Distribution and Species-specific Egg Production by *Pseudocalanus* spp. in the Gulf of Alaska

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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) in the eastern North Pacific Ocean. The program has two study sites, the coastal Gulf of Alaska (CGOA) and the California Current System (CCS). The highly productive coastal Gulf of Alaska ecosystem is anomalous among the world's most productive systems in that the dominant winds produce downwelling at the coast for most of the year. This poster combines the results from two projects that seek to understand the interaction of climate and trophic dynamics which affect the transfer of energy to pink salmon juveniles (*Oncorhynchus gorbuscha*) migrating out of Prince William Sound.

Methods

Samples were collected and experiments were conducted aboard the R/V *Alpha Helix* during GLOBEC Process and Long-Term Observation Program (LTOP) cruises in 2001. Process cruises were April, May, and July of 2001, and LTOP cruises were April, May, July, August, and October. Investigations were generally conducted in 3 regions of the shelf (Inner, Middle, Outer) and Prince William Sound, a large fjord (Fig. 1).

Plankton abundance and distribution were quantified using established GLOBEC protocols. Large mesozooplankton were sampled at night from 5 different depth strata using a 1 M^2 MOCNESS with 500 µm mesh nets. Small mesozooplankton were sampled in vertical tows of a 20 cm diameter mouth CalVET frame or QuadNet equipped with 150 µm mesh nets. Volume filtered was estimated with flow meters.

Females for egg production studies were captured using a 0.8 m, 150 or 200 µm mesh ring net (Process) or a 0.5 m, 200 µm mesh net (LTOP). Both nets had non-filtering cod ends. Sorting was complete within 1, or at most 2, hrs of capture. Females were transferred with a wide bore pipette to the incubation chambers (20 ml plastic vials, Process; 70 ml polystyrene tissue culture flask, LTOP). Process cruises incubated females in the dark for 24 hr. at the mixed layer temperature. All females were preserved at the end of the experiment by addition of formalin to the vial. LTOP cruises incubated females under natural lighting cycles at mixed layer temperatures for 3 days. Females were checked every 24 hr; females producing egg sacs before the conclusion of the experiment were removed and preserved individually. All non-producing females were preserved together at the end of 72 h. In the laboratory, females were identified to species (Frost 1989) and measured for prosome length. The number and size of eggs in a clutch were also determined, with either an ocular micrometer (Process) or a computer-assisted measuring system (LTOP; Roff and Hopcroft, 1986). The operational measurement accuracy was 6 µm for the ocular micrometer measurements of eggs, 36 µm for female prosome length, and 5 µm for the computer-assisted method.

Conclusions

- The copepods *Pseudocalanus* and *Oithona* were the most abundant organisms sampled.
- *P. newmani* females dominated in Prince William Sound and *P. mimus* dominated on the Inner and Middle shelf. The species proportions used in the experiments were similar between the two projects.
- Clutch size per female length did not differ between the two laboratories.
- *Pseudocalanus* clutch size (as number of eggs) increased with female prosome length, but there was a significant affect of month and region.
- Female size decreased as a function of season (and temperature), from April to July.
- For the same sized female, *P. newmani* tended to produce more eggs per clutch than *P. mimus*. *P. mimus*, however, tended to have a larger mean egg size than *P. newmani*.
- *Pseudocalanus* individual egg production rates were lower in July/August than April and May, but total egg production was nearly equivalent for the three time periods due to higher female concentrations in July.

Coastal Gulf of Alaska Study Area

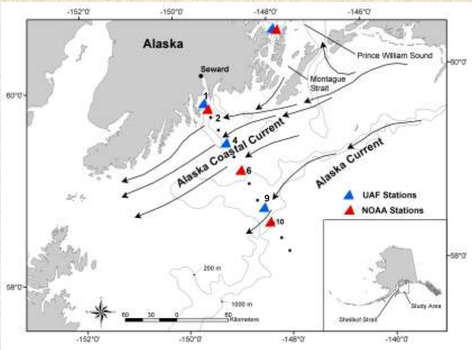


Figure 1. We examined the plankton community and *Pseudocalanus* spp. egg production in four principal areas or regions: Inner Shelf (GAK Stations 1 - 2), the Middle Shelf (Stations 4 & 6), the Outer Shelf (Stations 9 & 10) and Prince William Sound.

Temporal and Spatial Distribution of the Copepod Community

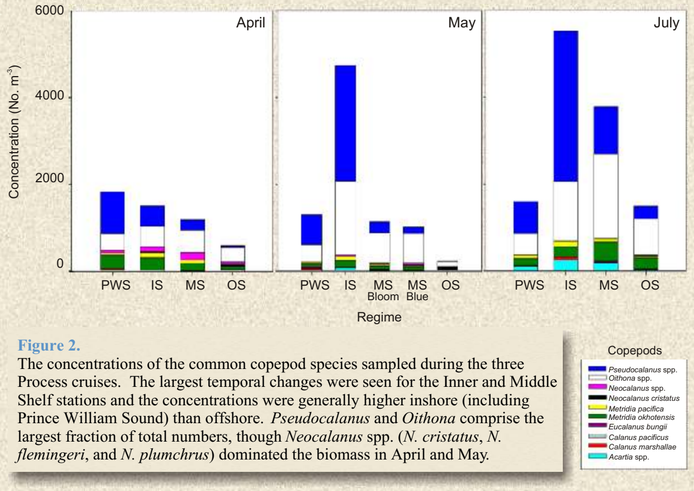


Figure 2. The concentrations of the common copepod species sampled during the three Process cruises. The largest temporal changes were seen for the Inner and Middle Shelf stations and the concentrations were generally higher inshore (including Prince William Sound) than offshore. *Pseudocalanus* and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

Pseudocalanus species from the Coastal Gulf of Alaska

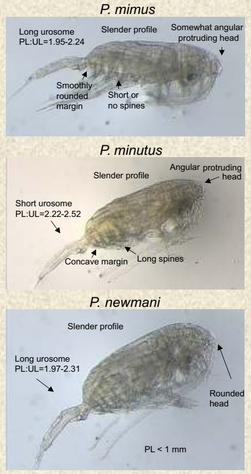


Figure 3. We found three species of *Pseudocalanus* in our samples: *P. minutus*, *P. mimus*, and *P. newmani*. They are distinguished using shape of the prosome, presence/absence of spines and certain basic morphometrics (Frost 1989). In Shelikof Strait, Alaska, downstream of this study area, we found an additional species, *P. moultani* during the spring (Siefert, 1994), however, *P. moultani* was not present in the GLOBEC study area.

Pseudocalanus Species Composition

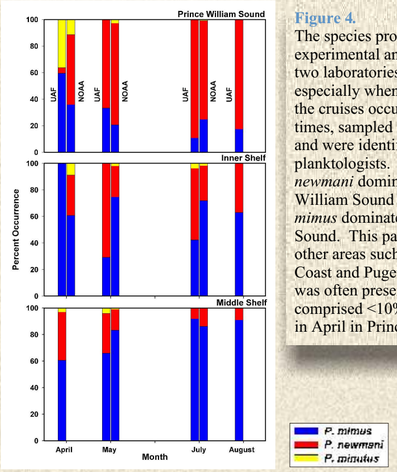
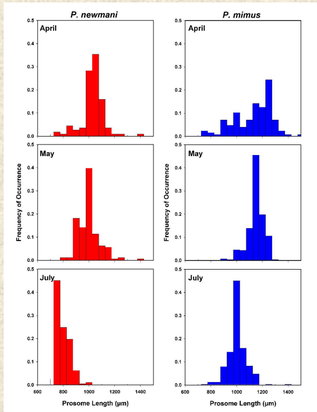


Figure 4. The species proportions of experimental animals between the two laboratories was very similar, especially when one considers that the cruises occurred at different times, sampled different stations, and were identified by different planktologists. In general, *P. newmani* dominated the Prince William Sound samples, while *P. mimus* dominated outside the Sound. This pattern is similar to other areas such as the Washington Coast and Puget Sound. *P. minutus* was often present, but usually comprised <10% of the total except in April in Prince William Sound.

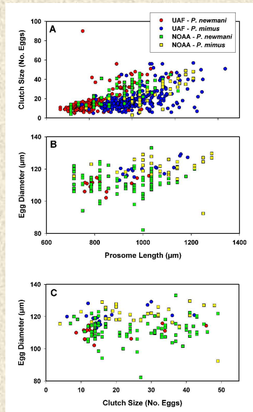
Species- & Month-Specific Prosome Length Histograms

Figure 5. The female prosome length of both species decreased over time in the NOAA data set. We attribute this to the increasing water temperature. *P. newmani* had the greatest decrease from a mean of 1009 µm to 776 µm in July. During this period the surface water temperature increased from about 5 or 6 °C to nearly 15 °C.



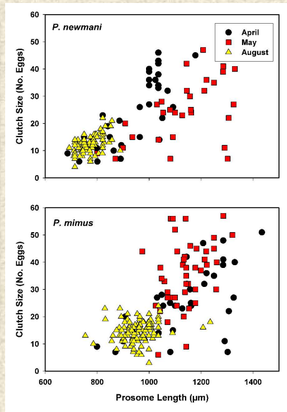
Species-Specific Egg Production by *Pseudocalanus*

Figure 6. The number of eggs per clutch increased as a function of female prosome length, and for the same size female, *P. newmani* tended to lay more eggs per clutch than *P. mimus* (A). There were no significant differences between the NOAA and UAF data sets for clutch size as a function of female length for the two species (ANCOVA; *P. newmani*, P > 0.68; *P. mimus*, P > 0.34). *P. mimus* had a larger mean egg size than *P. newmani* (B). Egg diameter does not appear to be a function of the size of the clutch (C). Clutch volume (number of eggs X average egg diameter) for the two species was nearly equivalent and a function of female length (not shown).



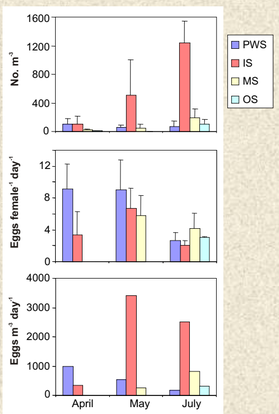
Predicting Clutch Size From Female Length

Figure 7. The statistics of predicting clutch size from female length was very complicated for our data set. There was a strong affect of month and region in the data. Analysis of Covariance (ANCOVA) identified a statistically significant interaction term Month * Region in the *P. newmani* data (P < 0.0001), and statistically significant effects of Region and Month (P = 0.0233 & P < 0.0001, respectively) in the *P. mimus* data. Month had the strongest affect in the two data sets. The affect of month is independent of the temperature dependent changes in female length.



Temporal Trends in *Pseudocalanus* Egg Production

Figure 8. During the Process cruises, *Pseudocalanus* spp. females were most abundant in the Inner Shelf (Alaska Coastal Current) and their concentration increased during the year (top panel). Individual egg production, on the other hand, decreased from about 6-8 eggs $female^{-1}$ day^{-1} in May to 2 - 4 eggs $female^{-1}$ day^{-1} in July (middle panel). The resulting population egg production is thus compensated for by the seasonal increase in female abundance (bottom panel). Population egg production in the Inner Shelf tripled between April and May, but only decreased by about 30% or less in July. Over the course of the year, population egg production decreased in Prince William Sound, but increased over the middle shelf.



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Acknowledgements

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