The influence of ocean dynamics and climate changes on the Lemuru (*Bali Sardinella*) abundance in the Bali Strait, Indonesia

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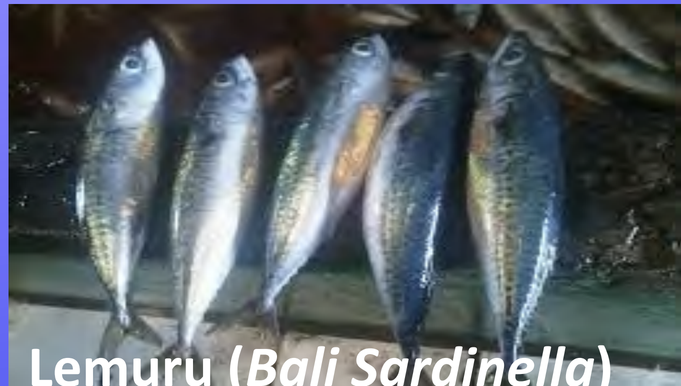
Outline



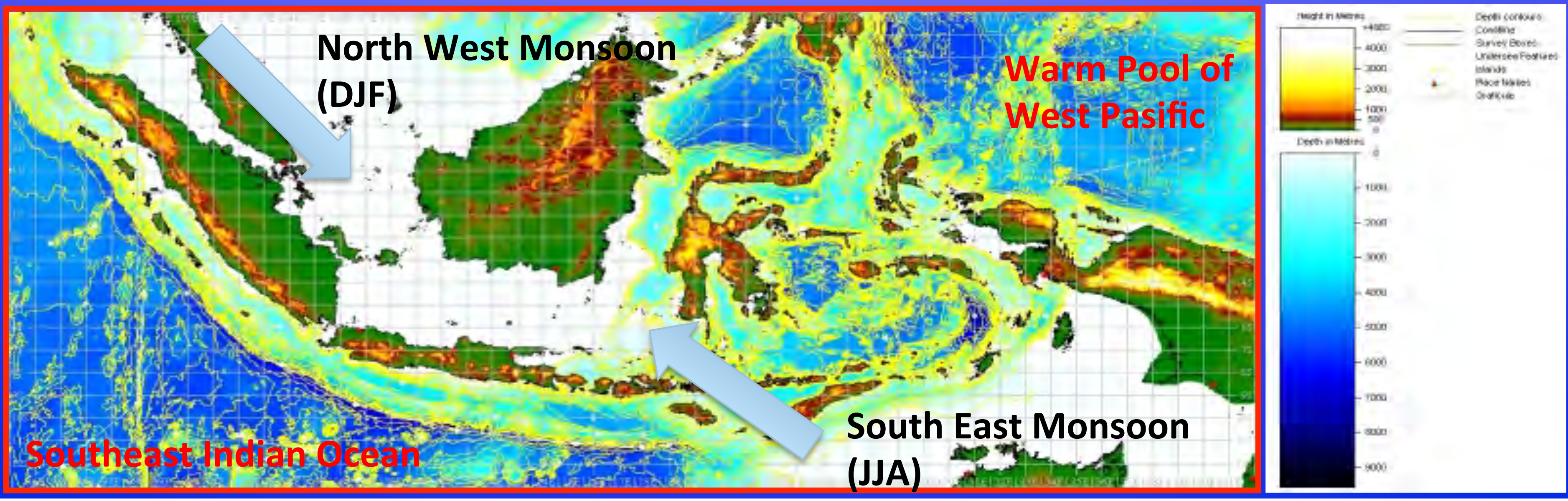
Lemuru (*Bali Sardinella*)

- **Background**
- **Purposes**
- **Data and Methodology**
- **Results and Discussion**
- **Conclusions**

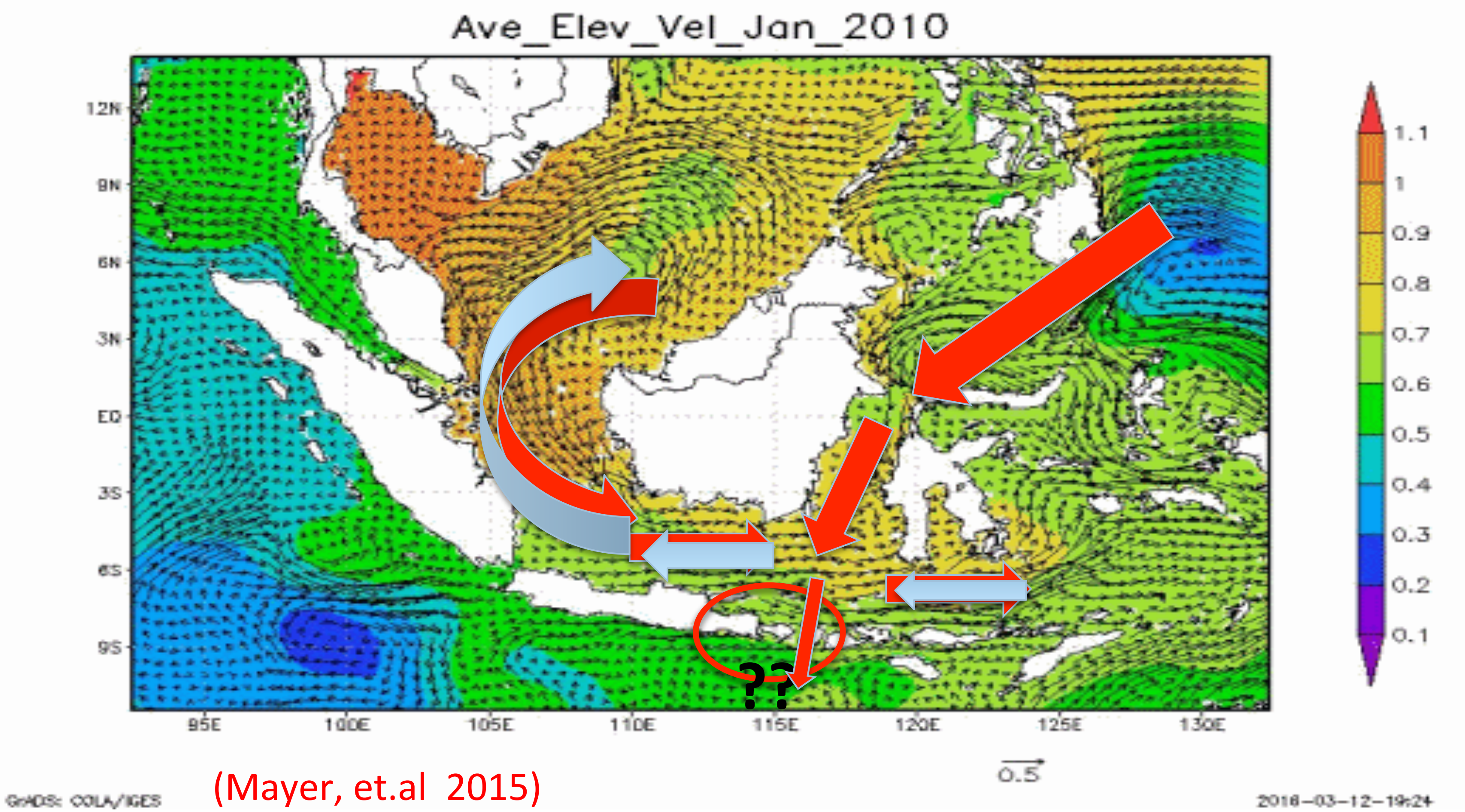
Perancak Estuarine - Bali

Background

- Why the Indonesian waters potential for fisheries?
- General condition of Indonesian waters
    Indonesian Throughflow (ITF) and Monsoon Current

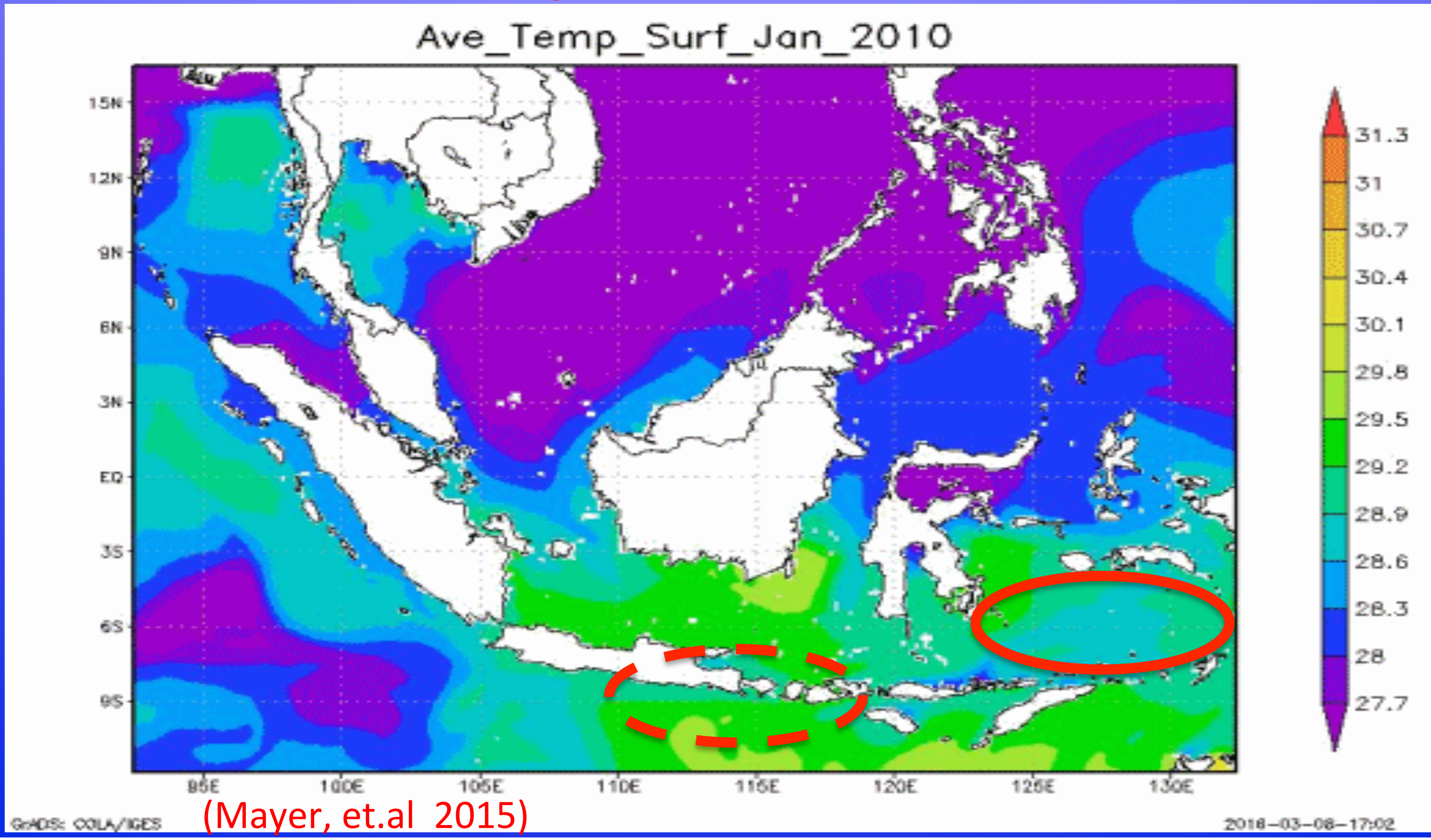


Ocean Current System of Indonesia Seas

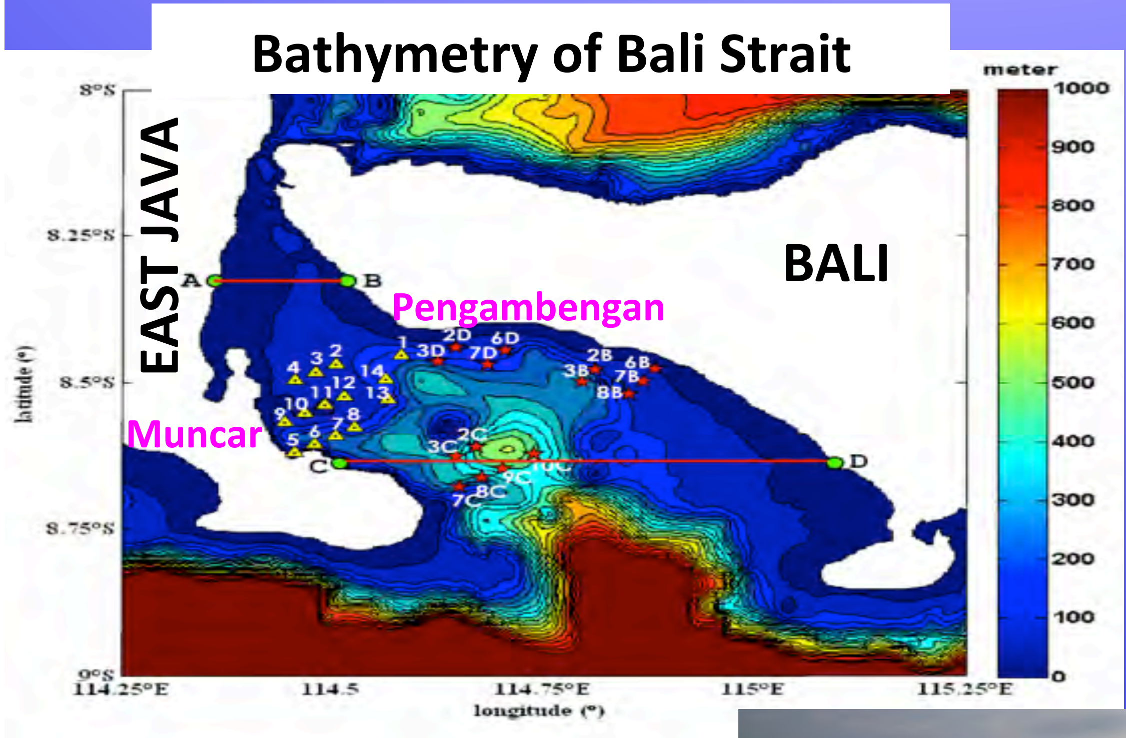


(Mayer, et.al 2015)

Sea Surface Temperature of Indonesia Seas



(Mayer, et.al 2015)



Bali Strait

Bali Strait is a semi-enclosed waters with high productivity during east monsoon due to the occurrence of upwelling in the southern part.

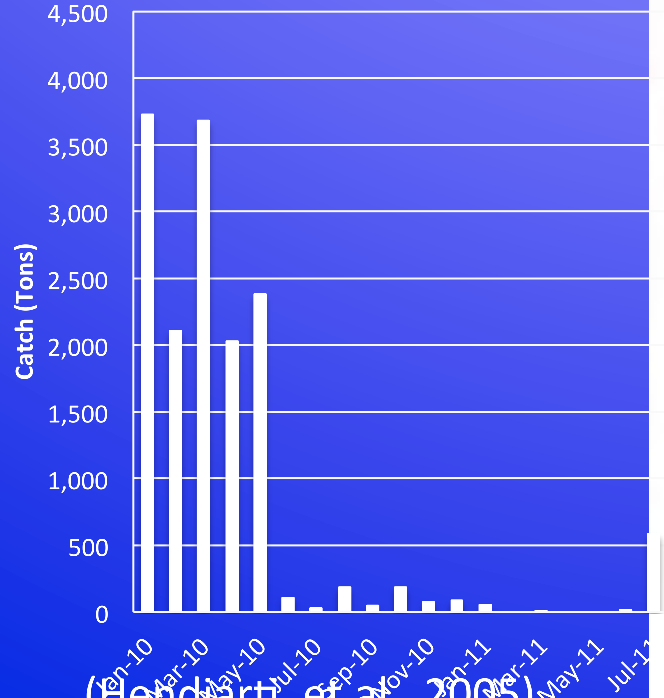
Lemuru (Bali Sardinella) living in the coastal area around Bali Strait and the eastern part of East Java with depths less than 100 m. At daytime, Lemuru mostly swim close to seabed and rise to the surface at night time. Their food is around 95% zooplankton (mostly copepods) and 5% phytoplankton.


(IMRO, 2011)

Chlorophyll-a abundance is usually used as an indicator for primary production.

Issue :

The capture of Lemuru decreased in the last 5 years (Jun 2010 until Jun 2014)?



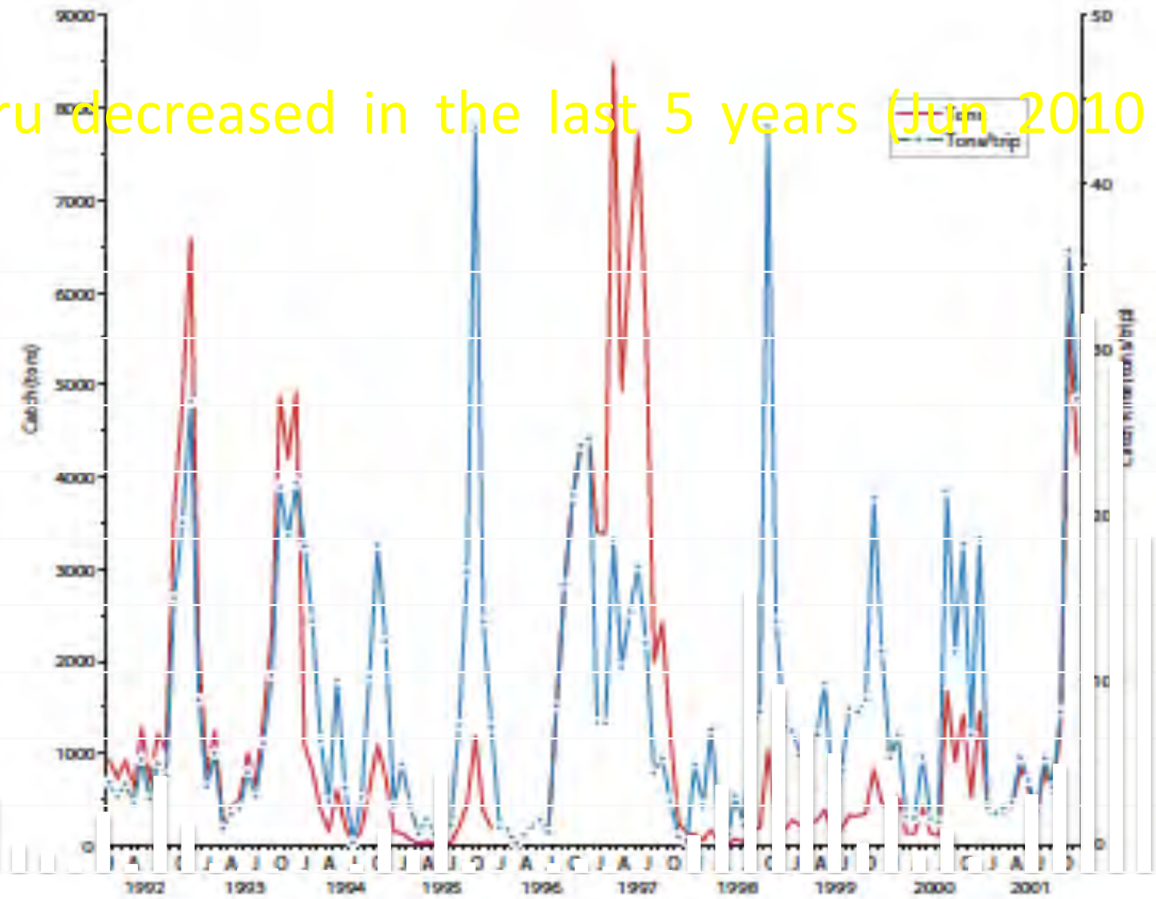


Figure 7. Fluctuation of the catch (tons) and catch rate (ton/trip) of Lemuru (Sardinella lemuru) in the Bali Strait landed at Muncar (East Java) from 1992–2001.

(Hendiarti, et.al., 2005)

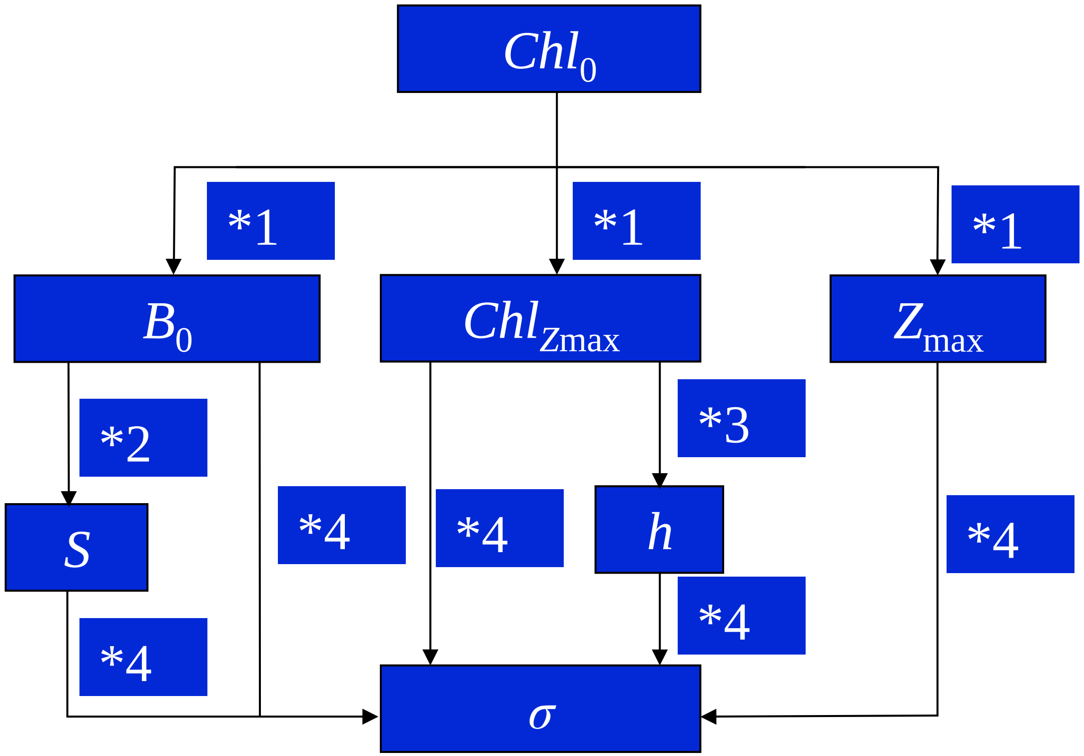
Purposes of the research

- To estimate the horizontal and vertical distribution of chlorophyll-a in Bali Strait during east monsoon and second monsoon transition (JJA-SON).
- To analyze the influences of ocean dynamics and climate change to Lemuru's capture production. (2010 – 2014)

Data and Methodology

- Analyzing the ocean dynamic using results from HAMburg Shelf Ocean Model (HAMSOM).
  - baroclinic mode
  - horizontal resolution of 6’ (~ 9 km)
- Estimating the concentration of chlorophyll-a and primary production around the Bali Strait using Gaussian Model
- Collecting oceanographic data around the Bali Strait through field observation
- Collecting available statistics data of Lemuru’s capture production from the Ministry of Marine Affairs and Fisheries (MMAF)

Gaussian Method



- Procedure for estimating five parameters from chlorophyll-a concentration at the surface (Chl_0).
  - Chl_{Zmax} is the maximum chlorophyll concentration at chlorophyll-a maximum layer.
- *1 Regression as functions of Chl_0;
- *2 Regression as functions of B_0;
- *3 Regression as functions of Chl_{Zmax};
- *4 Calculated by equation as follows:

$$\sigma = h / \left(\sqrt{2\pi} \left(Chl_{Zmax} - B_0 - S \times Z_{max} \right) \right)$$

$$Chl(Z) = B_0 + S \times Z + \frac{h}{\sigma\sqrt{2\pi}} \exp\left[-\frac{(Z - Z_{max})^2}{2\sigma^2} \right]$$

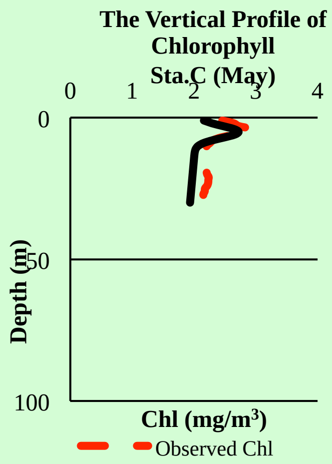
- Vertical profile of chlorophyll-a concentration were measured in June and September 2012 and May 2013 by the Institute for Marine Research and Observation (IMRO) - MMAF, Bali until 90 meters depth.
- Surface chlorophyll-a concentration (Chl_0) from MODIS.

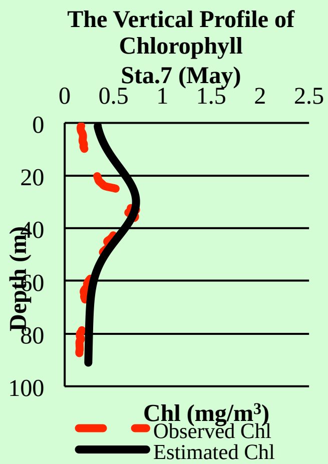
Table 1. Gaussian parameters to estimate vertical distribution of chlorophyll-a concentration during first transition, east and second transition monsoons.

Parameter	1st Transition Monsoon	East monsoon	2nd Transition monsoon
B_0	$1.153*Chl_0+0.105$	$0.026*Chl_0+0.403$	$0.109*Chl_0+0.213$
S	$-0.002*B_0$	$-0.006*B_0$	$-0.006*B_0$
Chl_{max}	$1.453*Chl_0+0.490$	$0.632*Chl_0+2.030$	$0.275*Chl_0+1.803$
Z_{max}	$5.669*Chl_0+29.21$	$5.239*Chl_0-20.85$	$21.83-8.675*Chl_0$
H	$21.87*Chl_{max}-0.915$	$11.56*Chl_{max}+ 39.70$	$16.09*Chl_{max}+11.36$

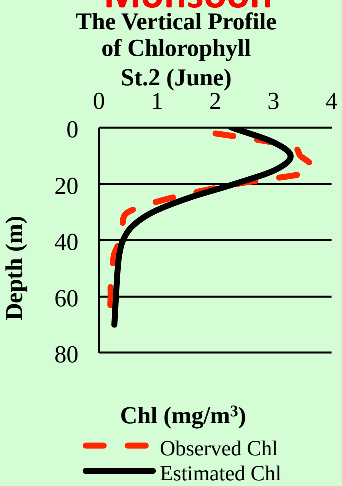
Vertical profile of Chlorophyll-a concentration Estimation vs Observation

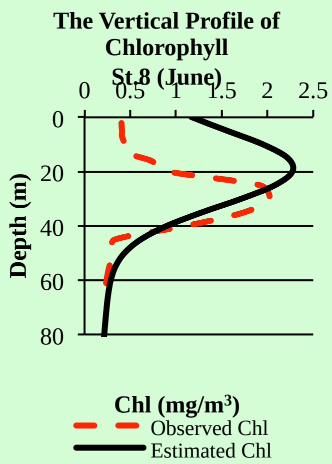
1st Transition Monsoon



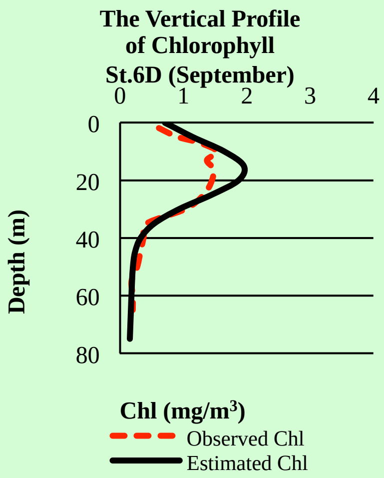


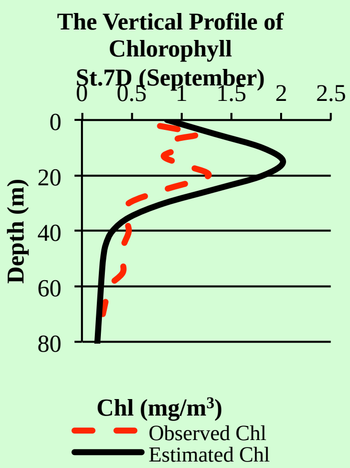
East Monsoon

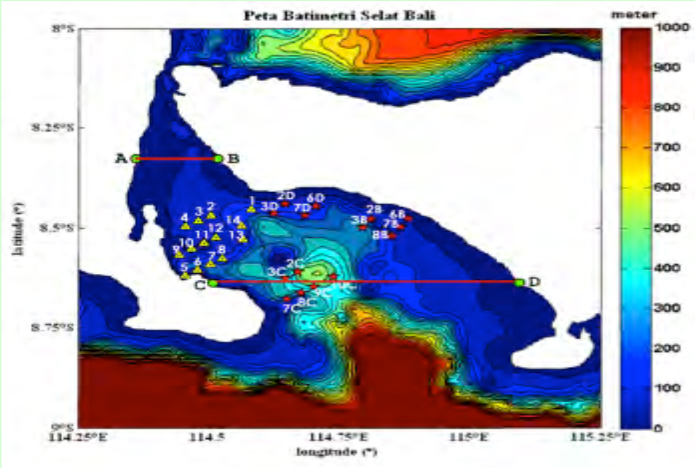




2nd Transition Monsoon



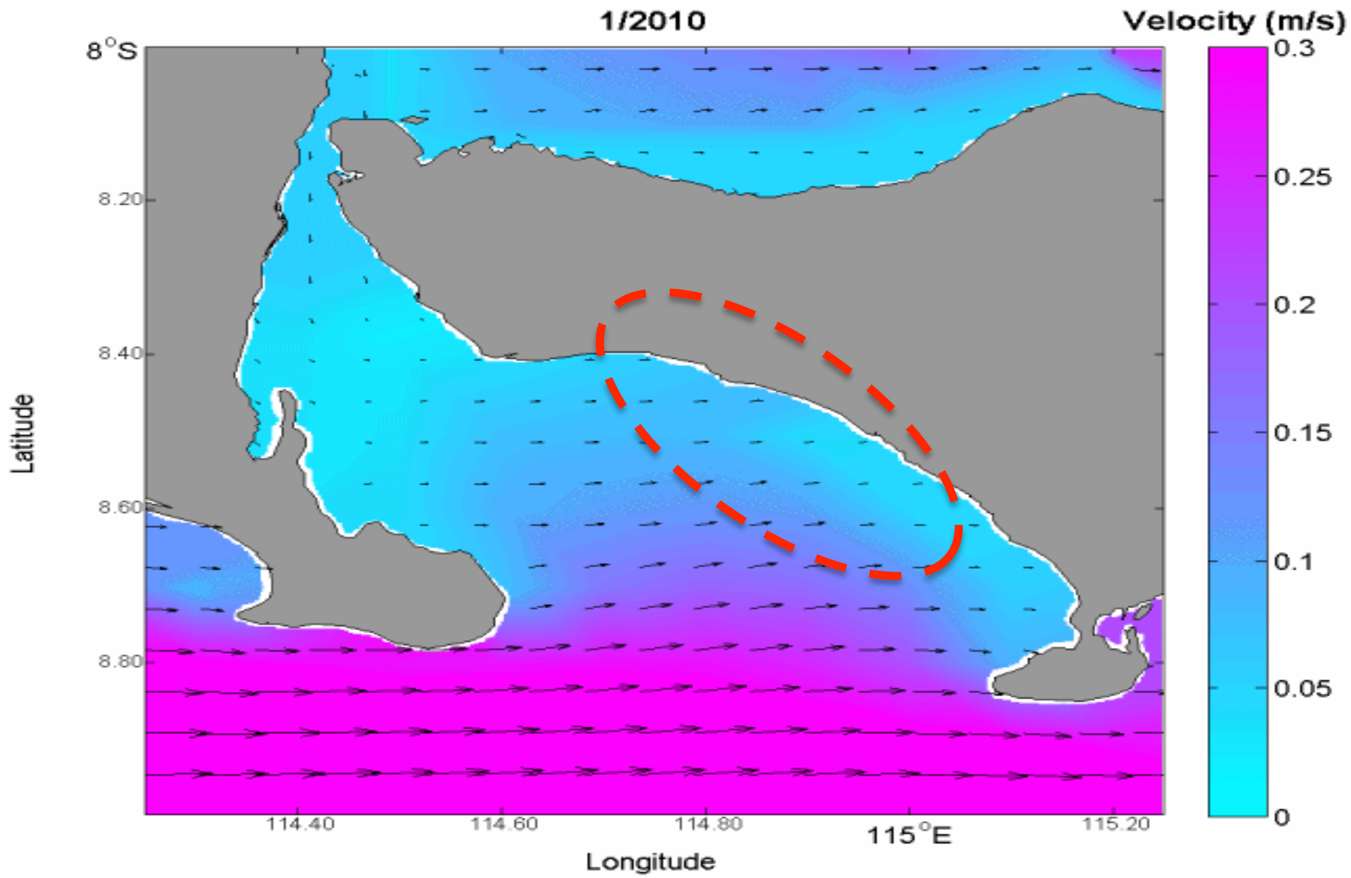




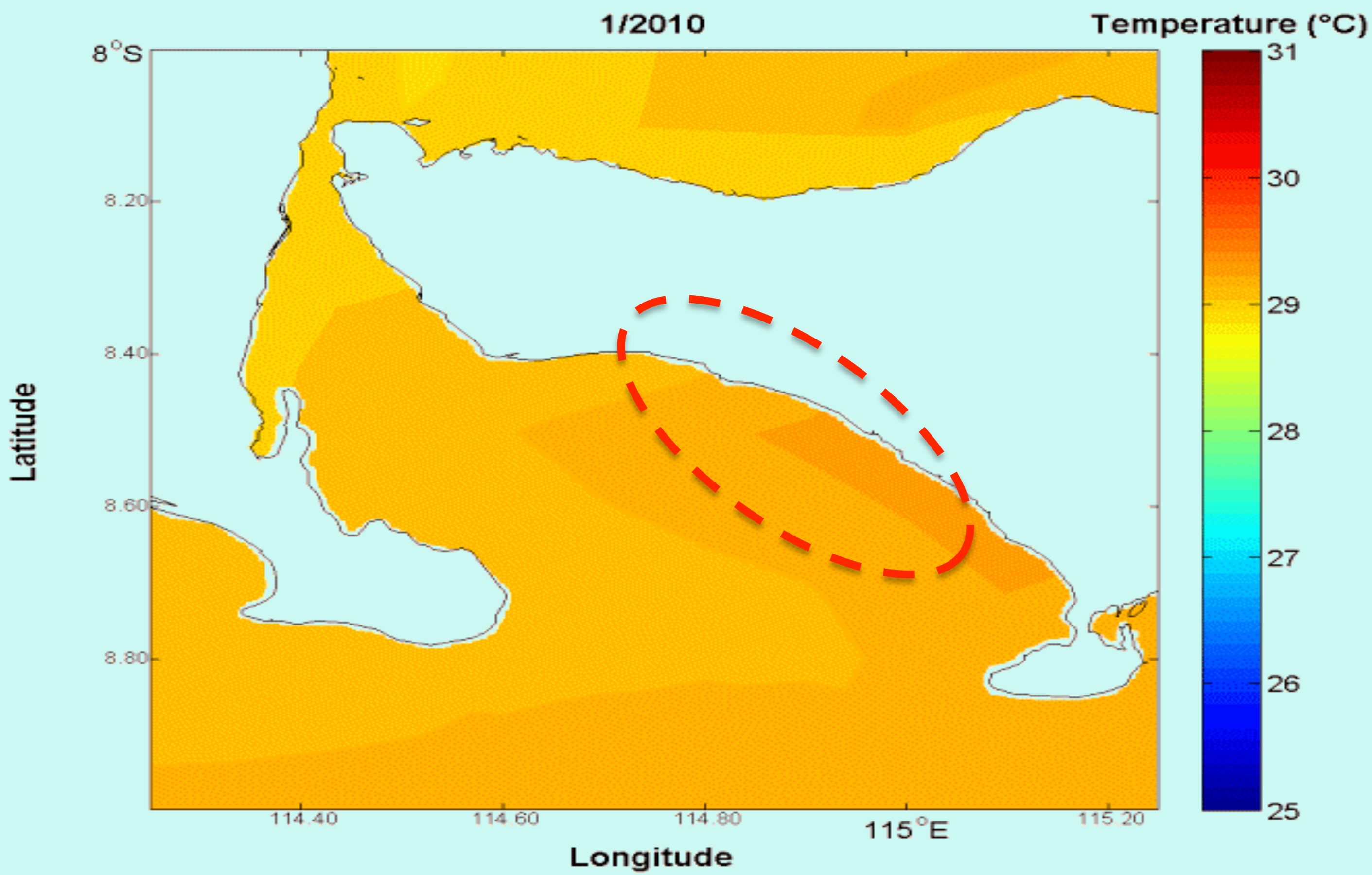
Results and Discussion

1. Hydrodynamic of Bali Strait
2. Ocean Productivity of Bali Strait
3. Interaction of Ocean Dynamic and Lemuru

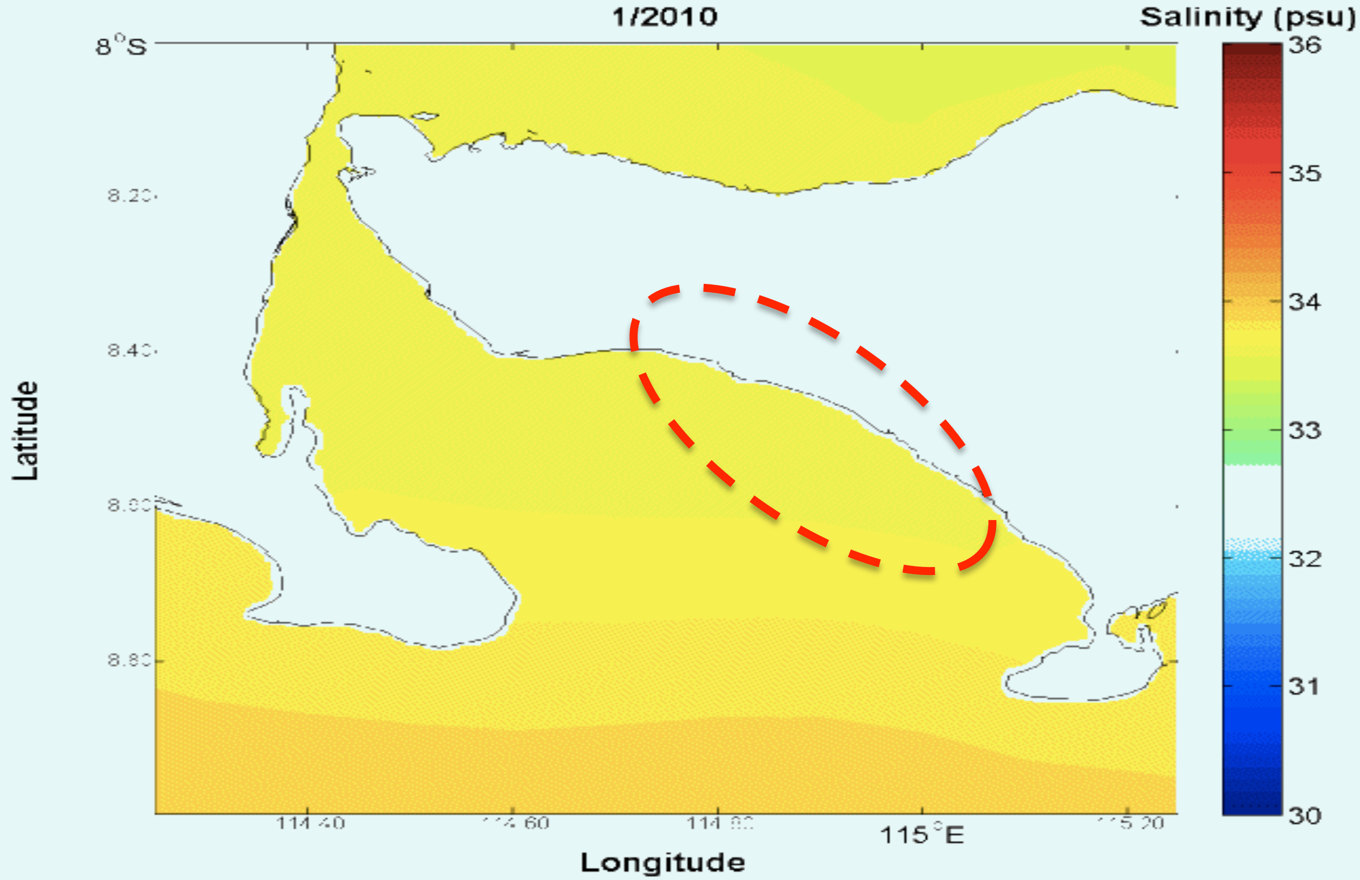
Hydrodynamic of Bali Strait

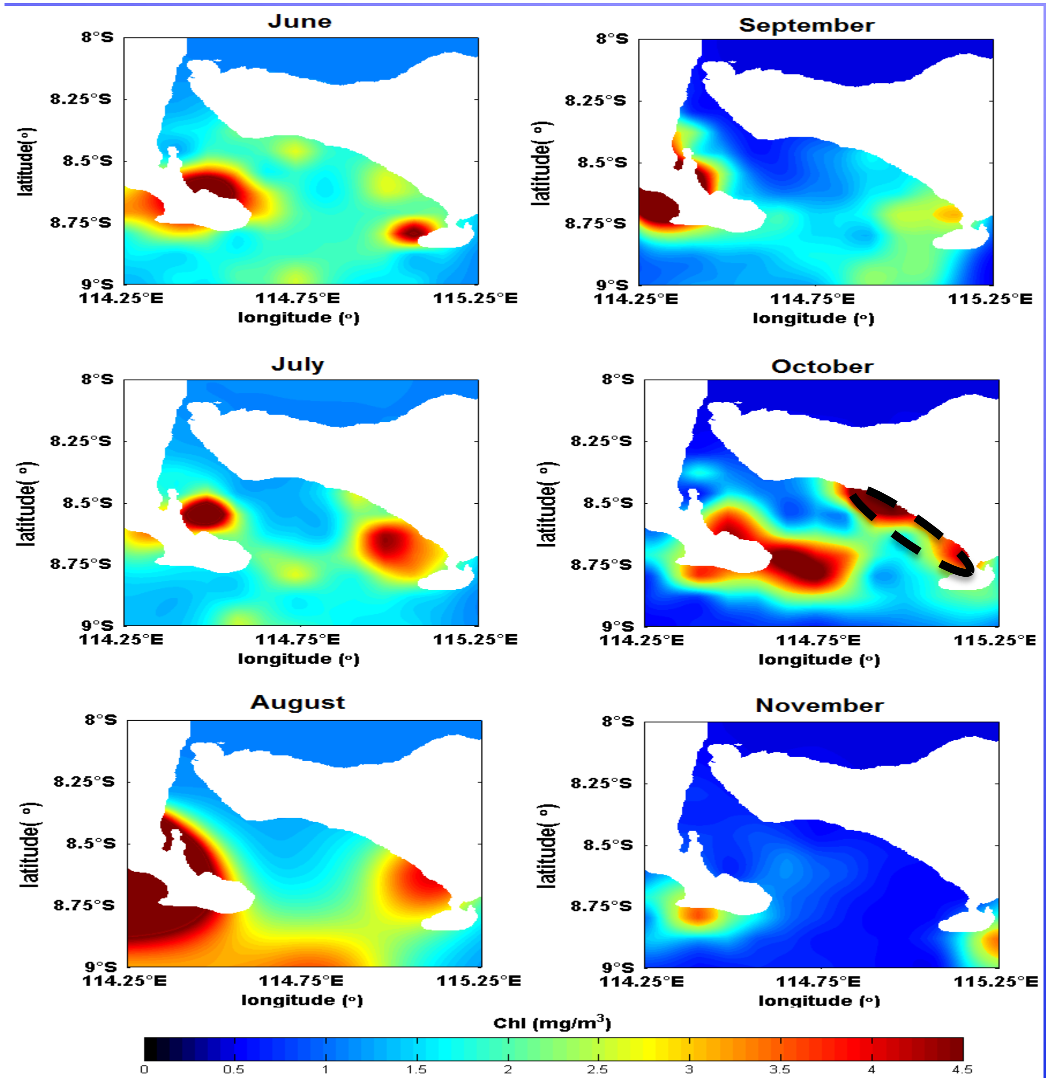


Sea Surface Temperature



Sea Surface Salinity



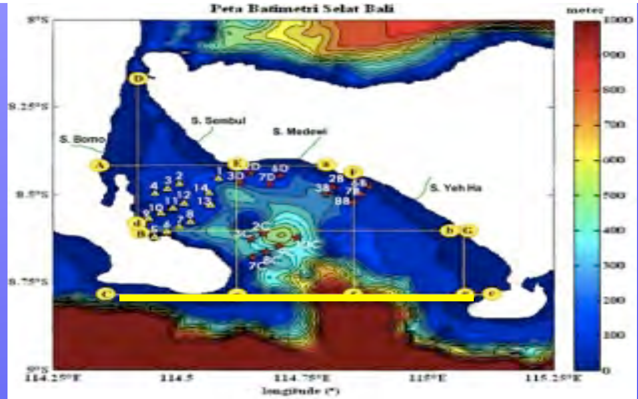


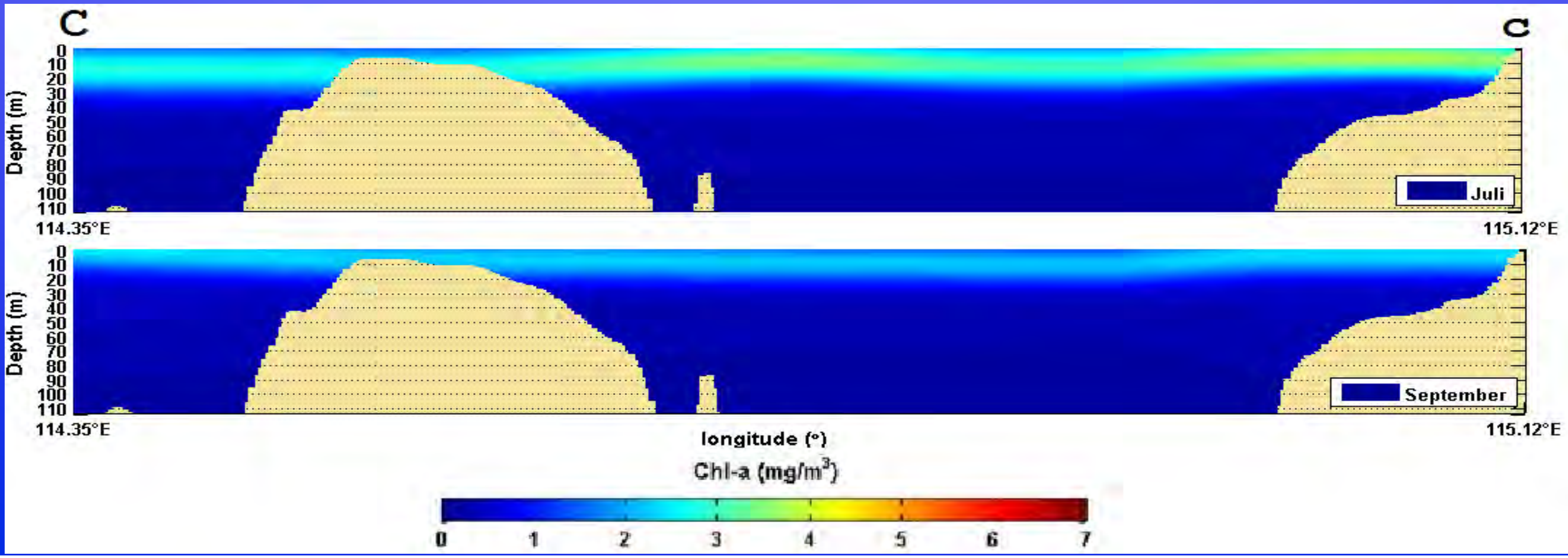
The estimation of sea surface chlorophyll-a concentration in Bali Strait

The monsoon influencing the concentration of chlorophyll-a:

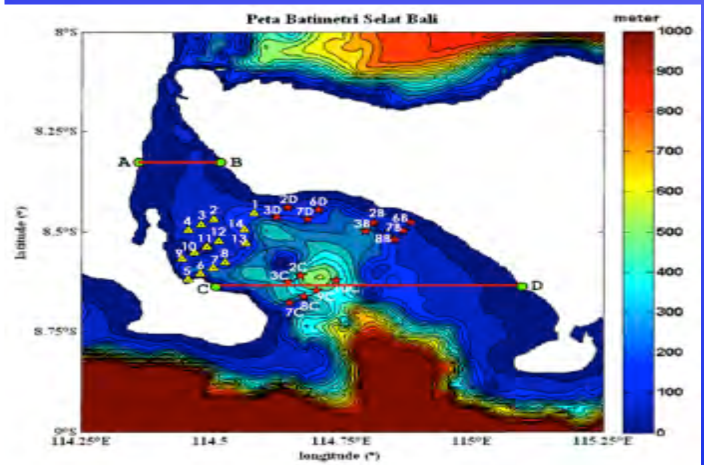
- increased during east monsoon
- decreased during west monsoon until the 1st transition monsoon.

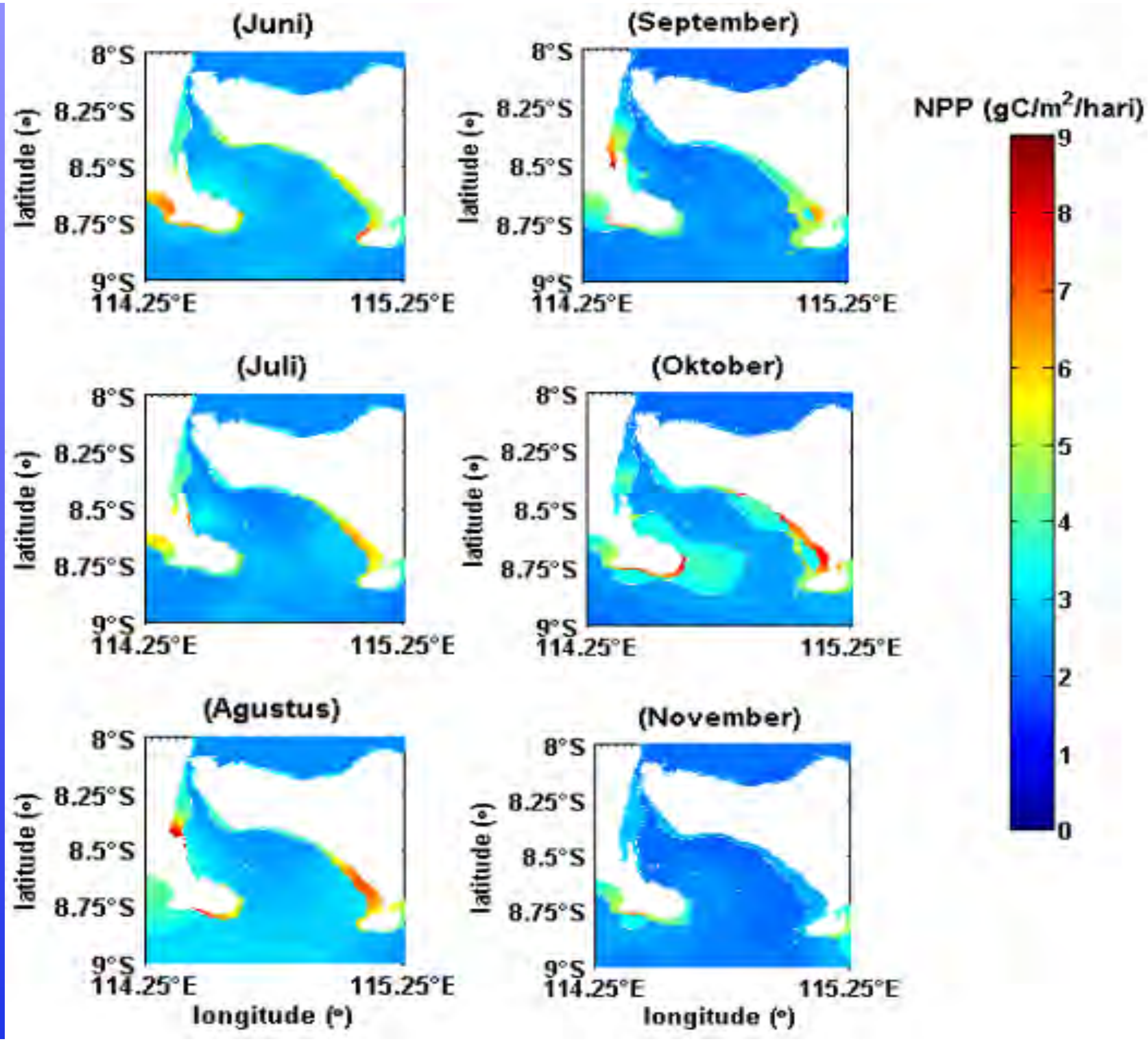
- The maximum chlorophyll-a concentration (> 3 mg/m^3) during east monsoon is found at 10 meters depth, and becoming deeper (up to 20 meters) during the monsoon transition (MAM and SON) with concentration of 1.5 to 2 mg/m^3.





Estimation of Net Primary Production in the Bali Strait





The Fishing Ground of Lemuru in Bali Strait

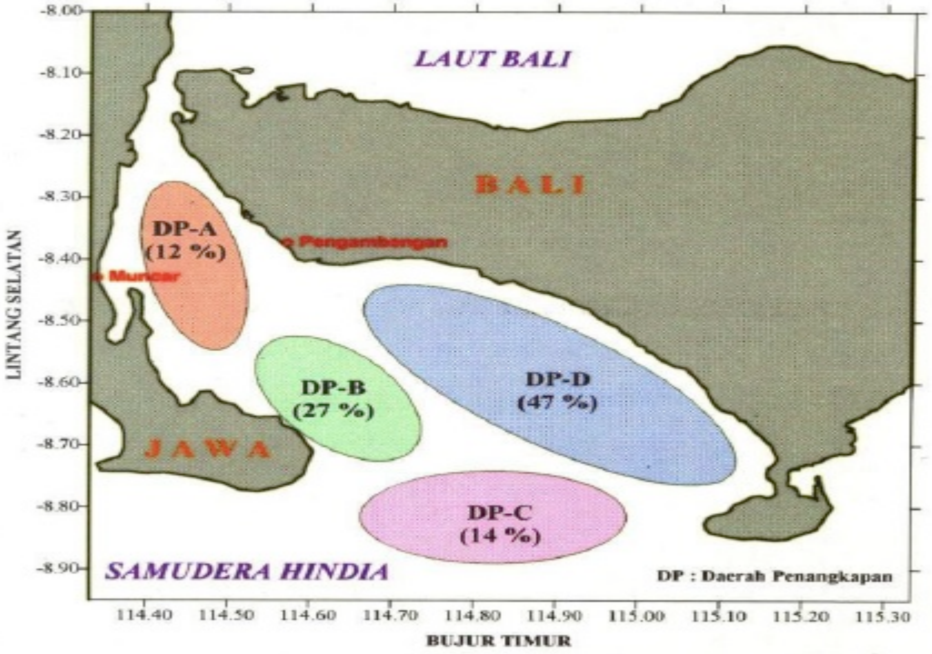
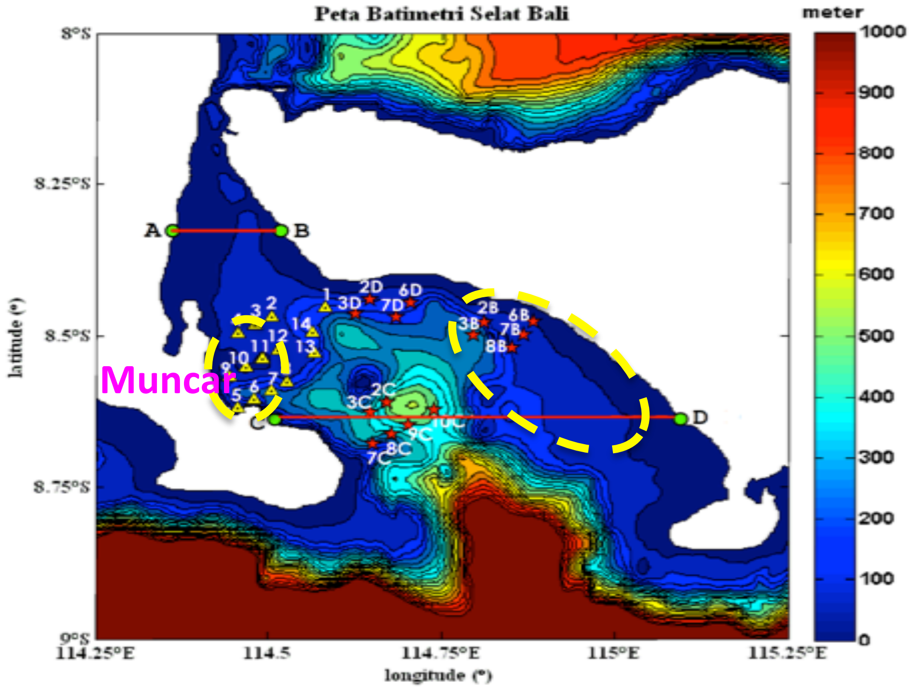
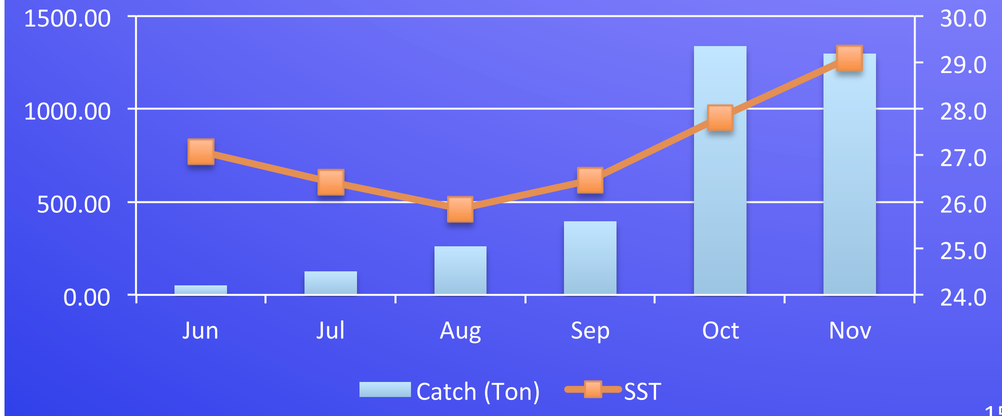


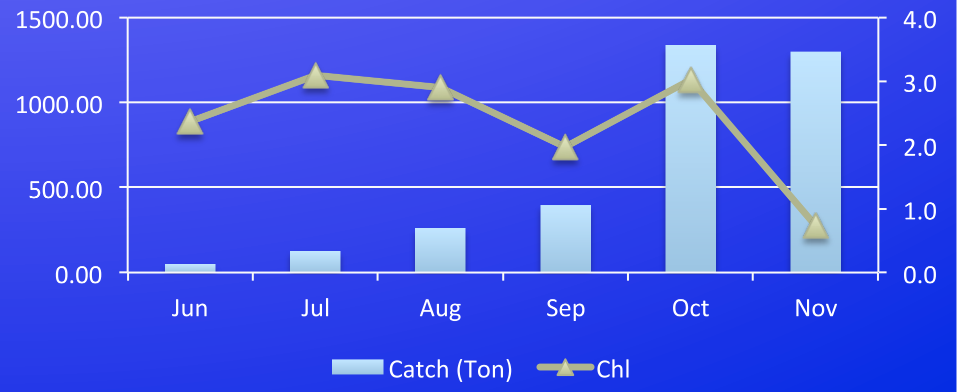
Figure 4. Fishing grounds of lemuru (Wudianto, 2001)



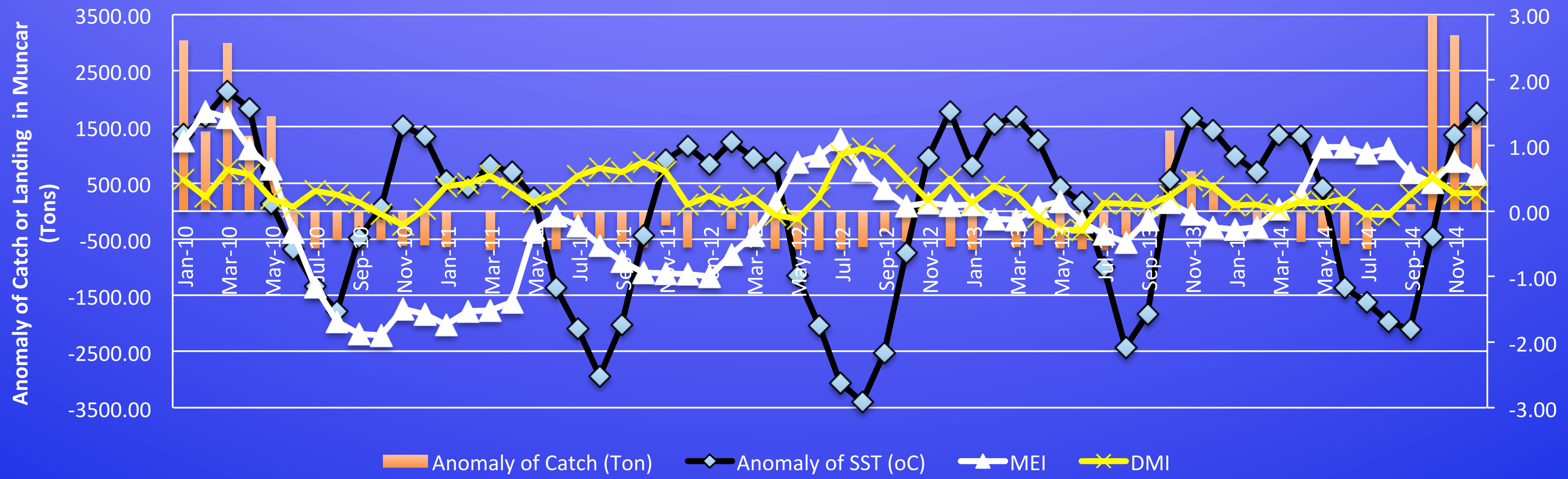
From the hydrodynamic model and estimation of Chl and NPP

The relationship between 5-years averaged of Lemuru's capture production and SST as well as chlorophyll-a concentration





The relationship between anomalies of SST and Lemuru’s capture production

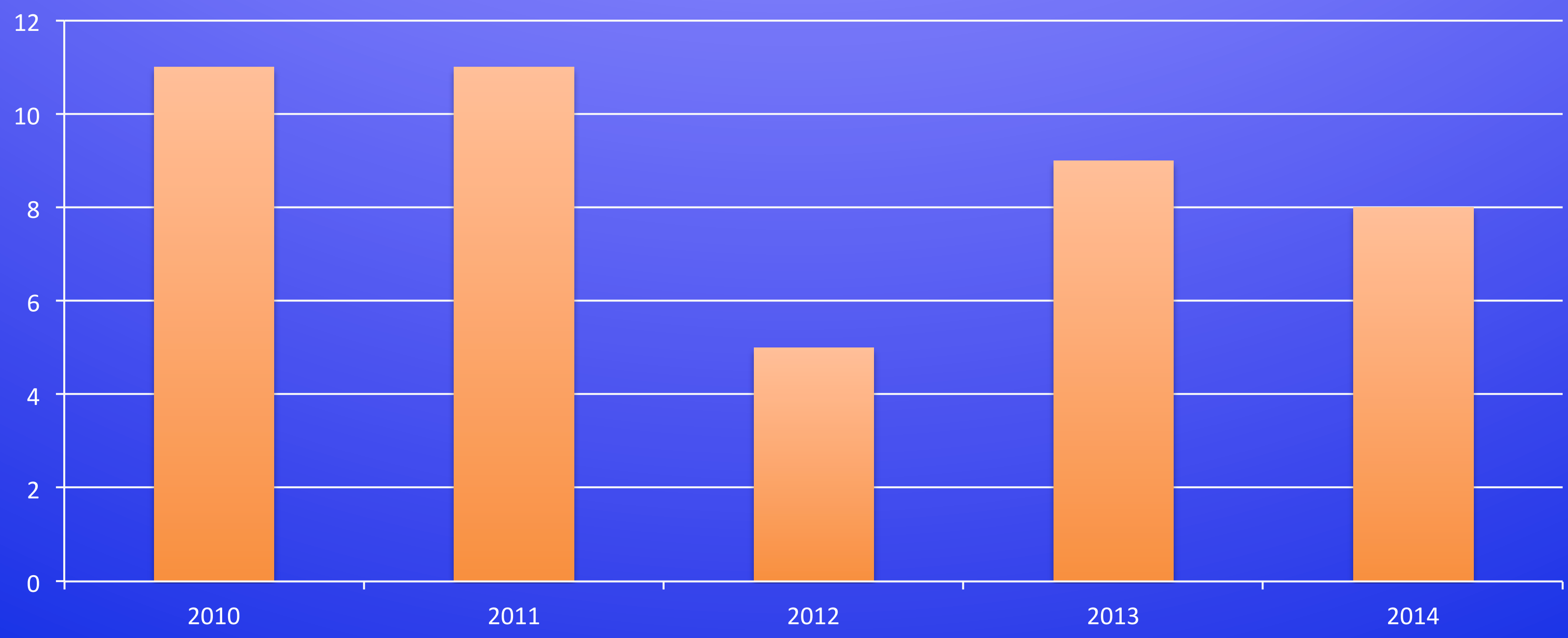


SST Average = 27.99 °C and Lemuru’s Production Average = 689.125 Ton

Correlation :

SST vs MEI : -0.06; SST vs DMI : -0.24; Catch vs SST : +0.8;

Number of Storm Occurrances at Southeast Indian Ocean



http://www.bom.gov.au/announcements/sevwx/

Conclusions

- The maximum concentration of chlorophyll-a that indicating ocean primary production usually started to occur on July and reach its maximum on August. With lag time of 2-3 months, the maximum of Lemuru's capture production usually occurred on November every year.
- Results from hydrodynamics numerical model for 5 years show that there was strong upwelling during this period. Insignificant changes on trend of (sea surface) temperature, but the capture production of Lemuru tends to decrease. This condition probably occurs due to extreme weather condition (strong wind, strong currents, as well as big waves) and also decreased on seawater quality (no data ?).

- In general, results from this research can clearly explain the relationship between the current system, primary production, and capture fisheries production.
- The current system of Indonesian waters is strongly influenced by the monsoon, meanwhile the monsoon itself strongly influenced by the regional and global climate. While due to climate change the regional and global climate were shifted, therefore factors related to climate change become a key issue that should be taken into account on capture fisheries industries in Indonesia.

Future Works :

- **Couple Hydrodynamic and Ecosystem Model**
- **IBM or other "Fisheries Modeling"**

Acknowledgment

- Thank you very much for the financial support from PICES to attend the International Symposium “Drivers of dynamic of Small Pelagic Fish Resources” in Victoria, Canada, 6-11 March 2017.
- This result is part of research activity “The Ocean Current System of Indonesian Waters and its effects on Marine Fisheries Production” funded by Research and Innovation, Institute Technology of Bandung (ITB) - 2017.

Thak You

Terima Kasih ......

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