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On the Physical Oceanographic Conditions in the Scotia-Fundy Region in 1993

by

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[1]La présente série documente les bases scientifiques des évaluations des ressources halieutiques sur la côte atlantique du Canada. Elle traite des problèmes courants selon les échéanciers dictés. Les documents qu'elle contient ne doivent pas être considérés comme des énoncés définitifs sur les sujets traités, mais plutôt comme des rapports d'étape sur les études en cours.

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ABSTRACT

During 1993 cold air temperatures were observed off eastern Canada in winter. This contributed to colder-than-normal annual air temperatures along the Atlantic coast of Nova Scotia and in the Gulf of Maine. At Sable Island, the annual mean air temperature was slightly warmer-than normal. A general decline in air temperatures has occured since the 1980s in the Scotia-Fundy region.

The relatively cold winter of 1993 lead to severe ice conditions in the Gulf of St. Lawrence with earlier ice formation, longer duration, greater areal extent and later retreat than usual. Ice flowed out of the Gulf onto the Scotian Shelf and extented southwestward along the coast of Nova Scotia during late February and early March. The southward extent of ice on the Scotian Shelf at this time was at or near the long-term maximum.

Ocean temperature conditions in 1993 varied with location and depth. In the 50-100 m depth range over the Shelf, coincident with the cold intermediate layer, temperatures were generally colder-than-normal which continues a trend that has existed for several years. In some locations temperatures match those last seen in the 1960s. There is some suggestion, however, that temperatures in this depth range may be warming. The bottom waters (> 150 m) in the deep regions, such as Emerald Basin, Cabot Strait and Northeast Channel, have warmed substantially during the past two years. This is related to a warming of the offshore Slope waters. The greatest variability has been in the upper 50 m where there has been a tendency towards negative temperature anomalies but the magnitude and even the sign of the anomalies have varied both spatially and temporally.

RÉSUMÉ

Durant l'hiver 1993, on a enregistré des températures de l'air froides au large de l'est du Canada. Cela explique que les températures de l'air le long de la côte atlantique de la Nouvelle-Écosse et du golfe du Maine aient été plus froides que la normale, exception faite de l'île de Sable où elles étaient légèrement supérieures à la normale. La région de Scotia-Fundy connaît une baisse générale des températures de l'air depuis les années 1980.

L'hiver relativement froid de 1993 a été à l'origine de fortes concentrations de glace difficiles dans le golfe du Saint-Laurent, où la glace s'est formée plus tôt, est restée plus longtemps, s'est étendue sur une plus grande surface et s'est retirée plus tard qu'à l'accoutumée. Cette glace est sortie du golfe pour gagner la plate-forme néo-écossaise et s'est répandue vers le sud-ouest le long de la côte de la Nouvelle-Éçosse à la fin de février et au début de mars. À cette période, l'étendue de la glace sur la plate-forme néo-écossaise en direction sud atteignait le maximum enregistré à long terme ou s'en approchait.

Les températures de l'océan en 1993 ont varié selon l'endroit et la profondeur. Sur la plate-forme, à des profondeurs de 50 à 100 m, soit dans la couche froide intermédiaire, elles étaient généralement inférieures à la normale, poursuivant une tendance qui se manifeste depuis plusieurs années. À certains endroits, elles étaient comparables à celles des années 1960. Selon certaines indications, cependant, les températures à ces profondeurs pourraient connaître un réchauffement. Quant aux températures des couches du fond (> 150 m), dans des eaux profondes comme le bassin Émeraude, le détroit de Cabot et le chenal nord-est, elles se sont considérablement réchauffées au cours des deux dernières années. Ce phénomène est associé à un réchauffement des eaux de pente du large. C'est dans la couche située au-dessus des 50 m que la variabilité était la plus grande. On y a observé une tendance à des anomalies de températures négatives, mais l'ampleur et même la manifestation de ces anomalies variaient dans le temps et dans l'espace.

INTRODUCTION

This paper focuses upon the physical oceanographic conditions in the Scotia-Fundy region in 1993, in particular air temperatures, sea ice and sea temperatures. These are presented as anomalies relative to their long-term means which, where possible, have been estimated over the period 1961-90. For completeness, some of the information from the broadscale environmental overview presented to the Fisheries Oceanography Committee in March (Drinkwater, 1994) is included herein.

AIR TEMPERATURES

The Atmospheric Environment Service of Canada publishes the annual and monthly mean air temperature anomalies for Canada in the *Climatic Perspectives.* Their anomalies are still calculated relative to the 30-yr mean, 1951-80. The 1993 annual air temperature anomalies were colder-than-normal over all of eastern Canada (Fig. 1) and contrast with the warmer-than-normal temperatures in the west, similar to the pattern observed in 1992. The coldest region extended from central Baffin Island to northern Labrador. Over most of the remainder of the eastern Canadian marine areas, the annual anomalies ranged from -0.5°C to -2°C. These generally exceeded the standard deviations of the long-term means (Trites and Drinkwater, 1986). Time series of the annual anomalies relative to 1961-90 at 4 sites in the Scotia-Fundy region are shown in Fig. 2. Consistent with Fig. 1, the 1993 annual temperature anomalies at the coastal sites were below normal although Sable Island was slightly above normal (0.2°C). There was a general decrease in the amplitude of the coastal station anomalies towards the south. The long-term temperature trends show high similarity between the four sites, with minima in the 1880s, the 1920s and the 1960s and a peak in the 1950s. In the early 1980s conditions were generally warmer-than-normal but in the 1990s they have been declining slightly.

The monthly mean air temperature anomalies in 1993 (Fig. 3) show that conditions varied substantially with the coldest period in the winter (January to March). Anomalies of -3°C or lower were observed at all three mainland sites and about -1.5°C at Sable Island. Below normal air temperatures were also recorded in the early summer and October-November, with above normal conditions in the spring, the late summer and December.

SEA ICE OBSERVATIONS

Information on the location and concentration of sea ice is available from the daily ice charts published by Ice Central of Environment Canada in Ottawa. The long-term medians, maximum and minimum positions of the ice edge (concentrations above 10%) for the years 1962 to 1987 were published by (Coté 1989).

Ice spread more rapidly then usual through the Gulf of St. Lawrence in January of 1993 such that by 1 February the Gulf was covered except for a small area off southwestern Newfoundland (Fig. 4). At this time, ice also extended onto Sydney Bight, offshore of western Cape Breton, similar to last year. During February continued cold air and northwesterly winds pushed the ice further onto the Scotian Shelf. The ice edge at the beginning of March had extended south of Halifax beyond the long-term (1962-87) maximum value. At this same time, the offshore position of the ice edge in the eastern Scotian Shelf area was greater-than-normal but was well inshore of the maximum extent. Through March the ice began to retreat. On 1 April, there was still ice on the eastern Scotian Shelf and the coverage was much closer to the maximum extent than the median. Ice was last observed in Sydney Bight and Cabot Strait around the 20-24 of April.

The Ice Climatology and Application Division of Environment Canada undertakes an annual analysis of ice conditions off the east coast of Newfoundland and southern Labrador and in the Gulf of St. Lawrence by determining the time of onset, duration and last presence of ice at 24 grid sites (Fig. 5). In Cabot Strait (G33) and off southeastern Cape Breton (G87), ice appeared early by approximately a week to two and it left two weeks later than normal off Cape Breton Island and a week later than normal in Cabot Strait. The duration of sea ice (which is not the difference between first and last presence of ice because at certain times of the year ice may dissappear) was 1 week longer than usual off Cape Breton and almost 4 weeks longer in Cabot Strait. Indeed, 1993 matched the record for maximum duration at Cabot Strait. The time series of ice duration at these two sites shows a minimum in the early 1980s, a general rise through the 1980s and record or near record durations in the 1990s (Fig. 6). In 1983 no ice was observed off southeastern Cape Breton at anytime through the winter.

OCEANOGRAPHIC OBSERVATIONS

Coastal SST data

Monthly averages of SST are available from Halifax Harbour, St. Andrews and Boothbay Harbor. During 1993 the coastal SST anomalies (relative to the 1961-90 means) at the three sites were generally negative with monthly mean temperatures at St. Andrews and Halifax reaching above normal only during two and three months of the year, respectively (Fig. 7). At Boothbay Harbor, temperatures were above normal for half of the year and below normal for the other six months. February and March, in particular, were well below normal at all three sites with anomalies in excess of -2°C at both St. Andrews and Halifax. December, on the other hand, was above normal at all sites with anomalies of upwards of 1°C at Boothbay and St. Andrews.

Annual SST mean temperatures for 1993 were 8.5°C (equalling the 1961-90 mean) at Boothbay Harbor, 6.7°C (0.4°C below normal) at St. Andrews, and 7.1°C (0.7°C below normal) at Halifax. Similar to last year, the magnitude of the anomalies decreased southwards. The annual temperatures at all three sites decreased relative to the previous year (Fig. 8). At St. Andrews, SSTs have been generally below the long-term normal since the mid-1980s. The beginning of this period coincides with the reconstruction of the wharf at St. Andrews Biological Station where the measurements are recorded. Drinkwater et al. (1992) noted inconsistencies in the SSTs between the pre- and post-reconstruction periods through comparisons with Prince 5 data. Differences in SSTs were significantly greater after the reconstruction with St. Andrews being lower than Prince 5. They speculated that the negative anomalies in the late 1980s and early 1990s at St. Andrews may, in part, be due changes in the flow characteristics in and around the wharf resulting from the reconstruction rather than reflecting a true decrease in surface temperatures in the region. However, other data (see below) corroborate the decline in sea temperatures in the region but caution must be exercised in interpretating both the timing and magnitude of the recent decrease based on the St. Andrews data alone.

Offshore SST Data

Sea-surface temperatures from the "marine deck" observations (obtained primarily from ships-of-opportunity" through the ship's intake and research vessels) were supplied by the U.S. Marine Fisheries Service. SST anomalies relative to 1972-90 means were determined for 24 areas in the northwest Atlantic (Fig. 9A). The monthly anomalies for 1993 from the 4 areas covering the Scotian Shelf and the 4 covering the Gulf of Maine were averaged and plotted in Fig. 9B. They show that on the Scotian Shelf, SSTs were above normal through most of the year except in July when relatively cold temperatures were observed. The highest values were in December. In the Gulf of Maine the warmest month was also in December but the coldest was in June. The annual anomalies on the Scotian Shelf dipped to a minima in the mid-1970s, rose through to a maximum in the early 1980s, fell sharply in the mid-1980s and in recent years have been near the long-term mean although slightly above normal (Fig. 10). The SSTs in the Gulf of Maine are generally of lower amplitude. They show some of the same features as observed on the Scotian Shelf but with much higher temperatures in 1976 and in the late 1980s and early 1990s.

Prince 5

Temperature and salinity measurements are taken once per month at Prince 5, a station off St. Andrews, New Brunswick, near the entrance to the Bay of Fundy. Monthly anomalies relative to the 1961-90 means were calculated for 1993. Single measurements per month, especially in the surface layers in the spring or summer, under stratified conditions are not necessarily representative of the "average" conditions for the month and therefore the interpretation of the anomalies must be viewed with some caution. No significance should be placed on any individual anomaly but persistent anomaly features are likely to be real. There is generally strong similarity in the anomaly patterns of both temperature and salinity in all years throughout the water column. This relative homogeneity of the water column is due in large part to the strong tidal mixing in the Bay of Fundy.

In 1993, temperatures ranged from a minimum of less than 2°C in February and March to a maximum of over 10°C in September (Fig. 11). The temperature anomalies throughout the year were mostly negative, although in December positive anomalies of over 1°C were observed. Anomalies exceeded -1°C in March and in the lower half of the water column from May to August. The maximum negative anomaly was approximately -1.5°C in the waters just above the bottom in August. The long-term annual temperature records at surface and 90 m for Prince 5 show high similarity (Fig. 12). The annual anomalies in 1993 were -0.5°C and -0.6°C at the surface and bottom (90 m), respectively. These are slightly warmer than last year's means, by 0.2°C and 0.1°C, respectively. The extremes at both depths were maxima in the early 1950s and minima in the mid 1960s, with recent values below the long-term mean (Fig. 12). There has been a gradual temperature decrease since the late 1970s at 90 m and since the mid-1980s at the surface.

Salinities at Prince 5 during 1993 were fresher-than-normal (Fig. 11). The lowest salinities (<30.5 psu) occurred during April resulting in salinity anomalies of -0.8 psu in the surface waters. These low salinities in spring also penetrated throughout the water column.

Emerald Basin Temperatures

Petrie and Drinkwater (1993) assembled a time series of monthly temperature data from 1946 to 1988 at multiple depths in Emerald Basin in the center of the Scotian Shelf. They observed similar long-period temperature variability at all depths. The signal was most visible at depth (below 75 m) where the amplitude of the signal was higher and there was less high-frequency "noise". Similar temperature trends were found from the mid-Atlantic Bight to the Laurentian Channel, although year-to-year differences between regions were observed. This data set has been updated and expressed as anomalies relative to 1961-90.

In 1993 the deep temperature anomalies (250 m) in Emerald Basin were 1°-2°C above normal (Fig. 13). The long-term annual average is 8.5°C and the monthly means range from 7.9°C to 9.4°C. These anomalies were typically representative of conditions below approximately 150 m (Fig. 14). The warm temperatures are believed to be due to an intrusion of warm slope water late in 1991 or early in 1992. In the upper layers (0-30 m), temperatures oscillated between above and below normal throughout the year but at 50-75 m, temperature anomalies were predominantly negative (Fig. 14).

Other Scotian Shelf Temperatures

Drinkwater and Trites (1987) tabulated monthly mean conditions for irregularly shaped areas on the Scotian Shelf that generally corresponded to topographic features (Fig. 15). From data collected in 1993, we have produced monthly mean conditions at standard depths (averaging any data within the month anywhere within these areas) and compared them to the long-term (1969-90) averages. Unfortunately, data are not available for each month at each area and in some areas the monthly means are based on only 1 profile. Thus, care must be taken in interpreting these data and little weight given to any individual mean.

a. Lurcher Shoals

Monthly mean temperature profiles for Lurcher Shoals (area 24, Fig. 15) show that from January to November of 1993 temperatures were below normal (Fig. 16A). In December, however, a strong positive anomaly of upwards of 3°C was observed. This must be viewed with some caution because it is based upon only one observation. It also was taken at the edge of the shoals almost in Roseway Channel. However, comparison with Prince 5 shows strong similarity indicating the likelihood of a positive anomaly at that time. A time series of monthly mean temperature data at 50 m shows that in recent years cold conditions have prevailed (Fig. 16B). The long-term trend has been dominated by warm periods in the 1950s and mid-1970s to mid-1980s and cool periods in the 1960s and since the mid-1980s. These conditions are generally representative of the average conditions throughout the water column.

b. Roseway Channel

Roseway Channel separates Lurcher Shoals from Browns Bank and connects Roseway Basin with the Gulf of Maine (area 23; Fig. 15). The 1993 monthly mean profiles show that during most of the year, the upper layer temperatures were colder-than-normal although in October, warmer conditions were observed down to the maximum depth of 100 m (Fig. 17A). In July, when the deepest profile was obtained, the upper waters were colder-than-normal but the deep waters were warmer-than-normal, consistent with the Emerald Basin deep water temperatures. The time series of monthly mean temperatures at 50 m shows cooler conditions in recent years, similar to Lurcher Shoals but of slightly lower amplitude (Fig. 17B).

c. Middle Bank

Middle Bank lies inshore of Sable Island (area 7, Fig. 15). Data in the first two months of 1993 show that the upper water column was slightly warmer than normal (Fig. 18). However, by March and April these waters had cooled to below normal. May was again slightly above normal but July and August were subtantially below. The deeper waters (100 m and greater) were above normal in each of the three months when they were sampled. Few data are available in recent years at Middle Bank and hence the time series have not been plotted.

d. Misaine Bank

Misaine Bank is located inshore of Banquereau Bank (area 5, Fig. 15). Temperature measurements were only recorded in three months during 1993. In each month the water from 50 m to 100 or 150 m was colder-than-normal. This is the depth range of the CIL (cold intermediate layer). The waters above 50 m were also colder-than-normal in March and July but warmer-than-normal in November. The waters below 200 m which were sampled in July were warmer-than-normal. These data were obtained at the shelf edge on the southern side of the Laurentian Channel. The cold conditions in recent years are seen in Fig. 19B. A similar pattern of warm in the 1950s and 1980s and cold in the 1960s and recent years was also seen at 100 and 150 m but to a much lesser extent at the surface. This may be due to inadequate sampling of the later which is influenced much more by short-term weather systems.

e. Shelf Temperatures in July

Extensive temperature data are available during July, 1993, for all of the Scotian Shelf having been obtained during the annual groundfish survey. The have been averaged for the areas in Fig. 15 and expressed as anomalies relative to the 1961-90 means. The results for 0, 50 and 100 m are plotted in Fig. 20. They show that cold conditions persisted at the surface over the Scotian Shelf except in the vicinity of Roseway Basin in the western region. Warmer-than-normal temperatures were observed off the shelf and on Georges Bank. A warm-core ring at the mouth of Northeast Channel contributed to the very high anomalies in that region. At 50 m cold conditions continued to persist although there is evidence of penetration of the warmer slope waters in the Gully and Northeast Channel. Roseway Basin also shows warm conditions at 50 m. At 100 m the coldest waters are found near shore although the outer banks also show evidence of these cold waters. Elsewhere the influence of the offshore waters caused warm conditions. The warm offshore conditions were also observed in all other months when data were collected.

Cabot Strait Deep Temperatures

Bugden (1991) investigated the long-term temperature variability in the deep waters (200-300 m average) of the Laurentian Channel in the Gulf of St. Lawrence from data collected between the late 1940s to 1988. The variability was dominated by low-frequency (decadal) fluctuations with no discernible seasonal cycle. A phase lag was observed along the major axis of the channel such that events propagated from the mouth towards the St. Lawrence Estuary on time scales of several years. The updated time series based upon ice forecast cruises conducted by the Bedford Institute in November-December show that temperatures declined steadily between 1988 and 1991 to their lowest value since the late 1960s (near 4.5°C and an anomaly of exceeding -0.5°C; Fig. 21). In 1992, however, temperatures rose dramatically to 5.3°C (an anomaly of 0.2°C) and to over 6.0°C (anomaly of 1°C) in 1993. This temperature pattern is similar to that in the deep waters in Emerald Basin and reflects changes in the slope water characteristics near the mouth of the Laurentian Channel (Bugden, 1991; Petrie and Drinkwater, 1993).

Shelf/Slope and Gulf Stream Fronts

The position of the Shelf/Slope and Gulf Stream fronts has been discussed by Drinkwater (1994). He found that the Shelf/Slope front was approximately 60 km closer inshore relative to the long term mean off the Scotian Shelf (Fig. 22A). This differs from recent years when the front was near its long-term mean (Fig. 22B). The Gulf Stream was also generally onshore relative to normal but this is similar to recent years (Fig. 23A). Indeed, the Gulf Stream position has been at or near its maximum onshore position over the duration of the record during the last couple of years (Fig. 23B).

SUMMARY

Annual air temperatures over the Scotia-Fundy region in 1993 were generally below normal, consistent with the rest of eastern Canada. An exception was Sable Island where they were slightly above normal. At Halifax and St. Andrews, sea surface temperatures were generally below normal but offshore they were near normal with a tendency to be slightly warmer than usual. Cold conditions were observed throughout the water column during most of the year at Prince 5 and in the tidally-mixed waters off southwest Nova Scotia. Warm conditions appear to have returned in December. Cold conditions also persisted in the CIL waters (50-100 m) throughout most of the Scotian Shelf. This continues a trend of cool temperatures in this layer that began in the mid-1980s. Temperatures this year, although below normal, are generally warmer than last year. Temperatures in the waters above 50 m varied between above and below normal depending upon the month and location. During July,

the time of the ground fish survey, the temperatures in the upper 50 m was cold throughout most of the Scotian Shelf. These cold conditions were also observed down to 100 m but conditions were warm below this depth. Offshore, temperatures were much warmer than normal in July as well as throughout the year. Penetration of this water onto the Shelf at depth through the gullies and channels was observed. Temperatures in the deep waters of Cabot Strait were also above normal showing a rapid rise for the second consecutive year from the very low values observed in 1991. The shelf/slope and Gulf Stream fronts between Cape Hatteras and the Tail of Bank lay north of their mean positions.

OUTLOOK FOR 1994

In the Gulf of St. Lawrence extreme ice conditions persisted during the first months of 1994 and extensive ice cover has covered the Scotian Shelf reaching as far south as Halifax, much further than normal but comparable to 1993. Given the extremely cold winter in the Gulf of St. Lawrence, on the Scotian Shelf and in the Gulf of Maine, surface ocean temperatures through to spring are expected to be have been colder-than-normal. The relatively warm April suggests the possibility that faster than normal heating of the surface waters may be occuring. The deep basins are expected to remain warm whereas the cold intermediate depth waters are expected to remain cold but may warm slightly due to the presence of relatively warm waters in the basins and offshore.

ACKNOWLEDGEMENTS

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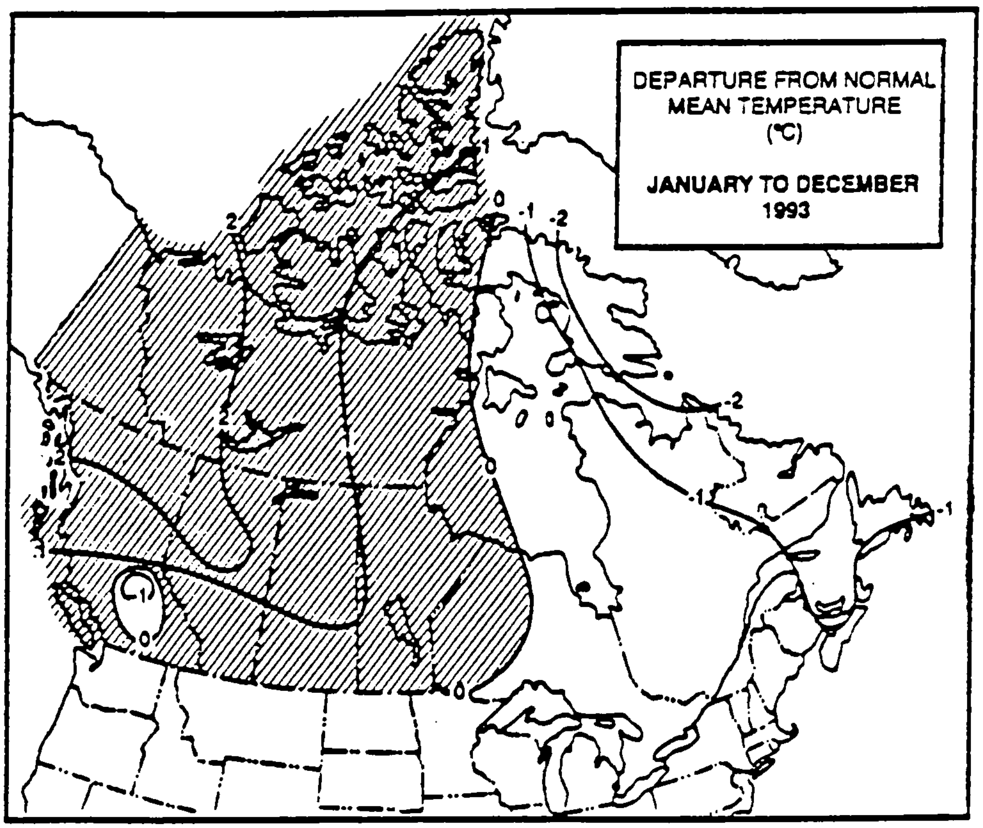


Fig. 1. Annual air temperature anomalies (°C) over Canada in 1993 relative to the 1951-80 means. Shaded areas are positive anomalies. (From *Climatic Perspectives*, Vol. 16)

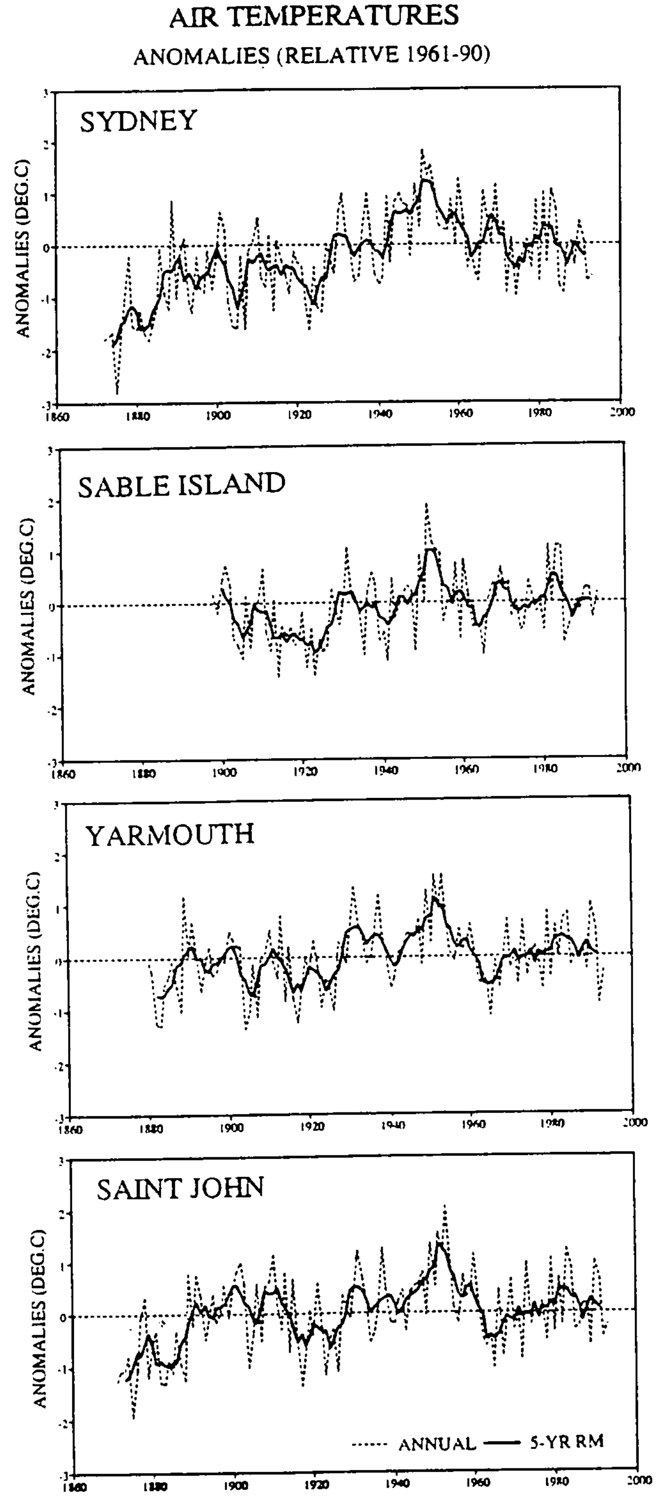


Fig. 2. Annual air temperature anomalies and the 5-yr running means for four sites in the Scotia-Fundy region.

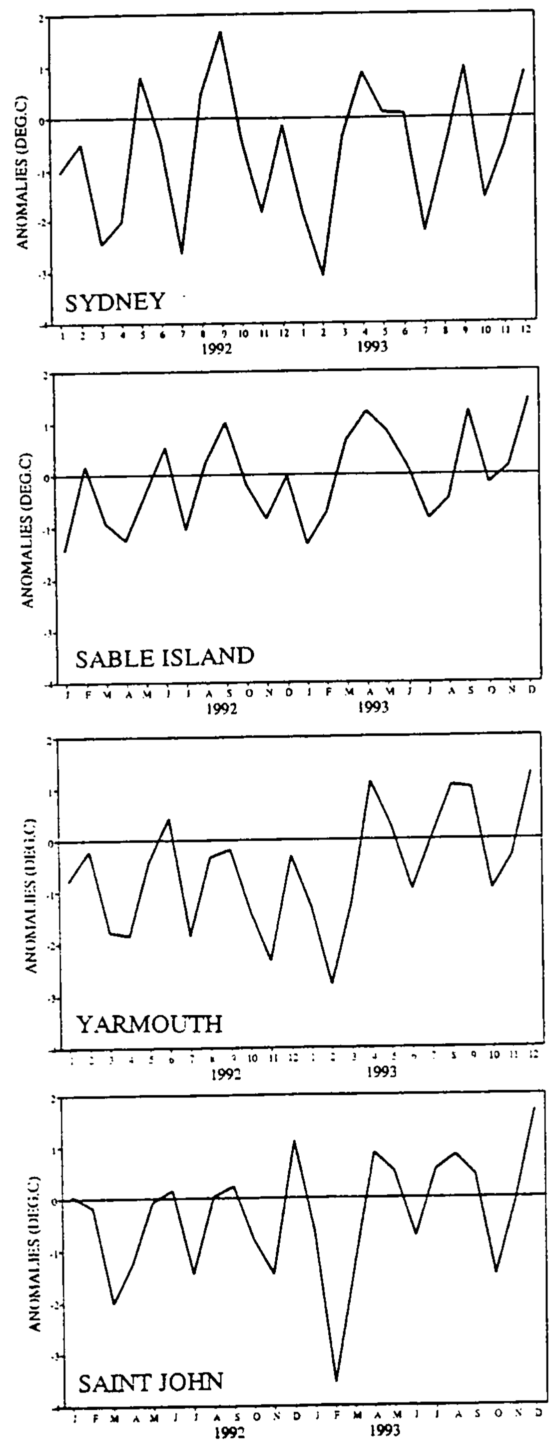


Fig. 3. Monthly means of air temperature anomalies in 1992 and 1993.

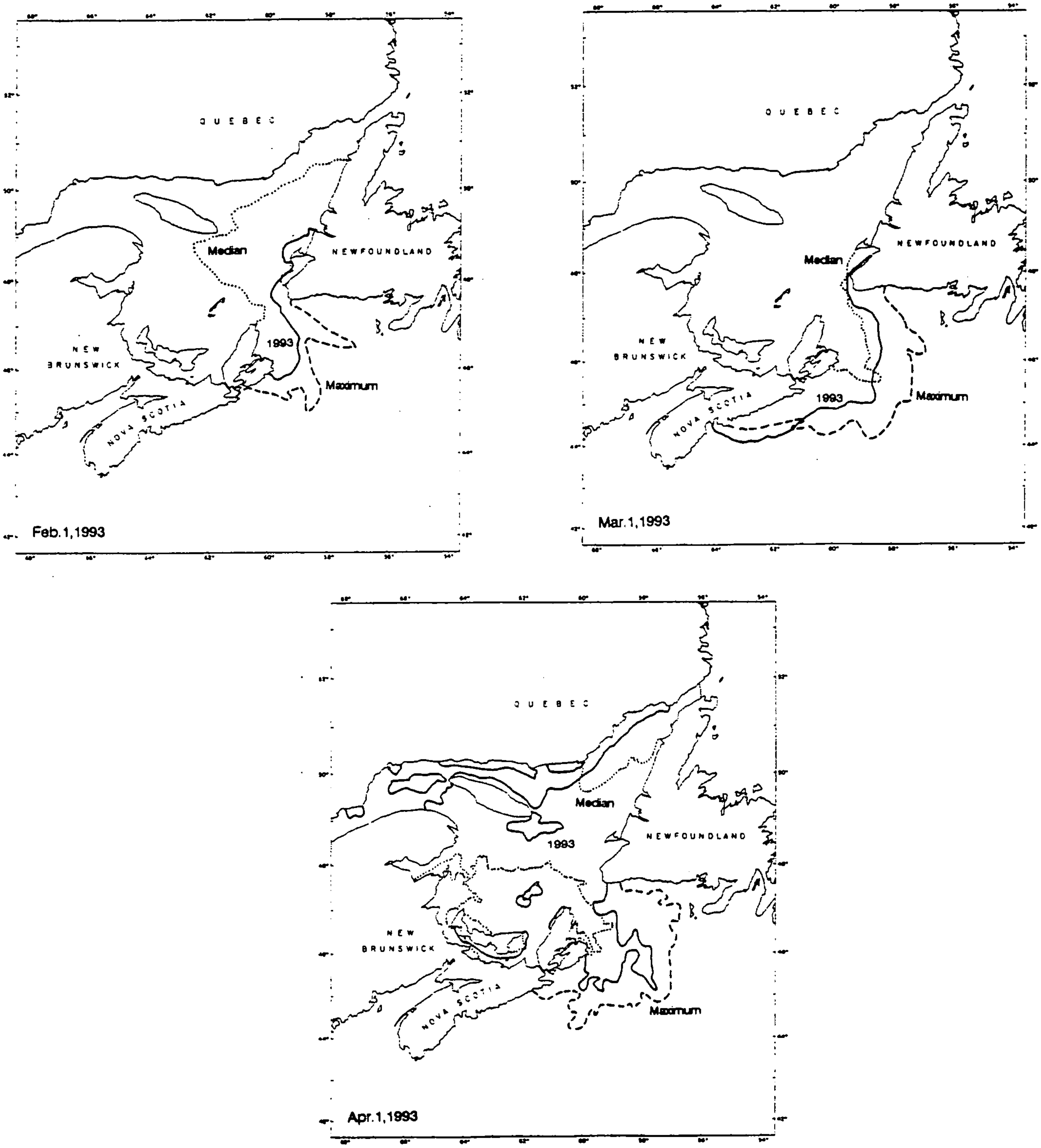


Fig. 4. The location of the ice edge (concentrations >10%) in the Gulf of St. Lawrence and on the Scotian Shelf between February and April, 1993. The historical (1962-1987) median and maximum positions of the ice edge are also shown.

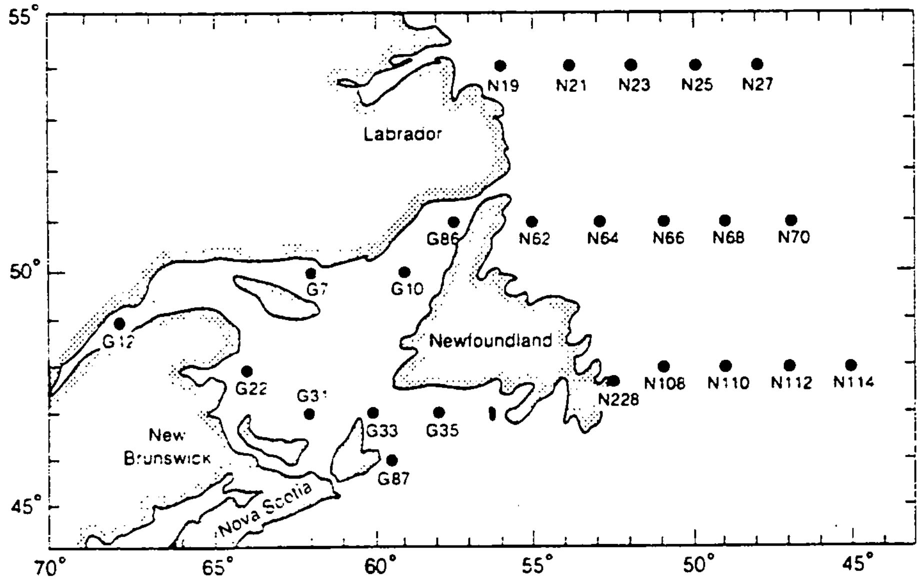


Fig. 5. Location of grid points where statistics on ice duration have been extracted from ice charts by Ice Central in Ottawa.

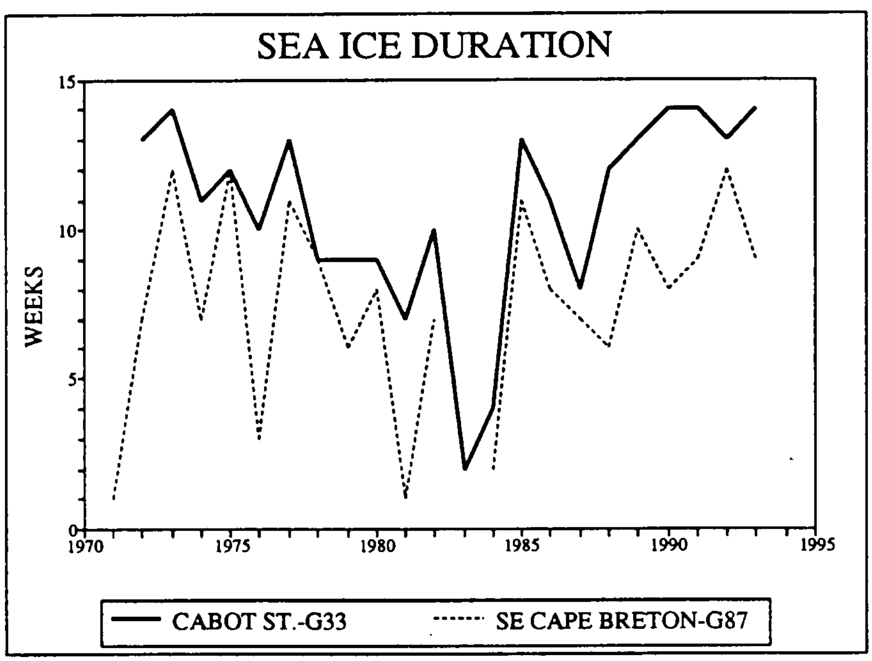


Fig. 6. The time series of sea ice at grid points in Cabot Strait and off southeastern Cape Breton Island.

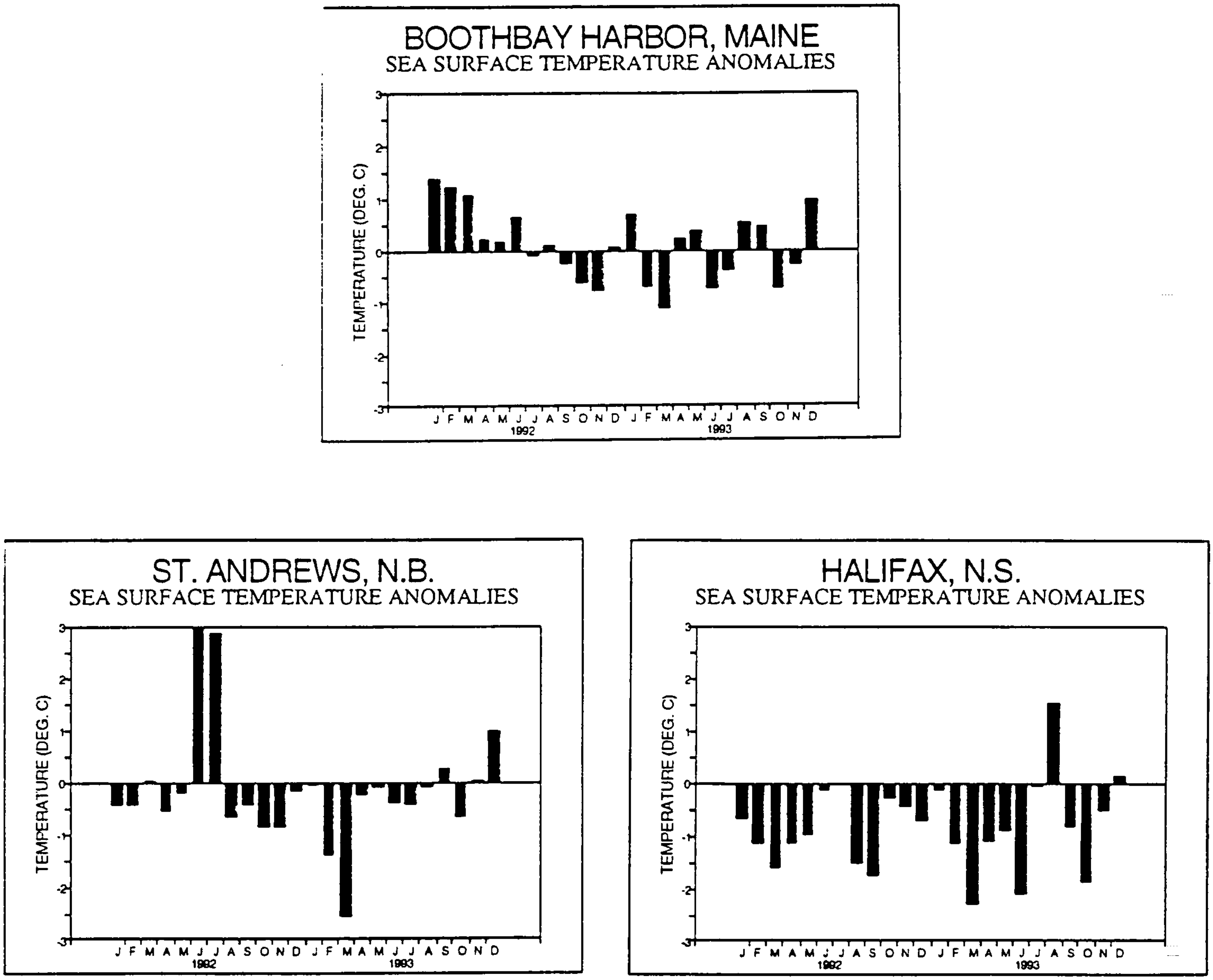


Fig. 7. Monthly sea surface temperature anomalies during 1993 at Boothbay Harbor, St. Andrews and Halifax Harbour.

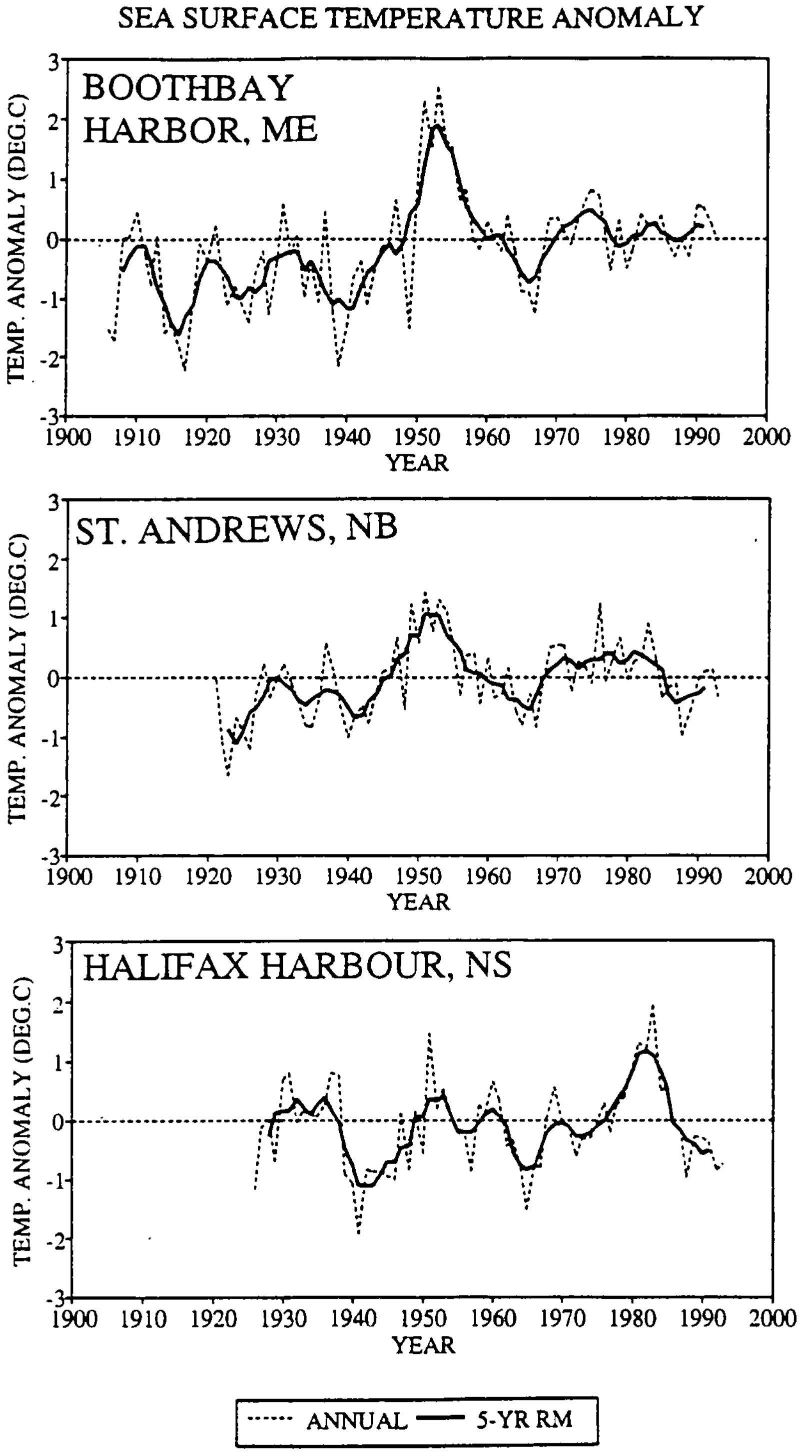


Fig. 8. The annual anomalies of sea surface temperature and their 5-yr running means at coastal sites.

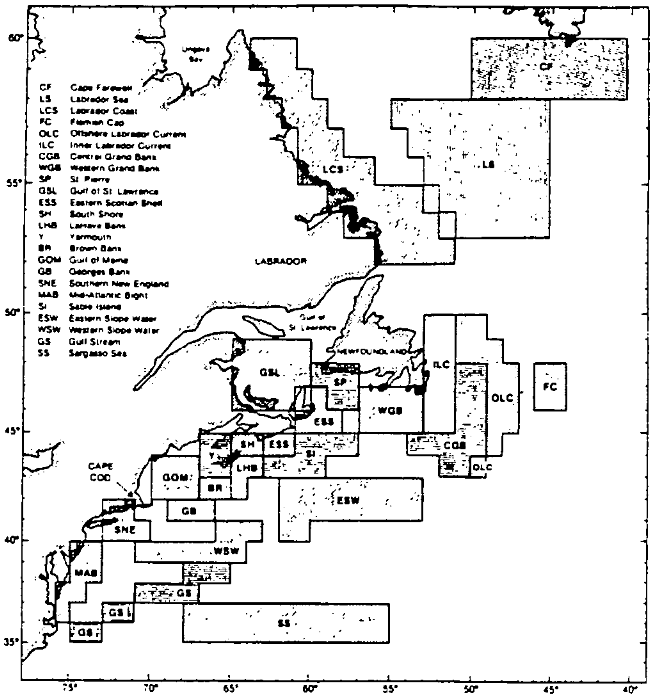


Fig. 9A. The geographic boundaries of the subregions for which SSTs were estimated.

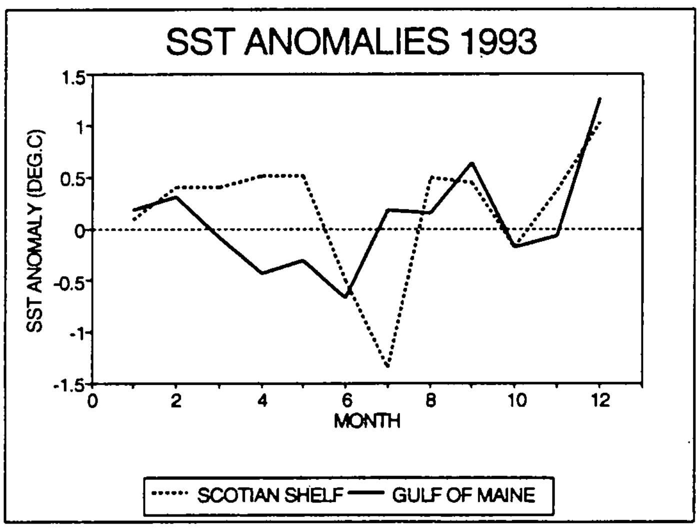
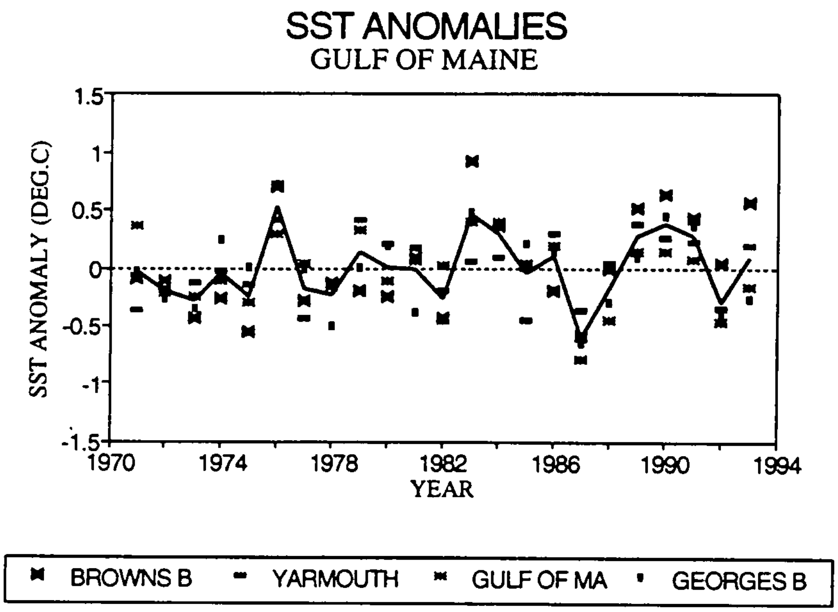


Fig. 9B. The monthly sea surface temperature anomalies for the Gulf of Maine and the Scotian Shelf.



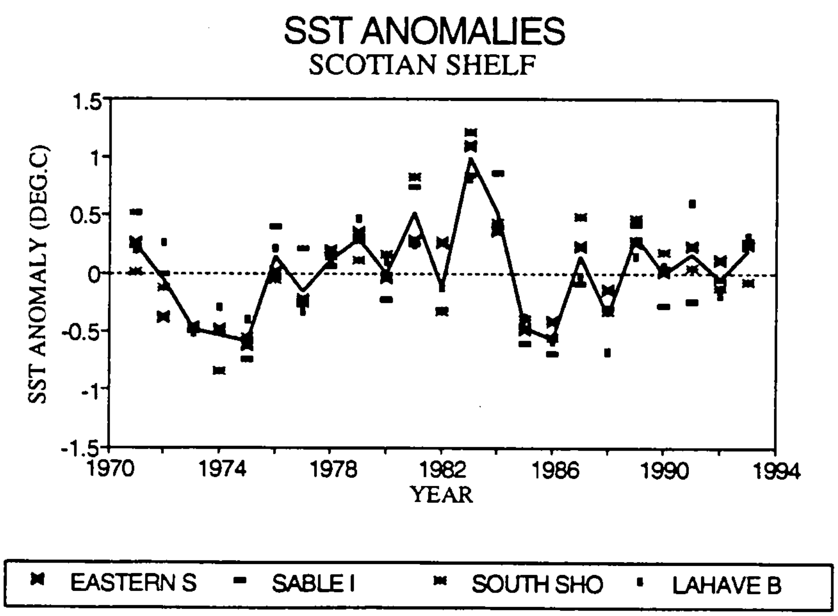


Fig. 10. The annual mean SSTs for the Gulf of Maine (top) and the Scotian Shelf (bottom) together with the means for the four areas from Fig. 10 that cover each region.

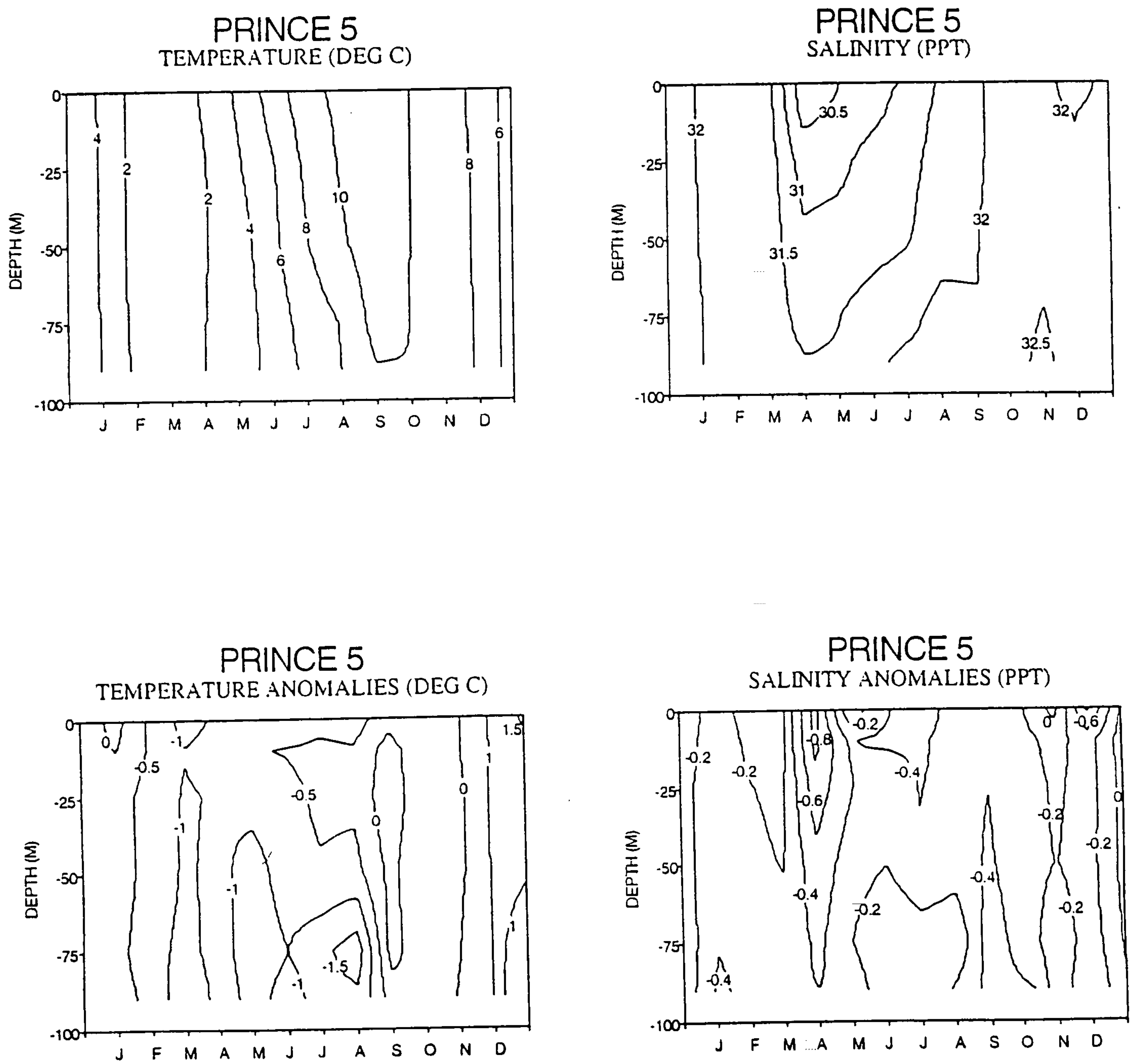
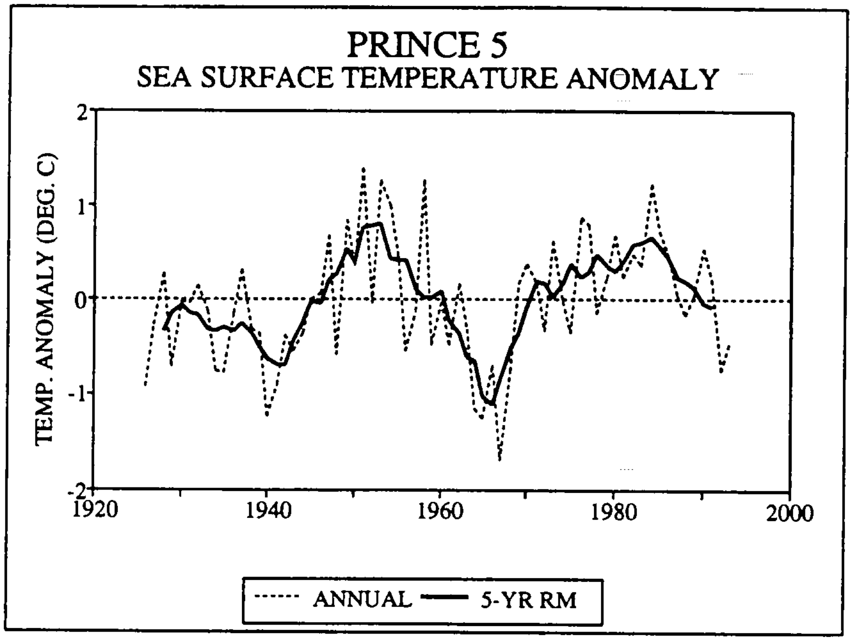


Fig. 11. Monthly temperatures and salinities and their anomalies at Prince 5 as a function of depth during 1993.



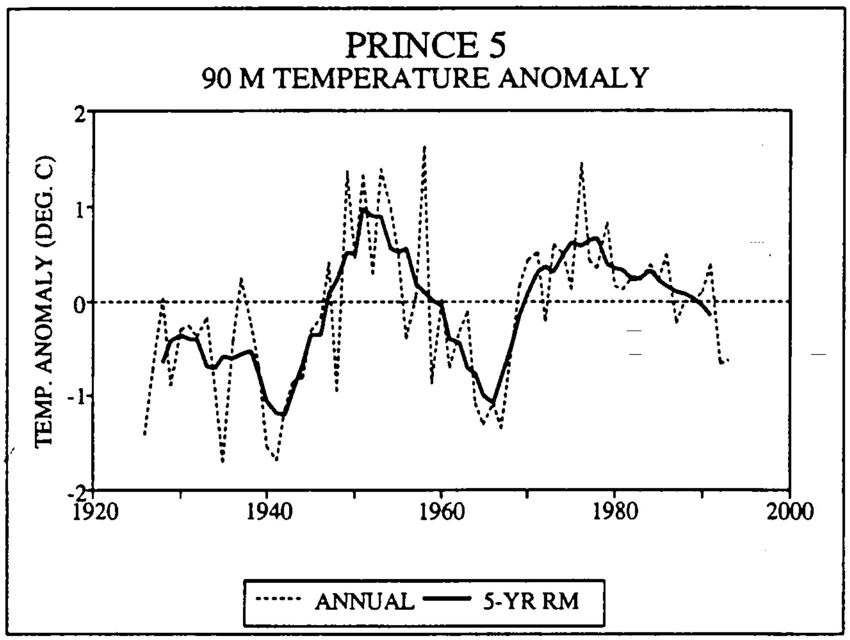


Fig. 12. The annual means and the 5-yr running means of the temperature anomalies at Prince 5, 0 and 90 m.

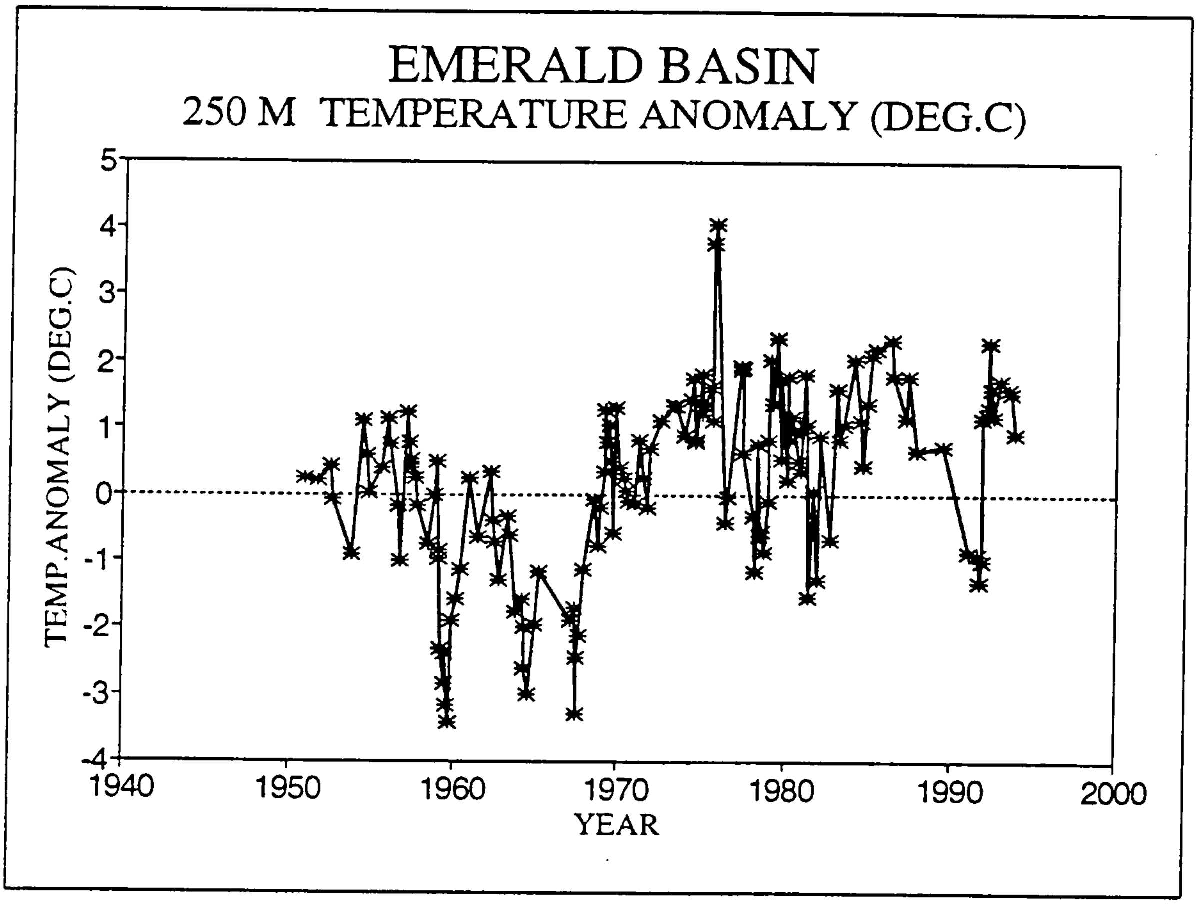


Fig. 13. Temperature anomalies at Emerald Basin at 250 m.

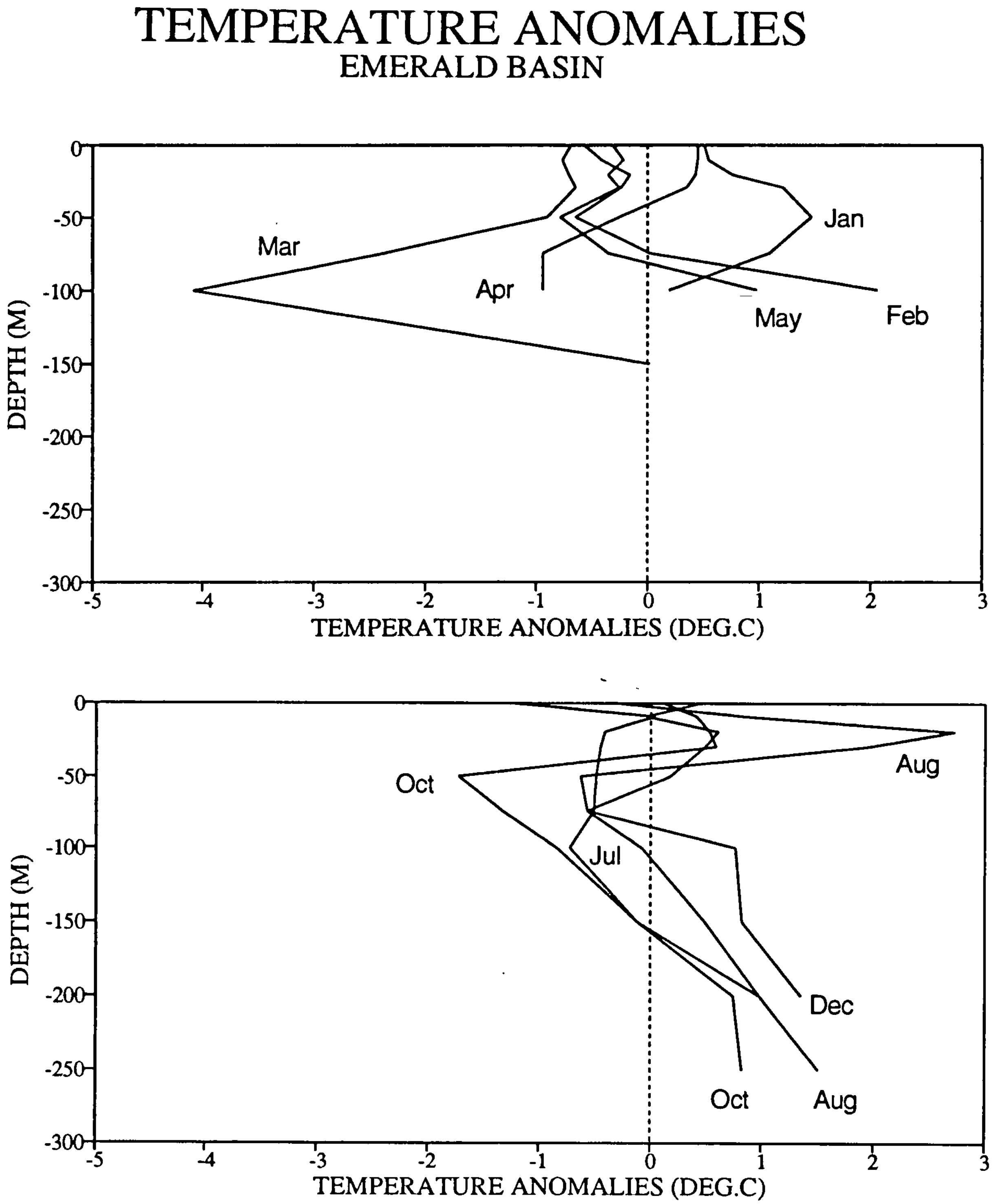
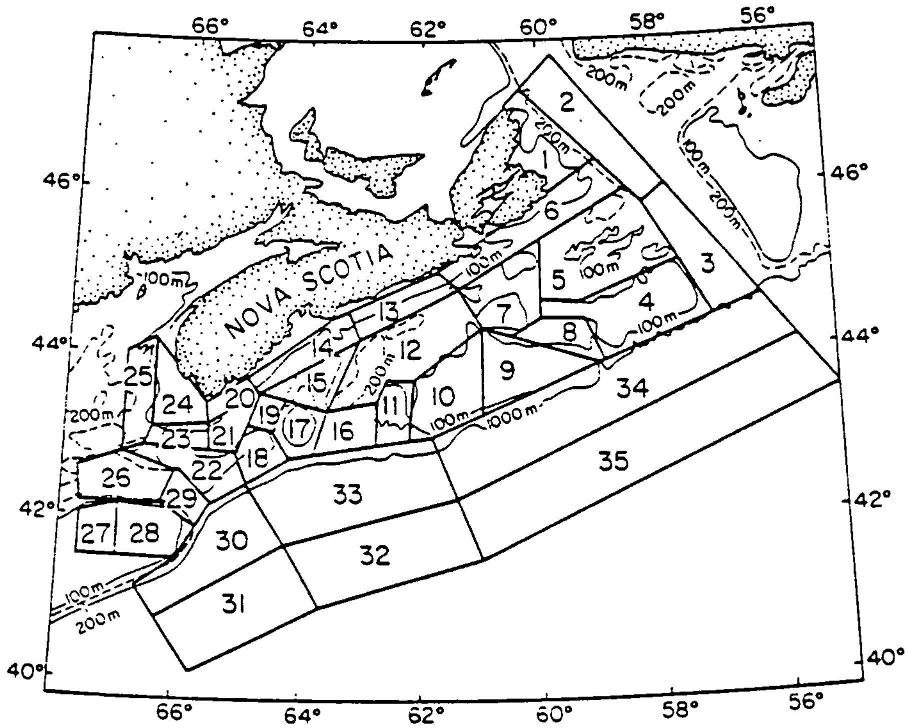


Fig. 14. Monthly temperature anomalies at Emerald Basin during 1993.



1. SYDNEY BIGHT
2. N. LAURENTIAN CHANNEL
3. S. LAURENTIAN CHANNEL
4. BANQUEREAU
5. MISAINE BANK
6. CANSO
7. MIDDLE BANK
8. THE GULLY
9. SABLE ISLAND
10. WESTERN BANK
11. EMERALD BANK
12. EMERALD BASIN
13. EASTERN SHORE
14. SOUTH SHORE
15. LAHAVE BASIN
16. SADDLE
17. LAHAVE BANK
18. BACCARO BANK
19. ROSEWAY BANK
20. SHELBURNE
21. ROSEWAY BASIN
22. BROWNS BANK
23. ROSEWAY CHANNEL
24. LURCHER SHOALS
25. E. GULF OF MAINE
26. GEORGES BASIN
27. GEORGES SHOAL
28. E. GEORGES BANK
29. N.E. CHANNEL
30. SOUTHERN SLOPE
31. SOUTHERN OFFSHORE
32. CENTRAL OFFSHORE
33. CENTRAL SLOPE
34. NORTHERN SLOPE
35. NORTHERN OFFSHORE

Fig. 15. The areas in which temperature and salinity monthly means were estimated by Drinkwater and Trites (1987).

TEMPERATURE ANOMALIES
LURCHER SHOALS

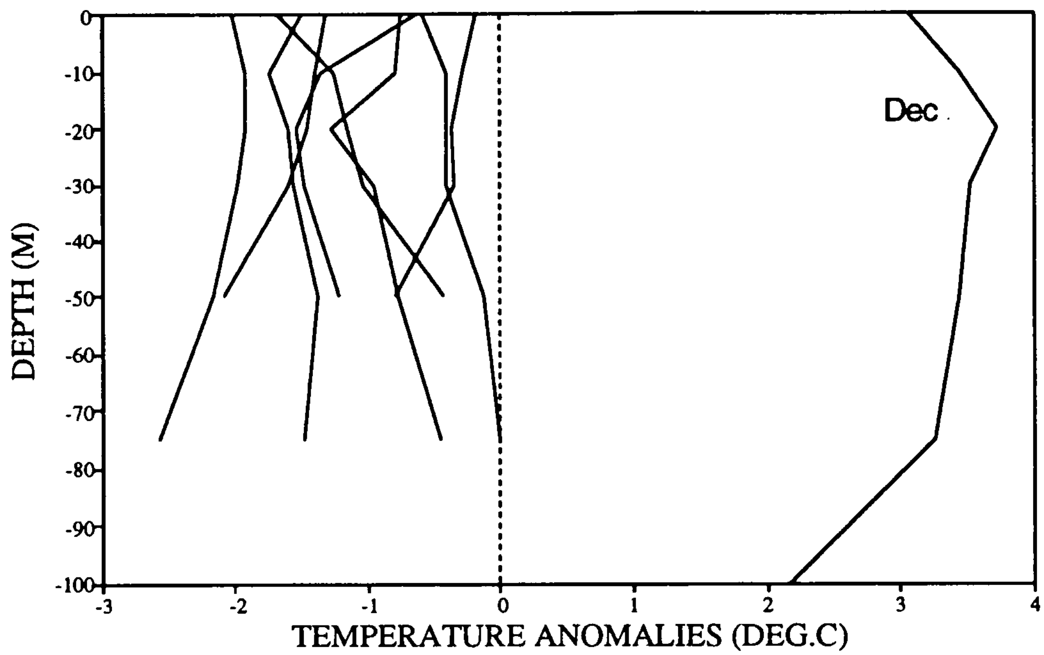


Fig. 16A. The 1993 monthly temperature anomaly profiles for Lurcher Shoals (area 24 in Fig. 15).

Lurcher Shoals at 50m.
Anomalies relative to 1961-90 means

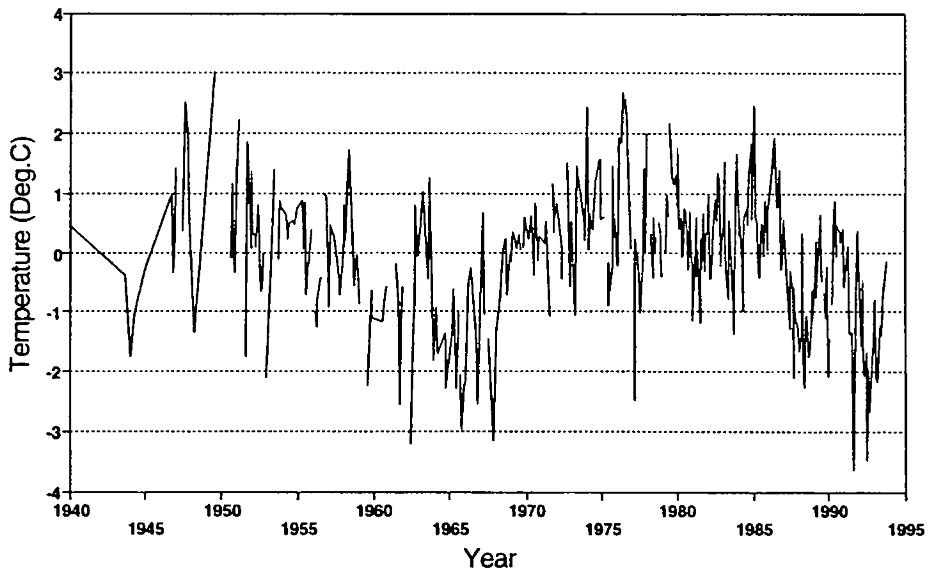


Fig. 16B. The time series of the temperature anomalies at Lurcher Shoals.

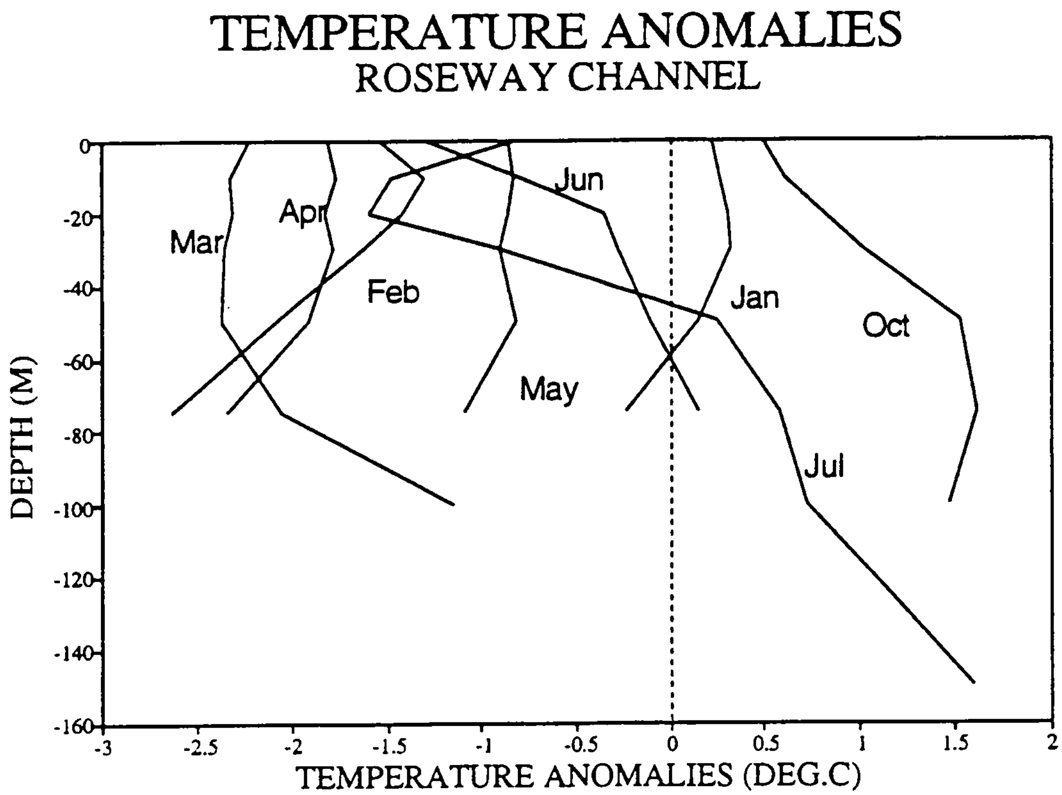


Fig. 17A. The 1993 monthly temperature anomaly profiles for Roseway Channel (area 23 in Fig. 15)

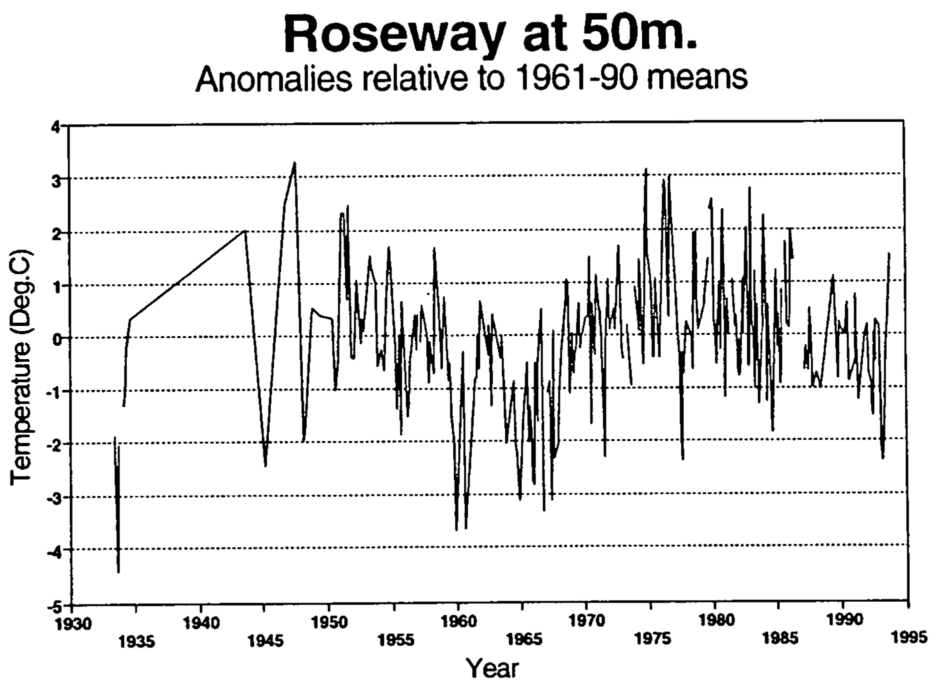


Fig. 17B. The time series of the temperature anomalies at Roseway Channel.

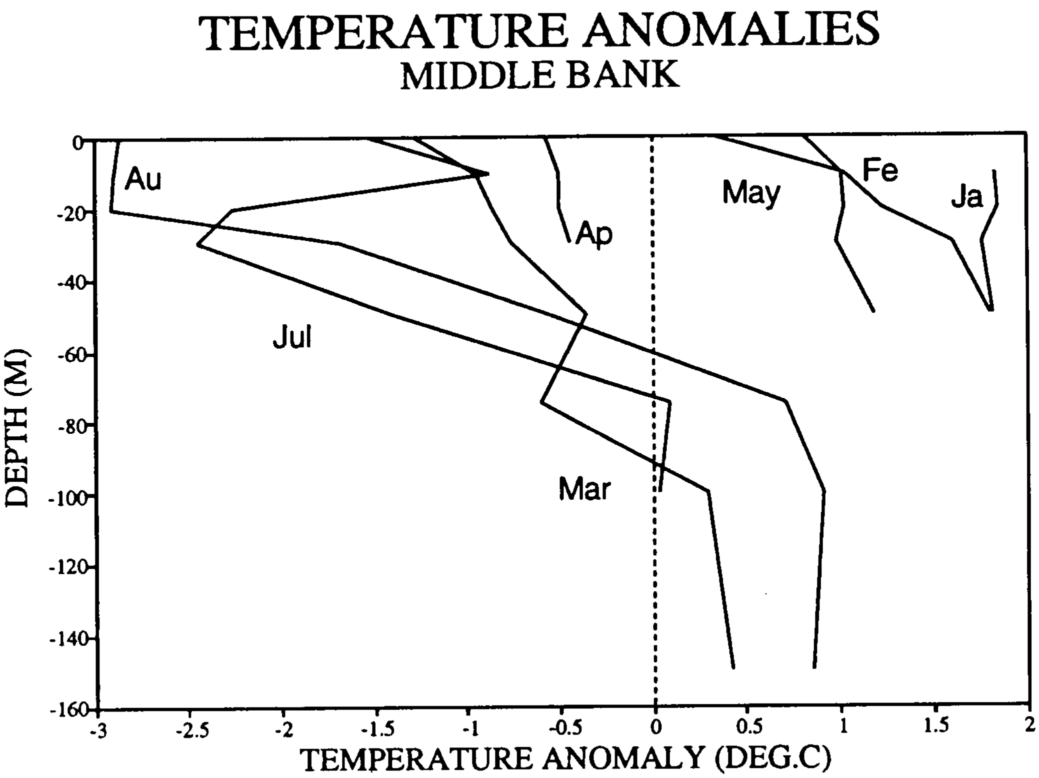


Fig. 18 . The 1993 monthly temperature anomaly profiles for Middle Bank (area 7 in Fig. 15)

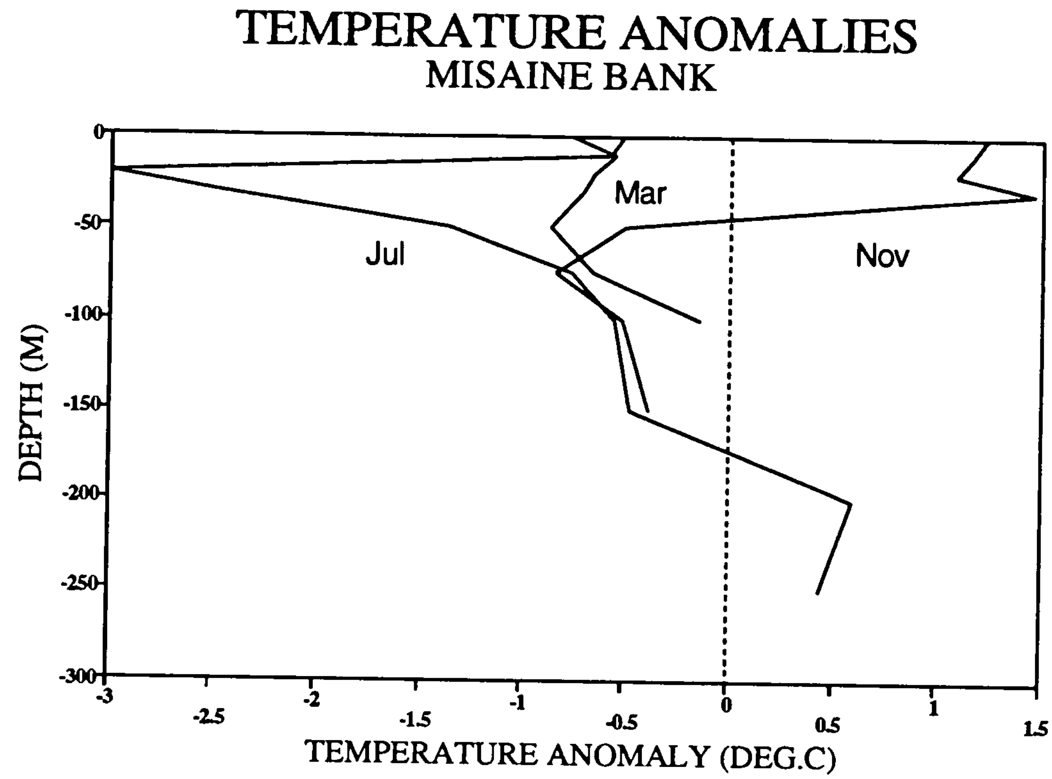


Fig. 19A. The 1993 monthly temperature anomaly profiles for Misaine Bank (area 5 in Fig. 15).

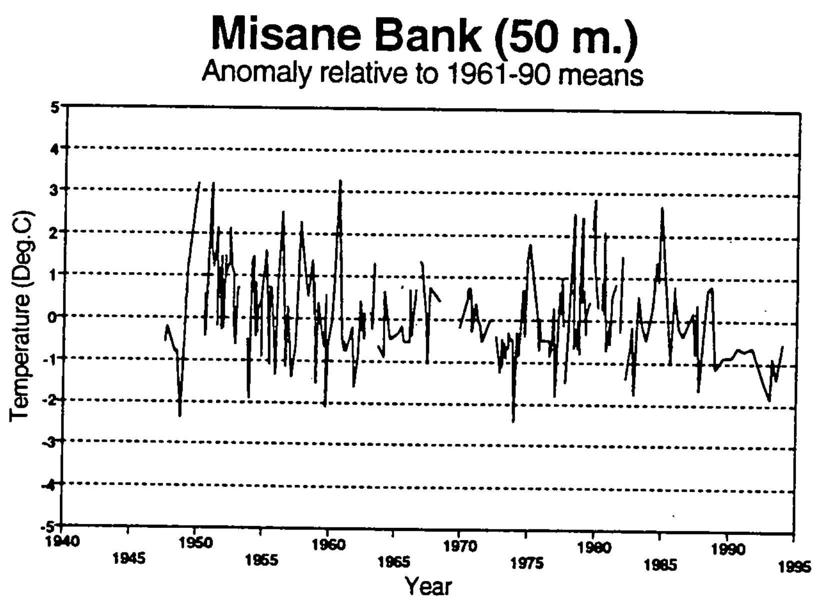


Fig. 19B. The time series of the temperature anomalies at Misaine Bank.

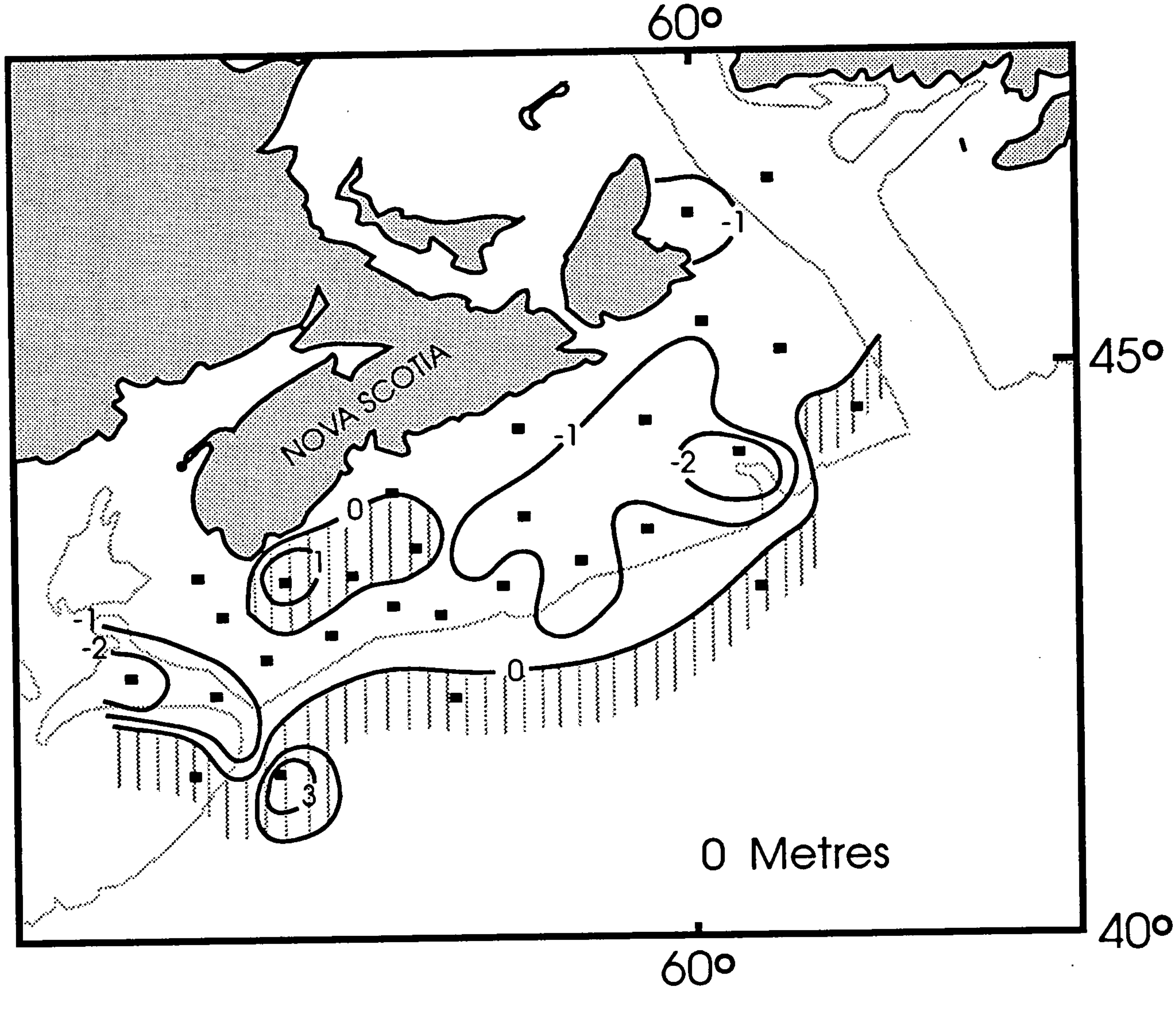


Fig. 20A. The temperature anomalies during July at 0 m averaged over the areas in Fig. 15. The center of the areas are denoted by the small solid squares. Areas with positive anomalies are shaded. Note the eddy off Northeast Channel.

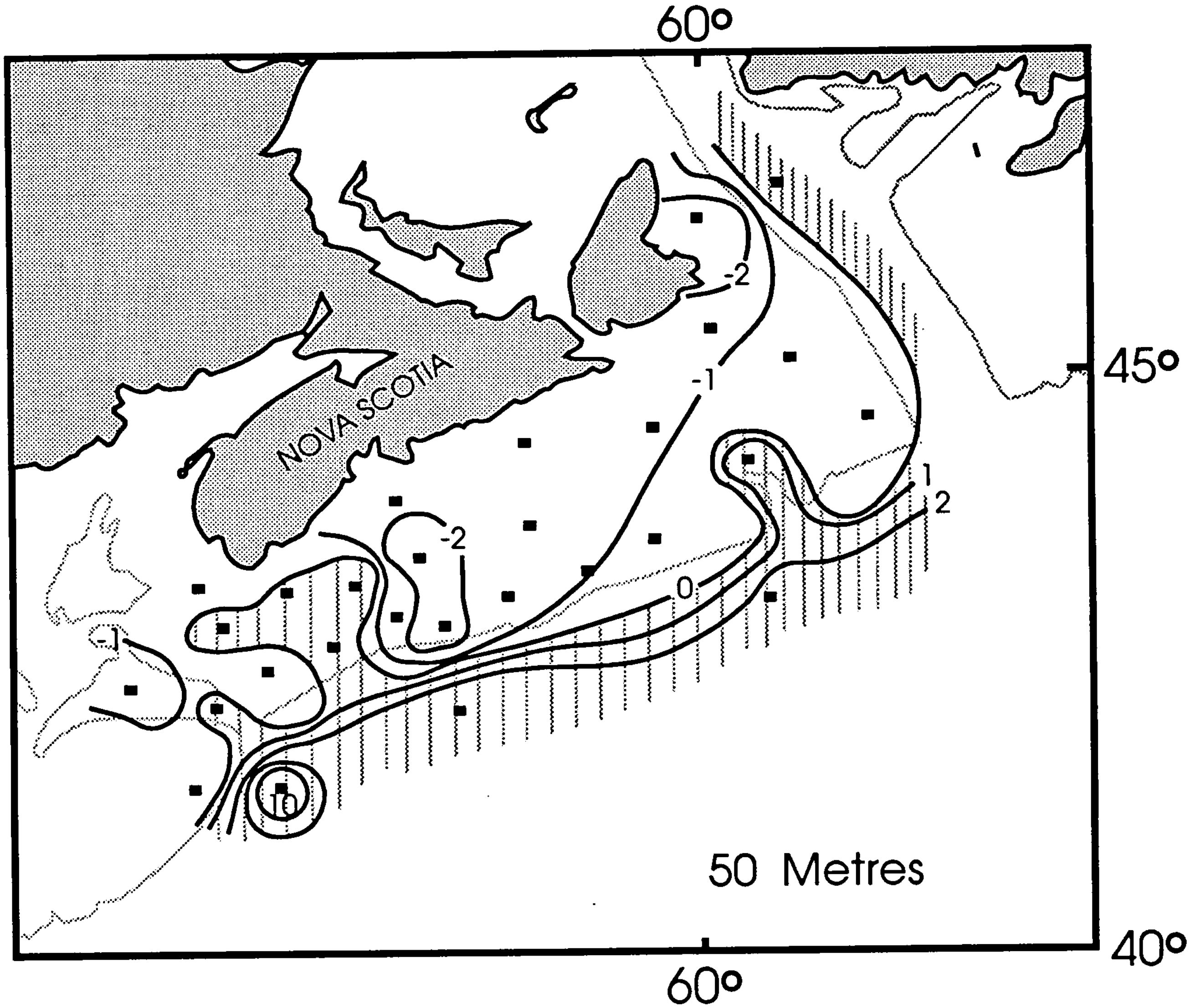


Fig. 20B. The temperature anomalies during July at 50 m averaged over the areas in Fig. 15. The center of the areas are denoted by the small solid squares. Areas with positive anomalies are shaded.

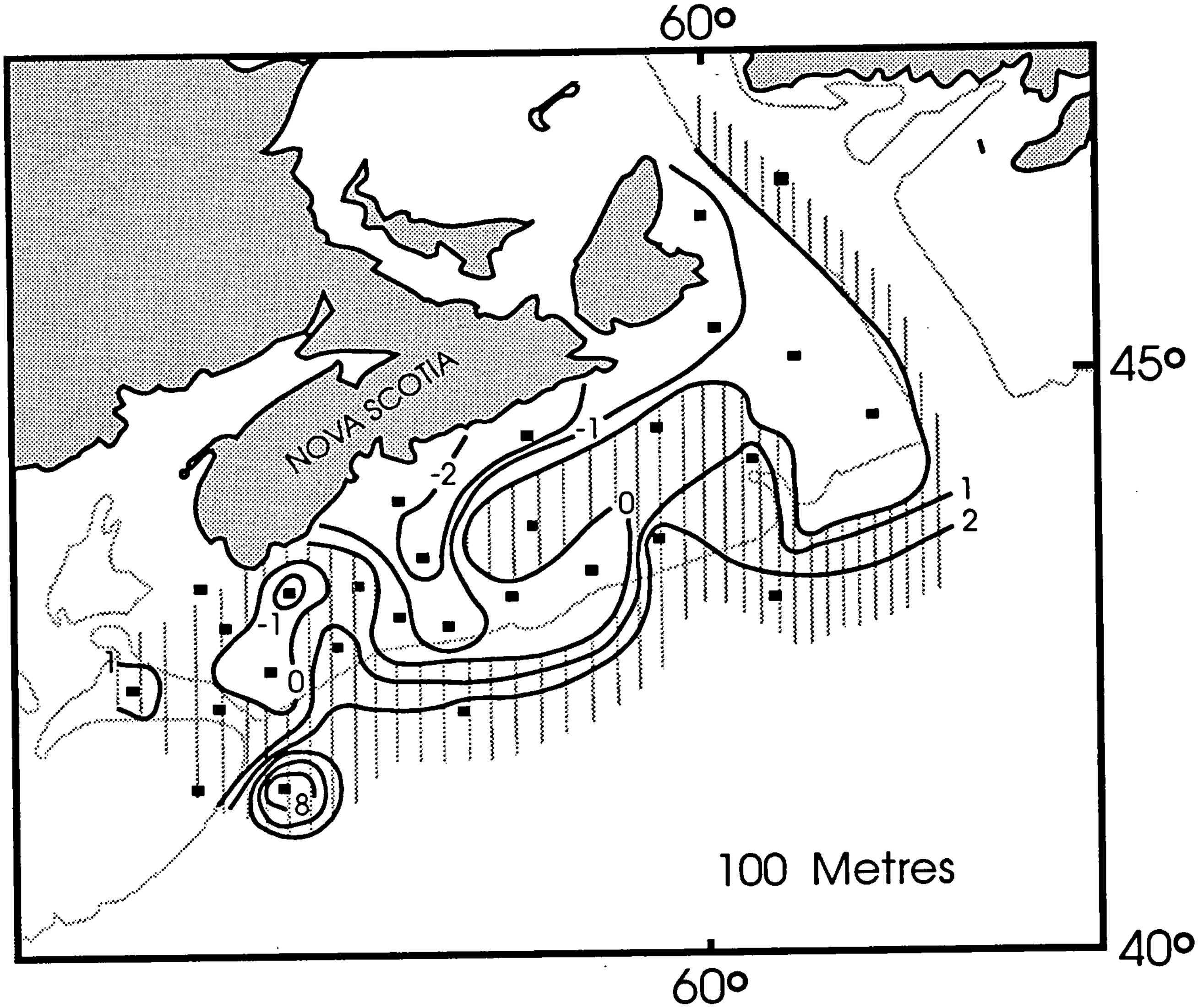


Fig. 20C. The temperature anomalies during July at 100 m averaged over the areas in Fig. 15. The center of the areas are denoted by the small solid squares. Areas with positive anomalies are shaded.

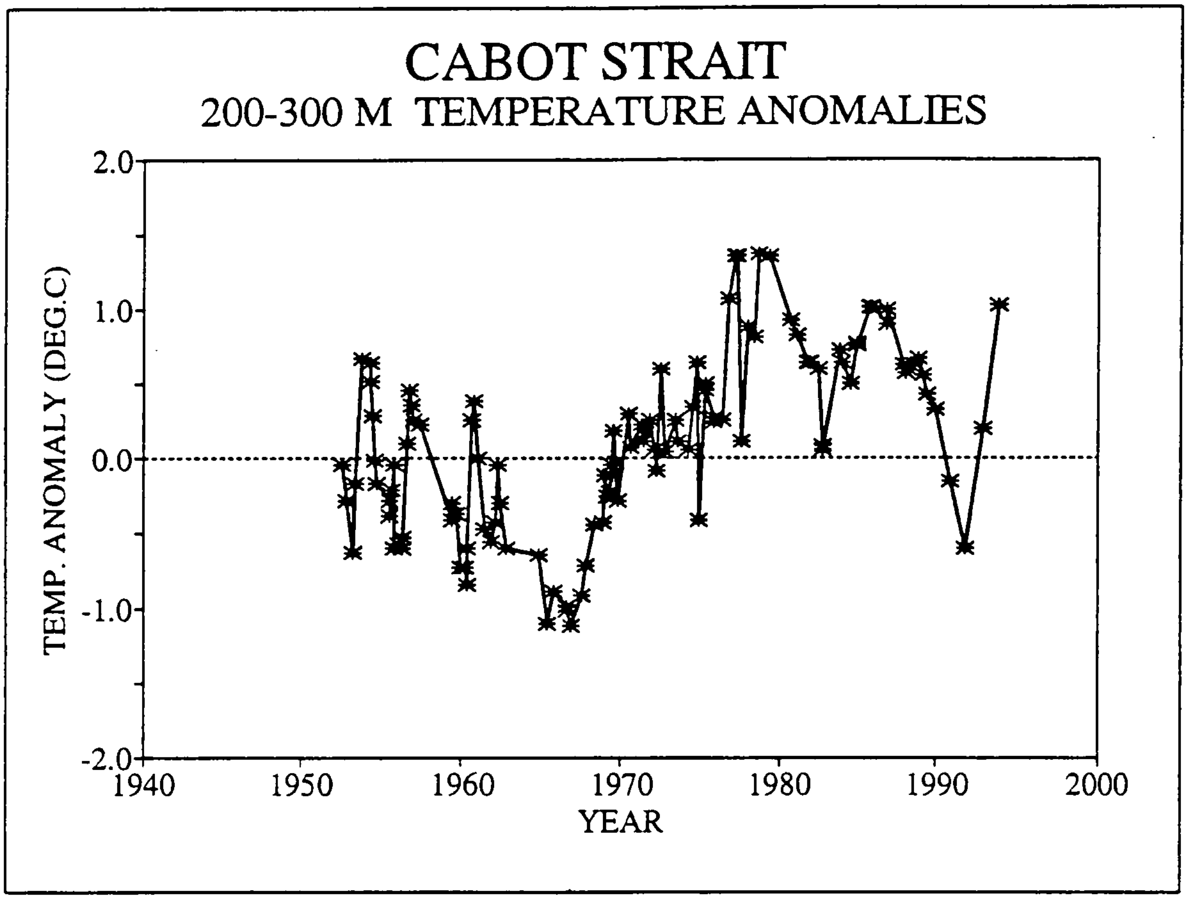


Fig. 21. Temperature anomalies for 200-300 m average in Cabot Strait.

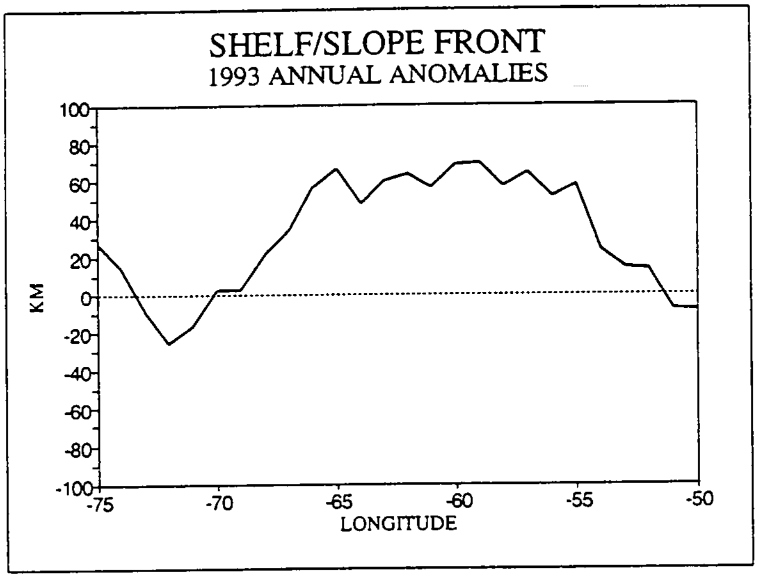


Fig. 22A. The 1993 anomalies of the shelf/slope frontal position as a function of longitude relative to its long-term mean.

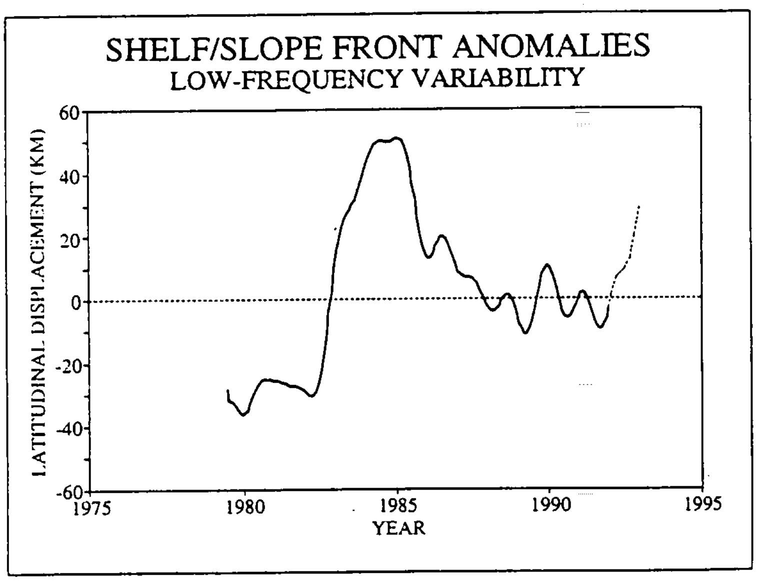


Fig. 22B. The low-pass filtered time series of the anomaly of the averaged (50°-75°W) position of the Shelf/Slope front. The dashed line indicates the new data using the 1993 data.

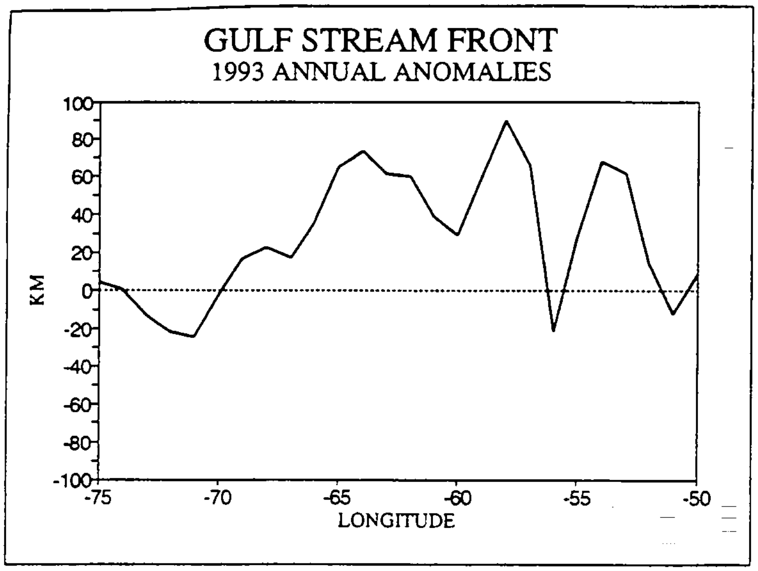


Fig. 23A. The 1993 anomalies of the Gulf Stream frontal position relative to its long-term mean.

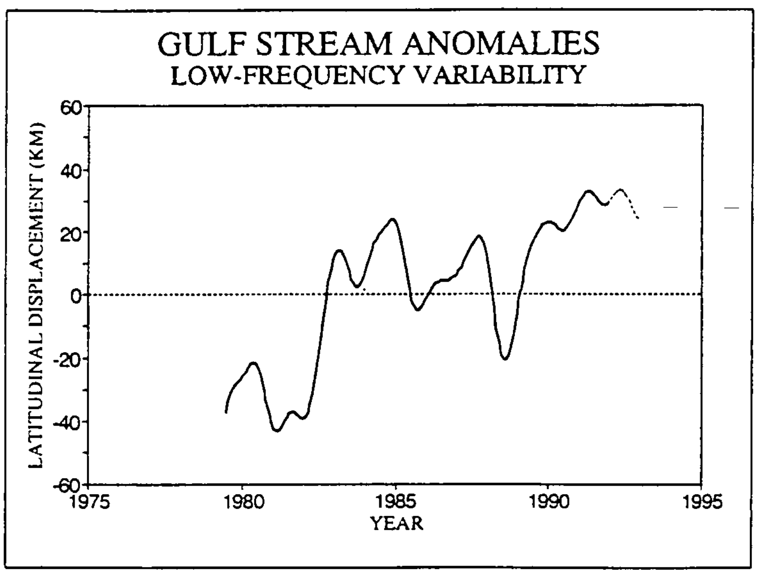


Fig. 23B. The low-pass filtered time series of the anomaly of the averaged (50°-75°W) position of the Gulf Stream front. The dashed line indicates the new data using the 1993 data.