Seasonal and interannual variability of mixed layer nitrate in the central Irminger Sea

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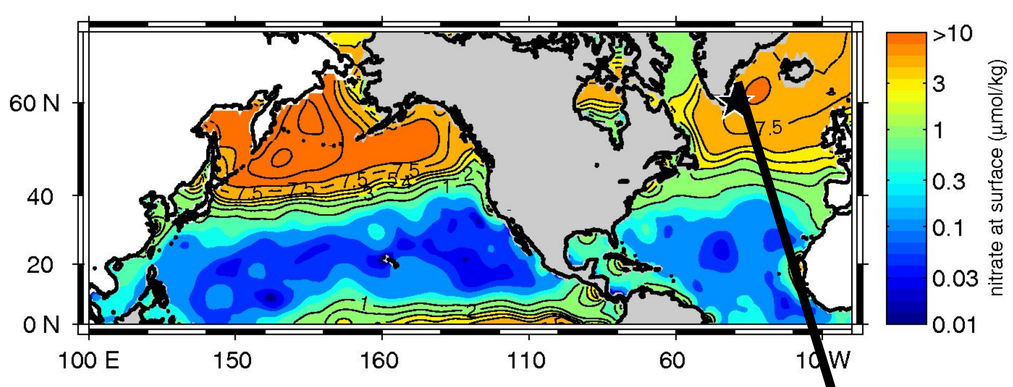
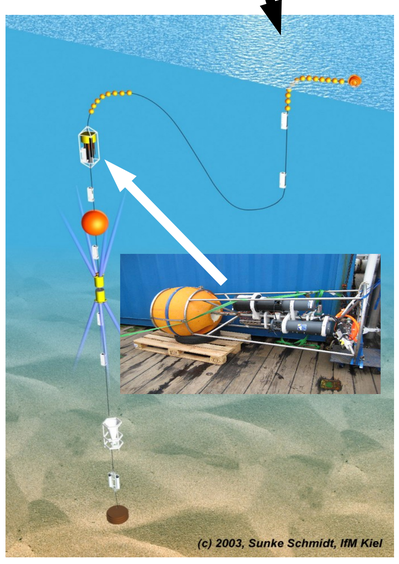
Introduction

Two years of high temporal resolution (<0.5 days) near surface (<40m depth) nitrate data from the central Irminger Sea is used to explore processes that control mixed layer (ML) nitrate in the subpolar North Atlantic. One focus is on factors that determine the nitrate to temperature relation. By scaling nitrate with the locally observed mixed layer depth the mixed layer nitrate removal is derived. It is found that under low light conditions, before mid April, new production and carbon fixation can be as large as 30% of the spring bloom fixation. Significant deviations from the linear T/N relation are related to short-term bloom events triggered by short-term stratification events.



Instrumentation

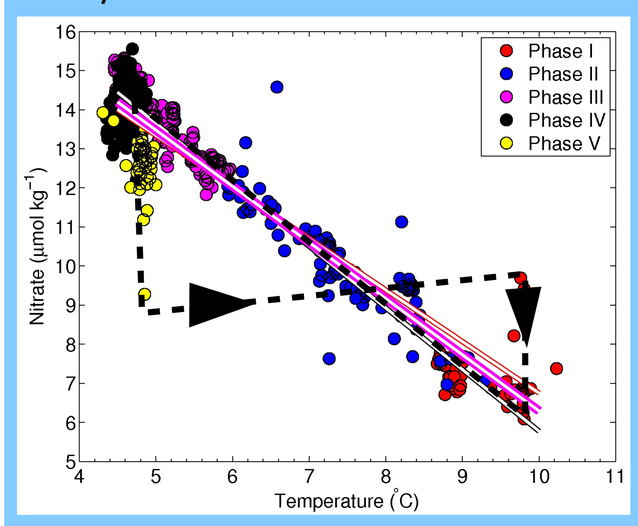
- Steel wire mooring with surface telemetry module
- Nitrate autonomously analyzed with an Envirotech LLC NAS©
- Dedicated frame for the biogeochemical sensors has been designed.

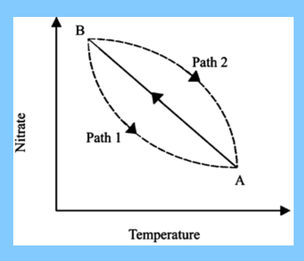


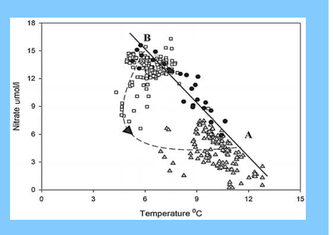
Nitrate/temperature relation

Surface nitrate and temperature can show a surprisingly linear evolution over time. The linear relation has been used to estimate ocean primary productivity from space.

During certain periods of the seasonal cycle physical factors (warming/cooling and convection/stratification) dominate over biological – and while at other times they biologically influence the nitrate in parallel and the T/N relation is non-linear.



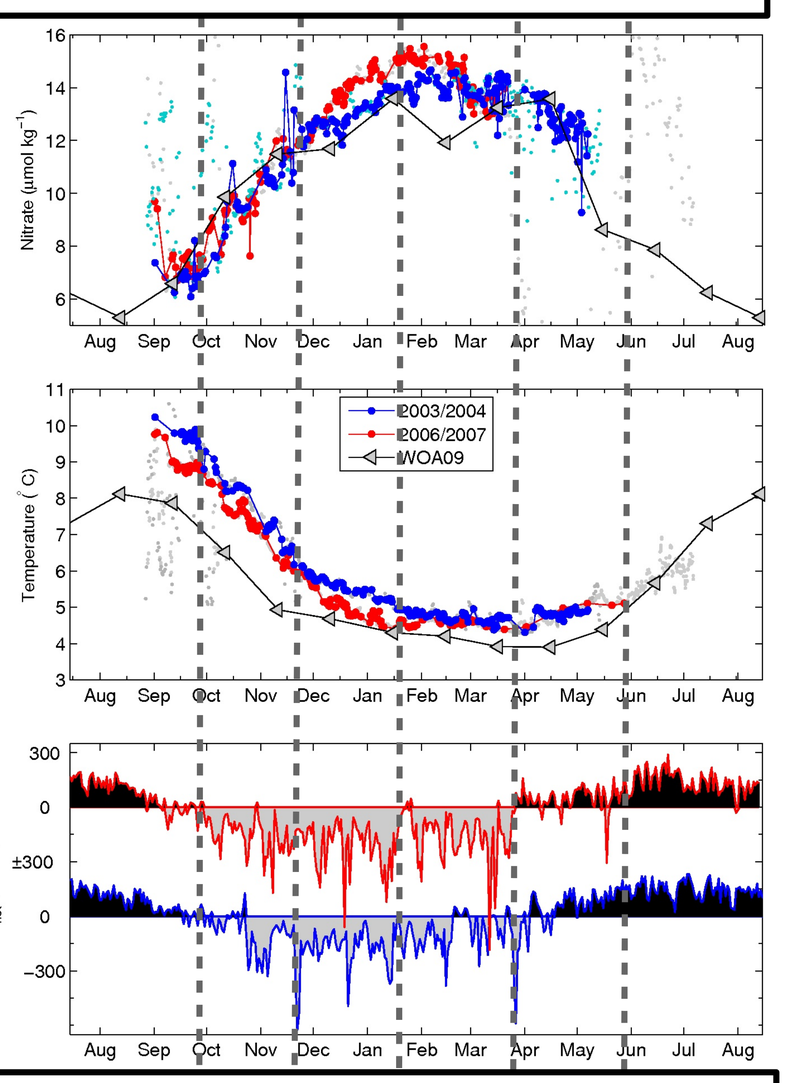




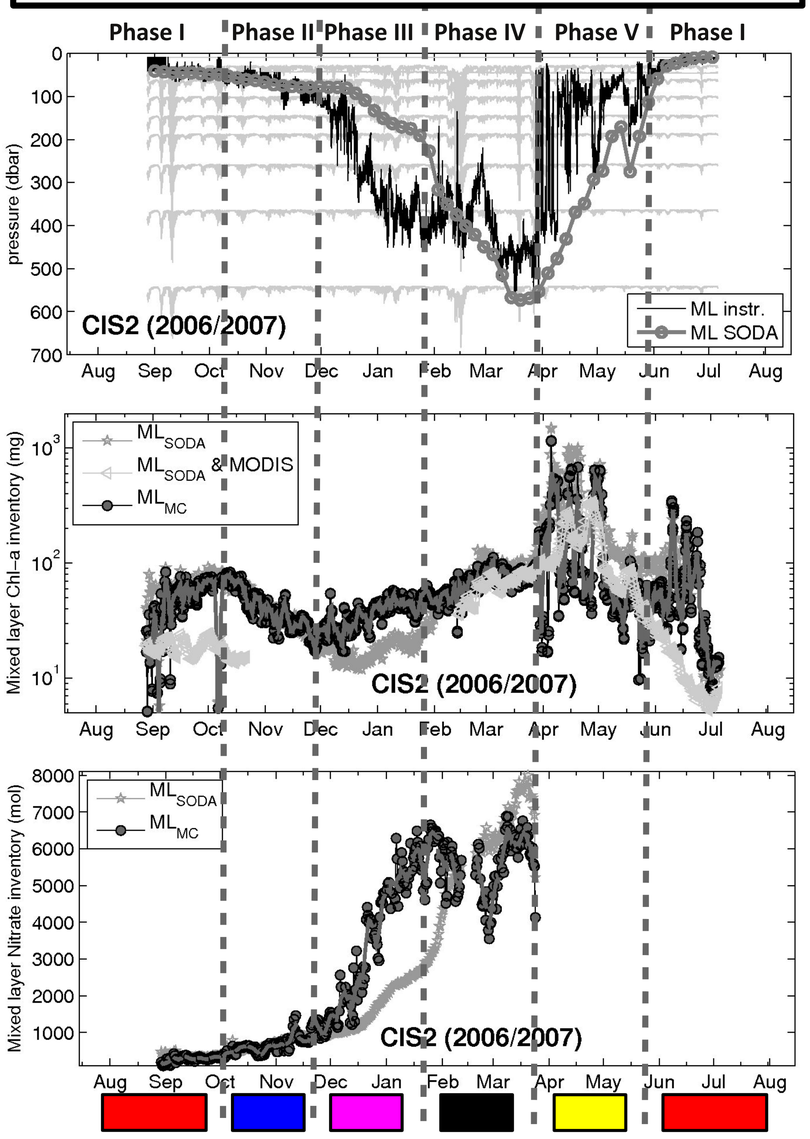
Based on ship data Henson et al. (2003) found a linear T/N relation while during the ML deepening (A to B) and a path 1 relation in spring/summer.

Our high resolution data suggest a mixture of Path 1 and Path 2 typically masked by the merging of temporal and spatial variability.

2003/2004 and 2006/2007



2006/2007 only



Time series

- With onset of heat loss an mixed layer nitrate increases to approx. 15 µmol l^{-1} which is close to deep water value
- In parallel temperatures decrease to about 4.5 °C
- Colder temperatures and higher nitrate suggest that the mixed layer was deeper in 2006/2007 than in 2003/2004
- Integrated heat loss (NCEP/NCAR Reanalysis data) was in 2006/2007 about 25% larger (1.03*10^{12}J) compared to 2003/2004 (0.75*10^{12}J)

Mixed Layer evolution and Productivity

- Five different phases influence the nitrate concentration in the mixed layer. These are related to the surface heat flux; intensity and timing of stratification and mixing; and the vertical gradient in the existing stratification.
- In 2006/2007 a Wetlabs FLNTU recorded chlorophyll fluorescence in parallel to the NAS. Fluorescence was converted to Chl-a via filtration
- The integrated Chl-a content is at minimum in December
- Small changes in Chl-a but over a deep ML indicate about 30% of primary productivity (Chl-a increase) happens between Dec and April
- Nitrate is continuously added to ML via deep water entrainment

Conclusion

Nutrient (and other biogeochemical) data in high temporal resolution from autonomous instrumentation can provide a new insight to the functioning of the marine ecosystem – in particular to the interaction between physical and biogeochemical processes.