The Equatorial Current System

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General Physical Oceanography

MAR 555

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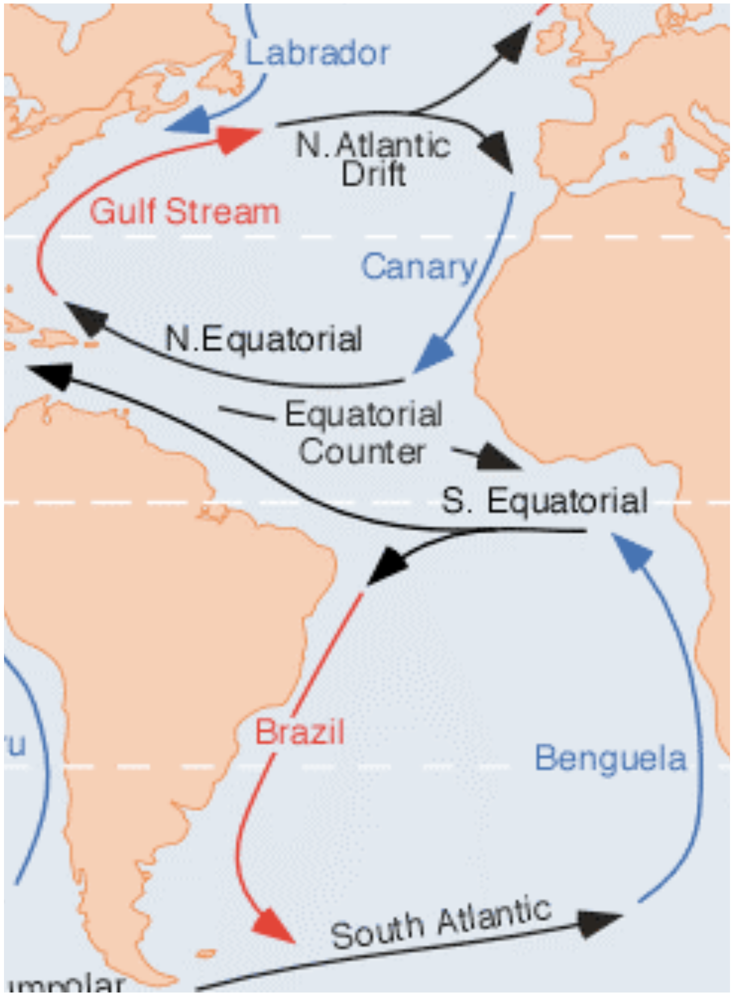
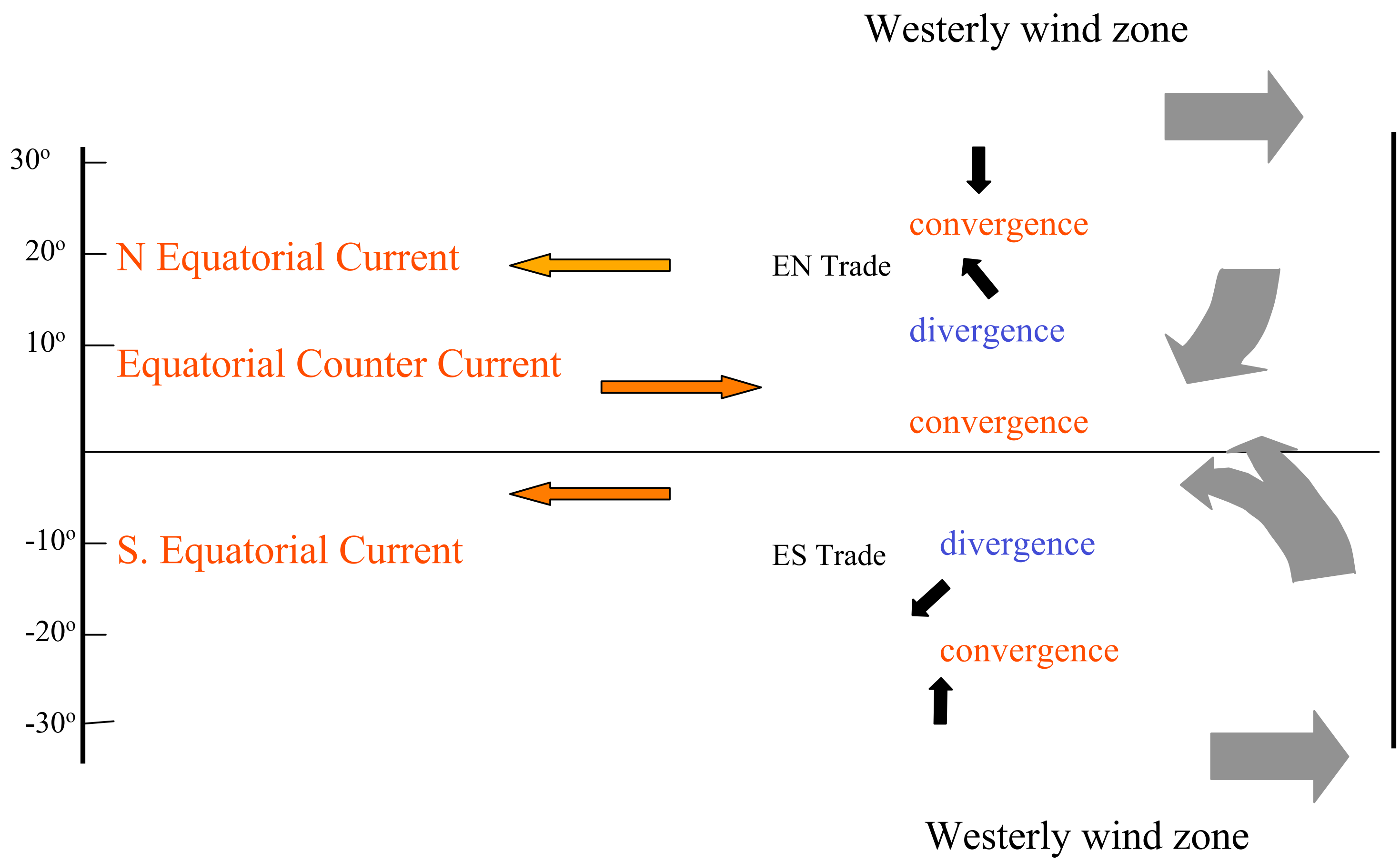


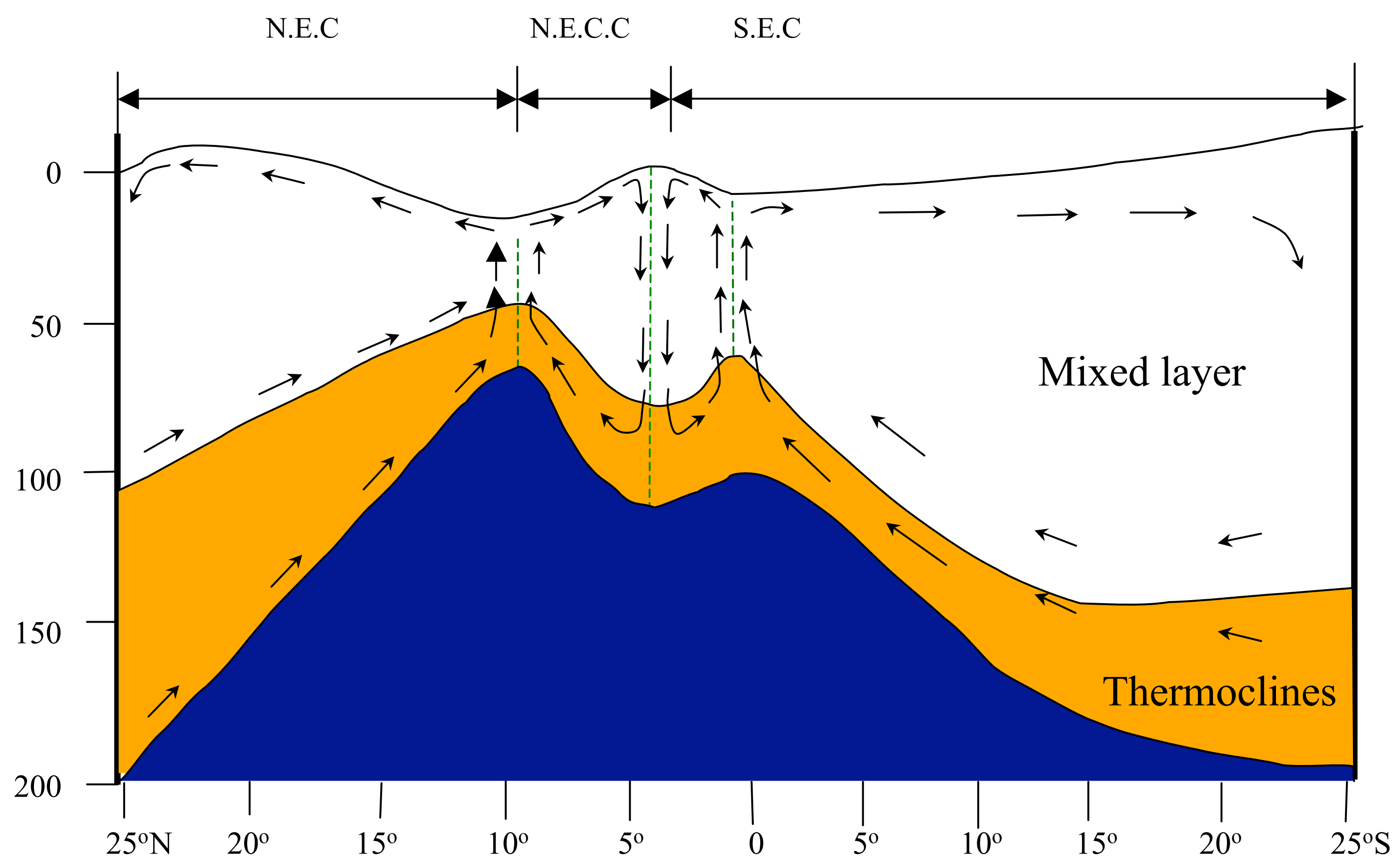
Two subtropic gyres:

Anticyclonic gyre in the northern subtropic region;
Cyclonic gyre in the southern subtropic region

Continuous components of these two gyres:

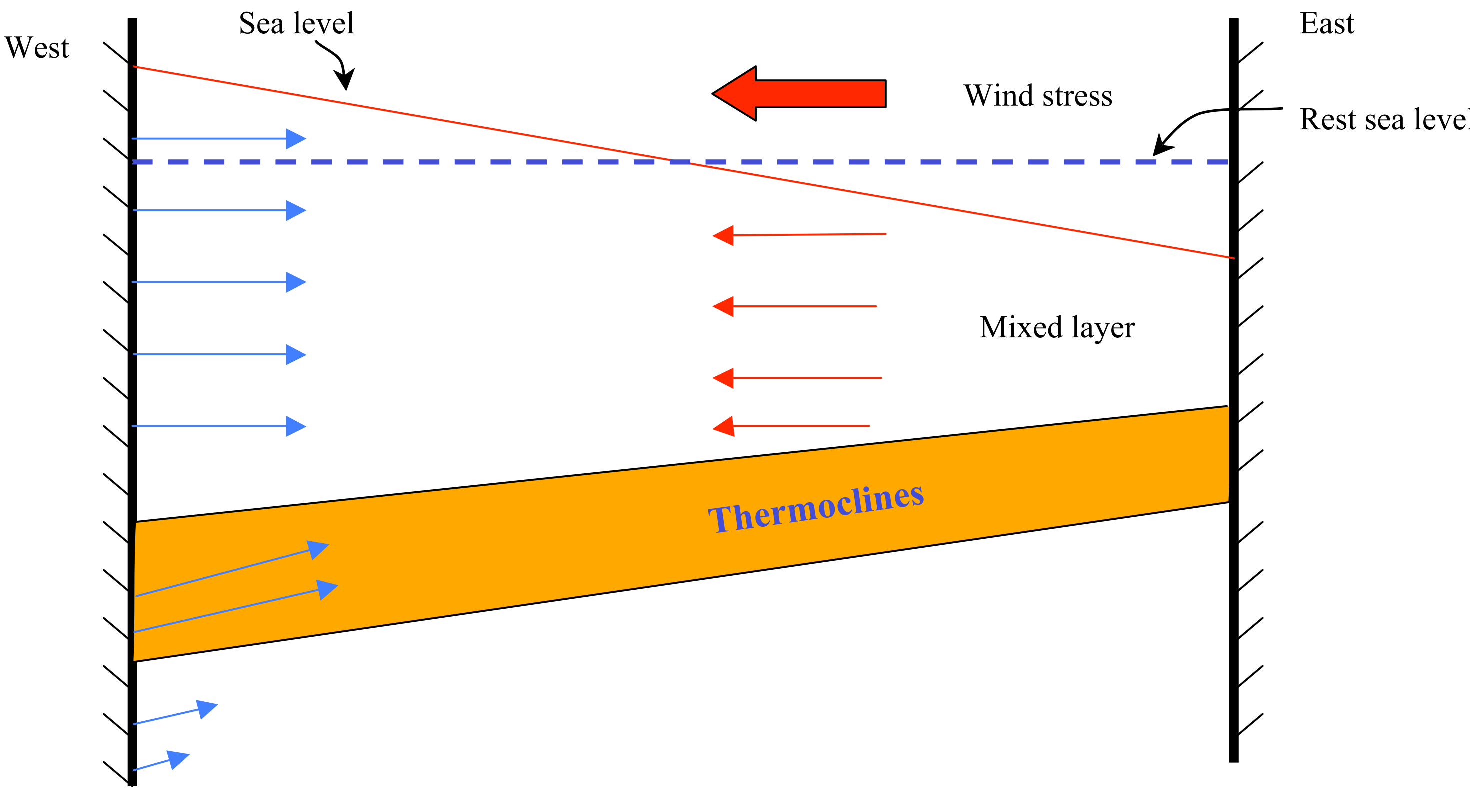
- **The North Equatorial Current (NEC) flowing westward around 20^o N;**
- **The South Equatorial Current (SEC) flowing westward around 0^o to 5^o S**
- **Between these two equatorial currents is the Equatorial Counter Current (ECC) flowing eastward around 10^o N.**


Westerly wind zone
30°
20°
N Equatorial Current
10°
Equatorial Counter Current
-10°
S. Equatorial Current
-20°
-30°
EN Trade
ES Trade
convergence
divergence
convergence
divergence
convergence
Westerly wind zone

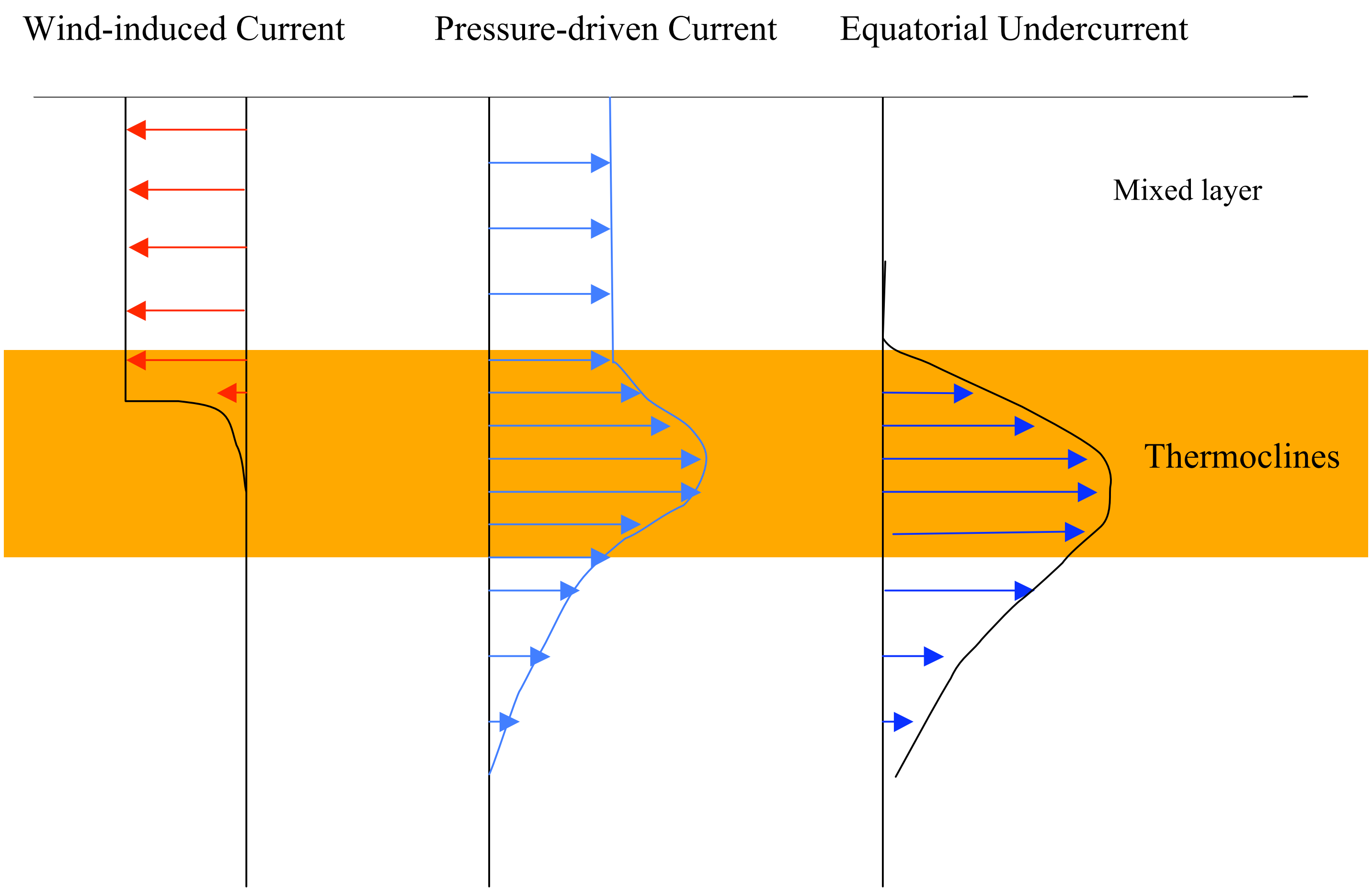


N.E.C
N.E.C.C
S.E.C
0
50
100
150
200
Mixed layer
Thermoclines
25ºN
20º
15º
10º
5º
0
5º
10º
15º
20º
25ºS

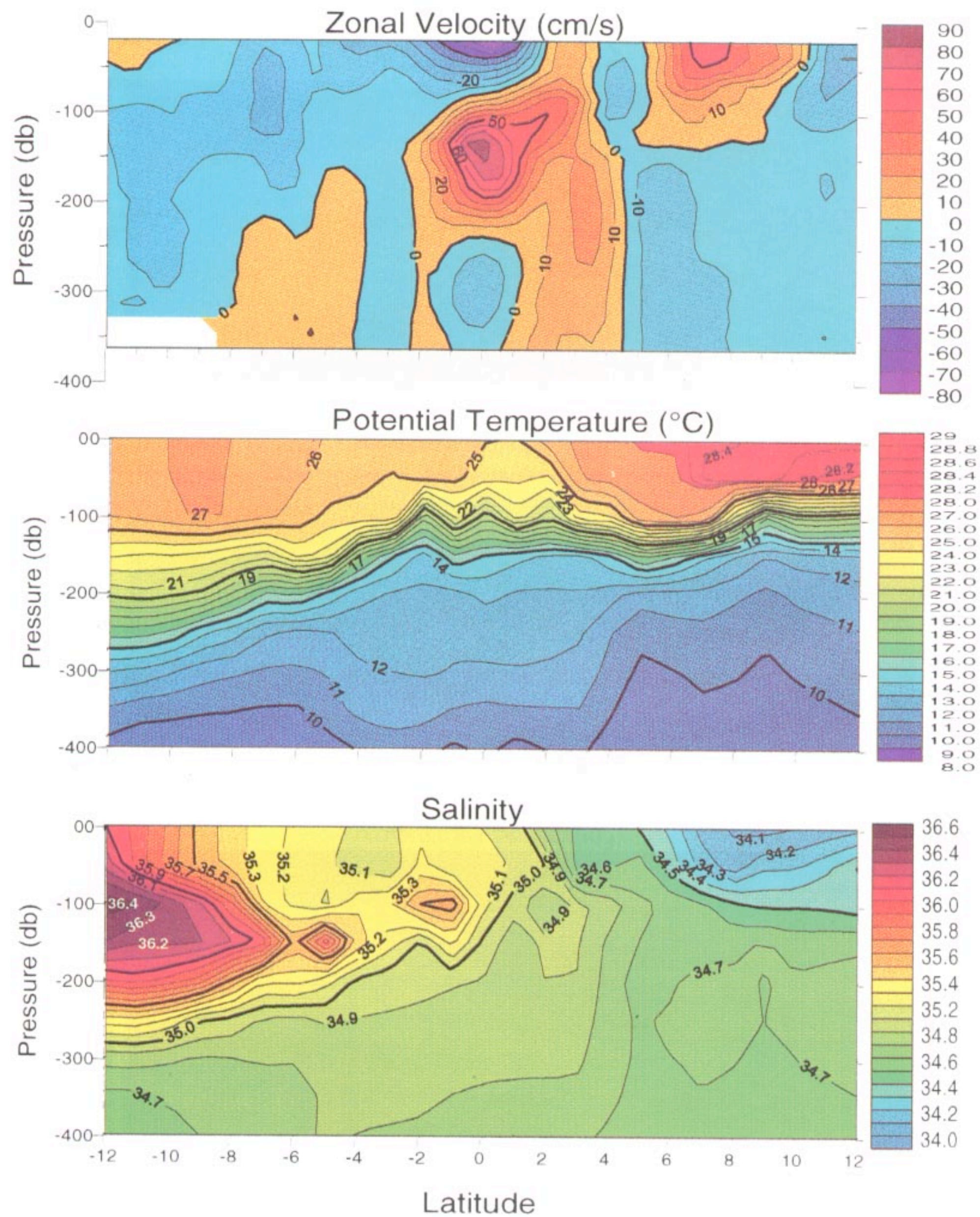
Equatorial Undercurrent



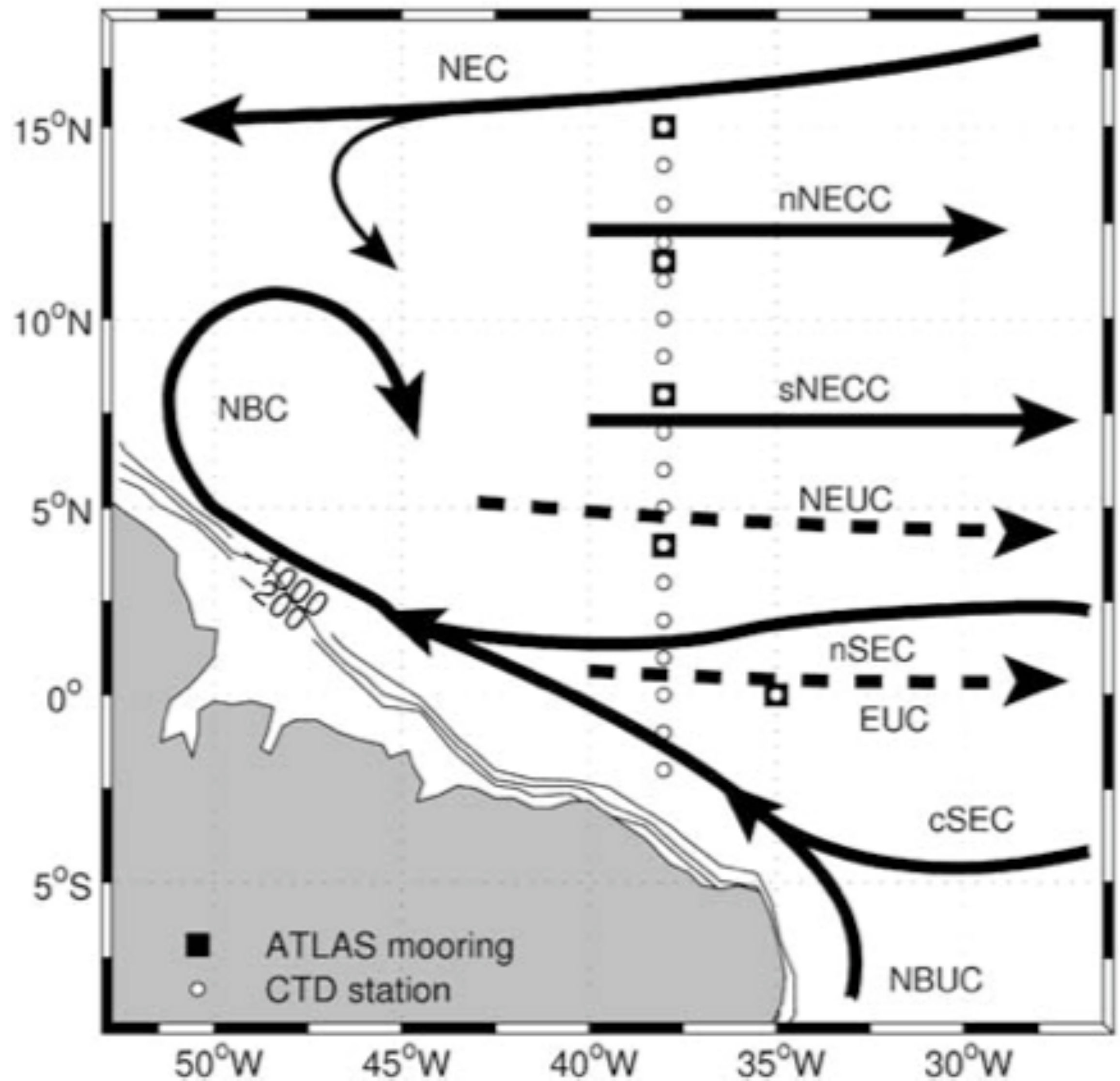
- At equator, f =0, the current follows the wind direction, and the wind drives the water to move westward;
- The water accumulates against the western boundary and cause the sea level rises over there;
- The surface pressure gradient pushes the water eastward and cancels the wind-driven westward currents in the mixed layer.


Wind-induced Current
Pressure-driven Current
Equatorial Undercurrent
Mixed layer
Thermoclines

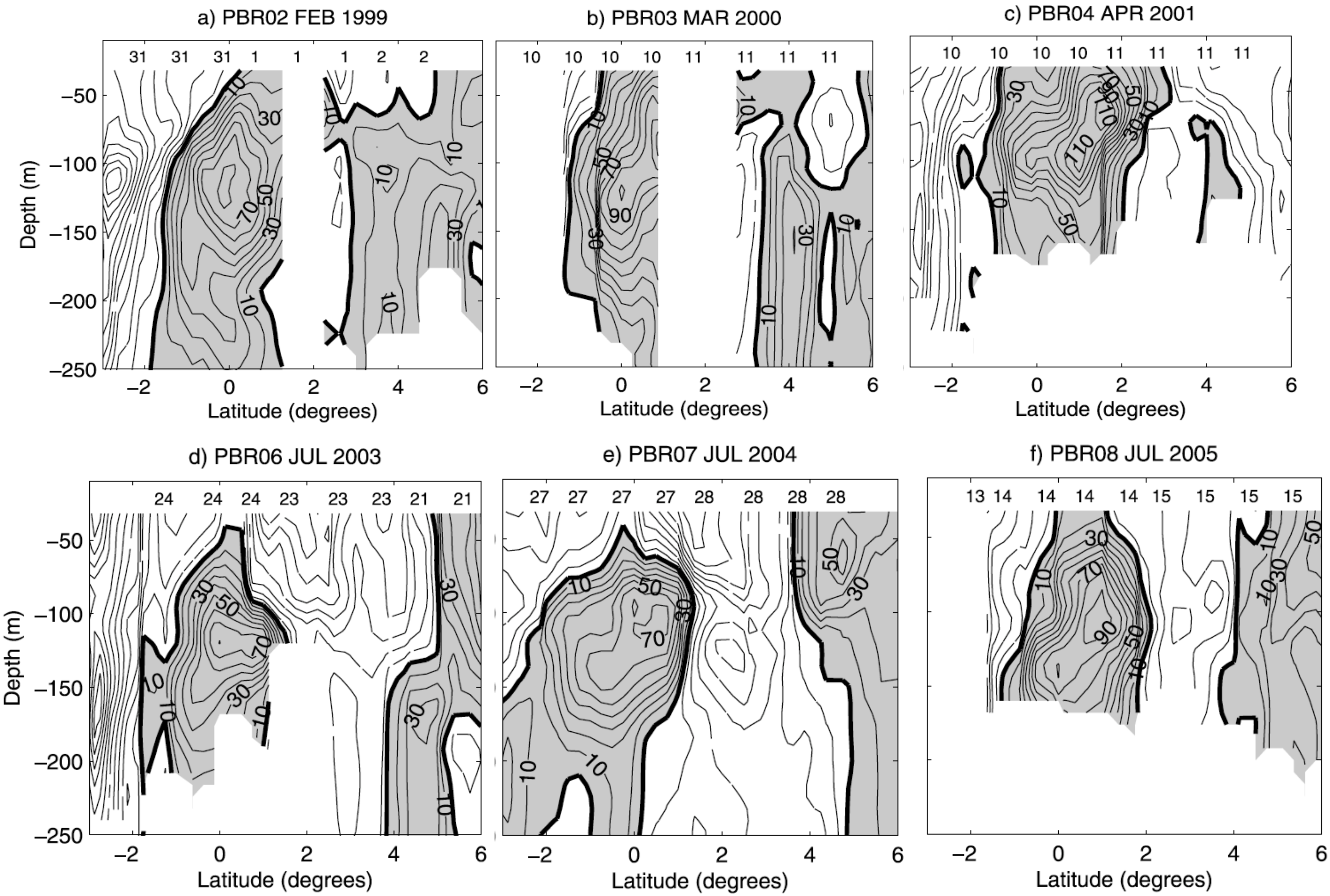
Observational Evidence



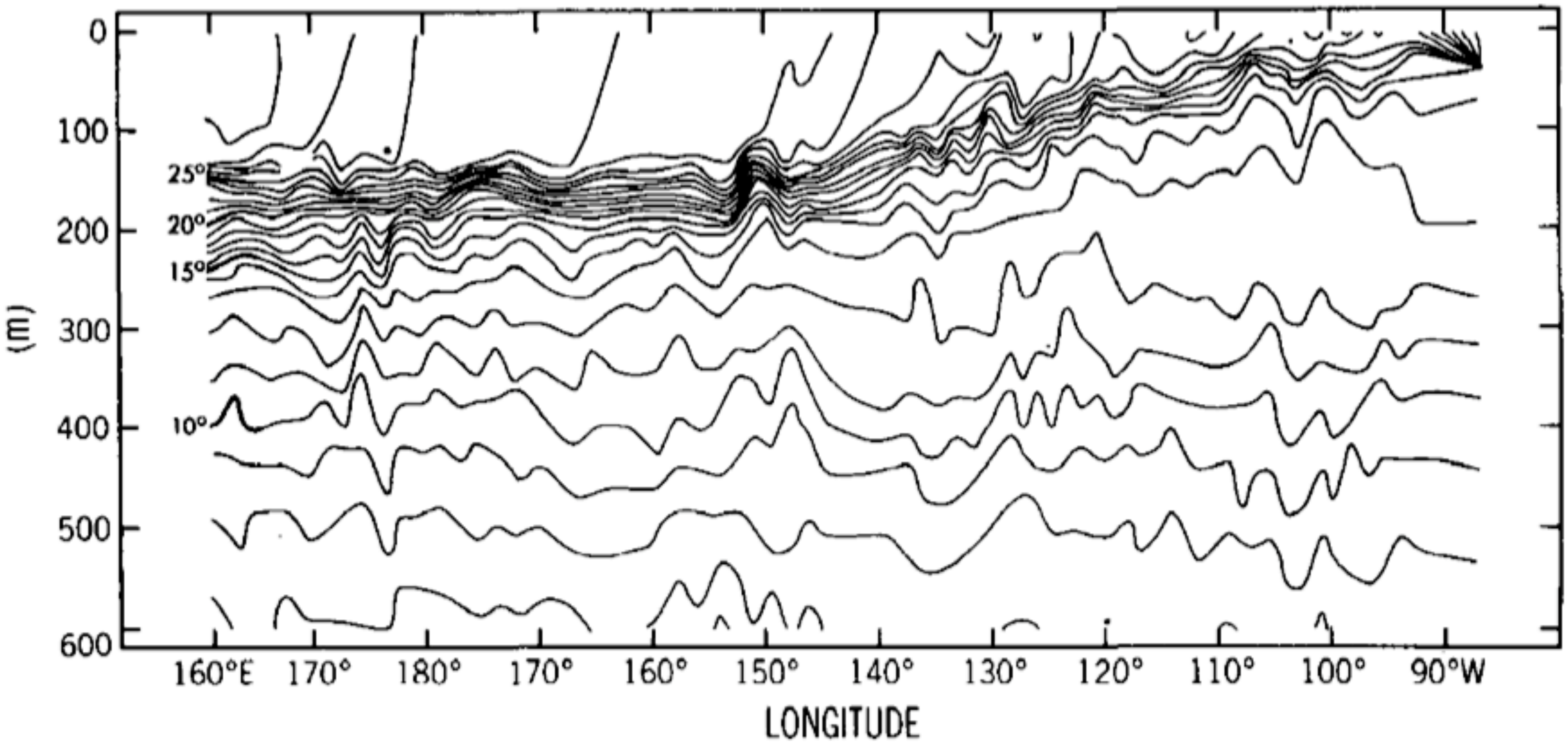
Urbano et al. (2008), JGR-Ocean, 113, C04041, doi: 10.1029/2007/JC004215



Observed Seasonal Variability of the EUC (Urbano et al. 2008)

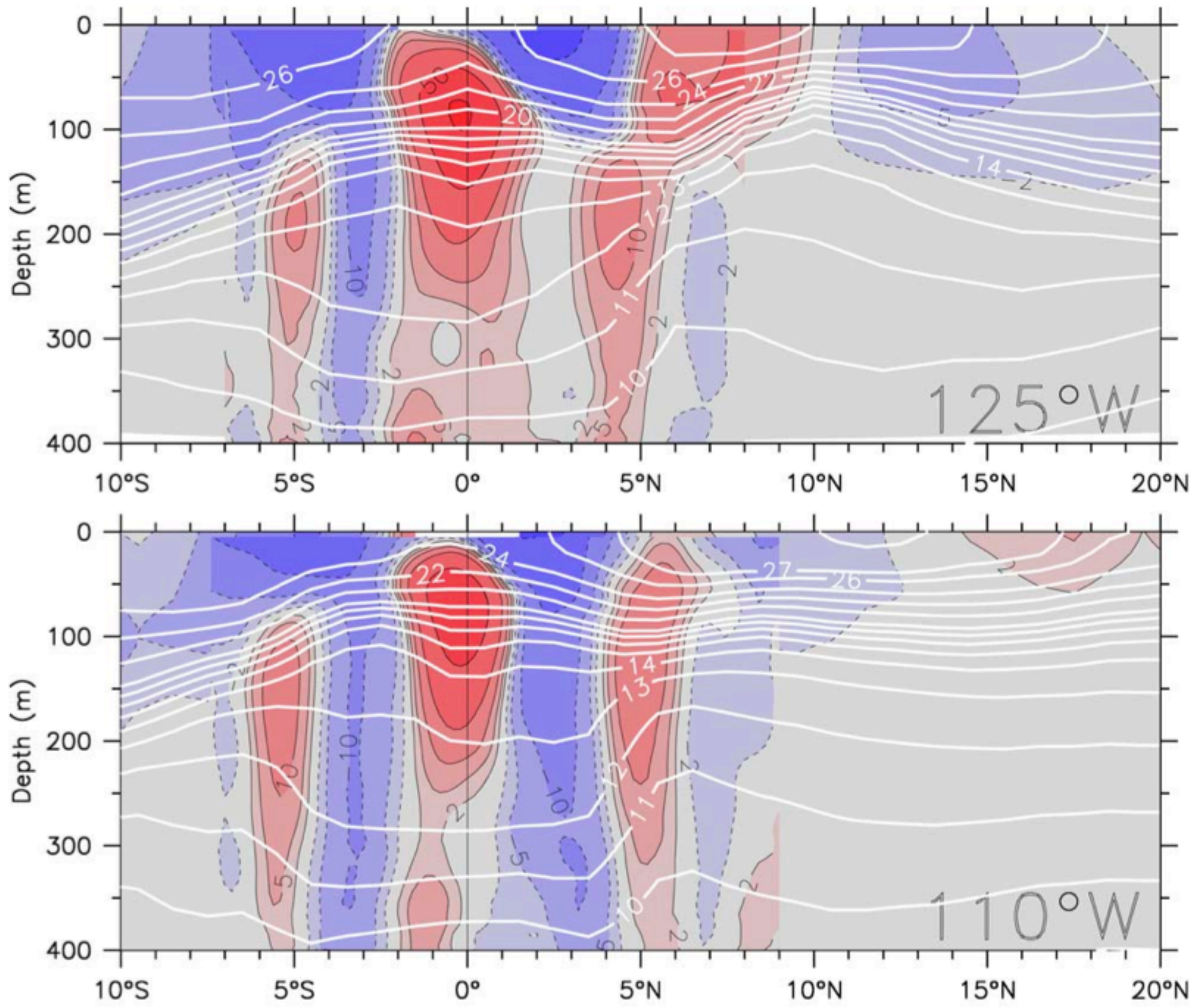


Equatorial Undercurrent in the Pacific Ocean



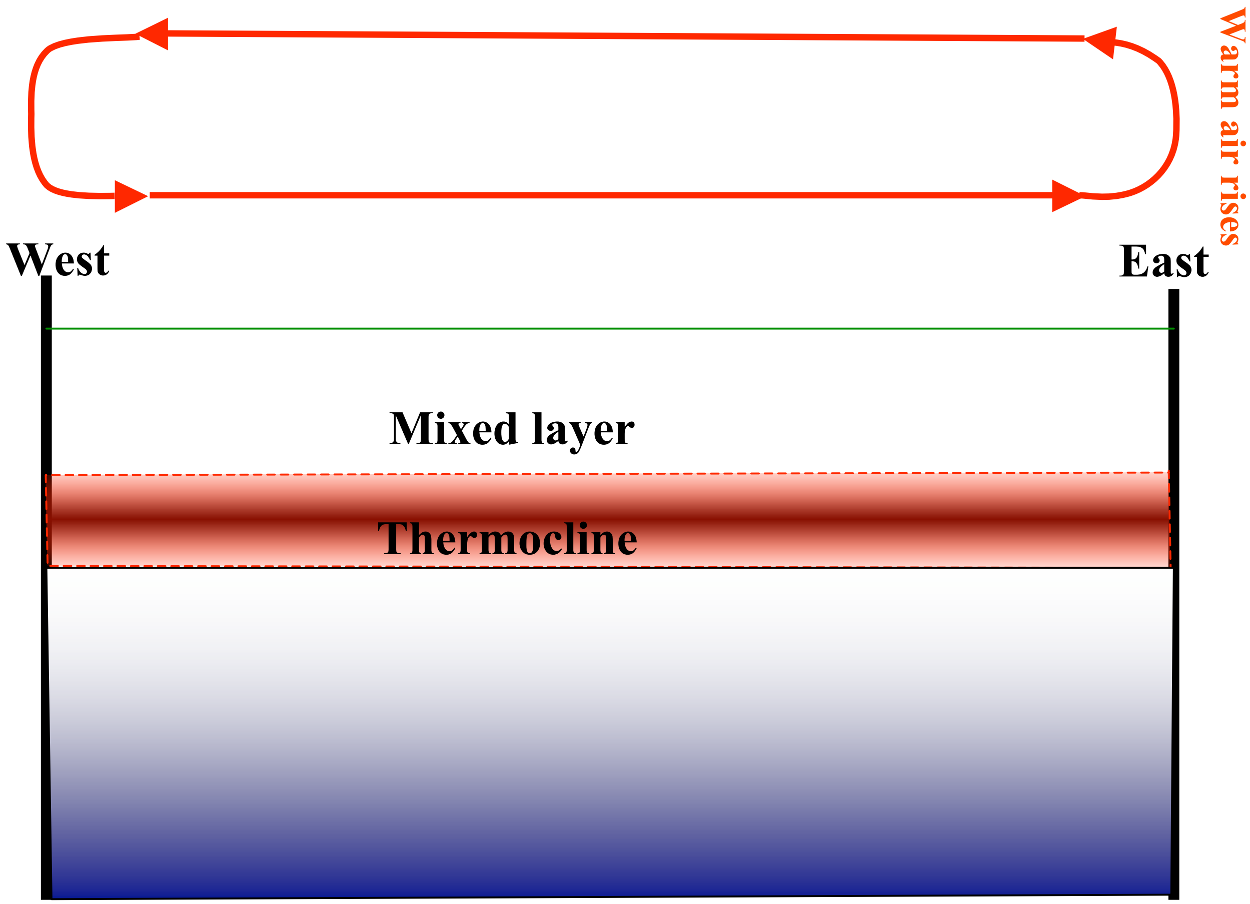
Isotherms in an equatorial plane in the Pacific Ocean (from Philander, 1980)

In the Pacific Ocean, it is called "the Cormwell Current};
In the Atlantic Ocean, it is called "the Lomonosov Current"

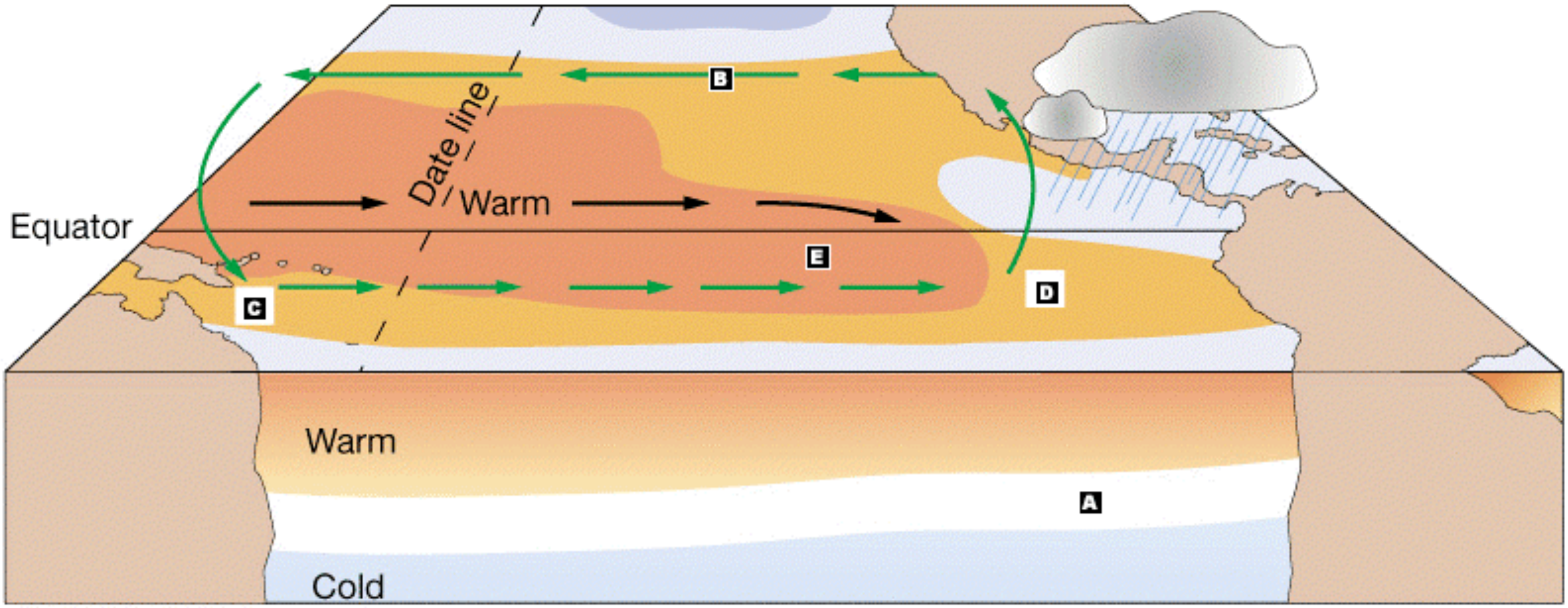


Kessler, W, Progress in Oceanography, 69 (2006)

In the equatorial Pacific, when the South-East Trade relaxes or turns to the east, the sea surface slope will “collapse”, causing a flat mixed layer and thermocline. This can cause unusual increases in temperature of coastal water occurring around Christmas time: El Niño.



Firing et al., 1983, Science, 222 (4628): 1121-1123: “The E.U.C. at 159^{o}W decayed during August, partially revised during September, and rapidly reappeared in January 1983. The virtual disappearance is consistent with the basin wide adjustment of sea surface slope to the strong westerly winds in the western and central Pacific that caused the 1982-1983 El Nino event.”



(b) El Niño conditions

From the Web

The TAO (Tropic Atmosphere and Ocean) buoy network-JGOFS (Joint Global Ocean Flux Study)

1991-1993 El Nino years

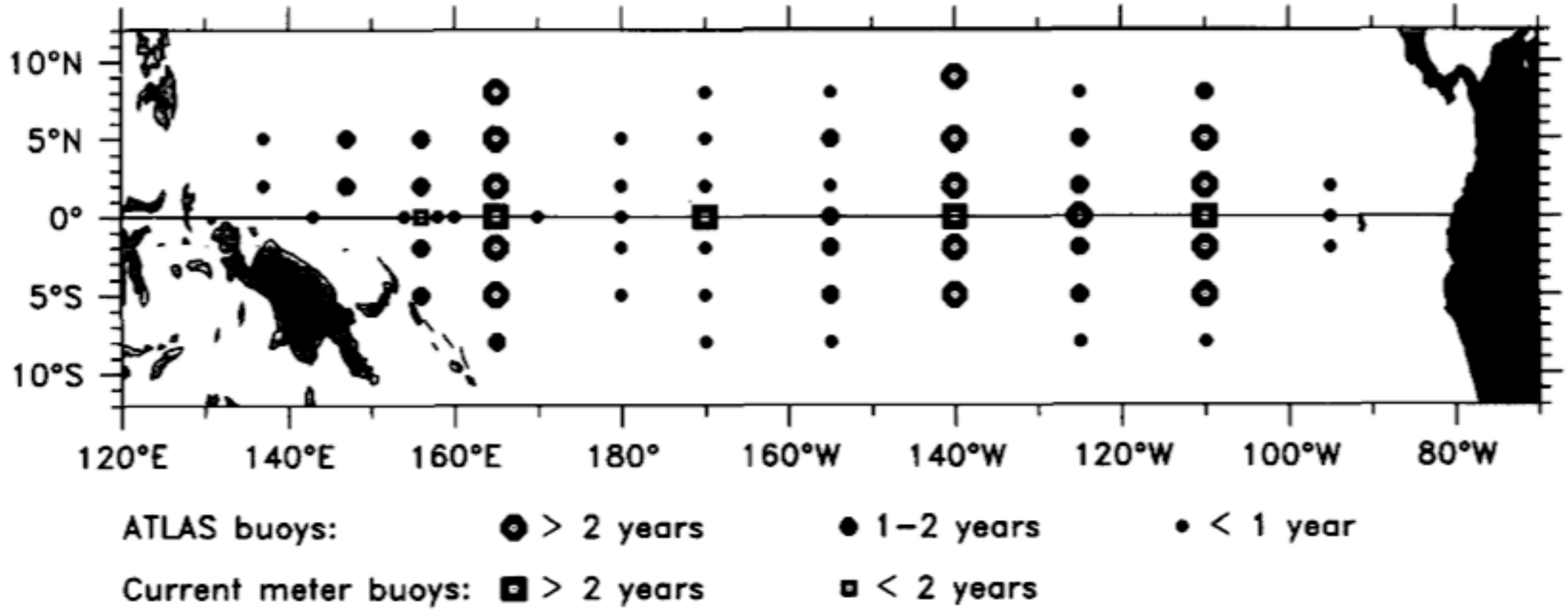


Fig. 1. Map of the TAO buoy network as of September 1993. The symbols indicate the length of time a buoy has been in the water at each location.

From Kessler and Mcphaden (1995), DSR, 42, 295-333.

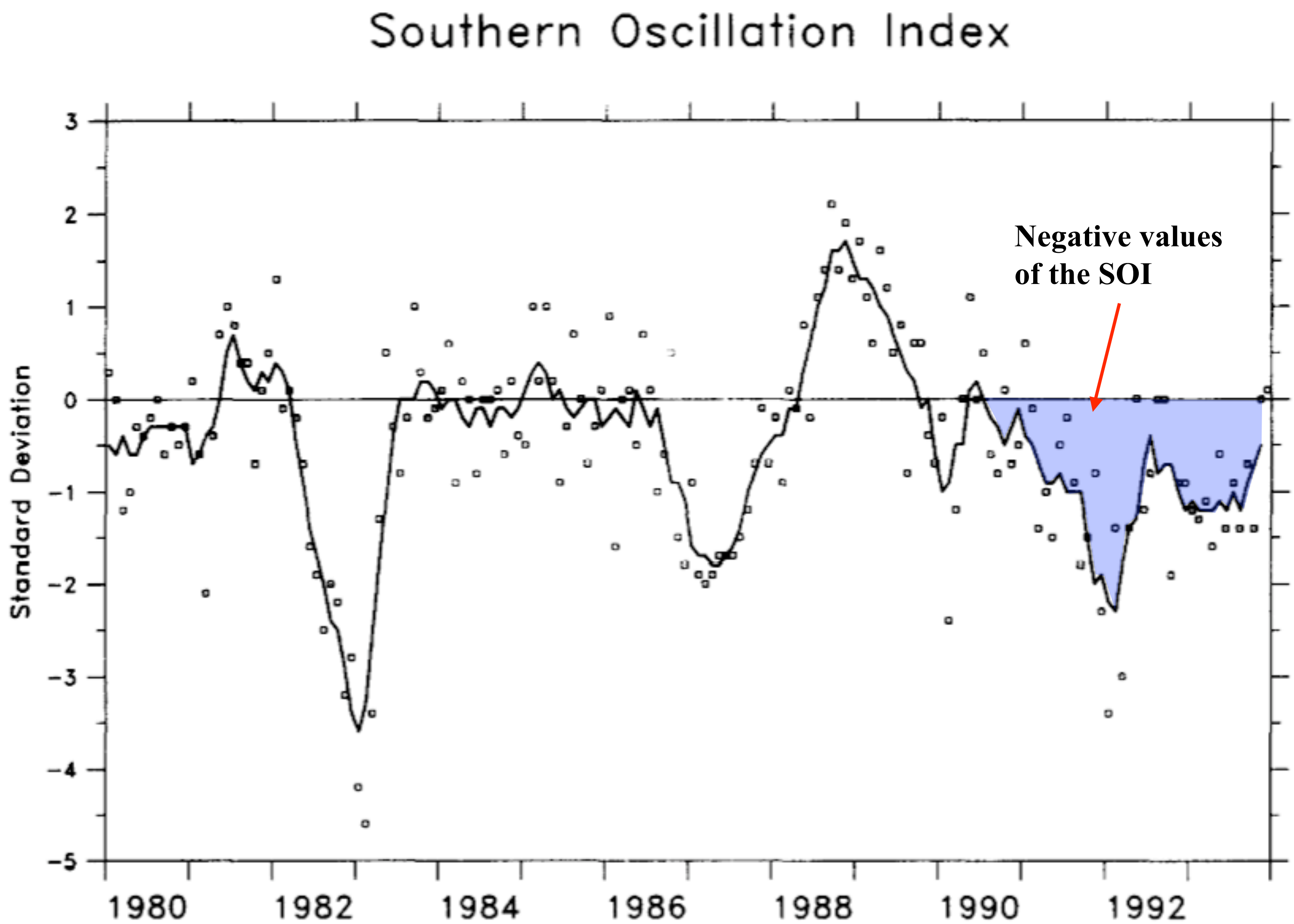
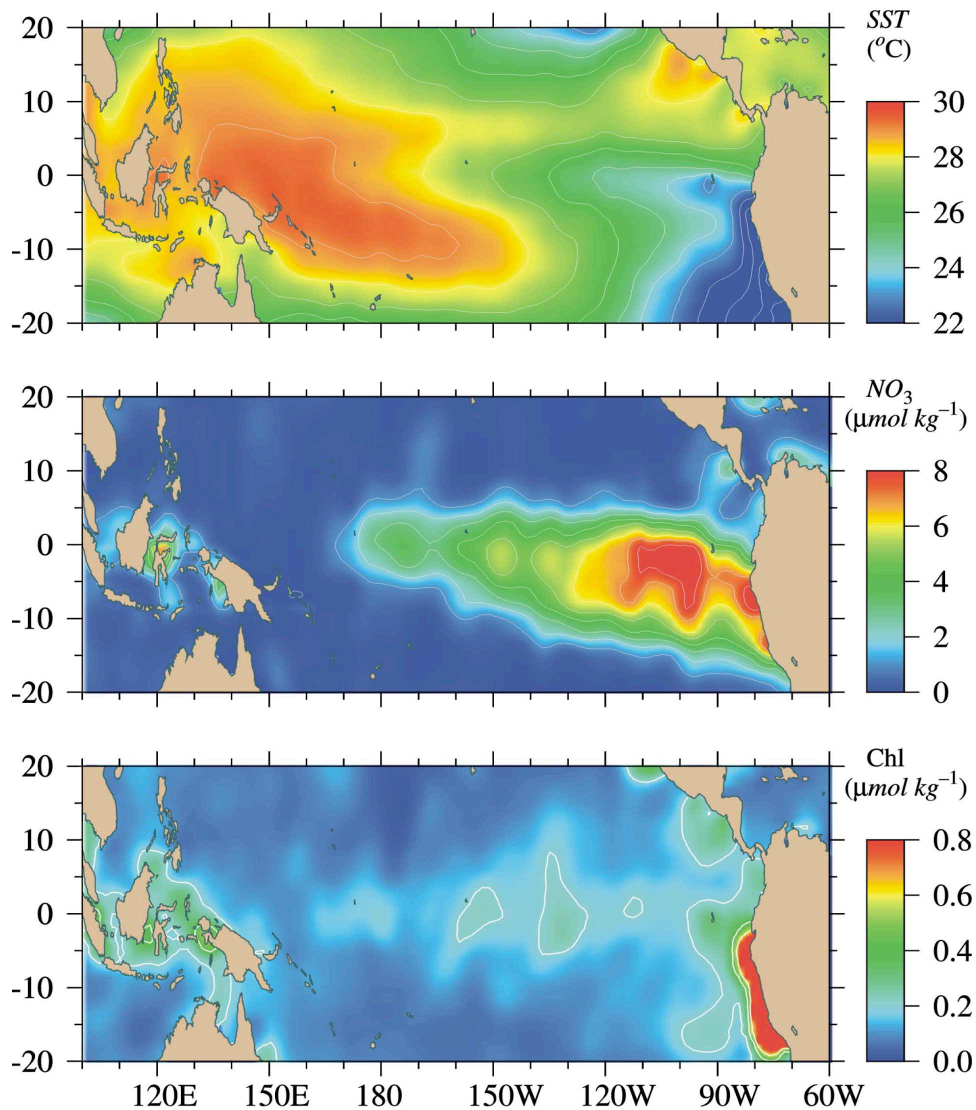


Fig. 2. Southern Oscillation Index (SOI). Monthly values (squares) and 5-month running mean (line). The SOI is based on the surface atmospheric pressure difference between Tahiti and Darwin, Australia. Negative values of the SOI indicate negative anomalies of surface pressure in the eastern Pacific, which are associated with El Niño.

JGOFS Observations

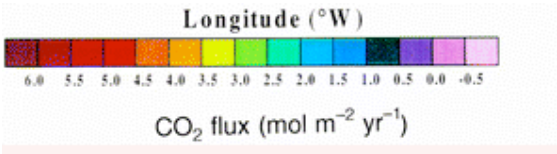
Equatorial region is characterized by high-nutrients and low chlorophyll (HNLC).



Why?

Shallower mixed layer

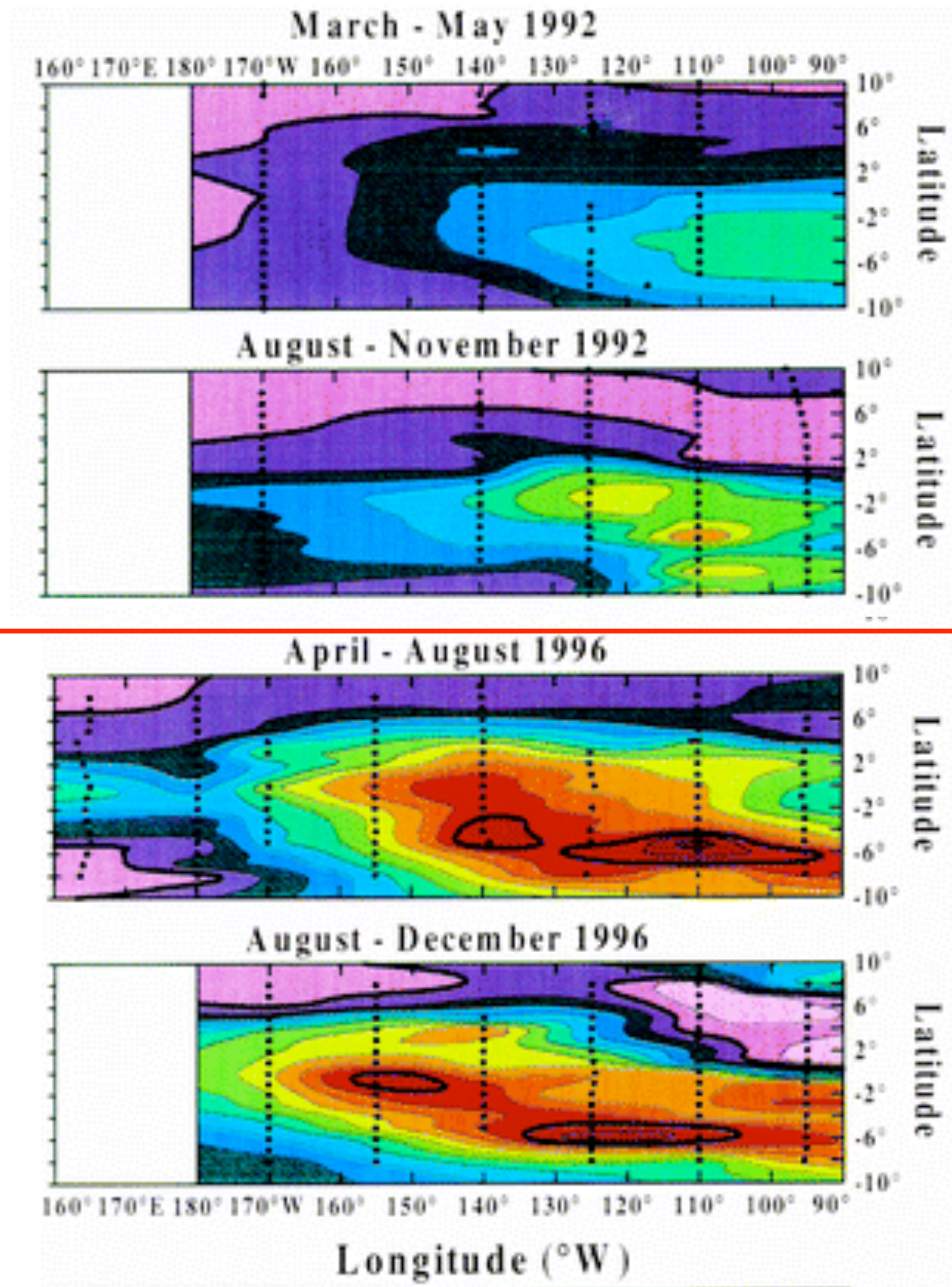
Sufficient light



A El Nino Year

Weaker winds and E.U.C.

A Non-El Nino Year



Feely et al. 1999 Nature, 398.

Discussion

QS. 1: During the El Nino event, why do you expect to see the change in the Equatorial Undercurrent?

QS. 2: Why is the thickness of the mixed layer thinner at the equator than in high-latitude regions?

QS. 3: How does the Equatorial Undercurrent influence the biological productivity in the equatorial region?