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SPATIAL DATABASE FOR THE IMPACT OF GLOBAL WARMING AND CLIMATE CHANGES TO VULNERABLE FISHERIES RESOURCES AND ADAPTATION STRATEGIES

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ABSTRACT . *Analysis on 25 years data in Java sea since 1980 to 2008 had detected a significant Sea Surface Temperature (SST) positive anomaly which regarded as an impact of climate change in terms of ecological or oceanographical variables, had been coupled with an extreme seasonal changes of ocean wind, wave height, and tide-height. Some fishing port and fish landing places in Java reported in fish production and seasonal changes. The argument was that the seawater temperature (both SST and sub-surface) was assumed as one of the limiting factor for some small pelagic fish community structure, and some other species is known as seawater temperature conformer (poikilothermic species).*

The study was designed to develop an integrated Spatial Database System to detect and monitor the phenomena of global warming through the change on SST and sub-surface seawater temperature and its impact to oceanographic phenomena such as up-welling, El Nino, La Nina, 10D, and on the ecosystem phenomena such as on the seasonality on plankton and larval community, fish behavior and life cycles such as gonad maturation, spawning cycles, egg development, vertical and horizontal migratory behavior and ultimately its impact on the vulnerable marine fish resources. The fundamental concept and approach in the study is 'dynamic-mapping' based on time-series data and development of 'spatial multilayer ecosystem data interaction analysis' and identification of any specific of ecosystem character in each area, actual spatial distribution pattern. Time series data was built from NCEP, Landsat_TM, MODIS, ALOS satellite data and in situ vessel expeditions, TRITON buoy, ARGO float and others. Therafter to outline the grass-root strategy on adaptation for the climate change in the vulnerable fisheries sector is necessary, for sustainable use.

Some ambitious but important phenomena had been taken into account regarded with the vulnerable species were : benthic fish community in the shallow Java sea such as flat fish (Psettodidae); truly surface water plankton community and flying fish (Cypsilurus.sp); high migratory species in deepwater Thunnus.sp and Anguila.sp of North Sulawesi, south Java and west Sumatra Indian ocean; the living fossil of Caelacanth : Latimeria menadoensis off the north Sulawesi, Nautylus in Mollucas, Banda, Kangean islands, horse-shoe crab Limulus_sp, Loligo.sp, and Octopus in several coast of in Indonesia, turtle tracking. The ultimate use of the above approach would be to detect and comprehensive analysis on the ecological parameters interaction in order to understand the spatial character of the seawater as a an ecosystem, based on the digital layer of physical variable had been developed earlier sea surface and sub-surface seawater temperature, conductivity, salinity; chemical variables : pH, phosphate, nitrate, dissolved oxygen and biological variables : chlorophyll, phytoplankton, zooplankton and larvae (mostly fish and crustacean larvae) of shallow water Java sea, small pelagic or deepwater large pelagic refer to each special purposes.

Keywords: *spatial-database, climate-change, vulnerable, fisheries, adaptation-strategy*

1. INTRODUCTION

The increasing need to introduce and emphasis the analysis of SST and its sub-surface layers of deep water temperature (both horizontal and vertical) profile to analyze of some oceanographic phenomena such as up-welling process and its relationship to its seasonal variability and spatial distribution was inevitable. Especially to avoid the misleading interpretation of using only sea surface temperature data for deep water fish biomass distribution analysis, etc. Average daily SST east monsoon 1997 (El Nino event) was 28.46°C, where as presumably La Nina event 2002: the average daily SST was 29.75°C and for 2007 was : 29.83°C indicates a higher SST than both 1997 and 2002. Average daily SST of west monsoon 2007 was 29.69°C. Daily SST of 2007 east monsoon was about 0.08 - 0.5°C higher than same season of 2002 (TRITON Buoy data) (Hartoko, 2007). The paper analyze and revealed the fate / occurrence of up welling zone in adjacent of Halmahera islands as well as the Hot Event (HE) phenomena through the analysis based on multi-layer and sub-surface horizontal of both horizontal and vertical temperature of the field measurement 1997 and 2002 and 2007 TRITON data. Spatial multi-depth-layer seawater temperature approach has been developed in the paper is important to detect its impact and analysis of deep water large pelagic fishery such as tuna fishery and its seasonal spatial distribution pattern (Hartoko, 2009; Hartoko, 2010a).

The paper would also specially analyze and discuss the sub-surface of horizontal temperature profile, which is not yet known and not developed yet to this matter before. The study was the first ever attempt in fisheries oceanography sciences to explore the empiric correlation between the spatial distribution of tuna (Thunnus.sp) and sub-surface in-situ temperature data. By means of optimalization and use of an in-situ data of both vertical and horizontal which will be processed into a multilayer subsurface seawater temperature of ARGO Float in Indian ocean. So far only sea surface temperature (with temperature around 29 °C) data were used to look for the correlation for tuna spatial distribution, while the Thunnus.sp swimming layer as widely known is in about 80 — 250m depth with seawater temperature between 15 — 23 °C. The noble character of ARGO Float data is as in-situ data recorded directly by the sensors, transmitted to the satellite, transmitted to the ground station and ready to be used by researcher all over the world.

The important of the paper is that first effort ever to elaborate and discuss a the possible real impact of global warming or climate change in term of sea surface temperature changes to endemic and vulnerable marine species in a tropical country such as Indonesia. As an example such as the spatial variations of benthic fishery resources, which is so far is very limited up to this day. Two important characters of benthic fishery, is firstly that they are sensitive to environmental changes due to their limited movement or sessile ness; secondly is the close relationship of benthic organisms to its bottom texture and character. In other perspective, these two characters can be used to monitor both the impact and dynamic responses of the benthic community due to environmental changes, such as seawater pollution, global changes, climate changes such as seawater temperature anomalies, sea level rise, etc. The group of benthic fishery and regarded as vulnerable species such as flat-fish (Psettodidae), mollusca: Loligo.sp, Sephia.sp and Octopus which is believed as the most vulnerable coastal/ shallow fisheries resources which would be such important database for the adaptation strategy due to climate change, especially to seawater anomaly and for the benthic and coastal fishery management in the future.

2. METODOLOGY

In-situ data of 1997 — 2009 was a part of Fish Stock Assessment Expedition by RV. Baruna Jaya IV (BPPT) Length Over All : 60.4m; 1200GT, June — August 1997 off the North of Papua, south Java and west Sumatra Indian ocean and some other Indonesian seas had been collected. Both horizontal (surface water) and vertical temperature data was measured using CTD with 0.01 degree Celsius accuracy. GPS coordinate recorded every 6 minute interval. Design of survey track was `U' parallel grid track ranged from 120 - 240 mile off the North of Papua 60 interval between the main-leg, with total length of 3375 mile survey track (Johannesson and Mitson (1982) and MacLennan and Simonds (1992) in Nugroho *et.al* (1996). Field CTD data were processed using `Kriging' method using Er-Mapper software (licensed user). Analysis of horizontal temperature data approached with a multi-layer spatial analysis method hab been developed earlier (Hartoko, et all. 2000a, 2000b, Hartoko and M Helmi, 2004).

TRITON *(Triangle Trans-Ocean buoy Network)* was a series of oceanographic buoy built and set on the ocean by JAMSTEC *(Japan Agency for Marine-Earth Science and Technology)*, used to measure marine meteorological and ocean surface parameters in order to monitor ENSO phenomena *(El Nino-Southern Oscillation)*. Parameters measured by TRITON are wind speed, air temperature, humidity, rain precipitation, short wave solar radiation, sea surface temperature, current and water salinity. Specialy for sea water temperature were also measured vertically to the depth of 500m. Measured data which was recorded in the sensor of TRITON then transmitted to satellite and distributed to researcher all over the world. There were at least about 18 TRITON buoy had been deployed by JAMSTEC on the west Pacific ocean and east Indian ocean. Sea water temperature data of the TRITON buoy was split into two parts, that is daily and hour data, for daily data was sampled at every 09.00 in the morning East Indonesian time (about 00.00 UTC). The 2002 and 2007 in-situ data of sea surface and vertical temperature of the sea water were measured by TRITON buoy using Conductivity, Temperature and Depth (CTD) thermometer sensor of MicroCAT, SBE37-IM attached underwater at the depth of 1 meter up to 500 meter. This thermometer sensor using Titanium for the sea water temperature measurement manufactured by *Sea Bird Electronic* with temperature accuracy of 0,002 °. SST ARGO Float, physically there were four cylinder floating on the water surface that is data processing, data transmitter ARGOS *(Array for Geostrophic Oceanography System)*, and two units of batery. Surface meteorological data transfered into the data processing and stored internally. Deep water data were transmited from each sensors in the data processors with magnetic induction method by a telegrapgic wire in the water. Water temperature data that transmitted by ARGOS were stored in ASCII data package that later downloaded and processed with Windows operations.

The fundamental scientific concept to be applied in the study is *Dynamic Mapping,* that is building spatial database of variabel data based on *spatial-temporal,* according to seasonal pattern (east and west season) and exploring any specific ecosystem variabels as well as spectral specific (Hartoko, 2000a; Hartoko and M.Helmi, 2004). Other data used in the study are : (1) Actual Thunnus.sp catch specifieid to the east and west season from PT. PSB Benoa, Bali in Indian ocean, year 2007; (2) Sea surface and 80m, 100m, 150 m and 200 m temperature of *Argo Float* data in Indian ocean *coverege area* antara 8° — 18° S and 100° — 118° E. (A) Argo Float Data, was processed using Hartoko procedure (Hartoko, A *.2010a,).* Software used in the study are : ER.Mapper 6.4 to built horizontal sub-surface seawater temperature layer with Kriging method (spatial interpolation method). WinRar and *Ocean Data View* (ODV) 4.1.3 Software to exctract seawater temperature data of *Argo Float.* (a). Data downloaded from Argo Data Center (GODAE *Webserver);* (b). Data Extraction, using WinRar software; Extracted data then opened, read and displayed using ODV *(Ocean Data View)* software and then saved in *a* ".txt" file format; and finally opened using Microsoft Excel *software* in a table format. Followed by *Kriging* steps in ER Mapper *software* in order to convert from points (coordinates) into a spatial layer data. (B). Actual Thunnus.sp catch data. The actual Thunnus.sp catch data was compilled from *Log-book* of each Tuna fishing vessels from PT. PSB Benoa, Bali and splitted into two season, that is the east season (April - November) and west season (December - March) in a tabel format in a Microsoft Excel, then saved into a .txt format file for the input process in the Kriging of Er-Mapper *software.* Fishing gear used is *Deepsea Tuna Long Liner.* In standard form, each Long Line unit consist of 15 main long line and 14 hook-eye, 1 float and 1 float-rope. Curve coeficient of the tuna long-line was set 0,70 and thus the distance of one float to the next is : 0,70 x 15 x 50 m = 525 m, and the hook reach to the depth between 85 m up to 277 m.

Study area for benthic/ demersal fishery resources is the North coast of Semarang, central Java. Measurement of research variables such seawater depth using a Garmin echo-sounder. Salinity was measured in-situ using HORIBA Water Quality Checker. Samples of bottom substrate collected using 5 kg Grab and samples of demersal shrimp using a local

fisherman bottom net on board of local fisherman boat 15- GT during the study completed with a GPS station coordinates recorded simultaneously (latitude and longitude). About 22 stations of field data and samples were collected. First step in building a digital layer for the ecosystem model was transferring 'geodetic/ position data (degree; minute; second / D° M' S") of latitude and longitude data into a single-numerical value with a formula of (Hartoko and Helmi,2004).

3. RESULT AND DISCUSSION

Hartoko (2000a. 2000b.2004) had analyze and revealed the fate or occurrence of up welling zone in adjacent of Halmahera islands based on the analysis of both multi-layer horizontal and vertical temperature profile as indicated on Fig 1 and Fig 2. Where the water mass with temperature of 27 °C from depth of 80 — 100m from the North Papua flows vertically onto the surface layer at the up-welling zone at corridor between Halmahera island and West Papua peninsula (Hartoko,2000a; 2007). The most relevant data was offered by the study of Kuroda *et.al* (1995) 'for the occurrence of North Guinea Coastal Under Current (NGCUC), but its effect to the development process of up welling at north Papua waters adjacent of Halmahera islands was not known yet since. As performed on the SST 1997 was clearly indicated the occurrence of high sea water temperature which was later recognized as Hot Event (HE) by Kawamura et al (2008), where in that special condition of HE regularly generates the sharp gradient of daytime vertical temperature profile in the near-surface layer (i.e. warm layer). Another supporting information as recorded SST from December 1996 to June 1997 indicates the flow of hot water from the west of Peru flows along the equator to the north off Papua (west end Pacific) on global SST released by TOPEX Poseidon Jet Propulsion Lab (NASA,1997). This hot water mass contribute to 1°C SST increase/ anomaly.

In line to the above case Gordon (2005) confirmed that large scale of Indonesian Through Flow (ITF) was *the* flow of Pacific water along *the* equator westward into the Indian ocean via the Indonesian seas, with primary ITF portals flow westward along the north coast of Papua. Especially passes through Halmahera — Papua corridor later known as South Pacific inflow or South Pacific thermocline where it first up well into the surface layer before spreading southward within the surface Ekman layer, as revealed above. Analysis on in-situ sea water temperature derived from TRITON buoy data at La Nina event 2002 : the average daily SST at east monsoon (July — November 2002) was 29.75°C, with temperature range from 28.3 - 31.3 T. Furthermore. with a multi-layer special analysis method had revealed and it was clearly detected that HE not only on the SST but also as well as its subsurface layers at the depth of 50m. 100m, I 50m, flowing along the coast, with high sea water temperature range from 29 — 30.5 °C during east monsoon 2002 as in Fig 3 and during the west and east monsoon 2007 as in Fig 4. Average sea surface temperature in 2007 was : 29.83°C indicates higher SST than both SST of 1997 and 2002 (Fig.5). Average daily SST of west monsoon 2007 (December 2006, January and February 2007) was 29.69°C as in Fig 6 and 7. Where daily SST of 2007 east monsoon (July — September 2007) were about 0.08 - 0.5°C higher than same season of 2002 (TRITON Buoy data).

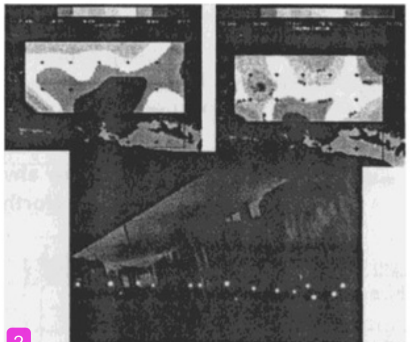


Figure 1. Sea surface temperature and sub-surface temperature at depth of 80m, east-onsoon 1997 (EI-Nino event). Field measurement. BARUNA JAYA IV Expedition. (Arrow always point to North).

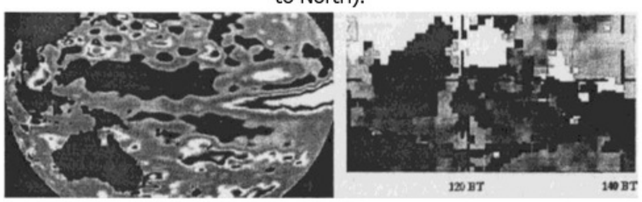


Figure 2. Hot sea water flows and SST anomaly on Global SST released by TOPEX Poseidon Jet Propulsion Lab (NASA,1997).

Figure 1. Sea surface and sub-surface temperature, at depth of 50m, 100m,150m east-monsoon 2002 (La Nina event), Triton Buoy data. (Arrow always point to North).

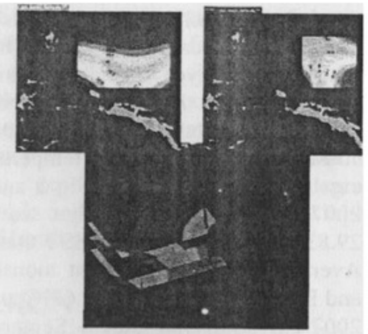


Figure 4. Sea surface temperature at West-monsoon (above) and East-monsoon 2007 (below). Triton Buoy data, sub-surface temperature at depth 50m,100m and 150m, East-monsoon 2007. Triton Buoy Data (Arrow always point to North.)

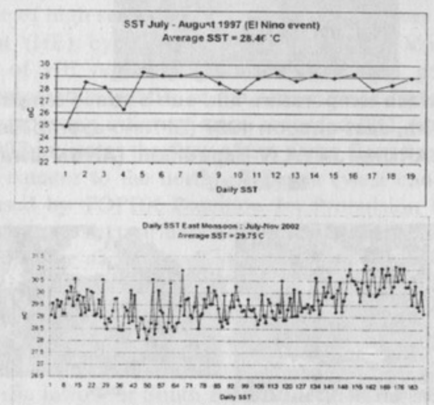


Figure-5 : East monsoon SST (July – August 1997) North Papua, field data measurement CTD – RV.BARUNA JAYA IV and East monsoon SST (July – November 2002) North Papua, TRITON data.

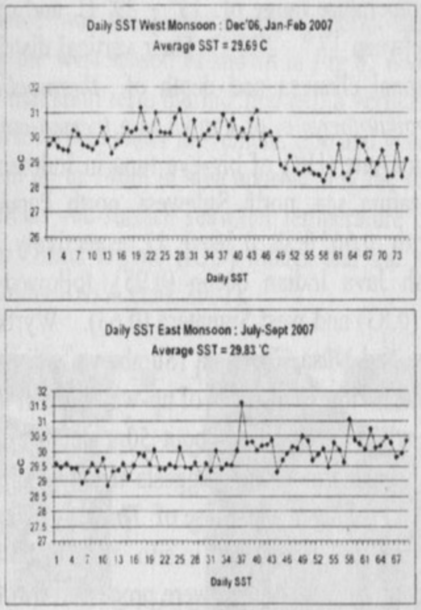


Figure-6 : West monsoon SST (Dec '06, Jan – Feb 07) and East monsoon SST (July - September 2007) North Papua, TRITON data

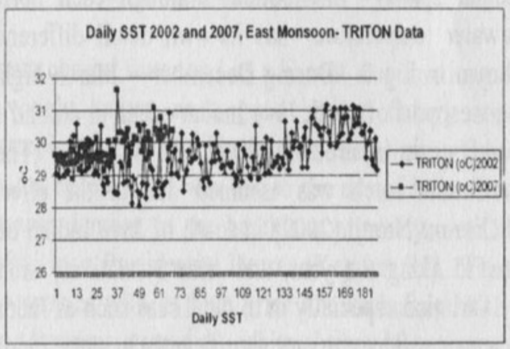


Figure-7 : Average daily SST of east-monsoon 2002 and 2007 (TRITON data)

Several tuna belongs to the Family of Scombridae are *Thunnus alalunga* (Albacore), *Thunnus albacores* (Yellowfin tuna), *Thunnus macoyii* (Southtern Bluefin tuna), *Thunnus obesus* (Big eye tuna) and *Thunnus tongkol* (Longtail tuna). Unlike with other fish species that has a whitish flesh meat color, the group of Thunnus.sp has a reddish flesh meat color, this is since tuna flesh meat has more myoglobine content. Tuna as widely known as a fast swimming fish and a highly migratory species. Hayes and Laevastu, 1970; Marpaung (2001) explained that big-eye tuna can be found in both tropical and sub-tropical waters such as in Atlantic, Indian and Pacific ocean. These species enjoy very much in seawater temperature range of 18" — 29° C, and optimum seawater temperature between 17 ° - 22 " C. Their vertical distribution may vary due to a seasonal changes and depth of *thermocline layer*. They belongs to a *poikilothermic* or known as a *thereto-conformer* group of fish. High hook-rate (HR) of big-eye tuna in Indonesia was found in Banda and Arafura sea, north Sulawesi. north Papua, Mollucas and Tomini bay with 0.66; 0.58; 0.56; 0. 41 respectively. Highest HR was found in south Java Indian ocean (0.95), followed by south BaliNusatenggara (0.83) and west Sumatera (0.63). Wyrtki (1961) suggest that south Java and Nusa Tenggara (Sumbawa - Timor) known as the up-welling zone. With occurrence of up-welling will increase the depth of the thermocline layer up to about 50m depth approaching to the surface water. Furthermore, he suggests that the HR of big-eye tuna *(Thunnus obesus)* is bigger than those of *Thunnus albacares*.

Spatial horizontal sub-surface in-situ data of both tuna catch and ARGO Float data in Indian ocean were processed from 216 coordinates and focused into four main seawater temperature layer depth, that are 80m, 100m, 150m and 200m depth. Sub-surface in-situ seawater temperature at those depth was assumed as the more associated with tuna horizontal spatial distribution, although each horizontal sub-surface seawater temperature has its own detail differences in each depth as shown in Fig 8. During December — March high tuna catch move to the west part of south Java Indian ocean at around 15.5° S and 115.5° E and some in around 14° S and 114° E. The westward movement of tuna catch was assumed due to the effect of *South Equatorial Current* Nontji (2002) in south of Java Indian ocean, which move westward along the year, and with a relatively small seawater temperature variation especially in tropical seas such as Indonesian seas.

Horizontal seawater may not vary significantly in some Indonesian seas, especially those surface *isothermal* zone on the surface water was generally parallel with the earth latitude, where area in the same altitude will have a similar sun light radiation. Hartoko, et al. (2000a); Hartoko,A. (2007); Hartoko,A. (2009) and result of this study (as in Fig 8) revealed that vertical seawater distribution in Indonesia was basically can be classified into three main seawater layer, that are the warm *homogenous layer* near to the surface layer up to 80m to 100m with seawater temperature about 28 °C; the thermocline *(discontinuity layer)* in the middle column of water where seawater temperature decrease extremely from 20 °C to 10 °C in the depth range of 200 m — 300m; and the cool *deep layer* below 300m depth, usually with seawater temperature below 10 °C and seawater temperature decrease gently less than 5 °C in depth below 1000m or deeper. Important finding from this is that there was the increase of the thermocline layer depth happened during the west season as shown in Fig 8. Wyrtky (1961 and 2005) explained that short term thermocline depth vertical variation was itirected by the sea surface water movement, tide and water current, in a depth from 120 m up to 140m in area approaching the south equatorial current. As well as sub-surface seawater temperature changes as the flied of Indian Ocean Dipole (IOD) modes and the role of Rossby waves (Suryachandra Rao A.et.al. 2001).

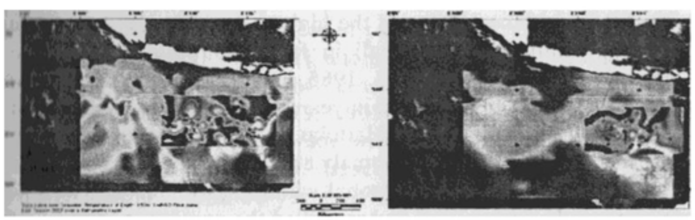


Figure 8. Overlay of Thunnus.sp actual catch on seawater temperature in depth of 150m during east season 2007 (left) and during west season 2007 (right)

Semarang coastal water and its adjacent area in a long time before 1981 was widely known as a good shrimp fishery zone, until it decreased sharply after 1985. The phenomenal shrimp fishery with its over production before 1981 was due to the use of bottom trawl, which cause a massive damage to the benthic community, until it is totally banned in 1981 by a Presidential Decree (Keppres 81). There are three main shrimp species with its high price known before 1981 period are tiger shrimp *(Penaeus monodon)*, white shrimp *(Penaeus merguiensis)* and Metapenaeid. In this study, only two species of shrimp were found during the field sampling, that is white shrimp *(Penaeus merguiensis)* and Metapenaeid. The spatial distribution of the total shrimp, Penaeid, Metapenaeid, dominant silt substrate and salinity of the seawater as shown in Fig 9 as in Hartoko and P. Wibowo (in press, 2011)

Climate change - Variability of 30 years Sea Surface Temperature of the Java sea. The importance of sea surface temperature (SST) is the role of SST as the interface from the atmospheric to the oceanographic environment. Based on three coordinate (represent the west, central and east region) 30 years data recorded from 1971 - 2000 the range of SST in Java sea is 27,48 °C - 29,66 °C. There were two cycles of low (February and August) and high (May and November) SST in avearage during 30 years period 1971 -2000. During the periode before 1980, the anomaly of SST was in general below normal, or cooler than its average value. The important evidence had been discovered that after 1980 indicates an SST anomaly above normal, or above its average. This means that the SST of the Java sea was tends to increase after 1980. The highest SST anomaly during periode of 1971 - 1980 is 0,72 °C happened in August 1973 and lowest -1,47 °C in January 1976. While during the periode of 1981 — 1990 the highest SST anomaly is 1,39 °C (almost double than befor 1980 period) in March 1983 and lowest is -1,02 °C in November 1982. In the periode of 1990 — 2000 lowest is -1,0 °C in June 1994, and the highest deviation is 1.82 °C in July 1998. A positive SST anomali in Java sea (more warm) were significant in year of : 1973, 1983, 1985, 1988 and 1998. A negatif SST anomaly (cooler) had happened in year of : 1974, 1976. 1982. 1994 and 1997 (Widada.S.et al. 2007a: Hartoko.A and W Sulistya. 2010a). Based on the SST variability and anomaly analysis as above for 30 years periode (1971 — 2000), beside a seasonal variability (regular) as well as interannual (irregular variability) had revealled the consistant increase of 0,7 °C for 30 years. This persistant seawater temperature increase was assumed as the effect of global ocean phenomena known as *global warming*. Based on small scale fishery resources point of view, SST anomaly of 0.5 °C (positive and negative) is still tolerable, which is actually happened until 1980 (Fig 10 and 11). SST anomaly up to 2.0 °C and could be more in the future is regarded would be harmfull for small scale fishery resources.

That is related to the temperatuare tolerance and survival of microbial. planktonic. larvae, and fish biomass. and the extreme SST anomaly which had happened since 1980 — 2000 (Hartoko,A dan W.Sulistya (2010b). Swarinoto and Kartiningsih Y (2007), in the periode of 1971 — 2000 the event of El Nino had happened in year

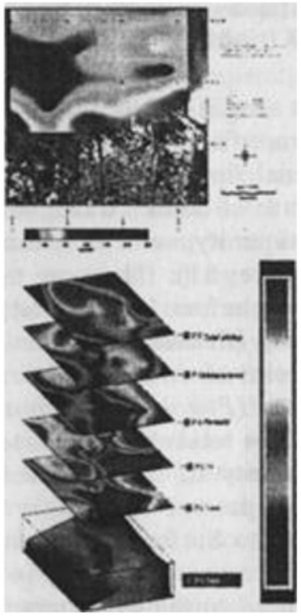
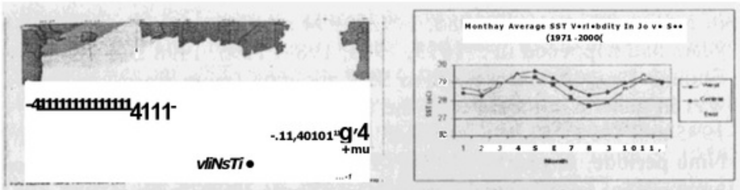


Figure 9. Spatial distribution of the coastal benthic shrimp (above) and multi-layer of research variables (below)

of : 1972, 1974, 1982. 1986. 1992. 1994 and 1997. While the La Nina years had happened in : 1973. 1975, 1988, 1995, 1998 and 1999. This findings suggest that a positive SST anomaly (more warm) in Java sea wus in general coincide with the event of La Nina periode, in : 1973, 1995 and 1998. While a negative (cooler), surprisingly coincide with El Nino periode, in year of : 1974, 1982, 1986, 1994 and 1997. Based on a more global ocean phenomea such as *Dipole Mode Index* (DMI) data in the periode of 1971 — 2000, indicates that a positive DMI had happened in year of : 1972, 1974, 1977, 1982, 1986, 1991, 1994, 1997 and 1999. Negative DMI periode in year of : 1971, 1975, 1983, 1984, 1989, 1992. 1995, 1996 and 1998. SST anomaly of the Java sea shows a positive deviation (more warm) that coincide with the negative DMI had happened in year of : 1973, 1995 and 1998. While a negative SST anomaly (cooler) was coincide with a positive DM1 event in year of : 1972, 1982, 1994 and 1997. Based on the SST variability and anomaly analysis as above for 30 years periode (1971 — 2000), beside a seasonal variability (regular) as well as interannual (irregular variability) had revealled the consistant increase with 0,7 °C for 30 years. During the winter periode in Asia, a warm seawater inflow from South China sea towards Java sea. The effect of this water mass spread over to the strait of Makassar also in the north of Lombok island in February. On other perspective there is also a seawater input flows into strati of Makasar from Pacific ocean which is called *Indonesia Through Flow* (Susanto, D and J Marra, 2005). During the east monsoon a cooler seawater mass flows from the north of Australia ark; Indian Ocean into the Java sea, especially during Agustus. This cool seawater mass flows into Java sea through Lombok and Bali strait and spread over to the north in Karimata strait. The phenomena was also reflected with the surface water current during the west and east monsoon (Wyrtky, 1961 and 2005Susanto D and J Marra, (2005) postulated that interannual variation of SST in Indonesia was also affected by ENSO. This was reflected in the periodic cycles of SST in the Java sea, beside a seasonal, but also yearly and 8 years variation. But up to this date there were less interaction *Dipole Mode* phenomena originated from Indian Ocean to the El Nino/La Nina from SST variation in Pacific ocean (Hartoko,A dan W.Sulistya. 2010b; Sulistya W., A.Hartoko, S.B.Prayitno. 2007a).



1-figure 10. Average monthly SS I in Java sea year 1971 — 2000 and SST (˚C) and seawater spatial distribution during west monsoon February), year 1971-2000 (NCEP, Hartoko & W Sulistya. 2010a)

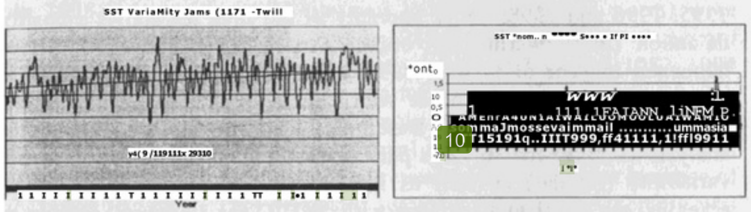


Figure 11. SST variability and SST anomaly from 1971 — 2000 in Java sea

The possible effect of sea temperature rise especially to the gonad maturation, eggs development. spawning and hatching rates, to marine life and vulnerable fisheries resources had been emphasized in the study. The special focus of study would be carried out for the group of vulnerable species such as the endemic species of 'horse-shoe crab' Limulus.sp: benthic fish : Cynoglosidae. Psettodidae (flat fish); Copepods or the 'truly' flying fish Cypsilurus.sp and egg-placenta of Loligo.sp and Sephia.sp (Fig 13 and 14).

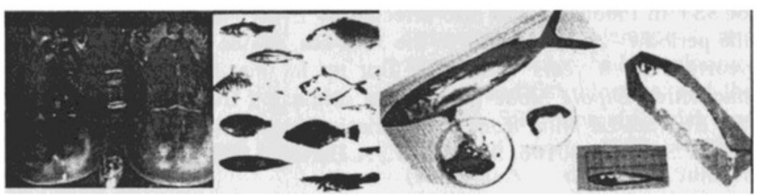


Figure 13. Endemic species Limulus.sp, benthic fish and Mollusc, Copepods and flying-fish Cypsilurus.sp, small pelagic fish Rastrelliger.sp and Sardinella.sp

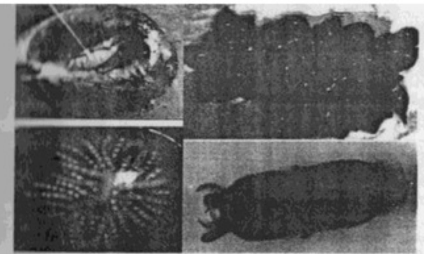


Figure '14. Gonade maturation stages of Rastrelliger.sp (above), eggs-placenta of Loligo.sp and Serthia sn thelowl

Figure 15. Fish larvae and "larvae-zone" or spawning-ground off the west Sumatera (Photograph of fish larvae by Suradi WP)

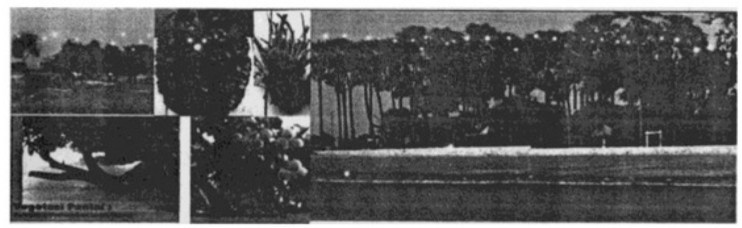


Figure 16. Coastal habitat rehabilitation and seed production of Pandanus.sp, and *Calophyllum inophyllum* other than mangrove

Figure 17. Fish aggregating devices, echosounder and fish catch

Adaptation strategies :

1. Spawning ground and feeding ground mapping and spatial database development for protection zone and seasonal fishing measures (Fig 15 and 16).
   Coastal vegetation and habitat rehabilitation (Figure 16) and as a nursery ground development
3. Fish Aggregating, Sheltering and Protection Devices (Figure 17)

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