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

Observation Synthesis and High Resolution Numerical Modeling

WHY IT'S NECESSARY IN THE BERING SEA

Over the past several years, the Bering Sea Project has accumulated an unprecedented amount of ocean and sea ice observations. These have been obtained in different seasons using different platforms (e.g CTD, moorings, Argo floats, surface drifters, moorings). The rich collection of Bering Sea Project *in situ* and satellite observations now provide an excellent opportunity for synthesis, through modeling and data assimilation (DA), in order to improve our understanding of the impacts of changes in the physical forcings of the Bering ecosystem in response to climate change. Synthesis of available data allows us to improve estimates of the state of the Bering Sea and to obtain dynamically balanced fields of all physical parameters. After assimilation, we will be able to quantify the volume, heat, and salt transports over the eastern Bering Sea. High-resolution computer modeling will complement the DA efforts, providing a tool for studies of processes that influence transports, mixing, and hydrographic changes in the Bering Sea on temporal scales from hours (tidal) to years (inter-seasonal).

How We Did It

Two approaches were used in our research. The first combines a technique called Four-Dimensional Variational Data Assimilation (4DVAR), an existing numerical ocean model, and an optimal interpolation algorithm used in the Bering Ecosystem STudy ice–ocean Modeling and Assimilation System (BESTMAS). The technique is based on the least squares fit of the model solution to observations. It demands thousands of model runs and significant computational resources. However, as an advantage, 4DVAR allows assimilation

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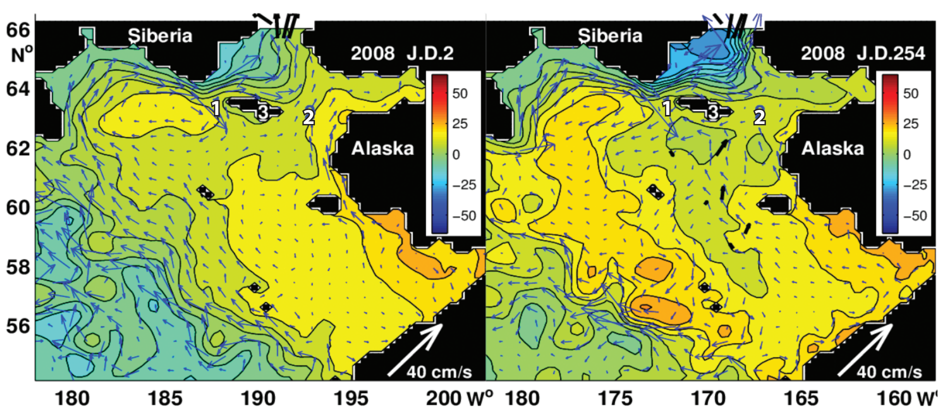
The Big Picture

There has been a significant increase in operational *in situ* and satellite observations during the last decade. This creates the potential for more accurate hindcasting and forecasting of circulation, water, and ice properties in the region. These capabilities are boosted by new and more sophisticated and efficient data assimilation systems, based on high-resolution models that include biogeochemical components. The resulting patterns enhance our ability to understand and manage the rich eastern Bering Sea ecosystem.

Fig. 1



Snapshots of reconstructed sea surface height (cm; see color bar) and surface circulations in the Bering Sea in 2008 (left: 2 January; right: 10 September). Thicker black arrows designate the locations of the moorings in the Bering Strait and the Eastern Bering Sea shelf. Numbers 1,2,3 designate the Anadyr and Spanberg straits and St. Lawrence Island, respectively.

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of any type of observations. In our case, the variety of assimilated data includes both *in situ* (e.g., temperature, salinity, velocity) and satellite (Sea Surface Height (SSH), Sea Surface Temperature (SST), ice concentration, velocity) observations. Our results indicate intensification of the Bering Slope flow in winter and enhanced variability of circulation over the Eastern Shelf during the summer and fall (Figure 1).

The second approach uses high-resolution numerical modeling. The dominant spatial scale of variability in the Bering Sea (the scale of the width of coastal jets and eddies) may be as small as 20 km. Because of the large area of the Bering Sea and the computational cost of resolving ocean features on these scales, most previous modeling studies have failed to achieve sufficient resolution to represent many important phenomena. We developed a 2-km horizontal resolution model that describes ocean circulation in the Eastern Bering Sea. This model is run for the ice-free period of July-October 2009. It exhibits correct ocean behavior, as verified using the Bering Sea Project mooring data along with Argo drifters and satellite SST and SSH. This model allowed us to analyze variability in flows through numerous passes of the Aleutian Island chain and provided a dynamic picture of the erosion of the "cold pool" (an area in the middle of the Bering Sea shelf where the dome of very cold near-bottom water is capped by the surface layer of warmer water in summer; Figure 2).

Why We Did It

Quantifying the currents in the Bering Sea is important for depicting accurate patterns of physical and biochemical parameters in the region. For example, strong flow through the Spanberg Strait during the late summer and fall (Figure 1) may significantly affect conditions in the cold pool that are extremely important for local biological production. Other, smaller-scale motions, evident in our reconstructions, may play a critical role in eroding the cold pool and providing nutrients from near the sea floor to the surface mixed layer of the Bering Sea shelf.

The cold pool frontal boundary (Figure 2) erodes during summer at varying rates at different locations, leading to a highly corrugated frontal boundary. The Pribilof Islands act as a region of enhanced cold pool erosion due to tidal mixing. The highly variable rate of erosion of the pool and the characteristics of its boundary introduce ecological patchiness, and potentially alter the rate at which larvae and juvenile fish can be transported or migrate from recruitment regions near the shelf break to settlement zones on the inner shelf.

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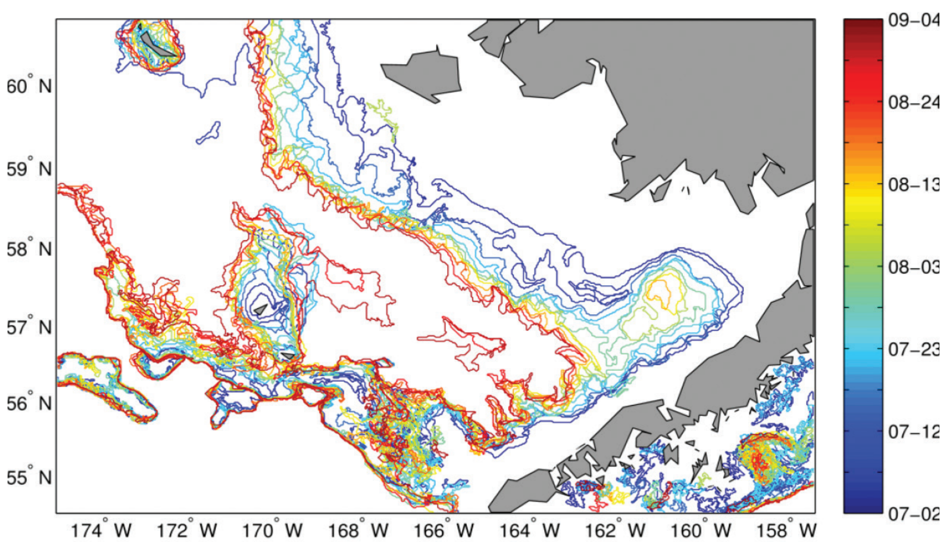
The Bering Sea Project is a partnership between the North Pacific Research Board's Bering Sea Integrated Ecosystem Research Project and the National Science Foundation's Bering Ecosystem Study. **www.nprb.org/beringseaproject**

Fig. 2



This figure illustrates the seasonal retreat of the cold pool, from early July 2009 through early September 2009, in the model simulation. Contour lines indicate the position of the cold pool front, as indicated by locations where the 3.5 °C isotherm intersects the sea floor in the high-resolution Bering Sea model. Color indicates the date for which the contour line corresponds. Rapid erosion of the cold pool is observed especially early in the season and around the Pribilof Islands. Erosion along the edges of the cold pool is highly irregular and likely due to a combination of tidal and convective mixing effects.