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

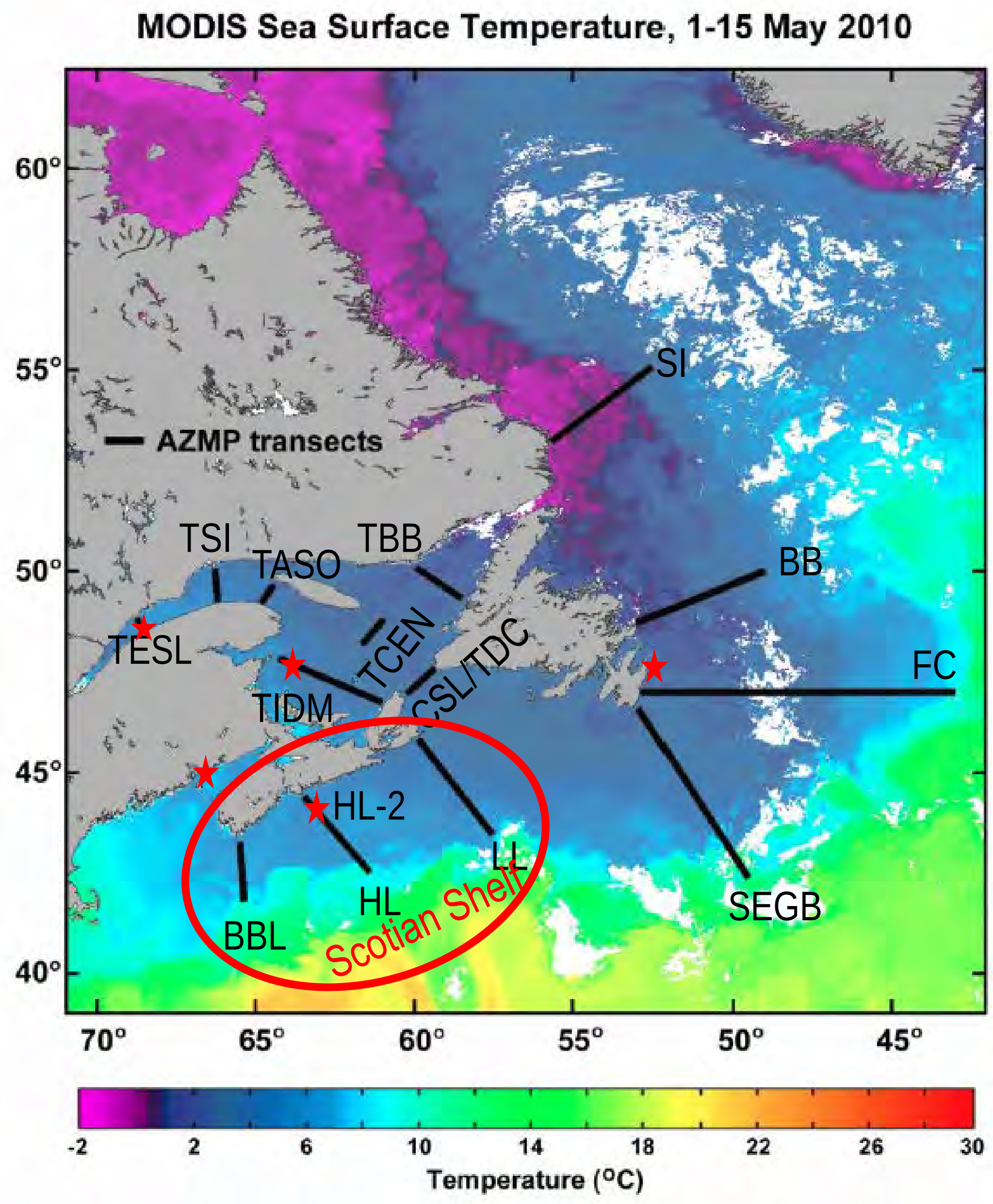
Canadian NW Atlantic shelf zooplankton community

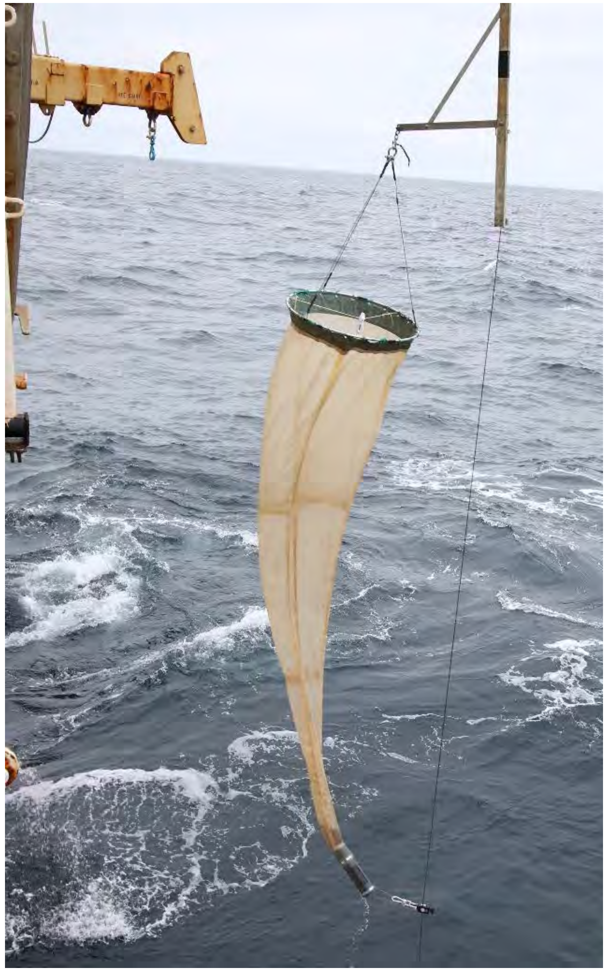
- 1999-2011 copepod community composition
- 1999-2011 zooplankton community spatial pattern
- Temperature trends
- Changes in dominant taxa and groups in the 2010s

Scotian Shelf region copepod community

- Changes in diversity
- Changes in rank abundance and biomass

Atlantic Zone Monitoring Program Domain





Vertical ring net

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

CTD and rosette

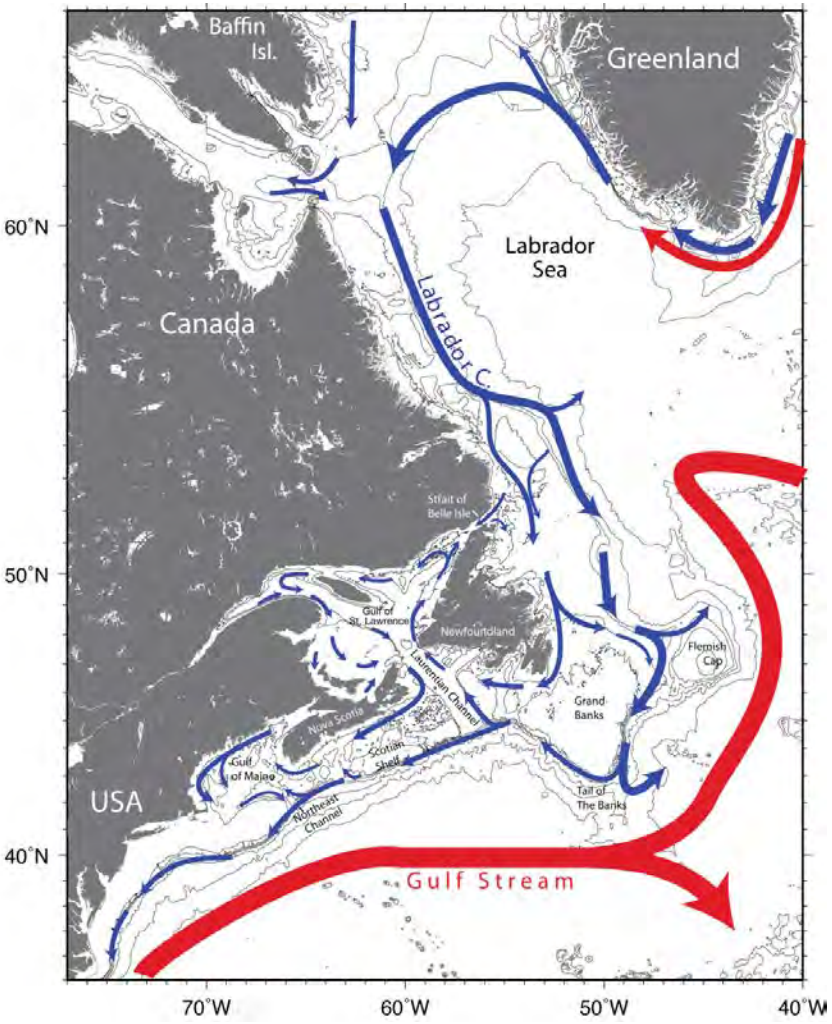
- Temperature, salinity, oxygen, nutrients, chlorophyll…

▬ Sections sampled 2X / year since 1999

★ High frequency stations sampled 1-2X / month

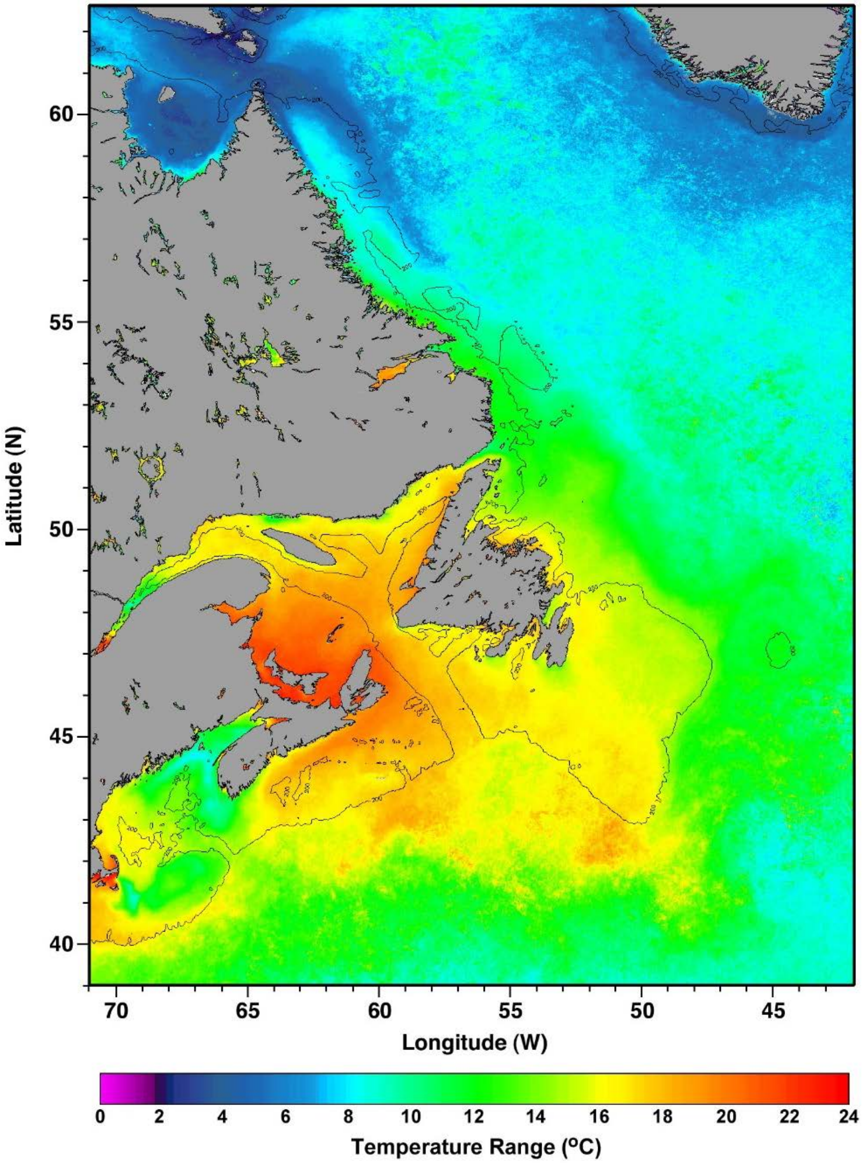
Northwest Atlantic shelf system

NW Atlantic circulation



Schematic circulation based on **Fratantoni & MacCartney** (2010) Deep-Sea Res. 57: 258-283; **Hannah et al.** (2001) J. Phys. Oceangr. 31: 591-615; **Drinkwater & Gilbert** (2004) J. NW Atl. Fish. Org. 34: 85-101.

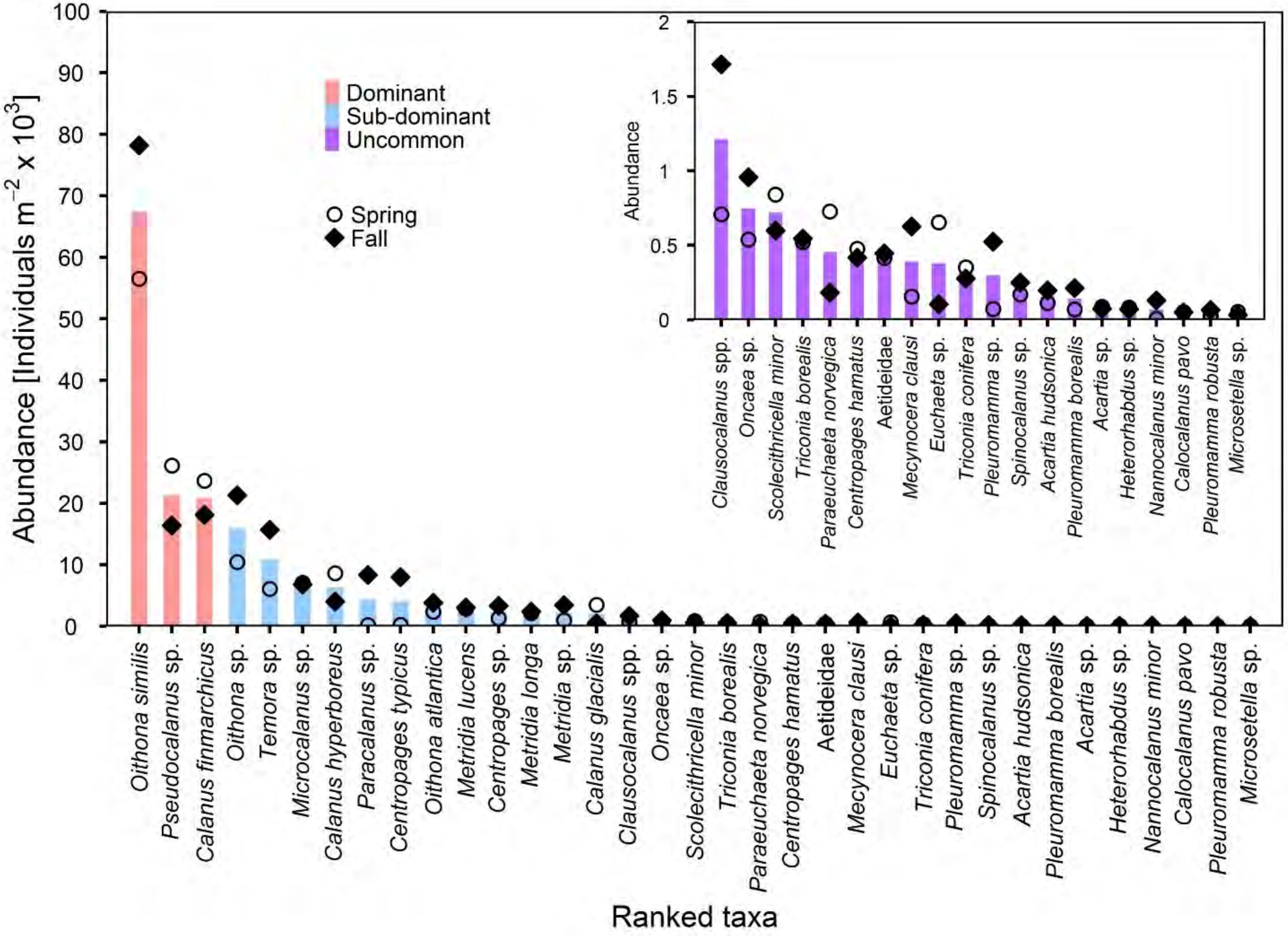
Annual range of surface temperature



Rank abundance of NW Atlantic shelf copepods, 1999-2011

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

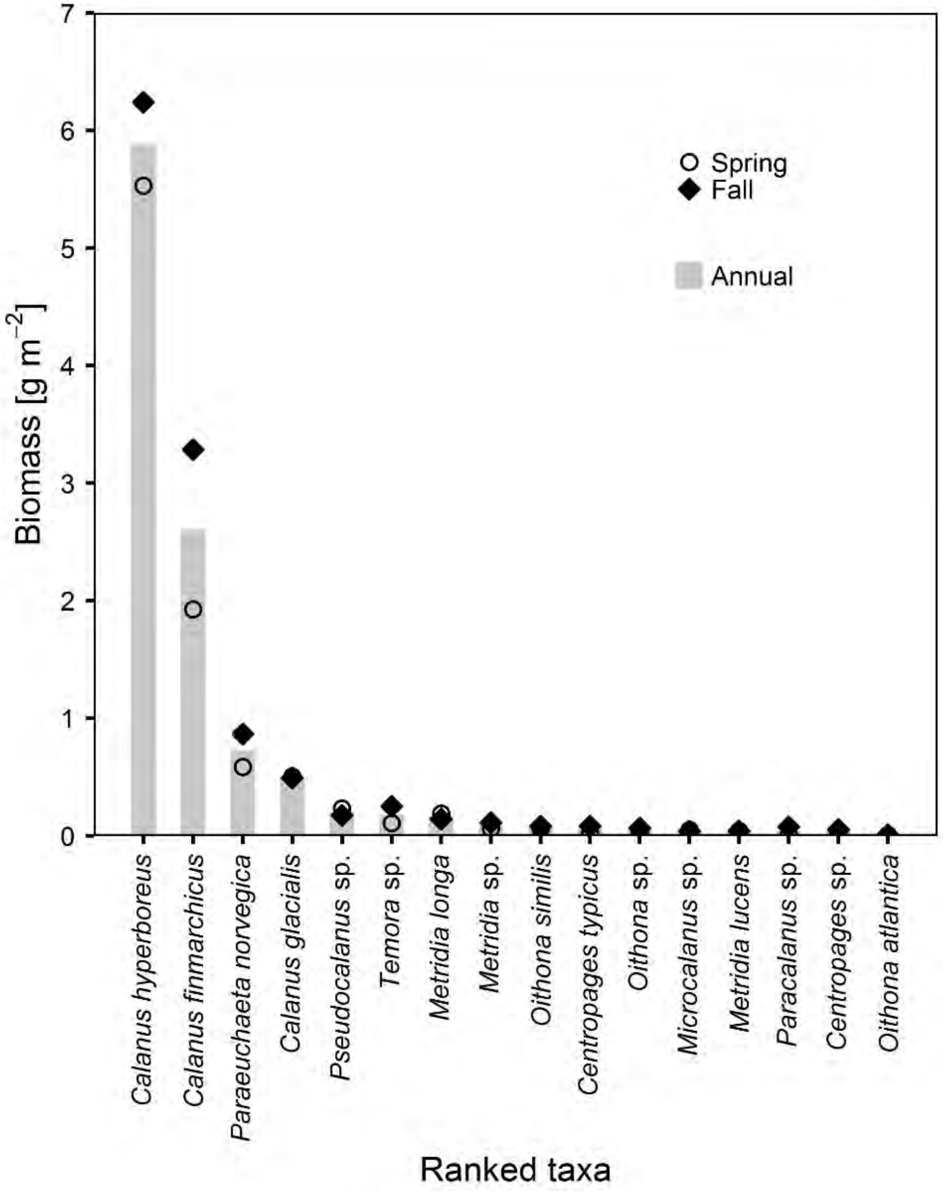
- Dominants (3) are **ubiquitous**
- Distributions of 12 subdominants show **habitat associations**, *e.g.*,
  -shallow banks
  -deep shelf water
  and **latitudinal gradients**
- Many of the 20 uncommon taxa are associated with **marginal habitats**:
  -slope water
  -nearshore
  -deep water



Johnson, Pepin, Casault, Harvey (in prep.)
NW Atlantic zooplankton atlas

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



Copepod biomass estimated from published length and length-dry weight relationships

Johnson, Pepin, Casault, Harvey (in prep.)
NW Atlantic zooplankton atlas

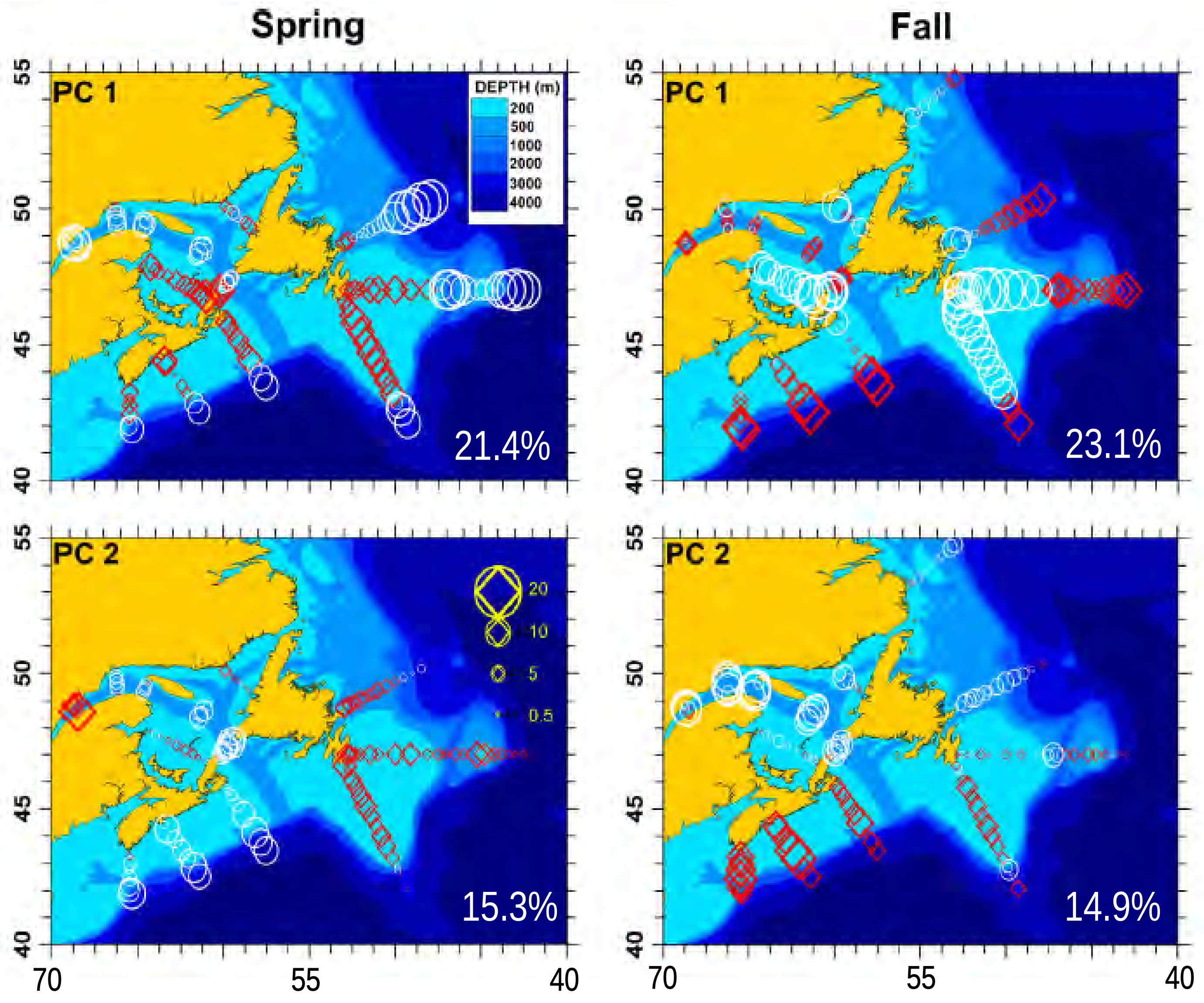
Spatial zooplankton community pattern, 1999-2011

- 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

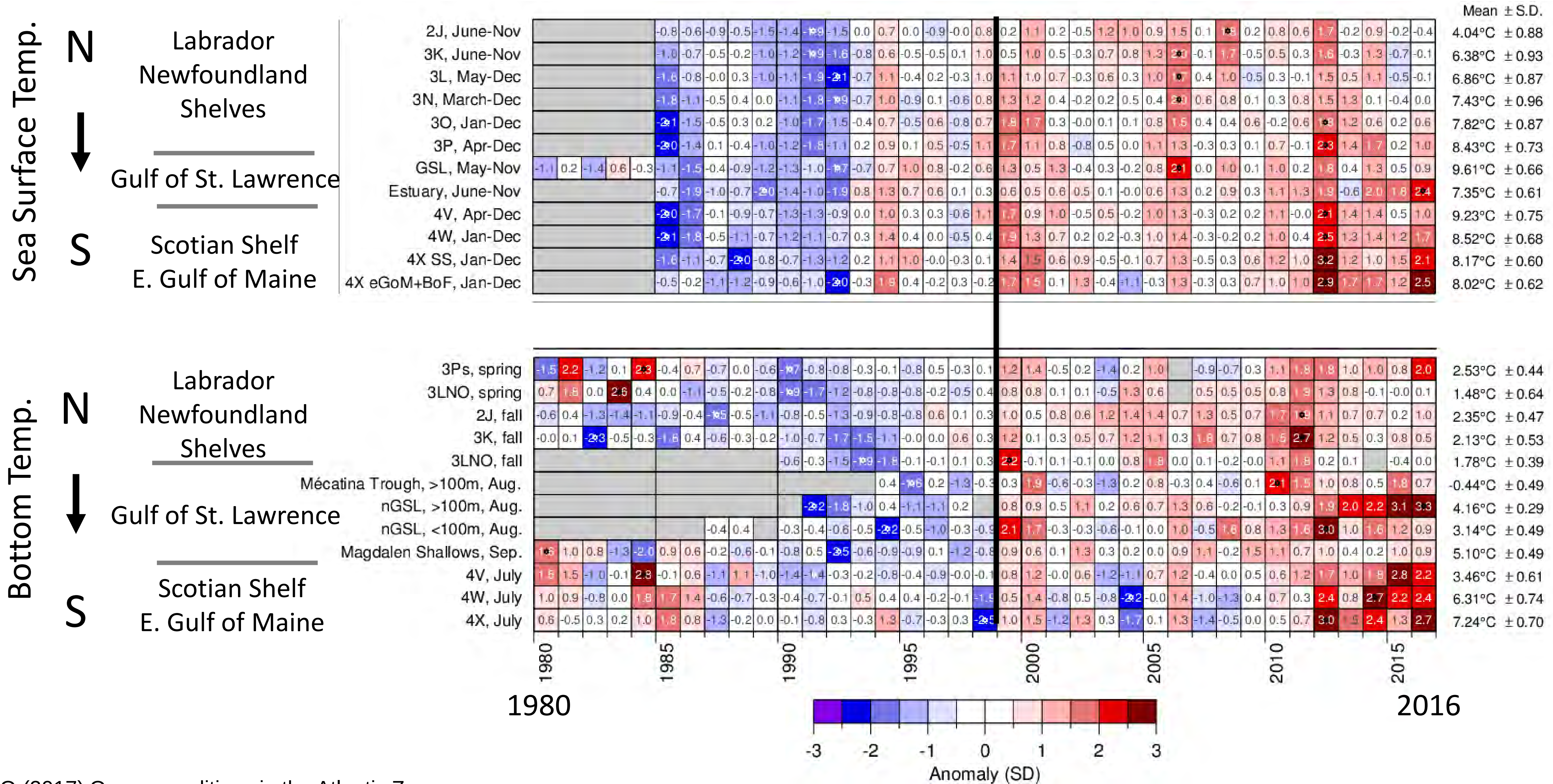
- The second mode of community spatial variation reflects latitudinal (fall) or along-shelf (spring) environmental gradients

Principal component analysis of zooplankton community composition



Pepin, Johnson, Harvey, et al. (2015) A multivariate evaluation of environmental effects on zooplankton community structure in the western North Atlantic Progr. Oceanogr. 134:197-220

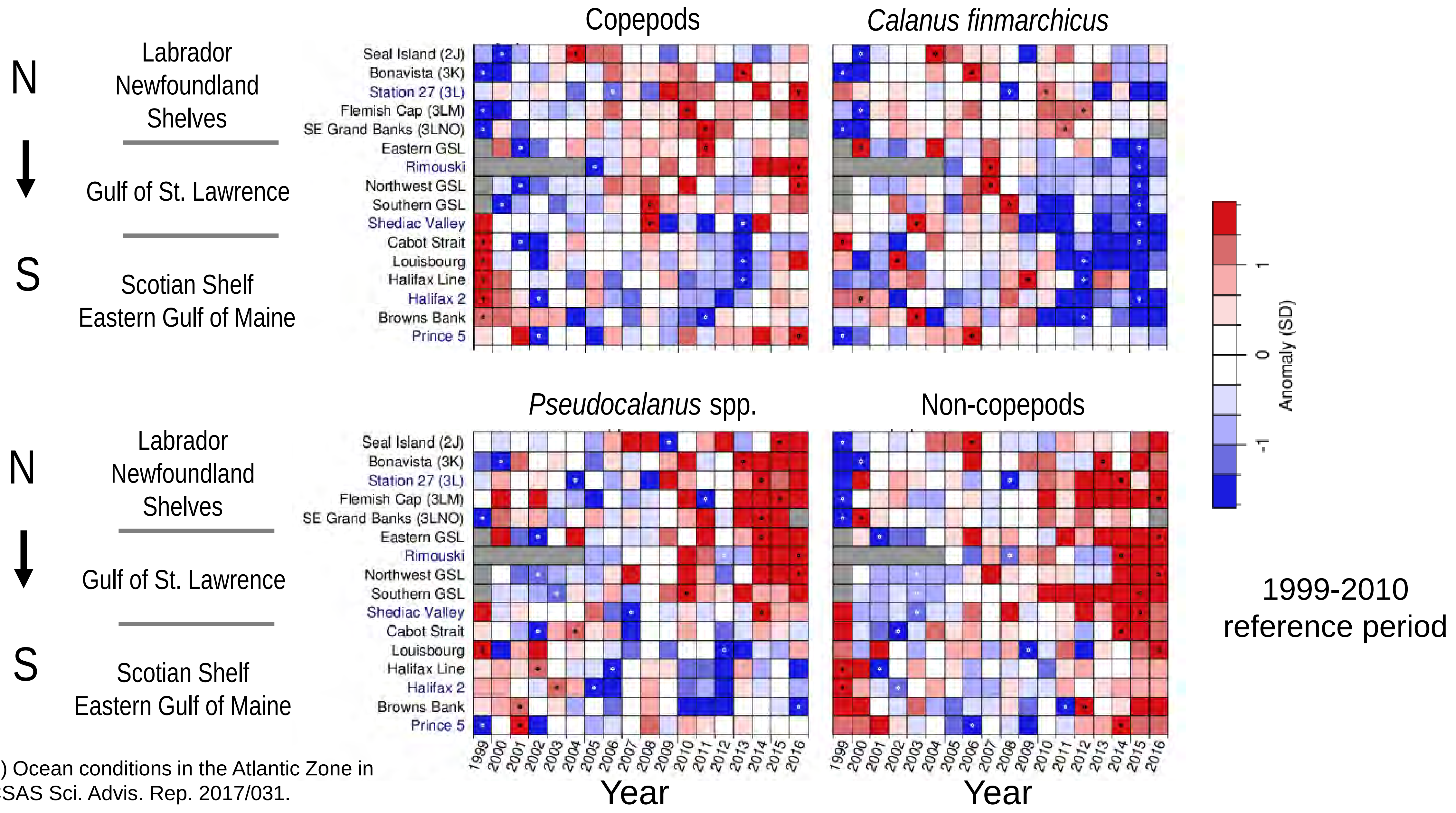
Canadian northwest Atlantic temperature anomaly trends



Standard anomalies (1981 - 2010 reference period)

DFO (2017) Ocean conditions in the Atlantic Zone in 2016. CSAS Sci. Advis. Rep. 2017/031

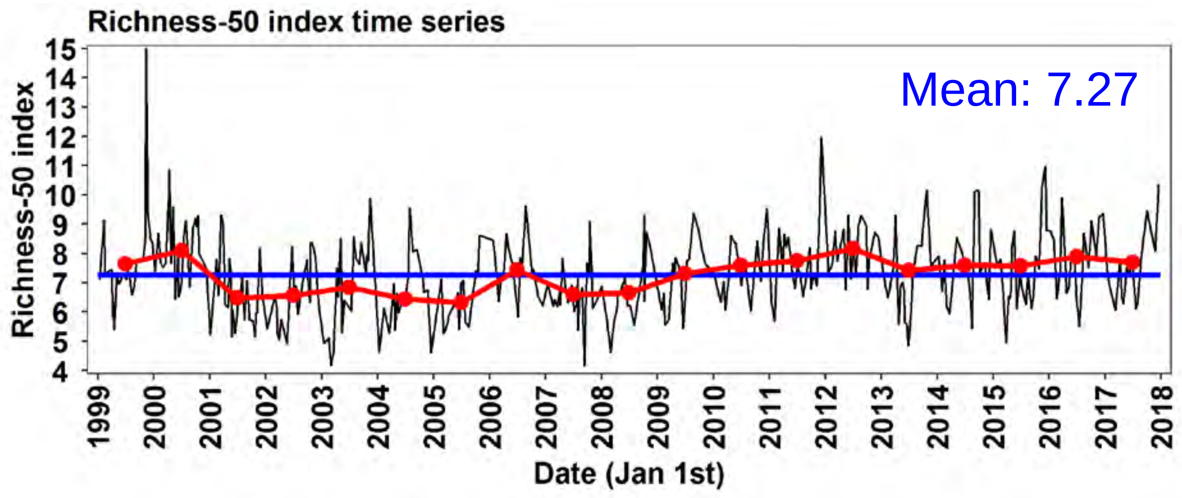
Abundance anomalies in dominant NW Atlantic taxa and groups



DFO (2017) Ocean conditions in the Atlantic Zone in 2016. CSAS Sci. Advis. Rep. 2017/031.

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

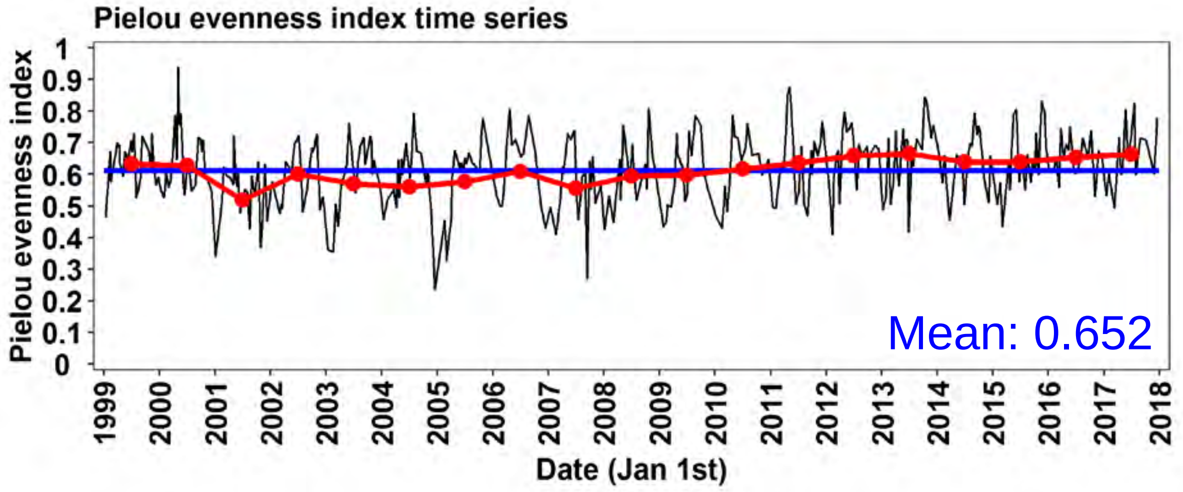
Species Richness



Correlation with environmental metrics

Metric	p	r^2
Temperature (0-50 m)	<0.001	0.647
Bottom temperature	<0.001	0.541
Stratification	0.057	0.196

Evenness



Correlation with environmental metrics

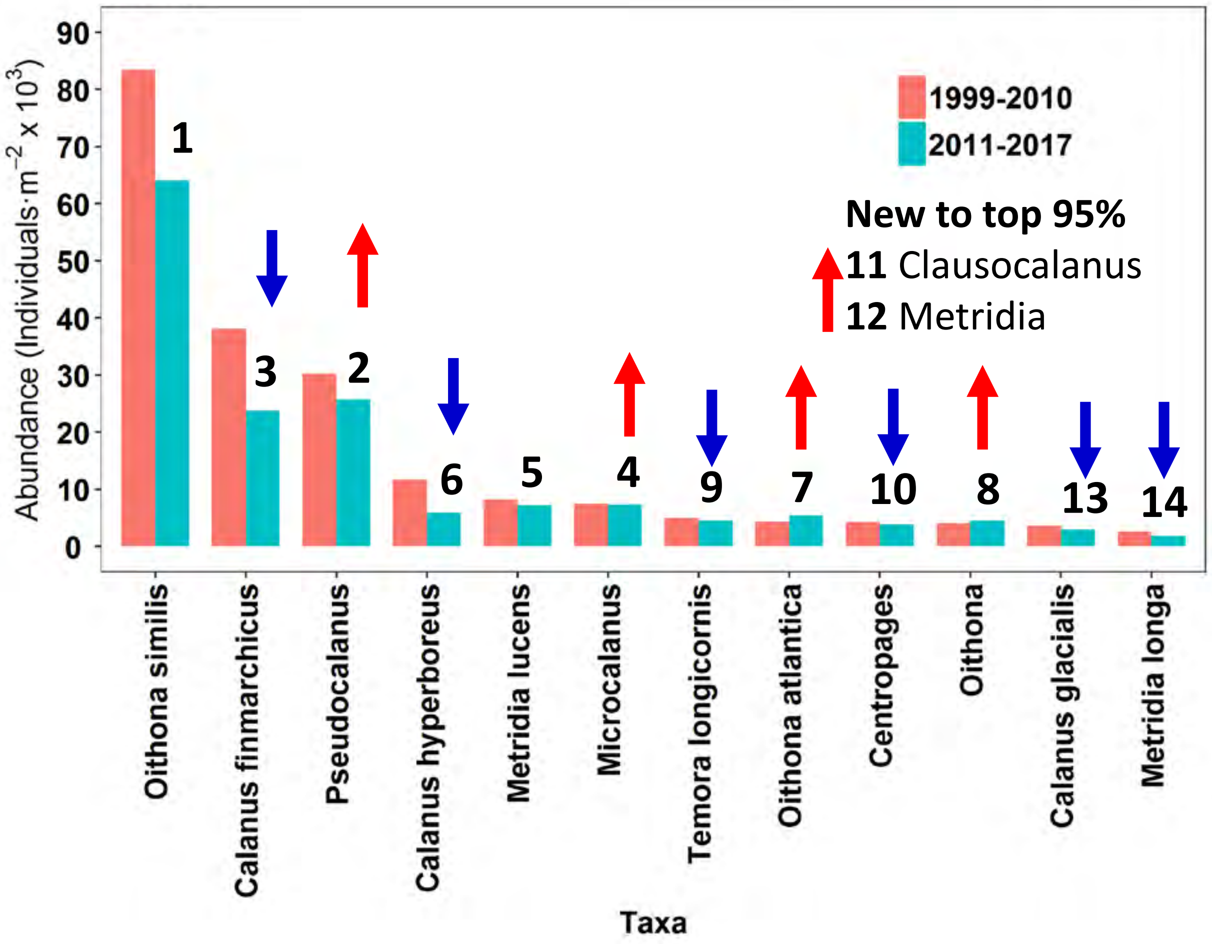
Metric	p	r^2
Temperature (0-50 m)	0.0014	0.457
Bottom temperature	<0.001	0.515
Stratification	0.012	0.319

Richness and evenness metrics based on adult copepods

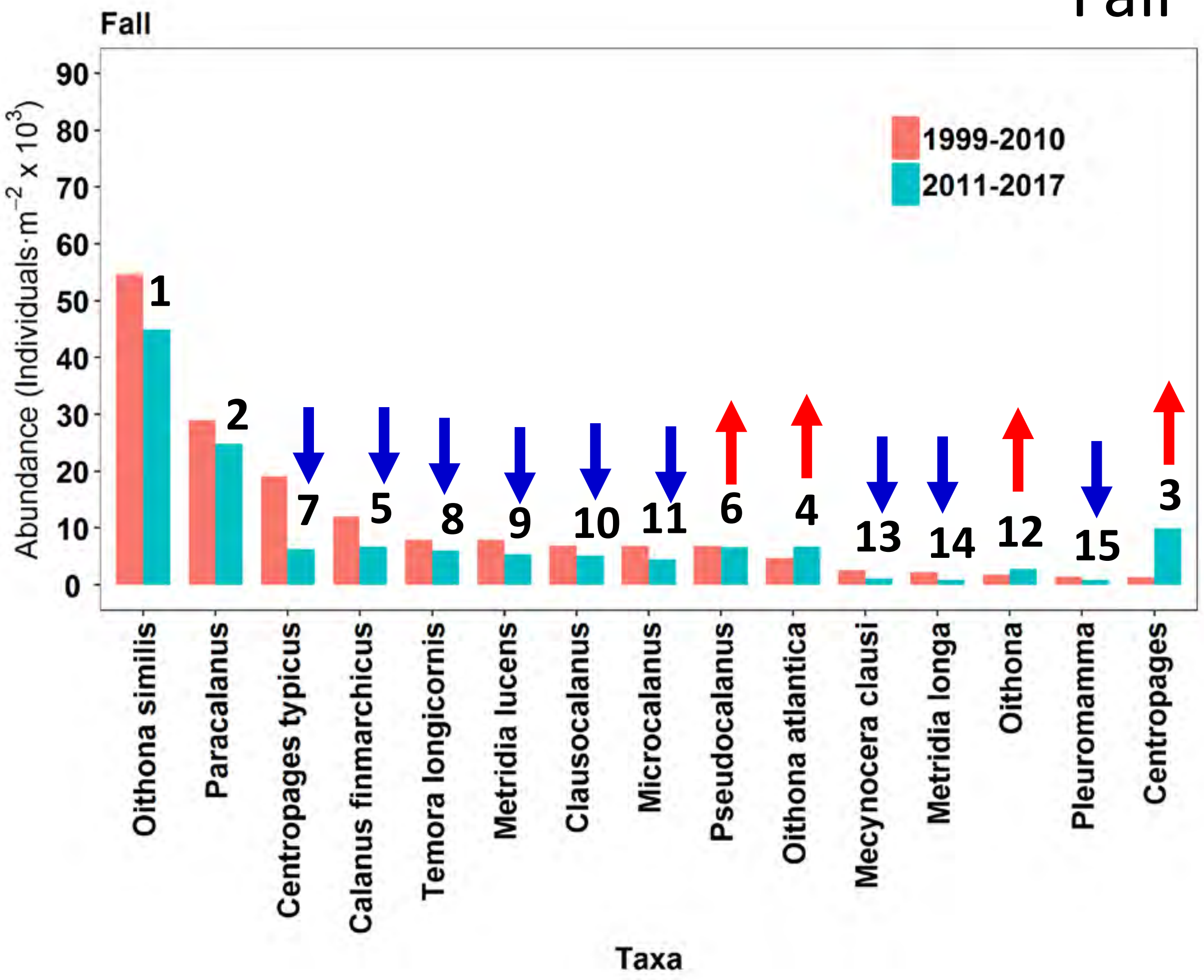
Changes in Scotian Shelf copepod rank **abundance** (top 95%) between 1999-2010 and 2011-2017

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

Spring



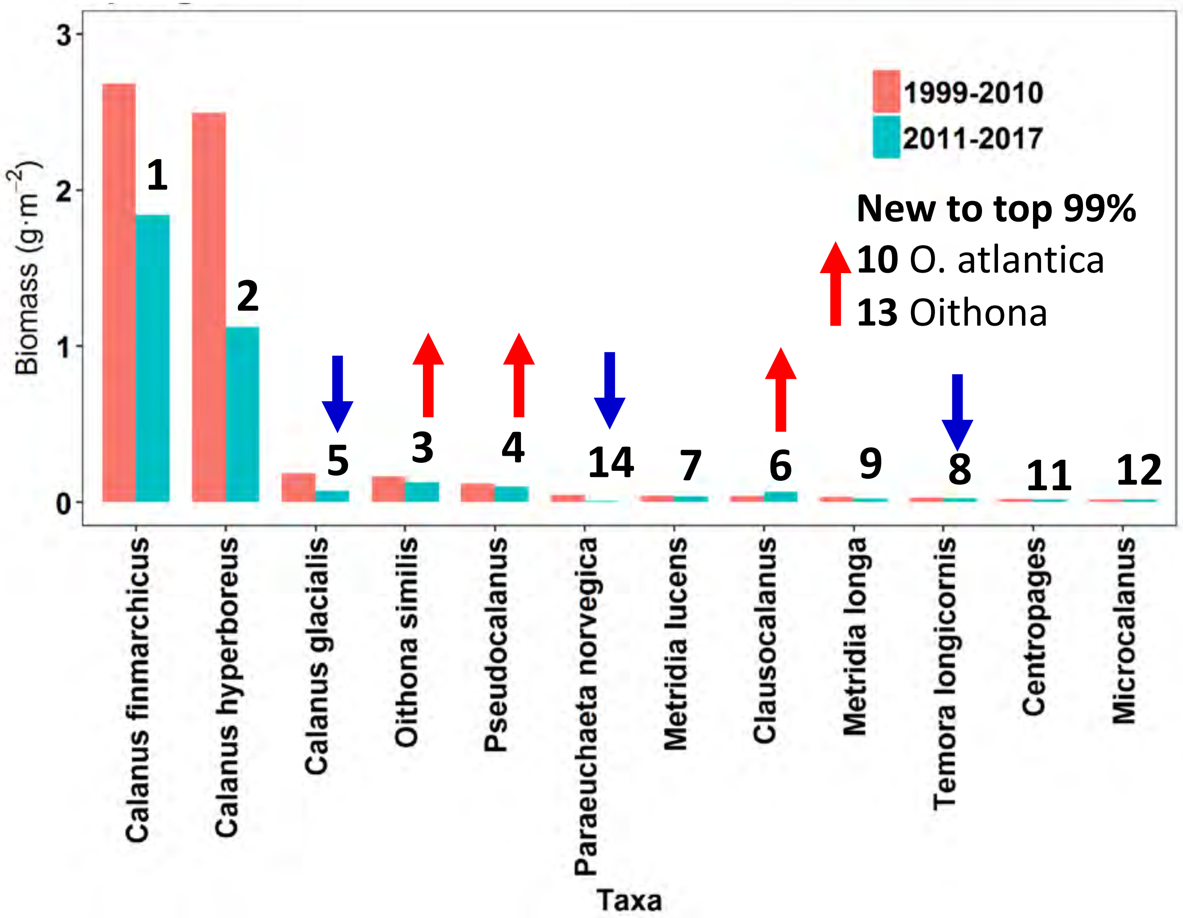
Fall



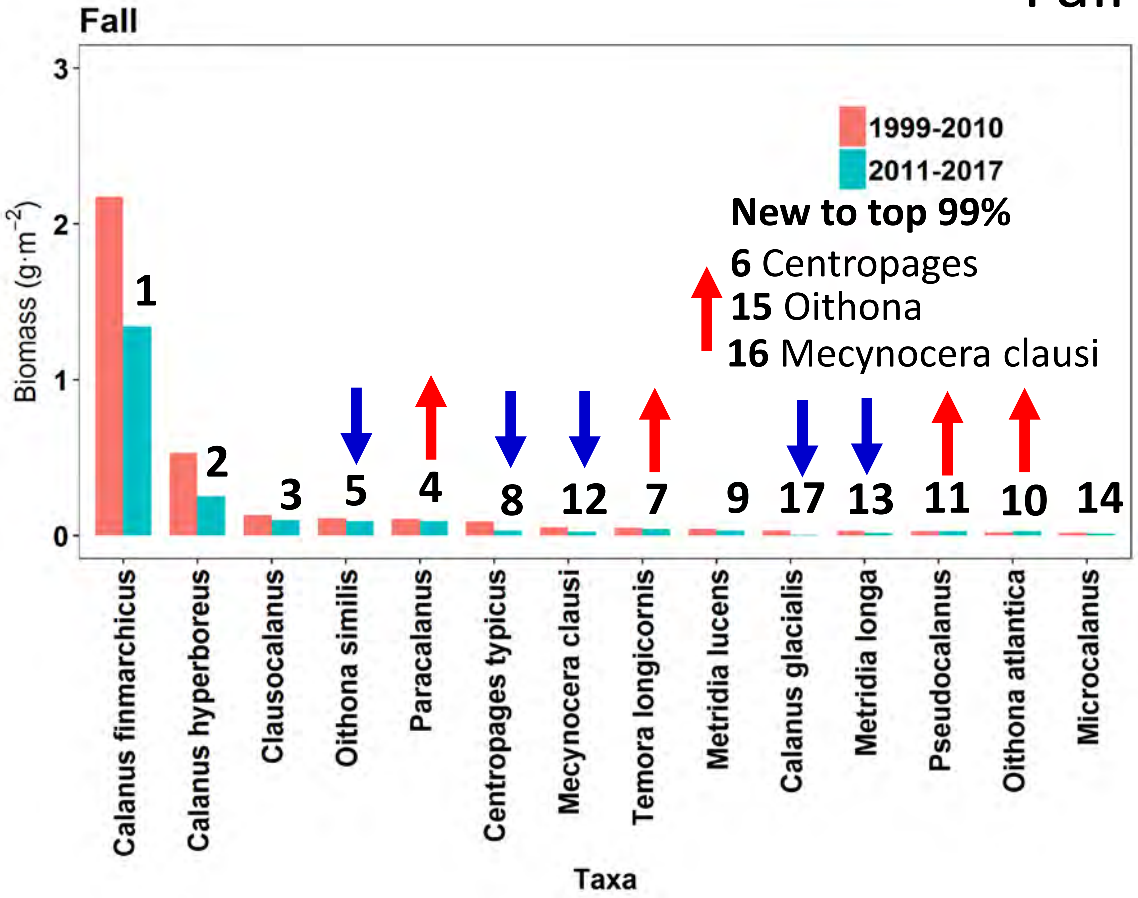
Changes in Scotian Shelf copepod rank **biomass** (top 99%) between 1999-2010 and 2011-2017

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

Spring



Fall



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