in Indonesia, especially changes in sea surface temperature is El Nino Southern Oscillation (ENSO) (Kunarso, 2011). ENSO is a form of climate deviation in the Pacific Ocean. ENSO is an atmospheric oceanic interaction centered in the equatorial region of the Pacific Ocean that causes global climate anomalies (Muhammad et al. 2012). This causes two phenomena, namely El Nino and La Nina. In general, experts divide ENSO into warm ENSO (El Niño) and cold ENSO (La Niña). The term El Nino was originally used to describe the annual state of weak warm currents along the southern coast of Peru and Ecuador which caused a decrease in fish catch (Stevenson and Kemper 2012). The decline in fish catches is caused by nutrients that are usually brought to the surface by weak upwelling (Putra et al. 2012). From the explanation above, that ENSO affects changes in temperature and chlorophyll-a, which will cause upwelling when El Nino occurs, so that chlorophyll levels increase.

Fish naturally choose oceanographic conditions such as currents, temperature, chlorophyll-a that are suitable for their habitat. Chlorophyll-a content can be used as an indicator of the level of fertility and productivity of waters (Lalli & Parson, 1994). Fish life patterns cannot be separated from the various environmental conditions. The abundance of skipjack fish is significantly related to the presence of small pelagic fish and plankton. In waters with a lot of phytoplankton, small fish are often found in the waters which eventually skipjack are also found in these waters (Irawan, 1995).

The number of small pelagic fish and plankton is due to the large amount of nutrients that come from the upwelling process.

METHOD

This research was conducted in October-December 2016. Data processing was carried out at the Computer Laboratory of the Faculty of Fisheries and Marine Sciences, Padjadjaran University. The study area is in Pelabuhan Ratu Waters with coordinates of 6°LS-10°LS and 100°BT-107°BT.

Figure 1. Research Location

This research uses descriptive method which is conducted with the approach of spatial and temporal analysis methods. The method of spatial and temporal analysis is by processing secondary data obtained from the official web of agencies and research bodies on oceanography which are then processed using software to produce output in the form of vertical profiles. This research consists of three stages, namely the preparation stage, the data processing stage, and the analysis.

The initial stage of this research is preparation by making a basic map of the study area using ArcGis 10.1 software. Then download the data needed, namely sea surface temperature, chlorophyll-a data, Niño index 3.4, and Skipjack fish. The data used are data from 2009 to 2015. All data are downloaded in NetCDF or .NC format while Skipjack fish data is obtained from PPN Pelabuhan Ratu.

RESULTS AND DISCUSSION

ENSO Variability

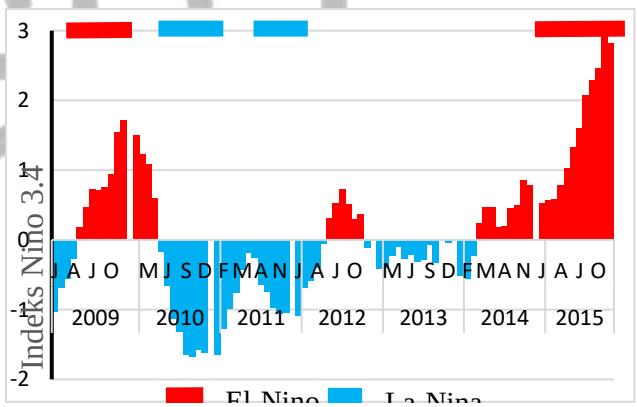

Figure 2. Nino Index 3.4

The ENSO phenomenon is represented by the Nino Index graph 3.4 (Figure 2). The El-Nino phenomenon can occur if an increase in SPL> 0.5°C and in the La-Nina phenomenon there is a decrease in SPL> 0.5°C for at least 5 consecutive months or more in the Nino region 3.4. Based on the

Nino Index 3.4 value, it can be seen that the ENSO phenomenon occurred between 2009 and 2015. The El-Nino phenomenon occurred in 2009 2010, 2014 and 2015, which was marked by an increase in SST values of more than 0.5^{o}C and occurred for five months or more, starting from July 2009 to April in 2010, this was marked by rising sea surface temperatures 0.71 in August 2009 to the highest temperature of 1.72^{o}C in December 2009. Then in November 2014 to December in 2015 marked by rising surface temperatures sea level of 0.53^{o}C in January 2015 and the highest rise in sea surface temperature up to 2.95^{o}C in November 2015.

In 2010, 2011 and 2012 the La-Nina phenomenon was marked by a decrease in the SPL value of more than -0.5^{o} C and occurred for five months or more, starting from June 2010 to April in 2011 marked by a decrease in temperature of 0.65^{o}C at in June 2010, up to a high of 1.68^{o}C in October 2010. Then in August 2011 to March in 2012 the La-Nina phenomenon occurred, marked by a decrease in temperature of 0.58^{o}C in April 2012 to a decrease in the highest temperature of 1.08^{o}C. Then in 2012 in April to December then in 2013 and in January 2014 to October 2014 there was no El-Nino or La-Nina phenomenon, because there was no increase in SPL with a value of more than 0.5^{o}C or a decrease in SPL of more than -0.5^{o}C , so this phenomenon is called a normal event.

Skipjack Fish Production

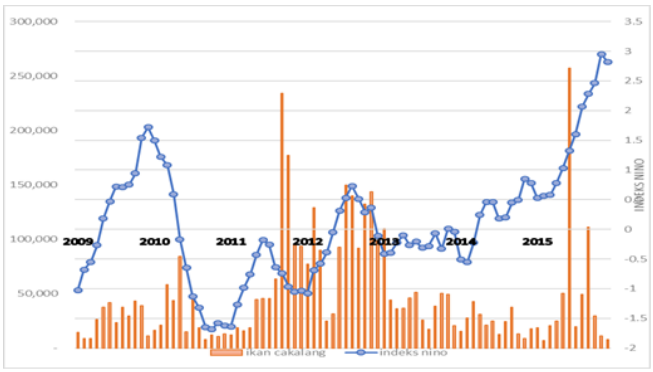

Figure 3. Skipjack Fish Production

The production of skipjack fish in this region has fluctuating values. In general, the results can explain the differences in production results during El-Nino, La-Nina, and normal conditions. Based on Figure 7 it can be seen that skipjack tuna catches are very varied, when the El-Nino that occurred in July 2009 to March 2010, the total tuna catches were 278,933 kg, from November 2014 to December 2015 the total catch in 2015 was 632,718 kg with an average capture yield in the El-nino phase is 39806.

Furthermore, when La-Nina occurred in 2010,2011, and 2012. In 2010 from June to April 2011, the total catch of skipjack fish in 2010 was 192,095 kg, then in 2011 from August to March 2012 with a total catch of 959,465 kg , with an average yield of 53,799 kg. In the normal phase that is in the months that do not experience the El-Nino and La-

Nina phases, the total catch is 2,003,046 kg, with an average catch of 52,712 kg.

Temperature and Chlorophyll-a Variability When Normal

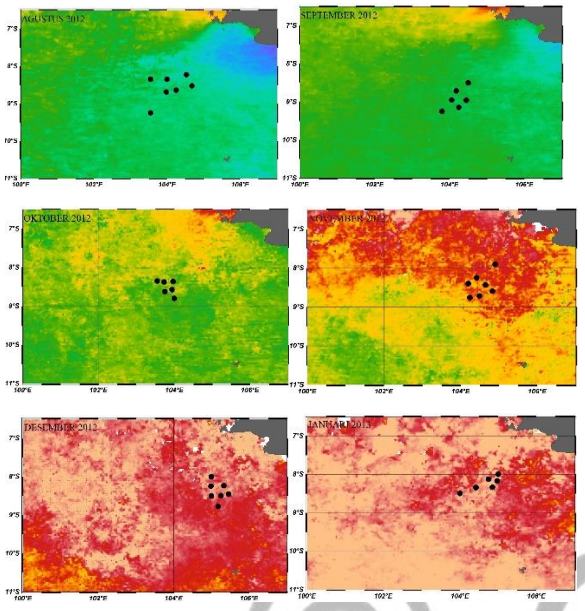

Figure 4. Temperature Profile when Normal

In August 2012 the average sea surface temperature was 26^{o}C, with a catch of 139,591 kg tuna. The location of capture is at coordinates 8^{o}S-9.5^{o}S and 103.5^{o}E-104.5^{o}E. The fishing area has a temperature range of 26^{o}C-27^{o}C which is an area of water temperature that is still found skipjack fish. Based on the nino 3.4 index in August 2012 it showed an increase of 0.73^{o}C. In September 2012 the average sea surface temperature was 26.07^{o}C, with a catch of 91572 kg. The location of capture is at 8.5^{o}S-9.5^{o}S and 103.5^{o}E-104.5^{o}E. The capture area has a temperature range of 26^{o}C-27^{o}C. According to the nino 3.4 index in September 2012 an increase of 0.5^{o}C. In October 2012 with an average sea surface temperature of 26.8^{o}C, with a catch of tuna of 132,154 kg. The location of capture is at coordinates 8.3^{o}S-9^{o}S and 103^{o}E-104^{o}E. The capture area has a temperature range of 27^{o}C-28^{o}C.

In November 2012 the average sea surface temperature was 27.88 ^{o}C, with the catch of the tuna tuna 143,798 kg. The location of capture is at coordinates 8^{o}S-9^{o}S and 104.2^{o}E-104.9^{o}E. The fishing area has a temperature range of 28^{o}C-29^{o}C which is an area of water temperature that is still found skipjack fish. Based on the nino 3.4 index in November 2012 it shows 0.36^{o}C.

In December 2012 the average sea surface temperature was 29.26^{o}C, with the catch of skipjack 98.190 kg. The location of capture is at coordinates 8^{o}S-8.9^{o}S and 104.5^{o}E-105.5^{o}E. The fishing area has a temperature range of 29^{o}C-30^{o}C which is an area of water temperature that is still found skipjack fish. Based on the nino 3.4 index in December 2012 it showed at -0.11^{o}C.

In January 2013 the average sea surface temperature was 29.66 ^{o}C, with the catch of skipjack fish 109,466 kg. The location of capture is at coordinates 8.^{o}S-8.5^{o}S and 104. ^{o}E-105 ^{o}E. The fishing area has a temperature range of 29^{o}C-30^{o}C which is an area of water

temperature that is still found skipjack fish. Based on the nino 3.4 index in Januri 2013 it shows a figure of -0.41°C.

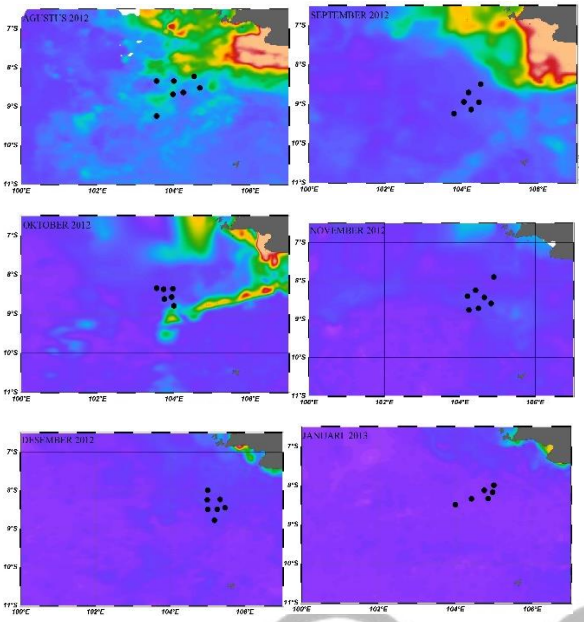

Figure 5. Chlorophyll-a profile when normal

In August 2012 the average concentration of chlorophyll-a was 0.4 mg / m^3. The fishing area has a chlorophyll-a concentration range of 0.2-0.8 mg / m^3 which is the preferred waters area for skipjack fish. In September 2012 the average chlorophyll-a concentration was 0.4 mg / m^3, with the capture area having a range of chlorophyll-a concentrations of 0.2-0.4 mg / m^3. In October 2012 the average concentration of chlorophyll-a was 0.45 mg / m^3, with the capture area having a range of chlorophyll-a concentration of 0.2-0.6 mg / m^3. In November 2012 the average concentration of chlorophyll-a was 0.22 mg / m^3. The capture area has a chlorophyll-a concentration range of 0.2 mg / m^3. In December 2012 the average chlorophyll-a concentration was 0.09 mg / m3. The catching area has a chlorophyll-a concentration range of 0-01 mg / m^3. In January 2013 the average chlorophyll-a concentration was 0.08 mg / m^3. The catching area has a chlorophyll-a concentration range of 0-0.1 mg / m^3.

Temperature and Chlorophyll-a Variability in El-Nino

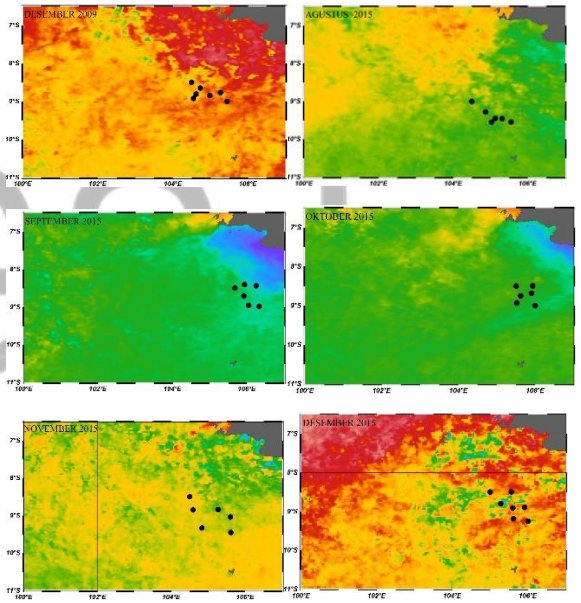

Figure 6. Temperature profile at the time of the El-Nino phenomenon

In December 2009 the average SPL was 28.05°C, the catch in December 2009 was 10916 kg. The location of capture is at coordinates 8.5°S-9°S and 104.5°E-105.45°E. The skipjack fishing area has a temperature range of 28°C-29°C. Based on the nino 3.4 index in December 2009 there was an

increase in SST of 1.7ºC, so in December 2009 was included in the El-Nino phenomenon. In August 2015 the average SPL showed 26.84ºC, the catch in August 2015 was 49125 kg. The location of capture is at coordinates 9ºS-9.55ºS and 104.5ºE-105.55ºE. Based on the nino 3.4 index in August 2015 there was an increase in SPL of 2.07ºC. The skipjack fishing area has a temperature range of 27ºC-28ºC. In September 2015 the average SPL showed 25.92 ºC, with catches of 111,252 kg. The location of capture is at coordinates 8.4ºS-9ºS and 105.5ºE-106.5ºE. Based on the nino 3.4 index in September 2015 there was an increase in SST of 2.28ºC.

In October 2015 the average SPL showed 27.09 ºC, with a catch of 29266 kg. The location of capture is at coordinates 8.4ºS-9ºS and 105.5ºE-106.5ºE. Based on the nino 3.4 index in October 2015 there was an increase in SST of 2.28ºC.

In November 2015 the average sea surface temperature was 27.09 ºC, with the catch of skipjack fish 10,944 kg. The location of capture is at coordinates 8.5ºS-9.5ºS and 104.5 ºE-105.5 ºE. The fishing area has a temperature range of 26.5ºC-27.5ºC which is an area of water temperature that is still found skipjack fish. Based on the nino 3.4 index in November 2015 it showed at 2.95ºC.

In December 2015 the average sea surface temperature was 28.06ºC, with the catch of cakalang fish 7722 kg. The location of the arrest is at coordinates 8.5ºS-9.3ºS and 105 ºE-106 ºE. The fishing area has a temperature range of 27ºC-29ºC which is an area of water temperature that is still found skipjack fish. Based on the nino 3.4 index in December 2015 it showed at 2.82ºC.

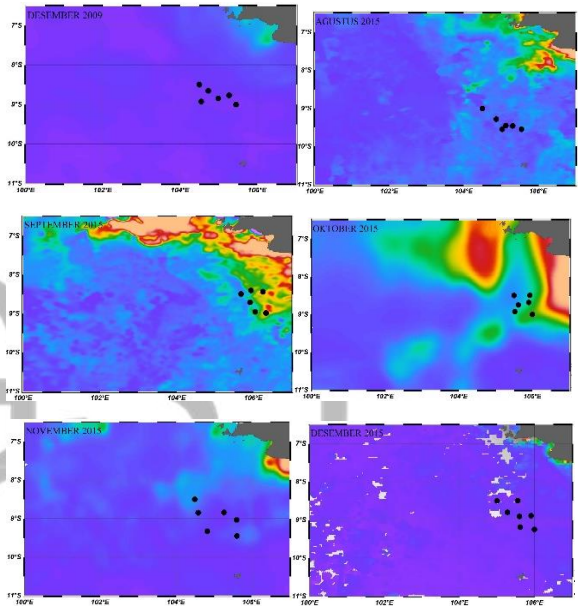

Figure 7. Chlorophyll profile during the El-Nino phenomenon

In December 2009 the average concentration of chlorophyll-a was 0.1 mg / m^3. The fishing area has a chlorophyll-a concentration range of 0.2-0.8 mg / m^3 which is the preferred waters area for skipjack fish. In August 2015 the average concentration of chlorophyll-a was 0.26 mg / m^3, with the area of capture having a range of chlorophyll-a concentration of 0.2-0.4 mg / m^3. In

September 2015 the average concentration of chlorophyll-a was 0.58 mg / m^3, with the area of capture having a range of chlorophyll-a concentration of 0.2-0.6 mg / m^3. In October 2015 the average chlorophyll-a concentration was 0.46 mg / m^3. The capture area has a chlorophyll-a concentration range of 0.2 mg / m^3. In November 2015 the average chlorophyll-a concentration was 0.18 mg / m^3. The catching area has a chlorophyll-a concentration range of 0-01 mg / m^3. In December 2015 the average chlorophyll-a concentration was 0.09 mg / m^3. The catching area has a chlorophyll-a concentration range of 0-0.1 mg / m^3.

Temperature and Chlorophyll-a Variability when La-Nina

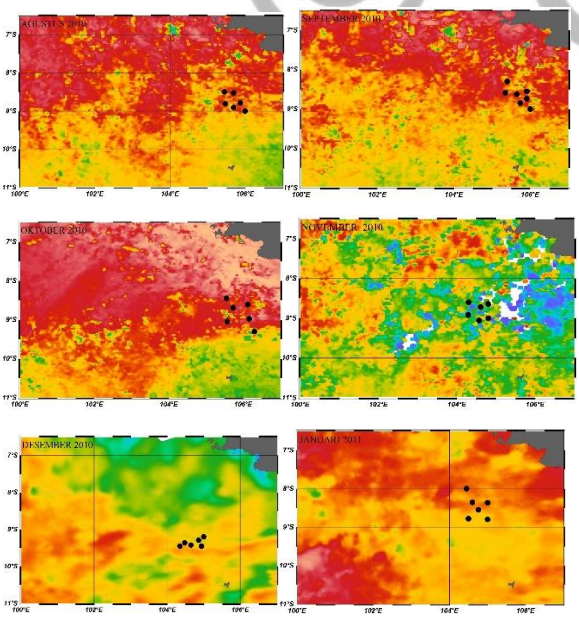

Figure 8. Temperature profiles at the time of the La-Nina phenomenon

In August 2010 the average SPL was 28.05ºC, the catch in August 2010 was 18681 kg. The location of capture is at coordinates 8.5ºS-9ºS and 105.5ºE-106ºE. The skipjack fishing area has a temperature range of 28ºC-29ºC. Based on the nino 3.4 index in August 2010 there was a decrease in SST of 1.32ºC. In September 2010 the average SPL showed 27.93ºC, the catch in September 2010 was 7999 kg. The location of the arrest is at coordinates 8.5ºS-9ºS and 105ºE-106ºE. Based on the nino 3.4 index in September 2010 there was a decrease in SST of 1.65ºC. The skipjack fishing area has a temperature range of 28ºC-29ºC. In October 2010 the average SPL showed 28.52 ºC, with catches of 12,012 kg. The location of capture is at 8.5ºS-9.5ºS and 105.5ºE-106.5ºE. Based on the nino 3.4 index in October 2010 there was a decrease in SST of 1.68ºC.

In November 2010 the average SPL showed 27.08 ºC, with catches of 10496 kg. The location of capture is at coordinates 8.4ºS-9.2ºS and 104.2ºE-105ºE. Based on the nino 3.4 index in November 2010 there was a decrease in SST of 1.58ºC.

In December 2010 the average sea surface temperature was 27.39ºC, with a catch of tuna 12,990 kg. The location of capture is at coordinates 9ºS-9.5ºS and 104.5

ºE-105ºE. The fishing area has a temperature range of 27ºC-28ºC which is an area of water temperature that is still found skipjack fish. Based on the nino 3.4 index in November 2015 it shows 1.62ºC.

In January 2011 the average sea surface temperature was 28.15ºC, with a catch of 12247 kg of tuna. The location of capture is at coordinates 8.ºS-8.9ºS and 104.2ºE-105ºE. The fishing area has a temperature range of 27ºC-29ºC which is an area of water temperature that is still found skipjack fish. Based on the nino 3.4 index in January 2011 it shows at 1.64ºC.

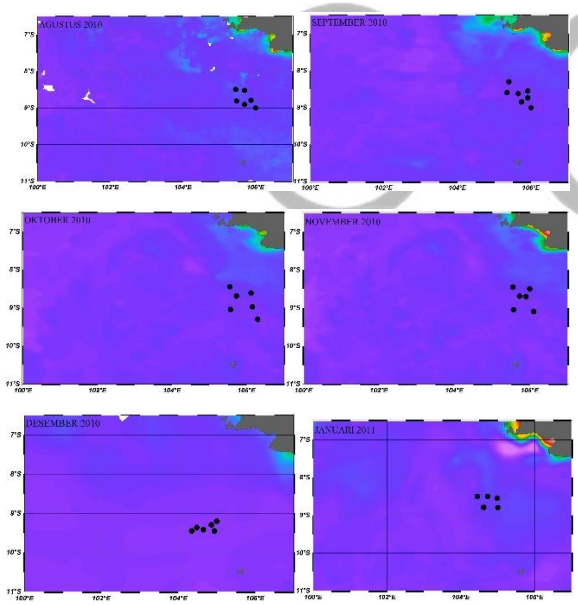

Figure 9. Chlorophyll-a profile during the La-Nina phenomenon

In August 2010 the average chlorophyll-a concentration was 0.12 mg / m^3. The catching area has a chlorophyll-a concentration range of 0.2-0.4 mg / m^3 which is the preferred waters area for skipjack fish. In September 2010 the average concentration of chlorophyll-a was 0.11 mg / m^3, with the area of capture having a range of chlorophyll-a concentration of 0-0.1 mg / m^3. In October 2010 the average concentration of chlorophyll-a was 0.09 mg / m^3, with the area of capture having a range of chlorophyll-a concentration of 0-0.2 mg / m^3. In November 2010 the average chlorophyll-a concentration was 0.08 mg / m^3. The capture area has a chlorophyll-a concentration range of 0-0.2 mg / m^3. In December 2010 the average chlorophyll-a concentration was 0.08 mg / m^3. The catching area has a chlorophyll-a concentration range of 0-0.1 mg / m^3. In January 2011 the average chlorophyll-a concentration was 0.1 mg / m^3. The catching area has a chlorophyll-a concentration range of 0.1-0.2 mg / m^3.

Effect of SPL on Skipjack

Figure 10. Sea Surface and Skipjack Fish Temperature Graph

Sea surface temperature in the study area ranged from 25.5ºC - 30.5ºC. This SPL value is still in the temperature range preferred by skipjack fish. Skipjack tuna likes warm waters for their place of life, the range of warm water temperatures for skipjack fish is 14.7-30ºC (Collete and Nauen, 1983 in Octorina, 2002). Gunarso (1985) optimum temperature for skipjack catching in Indonesia ranges from 28ºC-29ºC. Large skipjack fish are able to be in both cold and warm temperatures because they have a good metabolic system, while the smaller tuna body is only able to adjust to the warmer SPL (Arifin, 2006).

In the El-Nino event, namely in December 2009, August 2015 to December 2015 the sea surface temperature in the study area experienced a decrease in SST, where the average SST at the time of El-Nino was 27.05ºC and during the normal phase 27.62ºC this because the water column shifted to the Pacific causing the region where the study, including the southern part of Java to be colder. In the La-Nina incident, namely in August 2010 to January 2011 the graph above shows that the catch of Cakalang fish is more decreased compared to the El-Nino phase, the average SPL in the La-Nina phase is 27.85ºC with 74.425 catches kg.

Based on (Alimina, 2005) a tendency to decrease in sea surface temperature will be followed by an increase in catches, conversely an increase in sea surface temperature will be followed by a decrease in catches. But in the month of the ENSO phenomenon the EL-Nino phase with a lower SST than the normal phase decreased fish production from the normal phase. Where the average yield of skipjack tuna in the El-Nino phase is 219,225 kg, while in the normal phase it is 714,771 kg. According to Hamnett and William (1996) tuna and yellowfin tuna will move eastward during the El-Nino event. This is thought to be the cause of the catch when El-Nino decreases compared to the normal phase. According to (Hela and Laevastu, 1981) the effect of the SPL on the spread of skipjack to tropical waters is small because the temperature is relatively the same (constant) throughout the year. Simbolon (2007) states that the influence of water temperature on fish distribution is highly dependent on the temperature variability itself. If the distribution of water temperature is still in the range of values that can be tolerated by fish, the water temperature generally does not significantly affect the presence of fish. Syahdan et. al. (2007) and Simbolon (2003) also report that the number of skipjack tuna is not only

influenced by water temperature but is also influenced by other oceanographic parameters such as currents, salinity, and chlorophyll-a content, and is also influenced by technical factors of fishing operations fish.

ffect of Chlorophyll-a with Skipjack fish

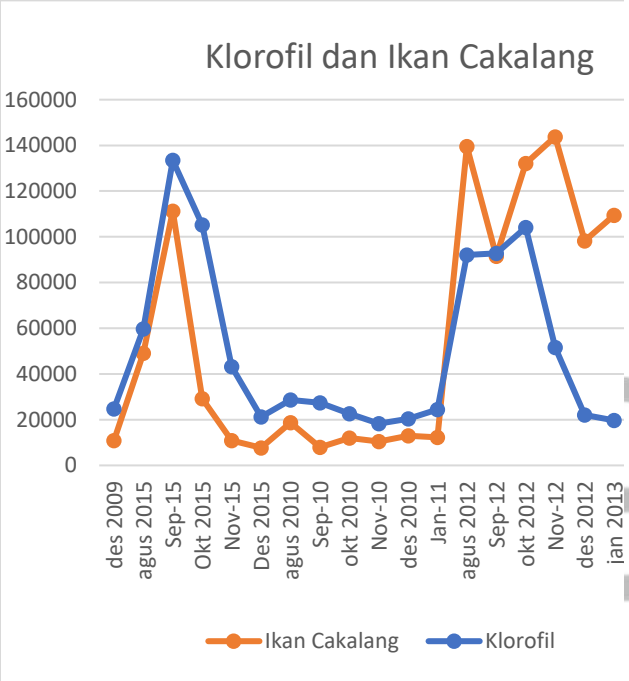

Figure 11. Concentration of Chlorophyll-a and Skipjackfish

In Figure 16 is a graph of tuna catches which is connected with chlorophyll-a concentration. Viewed from the graph above, an increase in chlorophyll-a concentration is followed by an increase in catch yield, and vice versa. In September 2015 the El-Nino phase ENSO phenomenon occurred with the highest catch of 111,252 kg followed by the highest chlorophyll-a concentration of 0.58 mg / m^3. However, in September 2010 during the ENSO phenomenon the La-Nina phase with the lowest catch of 7999 kg, there was a chlorophyll-a concentration which was quite low at 0.1 mg / m^3.

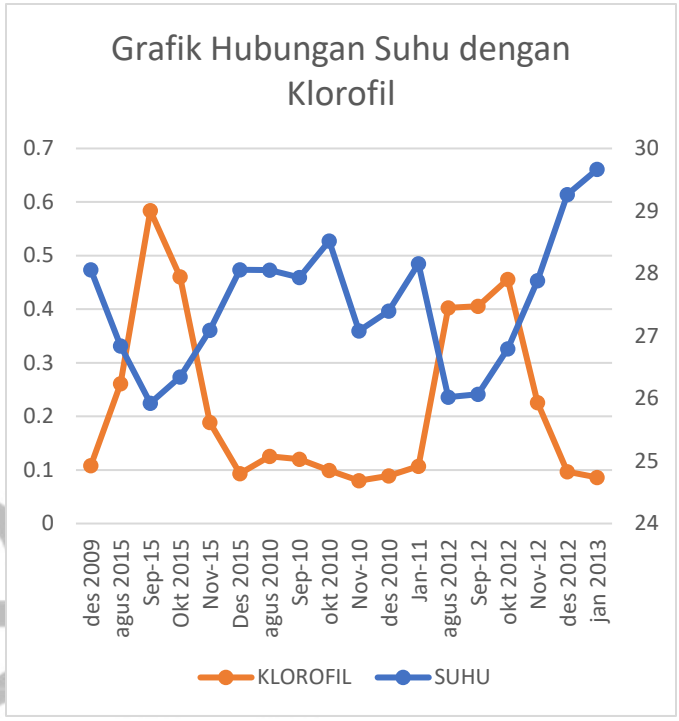

Figure 12. Chlorophyll-a Concentration and Temperature

Figure 17 is a graph of concentration-a associated with SPL. Based on (Kunarso & Wiwieka, 2008) low sea surface temperatures will lead to fluctuations in the concentration of chlorophyll-a, this is due to the Upwelling phenomenon that causes increased chlorophyll-a at sea level. Based on the graph above, an increase in chlorophyll-a concentration is followed by a decrease in sea surface temperature, and conversely a decrease in chlorophyll-a concentration is

followed by an increase in sea surface temperature. This is because when the SST is cold there will be an Upwelling phenomenon, so that nutrients will be raised to the surface eventually become a source of primary productivity in these waters. With an optimal temperature and a high enough concentration of chlorophyll-a, it will increase the yield of skipjack fish. According to some studies the abundance of skipjack fish is significantly related to the presence of small pelagic fish and plankton. The waters are abundant phytoplankton so there are also lots of zooplankton, so there are lots of small fish so that skipjack fish will also be abundant in these waters (Muhammad 1970 in Kusnawan 1999).

From the results of the chlorophyll-a map presented, it was found that the chlorophyll-a concentration towards the coast was relatively higher when compared to the offshore chlorophyll-a concentration. This condition is due to the high nutrient supply from the mainland through river runoff to the sea, so that the coastal area will have a higher concentration of chlorophyll-a than the concentration of chlorophyll-a offshore. However, high concentrations of chlorophyll-a are still found offshore. The situation is caused by the existence of a process of mass circulation of water that allows the transport of a number of nutrients from other places, as happened in the upwelling area.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

1. ENSO phenomenon influences the change of SPL in the waters of Pelabuhan Ratu, when the EL-Nino phenomenon the average SPL is 27.05ºC, when the La-Nina phenomenon the average SPL is 27.85ºC, whereas in the normal phase the average SPL is 27.61ºC.
2. ENSO phenomenon influences changes in chlorophyll-a concentration in the waters of Pelabuhan Ratu, when the EL-Nino phenomenon the average concentration of chlorophyll-a is 0.282 mg / m^3, when the La-Nina phenomenon the average concentration of chlorophyll-a is 0.103 mg / m^3, while in the normal phase the average concentration of chlorophyll-a is 0.278 mg / m^3.
3. The ENSO phenomenon influences the yield of skipjack fish in the waters of Pelabuhan Ratu, at the time of the El-Nino phenomenon the average

yield of the catch was 39,806 kg, when the La-Nina phenomenon was 53,799 kg, whereas during normal conditions it was 52,712 kg.

Suggestion

It is necessary to analyze the pattern of current distribution in the fishing area because the spread of skipjack fish often follows the current circulation.

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