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Sea-surface Temperature and Water Boundaries in the Northwest Atlantic in 2000

by

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Abstract

The summary of sea water temperature at 13 locations within Labrador Current and Gulf Stream activity zones between 40°-55° N and 45°-65° W as well as water mass boundaries at the surface in the area between 37°-47°N and 55°-70°W (the boundary of the Cold Shelf water, the Slope water and the northern boundary of Gulf Stream front) is presented. To assess the conditions the mean monthly SST anomalies for 1977-1996 and water boundaries location indices for 1962-1992 were used. The conclusion was made that SST in the Labrador Sea, main Labrador Current flow, shelves of Grand Newfoundland Bank and New Scotia as well as in the Gulf Stream exceeded the mean long-term values during the most part of the year. In some areas SST during certain months were close to the mean long-term level. The Cold Shelf and Slope water boundaries in New England and New Scotia areas fluctuated synchronously according to the annual wave pattern with positive anomalies in winter and spring and negative in summer and autumn. In Laurentian Channel area the Cold-water mass boundary shifted respectively, while the Slope water boundary located northwards of the long-term line during the most part of the year.

The Gulf Stream front boundary shifting during 2000 followed a half-year wave pattern. On the basis of SST and water boundaries analysis the year 2000 is classified as a relatively warm year of the latest set.

Introduction

In 2000 the monitoring of hydrological conditions in the North-Western Atlantic Ocean was continued on the basis of SST data analysis in the area between 40°-55°N and 45°-65°W and data on hydrological fronts location near the surface (the boundary of the Cold Shelf water - CSH, the Slope water - SL and the northern boundary of Gulf Stream front) in the area between 37°- 47°N and 55°-70° W (Fig. 1).

As before, the mean monthly SST values at the typical 13 locations within Labrador Current and Gulf Stream activity zones were used. Locations 1, 4, 6 and 8 are situated along the main flow of the Labrador Current. Location 2 reflects SST fluctuations in the open Labrador Sea, while locations 3 and 5 are situated near the North-Atlantic Current. Location 7 characterised the conditions in the area northwards Flemish Cap. In the Grand Bank area SST fluctuations are reflected by the data of location 9. In the Scotian shelf area SST in location 10 characterized the conditions in the upper layer of the "cooler" eastern shelf area, while location 11 reflects SST variability at the slope. In the open sea area outside the shelf SST of the Slope water and at Gulf Stream front is monitored in locations 12 and 13 respectively. In Fig.1 the long-term location of three water masses boundaries in summer is also shown. Their shift is monitored in 3 conventional areas: "New England" (70-66º W), "New Scotia" (65-59ºW) and "Laurentian Channel" (58-55ºW). The proposed scheme of oceanographic conditions monitoring includes consideration of certain impact of water advection upon SST fluctuations in NWA and may be used as the additional mean of environment monitoring in this area.

Materials and Methods

As before, the mean monthly SST values in 13 above-mentioned locations within Labrador Current and Gulf Stream activity areas were used to analyse SST. SST in these locations were obtained by means of interpolating the values in intersects of the grid 2ºx2º out of monthly SST tablegrams provided by Roshydrometeocenter (Moscow). SST deviations from the norm in each location and by months were calculated based on mean values for 1977-1996 as before.

To analyse seasonal and inter-annual variability of three water boundaries location in NWA we used their latitudal fluctuations at the surface obtained either from the facsimile maps of water boundaries ("Ocean feature analysis") or from SST map ("Sea SFC temperature analysis"), issued by Canadian forces meteocenter, HALIFAX. The distance (in tens n. miles) between 37ºN and the boundary cross point at each meridian is assumed to bee the index of any boundary location. Mean indices are estimated by means of averaging their values for 8-9 periods during a month. Estimation of water masses boundaries location indices was made on the basis of mean values for 1962-1992. Water titles in the text correspond their titles in maps "Ocean feature analysis".

Sea-surface Temperature

In the open Labrador Sea area as mean monthly temperatures were positive and exceeded the long-term level and the level of 1999. The highest values were observed in January and July, and the lowest ones in May and December (Fig. 2). In the south-eastern Labrador Sea area adjacent to the North-Atlantic Current (locations 3 and 5 in Fig. 1). Mean SST also were positive and mostly exceeded mean long-term values.

In the main flow of the Labrador Current between 55º and 50º N positive SST anomalies predominated also with maximum values in July, August and in some areas in January (Fig. 3).

Thus at 55ºN SST values were close to the mean long-term during January-July with anomalies from -0.6ºC to 0.5ºC, while in July-December SST exceeded the mean long-term values with maximum anomalies 2.6ºC-2.3ºC. Southwards at 52º30N the mean monthly SST values were close to the norm during the most part of the year, while in July-September and in November they exceeded the norm by 1.1-3.6ºC. Further southwards at 50ºN SST either exceeded the mean long-term values the most part of the year. At the eastern slope of the Grand Bank (location 8 in Fig. 1) SST during some months were lower than in 1999, however the mean monthly values were positive and mostly exceeded the norm by 0.3-2.9ºC. June was the "coolest" month with anomaly –0.4ºC. In the south-eastern part of the Grand Bank SST exceeded the norm during January-November and approached the norm only in December (Fig. 4).

In the Labrador Current branch surrounding the Flemish Cap from the north (50ºN-49ºN) SST were close to the norm in January and February. In June and October SST were below the norm by 0.7ºC while during the other months these were positive and exceeded the norm by 0.7-2.7ºC (Fig. 4).

In the New Scotia shelf area (Fig. 5) within the coldest eastern part the mean monthly SST values exceeded the norm by 0.9-1.6ºC. It should be mentioned that the shallow locations of Sable Island and Emerald Bank being the basic spawning areas of hake in July-August, SST values approached the level 10ºC typical to spawning in middle June. By the middle July SST increased up to 13-15ºC, while by the late August they approached 18-21ºC. This evidenced of the thermal conditions favourable to hake spawning in 2000 similar to 1999.

At the shelf slope where advection processes in the upper 500-m layer became the major factor of oceanological conditions formation while the mean SST values during the whole period were above the long-term average owing to increase of the warm slope water mass advection observed in spring-summer.

In the area off the shelf (location 12 in Fig. 1) in the slope water mass SST positive anomalies (0.6-2.2ºC) were recorded during January-March while in April, July, August, October-December SST values were close to the norm and mostly lower than in 1999.

Near Gulf Stream front SST distinctly exceeded the long-term average in January-November and were close to the level in 1999. The peak values were observed in May (2.5ºC) and the lowest ones (0.1ºC) in December. If we follow SST anomalies trends in locations of the same branch, the qualitative similarity between these data may be noted. For example, SST anomalies curves in two points of the North-Atlantic Current (locations 3 and 5, Fig. 1) were similar in 1999 and 2000. The same may be noted concerning locations in the Labrador Current (locations 1, 4, 6) and in the Grand Bank (locations 8 and 9). SST trends in location 7 (Flemish Cap) were similar to anomalies trends in location 6 of the Labrador Current.

Water Boundaries at the Surface

In the New England area (66-70ºW) the Cold Shelf Water boundary (CSH) was shifted about 40 miles northwards as compared to the previous year in February-May 2000, while in June-December it shifted about 70 miles southwards (Fig. 6). The curves of location indices anomalies revealed two periods of the boundary northwards shift and two periods of southwards shift forming a half-year wave. In the New Scotia area (59-65ºW) this boundary shift pattern showed one northward shift (January-April) and one southward shift (June-October). Further to the east in the St. Lawrence Channel area (58-55ºW) the CSH boundary shifted northwards to about 50 miles in January-May and then returned to the position close to the long-term average. In general it may be noted that in 2000 the CSH boundary fluctuations in the New England and New Scotia areas were of wave-like pattern with a general northward shift during the cold season and southward shift during the warm part of the year. These waves fluctuations reached 130-140 miles. This feature appears each year to different extent and is related to increase of the northward water drift transport of Gulf Stream system, and increase of cool water southward out flow with the Labrador Current owing to ice melting and predominated winds strengthening. The cool water escaping from the St. Lawrence Gulf and the Grand Bank area migrate westwards along New England and New Scotia coastline, extending over the waster space than usually and sometimes even shifting into the open area outside the shelf. If we compare the dynamics of CSH boundary in 2000 to the fluctuations in 1999, it may be noted that in New England area the annual wave was distinct during both years. In New Scotia area CSH boundary was shifted northwards in 1999, while in 2000 its dynamics followed a year-wave pattern. In the Laurentian Channel area CSH boundary fluctuations were similar to those in 1999 and also followed a year-wave pattern.

In 2000 the Slope water (SL) boundary also fluctuated according to a year-wave pattern in New England and New Scotia areas, i.e. the boundary shifted northwards in January-May and southwards in June-December (Fig. 7). The fluctuation amplitude reached 67 miles. In 1999 the slope water mass boundary was located mainly northwards of the average long-term position and northwards of its position in 2000. In the Laurentian Channel area the Slope water boundary in 1999 fluctuated according to a year-wave pattern shifting northwards in winter and summer. In 2000 its fluctuations were of uncertain pattern, however, it was shifted northwards of the middle line or was close to the latter during the most part of the year.

In 2000 fluctuations of Gulf Stream front northern boundary differed from those of CSH and SL boundaries. The Gulf Stream front boundary fluctuations followed a half-year wave pattern with a negative deviations in winter and summer and positive deviations in spring and autumn (Fig. 8). The fluctuation pattern in 2000 and 1999 were similar, especially in New England and Laurentian Channel areas. As is seen in the Figure the northern boundary of Gulf Stream front was located northwards in 2000 as compared to 1999 in all three areas.

Conclusions

Thus it may be assumed that in 2000 SST in most of the Labrador Sea area and in the active zones of the Labrador Current and Gulf Stream, including shelves of the Grand Newfoundland Bank and New Scotia were higher than the long-term level during the most part of the year. In some areas during certain months this level was close to the mean long-term one.

It may be concluded that in 2000 the Cold Shelf and Slope water boundaries in New England and New Scotia areas fluctuated synchronously according to the annual wave pattern with northward shift in winter-spring season and southward shift in summer and autumn. This means the increase of warm water advection in these areas shelves in winter and spring and reduction in summer and autumn. In Laurentian Channel area in 2000 the Cold-water boundary shifted northwards during the first half of the year and returned back during the second half. The Slope water was either shifted northwards or were close to the mean long-term location contributing in general the thermal front rise. The Gulf Stream front northern boundary shifted during 2000 followed a half-year wave pattern irrespective of the Cold Shelf and Slope water boundaries fluctuations and was located northwards of the position in 1999.

On the basis of SST and hydrological fronts location analysis in NWA the year 2000 is classified as a relatively warm year of the latest set. This conclusion is confirmed by the results of environment conditions assessment presented by K.F. Drinkwater, E. Colbourne and D. Gilbert in the data review for 1999 and 2000 (Drinkwater *at al.*, 2000, 2001).

Acknowledgements

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K.F. Drinkwater, E. Colbourne, and D. Gilbert. Overview of Environmental Conditions in the Northwest Atlantic in 1999. NAFO SCR Doc. 00/ 21, Serial No. N4250, 87 p.

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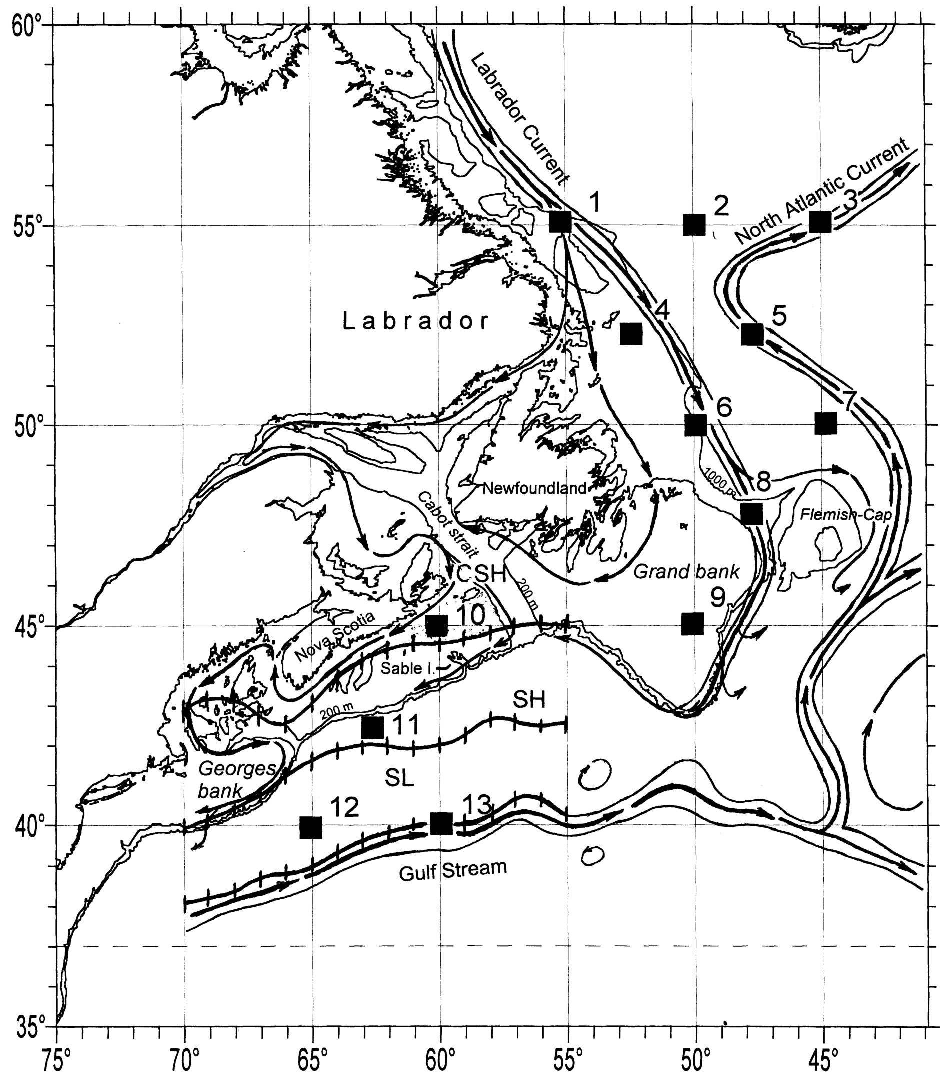

Fig.1. Map of SST monitoring locations distribution and mean summer location of water masses boundaries in the Labrador Current and Gulf Stream action zones. (CSH – the Cold Shelf water, SH – the Warm Shelf water, SL - the Slope water)

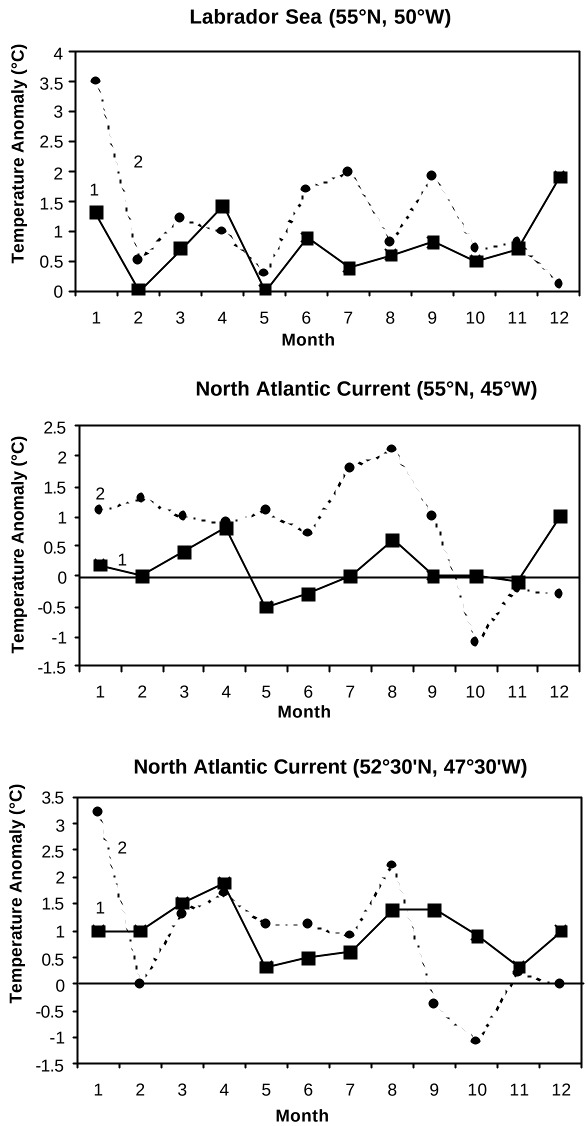

Fig.2. SST anomalies in the open Labrador Sea (location 2) and in the North-Atlantic Current flow (locations 3, 5) in 1999 (1) and 2000 (2).

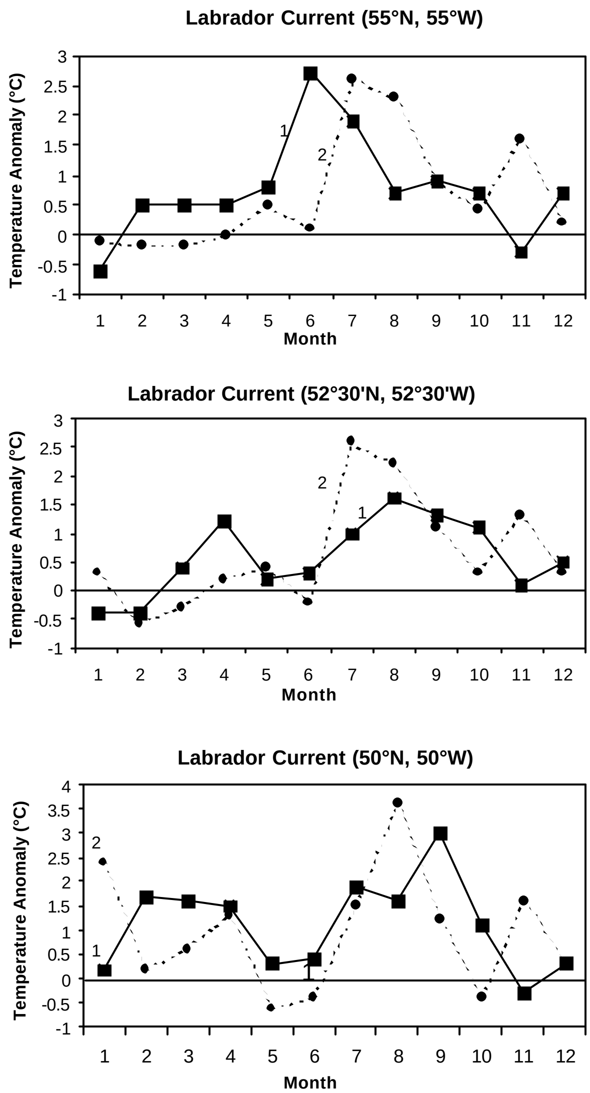

Fig.3. SST anomalies in the off-shore flow of the Labrador Current (locations 1, 4, 6) in 1999 (1) and 2000 (2).

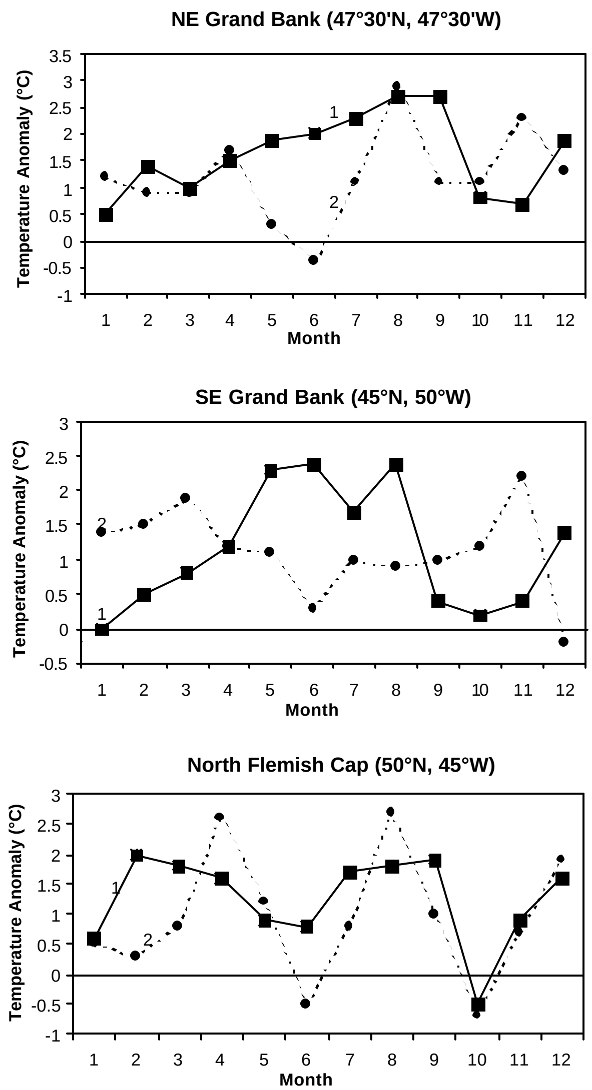

Fig.4. SST anomalies in the Grand Newfoundland Bank area (locations 8, 9) and northwards of Flemish Cap Bank (location 7) in 1999 (1) and 2000 (2).

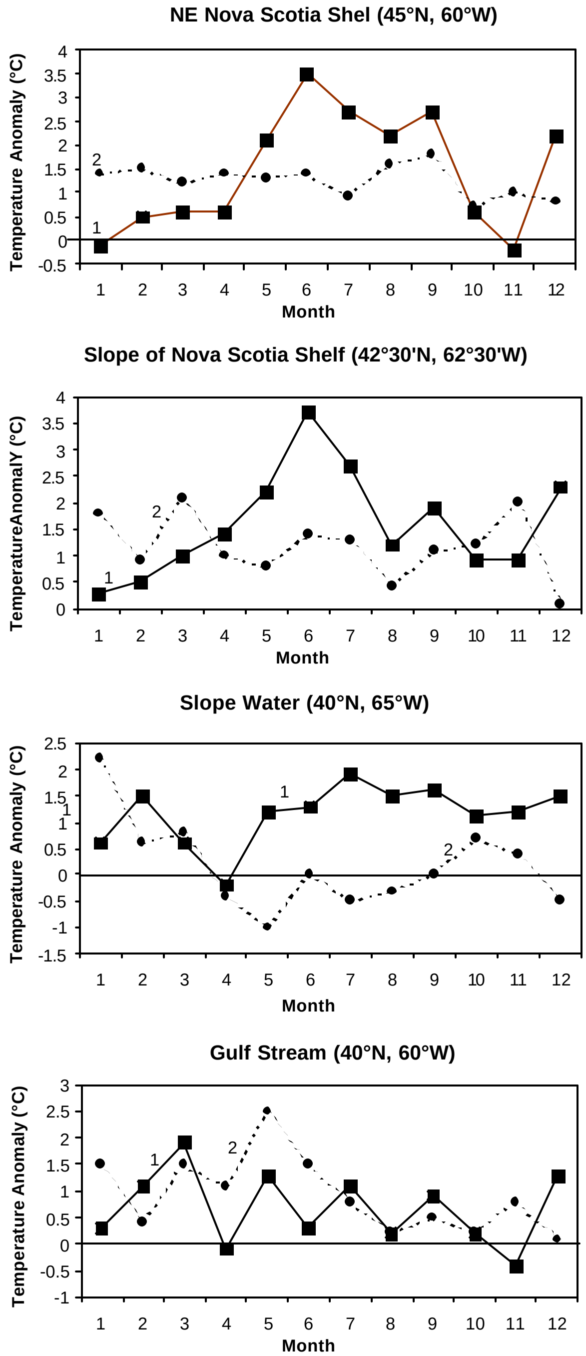

Fig.5. SST anomalies in the New Scotia shelf area (locations 10, 11), in the Slope water (location 12) and Gulf Stream (location 13) in 1999 (1) and 2000 (2).

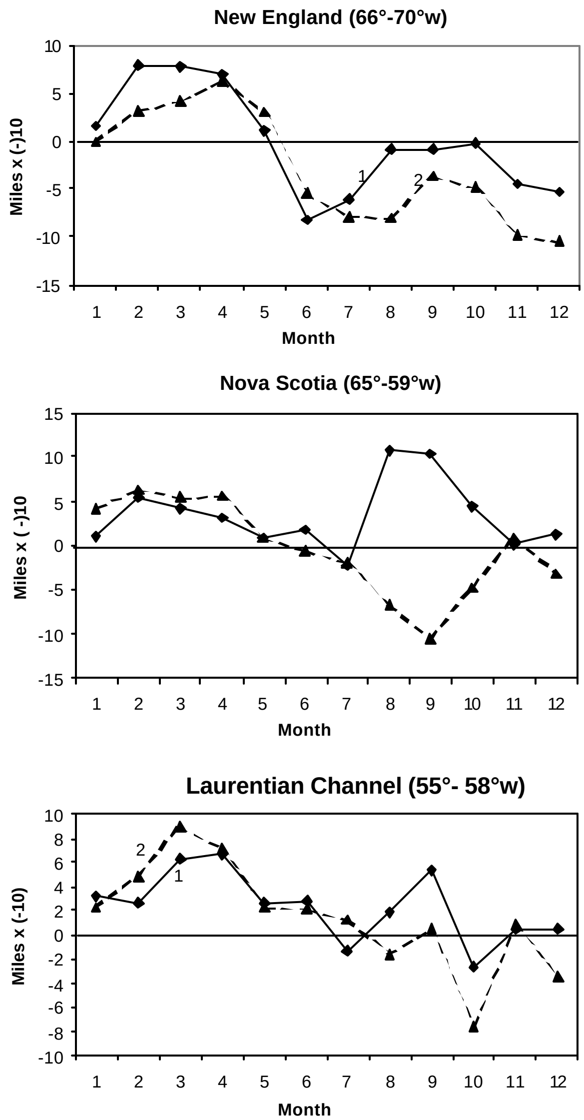

Fig.6. Anomalies of the Cold Shelf water boundary location index in 1999 (1) and 2000 (2).

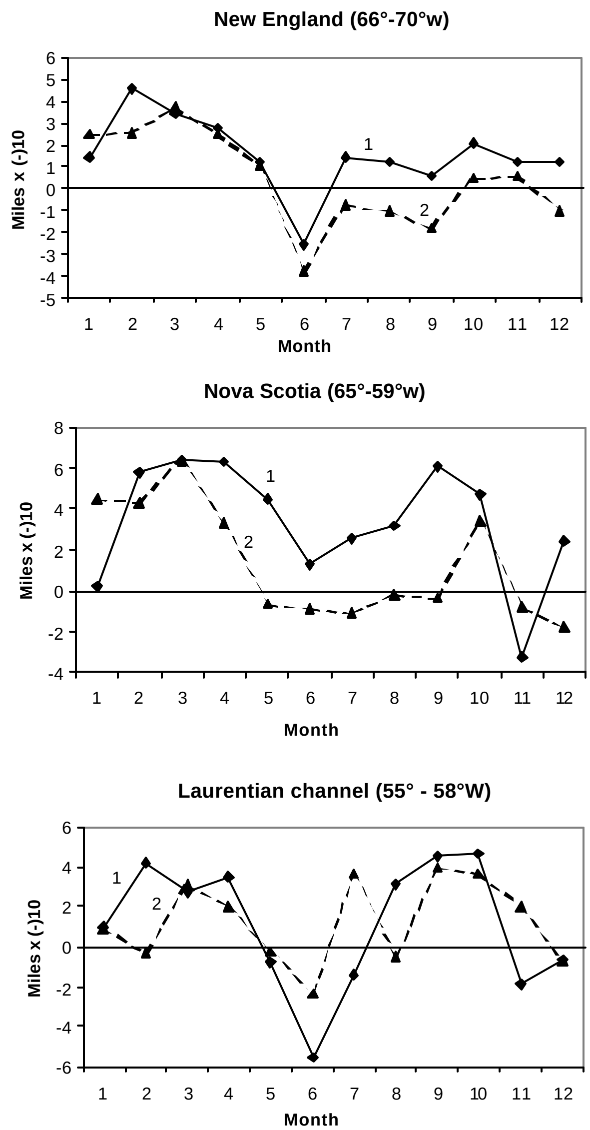

Fig. 7. Anomalies of the Slope water boundary location index in 1999 (1) and 2000 (2).

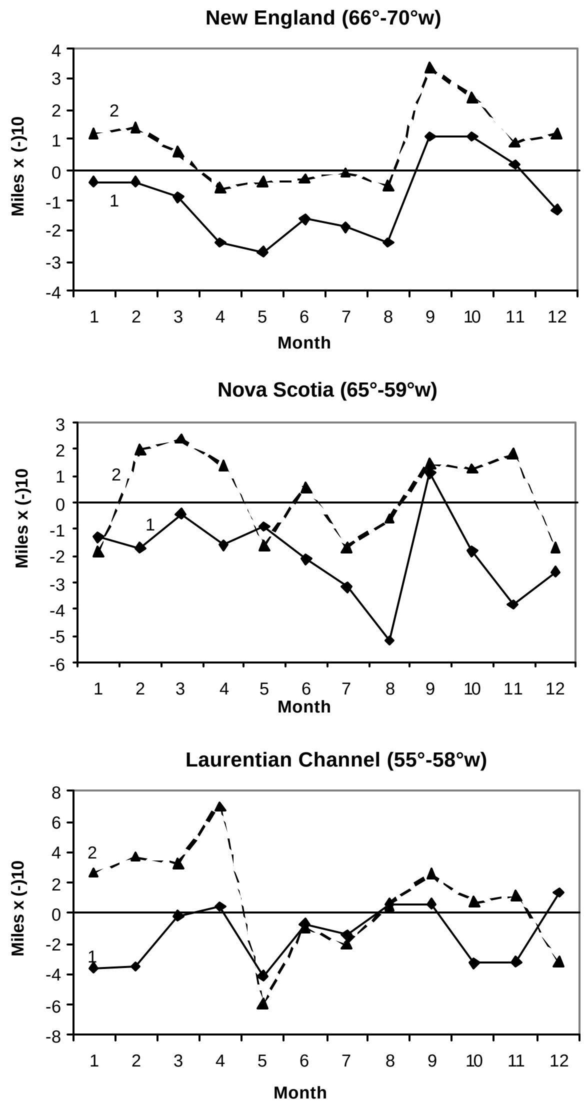

Fig. 8. Anomalies of the northern Gulf Stream front boundary location index in 1999 (1) and 2000 (2).