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Seasonal phenology of zooplankton composition in the SE Bering Sea, 2008-2010

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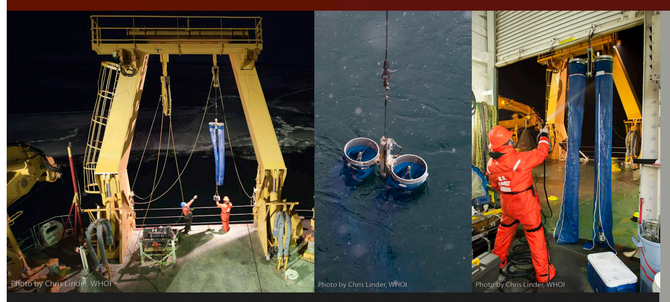
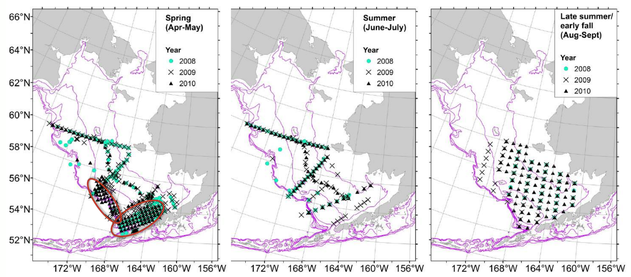


Objectives

- Evaluate differences in zooplankton communities (taxa/stage) during cold/ high ice years
  - Seasonal
    - ❖ Spring, Summer, early Fall
  - Interannual
    - ❖ 2008, 2009, 2010
- Evaluate environmental drivers
    - ❖ Ice retreat and spring phytoplankton bloom timing, temperature
- Compare zooplankton and ichthyoplankton

Methods

Zooplankton Collection



- Stations (above) sampled by Bering Sea Project (spring, summer), EcoFOCI (spring, red ovals and 70 m isobath), BASIS (early fall)
- Zooplankton vertical tows, near bottom to surface
- 150 µm mesh (primarily), 335 and 505 µm mesh (large taxa, EcoFOCI)
- Concurrent CTD (temperature, salinity) data
- Concurrent Ichthyoplankton /juvenile fish data

Data Analysis

- Bray-Curtis similarity of 4th root transformed abundance (No. m^{-3})
- Cluster analysis of taxa/stages for zooplankton and ichthyoplankton (Primer –E)
- nMDS and ANOSIM to evaluate differences among seasons (Primer-E)
- Bar plots to show variations of taxa and copepod stages from April –August for 2008, 2009 and 2010

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Reference

Sigler, M., Stabeno, S., Eisner, L., Napp, J., Mueter, F. 2013. Spring and fall phytoplankton blooms in a productive subarctic ecosystem the eastern Bering Sea during 1995-2011. *Deep Sea Res II* 109:71-83.

Abstract

The availability of large crustacean zooplankton prey is critical to the condition and survival of forage fish (e.g., age-0 Walleye Pollock), sea birds, and marine mammals in the eastern Bering Sea. Zooplankton community composition and abundances of large lipid-rich copepods (e.g., *Calanus* spp.) have been evaluated for single seasons, but few studies have investigated seasonal variations in this region. Here, we investigate seasonal changes in taxa (community structure) and stage composition (where appropriate) from spring through late summer/early fall over three consecutive cold years in the SE Bering Sea (south of 60 °N). Zooplankton phenology is compared to changes in ichthyoplankton composition to investigate common environmental drivers and potential overlap of fish predators and zooplankton prey.

Conclusions

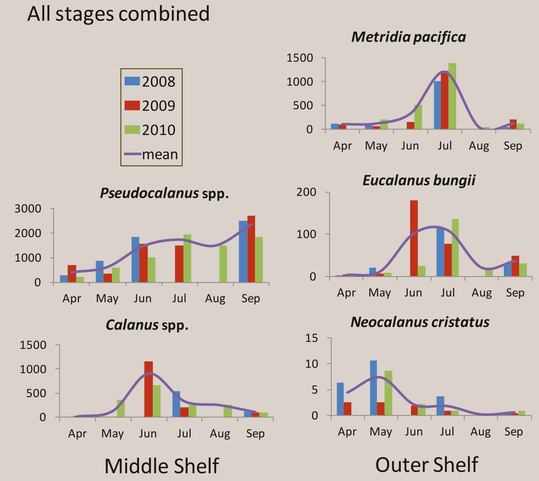
1) The large seasonal differences in zooplankton communities are due to variations in taxonomy and stage structure of copepods.
2) Interannual differences are greatest in spring, primarily due to variations in stage structure of copepods, and are related to differences in spring bloom timing and seasonal temperature progression.
3) Zooplankton and ichthyoplankton communities may co-vary (e.g. both communities were different in spring 2009 compared to 2008 and 2010).

Results

Seasonal Differences

Copepod abundance (No. m^{-3}), common taxa

All stages combined

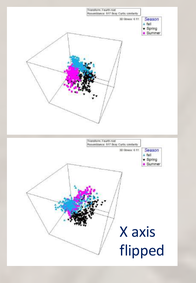


Timing of peak abundance varies by taxa. For example, highest numbers were seen in spring for *N. cristatus*, summer for *Calanus* spp. (*C. marshallae* + *C. glacialis*) and fall for *Pseudocalanus* spp.

Seasonal differences in community structure

All years combined (excluding spring EcoFOCI)

nMDS

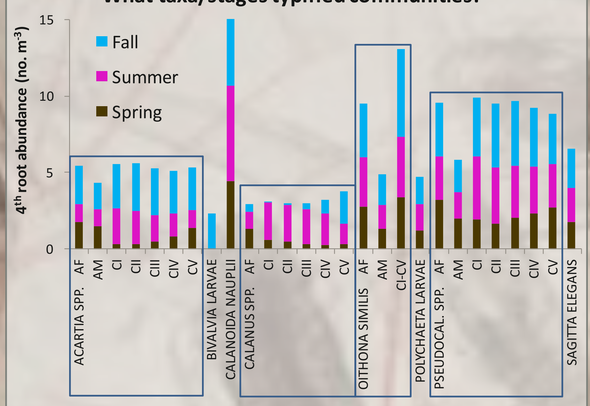


ANOSIM Pairwise comparisons

Groups	R statistic	Sig. level
Spr, Sum	0.42	0.001
Sum, Fall	0.35	0.001
Spr, Fall	0.50	0.001

Community composition varied significantly by season; largest differences for Spr, Fall and smallest for Sum, Fall

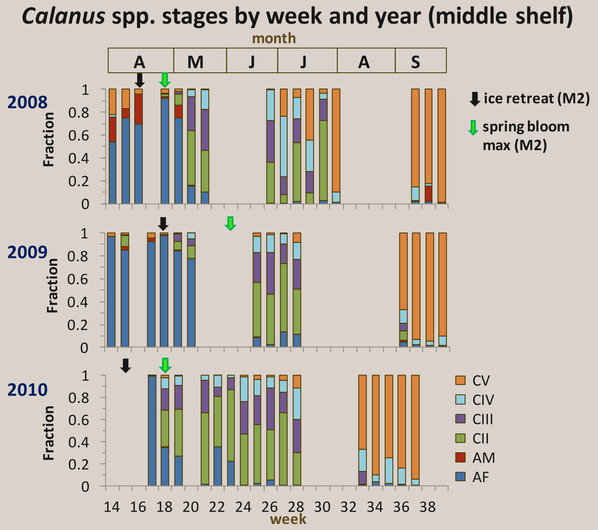
What taxa/stages typified communities?



Seasonal differences were primarily due to changes in taxonomic composition and stage of copepods (see boxes). For example, *Calanus* was in highest abundance in summer and *Acartia* was highest in fall. Copepodites (particularly CI-CIV) were less abundant in spring than in summer or fall.

Interannual Differences

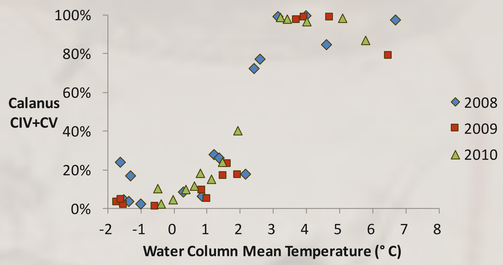
***Calanus* spp. stages by week and year (middle shelf)**



In these three cold years, stages progress from adults (males (AM) and females (AF)) to early copepodite stages (CI (not shown), CII, CIII) in spring, with early and late stages in mid summer to almost entirely CV by Aug-Sep. However, interannual variations were observed. In 2009 stage progression was delayed likely due to delay in the spring bloom (food for reproduction). In 2008, there were higher ratios of late stages (CIV+CV) in June-July likely due to higher water temperatures (see below).

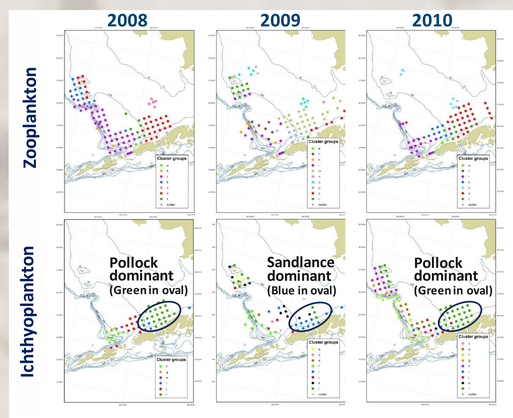
PMEL Mooring 2 (M2) ice retreat and spring bloom timing from Sigler et al. (2014).

***Calanus* spp. CIV + CV (late stages) in relation to temperature on middle shelf**



There was an increase in % late stages from 0 to 3 °C. As the season progresses and temperature increases ~ all are stage CV. These copepods will increase lipid content until overwintering (as CV).

Zooplankton and ichthyoplankton cluster groups for spring 2008, 2009, 2010 (EcoFOCI stations only)



Cluster groups were different in 2009 compared to 2008 and 2010 for both communities. Copepod stage structure drove changes in zooplankton (as described for *Calanus* spp.), while changes in dominant taxa were important for ichthyoplankton (e.g. near the Alaska Peninsula (oval), pollock were dominant in 2008 and 2010, while sandlance were dominant in 2009. (Note, 2008 turned out to be a strong year class for pollock).

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