

Gulf of Guinea Oceanography

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GoG: Geography

- ✓ North easternmost part of the tropical Atlantic Ocean between Cape Lopez in Gabon, north and west to Cape Palmas in Liberia.
- ✓ closed boundary to the east and north and an open South Atlantic Ocean to the south.
- ✓ provides the main oceanic connection between the South Atlantic Ocean and the SE trade winds with the climate of West Africa and the Sahel.

this facilitates the impact of oceanic forcings onto the land via the atmosphere as a result of temperature gradient between ocean and land.

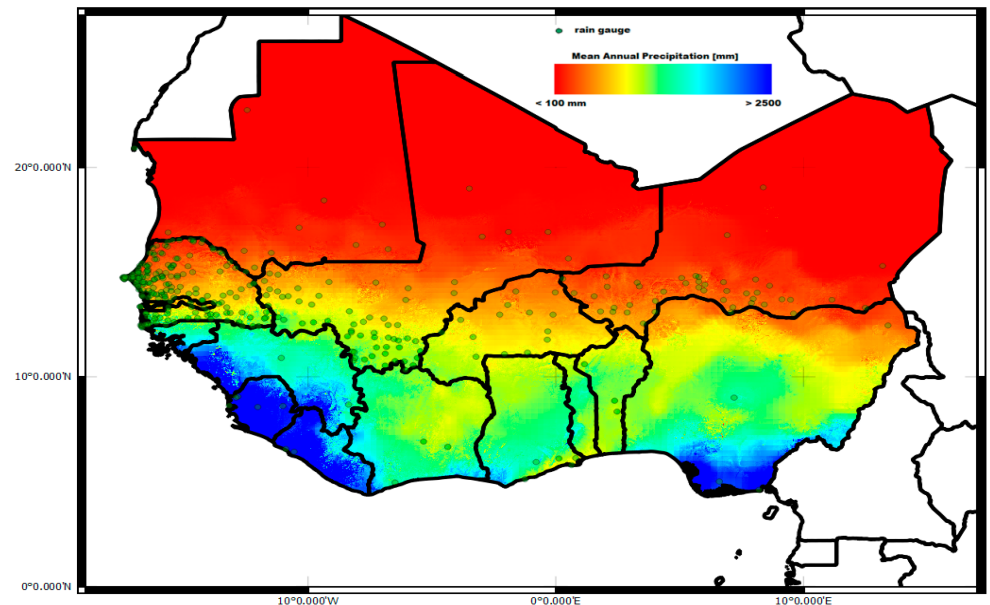


GoG: Geography

- ✓ The Gulf of Guinea covers an area of 2,350,000 sq. Km (910,000 miles).
- ✓ Countries: Ghana, Liberia, Nigeria, Gabon, Cameroon, Sao Tome, Angola, Congo Republic, Togo, Ivory Coast and Equatorial Guinea.
- ✓ Main rivers: River Niger and River Volta
- ✓ Salinity : low because of high rainfall and river runoff
- ✓ The only region in the Gulf of Guinea with volcano activity is the Island Arc, which is parallel with Mount Cameroon on the coast of Cameroon.

GoG: climate and seasons

- ✓ equatorial humid zone: a **humid tropical climate** with almost constant monthly temperatures
- ✓ relatively large amount of precipitation; precipitation generally much more important than evaporation
- ✓ annual climatic cycle dominated by **Saharan atmospheric depression** that begins around April; caused by increased solar insolation warming the continental landmass.
- ✓ **depression generates the monsoon**, which is responsible for most of the region's rainfall



GoG: climate and seasons

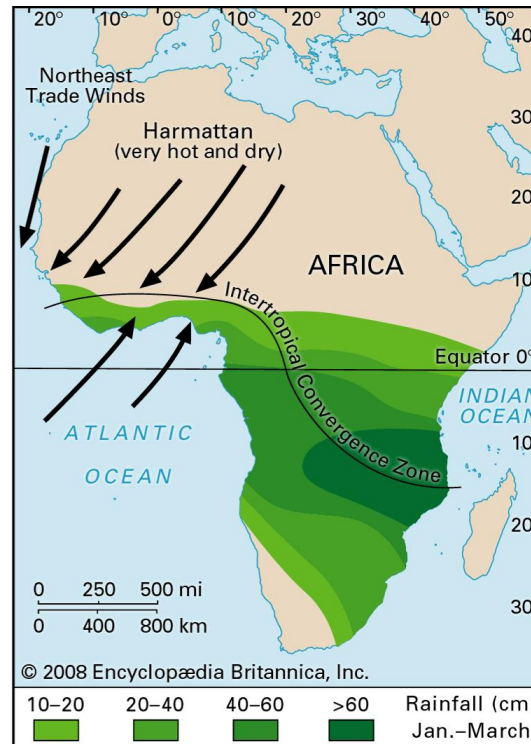
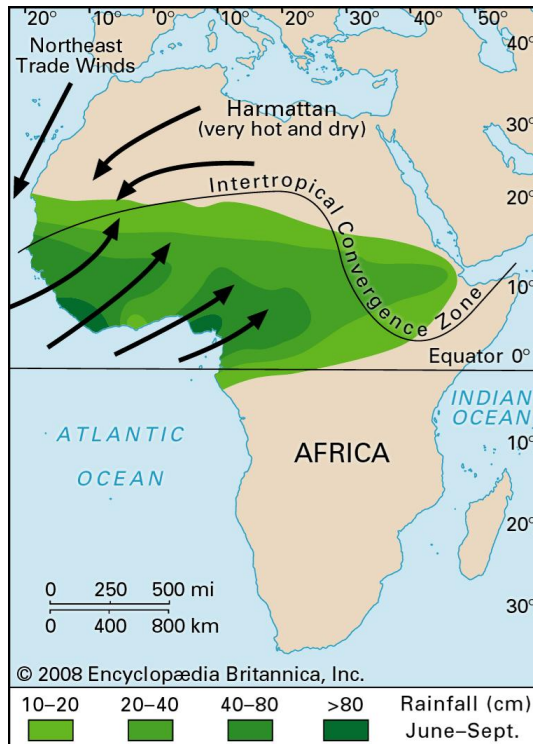
✓ Four maritime seasons:

short cold season Dec-Jan ($\sim 26.5^{\circ}\text{C}$)

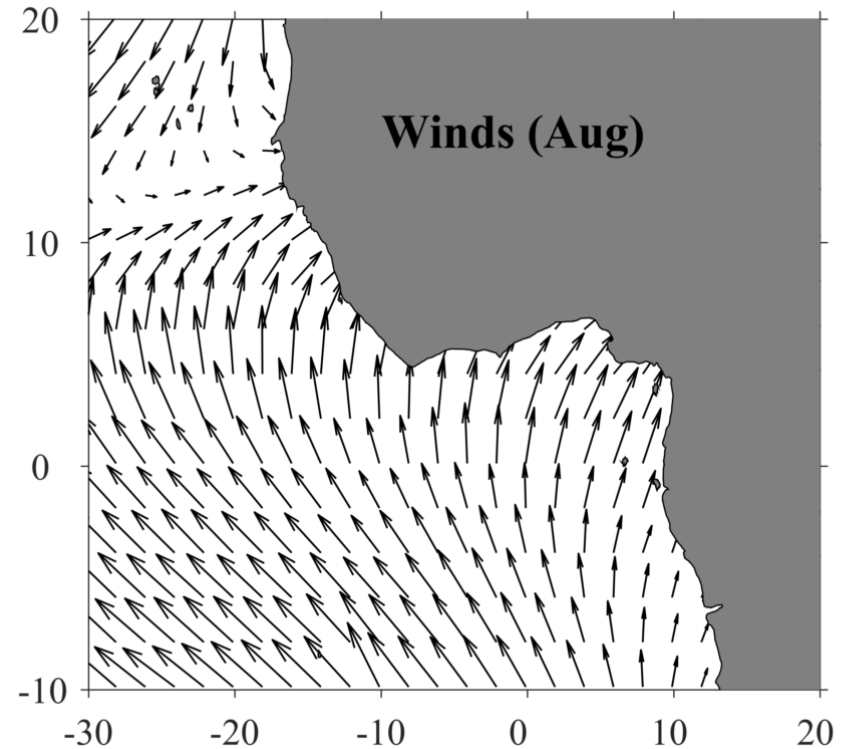
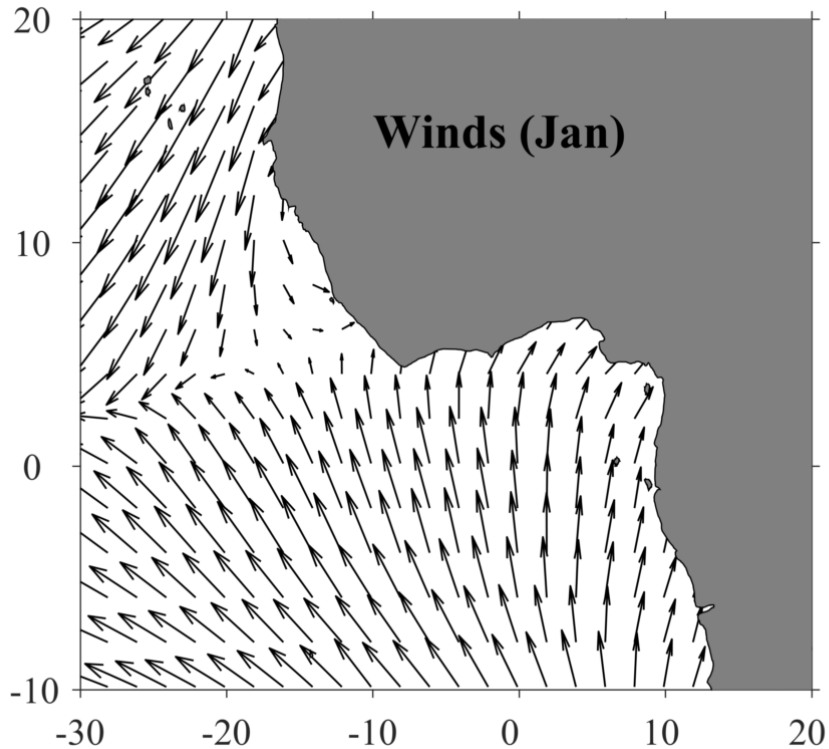
long warm season Feb-Jun ($27\text{--}29^{\circ}\text{C}$)

long cold season Jul-Sep ($22\text{--}25^{\circ}\text{C}$)

short warm spell Oct-Nov ($27\text{--}29^{\circ}\text{C}$)

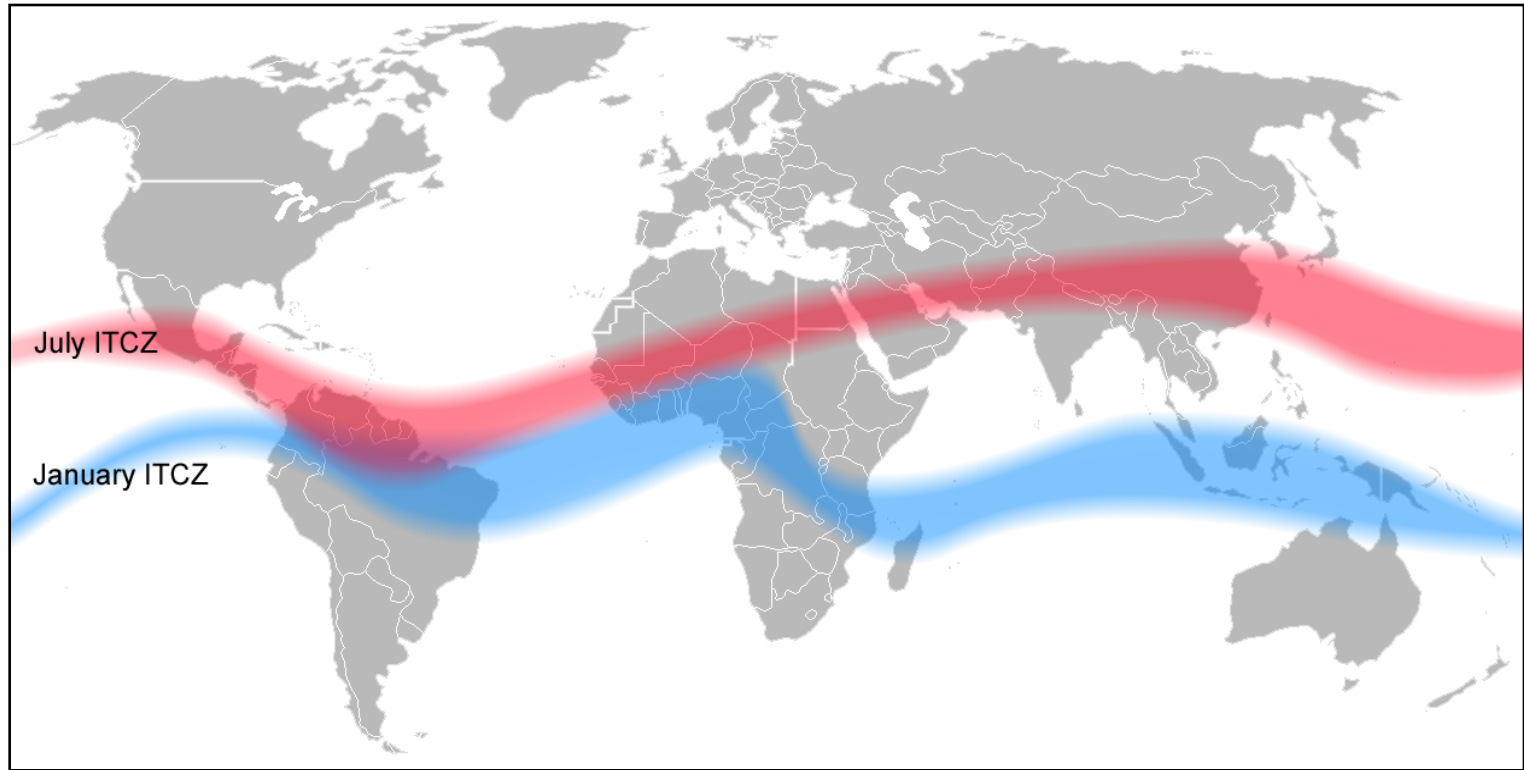


Wind System



- ✓ SE winds in summer
- ✓ Dry NE harmattan winds in winter

Wind System



- ✓ Climate system influenced by wind variability and ITCZ migration
- ✓ ITCZ: band where the southeasterly and northeasterly wind converge
- ✓ SE winds in summer
- ✓ Dry NE harmattan winds in winter

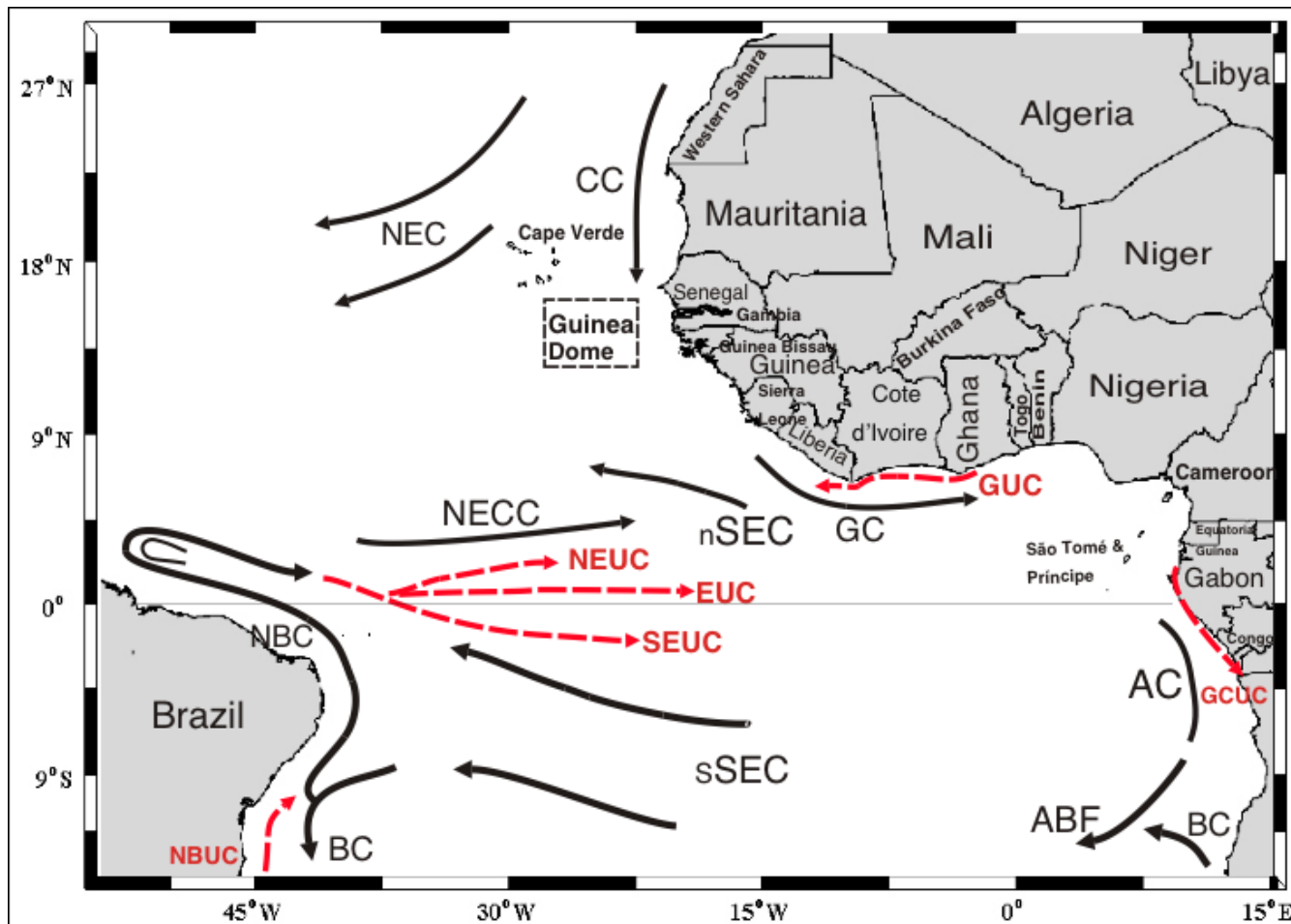
Ocean Current System

Surface currents:

eastward Guinea Current

westward South Equatorial Currents

southward Angola Current



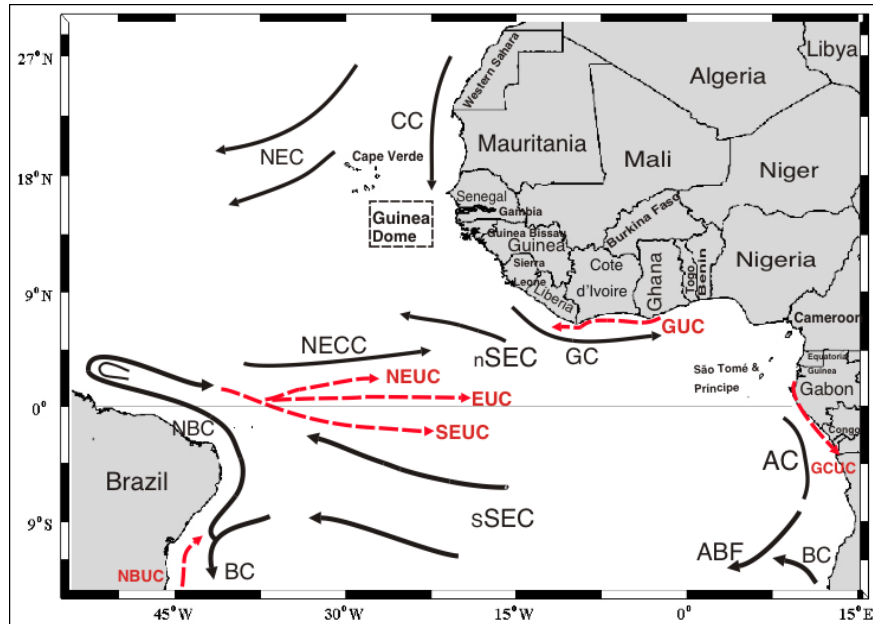
✓ GC: an eastern boundary current

✓ Current shear instability can cause TIW

(Source: I. Muhammed, 2011)

Ocean Current System

Surface currents: eastward Guinea Current



- ✓ Speed can reach 1 ms^{-1} near 5°W
- ✓ Current speed minimum during winter and maximum during summer
- ✓ shallow, average depth of 15m near the coast and 25m offshore
- ✓ Source: North Equatorial Countercurrent (NECC) and the Canary Current

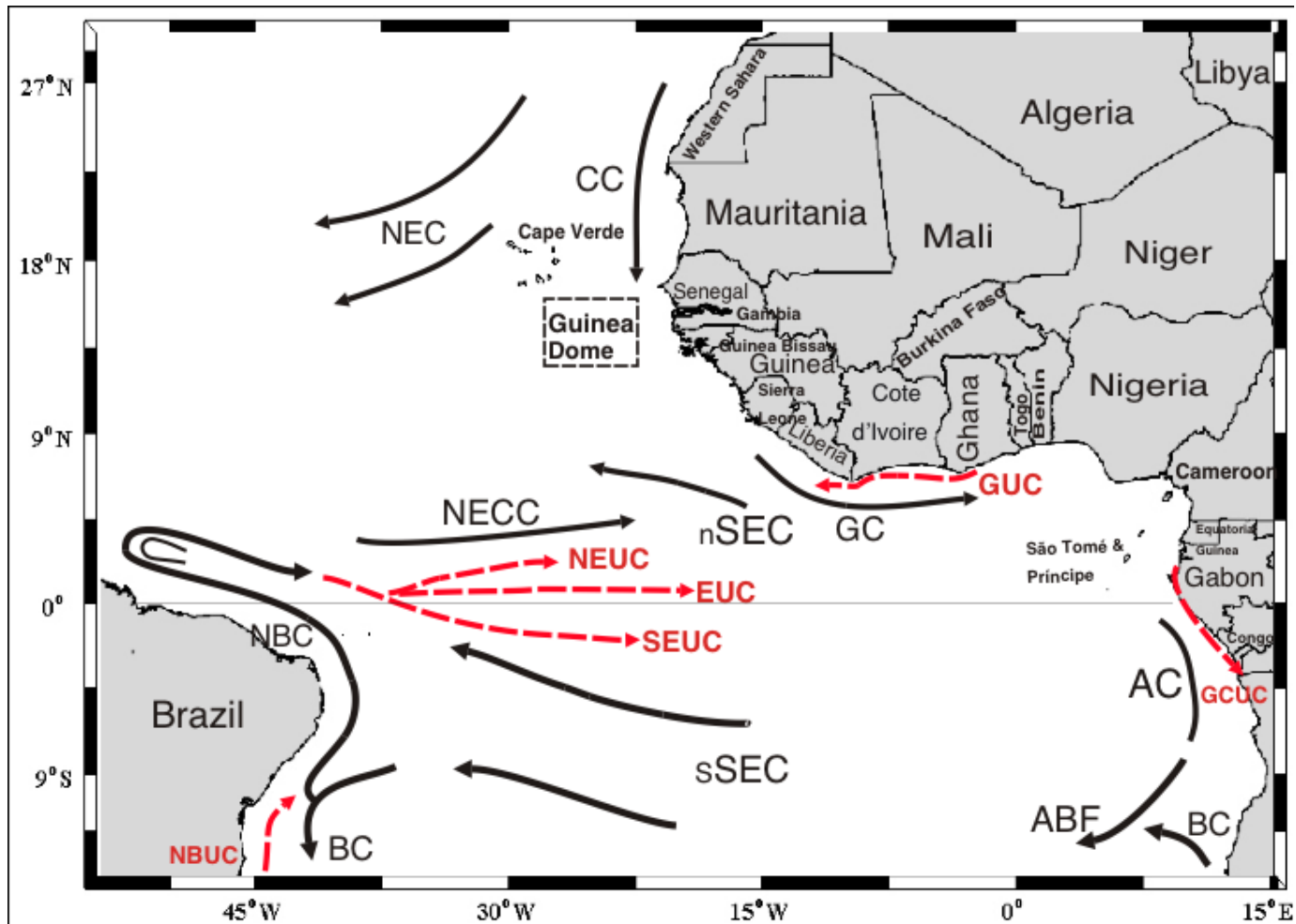
Ocean Current System

Subsurface currents:

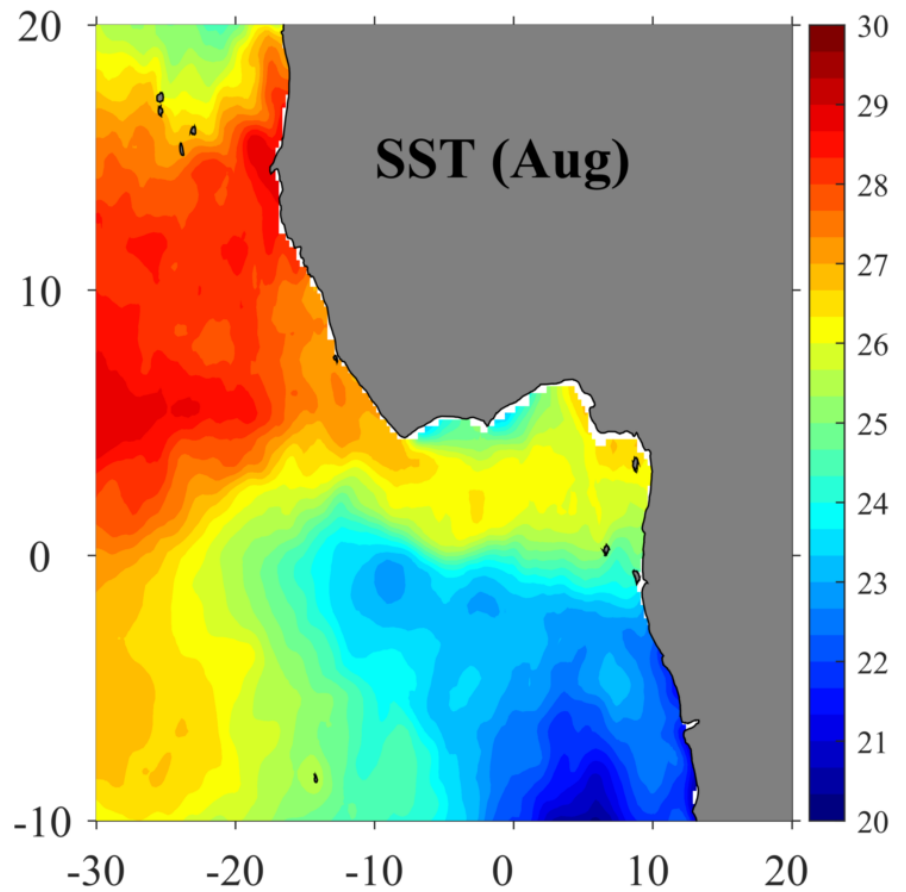
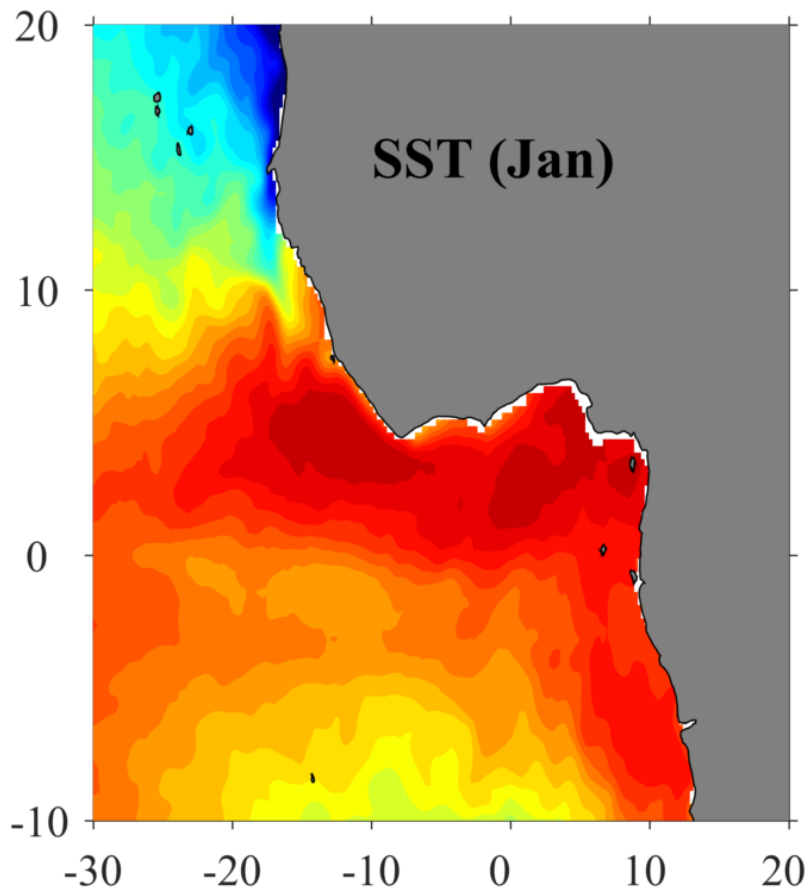
eastward Equatorial Undercurrent (EUC)

westward Guinea Undercurrent (GUC)

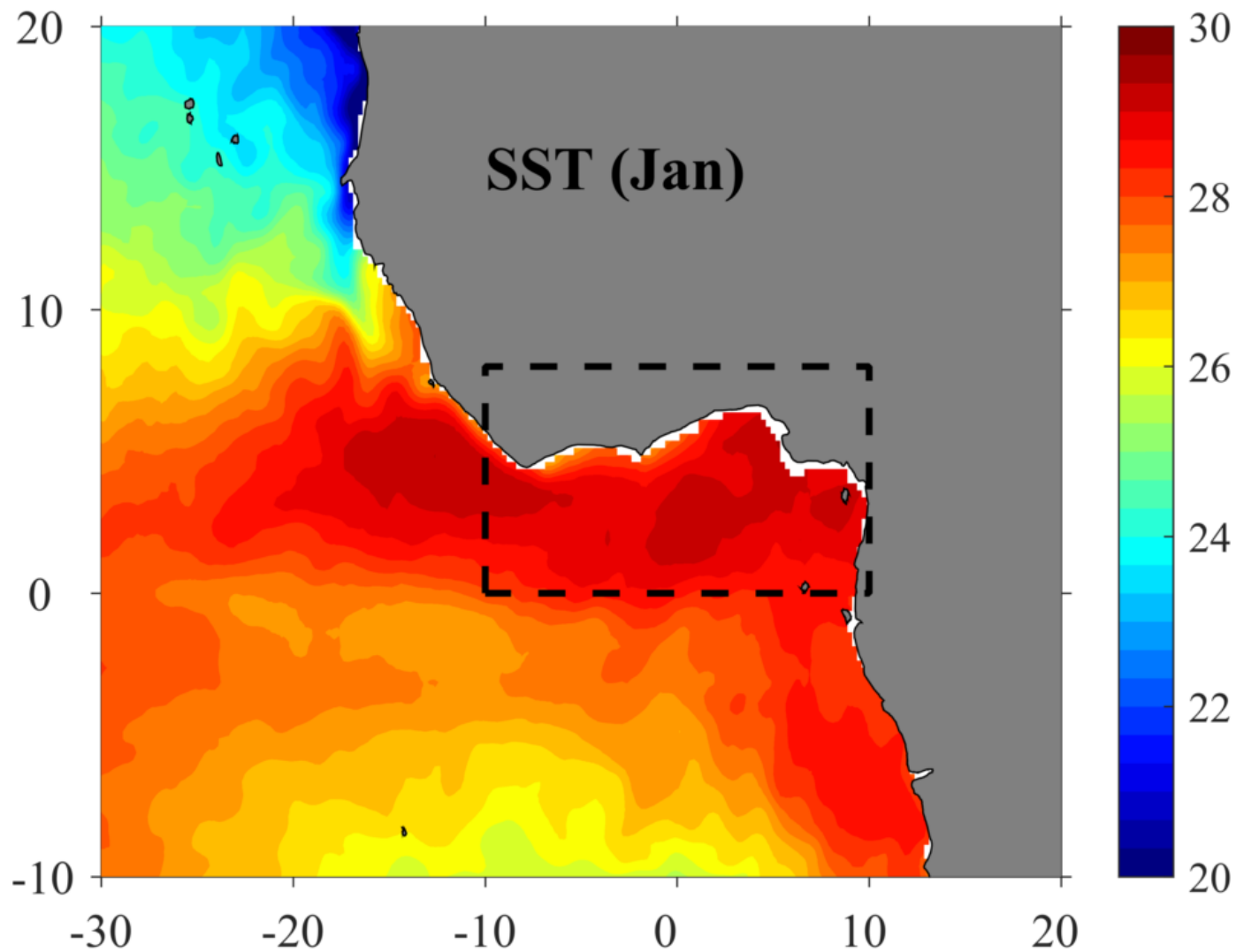
southward current Gabon-Congo Undercurrent



Temperature



Temperature

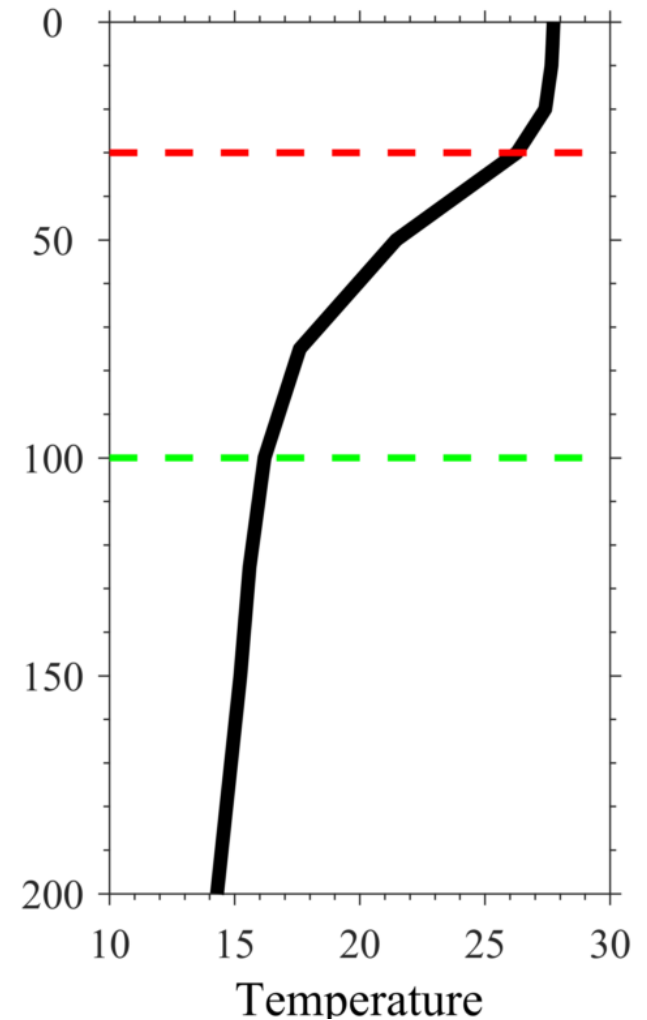
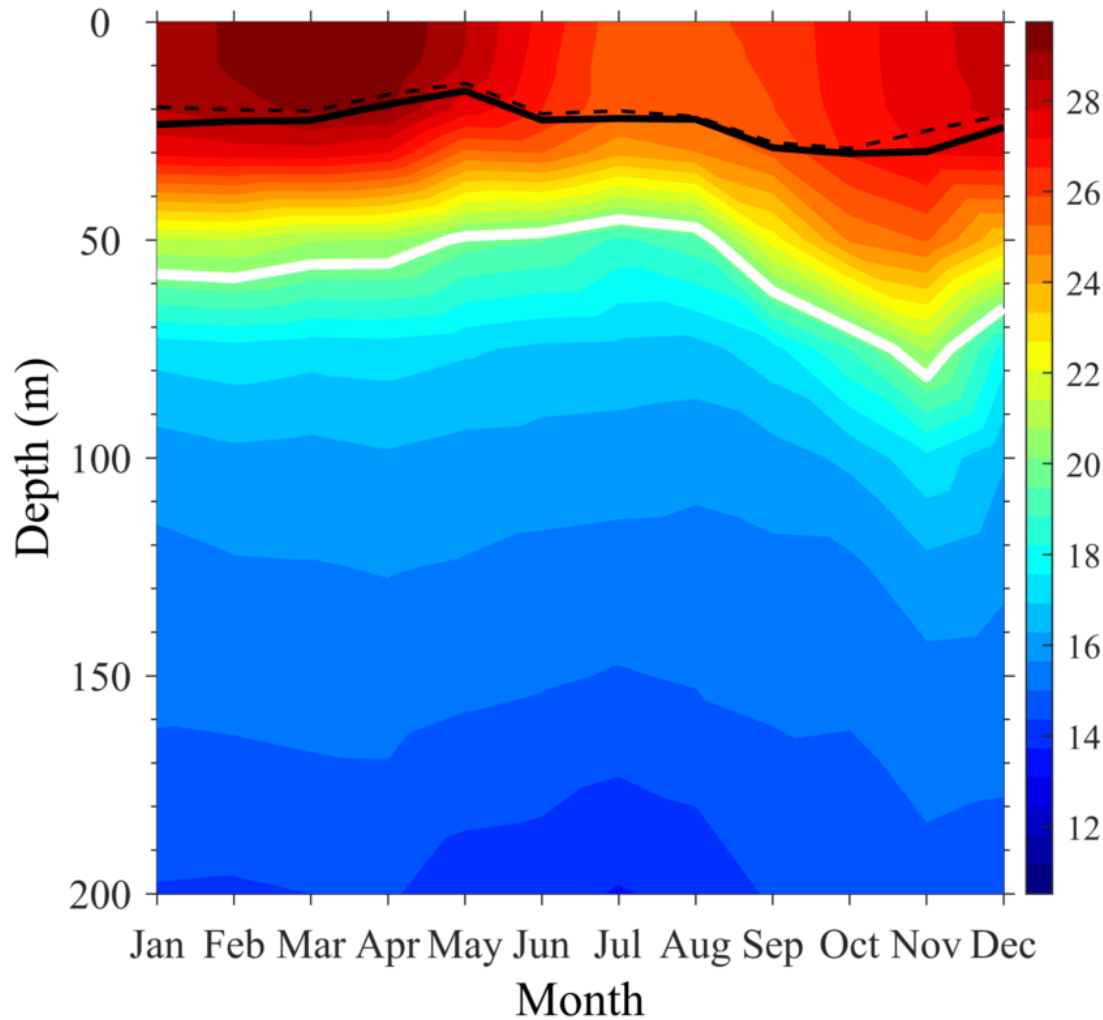
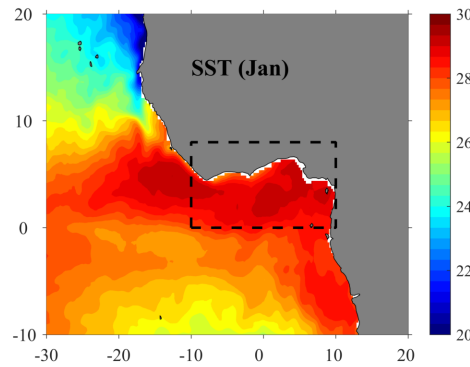


Temperature

MLD – mixed layer

ILD – isothermal layer depth

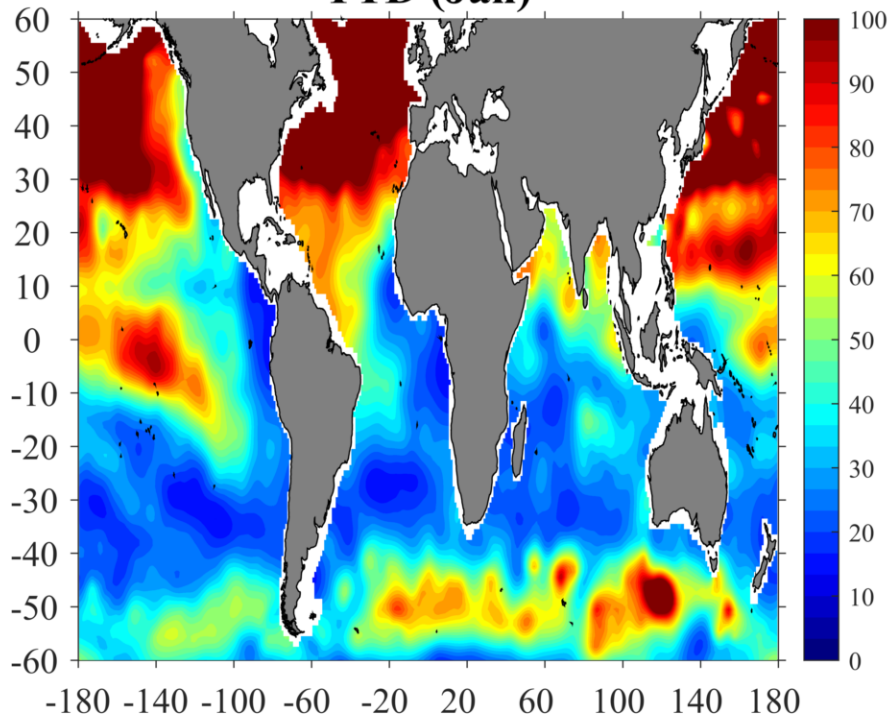
Thermocline Depth (~ 10-60 m in the GoG)



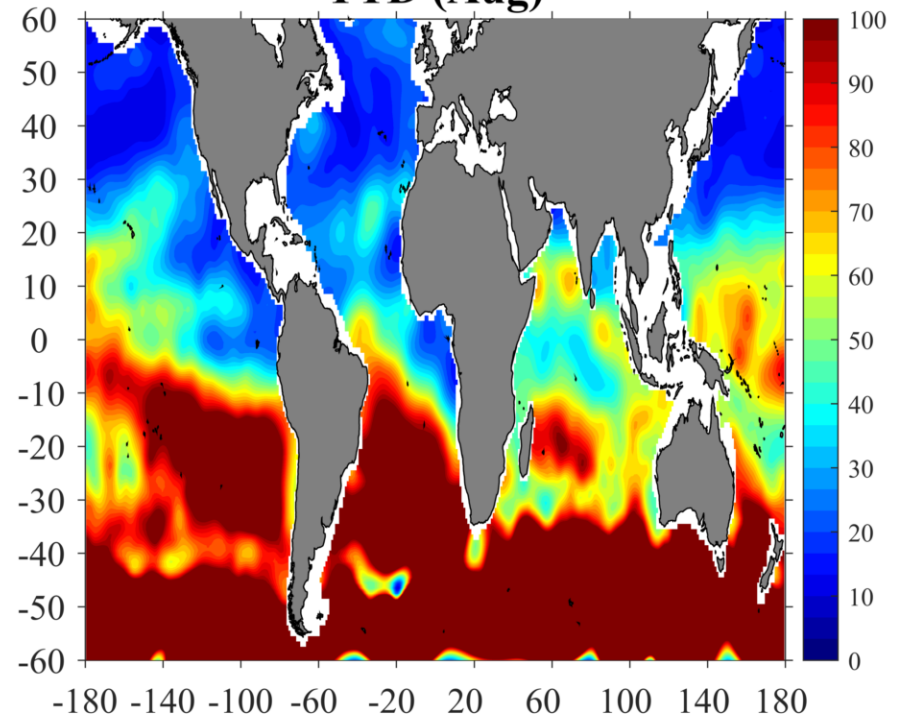
Temperature

TTD – top of thermocline depth

TTD (Jan)

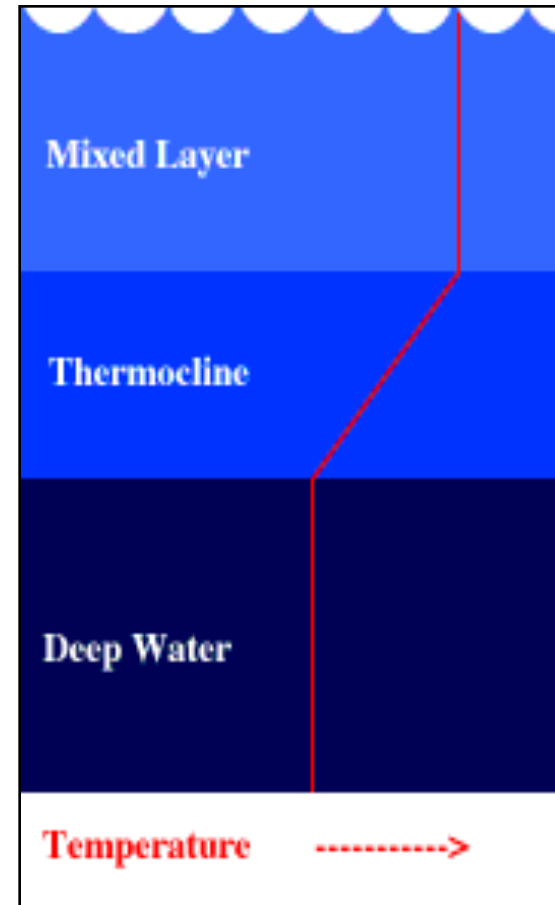
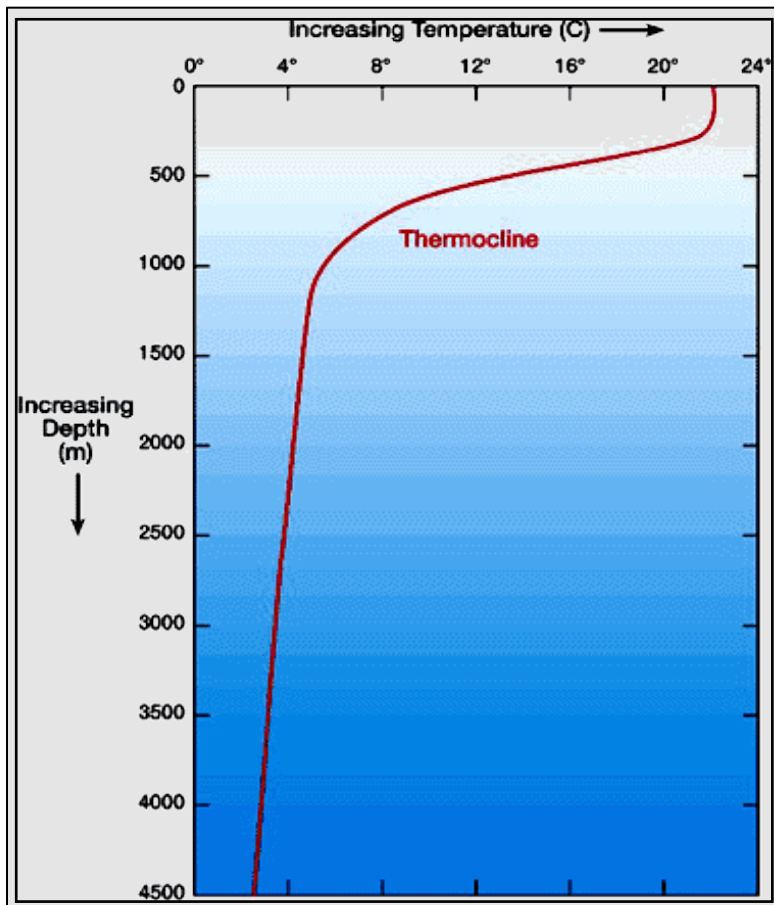


TTD (Aug)



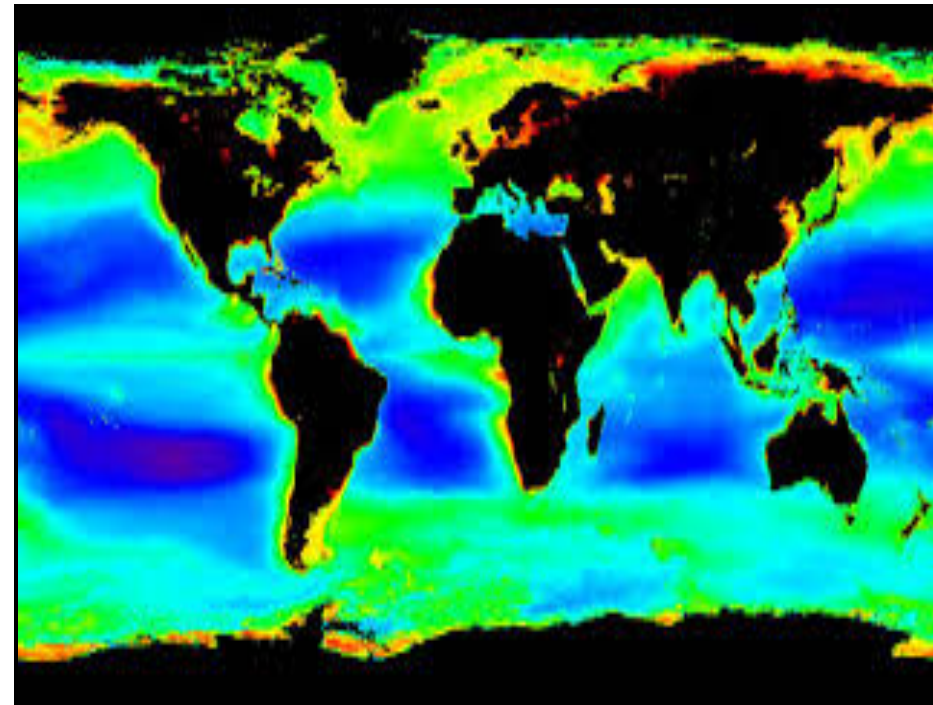
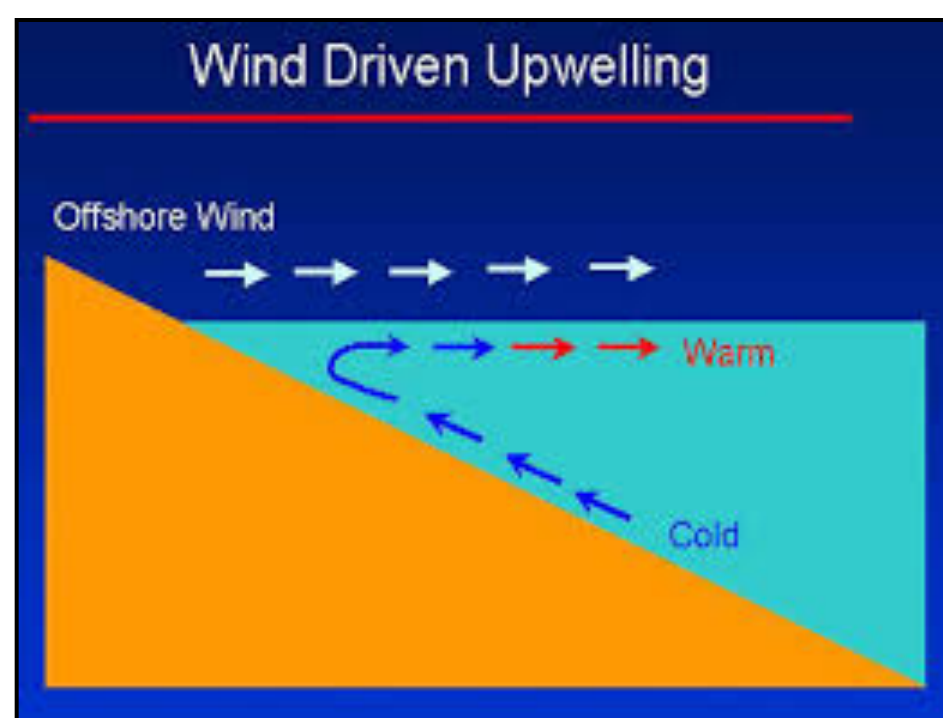
GoG Upwelling

- Thermocline inhibits exchange of surface and subsurface waters.
- High nutrient-rich waters are locked up in subsurface waters.



Background: Upwelling

- Cold nutrient-rich waters are brought into the surface ocean through upwelling.
- Indicators: low SST, low oxygen, high nutrients and increased primary productivity.



Ekman transport:

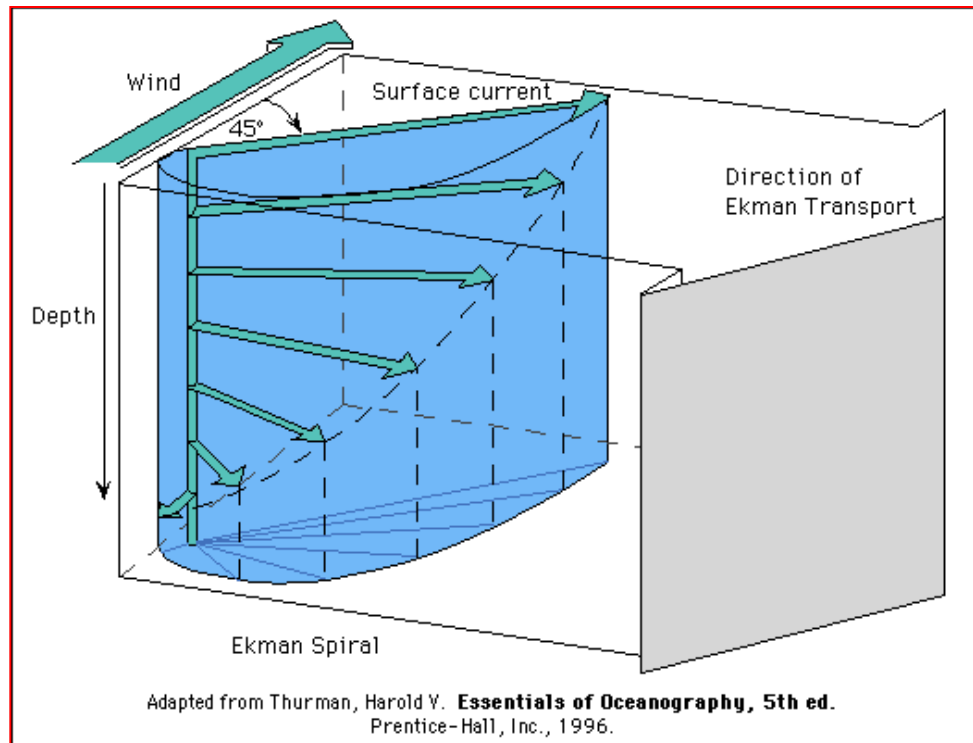
$$\mathbf{M} = \frac{\boldsymbol{\tau}}{\rho_o f}$$

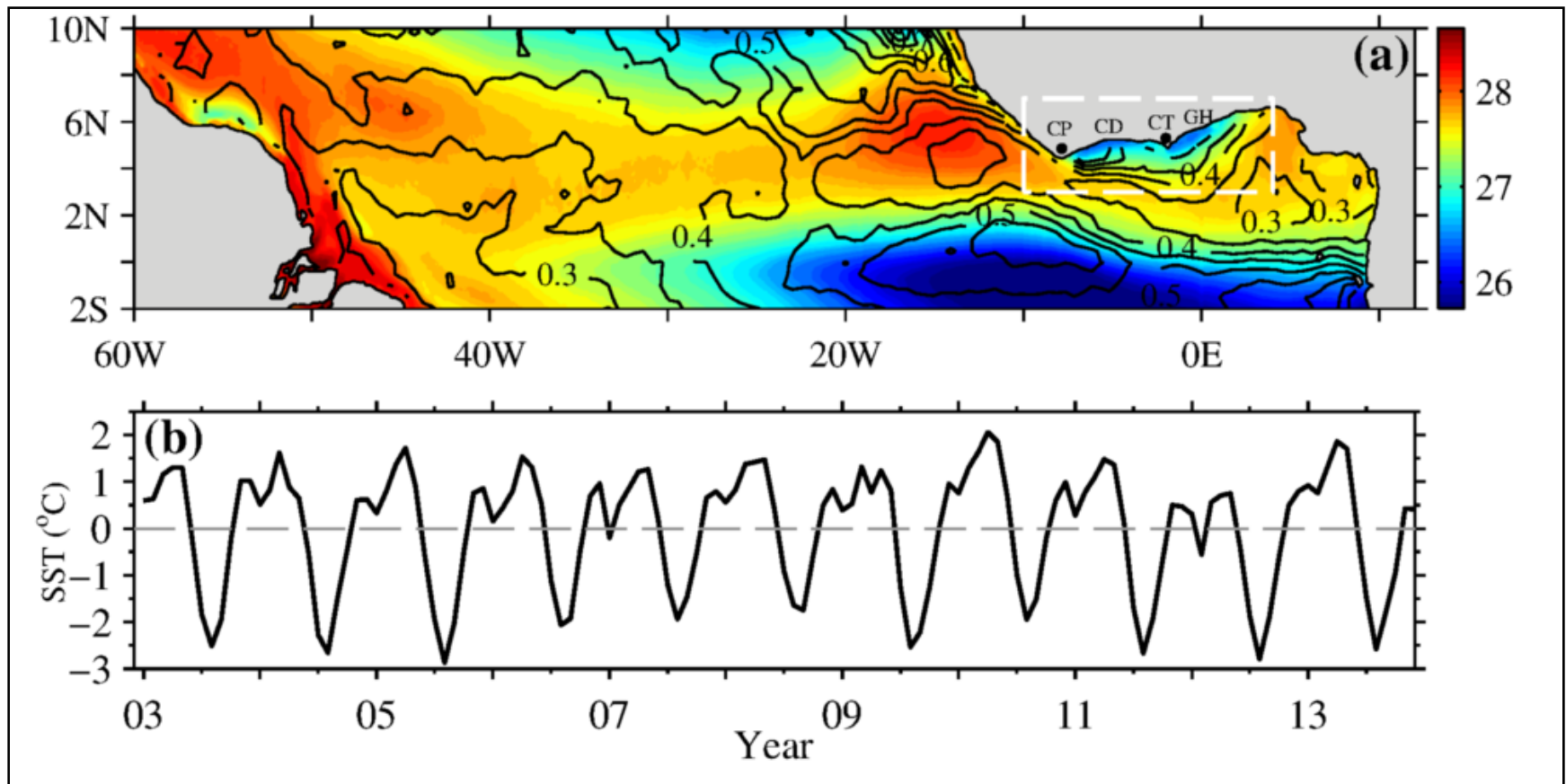
units = $\text{m}^2 \text{s}^{-1}$

Ekman pumping velocity:

$$w_e = \frac{1}{\rho_o f} \nabla \times \boldsymbol{\tau}$$

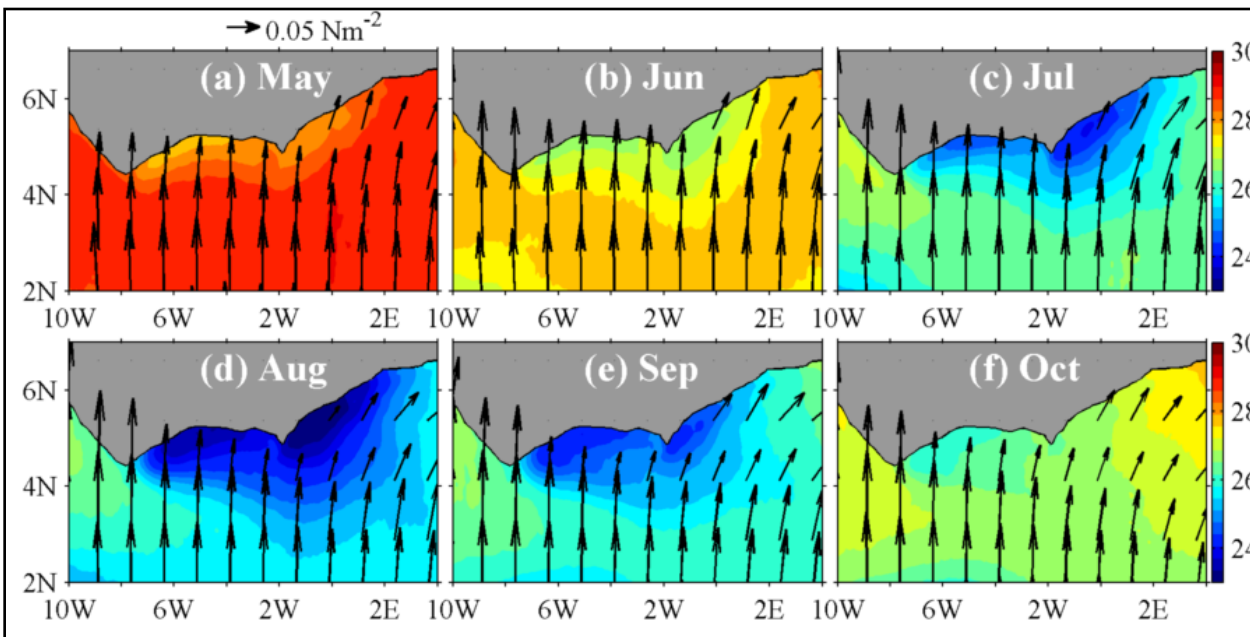
units = m s^{-1}





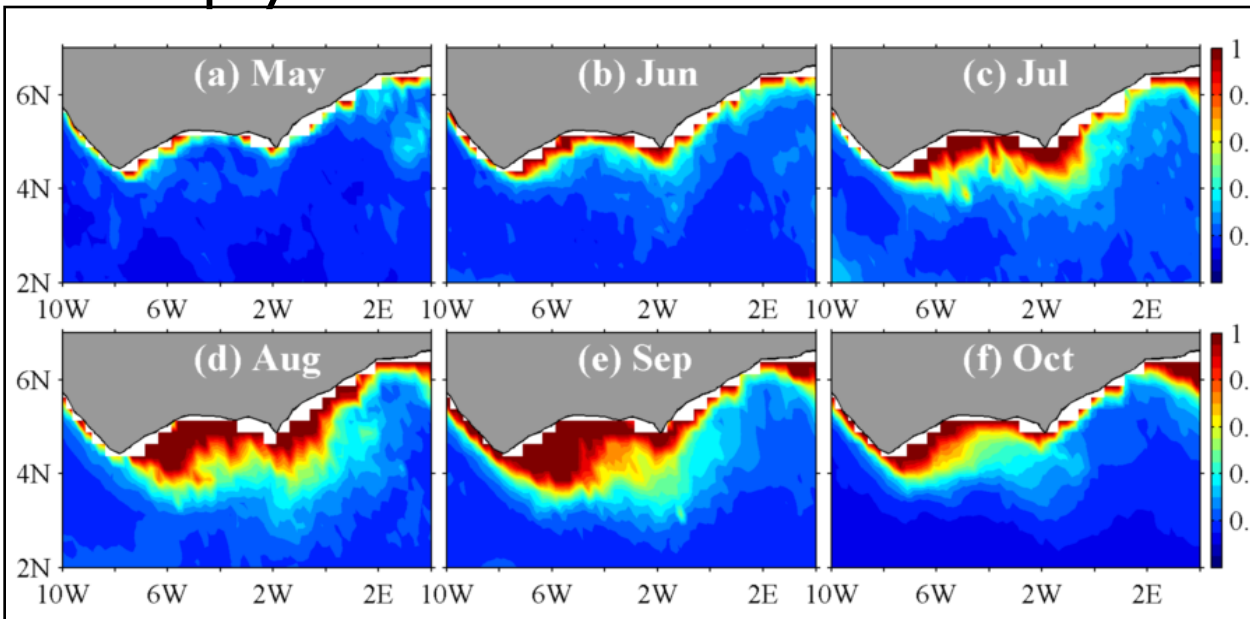
- 2 types of upwelling: equatorial and coastal
- Minor upwelling: typically 3 weeks; between December-March
- Major upwelling: July-September
- Significant variability in the NW GoG

SST, Winds



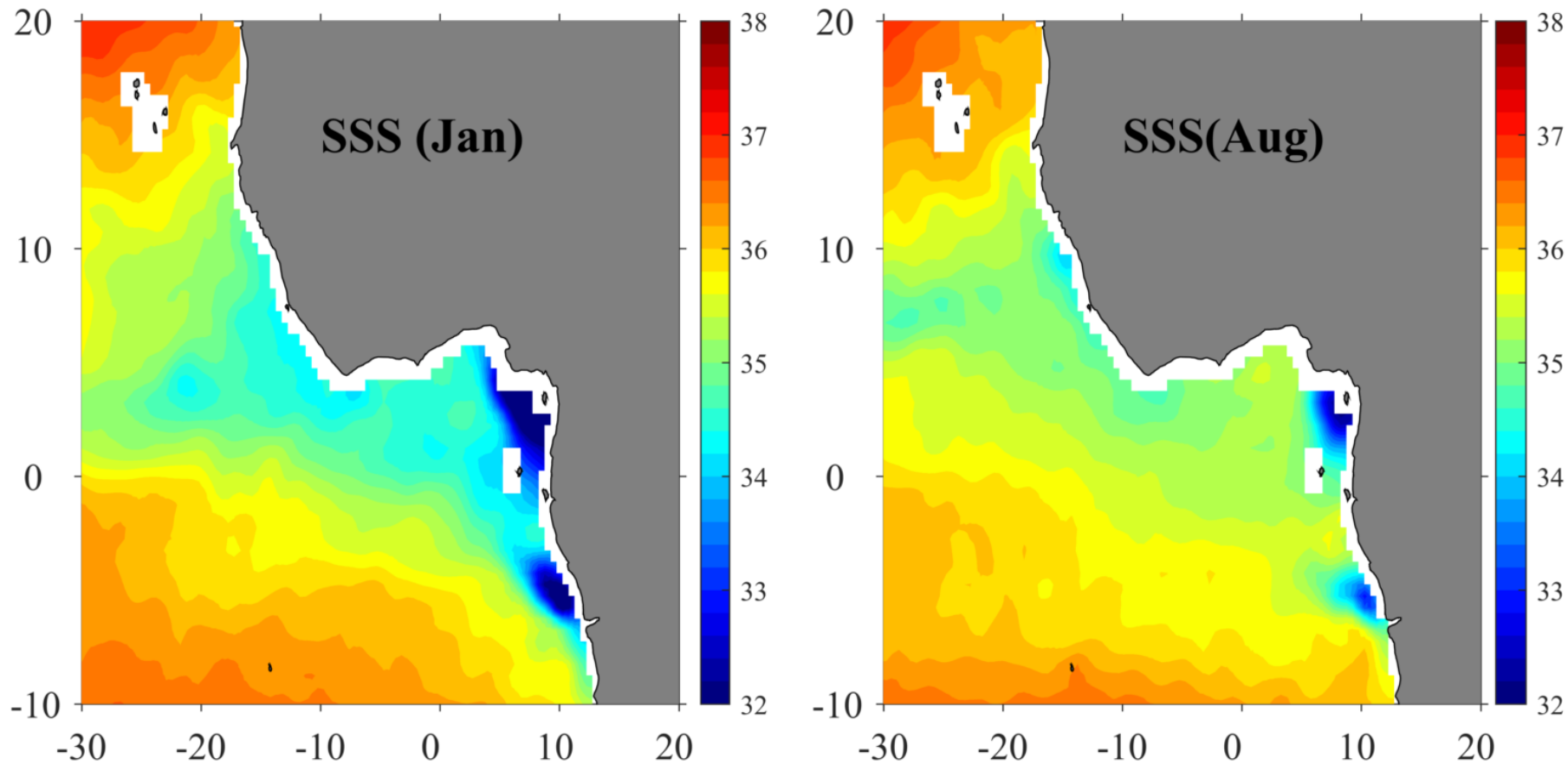
- Strong summer wind stress
- Non-favorable winds west of 2°W
- Western low SST from other regions??

Chlorophyll

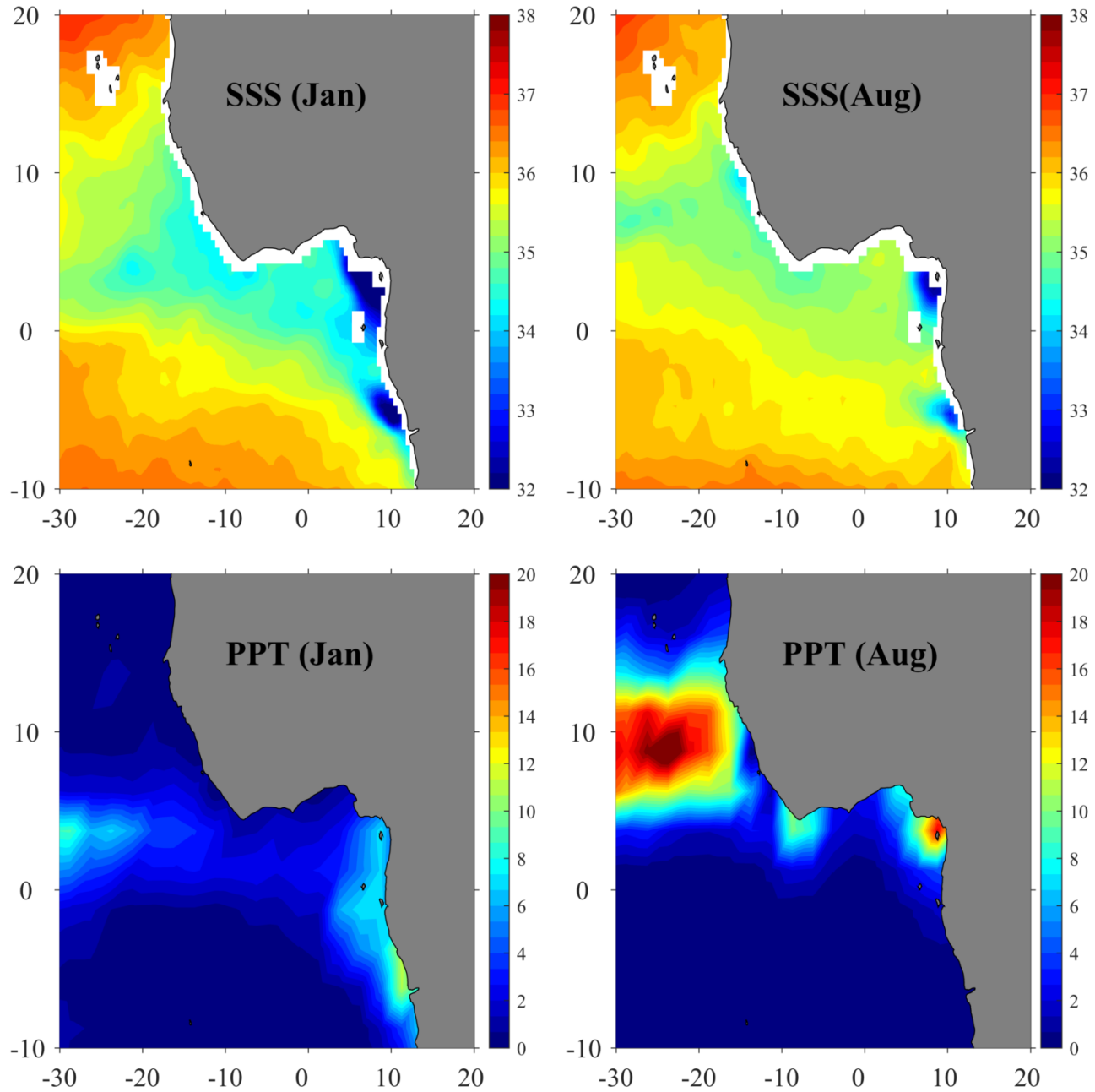


- Chl captures upwelling variations
- Offshore spreading of upwelling cell
- Potential for varying dynamics in the area

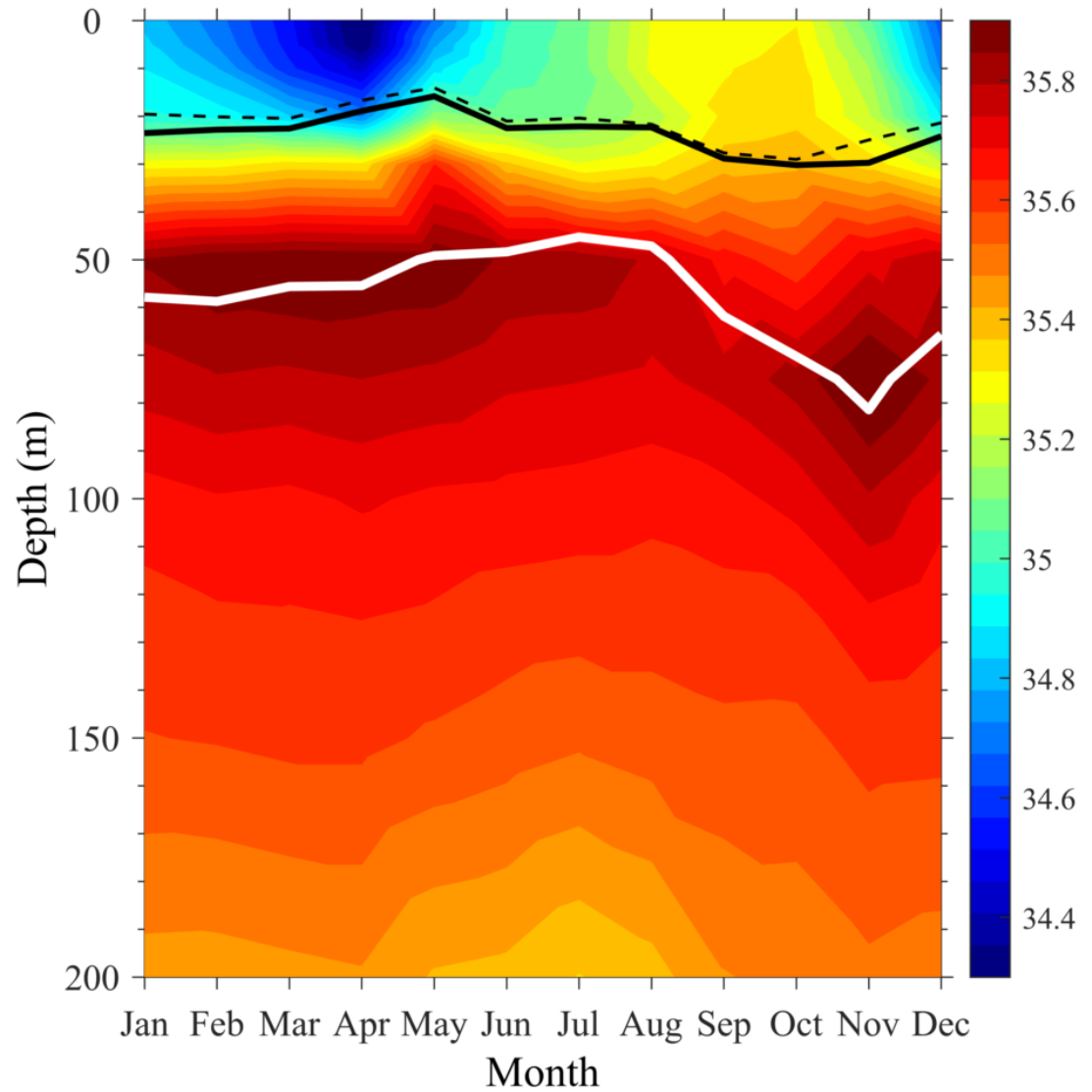
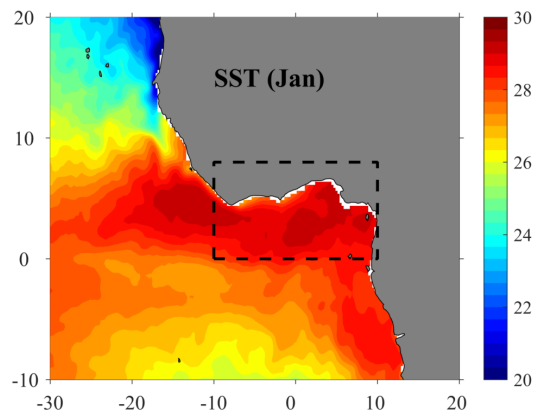
Salinity



Salinity



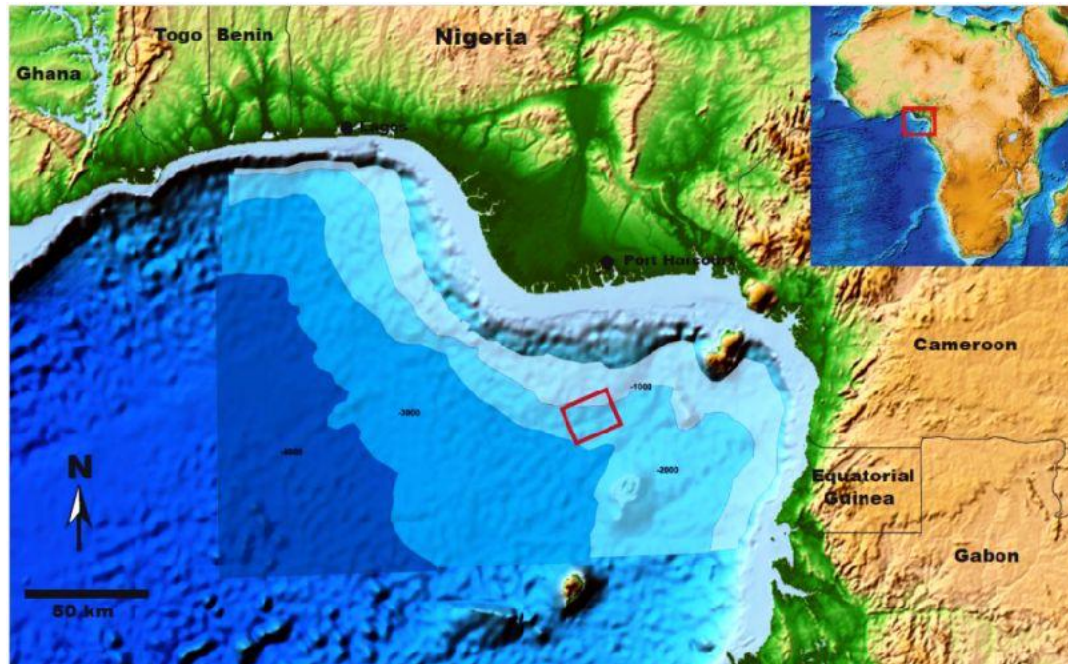
Salinity



Bathymetry

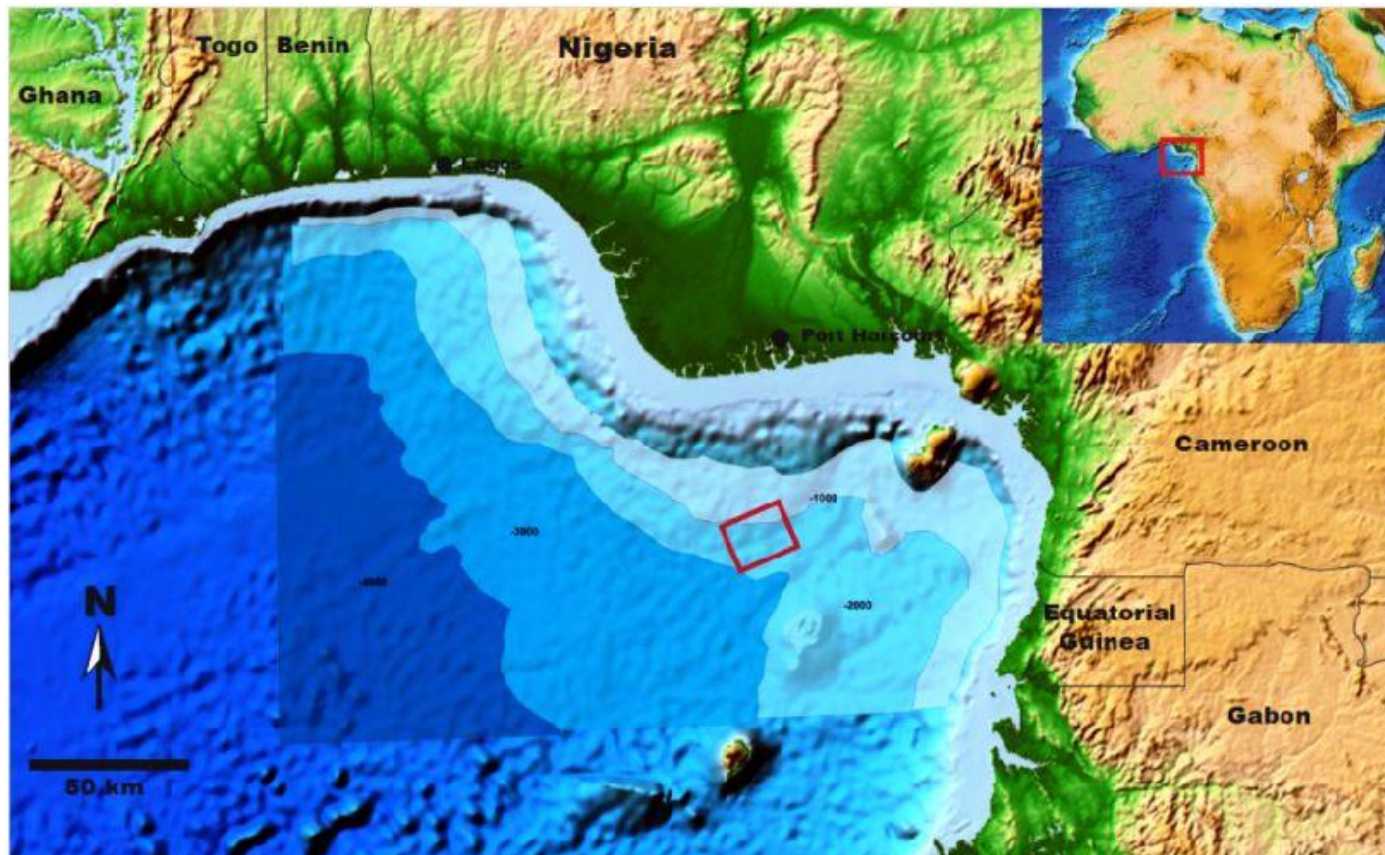
Continental shelf: the edge of a continent that lies under the ocean; extends from the coastline of a continent to a drop-off point called the *shelf break*. From the break, the shelf descends toward the deep ocean floor in what is called the *continental slope*.

The continental shelf of the Sierra Leone-Guinea Plateau is the largest in West Africa, especially off Guinea-Bissau, covering approximately 53,000 km² and up to 150 km wide.



Bathymetry

In the central and eastern Gulf of Guinea, the continental shelf is narrow. Shelf widths are 20-25 *km* along the coast from Côte d'Ivoire to Cameroon, except between Cape Three Points and the Volta Delta, where it reaches 80 *km* wide in parts, and around the Niger Delta, where it has a width of 50-65*km*.



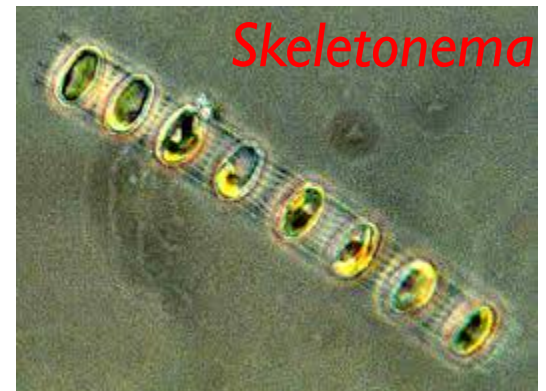
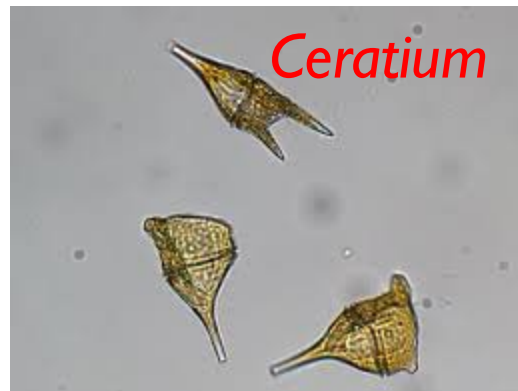
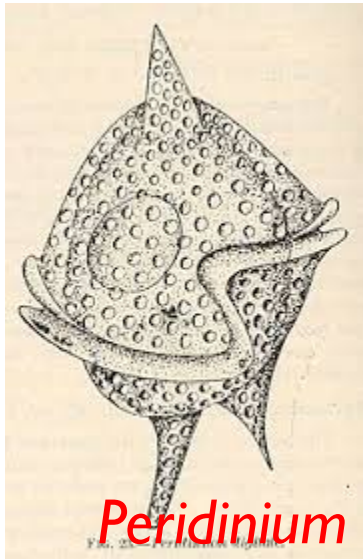
Biology

Dinoflagellates form the main components of the phytoplankton population during the non-upwelling period

Diatoms dominate at other times.

The dinoflagellates consist of such genera as *Peridinium*, *Ceratium*, *Prorocentrum* and *Dinophysis*

Diatom flora include *Skeletonema*, *Nitzschia* and *Thalassiosira*

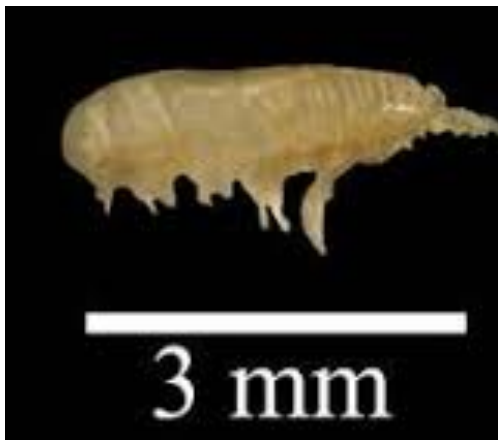


Biology

Copepods dominate zooplankton groups in the GoG; mainly *Calanoides carinatus*

Makes up about 88 % of the zooplankton organisms in the coastal area during the upwelling season. About 20-40% in the open ocean.

Other zooplankton groups include Ostracoda, Cladocera, Decapoda, Larvacea, Thaliacea, Chaetognatha and larvae of bottom invertebrates.



Calanoides carinatus



Ostracods



Decapods

Fisheries



Fisheries: fishes, their environments and the activities associated with them

Fisheries: source of income for about 5 million people in the GoG (De Graaf and Garibaldi, 2014)

Issues: declining catches, overfishing, overcapacity, pollution, and habitat degradation.

Fisheries

Food security: source of protein; about 45-60% of animal protein in Ghanaian diet from fish (FAO, 2006)

In Ghana, annual fish consumption per capita of about 25 kg; global average of 19 kg and Africa average of 10 kg (FAO, 2014)

Major fishes in GoG:



Sardine



Mackerel



Anchovy



Tuna



Snappers



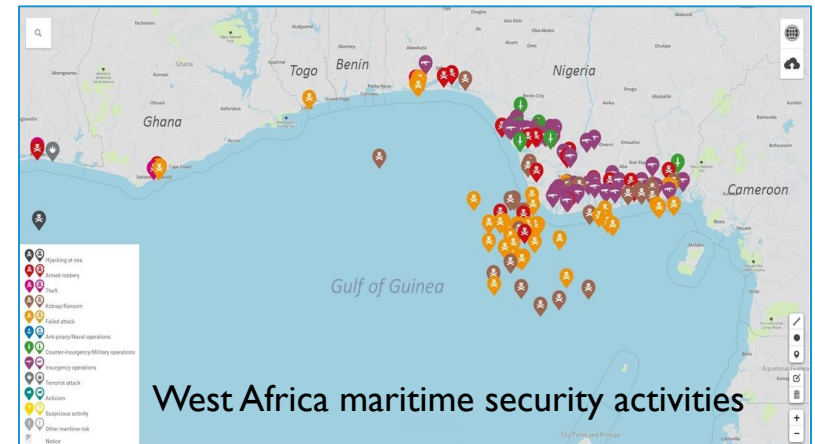
shrimps



Maritime (in)security

Key issues:

- piracy
- terrorism
- marine environmental protection
- IUU fishing
- trafficking
 - people
 - drugs
 - ammunitions



Maritime (in)security

- The Gulf of Guinea is the world's most pirate-infested sea.
- According to the International Maritime Bureau, reports of attacks between the Ivory Coast and the Democratic Republic of Congo more than doubled in 2018
- This includes all six hijackings worldwide, 13 of the 18 ships (**72%**) fired upon, 130 of the 141 hostages (**92%**) taken globally, and 78 of 83 seafarers kidnapped for ransom
- UNCLOS:Article 100-107 (Piracy)



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