Importance of Arctic Melt Ponds for Primary Productivity during summer 2011

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Abstract

During the Polarstern summer expedition TransArc 2011 to the Central Arctic, the biological and physical importance of melt ponds was assessed in terms of primary productivity and light transmittance.

A seasonal succession could be observed: thick algal aggregates with high Net Primary Productivity (NPP) rates were found during late summer in open ponds, while low NPP were found in early autumn in refrozen closed ponds. These different NPP rates are not correlated with nutrient concentrations. Thus, light seems to be the relevant factor for NPP. Indeed according to Lee *et.al.* 2011 light intensity at the pond surface favours, rather than inhibits carbon uptake rates.

Besides their potential for carbon sequestration, melt ponds will also impact the entire Arctic ecosystem as they allow more incoming light to reach the water column and therefore NPP rates in the water under the ice might increase.

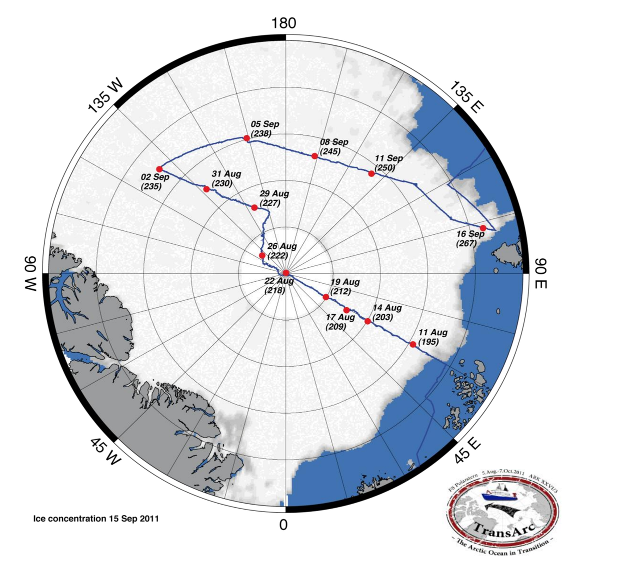
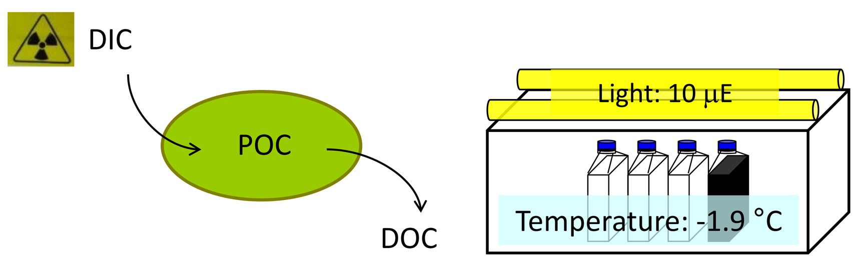


Figure 1. Cruise track (blue line) and ice stations (red dots)

Methods

Primary Productivity

Radioactive isotope ^{14}C-Method



1. 24 h Incubation
2. Filtration 0.2 µm poresize
3. Acidification 6M HCl
4. Liquid scintillation counting

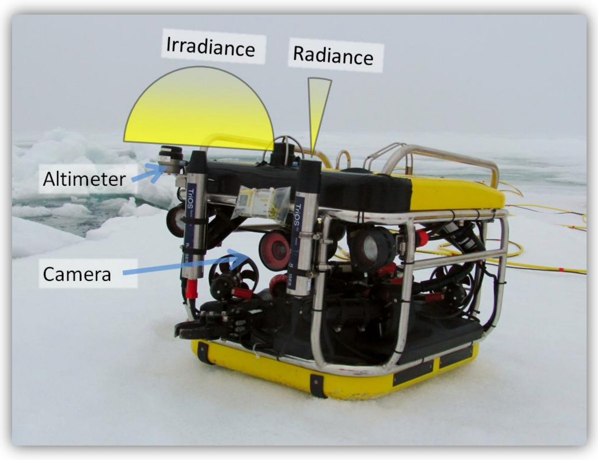
Light transmission

Remotly Operated Vehicle (Ocean Modules V8 Sii)

2 Spectral radiometers (TriOS Ramses-ARC/ACC) with a spectral range of 320 to 950 nm (3.3 nm resolution)

PAR values computed out of the spectra

Total of 4.5 km of data (1m spatial resolution)



Results I: Net Primary Productivity

- August (Atlantic waters) : 2-350 µg C (µg Chl *a*) $^{-1}$ d^{-1}
- September (Pacific waters) : 0.4-33 µg C (µg Chl *a*) $^{-1}$ d^{-1}

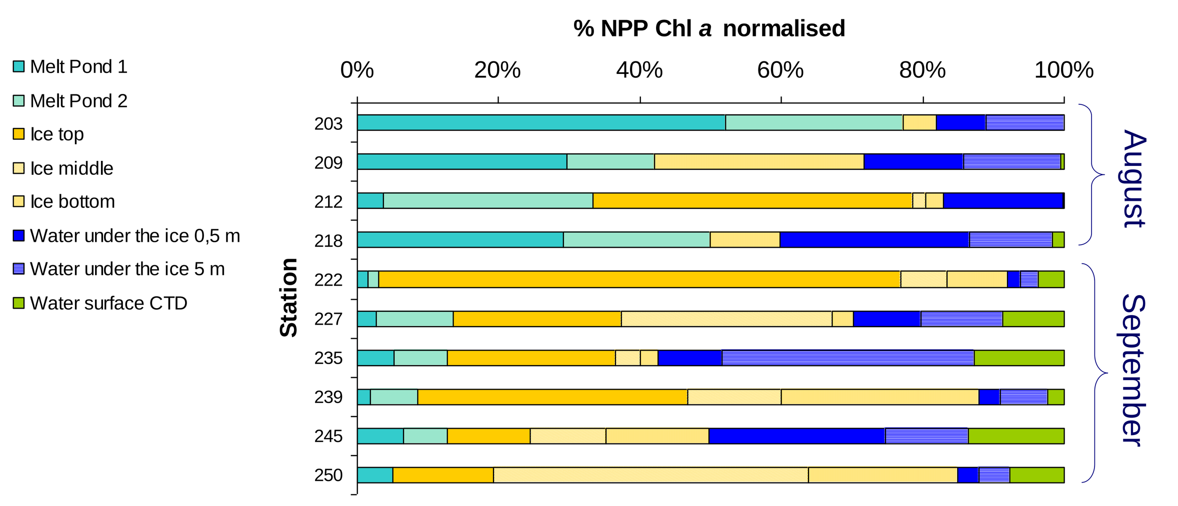


Figure 2. Contribution in percentage of melt ponds, ice and water to primary productivity in each ice station (see Figure 1)

Results II: Light

Percentage of incoming irradiance transmitted through the ice cover:

- 2-7% under bare ice
- up to 30% under ponded ice

Figure 3. Melt pond seen from below the ice.

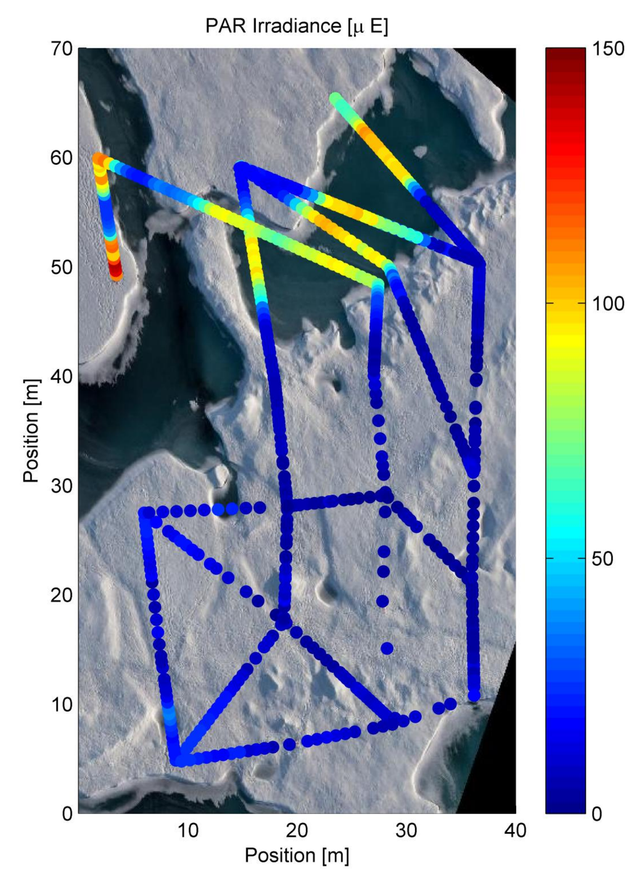


Figure 4. PAR Irradiance below the ice at station 218 (see Figure 1).

Results III: Nutrients and composition

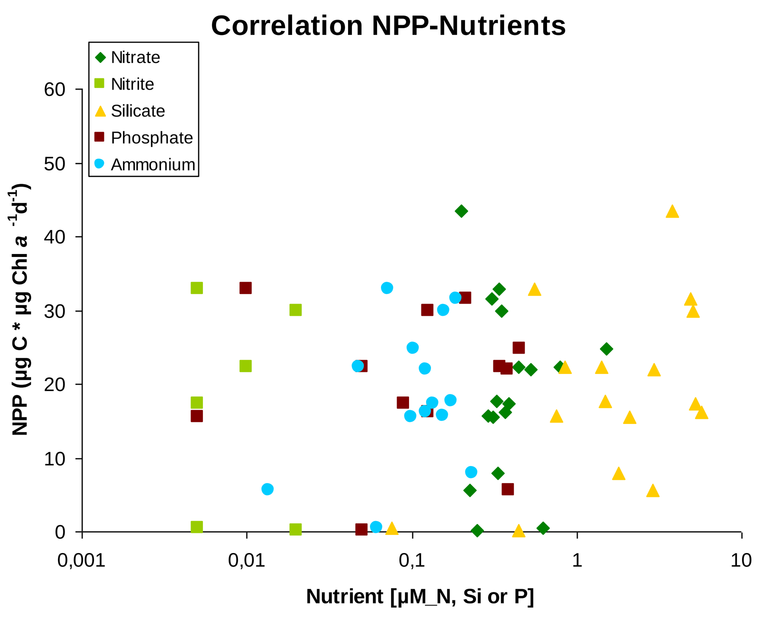


Figure 5. Semi-logaritmic plot showing the correlation between nutrients and NPP- Chl *a* normalised rates in melt ponds of salinities ranging from 0 to 32.

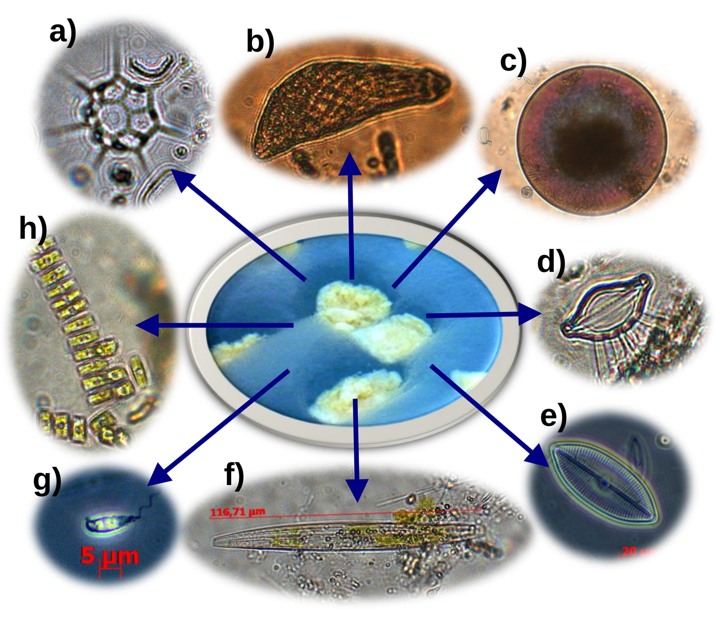


Figure 6. Composition of Melt Pond aggregates found on stations 203, 209 and 212. a) Silicoflagellate b) Ciliate c) Centric diatom d) Spore e) & f) Pennate diatom g) Dinoflagelate h) Chain forming diatom.

Conclusions & Outlook

- Melt Ponds play a so far overlooked role in the Arctic carbon cycle as they host **high NPP rates** in late summer.
- Melt Ponds allow **more light** to reach the Arctic Ocean in ice covered areas.
- NPP variability can not be explained by nutrient concentration.
- High spatial variability makes modelling and up-scaling of NPP estimates for the rapidly changing Arctic challenging.
- Combining methods to find a correlation between biomass, NPP and light in sea ice and melt ponds.
- Determining the limiting factor for NPP with Photosynthesis-Irradiance curves and Nutrient Bioassay experiments.

References

- Lee, S.H. et.al. (2011) Holes in progressively thinning Arctic sea ice lead to new ice algae habitat. *Oceanography* 24(3):302–308

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