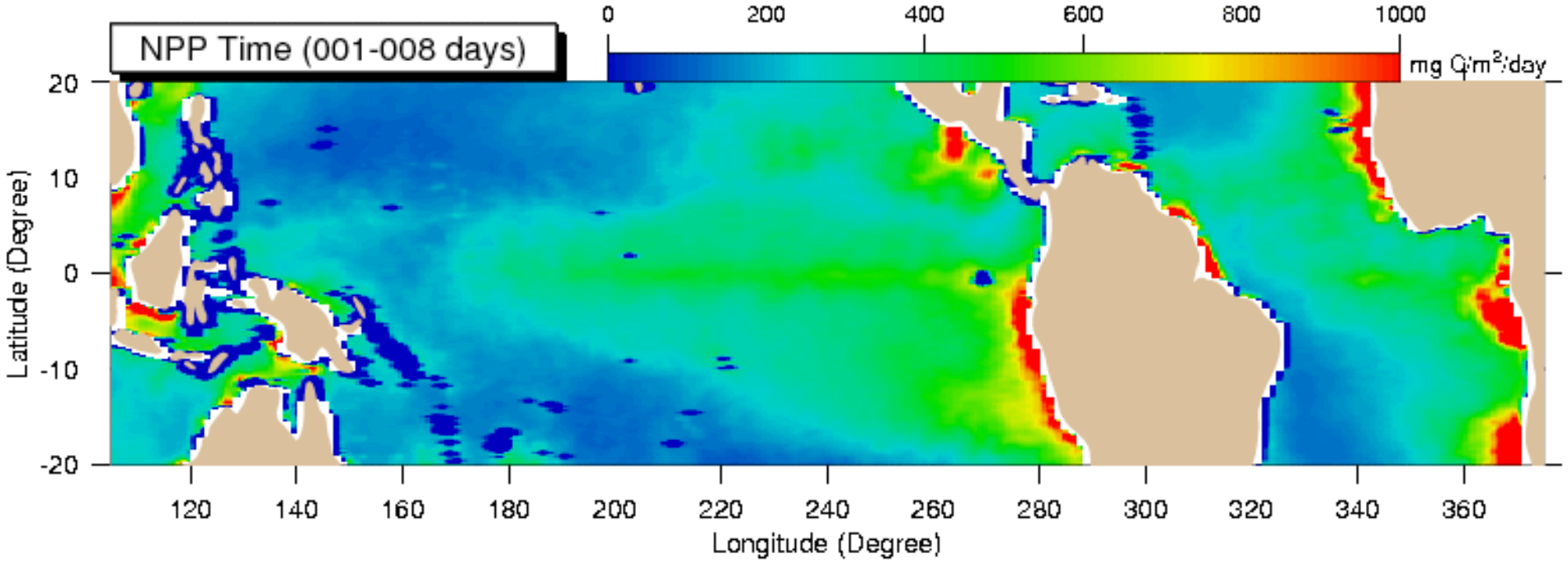
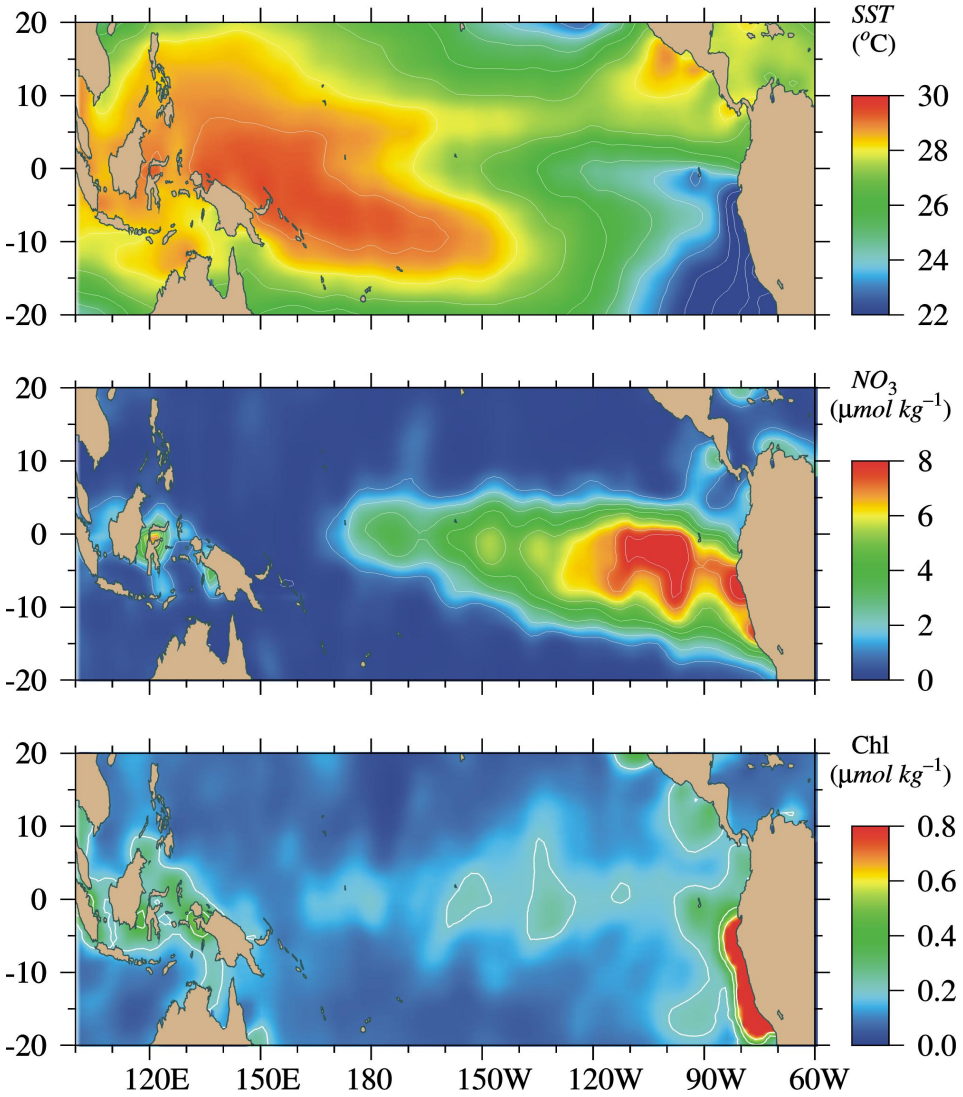
MAR650 Lecture 6: Equatorial Ocean Ecosystems



JGOFS Observations

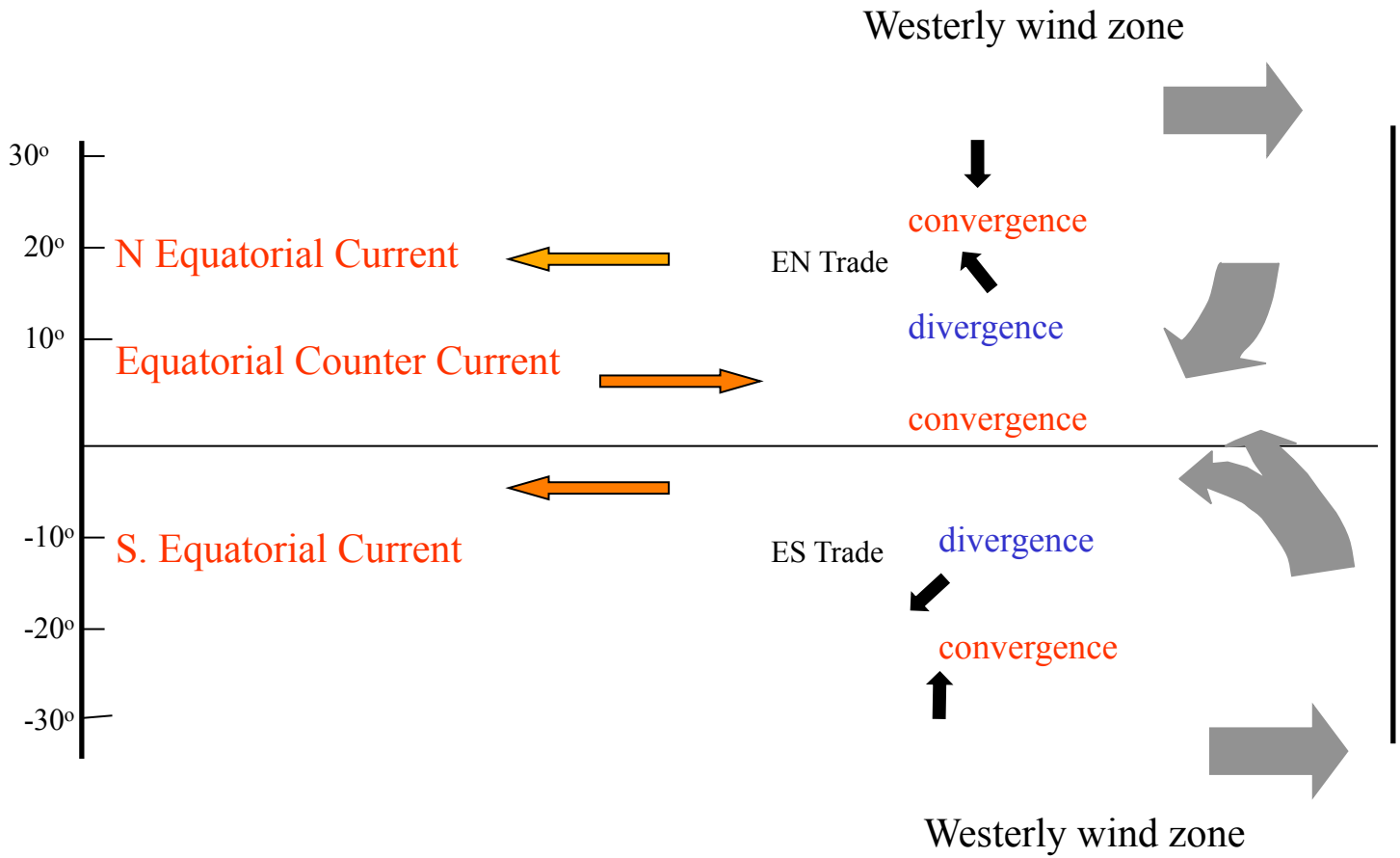
Equatorial region is characterized by high-nutrients and low chlorophyll (HNLC).

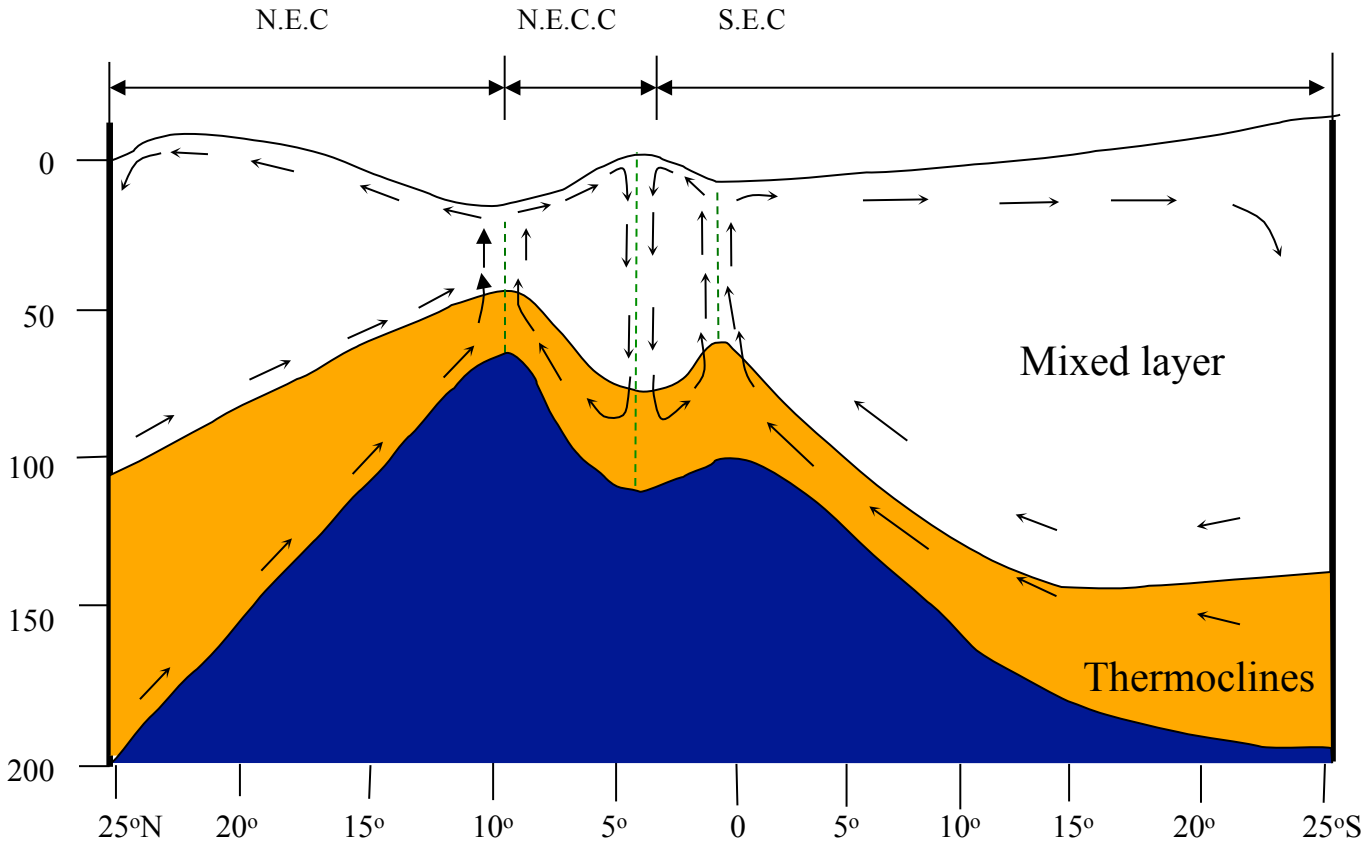


Why?

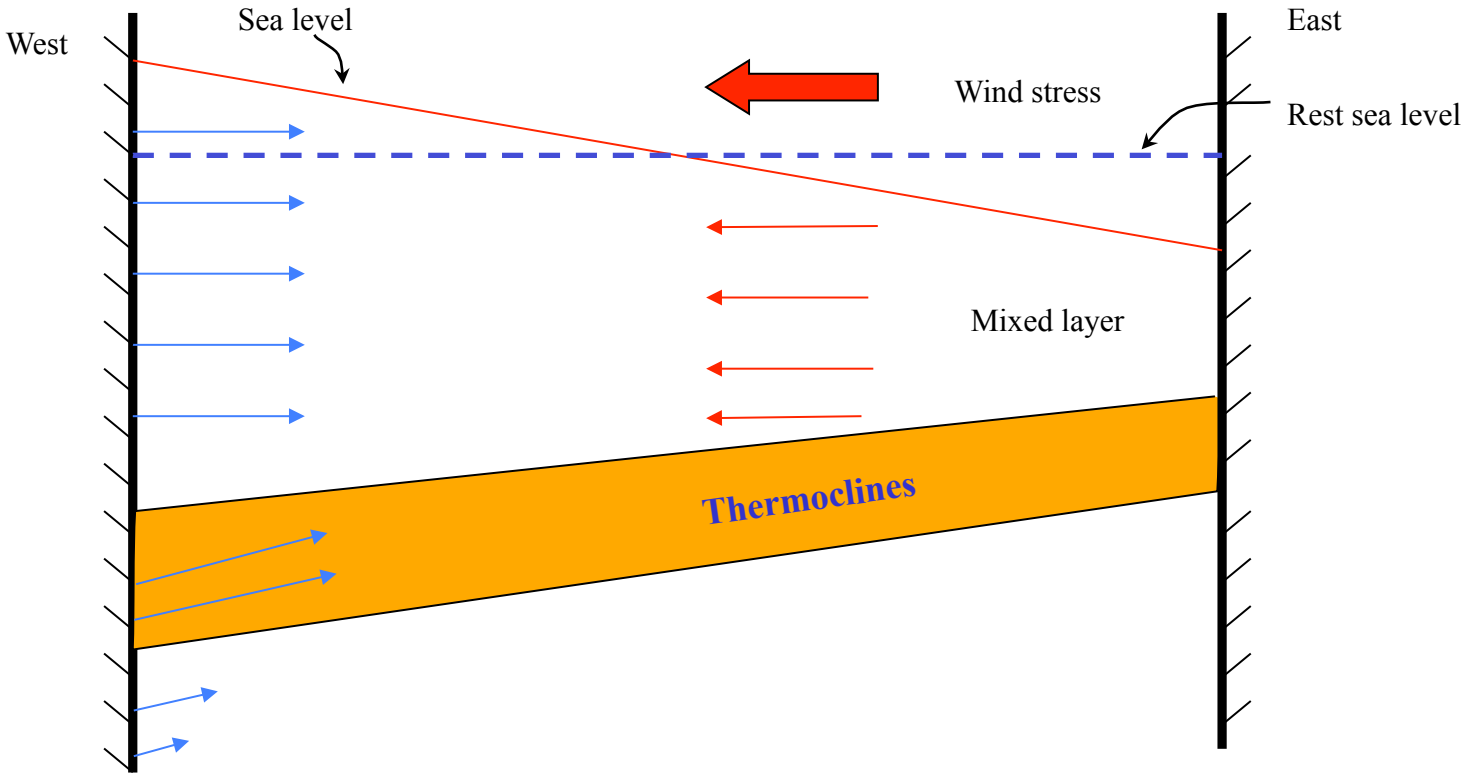
Shallower mixed layer

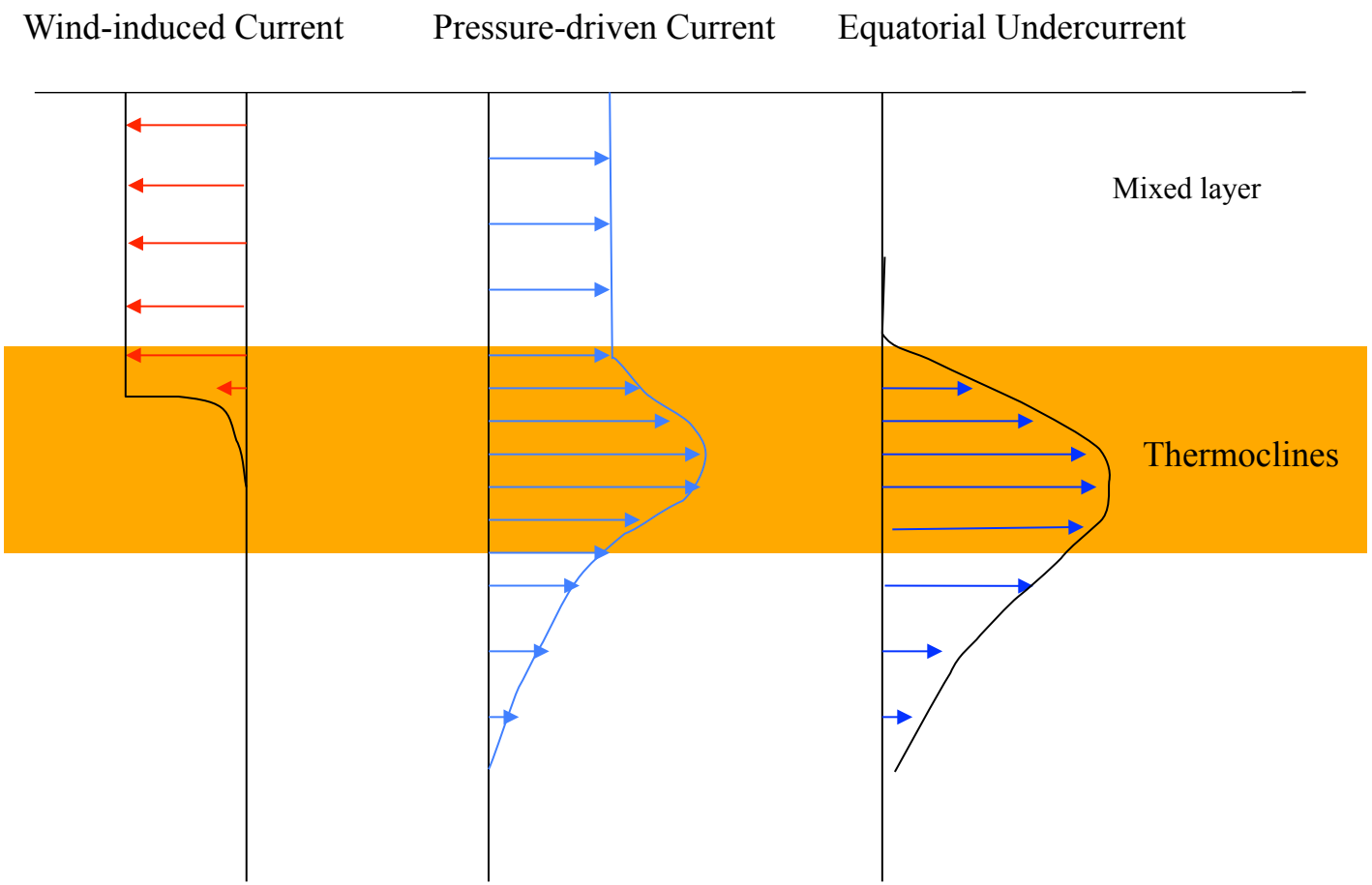
Sufficient light

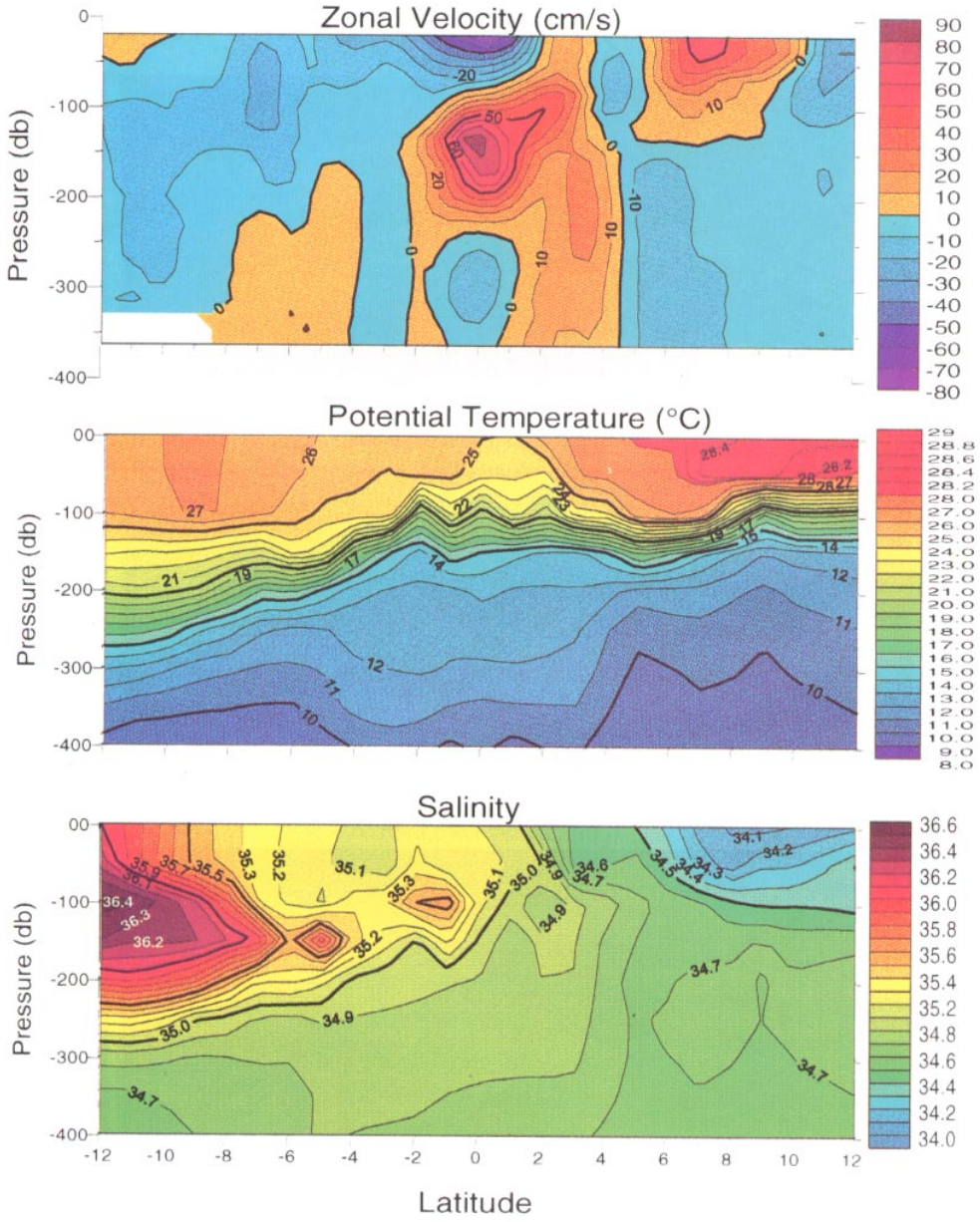

Westerly wind zone
30°
20°
10°
-10°
-20°
-30°
N Equatorial Current
Equatorial Counter Current
S. Equatorial Current
EN Trade
ES Trade
convergence
divergence
convergence
divergence
convergence
Westerly wind zone

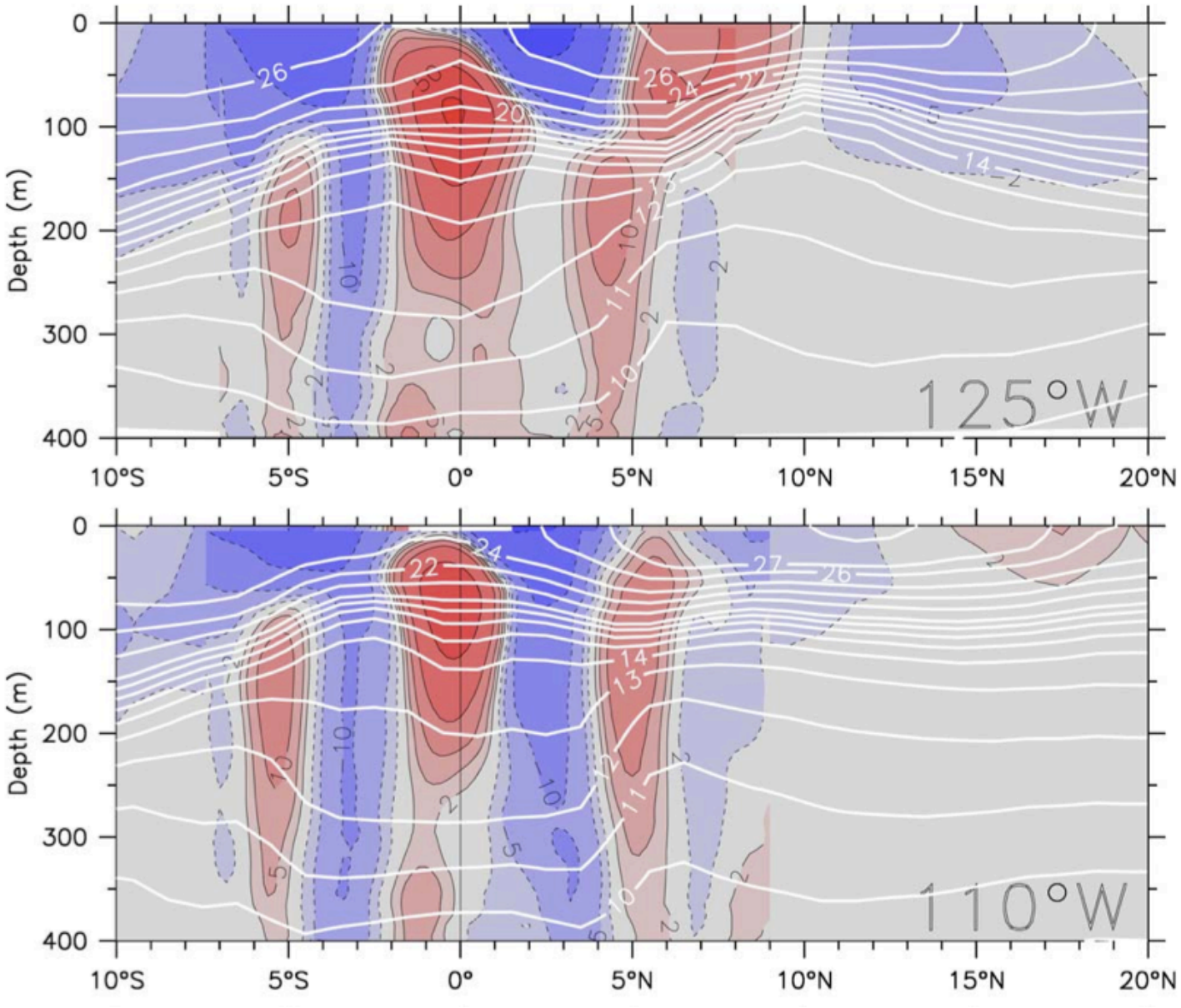

N.E.C
N.E.C.C
S.E.C
0
50
100
150
200
Mixed layer
Thermoclines
25°N
20°
15°
10°
5°
0
5°
10°
15°
20°
25°S

Equatorial Undercurrent



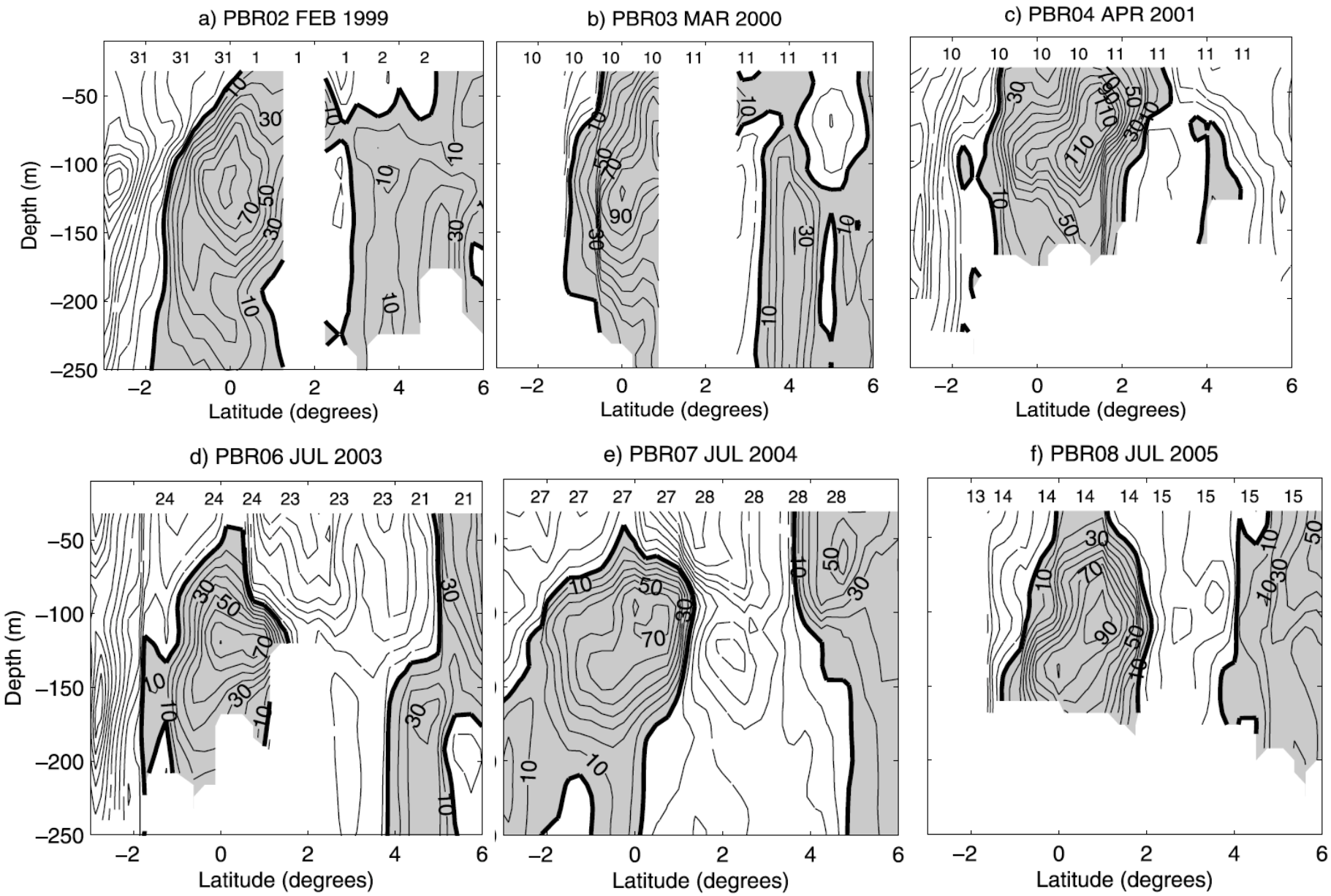

Wind-induced Current
Pressure-driven Current
Equatorial Undercurrent
Mixed layer
Thermoclines


Zonal Velocity (cm/s)
Pressure (db)
0
-100
-200
-300
-400
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
Potential Temperature (°C)
Pressure (db)
00
-100
-200
-300
-400
29
28.8
28.6
28.4
28.2
28.0
27.0
26.0
25.0
24.0
23.0
22.0
21.0
20.0
19.0
18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
Salinity
Pressure (db)
00
-100
-200
-300
-400
36.6
36.4
36.2
36.0
35.8
35.6
35.4
35.2
34.8
34.6
34.4
34.2
34.0
-12
-10
-8
-6
-4
-2
0
2
4
6
8
10
12
Latitude



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

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



Nutrients?

No_3 : Normal year:	6.5 μmol/L	NH_4: El Niño:	1.0 μmol/L	(surface)
El Niño:	2-4 μmol/L		0.2-0.3 μmol/L	(100 m)
All the times:	> 2 μmol/L	Normal year:	0.5 μmol/L	(surface)
			0.1 μmol/L	(100 m)

Nutrients are sufficient for the growth of phytoplankton.

Zooplankton grazing?

Depth (m)	Zooplankton grazing rate (per day)	Phytoplankton growth rate (per day)
10-20	0.72 (0.57)	0.83 (0.98)
40-50	0.22 (0.42)	0.34 (1.0)
70-80	0.21 (0.27)	0.22 (0.32)

Red: during El Niño event; black: after El Niño event

Growth rate of phytoplankton is generally larger than the zooplankton grazing rate, so zooplankton grazing is not a critical process to cause a low concentration of phytoplankton, but it does contribute to maintaining low concentration status.

Phytoplankton production

Primary production (mmol C/m^2/d)	New production (mmol C/m^2/d)	Regenerated production (mmol C/m^2/d)
45-90 (100-138)	3-5 (11-19)	40 (120)

Red: during El Niño event; black: after El Niño event

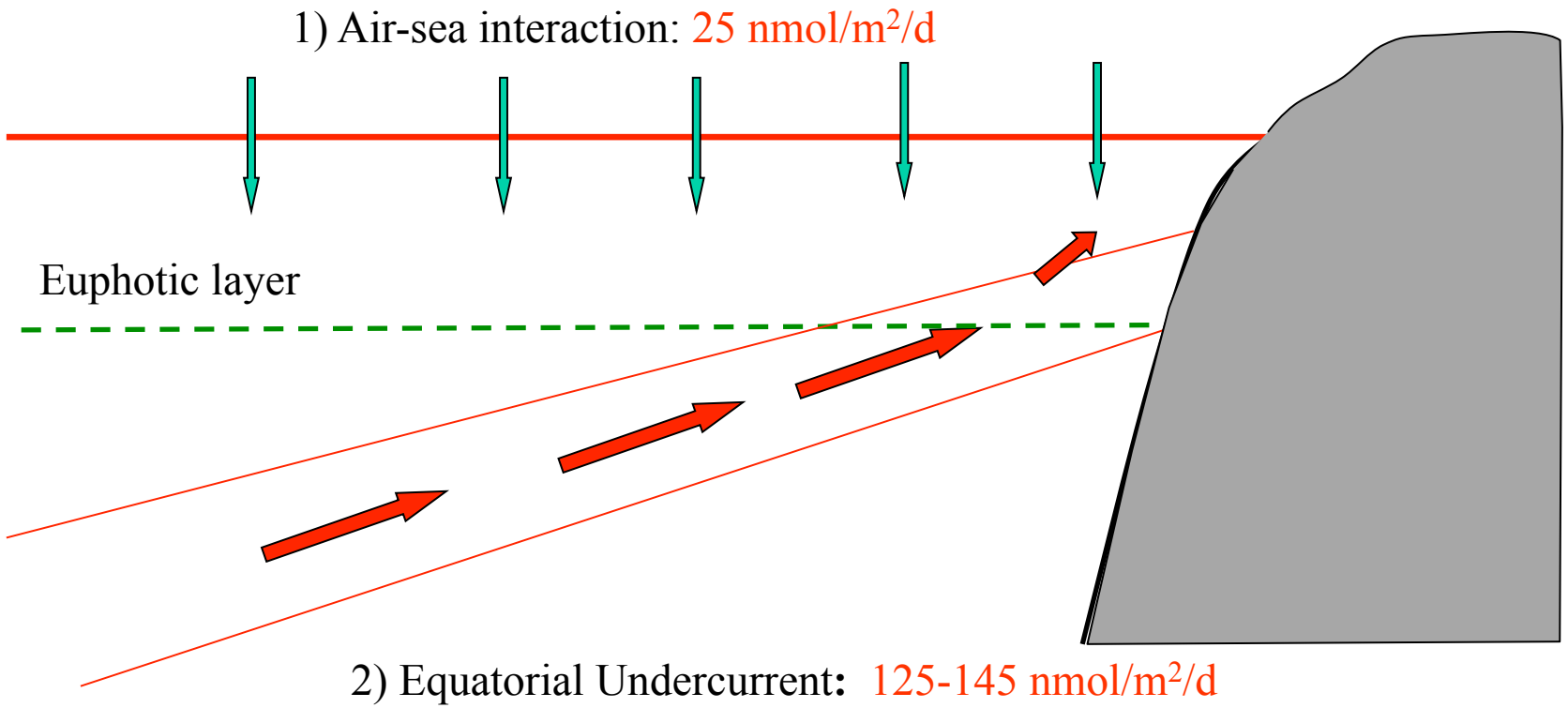
$$f = \frac{\text{New production}}{\text{New production + Regenerated production}} \sim 0.07\text{-}0.1\ (0.08\text{-}0.14)$$

Equatorial region is usually in a status of low new production!

QS. What is the key biological process to cause the low concentration of chl-a in the equatorial region?

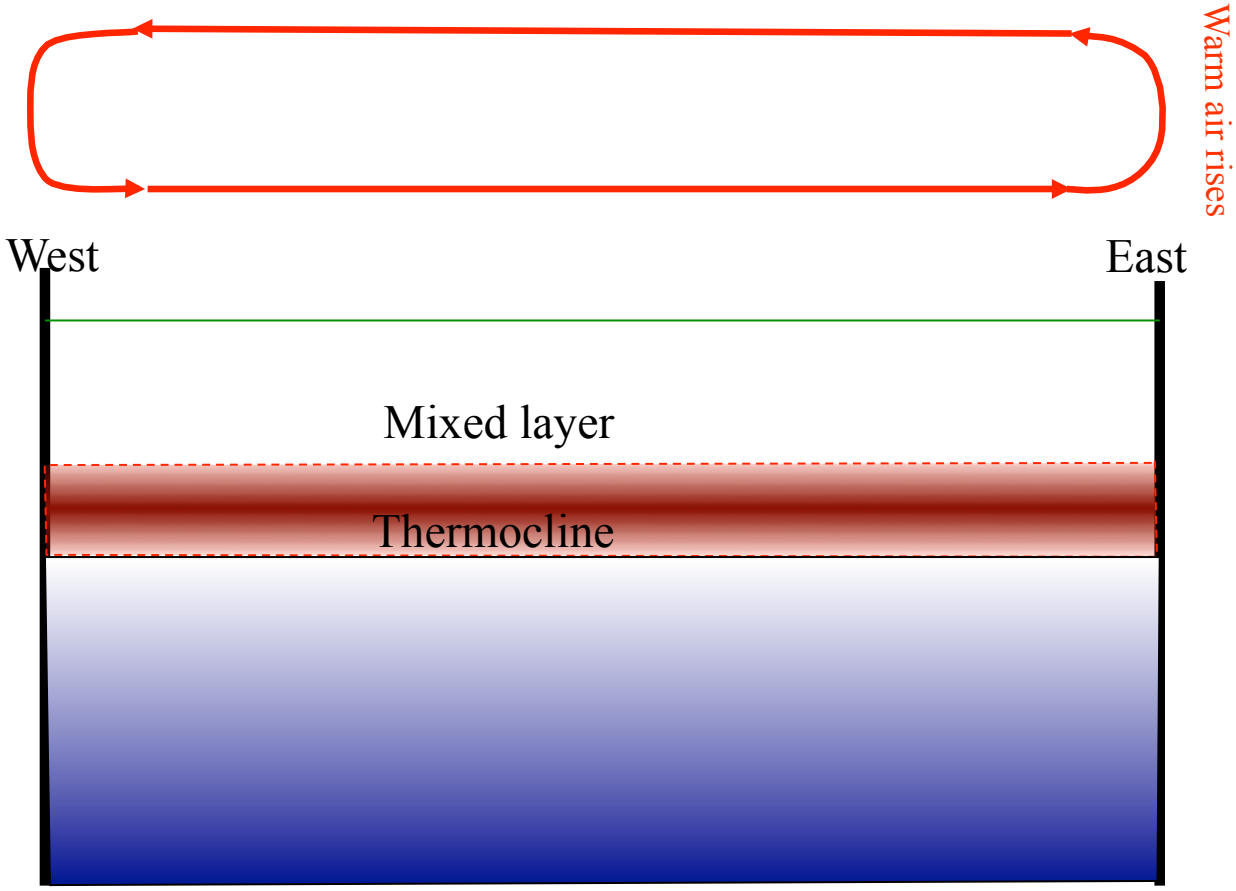
Irons (Fe)

Sources of irons in the equatorial region:



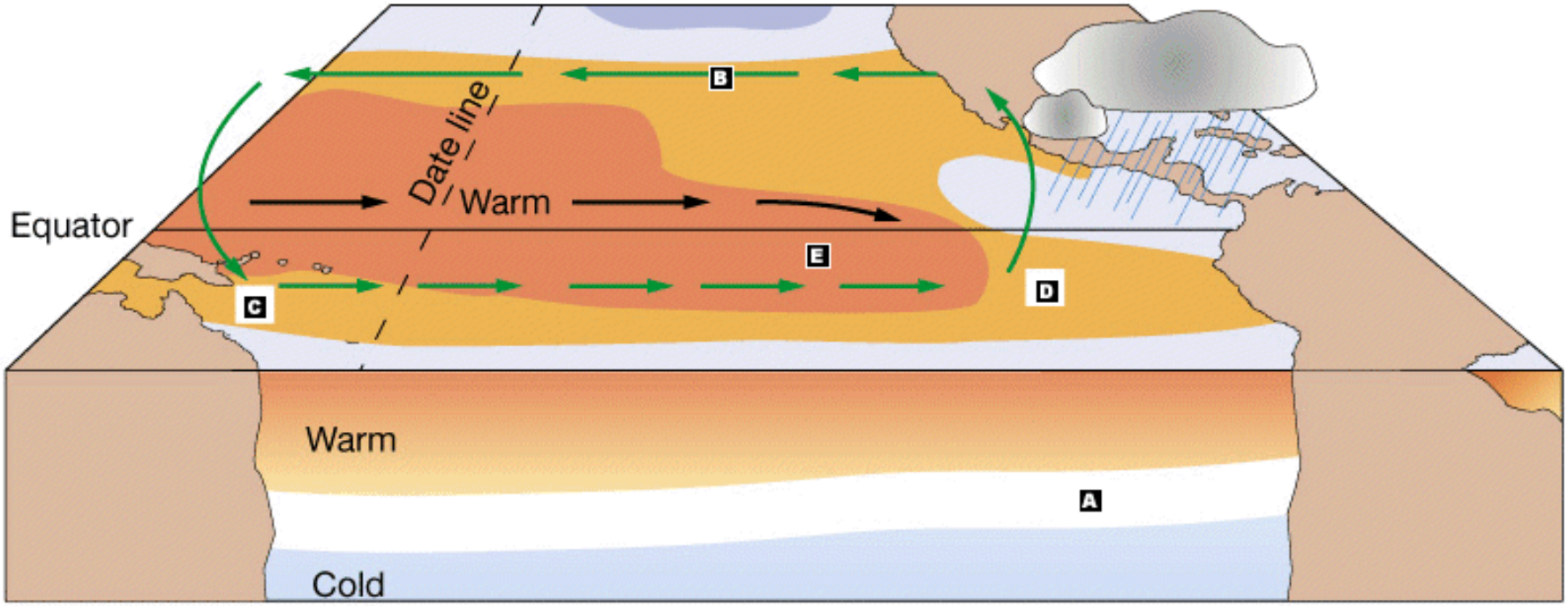
Air-sea interaction varies seasonally, the limits of irons to primary production near the surface should changes with season.

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 the Christmas time: El Niño.



Firing et al., 1983, Science, 222 (4628): 1121-1123: "The E.U.C. at 159°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."

Download by the google search.



(b) El Niño conditions

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

1991-1993 El Nino years

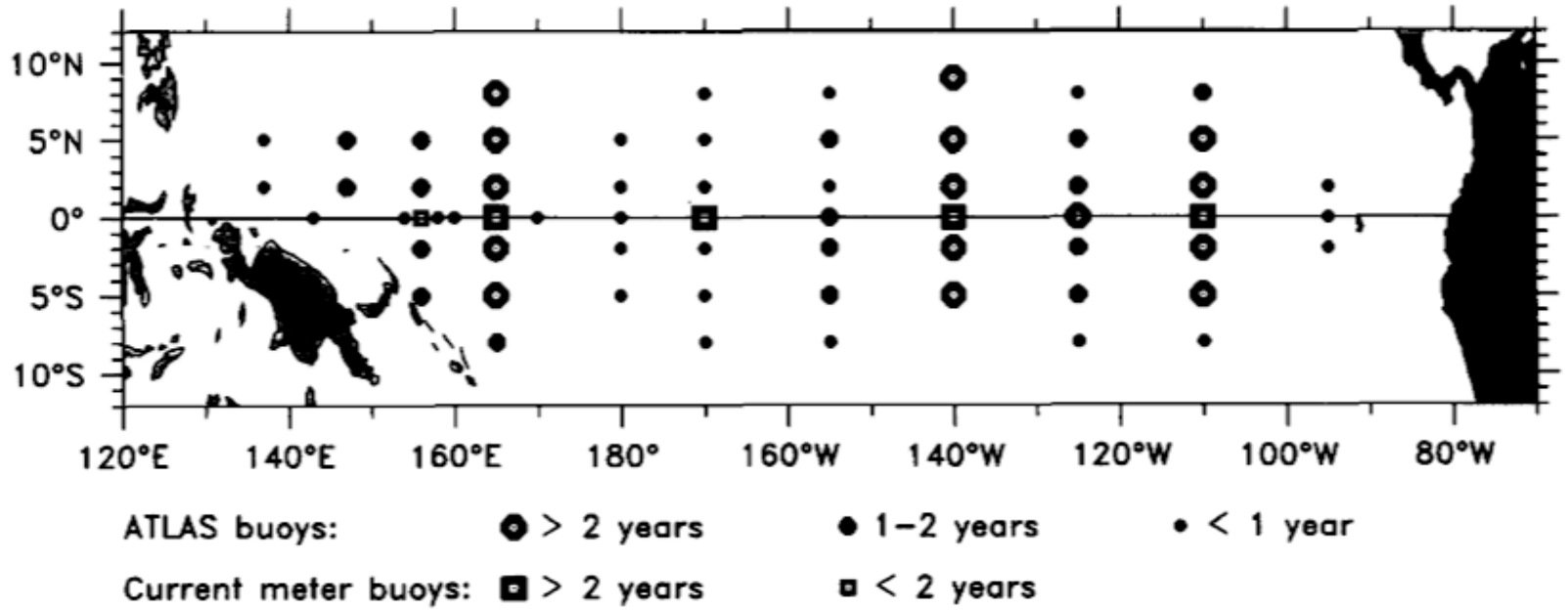


Fig. 1. Map of the TAO buoy network as of September 1993. The symbols indicate the length of time a buoy has been in the water at each location.

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

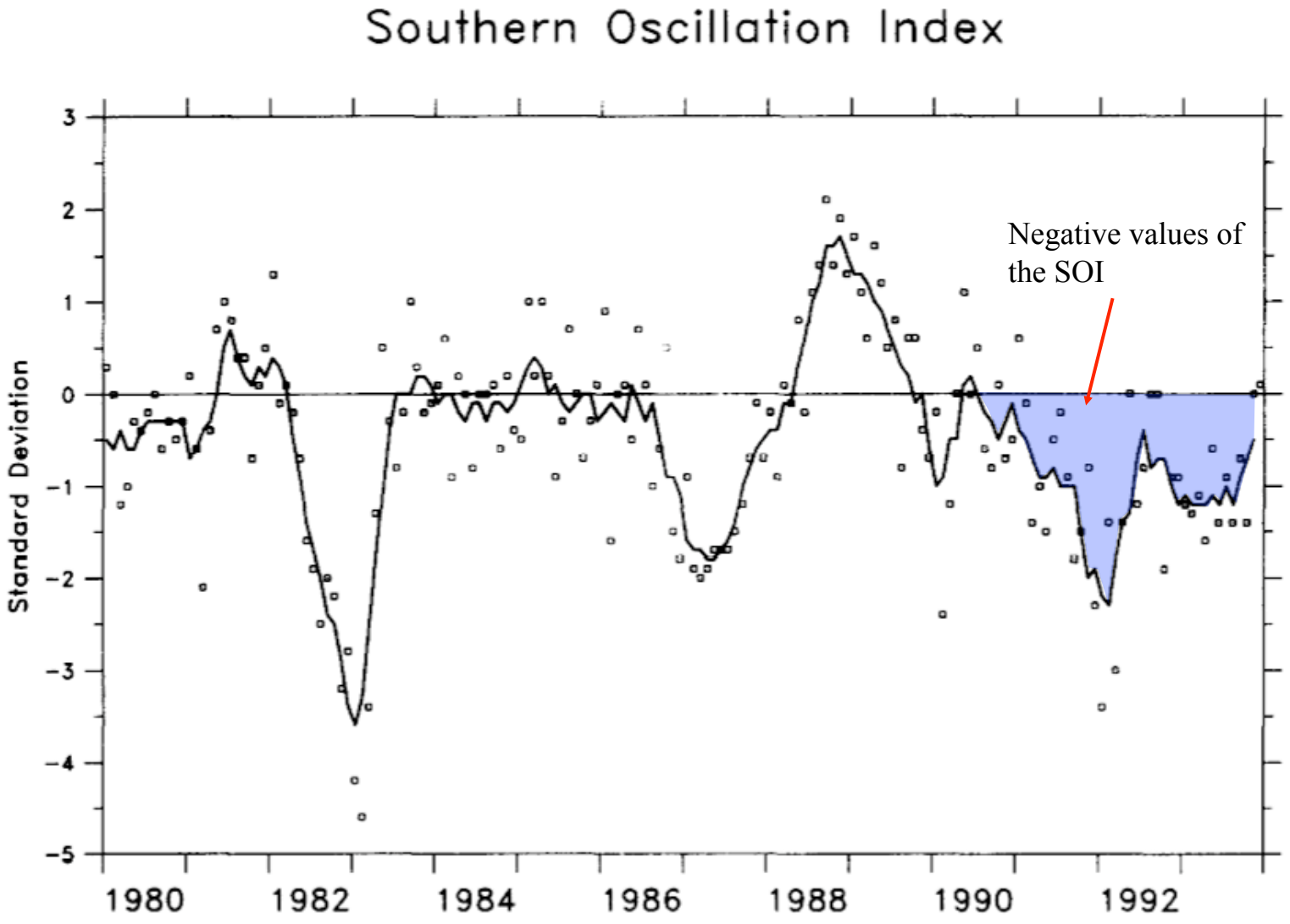
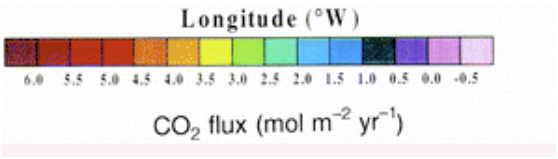
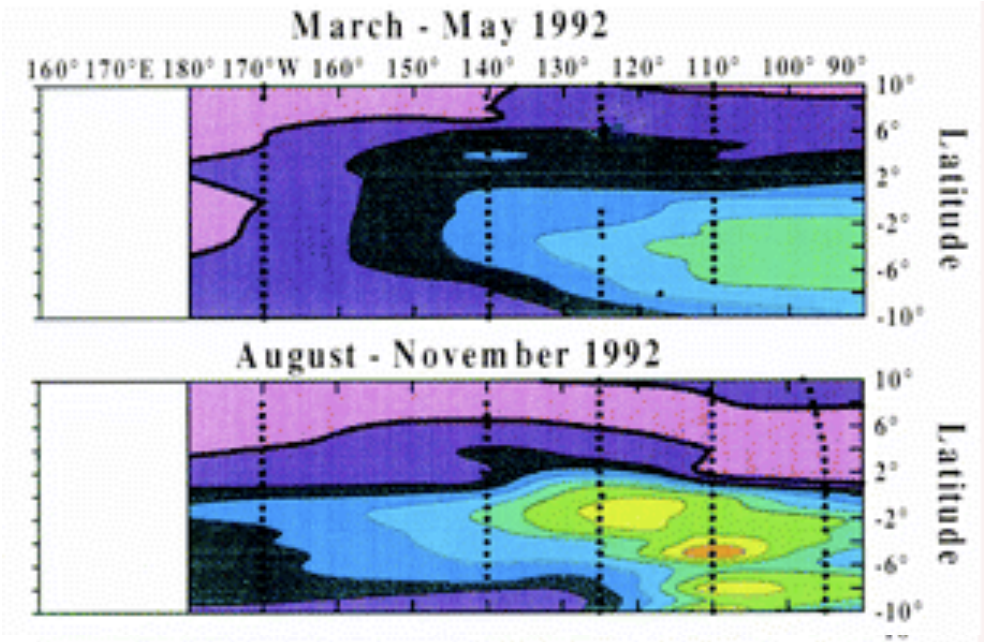


Fig. 2. Southern Oscillation Index (SOI). Monthly values (squares) and 5-month running mean (line). The SOI is based on the surface atmospheric pressure difference between Tahiti and Darwin, Australia. Negative values of the SOI indicate negative anomalies of surface pressure in the eastern Pacific,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

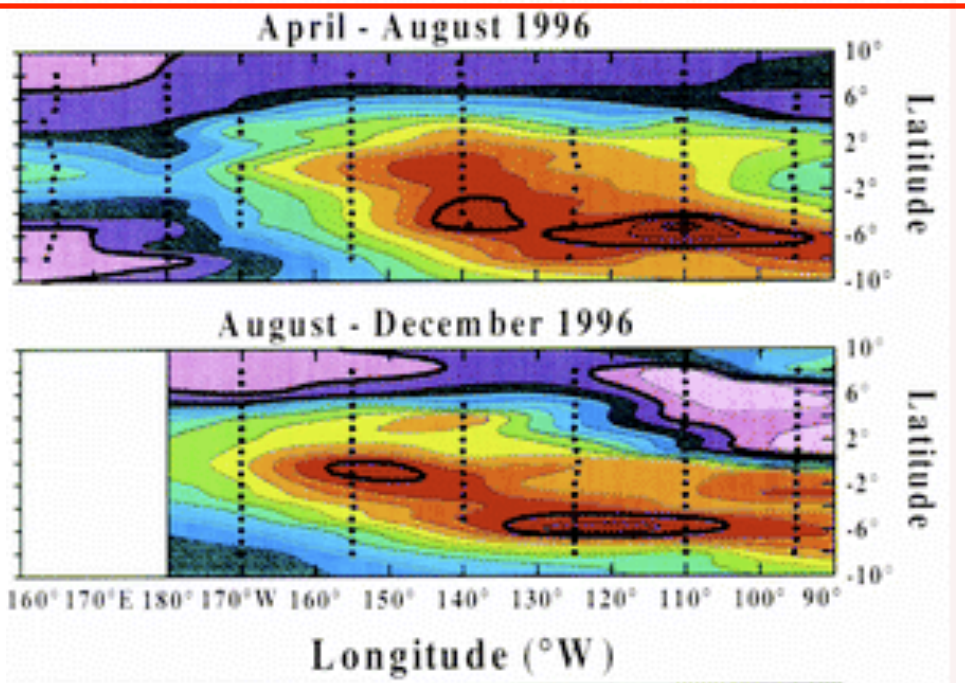


A El Nino Year

Weaker winds and E.U.C.



A Non-El Nino Year



Feely et al. 1999 Nature, 398.