Recent Changes in Summer Zooplankton Abundance and Biomass in the Eastern Bering Sea

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Abstract

Observations of zooplankton biomass and community composition during the recent warm and cold periods in the eastern Bering Sea provide insights into the mechanisms responsible for influencing energy flow and carrying capacity on this productive continental shelf. The updated biomass time series from the *T/S Oshoro Maru* as well as community composition data from two of NOAA's ecosystem observation programs (EcoFOCI and BASIS) show increases in the biomass and abundances of some key species with the return of cold conditions (e.g. *Calanus*, *Neocalanus*). The large mesozooplankton species are important prey for planktivores as different as age 0 pollock, least and crested auklets, and North Pacific right whales. We investigate recent changes in community composition by comparing summer zooplankton community composition data from three years, 2005 (warm), 2006 (cool) and 2007 (cold). In addition, we examine EcoFOCI and BASIS data sets from early, middle, and late summer to see if our conclusions are robust to changes in sample date. Finally we compare late summer results from EcoFOCI and BASIS to determine if the two data sets provide the same conclusions on the differences between the northern and southern middle shelf domain communities and the location of the transition zone between them.

Conclusions

1. **The southern extent of the cold pool was similar in transects occupied by the two programs. There were, however differences in mixed layer depths, surface temperatures, and near bottom salinities. Some of these differences were due to the difference in sampling dates.**

2. **The July zooplankton concentrations (*T/S Oshoro Maru and F/V Arcturus*) were similar, while there were obvious differences between the July and August samples. Often (but not always) the August concentrations were lower.**

3. **Large zooplankton taxa (*Calanus* spp. and *Neocalanus* spp.) increased in concentration with the evolution of cool or cold conditions. Concentrations of small zooplankton taxa [*Pseudocalanus* spp. and *Acartia* spp.) did not show an increase with warm conditions and a decrease with cool or cold conditions.**

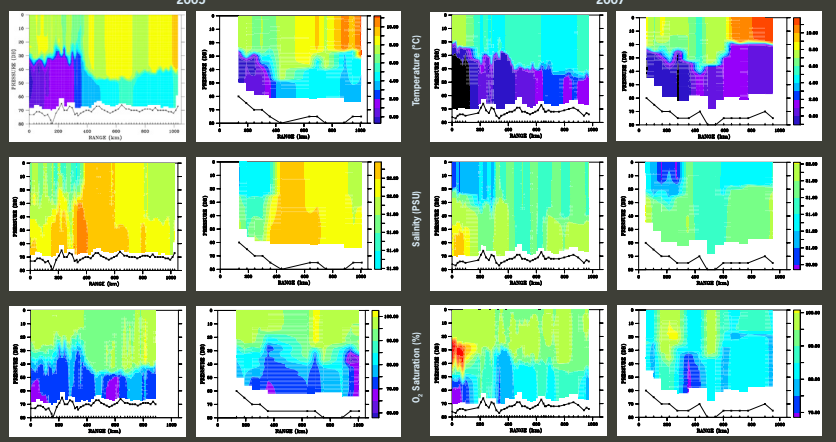
4. **The August zooplankton samples may have captured a rare second generation of *Neocalanus* spp. in 2005. This could have had important consequences for planktivorous fishes, marine mammals, and sea birds.**

5. **The Middle Shelf Domain zooplankton community structure exhibited north-south variation. Only in 2007 was there a recognizable southern, transitional, and northern community. Community structure around St. Matthews Island was always the most variable, both within and among years.**

6. **Continental slope and Outer Shelf Domain zooplankton taxa were observed in the Middle Shelf Domain at mooring M8. We hypothesize (based on satellite-tracked drifter results) that these taxa were entrained into the 100 m isobath flow and then entered the Middle Shelf Domain when that flow separated from the isobath.**

Acknowledgments We thank Dave Kachel (PMEL) for preparing the CTD data and plotting the transects, C. Harpold (AFSC – Seattle) and A. Andrews (AFSC – Juneau) for uploading and maintaining our two zooplankton databases, Jeanette Gann and Chris Cieciel (both of AFSC – Juneau) for CTD data processing and maintenance of CTD databases, and Kathryn Mier (AFSC – Seattle) who completed the zooplankton community analyses and cluster maps. We also gratefully thank W. Carlson (AFSC – Seattle) for her artistic preparation of the poster. The Bering – Aleutian Salmon International Study (BASIS) results presented here were supported with NOAA base funds, funding from NOAA's Fisheries and the Environment (FATE) program and funding from the Bering Sea Fisherman's Association (BSFA). EcoFOCI was supported by NOAA base funding, NOAA's North Pacific Climate Regimes and Ecosystem Productivity program and generous funding from the North Pacific Research Board (517, 602, 701, and BS2).

CTD Transects

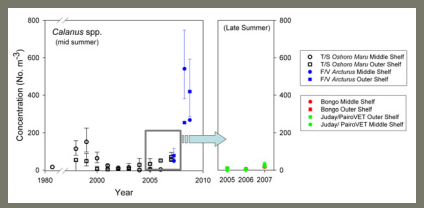


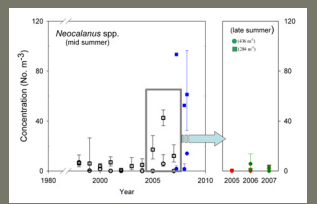
Eco-FOCI conducted dedicated transects along the 70 m isobath line of the Middle Shelf Domain (2005 – 2007). At each station a SeaBird 911 plus CTD was lowered through the water at 15 m min-1 above and through the thermocline and 30 m min-1 below the thermocline to near bottom. The instrument had dual, calibrated temperature and salinity sensors and two SeaBird SBE 43 O_2 sensors. A salinity sample was taken on each cast and processed later on a laboratory salinometer.

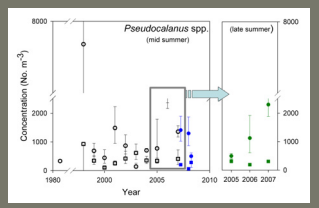
BASIS sampled a fixed grid of stations and for this analysis we selected those Middle Shelf Domain stations that most closely approximated a north south transect on or near the 70 m isobath. BASIS used a SeaBird 9XX plus CTD or an SBE 25 with single temperature and salinity sensors, and an SBE 43 O_2 sensor. Salinity samples were collected at every other station and processed on a laboratory salinometer.

Zooplankton Concentrations

We compared the concentrations of 4 taxa among two regions (Outer and Middle Shelf), multiple years, two time periods during summer, and two collection programs operating in the southeastern Bering Sea. For each set of graphs, the left hand panel is the data collected by the AFSC-Seattle, EcoFOCI Program (except for 1981 data from PROBES). Collections were made either from the *T/S Oshoro Maru* (1997 -2007) or the *F/V Arcturus* (2007 – 2008) in mid summer (July) with both 150 µm mesh 20 cm bongo nets and 333 µm mesh 60 cm bongo nets. All stages of copepods were enumerated except for *Acartia* where only the adults (C6) were counted. The right hand panel shows data collected by the AFSC – Juneau, BASIS Program made from different vessels in late summer (August to September), 2005 - 2007. The BASIS used 60 cm bongo nets with 505 µm mesh nets, and two different types of vertical tows with finer mesh – 2005 & 2006 data are from Juday nets (160 µm mesh) and 2007 data are from a PairoVET (150 µm mesh). Some of the smaller stages of these taxa may be under-represented in the large mesh (505 µm) net collections.







Zooplankton Community Structure

Zooplankton taxa with high frequency of occurrence were selected for analysis of community structure in the Middle Shelf Domain using Eco-FOCI cruises from the late summer, 2005 - 2007. Station data from locations around the cardinal moorings (M2, M4, M5, and M8) were analyzed separately from data of stations occupied along the 70 m isobath. Hierarchical cluster analyses was applied separately to the both station and species data for all three years using the relative Bray-Curtis dissimilarity coefficient as the distance measured on 4th root transformed data for station analyses and on untransformed, standardized by totals data for species analyses. A flexible linkage (β= -0.25) was used for agglomerative clustering. Bi directional matrices of stations x species were produced. We mapped the stations clustered by taxa using ArcMap (v. 9.3.1).