Diatoms in ice and sediment – do they cope with climate change?

Angela Wulff
Dept of Biological and Environmental Sciences,
University of Gothenburg, Sweden

1 m depth, Swedish west coast, 31 Jan, 2006

F. Larsson
7 m depth, Potter Cove, Antarctica

Benthic diatoms

- overlying water
- naviculoid diatoms on the sediment surface
- organic material

water – sediment interface

cryo-SEM
- In many polar areas the phytoplankton biomass is not sufficient to explain the benthic consumer abundance

- Sediment-associated benthic microalgae are present throughout the year, making up the basis for local food webs, and in the end the production of fish.

Benthic microalgae can account for 50% or even more of the total primary production in shallow estuaries and bays (Underwood and Kromkamp 1999)
In nearshore coastal systems, the enhanced glacial melting will impact water column stratification & change light regime, temperature & salinity in surface waters.

Microalgae were sampled at 3 sites on the Swedish west coast.

Benthic diatoms were active (epifluorescing) under very low light conditions (single μmol photons m$^{-2}$ s$^{-1}$) \textit{in situ}.
Scenario 1: Increased sedimentation → decreased radiation

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<th>PAR</th>
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<tr>
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<td>12 Feb</td>
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15 days in the dark
63 days in the dark

“...obligate benthic diatoms living as deep as 191 m substantially extends the known depth range of these primary producers...“

Mid-day PAR at the 191 m site averaged 0.1 µmol photons m⁻² s⁻¹

McGee et al MEPS 2008
Scenario 2:  
Less ice → increased radiation
Underwater PAR for the experimental depths 0.5 and 8 m; 100 – 300 – 600 μmol m$^{-2}$ s$^{-1}$ & 30 – 100 – 150 μmol m$^{-2}$ s$^{-1}$ for midnight – 18:00. – 12:00

Experimental units

PAR

PAR+UV-A

PAR+UV-A+UV-B

Closed no grazers

Open grazers

Controls for cages & light filters

N=4 32 cages
Effect of grazers but not of UVR

Scenario 2: Less ice → increased radiation

Methodological approach for some indoor experiments with diatom assemblages

Sterile quartz sand plus diatoms, <1 mm layer (max. light penetration)

Scenario 2: Less ice → increased radiation

Some results on $F_v/F_m$

Disturbance and/or migration?

Repeatedly measured using a non-destructive probe (PAM 2100)
"Ok, lets put them in the fridge first and then lets fry them with UVR"

UV-B 0.7 W m\(^{-2}\)
UV-A 9.8 W m\(^{-2}\)
PAR 40 \(\mu\)mol photons m\(^{-2}\) s\(^{-1}\)

15 days in the dark

64 days in the dark

Wulff Univ. of Malaga 2014
The effect of increased temperature (+4°C) on a shallow-water system was studied for 1.5 months. Oxygen production, biomass, and species composition of benthic microalgae did not respond to warming. Heterotrophic variables responded more clearly to warming than did autotrophic variables.

**Scenario 3: Increased temperature**

**Continued GHG emissions** ... *would induce many changes ... that would very likely be larger than those observed* ...

*IPCC (2007):*
The Physical Science Basis: Latest Findings to be Assessed by WGI in AR5

1. CO₂: Higher levels and more rapid increase

2009: 387 ppm

(Siegenthaler et al., 2006; Lüthi et al., 2008, NOAA)

Life on, in and under sea ice
3 m long “curtains”

A. Torstensson
Mostly pennate diatoms
Extracellular polymeric substances (EPS)

- Motility
- Cryoprotection

Scenario 4: Increased CO\textsubscript{2} and increased temperature

**Aim:**

Study the ecophysiological response of increased carbon dioxide and temperature levels of the arctic diatom *Navicula directa*.

Simulating a "worst-case" scenario for the year 2100
Scenario 4: Increased CO₂ and increased temperature

Mean ± SE (n = 4)

- 42% higher growth in +4°C!
- 5% lower growth in 960 ppm CO₂!

But...

- Laboratory study
- 100 years of climate change in 7 days
- Cultured organisms
- Intraspecific variation
Diurnal changes of photosynthetic efficiency in the diatom species *Thalassiosira* sp., *S. hyperborea*, and *P. glacialis*

**About experimental design / approach**

Single species or communities / assemblages?

Cascade effects – several trophic levels?

Field experiments and/or laboratory expts?

Single factor or a multifactorial approach?
Being attached – another problem?

Some of the colleagues & friends who contributed:

Kristina Sundbäck, Anders Torstensson, Melissa Chierici, Christian Alsterberg, Fredrik Larson, Anna Engelsen, Adil Y. Al-Handal, Sirje Vilbaste, Katharina Zacher, Michael Roleda, Gabriela Campana, Dieter Hanelt, Christian Wiencke

& of course the logistic staff at various field stations!