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

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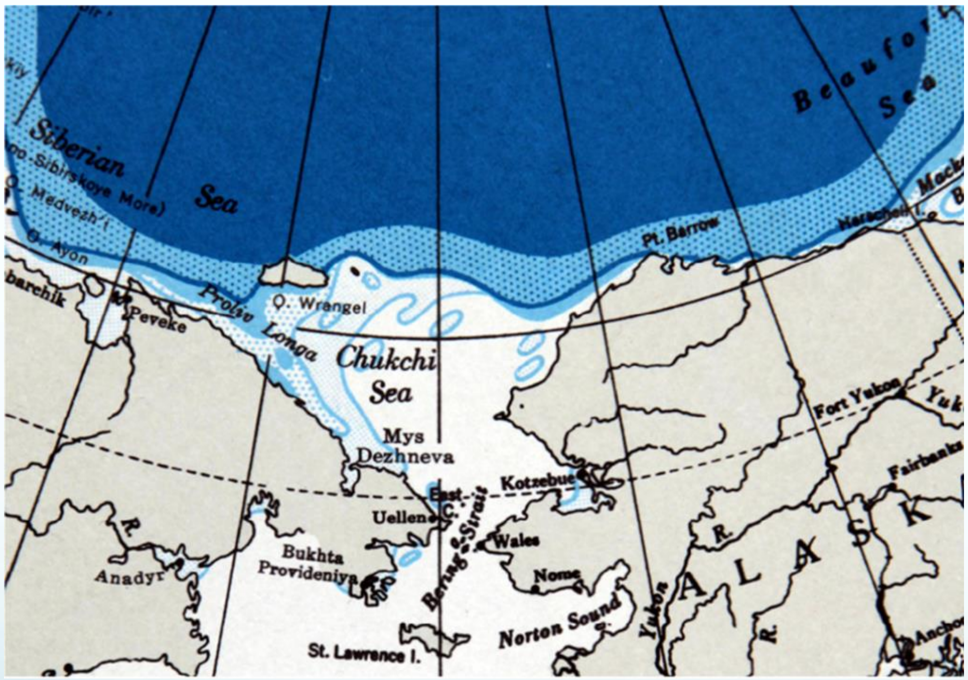
A rapidly changing Arctic

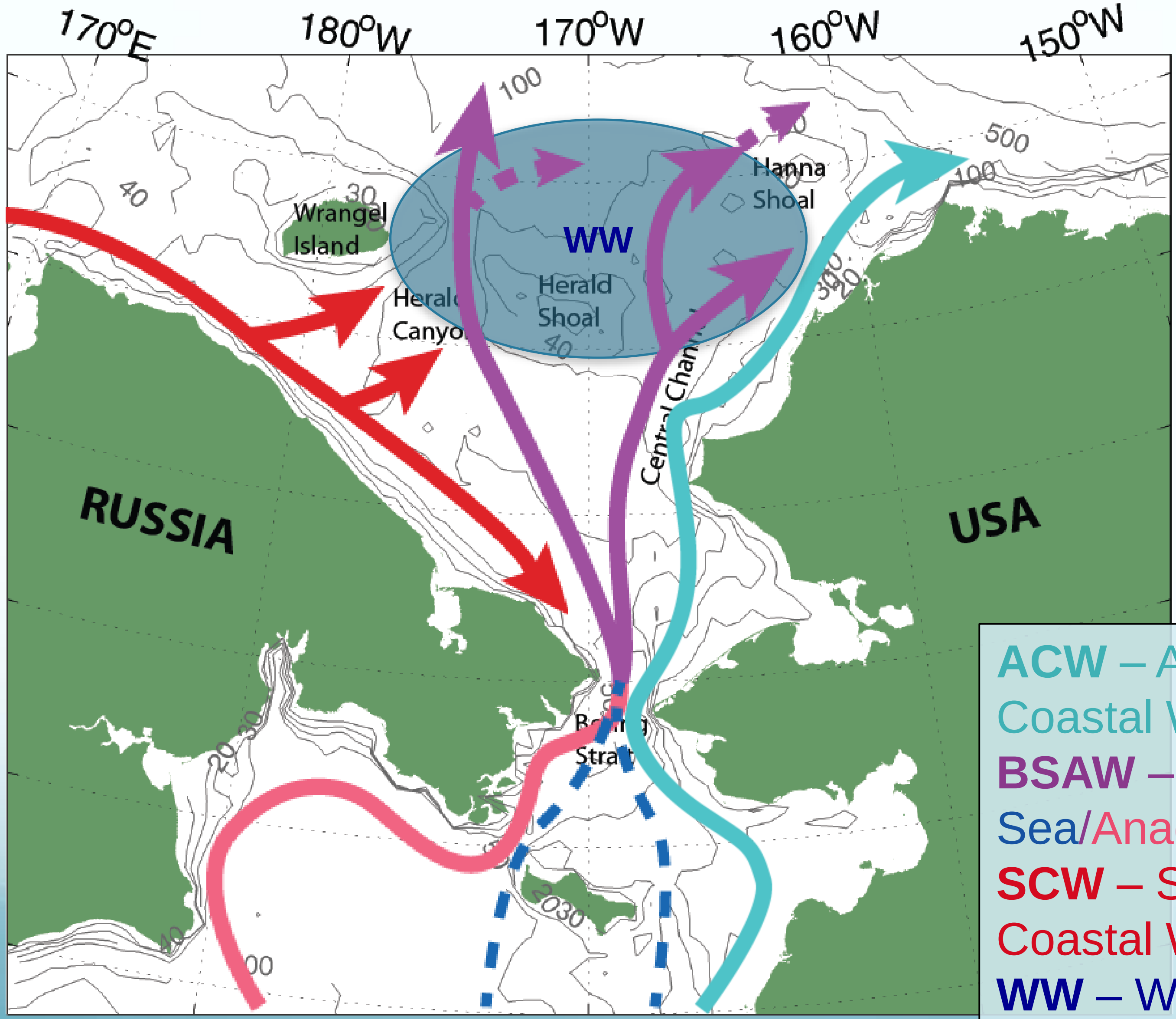


September sea ice extent from the Ice Atlas of the Northern Hemisphere (Hydrographic Office, 1946)

Sea ice extent in September 2012

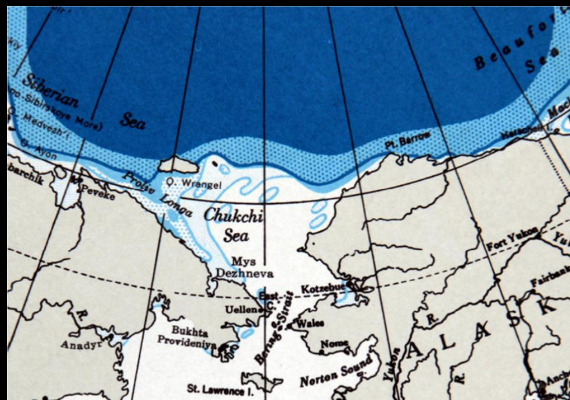
A "new normal" climate in the Pacific Arctic?

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?

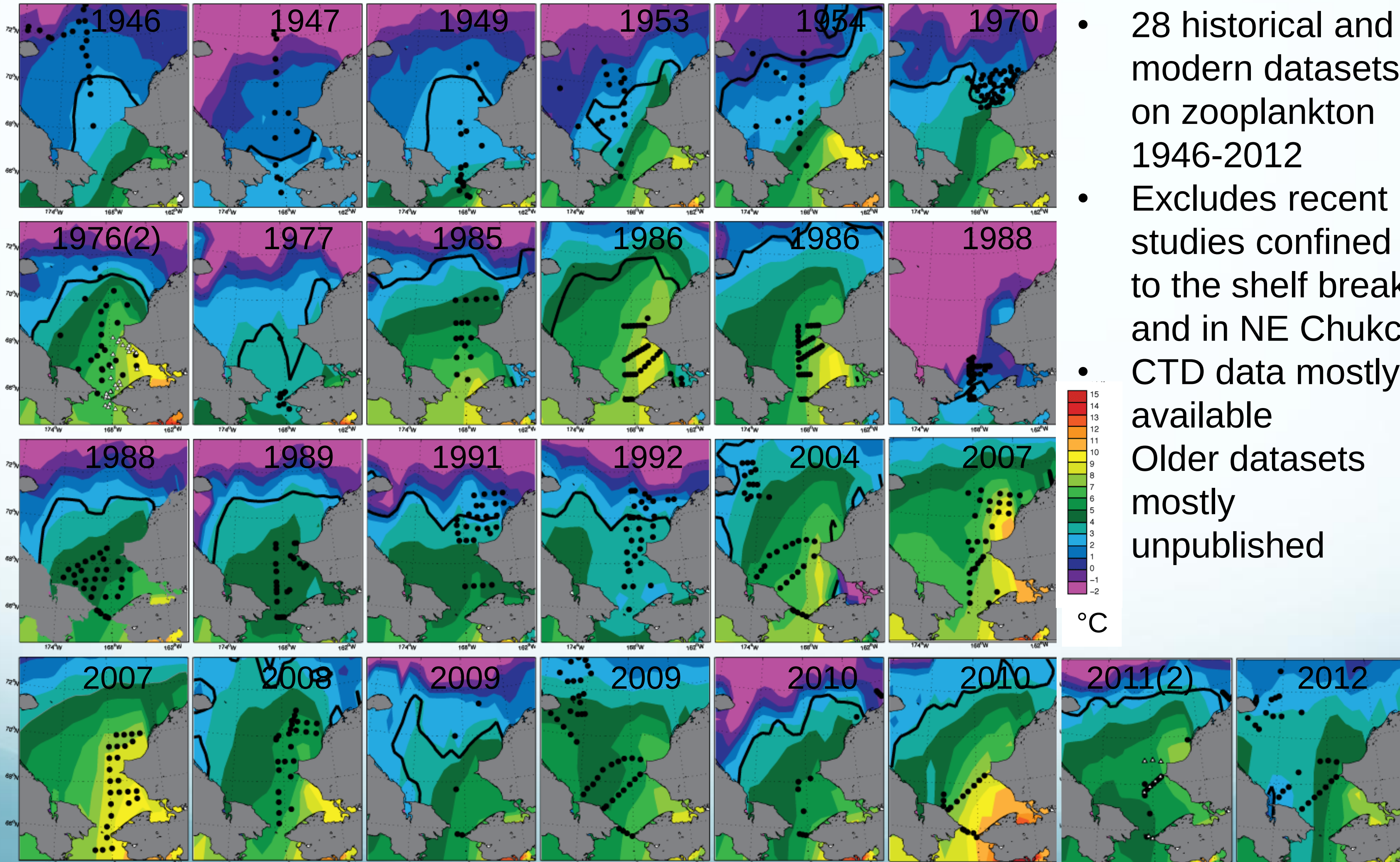


1946

2012

- *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



June July August September

Sea ice extent during sampling period

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

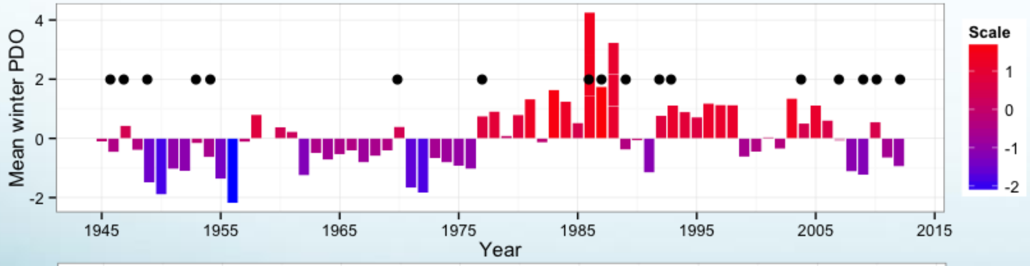
Older datasets mostly unpublished

Challenges

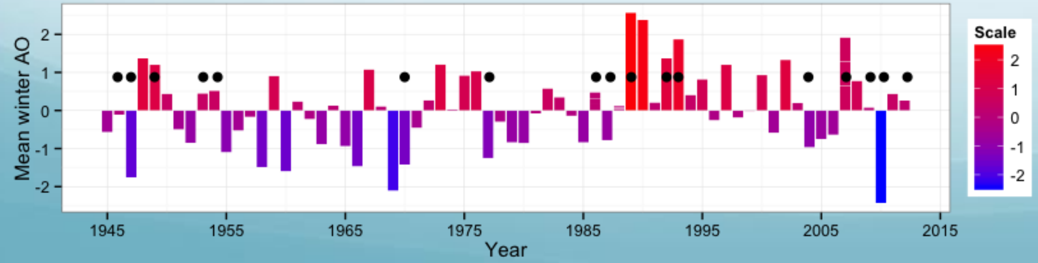
- Different spatial coverage and seasonal timing (June-September)
- Large gaps in study years (i.e. 1955-1969; 1993-2003)
- Sampling gear:
  - Russian studies mainly use small, fine mesh nets (Juday, ~150μm)
  - American studies mainly use coarse Bongo (~500μm) nets
- Different methods for calculating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

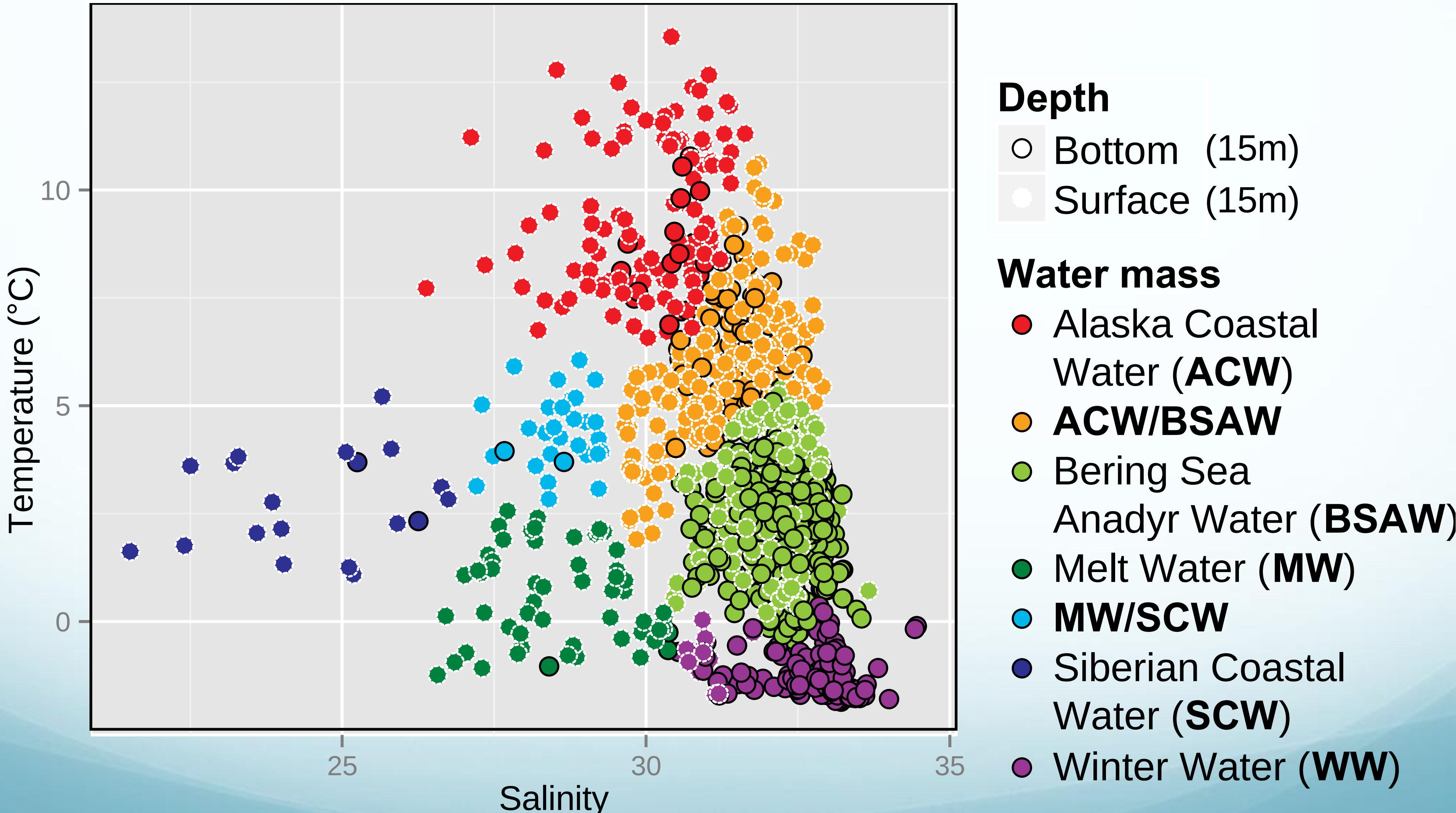


Pacific Decadal Oscillation

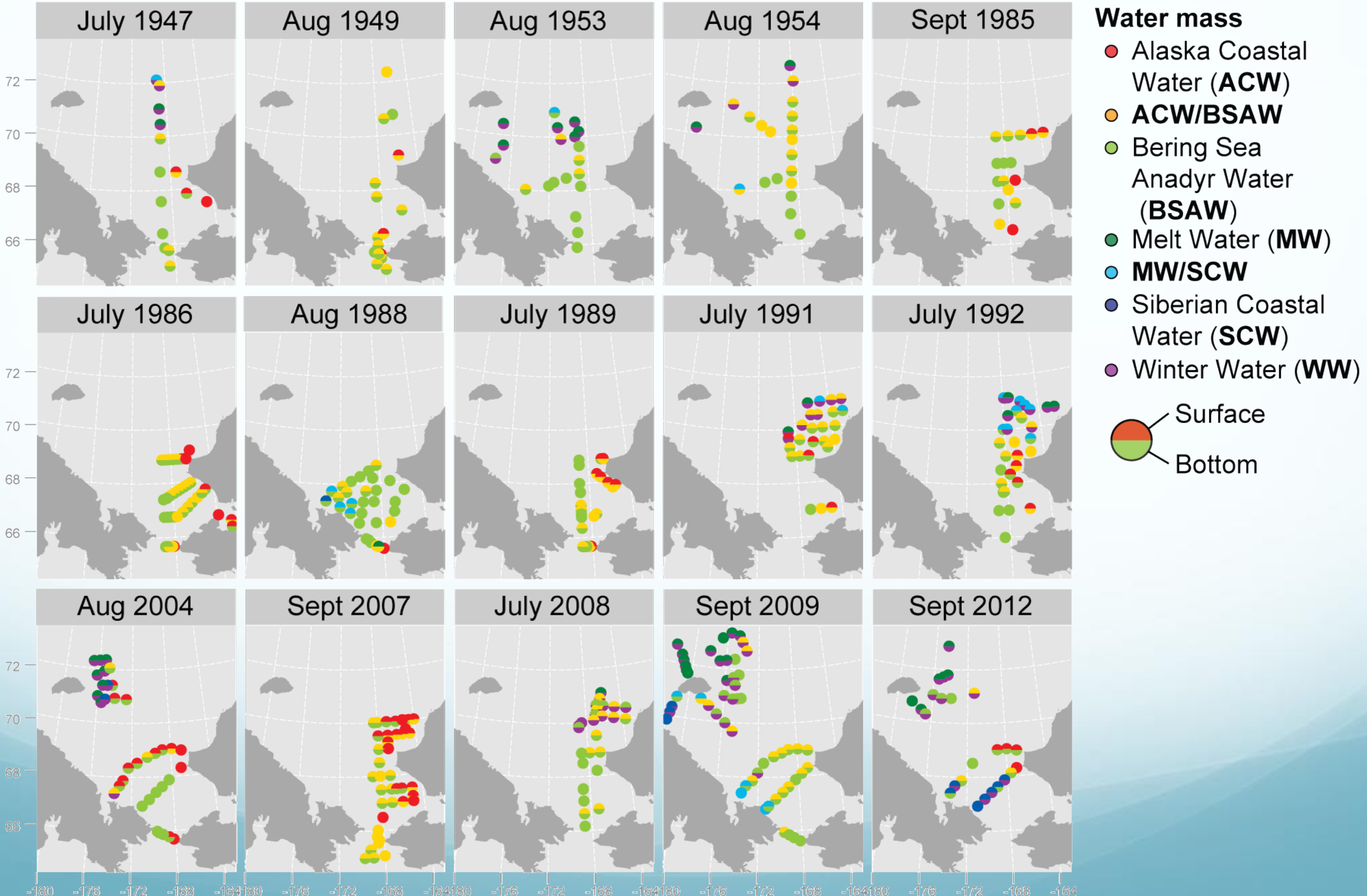


Arctic Oscillation

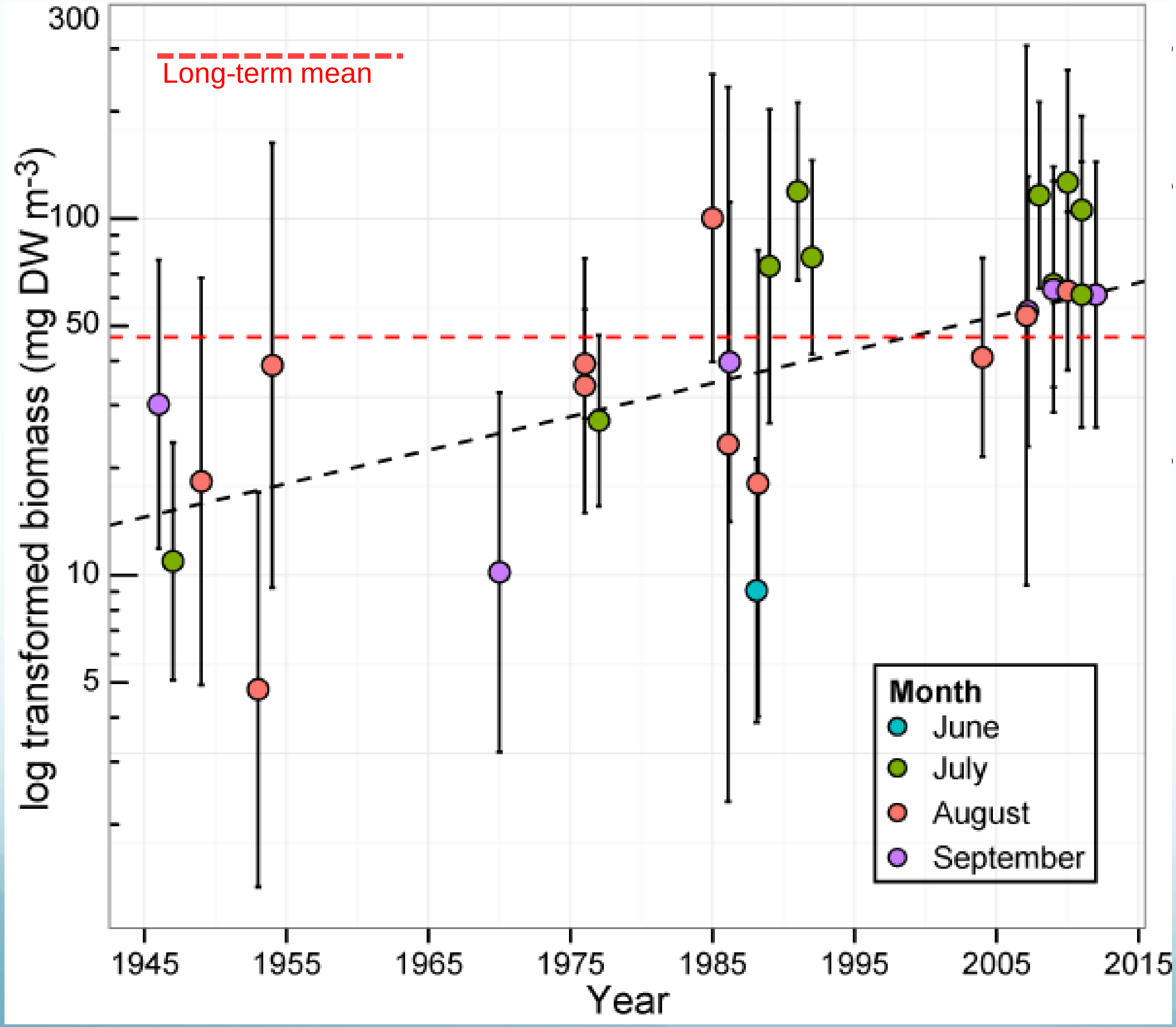
Water masses



Water masses

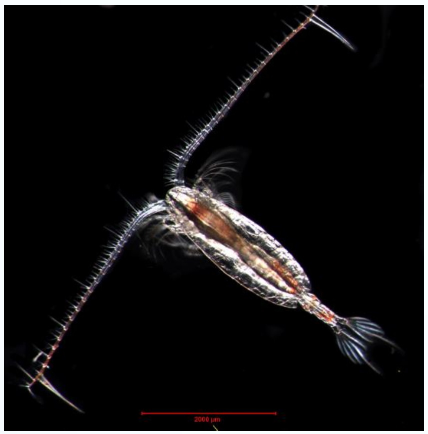


Zooplankton biomass

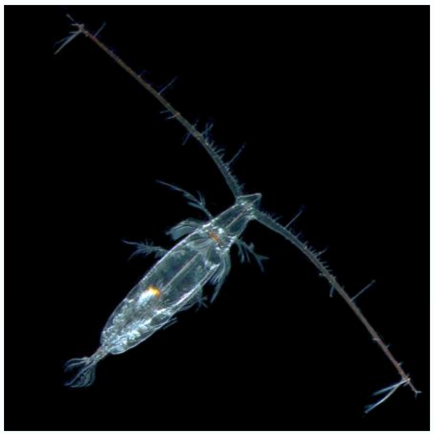


- Very high variability
- Average increase in biomass ~10mg DW/m^3 per decade
- Other significant factors related to biomass
  - Month sampled
  - **Water mass type**
  - PDO/AO signal

BSAW communities

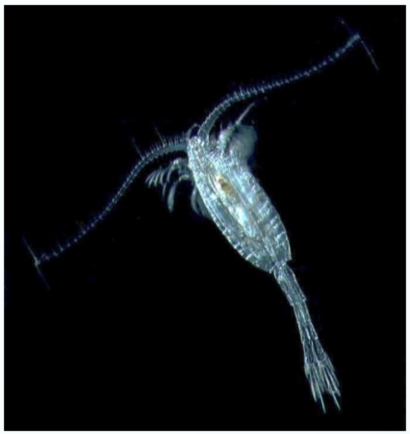


Calanus glacialis



Eucalanus bungii

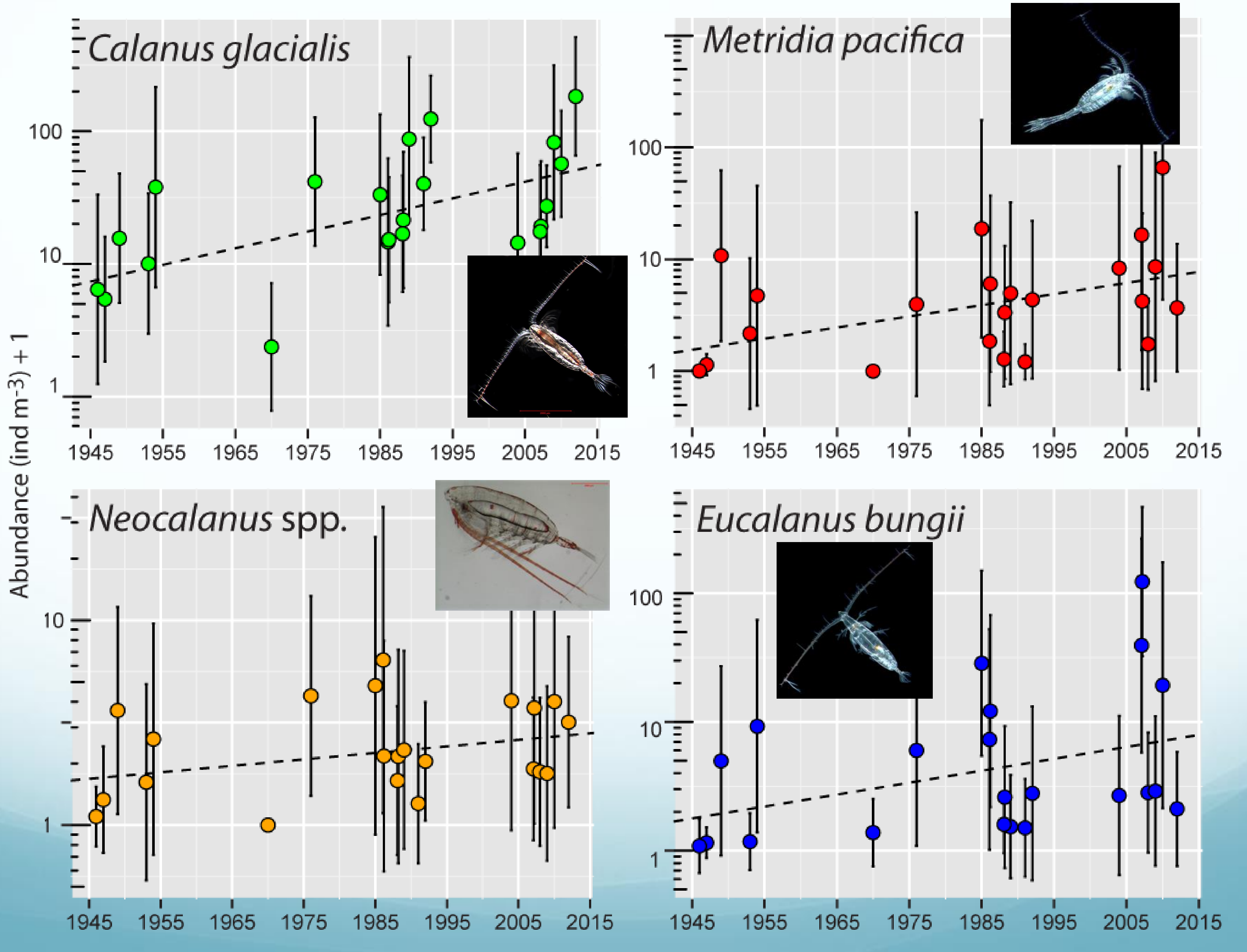
Neocalanus spp.



Metridia pacifica

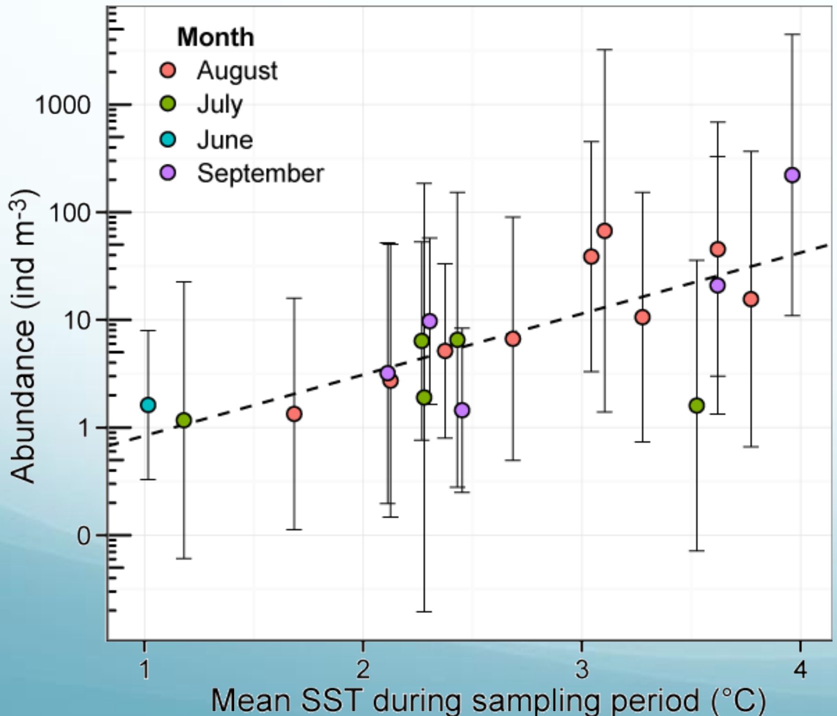
- Indicator species for Bering Sea water
- Large enough for all developmental stages to be captured by coarse nets; common enough to be sufficiently represented by fine nets; least likely to be misidentified

Abundance in BSAW

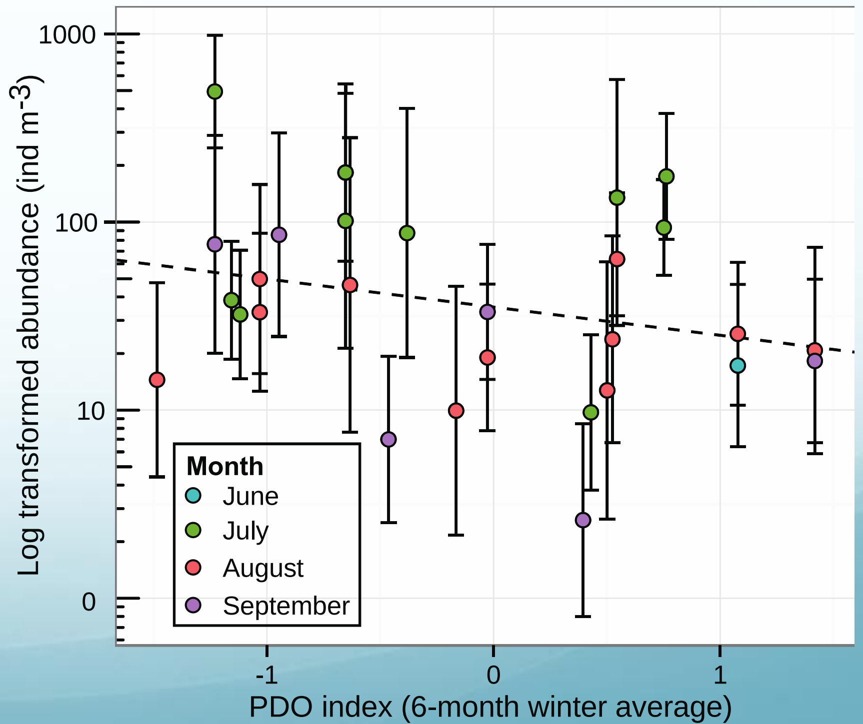


Factors driving variability

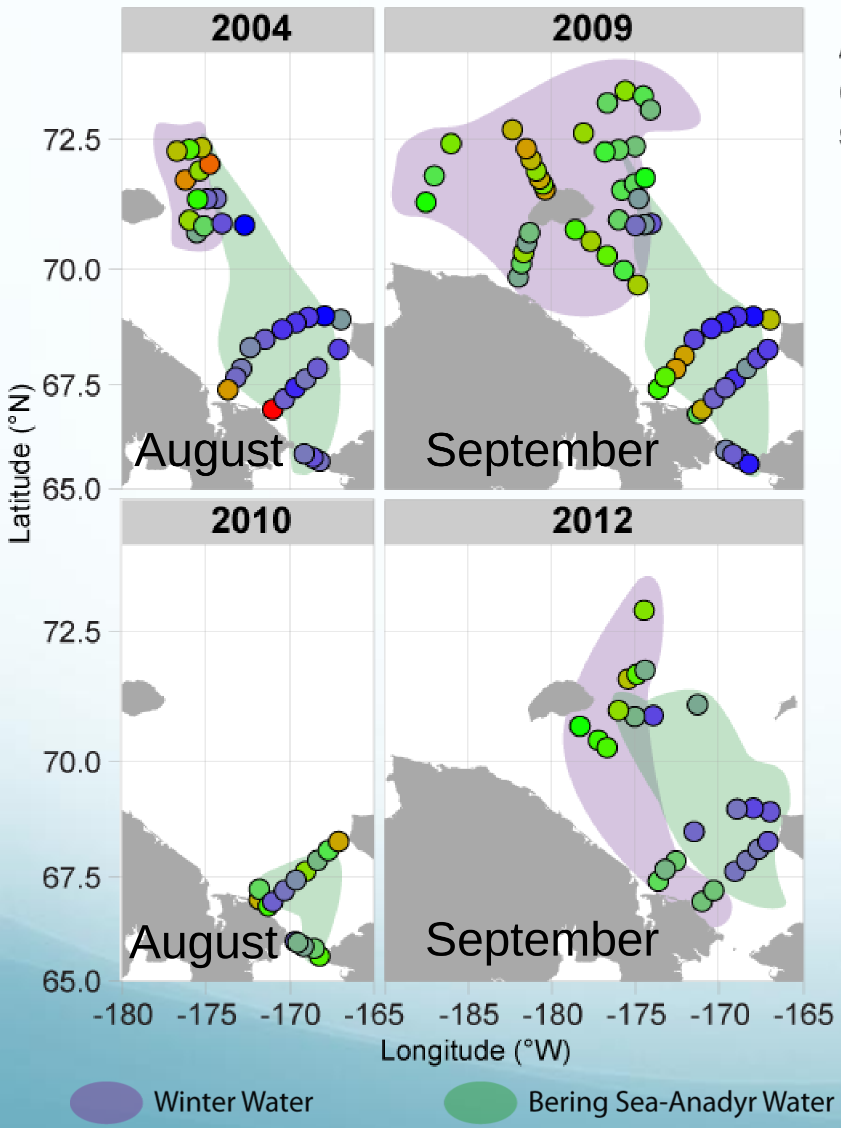
Eucalanus bungii
Neocalanus ***spp.***
Metridia pacifica
Significant relationship to water column temperature (**short-term**)

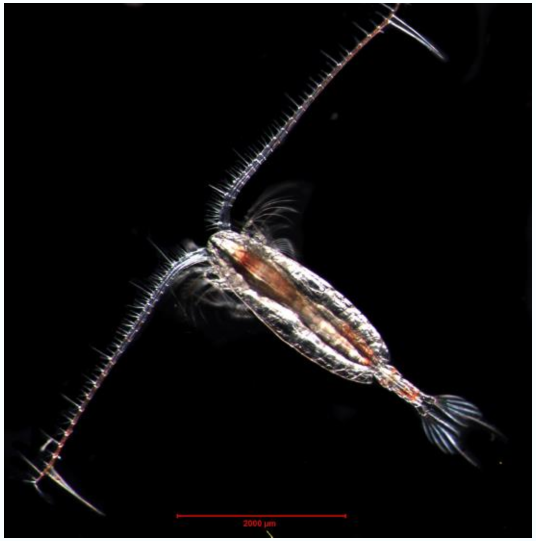


Calanus glacialis
No relationship to temperature, negative correlation to PDO signal (**long-term**)



Calanus glacialis distribution

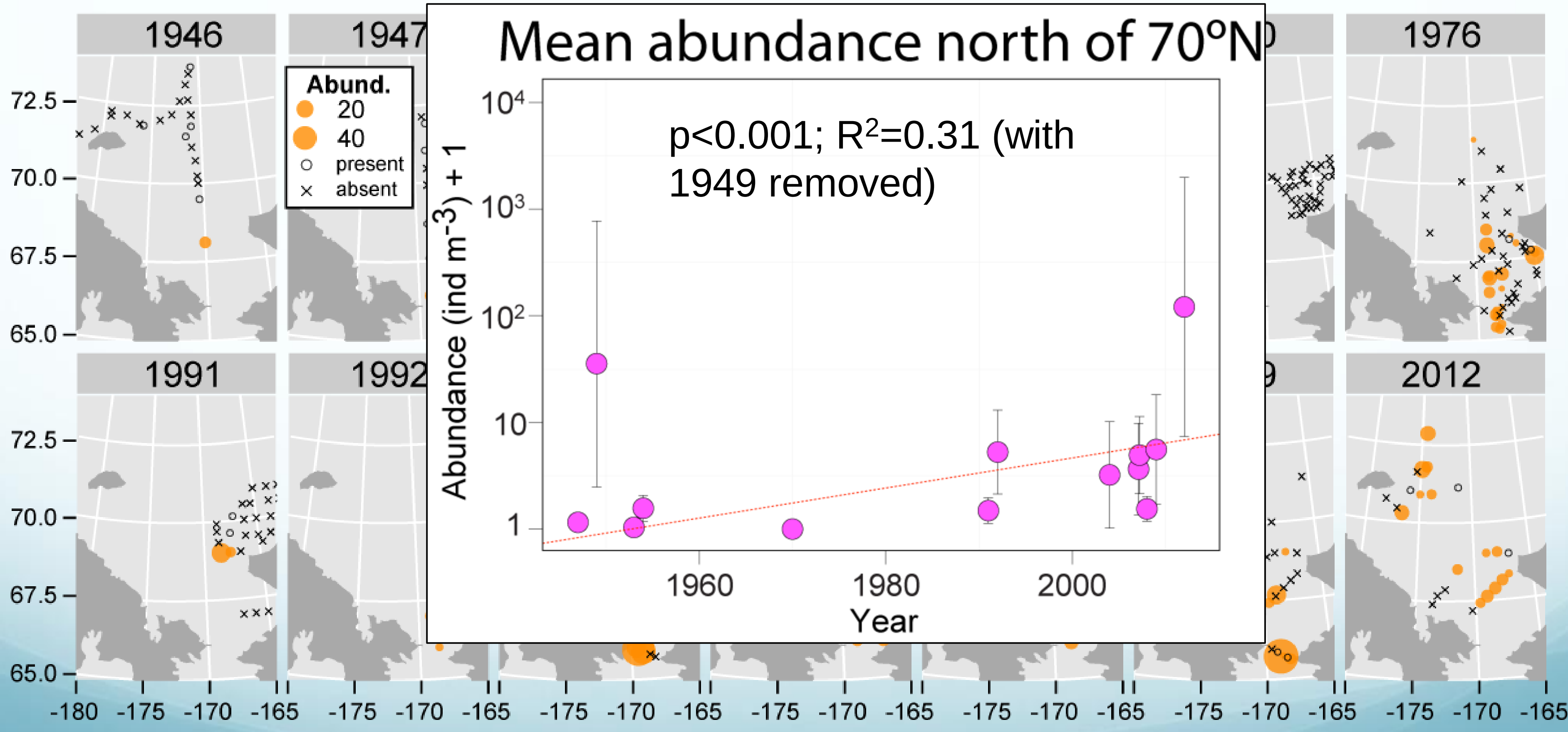




- **Pacific population**: C4-C5 sub-adults
- **Chukchi (resident) population**: C1-C3 larval stages; few adults

Are Pacific species being advected farther north?

Neocalanus spp.



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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