BEST-BSIERP Bering Sea PROJECT

UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

Seasonal Bioenergetics in the Bering Sea

THE FATTER THE BETTER

Being fat is good when you have to survive a long winter with very little food to eat. This seems obvious, but it is one of the most interesting and important discoveries we have made from our studies of juvenile pollock in the Bering Sea. Winter is a time when food is scarce for juvenile fish that must use their fat stores to survive. We found that fish that are fat at the beginning of winter survive better than those that are lean. Apparently, the more fat they have the better, because small fat fish do not survive as well as big fat fish. We also realized that fish get big and fat by eating fatty prey, and we found that fatty prey were most abundant when conditions in the Bering Sea were cooler, with longer lasting sea ice, rather than when they are warmer (Figure 1).

How We Did It

Fat fish have more calories per unit weight than lean fish. We used a method called bomb calorimetry to measure the number of calories in a fish. Essentially, we dry the fish, put it in a machine that sets it on fire and then measures how much heat is produced (Figure 2). The amount of heat produced directly reflects its calorie content. We applied this method to samples of fish and their prey collected from the Bering Sea between 2003 and 2010. During this period, the Bering Sea underwent a shift from "warm years" characterized by an early sea ice retreat to "cool years" characterized by late sea ice retreat. When we compared the calorie content of the fish and their prey to these different climatic conditions, we saw fish and their prey were leaner in warmer years than in cooler years. We were also able to

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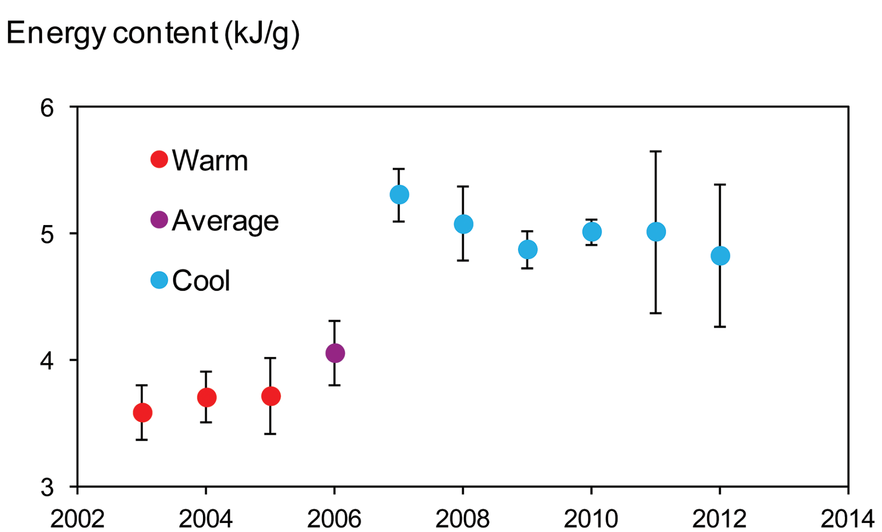
Fig. 1



This is the amount of energy in a gram of juvenile pollock tissue (measured in kilojoules per gram) in each of the years we have surveyed the Bering Sea. The red symbols show the energy content in warm years and the blue symbols show the cool years. It is clear that the energy content of pollock has changed between warm and cool years.

The Big Picture

We found a similar story for Pacific cod as we did for pollock. This suggests that a warming Bering Sea is likely to produce less protein for us to consume, or that the protein we harvest from the Bering Sea may have to come from new sources. Predicting how climate change will influence the Bering Sea ecosystem was a primary goal of the Bering Sea Project. The observations we made were consistent with an overall picture that the organisms we depend on from the Bering Sea have evolved life history strategies that rely on the presence of ice in spring. As the Bering Sea warms and ice retreats earlier and earlier, juvenile forms of the species we depend on will find it more and more difficult to survive.

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compare the total number of calories in the fish to the number of fish that survived and were eventually caught in fisheries. We discovered that the years that produced big and fat juveniles were the same years that produced more fish for the fishery.

Why We Did It

The pollock fishery in the Bering Sea is one of our largest fisheries, and it represents an important source of protein for the country. So understanding how climate affects fisheries can be thought of as a question of food security for our country. We believe that the impacts of climate on fisheries and fish populations are most discernible among juvenile fish because they must use energy to grow and avoid predation or store it to avoid starvation, especially over the winter. Climate has a profound influence on how fish deal with these conflicting demands by influencing the availability and quality of their food, the rate at which they use energy for daily activities, and how much food their predators need.

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Fig. 2

This shows our calorimeter and all the various components. Fish (1) are ground up (2) and dried into a powder (3). A sample of the powder is pressed into a pellet (4) and loaded into the pellet holder (5), which has a fuse installed. The pellet and fuse are loaded into the bomb casing (6) and the casing is filled with oxygen and then placed in the water bath (7). Electrodes heat the fuse, which ignites the powder and generates heat that warms the water bath. A thermometer in the water bath records the change in temperature, and a computer converts the temperature change into calories.