Influence of equatorial upwelling on biological productivity in the eastern equatorial Atlantic

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Chlorophyll biomass in the surface ocean regulates the rates of primary production and export of organic carbon to the deep ocean (Irwin & Finkel, 2008). The standing stock of phytoplankton biomass is a primary determinant of the rates of primary production and export of carbon out of the surface ocean (Laws et.al. 2000).

Background

- PROPAO Initiative.

- Oceanographic data from EEA collected during EGEE cruises (Oceanographic component of AMMA) between 2005 and 2007 were analyzed to study the influence of equatorial upwelling on the biological productivity in this region.

Upwelling - A useful Event

- Upwelling brings nutrient-rich deep waters to the surface.
- The success of fishermen greatly depend on this.
- It has considerable effect on the heat budget of the planet.
- Basically, upwelling in the tropics, along the eastern boundary currents and in the eastern equatorial high productivity regions, cools the tropics.

Upwelling and Climate Change

- In any region, upwelling is intermittent.
- Climate Change has been shown to affect upwelling and productivity. The strong dependency of upwelling processes on the strength of trade winds is the major factor.
- The weakening of an upwelling system can bring about ecological / economic / health / environmental disaster.
- Threatens the existence of Man and other living resources.

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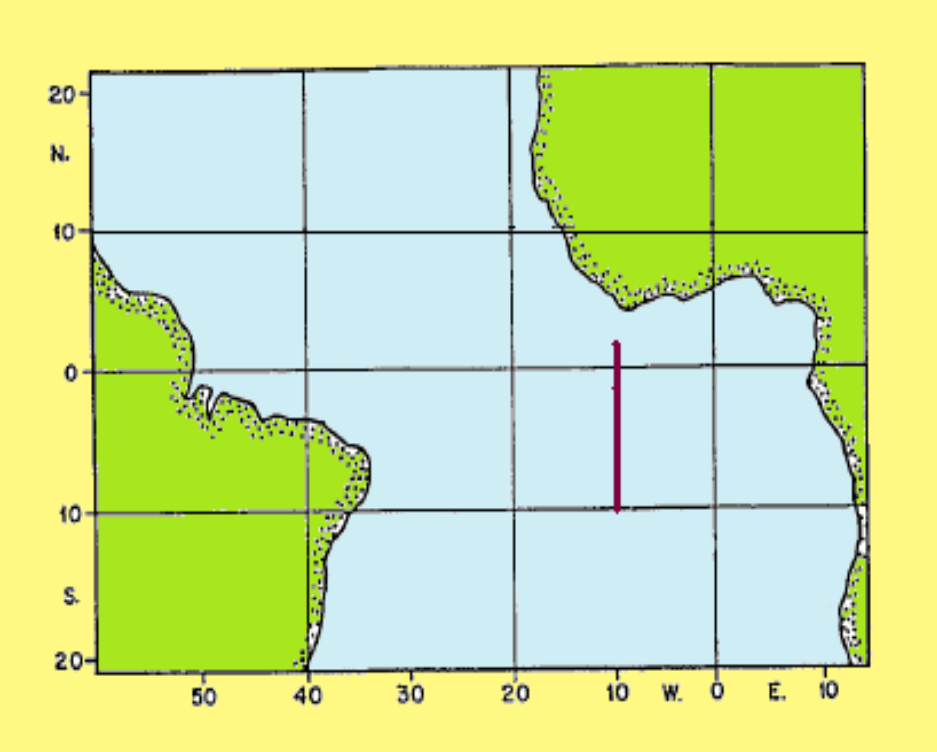
Eastern Equatorial Atlantic

- The EEA is a region of intense upwelling (Foster et al. 2009). It has significant impacts on the climate and fisheries of the area.
- The shoaling of the EUC has been linked to thermocline shoaling, and consequently to equatorial upwelling and enhanced vertical mixing (Bourles et al. 2002).
- Salinity maximum of the EUC has been used for estimating nutrient enrichment and primary production in the Gulf of Guinea (Herbland & Voituriez 1979).

EGEE- AMMA Ocean Cruise (2005 - 2007)

- This study aimed at studying the influence of equatorial upwelling on the meridional distribution of some **upwelling indicators** relative to biological productivity in the EEA (along 10ºW) using EGEE-AMMA ocean cruise data between 2005 and 2007 during a boreal summer (June).

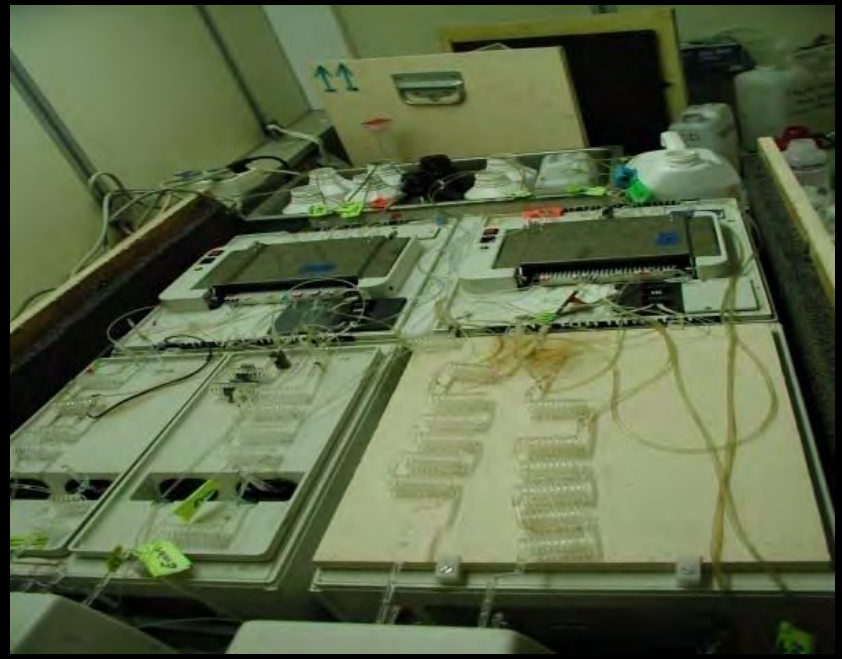


Objectives are:

- To describe the meridional distribution of some upwelling indicators along 10^{o}W with a view of identifying the presence of equatorial upwelling.
- To study the inter-annual variability in upwelling signal strength relative to biological productivity.
- To study the biological viability of the region at 0^{o}N using the nitrate- phosphate distribution - Redfield Ratio (N : P = 16 : 1).

Materials & Methods

- Profile samples for nutrients, and in-situ data for temperature, salinity, and dissolved oxygen were collected with the aid of a CTD.
- A spectrofluorometer was used to capture the chlorophyll fluorescence.
- Zonal Currents - ADCP



Results - EGEE 1 – June 2005.

- The zonal current (ms^{-1}) along 10°W in June 2005, during EGEE1 is as presented in figure 1.
- It shows the core of the Equatorial UnderCurrent (EUC) (>0.9m/sec) at the depth of about 50m (with vertical extension to about 250m) within 1°N and 1°S.

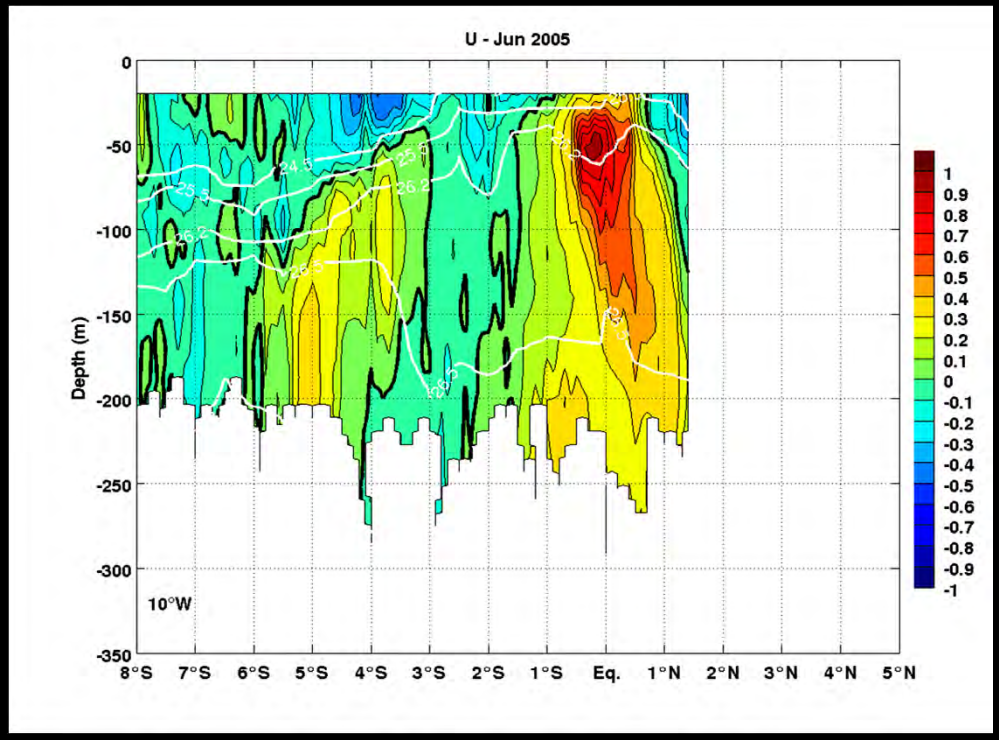


Fig 1: The zonal current velocity (ms^{-1}) along 10°W in June 2005 (EGEE1)

Upwelling Signatures during EGEE 1 – June 2005.

- Temp, sal, diss oxy, and chlor fluo along 10°W in June 2005 (figure 2).
- There is presence of Eq. upwelling and biological productivity within 1.5°N and 2°S latitudes from 50m depth to the surface.
- This corresponds to EUC location (figure1).

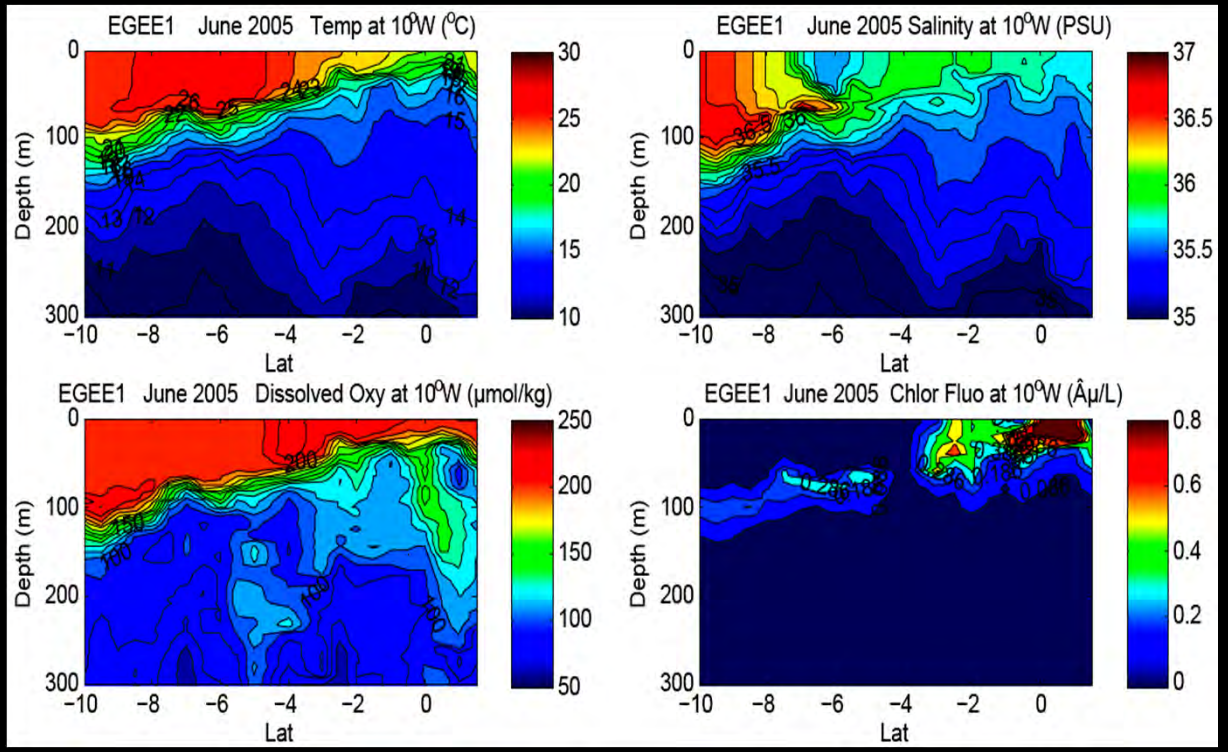


Fig 2: Temp, sal, DO_2, and chlo fluo along 10°W in June 2005 (EGEE1)

Upwelling Signatures during EGEE 1 – June 2005.

- The meridional distribution of the nutrients also indicates the presence of equatorial upwelling during June 2005 (figure 3).

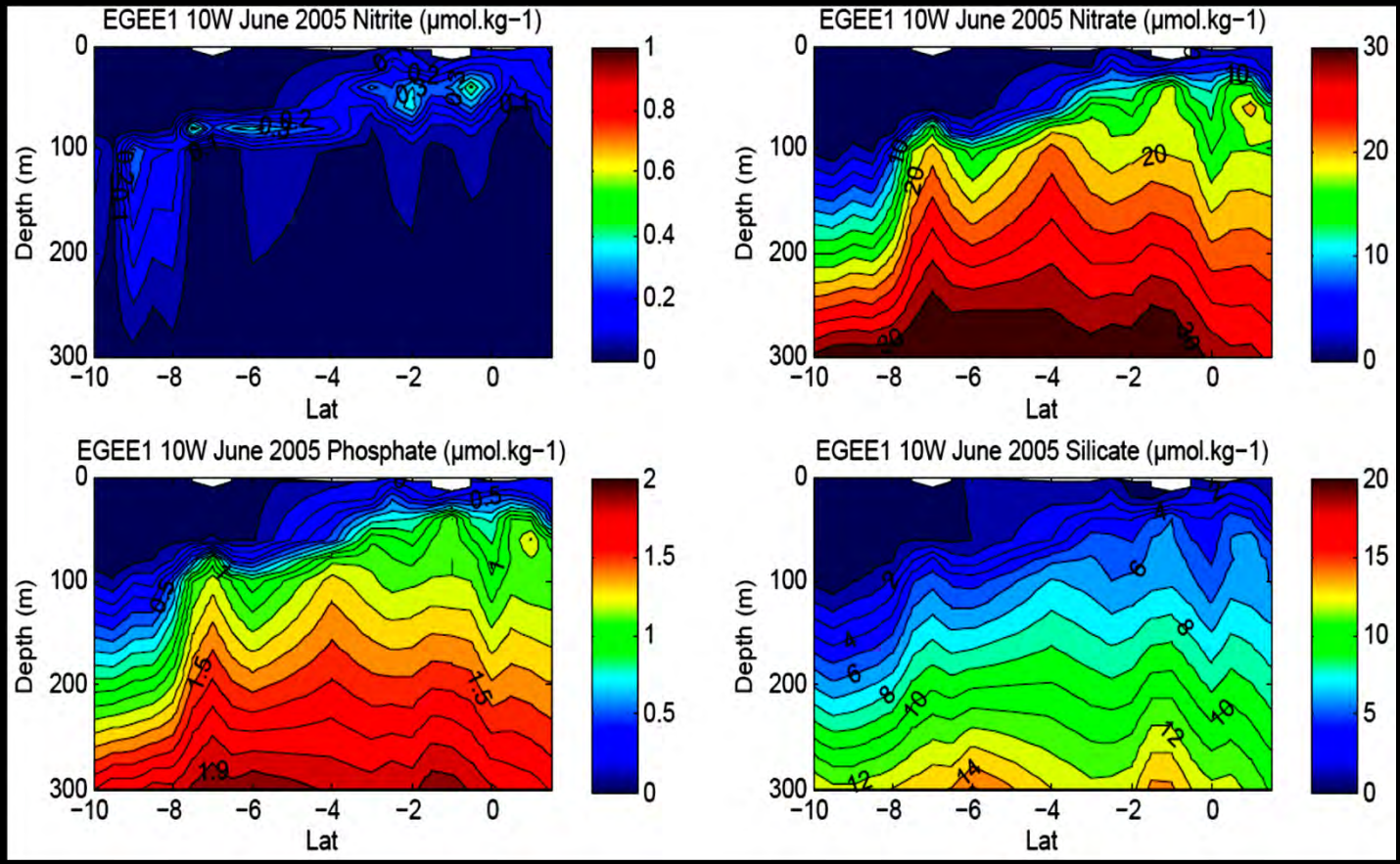
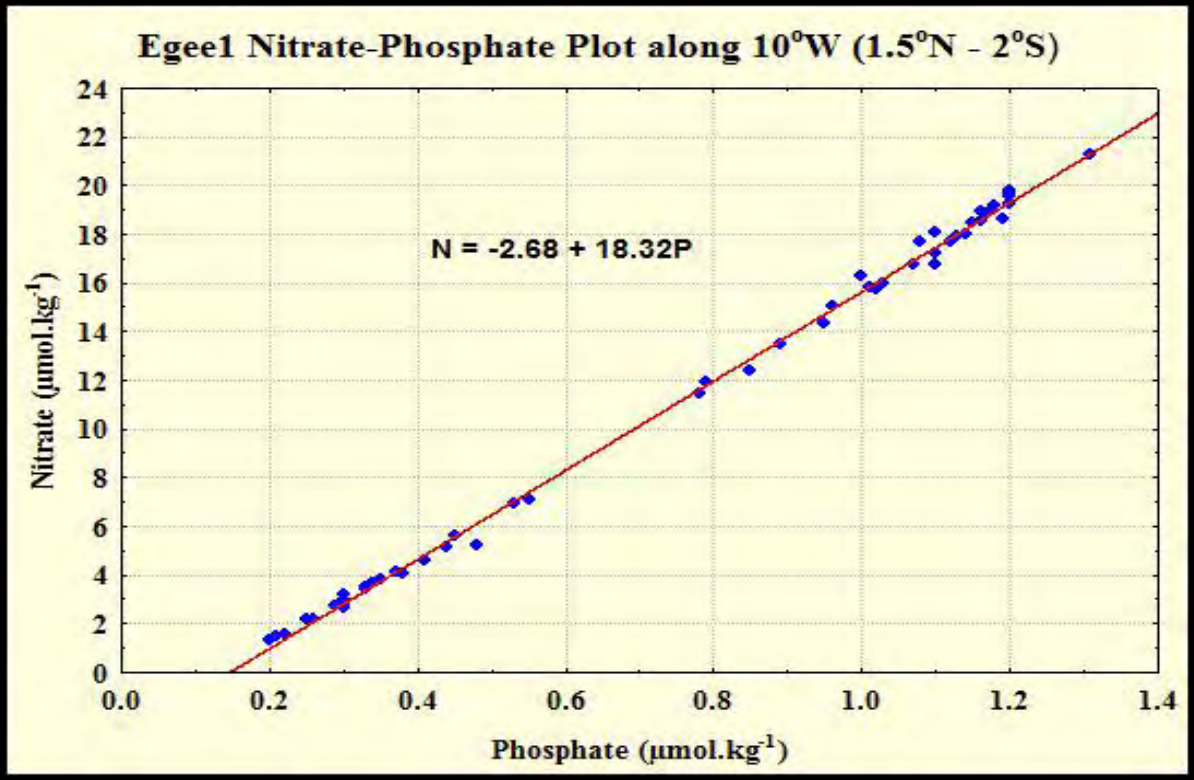


Fig 3: Nitrite, nitrate, phosphate, and silicate along 10°W in June 2005 (EGEE1)

N – P Ratio in June 2005 along 10°W (1.5°N and 2°S).

- This section establishes the biological viability using the vertical distribution of nitrate and phosphate between 0m to 100m depth (figure 4).



RR = 18.32 >> 16

Fig 4: Nitrate – Phosphate Plot in June 2005 between 1.5°N and 2°S, along 10°W.

EGEE 3 – June 2006.

- The zonal current (ms^{-1}) along 10^{o}W in June 2006, during EGEE3 is as presented in figure 5.
- It shows the core of the EUC (<0.8m/sec) at depth of about 50m (with vertical extension greater than 200m) within 1^{o}N and 1^{o}S latitudes.

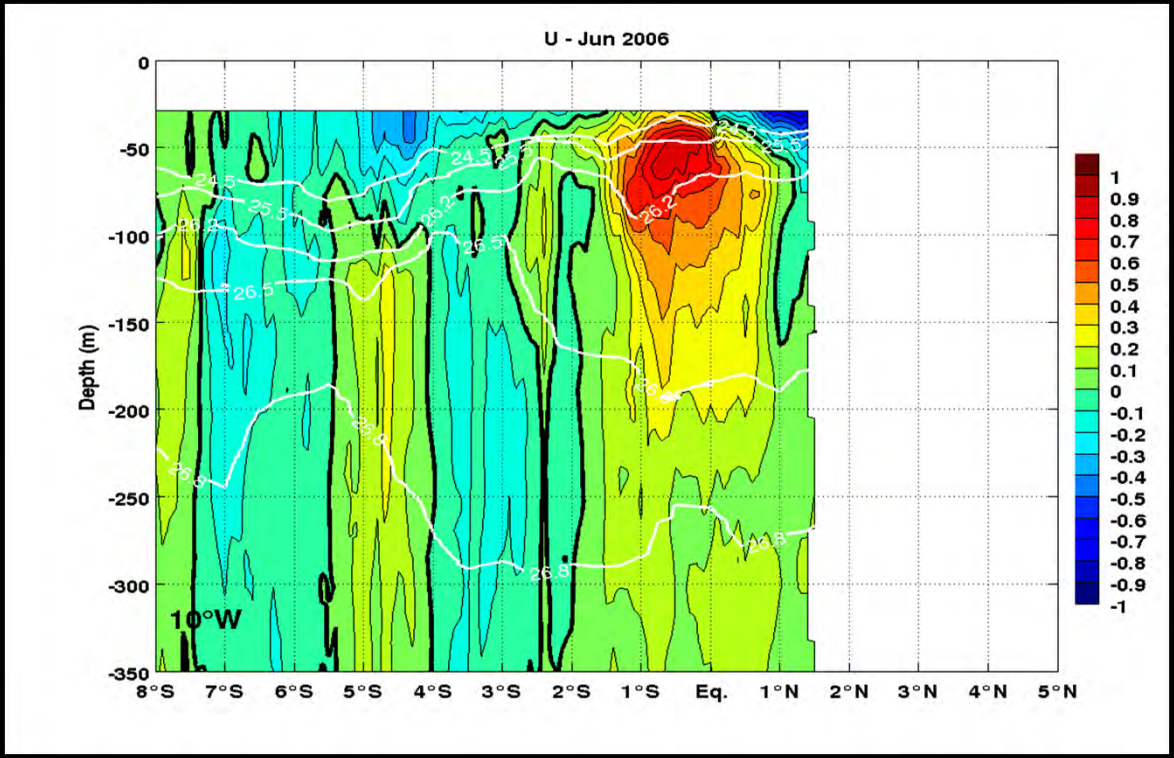


Fig 5: The zonal current velocity (ms^{-1}) along 10^{o}W in June 2006 (EGEE3)

Upwelling Signatures during EGEE 3 – June 2006.

- Temperature, salinity, dissolved oxygen, and chlorophyll fluorescence along 10°W in June 2006 are presented in figure 6.
- Upwelling indicators show a weak equatorial upwelling and low primary productivity within 1.5°N and 2°S latitudes from 50m depth upward.

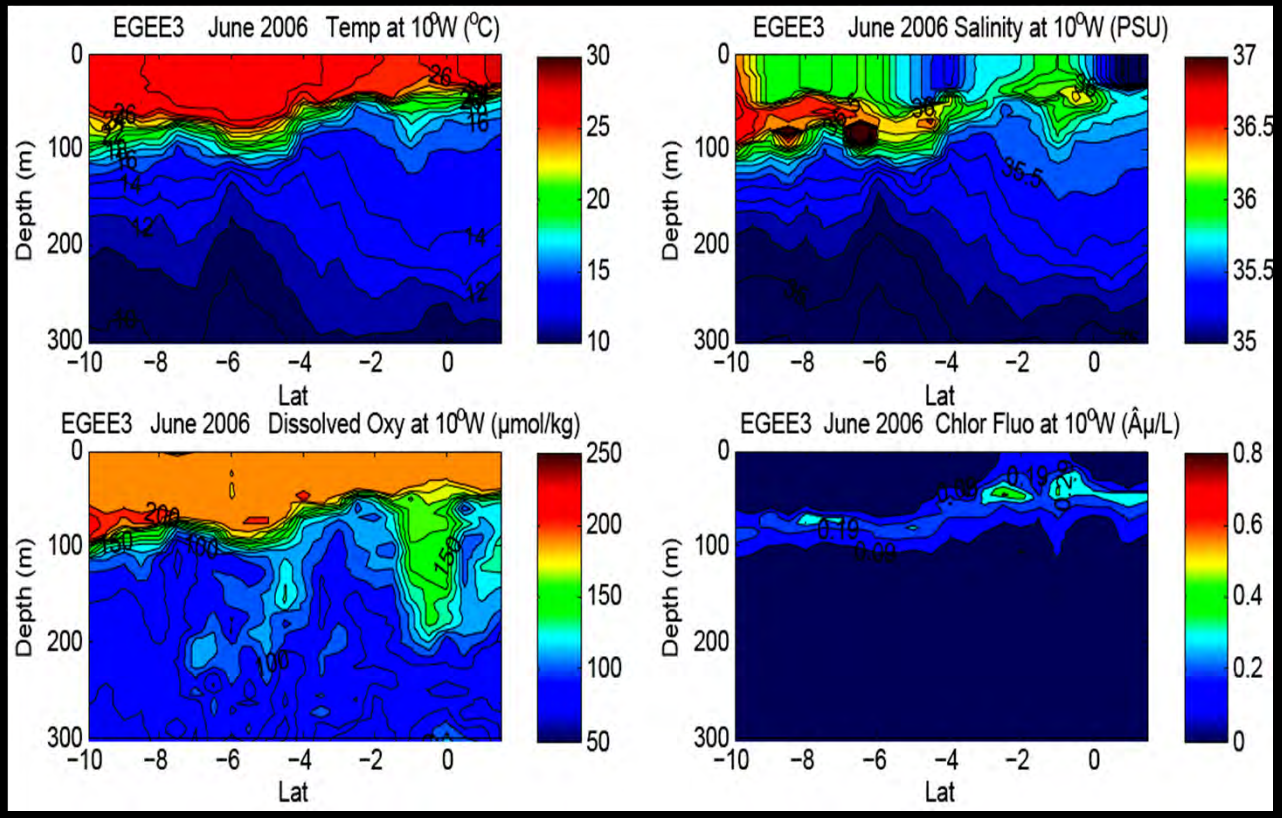


Fig 6: Temp, sal, DO_2, and chlo fluo along 10°W in June 2006 (EGEE3)

Upwelling Signatures during EGEE 3 – June 2006.

- The meridional distribution of the nutrients also indicates a weak equatorial upwelling during June 2006 (figure 7).
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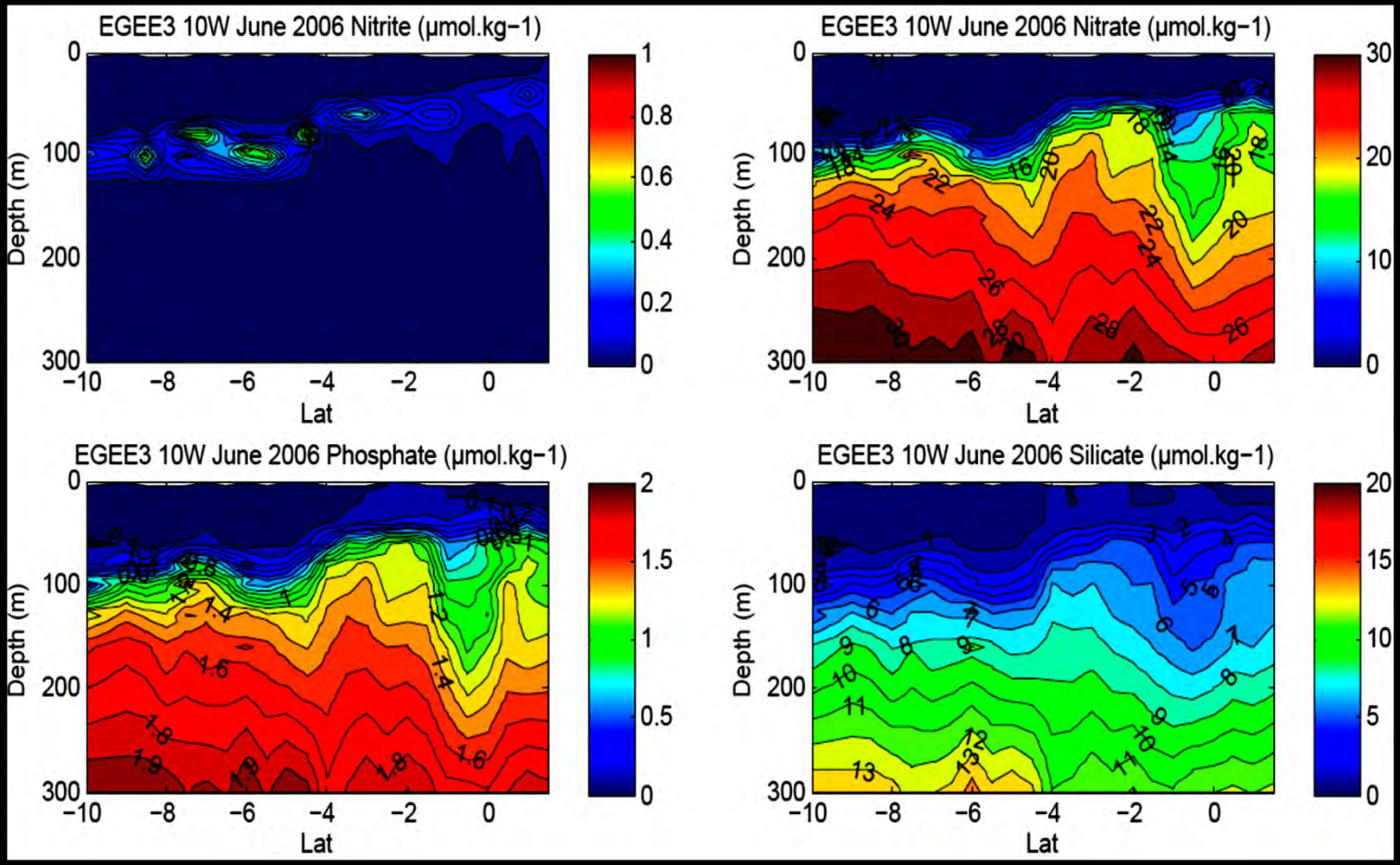
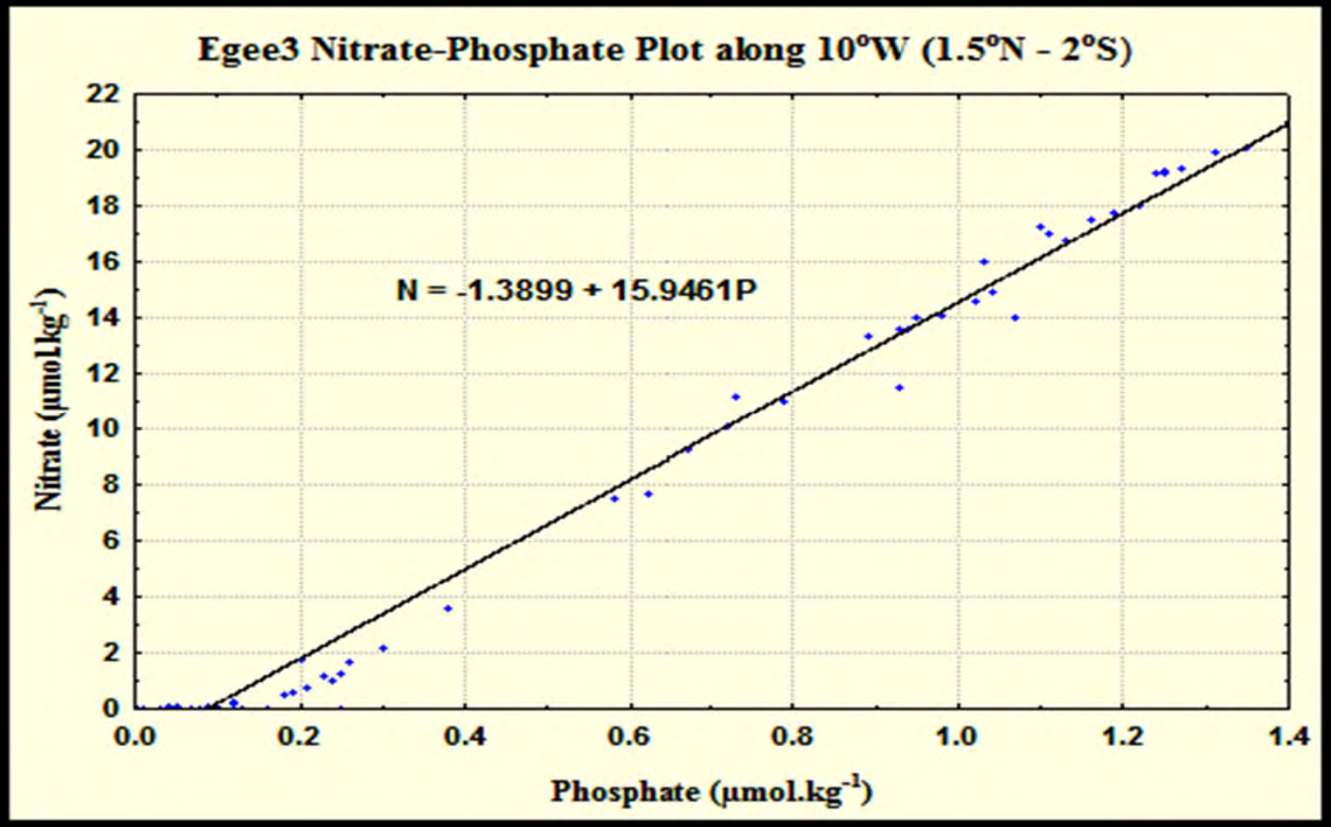


Fig 7: Nitrite, nitrate, phosphate, and silicate along 10°W in June 2006 (EGEE3)

N – P Ratio in June 2006 along 10°W (1.5°N and 2°S).



RR = 15.95 < 16

Fig 8: Nitrate – Phosphate Plot in June 2005 between 1.5°N and 2°S, along 10°W.

- Condition was slightly less viable for biological productivity in June 2006.

EGEE 5 – June 2007.

- The zonal current (ms^{-1}) along 10°W in June 2007, during EGEE5 is as presented in figure 9.
- It shows the core of the Equatorial UnderCurrent (EUC) (0.8m/sec) at the depth of about 50m (with vertical extension to about 250m) within 1°N & 1°S.

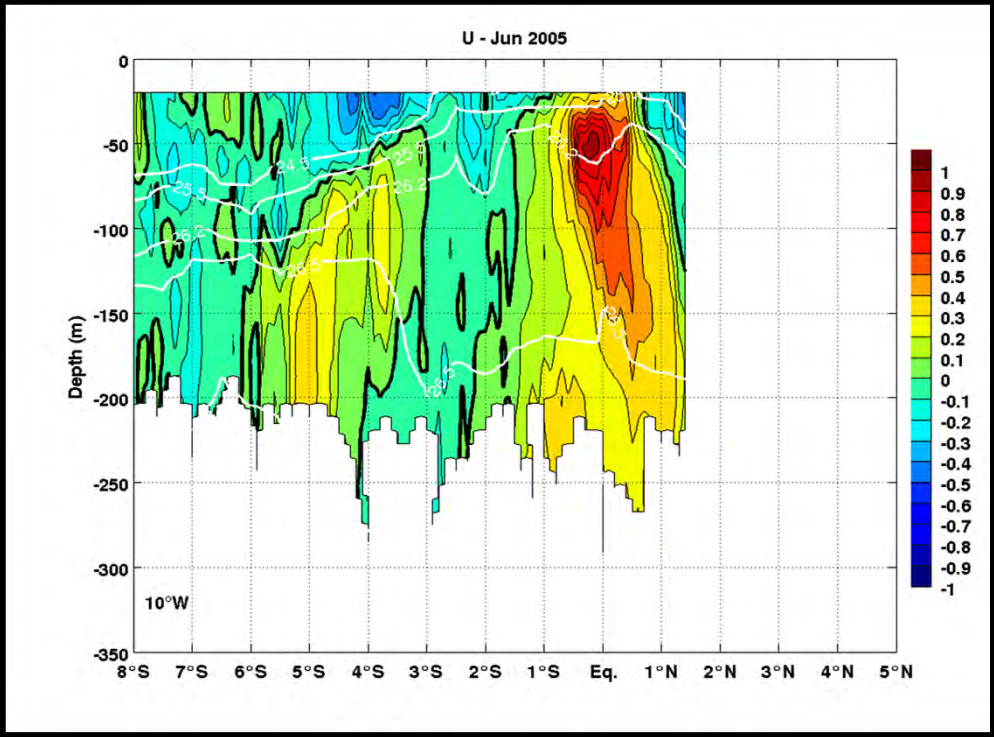


Fig 9: The zonal current velocity (ms^{-1}) along 10°W in June 2007 (EGEE5)

Upwelling Signatures during EGEE 5 – June 2007.

- Temperature, salinity, dissolved oxygen, and chlorophyll fluorescence along 10°W in June 2005 are presented in figure 10.
- There is presence of equatorial upwelling and biological productivity between 1°N and 1°S, from 50m depth upward.

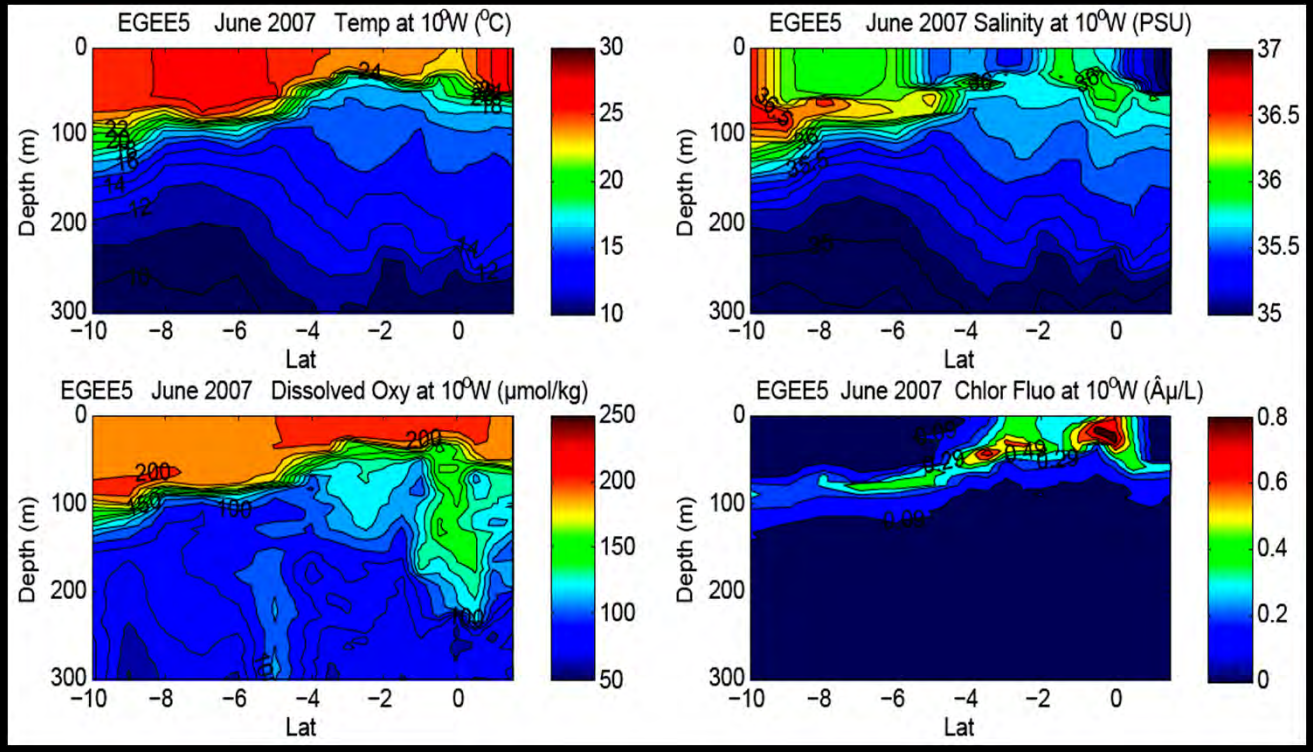


Fig 10: Temp, sal, DO_2, and chlo fluo along 10°W in June 2007 (EGEE5)

Upwelling Signatures during EGEE 5 – June 2007.

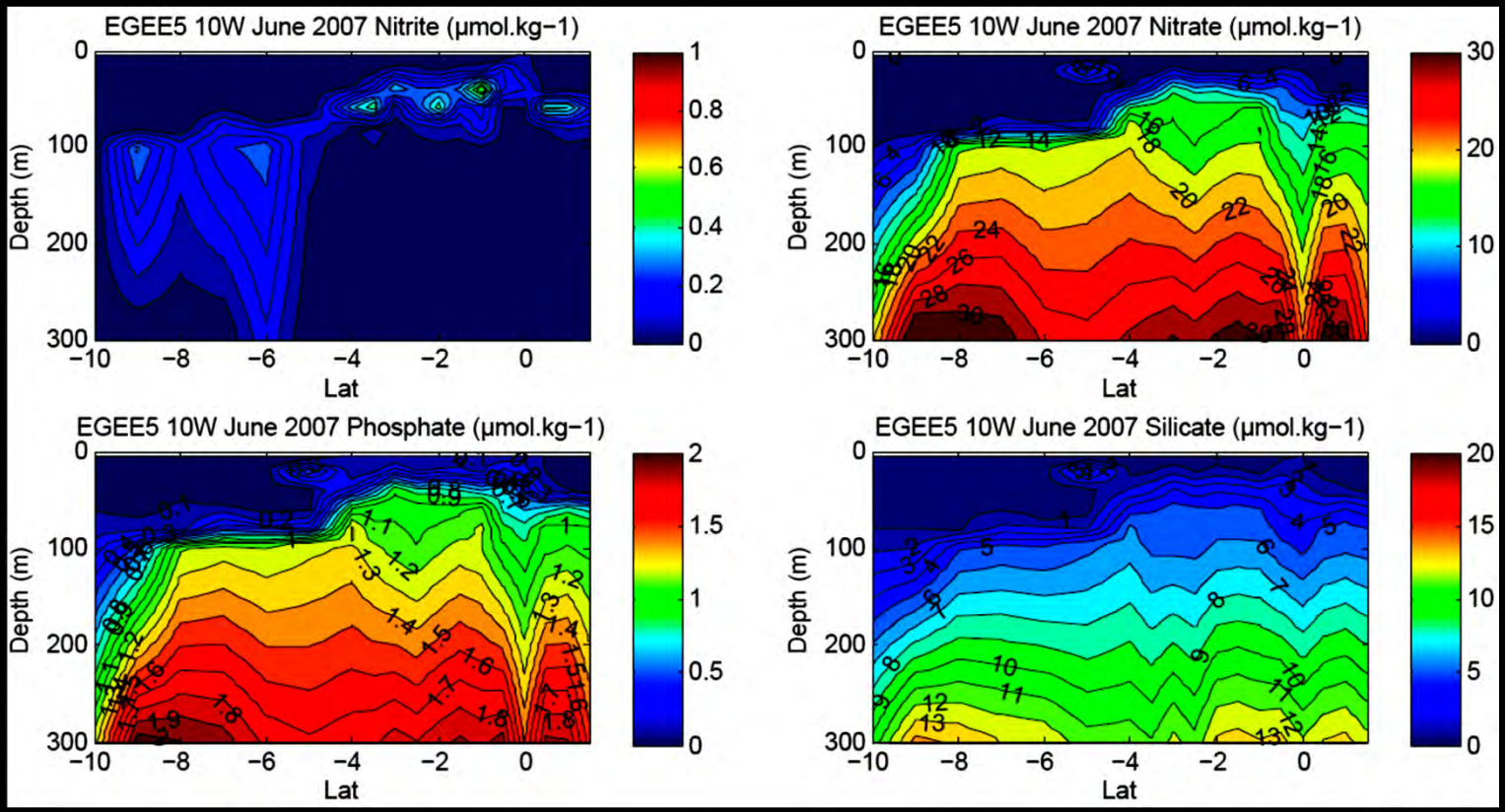


Fig 11: Nitrite, nitrate, phosphate, and silicate along 10°W in June 2007 (EGEE5)

The meridional distributions of the nutrients suggest the presence of equatorial upwelling during June 2007.

RR (1.5°N & 2°S) = 16.75 > 16

Interannual Variability in Upwelling Signals at 0°N along 10°W.

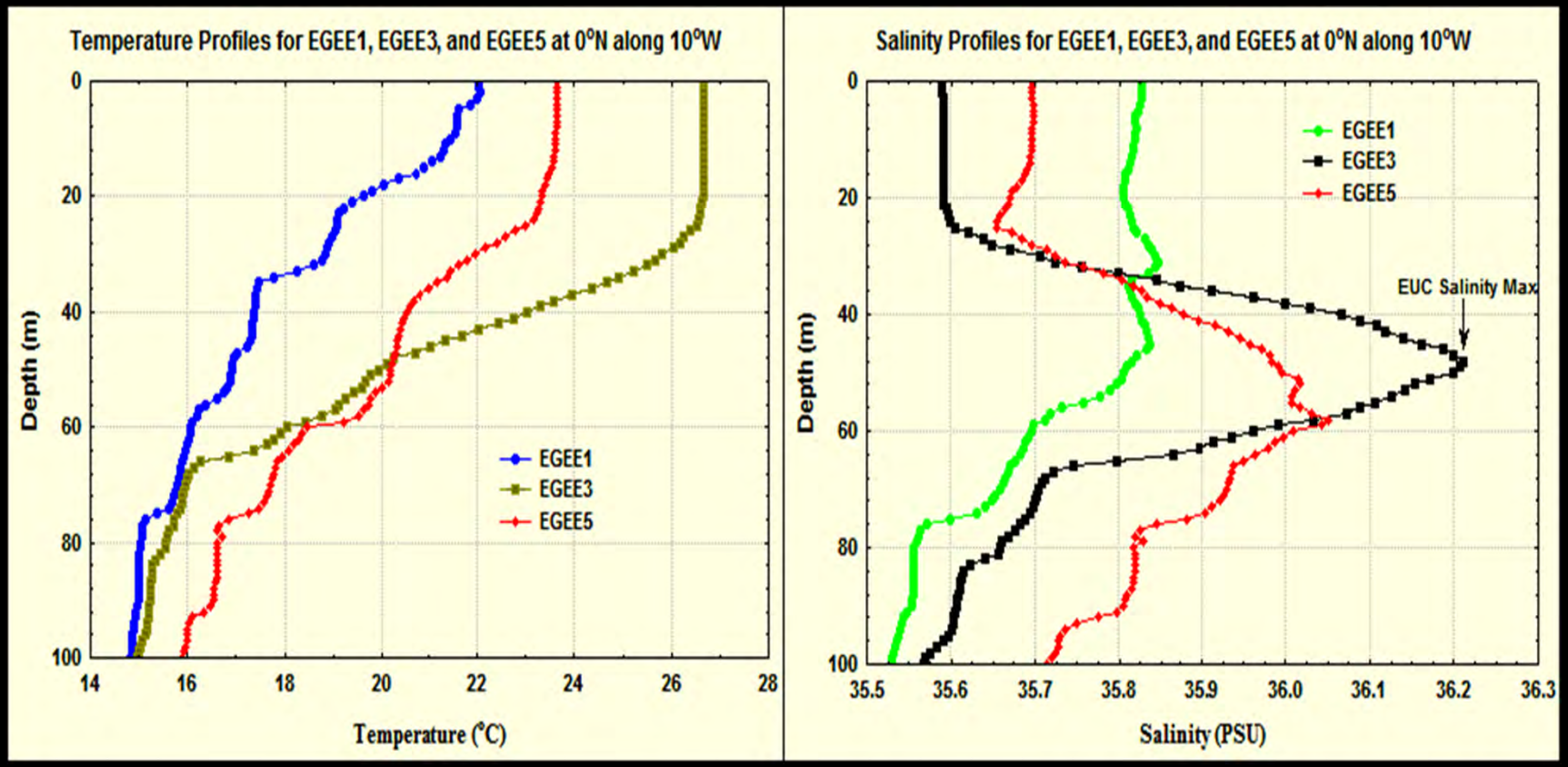


Fig 12: Profiles for Temperature and Salinity at 0°N along 10°W in June 2005, June 2006, June 2007

Equatorial Upwelling was strongest in June 2005

Interannual Variability in Productivity at 0°N along 10°W.

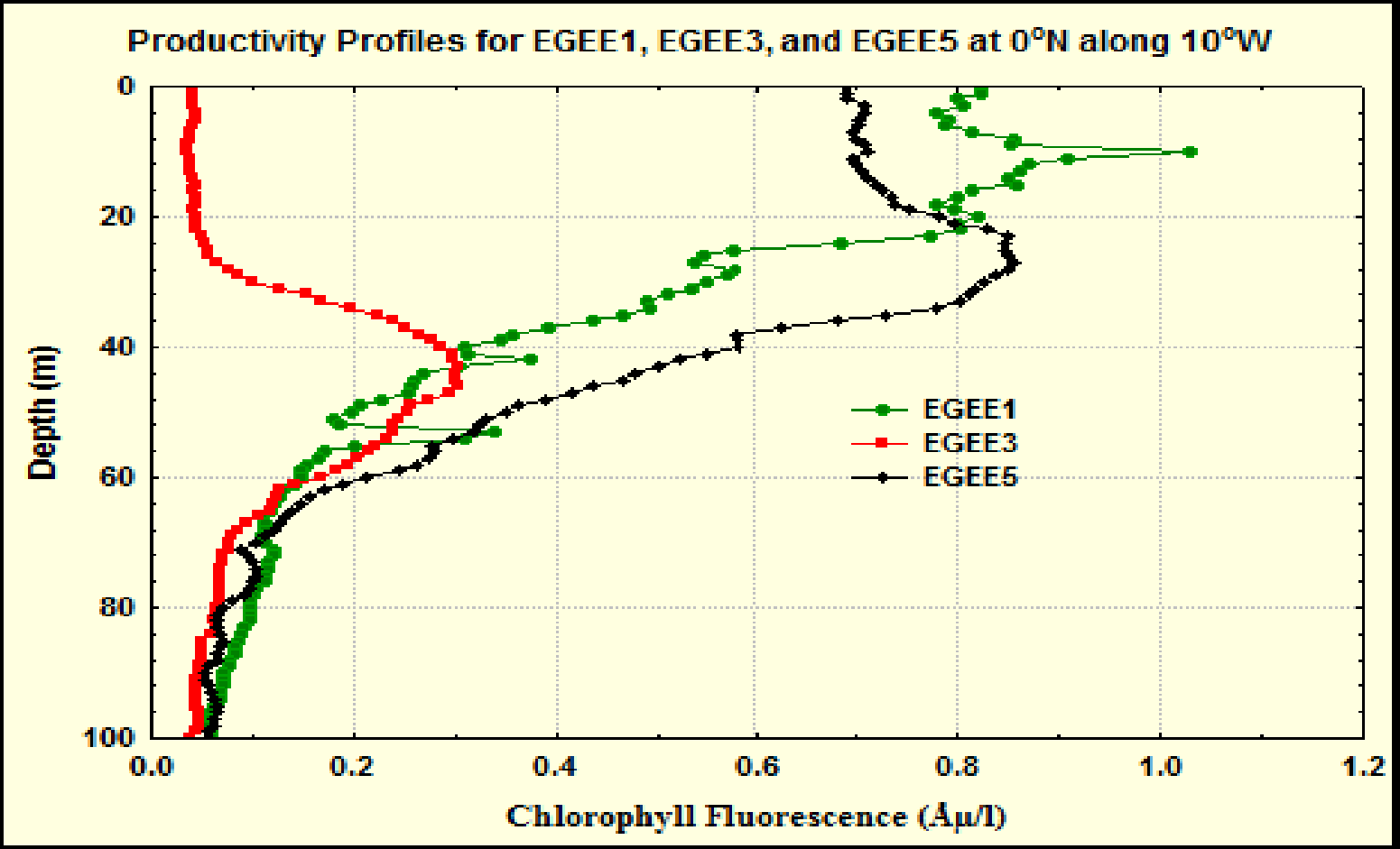


Fig 13: Productivity Profiles at 0°N along 10°W in June 2005, June 2006 & June 2007.

Productivity was observed strongest in June 2005

- Biological Viability in terms of the RR is:

- June 2005 > June 2007 > June 2006.

Conclusions

- The influence of equatorial upwelling was evident in the meridional distribution of upwelling indicators in the EEA.
- Of the years studied, nutrient enrichment / biological productivity was highest in June 2005 between 1ºN & 1ºS.
- Upwelling signal was weak in June 2006 due to delayed onset of upwelling in the GoG. (Marin *et al*. 2009; Brandt et al. 2010).
- Of the years studied, condition was most viable for biological productivity in June 2005 in terms of RR.

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Many thanks for Your Attention