BEST-BSIERP Bering Sea PROJECT

UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

North-South Differences in the Eastern Bering Sea Shelf

CHANGES IN LATITUDE; CHANGES IN ATTITUDE

In the ocean, hard physical borders do not exist. So what environmental cues tell organisms when they are in a suitable habitat? One feature, which splits the Bering Sea middle shelf in two and forms a transitional line between the northern and southern Bering Sea, is defined by seasonal sea ice and water temperature. We discovered that this line, found between 59° and 61° latitude, is essentially the divide between the cold north, where salt and temperature both play a role in vertical stratification, and the warmer, more sharply stratified southern shelf. This boundary persists through the summer, but may become more diffuse due to the horizontal transport of water onto the shelf.

We observed that the presence or absence of seasonal ice affected the strength and location of the boundary, along with water characteristics such as currents and temperature on either side. The southern shelf was sharply stratified by temperature during summer into warm upper and cooler bottom layers, while the northern shelf had a more gradual change in temperature and salinity. The southern shelf was also much warmer in years without seasonal ice cover. We explored the temperature preferences of Bering Sea fish and snow crab to help predict who the "winners" and "losers" might be in a warmer climate without seasonal sea ice. We discovered that some fish, such as pollock, which

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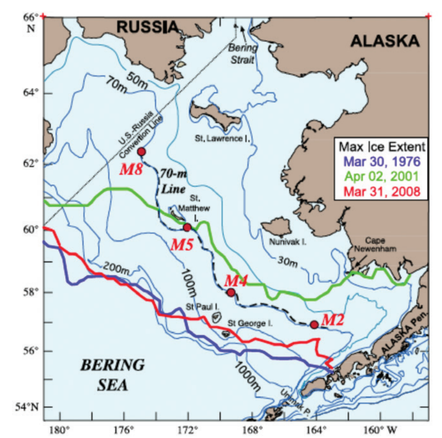
Fig. 1



Annual ice extent and mooring locations in the eastern Bering Sea. Mooring locations are indicated with the red dot (•) and the north-south transect by the broken line (---). Scientists took measurements in the spring and late summer at the 50+ stations along the transect line. Also shown is the maximum ice extent in three different years; 1976 and 2008 were cold years with lots of sea ice, 2001 was a warm year with minimal ice penetration into the southeastern Bering Sea.

The Big Picture

As the climate changes, water temperatures on the northern shelf will likely remain cold during spring and summer due to seasonal sea-ice cover and darkness, making a simple northward shift in the distribution of Bering Sea species unlikely. However, if the global climate continues to warm, the southern shelf will have less ice, though large interannual variation in ice cover is expected. Biological responses to climate warming could include greater north–south differences in zooplankton communities, the transport of some large zooplankton from the outer to the middle shelf, and the disappearance of two important zooplankton prey (large copepods and krill) for planktivorous fish, seabirds, and whales. The response of commercially and ecologically important fish species is predicted to vary. Some species of fish, such as juvenile sockeye salmon, may expand their summer range into the northern Bering Sea; some (e.g., pink salmon) may increase in abundance, while still other species (e.g., walleye pollock and arrowtooth flounder) are unlikely to become common in the north. Warming of the southern shelf will likely make it more hospitable for subarctic species, but Arctic species, such as snow crab, will be restricted to colder northern waters. Baleen whales will likely be able to extend their range to follow their prey (krill and small fishes) into new areas.

BIOPHYSICAL MOORINGS

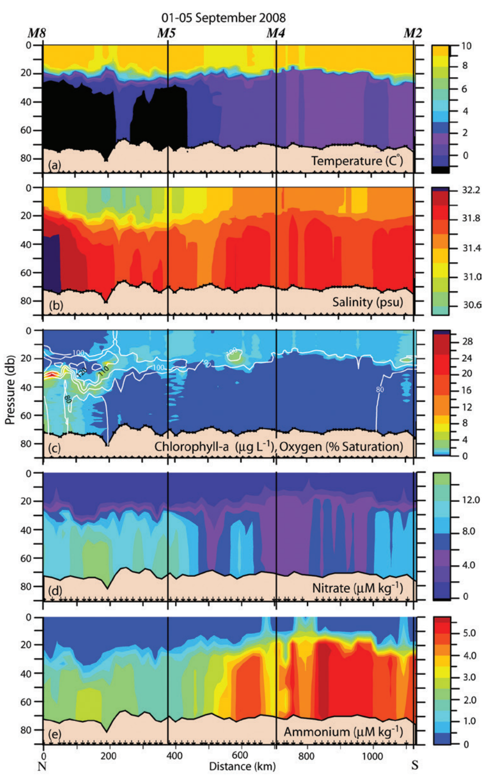
A component of the BEST-BSIERP Bering Sea Project, funded by the National Science Foundation and the North Pacific Research Board with in-kind support from participants.

avoid the coldest waters, could not shift their ranges northward, while others, such as pink salmon, may adapt more easily.

How We Did It

We used sea ice data from moorings and satellites, and data from ships occupying a north-south transect between St. Lawrence Island and Bristol Bay, Alaska. EcoFOCI (Ecosystems & Fisheries-Oceanography Coordinated Investigations), a joint research program between the Alaska Fisheries Science Center and the Pacific Marine Environmental Laboratory, maintains an array of four long-term biophysical moorings in the Bering Sea (Figure 1). Each mooring hosts instruments that make hourly measurements of temperature, salinity, nitrate, chlorophyll (fluorescence), currents, and marine mammal vocalizations, year-round. The M2 mooring also hosts acoustic instruments that record zooplankton size and abundance. Water column measurements of temperature, salinity, oxygen, nutrients and zooplankton were also collected from ship-based surveys (Figure 2). Fish and crab data were obtained from the Alaska Fisheries Science Center trawl surveys (Groundfish Assessment Program, Resource Assessment and Conservation Engineering Division). Whale data were from both visual surveys and moored and shipboard acoustics.

Fig. 2



Results from the north-south transect line sampled in September 2008. Shown from top to bottom: temperature, salinity, chlorophyll-a, nitrate, and ammonium. The four vertical lines through each panel indicate the positions of the four moorings. Note the strong break in temperature and salinity near mooring M5 at roughly 60 N. This is the feature that separates the northern and southern portions of the eastern Bering Sea.

Why We Did It

The Bering Sea supports abundant and diverse wildlife and some of the world's most commercially valuable fisheries. Predicting how these animals will respond to changing conditions will help coastal communities, subsistence users, and commercial fishers prepare for a changing Bering Sea. We wanted to understand if some species would simply move north as seasonal sea ice declines, and which species might be most vulnerable in a rapidly changing ecosystem.

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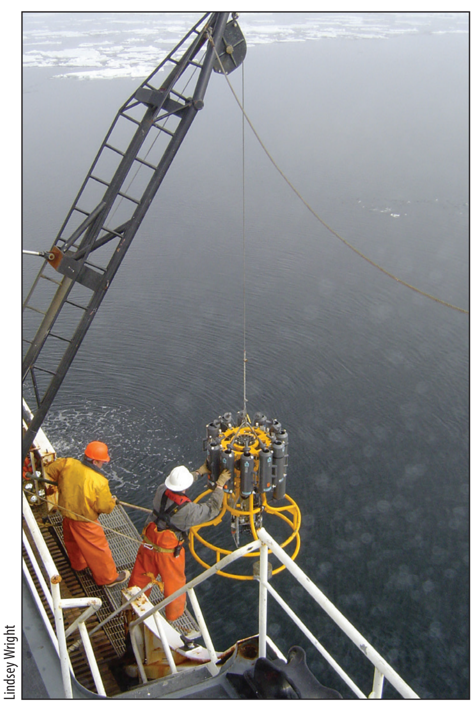
The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Project and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**



Lindsey Wright

Casting the CTD (conductivity, temperature, and depth instrument) in a sea of ice and jellyfish aboard the NOAA Ship Miller Freeman.

Jeffrey Napp

EcoFOCI Scientists Nancy Kachel and Carol Ladd deploy a bongo net aboard the R/V Thomas G. Thompson.

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