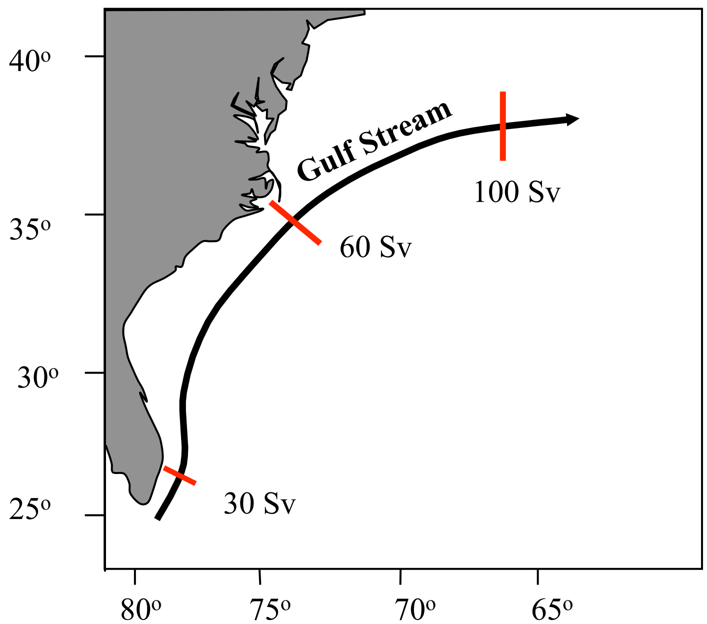
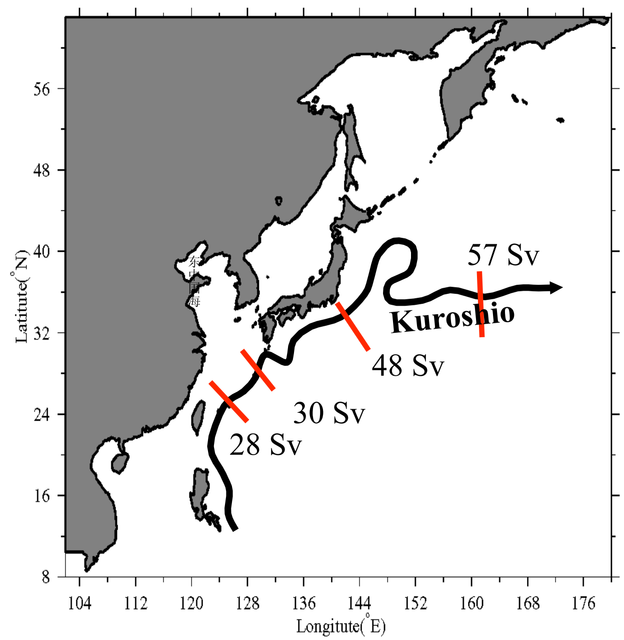
MAR650 Lecture 4: Ecosystem of the Western Boundary Current

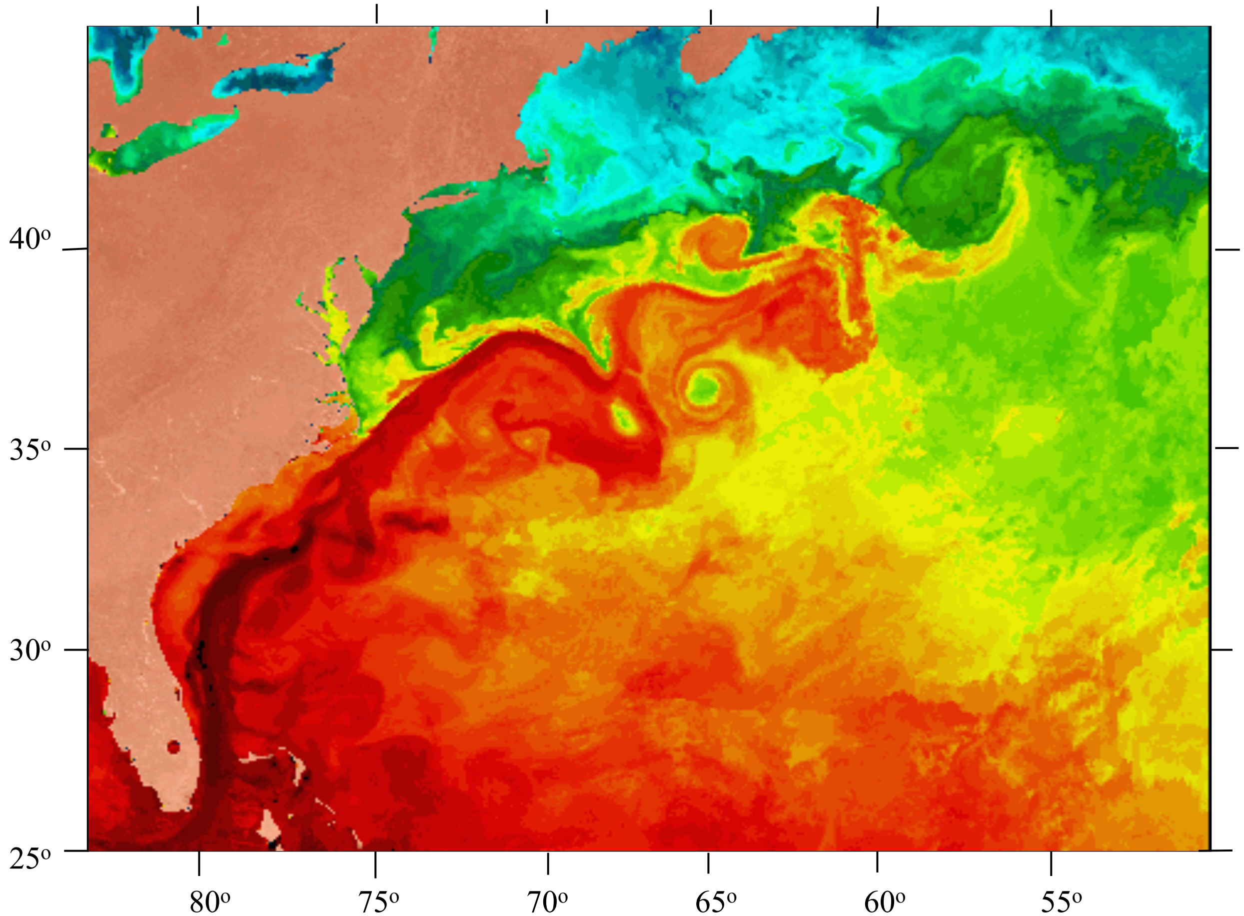
Transport $V = \iint_A v_n \, dx dz$ 1 Sv = 10^6 m^3/s



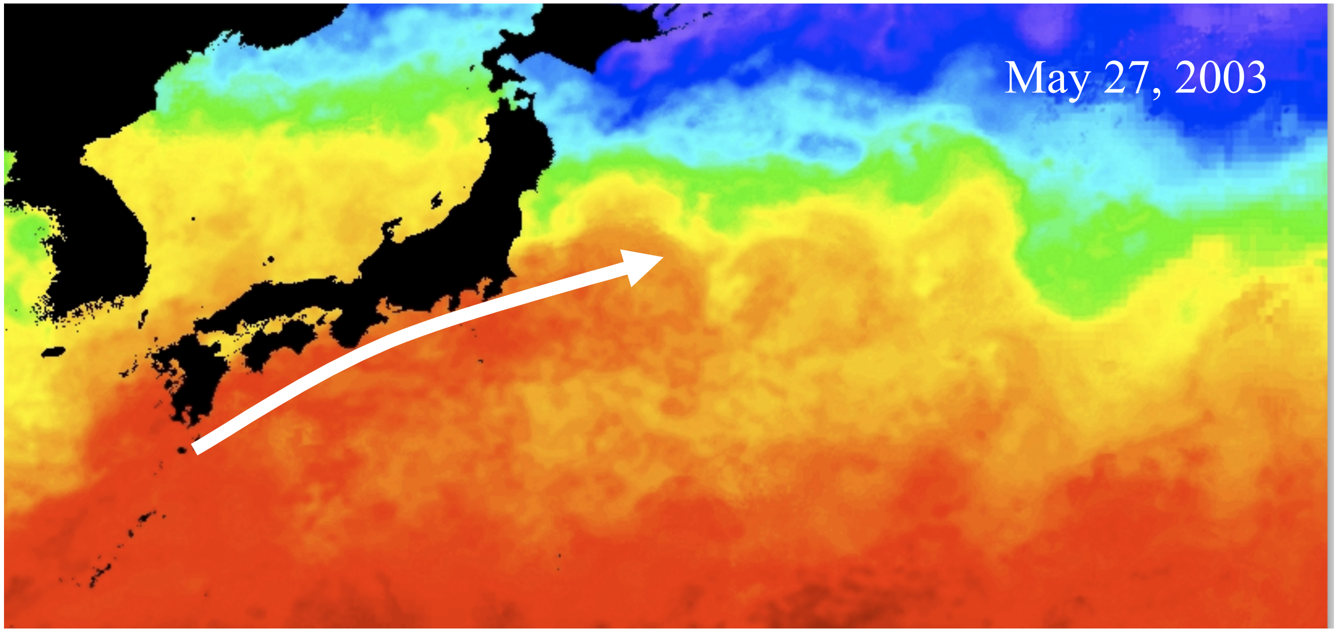


The Atlanta Ocean   **The Pacific Ocean**

Ecosystem of Warm-core and Cold-core Rings

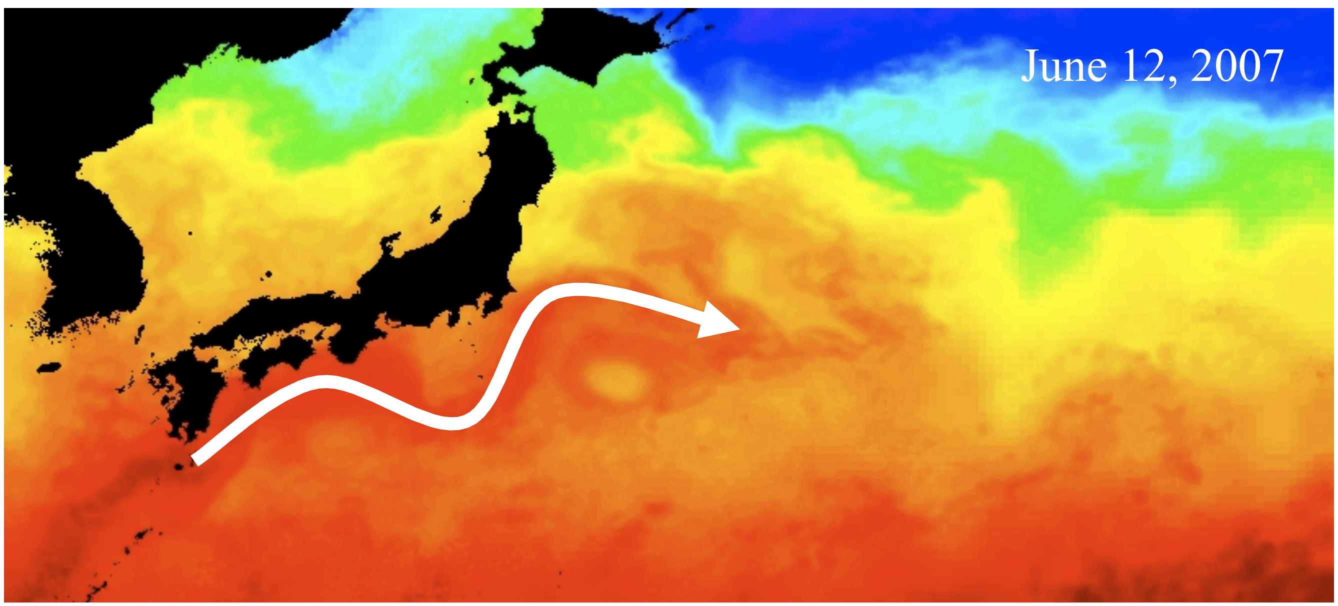


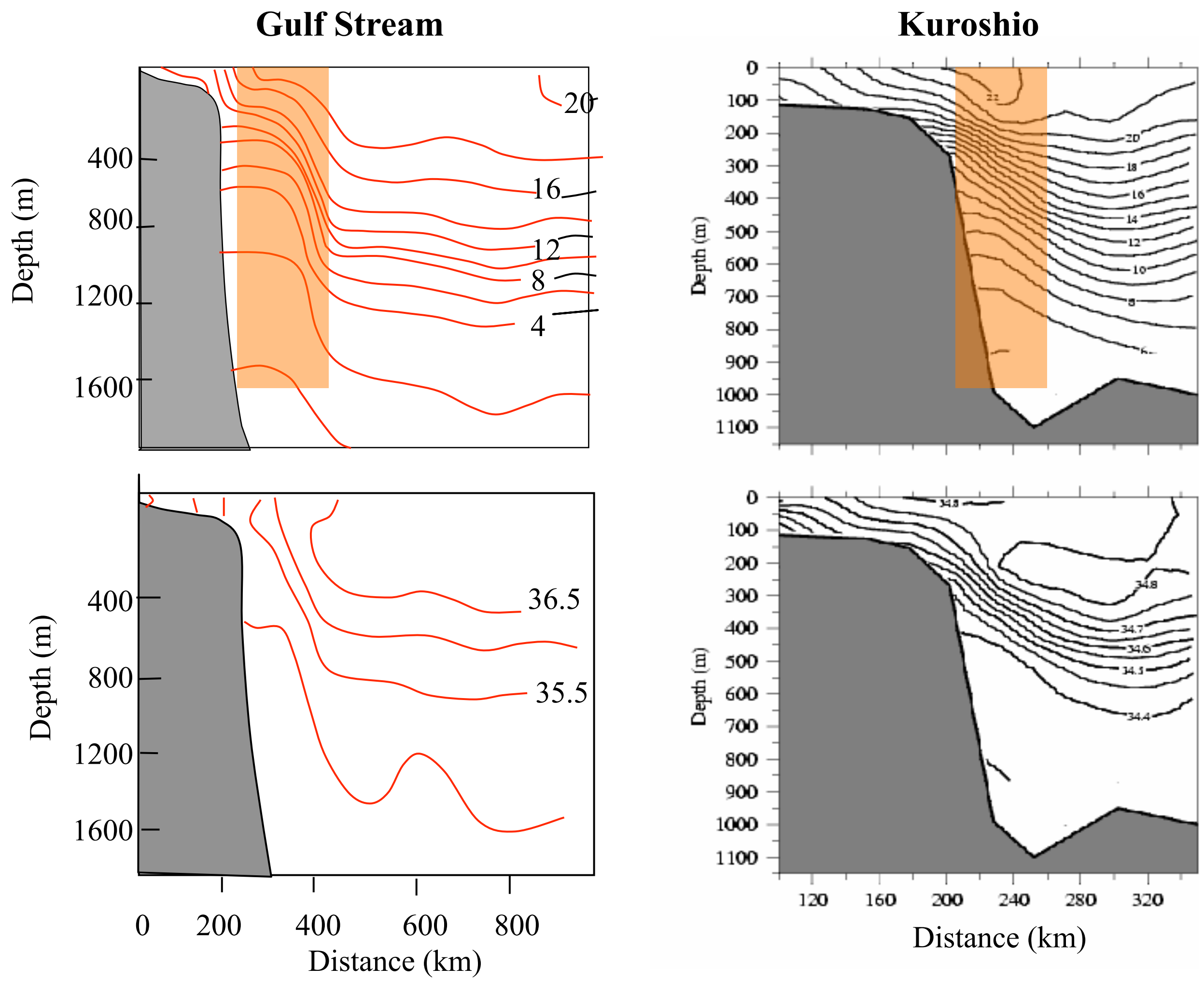
Mixed barotropic/.baroclinic instabilities, bottom topography (seamount)



Characteristic of Kuroshio:

Bi-mode paths





Characterized by the thermal and salinity fronts

Roles of the Western Boundary Current in the Ecosystem

1) The Gulf Stream or Kuroship is one of the key physical processes that transport the nutrients, phytoplankton, and zooplankton as well as fish larvae northward from low latitude to high latitude.

2) Enhance the biological production within the frontal zone.

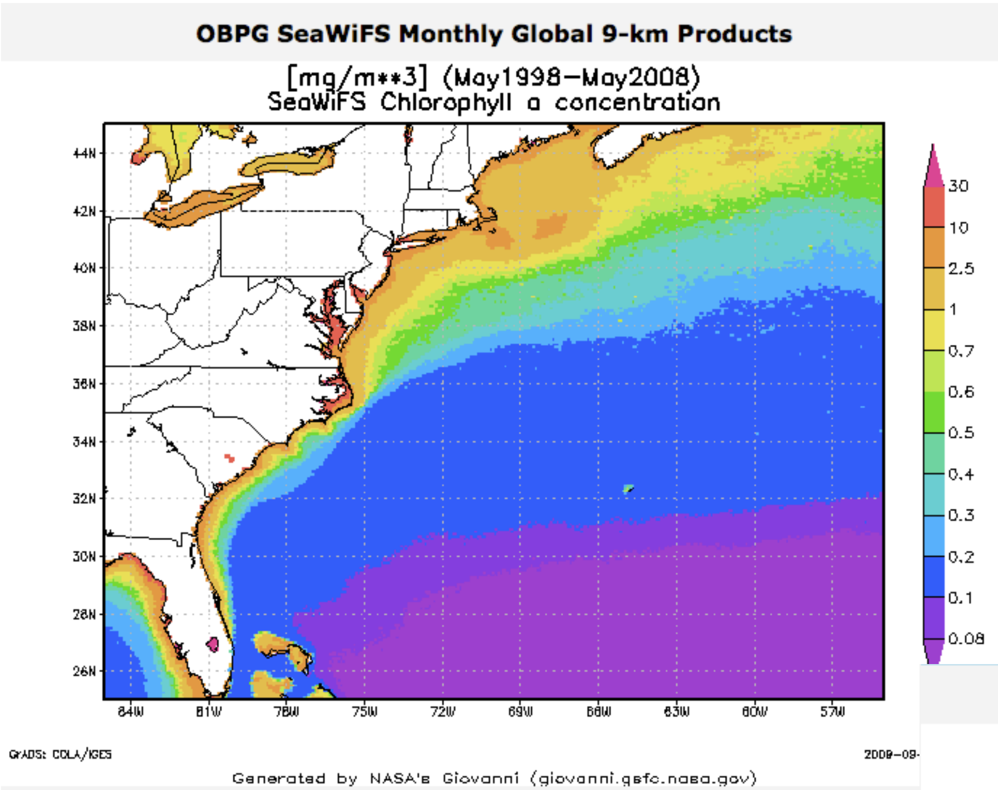
Example 1:

Squids:

Produce eggs in a region with water temperature higher than 13^{o} C in the East China Sea.

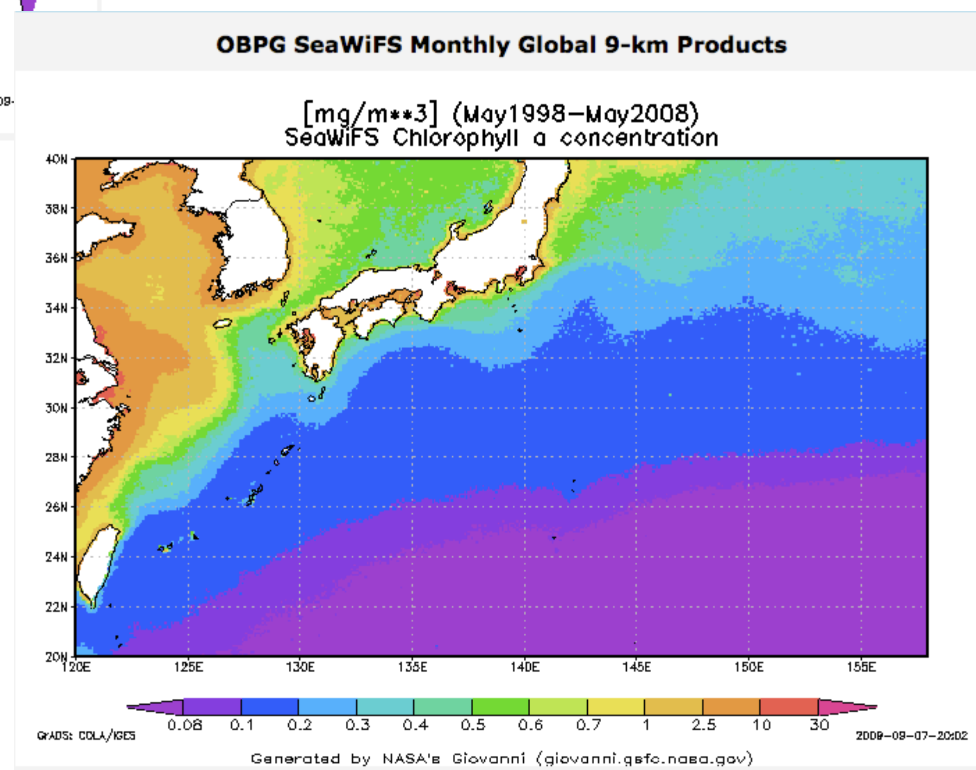
In winter, they are located over the continental shelf between the Kuroshio and a transect from Hangzhou Gulf to Jizhou island. When eggs grow up to larval fishes, they are carried to the east of Japan by the Kuroshio. Therefore, the best fishing area for squids in summer is near the Japanese coast, but the source of squids come from the East China Sea.

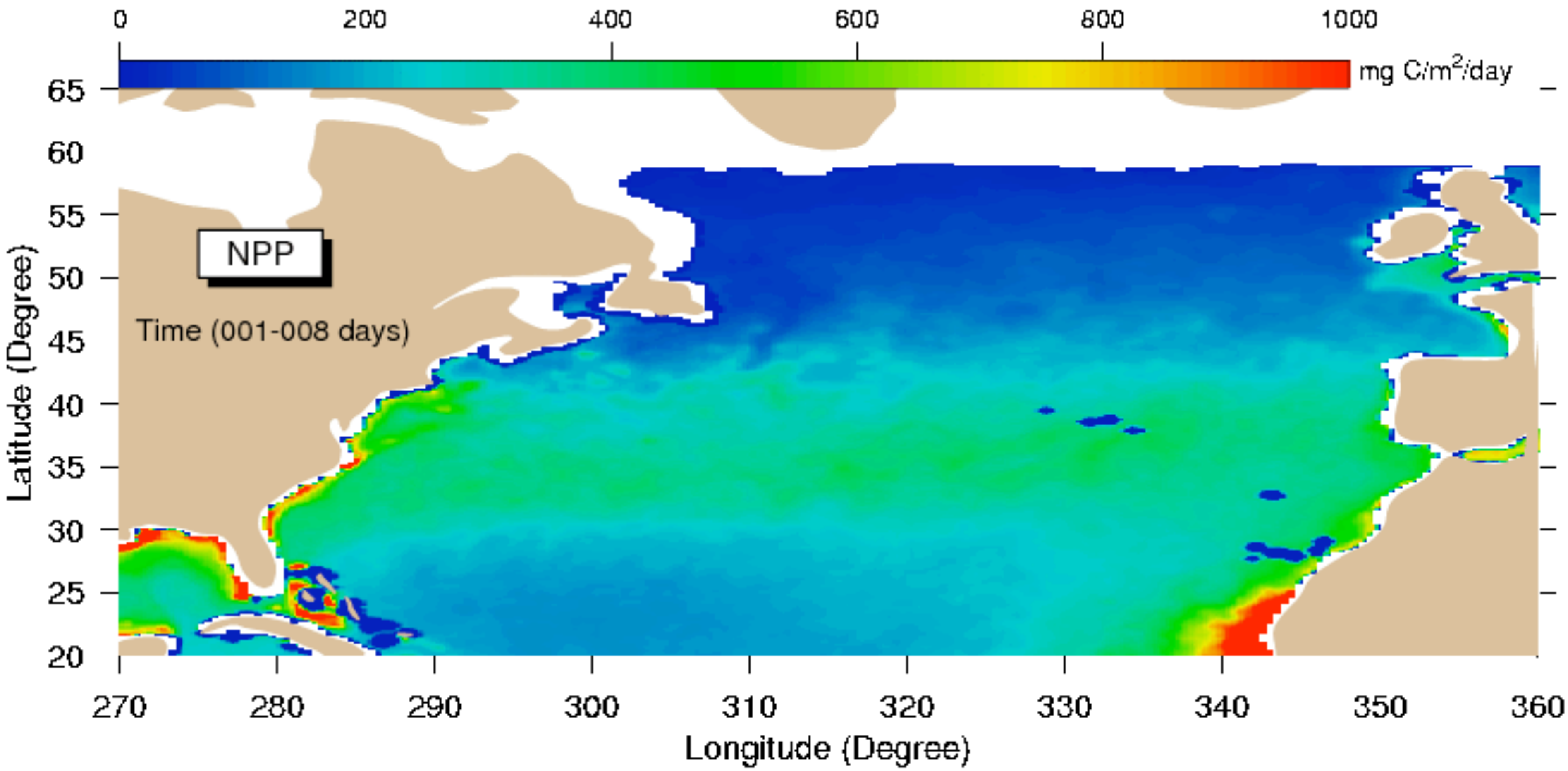
In summer, water temperature in most of the region in the East China Sea is higher than 20^{o} C, so the squid's egg production is not restricted by water temperature, they generally prefer to produce eggs in the inner shelf. Larval squids could be advected to the Japan Sea or East of Japanese coast by the Kuroshio, Changjiang River, and also southwesterly winds.

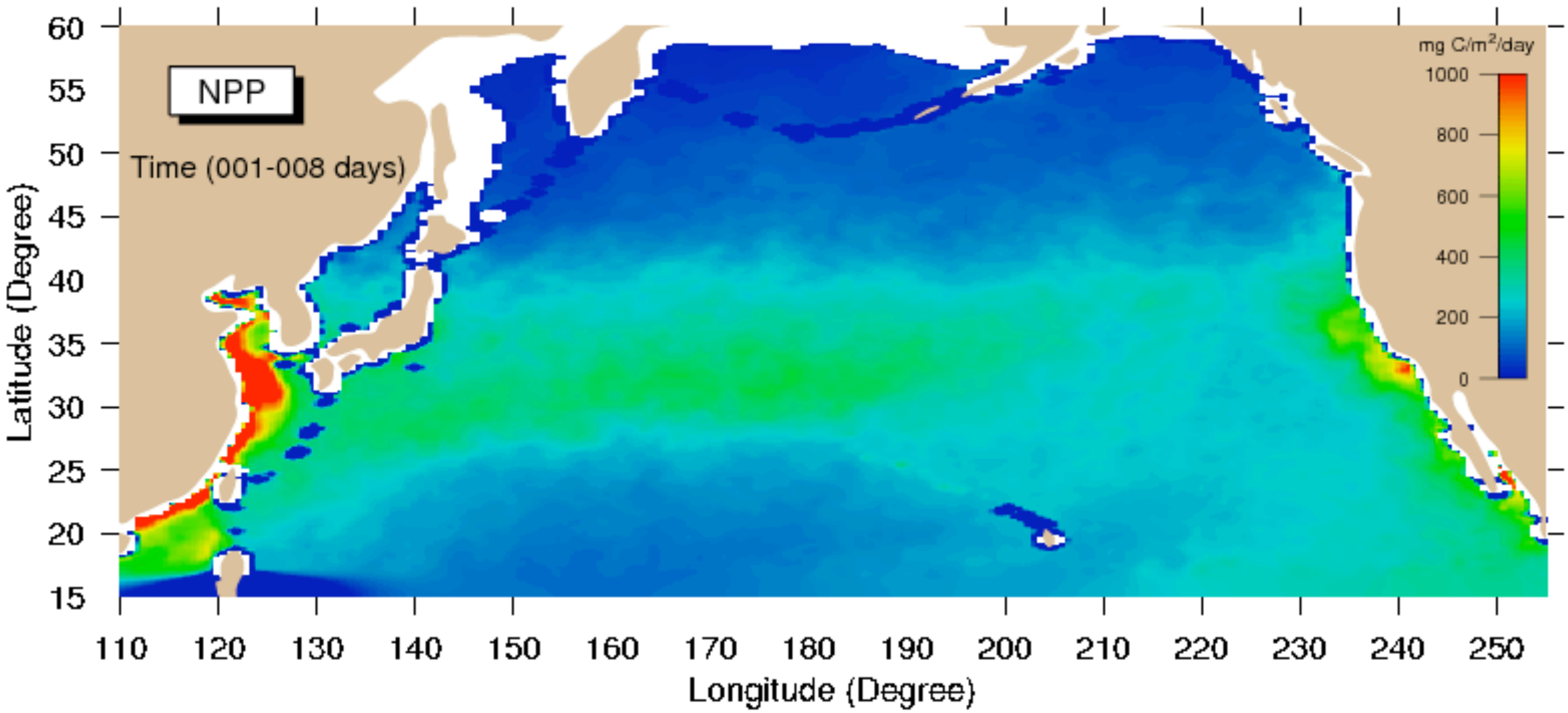


Gulf of Stream

Kurioshio



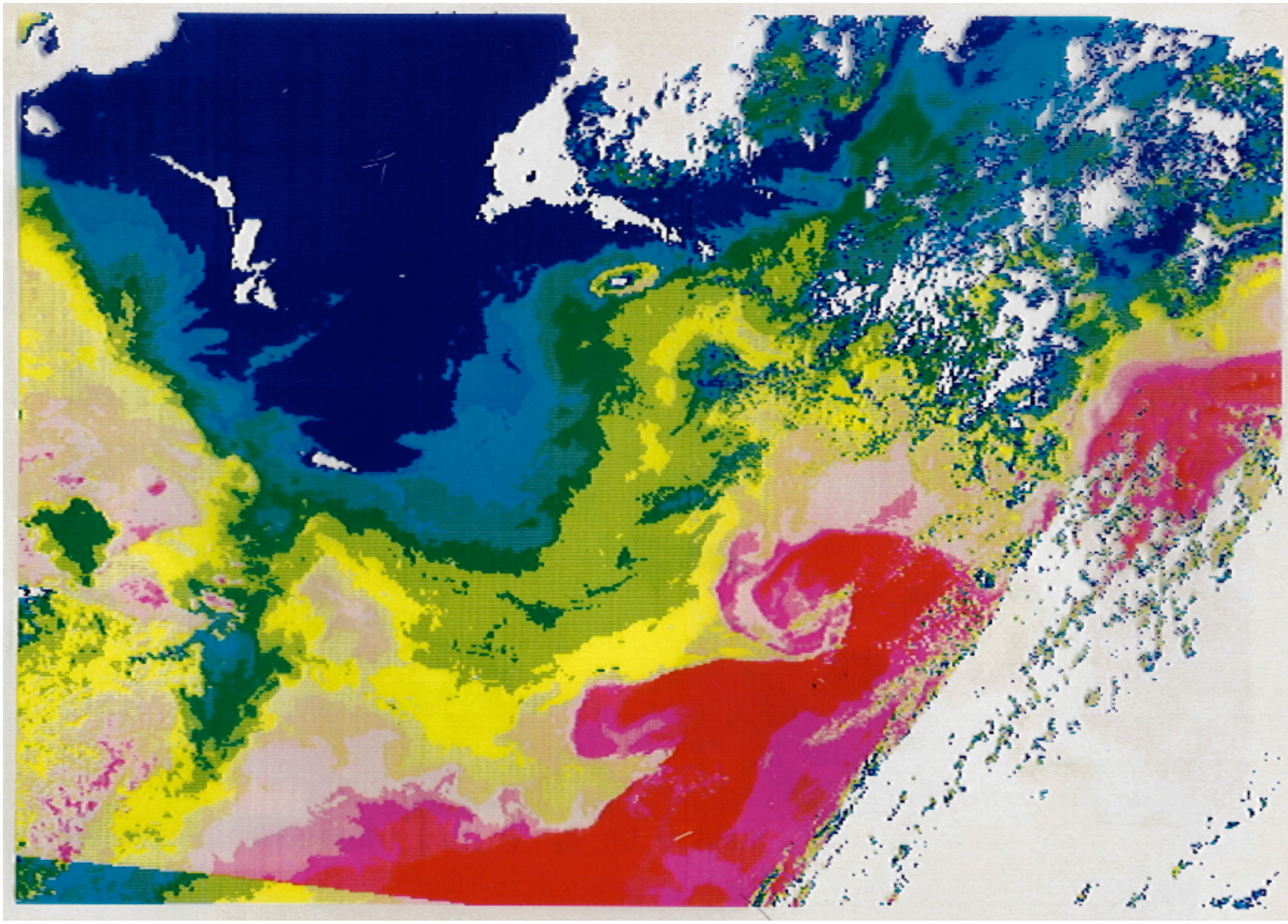

0
200
400
600
800
1000
mg C/m2/day
NPP
Time (001-008 days)
Latitude (Degree)
65
60
55
50
45
40
35
30
25
20
270
280
290
300
310
320
330
340
350
360
Longitude (Degree)



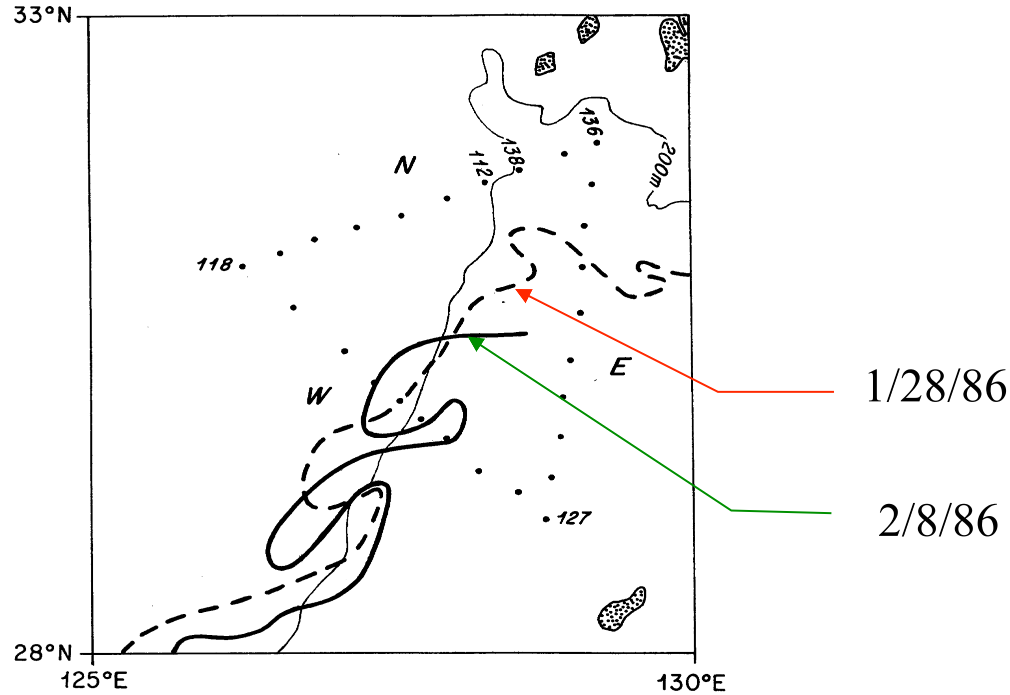
NPP
Time (001-008 days)
mg C/m2/day
1000
800
600
400
200
0
60
55
50
45
40
35
30
25
20
15
Latitude (Degree)
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
Longitude (Degree)

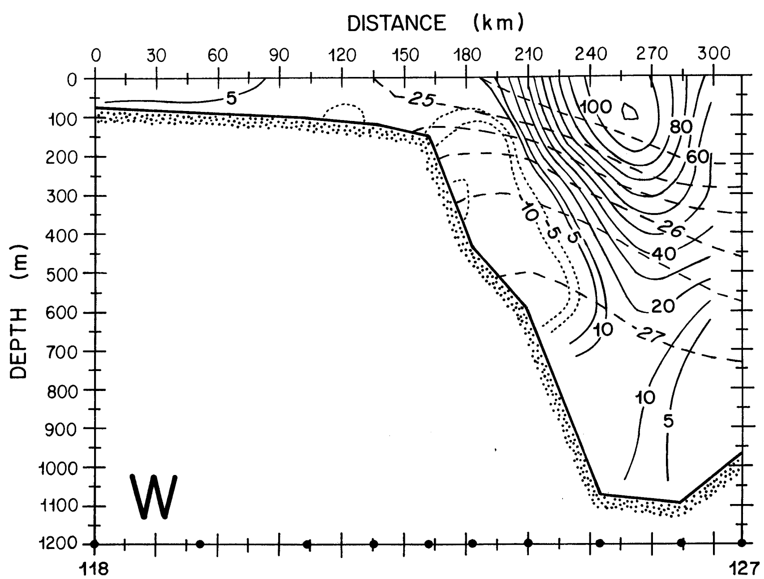
Example 2: Frontal eddies

NOAA-AVHRR Satellite Image: June 3 1986



Horizontal scale: 10-100 km; life time: 10-30 days; velocity: 10 m/s

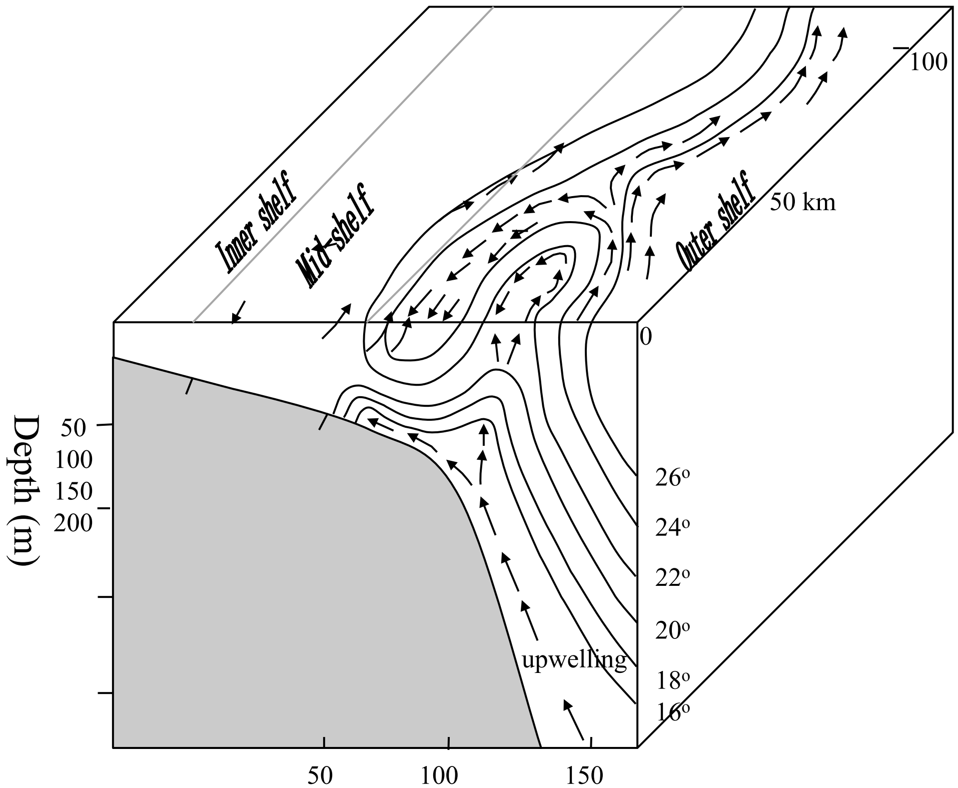




Eddy diameter: 60 km;

Moving speed: 20-40 cm/s

Eddy rotating velocity: 5-15 cm/s



Upwelling advects nutrients upward to the euphotic layer: producing near-surface phytoplankton bloom. The euphotic layer depth: > 20 m in the outer shelf.

Sverdrup theory: The seasonal variation of the phytoplankton bloom depends on the ratio of euphotic layer depth to mixed layer depth, i.e.:

$$R = \frac{D_I}{D_M}$$

In winter: R is smaller due to large D_M, phytoplankton biomass is lower;
In spring-summer, R is bigger due to small D_M, phytoplankton biomass is higher.

Over the southeastern US continental shelf :

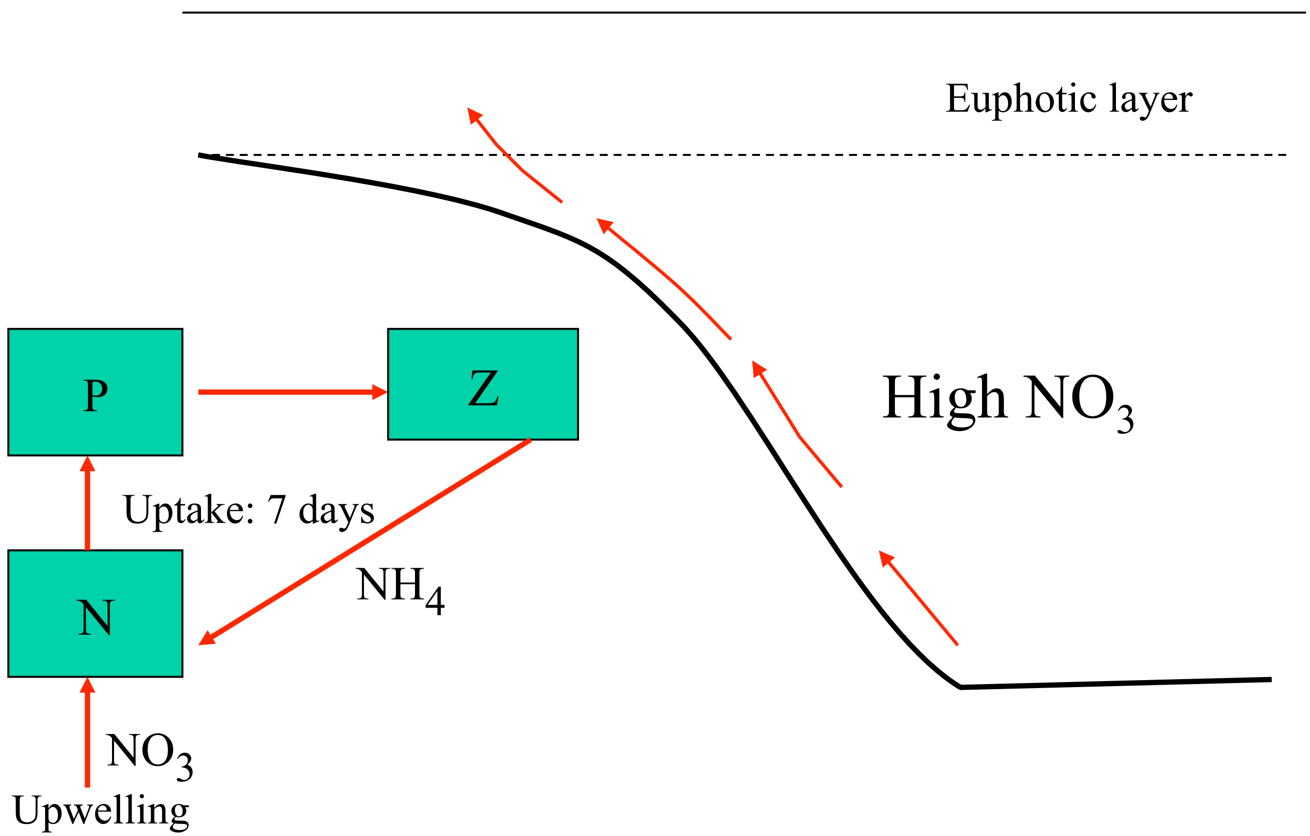
1) $D_I \sim$ 40-50 m, the same as or deeper than local water depth, so that the uptake of nutrients by phytoplankton can occur at any depth of the whole water column;

2) Nutrients are not sufficient throughout the entire water column, so that vertical stratification does not have a role in restricting the upward nutrient supplies.

Sverdrup theory does not apply for this region! The seasonal variation of the phytoplankton depends directly on upwelling due to frontal eddies or southwesterly winds.

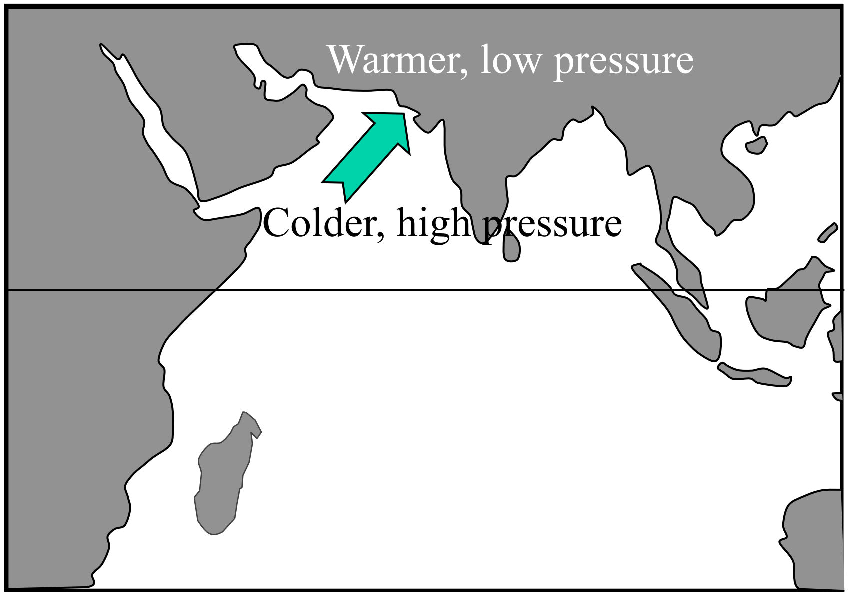
Uptake time scale: 7 days; the primary production reaches 1.9 g $C/m^2/d$, which is much larger than 0.4 g $C/m^2/d$, a value that is generally observed on the outer shelf.

Phytoplankton bloom: 15 days. The eddy time scale is 10-30 days. Sometimes, observations show that the bloom still exist after eddy disappears, suggesting the internal cycling of nutrients are also very important.

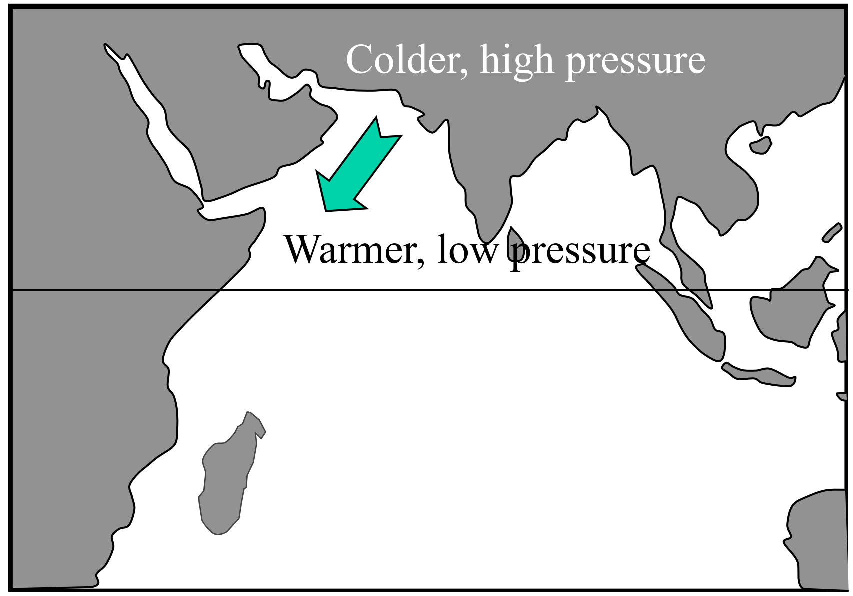


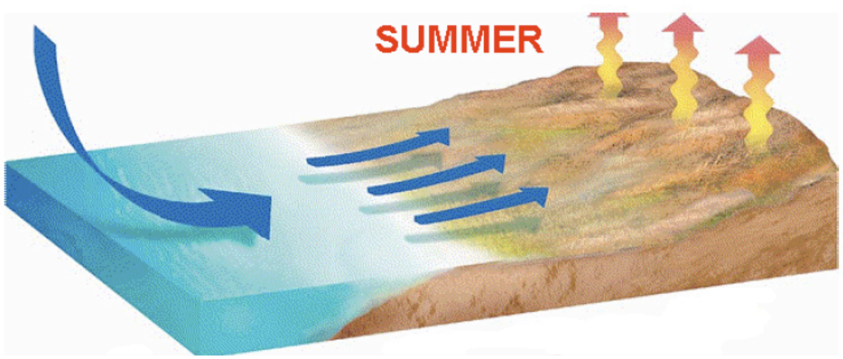
The Indian Ocean: Monsoon Climate: Monsoonal circulation

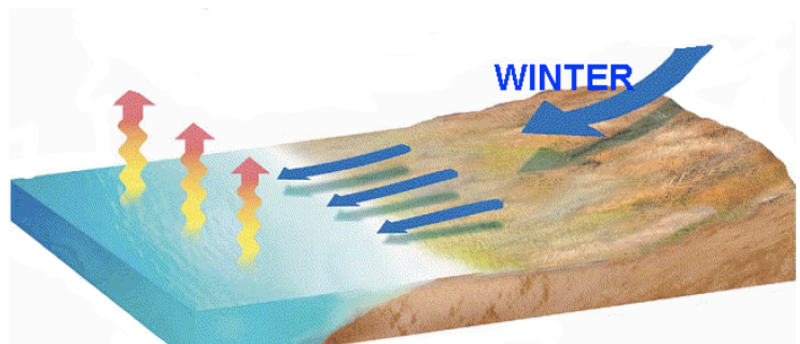
Summer: South-west monsoon

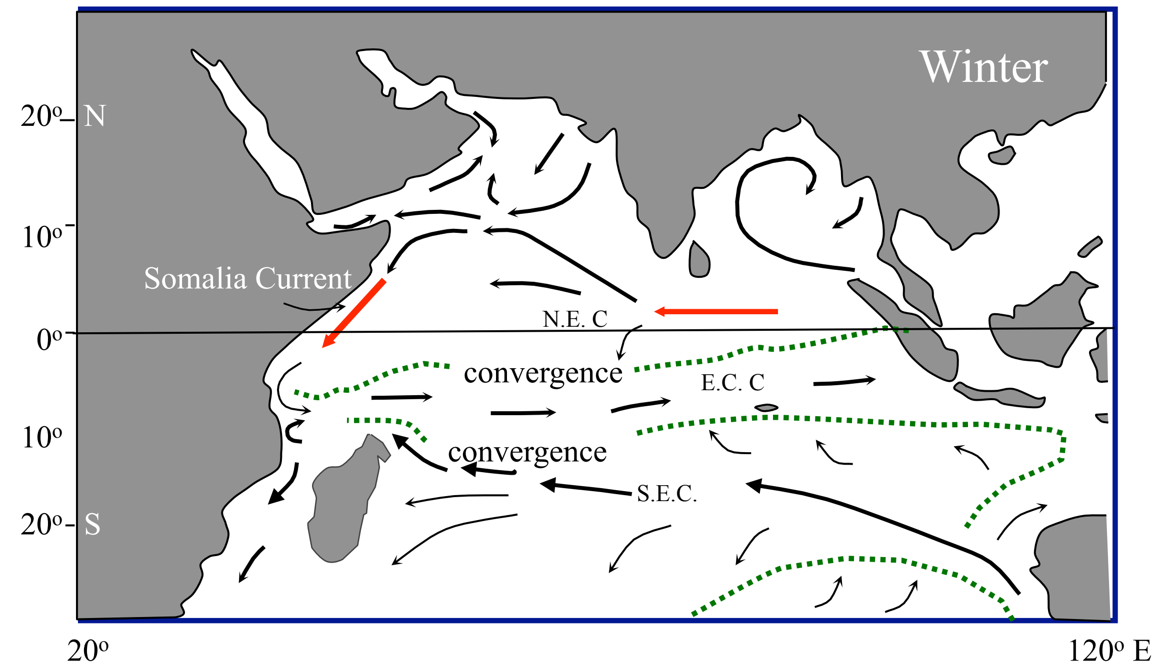


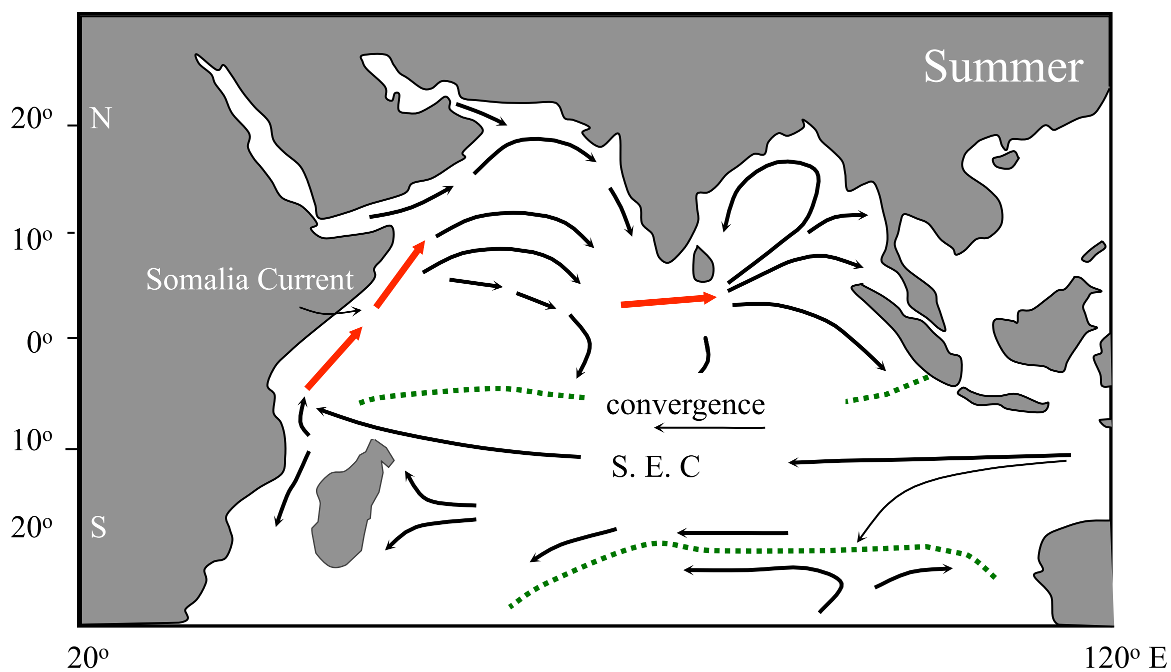
Winter: North-east monsoon



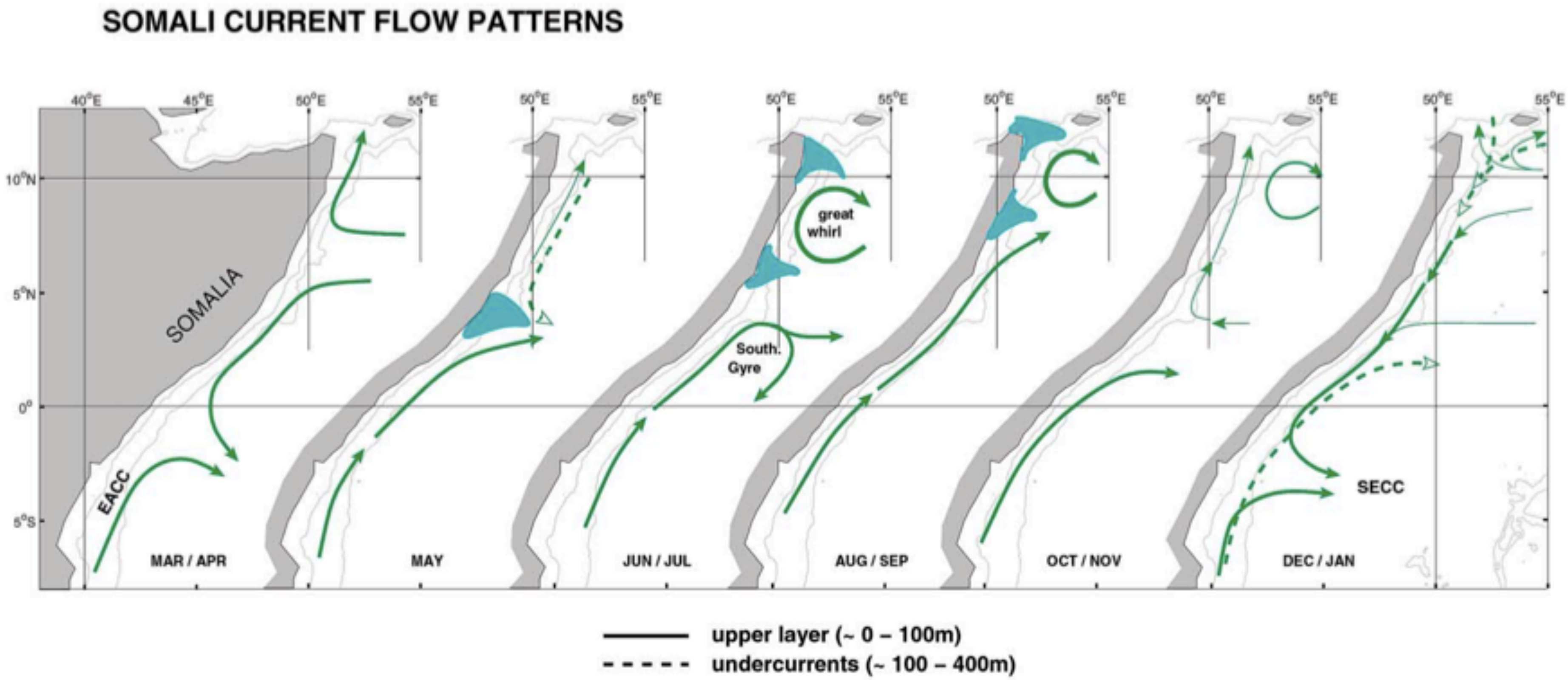





Winter
20°
N
10°
Somalia Current
0°
N.E. C
convergence
E.C. C
10°
convergence
S.E.C.
20°
S
20°
120° E


Summer
20°
N
10°
Somalia Current
0°
convergence
10°
S. E. C
20°
S
20°
120° E

From Schott and McCreary (2001)



1. Velocity: ~3.7 m/s
2. Transport: ~ 60 SV in the upper 200 m;
3. Change of its direction with season
4. Energetic upwelling during summer

Northern Summer