The status of the Bering Sea: June – December, 1999

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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.

Physical observations of the eastern Bering Sea shelf in 1999 contrasted sharply with those of the previous two years. From June to December of 1997 and 1998, warm water persisted over the southeastern shelf. In 1999, colder surface and depth-averaged sea temperatures existed until the end of the year. Observations collected at Site 2 (Fig. 1) are representative of conditions over the southeastern middle shelf. When ice was advected over the mooring the water column quickly cooled (black; Fig. 2) and salinity was reduced. In March 1999, strong winds quickly mixed the water column, cooling it uniformly to ~1.7°C. In contrast, weaker winds in May only provided energy to mix the upper 20-m of the water column. In addition to cooling the upper water column via ice melt, ice in May delayed the seasonal warming that typically begins in April.

The presence of sea ice is a defining characteristic of the continental shelf of the Bering Sea. The greatest variability in the amount and persistence of ice cover occurs over the southeastern shelf. As part of the ongoing Southeastern Bering Sea Carrying Capacity (Coastal Ocean Program/NOAA), we developed an index of sea ice extent and persistence for the southeastern Bering Sea. This index consists of the percentage of ice coverage in a 1° band (57°N-58°N: see Fig. 1) across the shelf. The index was determined from Alaska Regional Ice Charts (NOAA) since 1994, and from the Joint Navy/NOAA charts before 1994. The maximum ice coverage did not differ greatly between 1997 and 1999, although in 1998 it was lower. The arrival date of sea ice does not appear to be important in establishing conditions the following summer, but the departure date is important. Sea ice conditions were similar in 1997 and 1999, however, ice persisted into May of 1999. This contributed to the cold depth-averaged temperatures throughout the remainder of the year over the shelf.

A major feature of the surface atmospheric conditions over the North Pacific and Bering Sea is the frequent passage of low-pressure centers along the Aleutian Island chain. This results in the feature known as the Aleutian Low, which varies on multi-decadal time scales (10 to 70 years). The Aleutian Low, in turn, is affected by both oceanic and atmospheric phenomena. No single tropospheric teleconnection pattern accounts for the variance of the Aleutian Low. Both the variability in SST patterns (the Pacific Decadal Oscillation, PDO) and the pattern of atmospheric pressure variability (Arctic Oscillation, AO) affect conditions in the Bering Sea. Analyses of numerous physical and biological time series indicate that a regime shift occurred in 1977. This is associated with the PDO shifting from a strongly positive to a negative mode. A second weaker regime shift occurred in 1989 related to changes in the AO.

Using the time of the suggested regime shifts, we divided the ice coverage observations into three regimes: the cold period of 1971-1976; the warm period of 1977-1989; and the moderate period of 1990-1999 (Fig. 3). There was little difference in the arrival date of ice among these periods, however during the cold period, ice persisted through the

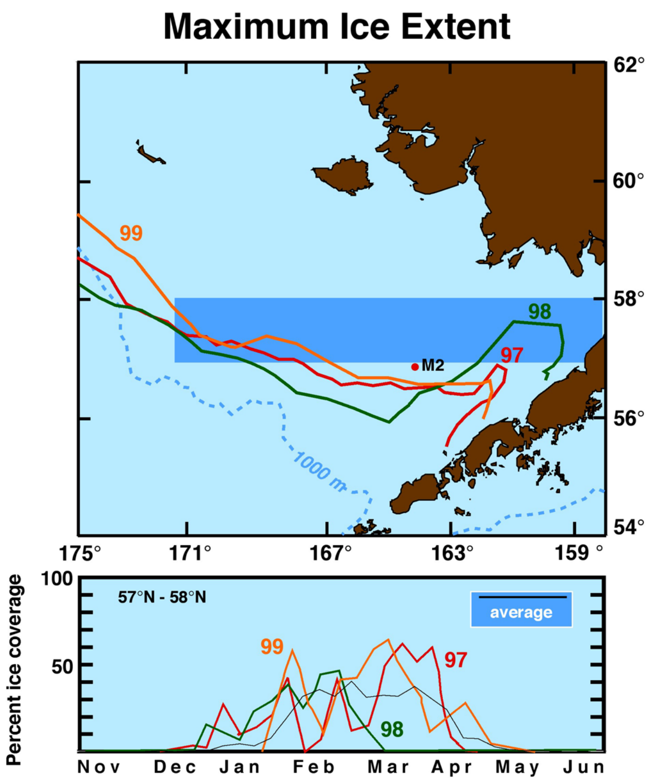

Fig. 1 *(a) The southeast Bering Sea shelf. Site 2 (M2: 56.9°N, 164°W) is located on the 70m isobath of the middle shelf. The maximum ice extent for 1997-99 is indicated. The blue band is the region used to calculate average ice coverage. (b) The percent ice coverage in the blue band (map) for 1997-99. The dark line is the average ice coverage during the 1990-1999 period.*

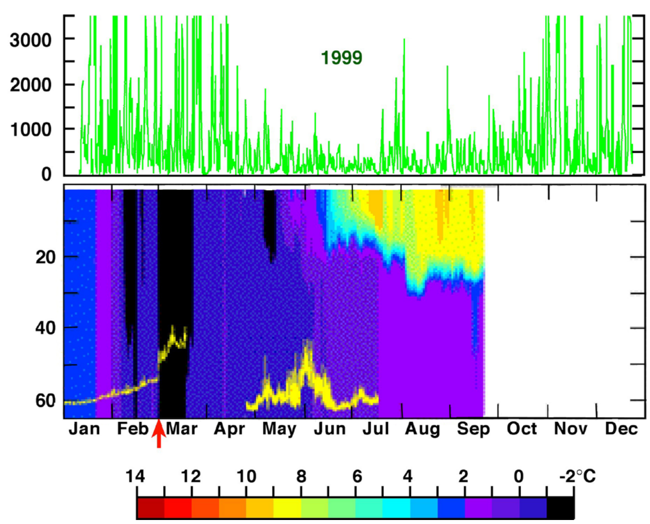

Fig. 2 *(a) Wind speed cubed at Site 2 (M2 in Fig. 1). (b) Contour of temperatures measured at M2. The yellow line is fluorescence from a depth of 11 m. Note an increase in fluorescence in March associated with the presence of ice, while the increase during May/June may be associated with both ice and the beginning of stratification.*

winter and departed late. During the warm period, ice extent was less on average and ice departed earlier. In the moderate period, timing was the same as the warm period, but more extensive. In the fall/winter of 1999, ice first appeared in November, and by the end of December ice covered ~20% of the 1° band. This early arrival and relatively extensive coverage is more typical of cold period years. If this persists into 2000, it will lend support for a regime shift.

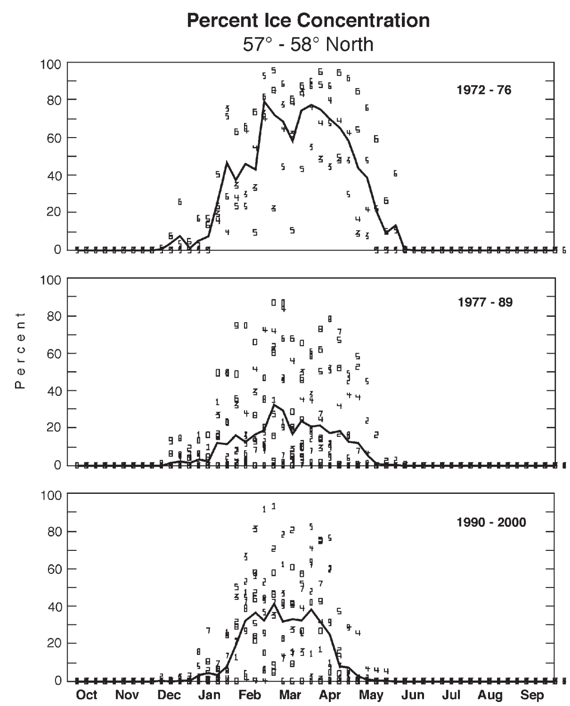

Fig. 3 *Percent ice concentration during three regimes in the one degree band (57°-58°N, see Fig. 1).*

A coccolithophore bloom that was first observed in SeaWiFS images in 1997 recurred for the third year. Coccolithophores are small cells covered by calcareous plates (liths), from which light reflects giving the water its distinctive milky white color. In 1999, the bloom was first observed in February from both satellite and ships. By August, it covered a significant portion of the eastern Bering Sea shelf. Surprisingly, cooler SSTs did not appear to restrict its location.

These observations were collected as part of the Southeast Bering Sea Carrying Capacity and the Inner Front Program (an NSF program). One fundamental result is that our understanding of the importance of sea ice, in terms of its timing and duration, over the southeastern Bering Sea shelf, has increased markedly. This also has implications for biota. For example, the median biomass of large medusae over the southeastern shelf increased tenfold between the warm and moderate periods found in the sea ice index. Increasing our knowledge of the germane physical processes is allowing examination of pathways that potentially transfer physical changes to biota, shedding new light on how this vibrant ecosystem functions.