THE CHARACTERISTICS AND VARIABILITY OF SEA SURFACE TEMPERATURE IN JAVA SEA

WIDADA SULISTYA[1], AGUS HARTOKO[2], AND S. BUDI PRAYITNO[2]

Abstract

The phenomena of marine climate can be identified by the sea surface temperature, as Illahude (1999) reported that one of the parameters of oceanography which characterized of sea water mass is sea surface temperature (SST). The distribution of sea surface temperature can be used as an indicator of fishing ground. However, as understanding of marine climate variability it does not well enough (Hartoko, 2000). The characteristic and variability of SST in Java Sea are not sufficiently enough understood. In order to better understand, we need the Spatial-Temporal Analysis of SST. The Spectral Analysis Method is used to study the characteristic and seasonal variation of SST, while GIS Analysis is used to study SST spatial distribution pattern. Temporally, the highest temperature at Java Sea occurs in April - May and November, whereas the lowest temperature in February and August. The SST fluctuation of Java Sea ranges from 27.48^0 C to 29.66^0 C and its periodic cycle generally occurs for 6 months, 1 year and 8 years.

Key Word: SST, Variability, Spatio-Temporal Analysis

I. Introduction

The climate and weather change in the ocean is related closely with fishery activity (J. Le Blanc *et. al.*, 1999). The influence of climate and weather change depends on scale of space and time. It occurs from local scale (as thunderstorm), regional scale (as monsoon) to global scale (as El Nino). Those phenomena used to have a great influence on migration, reproduction and fish catchments. Marine climate can be identified by Sea Surface Temperature (SST) monitoring, as Ilahude (1999) reported that SST is one of the oceanographic parameter which characterized water mass.

The understanding of marine climate variability is not sufficient well until now. Handoko (2000) reported the fact that characteristic and variability of SST of Java Sea is not yet understood well, and Spatio-Temporal SST is very useful to understand SST of Java Sea. Based on the study of Widyaprasetya (2000), spatial analysis of SST using Geographic Information System (GIS) which is processed with satellite images can be applied to indicator of fishing ground. This idea also was supported by Aryana (2005) resulting that small pelagic fish are more comfortable stay at the top of the layers of warm waters. Until present time, Java Sea is good fishery area where small pelagic is caught for more than 8 million ton and fishermen time is depend on their life from the production abundance of fishes in Java Sea.

1 Meteorological and Geophysical Agency, Bali
2 Doctoral Program of Coastal Resources Management, Undip – Semarang

According to influence of marine climate on fisheries, the understanding of SST variability in waters can help understanding of fluctuation of fishes stock. Based on above description, the study of SST variability in Java Sea is important.

II. Material and Method

In order to study of SST variability the data of SST in Java Sea for within 30 years is used, insitu data has range from 2^0 S - 9^0 S and 105^0 E - 120^0 E. The coordinate of west part is (108^0 E; -4^0 S), the coordinate of central area is (116^0 E; -6^0 S) and coordinate of east area is (116^0 E; -6^0 S). The results of reanalysis from satellite images producing from NCEP Data Centre are used for west, central and east areas.

The SST monthly mean fits with the standard of WMO (World Meteorological Organization) are used as series data for 30 years (1971-2000). The SST variability characteristic of Java Sea is analyzed by Descriptive Statistic Analysis Method. The variability and the anomaly in certain period are evaluated by the monthly mean of SST. Meanwhile, the SST spatial distribution is known by spatial analysis using GIS. Based on monthly spatial analysis, we can also know the monthly spatial distribution of SST. This analysis can also describe the dynamic pattern of ocean (Hartoko, 2000), while Spectral Analysis Method is applied to 30 years data series to study the SST seasonal variation.

III. Result

a. SST Monthly Mean in Java Sea

In order to study the characteristic of SST distribution of Java Sea, three areas representing west part, central part and east part of Java are taken. West part of Java Sea has temperature variation range from 28.25^0 C - 29.66^0 C with the highest temperature in May and the lowest temperature in August. The temperature of SST in east part of Java Sea varied from 27.48^0 C - 29.36^0 C. and the highest temperature is in April and the lowest temperature is in August (see Figure 1).

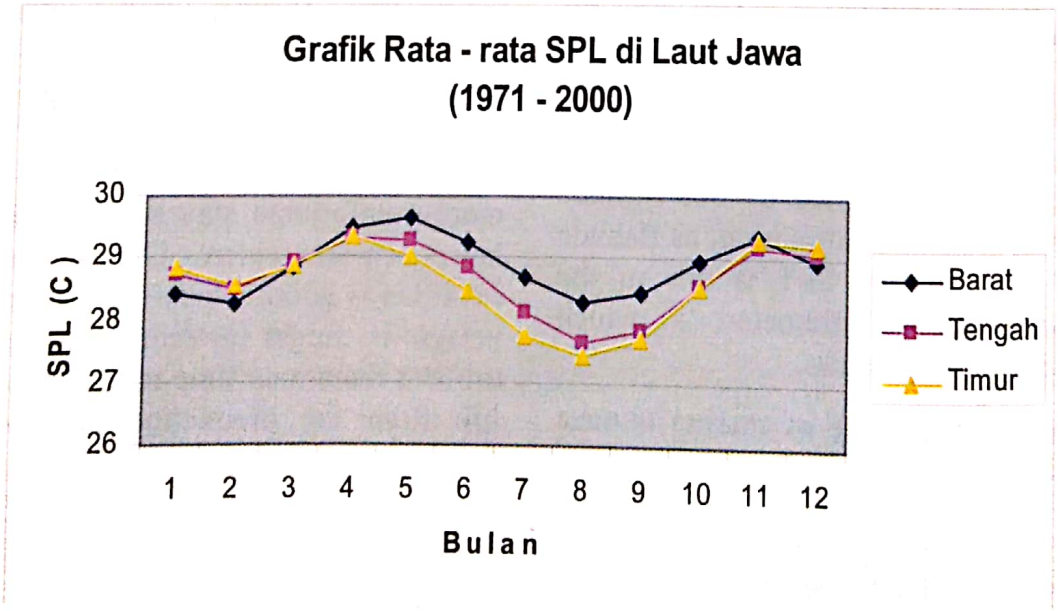

Fig. 1. Monthly SST Pattern of Java Sea

In general, the variation of SST distribution in Java Sea shows that the lowest averaged SST occurs in the eastern part of the sea while the highest SST is in the western part. The variation of SST at eastern part of Java Sea is relatively bigger than both of central and western parts. The whole part of Java Sea has cycle of the highest SST and the lowest SST for two times in a year. The first highest SST is in April to May, and the second one occurs in November. The first lowest SST occurs in February and the second one is in August.

b. Anomaly of SST in Java Sea

It is also necessary to consider the SST anomaly for each month in 30 years to study of the characteristics of SST of Java Sea. For this purpose, we chose the coordinate in 110^0 E -6^0 S located in the middle of Java Sea (see Figure 2). As general tendency, in the period before 1980 SST anomaly distribution is below averaged temperature or colder than the average. After 1980, the SST anomaly is above averaged temperature or warmer than the average. In the period of 1971-1980, the highest anomaly is 0.72 ^{0}C and it occurred in August 1973, and the lowest anomaly is -1.47 ^{0}C and it occurred in January 1976. While in the period of 1981-1990, the highest anomaly is 1.39 ^{0}C in March 1983 and the lowest anomaly is -1.02 ^{0}C in November 1982. In the period of 1990-2000, the highest anomaly is 1.82 ^{0}C in July 1998 and the lowest anomaly is -1.0 ^{0}C in June 1994.

c. Spatial Distribution of SST

Based on the analyses above, it shows that the highest monthly SST occurs in April and November, and the lowest monthly SST occurs in February and August. According to this description, SST monthly mean of February, April, August and November are chosen as the samples of spatial distribution for discussion.

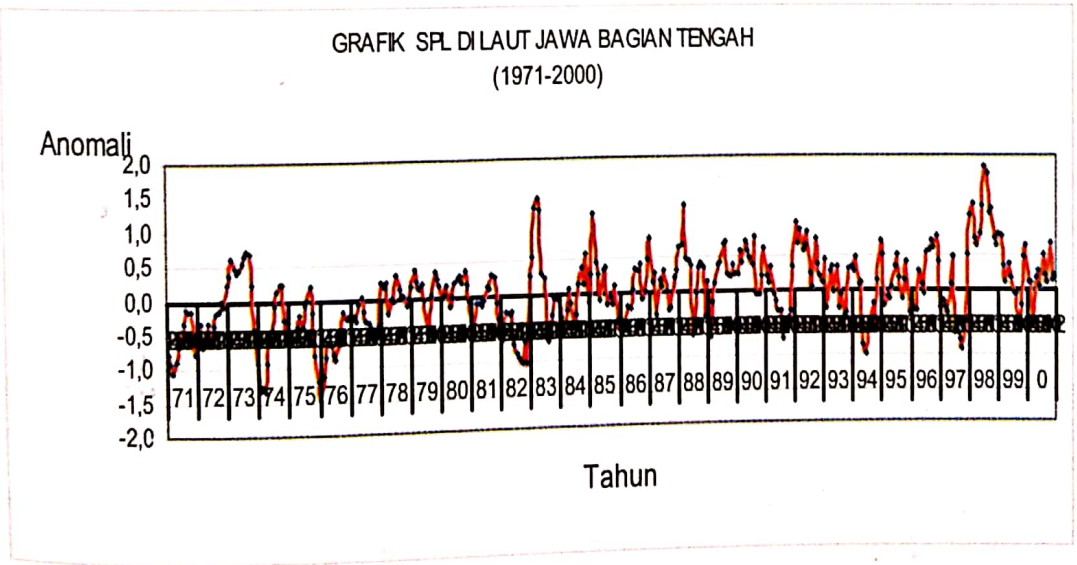

Fig. 2. SST Anomaly of Java Sea (monthly)

c.1. SST distribution of February

The first lowest temperature of SST temporal distribution appears in February, while the SST spatial distribution of Java sea spreads evenly with the temperature range from 28.2 ^{0}C to 28.8 ^{0}C. Water mass is relatively cold (28.2 ^{0}C) and distributed in the western part of Java Sea, where mainly at the north part is closed to South China Ocean. The water mass is warm (28.8 ^{0}C) and concentrated in the middle and western parts (see Figure 3).

c.2. SST distribution of May

The first highest temperature of temporal distribution of SST pattern appears in May, and SST spatial distribution of Java Sea spreads evenly between 28.6 ^{0}C to 29.8 ^{0}C. Water mass is relatively cold (28.6 ^{0}C) in the eastern and mainly in the south part, while water mass is hot (29.8 ^{0}C) in west and north part (see Figure 4).

c.3. SST distribution of August

Temporal distribution of SST pattern in Java Sea gets the second lowest temperature in August, and its SST spatial distribution also spreads evenly around range from 26.4 ^{0}C – 28.6 ^{0}C. Water mass is relatively cold (26.4 ^{0}C) distributed in eastern of Java Sea mainly, while the water mass is relatively warm (28.6 ^{0}C) concentrated in the west part (see Figure 5).

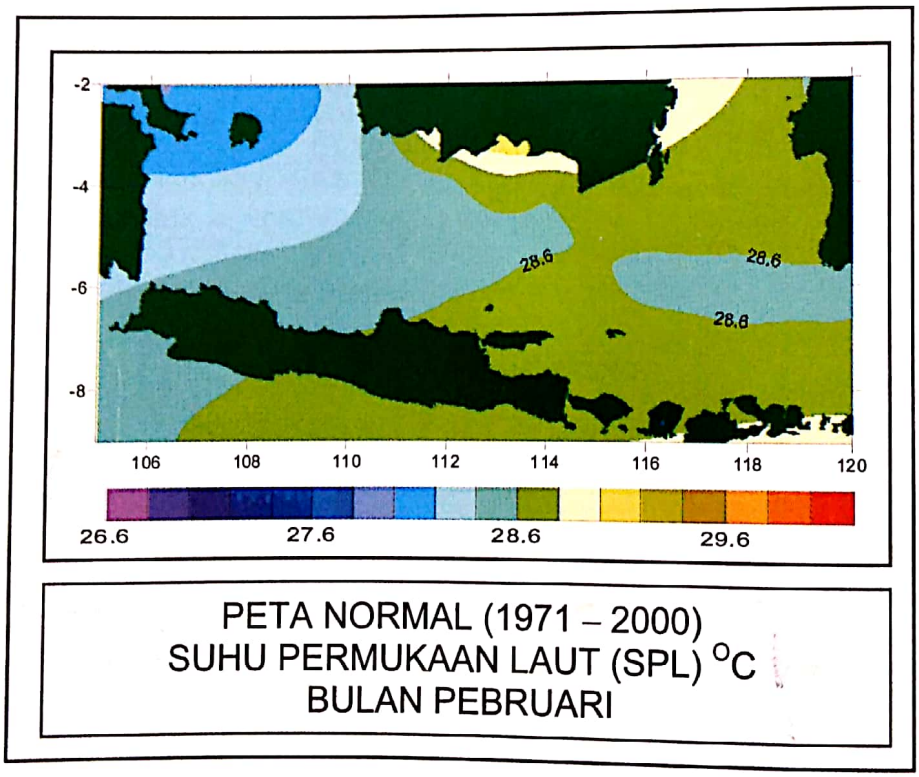

Fig. 3. SST Distribution of February

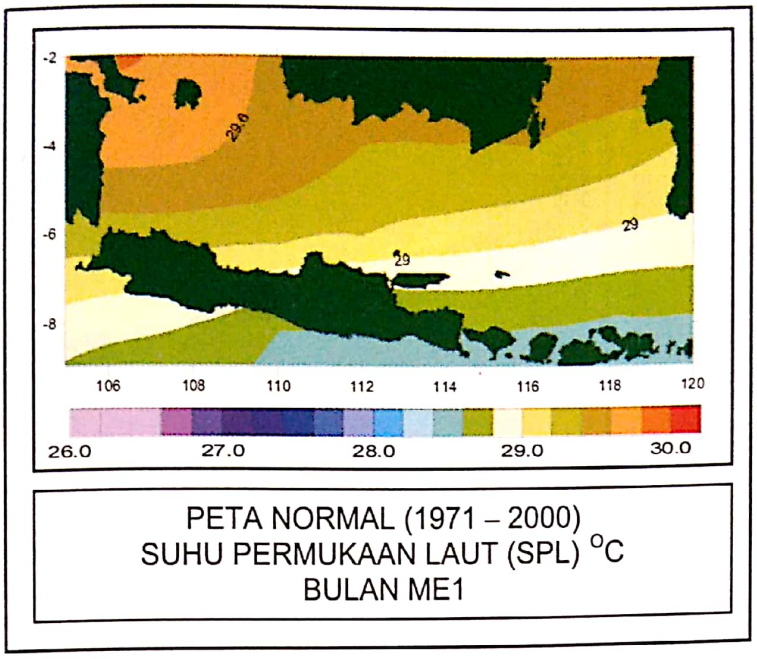

Fig. 4. SST Distribution of May

c.4. SST distribution of November

The second highest temperature of SST temporal distribution appears in November, whereas SST spatial distribution of Java Sea spreads evenly with ranges from 28.8 ^{0}C – 29 ^{0}C. Water mass is relatively cold (28.8 ^{0}C), spreading in western of Java Sea and mainly in the south part, while water mass is relatively warm (29.6 ^{0}C) concentrated in the eastern sea, and mainly in the north part (see Figure 6).

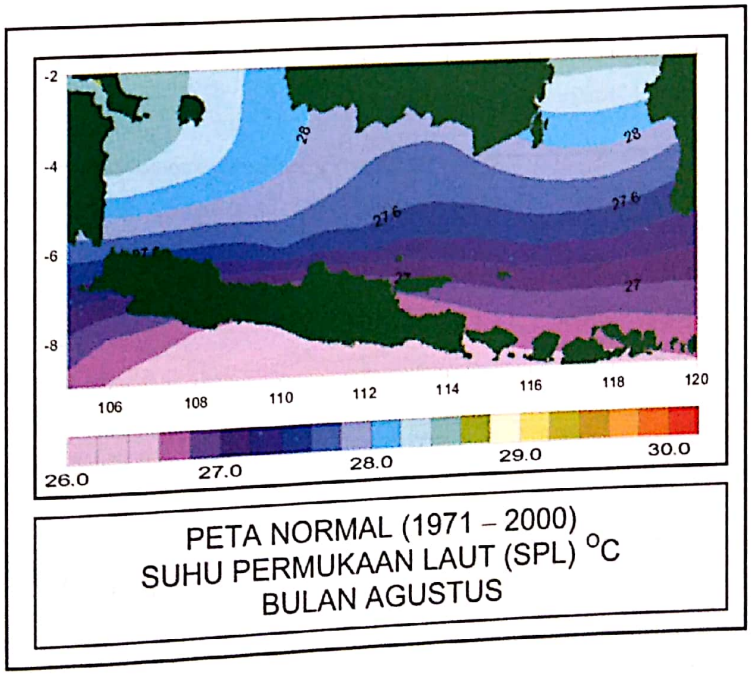

Fig. 5. SST Distribution of August

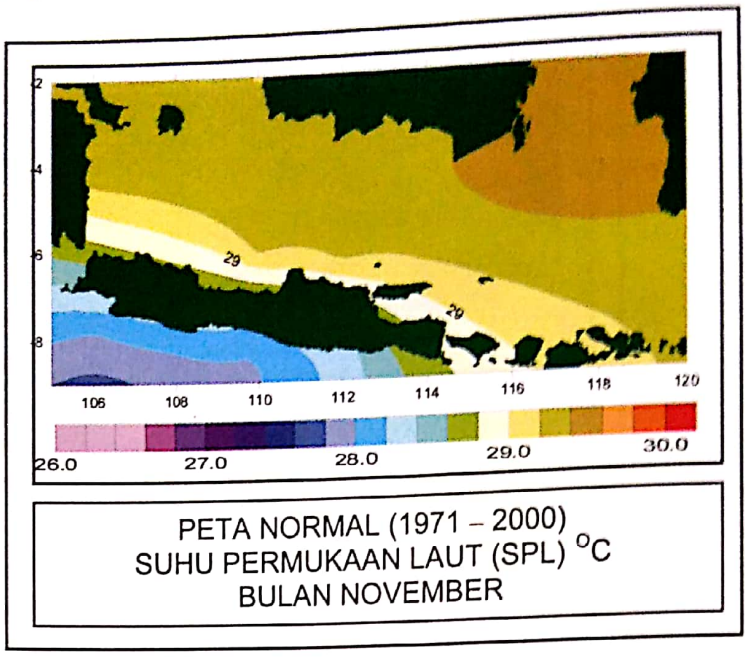

Fig. 6. SST Distribution of November

d. Spectrum Analysis

According to the result of spectrum analysis, it shows that the fluctuations of SST in Java Sea have a cycle of period for half year, 1 year (annual), and 8 years (interannual). In the western sea, the strong signal happens for 8 and 0.5 years cycle period, while the weak signal happens for 1 year cycle period (see Figure 7a). The highest spectrum appears for annual period at the middle and the western sea, whereas the lowest signal occurs in 0.5 and 8 years cycle period (see picture 7b and 7c). Generally Java Sea has seasonal, annual and interannual variations.

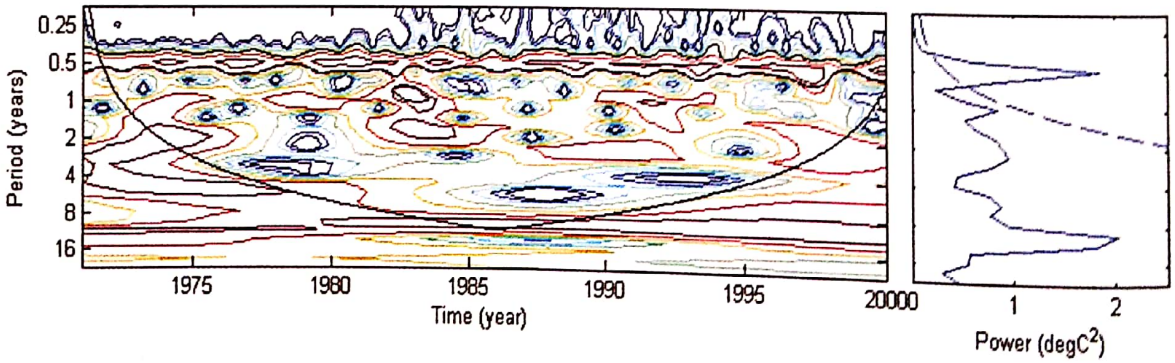

Fig. 7a. Spectrum Analysis of SST in Western of Java Sea

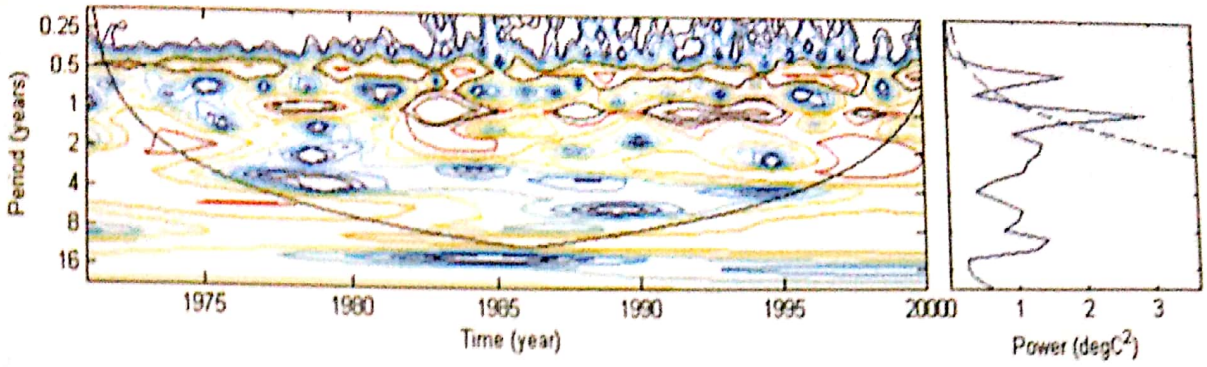

Fig. 7b. Spectrum Analysis of SST in centre of Java Sea

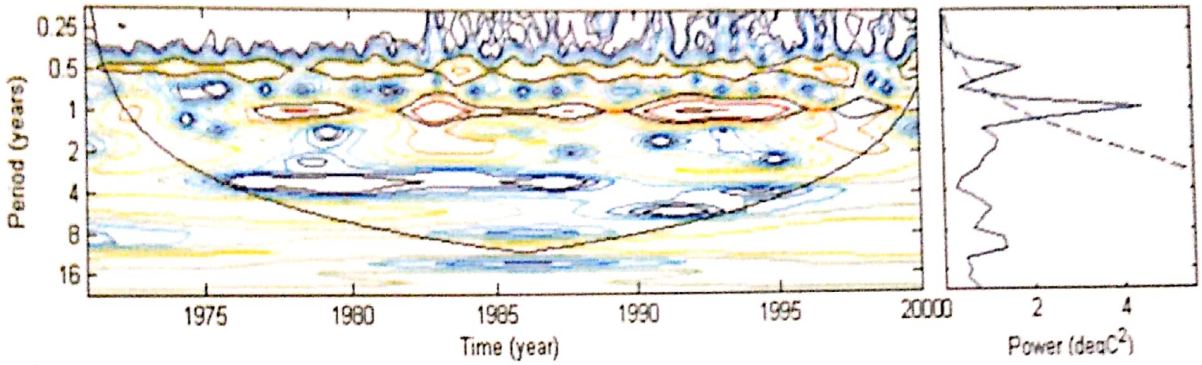

Fig. 7c. Spectrum Analysis of SST in eastern of Java Sea

IV. Discussion

Based on the description above, the SST monthly variation in certain area of Java Sea gets the highest temperature in April to May and November and the lowest temperature in February and August. Both of the highest and the lowest temperature occurred for two times. The SST cycle in Java Sea shows that the warm water mass oscillation depends on the position in the sun relative to the equator.

In March and September the position of sun is on above equator. T he furthest position in the southern hemisphere comes on January, and in the northern hemisphere comes on July. When sun leaves the equator, maximum SST happened in the next month, whereas the minimum SST occurs after sun arrives in furthest position. T he duration of time between those cycles is approximately for 6 months.

The SST variability in Java Sea is also influenced by the seasonal variability as a consequence of monsoon. The Asian Monsoon has a dominant influence to the variation of Indonesian sea SST (Qu *et al.*, 2005). The maritime continent of Indonesia is situated in a monsoon regime, with a major shift in wind direction between seasons, namely South East Monsoon and North West Monsoon. The South East Monsoon takes places from April to October, the wind blows from Australia continent and brings fresh water mass from the east. On the contrary, the North West Monsoon occurs in October to April (Susanto *et al.*, 2005). In this period

the wind blows from Asia continent, and fresh water mass comes from the South China sea to the Makassar Strait (Qu T. *et al.*, 2004 and 2005).

As the consequence of fresh water supply, the South East Monsoon period is followed by cold SST that covered Java Sea. The impact of South East Monsoon is obviously seen on the SST distribution in August. The cold water mass from Indonesia Sea around Australia comes through the Lombok Strait and the Bali Strait and spreads to the Karimata Strait.

The Java Sea becomes warm in the transition period that happened in April to May. Whereas the warm water is in north part and the cold water is in south part. The influence of North West Monsoon to SST distribution shows in February. T he cold water mass comes from the South China Sea and spreading up to north of the Bali Island. However around the Makasar Strait, there is fresh water mass supply coming from the Pacific Ocean through the Makasar Strait that is usually called ARLINDO (Indonesian Through Flow) (Susanto, 2005).

The variability of the marine climate in the Java Sea is not just influenced by monsoon, but also the following phenomena in the Indian and Pacific Ocean. The waters of eastern of Indian Ocean (near by Indonesia) is influenced by the Dipole Mode (Saji *et al.*, 1999), Webster *et al.* (1999), Martugude *et al.* (2000), J.L. Gaol (2004) and the interannual variation of SST in the Java Sea also influenced by ENSO (Susanto, 2006). It can be seen that the SST cycle periods of the Java Sea are seasonal, annual and also interannual variations (8 years). The interaction between monsoon, the Dipole Mode from Indian Ocean and ENSO from Pacific Ocean are not still understood.

IV. Conclusion

a. The characteristic of the SST distribution in the Java Sea is identified by the monthly mean fluctuation range from 27.48 ^{0}C to 29.66 ^{0}C. The SST variability in Java Sea shows seasonal, annual and interannual variation.

b. In the North West Monsoon period, the cold water mass is concentrated in the western part and warm water mass in the eastern part. While in the South East Monsoon period, inversely cold water mass is concentrated in the eastern and warm water mass in the western. In the transition period, the warm water mass distribution pattern is in the north part and the south part for cold.

c. The SST distribution of the Java Sea is the result of the interaction of a few phenomena as seasonal factor (monsoon), ARLINDO, El Nino/La Nina (come from the Pacific Ocean) and Dipole Mode (come from the Hindia Ocean).

d. Regarding to the regularity of the SST variability in Java Sea, this study needs to be continued for further understand of the respond of primary productivity to the SST variability. The result of this study is expected to help better understand to the fluctuation of fish production in the Java Sea.

Acknowledgement

This study is written in portion of doctoral program in Coastal Resources Management UNDIP Semarang. Author would like to appreciate to the support and encouragement by Professor Lamudin Syahrani, Professor S. Budi Prayitno and Dr Agus Hartoko. I also wish to thank

BMG for the recommendation, and my colleagues in BMG that have provided a great deal of input and much help for this study.

References

Aryana, I.N. 2005. The Assessment of Pelagic Fish Stock and Its Distributions in Indian Ocean By Split Beam Acoustic System. International Journal of Remote Sensing and Earth Sciences, Vol 2, September. Denpasar.

Blanc, J.L.L. and F. Mirsac. 1999. Climate Information and Prediction Services for Fishiers. Climar 99, WMO – NOAA – Eenvironment Canada. Canada.

Gaol, J.L., Wudianto, B.P. Pasaribu, D. Manurung, and Endriati. 2004. The Fluctuation of Chlorophyll A Concentration Derived from Satellite Imagery and Catch of Oily Sardine (Sardinella Lemuru) in Bali Strait. International of Journal Remote Sensing and Earth Sciences, Vol 1, September, IReSES. Denpasar

Gordon, A. 2005. Oceanography of the Indonesian Seas and Its Their Throughflow, Oceanography, Vol 18, No. 4. Dec.

Hartoko. A., N.R. Nganro, J. Rais, S. Mira, and J. Kahar. 2000. Aplikasi Inderaja Untuk Pemetaan Karakter Ekosistem Ikan Pelagis Besar di Utara Irian Jaya/Papua. Konperensi Nasional II Pengelolaan Sumber Daya Pesisir danLautan di Indonesia, Mei. Makasar.

Ilahude, A. 1999. Pengantar ke Oseanologi Fisika. Puslitbang Oseanologi LIPI. Jakarta.

Susanto, D. and J. Marra. 2005. Effect of the 97/98 El Nino on Chlorophyll a Variability Along the Souther Coast of Java and Sumatra. Oceanography, Vol 18, No. 4 Dec.

Susanto, D., I.I. Moore, S. Thomas, and J. Marra. 2006. Ocean Color Variability in the Indonesian Seas during the SeaWiFS Era. Electronic Journal of Earth Sciences, Vol 7, No. 5, May.

Widyaprasetya, G. 2000. Penentuan Daerah Ikan Pelagis Dengan Teknologi Inderaja di Perairan Natuna Laut Cina Selatan. Remote Sensing and Geographic Information System, Year Book 2000, BPPT, Jakarta.

Qu Tangdong, Du Yan, J. Strachan, G. Gary and J. Slingo. 2005. Sea Surface Temperature and Its Variability in The Indonesian Region, Oceanography, Vol 18, No. 4, Dec.