



Physical and Biological Coupling in the Coastal Gulf of Alaska: Effect of Microplankton Assemblages on Diet and Egg Production Rates of Copepods

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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 (GOA) 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. The goals of the NEP GOA GLOBEC Process projects is to understand the interaction of climate and trophic dynamics that affect the transfer of energy to pink salmon juveniles (*Oncorhynchus gorbuscha*) migrating out of Prince William Sound.

Reproductive output and egg viability of marine copepods are hypothesized to be functions of food quality. One line of evidence for this is laboratory experiments using single species diets. Those experiments demonstrate a depression of egg production and viability when certain prey taxa (diatoms) are consumed by female copepods (e.g. Ban *et al.*, 1997). In the ocean, however, individuals rarely encounter monoculture prey fields. Even in single species phytoplankton blooms, there are other phytoplankton taxa as well as microzooplankton that are potential prey. We attempted to test the food quality hypothesis during two field seasons in the Gulf of Alaska. This poster reports our results for the first year, 2001.

Methods

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

Zooplankton Community -- Plankton abundance and distribution were quantified using established GLOBEC protocols. Large mesozooplankton was sampled at night from 5 different depth strata using a 1 m² MOCNESS with 500 μ m mesh nets. Small mesozooplankton was sampled in depth-integrated vertical tows of a 20 cm diameter mouth CalVET frame or QuadNet equipped with 150 μ m mesh nets. Volume filtered was estimated with flow meters.

Grazing -- Macrozooplankton grazing experiments were simultaneously performed with microzooplankton grazing and phytoplankton growth experiments (the dilution technique; Landry and Hassett, 1982). Macrozooplankton grazing experiments used 24-hr. on deck incubations in 2.3 l bottles strapped to a rotating wheel cooled with running sea surface water. Bottles were screened for either 50% or 12% incident light depending on the depth of the source water. We typically used 4 to 6 replicates for each treatment. Initial, control, and treatment bottles were analyzed for total chlorophyll, chlorophyll size fractions (cascade filtration), and cell counts (preserved in Lugol's). Chlorophyll ingestion and grazing rates were calculated after correction for the effect of microzooplankton grazing using the general method of Nejstgaard *et al.* (2001).

Egg Production -- Females of *Pseudocalanus*, *Calanus*, and *Metridia* were captured using a 0.8 m diameter Ring net (150 or 200 μ m mesh) equipped with a large volume codend, slowly towed vertically through the upper water column. Females were transferred with a wide bore pipette to the incubation chambers. *Pseudocalanus* spp. were incubated in 20 ml plastic scintillation vials; *Calanus* and *Metridia* in 20 ml polypropylene vials with screen at the bottom to separate eggs from females. All incubations were in the dark for 24 hr. at the mixed layer temperature. The contents of the chambers were preserved with formalin at the end of the experiment. In the laboratory, females were identified to species and the number of eggs was recorded. Female prosome length and egg diameter were determined with an ocular micrometer.

Conclusions

- The microzooplankton community appeared to be much less variable at the Prince William Sound station than at the inner shelf stations. Mean, nonzero grazing on microzooplankton by female copepods ranged from 0.2 to 0.6 (d⁻¹) and was difficult to measure in Prince William Sound where the proportions of ciliates and dinoflagellates were approximately equal.
- At all stations, and in all months, a large fraction of the phytoplankton carbon was in the > 20 μ m size fraction. These cells were predominantly chain-forming diatoms. A large part of the diet of female copepods was cells > 20 μ m.
- The majority of ingested carbon was in the form of phytoplankton; microzooplankton usually constituted < 20 % of ingestion, even in the summer.
- The ingestion rate of female *Calanus marshallae* and *Pseudocalanus* spp. generally increased with the concentration of available food.
- A strong functional response in egg production as a function of food quantity was not apparent when three different indices of food were used (total carbon; phytoplankton carbon > 20 μ m; microzooplankton carbon).
- We will continue our investigations of egg production and food using recently analyzed HPLC samples from these grazing experiments. Linear statistical methods will be used to examine how much of the variance in egg production is explained by the ingestion of different pigment groups (e.g. those pigments contained in diatoms).

Coastal Gulf of Alaska Study Area

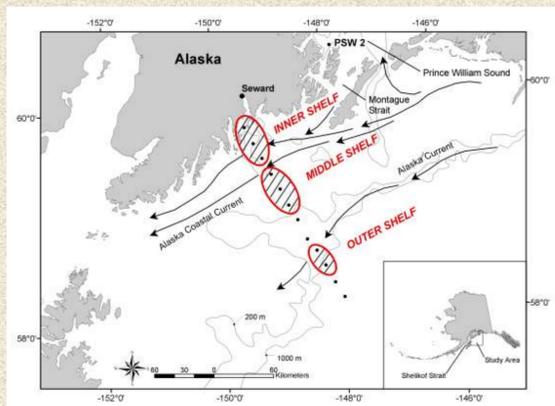
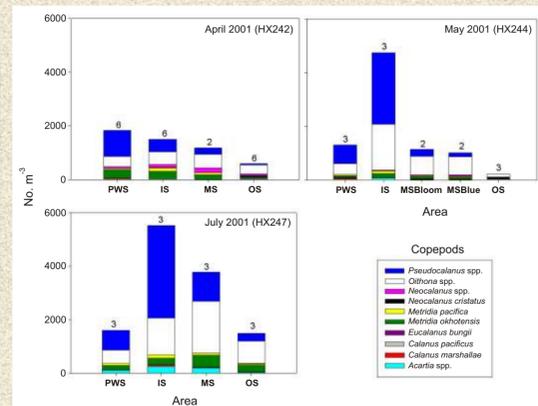


Figure 1. We examined the plankton community and conducted our experiments in four principal areas or regions: inner shelf (GAK Stations 1 - 3), middle shelf, (Stations 4 - 6), outer shelf (Stations 9 & 10) and Prince William Sound (Knight Island Passage, PWS2). The inner shelf stations were always within the Alaska Coastal Current.

Figure 2. The largest temporal changes were at the inner and middle shelf stations. The concentrations were generally higher inshore (including Prince William Sound) than offshore. *Pseudocalanus* and *Oithona* were numerically dominant, though *Neocalanus* spp. (*N. cristatus*, *N. flemingeri*, and *N. plumchrus*) dominated the biomass in April and May.

Temporal and Spatial Distribution of the Copepod Community



Estimated Biomass of the Microzooplankton Community

Figure 3. Estimated carbon biomass (from volume of various taxa present in our initial (T₁) copepod grazing samples. Biomass at the Prince William Sound stations was comparable to 4 of the 6 Inner Shelf stations. The community structure was more consistent within and between cruises in PWS than at the Inner Shelf. The proportion of dinoflagellates to ciliates was roughly equal in PWS during spring. At the inner shelf stations the proportion of ciliates was greater than that of dinoflagellates in the majority of the samples. The high biomass at the summer inner shelf station was observed both in our grazing experiment as well as in the Strom *et al.* dilution experiment.

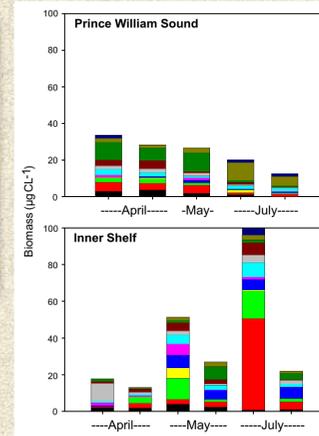
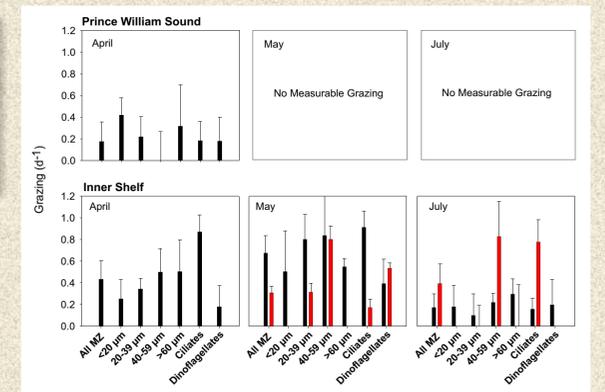


Figure 4. Mean (\pm 2 s.d.) grazing coefficient, g (d⁻¹), for female copepods grazing on microzooplankton. Measurable grazing rates were not obtained in most of the experiments conducted in Prince William Sound. At that station (PWS2), dinoflagellates often constituted a large fraction of the microzooplankton biomass (Fig. 3).

Grazing on Microzooplankton



Size Fractionated Phytoplankton Carbon -- Ambient vs. Ingested

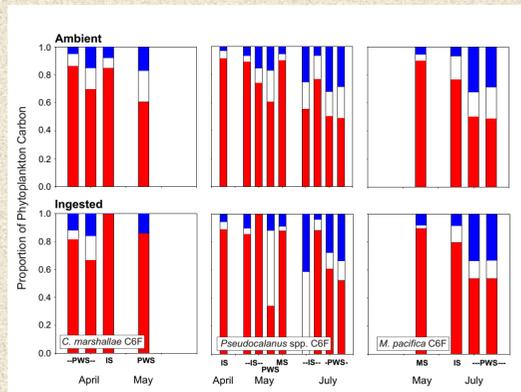


Figure 5. Top Panels -- Proportion of total phytoplankton carbon (estimated from chlorophyll) in three size fractions from the T₁ samples. The > 20 μ m size fraction was diatoms and the high proportion of > 20 μ m carbon in July was due to an upwelling event that preceded our cruise (Strom *et al.*, in prep.). Bottom Panels -- Proportion of phytoplankton carbon ingested by three species of female copepods. PWS = Prince William Sound; IS = Inner Shelf; MS = Middle Shelf.

Figure 6. Top Panels -- Proportions of phytoplankton and microzooplankton in the total carbon from the T₁ samples. Note that most of the carbon available in the form of phytoplankton. Bottom Panels -- Proportion of phytoplankton and microzooplankton carbon ingested by three species of female copepods. Note that the majority of their diet was phytoplankton with one exception, *Pseudocalanus* spp. on the inner shelf in July. Numbers at the top of the graphs are the total carbon concentrations (μ g C L⁻¹).

Total Carbon -- Ambient vs. Ingested

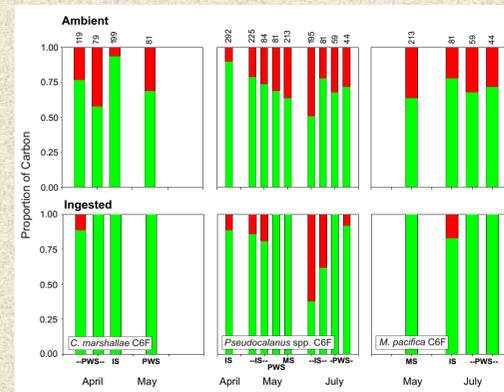


Figure 7. Ingestion rate versus available carbon for 2 species of grazers and three different months. In general, there was a positive response (ingestion increasing with increasing food concentration). Note that ingestion by *Pseudocalanus* spp. is maximal above about 200 μ g C L⁻¹. The April data point for *Pseudocalanus* seems anomalously high (twice their bodily carbon).

Grazing Functional Response

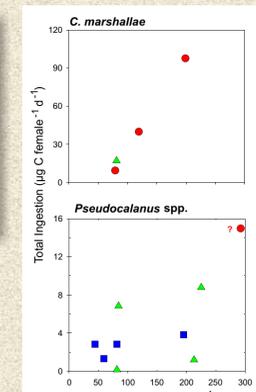
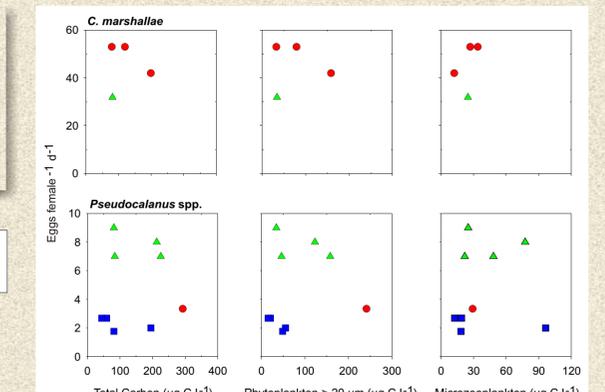


Figure 8. Egg production rate for two species as a function of food quantity. There appears to be an absence of strong trends in egg production as a function of any of the three indices for food. Grazing rate on particular components of the phytoplankton will soon be calculated using our HPLC data.

Egg Production Functional Response



References

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Acknowledgements

We gratefully acknowledge the financial support of the NOAA Coastal Ocean Program & NSF Biological Oceanography Program (E. Turner & P. Taylor, Program Managers). We thank all those who participated in the GLOBEC Process cruises for their assistance and camaraderie at sea. J. Lanksbury and C. Harpold (AFSC) assisted with data collection and analysis. 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. Wendy Carlson of the AFSC Graphics Unit prepared the poster presentation.