A Winter Expedition to Explore the Biological and Physical Conditions of the Bering, Chukchi and Southern Beaufort Seas

Carin J. Ashjian, Biology Department

Our understanding of winter conditions and processes in the Arctic is severely limited because of difficulties in accessing these regions at that time of year. This lack of knowledge has compromised our ability to model and to predict future states of Arctic ecosystems – efforts that are central to our ability to understand the potential impacts of ongoing climate change.

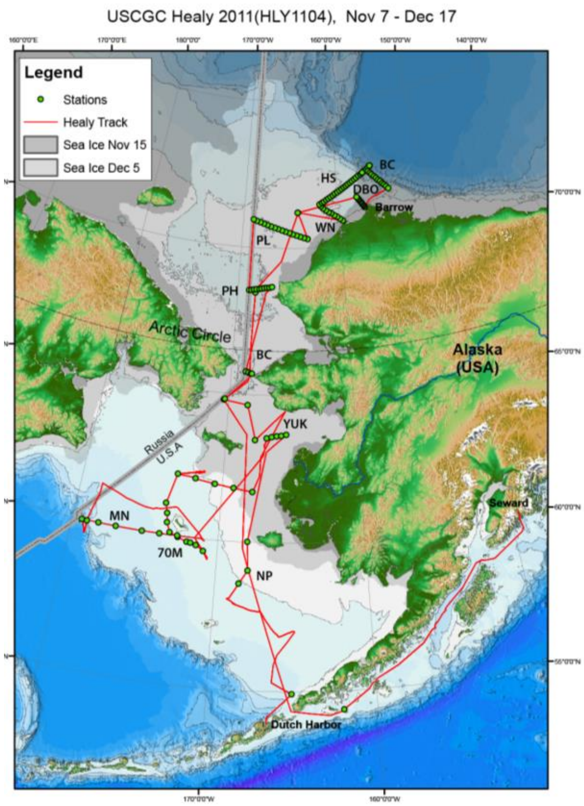

Figure 1: Cruise track of USCGC *Healy*. Dark gray shading indicates ice edge on November 15, 2011; light gray shading indicates ice edge on December 8, 2011. The cruise started in Seward AK and ended in Dutch Harbor AK. Green symbols indicate the locations where sampling was conducted (stations). Text indicates the designation or name of the key transects.

Zooplankton, such as copepods, are important links in the food chain. Copepods feed on phytoplankton, ice algae, and much smaller zooplankton called microzooplankton and, are in turn, consumed by larger animals such as jellyfish, fish, baleen whales, and seabirds. The dominant copepod species in the Bering and Chukchi Seas, *Calanus* spp., enters a quiescent state similar to hibernation during winter and, hence, should not be feeding. However, other copepod species remain active and feeding. During winter, grazing on plant material such as phytoplankton should be minimal because with little or no light there is no plant growth. Therefore, these still active copepod species may rely on microzooplankton as food. Copepod respiration (consumption of oxygen) also reflects activity, with hibernating copepods respiring at much lower rates than active copepods. Only a few measurements of respiration exist for Arctic copepods. The questions of whether zooplankton are feeding during winter, on what they are feeding, and how much they are respiring are key to understanding biological activity in Arctic seas during winter.

During November and December of 2011, my colleagues and I conducted a 6-week, interdisciplinary cruise on the icebreaker USCGC *Healy* to the Bering, Chukchi, and Beaufort Seas that was funded by the National Science Foundation (Figure 1). To my knowledge, *this was the first such research cruise to these regions during winter* (all other winter sampling has been conducted from ice camps or ships frozen into the ice). The objectives and scope of the NSF-funded work included measuring water types; circulation; zooplankton abundance and distributions; and identifying where and how the important copepod *Calanus* spp. is overwintering. With additional funding from The Clark Arctic Initiative, we were able to expand our work to include measuring the grazing rates, food types, and respiration rates of the dominant zooplankton types. We sampled across a set of key transects in the Chukchi and Beaufort Seas. Unfortunately, because of bad weather, our sampling was severely curtailed in the Bering Sea.

We found that:

- Sea ice was forming as we entered the Chukchi Sea in mid-November. Almost all of the stations (locations) that we sampled were ice covered. Day length was extremely short and we experienced continuous night for about 10 days while in the northern Chukchi Sea. Sea ice extended south into the northern Bering Sea as well and provided a refuge from the high seas that we encountered in the open water as successive Aleutian lows rolled through the Bering Sea in early-mid December.

- Detectable but very low quantities of chlorophyll (phytoplankton) were present with the highest levels being located in the northern Chukchi Sea during the first portion of the cruise, before the absence of light prevented further growth of phytoplankton.

- Zooplankton, including the important copepod species *Calanus* spp., were still active (*Calanus* was not quiescent) and feeding and respiring at low but measurable rates (Figure 2, next page).

- Microzooplankton were an important part of the zooplankton diet.

- Some copepod species were still reproducing, based on the presence of their young life stages in the plankton samples.

- *Calanus* spp. was storing lipid (fat) for overwintering, but estimates of lipid consumption based on respiration suggested that many may not have had enough lipid to survive until spring (Figure 3, next page). The longest survival time was on the order of 120 days, meaning that those animals might survive until late March, when ice algae would begin to bloom and become available as a food source.

- The northern Chukchi Sea was physically and biologically distinct from the southern Chukchi Sea and northern Bering Sea that were similar to each other.

- Zooplankton species distributions were closely associated with the different water mass types observed in the region and with the prevailing circulation.

- Two populations of the important copepod species *Calanus glacialis/marshallae* were observed, based both on life stage structure and genetics; one on the Chukchi Shelf and the second on the Chukchi/Beaufort slope and Canada Basin, and in water originating in those locations (Figure 4, next page). The Chukchi Sea population appears to follow a one-year life cycle while the population from the deeper water of the slope and basin appears to follow a two-year life cycle.

These results can be used to better inform biological modeling efforts that seek to describe how carbon is transferred through the Arctic food web and how ongoing climate change may modify that transfer and the success of different types of producers and consumers.

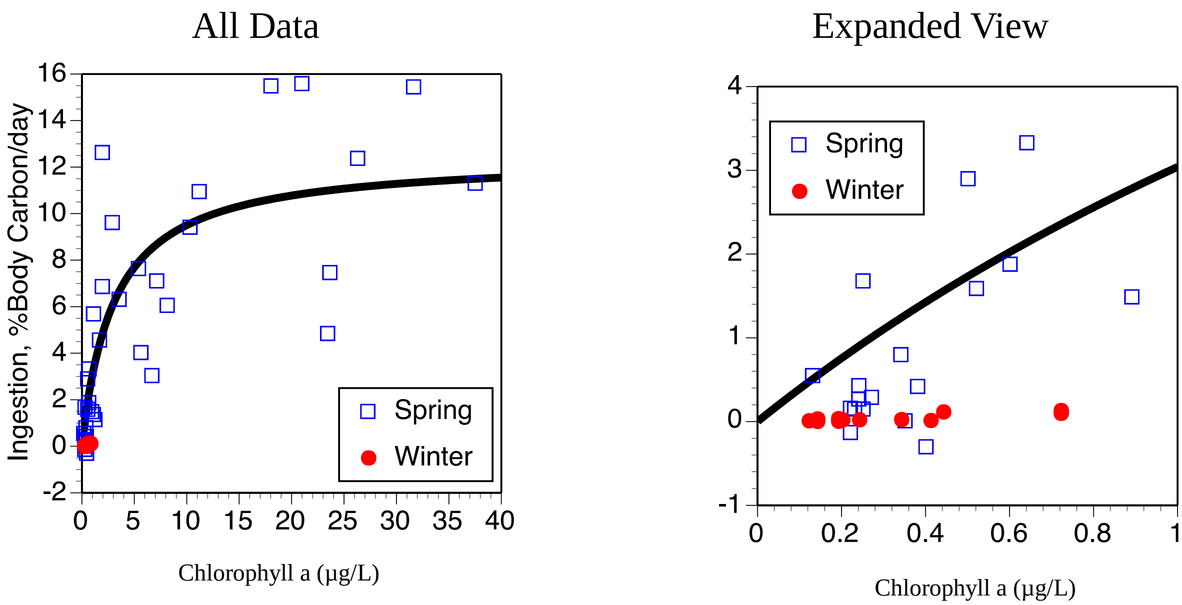

Figure 2: Feeding (ingestion) rate of *Calanus* spp as a function of chlorophyll a concentration. Data from the winter cruise are shown in red; data from previous cruises in spring are shown in blue. Feeding was very low but detectable. The right hand panel shows an expanded view of the lower portion of the left hand panel.

Figure 3: Two examples of females of the copepod *Calanus* spp. The animal on the left is full of lipid (see shiny sac inside body) and is ready for overwintering, while the animal on the right has virtually no lipid.

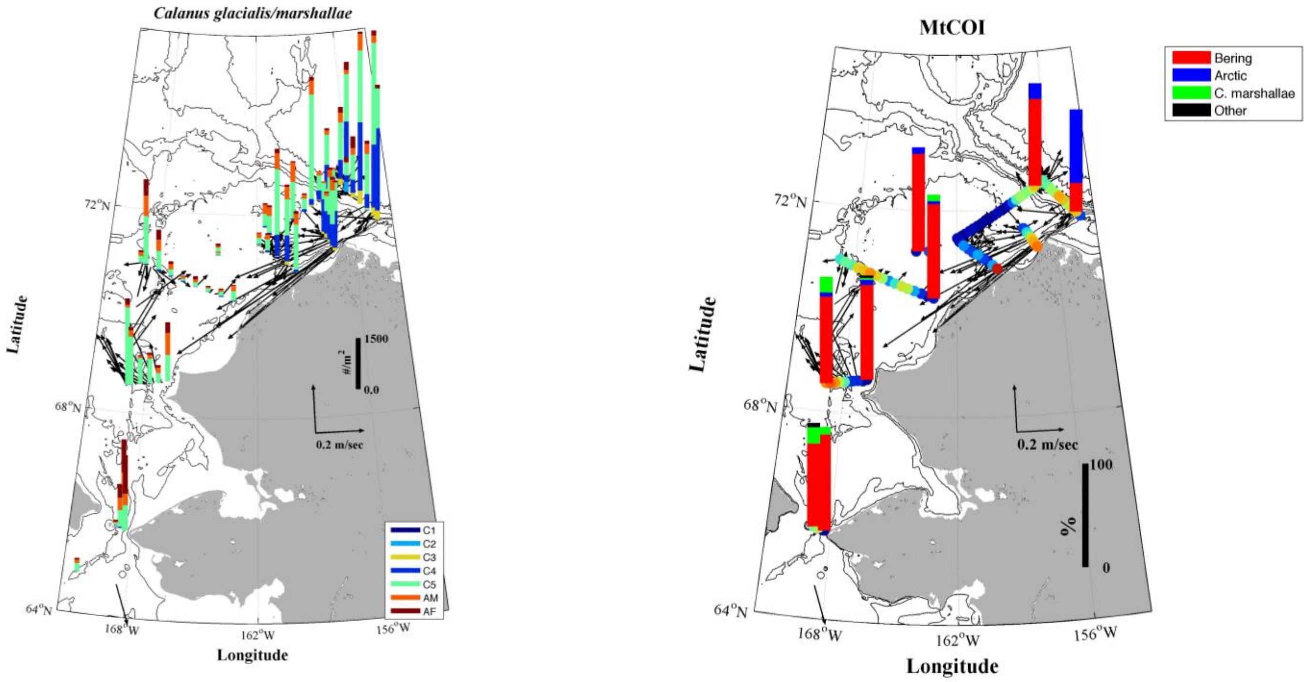

Figure 4: Distribution of the important copepod *Calanus* spp. (left) and of different genetic populations of the species (right). Each figure also shows the prevailing velocity at each sampling location as a vector (line), with the length of the vector indicating the strength of the current and the orientation indicating the direction of the current. For the abundance measurements (left), the height of the bar shows the total number of copepods in the water column at each location with the different colors indicating the different numbers of each life stage. Note that in the northeastern region there were high numbers of the life stage C4 (blue) while at other locations this life stage was not important. For the genetic results, most of the copepods were from Bering Sea populations (red) except in the northeastern region where copepods from an Arctic basin population (blue) were present. Both types of data indicate that two different populations of this species, with different life cycles, were present in the study area. The direction of the current vectors shows that the Arctic population was brought south from the Arctic basin by the currents.