Eastern Bering Sea - 2006

S. Rodionov, P. Stabeno, J. Overland, N. Bond, and S. Salo

Summary. *Although the average seasonal characteristics of thermal conditions in the Bering Sea were close to normal, the winter of 2006 was characterized by a significant degree of month-to-month variability. In January surface air temperature (SAT) in St. Paul plunged to almost 2 standard deviations below normal. In the next two months SAT anomalies became positive, exceeding one standard deviation in March. These temperature swings were associated with a restructuring of atmospheric circulation patterns over the North Pacific. Spring months were colder than normal, with ice extent being south of its normal position. The ice retreat index indicates that ice stayed in the vicinity of Mooring 2 for almost 1.5 months after March 15, which is much longer than in the previous six years. Sea surface temperatures in May were the coldest since 1999, which suggests a more extensive cold pool than normal in the summer of 2006. Cold spring and late ice retreat were, probably, the most important features of the physical environmental conditions in 2006.*

In an overall sense, the winter of 2006 in the Bering Sea was close to normal, but contrasts to the warm conditions of the recent decade. The mean winter (DJFM) surface air temperature (SAT) at St. Paul was -3.18˚C, or 0.44˚C above the average for the base period 1961-2000 (Fig. 1a). The Bering Sea pressure index (BSPI) remained negative, as it had been since 1998. Negative (positive) values of the BSPI indicate predominance of cyclonic (anticyclonic) conditions in the region. The ice cover index was slightly positive (Fig. 2a) and the ice retreat index indicate that ice stayed for 46 days in the 2° x 2° box (56-58°N, 163-165°W) after March 15 (Fig. 2b).

These average numbers, however, do not reflect substantial month-to-month variability in the Bering Sea. As shown in Fig. 3, after a relatively mild December, SAT at St. Paul dropped in January to -8˚C, which was 4.7˚C below the 1961-2000 average. It was the coldest January since January 2000. In February 2006, SAT rebounded to 1.6˚C above the average, and in March it was 3.5˚C above the average. Later in the spring, however, SAT anomalies were on the cold side again. These month-to-month variations in SAT are associated with a restructuring of atmospheric circulation over the North Pacific from a strong Aleutian low in December to a weak and split Aleutian low in January. A high pressure anomaly that formed over the central North Pacific in January strengthened even further in February and March. During these last two month, however, storms were frequent in the high latitude bringing warm Pacific air into the Bering Sea (For details on atmospheric circulation see the Pacific Climate Overview section).

The high degree of variability within the 2006 winter season is also seen in ice cover, presented in Fig. 4 as a percentage of ice in the 2˚ x 2˚ box (56-58°N, 163-165°W) surrounding Mooring 2. Ice appeared in the box in the mid-January, which is an average date of the start of ice season in the area (Fig. 5). Due to a very cold weather in January, ice quickly extended south, covering more than 80% of the box. Anomalously mild and stormy weather established in February and March cased ice to retreat as quickly as it arrived. Because of cold weather spells later in spring, ice peaked again around April 1 and May 1. Ice finally cleared the box in the second week of May, which made the IRI the highest since 1999 (Fig. 2b).

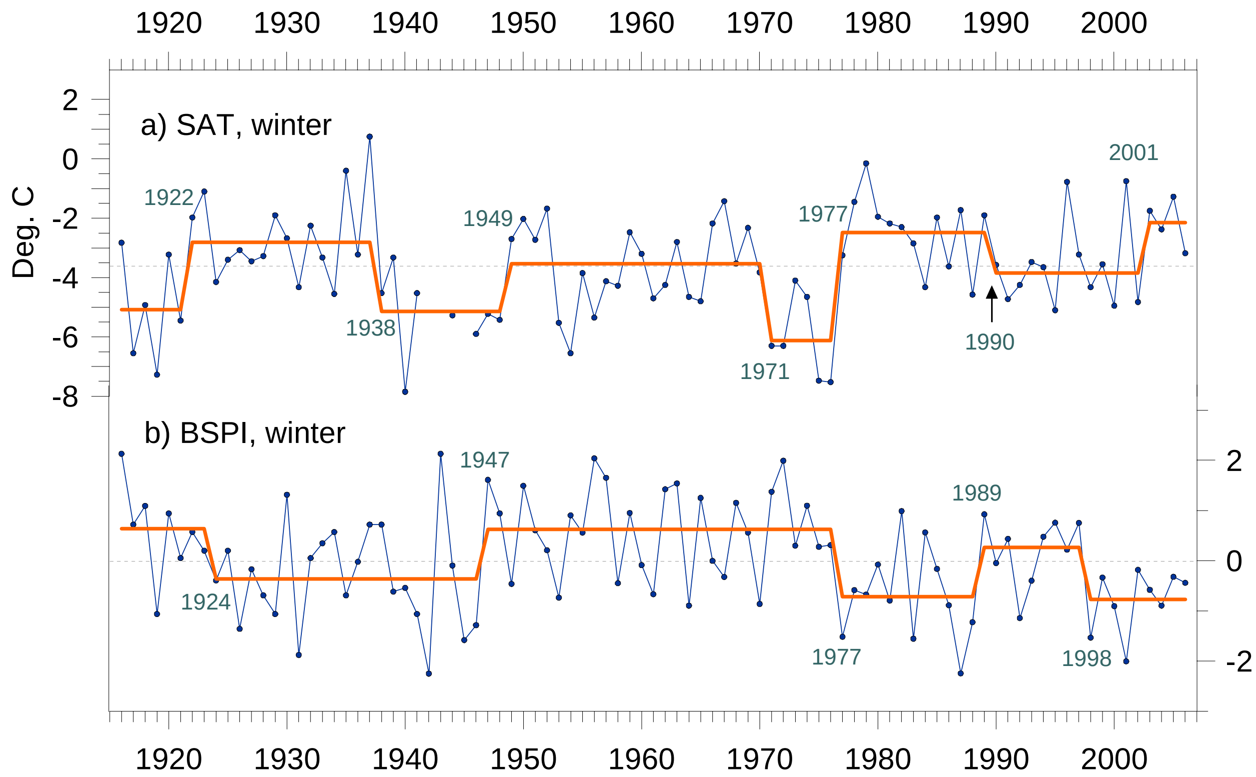

Fig. 1. Mean winter (DJFM) a) surface air temperatures in St. Paul, Pribilof Islands and b) Bering Sea pressure index. The dashed line for the top graph indicates the mean SAT value of -3.62˚C for the base period, 1961-2000. The stepwise functions (orange lines) characterize regime shifts in the level of fluctuations of the variables. Shift points were calculated using the sequential method (Rodionov 2004), with the cutoff length of 10 years, significance level of 0.2, and Huber weight parameter of 1.

.

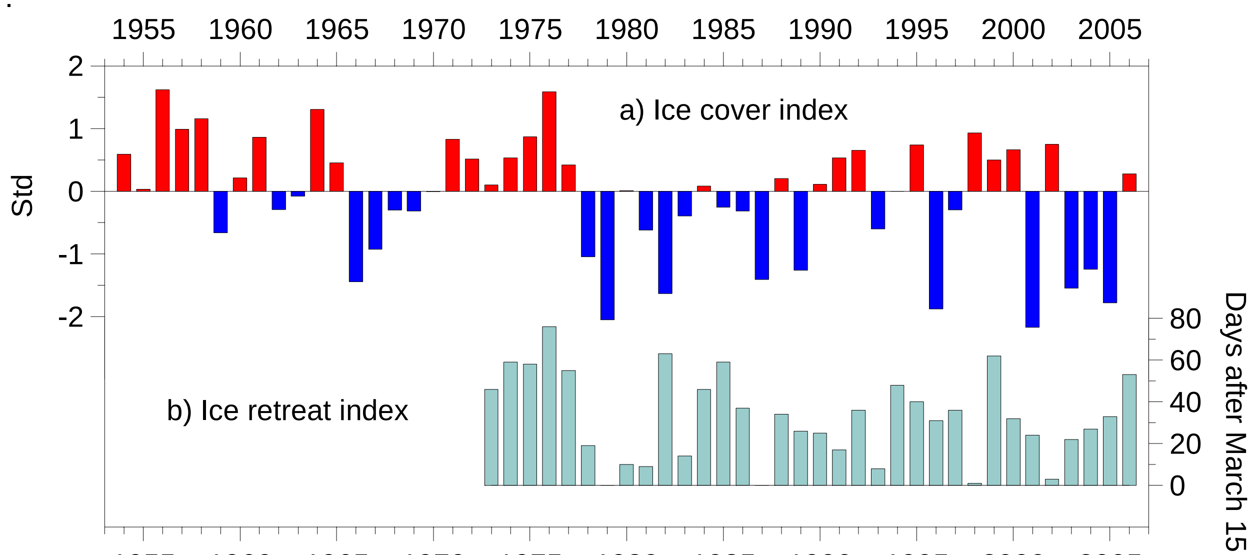

Fig. 2. a) Ice cover index, 1954-2006, and b) ice retreat index and its linear trend (orange line), 1973-2006.

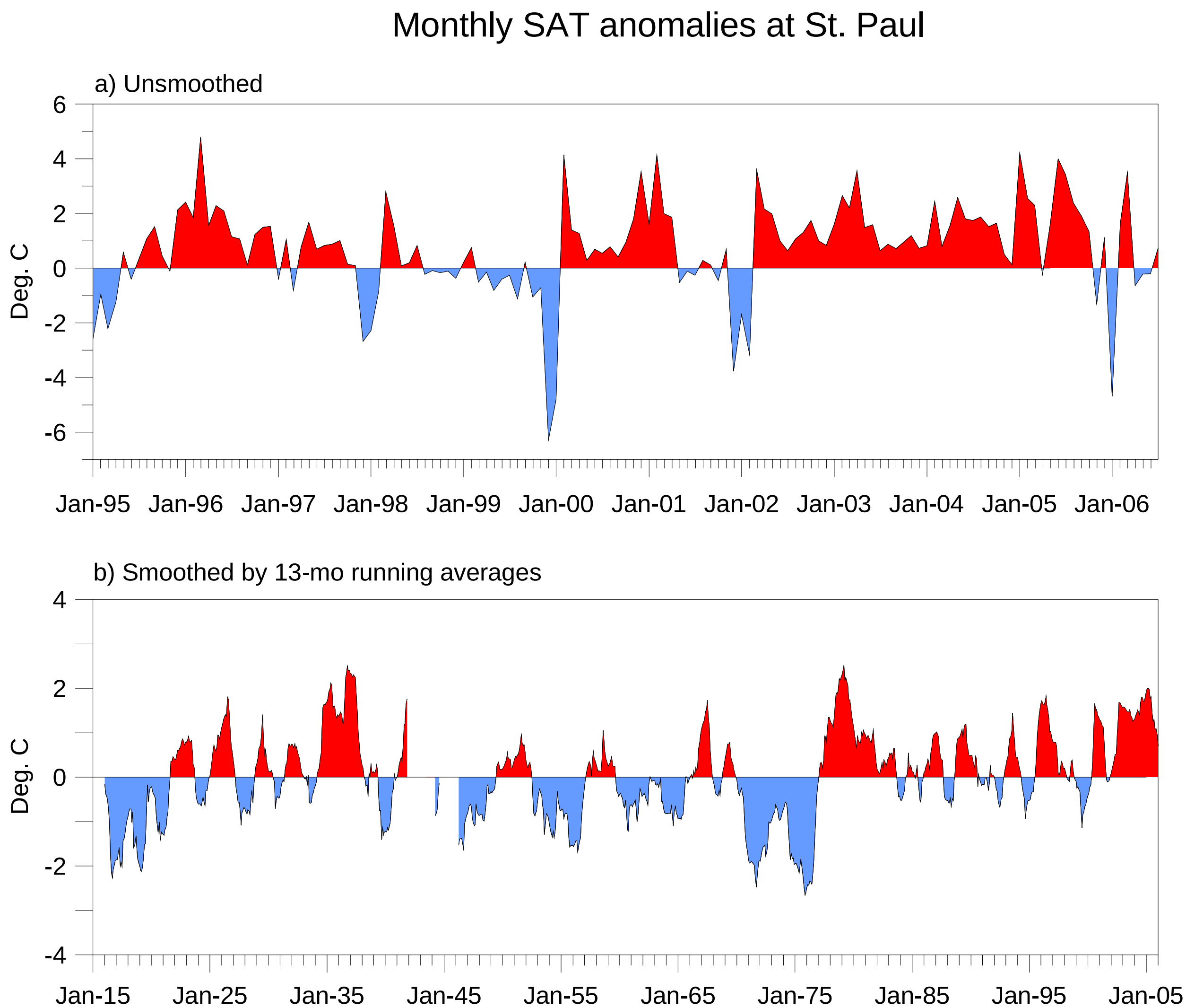

Fig. 3. Mean monthly surface air temperatures anomalies in St. Paul, Pribilof Islands, a) unsmoothed, January 1995 through July 2006, and b) smoothed by 13-mo running averages and referred to the central month of the window, January 1916 through January 2006. The base period for calculating anomalies is 1961-2000.

It is interesting that the Bering Sea was about the only place in the Arctic where sea ice extent anomalies in January 2006 were positive and ice extent was south of its median position for the period 1979-2000 (Fig. 6, top panel). By March 2006, however, sea ice concentration anomalies were negative practically everywhere along the periphery of Arctic ice extent (Fig. 6, middle panel). The total Arctic sea ice extent for this month was 14.5 million sq. km., or 1.2 million sq. km. below the 1979-2000 mean value. This makes March 2006 the record low March for the entire period of observations since 1979. In April sea ice in the Bering Sea advanced again. Fig. 7 illustrates how far south the ice edge was compared to the previous five years. In May, sea ice concentration anomalies in the Bering Sea remained positive, and sea ice extent was much father south than its median position for this month (Fig. 6, bottom panel).

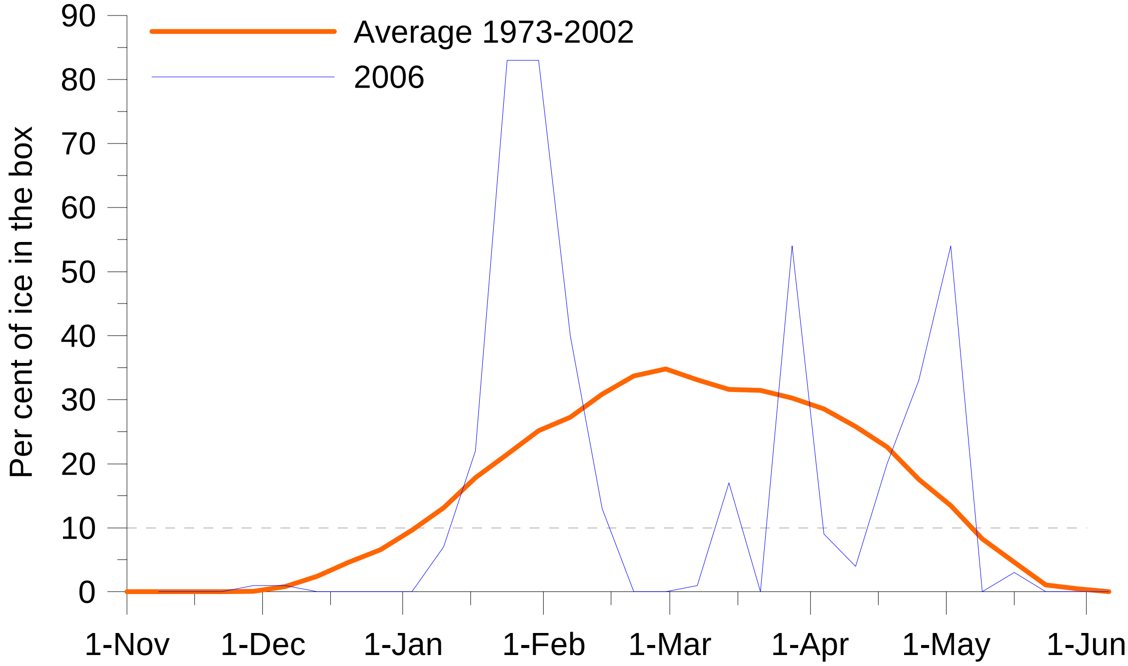

Fig. 4. Percentage of ice in the 2° x 2° box (56-58°N, 163-165°W) during the winter of 2006.

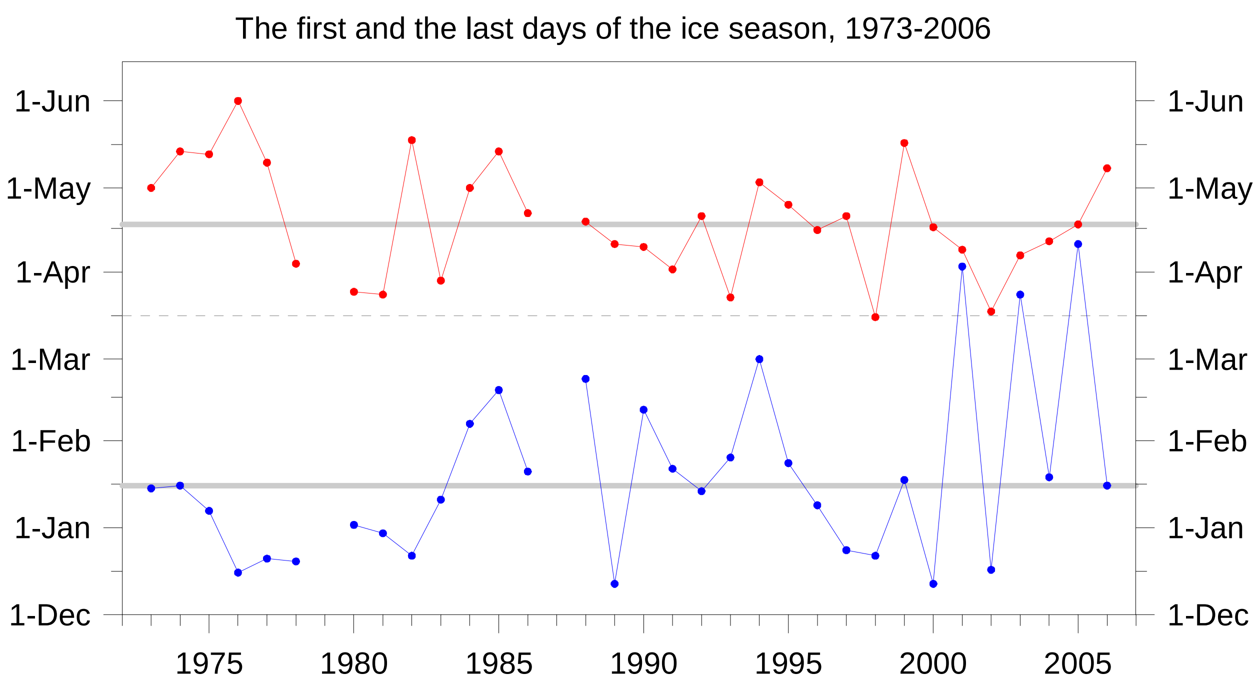

Fig. 5. The first and last days of the ice season, 1973-2006. The gray solid horizontal lines are the mean dates for these two variables. The dashed line (March 15) is used as a threshold to calculate the ice retreat index. No ice was present in the box in 1979 and 1987.

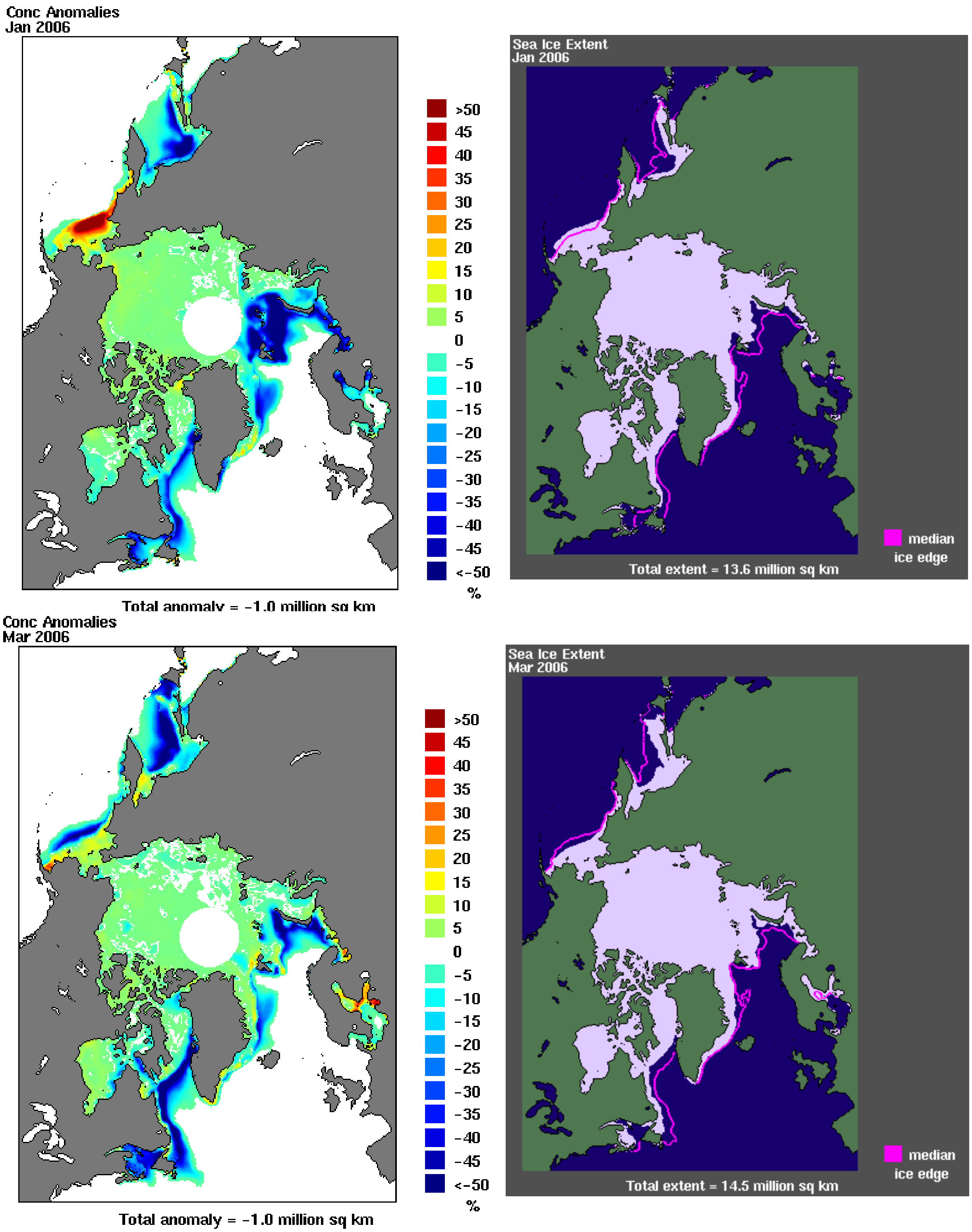

Fig.6. Sea ice concentration anomalies (left column) and extent (right column) in the Arctic during January (top panel), March (bottom panel) and May (next page) of 2006.

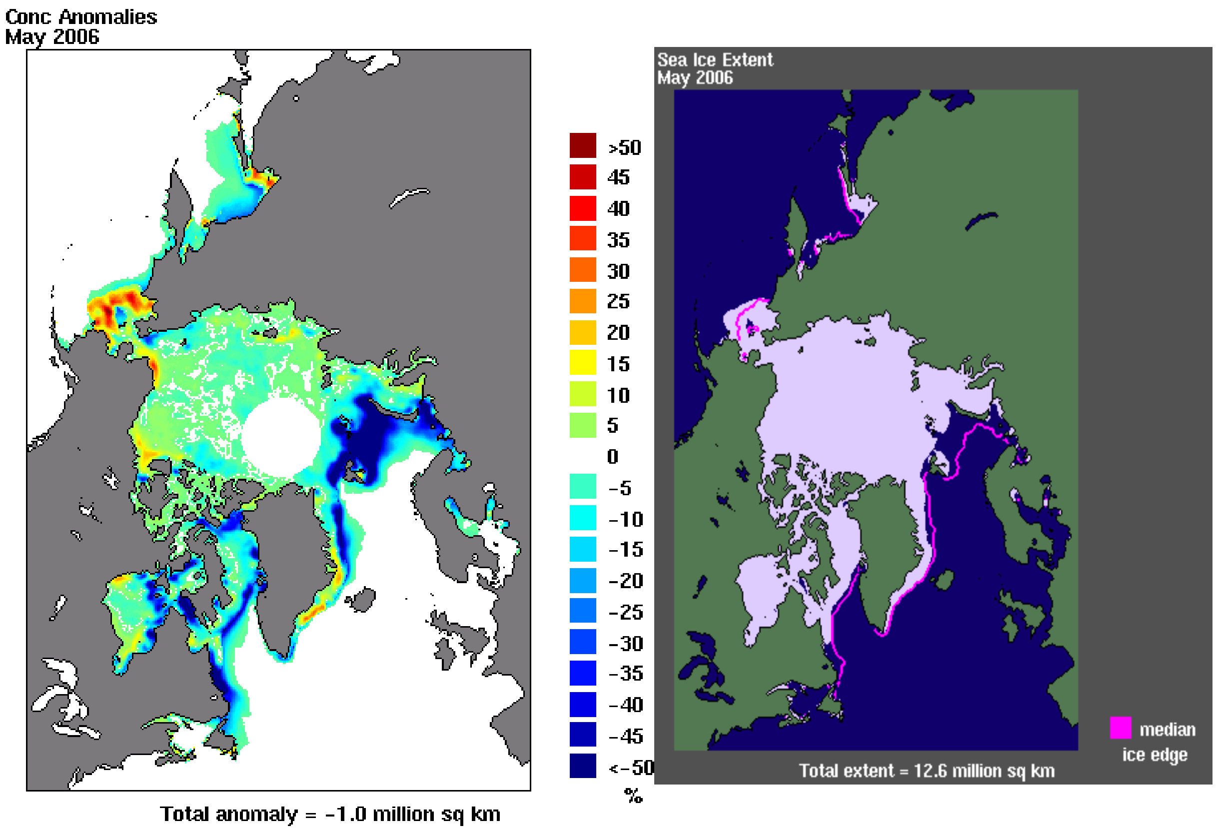

Fig. 6. (continued). The base period for anomalies is 1979-2000.

Due to anomalous ice cover extent, average sea surface temperature (SST) over the eastern Bering Sea in May was sharply lower (Fig. 8). May SST is a good predictor of summer bottom temperatures and the extent of the cold pool. Although sea ice concentration in the eastern Bering Sea between 57°N and 58°N (Fig. 9) was not particularly high after early February, especially as compared with other heavy ice years, ice stayed longer in the area than in any other year since 1999. Bottom temperature data for the summer of 2006 was unavailable at the time of writing, but given the relatively late ice retreat, it is strongly suspected that the cold pool was the most prominent it has been since 1999. The extent of the cold pool relates not only to the near-bottom habitat, but also impacts the overall thermal stratification and ultimately the mixing of nutrient-rich water from depth into the euphotic zone. Regarding the latter process, June-July wind mixing at M2 during 2006 (not shown) was the strongest since 1996, and the second strongest since 1979. We do not know yet whether the upper mixed layer was anomalously thick in 2006 like it was in 1996. All in all, it appears that the most important aspect of the physical environmental conditions in the eastern Bering Sea during 2006 was the unusually late retreat of the sea ice in the spring.

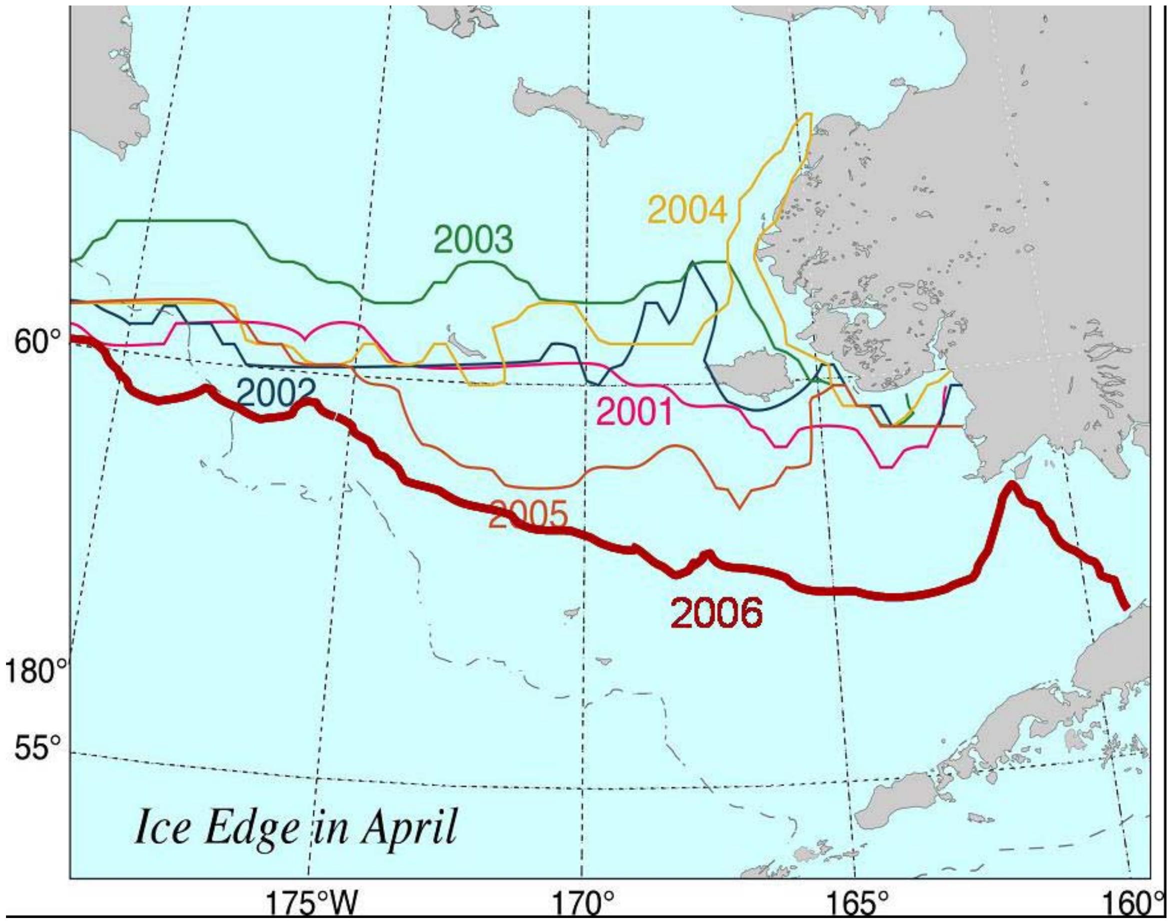

Fig. 7. Ice edge in April 2006 in comparison to the previous five years.

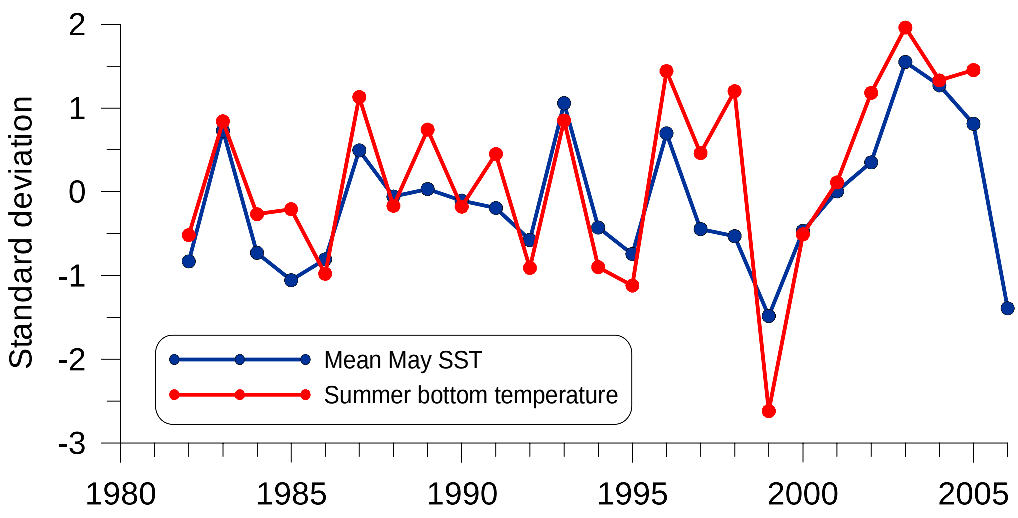

Fig. 8. The MaySST index and mean summer bottom temperature in the southeastern Bering Sea, 1982-2006.

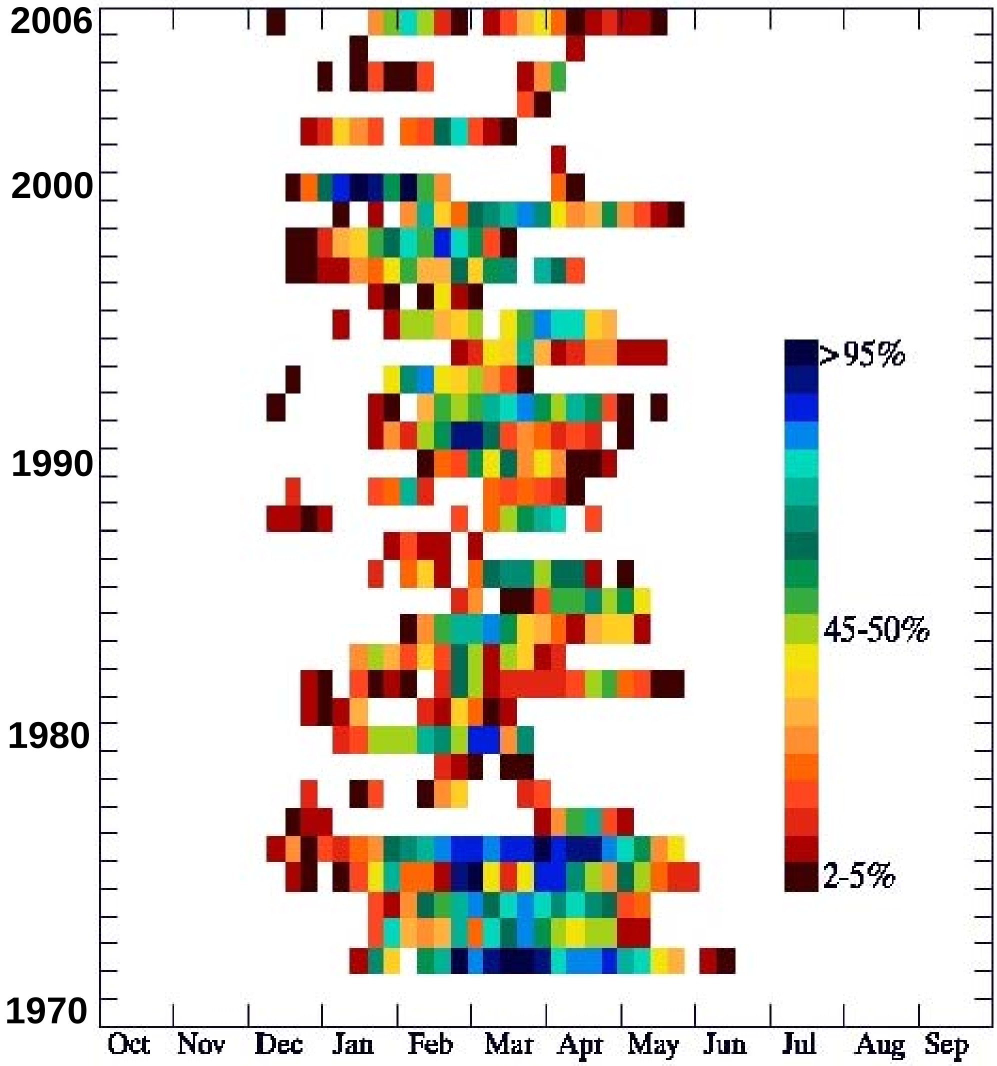

Fig. 9. Percent of ice coverage between 58°N and 60°N in the eastern Bering Sea, 1972-2006.