

# BEST-BSIERP *Bering Sea* PROJECT

UNDERSTANDING ECOSYSTEM PROCESSES IN THE BERING SEA 2007–2013

## Circulation on the Bering Sea Shelf Revealed by Temperature and Salinity Measurements

AUGMENTING NOAA FISHERIES ANNUAL BOTTOM TRAWL SURVEY

Summer 2008–2010 measurements of the ocean currents inferred from mass density differences on the eastern Bering Sea continental shelf show predominantly north-westward flow (Figure 1). The current is strongest seaward of the 100-m depth contour that crosses the shelf from the Pribilof Islands (~57°N) toward St. Matthew Island (~60°N) giving a cross-shelf component to the flow. There are differences between the years. In 2008 and 2010, low-density water surrounding St. Matthew Island,

probably due to sea-ice melt, suggests a clockwise circulation around the island. That less-dense lens was absent in 2009, and saltier, denser water intruded across the shelf to the 100-m contour. Measurements in 2010 went farther north and reveal dense water and implied flow entering Bering Strait (~65°N).

### How We Did It

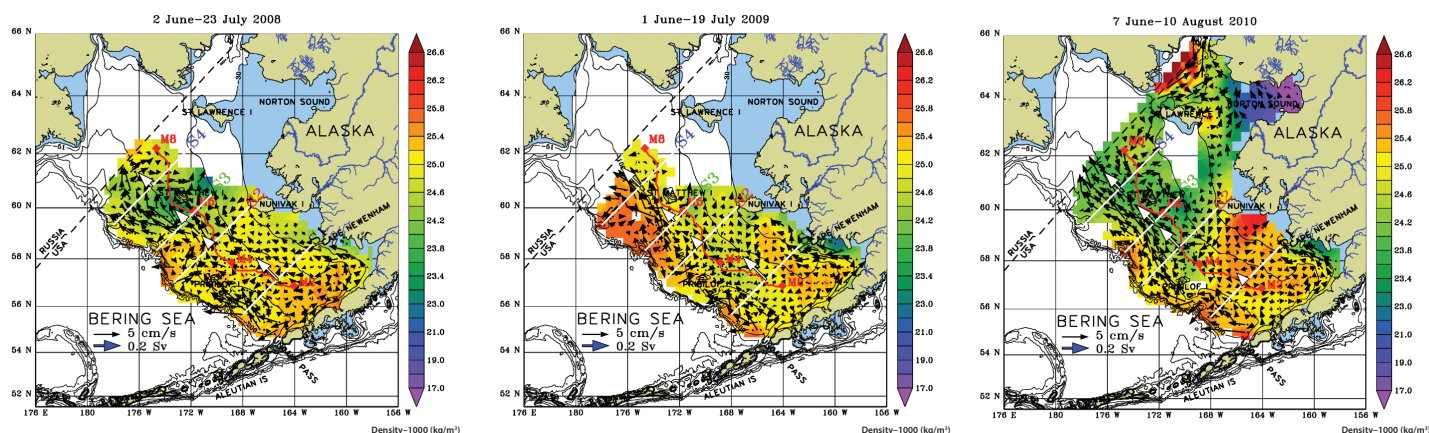
Ocean currents are driven by wind, tide and horizontal differences in the water's density (the

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### The Big Picture

Unlike other sampling during the Bering Sea Project, the bottom-trawl survey CTD measurements are unique in two regards. The new measurements are made at no additional cost in ship time at established trawl sites where the ships are already scheduled to sample. Also, they cover the Bering Sea shelf on a uniform grid that is reoccupied annually, in contrast to process-oriented cruises that sail at varying times of the year and seek to study specific processes along scattered transects. This gives a shelf-wide scan of the temperature, salinity and density, providing new understanding of the geostrophic currents.

Fig. 1



Maps of geostrophic velocity vectors drawn on a colored background of seawater mass density at the sea surface for the summer bottom trawl surveys of 2008–2010, with purple denoting lower density and red higher density. White arrows show the geostrophic transport (in  $\text{Sv} = 10^6 \text{ m}^3/\text{s}$ ) across sections S1–S4. PMEL EcoFOCI mooring sites (M2, M4, M5 and M8) along the 70-m isobath are plotted in red, and depths are contoured at 30, 50, 100, 200, 1000 and 2000 m.

Credit: Cokelet, E.D., 2014. 3-D water properties and geostrophic circulation on the eastern Bering Sea shelf. submitted to Deep Sea Research Part II: Topical Studies in Oceanography.

weight of a volume of water). Temperature and salinity together determine the density. Ocean water does not have the same density everywhere. Warmer, less-salty water is less dense than colder, saltier water. One might expect less-dense liquid to flow out over denser liquid until it reaches a uniform thickness and stops flowing, as seen in an exotic drink made with layered, colored ingredients. However, in the big ocean something else happens. The pressure force generated by horizontal differences in density can be balanced

by the effects of the Earth's rotation, resulting in an ocean current. This is similar to the winds that circulate around a high-pressure system in the atmosphere. Such currents are called 'geostrophic' currents, from the Greek for Earth ('geo') and turning ('strophe'). In the northern hemisphere, the current flows with the low-density water on its right (when looking downstream), and the sea surface slopes upward to the right, as well. The flow is faster where the horizontal density difference is larger and extends over a greater depth.

Each summer NOAA's Alaska Fisheries Science Center conducts a bottom trawl survey, sampling fish at over 350 sites spaced 37 km apart to determine commercial fish stocks on the eastern Bering Sea continental shelf. We attach ruggedized CTD (conductivity-temperature-depth) instruments to the headropes of the bottom trawl nets to measure temperature and salinity profiles through the water column (Figure 2). From these measurements, we compute the water density at each site and then apply the known effect of the Earth's rotation to infer the current.

Fig. 2



A ruggedized CTD being attached to the bottom trawl net on the NOAA contract survey vessel F/V Arcturus.

## Why We Did It

Ocean currents transport nutrients, plankton, fish eggs and larvae – important elements of the Bering Sea ecosystem. Adding CTD measurements to the existing bottom survey provides a relatively low-cost method with broad coverage to infer ocean currents. Those observations help us to understand the ecosystem, to measure its variability and to calibrate predictive computer models that estimate future conditions under different climate scenarios.

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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](http://www.nprb.org/beringseaproject)*