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

Hungry Fish Make a Difference

LINKING CLIMATE AND KRILL ABUNDANCE

Many fish, seabirds, and whales feed on krill, but there is only so much to go around. Every year, krill (or euphausiids) abundance peaks in late spring – early summer, and bottoms out at the end of winter. Migrations and movement are tuned to the seasons, but what happens when there is overall less or more krill, as can happen in cold and warm years? Do fish make a noticeable dent on the available krill? How much and where?

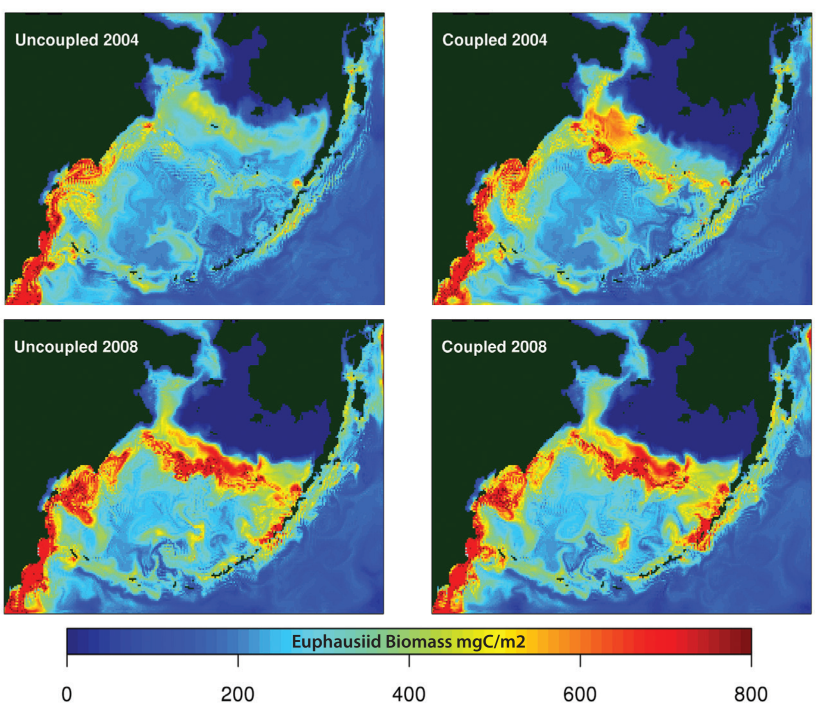
Krill abundance is higher during cold years and lower during warm years. The amount of energy fish need to grow also changes with temperature. To grow the same amount, fish require less energy in cold temperatures, more in warm temperatures, thus eating less krill in cold years and more in warm years. This creates large areas where krill is grazed down in warm years but not in cold years, impacting krill predators such as forage fish, seabirds, and marine mammals (Figure 1).

continued on page 2


REEM/AFSC/NOAA

Hungry fish – warm temperatures increase fish metabolism, meaning they eat more krill in warm years, changing the availability of krill to other predators throughout the Bering Sea shelf and slope.

Fig. 1



Average krill biomass in the eastern Bering Sea shelf and slope for 2004 (warm year) and 2008 (cold year) assuming zooplankton mortality is proportional to biomass (uncoupled) and linking a bioenergetics fish model (coupled).

The Big Picture

Forage fish are the link between zooplankton and many larger fish-eating predators such as large fish, seabirds and marine mammals. For example, walleye pollock is the single most abundant fish on the eastern Bering Sea shelf, with an estimated 6.5 million tons per year consumed by predators. It also supports a fishery of over 1,000,000 tons annually, with revenues upwards of 2 billion dollars. Keeping track of krill and forage fish response to different climate conditions, and the cascading effects on the food web, builds on our understanding of processes such as population growth, feeding grounds, "hot spots," consequences of fat and skinny krill, as well as fishermen's behavior. Combined with climate forecasts, it has the potential to complement current conservation and management in the Bering Sea with more proactive and strategic actions.

FORAGE AND EUPHAUSIID ABUNDANCE IN SPACE AND TIME (FEAST)
A component of the BEST-BSIERP Bering Sea Project, funded by the National Science Foundation and the North Pacific Research Board with in-kind support from participants.

How We Did It

We used a 3D model for oceanography, nutrients and plankton (NPZ) constructed for previous work, and we added data for several species of fish at different lengths based on historical databases from the National Marine Fisheries Service and National Oceanic and Atmospheric Administration. Rather than assuming zooplankton gets eaten in proportion to their biomass, we assumed it gets eaten according to fish energy needs or bioenergetics. We gave the different types of zooplankton (such as krill) and fish values in calories, and then based the fish consumption and growth on how many calories they ate and how they spent them on swimming, living and growing, all of which is affected by temperature. We then ran the model for the entire Bering Sea, estimating everything from oceanography to plankton dynamics, fish numbers, distribution, length, and weight. This requires a lot of calculations, so we use a supercomputer, which means we divide the whole region into small squares and send them out to 384 processors that talk to each other. One simulated year takes about 16 hours to run.

Why We Did It

In the eastern Bering Sea most of what we know about fish occurs in summer and early fall, and relates to their feeding habits, species abundance and their distribution. We know very little about the rest of the year, including interactions with climate, winds, currents or zooplankton. We are now working on integrating oceanography with zooplankton and fish dynamics. Because many predators eat either zooplankton or forage fish, it is important to understand how much and where zooplankton (like krill) is consumed by forage fish (small fish like young pollock, capelin and herring) year round and in multiple years. We wanted to quantify the difference between assuming that fish predation is proportional to krill biomass (uncoupled mode) versus using bioenergetics (coupled mode) (Figure 2), and to measure changes in the spatio-temporal availability of krill (Figure 3).

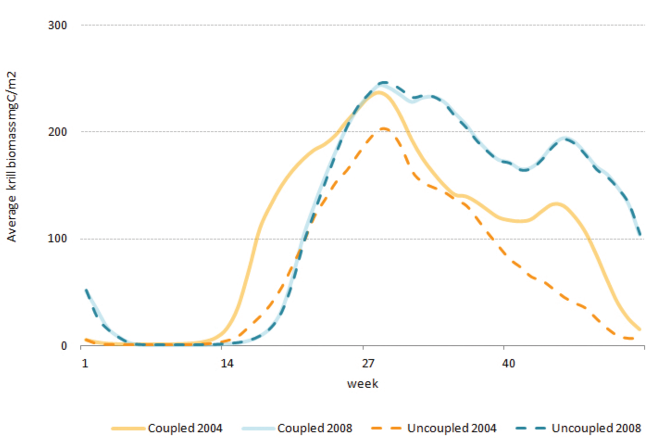
Ivonne Ortiz, University of Washington (UW)/ Alaska Fisheries Science Center (AFSC), National Oceanic and Atmospheric Administration (NOAA)

Kerim Aydin, AFSC, NOAA

Al Hermann, UW / Pacific Marine Environmental Laboratory, NOAA

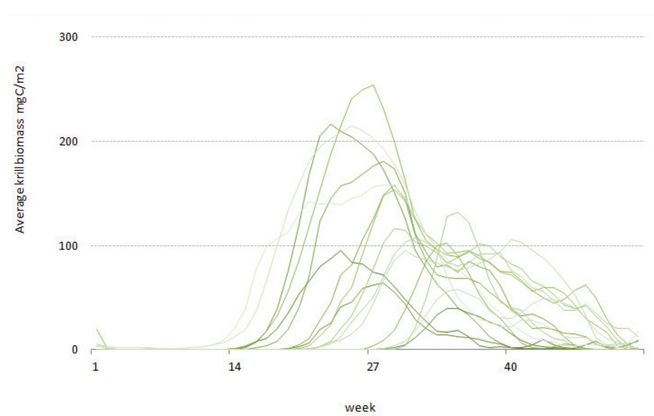
The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Program and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**

Fig. 2



Average krill biomass in the eastern Bering Sea shelf and slope for 2004 (warm year) and 2008 (cold year) assuming zooplankton mortality is proportional to biomass (uncoupled) and linking a bioenergetics fish model (coupled).

Fig. 3



Variability in space and time of krill biomass in different regions of the eastern Bering Sea shelf and slope as estimated for 2004 using the fish bioenergetics model to estimate predation on krill.