The North Equatorial Countercurrent: an anomalous boundary current with biologically significant upwelling and a predictable response to climate forcing

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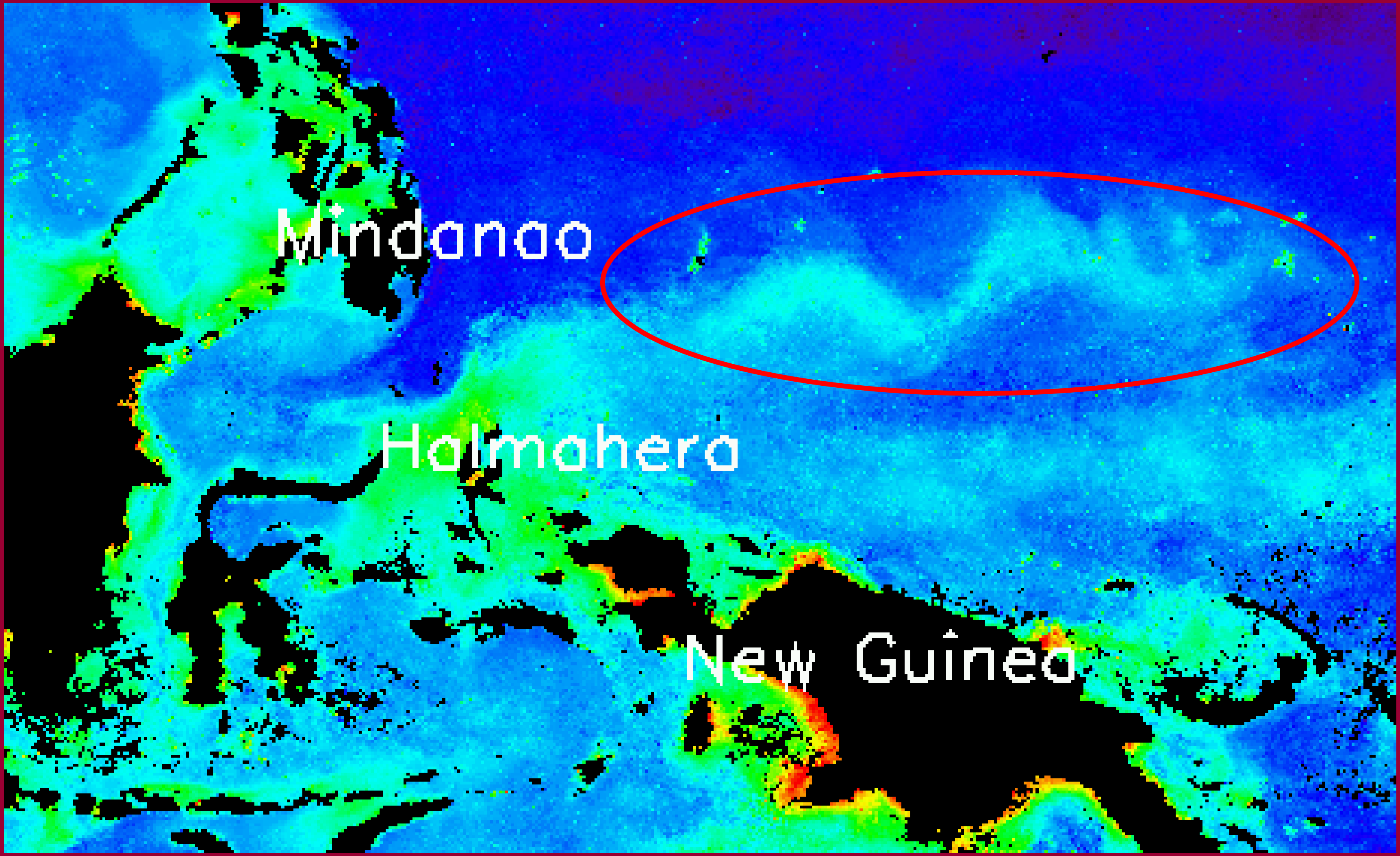
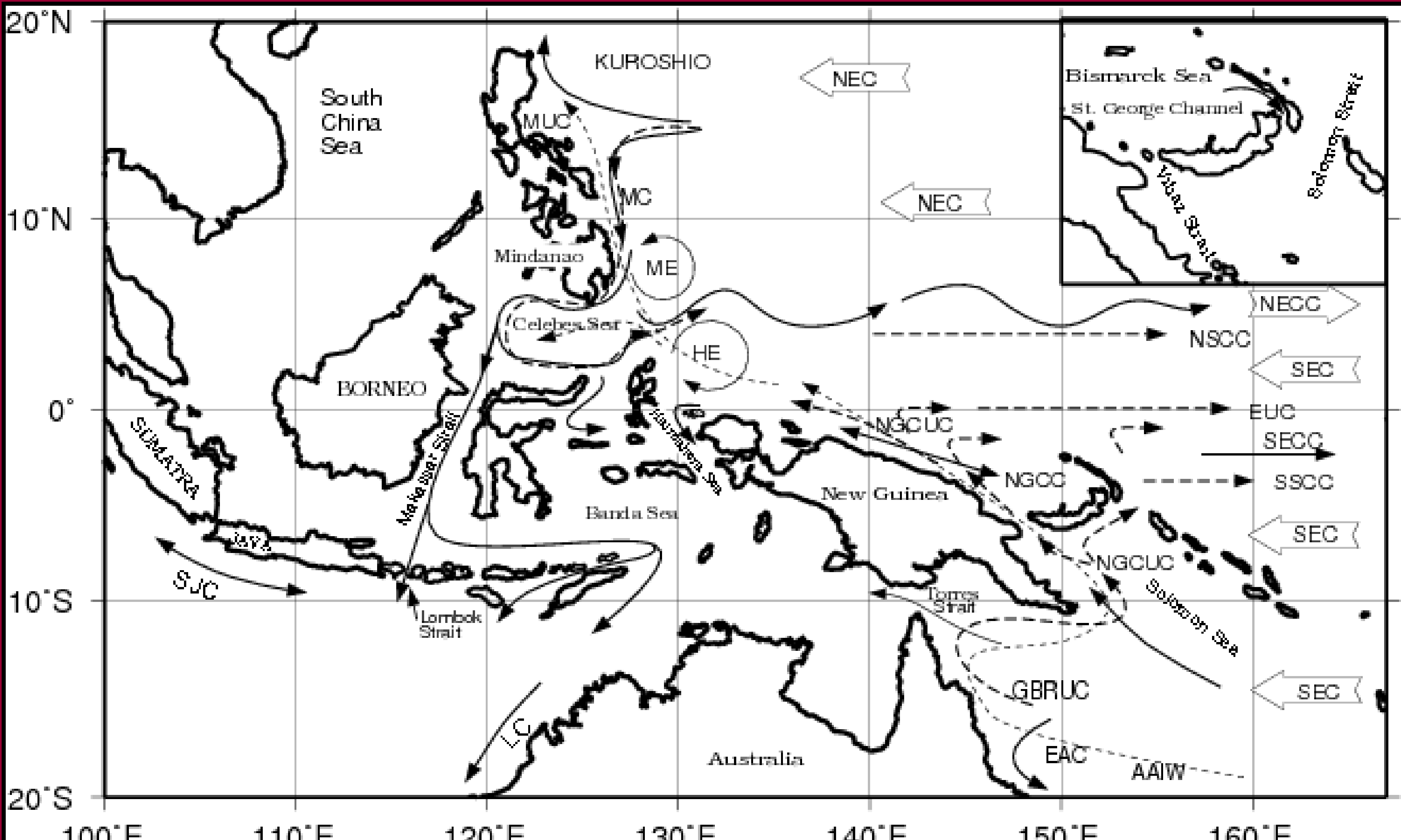
CCCma

IOS

NASA

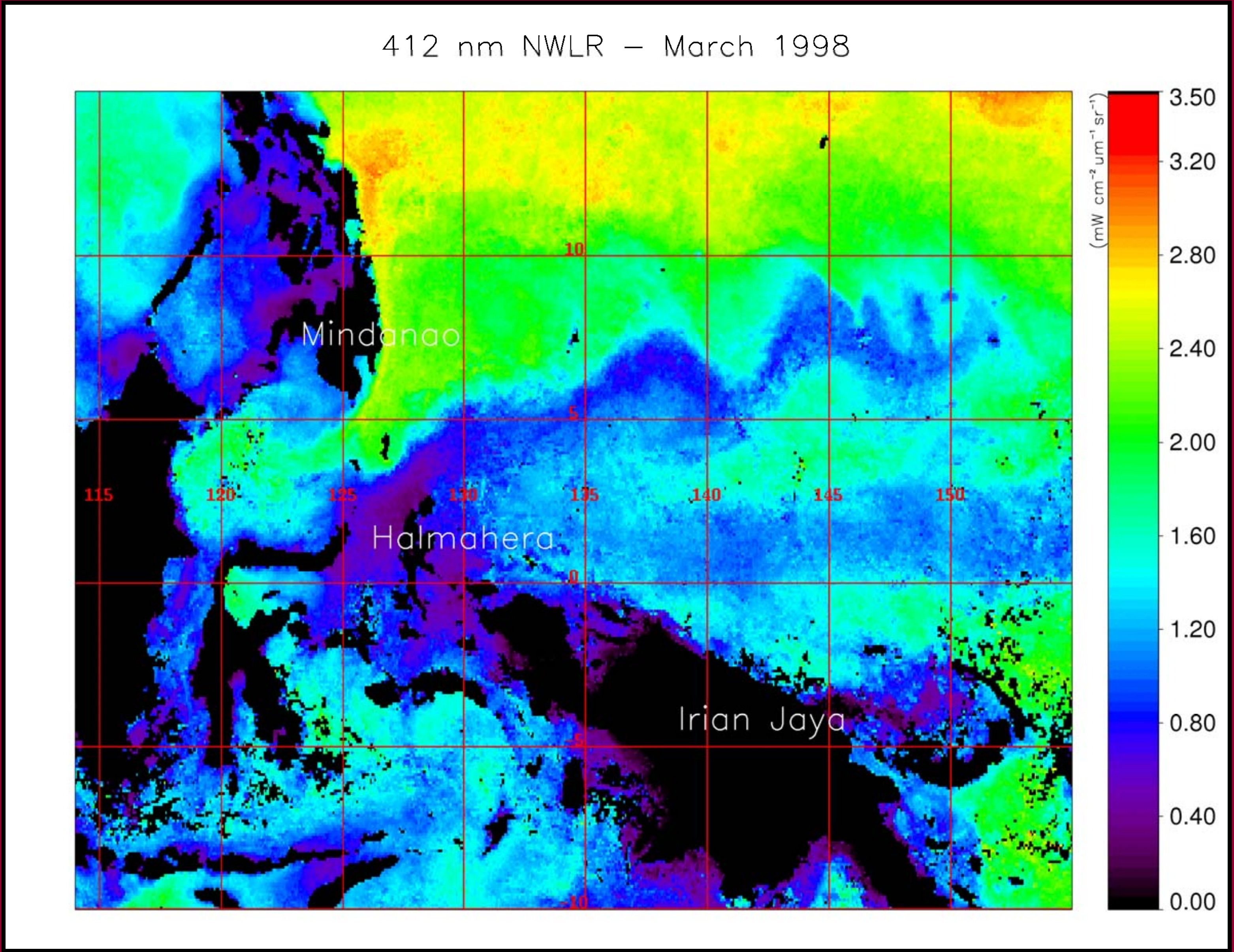


During the 1997-98 El Niño the meanders of the NECC supported an enormous phytoplankton bloom covering some 400000 km^2

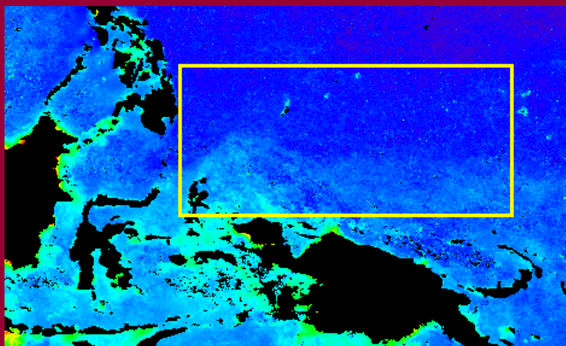


from Fine et al 1994, JGR 99: 25063

A “ribbon of dark water”



November 1997



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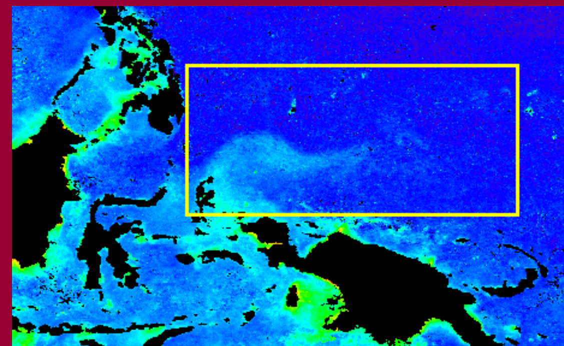
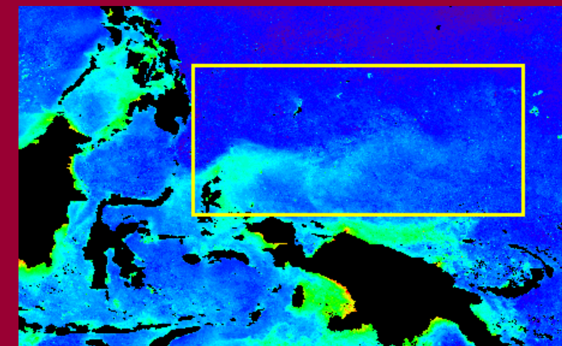
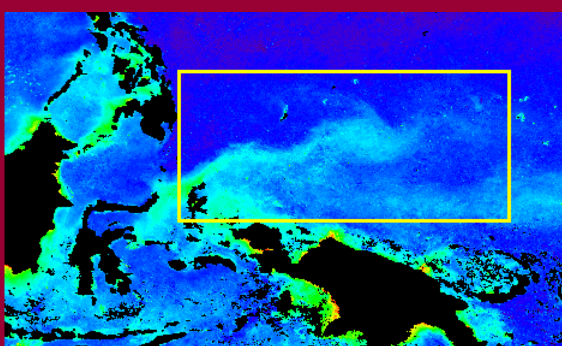


January 1998



February 1998



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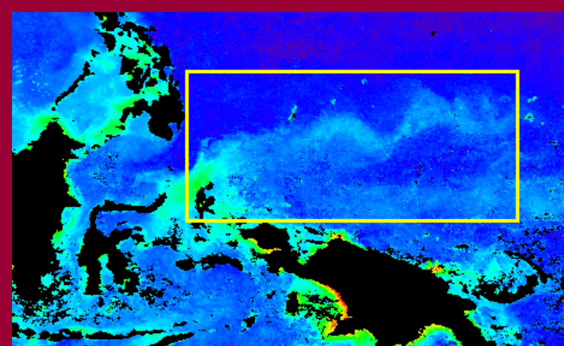

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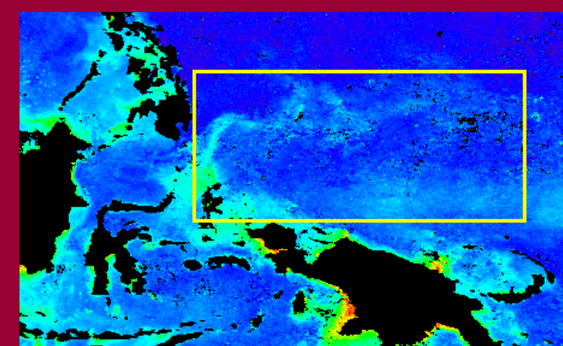
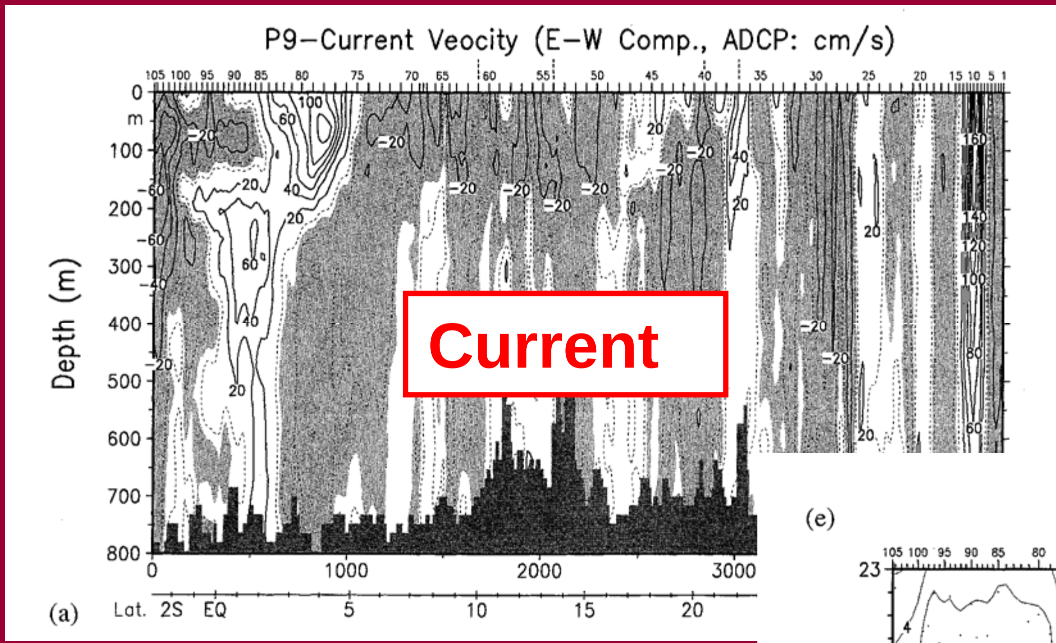
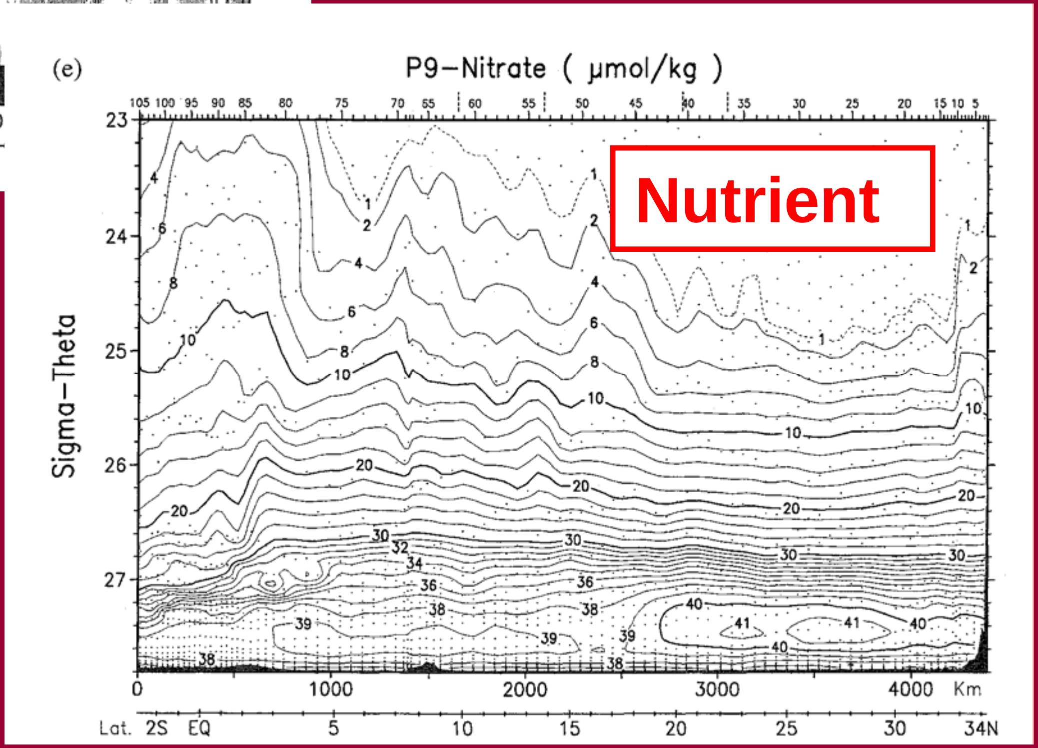
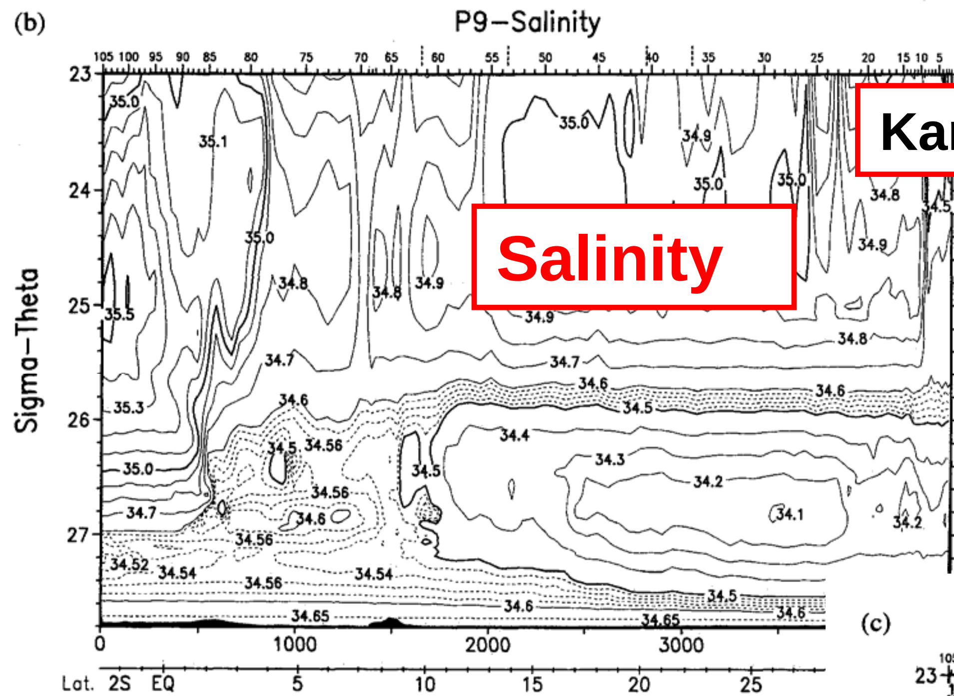


Kaneko et al. 1998. JGR 103 : 12959



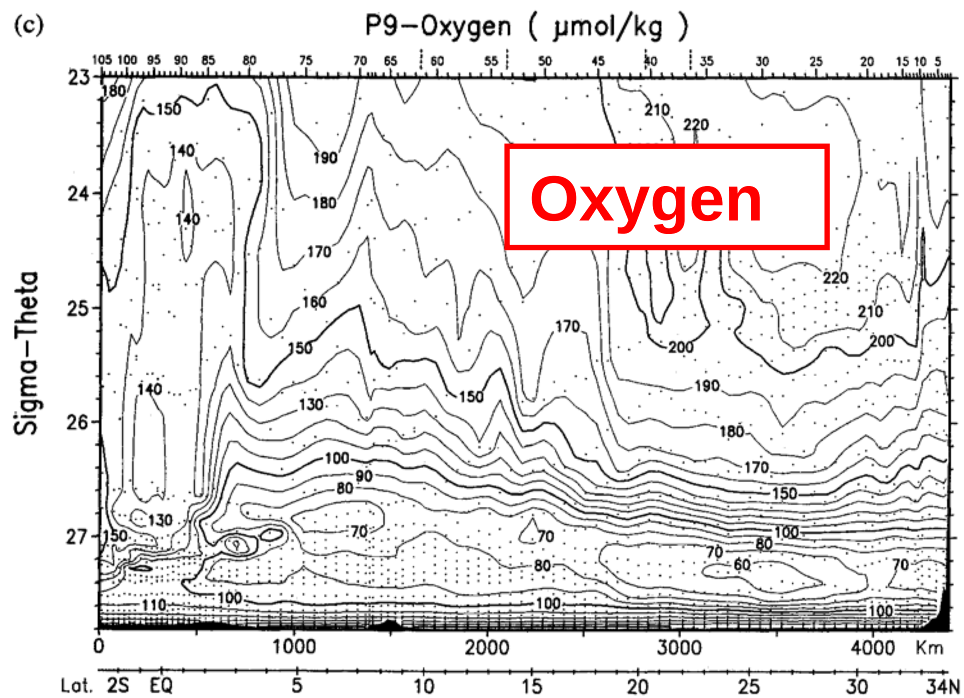


Kaneko et al. 1998. JGR 103 : 12959



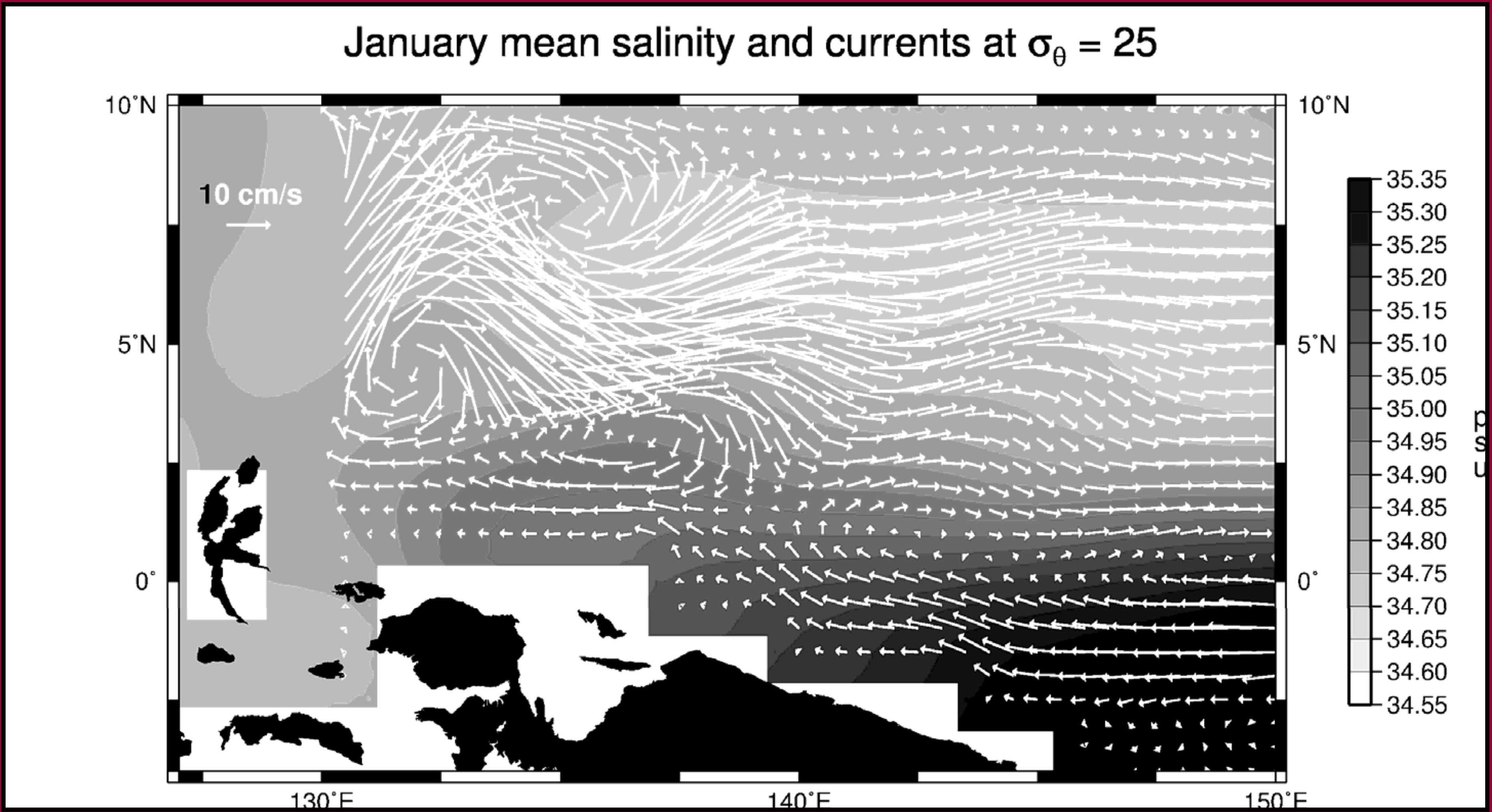
Salinity

Figure 10. (continued)



Oxygen

Figure 10. (continued)

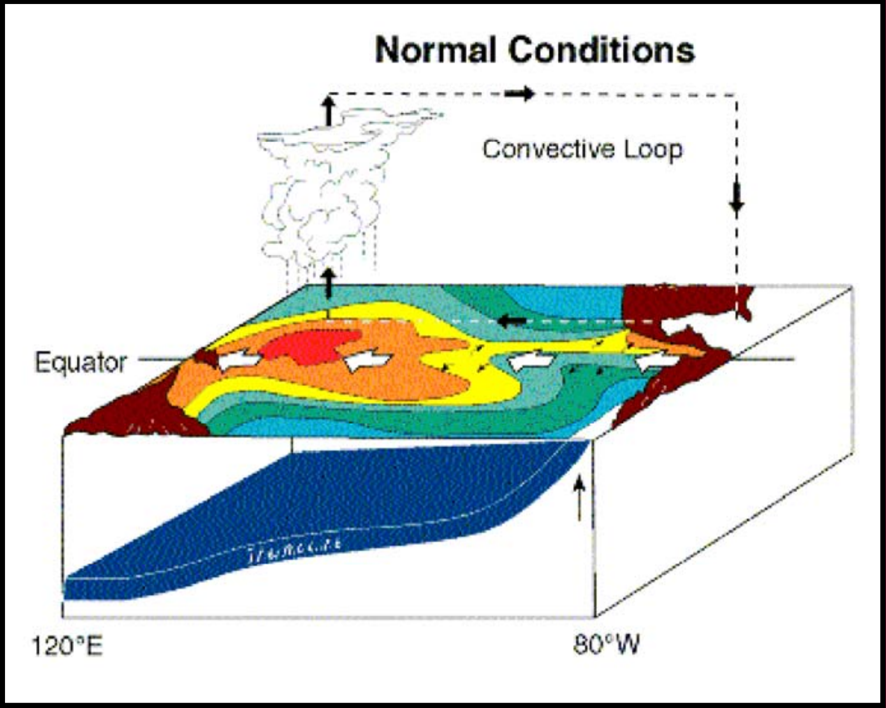


New Guinea coastal undercurrent (NGCUC) brings nutrient-rich water from the South Pacific subtropical gyre, especially in winter

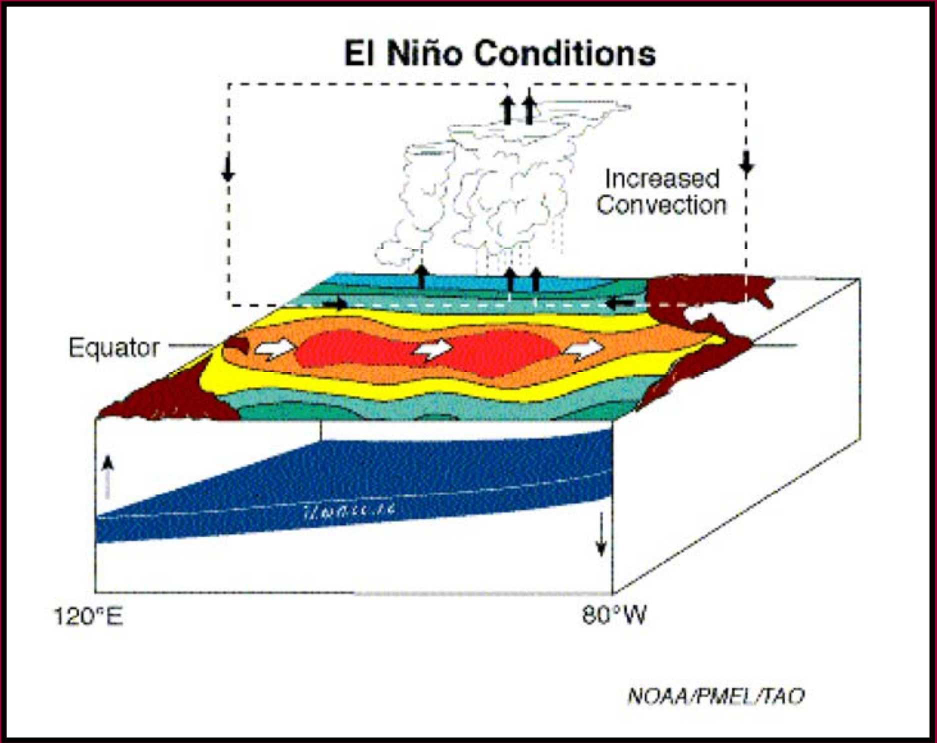
Transport of SPTW by NGCUC and sharp property gradients across the NECC explain why blooms happen in the NECC meanders and not within the interior of the Mindanao Dome.

It also explains, in part, the seasonality.

But what is the association with ENSO? Why don't these blooms happen every year?



El Niño implies large excursions of the thermocline, mirrored in the SSHA



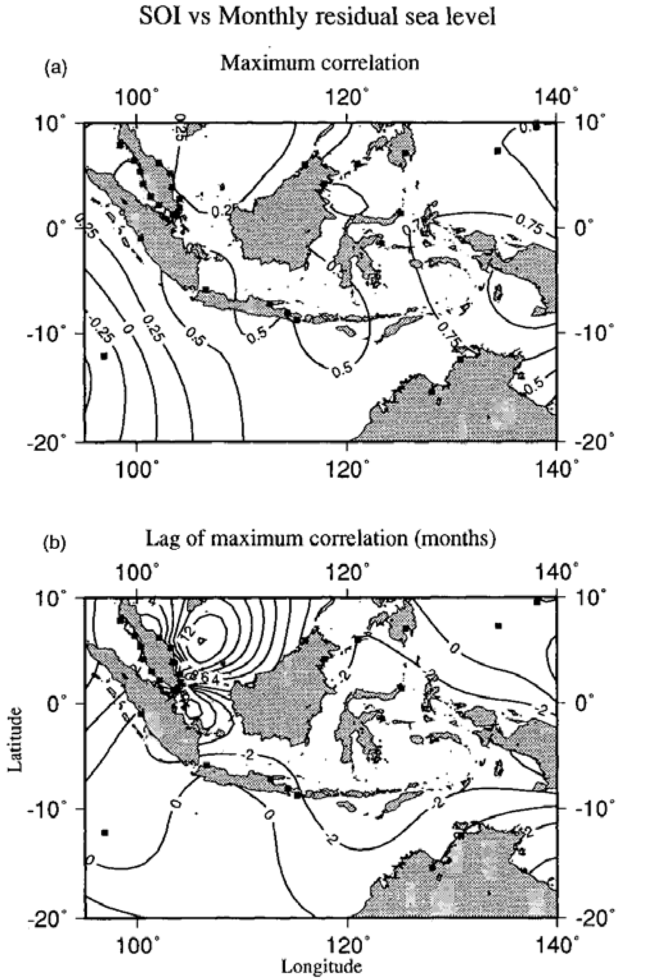
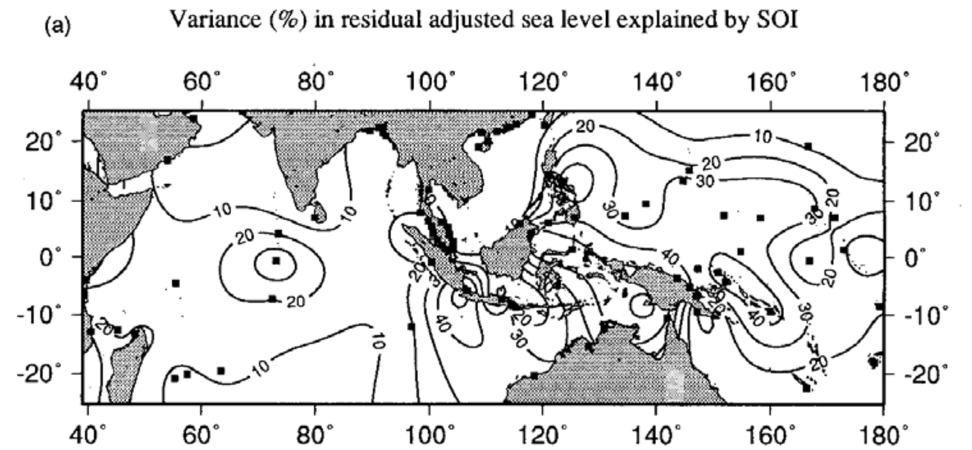


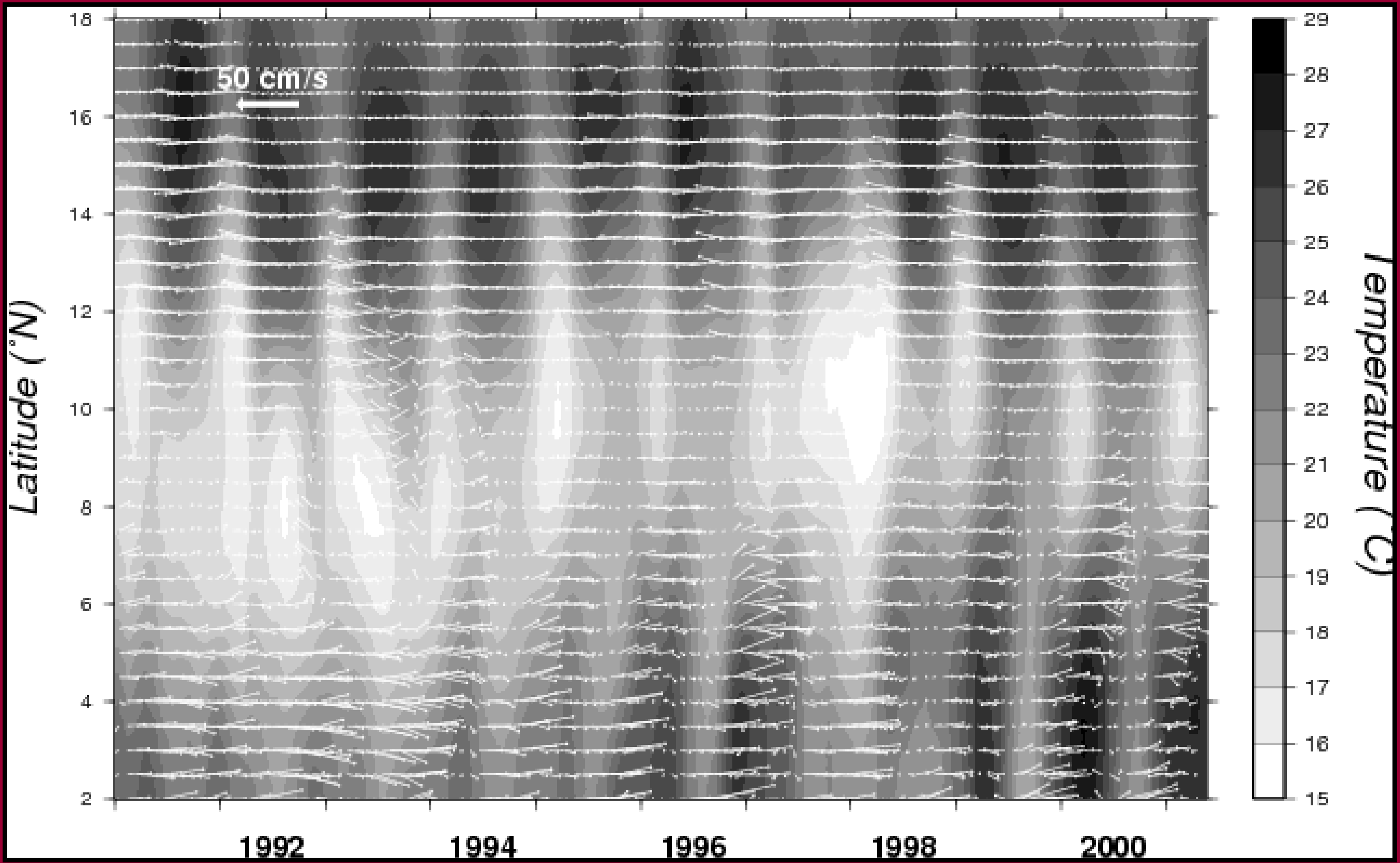
Figure 16. (a) Maximum (lagged) correlation between residual sea level and the SOI. (b) Lag (in months) of the maximum correlation shown in Figure 16a.



In the NECC region the SSHA has a very strong correlation with the state of the tropical Pacific as a whole as expressed by ENSO indices.

When the thermocline of the equatorial Pacific moves, the thermocline of the Mindanao Dome moves in the opposite direction.

Bray et al. 1996. JGR 101: 12239



Thermocline shoaling reflects the evolution of ENSO warm and cold phases throughout the 1990's

The flux of nutrient to the mixed layer in the NECC appears to be maximal during boreal winter and during ENSO warm phase.

This results from a confluence of several factors:

- **the thermocline shoals due to remote ENSO forcing (predominantly interannual)**

- **the current accelerates, increasing meander-induced upwelling (predominantly interannual)**

- **the flow of nutrient rich water via NGCUC increases (predominantly seasonal)**

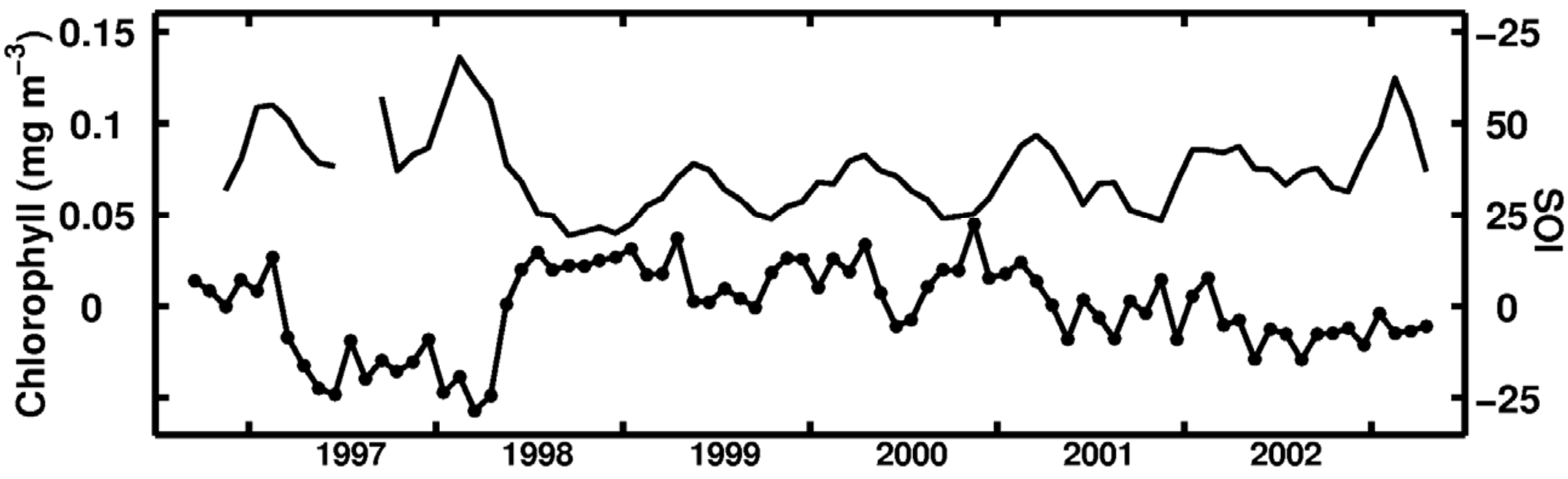
- **the wind stress becomes upwelling-favourable in boreal winter (predominantly seasonal)**

Chlorophyll, SST, and SSHA are strongly correlated with ENSO indices, not with the local wind stress

	CHL	SST	SSHA	SOI	NINO3	TAUX
SST	**-0.84					
SSHA	*-0.62	*0.56				
SOI	**-0.72	**0.60	**0.71			
NINO3	**-0.69	**-0.52	**-0.91	*-0.78		
TAUX	-0.18	0.40	0.06	-0.14	0.02	
TAUY	0.37	0.62	-0.38	0.17	-0.24	*0.87

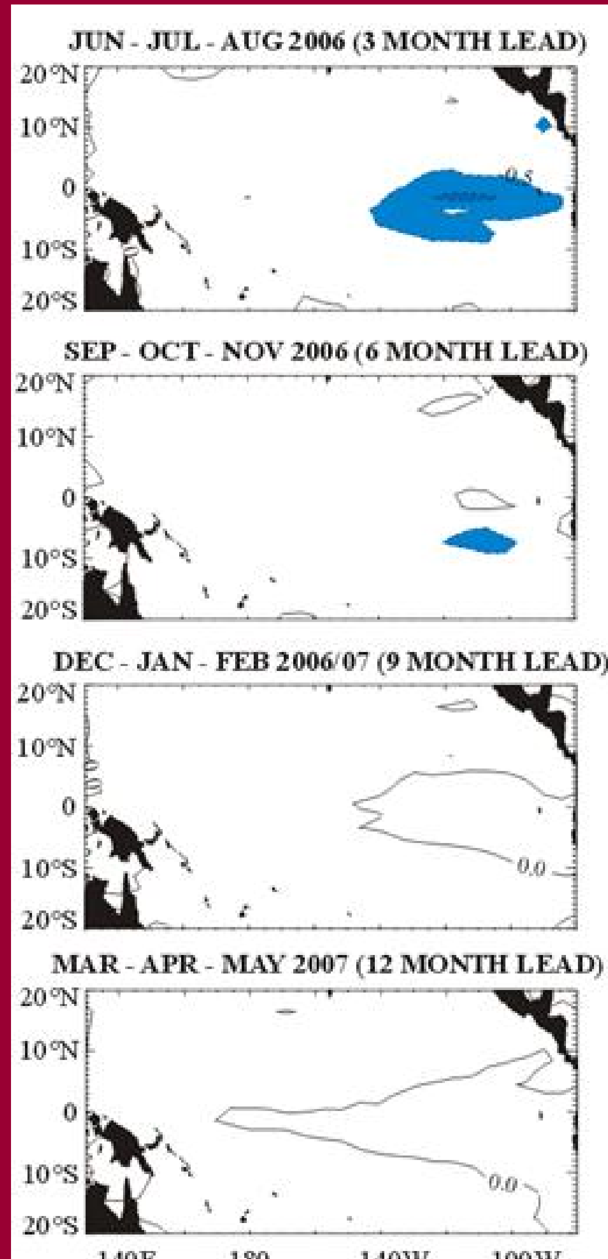
The thermocline responds to remote forcing, and biology responds to the thermocline

We can predict ecosystem response from ENSO indices, and eventually from ENSO prediction models

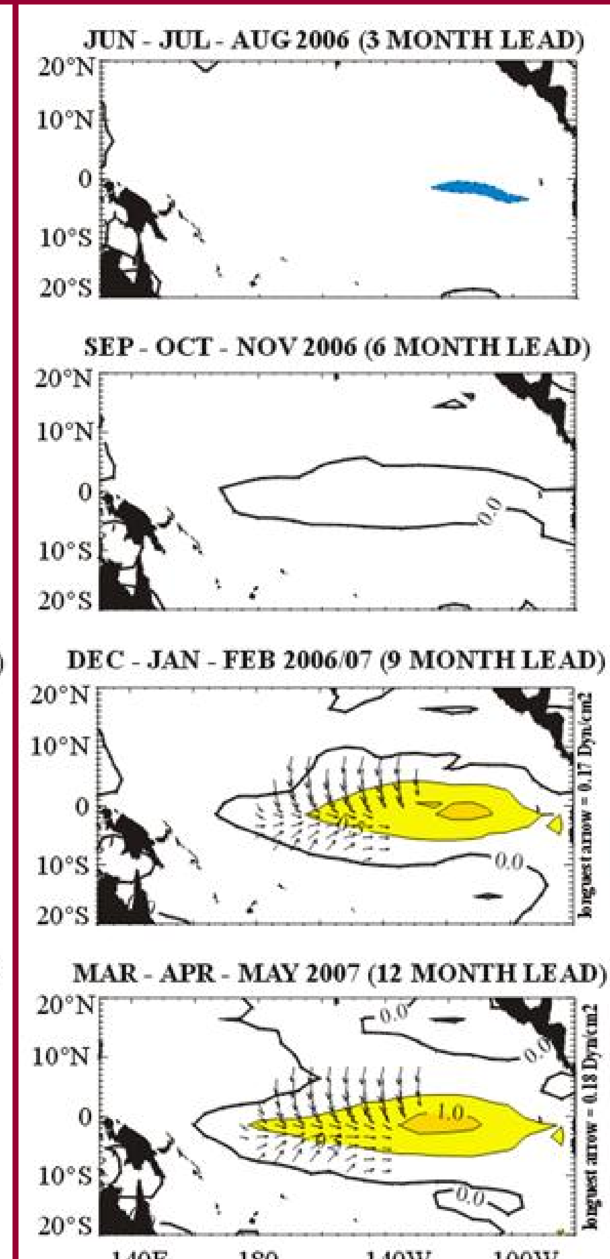


Prediction of ENSO remains unsolved, but we can observe the ocean in real time to 'predict' the biological response

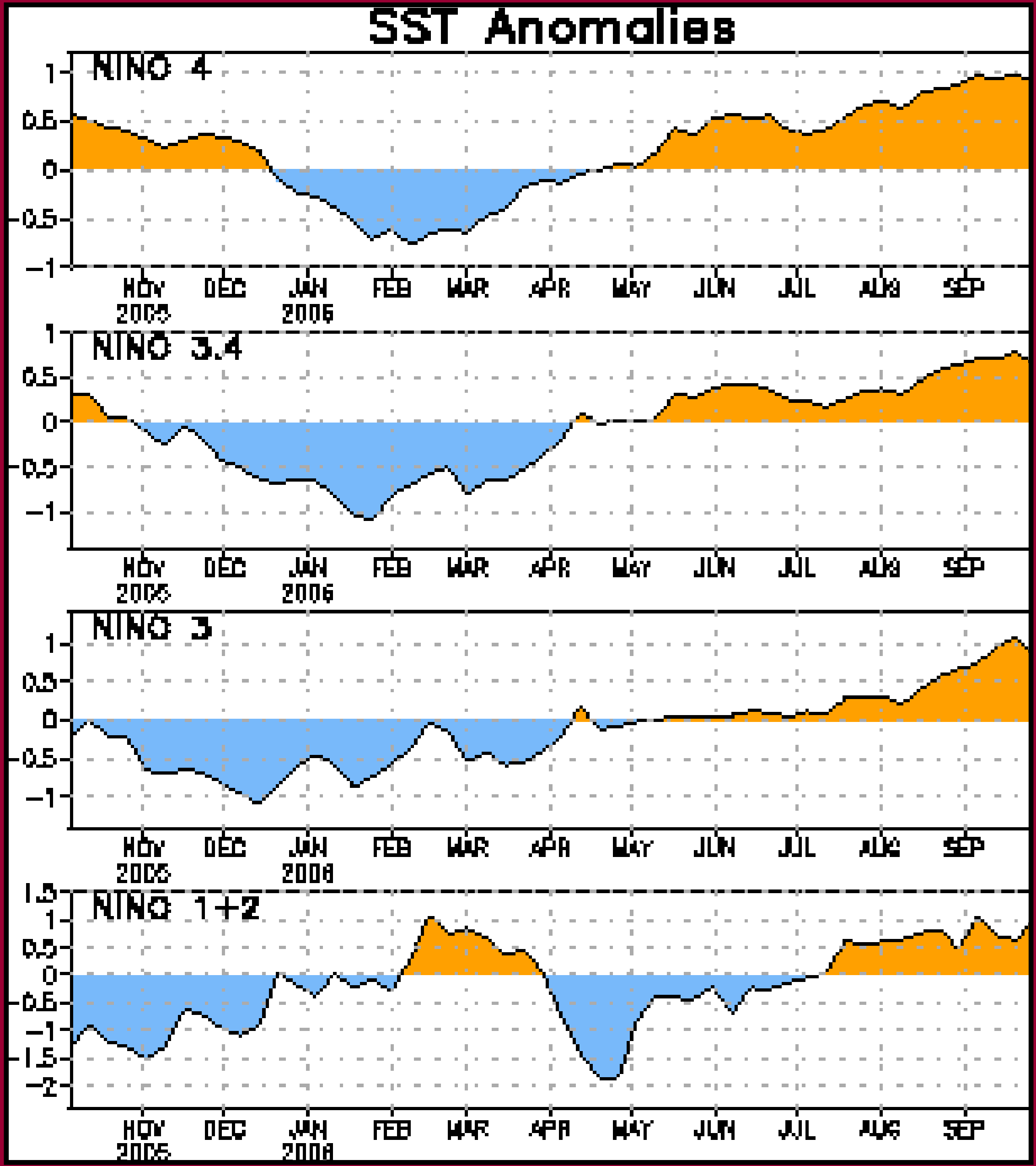
Statistical Atmosphere



Dynamical Atmosphere



from DeWitte et al in Experimental Long-lead Forecast Bulletin (June 2006)



Source: NOAA Climate Prediction Center

“Papua New Guinea's 5957 million square kilometre Exclusive Economic Zone is one of the largest marine jurisdictional zones in the Pacific and the richest in fisheries resources in the region.”

“Current production of fish in the country is estimated at about 145,000 metric tonnes per annum of tuna and tuna-like species and other pelagic fish. It is estimated that the potential yield of those species is about 370,000 metric tonnes per annum.”

Source: Government of Papua New Guinea

Conclusions

NECC upwelling is predictable from real-time ocean observations, even if ENSO itself is not predictable beyond 6-9 months.

This creates opportunities for developing a sustainable fishery in one of the last areas where large pelagics are still underexploited.

More information: Christian, J.R., R. Murtugudde, J. Ballabrera-Poy, J., and C.R. McClain, 2004. A ribbon of dark water: phytoplankton blooms in the meanders of the Pacific North Equatorial Countercurrent. Deep-Sea Research II 51: 209-228