The status of the Bering Sea: June – December 2000

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Dr. Phyllis J. Stabeno, a physical oceanographer at the Pacific Marine Environmental Laboratory (PMEL) of NOAA, conducts research focused on understanding the dynamics of circulation of the North Pacific, Bering Sea and their adjoining shelves. She is the PMEL Director of NOAA Fishery Oceanography Coordinated Investigations (FOCI), and by applying her knowledge of physical processes to fisheries oceanography, she plays a vital role in its success. FOCI research focuses on building sustainable fishery resources in the Gulf of Alaska and Bering Sea while maintaining a healthy ecosystem. Phyllis is also a Principal Investigator on several research elements for other programs, including: Southeast Bering Sea Carrying Capacity (Coastal Ocean Program), the Bering Sea Green Belt: processes and ecosystem production (Arctic Research Initiative) and Prolonged Production and Trophic Transfer to Predators: processes at the inner front of the southeast Bering Sea (National Science Foundation). This research seeks to improve our understanding of ecosystems through the integration of physical and biological phenomena.

Observations collected at a single site (Site 2: 56.9°N, 164°W) over the middle shelf reveal the great year-to-year variability that characterizes the Bering Sea. This site has been occupied nearly continuously since 1995, for collecting time series of temperature, salinity, currents and fluorescence. In contrast to the warmer than normal sea surface temperatures (SST) during July and August of 1997 and 1998, SSTs during 1999 and 2000 were colder than normal (Fig. 1). In mid-August 2000, the average temperature of the water column was approximately 1° colder than in 1998, and only slightly warmer than that observed in the other four years. Depth-averaged temperatures in the fall of 2000, however, were markedly warmer than those observed in other years. During October, the average temperature of the water column was ~5°C, slightly warmer than the temperature observed in 1998. During the next two months of 2000, the water column cooled only slightly resulting in unusually warm water at Site 2. Examination of large-scale maps shows a positive SST anomaly over the whole eastern shelf of 0-2°C during December 2000. These warmer temperatures resulted from a combination of horizontal advection and atmospheric conditions.

During the summer, Site 2 at the center of the middle shelf is largely isolated from the rest of the shelf by a series of fronts. In the fall, the fronts begin to break down and cross shelf advection can modify the water column. Some evidence of increased cross shelf flow in the fall of 2000 exists from the mooring data. However, the limited number of moorings and satellite-tracked drifters deployed in 2000 makes the interpretation of the data difficult. The Bering Slope Current (BSC), which flows to the northwest along the Bering Sea shelf break, does not appear to be related to abnormally warm temperatures observed over the shelf. Transport in the BSC undergoes long-term variability. The largest observed transport was during 1997 (>6 x 10^6 m^3 s^{-1}). In 1998, transport weakened (~2 x 10^6 m^3 s^{-1}) and these conditions continued through the first 6 months of 1999. In August 2000, the transport was average (~4 x 10^6 m^3 s^{-1}).

A clearer picture of the causes of warm ocean temperatures can be found in the atmospheric data. Air-sea interactions in the Bering Sea during the latter part of 2000 were dominated by effects associated with an unusually strong and northward-displaced Aleutian low. This represented a marked change from the summer, in which the sea level pressure (SLP) averaged about 2 mb greater than normal in the southeastern Bering Sea. The SLP anomaly map for October through December 2000 features a negative center of 10 mb in the central Bering Sea (Fig. 2). The SLP was especially low (anomalies of ~14 mb) in November and December. The consequences of these pressure anomalies for the Bering Sea included anomalous winds of 2-3 m s^{-1} from the south over the shelf in its eastern portion, and anomalous winds from the north off the Kamchatka Peninsula. The anomalous winds in the northern Bering

Sea blew from the east, and were substantially warmer than normal. These warmer than normal temperatures can also be attributed to the anomalous SLP. The mean SLP over the central Bering Sea was low because of the relatively frequent presence of cyclonic storms. These storms tend to originate well to the southwest off the east coast of Asia, and are associated with a net poleward flux of warmer air at low-levels. To a large extent, the warm December conditions observed over the northern Bering Sea resulted of the preponderance of maritime air masses originating from lower latitudes, rather than because of local wind anomalies. It is interesting to note that the SLP anomalies during the last part of 2000 are characteristic of those that tend to occur during El Niños, even though weak La Niña conditions were prevailing in the tropical Pacific.

The unusual atmospheric conditions in the fall of 2000 directly impacted the formation of sea ice over the shelf. Usually, cold winds out of the northeast freeze the seawater and advect the resulting ice southwestward across the shelf. Usually by December, much of the northern shelf is ice-covered. At the end of December 2000, however, the northern Bering Sea shelf was largely ice-free.

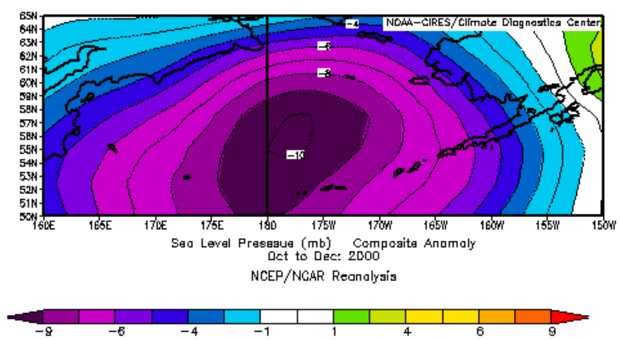

Fig. 1 Sea level pressure anomaly for October-December 2000 from the NCEP Reanalysis. Data provided by NOAA's Climate Diagnostic Center.

A series of major coccolithophore blooms have appeared over the eastern Bering Sea shelf during the last four years. Coccolithophores are small, photosynthetic cells covered by calcareous plates (liths), from which light reflects giving the water its distinctive milky white color. The bloom first appeared over much of the eastern Bering Sea shelf in 1997. During the first three years, the bloom appeared by early July, and typically reached its maximum extent in the early fall. During 2000, scientists on cruises began looking for the bloom in early July. A cruise in mid-July, sampling over the southern shelf, failed to find it. Two weeks later, however, it was observed over the middle shelf. Typically, the core of the coccolithophore blooms covers the shelf southwest of Nunivak Island. The northern and western extent, however, appear to vary each year. For example, in 1998 and 1999, the bloom was visible as far north as Bering Strait and into the Chukchi Sea. In 2000, the bloom occupied the region to the south and southwest of St. Lawrence Island and was not evident in Bering Strait. The variability in the position of the bloom is likely related to currents.

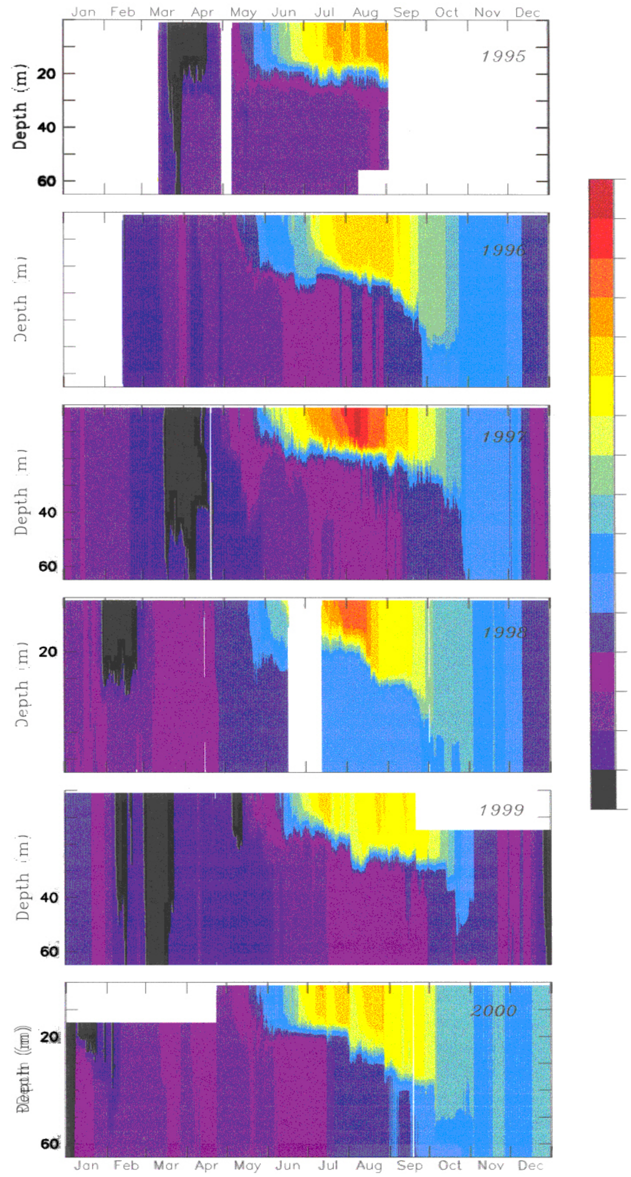

Fig. 2 Contours of temperature measured at the series of moorings deployed at Site 2 (56.9°N, 164°W). Vertical separation of temperature sensors was 3 m in the upper ~30 m and ~5-7 m in the bottom 40 m of the water column.

In general, major changes have occurred in the Bering Sea during the last decade. Presently there is evidence of an earlier transition from winter to spring. This has been evident in a more rapid retreat of the sea ice in the 1990s than previous decades, and also in an increase in the average April temperatures at 850 hPa of 3°C. Warmer conditions in spring, or delayed cooling in the fall, as was seen in 2000, could have significant impacts on the Bering Sea ecosystem.