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State-of-the-Ocean, Grand Banks Area (3L), Mid-Spring 1993, With a Comparison to the Mean

by

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INTRODUCTION

This report describes the state-of-the-ocean over the Grand Banks of Newfoundland during mid-spring 1993 with a comparison to the mean conditions based on all available historical data. The report presents a subset of the data collected on the first oceanographic cruise of the 1993 field season funded by the Northern Cod Science Program (NCSP) aboard the CSS PARIZEAU. This study is intended to provide information on oceanographic conditions during the inshore migration of northern cod to the bays along the east coast of Newfoundland at approximately one month intervals prior to, during, and after the peak cod migration. It was intended to make oceanographic measurements along transects running from the inshore areas of Conception Bay, Trinity Bay and Bonavista Bay and offshore to the shelf edge, however ice conditions prevented us from working north of Cape St. Francis. Instead the survey was conducted from the inshore areas along the Avalon Peninsula from Station 27 south to Cape Race and offshore to the shelf edge along the standard NAFO Flemish Cap transect. The survey then proceeded southwest along the shelf edge to Carson Canyon and shoreward to Cape Race. A final transect running from Cape Race across the northern Grand Banks in a northeasterly direction to the ice edge was conducted. Measurements along the transects included vertical profiles of current, temperature, salinity, chlorophyll and dissolved oxygen. In addition water samples were collected at each station for salinity, chlorophyll, oxygen and biological analysis.

METEOROLOGICAL AND ICE CONDITIONS

Figure 1 shows the monthly air temperature anomalies over Canada from January to April of 1993, 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, 1993). The anomalies are referenced to the 1951 to 1980 mean. In January air temperature anomalies were generally around -4.0 °C along the coast of Newfoundland and Labrador but had intensified to between -4.0 to -6.0 °C by February and warmed somewhat to -2.0 to -4.0 °C by March of 1993. The coldest monthly anomalies during the past three years occurred in January 1991 when the mean air temperature for the month dropped to -8.0 °C below normal. By early to mid-April of 1993 the air temperatures had moderated to between 0.0 to 4.0 °C above the mean. The negative air temperature anomalies experienced this past winter are a continuation of a cold trend that began during the late 1980s. 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.

Figure 2 shows the maximum extent of the ice edge (defined by one-tenth total coverage) during February to early May of 1993 together with the median and maximum positions of the ice edge for the period 1962 to 1987 along the coast of Newfoundland. The mid-monthly positions of the ice edge for 1993 were digitized from the daily ice charts published by Ice Central of Environment Canada, the median and maximum positions of the ice edge were published by Cote (1989).

The large upper layer negative water temperature (-1.0 to -2.0 °C) anomalies along the east coast of Newfoundland reported for the fall of 1992 (Colbourne, 1993) together with the large negative air temperature anomalies experienced during the winter of 1993 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, reaching south of 46° N latitude. By mid-April the ice edge had receded to about 47° N latitude and to about 48° N by early May as a result of favourable winds during the latter half of April. In general ice conditions along the east coast during the winter and early spring of this year were more severe than in 1992 but not as severe as in 1991, particularly in the inshore areas.

STATION 27 TIME SERIES

Figure 3 shows 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 and up to May 3, 1993, a total of 21 profiles. The anomalies were calculated from the mean of all data collected on the station since 1946.

The time series show upper layer (generally 0 to 50 m depth) temperatures decreasing from 0.0 °C in early January to -1.7 °C by early February, which persisted until early March. By the end of April and early May the temperature had again warmed to about 0.0 °C signalling the beginning of the seasonal warming. It is still to early in the season to compare this to the previous two years, however the temperature anomaly panel in Fig. 3 shows negative temperature anomalies ranging from -1.25 °C in January and between -0.50 to -0.75 °C by April in the upper layer. It was noted in a previous state-of-the-ocean report (Colbourne, 1992) that the seasonal warming of the upper mixed layer started in early May in 1992 compared to early June in 1991.

The figure shows the cold isothermal water column with temperatures ranging from -1.0 °C to -1.7 °C throughout the time series at depths below 80 meters. Temperature anomalies during this time period ranged from -1.25 to -0.5 °C over similar depth ranges.

Figure 4 shows monthly temperature and salinity anomalies at Station 27 from 1980 to May of 1993 at standard depths of 0, 30, 100 and 175 m again referenced to a 1946 to 1993 mean. At the surface the negative temperature anomalies that began in late 1990 and reached a peak in mid 1991 have continued into early spring of 1993. 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 at the surface and at 30 m depth show that the large fresher than normal anomaly that begin in early 1991 had returned to near normal conditions by the summer of 1992 and continued at near normal levels to the spring of 1993 over all depths. 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 large than average summer cold-intermediate-layer (CIL) areas on the continental shelf (Drinkwater, 1993).

VERTICAL TEMPERATURE DISTRIBUTION

Figure 5 shows contour plots of depth versus horizontal distance from the shore of the temperature and temperature anomaly field along the standard Flemish Cap transect for late April 1993. The observations were stopped short of the Flemish Cap due to ice conditions. The anomalies are calculated from the mean temperature field from mid-April to mid-May of all data available for the transect since the early 1930s. No attempts were made to adjust the mean for possible temporal aliasing arising from variations in the number of observations within this time interval.

The temperature in the upper 30 m of the water column ranged from -0.5 °C near the coast in the Avalon Channel to 0.5 °C over the middle of the Grand Banks. In deeper water (30 m to the bottom over the Grand Banks) the temperatures range from -1.0 to -1.5 °C with the coldest temperatures in the inshore Avalon Channel area and at the shelf break, about at the center of the inshore and offshore branches of the Labrador current (see Fig. 10). At the shelf break in about 200 m of water the temperature had increased to 0.0 °C, and to 3.5 °C at 500 m depth. The corresponding temperature anomalies ranged from -0.5 to -1.5 °C over the entire Grand Banks with the coldest anomalies in the offshore branch of the Labrador current. Figure 6 shows the corresponding salinities and anomalies along the Flemish Cap transect. The salinities generally range from 32.5 psu near the surface to 33.0 psu near the bottom over the Grand Banks to 35.0 psu at about 300 m depth. The salinity anomalies show fresher than normal conditions in the upper 50 m of the water column by up to 0.4 psu and near normal salinities near the bottom over most of the Grand Banks. In water depths greater than 150 m salinities were again up to 0.4 psu fresher than normal.

VERTICAL OXYGEN DISTRIBUTION

Figure 7 shows the oxygen data collected in conjunction with the temperature, salinity and chlorophyll data along the Flemish Cap transect. 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 220 water samples were collected at standard oceanographic depths for field oxygen calibrations. The oxygen levels of these samples were then determined by semi-automated analytical chemistry using a modified Winkler titration technique. A least-squares fit of the titration measurements to the electronic sensor measurements was then computed. The corrected sensor readings were found to be related by a linear equation with a slope of 1.1073 and an intercept of 0.3061 (ie. corrected probe value = 1.1073 x titration value + 0.3061).

This survey shows corrected dissolved oxygen levels of 7.5 ml/l near the bottom to 9.5 ml/l occurring near the surface over the Grand Banks. The corresponding oxygen saturations range from 100 % from the surface to about 90 m depth and to 90 % in the deeper water. The high oxygen values reported here probably resulted from the annual plankton bloom which usually starts in late March to early April in this area. The maximum oxygen levels observed here also coincided with the maximum in the relative chlorophyll signal obtained with a fluorometer connected to the Seabird-9 CTD system.

HORIZONTAL TEMPERATURE FIELD

Figure 8 shows horizontal maps of the near surface temperatures along the east coast of Newfoundland for the mid-April to mid-May period for all available data and from the data collected between April 26 to May 6, 1993. The 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 4.0 °C over the southern Grand Banks to 0.0 degrees °C over the northeast Newfoundland shelf. The surface temperatures during this cruise range from 0.0 to 1.0 °C. over the Grand Banks, about 1.0 °C below the mid-April to mid-May mean. Figure 9 shows the horizontal temperature field at 75 m depth (close to the bottom over most of the Grand Banks) during the same time periods. The average temperature at this depth ranged from 1.0 °C near the edge of the Banks to -1.0 °C over parts of the northeast Newfoundland shelf. The near bottom temperature over most of the Grand Banks in late April early May ranged from -1.5 to -1.0 °C, up to -1.5 °C below the mean.

THE LABRADOR CURRENT

The Labrador current along the transects occupied on this cruise was mapped with a hull-mounted 150 kHz RDI Acoustic Doppler Current Profiler (ADCP) at a spatial resolution of 4.0 m vertically by 1.5 km horizontally. Figure 10 shows the vertical distribution of currents along the Flemish Cap transect, the negative values correspond to southward flowing water. Preliminary analysis of this data show a well defined offshore branch up to 200 meters deep with current velocities reaching 40 cm/s (just under 1 knot) in a general southerly alongshelf direction. This branch of the current is much stronger than the inshore branch which was mainly restricted to the Avalon Channel with peak speeds of about 20 cm/s. Apparent counter currents (northward flowing water) with speeds up to 10 cm/s near the middle of the Grand Banks were observed. 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 barotrophic 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 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 Parizeau.

REFERENCES

Saulesleja, A., 1993. Climate Perspectives, Monthly and Weekly Reviews. Vol 15.

Cote, P. W. 1989. Ice limits eastern Canadian seaboard. Environment Canada, Ottawa. 39 p.

Colbourne, E. B., 1993. Oceanographic Conditions during the Annual Fall Groundfish survey in NAFO Divisions 2J3K. Fisheries Oceanographic Subcommittee working paper 93/44.

Colbourne, E. B., 1992. State-of-the-ocean, NAFO subarea 3L, spring 1992 with a comparison to 1991. (unpublished)

Drinkwater, K. F. 1993. Overview of Environmental Conditions in the Northwest Atlantic in 1992. NAFO SCR Doc. 93/45, 48p.

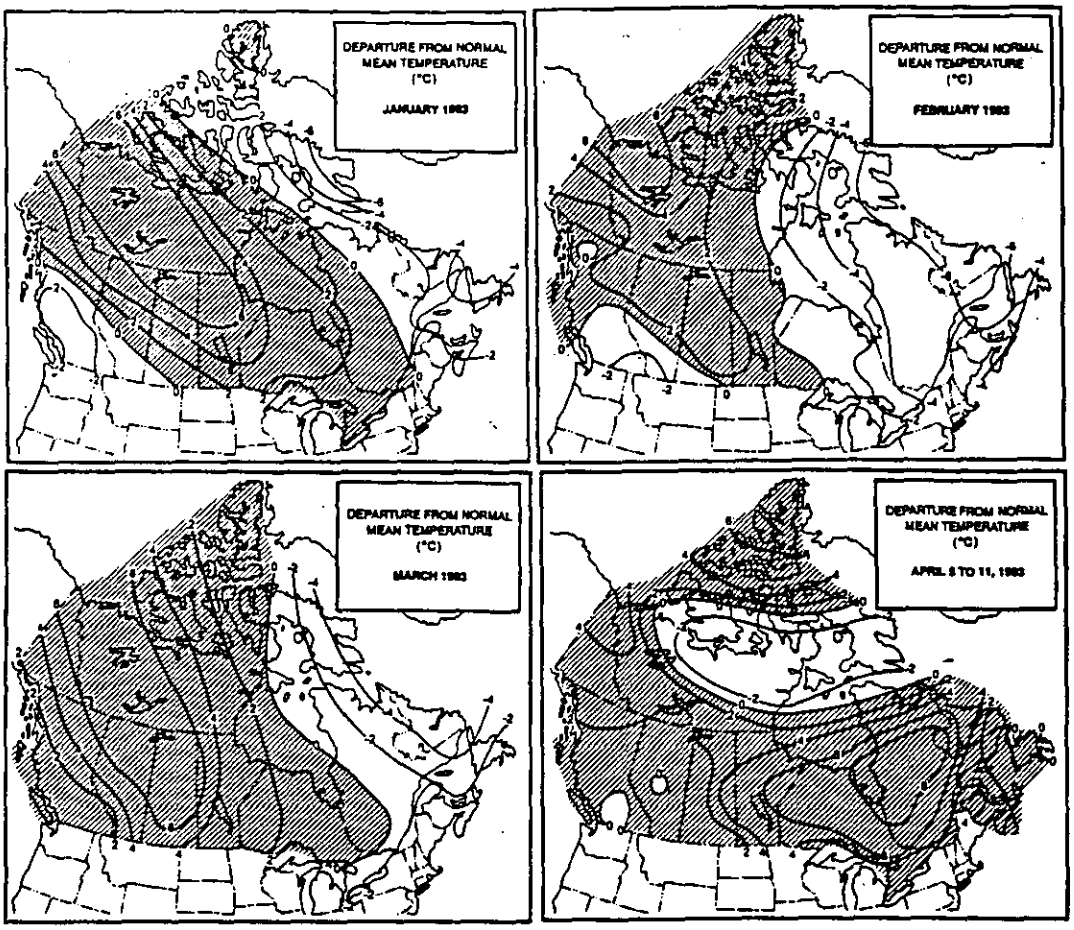

Fig. 1. Monthly air temperature anomalies over Canada for the winter and early spring of 1993. (From Climatic Perspectives, Vol. 15, 1993)

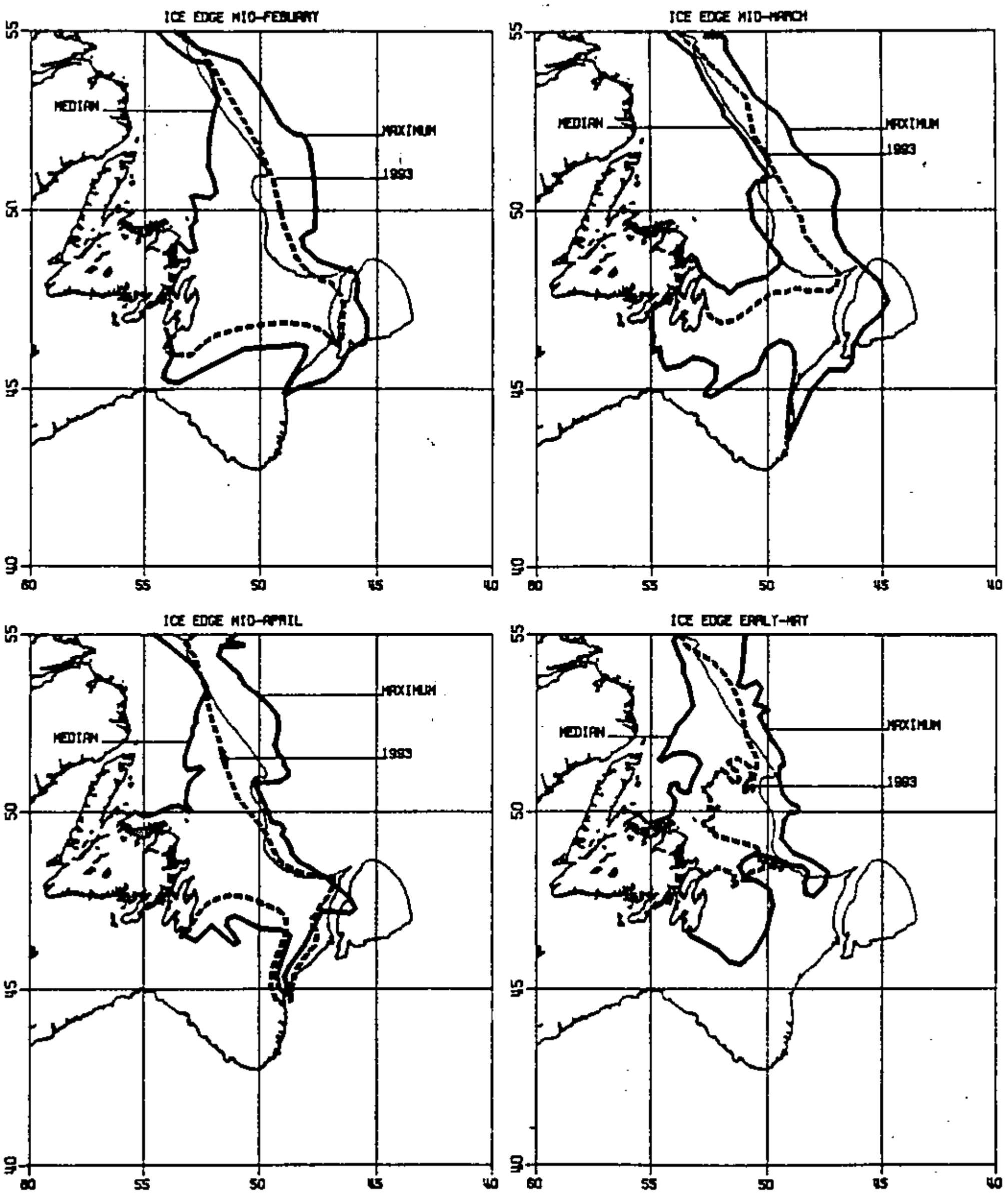

Fig. 2. Ice edge locations for mid-February to early May. The dashed lines are locations for 1993, the two heavy solid lines are the median and maximum positions for the same time period based on historical data from 1962 to 1987. (from Cote, 1989)

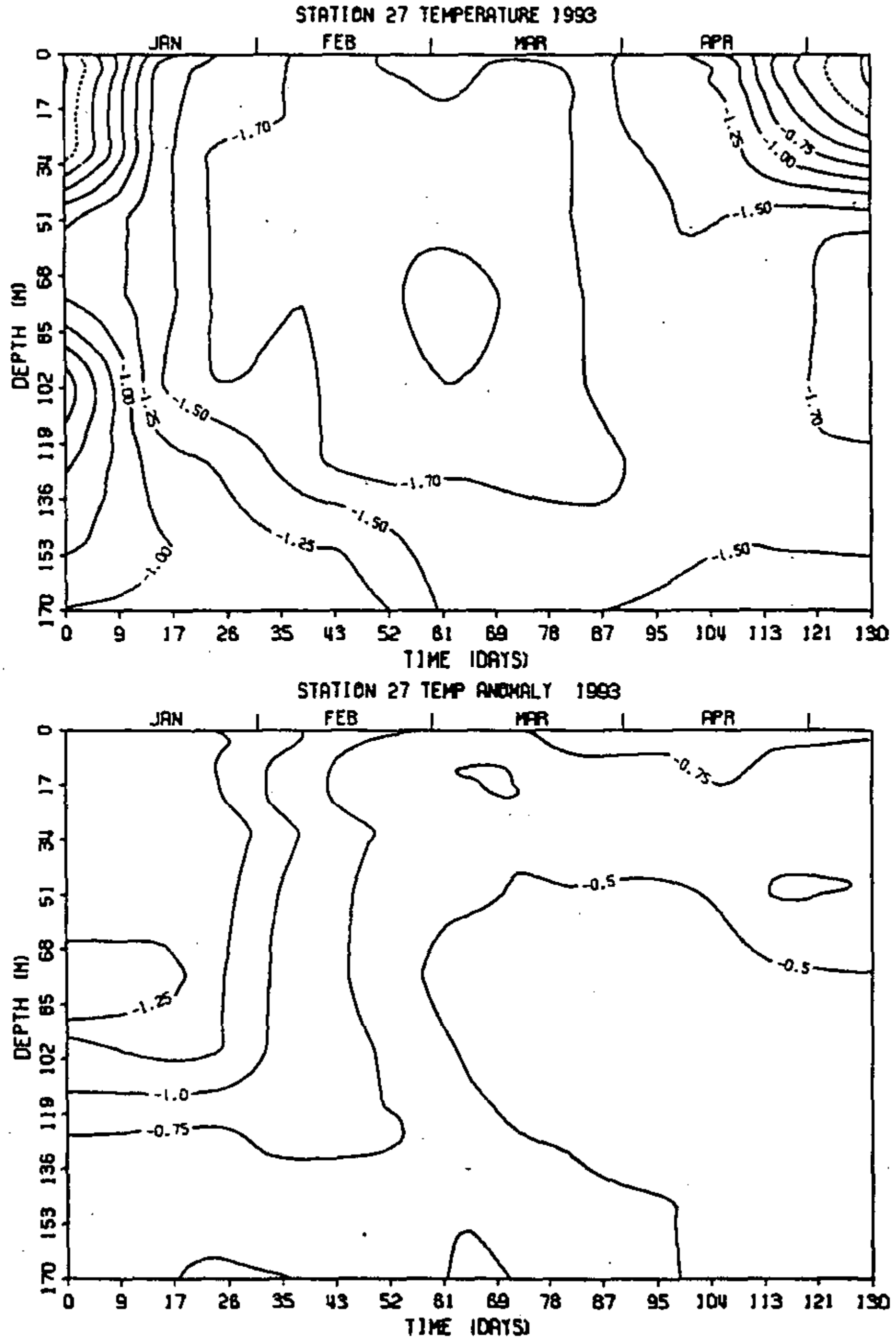

Fig. 3. Time series of temperatures and anomalies at Station 27 from January to May 3, 1993.

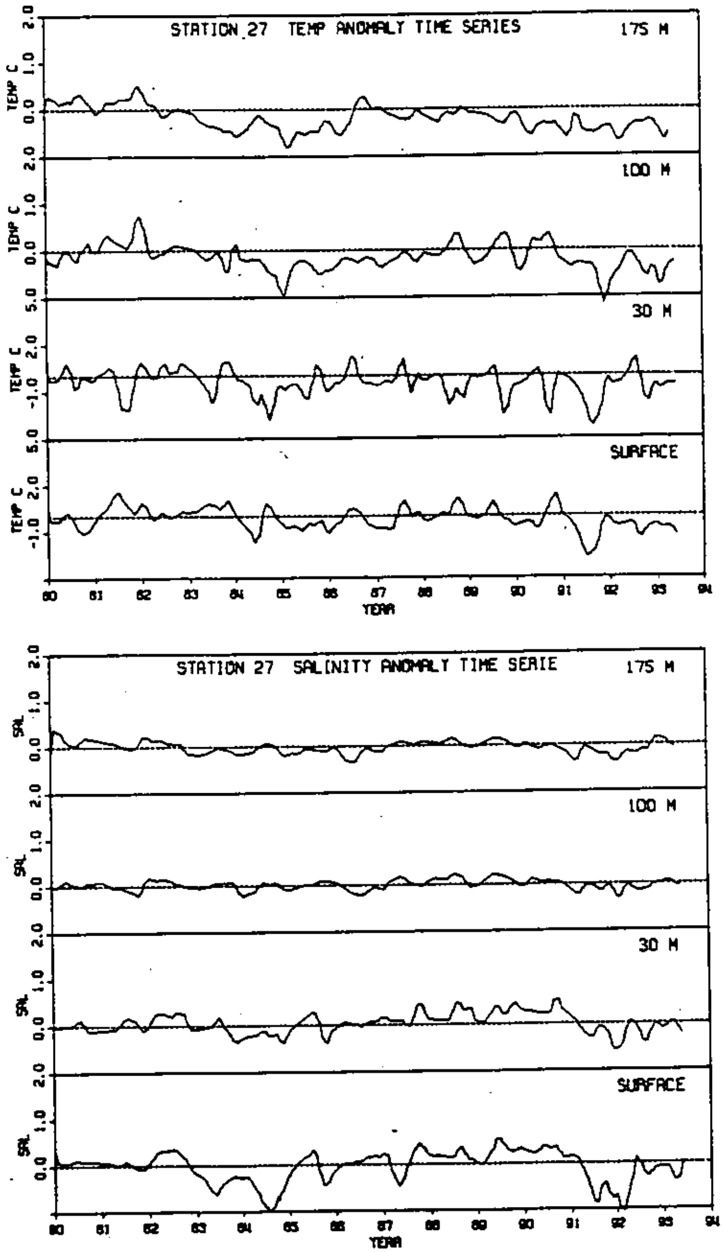

Fig. 4. Time series of monthly temperature and salinity anomalies at Station 27 at standard depths.

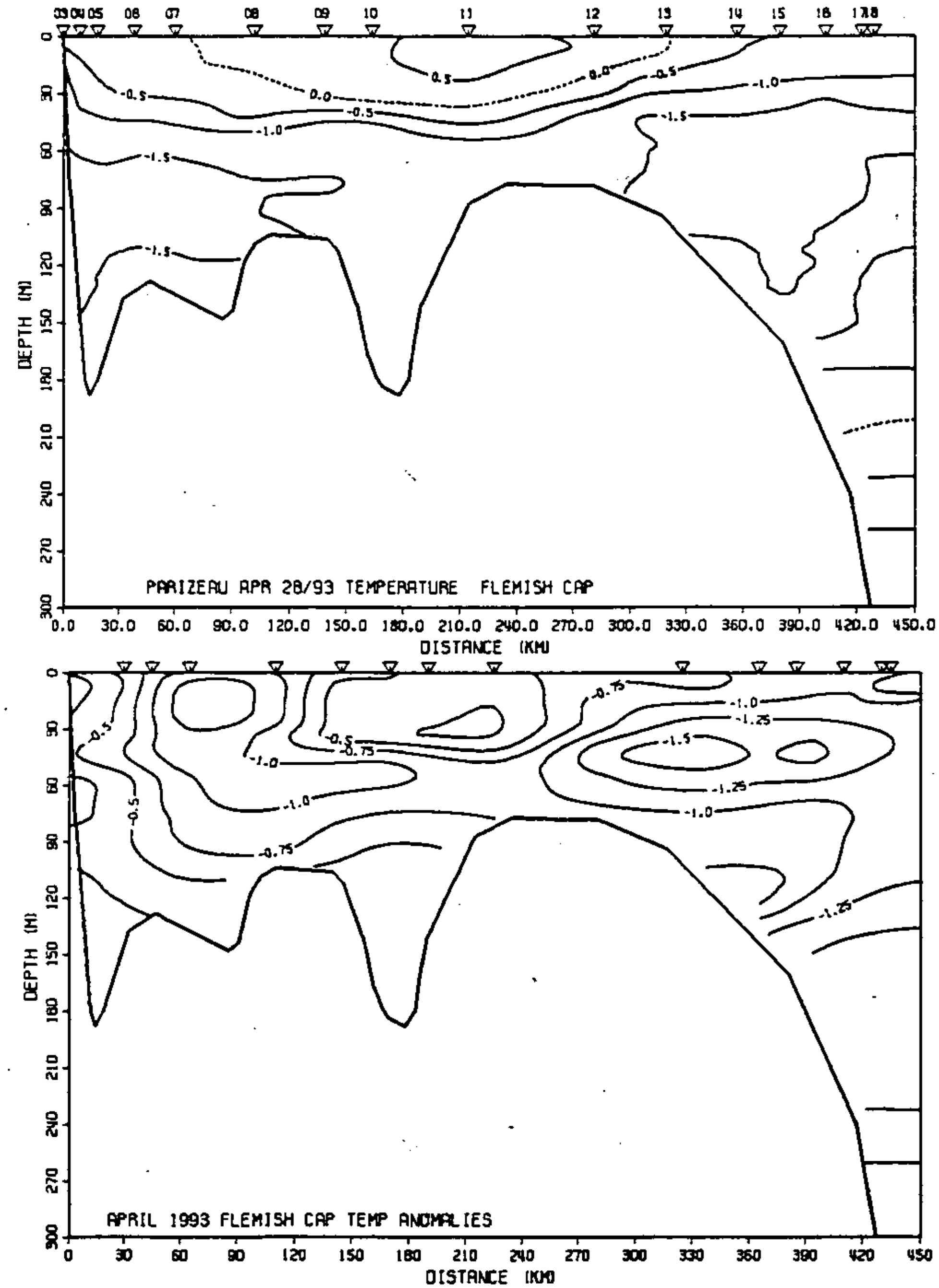

Fig. 5. The vertical distribution of temperature and anomalies along a portion of the Flemish Cap transect.

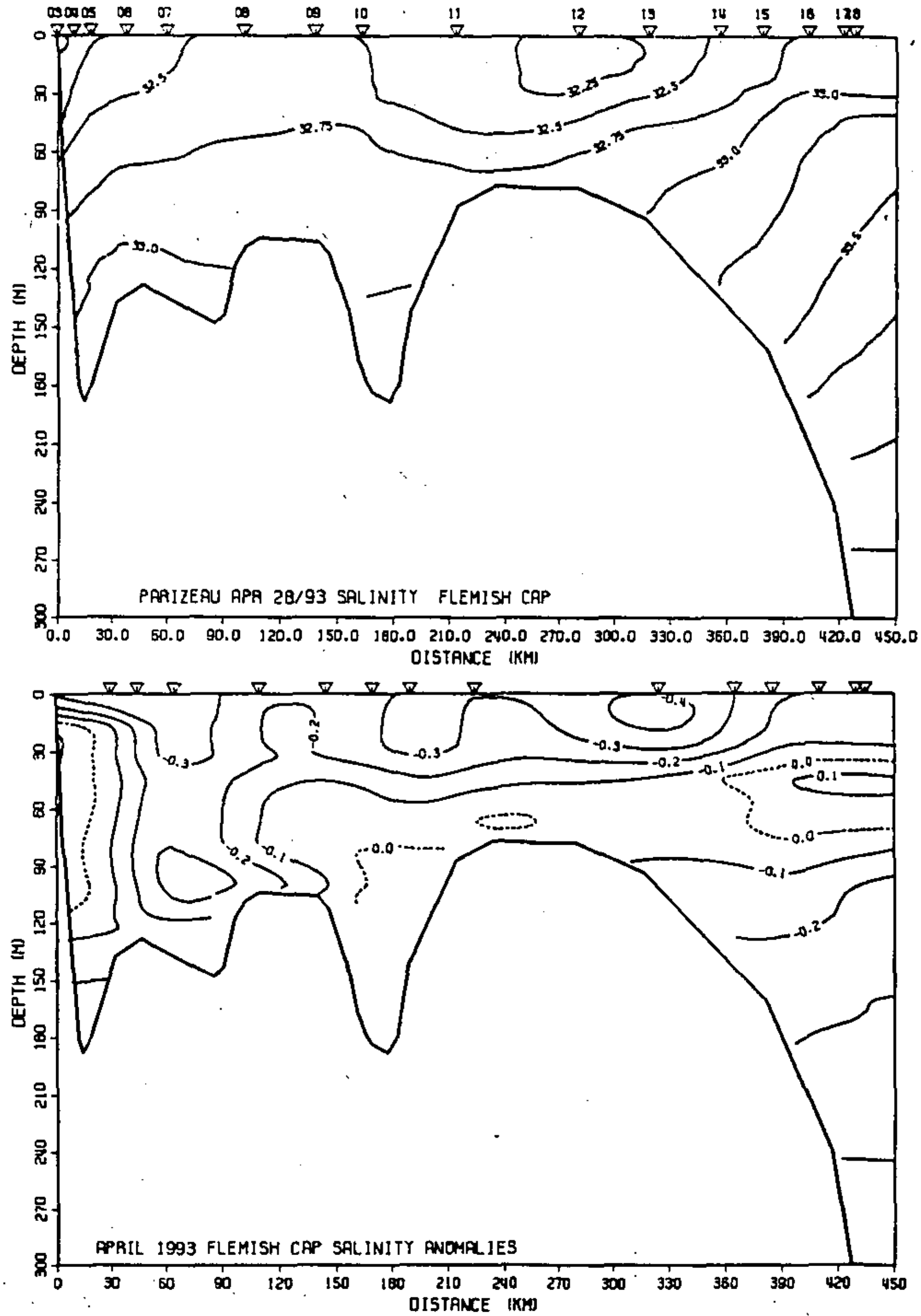

Fig. 6. The vertical distribution of salinity and anomalies along a portion of the Flemish Cap transect.

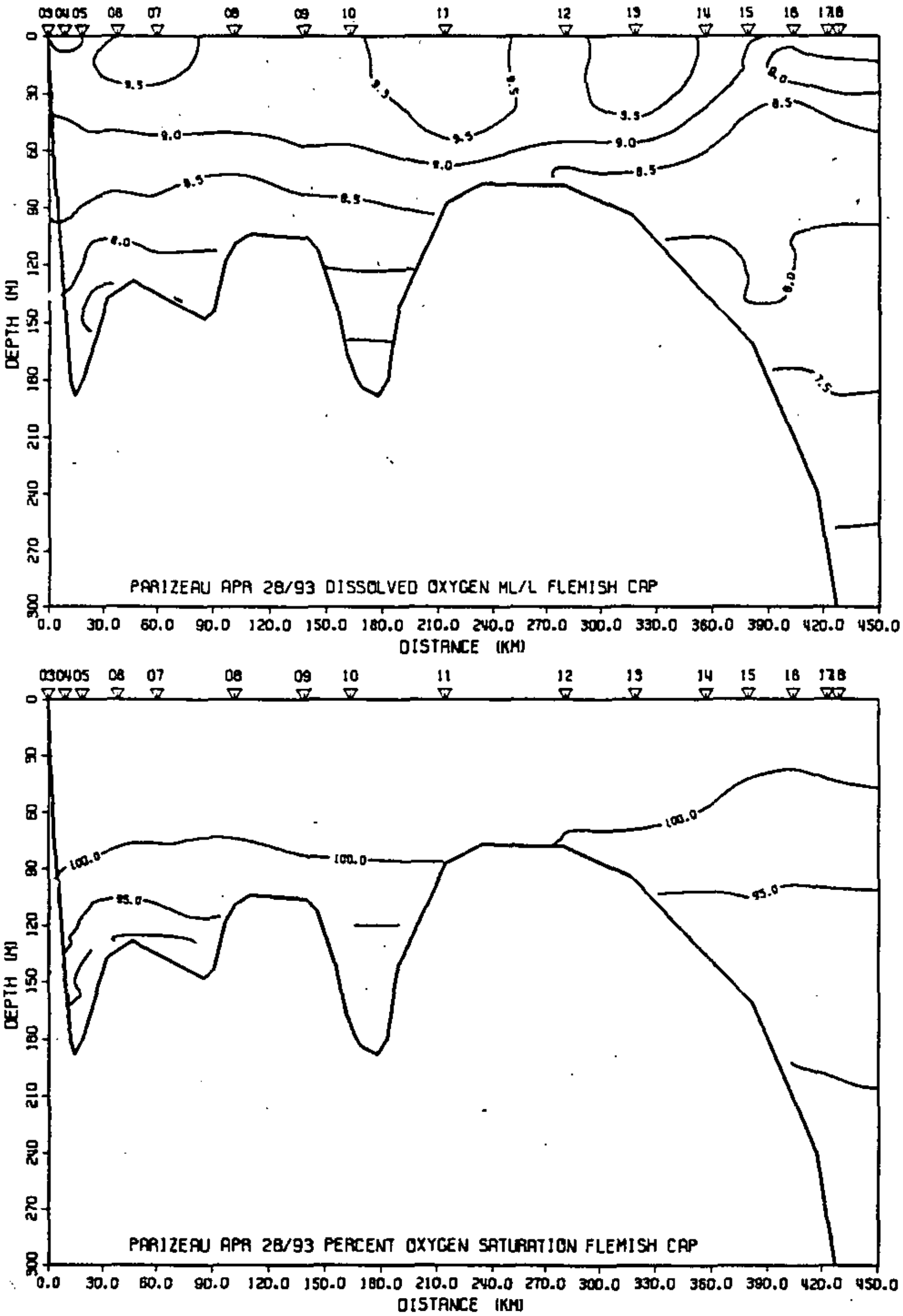

Fig. 7. The vertical distribution of dissolved oxygen concentration and saturation along a portion of the Flemish Cap transect.

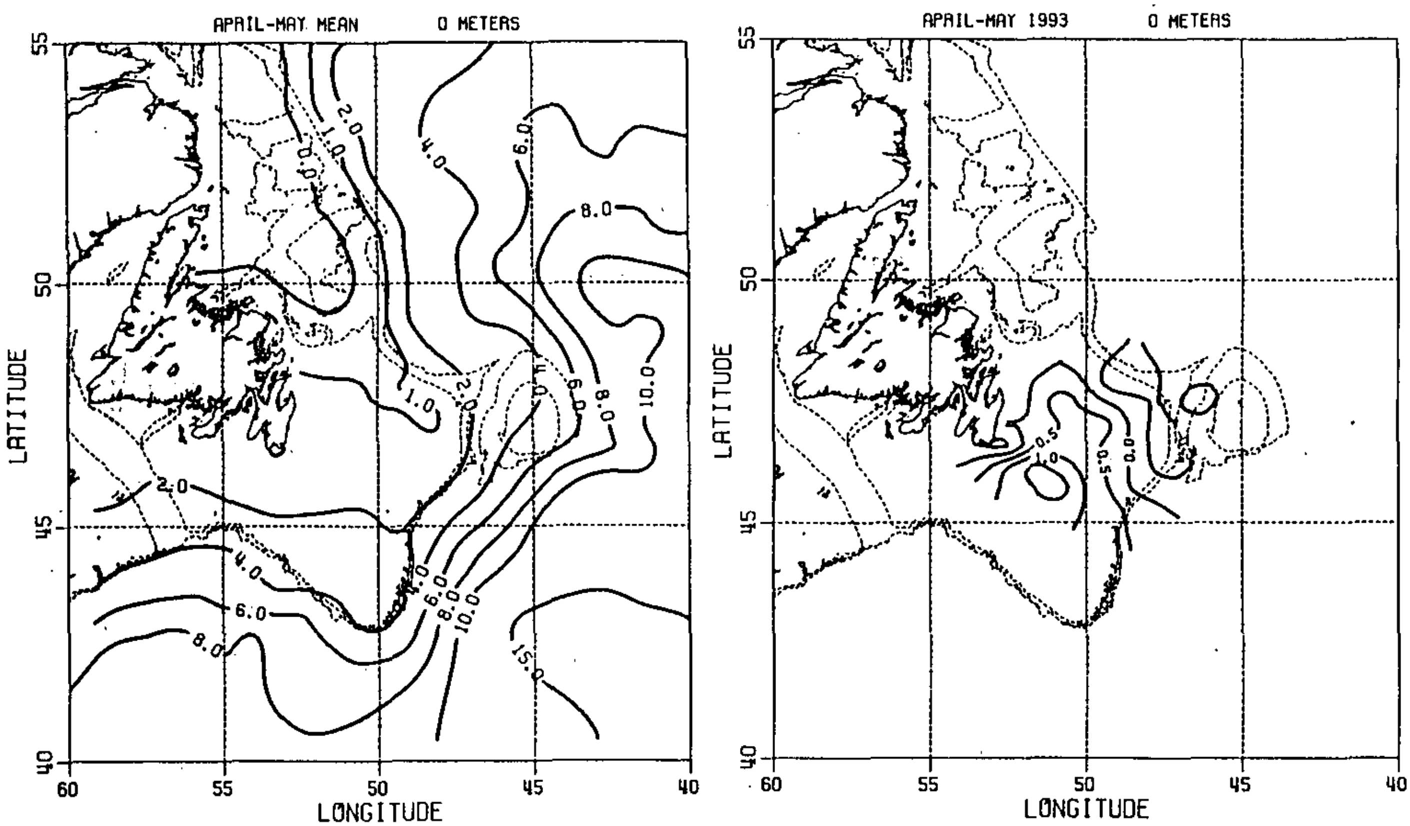

Fig. 8. The mean and late-April-early May, 1993 horizontal surface temperature maps for the Newfoundland region.

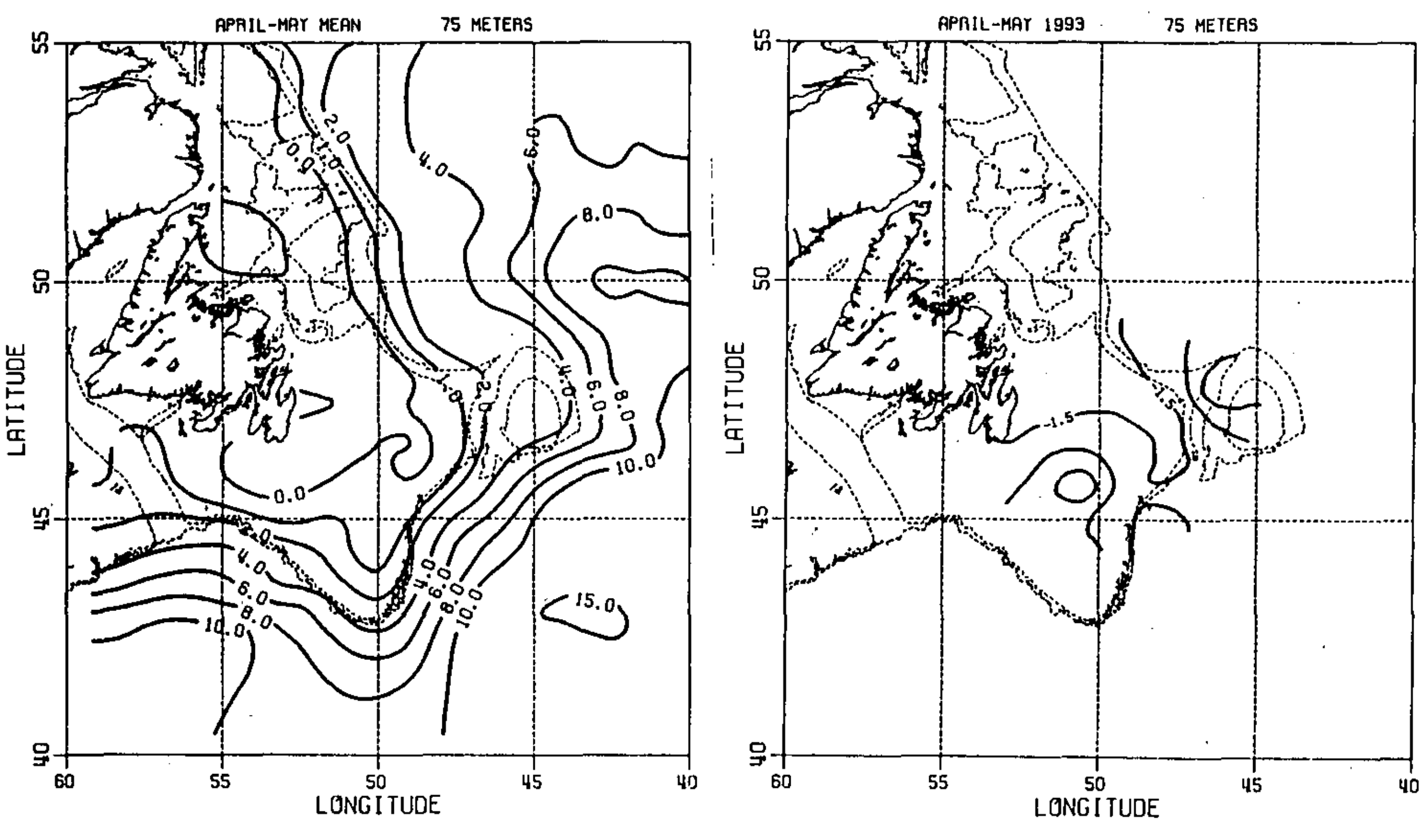

Fig. 9. The mean and late-April-early-May, 1993 horizontal temperature maps at 75 m depth for the Newfoundland region.

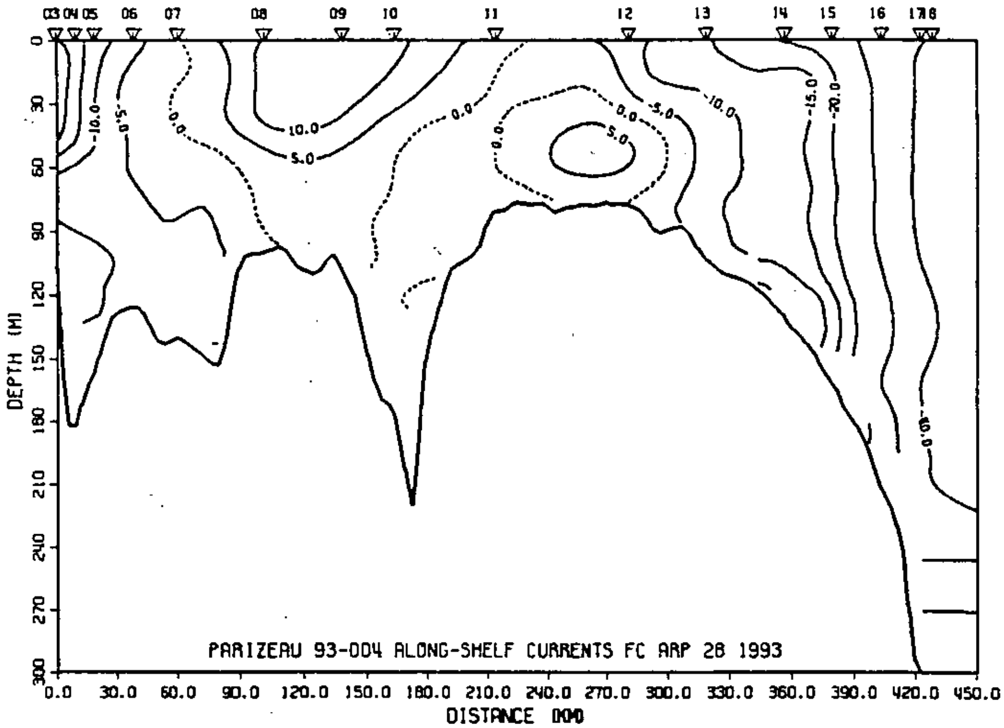

Fig. 10. The vertical distribution of the current field along a portion of the Flemish Cap transect. Negative currents are southward, from the ADCP survey.