Primary Productivity in sea ice and waters of the central Arctic during summer 2011

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Introduction

Primary Productivity in the central Arctic Ocean

What are the relative contributions to Primary Productivity of the different phototrophic communities in the central Arctic?
Methods

Sampling

Water column

Sea Ice

Melt Ponds

$^{14}$C radioactive isotope

1 $\mu$Ci/ml $^{14}$C

20 ml

Incubation 24 h

Light: 10 $\mu$E/m$^2$ s

Temperature: -1.9 °C

Potential Net Primary Production rate ($\mu$g C L$^{-1}$ d$^{-1}$)
Results TransArc 2011

Circulation in the subsurface and intermediate layers of the Arctic Ocean (Rudels et al. 2011)
Results TransArc 2011

Surface waters

Microscopy pictures by Henrieke Tonkes
Results TransArc 2011

Surface waters

Pacific waters
+P -N

Mixed waters
-P -N

Mixed waters
+P +N

Atlantic waters
-P +N

NPP (µg C · L⁻¹ · d⁻¹)

Ellen Damm

Post-Bloom situation
Results TransArc 2011

Ice

Microscopy pictures by Kristin Hänselmann
Results TransArc 2011

Higher activity in Atlantic region.

Bottom part of the ice is not always the most active.

Atlantic –P +N
Mixed +P +N
Pacific +P-N
Mixed -P-N
Results TransArc 2011

Melt Ponds

Melt pond algae are more active before re-freezing

170 (µg Chl a/L) 7000 (µg C/L d)

Aggregates (~10 cm)
Results TransArc 2011

Biomass normalized rates: carbon uptake per Chl $a$

% NPP ($\mu$g C*$\mu$g Chl $a^{-1}$*d$^{-1}$)

Sea Ice algae contribute the most to NPP activity per Chl $a$

Mar Fernández Méndez
Integrated rates

NPP (mg C m\(^{-2}\) d\(^{-1}\))

Sea ice NPP integrated is one order of magnitude lower as the entire mixed layer.
### Results TransArc 2011

#### Other variables

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>Ice</th>
<th>Melt Ponds</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEP (µg C/L)</td>
<td>0.09 ± 0.03</td>
<td>0.48 ± 0.14</td>
<td>0.11 ± 0.3</td>
</tr>
<tr>
<td>POC (µg C/L)</td>
<td>92 ± 40</td>
<td>1788 ± 1862</td>
<td>7422 ± 20542</td>
</tr>
<tr>
<td>C:N molar ratio</td>
<td>7 ± 1</td>
<td>10 ± 3</td>
<td>11 ± 4</td>
</tr>
<tr>
<td>Nitrate (µM)</td>
<td>0.07 – 3.7</td>
<td>0.07 – 1.6</td>
<td>0.2 – 8.1</td>
</tr>
<tr>
<td>Phosphate (µM)</td>
<td>0.09 – 0.8</td>
<td>0.02 – 0.2</td>
<td>0 – 0.6</td>
</tr>
<tr>
<td>Silicate (µM)</td>
<td>0.7 – 12.2</td>
<td>0.2 – 8.8</td>
<td>0 – 11.8</td>
</tr>
</tbody>
</table>

- Highest concentrations of carbon present in ice and melt ponds.
- C:N ratios in sea ice and melt ponds reflect detritus deposition.
- Nutrient concentrations are lower in the ice.
- Nitrate was never depleted in melt ponds.
Conclusions

- Comparing volumes of sea ice, melt ponds and surface waters, ice algae contribute most of the NPP.

- NPP is not limited to the bottom part of the ice in autumn.

- Before refreezing, melt ponds sustain the highest NPP rates.

- Phytoplankton in surface waters is more active in autumn in Mixed waters probably due to nitrate availability and less grazing.

- Comparing areal potential NPP rates (not considering light and nutrient limitation), sea ice contributes 1:9 of total productivity.
Outlook

- Infer the limiting factors for NPP by performing Photosynthesis-Irradiance curves and Nutrient bioassays.

- Upscaling NPP rates to the entire Arctic.

- Comparing surface water NPP rates with Net Community Production \textit{in situ} measurements with O$_2$/Ar Method (N.Cassar)

- Reveal the key groups responsible for carbon fixation.

- Determine the carbon transfer rates from melt pond algae to bacteria.
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Pacific waters
+P -N

Mixed waters
+P +N

Pacific waters
-P -N

Atlantic waters
-P +N
Results TransArc 2011

Nutrient concentrations in surface waters

Nutrients courtesy of Kai Uwe Ludwischowski
Results TransArc 2011

Surface vs Chl $\alpha$ max

![Graph showing NPP (µg C/L d) and NPP/Chl $\alpha$ (µg C/µg Chl $\alpha$ d) for different stations.](chart.png)
Results TransArc 2011

Water under the ice

Comparison Water under Ice and CTD water

NPP (µg C/L d)

Station

WUI 0
WUI 5
W 5
W ChlaMax
1. Limitation of PP in sea ice algae

Will higher light intensities due to thinner ice boost PP in the ice in summer or will it be limited by nutrient supply?