The State of the Bering Sea in 2010

by Skip McKinnell

Sea surface temperature

Since 1981, the dominant component of sea surface temperature (SST) variation within the Bering Sea is pan-regional (all locations are positively correlated with the dominant EOF (empirical orthogonal function). Hence, the leading EOF1 is somewhat of a Bering Sea thermometer (Fig. 1, left). While it accounts for 45% of the covariance, 19% is also associated with the subdominant EOF2, which has an interesting temporal pattern (Fig. 1, right). Since the fall of 2005, almost no positive values of EOF2 have occurred. The timing coincides with a shift to a colder eastern Bering Sea (Fig. 2) that appeared at the M2 mooring on the eastern Bering Sea shelf at the end of 2005.

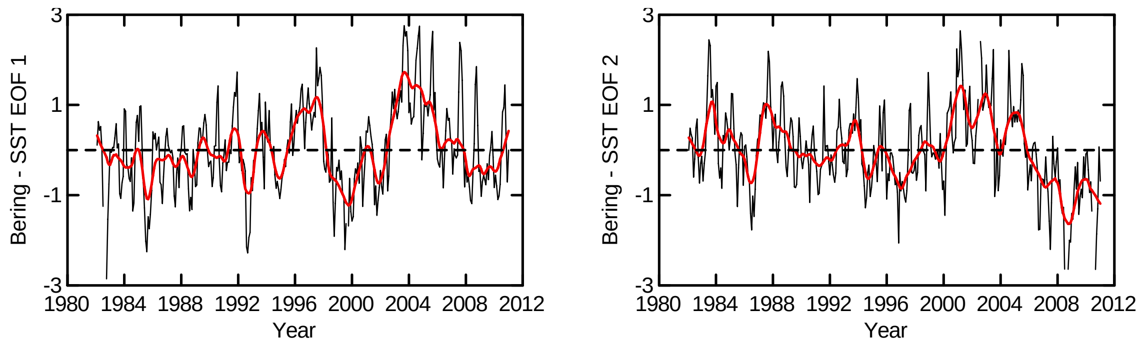

Fig. 1 EOF1 (46%) and EOF2 (19%) based on monthly average OIv2SST data for all grid points located within the Bering Sea, from January 1982 to December 2010.

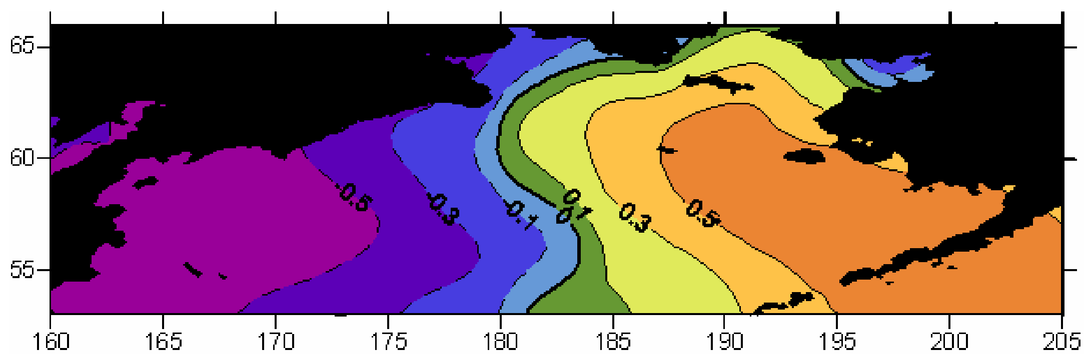

Fig. 2 Spatial pattern of the second empirical orthogonal function (EOF2) for Bering Sea SSTs. Negative (positive) values of EOF2 in Fig. 1 (right) are associated with cold (warm) surface temperature on the Alaskan side and the reverse on the Russian side.

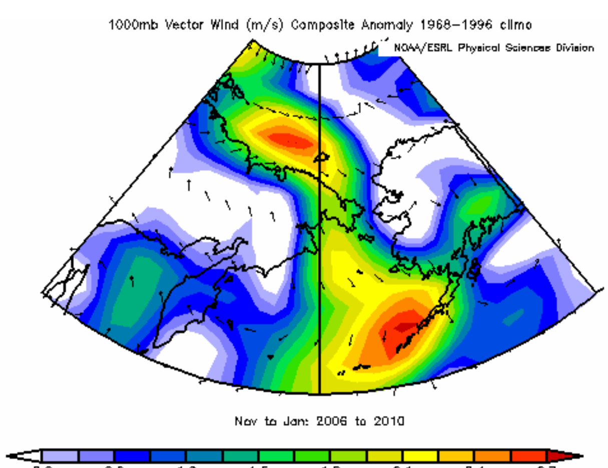

Fig. 3 Vector wind anomalies from the NCEP/NCAR re-analysis; November–January composites from 2006–2010.

At least some of the cold is related to the wind (Fig. 3). The SST-based EOF2 is significantly negatively correlated with sea level pressure (SLP) over the Bering Sea in each month from November to January. Positive SLP anomalies tend to coincide with negative EOF2 (East Cold West Warm – ECW^2 pattern), whereas negative SLP anomalies are associated with the opposite EW^2C pattern. Since the fall of 2005, EOF2 has been in a generally persistent ECW^2 pattern where anticyclonic atmospheric circulation (higher pressure) over the Bering Sea has cooled the Alaskan coast and warmed the Russian coast. Average November to January vector wind anomalies during 2006–2010 have been equatorward in the eastern Bering Sea, where the strongest anomalies can be found (Fig. 3). Weaker, but poleward wind anomalies occurred over Russia. SLP patterns indicate differences in winter as well (Fig. 4), with generally positive anomalies after 2005.

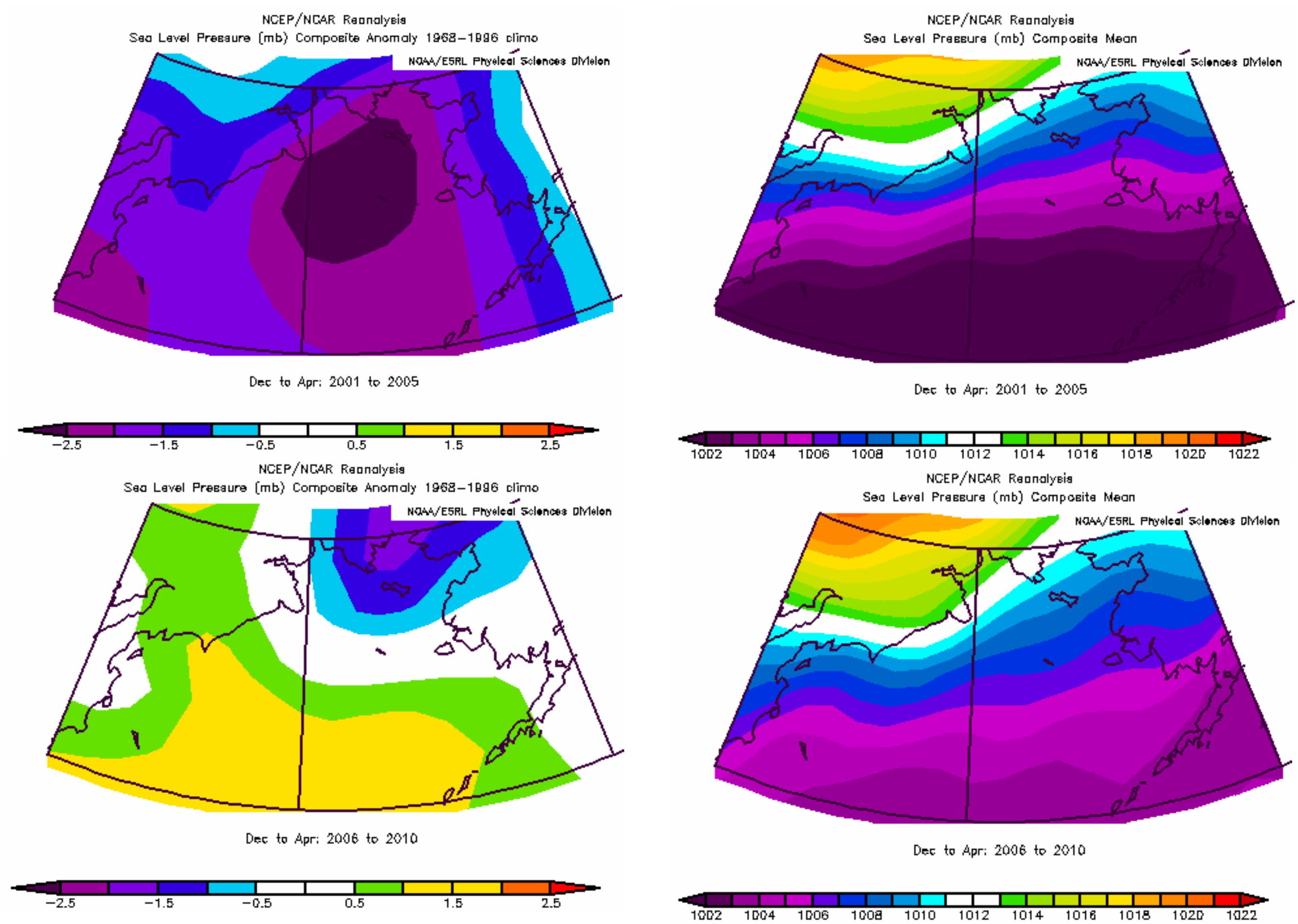

Fig. 4 *Winter (DJFMA) sea level pressure anomalies (left) from 2001–2005 (upper) and from 2006–2010 (lower). Average winter (DJFMA) sea level pressures (right) for the same periods. Note the lighter shade of pale on the lower right panel compared to the upper.*

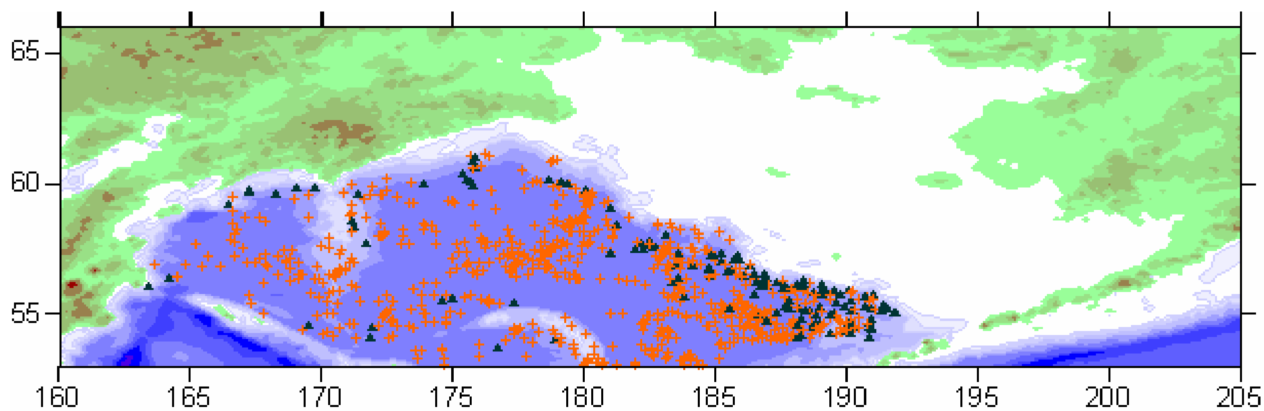

Fig 5 *Locations of Argo profiles from January to April (2003–2010) indicating those deeper (orange) or shallower (black) than 100 m, when measured as the depth of the maximum rate of change in density. Mixed layers tend to be shallower around the perimeter of the Deep Basin in all winter months.*

Project Argo in the Bering Sea Deep Basin

In January of 2010, there were 16 Argo floats in the Bering Sea Deep Basin going about their business of reporting pressures, temperatures and salinities. By the end of the year, there were 50% more Argo profiles recorded in the Basin than in the previous largest reporting year (2009). In the winter of 2010, each profile exhibited a classic winter pattern with a generally homogeneous water column from near-surface to depth, followed by an abrupt increase in density where the effect of winter winds and heat flux had yet to penetrate fully. Where this maximum rate of change in water density occurs is one potential indicator of the depth of the mixed layer.

Average Mixed Layer Depth (MLD) determined in this way indicates that the month of March is the time of deepest vertical mixing in the Deep Basin. There is a spatial pattern in MLD in the Deep Basin (Fig) that must be considered when developing a statistic for the entire Basin. After adjusting for location, it appears that average MLD in winter increased significantly in 2007 and this state of nature has persisted through 2010 (Fig. 6). Perhaps much of the deeper average MLD can be attributed to colder average winter air temperatures in the region as there is little evidence of higher average wind speed in these years.

As concentrations of nutrients that are important for biological productivity tend to increase rapidly with depth just below the mixed layer in the Deep Basin (Shiomoto 1999), it is reasonable to assume that increasing the MLD will increase the average pre-bloom nutrient concentrations and set the stage for greater production. It was rather disappointing to have sought out evidence of this in the average May chlorophyll (remotely sensed) in the Deep Basin, only to find that it was lower in 2007 and 2008 than in winters from 2003 to 2006 (Hunt *et al*. 2010). Perchance it was hidden in the sub-surface.

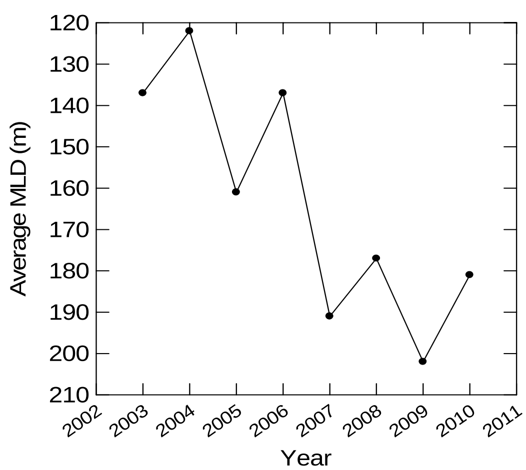

Fig. 1 March average mixed layer depth (m) determined from maximum rate of change in density with depth in the Deep Basin, 2003–2010. From data made available by Project Argo.

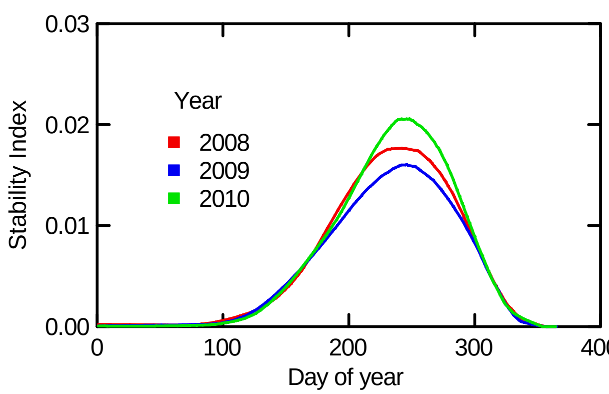

Fig. 2 Smoothed water column stability index for the Deep Basin of the Bering Sea for 2008-2010. From data made available by Project Argo.

The stability of a water column (resistance to vertical mixing) is an important factor affecting productivity in the Deep Basin of the Bering Sea. Overall, there appears to be variation in the degree of stability achieved in summer (Fig. 7). While exploring her idea about an optimal stability window, Gargett (2001) developed an index of water column stability for the west coast of Vancouver Island based on the average density difference between the surface layer and a deeper layer (60–80 m). Applying this index to the Deep Basin, only for years with greater numbers of profiles, indicates that water column stability tended to be higher in 2010 and lower in 2009, with 2008 being somewhat intermediate (Fig. 7).

References

Gargett, A.E., Li, M., Brown, R.M., 2001. Testing mechanistic explanations of observed correlations between environmental factors and marine fisheries. *Canadian Journal of Fisheries and Aquatic Sciences*, 58, 208-219.

Hunt, G.L, Jr., *et al.* 2010. Status and trends of the Bering Sea region, 2003–2008, pp. 196–267. *In* S.M. McKinnell and M.J. Dagg [Eds.] Marine Ecosystems of the North Pacific Ocean, 2003–2008. PICES Special Publication 4, 393 p.

Shiomoto, A. 1999. Effect of nutrients on phytoplankton size in the Bering Sea Basin, pp. 323–340. *In* T.R. Loughlin and K. Ohtani. [Eds.] Dynamics of the Bering Sea. Alaska Sea Grant.

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