Zooplankton community changes on the Canadian northwest Atlantic continental shelves during recent warm years

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Zooplankton community structure and change

Marine zooplankton community structure is an **emergent property** of interactions among

- Upstream supply: circulation and species composition and abundance
- Transport pathways
- Vertical migration behavior
- Time and space varying production, growth, and development
- Time and space varying mortality
Presentation Objectives

Characterize dominant patterns in the Canadian NW Atlantic shelf zooplankton community and response to recent environmental changes

**Canadian NW Atlantic shelf zooplankton community**
- 1999-2011 copepod community composition
- 1999-2011 zooplankton community spatial pattern
- Temperature trends
- Changes in dominant taxa and groups in the 2010s

**Scotian Shelf region copepod community**
- Changes in diversity
- Changes in rank abundance and biomass
Sections sampled 2X / year since 1999

- Vertical ring net
  - ¾ m diameter
  - 200 μm mesh
  - Towed from near-bottom or 1000 m to surface

- CTD and rosette
  - Temperature, salinity, oxygen, nutrients, chlorophyll…

High frequency stations sampled 1-2X / month
Northwest Atlantic shelf system

Copepods were divided into dominant, subdominant, uncommon, and rare taxa based on occurrence and relative abundance thresholds.

- Dominants (3) are ubiquitous.
- Distributions of 12 subdominants show habitat associations, e.g.,
  - shallow banks
  - deep shelf water
  and latitudinal gradients.
- Many of the 20 uncommon taxa are associated with marginal habitats:
  - slope water
  - nearshore
  - deep water
Rank biomass of dominant and subdominant copepods plus large, uncommon species *Paraeuchaeta norvegica*, 1999-2011

- *Calanus* species were biomass dominants
- *P. norvegica* was also in the top four copepods ranked by biomass
- Small-sized dominant copepods make up a small fraction of community biomass despite their high abundance
Spatial zooplankton community pattern, 1999-2011

• The dominant mode of community spatial variation in both spring and fall is associated with depth – shallow and shelf community vs. deep-water and offshore species

• Influence of fall slope water intrusion is evident on the western Scotian Shelf

• The second mode of community spatial variation reflects latitudinal (fall) or along-shelf (spring) environmental gradients

## Canadian northwest Atlantic temperature anomaly trends

### Sea Surface Temp.

<table>
<thead>
<tr>
<th>Location</th>
<th>1980</th>
<th>1981</th>
<th>...</th>
<th>2016</th>
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<tbody>
<tr>
<td>Labrador</td>
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<tr>
<td>Newfoundland Shelves</td>
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<tr>
<td>Scotian Shelf</td>
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<tr>
<td>E. Gulf of Maine</td>
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### Bottom Temp.

<table>
<thead>
<tr>
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<th>1981</th>
<th>...</th>
<th>2016</th>
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### Anomaly (SD)

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<th>Year</th>
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<tr>
<td>1980</td>
<td>-3</td>
</tr>
<tr>
<td>1981</td>
<td>-2.5</td>
</tr>
<tr>
<td>1982</td>
<td>-2</td>
</tr>
</tbody>
</table>

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Abundance anomalies in dominant NW Atlantic taxa and groups

<table>
<thead>
<tr>
<th>N</th>
<th>Labrador Newfoundland Shelves</th>
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<tbody>
<tr>
<td></td>
<td>Gulf of St. Lawrence</td>
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<tr>
<td>S</td>
<td>Scotian Shelf Eastern Gulf of Maine</td>
</tr>
</tbody>
</table>

**Copepods**

- **Calanus finmarchicus**
- **Pseudocalanus spp.**
- **Non-copepods**

Central Scotian Shelf (Halifax-2) copepod richness and evenness

Species Richness

Evenness

Mean: 7.27

Mean: 0.652

Correlation with environmental metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>p</th>
<th>r²</th>
</tr>
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<tbody>
<tr>
<td>Temperature (0-50 m)</td>
<td>&lt;0.001</td>
<td>0.647</td>
</tr>
<tr>
<td>Bottom temperature</td>
<td>&lt;0.001</td>
<td>0.541</td>
</tr>
<tr>
<td>Stratification</td>
<td>0.057</td>
<td>0.196</td>
</tr>
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</table>

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<tbody>
<tr>
<td>Temperature (0-50 m)</td>
<td>0.0014</td>
<td>0.457</td>
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<tr>
<td>Bottom temperature</td>
<td>&lt;0.001</td>
<td>0.515</td>
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<tr>
<td>Stratification</td>
<td>0.012</td>
<td>0.319</td>
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</table>

Richness and evenness metrics based on adult copepods
Changes in Scotian Shelf copepod rank **abundance** (top 95%) between 1999-2010 and 2011-2017

- Abundance of dominant species has declined
- Moderate changes in rank order in both seasons

**New to top 95%**
- Clausocalanus
- Metridia

**Spring**

**Fall**
Changes in Scotian Shelf copepod rank **biomass** (top 99%) between 1999-2010 and 2011-2017

- Biomass of dominant species has declined
- *Calanus* species retain top two ranks in both seasons

**Spring**

- New to top 99%
  - 10 *O. atlantica*

**Fall**

- New to top 99%
  - 6 *Centropages*
  - 15 *Oithona*
  - 16 *Mecynocera clausi*
Conclusions

• The Canadian NW Atlantic shelf copepod community exhibits relatively strong, recurring annual and spatial variability patterns.

• Abundances of dominant species and groups have shown persistent, large scale changes on the NW Atlantic shelves since about 2010-2012.

• On the Scotian Shelf in the 2010s, the copepod community shifted toward:
  - Lower abundance and biomass of dominant species, especially *Calanus*
  - Higher species richness and evenness
  - Moderate changes in rank abundance
  - Moderate changes in rank biomass
Implications of recent warm conditions

• Abundances of regional “immigrant” species are strongly related to shifts in water mass contributions.
  -e.g. Arctic *Calanus* vs. warm-water offshore copepods on Scotian Shelf
• *Calanus* species responses are more complex – although a decline was observed, interactions of diapause timing and vertical migration with shelf circulation and spring bloom timing may mitigate impact of warming in some areas.
• Shifts in the developmental stage ratios of some small copepod species suggest changes in timing of seasonal production cycle.
• Community changes suggest a potential shift in energy pathways for primary production in recent warm years, with production possibly consumed by smaller copepods and greater transport to deep water.
Thank you for your attention