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Sea-surface Temperature and Water Mass Boundaries in the Northwestern Atlantic Ocean in 2002

by

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Abstract

The results of SST monitoring in the Labrador Current and Gulf Stream between 40°-55° N and 45°-65° W and dynamics of the water mass boundaries at the surface area between 37°-47° N and 55°-70° W (the boundary of the Cold shelf water mass, the Slope water mass and the northern boundary of the Gulf Stream front) for 2002 are presented. As before (Sigaev, 2001), the average monthly deviations of SST values from the long-term average values for 1977-1996 and deviations of long-term average indices of the water boundaries location from their long-term average values for 1962-1992 were used to assess these characteristics. The conclusion was made that during the year SST values in the most selected areas within the Labrador Current system were higher or close to the normal however lower than in 2001. Within the Gulf Stream system areas (the Nova Scotia shelf slope, the Slope water mass off the shelf and near the Gulf Stream front) SST values exceeded the long-term average and were higher than in 2001.

The analysis of the three water masses boundaries dynamics (the Cold shelf water, the Slope water and the northern edge of the Gulf Stream front) in 2002 in three selected areas - New England (66°-70°W), Nova Scotia (59°-65°W) and Laurentian Channel (55°-58°W) revealed that these boundaries were shifted northwards of their long-term average line or close to it during the year. Only in the New England area the Gulf Stream front was located southwards of this line.

Introduction

In 2002 the monitoring of hydrographic conditions in the Northwestern Atlantic Ocean was continues on the basis of SST analysis in the area between 40°-55° N and 45°-65° W and analysis of three water masses (the boundary of the Cold shelf water mass, the Slope water mass and the northern boundary of the Gulf Stream front) boundaries location at the sea surface in the area between 37°-47° N and 55°-70° W (Fig.1).

As before (Sigaev, 2001), the average monthly SST values at 13 points located in the Labrador Current system and Gulf Stream were used in SST analysis. Points 1, 4, 6 and 8 were located along the main branch of the Labrador Current. Point 2 reflected SST variations in the open part of the Labrador Current and points 3 and 5 SST at the North Atlantic current front. Point 7 characterized the conditions in the area northwards of the Flemish Bank. Point 9 reflected SST fluctuations at the shelf of the Grand Bank. The temperature at point 10 in the Nova Scotia shelf area revealed the conditions in the upper layer of the eastern, more cold part of the shelf, while point 11 reflected SST variability on the slope. Outside the shelf SST fluctuations in the Slope water and at the Gulf Stream front was monitored at points 12 and 13.

Figure 1 shows also the long-term average location of three water masses boundaries in summer. Their latitudinal shift monitoring was carried out by three selected areas – New England (66°-70° W), "Nova Scotia" (59°-65° W.) and "Laurentian Channel" (55°-58° W). It is assumed that the scheme presented allows to assess SST background variations within certain limits and the advection of cold and warm waters transported by the main flows into the shelf, and could become a supplement to the environment conditions monitoring in this area.

Material and Methods

As before the average monthly SST values at above said 13 points were used in SST analysis. SST values at these points were obtained by means of interpolation of values in crossings of 2x2 degree grid from the monthly SST tabulagrams, provided by Roshydrometeocenter (Moscow). SST deviations from the normal by the points selected and by months were estimated, as previously, on the basis of the average values for 1977-1996.

In analysis of seasonal and interannual variability of three water masses boundaries location in NWA we used the latitudinal fluctuations of the latter at the sea surface, while these indices were obtained either from the facsimile maps with water masses boundaries ("Ocean features analysis") or from SST ("Sea SFC temperature analysis"), issued by the Canadian meteocenter HALIFAX. The distance in tens miles between 37°N and a point of interception of any boundary and every whole meridian was assumed to be an index of this boundary location. Average monthly indices were estimated by means of averaging their values for 8-9 periods during a month. Boundary location indices deviation was made on the basis of average values for 1962-1992.

Sea-surface temperature

Figure 2 shows SST annual trend at point 2 located in the adjacent area of the Labrador Sea and in points 3 and 5 in the North Atlantic Current. As is seen from the plots, SST anomalies in January-April in the Labrador Sea exceeded the long-term average level by 1°-3°C, while in some months it was higher than in 2001. In May-October SST reduced to the level close to the long-term average level and was lower than in 2001.

In the North Atlantic Current SST annual trend at points 3 and 5 was of unstable and undulatory pattern with sharp fluctuations during a year approaching 2-3°C in amplitude. SST values there mostly exceeded the long-term average values, however, they were lower than in 2001.

At points 1, 4, 6, located in the Labrador Current (Fig. 3) SST fluctuations were similar and also of undulatory pattern with the maximum amplitude of 3°C. SST values there in most cases exceeded the long-term average values or were close to them, however, they were lower than in 2001.

At the north-eastern slope of the Grand Bank (point 8) and northwards of the Flemish Cape Bank (point 7) SST fluctuations were of similar pattern (Fig. 4). Their annual trend includes two periods of SST reduction and two periods of SST increase with maxima in January-February and August and minima in June and October-November. As is seen from the figure, during most months SST values were either higher than long-term average or close to them, however lower than in 2001. On the Bank (point 9) the annual trend of SST in 2002 and 2001 were almost similar both in fluctuation pattern and in value, except of November and December. In 2001 during these months a sharp increase of SST by 1.5°-4°C above the long-term average values was observed, while in 2002 SST values in November were by 1.5°C higher than the normal values and in December slightly exceeded the norm.

Figure 5 shows the annual trend of SST at the self of Nova Scotia and adjacent waters of the open sea. In the eastern part of the shelf (point 10) SST fluctuations were of the wave-like shape with temperature reduction from January to May, temperature rising from May to August and the next reduction from August to November. The pattern of SST trend in 2002 was similar to that in 2001, however differed in value. In winter-autumn season 2002 SST values there were slightly higher, while in summer-autumn these were significantly lower than in 2001, however during the most part of the year SST anomalies were positive.

On the shelf slope (point 11) SST values were higher than the norm and mostly higher than in 2001 during all months, except for April.

In the open sea in the Slope water mass (point 12) SST values were either higher than the norm or close to it during all months except for March, when the negative anomaly did not reach - 1°C. As compared to 2001 the intra-annual trend of SST in 2002 occurred opposite to the latter from January to April, while further the trend was similar. The most positive SST anomalies were observed in August and October and were probably related to warm rings formation in this area.

Like in the Slope water mass, at the Gulf Stream front (point13) SST values exceeded long-term average values during all months, except for July, and revealed the trend to increase from January to March, and further the trend to reduction up to July and sustainable increase to the end of the year. In 2002 the monthly mean SST values were either higher or close to SST in 2001. As is seen from Fig. 5, the highest positive anomaly (above 2°C) was observed in March.

Summarizing the peculiarities of the sea surface temperature front in 2002, it is possible to note the following feature. In the Labrador Sea, the Labrador Current, on the Labrador and Newfoundland shelves and the eastern shelf of Nova Scotia SST values were in general lower than in 2001, however close to the long-term norm and in many cases were below the norm. At the same time at the slope of the Scotian shelf, in the Slope water mass of the open sea and at the Gulf Stream front SST values increased as compared to 2001 and to the norm.

Water masses boundaries at the surface

The Cold shelf water boundaries shifting at the surface during the year depends mainly on the cold water transport by the Labrador Current and overlapped seasonal warming cycle. Figure 6 presents this boundary shifts in 2001 and 2002 in three grounds. As is seen from the figure, during these years the boundary of the Cold shelf water in most cases was either shifted northwards of the average long-term location or close to the latter. In 2001 the boundary shifts revealed the pronounced wave-like pattern as compared to the more smooth pattern in 2002. If the boundary oscillation amplitude reached 160 miles in 2001, in 2002 the latter did not exceed 80 miles. During 5-6 months in 2002 the boundary was located more southwards than in 2001 evidencing more active water transport by the Labrador Current in 2002.

The boundary of the Slope water mass being modified Gulf Stream water, is likely to depend on the cold water transport from the north including that outside the shelf, on the one hand, and the extent of Gulf Stream meandring and eddy-formation, on the other hand. As far as the northern boundary of the Slope water mass in the upper layer is adjoining directly to the Shelf surface water mass forming under the impact of the local hydrological-meteorological conditions, the boundary location depends also on the extent of these water masses distribution in the open sea. The Slope water boundary in 2002 was mostly located northwards of the long-term average line or close to it in all three areas (Fig. 7). As compared to 2001 in the area of "New England" this boundary was located more southwards from January to July, while in the areas of "Nova Scotia" and "Laurentian Channel" the boundary often occupied a more northward location. The most shift to the north (20-60 miles) as compared to 2001 was observed in the area of "Nova Scotia" in March-June with the maximum shift in June. Two more peculiarities of the Slope water boundary dynamics in 2002 should be noted that: the higher amplitude of the boundary oscillations and a more frequent change of shifts direction as compared to 2001.

The northern boundary of the Gulf Stream front in "New England" area during January –August was located more southwards of the average long-term line, while in September-December the boundary was shifted slightly northwards of the latter (Fig. 8). In January-May the front was located more southwards, while in June-October – more northwards as compared to 2001. In "Nova Scotia" area the front boundary occupied the location close to the average long-term line from January to August, and further it shifted significantly northwards. In February-May it was located considerably more southwards, while in September and October – much more northwards than in 2001. In "Laurentian Channel" area the northern boundary of the Gulf Stream front was mainly close to the long-term average line and to the boundary location in 2001. Therefore, it can be assumed that in 2002 the trend appeared towards the boundary shift to the south in winter-spring and to the north in summer-autumn as compared to 2001. This trend is especially evident in "New England" and "Nova Scotia" areas.

Conclusion

On the basis of the above mentioned intra-annual trend of SST anomalies it seems possible to conclude that in 2002 the process of SST decrease continued in the Labrador Current system, while in the Gulf Stream system on the contrary the surface temperature increase was observed.

Analysis of the water boundaries dynamics showed that in 2002 the boundary of the Cold shelf water mass occupied generally the position similar to the long-term average, however it often shifted further southwards than in 2001. The boundary of the Slope water mass in the "New England" area was located slightly more southwards than in 2001, however, it was mostly shifted northwards in two other areas evidencing the strengthening of the warm Slope water advection on the Nova Scotia shelf. On this basis it can be assumed that in 2002 the strengthening of cold Labrador water transport occurred simultaneously with the strengthening of warm slope water advection on the shelf evidenced by SST analysis. Unlike two other boundaries, the fluctuation amplitude of the northern edge of the Gulf Stream in 2002 was lower than in 2001, while the boundary itself was located close to the long-term average line, or southwards of it.

Acknowledges

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References

Sigaev I.K., 2001. Sea-surface Temperature and Water Boundaries in the Northwest Atlantic in 2000. NAFO SCR doc. 01/83, Serial No. N4 470, 12 p.

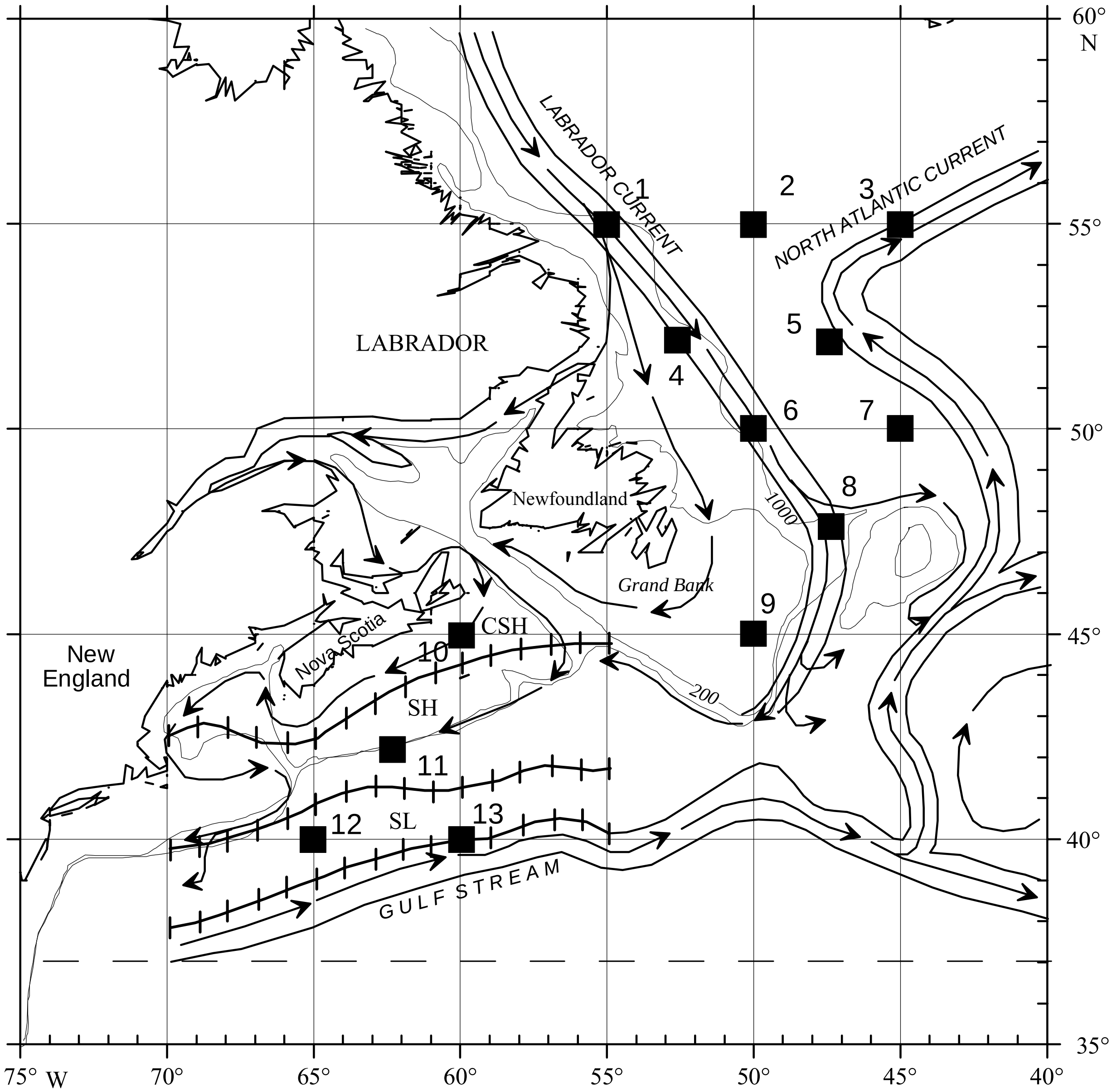

Fig.1. Map of points of SST monitoring and average location of water masse boundaries in the Labrador Current area and Gulf Stream in summer (CSH – Cold Shelf water, SH – Warm Shelf water, SL – Slope water).

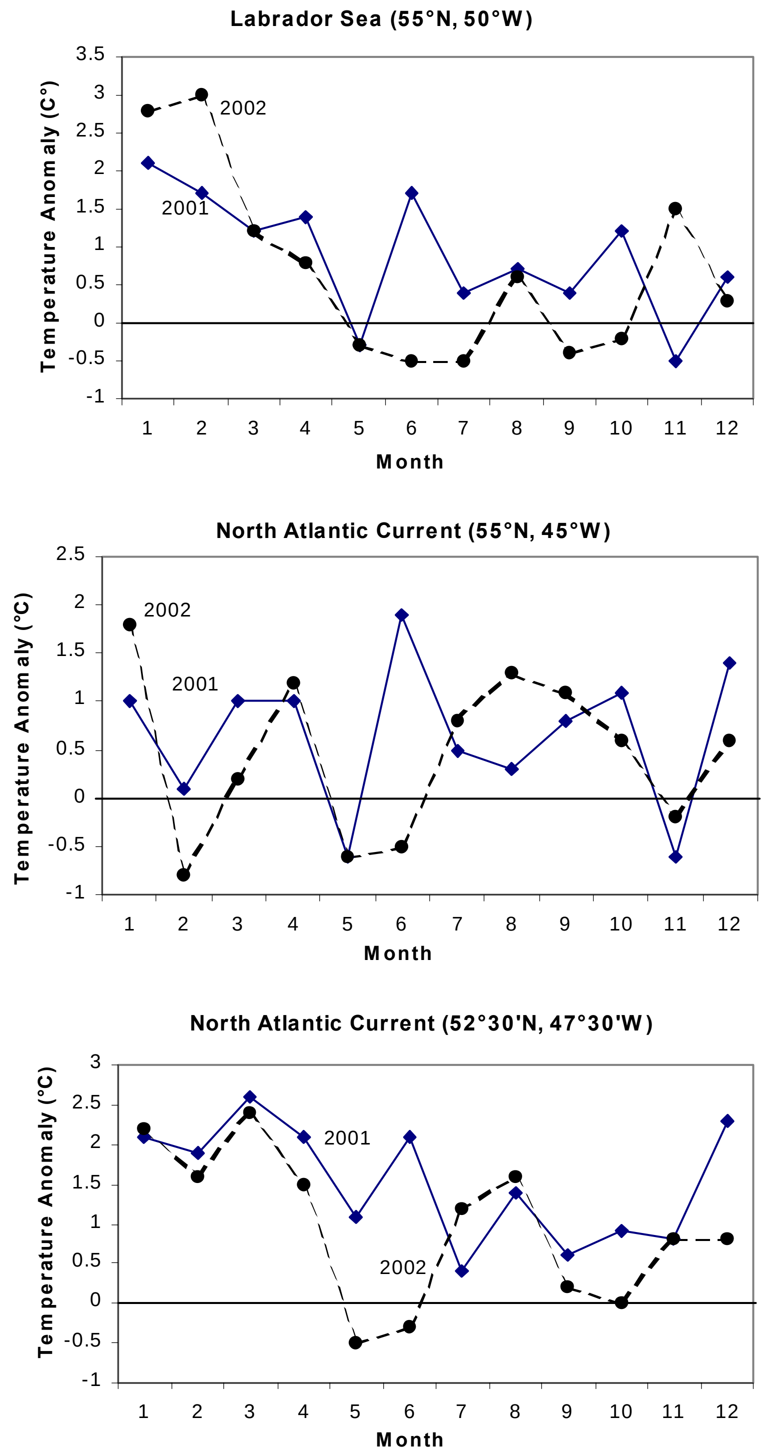

Fig. 2

Fig.2. SST anomalies in the open Labrador Sea (point 2) and the North Atlantic Current (points 3, 5) in 2001 and 2002.

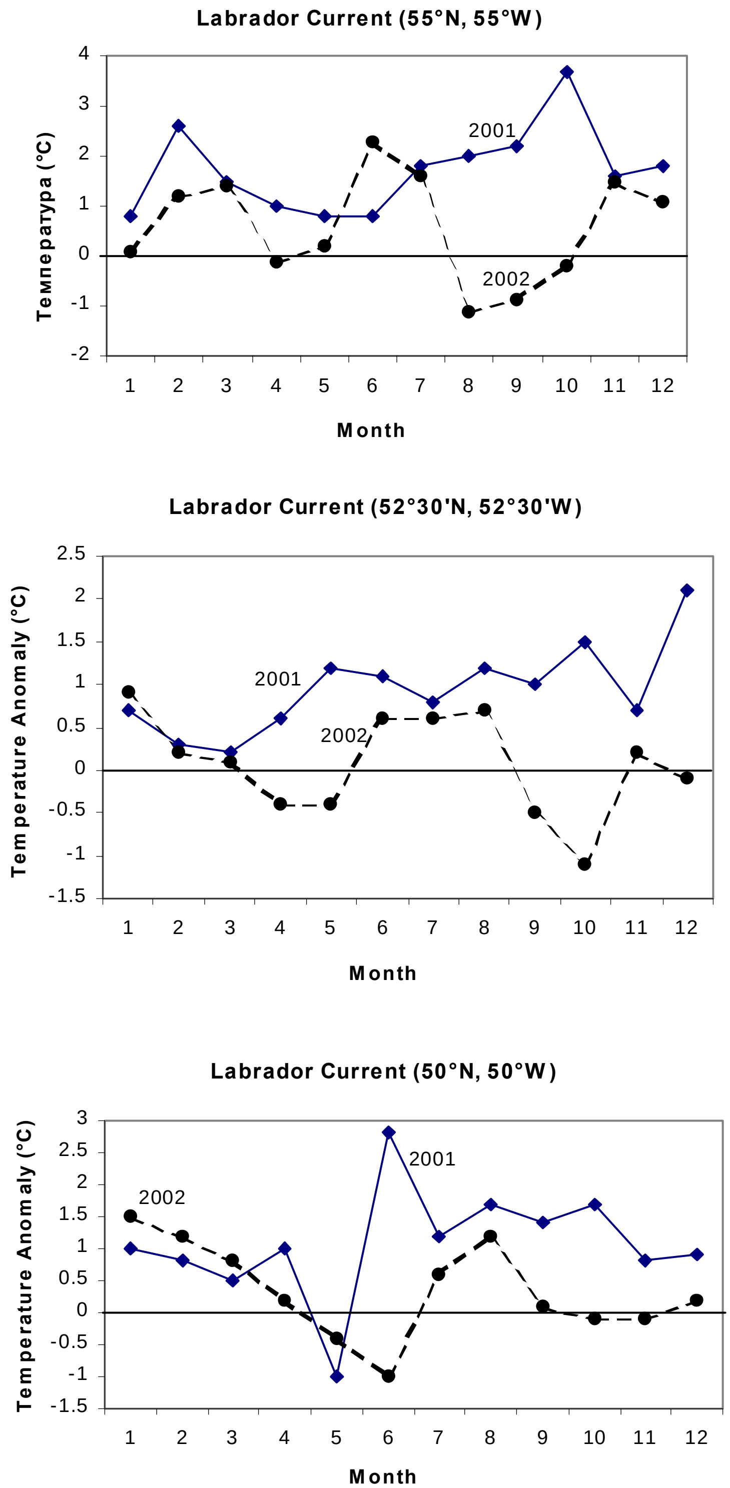

Fig.3. SST anomalies in the off shore flow of the Labrador Current (points 1, 4, 6) in 2001 and 2002.

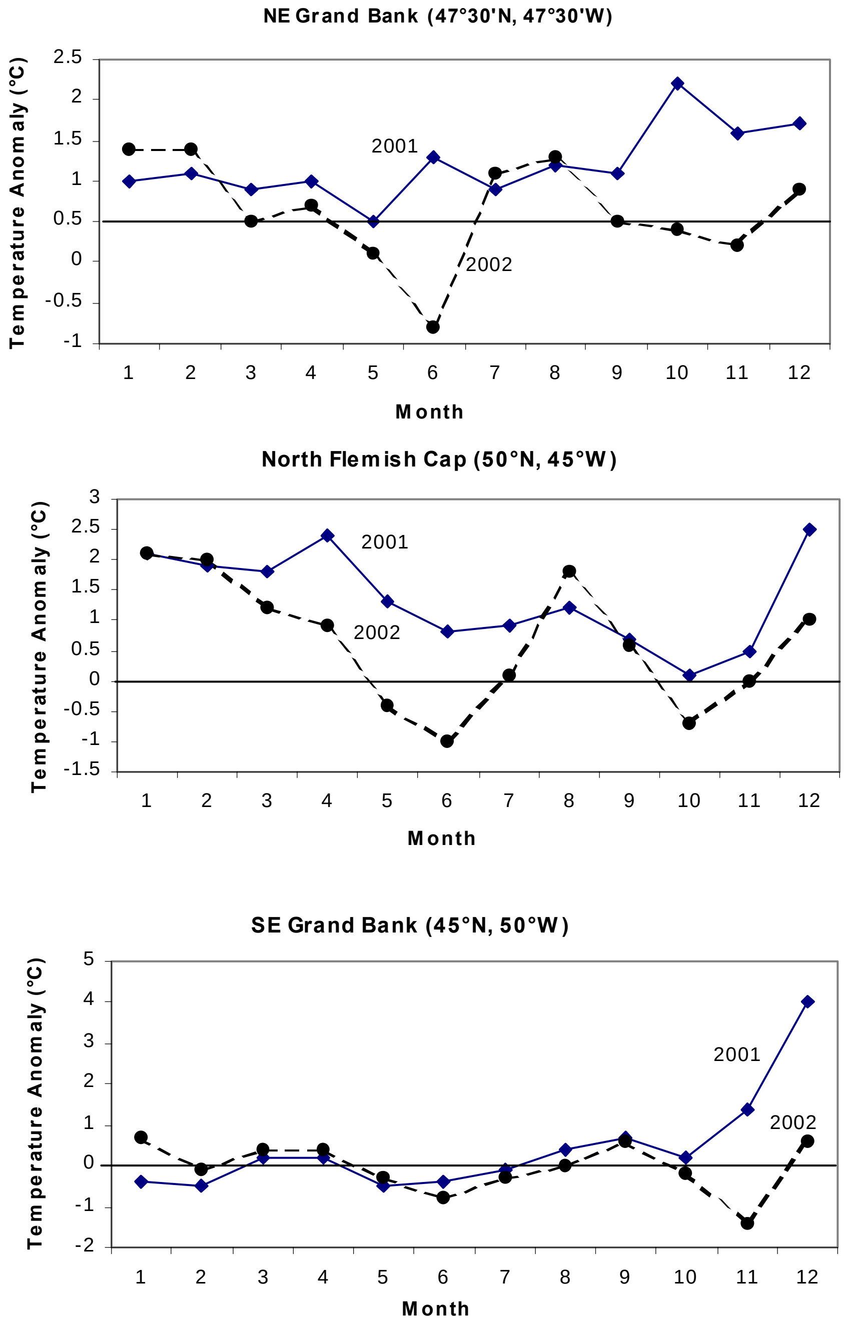

Fig.4. SST anomalies at the Grand Newfoundland Bank (points 8, 9) and northwards of the Flemish Cape Bank (point 7) in 2001 and 2002.

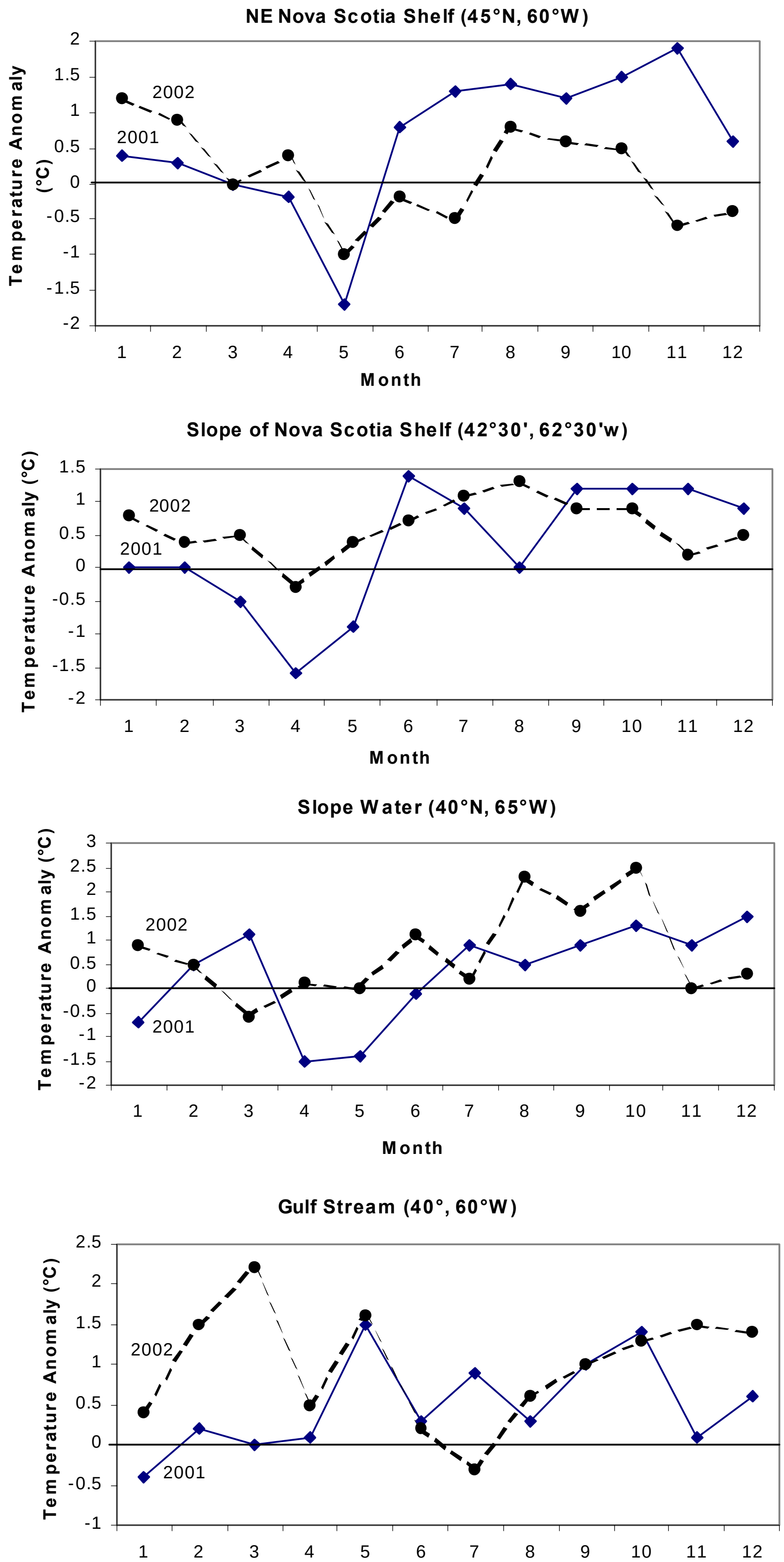

Fig.5. SST anomalies on the shelf of Nova Scotia (points 10-11), in the Slope water (point 12) in Gulf Stream (point 13) in 2001 and 2002.

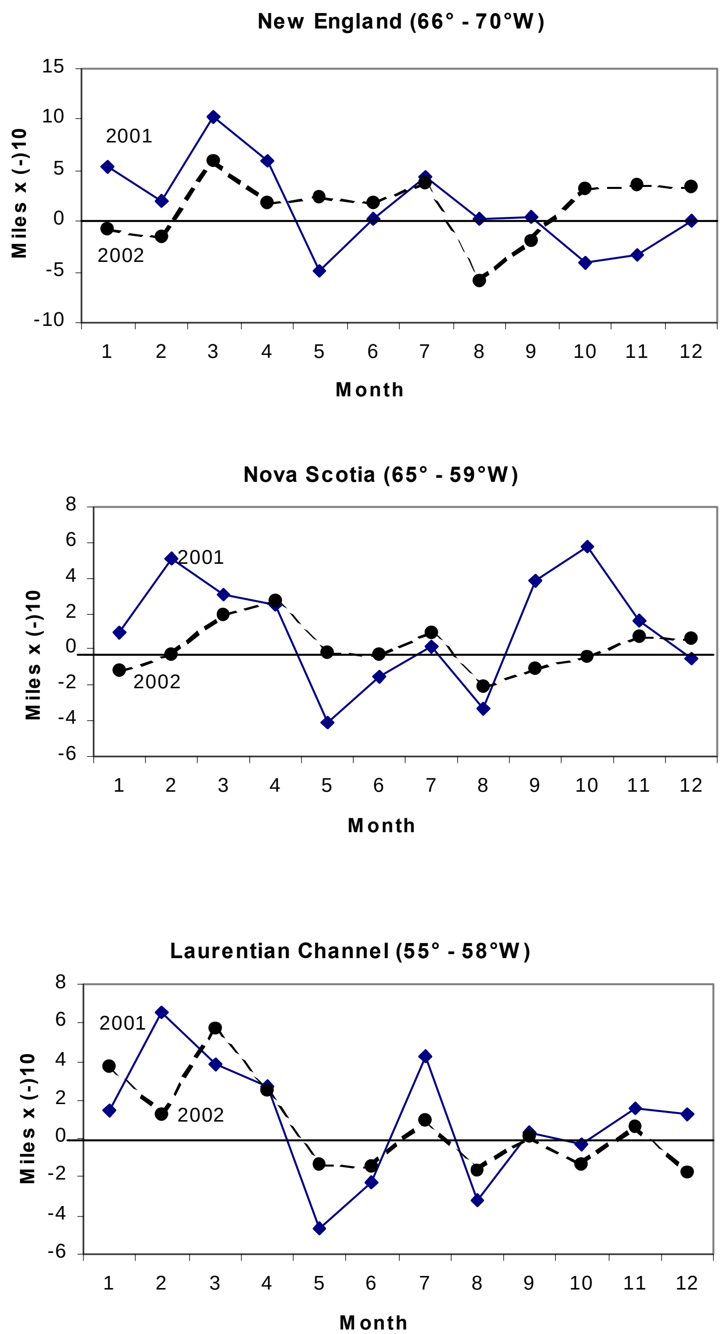

Fig.6. Anomalies of the Cold shelf water boundary location indices in 2001 and 2002.

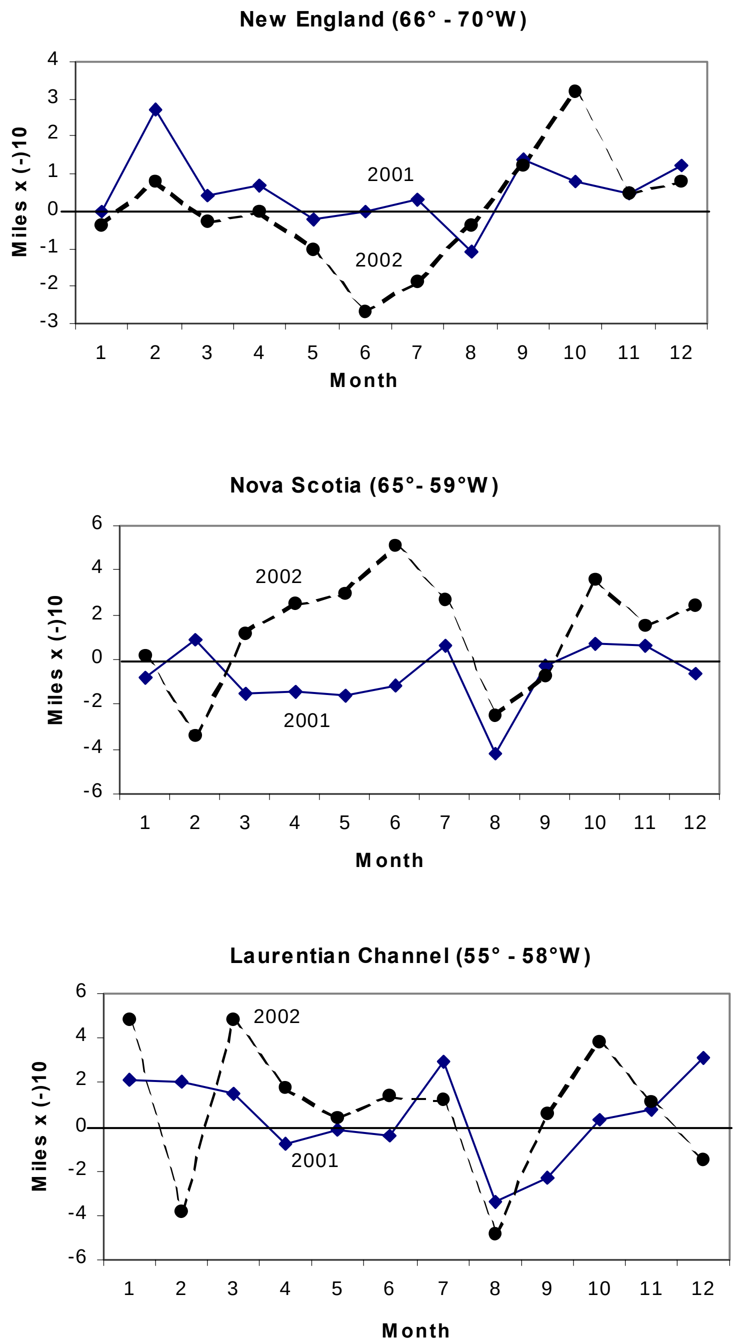

Fig.7. Anomalies of the Slope water boundary location indices in 2001 and 2002.

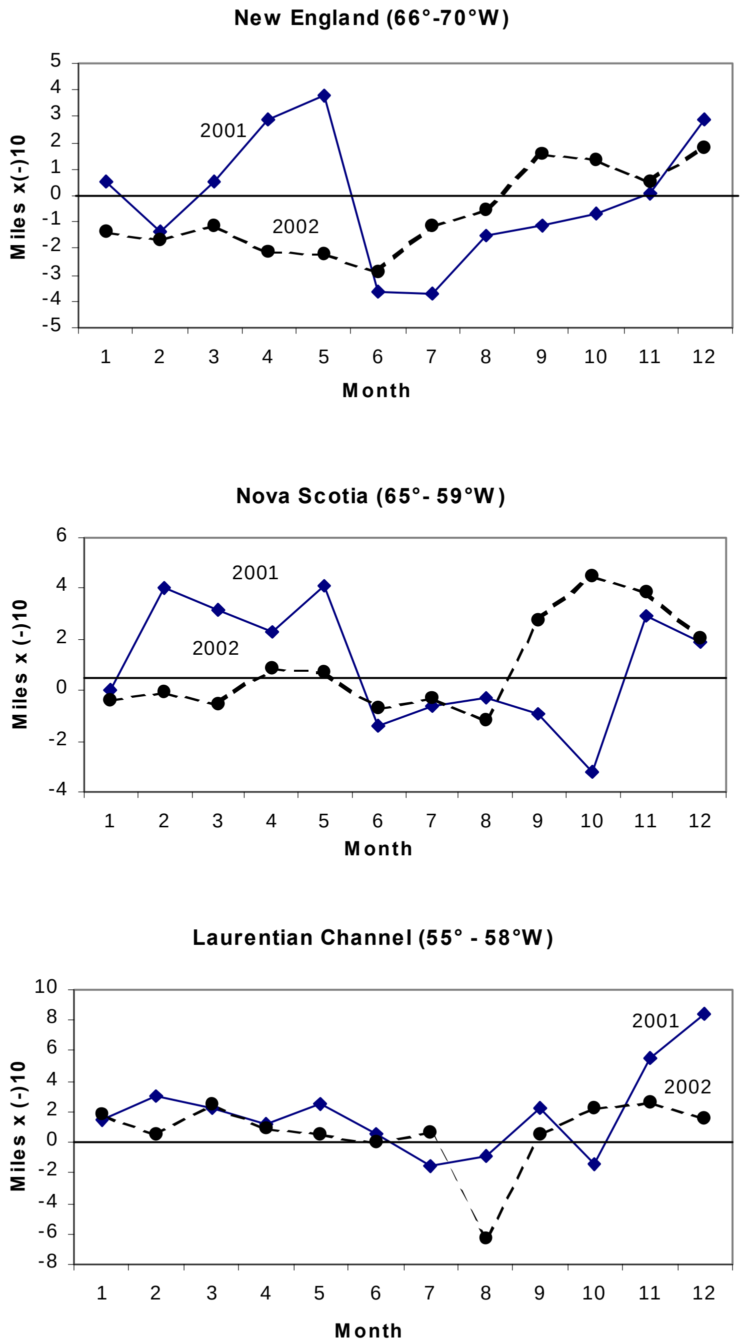

Fig.8. Anomalies of the northern edge of Gulf Stream front location indices in 2001 and 2002.