The Barents and Chukchi Seas: Comparison of Two Arctic Shelf Ecosystems

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Outline

• Geography and Fisheries
  – Location, Size, and Bathymetry
  – Physical Oceanography
  – Fishery Catches

• Comparisons of Standing Stocks and Productivity
  – Fish, Seabirds, Marine Mammals
  – Zooplankton
  – Nutrients, and Primary Production

• Potential Mechanisms Responsible for Differences in Fish
  – Water Depth and Carbon Export
  – Water Inputs and their Sources
    – Advection of Heat
    – Advection of Plankton
Location Map

Figure from Arrigo et al., 2008
Currents in the Chukchi and Barents Seas

Bering Sea Water - Green
Alaska Coastal Current - Red
Siberian Coastal Current - Blue

Figure from Norwegian Polar Institute
Fishery Catches

Chukchi Sea Catch

Barents Sea Catch

Figures from the Sea Around Us Project
### Primary Production & Nitrate

<table>
<thead>
<tr>
<th></th>
<th>Chukchi Sea</th>
<th>Barents Sea</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Primary Productivity</strong></td>
<td>Min</td>
<td>20</td>
</tr>
<tr>
<td><strong>1998-2006 gC m$^{-2}$ y$^{-1}$</strong></td>
<td>Max</td>
<td>&gt;400</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>100</td>
</tr>
<tr>
<td><strong>Nitrate</strong></td>
<td>ACW AW</td>
<td>5 µMl$^{-1}$</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20-25 µMl$^{-1}$</td>
</tr>
</tbody>
</table>

*(Sources: Primary Production: Sakshaug, 2004; Ellingsen et al., 2008; Walsh et al., 2005; Hill et al., 2005; Lee et al., 2007; Nitrate- Sakshaug 2004; Walsh et al., 2005)*
<table>
<thead>
<tr>
<th>Stock or Production Measured</th>
<th>Barents Sea</th>
<th>Chukchi Sea (area adjusted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fisheries Removals (2010)</td>
<td>$1.0 \times 10^6$ mt y$^{-1}$</td>
<td>$0.0013 \times 10^6$ mt y$^{-1}$</td>
</tr>
<tr>
<td>Fish Stocks (5 most abundant species)</td>
<td>$5.9 \times 10^6$ mt</td>
<td>$0.25 \times 10^6$ mt</td>
</tr>
<tr>
<td>Nesting Seabirds (individuals)</td>
<td>$8.0 \times 10^6$</td>
<td>$4.5 \times 10^6$</td>
</tr>
<tr>
<td>Total Seabirds</td>
<td>$16 \times 10^6 + ??$</td>
<td>$24 \times 10^6$</td>
</tr>
<tr>
<td>Pinnipeds (individuals)</td>
<td>$1.1 \times 10^6$</td>
<td>$2.2 \times 10^6$</td>
</tr>
<tr>
<td>Cetaceans (individuals)</td>
<td>$0.14 \times 10^6$</td>
<td>$0.07 \times 10^6$</td>
</tr>
<tr>
<td>Crustacean Zooplankton (dry biomass)</td>
<td>$6-7$ g m$^{-2}$</td>
<td>$2.1$ g C m$^{-2}$</td>
</tr>
<tr>
<td>Primary Production (model results)</td>
<td>$102$ g C m$^{-2}$y$^{-1}$</td>
<td>$100$ g C m$^{-2}$y$^{-1}$</td>
</tr>
<tr>
<td>Export to Benthos (% total ann. Prim. Prod)</td>
<td>34-47%</td>
<td>56%</td>
</tr>
<tr>
<td>Benthos, overall mean, wet biomass</td>
<td>$166$ g m$^{-2}$</td>
<td>$381$ g m$^{-2}$</td>
</tr>
</tbody>
</table>
Preliminary Findings

• Is the Barents more productive than the Chukchi?
  – Fisheries stocks and catches  YES
  – Marine Birds and Mammals  not clear
  – Primary production  NO

• Possible Mechanisms
  – Orientation of Currents
  – Heat content of advected waters
  – Temperature at the surface and at depth
  – Depth (bathymetric profile)
  – Abundance of zooplankton in advected water
Currents in the Chukchi and Barents Seas

Figure from Norwegian Polar Institute

Bering Sea Water- Green
Alaska Coastal Current- Red
Siberian Coastal Current- Blue
100 m Mean Temperatures (1977-96)

Winter (Feb-April)

Summer (August-October)

Seasonal Changes in Kola 0-200 m average temperature

Source: K. Drinkwater, IMR, Bergen
Bering Strait Temperatures

SST 26 August 2004

Woodgate & Aagaard 2005

Temperatures at 9 m above the bottom
Colors in lower figure coded to moorings at
Woodgate
Areal Distribution by Depth

Figures from Martin Jakobsson, 2002
Zooplankton Biomass

<table>
<thead>
<tr>
<th>Chukchi Sea Water Mass</th>
<th>Chukchi Sea Biomass (gm⁻² dry weight)</th>
<th>Barents Sea Water Mass</th>
<th>Barents Sea 2008 Biomass (gm⁻² dry weight) /SD (number of stations)</th>
<th>Barents Sea 2009 Biomass (g m⁻² dry weight) /SD (number of stations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Water</td>
<td>&lt;0.5</td>
<td>Coastal Water</td>
<td>3.90/2.57 (3)</td>
<td>13.5/9.12 (4)</td>
</tr>
<tr>
<td>Anadyr Water</td>
<td>2-4</td>
<td>Arctic Water</td>
<td>4.52/3.50 (6)</td>
<td>5.34/4.73 (28)</td>
</tr>
<tr>
<td>Bering Shelf Water</td>
<td>0.2-1.2</td>
<td>No. Atlantic Water</td>
<td>8.49/7.01 (41)</td>
<td>7.32/4.21 (73)</td>
</tr>
<tr>
<td>Overall</td>
<td>2.1</td>
<td>Polar Front Water</td>
<td>5.99/2.35 (8)</td>
<td>5.78/6.79 (58)</td>
</tr>
</tbody>
</table>

Barents Sea Data courtesy of P. Dalpadado; Chukchi data from Piatt & Springer, 2003; Hopcroft et al., 2010
Conclusions

- Is the Barents more productive than the Chukchi?
  - Fisheries stocks and catches  YES
  - Marine Birds and Mammals  not clear
  - Primary production  NO

- Possible Mechanisms
  - Orientation of Currents:  Chukchi- N/S; Barents- E/W
  - Heat content of advected waters:  Chukchi-cold; Barents- Warm
  - Temperature at the surface and at depth:  Warmer in So. Barents and at depth in north
  - Depth (bathymetric profile):  Chukchi much shallower
  - Abundance of zooplankton in advected water:  Barents richer, available earlier in spring; also from north