PROCEEDINGS

The Sixth Pan Ocean Remote Sensing Conference (PORSEC)

Bali, 3-6 September 2002

Remote Sensing and Ocean Science for Marine Resources Exploration and Environment

Vol. I

Editors

Bonar P. Pasaribu

Richardus Kaswadji

I Wayan Nurjaya

Jonson Lumban Gaol

Proceedings of the 6th Pan Ocean Remote Sensing Conference

Published by:
PORSEC 2002 Secretariat
Dept. of Marine Science and Technology
Bogor Agricultural University
Kampus IPB Darmaga
Bogor 16680, Indonesia

Agency for Marine and Fisheries Research,
Ministry of Marine Affairs and Fisheries
Jalan M.T. Haryono Kav. 52-53
Jakarta, Indonesia

Editorial Committee
Bonar P. Pasaribu
Richardus Kaswadji
I Wayan Nurjaya
Jonson Lumban Gaol

ISBN 979-493-091-1

Fish Catch Relative to Environmental Parameters Observed from Satellite during ENSO and Dipole Mode Events 1997/98 in the South Java Sea

J. LUMBAN GAOL[1], K. MAHAPATRA[2], Y. OKADA[3], B.P. PASARIBU[1], D. MANURUNG[1] & I W. NURJAYA[1]
[1]*Faculty of Fisheries and Marine Science, Bogor Agriculture University, Indonesia (jonsonl@lycos.com)*
[2]*Earth Weather INC., Shin-Yokohama, 222-0033 Japan*
[3]*School of Marine Science and Technology, Tokai University, 3-20-1 Orido Shimizu Shizuoka, 424-8610 Japan*

ABSTRACT

The investigation is aimed to clarify the influence of the El Niño Southern Oscillation (ENSO) and the Dipole Mode (DM) events to the spatio-temporal evolution of the sea surface temperature (SST) and Chlorophyll-a (Chl-a) as well as assessing of their impact to fish catchability. A time series of provincial monthly averaged of SST and Chl-a derived from satellite data, are used in this investigation. *Sardinella lemuru* (Lemuru) and tuna fish catch are obtained from the fishery statistic data report and the logbooks of ten fishing vessels operated in the south of Java seawaters. The SST indicated that the coolest period with maximum anomalies was observed during July-September 1997. Warmest period was during February-March 1998. It was occurred in Arafuru Sea and southeast off Lombok Strait (LS). The blooming of phytoplankton followed the coolest phase caused by upwelling at south of Java and southeast of Lombok Strait. The same condition was also observed on July-September 1999, but the scale and its quantity was different and smaller than on 1997. Monthly mean catch of Lemuru sharply increased during 1997-1998. The maximum of total catch and annual mean hook rate of tuna were highest during 1997 than 1998 and 1999. It seems have close correlation to the termocline layer in 1997, the depth of thermocline become shallower due to the DM-induced strong upwelling. Occurrence of thermal fronts around upwelling area might also have contributed to increase the fish catchability by providing suitable ambient temperature and feeding grounds for tuna.

Key words: El Niño , dipole mode, SST, Chlorophyll-a, satellite, Sardinella lemuru, tuna

INTRODUCTION

The eastern tropical Indian Ocean region off South Java Sea (4°S-16°S and 105°E-120°E) has long been considered as an important area for pelagic fisheries, especially tuna fisheries. The productivity of pelagic fisheries in this area are sustained through enhanced biological production due to seasonal coastal upwelling during the southeast (SE) monsoon (Wirtky, 1962, Purba, 1995). Geographically, the south of Java Sea is very unique because it is influenced by climatic phenomena such as El Niño Southern-Oscillation (ENSO) through the Indonesian throughflow (ITF). However, there is very little information about the impact of such phenomena on the marine living resources of that region.

Since 1982/83 the extraordinary ENSO occurred, the scientist's interest to its impacts on marine ecosystem rapid growth especially in Pacific Ocean. They conclude that climate variability was impact on community composition, species abundance and distribution, recruitment level, and tropics structure [*Arntz* and *Rarazona,* 1990; *Lehodey et al.,* 1997; *Kimura et al.*, 1997; Sanchez *et al.*, 2000; *Sugimoto et al.*, 2001; Gaol, et al., 2002].

The impact ENSO on the eastern of Indian Ocean on sea surface temperature, dynamic height and the 20° isotherm appears off Java coast and is strongest off the coast of Australia (Mayer, 1996). Meanwhile, the previous scientists reported recently discovered Dipole Mode (DM) events in the tropical Indian Ocean (*Behera, et al.*, 1999; Saji et al, 1999; Webster, et al., 1999). During this period occurred difference in SST anomaly between the tropical western Indian Ocean and the tropical south-eastern Indian Ocean. Cool SST anomalies first appear in the vicinity of the South Java coast by May-June, accompanied by moderate southeasterly wind anomalies in the southern tropical Indian ocean and than moves northwestward off Sumatra until September-October [*Webster et al.*, 1999; *Saji et al.*, 1999].

Our study focused on the inter-annual climate variability impact on small-scale area of South Java Sea. This study is aimed to understand of the influence of oceanographic conditions on Chl-a distribution and the fish catch in South Java Sea during 1997/98 ENSO and 1997 DM events.

DATA AND METHODS

The time series of weekly and monthly averaged near-surface Chl-a (1997-1999) were derived from the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS) and Ocean Color Temperature Scanner (OCTS) by SeaDAS 4.0 software. The time series of weekly and monthly averaged SST were derived from the Advanced Very High Resolution Radiometer (AVHRR) Pathfinder global data sets. Tuna fish catch data consisted of fishing position in latitude and longitude were acquired from the logbooks of the 10 long line fishing vessels operated south off Java for the corresponding period. Monthly Lemuru catch were obtained from the Fish Landing Statistic data. The study area was divided into two fishing ground areas (Fig .1): Lemuru fishing ground (LFG) and tuna fishing ground (TFG)

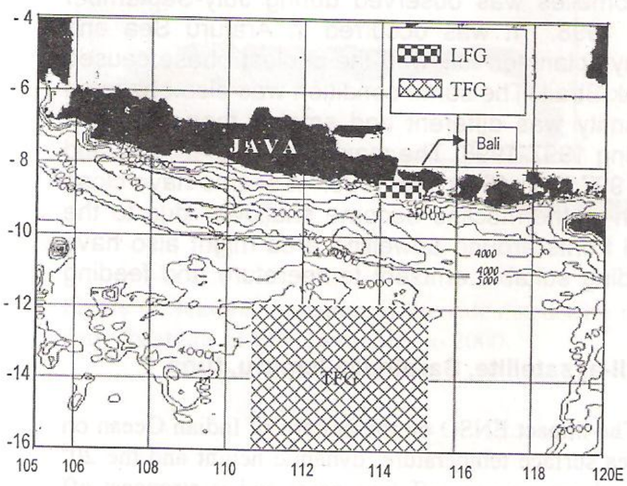


Fig 1. Location of study

RESULTS

Satellite-derived SST from NOAA-AVHRR for LFG and TFG covering DM and ENSO events 1997/98 is illustrated in Fig. 2c. The spatial distribution of SST shows that the cool water appears near coast of South Java Sea (Fig. 3). Seasonal variability of SST with markedly cool period from May to October can be attributed to impact of upwelling which generated by strong southwestward Ekman drift and wind stress due to southeast monsoon (*Qu et al*., 1996, *Susanto et al*., 2001). The warm period from November to April due to northeast monsoon and ITF which brings more warm water in to the South Java [*Qu et al.,* 1996].

Time series monthly mean Chl-a from October to December 1997-1999 for SFG is plotted in Fig. 2d During this period the seasonal high and low concentration in Chl-a occurs in August-November and December-Mach respectively. In this figure significant elevation in Chl-a concentration can be marked from September to October 1997. Maximum concentrations is 6.0 mg/m^3 observed in October 1997. Meanwhile, monthly mean chl-a concentration in TFG during 1997-1998 are relatively stable and chl-a concentration in TGF is lower than chl-a in LFG. The spatial distribution of Chl-a (1997-1999) is illustrated in Fig. 4

Time series monthly catch of Lemuru and monthly mean hook rate of tuna during 1997-1999 are plotted in Fig. 2e and 2f. Increases in Sardinelle lemuru catch during 1997-1998 can be attributed to high chl-a concentration started in September 1997. Annual mean tuna hook rate was 0.84, 0.78 and 0.57 during the year 1997, 1998 and 1999 respectively. The highest hook rate was occurred during upwelling season, particularly in 1997.

Satellite-derived SST and chl-a show that the favorable tuna fishing ground in South Java Sea was found near the thermal front and blue water (chl-a <0.3 mg m^{-3}) (Fig. 5). This result coincides with the previous study by *Laur et.al*, 1984. Thermal font formed by ITF, which bring warm watermass from Arafuru Sea to the South Java Sea.

DISCUSSION

The south Java Sea characterized by cool period during upwelling season as a result of southeast monsoon wind blows easterly or southeasterly. During the southeast monsoon SST is lower than during northwest monsoon. The negative SST anomalies computed from monthly average of 1987-99. It was noticed during cool period 1997, especially in LFG. This phenomenon attributed to the Indian Ocean DM impact when the strength of the zonal wind anomaly over the equator [*Saji et al.,* 1997]. Coincide with ENSO events in 1997/98 caused appearing of the SST anomalies from November 1997 to June 1998 in South Java Sea. The result agrees with the previous results that the Indonesian SST anomalies are closely related to the ENSO phenomenon [*Nicholls,* 1984; *Meyer*, 1996].

High concentration of Chl-a during September–December 1997 consistent with the oceanographic conditions anomalies. Their anomalous were also coincides with the Indian Ocean DM event. The starting formation of DM in the Indian Ocean was observed in June 1997 which was characterized by DM normalized anomaly > 1.5 (Fig. 2b) [*Saji et al.,* 1999]. Fig. 2d shows that high concentration of Chl-a observed when the Indian Ocean DM and strong upwelling phenomena. Well known that upwelling is a process of motion of water mass vertically from deep layer to surface layer. It normally brings cool ocean water enriched with high nutrient concentration to the sunlit upper mixed layer resulting stimulated

Fig 2a. SO index 1997-99

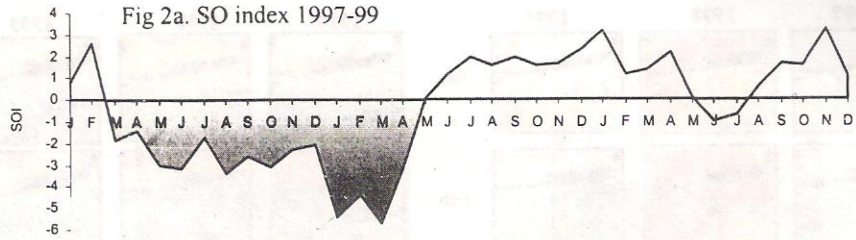


Fig 2b. IODM index 1997-99

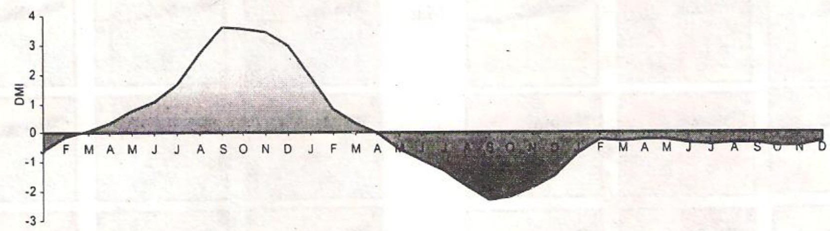


Fig 2c. Time series SST in LFG &TFG (1997-99)

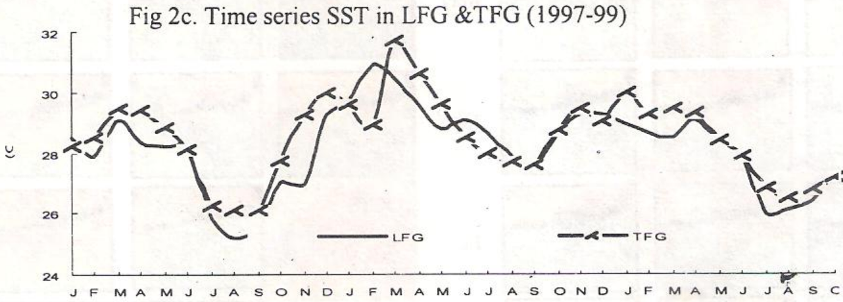


Fig 2d. Time series Chl-a in LFG and TFG (1997-99)

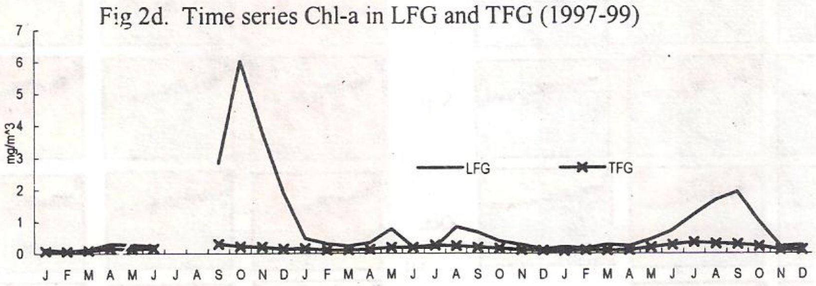


Fig 2e. Monthly *Sardinella Lemuru* catch (1997-99)

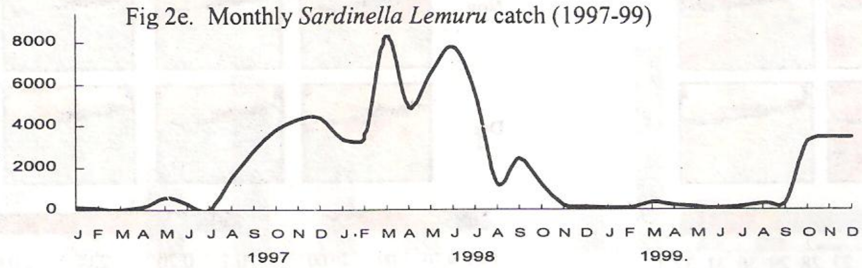
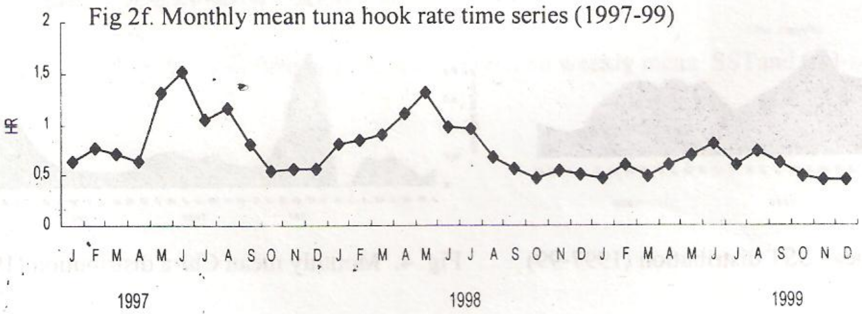


Fig 2f. Monthly mean tuna hook rate time series (1997-99)



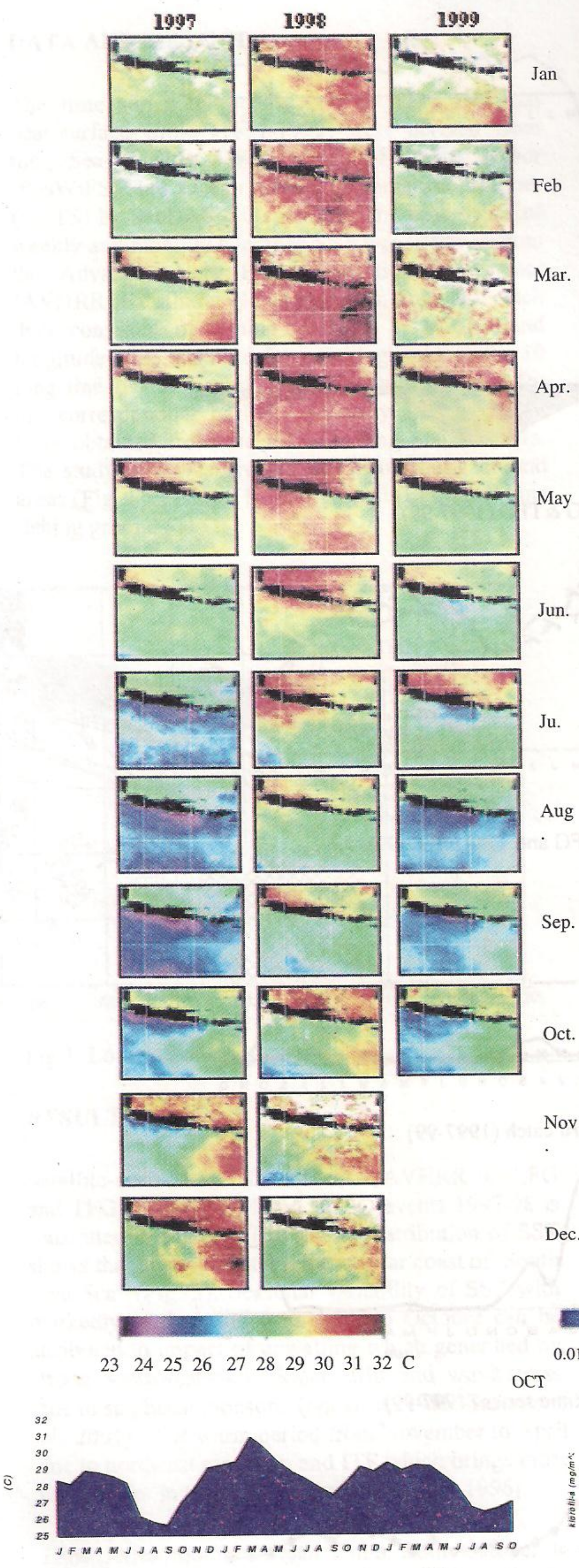


Fig. 3. Monthly mean SST distribution (1997-99)

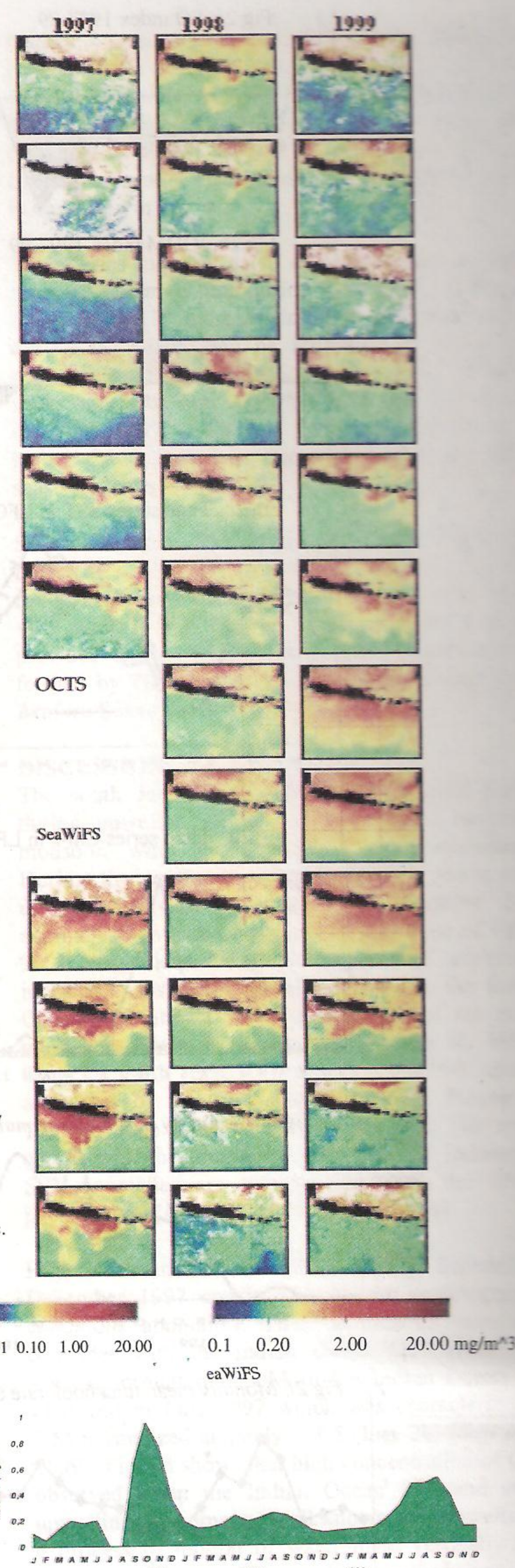


Fig. 4. Monthly mean Chl-a distribution (1997-99)

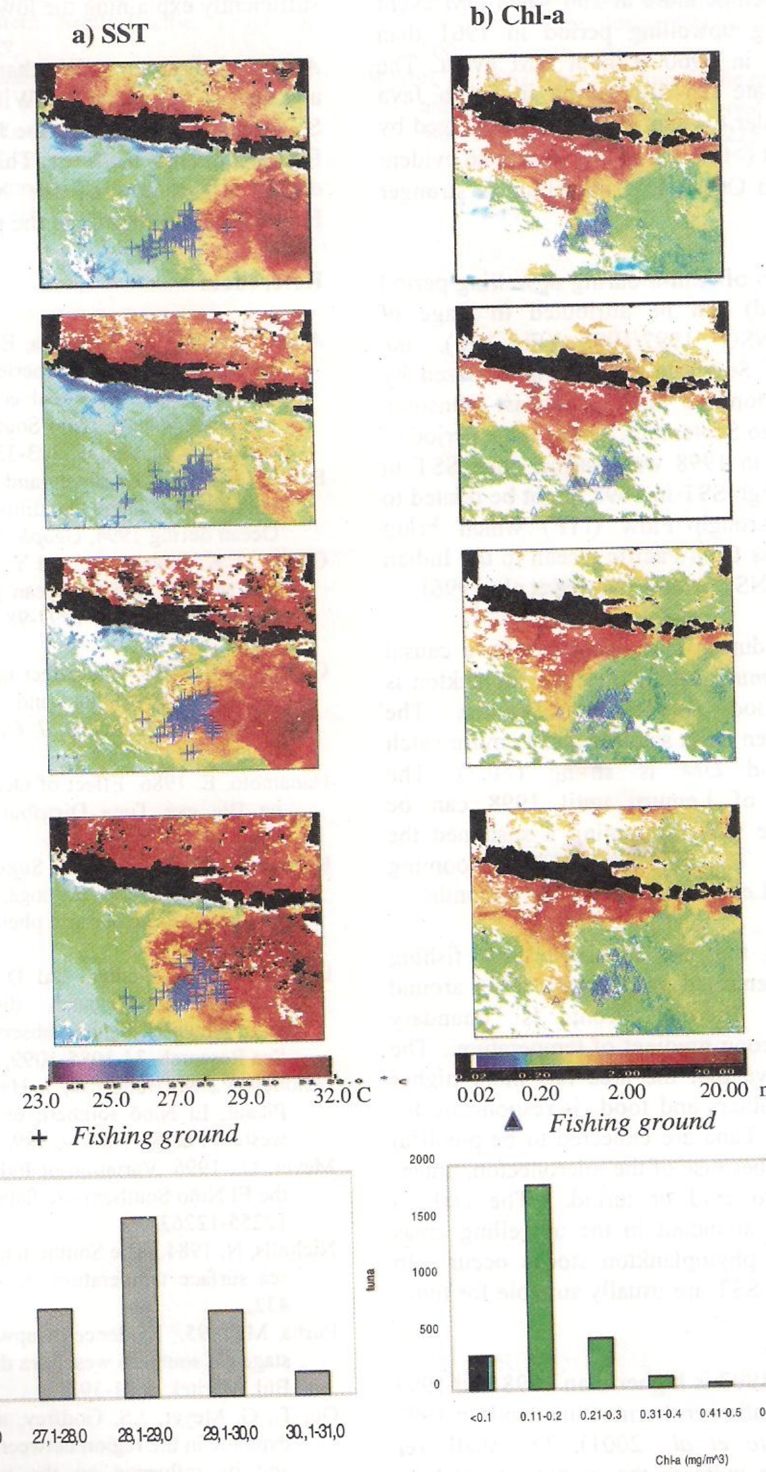


Fig. 5. Tuna fishing ground overlayed on weekly mean SSTand Chl-a

phytoplankton growth. The DM index or DMI (Saji et al., 1999) and isotherm at 200m (Wyrtki, 1962) show that water temperature at 200 when DM event was lower during upwelling period in 1961 than upwelling period in 1960 without DM event. The inorganic phosphate (P) distribution in South Java Sea was also similar to temperature characterized by high the P content (>0,7 • g-at P/l). It was an evident that during Indian Ocean DM upwelling is stronger than normal.

Low concentration of Chl-a during upwelling period of 1998 (Fig. 2d) can be attributed to stage of extraordinary ENSO 1997/1998 (Fig. 2a). the southern coast of South Java was characterized by low SST distribution due to the southeast monsoon, started from May to September. At the same period of welling, the SST in 1998 was warmer then SST in 1997 and 1999. High SST in 1998 might be related to the Indonesia Through Flow (ITF) which bring warmer water mass from Pacific Ocean to the Indian Ocean when the ENSO events [Meyer et al., 1996].

Increase in chl-a during DM event can be a causal factor for high *Lemuru* catch, since phytoplankton is an important food source for *Lemuru.* The relationship between chl-a satellite and Lemuru catch during the period DM is strong (>0.7). The abundance catch of Lemuru until 1998 can be explained, that the Chl-a blooming a sustained the stock of Lemuru. The time lag of Chl-a blooming and high catch of Lemuru are more than 6 months.

Our result shown that the favorable tuna fishing ground was concentrated in thermal front around upwelling area. Thermal front is boundary recognizable by strong gradient of temperature. The investigators believe that the area has more higher productivity than others and food is responsible for abundant of tuna. Tuna are expected to be plentiful in upwelling areas because of the micronecton, unless the waters are too cold or turbid. The crab, a herbivora, is most abundant in the upwelling areas where the highest phytoplankton stocks occur. In tropical upwelling, SST are usually suitable for tunas [*Sund et al.,* 1981]

Tuna hook rate in 1997 is higher than 1998 and 1999 can be related to shallower thermocline depth in 1997 (40-60 m) (*Susanto et al.*, 2001). The shallower thermocline will be increase the probability of long line gear to catch tuna fish because tuna distributions are influence by thermocline and mixed layer depth, due to suitable temperature for tuna. Optimum temperature ranges distributed for Big eye tuna are 10-15°C [*Hanamoto,* 1997]. The tuna longline gear is normally set between 100 and 250m. Therefore, tuna catch probability is the highest during upwelling period. Although a weak DM event in 1999 could cause moderate rise in phytoplankton production due to coastal upwelling, the thermocline could not rise sufficiently explaining the lower tuna catch.

Acknowledgements. We thank the SeaWiFS Project and the DAAC for the SeaWiFS data, and the JPL for SST data. We also thank the IORD, Tokai University for the research facilities. This work was undertaken during the tenure of the Matsumae International Foundation Fellowship to the principal author (JLG).

References

Arntz, W.F.,and J. Tarazona, Effects of El Niño 1982-83 on benthos, fish and fisheries off the South American Pacific Coast, *in* Global ecological consequences of the 1982-83 El Niño-Southern oscillation, *Elsvier Oceanogr. Series, 52*, 323-330, 1990.

Behera, S.K., R. Krishnan and T. Yamagata. Unusual ocean- atmosphere conditions in the tropical Indian Ocean during 1994, *Geoph. Res. Lett, 26,* 3001-3004.

Gaol, L.J, K. Mahapatra, and Y. Okada. 2002. Tuna catch and satellite derived ocean parameters in South Java Sea during Elnino 1997-98. *J. Fish. Sci. (accepted 2002).*

Godfrey, J.S. 1996. The effect of Indonesian throughflow on ocean circulation and heat exchange with the atmosphere: A review, *J. Geophys. Res., 101*, 12217-12237, .

Hanamoto, E. 1986. Effect of Oceanographic Environment on Big eye Tuna Distribution. Doctor Thesis. The Univ. of Tokyo.

Kimura, S., M. Nakai and T. Sugimoto. 1997. Migration of albacore, Thunnus alalunga, in the North Pacific in relation to large oceanic phenomena, *Fish. Oceanogr. 6*, 51-57,

Laur M.R, P.C. Fiedler, and D. R. Montgomery. 1984. Albacore tuna catch distributions relative to environmental features observed from satellites, Deep Sea Research, 31,1085-1099,

Lehodey, P., M. Bertignac, J. Hampton, A. Lewis, and J. Picaut, El Ninõ southern oscillation and tuna in the western Pacific, *Nature, 389*, 715-717, 1997.

Meyer, G.. 1996. Variation of Indonesian throughflow and the El Niño Southern oscillation, *J. Geophys. Res., 101*, 12255-12263,

Nicholls, N. 1984., The Southern oscillation and Indonesian sea surface temperature, *Mon. Wea. Rev., 112*, 424-432,

Purba, M. 1995. Evidence of upwelling and its generation stage off southern west Java during southeast monsoon. Bul. Maritek; 5:21-39.

Qu, T., G. Meyer, J.S. Godfrey, and D. Hu. 1994. Ocean dynamic in the region between Australia and Indonesia and its influence on the variation of sea surface temperature in a global general circulation model, *J. Geophys. Res., 99*, 18433-18455,

Sanchez, G., R. Calienes and S Zuta. 2000. The 1997-98 El Niño and its effects on the coastal marine ecosystem off Peru, *CalCOFI Rep., 41*, 62-86,

Saji, N.H., B.N. Goswani, P.N. Vinayachandran and T. Yamagata. 1999. A dipole in the tropical Indian Ocean, *Nature 4001*, 360-363, Sugimoto, T., S. Kimura, K. Tadakoro. 2001. Impact of El Niòo events and climate regime shift on living resources in the western North Pacific, *Progr. in Oceanogr., 49*, 113-127,

Sund, P.N., M. Blackburn and F. Williams, Tunas and their environment in the Pacific Ocean: A review, *Oceanogr. Mar. Biol. Ann. Rev., 19*, 443-512, 1981.

Susanto., R. D and A. L. Gordon. 2001. Upwelling along the coast of Java and Sumatra and its relation to ENSO. J. of Geophysical Research Letters, 28, 1599-1602.

Webster, P.J., A.M. Moore, J.P. Ioschningg, and R.R. Leben. 1999. Couple ocean-atmosphere dynamics in the Indian Ocean during 1997-98, *Nature, 401*, 356-360,

Wyrtki, K., 1962. The upwelling in the region between Java and Australia during the south-east monsoon, *Aust. J. Mar. Freshwater Res., 13*, 217-225.