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

Demography and Population Dynamics of Bering Sea Krill

COMPLICATED LIFE HISTORIES ACROSS THREE OCEANOGRAPHIC DOMAINS

Krill are an important food source for many larger animals such as whales, seals, and fish. As for many other organism populations, krill populations and their demographic structure in the ocean are due to their growth and death rates. Under favorable conditions the krill grow fast and build up their lipid storage for use during unfavorable conditions, such as the dark cold winters of the Bering Sea. In unfavorable conditions, krill populations have decreased growth rates and may even shrink. Krill growth and survival are structured, in part, by food availability. Important questions of intrinsic interest arise: How are growth and death rates affected by the changing conditions in the Bering Sea? How do these changes in growth and death relate to the demographic structure of krill?

In the Bering Sea, three major euphausiid groups occupy different habitats. *Thysanoessa raschii* were found in abundance in the middle and inner domains. *T. inermis* occurred more abundantly in the outer domain and *T. longipes* were more abundant through the outer domain and beyond the shelf-break (Fig. 1).

The demographic structure varied among different krill species. In general, the dominant age peaks for *T. raschii* and *T. inermis* were in the 3-9 month range. But in spring 2009, older individuals tended to be more abundant for both krill species (Figs. 2, 3).

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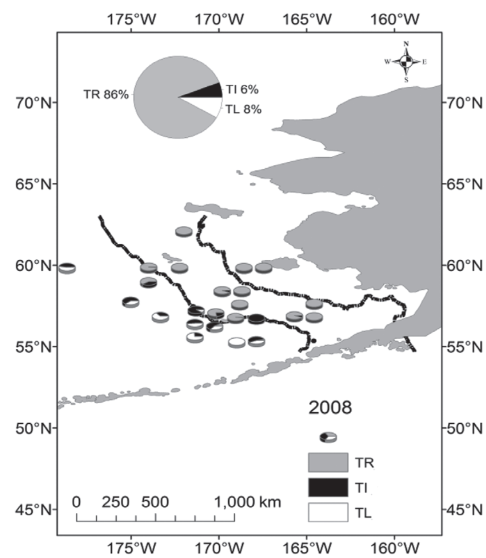
Fig. 1



Spatial distribution of different krill species: T. raschii *(TR),* T. inermis *(TI), and* T. longipes *(TL) in 2008. Two black lines indicate 50 m and 100 m bathymetry, respectively.*

The Big Picture

The Bering Sea is a very productive ecosystem, with many economically important organisms that rely on krill as a prey item. Variability in krill growth and survival is structured as a climate-driven bottom-up control system of food availability and predation. This project examines growth and vital rates in krill species to better understand their population dynamics and their trophic linkage with predators. Three key questions are: (1) How does krill demographic structure (age and size) vary across three oceanographic domains in the Bering Sea: the inner, middle, and outer shelf? (2) How do growth and vital rates vary in the three domains? (3) How do the variations in growth and vital rates contribute to different demographic structures? During the Bering Sea Project field years 2007 – 2010, several key parameters of krill populations were measured (age, lipid content, and growth) from the same individuals, which provided unprecedented detail for modeling vital rates. We developed an individual-based model to simulate demographic structure, and we concluded that depending on the location (e.g., inner shelf versus outer shelf), krill growth and survival respond differently to large-scale oceanographic changes.

INTEGRATION AND MODELING OF SPATIAL-TEMPORAL VARIATION IN VITAL RATES FOR EUPHAUSIIDS IN EASTERN BERING SEA: IMPLICATIONS FOR DEMOGRAPHICS
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The growth of *T. inemis* and *T. raschii* tended to be faster in 2008 than in 2009, whereas the growth of *T. rashii* was similar in 2008 and 2009. The difference in growth could be explained by age structure and survival rates: more young individuals, faster growth rate for the population; higher survival rate for old individuals, slower growth rate for the population.

How We Did It

At sea, we deployed a Multiple Opening and Closing Net with an Environmental Sensing System (MOCNESS) to collect krill samples. Samples were preserved and sorted to species level in the lab. Live krill samples were also collected at sea and then frozen for later age determination. A biochemical approach was used to determine krill ages in the lab. To examine the relationship between growth, survival, and demographic structure, individual based models were fit to the observed demographic and size data in spring and summer to determine krill growth rate estimates for 2008 and 2009.

Why We Did It

Krill are important prey for many predators, such as pollock, whales, seabirds. Their abundance will have major impacts on the food web. Due to their complicated life history and multiple molting cycles, it is difficult to determine their demographic structure and estimate their growth using conventional methods. Information on demographic structure, growth, and survival will facilitate our understanding of krill's response to environmental changes, which in turn will improve prediction of the health of the predator populations.

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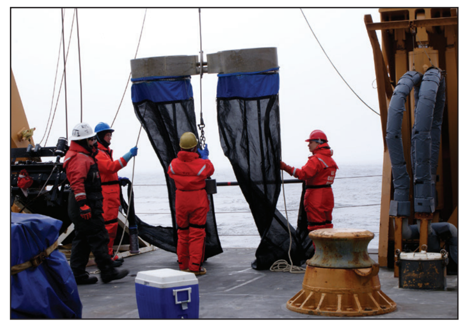
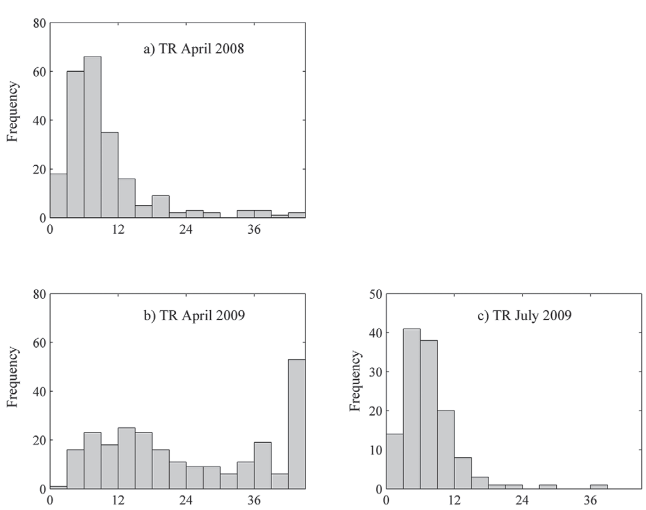
The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**



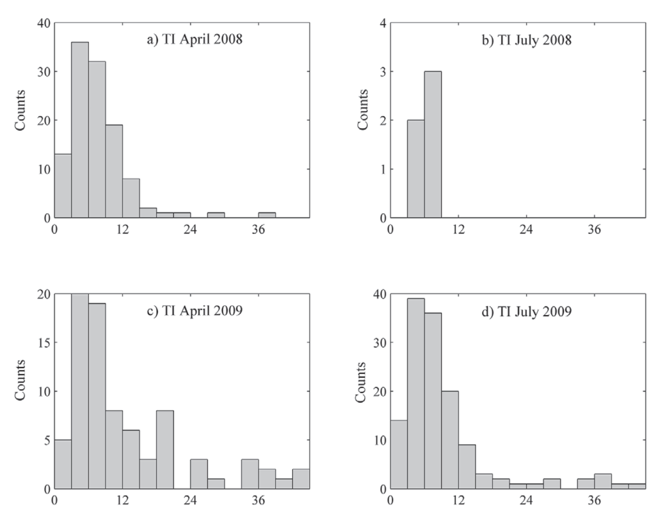
Deployment of a Bongo net to collect krill.

Fig. 2



Spring and summer age structure for T. raschii *in 2008 and 2009. In spring 2008, 6-9 month old krill were common. In spring 2009, older krill were more abundant, but disappeared in summer. No data were available for* T. raschii *in summer 2008.*

Fig. 3



Spring and summer age structure for T. inermis *in 2008 and 2009. Note that older krill were more abundant in spring 2009.*