Patterns of macrozoobenthic production in the deep Arctic Ocean

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Overview

92 stations (1991 – 2012)
Static parameters: abundance & biomass
Dynamic: secondary production

Patterns:
Water depth is main shaping factor; further:
• Regional effect
• Sea ice effect
• Latitudinal effect

Drivers:
Vertical and lateral transport processes
Climate change in the Arctic

- Deep-sea benthos is a good indicator of change.
- How will climate change affect benthic communities?
Benthic secondary production (P)

- Heterotrophic equivalent to primary production (ratio; $J$ or $g C m^{-2} y^{-1}$).
- Dynamic parameter (vs biomass which is static).
- Direct information on energy available as food for next trophic level in the food web (food web models!)

Energy Flow
Patterns of benthos distribution in the Arctic

- Significant decrease of standing stock with increasing water depth.

- Significant correlation of abundance & biomass with latitude (Bluhm et al. 2011).

- Effect of latitude independent from depth?
- Sea Ice effect?
- Regional differences?

\[ N = 253; R^2 = 0.74; p < 0.0001 \]

(unpublished data collection of Brey)
Water depth is the main factor

<table>
<thead>
<tr>
<th></th>
<th>Abundance R²</th>
<th>Biomass R²</th>
<th>Production R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Depth</td>
<td>0.43</td>
<td>0.27</td>
<td>0.32</td>
</tr>
<tr>
<td>Latitude</td>
<td>0.37</td>
<td>0.17</td>
<td>0.19</td>
</tr>
<tr>
<td>Sea Ice</td>
<td>0.22</td>
<td>0.08</td>
<td>0.11</td>
</tr>
</tbody>
</table>

➢ Depth used as co-variable in all following ANCOVA analysis!
Geographical entities differ significantly

**Region (Number of Stations)**
- Makarov Basin (2)
- Lomonosov Ridge (10)
- Amundsen Basin (20)
- Morris Jesup Rise (5)
- Gakkel Ridge (5)
- Nansen Basin (15)
- Fram Strait (4)
- Yermak Plateau (19)
- NW-Spitsbergen (12)

<table>
<thead>
<tr>
<th>ANCOVA</th>
<th>$R^2$</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance</td>
<td>0.69</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.49</td>
<td>0.0001</td>
</tr>
<tr>
<td>Production</td>
<td>0.56</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Latitudinal entities differ significantly.

**Latitude Zone (°N)**
- 88-90 (9)
- 86-88 (23)
- 84-86 (12)
- 82-84 (17)
- 80-82 (19)
- 78-80 (12)

**ANCOVA**

<table>
<thead>
<tr>
<th>Variable</th>
<th>$R^2$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance</td>
<td>0.67</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.44</td>
<td>0.0002</td>
</tr>
<tr>
<td>Production</td>
<td>0.5</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Sea ice zones differ significantly

Sea ice zone
Southern (11)
Marginal Ice Zone MIZ (14)
Northern (67)

Sea ice extent September 2013 (median)

Sea ice extent September (30 years median)

<table>
<thead>
<tr>
<th>ANCOVA</th>
<th>R²</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abundance</td>
<td>0.54</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Biomass</td>
<td>0.31</td>
<td>0.0496</td>
</tr>
<tr>
<td>Production</td>
<td>0.38</td>
<td>0.0173</td>
</tr>
</tbody>
</table>
Production: regional differences are visible

<table>
<thead>
<tr>
<th>Region</th>
<th>Depth (m)</th>
<th>P (mg C m⁻² y⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td>NE-Atlantik</td>
<td>2900</td>
<td>122</td>
</tr>
<tr>
<td>Barents Sea</td>
<td>50-150</td>
<td>200-5300</td>
</tr>
<tr>
<td>Lomonosov Ridge</td>
<td></td>
<td>42 - 130</td>
</tr>
<tr>
<td>Amundsen Basin</td>
<td></td>
<td>0 - 109</td>
</tr>
<tr>
<td>Morris Jesup Rise</td>
<td></td>
<td>4 - 205</td>
</tr>
<tr>
<td>Gakkel Ridge</td>
<td></td>
<td>0 - 12</td>
</tr>
<tr>
<td>Nansen Basin</td>
<td></td>
<td>1 - 1580</td>
</tr>
<tr>
<td>Fram Strait</td>
<td></td>
<td>9 - 70</td>
</tr>
<tr>
<td>Yermak Plateau</td>
<td></td>
<td>9 - 2530</td>
</tr>
<tr>
<td>NW-Spitsbergen</td>
<td></td>
<td>12 – 182</td>
</tr>
</tbody>
</table>
Production: latitudinal trend is visible, but weak

A, B: Tukey’s HSD posthoc test
Production: sea ice effect is visible

A, B: Tukey’s HSD posthoc test
High production in the high flux area MIZ

modified from CAFF report 2010
High production fueled by transport processes

Atlantic Water
Conclusions

- Depth effect
- Sea ice effect
- Latitudinal effect
- Regional effect

Outlook
- Use production data in ecosystem and foodweb models
Acknowledgements

- Captain and crew of RV Polarstern at Arctic expedition 2012
- Graduate school POLMAR

Dataset

- available via the online platform PANGAEA
  (http://doi.pangaea.de/10.1594/PANGAEA.828348)

Thank you for your attention!