Ecosystem Anomalies in the Eastern Bering Sea During 1997

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During summer 1997 much of the eastern shelf of the Bering Sea experienced an anomalous bloom of coccolithophorids, which was first observed as aquamarine waters from ships during July (Fig. 1; Vance et al., in press; Stabeno 1998). The bloom was also clearly visible from space, as shown by some of the first images fromthe multispectral Sea-viewing Wide-Field-of-view Sensor (SeaWiFS) scanner in September. Between August and September, reports of moribund and dead short-tailed shearwaters came from biologists and the public on both sides of the Alaska Peninsula including Bristol Bay. The sockeye salmon run in Bristol Bay was far below expectation: an estimated 5–12 million animals failed to appear in the fishery, which was declared a "commercial failure" (Fisheries 1998). At the same time, significant numbers of large baleen whales were observed foraging within the milky waters (Tynan 1998). Chlorophyll-a concentrations during the bloom were low in agreement with such blooms in other regions of the world (e.g., North Sea, Gulf or Maine; Fig. 2). The tiny phytoplankton cells contain little chlorophyll-a or particulate organic carbon, but they make a large impact on water color. Concomitant with these changes in the biological environment, anomalous conditions were evident in many of the features of the physical environment.

Much of the eastern Pacific Ocean exhibited warm sea surface temperature (SST) anomalies during 1997. The SST anomaly extended northward from the equator, where El Niño conditions existed.

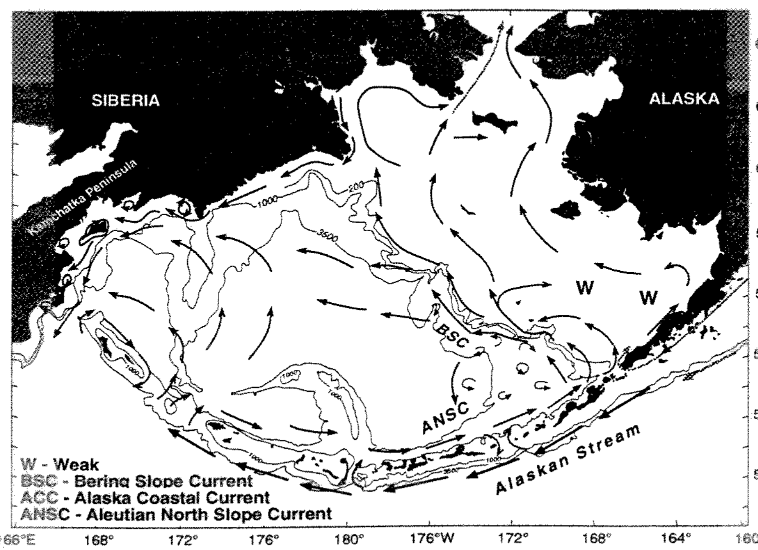

Fig. 1. A schematic of upper ocean circulation in the Bering Sea. Bering Canyons is located at about 54°N, 166°W, and the chlorophyll-a time series was collected at 56.9°N, 164°W (Site 2; after Stabento et al., in press; Schumacher and Stabeno, in press.)

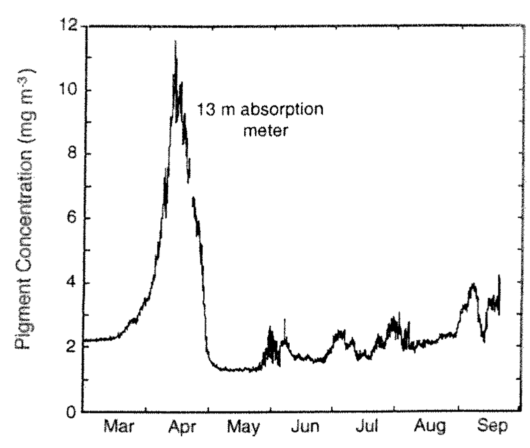

Fig. 2. Time series of concentration of chlorophyll-a at Site 2. Note the spring bloom in early April and the gradual increase during summer. The blooms in september followed storms. (These data are preliminary.)

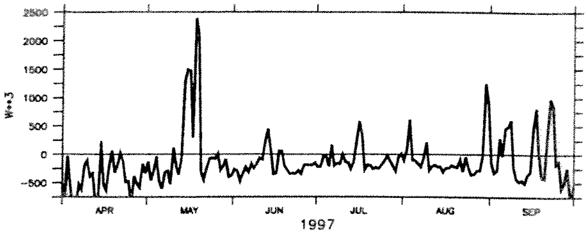

Fig. 3. Time series of the anomaly of the daily wind speed cubed using observations from St. Paul Island. Note the event in mid-May. The mean was defined as the daily average wind speed cubed from 1950-1996.

The signal in the Bering Sea, however, resulted from regional wind mixing and heat exchange with atmosphere, rather than propagation of an oceanic anomaly from the equator. As occurred in recent years (Stabeno et al. in press), an early spring diatom bloom (about 12 mg/m^3) was associated with sea ice (Napp et al. 1998). By the end of April, chlorophyll concentrations had decreased to pre-bloom values. During April, winds were unusually weak, and these conditions generally persisted through August. The anomaly in wind speed cubed (a proxy for mixing), follows the same general pattern as the winds (Fig. 3). A striking mixing event, however, did occur in mid-May. The impact of this storm was to mix the upper 45-50 m, thereby making nutrients from the lower layer available in the upper water column. This reduced the reservoir of nutrients typically found throughout the summer in the lower layer (Napp et al. 1998). While ice extent was rather typical, melt-back was rapid, and, together with the weakness of the vertical salinity structure, this suggests a minimal flux of low salinity water. As a result, the pycnocline was shallow but weak throughout the summer, permitting further depletion of nutrients. This likely occurred through both a vertical flux of nutrients across the pycnocline to the surface and net photosynthesis or both below the mixed layer throughout the summer. An examination of heat content revealed that it was similar to that in the previous year. The heat, however, was concentrated in a shallow mixed layer. The extreme SST anomalies appear to be due primarily to the lack of winds, rather than to increased solar radiation resulting from reduced cloud cover. This warm upper layer extended over portions of the coastal domain into waters as shallow as 35 m. In general, the coastal domain waters are mixed. One consequence was that the transition between coastal and middle shelf water was poorly defined and 10s of kilometers wider than previously reported (Schumacher and Stabeno, in press). The changes in structure likely affected the usual biophysical dynamics that result in primary and secondary production throughout summer.

While biophysical processes likely account for much of the nutrient depletion on the shelf, a change in the flux from source waters may have exacerbated this situation. Observations of temperature and salinity versus depth were collected along a slope/shelf transect. In spring 1997, transport in both the Aleutian north Slope Current (ANSC) and the Bering Slope Current was unusually large, $>6 \times 10^6$ m^3 s^{-1}, whereas transport is typically $<4 \times 10^6$ m^3 s^{-1}. Moored current records from the ANSC revealed strong consistent flow, supporting the inference of strong flow and showing that the flow was steady this year. How the enhanced strength of these currents affects shelf/slope exchange is not known. The flux of oceanic water through Bering Canyon also is a source of nutrients for the shelf (Schumacher and Stabeno, in press). During 1997, satellite tracked drifters revealed that little or no onshelf flow occurred.

Whether a part of an interdecadal cycle or of global warming, the arctic climate is warming. A group of scientists convened in 1995 to hypothesize physical change in the Bering Sea under a global warming scenario (U.S. GLOBEC 1996). Among the changes they forecast were that wind mixing energy, the supply of nutrients, and ice extent and thickness would decrease, and sea surface temperature would increase. These expected changes are consistent with those observed during 1997 in the eastern Bering Sea. The associated changes in biota, however, at present defy forecasting because knowledge of biophysical process, system time lags, and life histories of many of the important species is lacking.

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