

# The biogenic production of trace gases etc.....

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et al



LGMAC Marine Ecosystem & Biogeochemical Modelling Day 9/10/08

## Research interests

**Initial training in microbial physiology and biochemistry:**  
cyanobacteria & nitrogen fixation  
cyanobacteria and chemotaxis  
arabinose (aldopentose = 5 carbon monosaccharide)  
uptake in *E. coli* (molecular/biochem).

### Marine Trace Gas Biology:

Dimethyl sulphide  
Halocarbons  
Non-methane hydrocarbons

**Other aspects of biogeochemistry & biological oceanography:**  
Sulphur biogeochemistry - molecular approaches.  
Phytoplankton and cell death processes.

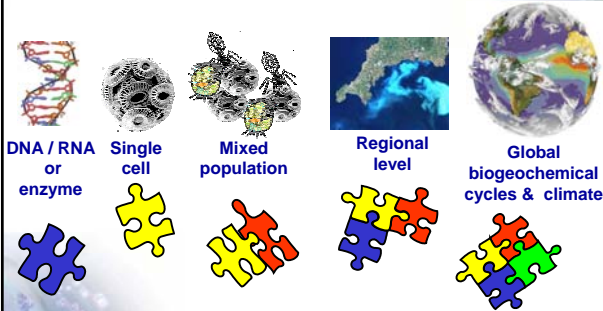
### 'Applied':

Exploitation of marine microbes - ELSA funding.  
Exploitation of seaweeds - atmospheric consequences.

**Context: Global Biogeochemical Cycles & Climate change**

## Global biogeochemical cycles

~ all are driven by microbes



Posing research questions:  
LAB - FIELD - MODELLING - FIELD - LAB

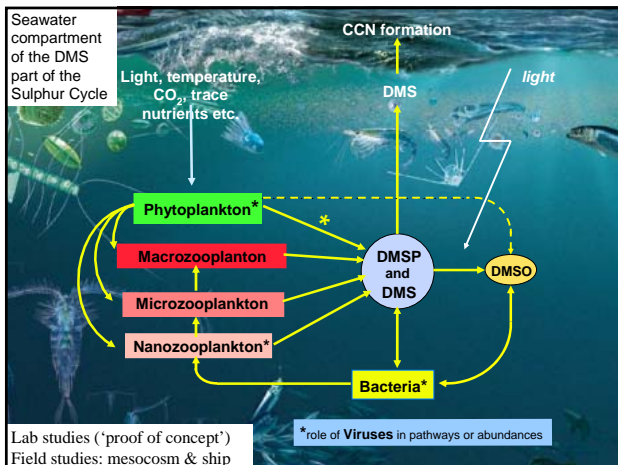
## Posing research questions:

Large scale process-based models are unlikely to improve in the absence of targeted laboratory studies and field data.

.....and vica versa

The more we talk to one another the better the research questions we pose will be

(and the results we get should be better and more applicable!)



## INSPIRE Investigation of the Near-Surface Production of Iodocarbons: Rates and Exchanges

### Iodocarbons

Volatile organic carbon compounds (VOC), mostly of natural origin. Low picomolar range concentrations in seawater.

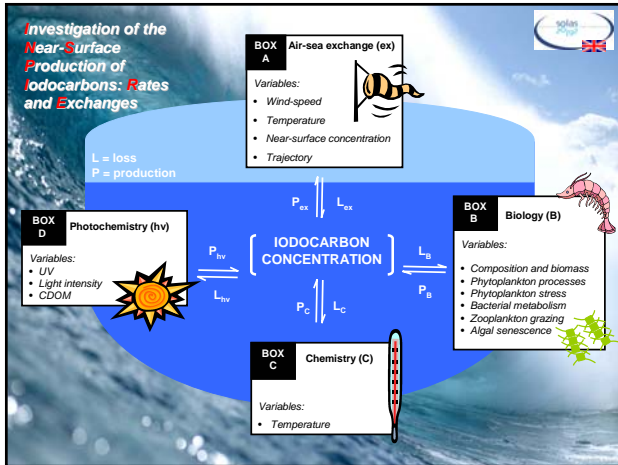
Global iodine cycle which impacts on human health.

New particle formation.

Impact on oxidising capacity of the atmosphere

Halogen oxides derived from seawater substantially reduce ozone levels in the sub-tropical Atlantic boundary layer.

- CH<sub>3</sub>I
- CH<sub>3</sub>CH<sub>2</sub>I
- CH<sub>3</sub>CHICH<sub>3</sub>
- CH<sub>3</sub>CH<sub>2</sub>CH<sub>2</sub>I
- CH<sub>2</sub>ClI
- CHCl<sub>2</sub>I
- CHClI<sub>2</sub>
- CH<sub>2</sub>BrI
- CHBr<sub>2</sub>I
- CHBrI<sub>2</sub>
- CH<sub>2</sub>I<sub>2</sub>
- CHI<sub>3</sub>

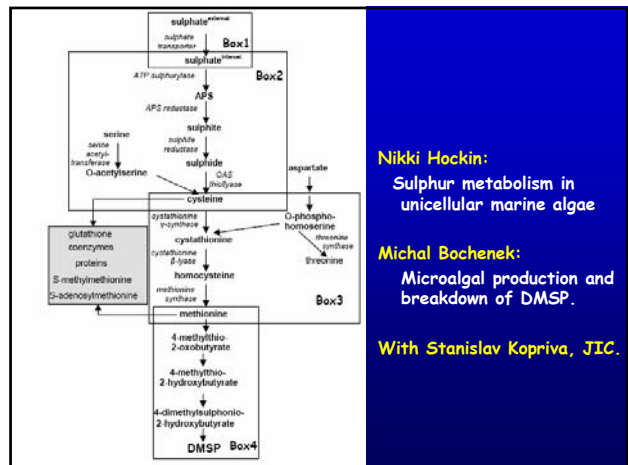


- ## Biogeochemistry / Biological Oceanography
- **Tanja Pangerc**: Environmental conditions regulating growth rates of coccolithophores in the ocean.  
 With **Corinne Le Quééré & Erik Buitenhuis**.
  - **Sophie Chollet**: The role of diatoms in the Antarctic carbon cycle.  
 With **Erik Buitenhuis**.
  - **Rachel Gibson**: Gene networks in diatoms and higher plants that are involved in acclimation to the changing climate.  
 With **Thomas Mock & Philip Wigge (JIC, NRP Studentship)**.
  - **Jan Strauss**: Whole genome expression profiling of the polar diatom *Fragilariopsis cylindrus*  
 With **Thomas Mock**

- ## DMS related projects current questions:
- How do phytoplankton cells die:  
 Grazing.  
 Viral lysis and bacterial pathogens.  
 Old age or suicide??
- Exudation also releases cell contents. Passive vs active processes.
- A key finding from the model calibration was the need to increase the DMS(P) algal exudation rate constant, which includes the effects of cell rupture due to grazing and cell lysis, to significantly higher values than previously used in other regions. This was consistent with the small algal cell size and therefore high surface area-to-volume ratio of the dominant DMSP-producing group—the picoeukaryotes.
- Gabric et al DSRII 2008.

- ## DMS related projects current questions 2:
- Stefels et al 2007 Biogeochemistry
- DMSP is a multifunctional compound and there is no doubt that it has a role as a compatible solute in cell metabolism, but the regulation of its internal concentration is still unresolved.
- A method for the measurement of *de novo* synthesis of DMSP is clearly warranted

- ## DMS related projects:
- Dan Franklin**
- Production of DMS and DMSP by coccolithophores: Is our current understanding an accurate reflection of the truth?
  - Mortality rates in key phytoplankton functional types: the nature of cell death and its biogeochemical consequences.
  - **Amandine Caruana**: Production of dimethylsulphide by marine dinoflagellates
  - **Michelle Fernandes**: Production of DMS and DMSP by picoeukaryotes and small nanoeukaryotes



- Nikki Hockin**: Sulphur metabolism in unicellular marine algae
- Michal Bochenek**: Microalgal production and breakdown of DMSP.
- With **Stanislav Kopriva, JIC**.

# PFT DMSP is the prerequisite for DMS emissions

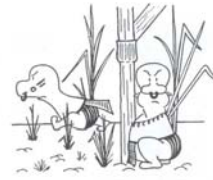
DMSP in phytoplankton ~ after Keller et al., 1989a.

DMSP per unit cell volume  
 $\mu\text{mol DMSP} / \text{cm}^{-3}$

Prymnesiophytes	n=28	mean 157 (sd 114)
Dinoflagellates	n=24	mean 288 (sd 493)
Diatoms	n=23	mean 19 (sd 55)



Biogeography / ecological succession



The wild-type microorganism lives a hardy life in its natural environment.



After isolation and many generations in the laboratory, there is a striking change in the microorganism's characteristics.

Cartoons from: What's so funny about microbiology?  
 by Joachim Czichos

# Are model species typical? PFT

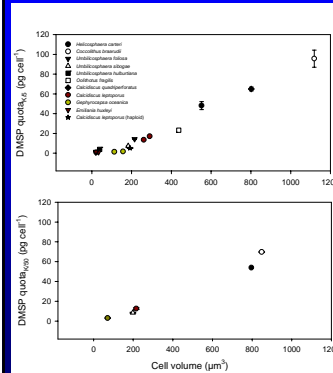


- A. *Oolithotus fragilis*
- B. *Coccolithus braarudii*
- C. *Calcidiscus quadrip perforatus*
- D. *Calcidiscus leptoporus* (diploid, heterococcolith)
- E. *Umbilicosphaera foliosa*
- F. *Gephyrocapsa oceanica*
- G. *Emiliania huxleyi*
- H. *Helicosphaera carteri*
- I. *Umbilicosphaera hultburtiana*
- J. *Umbilicosphaera sibogae*

SEM composite from Franklin et al. In prep.

# DMSP quota (pg cell<sup>-1</sup>) vs. cell size

Franklin et al. In prep.



Mean cell volume range:

20.5  $\mu\text{m}^3$  *Emiliania huxleyi*  
 1140  $\mu\text{m}^3$  *Coccolithus braarudii*

DMSP quota K/5 (pg cell<sup>-1</sup>) =  
 $-5.7 + 0.088 \cdot \text{cell volume}$   
 $R^2 = 0.97$  (P<0.01)

DMSP concentration range:  
 268 mM *Gephyrocapsa oceanica*  
 729 mM *Umbilicosphaera hultburtiana*

Mean value 458 mM.

# Relationships for dinoflagellates?

Caruana et al unpublished

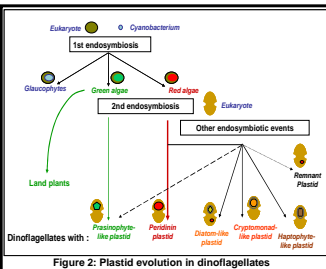


Figure 2: Plastid evolution in dinoflagellates

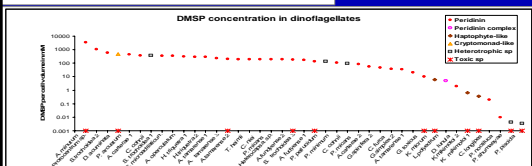
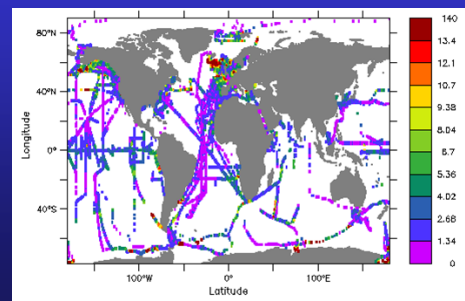


Figure 3: DMSP concentration per biovolume arranged in descending order. Three values from my lab work are added to the published field and lab data.

# Update on 'Kettle' DMS data base

From the Global Surface Seawater Dimethylsulfide (DMS) Database  
<http://saga.pmel.noaa.gov/dms>

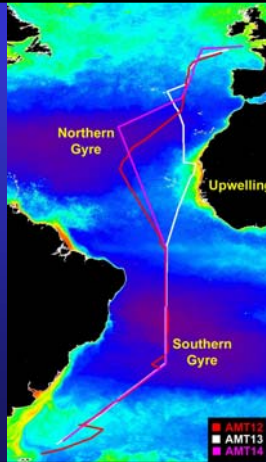


## Atlantic Meridional Transect Project (AMT)

➤ focus on open ocean  
regions.

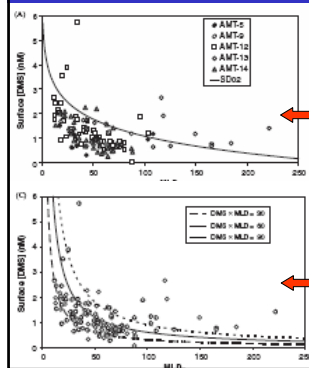
sub-tropical gyres  
= ~60% of the global  
ocean.

Suite of other data  
collected in parallel.



## Independent data for testing algorithms

Bell et al (2006) A comparison of DMS data from the AMT programme with proposed algorithms for global surface DMS concentrations Deep-Sea Research II 53: 1720–1735



For example:  
Comparing AMT data with surface  
[DMS] nM vs. mixed-layer depth  
relationships.

Simó & Dachs (2002)

Aranami & Tsunogai (2004)