Bioenergetic Assessment of Climate Change Impacts on Arctic Copepods

Rubao Ji, Carin Ashjian

Department of Biology
Woods Hole Oceanographic Institution

Climate change is likely to affect water temperature and snow/ice dynamics that in turn impact light conditions and the food environment for plankton populations in the Arctic Ocean. Copepods are key members of the Arctic planktonic food web, linking primary producers to upper trophic level consumers such as fish and planktivorous whales as well as modulating benthic-pelagic coupling in shelf seas. *Calanus hyperboreus* and *Calanus glacialis* are two dominant endemic Arctic *Calanus* species. *C. hyperboreus* is the largest, slowest growing and longest lived, and its population center is in the Arctic Basin where it is the biomass dominant of the zooplankton; whereas *Calanus glacialis* is the most important copepod species in terms of biomass on the Arctic shelves (Fig. 1). Both species play a key role in the Arctic pelagic food web, and their biogeography is likely affected by climate change.

With support from The James M. and Ruth P. Clark Arctic Research Initiative, we first reviewed existing literatures to assess the differences in the biogeographic distributions, life history strategies and bioenergetics characteristics of the two species. *Calanus glacialis* is dominant in the Chukchi shelf and slope and in the Barents Sea north of the polar front. It is found in the Arctic Basin, but is believed to require replenishment from the shelves to maintain its presence there. It is not successful south of the polar front where *C. finmarchicus* is the most important. It appears that *C. glacialis* has higher food requirements than *C. hyperboreus* which would explain its faster growth rates and shorter life cycles (1 to 2 yrs on the Arctic shelves relative to *C. hyperboreus* (3 to 4 yrs in the Arctic basin). Their reproductive strategies are quite different. *Calanus hyperboreus* uses lipids slowly accumulated over previous growing seasons to fuel reproduction that occurs at depth prior to the ice/water column vernal increase in primary production on which they can start to feed and grow. *Calanus glacialis* is adapted to the cold relatively food-rich Arctic shelves while *C. hyperboreus* is better suited to the low-food environment of the deep basin. Most of this information has been incorporated into an individual-based copepod

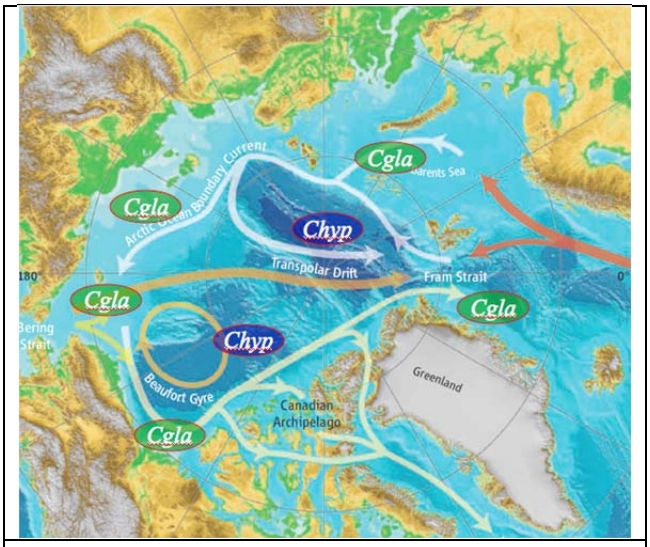

Figure 1. Biogeographic distributions of two key *Calanus* copepod species in the Arctic basin and surrounding shelf seas.

model to examine the climate impact on biographic boundaries (Ji et al., 2012, Progress in Oceanography)

The support also allowed us to examine another key aspect of the bioenergetics: the variability of timing and availability of food for the targeted copepod species. The results from this study have been recently published (Ji et al., 2012, Global Change Biology). Our results suggest:

1. Over a large portion of the Arctic marginal seas, the timing variability of ice retreat at specific locations has a strong impact on the timing of pelagic phytoplankton peaks but weak impact on the timing of ice-algae blooms in those regions
2. The model predicts latitudinal and regional differences in the timing of the ice algal biomass peak (varying from April to May) and the time lags between ice algal and pelagic phytoplankton peaks (varying from 45 to 90 days)
3. Time lags between ice algal and phytoplankton peaks are significantly correlated in areas where ice retreat has no significant impact on ice-algae peak timing, suggesting that changes in pelagic phytoplankton peak timing control the variability of time lags.
4. The model results suggest that phenological variability in primary production is likely to have consequences for higher trophic levels, particularly for the zooplankton grazers, whose main food source is composed of the dually pulsed algae production of the Arctic

The support of Arctic Research Initiative also allows the PIs to develop international collaborations. A newly funded collaboration through Norwegian Research Council will allow R. Ji to enhance his effort on this topic by interacting closely with Norwegian scientists (funds support Ji's visits and attending workshops). In addition, we are currently developing an NSF proposal to link the plankton phenology and biogeography by collaborating with scientists from University of Washington and University of Rhode Island.

Publications

Ji, R., C. Ashjian, R. Campbell, C. Chen, G. Gao, C. Davis, G. Cowles, R. Beardsley, 2012. Life history and biogeography of Calanus copepods in the Arctic Ocean: An individual-based modeling study. *Progress in Oceanography*. 96:40-56.

Ji, R., M. Jin, Ø. Varpe, 2012. Sea ice phenology and timing of primary production pulses in the Arctic Ocean. *Global Change Biology,* DOI: 10.1111/gcb.12074.