Secondary Production in a Downwelling Ecosystem: Egg Production Rates of *Calanus marshallae* and *Pseudocalanus* spp. in the Coastal Gulf of Alaska, 2001

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Introduction

The Northeast Pacific Global Ocean Ecosystems Dynamics Program (NEP GLOBEC) seeks to understand the effects of climate variability and climate change on the distribution, abundance and production of marine animals (including salmon and other commercially important living marine resources). As one of the studies funded to examine the processes by which climate and physical forcing affects production at lower trophic levels, we examined copepod egg production rates of several copepod taxa in April, May, and July of 2001 during GLOBEC Process cruises. Both GLOBEC target species and other taxa suspected of having a strong influence on mesozooplankton production, and of being potential prey items for juvenile salmonids, were selected.

Methods

Plankton abundance and distribution were quantified using established GLOBEC protocols. Large mesozooplankton were sampled at night using a 1 M^2 MOCNESS with 500 µm mesh nets. Small mesozooplankton were sampled in depth integrated vertical tows of a 20 cm diameter CalVET frame or QuadNet equipped with 150 µm mesh nets. Volume filtered was estimated with flow meters. Samples were preserved in 5% formalin and individuals were identified to the lowest possible taxon at the Polish Plankton Sorting Center, Szczecin, Poland.

Individual females for egg production studies were captured using a 0.8 m diameter Ring net (150 or 200 µm mesh) equipped with a large volume cod end. *Calanus* females were incubated individually in mesh-bottomed chambers that were suspended in another container filled with sieved seawater to reduce egg cannibalism. *Pseudocalanus* females were incubated in plastic scintillation vials. All females were incubated in the dark for 24 hr. at the mixed layer temperature.

Conclusions

- *Calanus marshallae*, a GLOBEC target species, was only abundant during the May cruise.
- All *Calanus* females were ovigerous and egg production rates were approximately 40 eggs female^{-1} day^{-1} with clutch intervals of 1-3 days.
- *Pseudocalanus* spp. were nearly 100X as abundant as *Calanus* females during the May cruise.
- *P. newmani* dominated in Prince William Sound and *P. mimus* dominated in the Alaska Coastal Current and on the middle shelf.
- *Pseudocalanus* clutch size (as volume or number of eggs) increased with female prosome length.
- *Pseudocalanus* individual egg production rates were lower in August than in April and May, but total egg production was higher on the shelf in May and July due to higher female concentrations.

Coastal Gulf of Alaska Study Area

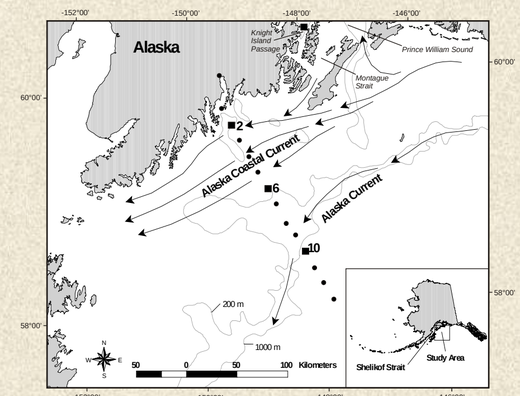


Figure 1.
We examined the plankton community in four principal areas or regions: Inner Shelf (between LTOP stations 1 & 3), the middle shelf (Station 6), the outer shelf (Station 10) and Prince William Sound (Knight Island Passage, KIP2). Cruises occurred in late April, mid May, and late July of 2001. Stations were occupied for approx. 3 consecutive days.

Temporal and Spatial Distribution of the Copepod Community

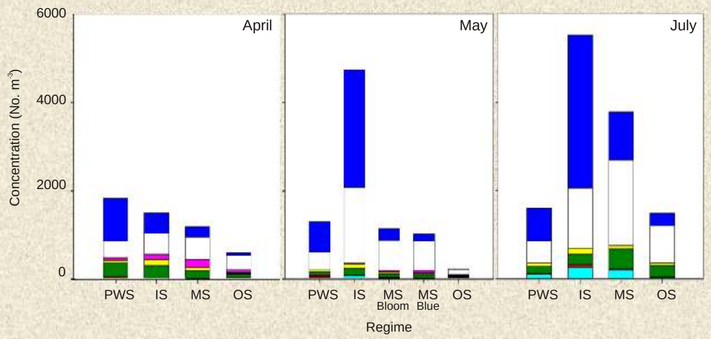


Figure 2.
Concentrations of the common copepod species sampled during our three cruises. The largest temporal changes were seen for the inner and middle shelf stations and the concentrations were generally higher inshore (including Prince William Sound) than offshore. *Pseudocalanus* and *Oithona* comprised the largest fraction of total numbers, though *Neocalanus* spp. (*N. cristatus*, *N. flemingeri*, and *N. plumchrus*) dominated the biomass in April and May.

Cross Shelf Distribution of Two Copepod Species in May

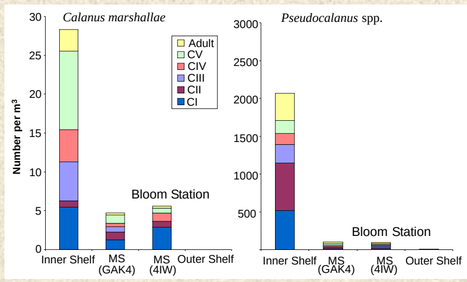


Figure 3.
May was the only cruise where we had appreciable numbers of *C. marshallae*, a GLOBEC target species. It was most abundant at the inner shelf station (Alaska Coastal Current) and absent from the outer shelf. *Pseudocalanus*, a much smaller calanoid copepod, was almost 100X more abundant than *Calanus* on the inner shelf. There were two middle shelf stations, one in relatively blue water (GAK4) and one in green water (4IW). There was no apparent difference in the concentrations of these two taxa between the bloom and non-bloom middle shelf stations.

Calanus Egg Production

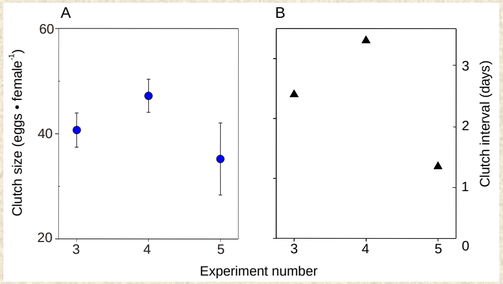
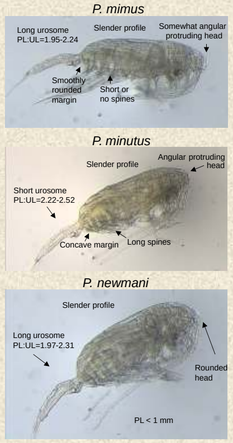


Figure 4.
An important rate process for determining the availability of future prey for juvenile pink salmon is the reproductive rate of the prey species. Shown are the egg production rates for *Calanus marshallae* from Prince William Sound in May. The average clutch size was 30 - 40 eggs per female. The clutch interval, estimated directly from the egg production rates, show that females were laying a new clutch every one to three days. All females were ovigerous. Thus two of the three experiments had moderate levels of production (40 eggs female^{-1} day^{-1}). This is somewhat higher than observed in the California Current off Oregon, but lower than maximum spring rates measured in the Bering Sea (unpublished data).

Pseudocalanus species from the Coastal Gulf of Alaska

Figure 5.
We found three species of *Pseudocalanus* in our samples: *P. minutus*, *P. mimus*, and *P. newmani*. They are distinguished using shape of the prosome, presence/absence of spines and certain basic morphometrics (Frost 1989). In Shelikof Strait, Alaska, downstream of this study area, we found an additional species, *P. moultani* during the spring (Siefert, 1994), however, *P. moultani* was not present in the GLOBEC study area.



Pseudocalanus Species Composition

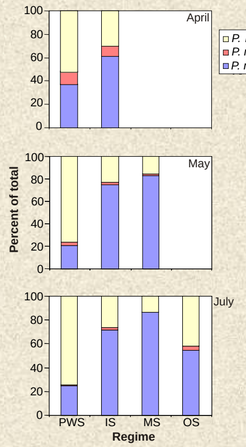


Figure 6.
P. newmani dominated the Prince William Sound samples, while *P. mimus* dominated outside the Sound. This is pattern is similar to other areas such as the Washington Coast and Puget Sound. *P. minutus* was often present, but only comprised 10% of the total when it was most abundant (April).

Pseudocalanus Species-Specific Differences

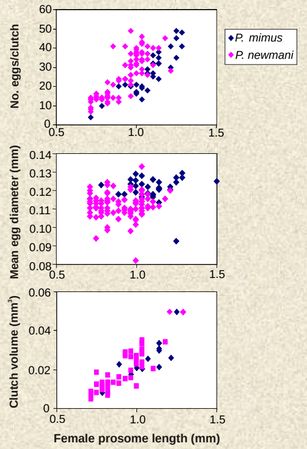


Figure 7.
The number of eggs per clutch increased as a function of female prosome length (top panel), and for the same size female, *P. newmani* tended to lay more eggs per clutch than *P. mimus*. On average, *P. mimus* females were larger than *P. newmani*. *P. mimus* had a larger mean egg size than *P. newmani*, but it was not related to the size of the female (middle panel). Thus clutch volume (number of eggs X average egg diameter) for the two species was nearly equivalent and a function of female length (bottom panel).

Temporal Trends in *Pseudocalanus* Egg Production

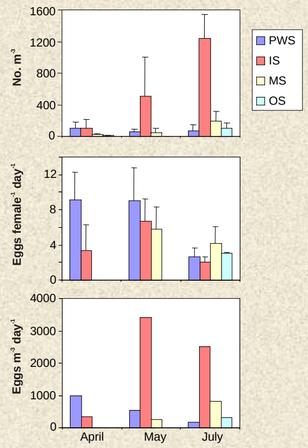


Figure 8.
Pseudocalanus spp. females were most abundant on the inner shelf (Alaska Coastal Current), and their concentration increased during the year (top panel). Thus, on the Inner Shelf the dramatic increase in total egg production in May is the result of increases in both female concentration and higher individual rates of egg production. In July the decrease in individual egg production is compensated by an increase in female concentration resulting in a small decrease in total egg production. Over the course of the year, population egg production decreases in Prince William Sound, but increases over the middle shelf.

References

Frost, B.W. (1989). A taxonomy of the marine calanoid copepod genus *Pseudocalanus*. Can. J. Zool. 67:525-551.

Siefert, D.L.W. (1994). The importance of sampler mesh size when estimating total daily egg production by *Pseudocalanus* spp. in Shelikof Strait, Alaska. J. Plankton Res. 16:1489-1498.

Acknowledgements

We gratefully acknowledge the financial support of NOAA's Coastal Ocean Program (E. Turner, Program Manager). This research was conducted on GLOBEC Process cruises. We thank our Process Principal Investigators, S. Strom (WWU) and M. Dagg (LUMCON) and the many members of their laboratories who sailed with us for assistance and camaraderie at sea. D.L.W. Siefert confirmed our identifications of *Pseudocalanus*. The support of the Captain, crew, and shoreside team for the R/V Alpha Helix (Univ. Alaska, Fairbanks) greatly facilitated this project and contributed to our success.

Poster design by Wendy L. Carlson, AFSC Graphics Unit, 2002