



# Factors controlling dimethylsulphide dynamics under different CO<sub>2</sub> concentrations in a mesocosm experiment

M. Vogt<sup>1,2</sup>, M. Steinke<sup>2,3</sup>, S. Turner<sup>2</sup>, A. Paulino<sup>4</sup>, M. Meyerhoefer<sup>5</sup>, U. Riebesell<sup>5</sup>, C. Le Quéré<sup>2,6</sup>, P. Liss<sup>2</sup>

<sup>1</sup>Max-Planck-Institute for Biogeochemistry, P.O. Box 10 01 64, D-07701 Jena, Germany; <sup>2</sup>School of Environmental Sciences, University of East Anglia, Norwich NR4 7TJ, UK; <sup>3</sup>present address: Department of Biological Sciences, University of Essex, Wivenhoe Park, Colchester CO4 3SQ, UK; <sup>4</sup>Department of Biology, University of Bergen, Box 7800, N- 5020 Bergen, Norway; <sup>5</sup>IFM-GEOMAR, Dienstgebäude Westufer, Düsternbrooker Weg 20, D- 24120 Kiel, Germany; <sup>6</sup>British Antarctic Survey, High Cross, Madingley Road, Cambridge CB3 0ET, UK

## Abstract:

We investigate the impact of ocean acidification on the production of dimethylsulphide (DMS) and its algal precursor dimethylsulphoniopropionate (DMSP) during a mesocosm experiment under present (P), double (F) and triple pCO<sub>2</sub> (FF). The results show similar temporal development of DMSP and DMSP-lyase activity, but different temporal development for DMS. Mechanisms that could potentially explain the differences include a sensitivity of the DMS yield from DMSP to pH.



## 3. TEMPORAL DEVELOPMENT

- Differences in the temporal development of DMS!
  - Ecosystem composition was similar in all mesocosm bags
  - Strong correlation between E. huxleyi and DMS in P
  - Weak correlation between E. huxleyi and DMS in F and FF
- Furthermore:
- Differences in bacterial community structure between P (similar to original population), F and FF
  - Differences in abundance of one group of viruses

## Summary:

- There were differences in the temporal development of DMS between unperturbed and perturbed treatments.
- DMSP and chlorophyll-a concentrations were similar in all treatments.
- DMS and E. huxleyi number were closely correlated in P, but not in F and FF.
- The DMS yield from DMSP and chlorophyll differed between treatments.
- Pattern differences could result from differences in algal composition or bacterial consumption of DMSP and DMS or from differences in viral lysis of algal cells.
- Integrated DMS concentrations showed no differences between the treatments.

## 1. EXPERIMENTAL SET-UP

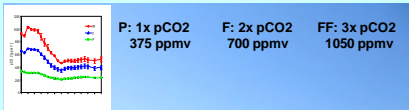


Fig.1: Experimental Set-Up and pCO<sub>2</sub>

During spring 2005, we conducted a mesocosm experiment in Bergen, Norway. We measured DMS and related compounds under present (P, 375 ppmv), double (F, 700 ppmv) and triple CO<sub>2</sub> (FF, 1050 ppmv) conditions in a natural phytoplankton bloom. The set-up consisted of 3x3 polyethylene enclosures filled with natural seawater. Bags were covered with transparent tents and headspaces of the mesocosms were flushed with CO<sub>2</sub> enriched air. Details can be found in Engel *et al.* 2005.

## 2. DMS & ACIDIFICATION

In this experiment, cumulative DMS is a measure of the integrated sea-air fluxes of DMS. Cumulative DMS concentrations were similar for all treatments. No influence of future pH on DMS emissions?

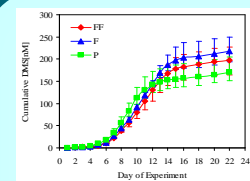
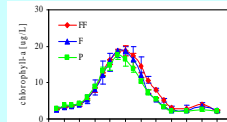


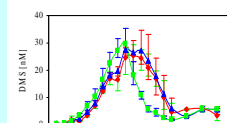
Fig. 2: Cumulative DMS [nM].

The cumulative DMS concentrations show slightly lower values for P, but the differences are not significant. This result is in contrast to the work by Hopkins *et al.* (see poster).

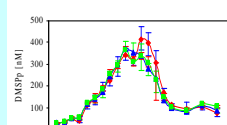
DMS affects the radiative properties of the atmosphere by increasing the concentration of cloud condensation nuclei and by reflecting solar radiation. In 1987 Charlson *et al.* postulated links between DMS, atmospheric sulphate aerosols and global climate. Is there such a feedback and, if so, will it be affected by ocean acidification? Our flux estimates show no differences between treatments.



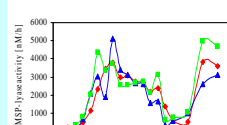
Chlorophyll-a and ecosystem composition were similar for all 3 treatments. This indicates similar ecosystem composition.



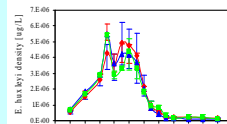
DMS showed significant differences in its temporal development. While DMS peaked on day 10 in P and declined steeply afterwards, DMS concentration stayed elevated in F and FF and declined more gradually.



Particulate DMSP (DMSP<sub>p</sub>) did not show any significant differences in the temporal development. Similar DMSP<sub>p</sub> and similar chlorophyll-a concentrations also indicate a homogeneous ecosystem structure.



DMSP-lyase is an enzyme that can cleave DMSP to DMS. It is produced by bacteria and some phytoplankton. The temporal development of DMSP-lyase activity was very similar in all treatments.



E. huxleyi were dominant and are good DMS producers, because they produce DMSP and contain DMSP-lyase. Differences in cell numbers can account for some of the difference in amount of DMS, but not for the temporal shift. E. huxleyi have been shown to be affected by ocean acidification (Riebesell *et al.*, 2004)

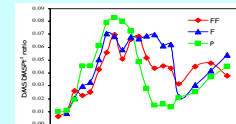
Fig.3: Temporal development of measured compounds

Which mechanism(s) in the production and consumption chain of DMS was (were) affected by the change in pH?

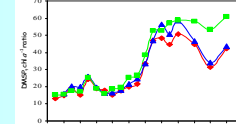
- Main factors controlling DMS concentrations:
- Ecosystem composition
  - Intracellular production of precursor DMSP
    - Direct exudation of DMS?
    - Viral lysis of planktonic cells
    - Grazing by zooplankton
  - Bacterial consumption of DMSP
  - Bacterial consumption of DMS
    - Photolysis of DMS

## 4. DMS yield

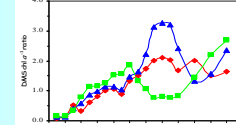
The DMS yield per DMSP and per chlorophyll varied between treatments. Can bacteria explain the differences in DMS?



The ratios of DMS per DMSP are different for the unperturbed compared to the perturbed treatments. There was more DMS per DMSP produced in F and FF.



The ratios of DMS per chlorophyll are similar for all treatments. This indicates similar ecosystem composition.



The ratios of DMS to chlorophyll confirms the hypothesis that the yield of DMS from DMSP and chlorophyll may have been affected by pH.

Fig.4: Temporal yield of DMS from chlorophyll and DMSP

Other work at UEA (Hopkins *et al.*, in preparation, Avgoustidi *et al.*, in preparation) confirm a sensitivity of the DMS yield to pH.

## ACKNOWLEDGMENTS:

This work was part of the Pelagic Ecosystem Enrichment Study (PEEE II) in 2005. The authors wish to thank all participants in the PECEE III experiment for their work. We thank C. Neil, J. Neillgaard, M. Algalter and R. Thybaug for providing necessary data for this work and for fruitful discussions. We furthermore thank E. Butterfield for many useful discussions. This work was funded by the Marie Curie Research Training Network GROWTHABLE. Contract Number: MCRTN-51264. Support for M. Steinke was provided by the UK Natural Environment Research Council (NERC, NER/I/S/2000/00897 and NE/E505282/1).

## REFERENCES:

- Vogt *et al.*, Dynamics of dimethylsulphoniopropionate and dimethylsulphide concentrations under different pCO<sub>2</sub> concentrations during a mesocosm experiment, submitted.
- Vogt *et al.*, Laboratory inter-comparison of dimethylsulphide measurements using purge-and-trap and solid-phase microextraction techniques during a mesocosm experiment, in preparation.
- Avgoustidi *et al.*, Dimethyl sulphide production in a double-CO<sub>2</sub> world, in preparation.
- Hopkins *et al.*, Ocean acidification: Impacts on marine trace gas emissions, in preparation.
- Charlson *et al.*, Oceanic phytoplankton, atmospheric sulphur, cloud albedo and climate. Nature 326: 655-661, 1987.
- Engel *et al.*, Testing the direct effect of CO<sub>2</sub> concentration on a bloom of the coccolithophore E. huxleyi in mesocosm experiments. Limnology and Oceanography 50: 493-507, 2005.
- Kjelson *et al.*, Impact of ocean acidification on coral reefs and other marine calcifiers: A guide for future research. Workshop held 18-20 April 2005, sponsored by NSF, NOAA and the U.S. Geological Survey, 2006.
- Riebesell *et al.*, Effects of CO<sub>2</sub> enrichment on marine phytoplankton. Journal of Oceanography 60:719-729, 2004.