Cluster 5

"Marine Biogeochemistry"

Nutrient distribution in the Indian Ocean off Java and Sumatra, Indonesia, related to coastal upwelling

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Introduction

On a global scale upwelling systems are of prime importance with respect to marine carbon and nitrogen cycling and the production of living natural resources. Monsoon-driven seasonal upwelling in the Indian Ocean south of Indonesia has been reported. Based on findings from remote sensing and oceanographic studies the Indonesia Upwelling is supposed to be of major importance for Indian Ocean climate and oceanography. However, little is known on the factors controlling carbon and nitrogen cycling in the area. In order to understand present and past functioning of the Indonesia Upwelling data and samples from the water column and sediments were collected during a 6-week cruise with the German research vessel "SONNE" in August and September 2005. Here we present physicochemical data and preliminary results of biogeochemical analyses from the water column.

Results

The density pattern shows a maximum off SE Java indicating upwelling of cold and saline deep water (Fig. 1A, St. 54). In that region nitrate and phosphate reached maximum concentrations of 2.4 and 0.3 µmol l^{-1}, respectively (Fig. 1B & C). Throughout the rest of the working area nitrate and phosphate concentrations were <0.5 µmol l^{-1} and <0.2 µmol l^{-1}, respectively.

Although nutrient concentrations were high off SE Java (St. 54) chlorophyll a was almost as low as in the entire working area. It appears that phytoplankton was low despite favourable growth conditions off SE Java. Slightly increased chlorophyll a coinciding with moderate nutrient concentrations in the easternmost part of the working area indicate onset of phytoplankton growth (Fig. 1D).

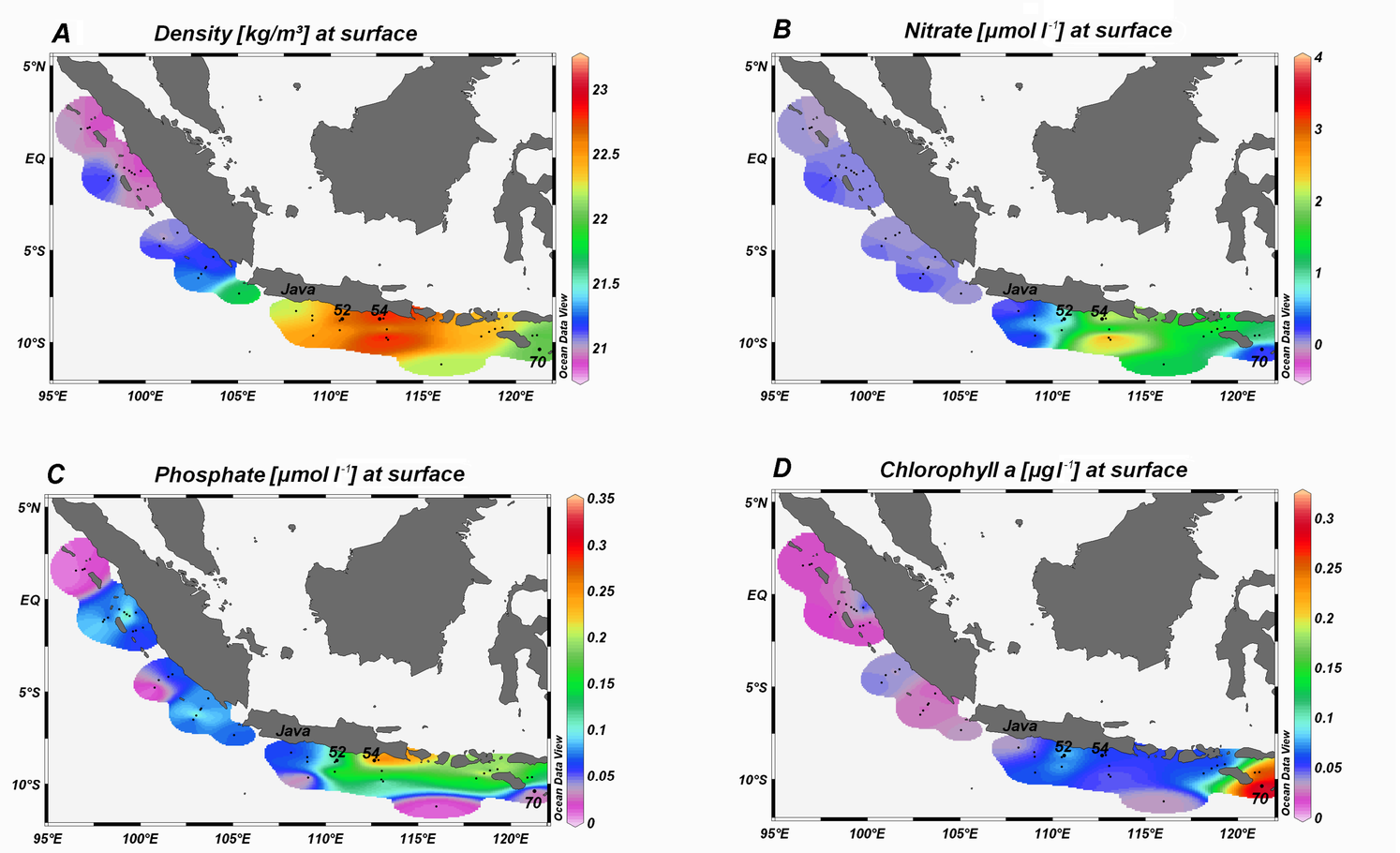

Fig. 1: Surface distribution of density (A), nitrate (B), phosphate (C) and chlorophyll a (D) south of Sumatra and Java.

Our data indicate that upwelling and attendant biological activity in 2005 was delayed by about one month. Oceanographic observations of the past two decades indicate maximum upwelling intensity off SE Java in July.

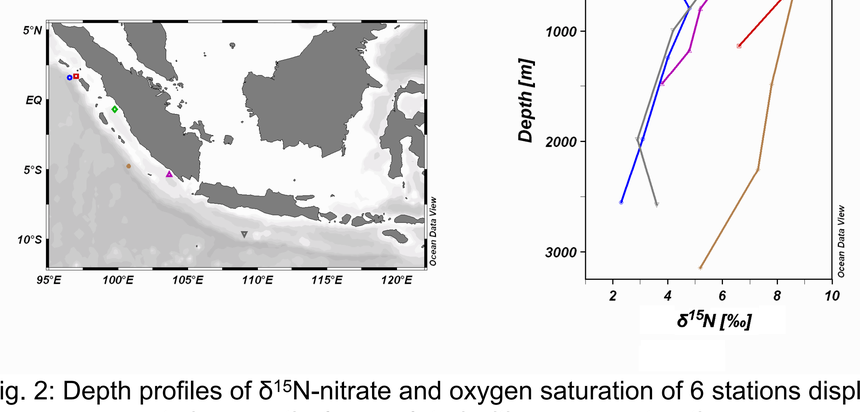

Fig. 2: Depth profiles of δ^{15}N-nitrate and oxygen saturation of 6 stations displayed in the map. δ^{15}N-nitrate appears to be negatively correlated with oxygen saturation.

The δ^{15}N-values of nitrate range between 2 and 9‰. With a few exceptions δ^{15}N-nitrate displayed maxima in the oxygen minimum zone and decreased with depth (Fig. 2). It is conceivable that nitrate was used as an oxidant (→ denitrification) for decomposition of organic matter (OM) after exhaustion of dissolved oxygen. Kinetic isotope fractionation during denitrification then led to an enrichment of ^{15}N in the remaining nitrate.

Maximum δ^{15}N-nitrate values of 8-9‰ are higher than average values of seawater nitrate around 5-6‰. Site specific variations cannot be explained as yet.

Conclusion

- A maximum of nutrient concentrations in surface waters was observed off SE Java during SE monsoon in August 2005.
- Low chlorophyll a concentrations indicate that phytoplankton growth had not yet commenced at that time.
- Maximum δ^{15}N-nitrate values of 8-9‰ are exceptionally high when compared to other regions of the world ocean.

Outlook

- Understanding present-day carbon and nutrient cycling in the Indonesia Upwelling requires more detailed information on production, transformation and sedimentation of OM. This shall be achieved through (i) analysis of labile OM fractions and relation to (ii) physicochemical water column properties and (iii) biogeochemical properties of dissolved nutrients.

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