

Sea Ice Primary Productivity in the Central Arctic Ocean during summer 2011

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Introduction

Arctic sea ice is a very dynamic environment which is currently suffering a rapid decline in extent and thickness. Besides the phytoplankton in the surface waters, sea ice algae can contribute up to 57% to primary production (Gosselin *et al* 1997), but our knowledge about their activity, especially in the central basins, is still limited.

During the Polarstern summer expedition TransArc 2011 to the Central Arctic, potential Net Primary Productivity rates (NPP) and Chlorophyll *a* were measured in different habitats: surface waters, sea ice and melt ponds; to assess the importance of sea ice algae carbon fixation and biomass compared to phytoplankton and melt pond autotrophs.

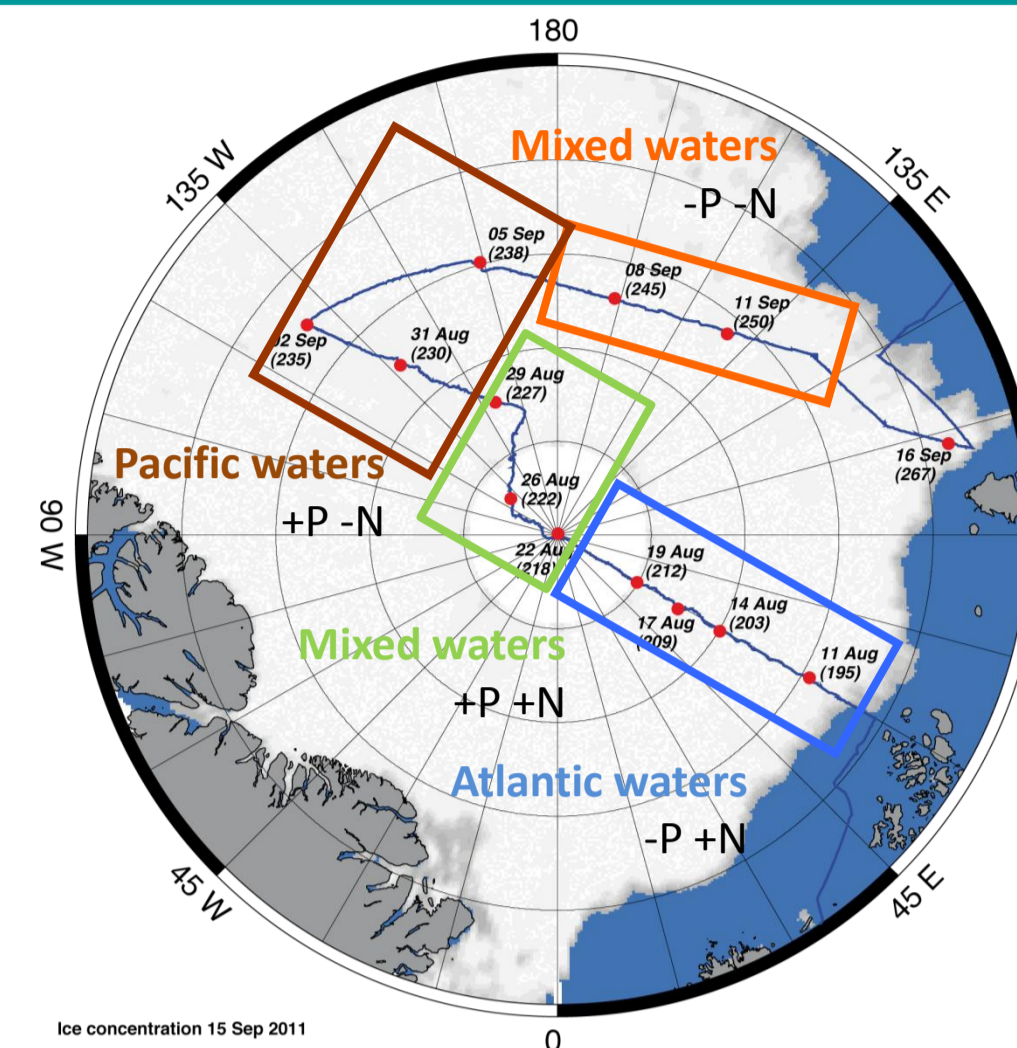


Figure 1. Cruise track (blue line) and ice stations (red dots) (M. Nicolaus). Nutrient provinces (boxes) defined by the differences in Phosphate (P) and Nitrate (N) concentrations (- stands for depleted) (E. Damm).

Methods



Figure 2. Sampling methods: CTD rosette, ice corer and vacuum pump.

Radioactive isotope ¹⁴C-Method

1. 24 h Incubation (10 μE/m² s; Light, -2°C)
2. Filtration 0.2 μm poresize
3. Acidification 6M HCl
4. Liquid scintillation counting

Results

Surface Water

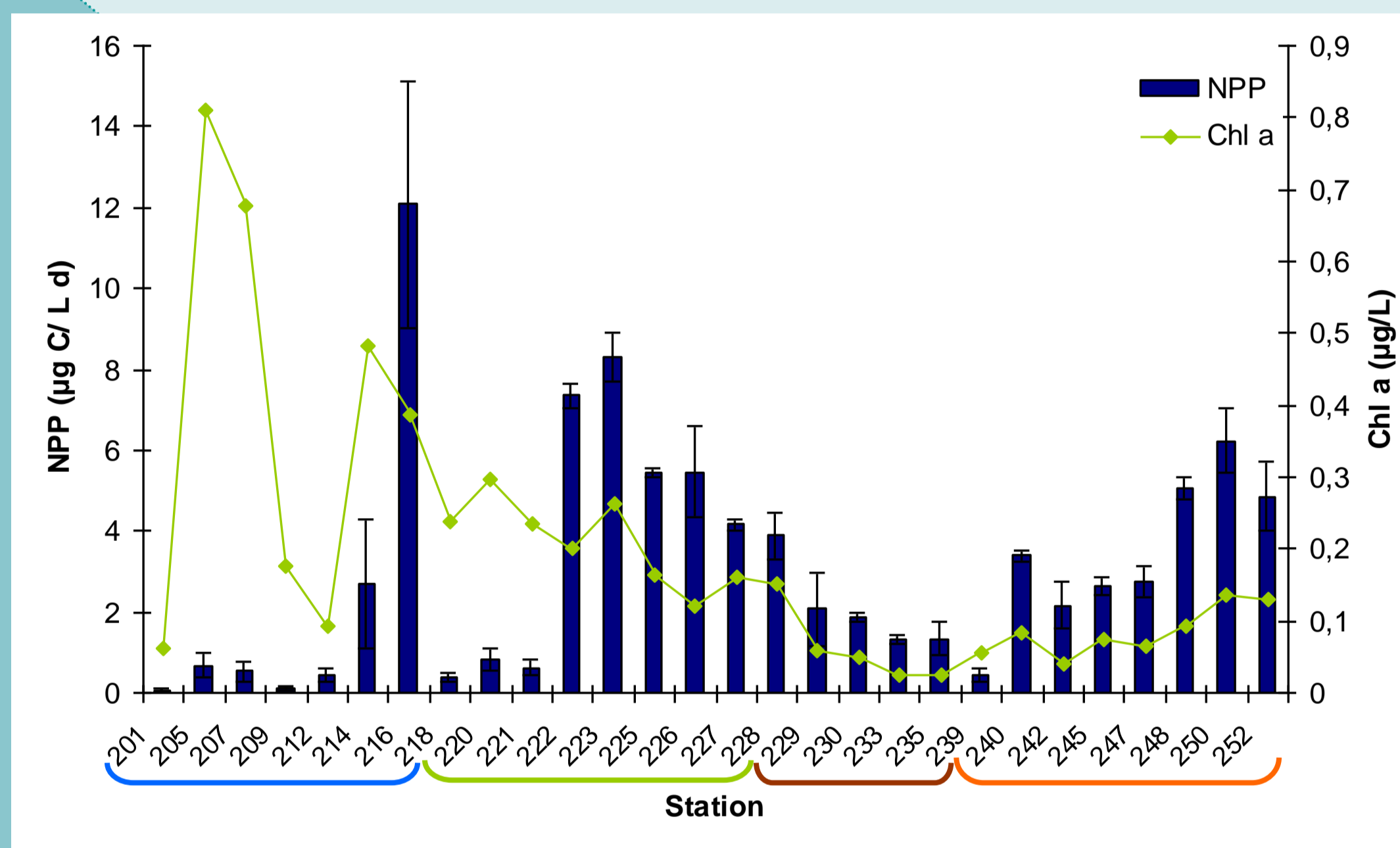


Figure 3. Net primary productivity rates and chlorophyll *a* concentrations in surface water samples (2-5 m depth) from Atlantic to Pacific influenced waters. First stations correspond to early August and the last ones to late September 2011.

Sea Ice

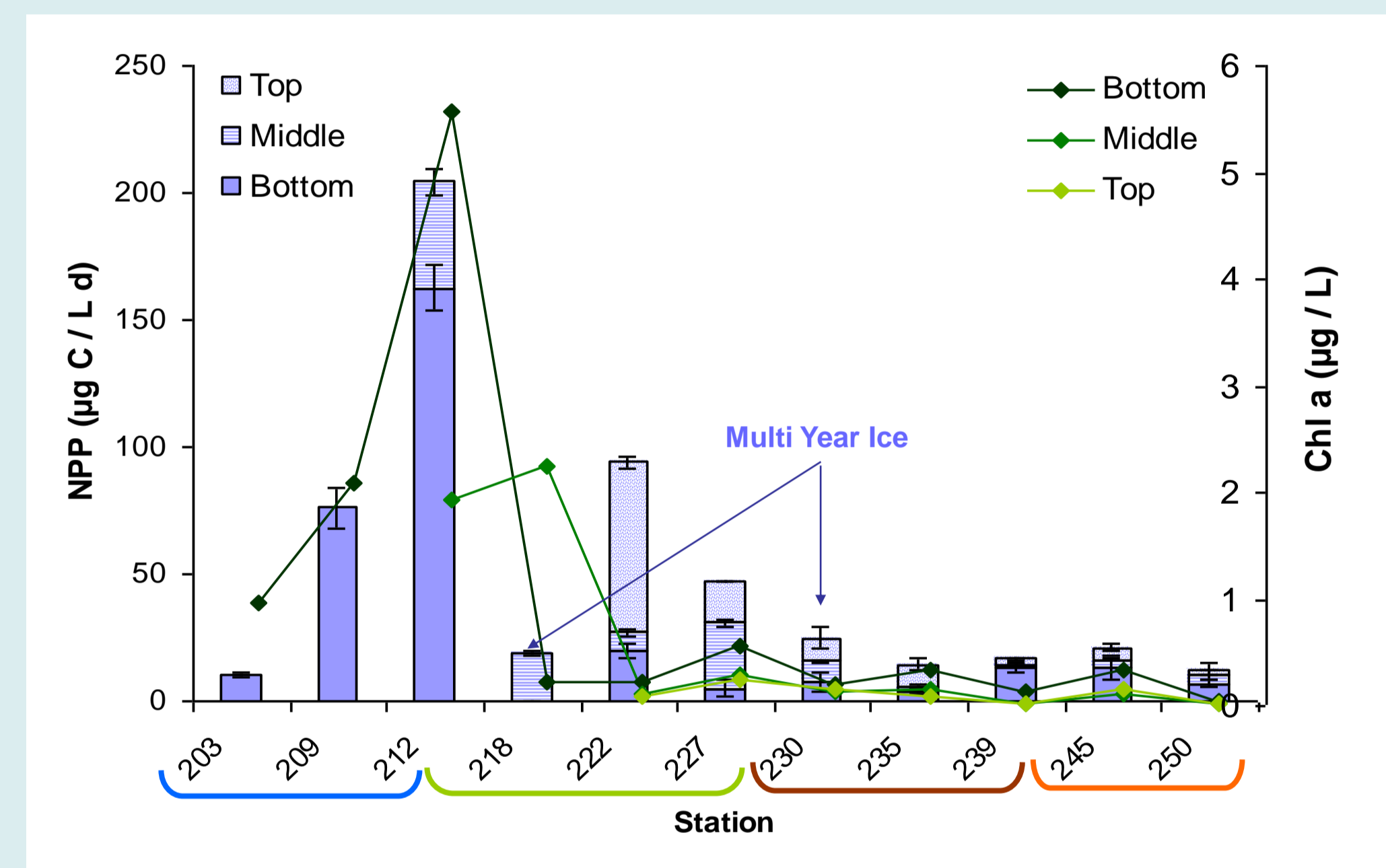


Figure 4. Net primary productivity rates and chlorophyll *a* concentrations of ice cores melted in filtered sea water divided in top, middle and bottom part. Note that in stations 203 and 209, top and middle were not measured.

Melt Ponds

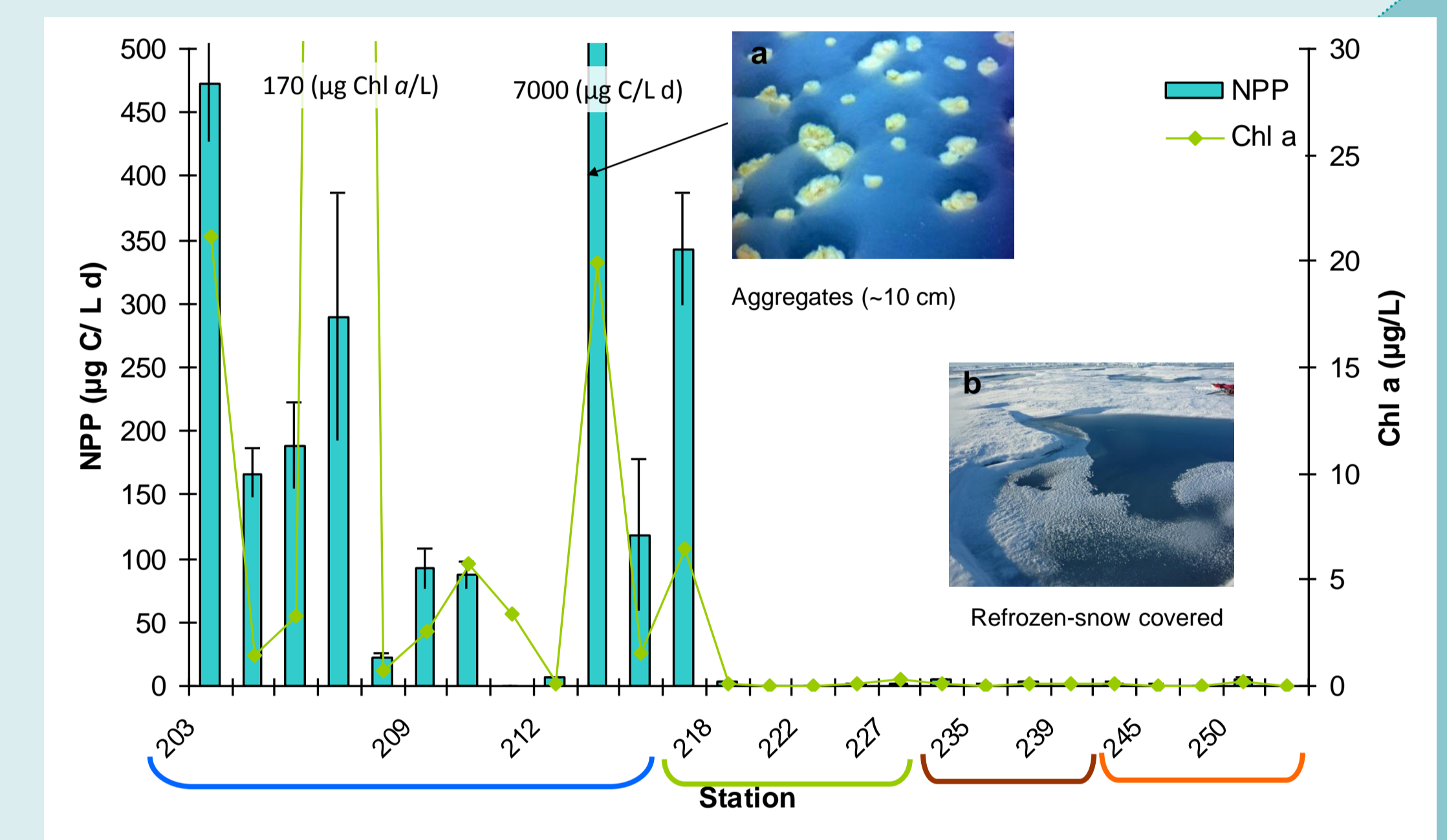


Figure 5. Net primary productivity rates and chlorophyll *a* concentrations of all melt ponds sampled during TransArc. Picture a shows aggregates found in open melt ponds at station 212. Picture b shows an example of refrozen melt pond covered by snow. Note that refreezing started in early september (station 218).

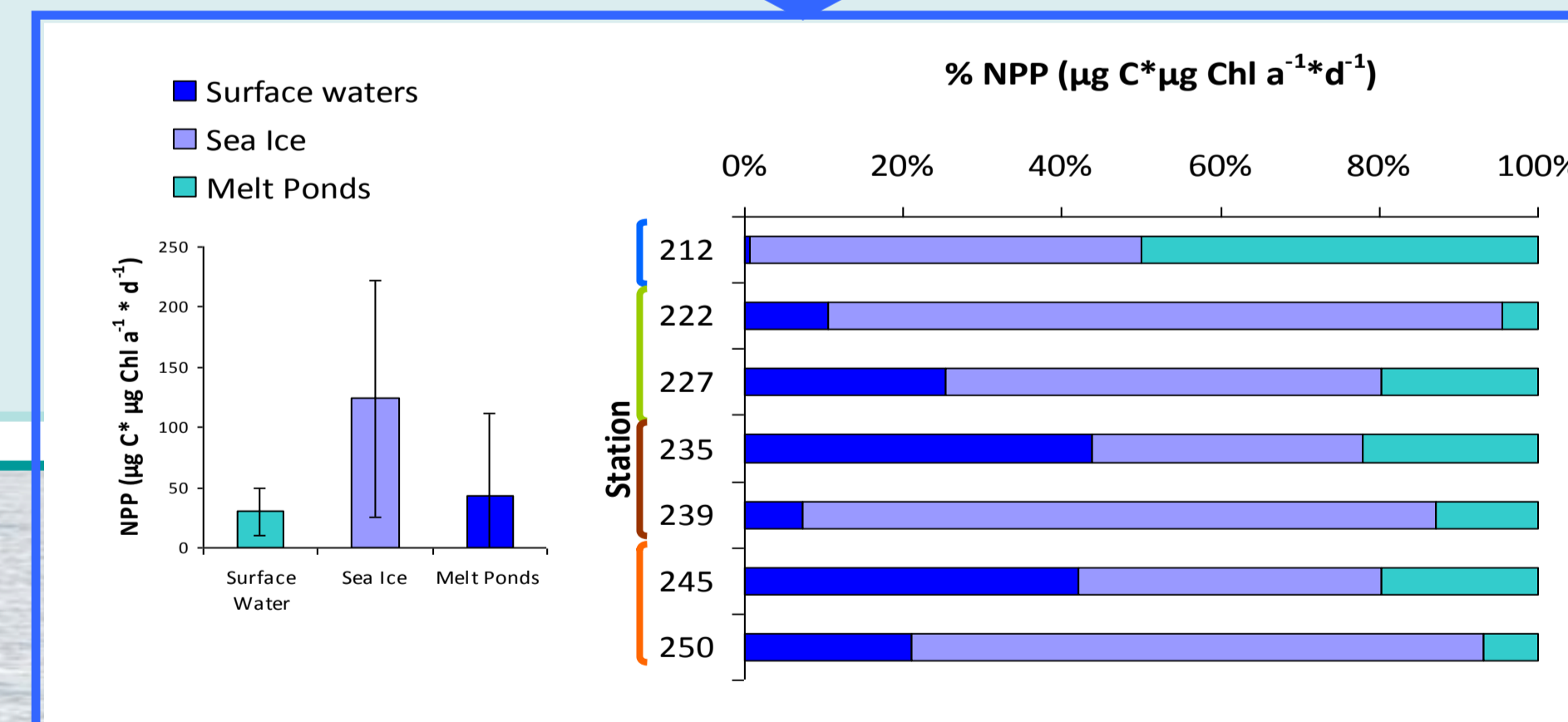


Figure 6. Relative contribution to NPP; Chl *a* normalized rates of the different habitats considering just surface waters, sea ice and melt ponds.

Conclusions

- Sea Ice hosts the most active autotrophs under low light conditions. Nevertheless, when compared to the integrated water column its contribution to the arctic carbon cycle during summer is one order of magnitude lower compared to the water column.
- Melt Pond aggregates sustain the highest productivity rates of all before the re-freezing starts.
- Surface waters from the Atlantic influenced region show high phytoplankton biomass standing stocks but low productivity, while the other regions are characterized by generally low NPP rates compared to sea ice and melt ponds.

Outlook

- Unravel the **limiting factors** for primary productivity in sea ice and surface waters by nutrient bioassays and photosynthesis-irradiance curves.
- **Upscale** primary productivity to the entire Arctic Ocean.
- Reveal the **key groups** responsible for carbon fixation in each habitat.
- Determine the **carbon transfer** rates from melt pond algae to bacteria.

Reference

Gosselin M, Levasseur M, Wheeler M, Horner RA & Booth BC. (1998) New measurements of phytoplankton and ice algal production in the Arctic Ocean. *Deep-Sea Research*. 44(8).

Acknowledgements

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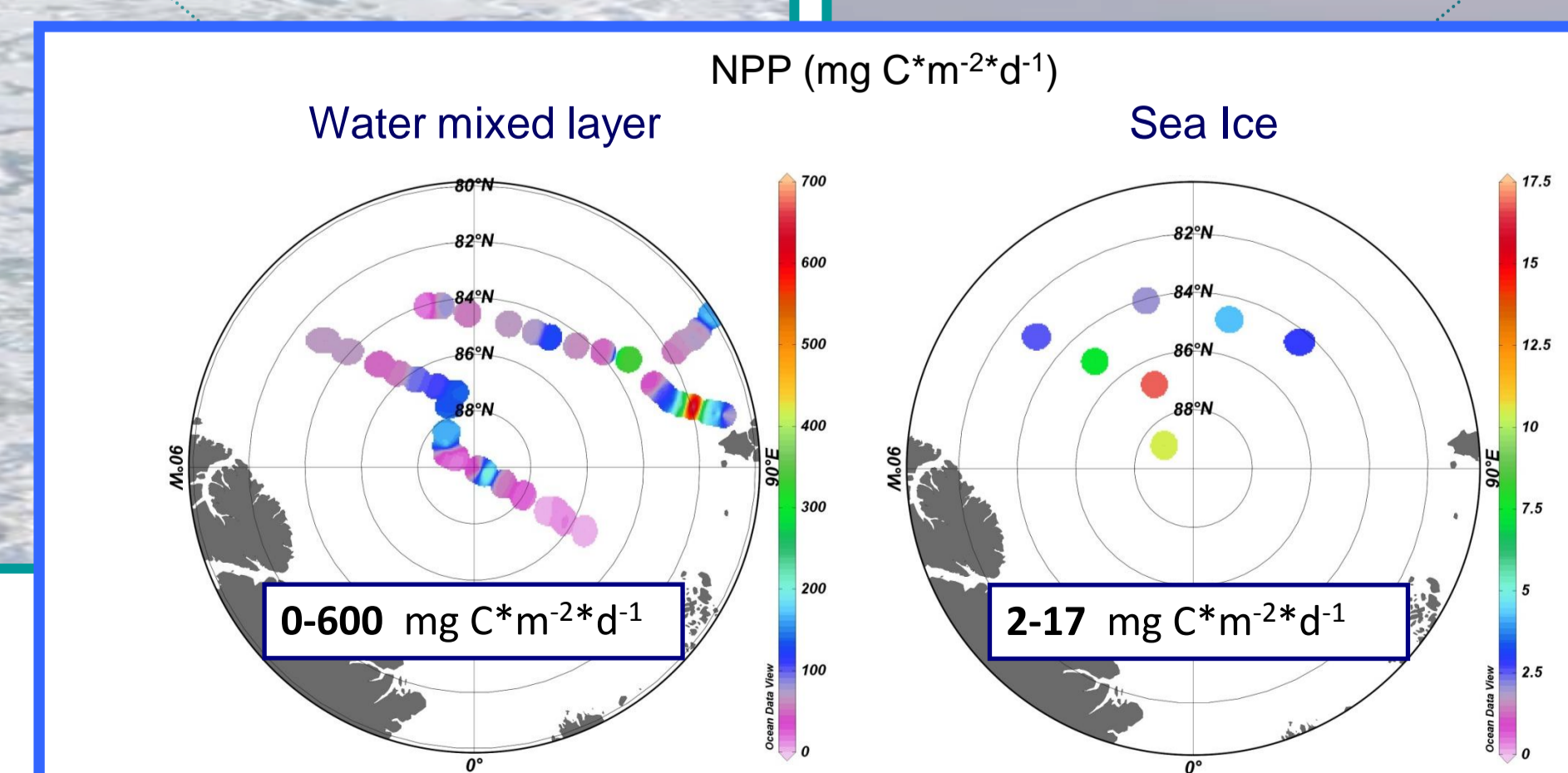


Figure 7. Integrated NPP rates for the euphotic zone assuming similar photosynthetic activity throughout the mixed layer (Mixed Layer Depth: 10 to 50 m) and for the sea ice (Sea Ice thickness: 1 to 3 m). Note that the scales differ by one order of magnitude.