Climatic and marine environmental variations associated with fishing conditions of tuna species in the Indian Ocean

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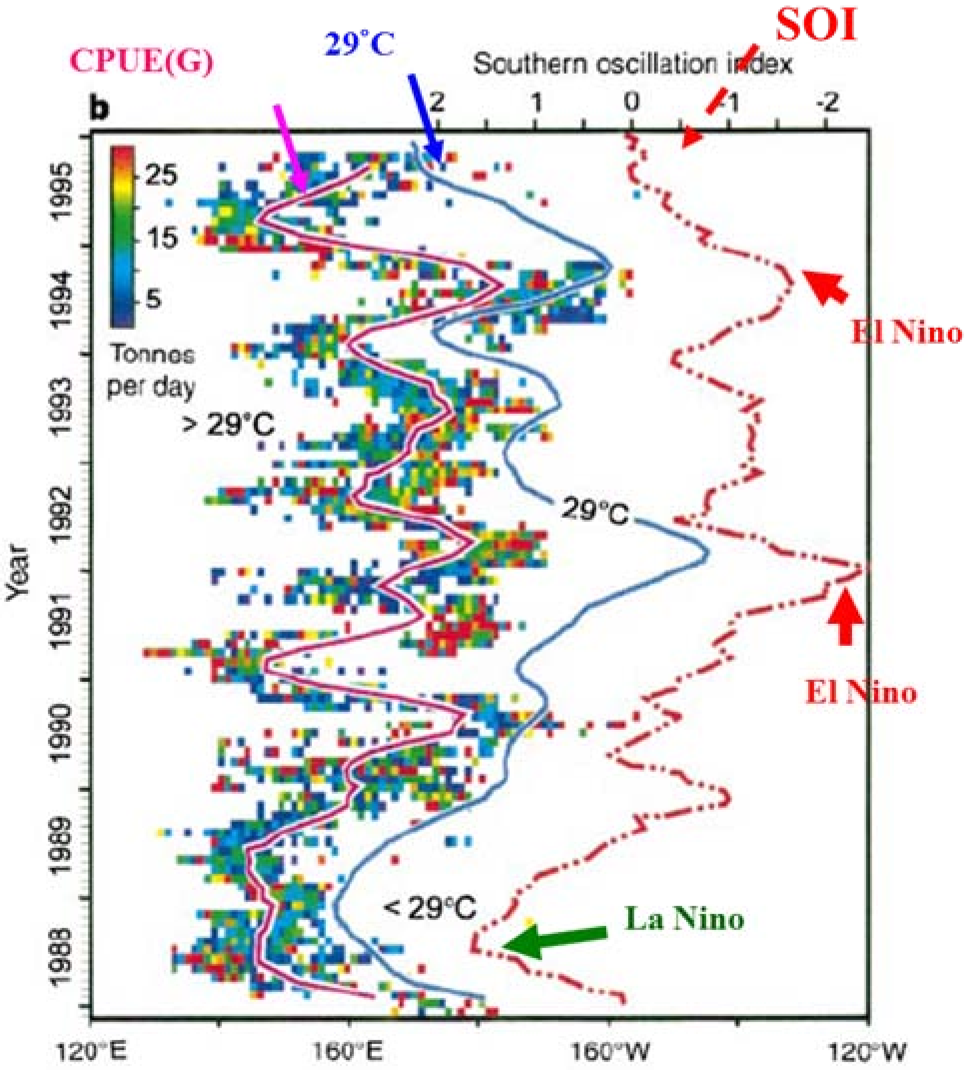
2nd Int. Symposium on "Effects of Climate Change on the World's Oceans"

Yeosu, Korea

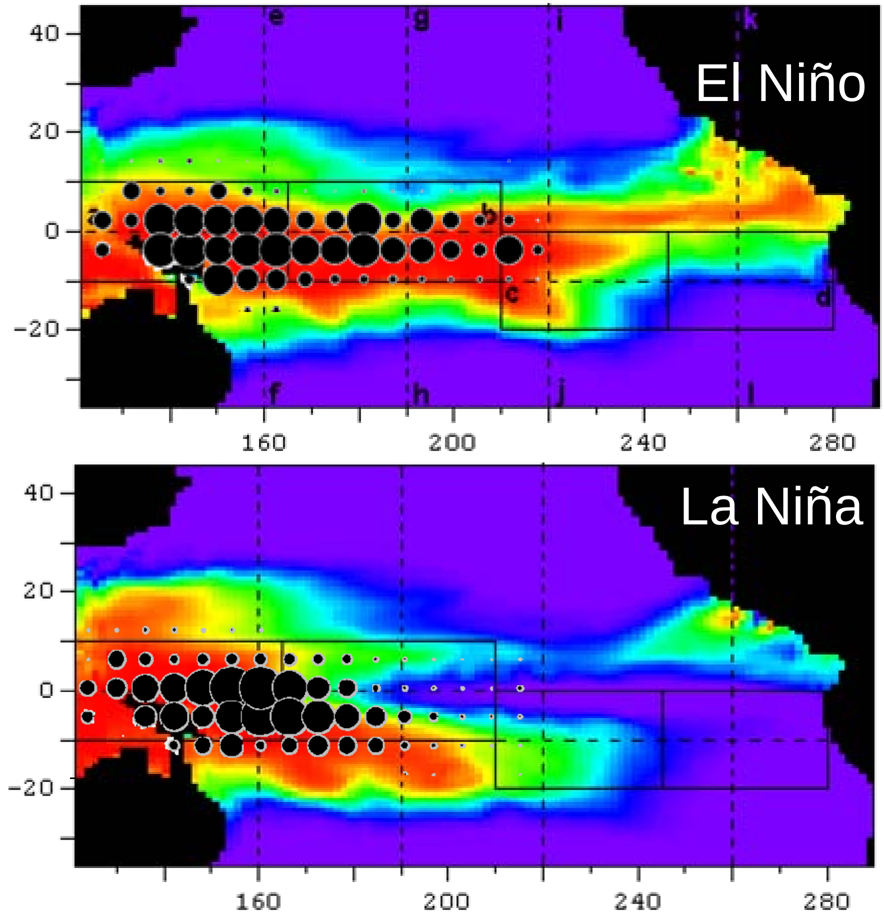
May 15~19, 2012

The climatic variability affects the distribution and production of tuna populations

- **Skipjack tuna catches and ENSO in the Pacific Ocean**



(Lehodey et al., 1997)

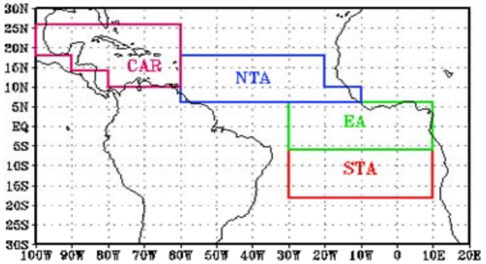


(Lu and Hseih et al., 2008)

The climatic variability affects the distribution and production of tuna populations

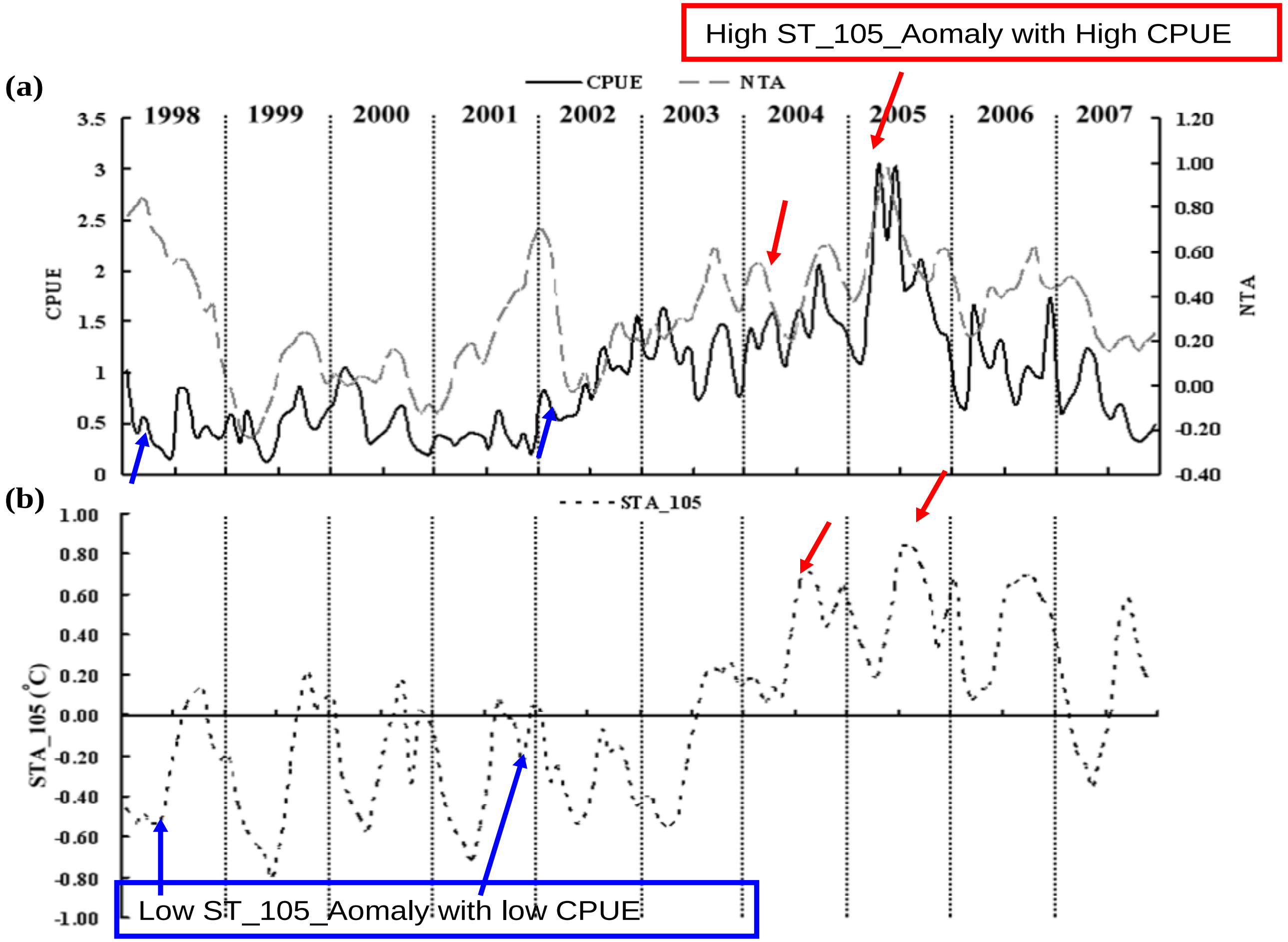
- **Yellowfin tuna CPUE and NTA in the Atlantic Ocean**

Climate index-
North Tropical Atlantic SST index



EOF analysis for the tropical Atlantic SST anomalies (region 100˚W–20˚E, 30˚S–30˚N) to predict NTA using the 20 leading Empirical Orthogonal Functions.

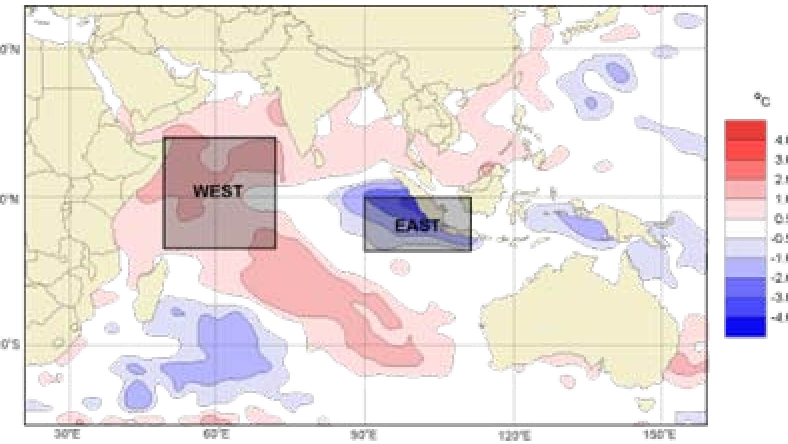
(Penland and Matrosova, 1998)



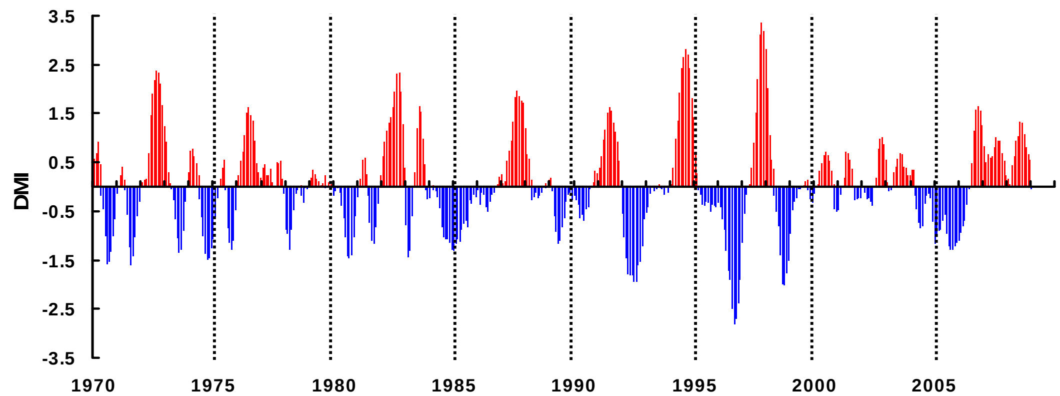
(Lan et al., 2011)

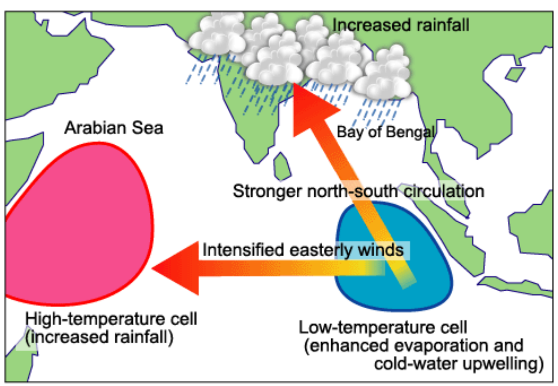
Indian Ocean Dipole (IOD)

The Indian Ocean Dipole is a coupled ocean and atmosphere phenomenon in the equatorial Indian Ocean that affects the climate of Australia and other countries that surround the Indian Ocean basin (Saji *et al.*, 1999).

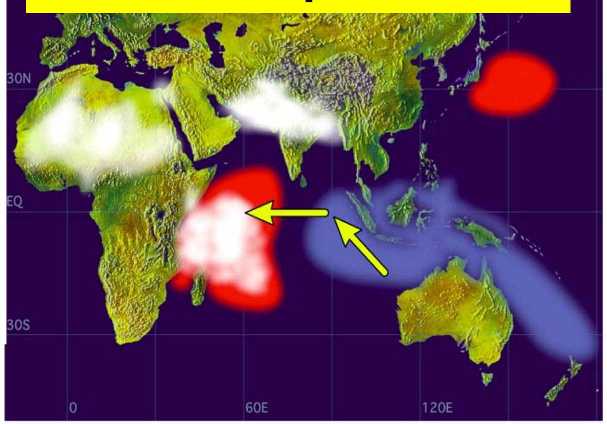


The Dipole Mode Index (DMI) is measured by the difference between SST in the western (50˚E to 70˚E and 10˚S to 10˚N) and eastern (90˚E to 110˚E and 10˚S to 0˚S) equatorial Indian Ocean

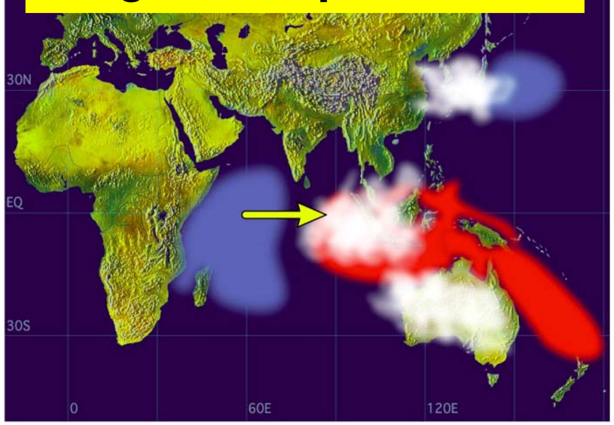




Positive Dipole Mode



Negative Dipole Mode



SST anomalies are shaded (red color is for warm anomalies and blue is for cold). White patches indicate increased convective activities and arrows indicate anomalous wind directions during IOD events.

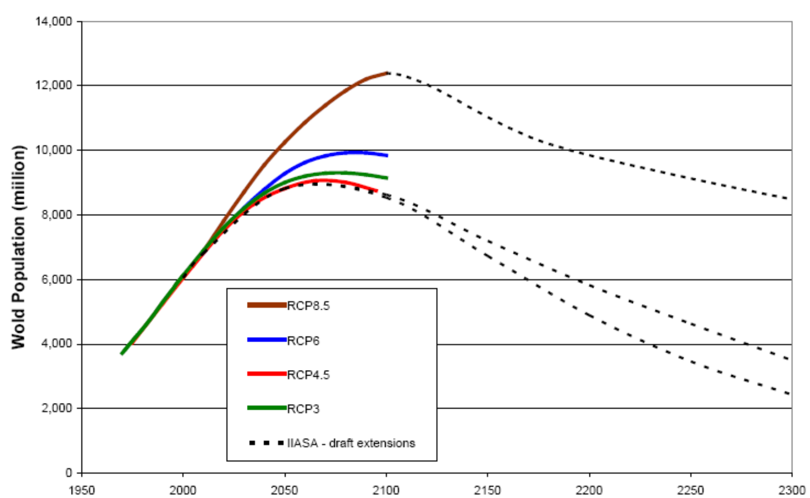
(http://www.jamstec.go.jp/frcgc/research/d1/iod/)

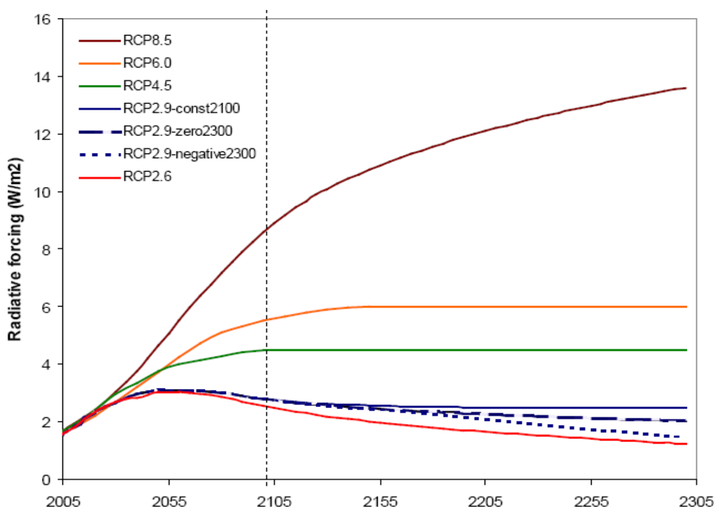
IPCC AR5 Generation of GFDL Earth System Model

The IPCC new scenarios referred to "Representative Concentration Pathways—RCPs. The RCPs will be used to initiate climate model simulations for developing climate scenarios for use in a broad range of climate-change related research and assessment and were requested to be "compatible with the full range of stabilization, mitigation and baseline emissions scenarios available in the current scientific literature."

Table 1.1: Overview of Representative Concentration Pathways (RCPs)

	Description[1]	Publication – IA Model
RCP8.5	Rising radiative forcing pathway leading to 8.5 W/m^2 in 2100.	Riahi et al. (2007) – MESSAGE
RCP6	Stabilization without overshoot pathway to 6 W/m^2 at stabilization after 2100	Fujino et al. (2006) and Hijioka et al. (2008) – AIM
RCP4.5	Stabilization without overshoot pathway to 4.5 W/m^2 at stabilization after 2100	Clarke et al. (2007) – MiniCAM
RCP3-PD[2]	Peak in radiative forcing at ~ 3 W/m^2 before 2100 and decline	van Vuuren et al. (2006, 2007) – IMAGE





(IPCC Expert Meeting Report: Towards New Scenarios, 2008)

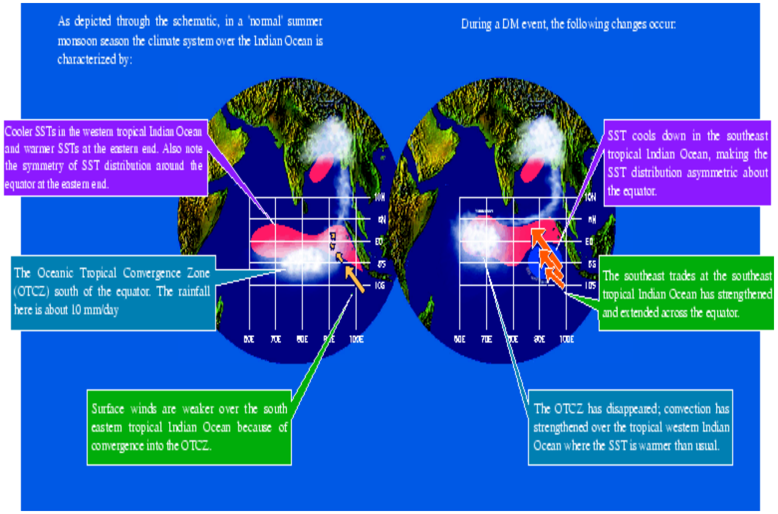
The purpose of present study

For the tropical Pacific and Atlantic oceans, the apparent abundance of tuna species related to climatic oscillations have been recognized, but in the Indian Ocean a similar interaction has not yet been found.

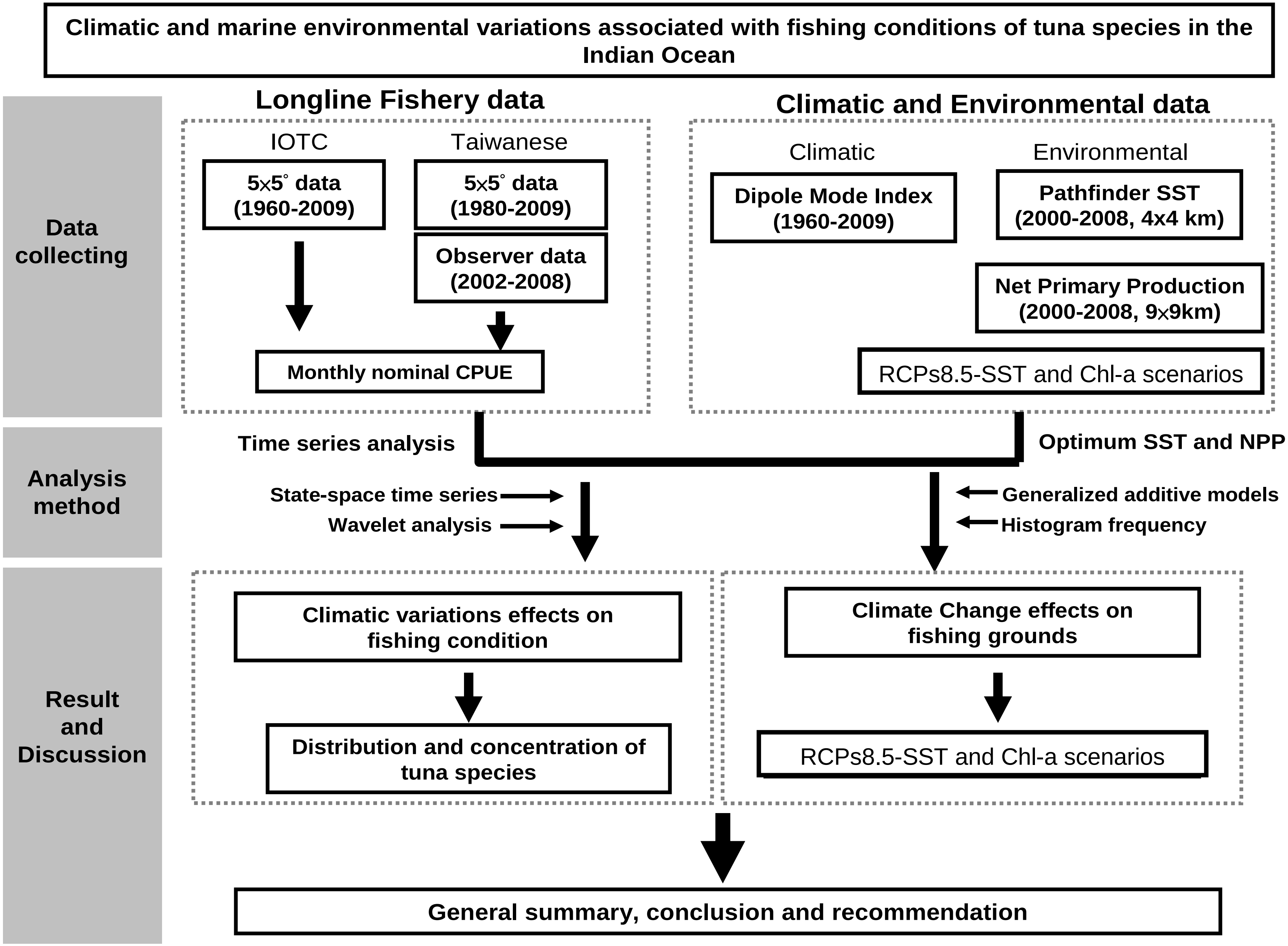
- **Topic 1: The catches and distributions of tuna species in relation to the climatic and marine environmental variations in the Indian Ocean.**

- **Topic 2: The large-scale climate change effect on the longline fishing grounds in the Indian Ocean.**

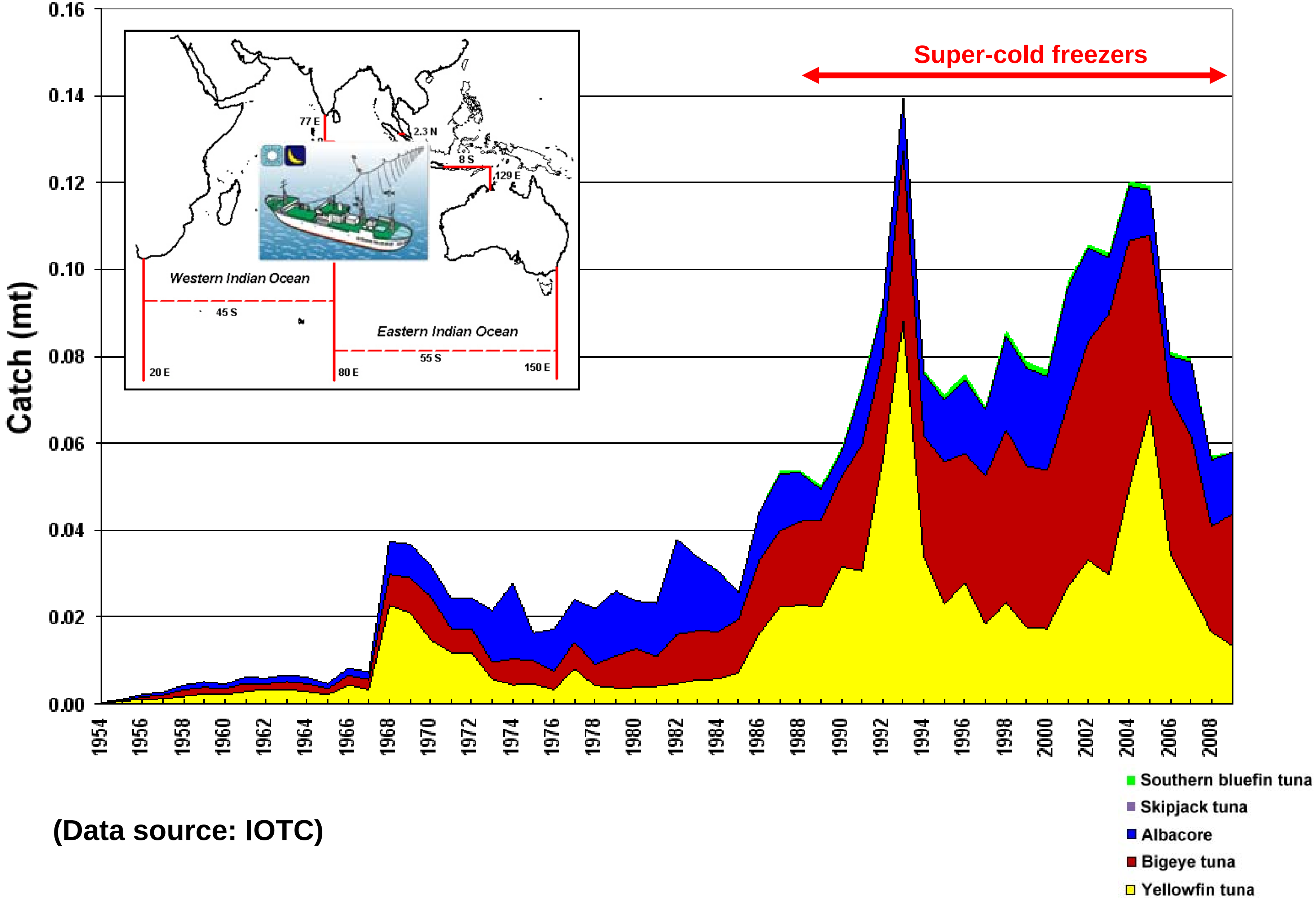
If we can know well of fishing ground through remote sensing and assimilation data, it will helpful for fishing management. This availability of oceanographic and biological information gained herein may be useful for the LL fishery and improve fishing operations as well as management of fishery resources.



Flowchart of this dissertation

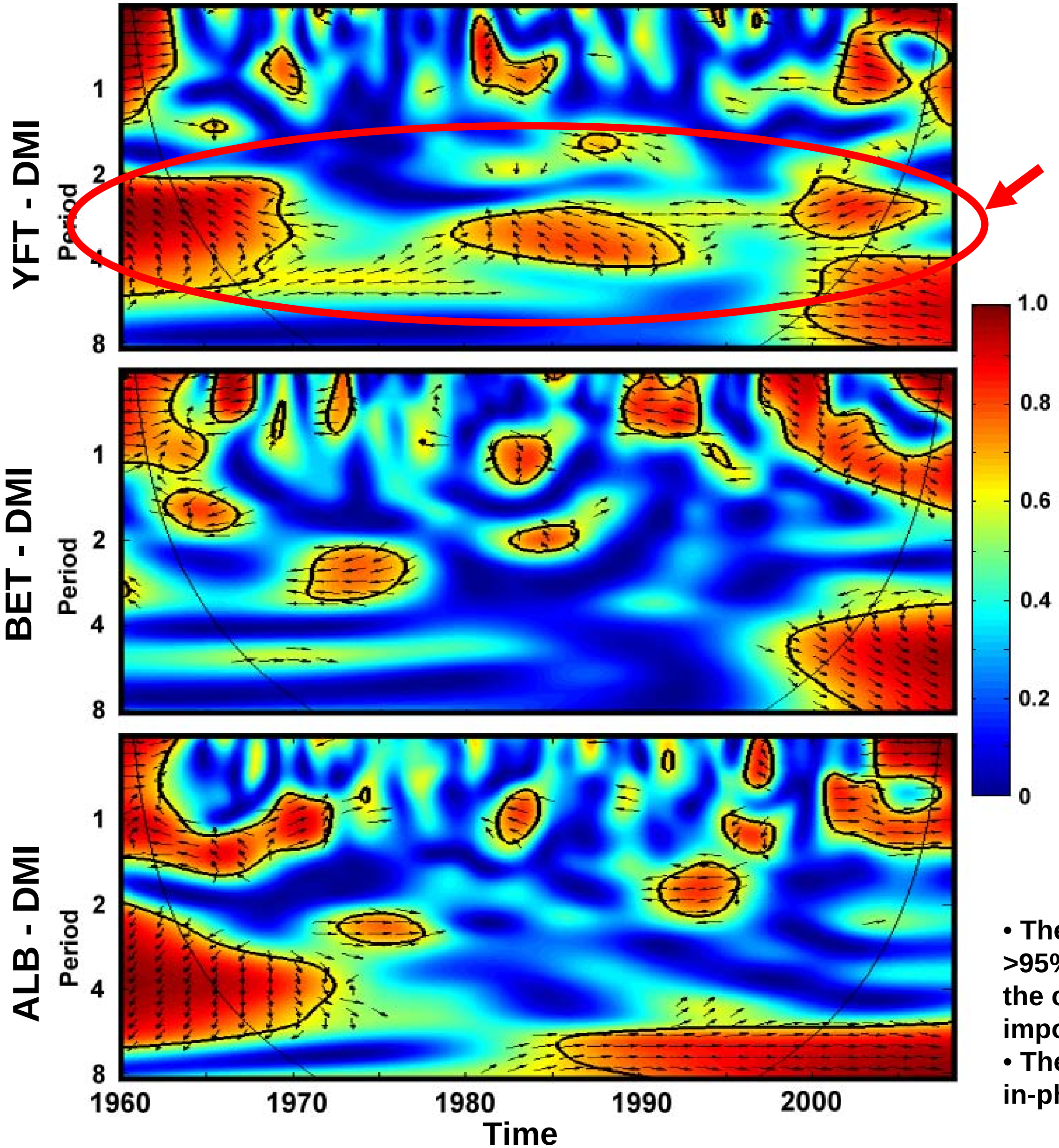


The important commercially pelagic fish species catch by Taiwanese longline fishery in the Indian Ocean



(Data source: IOTC)

Cross-wavelet coherence between Dipole Mode Index (DMI) and tuna species' CPUE in the Indian Ocean (1960-2009)

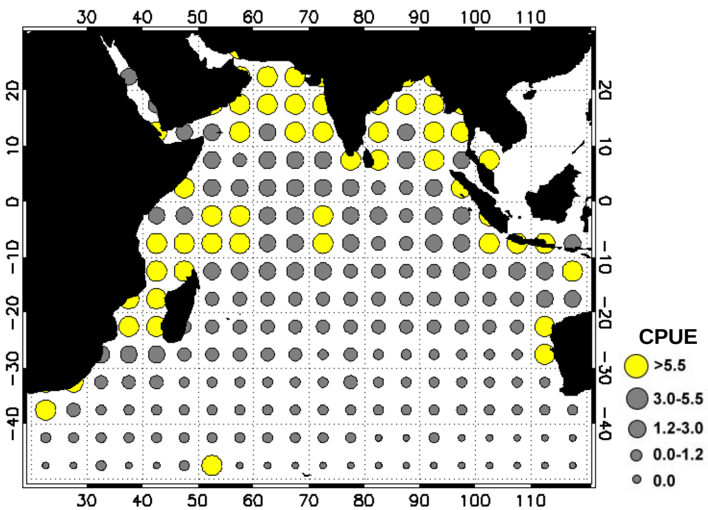


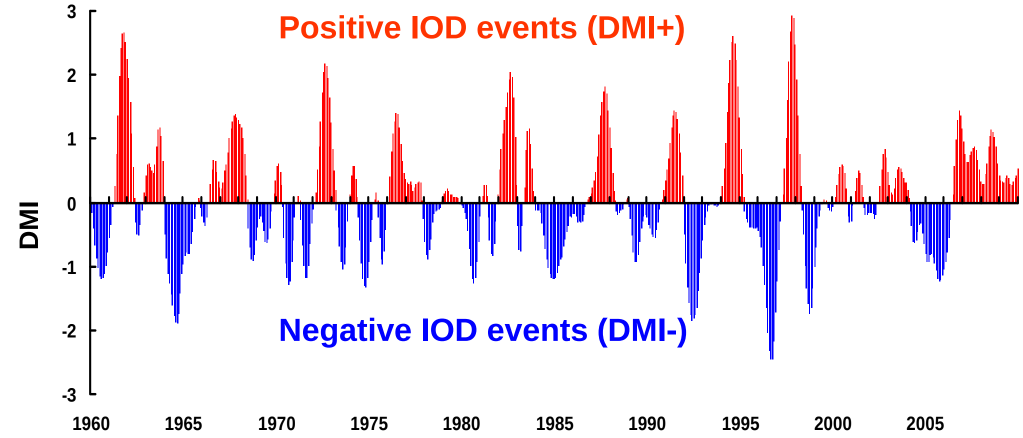
It showed a long-term negative significant coherence between the YFT CPUE and DMI with a periodicity of 4 yr.

- The solid black contour encloses regions of >95% confidence and the black lines indicates the cone of influence where edge effects become important.
- The phase relationship is shown as arrows, with in-phase pointing right, anti-phase pointing left.

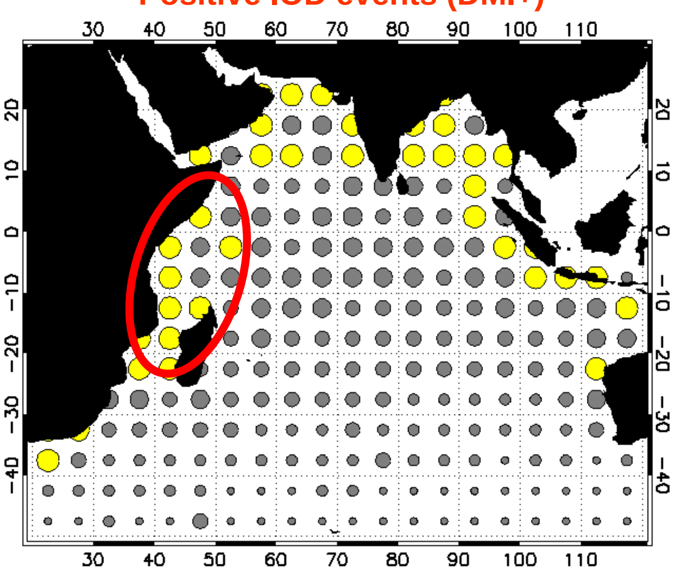
The distribution of yellowfin tuna nominal CPUE in the Indian Ocean

Mean YFT CPUE (1970-2009)



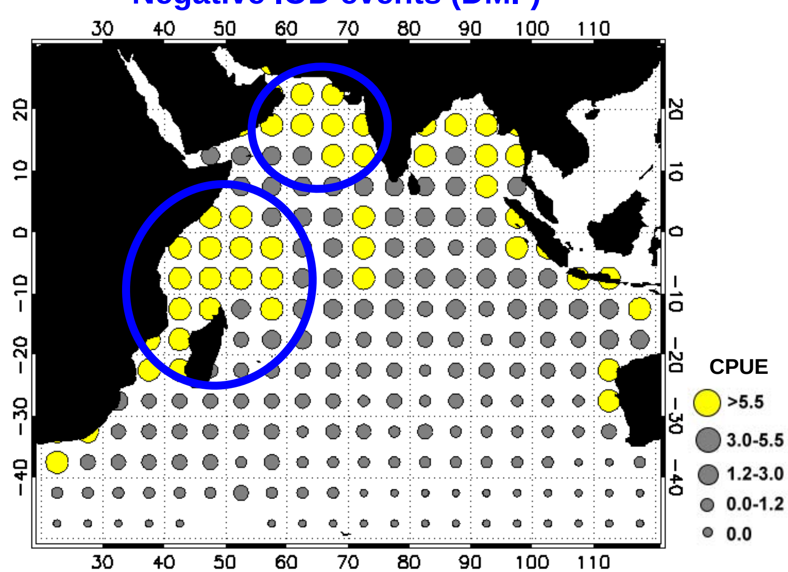


Positive IOD events (DMI+)



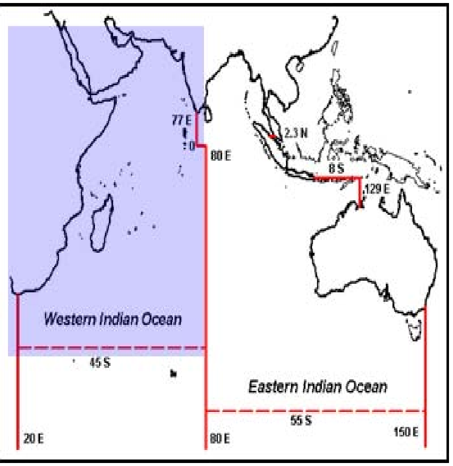
(1972, 1977, 1983, 1991, 1994, 1997, 2006, 2007, 2008)

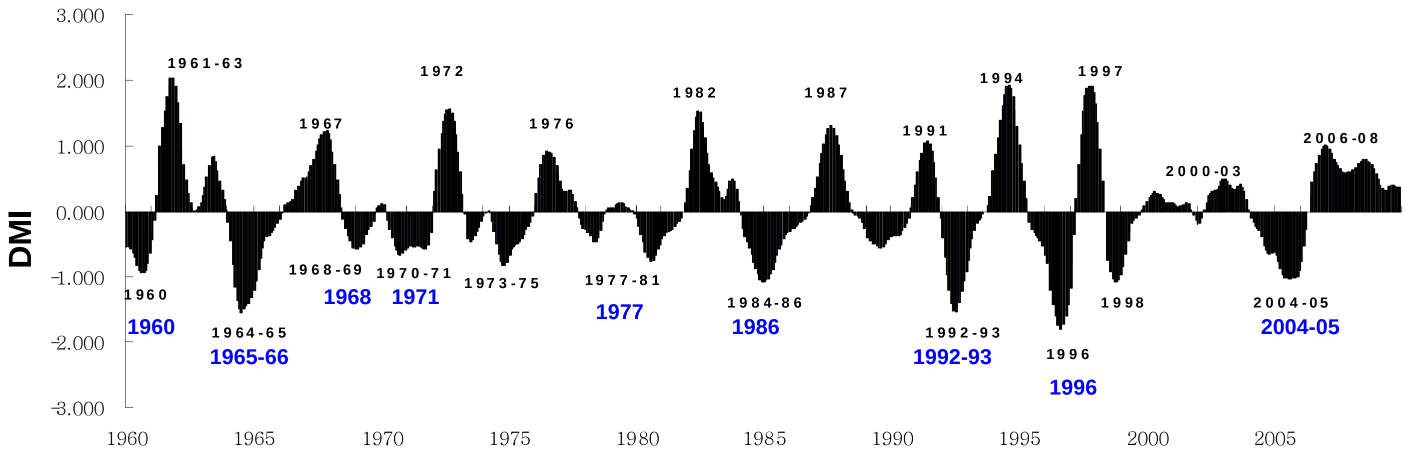
Negative IOD events (DMI-)

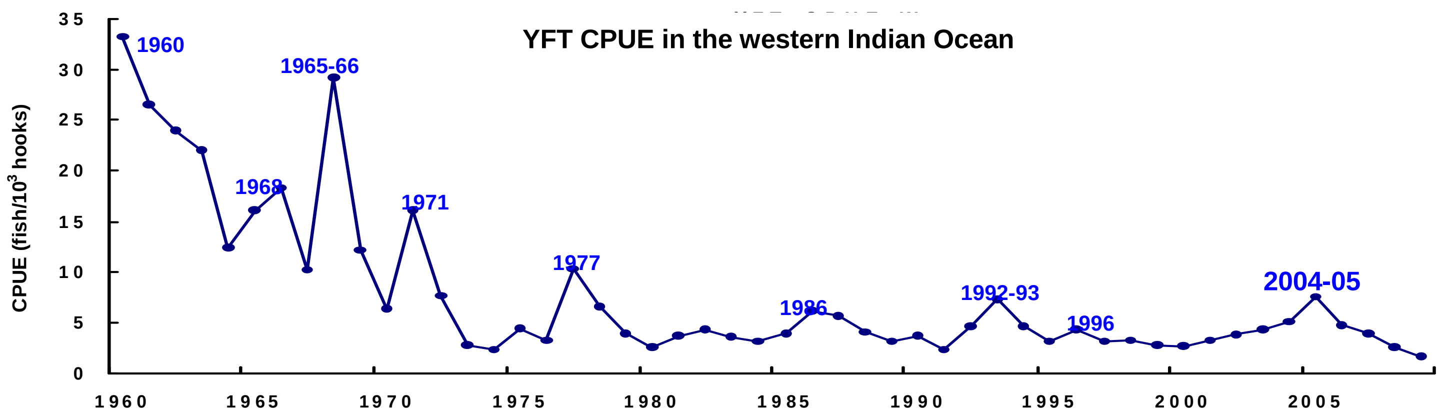


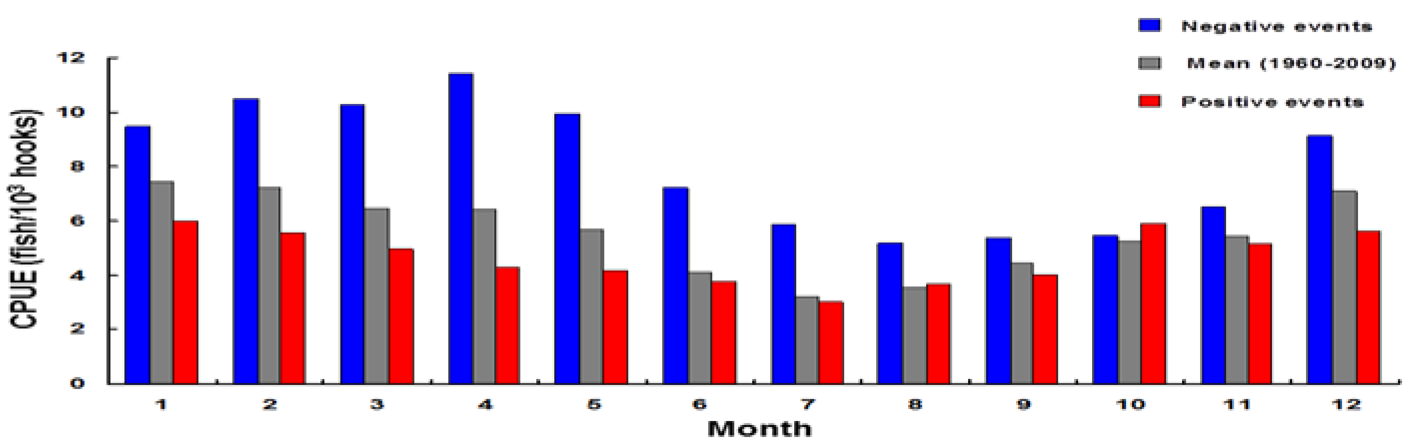
(1974, 1975, 1980, 1985, 1989, 1992, 1981, 2004, 2005)

The variations of the DMI and CPUE of yellowfin tuna in the Indian Ocean

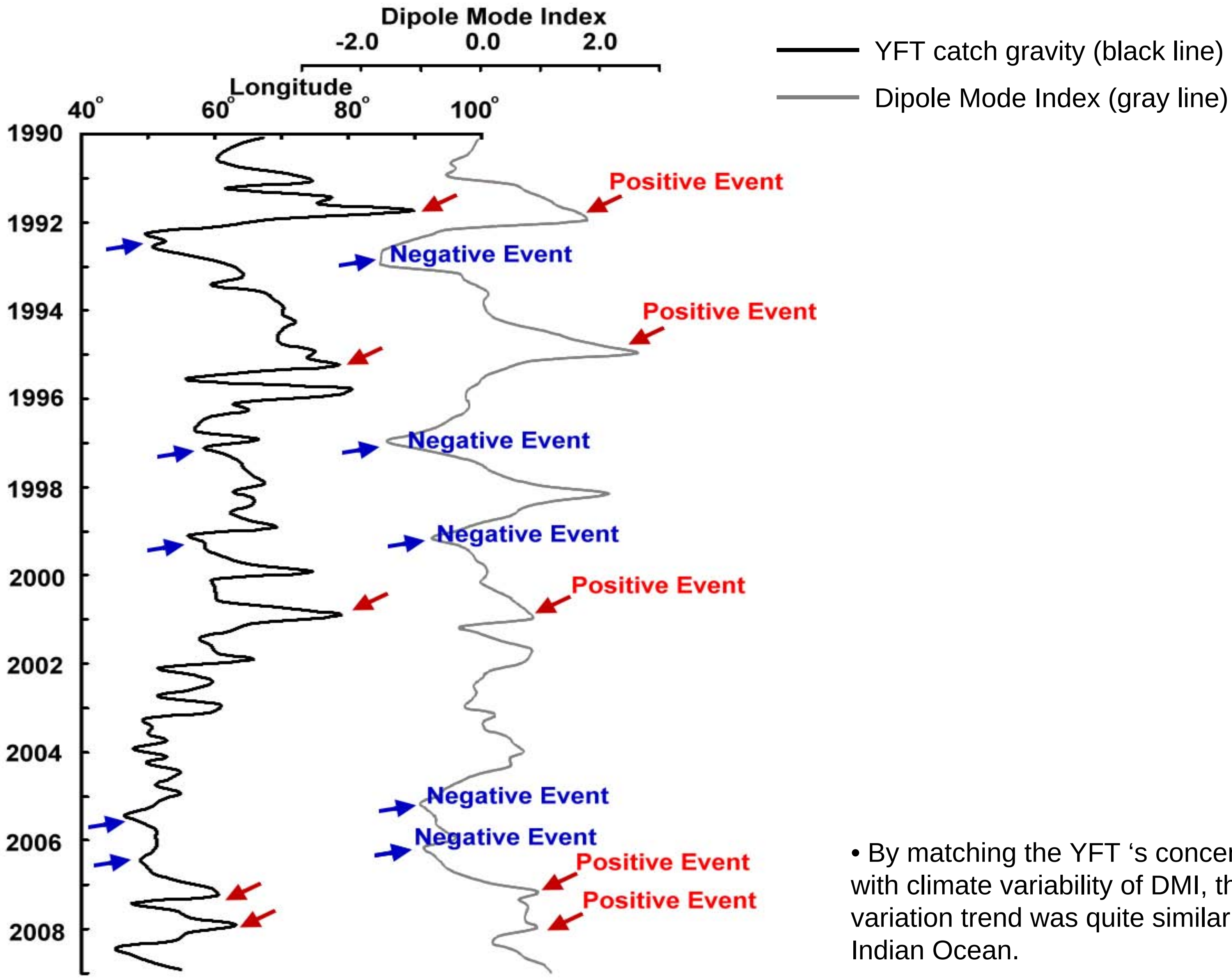








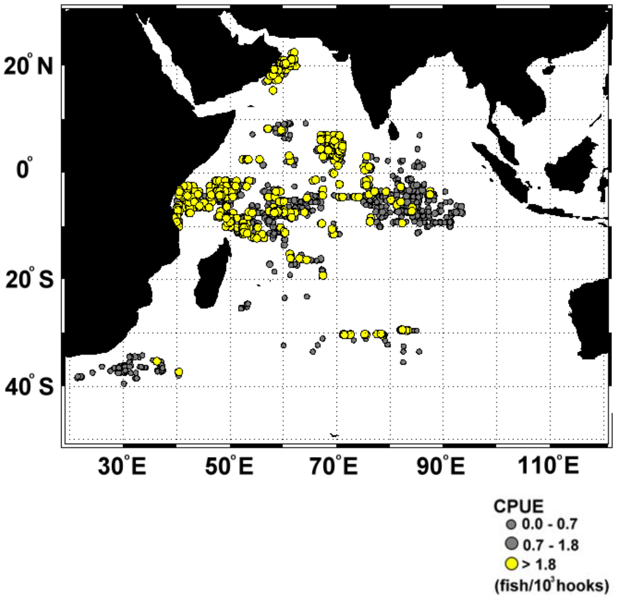
YFT catch gravity in relation to DMI during the fishing seasons in the Indian Ocean



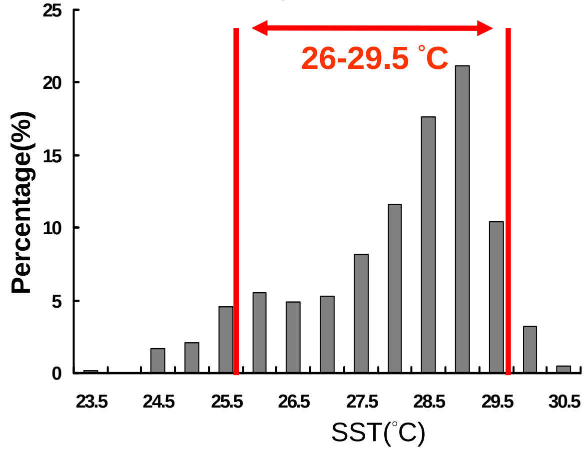
- By matching the YFT 's concentration with climate variability of DMI, the variation trend was quite similar in the Indian Ocean.

The relationship of SST, NPP and high YFT CPUE for 2002-2008 in the Indian Ocean

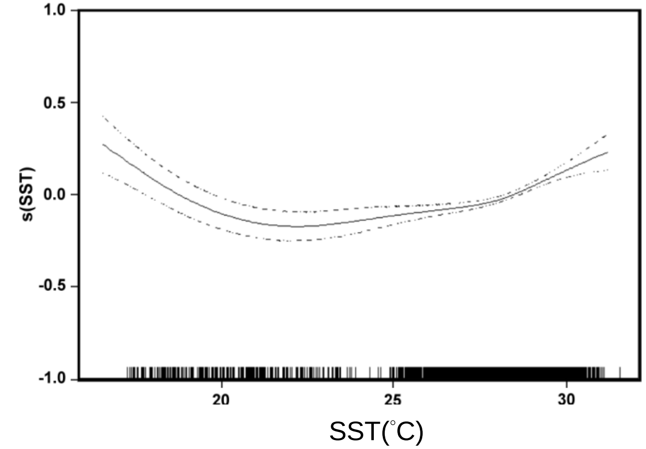
Taiwanese longlone observer data (2002-2008)



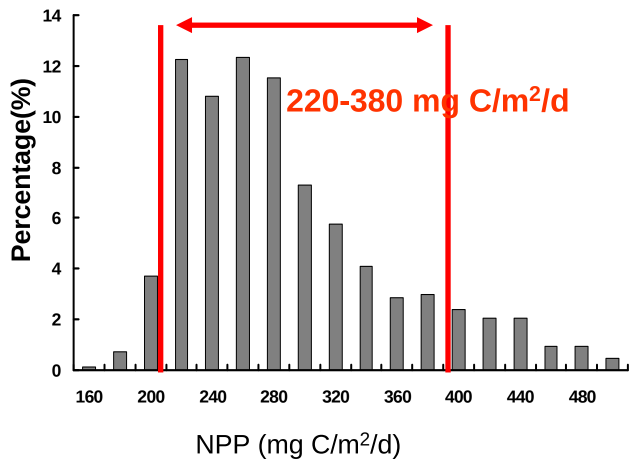
SST and High CPUE (>1.8)



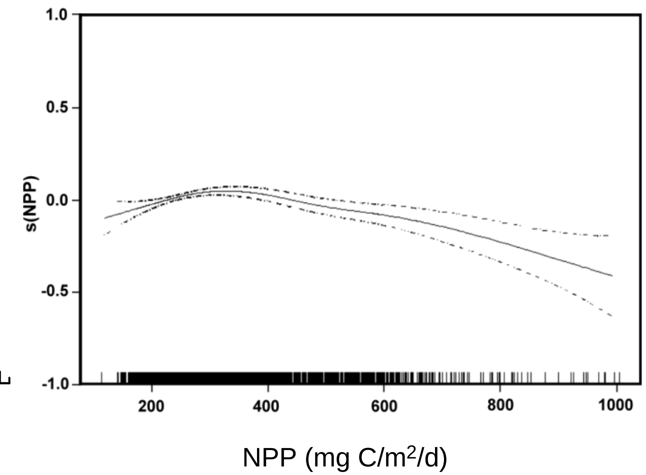
GAM- SST and CPUE



NPP and High CPUE (>1.8)



GAM- NPP and CPUE

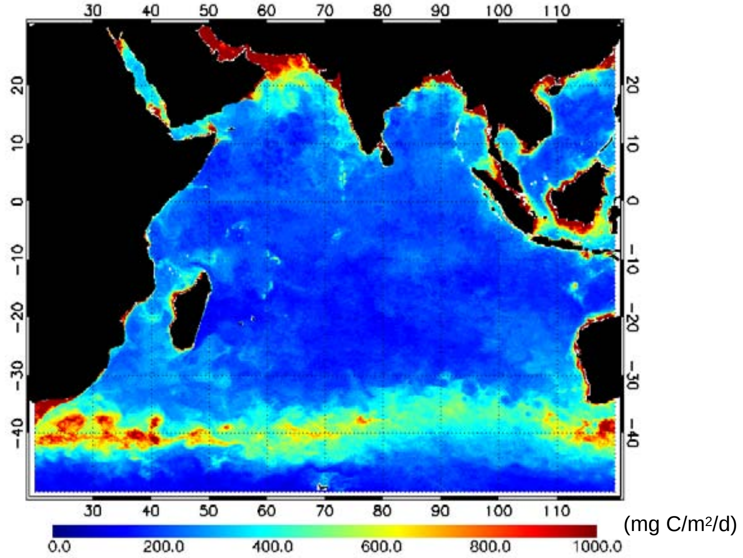


- **By using the Histograms and GAM analysis indicated that high YFT CPUEs were in the areas with sea surface temperature (SST) range of 26–29.5 °C and net primary production (NPP) in the range of 220–380 mg C/m^2/d.**

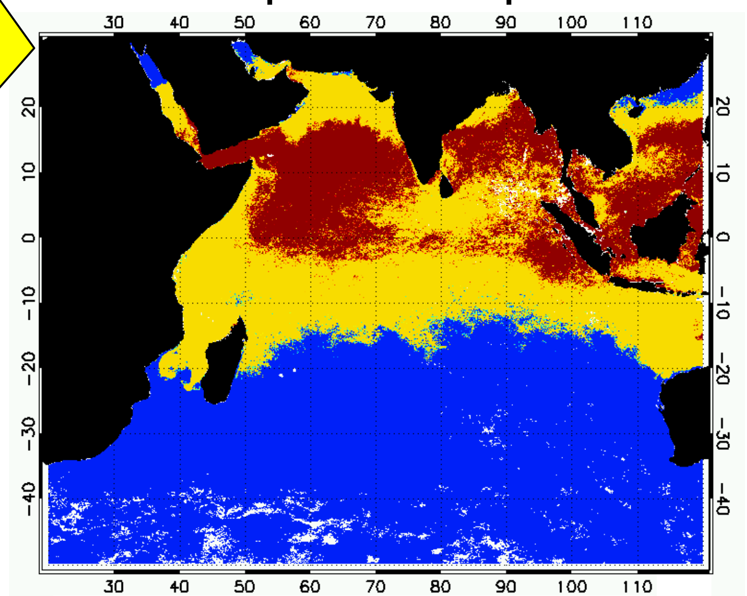
Predicted optimal SST and NPP areas of higher YFT abundances

Pathfinder AVHRR SST map

MODIS NPP map

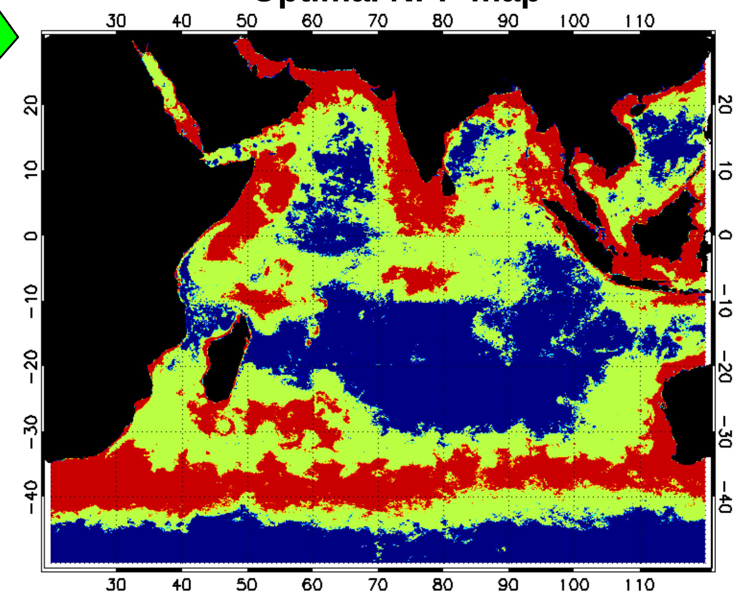


Optimal SST map



High SST (>29.5˚C) | Optimal SST (26-29.5˚C) | Low SST (<26˚C)

Optimal NPP map

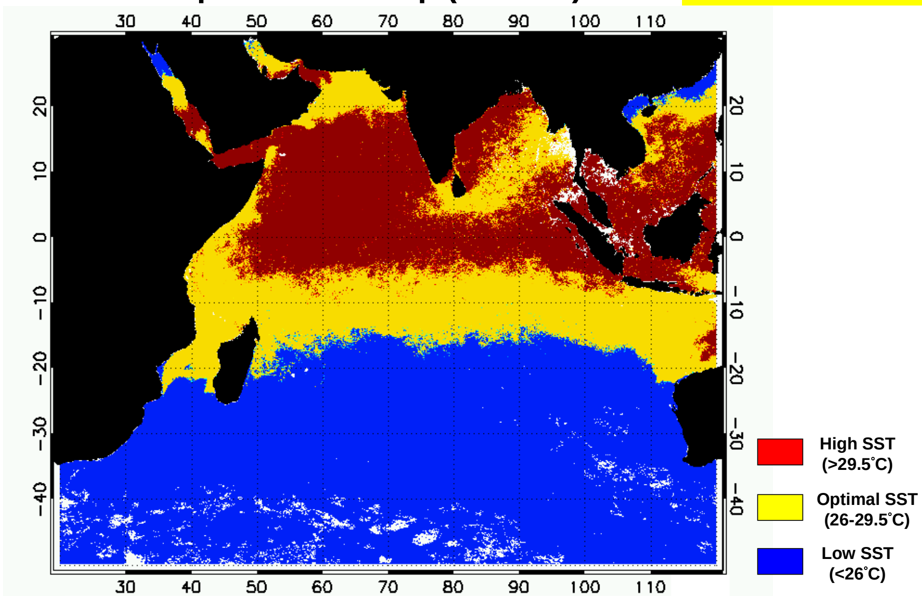


High NPP >380 mg C/m²/d | Optimal NPP 220-380 mg C/m²/d | Low NPP 220-380 mg C/m²/d

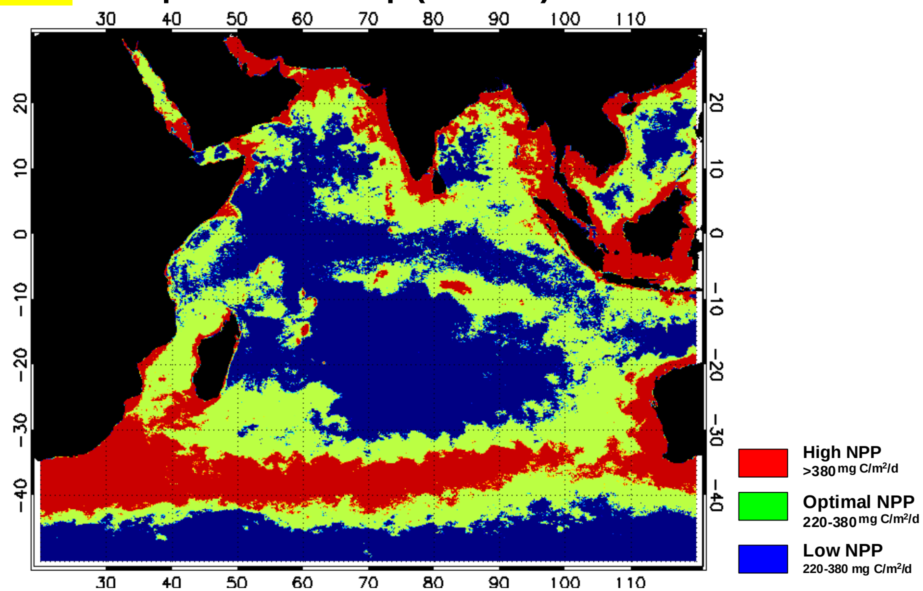
Comparison of the optimal SST and NPP maps in negative and positive events

Positive Event

Optimal SST map (2007/05)

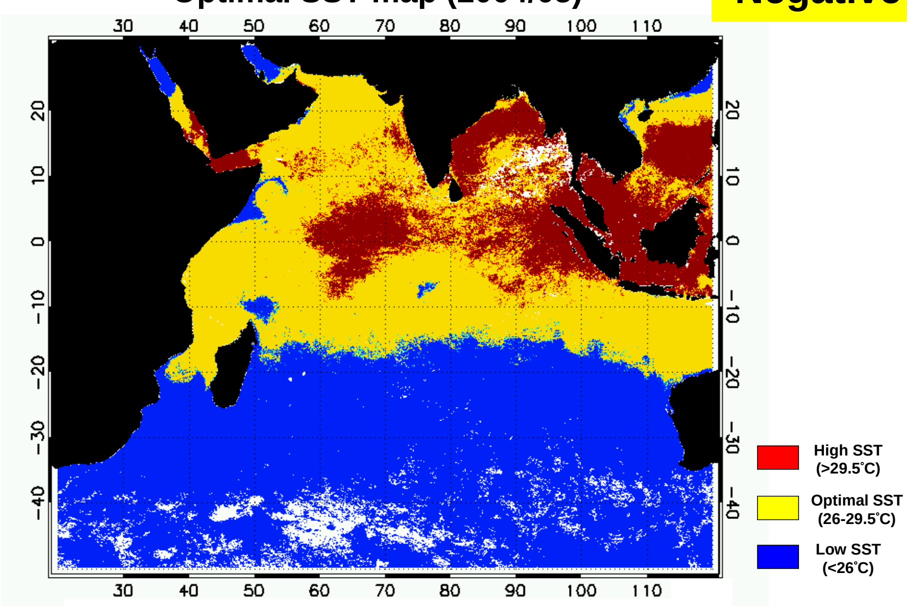


Optimal NPP map (2007/05)

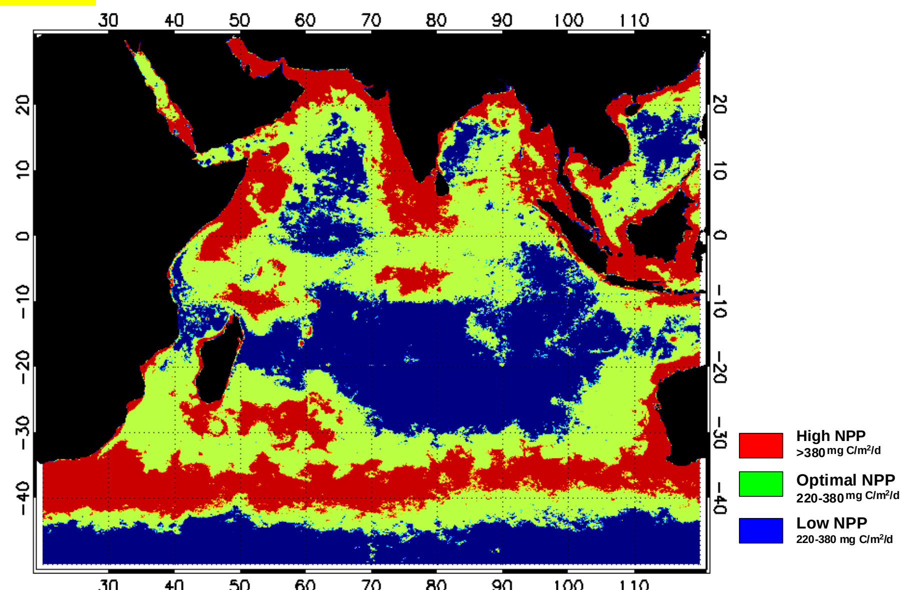


Negative Event

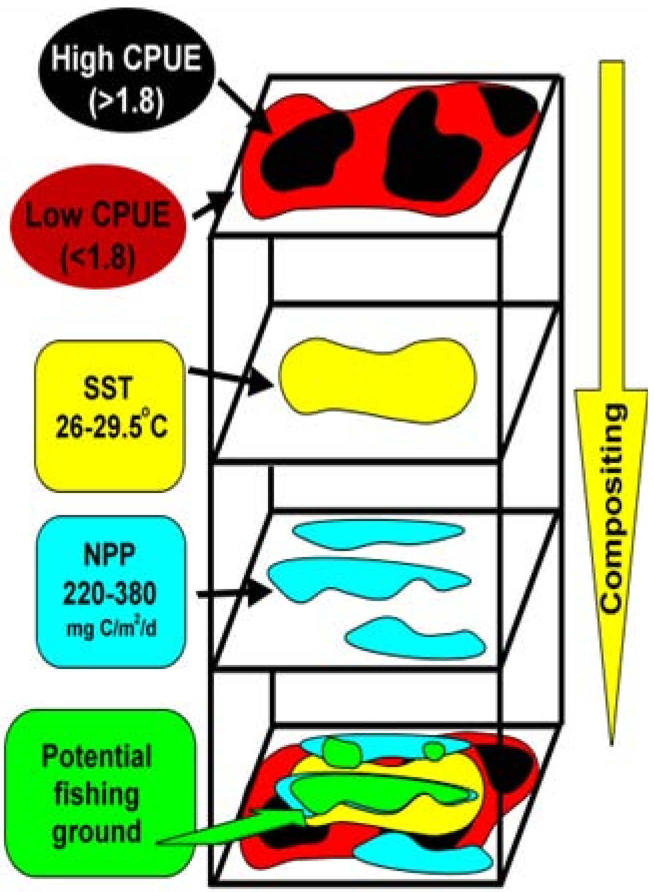
Optimal SST map (2004/05)

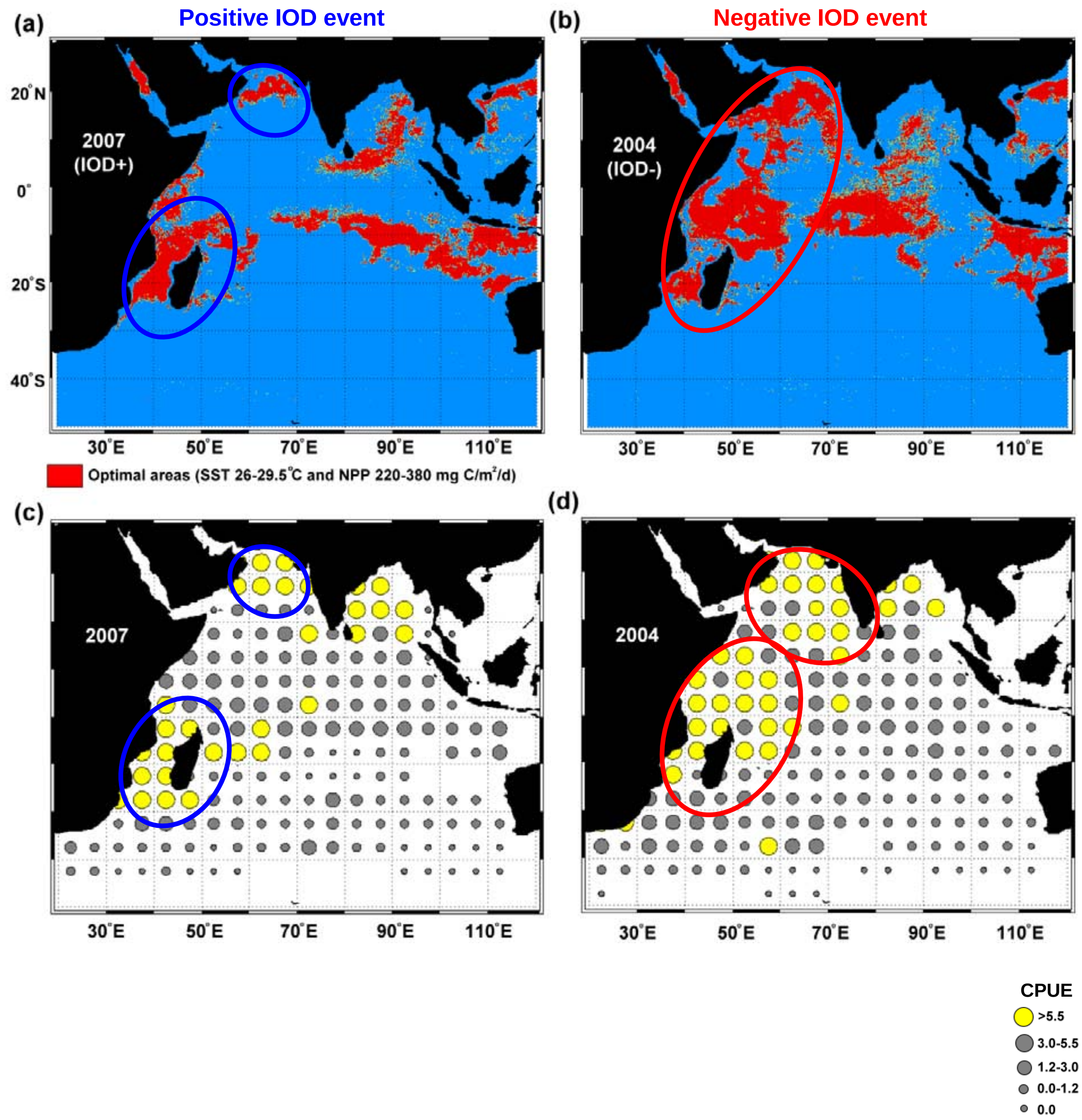


Optimal NPP map (2004/05)



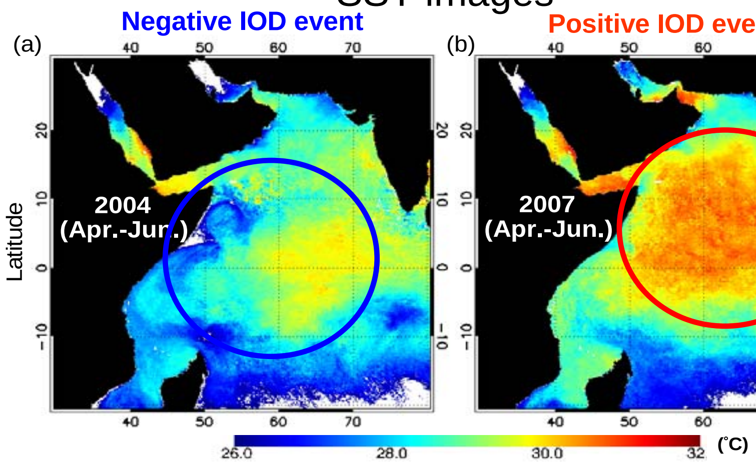
Comparisons of the potential fishing grounds in the positive and negative events



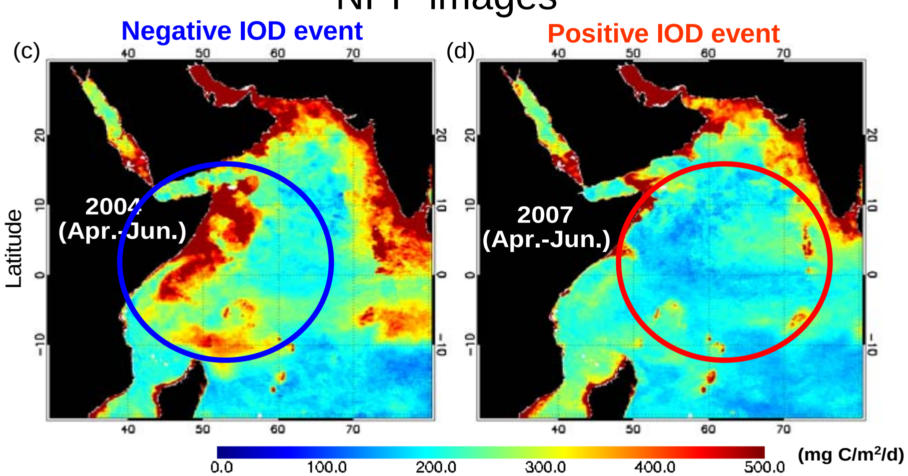


Positive (warm) and negative (cold) episodes associated with YFT fishing conditions in the Indian Ocean

SST images

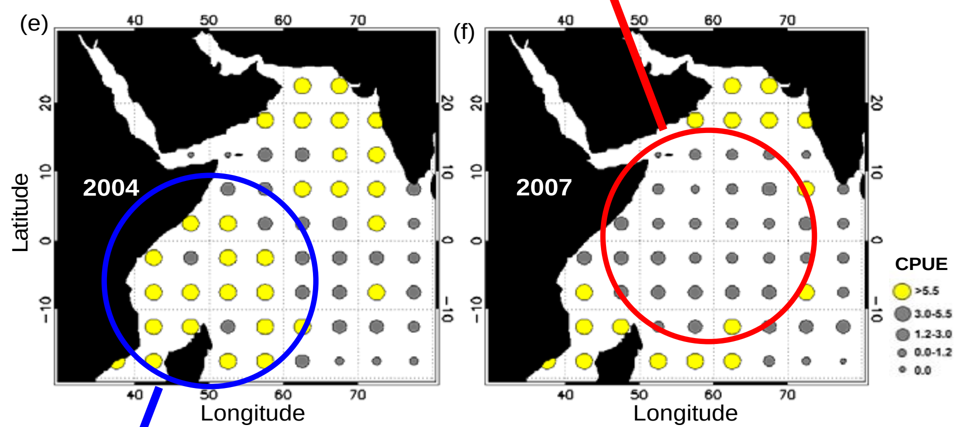


NPP images



Positive IOD event

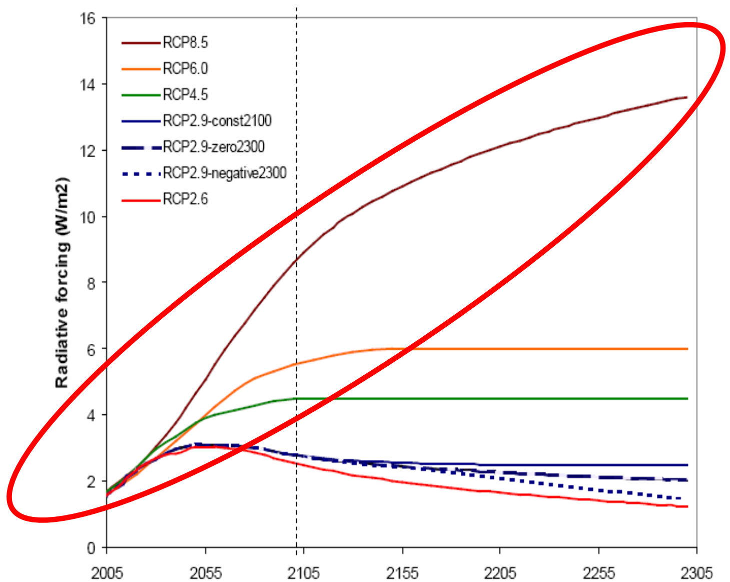
Increasing of SST, decreasing NPP in the western Indian Ocean would caused lower CPUE of YFT in the western Indian Ocean



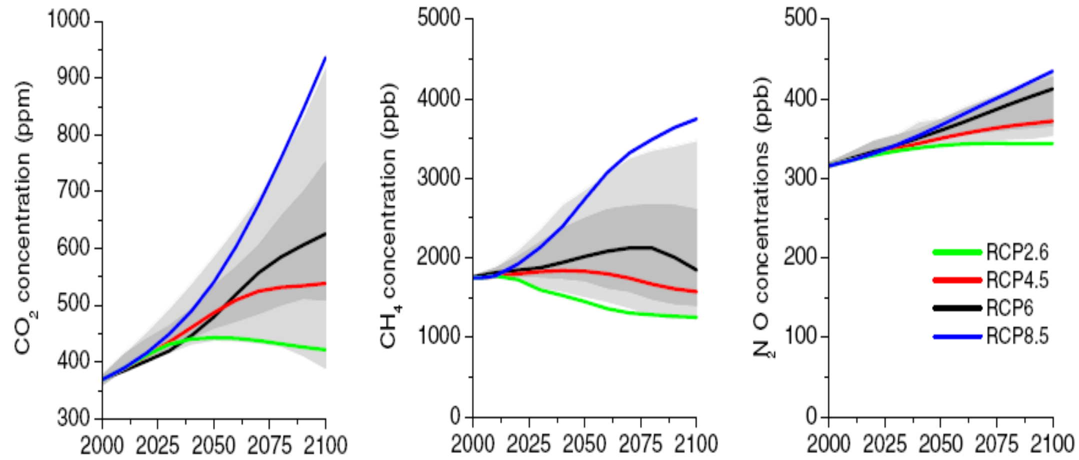
Negative IOD event

Decreasing of SST, increasing NPP in the western Indian Ocean would caused higher CPUE of YFT in the western Indian Ocean

Predicted Climate Change effects on the Indian Ocean

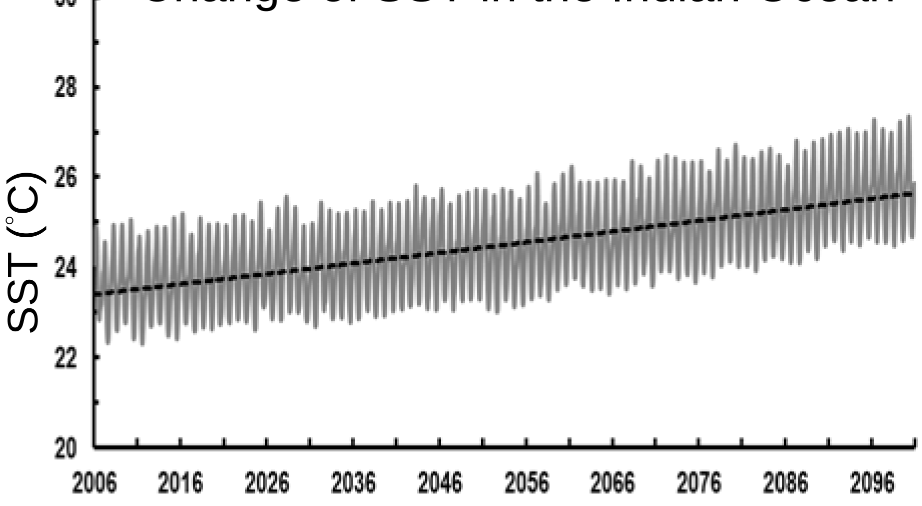


By following the GFDL RCP8.5

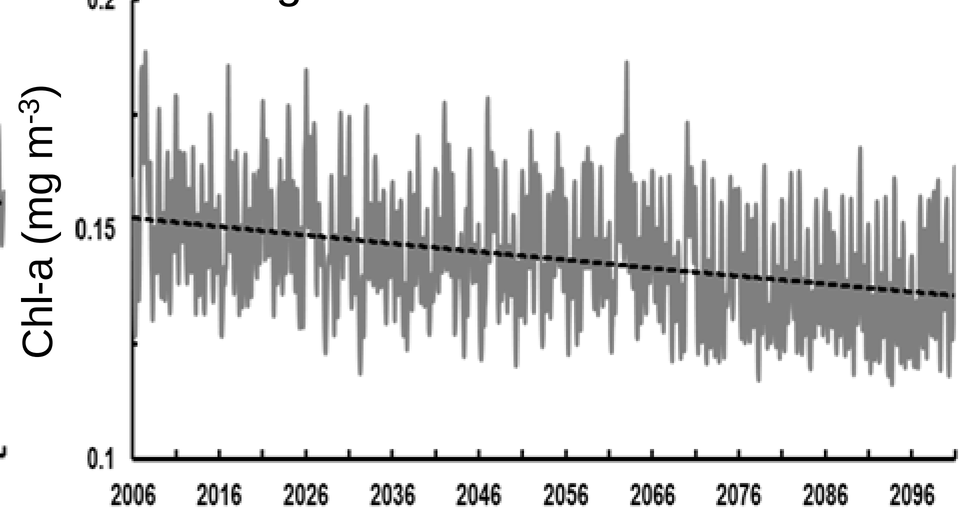


(Clarke et al., 2010)

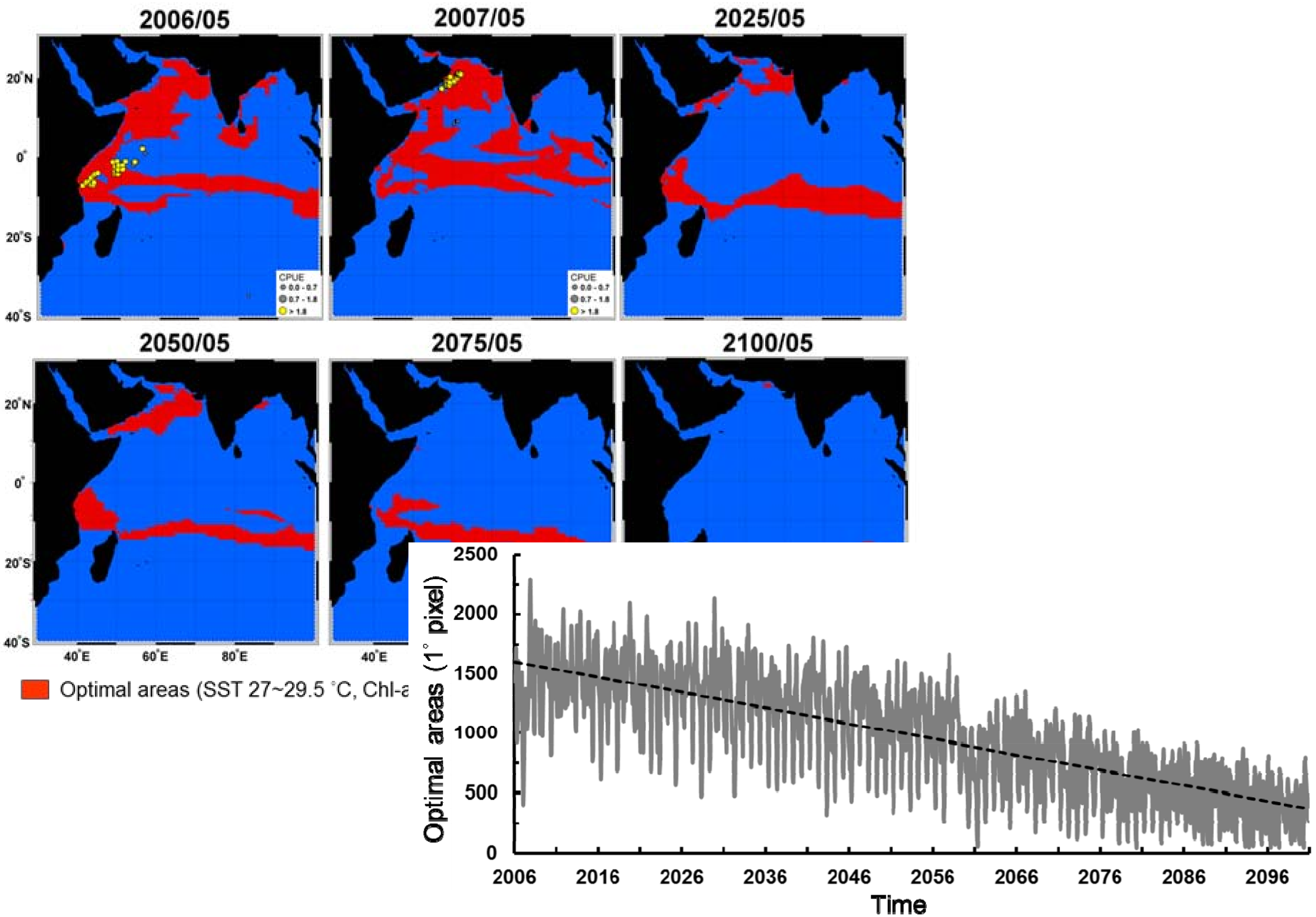
Change of SST in the Indian Ocean



Change of Chl-a in the Indian Ocean



Predicted Climate Change effects on YFT longline fishing grounds



Conclusion

- The advanced time series analysis showed the significant coherence between the DMI and YFT CPUE with a periodicity of 2-3 yr. The DMI was also found to be negatively correlated with YFT CPUE in the western Indian Ocean.

- It was suggested that decreasing the optimal areas of SST and NPP during the positive IOD events would cause the lower YFT CPUE in the western Indian Ocean, while increasing the optimal areas would result in higher YFT CPUE in the negative IOD events.

- Furthermore, an examination of the effects of climate change on possible displacements of potential habitats of yellowfin showed that an SST increase may resulted in decreases of the most suitable areas.

Thank you for your attention!