BEST-BSIERP Bering Sea PROJECT
UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

Hidden Food in the Coldest of Times

THE NUTRIENT ROLE OF SEA ICE

Copepods, tiny lipid-rich crustaceans in the Bering Sea, are a favored meal of larval and juvenile Pollock. One copepod that dominates the zooplankton on the Bering Sea shelf, and shelf areas around the Arctic Ocean, is *Calanus glacialis* (Figure 1). We know that the abundance of this species fluctuates between years. Surprisingly, colder years, when ice cover is more extensive and persists longer during spring, appear to favor growth of the copepod population. Why is this? We set out to answer this question during a cruise in late winter of 2009 through early spring of 2010, when ice covered most of the Bering Sea shelf.

Since reproduction and growth of this copepod is controlled by the availability of food, we thought that they must be obtaining sufficient food under the ice to initiate feeding and reproduction. A second question is "what is this food source"? One possibility was the layer of ice algae—a diverse community of microscopic plants and animals that grow under the ice during spring (Figure 2)—rather than from the more usual phytoplankton community in the water column beneath.

How We Did It

We collected zooplankton samples to see what the *C. glacialis* population was doing, whether the adult females were laying eggs or not, and how much food was in their guts. We determined the identity of individual prey species in their guts from their DNA and quantified the amount of this

continued on page 2

Fig. 1

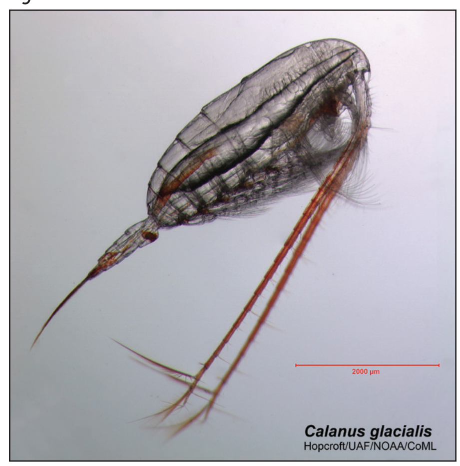
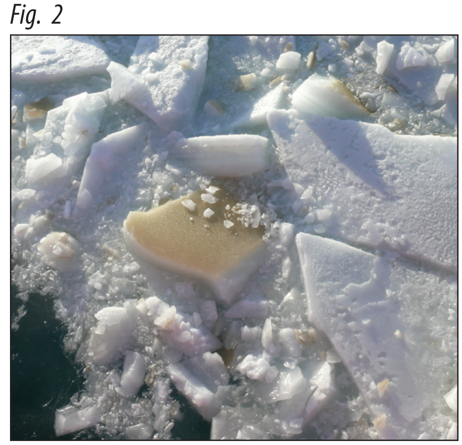
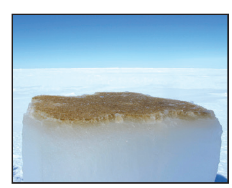


Fig. 2





Blocks of sea ice turned upside down to reveal a thick layer of ice algae.

The Big Picture

The high feeding rates of the copepod *Calanus glacialis* that we observed during a cruise in late winter and early spring of 2009/2010 could not have been sustained by the low levels of phytoplankton in the water column. This, and the presence of ice algae found in their guts, indicates that the copepods were obtaining their nutrition from ice algae. The higher feeding rates appeared to be associated with warmer air temperatures, which are, in turn, associated with the release of ice algae into the water. Before this ice algae is diluted by dispersion into the water column below, it is likely that it provides a dense layer of food for the zooplankton. In years when when ice cover is more extensive and persists longer, there is an extended period of higher food availability for *C. glacialis*, compared with the brief ice-edge or water column phytoplankton bloom. This results in a longer period of population growth, resulting in greater abundance later during the spring.

A NOVEL MOLECULAR APPROACH TO MEASURING IN SITU FEEDING RATES OF COPEPODS IN THE SOUTH EASTERN BERING SEA
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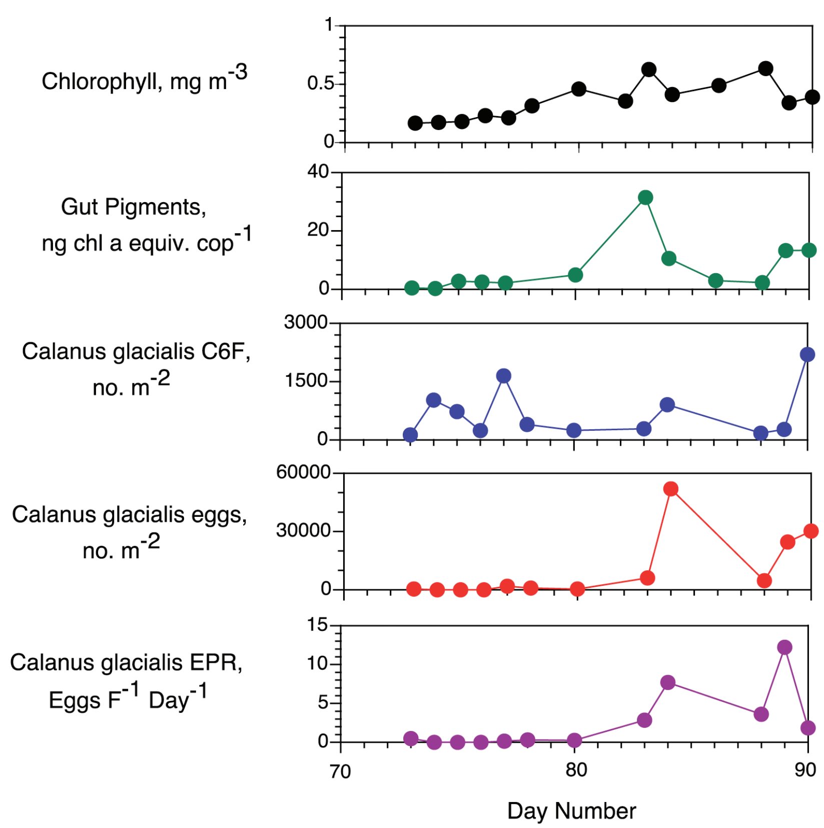
prey DNA to calculate consumption (Figure 3). The amounts of phytoplankton chlorophyll in their guts provided an independent measure of consumption (Figure 4). We also measured the amount of phytoplankton present in the water column beneath the ice, and used DNA analysis to characterize the potential prey species present both in the water column and in the ice algal community growing on the underside of the ice.

What we found:

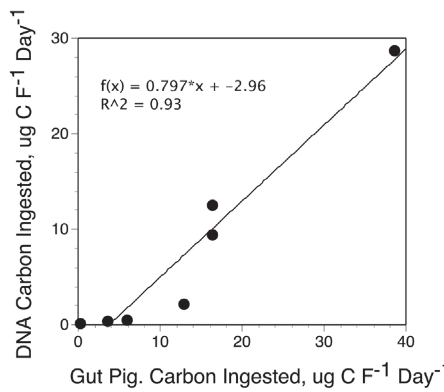
- *We found phytoplankton in extremely low concentrations within the water column under the ice, while a dense layer of ice algae was at the base of the ice at most locations.*
- C. glacialis *eggs began to appear in the water column during the cruise. At the same time we found large amounts of phytoplankton chlorophyll in the guts of adult female* C. glacialis, *indicating elevated feeding rates.*
- *The prey DNA in the guts of* C. glacialis *was mostly from ice algal species, indicating that ice algae were an important source of food.*
- *Quantification of this prey DNA followed the same pattern of variation over time as the chlorophyll a pigments, indicating that DNA can be used to provide a measure of feeding rate on individual prey species.*

Fig. 3



Mean water column chlorophyll a, Calanus glacialis *adult female gut pigments, abundance, egg abundance in the water, and estimated egg production rates between March 17 (Day 70) and March 31 (Day 90) 2010.*

Fig. 4



Estimated daily consumption by Calanus glacialis *adult females of the four diatom prey species, based on the 18S DNA copy numbers in their guts, plotted against estimated phytoplankton consumption, based on gut pigments.*

Why We Did It

Population growth of the dominant Arctic copepod *C. glacialis* appears to be dependent upon seasonal ice cover and its associated ice algae during spring. Changes in the extent of this seasonal ice cover associated with climate change will adversely affect higher trophic levels that feed upon this key species. The Bering Sea Shelf is a region of rapid climate change. Knowledge of how key species respond to this change will help predict overall ecosystem response, and how important fisheries, as well as endangered species, may be affected.

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The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**