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ENVIRONMENTAL CONDITIONS IN ATLANTIC CANADA, SUMMER 1994 WITH COMPARISONS TO THE LONG-TERM AVERAGE

by

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ABSTRACT

Oceanographic data from the Grand Bank, northeast Newfoundland Shelf and southern Labrador shelf during the summer of 1994 are compared to historical data from the area. In addition, meterological and ice cover data from the winter, spring and early summer are also presented. The analysis indicates that the cold air temperatures experienced in Atlantic Canada during the winter and early spring had moderated to near normal conditions by late spring of 1994. The above normal ice coverage along the east coast of Newfoundland and Labrador continued into spring, however, the rate of ice retreat was much more rapid than in the previous three years. The anomalously cold water temperatures experience in recent years had moderated in the upper water column at Station 27 by July of 1994 but remained below normal in deeper water. The Bonavista cold-intermediate-layer (CIL) was slightly above normal (7 %) but much less than the past four years (up to 68 % in 1991).

RÉSUMÉ

On compare les données océanographiques de 1994 concernant les Grands Bancs de Terre-Neuve, le nord-est du plateau terre-neuvien et le sud du plateau labradorien aux données historiques pour ces régions. On présente également des données sur la météo et sur la couche de glaces en hiver, au printemps et au début de l'été. Il ressort de l'analyse que les basses températures de l'air enregistrées au Canada atlantique en hiver et au début du printemps s'étaient modérées jusqu'à approcher de la normale à la fin du printemps 1994. L'étendue de la couche de glaces est demeurée supérieure à la normale le long de la côte est de Terre-Neuve au printemps, mais le retrait des glaces s'est effectué beaucoup plus rapidement qu'au cours des trois années antérieures. Juillet arrivé, la froideur anormale des températures de l'eau enregistrée ces dernières années s'était modérée dans la partie supérieure de la colonne d'eau à la station 27, ces températures restant toutefois inférieures à la normale dans les eaux profondes. La couche froide intermédiaire (CFI) était légèrement supérieure à la normale (7 %), mais très inférieure à celles des quatre dernières années (jusqu'à 68 % en 1991).

INTRODUCTION

This report presents an overview of environmental conditions in Atlantic Canada during the first half 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 annual oceanographic survey in July 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, spring and early summer of 1994.

During the July 1994 survey oceanographic measurements were made along transects running from the inshore areas along the east coast of Newfoundland and Labrador and offshore to the shelf edge across most major Banks. 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.

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. During the spring (March to May) an upper trough of low pressure extending from Davis Strait to Nova Scotia continued to give cool conditions during early spring over most of eastern Canada (Saulesleja, 1994).

The air temperature anomalies over Canada from January to July 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 slightly above normal over Newfoundland to between 0.0 and 2.0 °C below normal over much of eastern Canada (Fig 1a.). By May temperatures again ranged from 0.0 to 2.0 °C below normal but warmed to 0.0 to 2.0 °C above normal by June. During the first half of July temperatures ranged from 2.0 °C above normal along the east coast and northern regions to 2.0 °C below normal over central Quebec (Fig 1b.).

The recent negative air temperature anomalies experienced this past winter are a continuation of a cold trend that 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.

ICE CONDITIONS

The maximum extent of the ice edge (defined by one-tenth total coverage) during mid-January to mid-June 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 maximum ice coverage for mid-February, reaching south of 46° N latitude (Fig. 2a). 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 (Fig 2b.) the ice edge continued to lie south of 50 °N about 200 km south of the median position and by mid-June the ice had receded to about normal limits along the inshore regions of southern Labrador but had remained south of the median position over Hamilton Bank.

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. Along the east coast of Newfoundland the ice retreat was up to two weeks earlier than 1993.

STATION 27 TEMPERATURE AND SALINITY TIME SERIES

Depth versus time contour maps of temperature and salinity and anomalies based on all XBT and CTD profile data collected at station 27 from January to the end of July, 1994, a total of 33 profiles, are plotted in Figure 3. The anomalies were calculated from the mean of all data collected on the station since 1946.

The cold isothermal water column during the winter months has temperatures ranging from -1.0 °C to -1.7 °C and throughout the whole time period at depths below 85 m. The temperature time series (top 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 early February, and remained at that value until early April, when the surface warming commenced. By the end of April and early May the upper layer temperature had again warmed to above 0.0 °C and to above 12 °C by late July (Fig. 3a top panel).

Figure 3a (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 and to 3.0 °C above normal by late July in the upper 30 m. Below 85 m depth to the bottom temperature anomalies remained up to 0.25 to 0.5 °C below normal.

Figure 3b shows near normal salinities between 32.0 to 32.4 psu in the upper 50 m of the water column and values ranging from 32.4 to 33.0 from 50 m to the bottom throughout the time series, about 0.1 to 0.2 psu below normal.

The time series of monthly temperature and salinity anomalies at Station 27 from January 1, 1990 to July 30, 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 above normal conditions by July 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 summer 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 summer of 1994. Other periods with colder and fresher than normal salinities particularly in the early 1970s and mid 1980s are associated 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).

VERTICAL TEMPERATURE, SALINITY AND OXYGEN DISTRIBUTION

The vertical distribution (depth versus horizontal distance from the shore) of the temperature and temperature anomaly field along the standard Cape Bonavista transect for July, 1994 are presented in Fig. 5. These anomalies are calculated from the mean temperature field for the period June 23 to July 23 of all available data for the transect since the early 1930s. 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 6.0 °C near the coast and to 4.0 °C over most of the continental shelf. In deeper water (50 m to the bottom) the temperatures ranged from -1.0 to -1.5 °C 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 -0.5 °C near the coast to 0.0 to 1.0 °C in the surface layer over the continental shelf and to normal conditions over most of the water column from 50 m to the bottom across the shelf and in deeper water beyond the shelf edge.

The cold intermediate layer extends offshore to about 240 km, with a maximum thickness of about 200 m corresponding to a cross-sectional area of approximately 28 km^2 compared to 32 km^2 in June of 1994. The core of the CIL (temperatures less than -1.5 °C) extends to about 115 km offshore and has a maximum thickness of about 100 m corresponding to a cross-sectional area of approximately 7 km^2 compared to 9 km^2 in June. In July 1993 the CIL of water less than 0.0 °C extended to about 240 km offshore with a maximum thickness of about 250 m, corresponding to a cross-sectional area of 33 km^2 and about 11 km^2 for water less than -1.5 °C. The bottom temperature structure across the shelf were similar in both years.

Figure 6 shows a time series of the CIL cross sectional area (top panel) and CIL minimum temperatures (bottom panel) from 1948 to 1994. In 1994 the CIL area was about 7 % above normal compared to 28 % in 1993 and 68 % in 1991. The minimum temperatures observed in the core of the CIL were -1.70 °C in 1994 compared to -1.74 °C in 1993, slightly below the average of -1.64 °C.

Salinities generally ranged from 31.5 psu near the surface to 33.5 psu near the bottom over the inshore portion of the transect (Fig. 7, top panel), to 34.75 psu at about 325 m depth near the shelf edge. The salinity anomalies (Fig. 7, bottom panel) shows fresher than normal conditions ranging from 0.1 to 0.5 psu below average in the upper 20 to 40 m of the water column in the inshore and offshore branches of the Labrador current and from 0.1 to 0.2 psu saltier than normal in water depths of 50 m to the bottom over the shelf. Salinities in deeper water beyond the shelf edge were about normal.

The historical oxygen data along the Bonavista transect together with data collected in July 1994 in conjunction with the temperature, salinity and chlorophyll data are shown in Fig. 8. The 1994 measurements were made with a YSI 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. 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. The sensor values were then corrected by using a least-squares fit of the titrations measurements to the electronic sensor measurements.

The average oxygen distributions across the northeast Newfoundland shelf shows saturations ranging form 90 to 100 % in the surface layers to about 80 to 85 % over the shelf in the CIL and about 90 % in deeper water on the continental slope areas. This survey shows dissolved oxygen saturation levels ranging from 90 to 100 % from the surface to about 60 m depth and about 85 to 90 % from 60 m to the

bottom. These values are very similar to 1993 during the same time period and show no evidence of oxygen depletion.

HORIZONTAL TEMPERATURE AND SALINITY FIELD

Figure 9 shows horizontal maps of the average surface temperature field in Atlantic Canada for July from all available data (top left panel) and from the data collected in July 1994 (bottom right panel). 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 12.0 °C over the southern Grand Bank to 4.0 °C off southern Labrador. The surface temperatures during July 1994 ranged from 8.0 over the northern Grand Bank to about 4.0 to 6.0 °C off southern Labrador on Hamilton Bank. In general the surface temperature over most of the surveyed area was near the long-term average.

Similarly Figure 9b shows the horizontal temperature field at 75 m depth (close to the bottom over most of the Grand Banks) about at the center of the CIL during the same time periods. The average temperature at this depth ranged from 3.0 °C over the southern Grand Bank to -1.0 °C over parts of the northeast Newfoundland and Labrador shelves. The temperatures over the surveyed area in July 1994 at 75 m depth ranged from -1.5 °C near the coast to 1.0 °C at the shelf edge, about 0.5 °C below the long-term average.

The horizontal surface salinity maps (Fig. 9a, right panels) show slightly fresher than normal conditions and at 75.0 m depth (Fig. 9b, right panels) near normal conditions.

ACKNOWLEDGEMENTS

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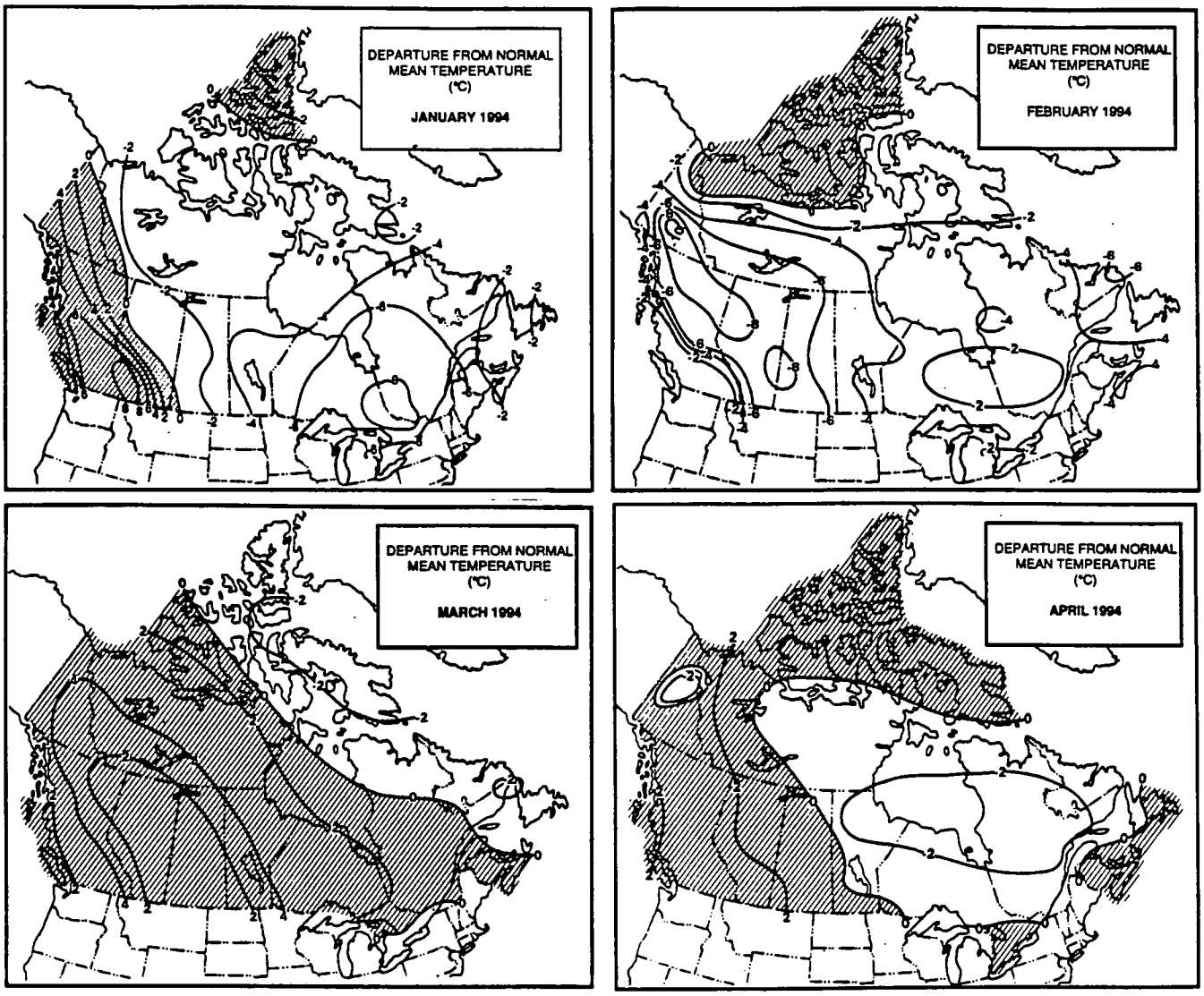

Fig. 1a. Monthly air temperature anomalies over Canada for the winter and early spring of 1994. (From Climatic Perspectives, Vol. 16, 1994)

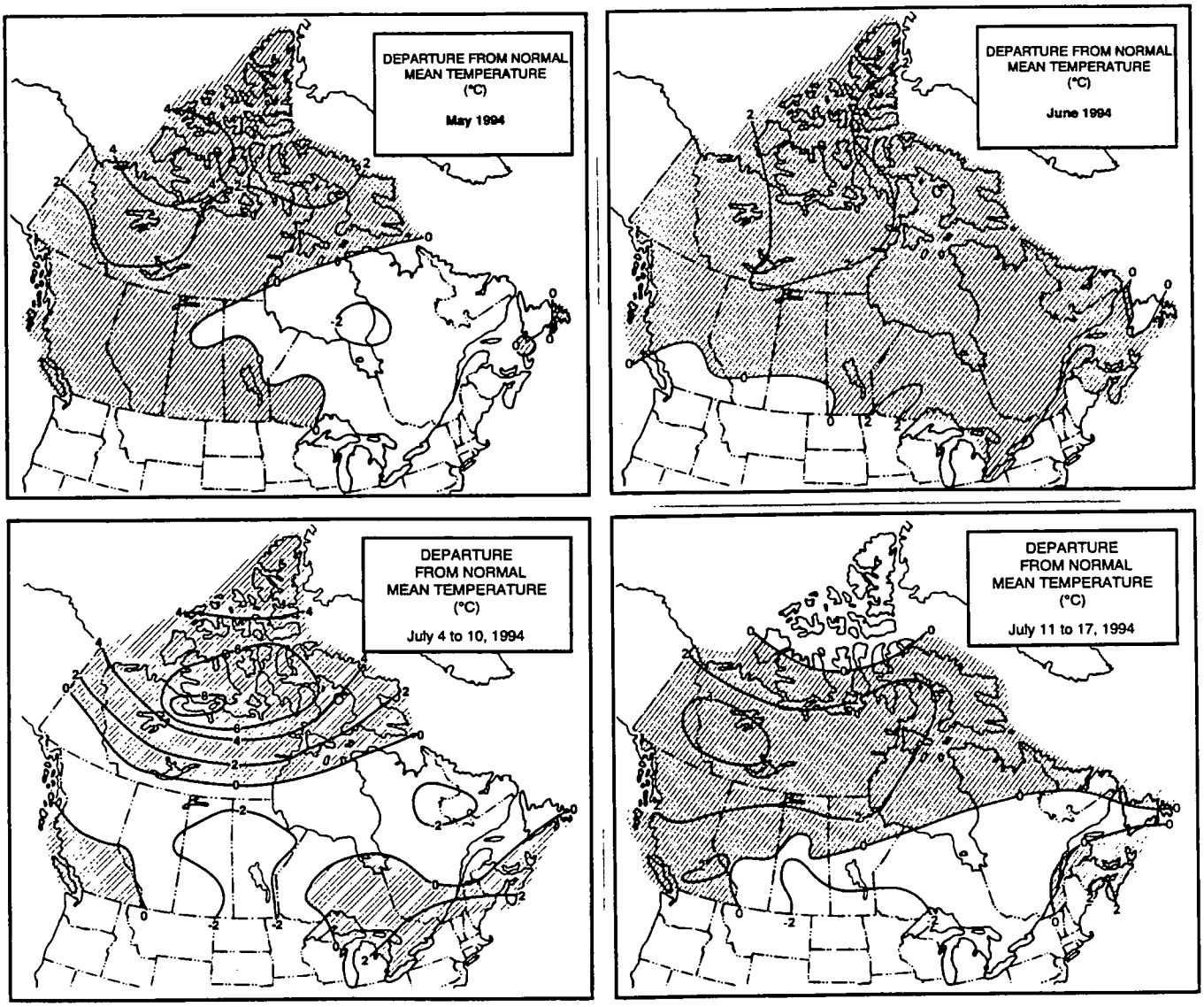

Fig. 1b. Monthly air temperature anomalies over Canada for the spring and summer of 1994. (From Climatic Perspectives, Vol. 16, 1994)

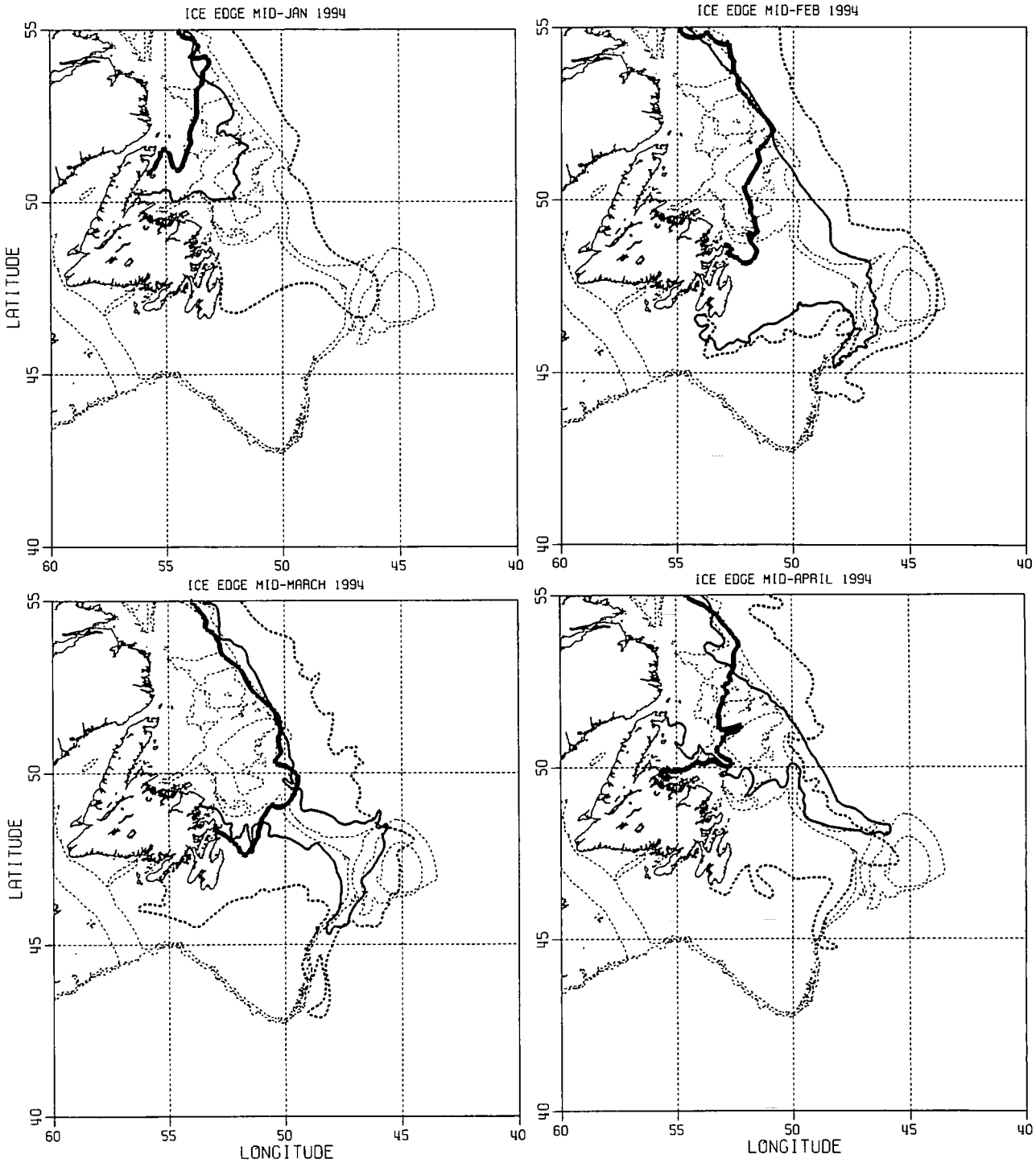

Fig. 2a. Ice edge locations for mid-January to mid-April of 1994 (light solid lines). The dashed and heavy solid lines are locations for the maximum and median positions for the same time period based on historical data from 1962 to 1987. (from Cote, 1989)

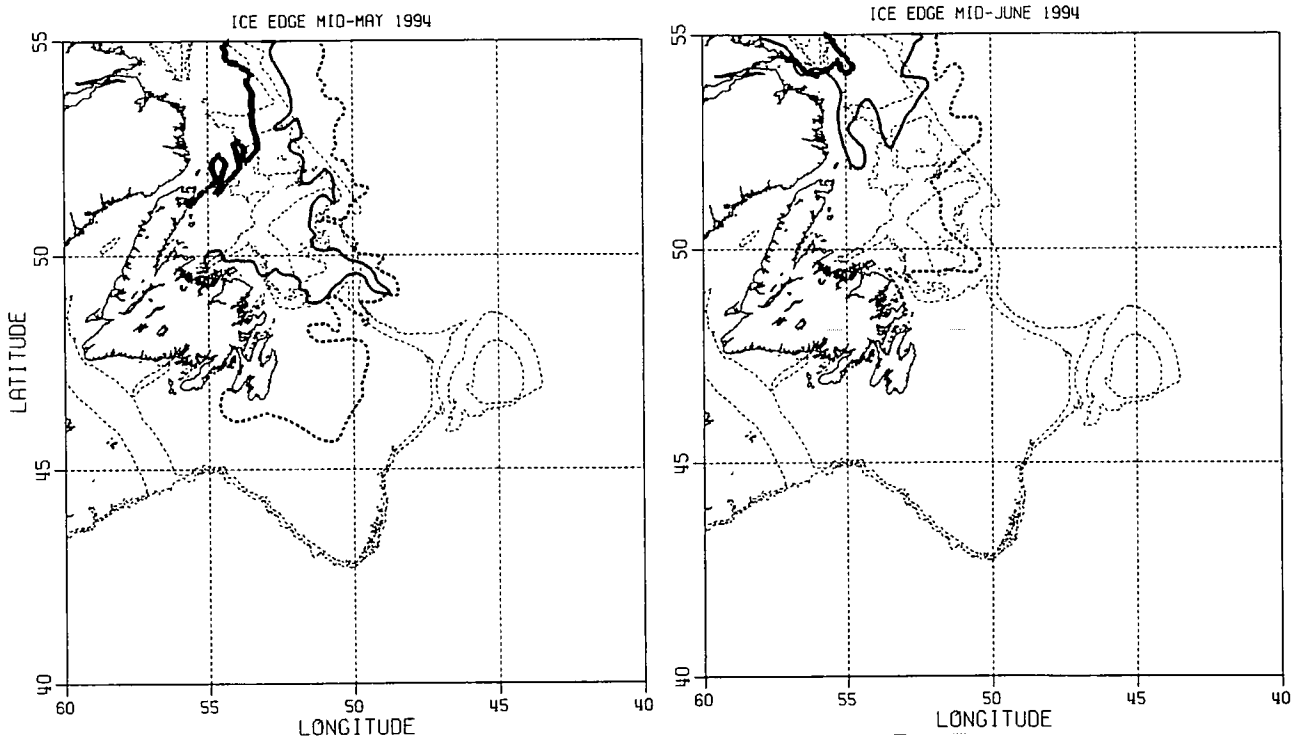

Fig. 2b. Ice edge locations for mid-May and mid-June of 1994 (light solid lines). The dashed and heavy solid lines are locations for the maximum and median positions for the same time period based on historical data from 1962 to 1987. (from Cote, 1989)

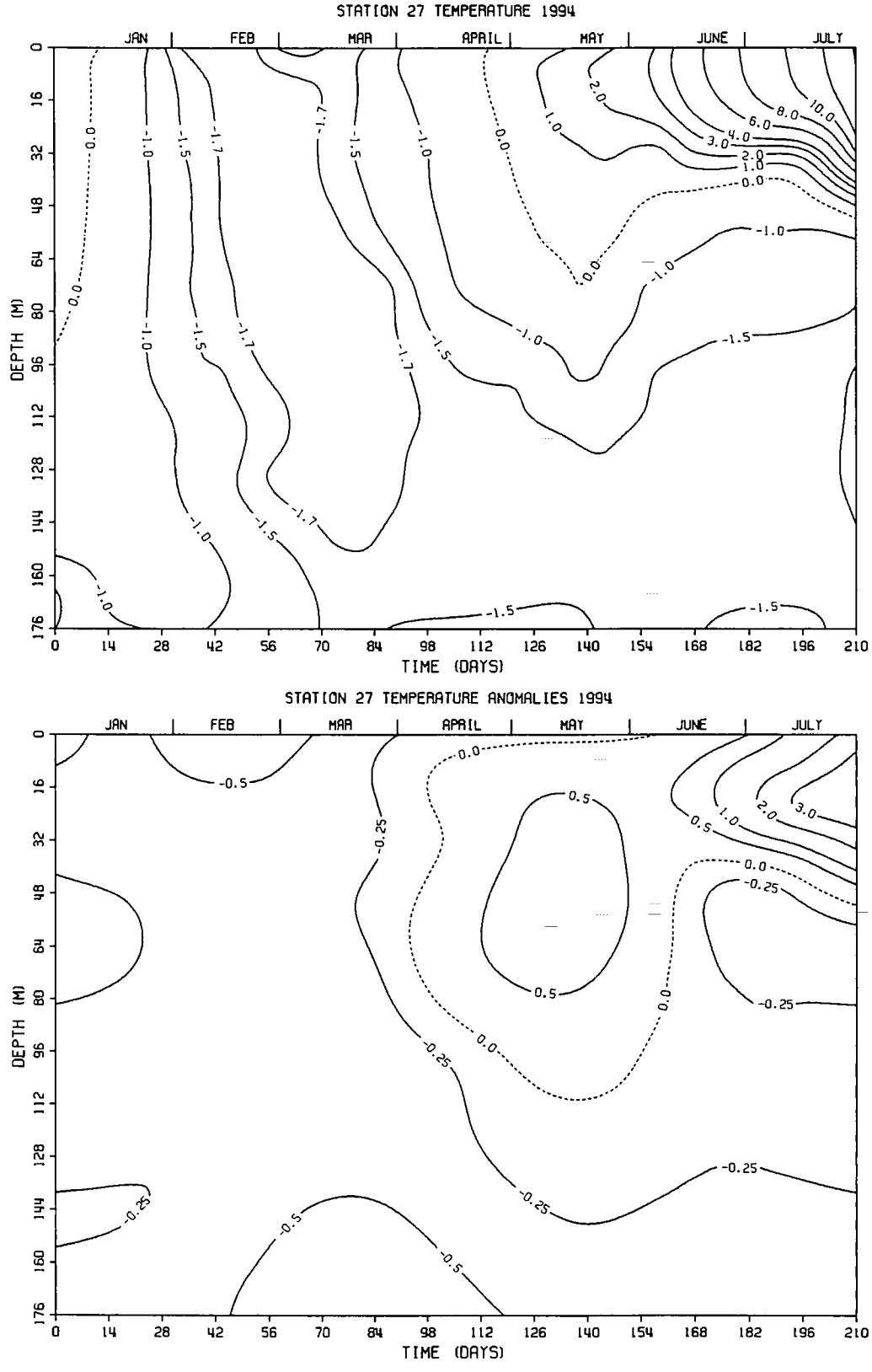

Fig. 3a. Depth versus time contour plots of temperatures and anomalies at Station 27 from January 1 to July 30, 1994.

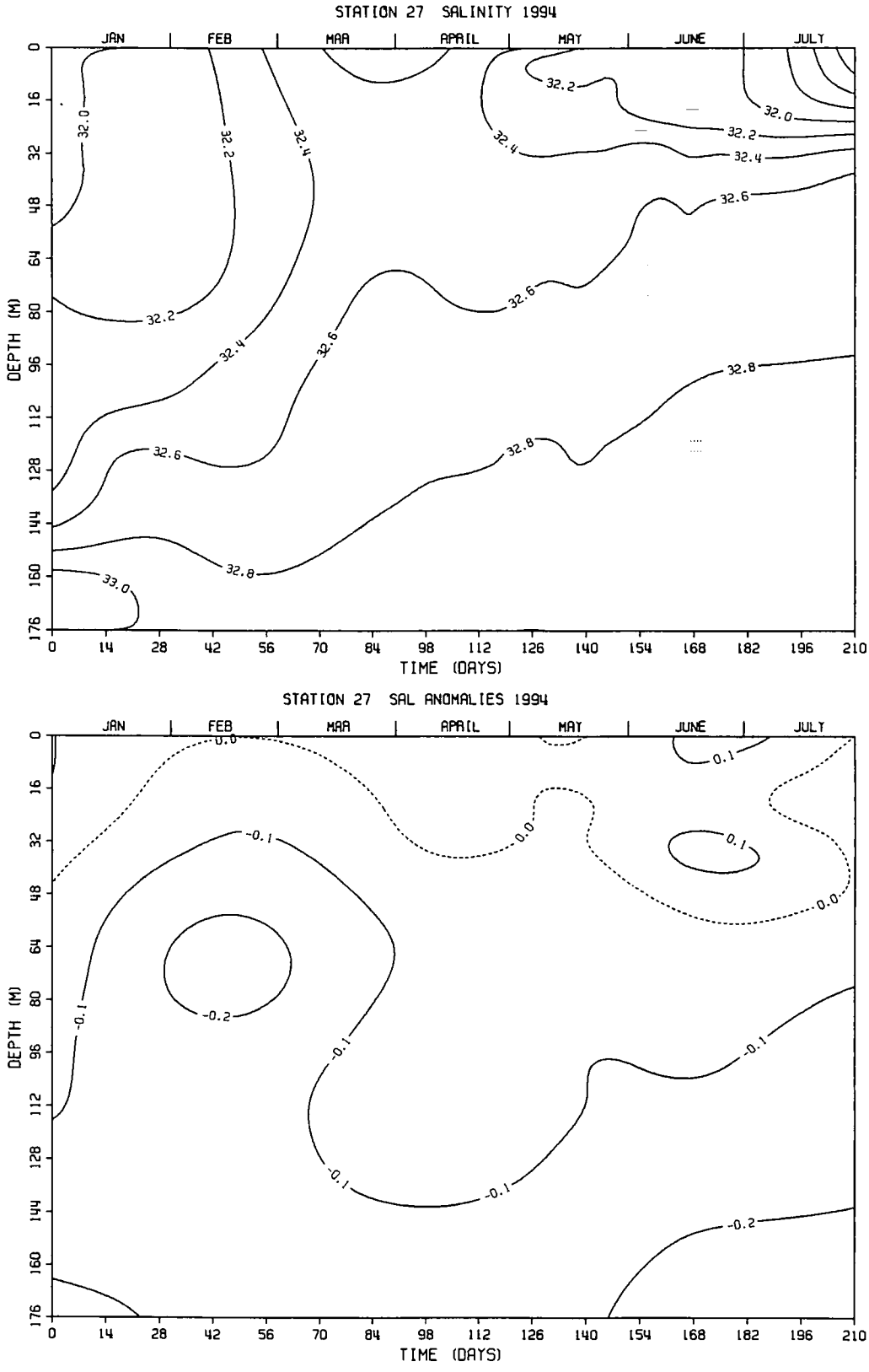

Fig. 3b. Depth versus time contour plots of salinity and anomalies at Station 27 from January 1 to July 30, 1994.

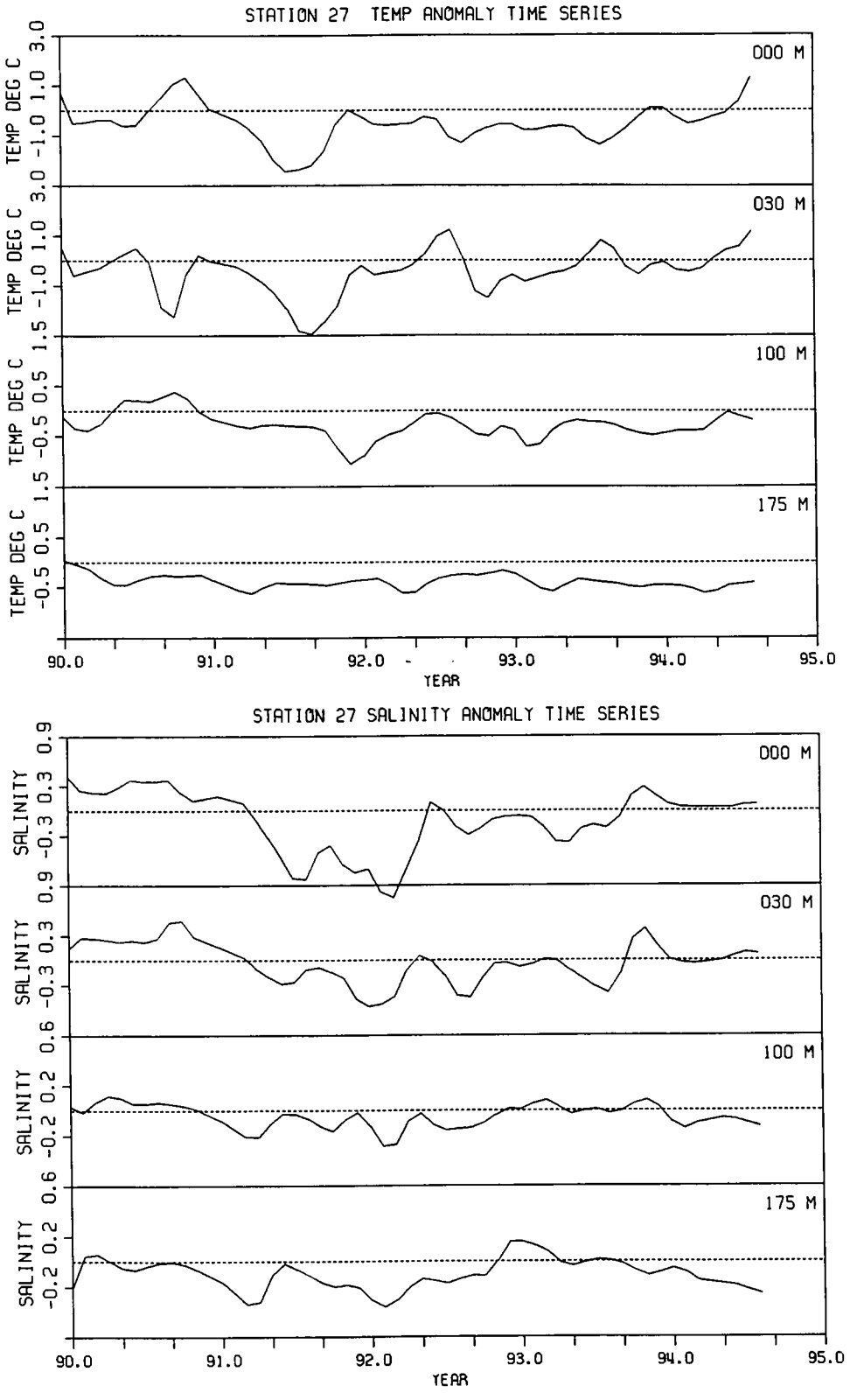

Fig. 4. Time series of monthly temperature and salinity anomalies at Station 27 at standard depths (0,30,100 and 175) from January 1, 1990 to July 30, 1994.

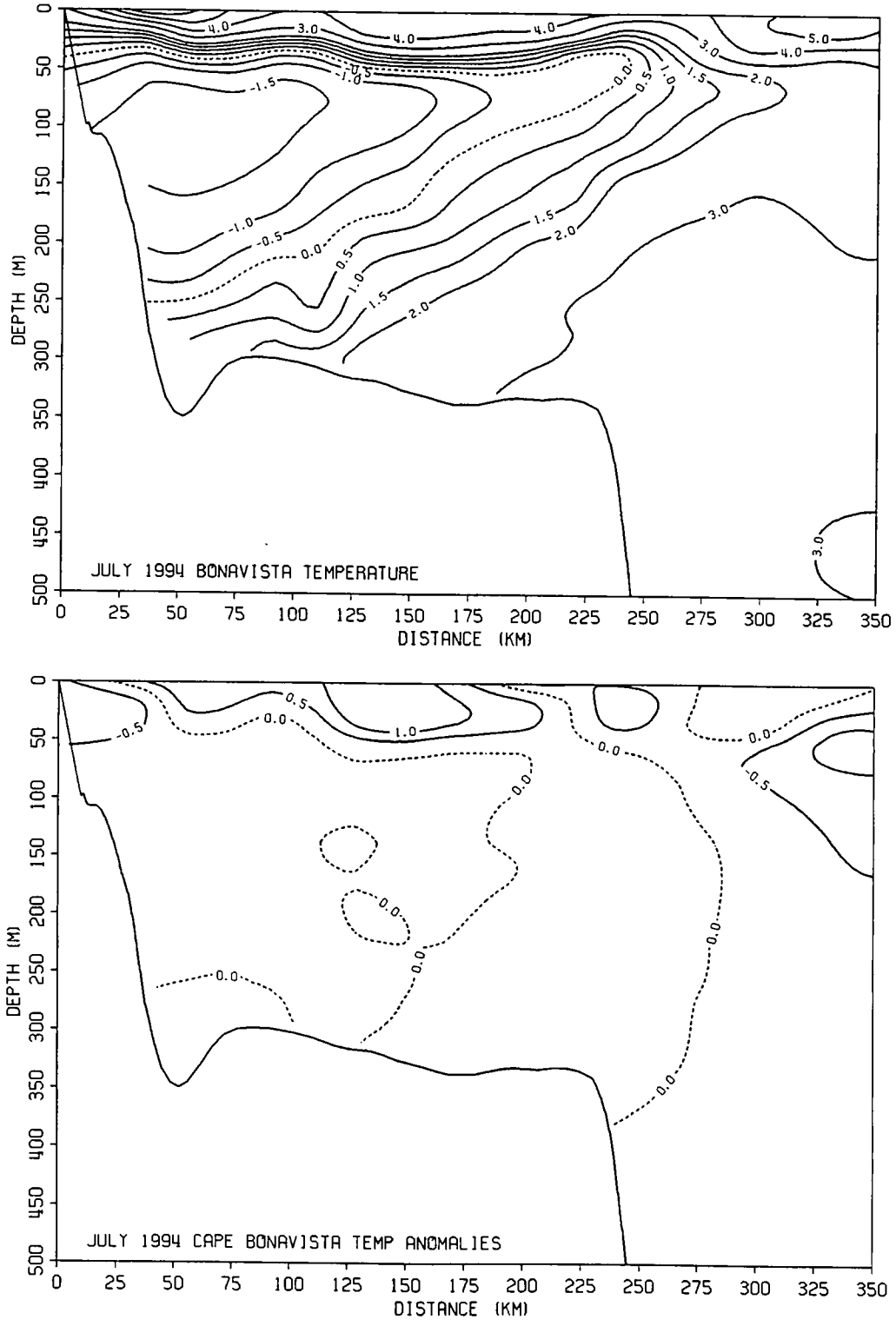

Fig. 5. The vertical distribution of temperature and anomalies along the standard Bonavista transect for July, 1994.

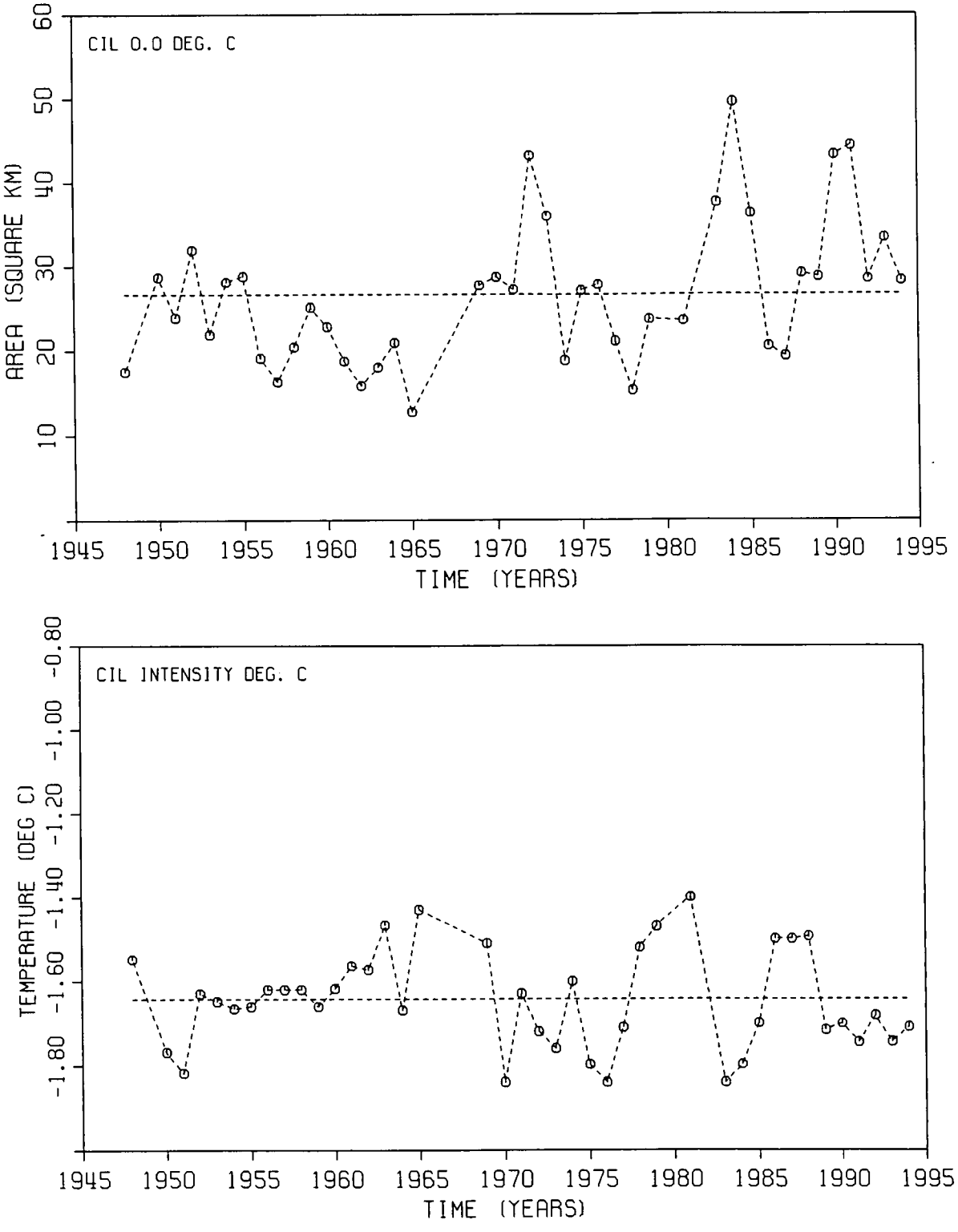

Fig. 6. Time series of CIL area along the Bonavista transect (top panel) and the CIL minimum temperature (bottom panel). The dashed line represents the average.

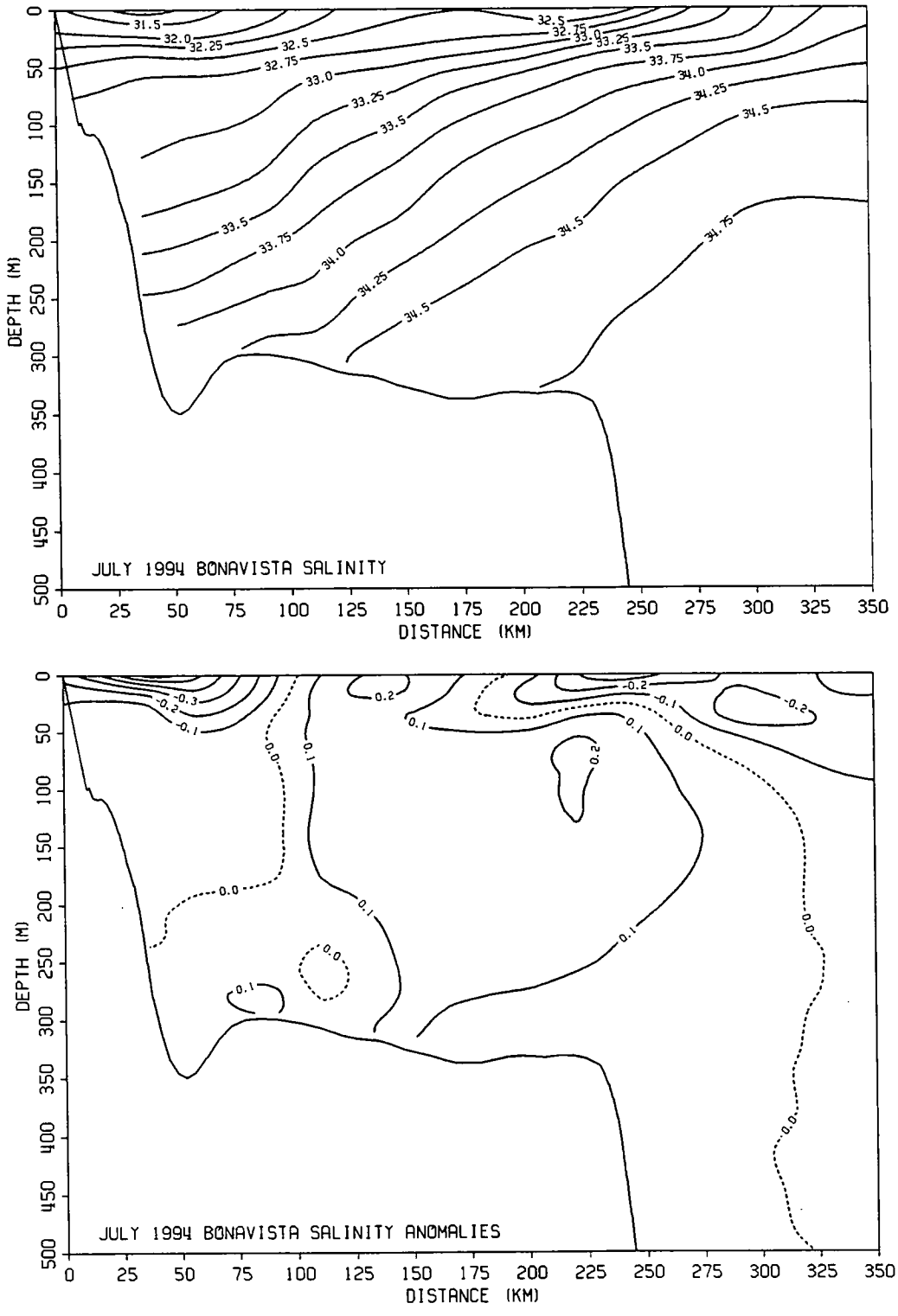

Fig. 7. The vertical distribution of salinity and anomalies along the standard Bonavista transect for July, 1994.

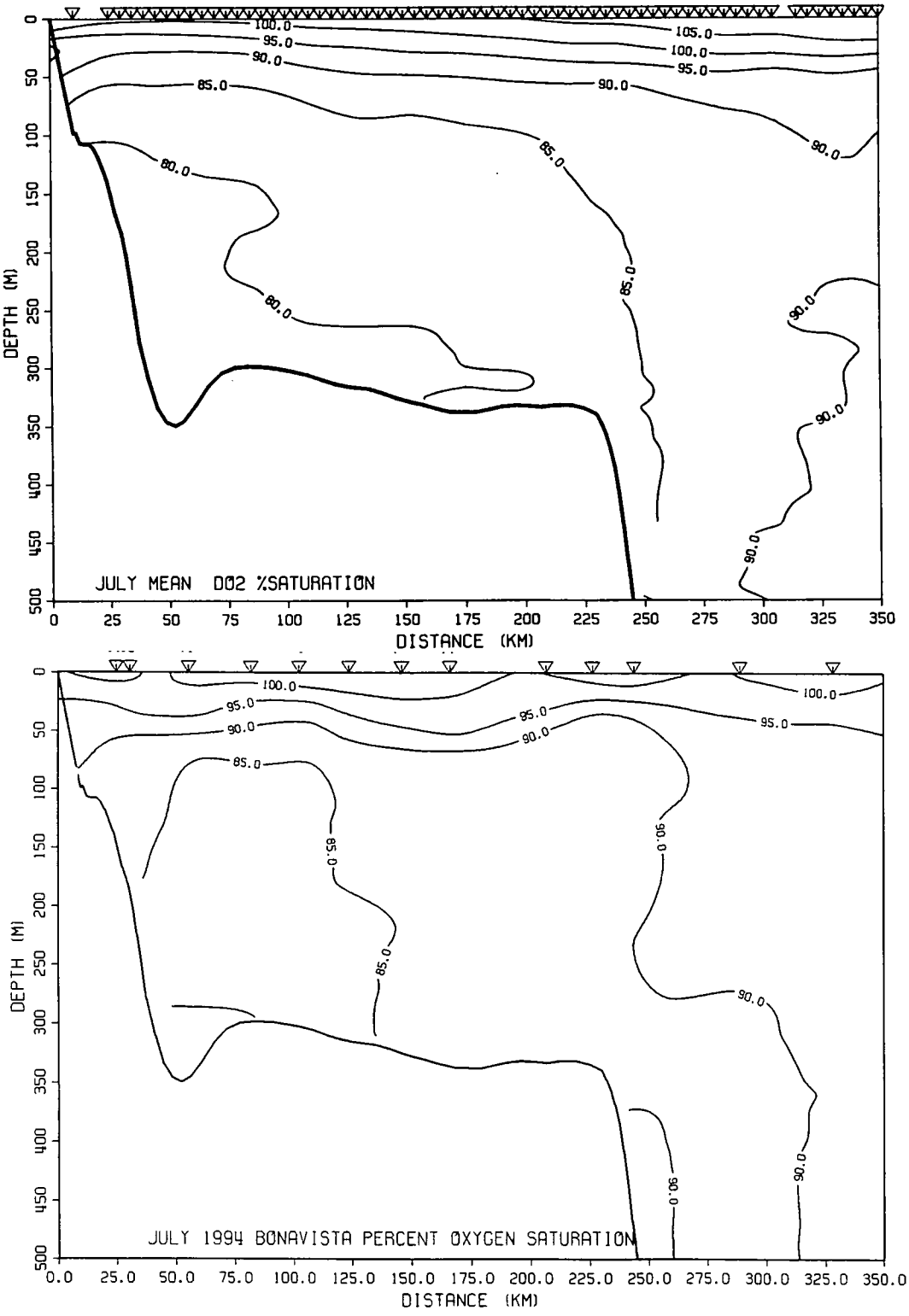

Fig. 8. The vertical distribution of dissolved oxygen saturation along the standard Bonavista transect for the average of historical data (top panel) and for July, 1994 (bottom panel).

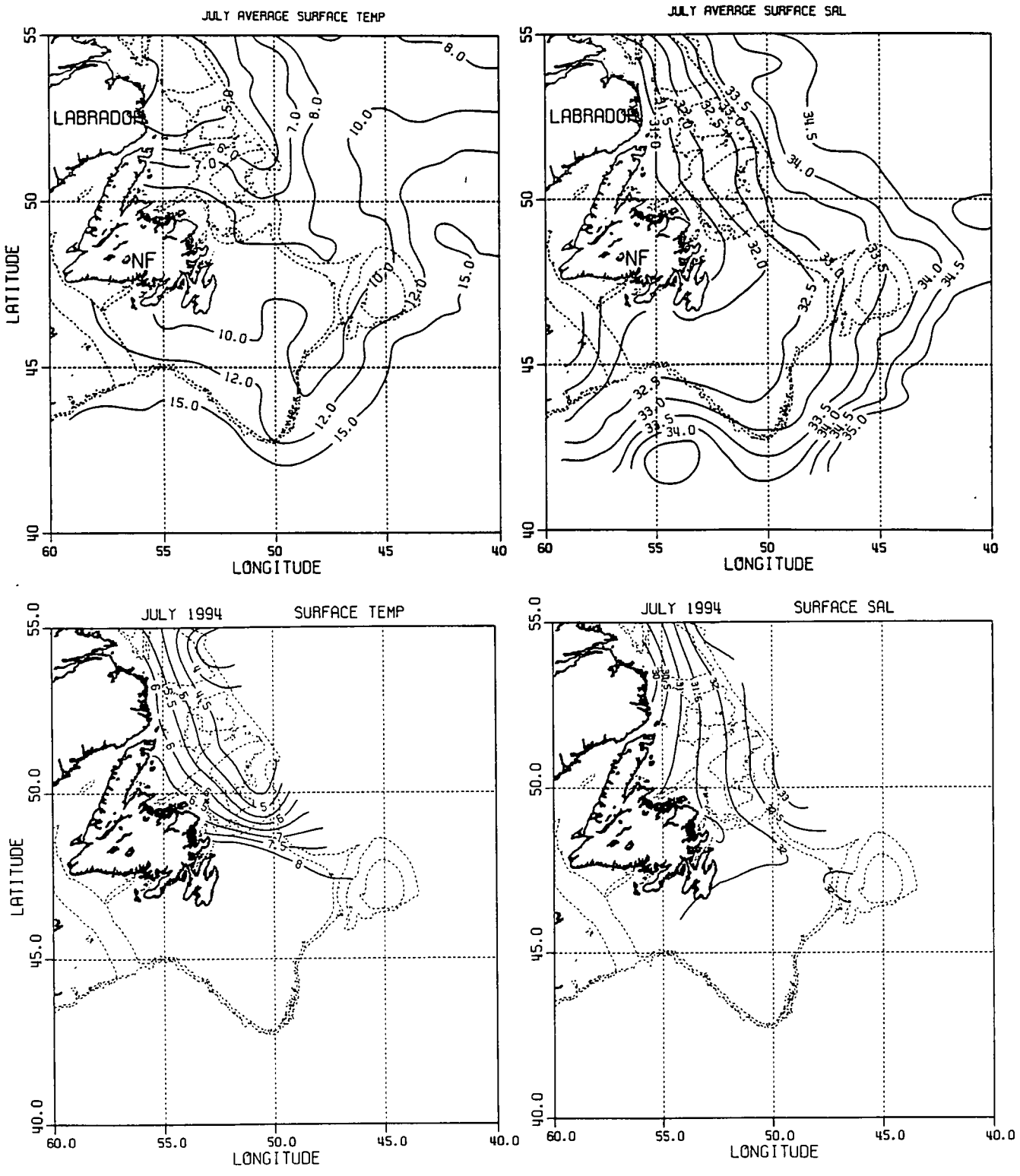

Fig. 9a. The July average (top panels) and July 1994 (bottom panels) surface horizontal temperature and salinity maps for the Newfoundland region.

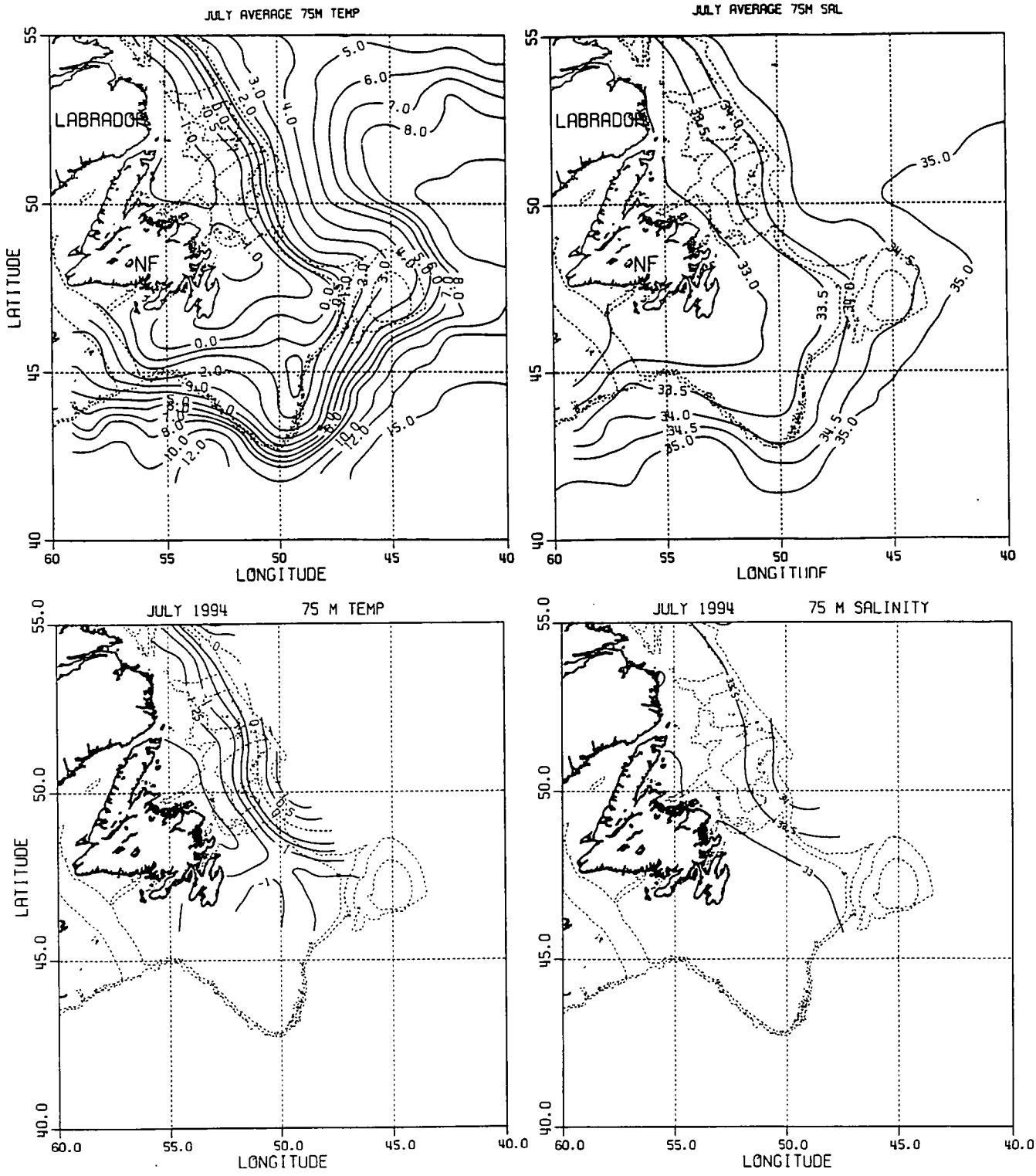

Fig. 9b. The July average (top panels) and July 1994 (bottom panels) 75 m horizontal temperature and salinity maps for the Newfoundland region.