Evidence of long-term change in the summer Chukchi Sea zooplankton communities

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et al.
A rapidly changing Arctic

A "new normal" climate in the Pacific Arctic?

September sea ice extent from the Ice Atlas of the Northern Hemisphere (Hydrographic Office, 1946)

Sea ice extent in September 2012
Chukchi Sea – a gateway into the Arctic

ACW – Alaska Coastal Water
BSAW – Bering Sea/Anadyr Water
SCW – Siberian Coastal Water
WW – Winter Water
Plankton – sentinels of climate change?

- Is there a change in abundance, biomass or composition in summer zooplankton communities in the Chukchi Sea over the given period?
- What are the main factors driving zooplankton variability in the Chukchi Sea on larger scales?
- Are Pacific species being advected farther north during the summer season?
Seven decades of studies

- 28 historical and modern datasets on zooplankton, 1946-2012
- Excludes recent studies confined to the shelf break and in NE Chukchi
- CTD data mostly available
- Older datasets mostly unpublished

Sea ice extent during sampling period

June       July       August       September
Challenges

- Different spatial coverage and seasonal timing (June-September)
- Large gaps in study years (i.e. 1955-1969; 1993-2003)
- Sampling gear:
  - Russian studies mainly use small, fine mesh nets (Juday, ~150μm)
  - American studies mainly use coarse Bongo (~500μm) nets
- Different methods for calculating biomass
- Very different taxonomic resolution
Methods

- Stations assigned to water mass types based on temperature and salinity data
- Abundance and biomass values standardized to ind. m\(^{-3}\) and mg DW m\(^{-3}\)
- Trends in abundance and biomass established using linear mixed-effects models
  - **Random effects**: station location, gear type
  - **Fixed effects**: year, month, water mass type, temperature, salinity, PDO and AO index (6-month average)
Water masses

Water mass
- Alaska Coastal Water (ACW)
- ACW/BSAW
- Bering Sea Anadyr Water (BSAW)
- Melt Water (MW)
- MW/SCW
- Siberian Coastal Water (SCW)
- Winter Water (WW)

Depth
- Bottom (15m)
- Surface (15m)
Zooplankton biomass

- Very high variability
- Average increase in biomass $\sim 10$ mg DW/m$^3$ per decade
- Other significant factors related to biomass:
  - Month sampled
  - Water mass type
  - PDO/AO signal
BSAW communities

- Indicator species for Bering Sea water
- Large enough for all developmental stages to be captured by coarse nets; common enough to be sufficiently represented by fine nets; least likely to be misidentified

- *Calanus glacialis*
- *Eucalanus bungii*
- *Neocalanus spp.*
- *Metridia pacifica*
Abundance in BSAW

**Calanus glacialis**

**Metridia pacifica**

**Neocalanus spp.**

**Eucalanus bungii**
Factors driving variability

*Eucalanus bungii*
*Neocalanus spp.*
*Metridia pacifica*

Significant relationship to water column temperature (**short-term**)

*Calanus glacialis*

No relationship to temperature, negative correlation to PDO signal (**long-term**)

![Graph showing abundance vs. temperature and PDO index](image-url)
Calanus glacialis distribution

- **Pacific population:** C4-C5 sub-adults
- **Chukchi (resident) population:** C1-C3 larval stages; few adults
Are Pacific species being advected farther north?

**Neocalanus spp.**

![Graph showing mean abundance north of 70°N.](image)

- **1946**
- **1947**
- **1976**
- **1991**
- **1992**
- **2012**

**Mean abundance north of 70°N:**

\[ p < 0.001; R^2 = 0.31 \] (with 1949 removed)
Conclusions

- Distribution of water masses highly variable but follows overall similar trend
- Significant increases in zooplankton biomass have been observed in recent study years
- Abundances of advected Pacific copepods have increased, with abundances correlated to water temperature
- Advected Pacific species may be now reaching higher latitudes during the summer months
- These findings are consistent with other studies, reporting northward shifts in distribution of planktivorous fish, marine mammals and birds
Thank you for your attention!

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