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Environmental Conditions in Atlantic Canada, Spring 1994, with Comparisons to the Long-term Average

by

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1. INTRODUCTION

This report presents an overview of environmental conditions in Atlantic Canada during the spring of 1994, with a comparison to the average conditions based on all available historical data. The information is based mainly on data collected during an oceanographic survey in early May of 1994 funded by the Northern Cod Science Program (NCSP) aboard the CSS Hudson. The report also presents meterological and ice cover data for Atlantic Canada during the winter, and early spring of 1994.

During this survey oceanographic measurements were made along transects running from the inshore areas of the Avalon Peninsula and offshore to the shelf edge across the Grand Bank. Measurements along the transects included vertical profiles of currents, temperature, salinity, chlorophyll and dissolved oxygen. In addition, water and plankton samples were collected at each station for salinity, chlorophyll, oxygen and biological analysis. Data from other fisheries research cruises as well as all historical data in the area are also included in the analysis.

2. METEOROLOGICAL CONDITIONS

During the winter of 1993-1994 (Dec. to Feb.) a ridge of high pressure extending from California to Alaska resulted in generally above normal temperatures across the west coast of Canada. A deep trough of low pressure extending from Baffin Island to southern Ontario combined with the ridge of high pressure to the west produced a strong northwesterly wind pattern resulting in colder than normal air temperatures over central and eastern regions of the country (Saulesleja, 1994).

The monthly air temperature anomalies over Canada from January to April of 1994 are shown in Fig. 1, the shaded areas indicate a positive anomaly. This data is published by the Atmospheric Environment Service of Canada in the Monthly Supplement to Climate Perspectives (Saulesleja, 1994). The anomalies are referenced to a 30 year (1951-1980) mean.

In January air temperature anomalies ranged from -2.0 °C below normal over Newfoundland and to -4.0 °C below normal over Labrador and intensified to between -4.0 to -6.0 °C by February and warmed to 0.0 to -2.0 °C by March of 1994. By April of 1994 the air temperatures had moderated to between 0.0 and 2.0 °C above normal by mid month over Newfoundland and Labrador but returned to below normal

conditions by month's end. The most recent negative air temperature anomalies experienced this past winter are a continuation of a cold trend than began during the late 1980s (Findlay and Deptuch-Stapf, 1991). In contrast to the colder than normal conditions in Atlantic Canada in the past several years western and most of central Canada have experienced above normal air temperatures, indicated by the shaded areas in Fig. 1.

3. ICE CONDITIONS

The maximum extent of the ice edge (defined by one-tenth total coverage) during mid-February to mid-May of 1994 together with the median and maximum positions of the ice edge for the period 1962 to 1987 along the coast of Newfoundland are shown in Fig. 2. The mid-monthly positions of the ice edge for 1994 were digitized from the daily ice charts published by Ice Central of Environment Canada in Ottawa, the median and maximum positions of the ice edge were published by Cote (1989).

The large upper layer negative water temperature anomalies along the east coast of Newfoundland reported for the fall of 1993 (Colbourne, 1994) together with the large negative air temperature anomalies experienced during the winter of 1994 had favoured extensive local ice growth along the Newfoundland and Labrador coast during the winter months. This together with the prevailing winter northwesterly winds had resulted in near record ice coverage by mid-February of 1994, reaching south of 46° N latitude (Fig. 2). By mid March the ice edge had receded to normal conditions along the east coast of Newfoundland but remained above normal in the offshore areas. By mid-April the ice edge had receded to about 50° N latitude in the inshore regions and to about 48° N in the offshore areas, near normal coverage inshore. By mid-May the ice edge continued to lie south of 50 °N about 200 km south of the median position.

In general, ice conditions along the east coast during the winter and early spring of 1994 were above normal (in terms of total ice coverage), but not as severe as in 1993, particularly in the inshore areas during April and May.

4. STATION 27 TEMPERATURE AND SALINITY TIME SERIES

Depth versus time contour maps of the temperature field and temperature anomalies based on all XBT and CTD profile data collected at station 27 during the winter months and up to May 10, 1994, a total of 23 profiles, are plotted in Fig. 3. The anomalies were calculated from the mean of all data collected on the station since 1946.

These maps shows the cold isothermal water column during the winter months with temperatures ranging from -1.0 °C to -1.7 °C throughout the time series at depths below 85 meters. The time series (upper panel) shows upper layer (generally the 0 to 50 m depth range) temperatures decreasing from 0.0 °C in early January to -1.7 °C by mid February, which persisted until early April. By the end of April and early May the upper layer temperature had again warmed to above 0.0 °C

Figure 3 (bottom panel) shows negative temperature anomalies ranging from -0.25 to -0.75 °C in January and between -0.25 to -0.5 °C in March and early April in the upper water column. By mid April to early May temperatures had warmed to 0.0 to 0.5 °C above normal in the depth range of 0 to 85 m. Below 85 m depth to the bottom temperature anomalies remained up to 0.25 to 0.5 °C below normal.

The monthly temperature and salinity anomalies at Station 27 from January 1 1970 to May 10 of 1994 at standard depths of 0, 30, 100 and 175 m, again referenced to a 1946 to 1994 mean, are shown in Fig. 4. The high frequency seasonal variations in the anomalies have been filtered out. At the surface and at 30 m depth the negative temperature anomalies that began in late 1990 and reached a peak in mid 1991 have moderated to near normal conditions by the spring of 1994. At the deeper depths of 100 and 175 m strong negative temperature anomalies have persisted since 1983 with a few periods of positive anomalies during the mid to late 1980s.

The time series of salinity anomalies (bottom 4 panels) at the surface and at 30 m depth shows that the large fresher than normal anomaly that began in early 1991 had returned to near normal conditions by the spring of 1994. Salinities in the deeper water (100-175 m) had returned to near normal conditions in early 1993 but returned to fresher conditions by the spring of 1994. Note also the large negative (fresher than normal) salinity anomaly beginning in 1983 and lasting to the end of 1984 particularly in the upper water column. These events are correlated with colder than normal air temperatures, heavy ice conditions and larger than average summer cold-intermediate-layer (CIL) areas on the continental shelf (Drinkwater, 1993, Colbourne et al. 1994).

5. VERTICAL TEMPERATURE, SALINITY AND OXYGEN DISTRIBUTION

5.1 CENTRAL GRAND BANK

The vertical distribution (depth versus horizontal distance from the shore) of the temperature and temperature anomaly field along the Grand Bank portion of the standard Flemish Cap transect for early May, 1994 are presented in Fig. 5. These anomalies are calculated from the mean temperature field from all available data for the transect since the early 1930s between April 20 to May 20. No attempts were made to adjust the mean for possible temporal biasing arising from variations in the number of observations within this time interval.

The temperature in the upper 50 m of the water column ranged from 0.0 to 0.5 °C over the Grand Bank and from -0.5 to -1.0 °C in the core of the Labrador current near the shelf edge. In deeper water (50 m to the bottom) the temperatures ranged from -1.0 to -1.5 °C over the bank and near the coast, to 0.0 to 3.0 °C further offshore near the edge of the continental shelf and beyond. The corresponding temperature anomalies (bottom panel) ranged from -0.25 to -1.0 °C in the upper water column over most of the Grand Bank and the slope area except the near shore region where temperatures were up to 1.0 °C above normal (see also Fig. 3). At mid-depth temperatures were near normal to 0.5 °C above normal near the middle of the bank. The total cross-sectional area of water less than 0.0 °C over the Grand Bank portion of the transect is approximately 38 km^2 compared to an average of 32 km^2 during the April 20 to May 20 time interval.

Salinities generally ranged from 32.5 psu in the surface layer near the coast to 32.75 psu in the depth range of 0 to 80 m over the rest of the bank (Fig. 6, top panel). At the shelf edge from 100 m to the bottom salinites generally ranged from 33.0 to 34.5 psu. The salinity anomalies (Fig. 6, bottom panel) show slightly saltier than normal conditions in the upper water column over portions of the bank and up to 0.3 psu fresher than normal near the shelf edge in water depths from 0 to 300 m.

5.2 NORTHERN GRAND BANK

The vertical distribution of the temperature and temperature anomaly field along a transect starting at Station 27 and across the northern Grand Bank in a northeasterly direction for early May, 1994 are presented in Fig. 7. Again these anomalies are calculated from the mean temperature field from all available data for the transect since the early 1930s between April 20 to May 20.

The temperature in the upper 50 m of the water column ranged from 0.0 to 0.5 °C at the surface near the coast and from -0.5 to -1.0 °C over the Grand Bank from

the surface to the bottom. Further offshore in the slope area of the continental shelf temperatures ranged from -0.5 °C at the surface to 3.0 °C at 350 m depth. The corresponding temperature anomalies (bottom panel) ranged from -0.25 to -1.0 °C over most of the water column on the Northern Grand Bank and near normal in the slope area below 300 m depth. In the inshore region near Station 27 in the upper water column and at mid depths over portions of the bank temperature anomalies ranged from near normal to 0.5 °C above normal (see also Fig. 3). The total cross-sectional area of water less than 0.0 °C over the Northern Grand Bank transect is approximately 56 km^2 compared to an average of 40 km^2 during the April 20 to May 20 time interval.

Salinities generally ranged from 32.5 psu in the surface layer near the coast and from 32.75 to 33.0 psu in the depth range of 0 to 175 m over the rest of the bank (Fig. 8, top panel). At the shelf edge from 200 m to the bottom salinites generally ranged from 33.5 to 34.5 psu. The salinity anomalies (Fig. 8, bottom panel) show slightly saltier than normal conditions in the surface layer near the coast (see also Fig. 4) and normal conditions over the rest of the bank except at the shelf break where salinities were up to 0.2 psu fresher than normal near the bottom.

6. OXYGEN DISTRIBUTION

The Grand Bank oxygen transect data collected in conjunction with the temperature, salinity and chlorophyll data are shown in Fig. 9. These measurements were made with a Beckman type polarographic element dissolved oxygen sensor with factory calibrated end-points at zero and air-saturated water oxygen levels. The sensor was interfaced to a Seabird-9 CTD system. A total of about 200 water samples were collected at standard oceanographic depths for field oxygen calibrations. The oxygen levels of these samples were determined by semi-automated analytical chemistry using a modified Winkler titration technique.

This survey shows dissolved oxygen saturation levels ranged from 95 to 100 % from the surface to about 60 m depth and about 80 to 90 % from 60 m to the bottom. These values are very similar to 1993 values during the same time period with no evidence of oxygen depletion. The high oxygen values observed coincided with very high phytoplankton levels from the annual spring bloom as indicated by the high chlorophyll signal obtained with a fluorometer (not shown).

7. HORIZONTAL TEMPERATURE AND SALINITY FIELD

Figure 10 shows horizontal maps of the average surface and 75 m temperature field in Atlantic Canada for April 20 to May 20 from all available data (left panels) and from the data collected in early May, 1994 (right panels). These contours were derived from unweighted averages (ie. data for the entire time period are assumed synoptic) of all data in a square grid of 0.25 degrees.

The average sea surface temperature for this time period ranged from 0.5 °C over the Northern Grand Bank to 4.0 °C over the southern Grand Bank. The surface temperatures during early May 1994 ranged from -0.5 °C over the Northern Grand Bank to about 3.0 °C over southern areas. In general the surface temperature over most of the surveyed area was about 1.0 °C below the average for this time period.

Similarly Figure 10 shows the horizontal temperature field at 75 m depth (close to the bottom over most of the Grand Bank), about at the cold core of the CIL, during the same time periods. The average temperature at this depth ranged from -1.0 °C over the Northern Grand Bank in the inshore areas to 0.0 °C at the edge of the bank and to about 3.0 °C in southern areas. In early May 1994 temperatures ranged from -1.0 °C in the north to about 2.0 °C in the south again up to 1.0 °C below normal.

Figure 11 shows horizontal maps of the salinity field at 0.0 and 75.0 m depth for the average (left panels) and for early May 1994 (right panels). Surface salinities along the east coast of Newfoundland are slightly saltier in the inshore regions as

indicated by the 32.5 psu contour and slightly fresher in the offshore areas of the Grand Bank (see also Fig. 6). At 75 m salinities are again fresher in the offshore regions and near normal inshore.

8. THE LABRADOR CURRENT

The Labrador current along the transects was mapped with a hull-mounted 150 kHz RDI Acoustic Doppler Current Profiler (ADCP) at a spatial resolution of approximately 1.5 km horizontally by 4.0 m vertically. Figure 12 shows the north-south vertical distribution of currents across the central portion of the Grand Bank for late April 1993 (top panel) and early May 1994 (bottom panel), the negative values correspond to southward flowing water. Preliminary analysis of this data shows a well defined offshore branch up to 200 meters deep with current velocities reaching 40 cm/s in a general southerly alongshelf direction. The offshore branch of the Labrador current appears to extend further onto the bank in 1993. Across the shelf, currents speeds generally ranged from 0 to 15 cm/s. It should be noted that these surveys are a one to two day snapshot of the Labrador current and may not represent the mean flow. Apparent counter currents (northward flowing water) are seen in both years with speeds ranging from 5 to 10 cm/s over parts of the shelf. These currents are not unusual, and have been observed on several ADCP surveys during 1991 and 1992, they also appear in drifter track data and satellite images. They are larger than predicted barotropic tidal currents and are thought to the result of eddies at scales of about 10 to 15 km.

ACKNOWLEDGEMENTS

I would like to thank the technical staff of the oceanography section at NAFC for the professional job done in data collection and processing and for the computer software support. I also thank D. Foote for data processing and technical assistance in the preparation of this document. I would also like to thank the captain and crew of the CSS Hudson. This project is funded by the Northern Cod Science Program (NCSP).

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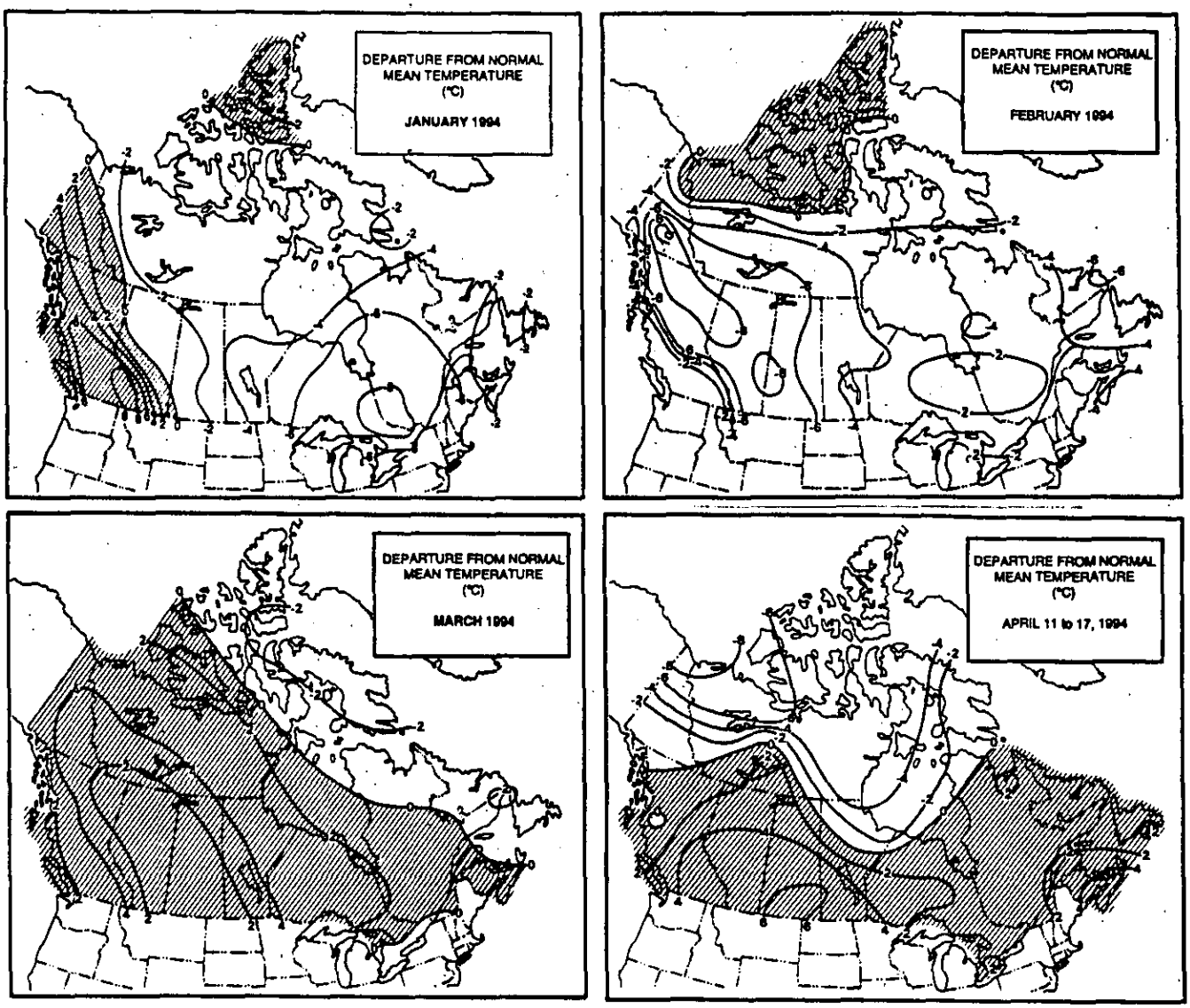

Fig. 1 Monthly air temperature anomalies over Canada for the winter and early spring of 1994. (From Climatic Perspectives, Vol. 16, 1994)

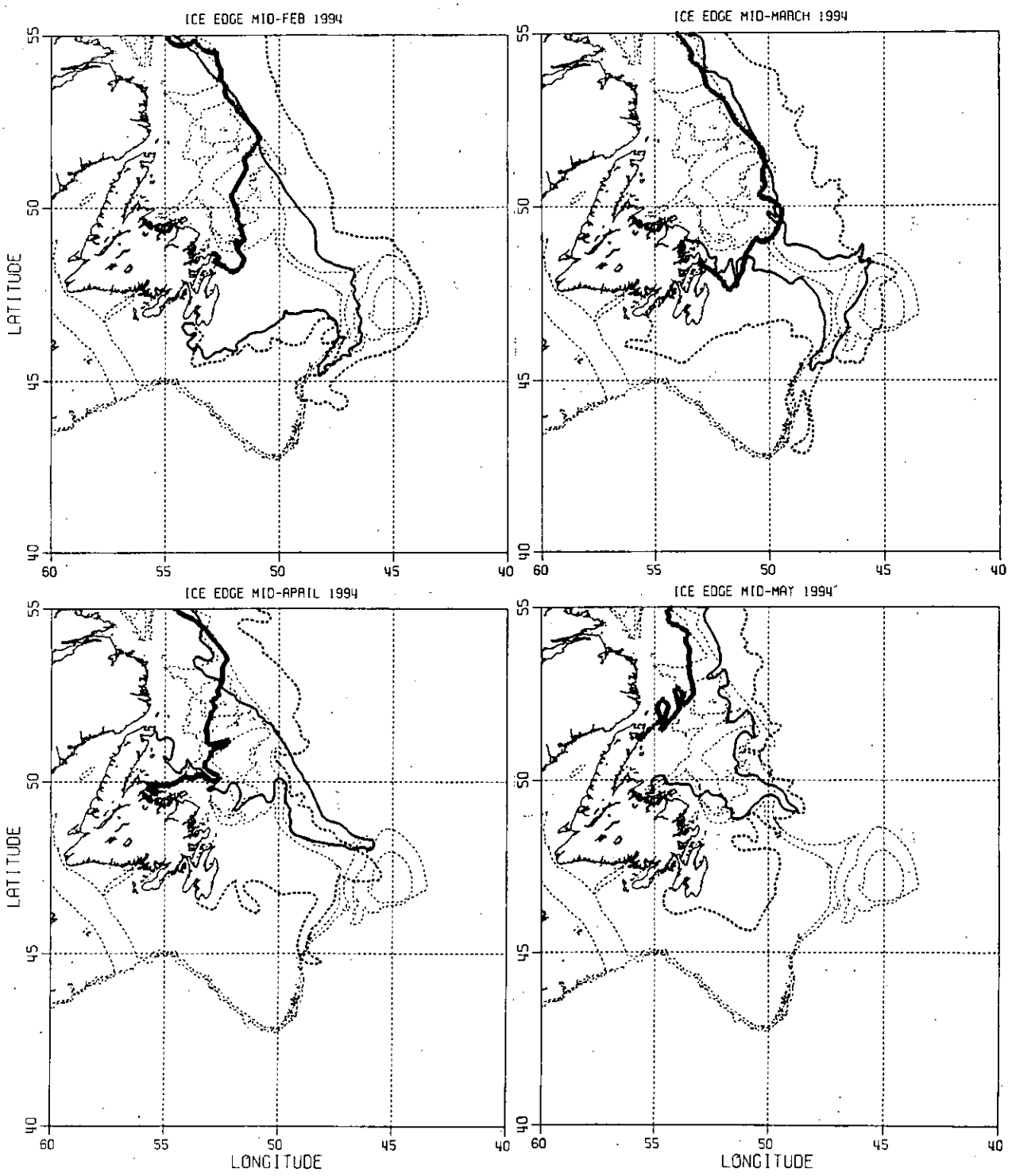

Fig. 2 Ice edge locations for mid-February to Mid-May of 1994 (light solid lines). The dashed and heavy solid lines are locations for the maximum and median positions for the same time period based on historical data from 1962 to 1987. (from Cote, 1989)

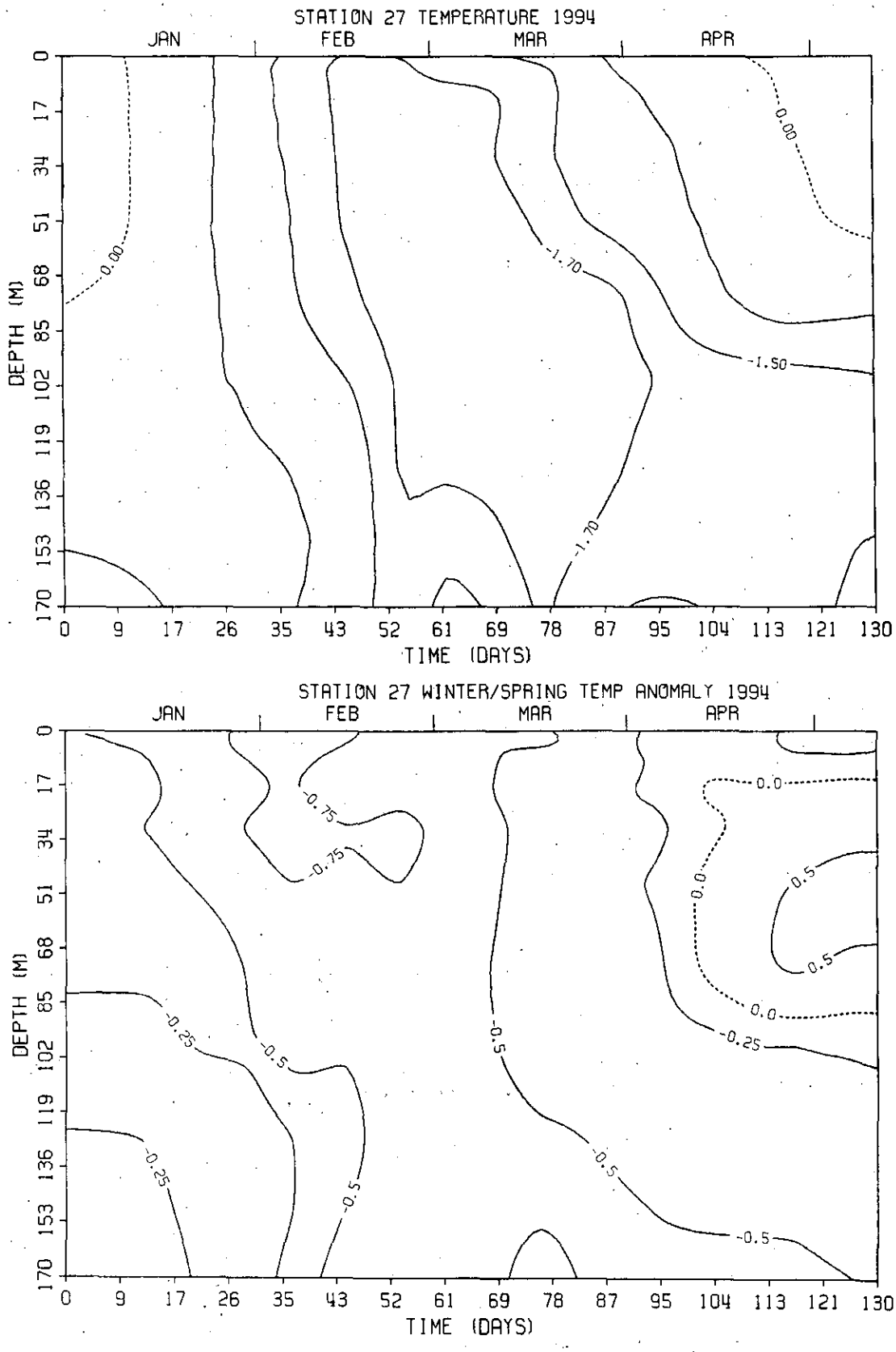

Fig. 3. *Depth versus time contour plots of temperatures and anomalies at* Station 27 from January 1 to May 10, 1994.

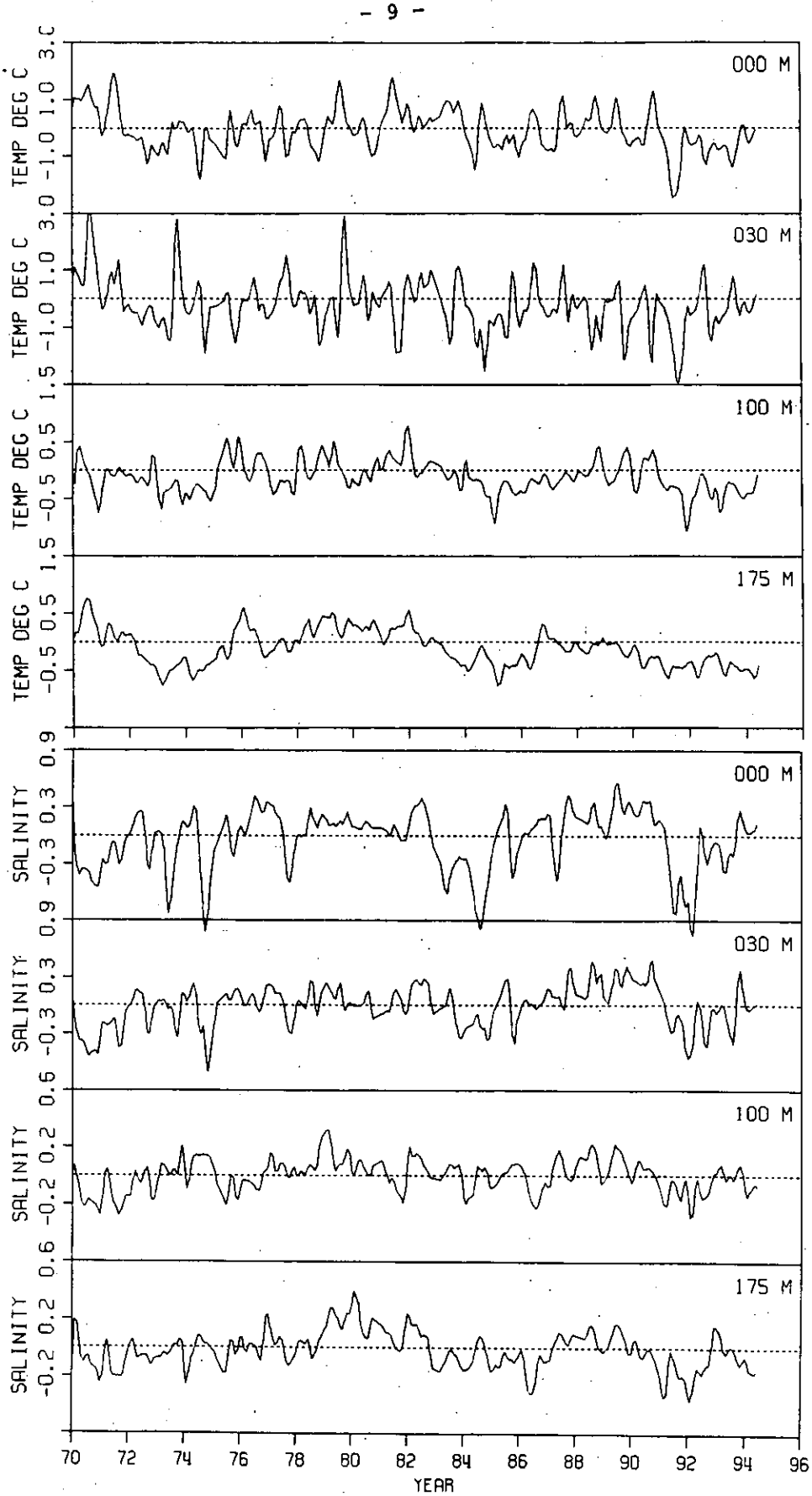

Fig. 4. Time series of monthly temperature and salinity anomalies at Station 27 at standard depths (0,30,100 and 175) from January 1 1970 to May 10 of 1994.

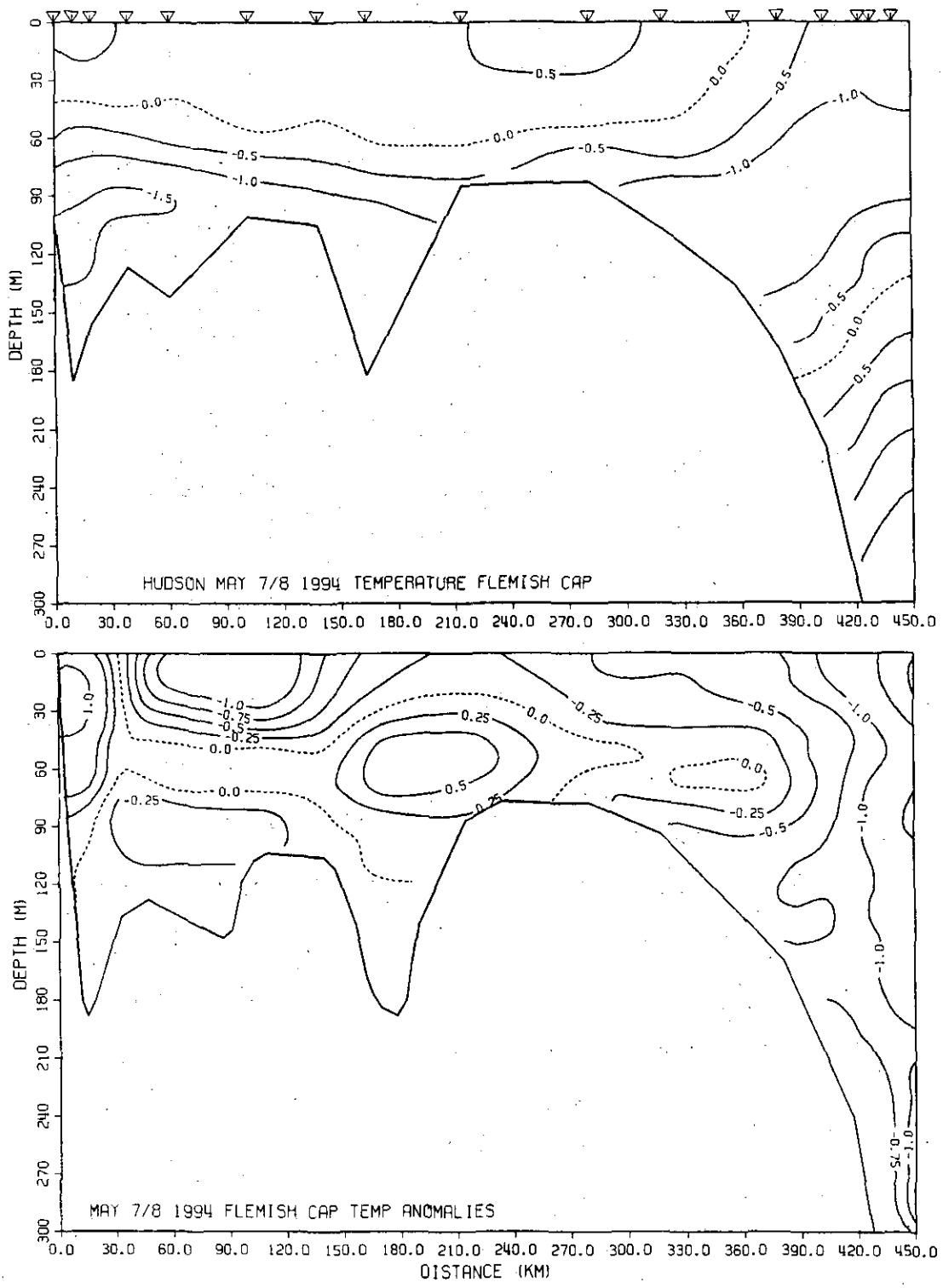

Fig. 5. The vertical distribution of temperature and anomalies along the Grand Bank portion of the standard Flemish Cap transect for early May, 1994.

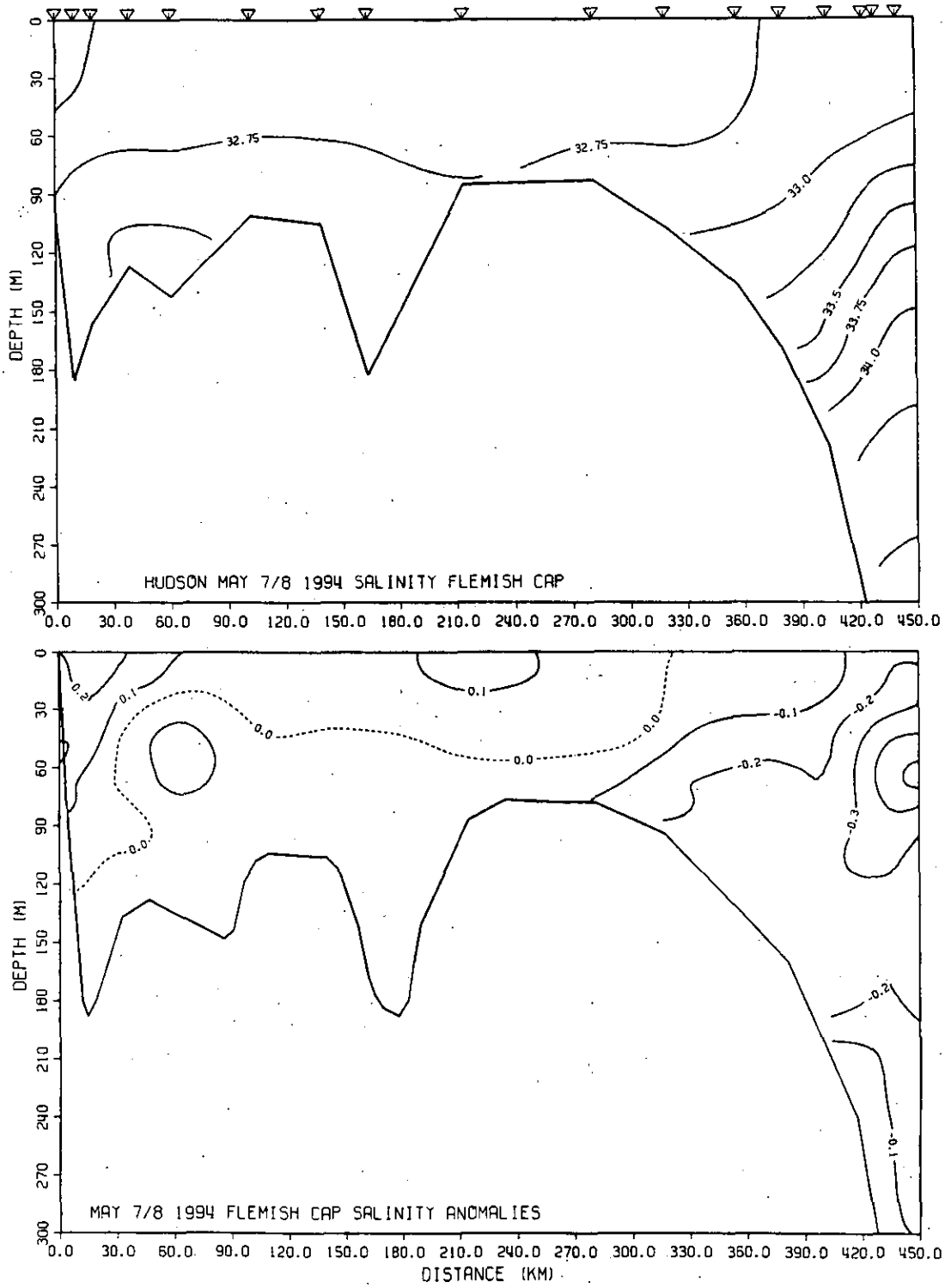

Fig. 6. The vertical distribution of salinity and anomalies along the Grand Bank portion of the standard Flemish Cap transect for early May, 1994.

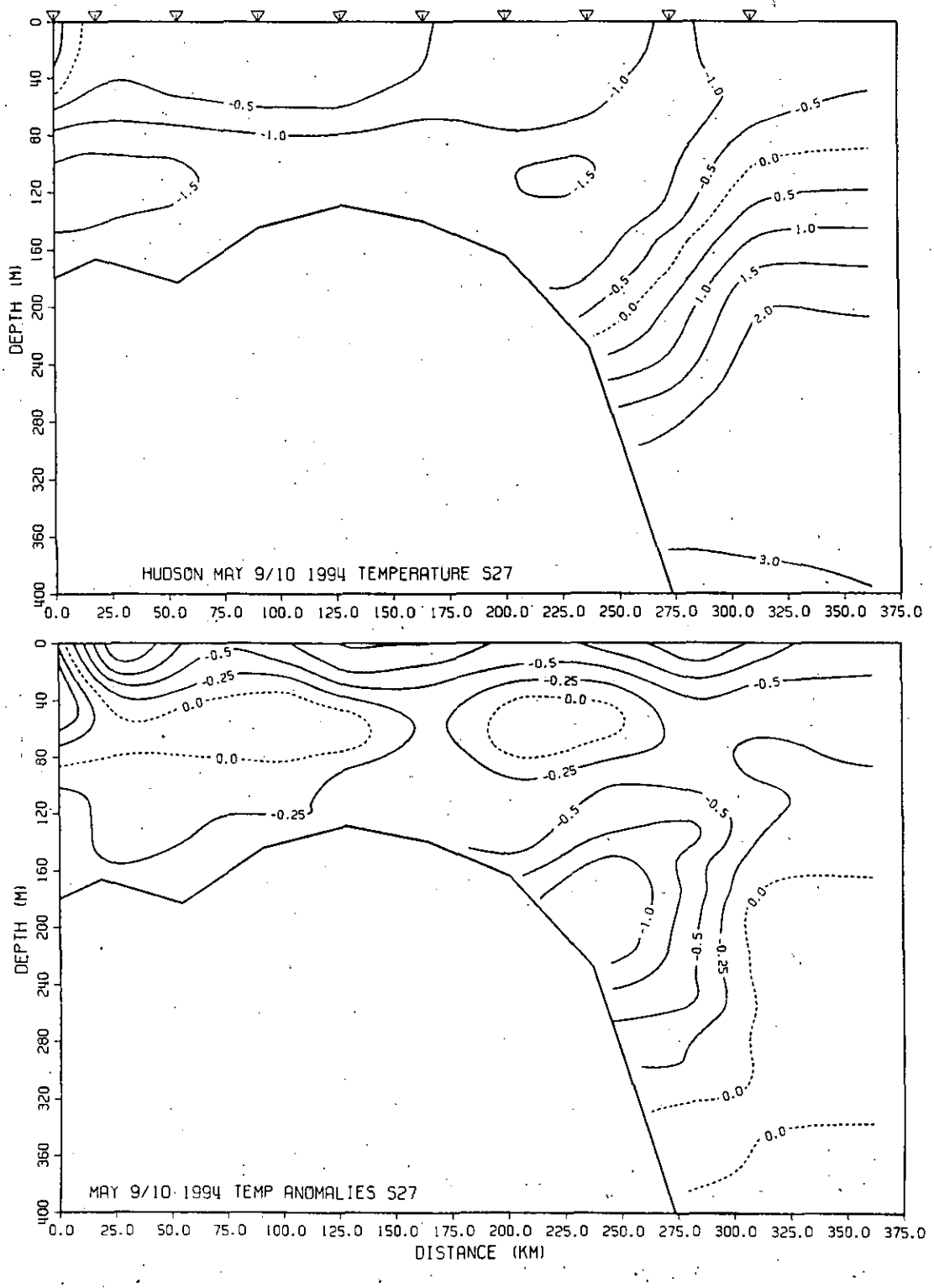

Fig. 7. The vertical distribution of temperature and anomalies across the Northern Grand Bank for early May, 1994.

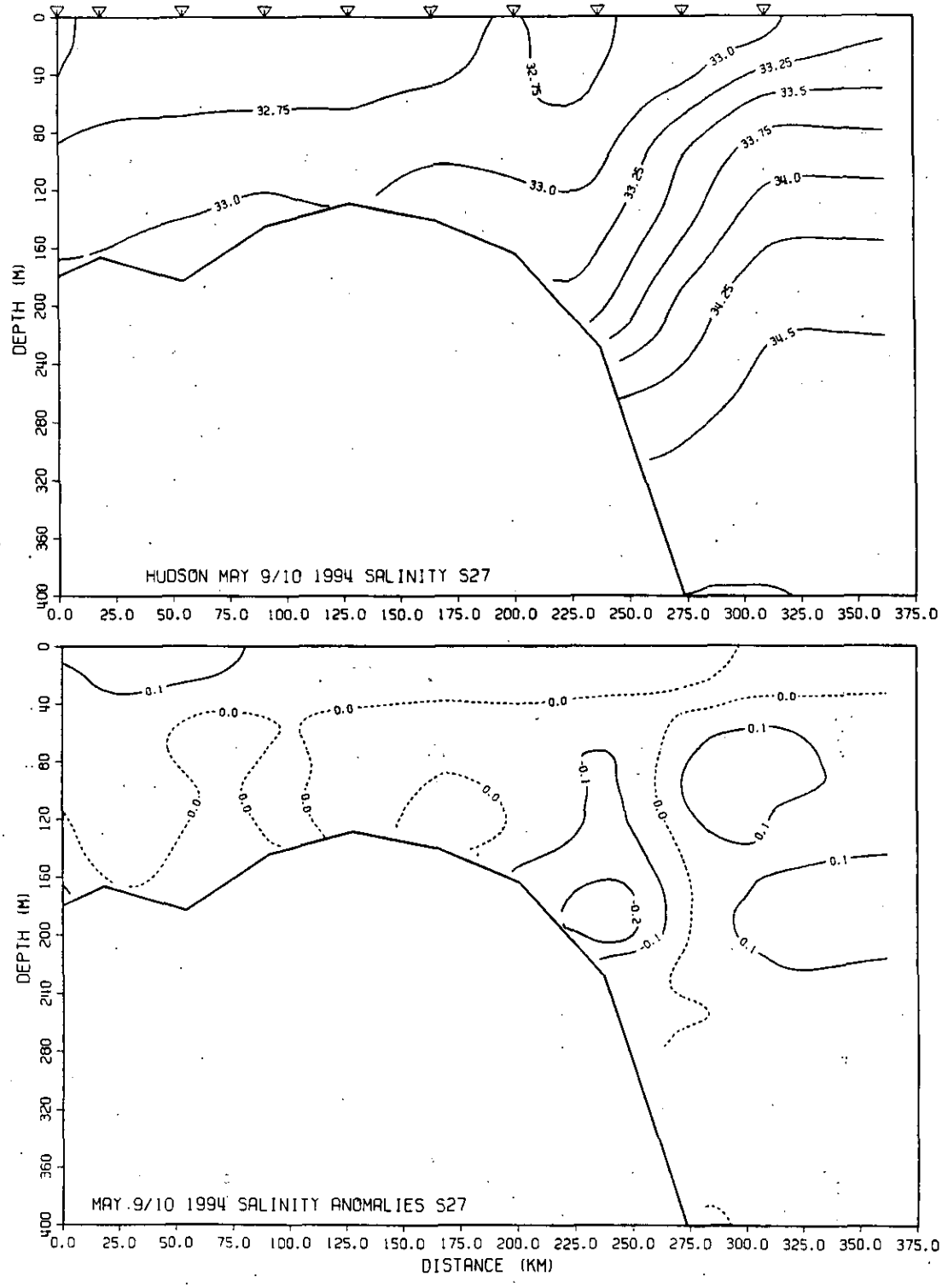

Fig. 8. The vertical distribution of salinity and anomalies across the Northern Grand Bank for early May, 1994.

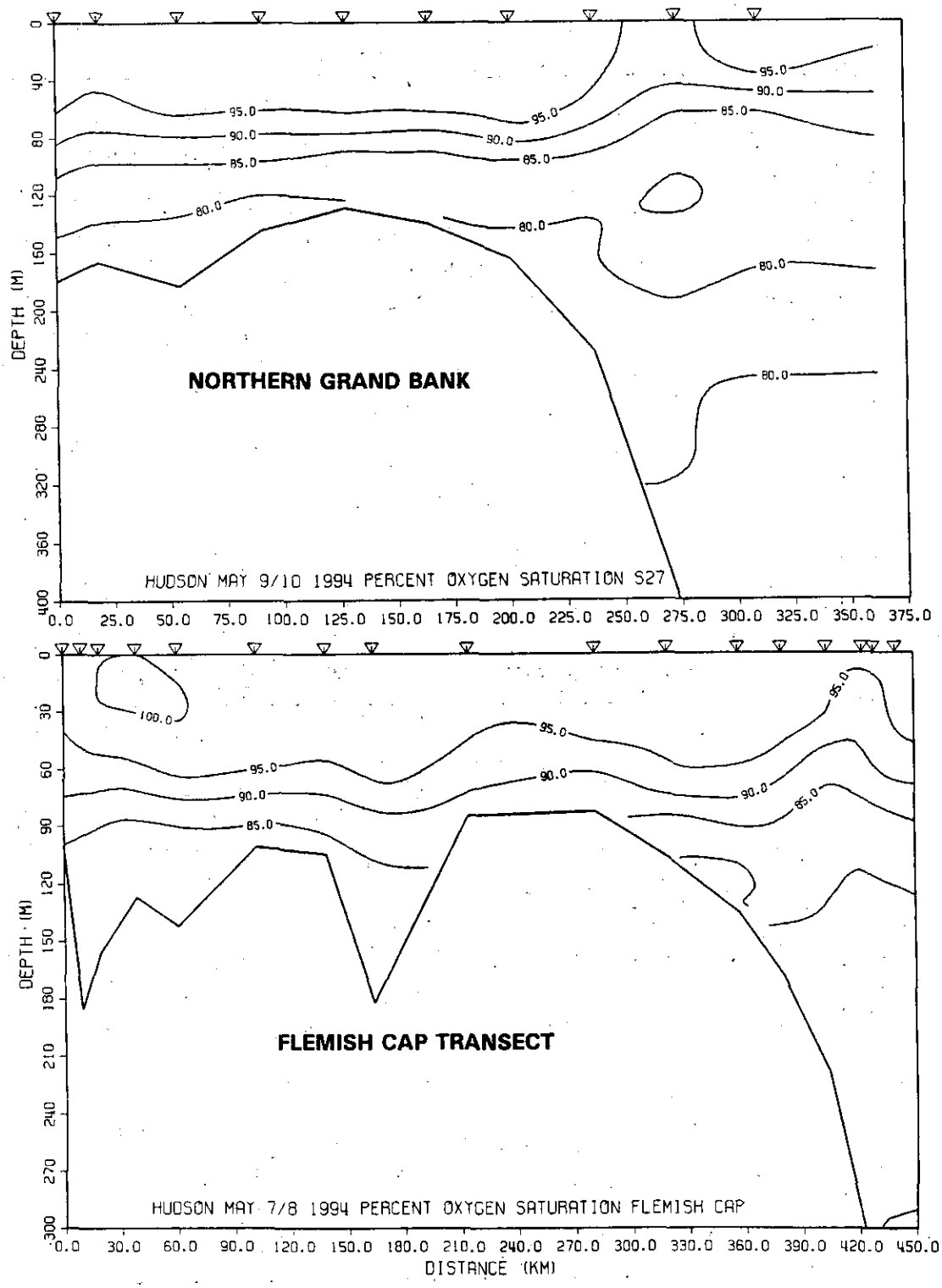

Fig. 9. The vertical distribution of dissolved oxygen saturation across the Northern Grand Bank (top panel) and along the standard Flemish Cap transect (bottom panel) for early May, 1994.

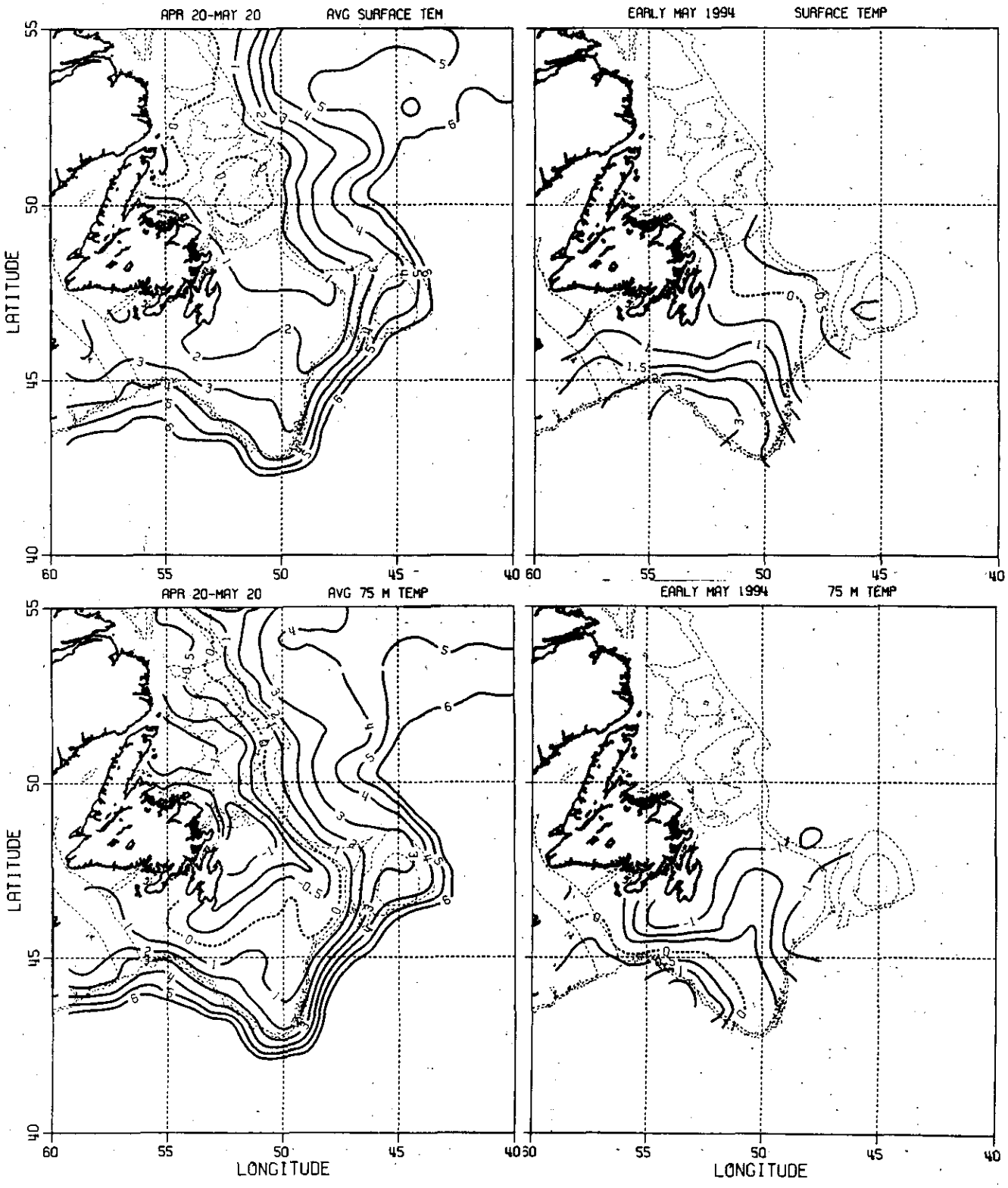

Fig. 10. The April 20 to May 20 average and the early May 1994 surface and 75 m horizontal temperature maps for the Newfoundland region.

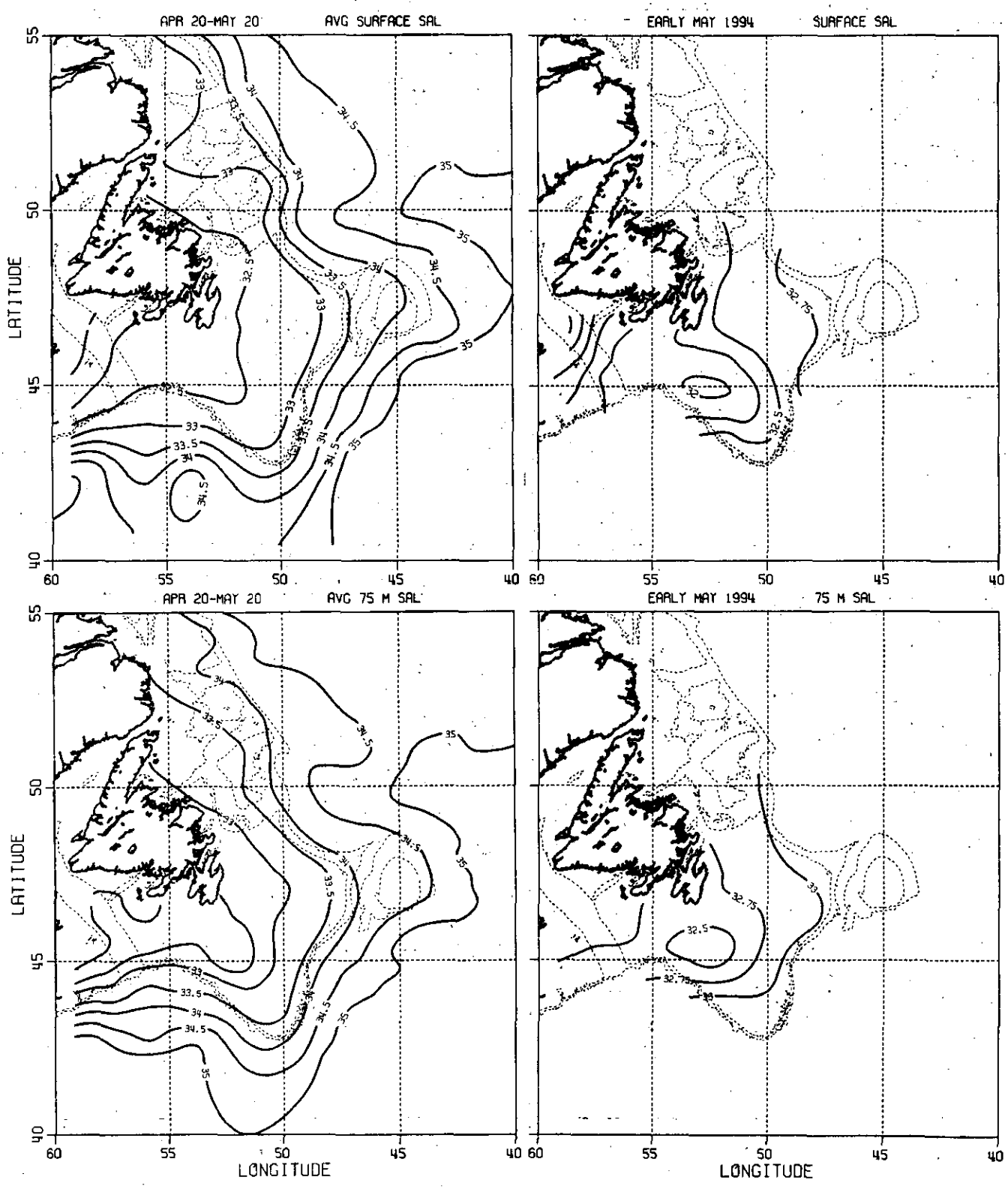

Fig. 11. The April 20 to May 20 average and the early May 1994 surface and 75 m horizontal salinity maps for the Newfoundland region.

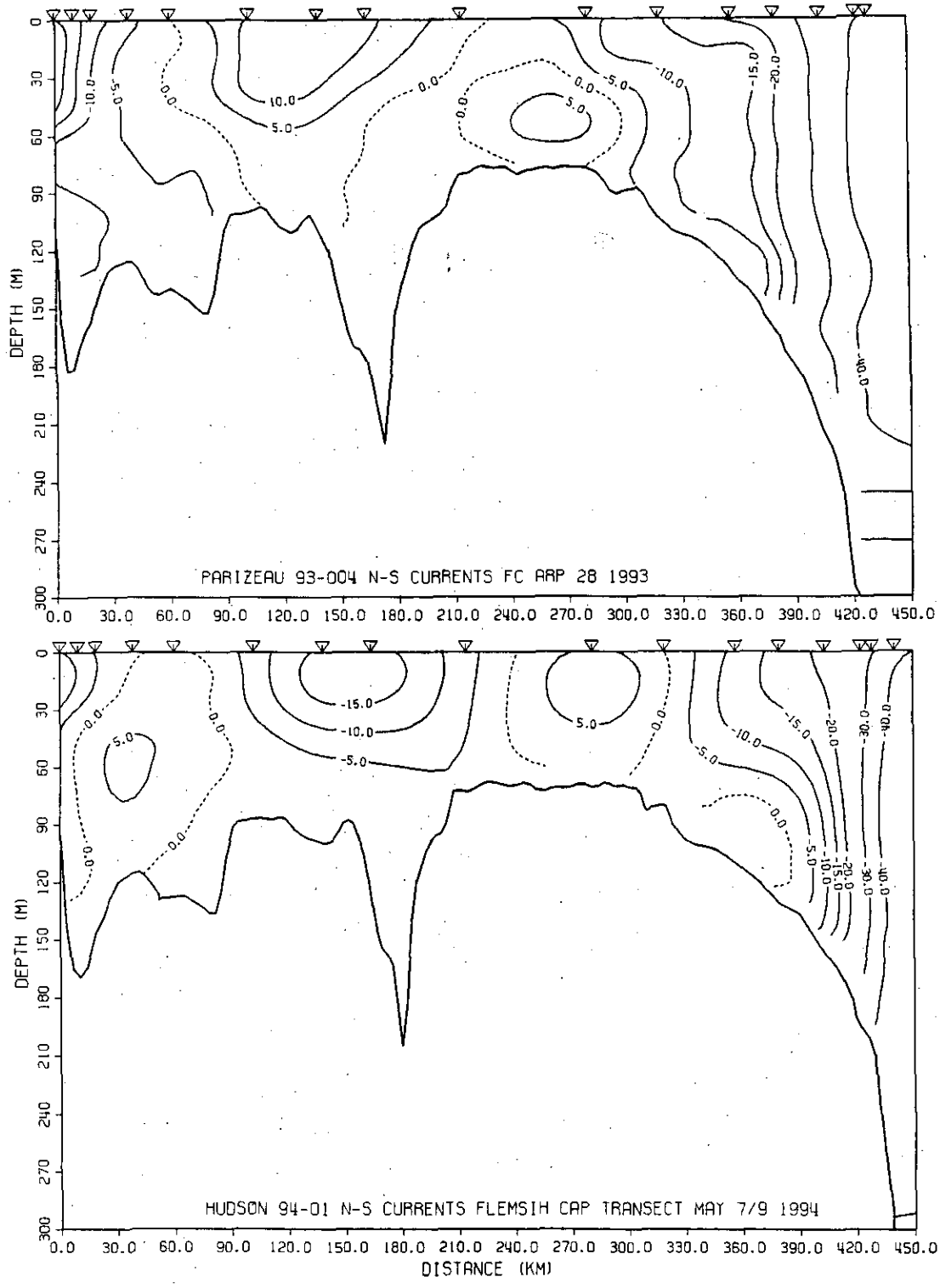

Fig. 12. The vertical distribution of the current field along the Grand Bank portion of the standard Flemish Cap transect for late April 1993 (top panel) and early May 1994 (bottom panel). Negative currents are southward, from an ADCP survey.