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Northwest Atlantic Fisheries Organization

Serial No. N2699 NAFO SCR DOC. 96/26

SCIENTIFIC COUNCIL MEETING - JUNE 1996

Environmental Conditions on the Newfoundland Shelf, Spring 1996 with Reference to the 1961-1990 Normal

by

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ABSTRACT

Oceanographic observations from the Grand Bank and the northeast Newfoundland Shelf during the spring of 1996 are presented and compared to historical (1961-1990) data from the area. In addition, ice cover data from the winter and spring are also presented. The analysis indicate that the moderate air temperatures experienced in Atlantic Canada during late fall of 1995 and winter of 1996 gave rise to below normal ice cover extent and concentration during winter and early spring of 1996 along the east coast of Newfoundland and Labrador which led to early ice clearing along the Newfoundland coast. At Station 27 the warming trend that began during the fall of 1995 continued into the winter and spring of 1996 with temperatures approaching 0.5 °C above normal by March over the entire water column. Salinities were near normal at Station 27 during winter and spring of 1996. Temperatures on the Grand Bank and along the east coast of Newfoundland were up to 1.0 °C above normal over much of the water column consistent with the lack of spring ice cover. The cold-intermediate-layer (CIL) was below normal along the Flemish Cap and Bonavista transects continuing a trend established in 1994 along the Bonavista transect. In general, the meteorological, ice and oceanographic conditions during the spring of 1996 continue to show a moderating trend that started in 1994 compared to the anomalous conditions of the early 1990s.

INTRODUCTION

This report updates environmental conditions in the Newfoundland region during the winter and spring of 1996, with a comparison to the average conditions based on historical data from the period 1961-1990 in accordance with the convention of the World Meteorological Organization and the NAFO Scientific Council. The 1996 observations were made during a spring oceanographic survey conducted by the Canadian Department of Fisheries and Oceans to the Grand Bank and along the east coast of Newfoundland from April 24 to May 3 aboard the CSS Parizeau. In addition, all Station 27 data collected since January of 1996 by fisheries research surveys are included in the analysis. The report also presents sea ice cover data for Atlantic Canada during the winter and spring of 1996.

During the spring 1996 survey oceanographic measurements were made along transects running from Cape Race to the southeast Grand Bank, along 47 °N (Flemish Cap transect) and along the Bonavista transect (Fig. 1). The measurements were made along the transects from nearshore along the east coast of Newfoundland and offshore to the shelf edge in about 2000 m of water. Measurements included vertical profiles of currents, temperature, salinity, chlorophyll and dissolved oxygen. In addition, water and plankton samples were collected at some stations for salinity, chlorophyll, oxygen and biological analysis.

ICE CONDITIONS

The maximum extent of the ice edge (defined by one-tenth coverage) during mid-January to mid-May of 1996 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 1996 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).

During 1995 water temperatures in many areas along the east coast of Newfoundland experienced a general warming trend, for example, the CIL along the Bonavista transect and across Hamilton Bank was the lowest in about 10 years (Colbourne 1996) this together with above normal air temperature during the winter of 1996 (February air temperature was 2-4 °C above normal, Yip 1996) resulted in normal ice extent (defined by 1/10 coverage) during January. By mid-February to mid-March the ice edge extended further offshore than normal in the northern areas but remained below normal coverage in the southern areas along the Newfoundland coast. By mid-April the ice edge had receded to below normal limits with only a narrow area of ice along the northeast coast and by mid-May the ice edge was located over Hamilton Bank, well north of the seasonal normal. It should also be noted that even though the total ice coverage (as defined by 1/10 coverage) approached normal limits during the winter months the ice concentration in many areas on the northeast coast of Newfoundland only ranged from 4 to 6 tenths, considerably lighter than normal.

Shown in Figure 3 are the cumulative percentage of total ice area south of 55 °N latitude along the east coast of Newfoundland and Labrador from January to June, for 1992 a heavy ice year and for 1996 a light ice year. During the first three months of each year the cumulative ice areas based on 1/10 coverage appears near normal with about 70 % of the years total reached by mid-March. In 1992 the total accumulated ice area for the year was not reached until mid-June indicating a late ice year whereas during 1996 about 98 % of the accumulated total was reached by mid-April indicating an early ice clearing season.

In general, ice conditions along the east coast during the winter and early spring of 1996 were among the lightest on record in terms of ice cover extent, concentration and duration. The southern most extent of the ice edge along the east coast of Newfoundland occurred during mid-March when the ice reached south to about 50 °N latitude. The complete absence of pack ice along the east coast south of 50 °N meant that the atmospheric heat flux that normally melted sea ice during the spring was available to heat the water column. Assuming that the normal thickness of sea ice is approximately 1.0 m we can estimate an equivalent temperature rise of the water column from $L\,\Delta h = \rho C_p \Delta T\,H$ where L is the latent heat of fusion for water, about 3.4 X 10^8 joules/m^3, Δh is the thickness of ice, ρ is the density of seawater, C_p is the heat capacity of water and ΔT is the associated temperature anomaly over the water depth H. If we assume that the effect of the absence of 1.0 m of ice is felt only in the top 100 m of the water column then ΔT is about 0.8 °C, implying that the water column temperature should be about 0.8 °C warmer than normal.

STATION 27 TEMPERATURE AND SALINITY

The Station 27 monthly temperature and salinity anomalies at standard depths of 0, 20, 30, 50, 75, 100, 150 and 175 m are shown in Figs. 4 and 5. These anomalies are based on a total of 20 profiles collected from January to May of 1996 and are referenced to a 1961 to 1990 normal. The value for May is based on four observations from May 1 to May 17 and hence may be biased low.

The above normal temperatures that began during the fall of 1995 over most of the water column continued into the winter and spring of 1996. For example, temperatures during March were 0.5 °C above normal from the surface to the bottom at 176 m depth. In fact, the bottom temperatures during the winter of 1996 are the warmest observed at Station 27 since the early 1980s. The large fresher than normal upper layer salinity anomaly observed during the summer of 1995 (Colbourne 1996) returned to normal conditions during the fall of 1995 and continued near normal into the winter and spring of 1996 over all depths.

VERTICAL TEMPERATURE AND SALINITY DISTRIBUTION

The vertical distribution of the temperature and salinity fields together with the anomalies along the standard Flemish Cap (47 °N) transect and the Bonavista transect for the spring of 1996 are presented in Figs. 6 to 8. The anomalies were calculated from the mean of all available data for the transect from 1961 to 1990 during a time period of two weeks on either side of the 1996 survey.

The spring temperature along the Flemish Cap transect (Fig. 6) ranged from 1.0 °C near the surface to -0.5 °C below 75 m in the Avalon Channel and at the edge of the continental shelf and about 3.0 to 3.5 °C over in the Flemish Pass and out over the Cap in the depth range from 80 m to the bottom. At the surface over the Flemish Cap temperatures reached 5.0 °C. These temperatures were more than 1.0 °C above normal in the upper layer over the Grand Bank and Flemish Cap and about 0.5 °C above normal in the depth range of 50 m to the bottom. Upper layer salinities (Fig. 7) were saltier than normal over the Grand Bank by more than 1.0 psu near the surface and to between 0.4 to 0.6 psu in deeper water over the Banks. This is consistent with a decrease in local freshwater input from melting sea ice.

Temperatures along the Bonavista transect (Fig. 8) in the upper 50 m of the water column ranged from -0.5 °C to 0.5 °C near the coast and to 2.0 to 3.0 °C over the outer most portion of the transect. In deeper water (50 m to the bottom) temperatures ranged from -0.5 °C to -1.0 °C near the coast and to 0.0 °C to 3.0 °C further offshore near the edge of the continental shelf and beyond. The corresponding temperature anomalies ranged from 0.25 to 0.5 °C above normal in the surface layer within 100 km of the shore and up to 1.5 °C above normal over the outer continental shelf areas. At mid-depths in the offshore branch of the Labrador Current temperatures remained from 0.25 to 0.5 °C below normal. In general these anomalies are consistent with the expected increase in temperature calculated above based on the absence of ice along the coast during the spring.

THE COLD INTERMEDIATE LAYER (CIL)

As shown earlier in Figs. 6 and 8 the vertical temperature structure on the Newfoundland Continental Shelf is dominated by a cold layer of water, commonly referred to as the CIL (Petrie et al., 1988), trapped between the seasonally heated upper layer and warmer slope water near the bottom. This feature undergoes large seasonal variations with the cross-sectional area of water reaching its maximum in January (Fig. 9) as the upper layer cools. By spring the warming of the upper layer commences and the cross-sectional area of sub-zero °C water decreases and reaches its minimum by October along the Bonavista transect and by December along the Flemish Cap transect. The variation in the area of sub-zero °C water along the Flemish Cap transect (Grand Bank portion) is mainly influenced by the seasonally heated upper layer. During winter and early spring when the entire water column on the Grand Bank is below 0.0 °C the CIL reaches its maximum at about 45 km^2 after which it decreases to approximately 25 km^2 by May and remains nearly constant during the summer.

During the spring of 1996 the total area of sub-zero °C water was below the long-term normal along both the Bonavista and Flemish Cap transects. During the period of 1990-1993 the total area of sub-zero °C water along the Bonavista transect was significantly above normal from spring to fall (Fig 9). The recent observations indicate a continuation of the warmer than normal conditions observed during the summer of 1995 when the CIL was the lowest in about 10 years along the Bonavista transect (Colbourne 1996). In general the anomalous meteorological, ice and oceanographic conditions of the early 1990s (Drinkwater, 1994; Colbourne et al. 1994; Findlay and Deptuch-Stapf 1991) have moderated significantly over the last couple of years or so.

ACKNOWLEDGEMENTS

I thank the technical staff of the oceanography section at NAFC for the professional job in data collection and processing and for the computer software support. I also thank the many scientists at the NAFC for collecting and providing much of the data contained in this analysis and to the Marine Environmental Data Service in Ottawa for providing most of the historical data. I would also like to thank the captain and crew of the CSS Parizeau.

REFERENCES

Colbourne, E. B., S. Narayanan, and S. Prinsenberg. 1994. Climatic Change and Environmental Conditions in the Northwest Atlantic during the period 1970-1993. ICES mar. Sci. Symp., 198:311-322.

Colbourne, E. 1996. Oceanographic conditions in the Newfoundland Region During 1995 with comparisons to the 1961-1990 Average. DFO AFRD. 96/1.

Colbourne, E. B. and D. R. Senciall. 1993. Temperature, salinity and density along the standard Bonavista transect. Can. Tech. Rep. Hydrogr. Ocean Sci. 150: V+311 p.

Colbourne, E. B. and D. R. Senciall. 1996. Temperature, salinity and sigma-t along the standard Flemish Cap transect. Can. Tech. Rep. Hydrogr. Ocean Sci. 172: V+222 p.

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

Drinkwater, K. F. 1994. Overview of Environmental Conditions in the Northwest Atlantic in 1993. NAFO SCR Doc. 94/20, Ser. No. N2385. 61p.

Findlay, B.F., and Deptuch-Stapf, A. 1991. Colder than normal temperatures over northeastern Canada during the 1980s. Climate Perspectives, April Monthly Review, 13:9-12.

Petrie, B., S. Akenhead, J. Lazier and J. Loder. 1988. The Cold Intermediate Layer on the Labrador and Northeast Newfoundland Shelves, 1978-1986. NAFO Sci. Coun. Stu. 12: 57-69.

Yip T. 1996. Canadian Climate Summary, February Monthly Review. Vol 1.

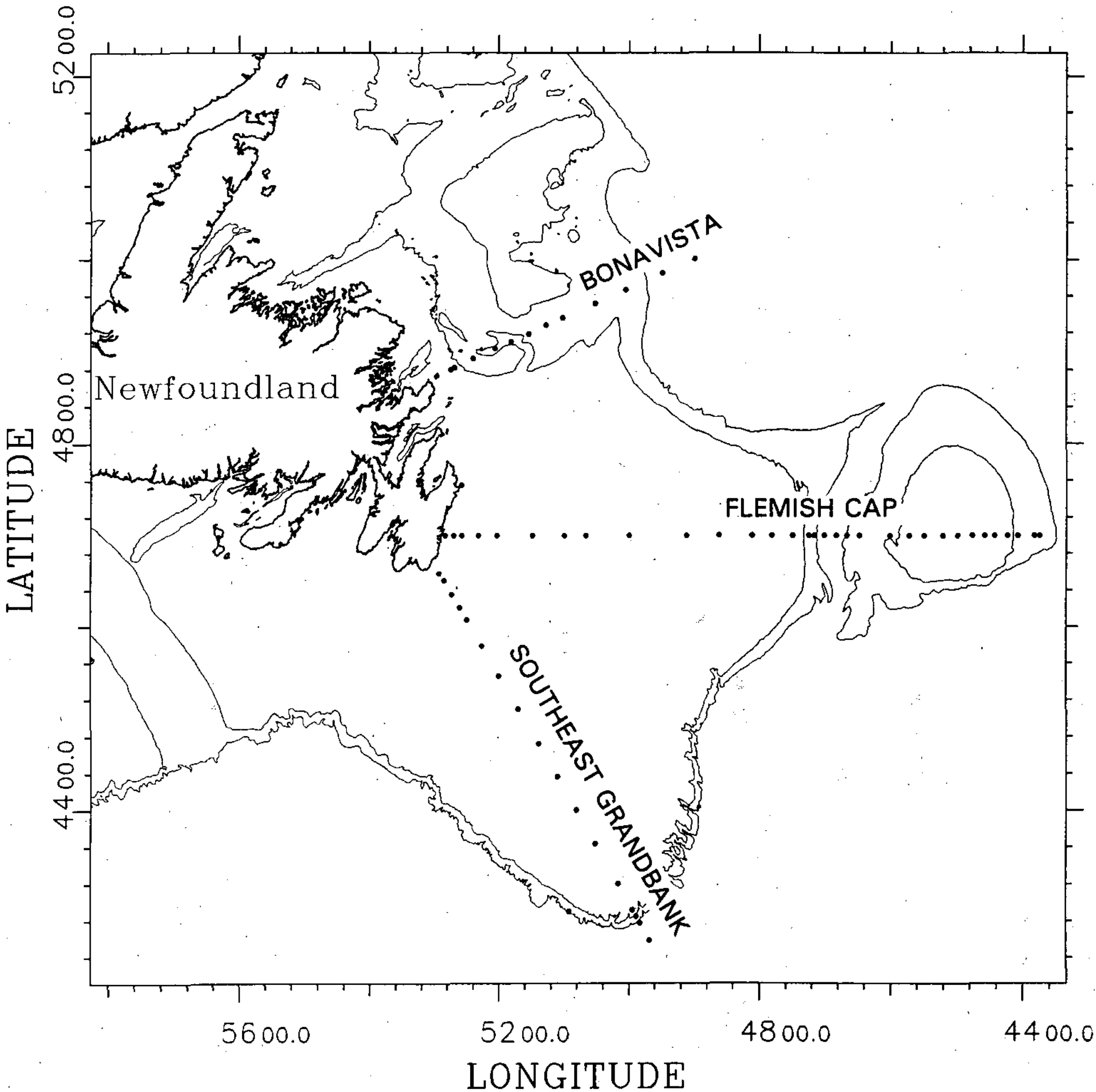

Fig. 1. Location map showing positions of the stations occupied during the spring 1996 oceanographic survey. The bathymetry lines are 300 and 1000 m.

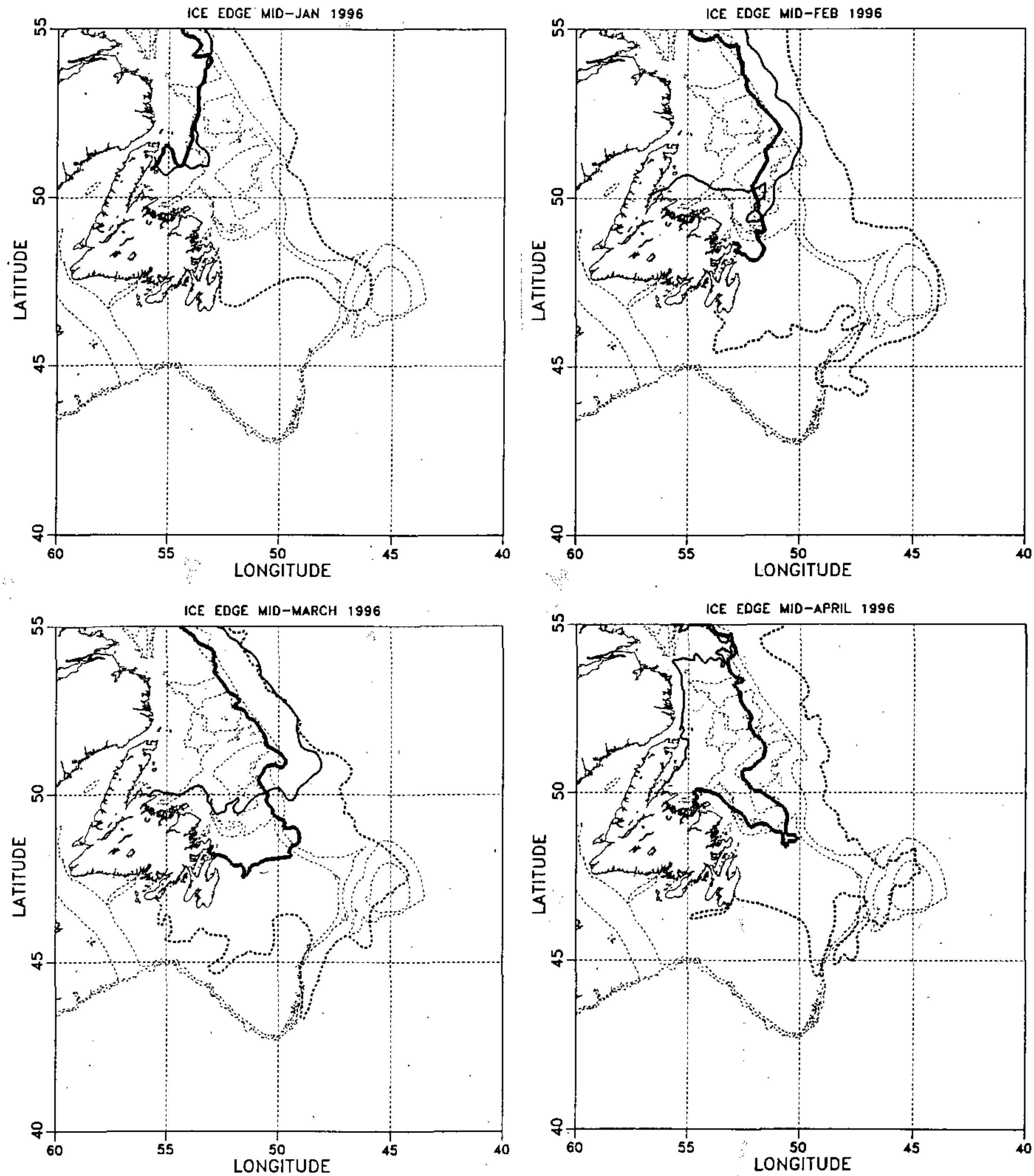

Fig. 2. Ice edge locations for mid-January to mid-April of 1996 (light solid lines). The dashed and heavy solid lines are locations for the maximum and median positions for the same time period based on historical data from 1962 to 1987. (from Cote, 1989)

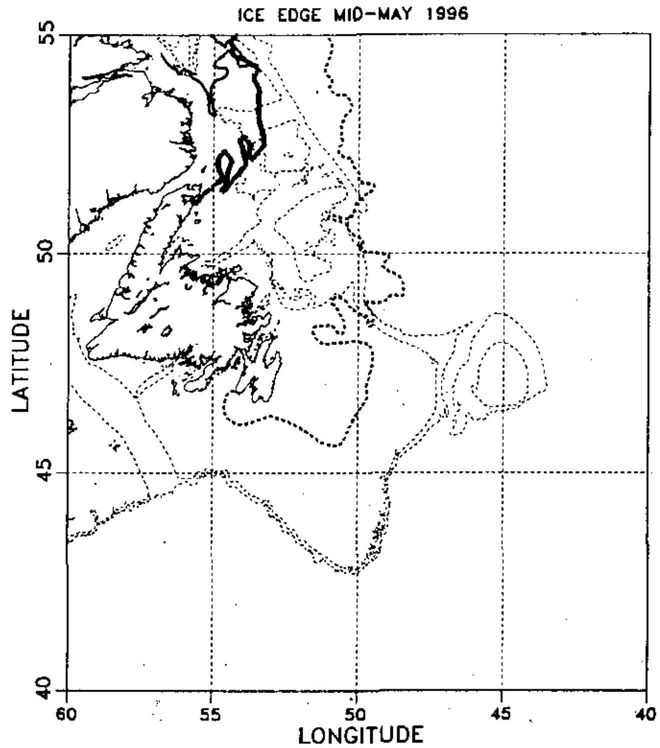

Fig. 2 (cont).Ice edge locations for mid-May of 1996 (light solid lines). The dashed and heavy solid lines are locations for the maximum and median positions for the same time period based on historical data from 1962 to 1987. (from Cote, 1989)

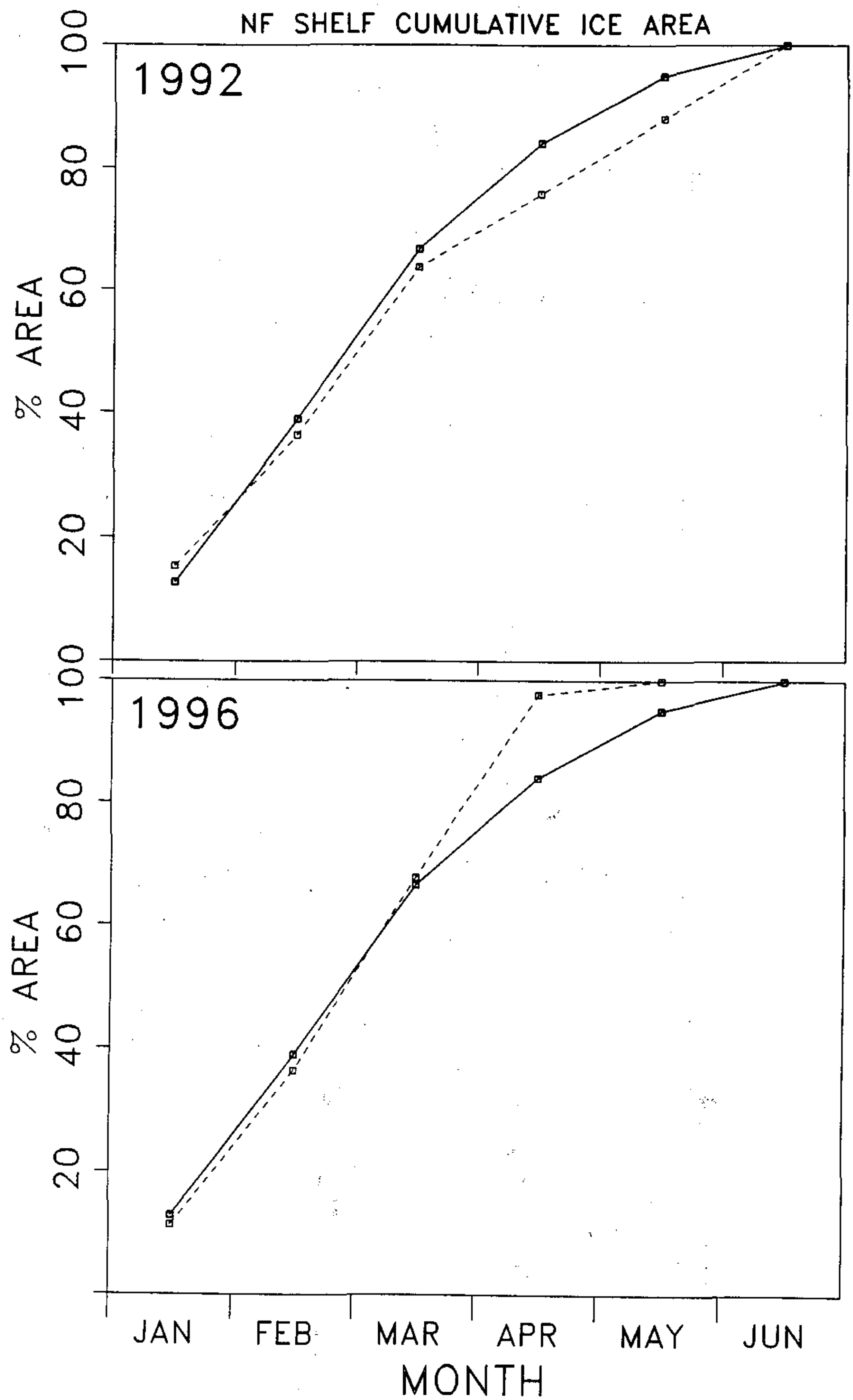

Fig. 3. The cumulative ice area along the east coast of Newfoundland south of 55 °N latitude (dashed line) for 1992, a heavy ice year and for 1996 a light ice year and the normal cumulative ice area (solid line), from Cote, 1989.

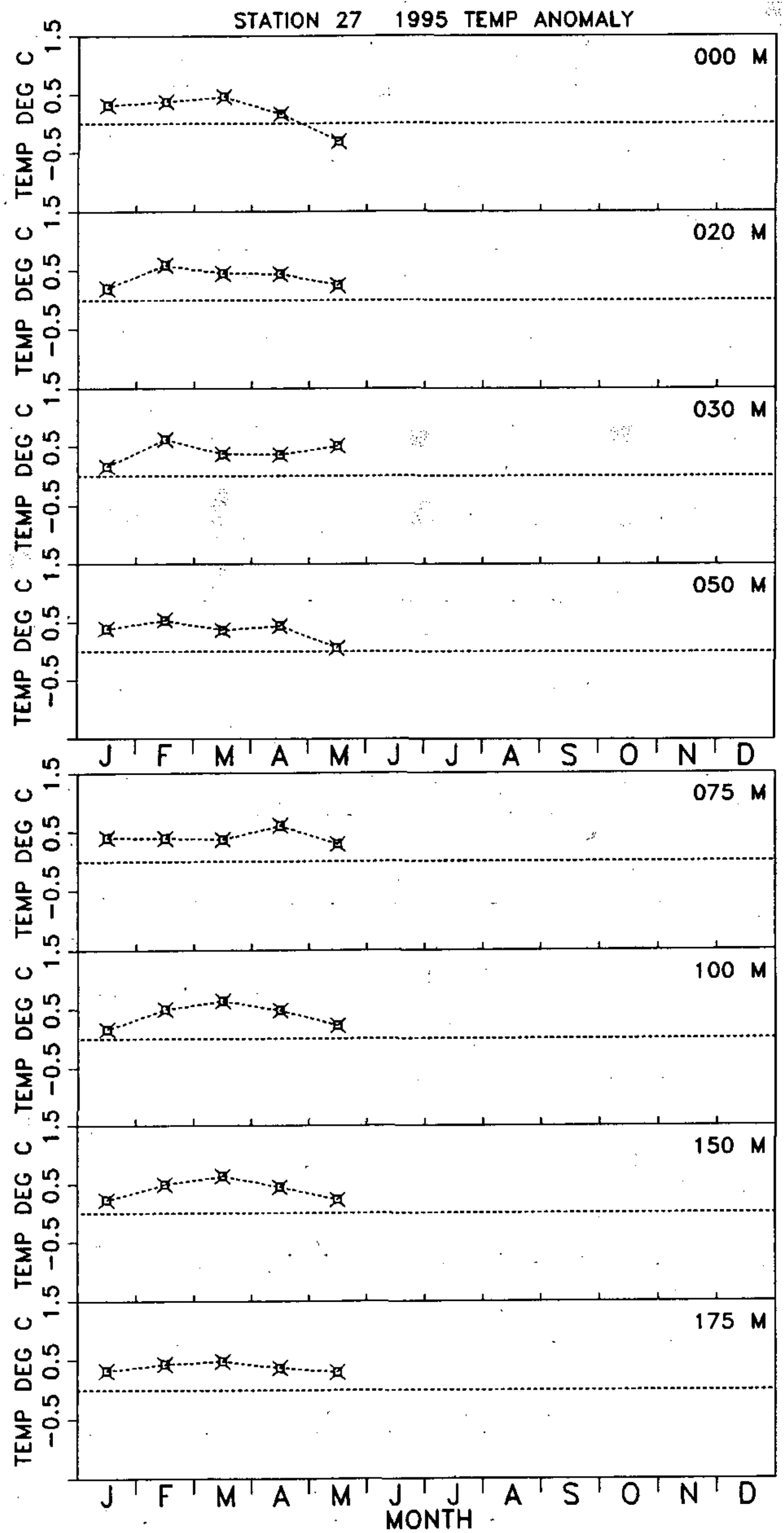

Fig. 4. Time series of monthly temperature anomalies at Station 27 at standard depths for January to May of 1996.

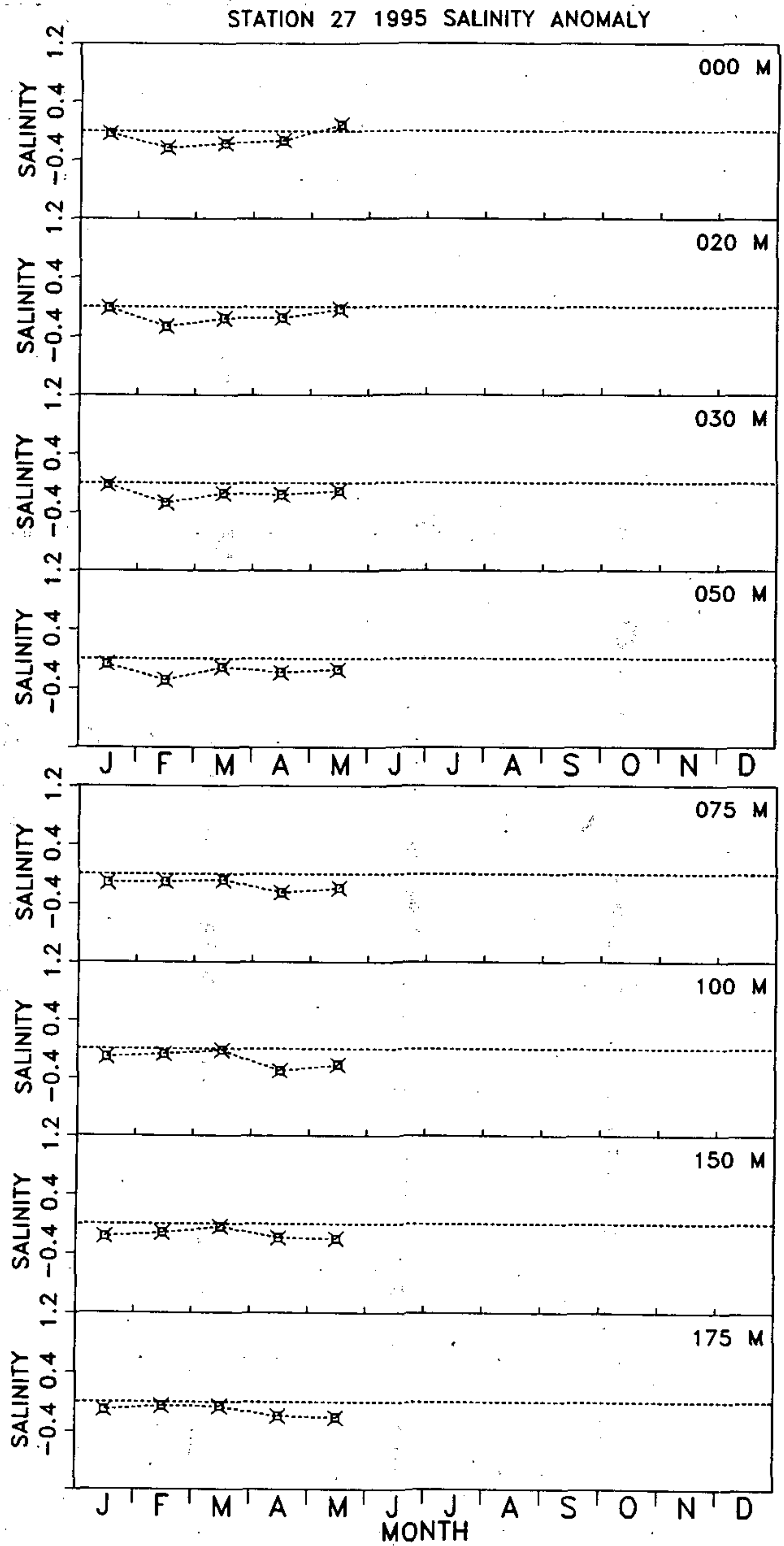

Fig. 5. Time series of monthly salinity anomalies at Station 27 at standard depths for January to May of 1996.

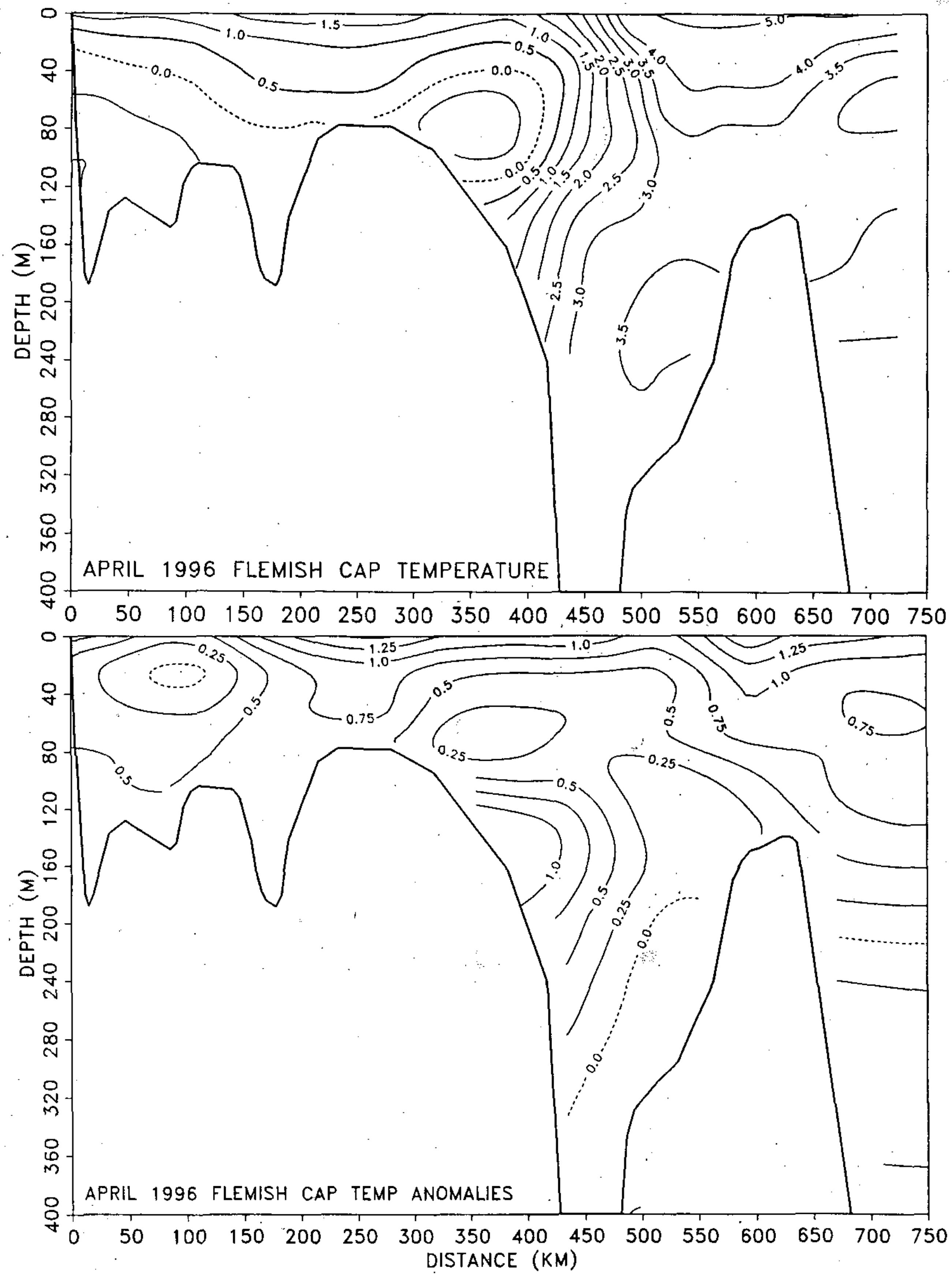

Fig. 6. The vertical distribution of temperature and temperature anomalies along the standard Flemish Cap transect for late April 1996.

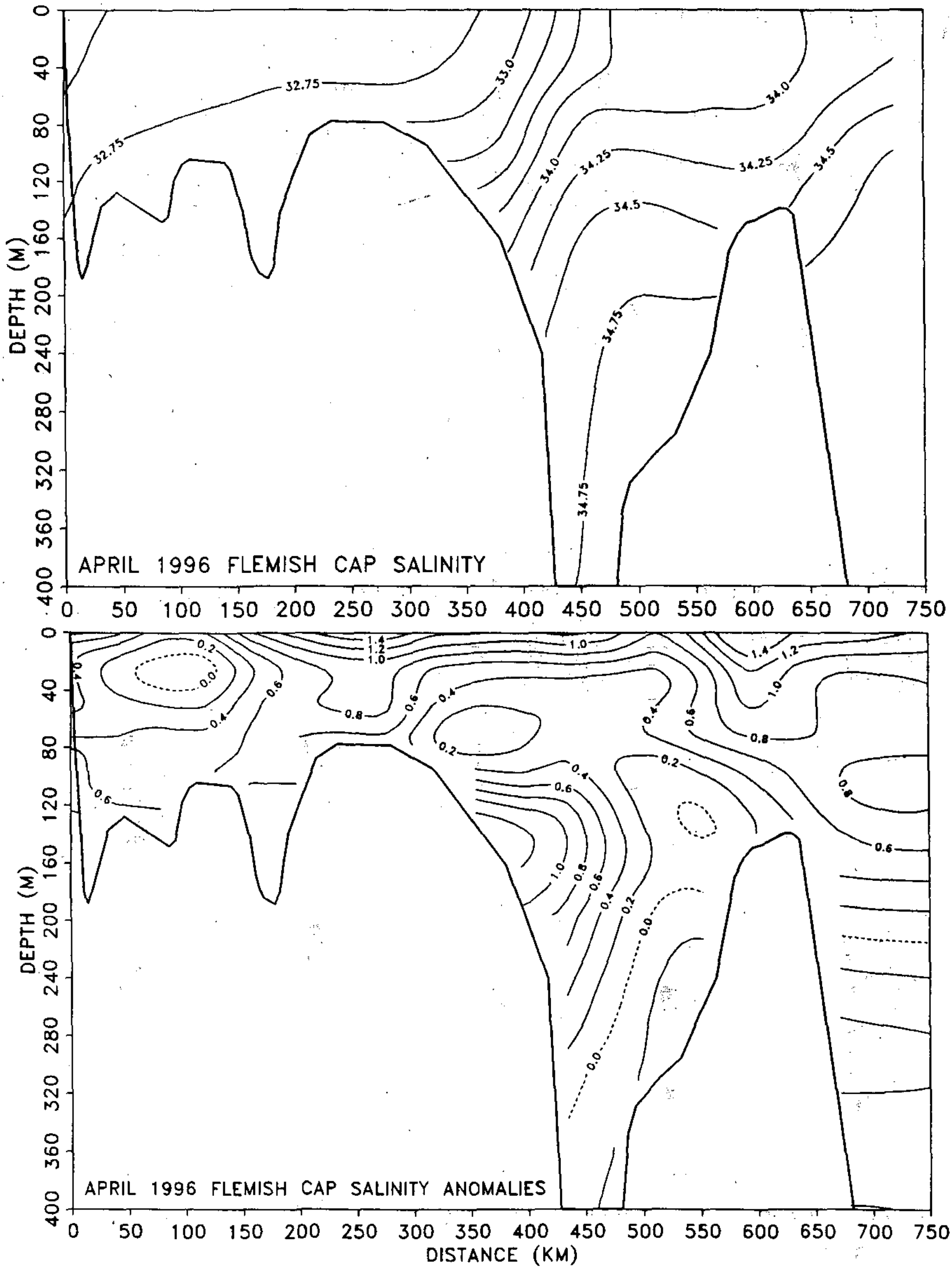

Fig. 7. The vertical distribution of salinity and salinity anomalies along the standard Flemish Cap transect for late April 1996.

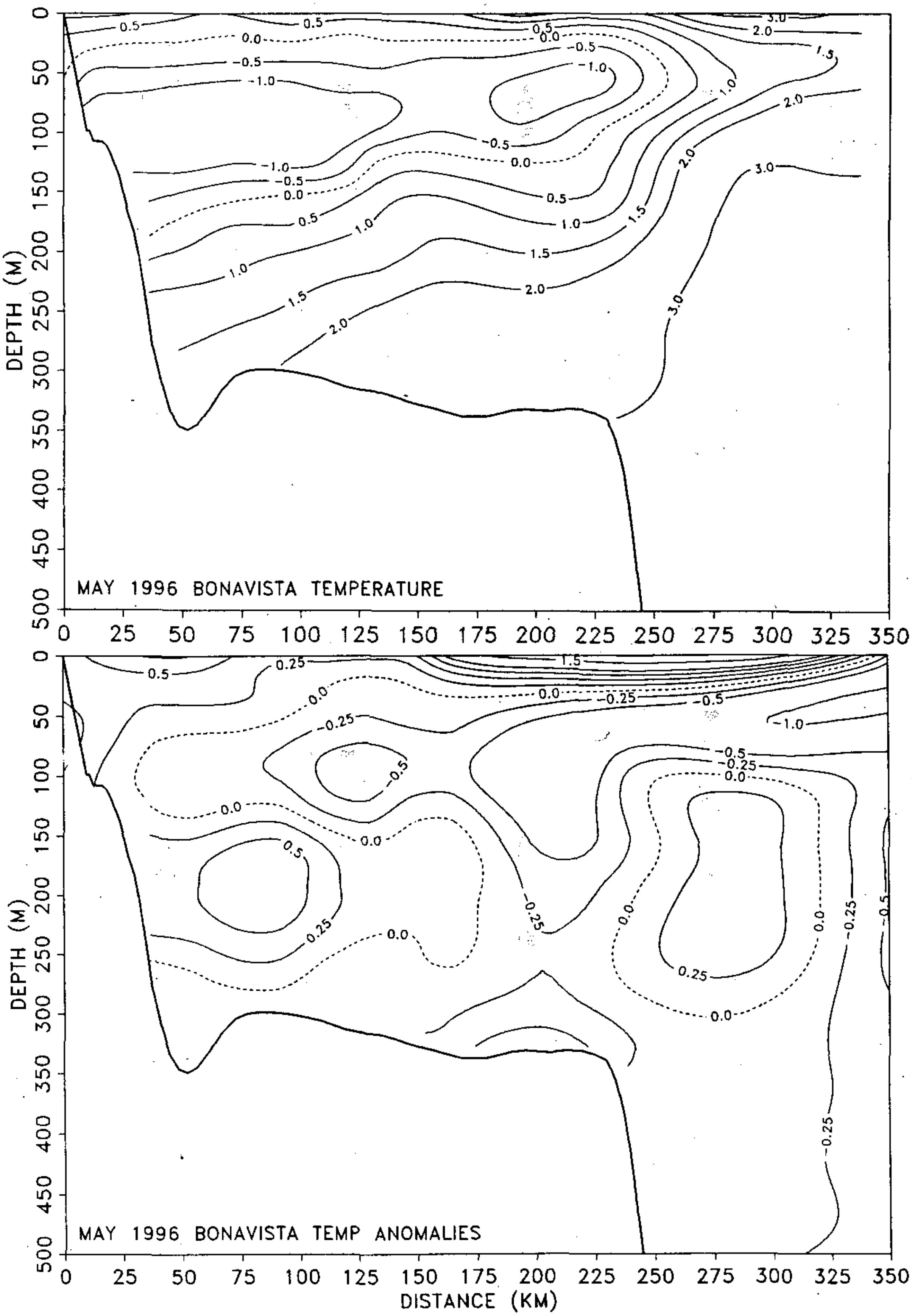

Fig. 8. The vertical distribution of temperature and temperature anomalies along the standard Bonavista transect for early May 1996.

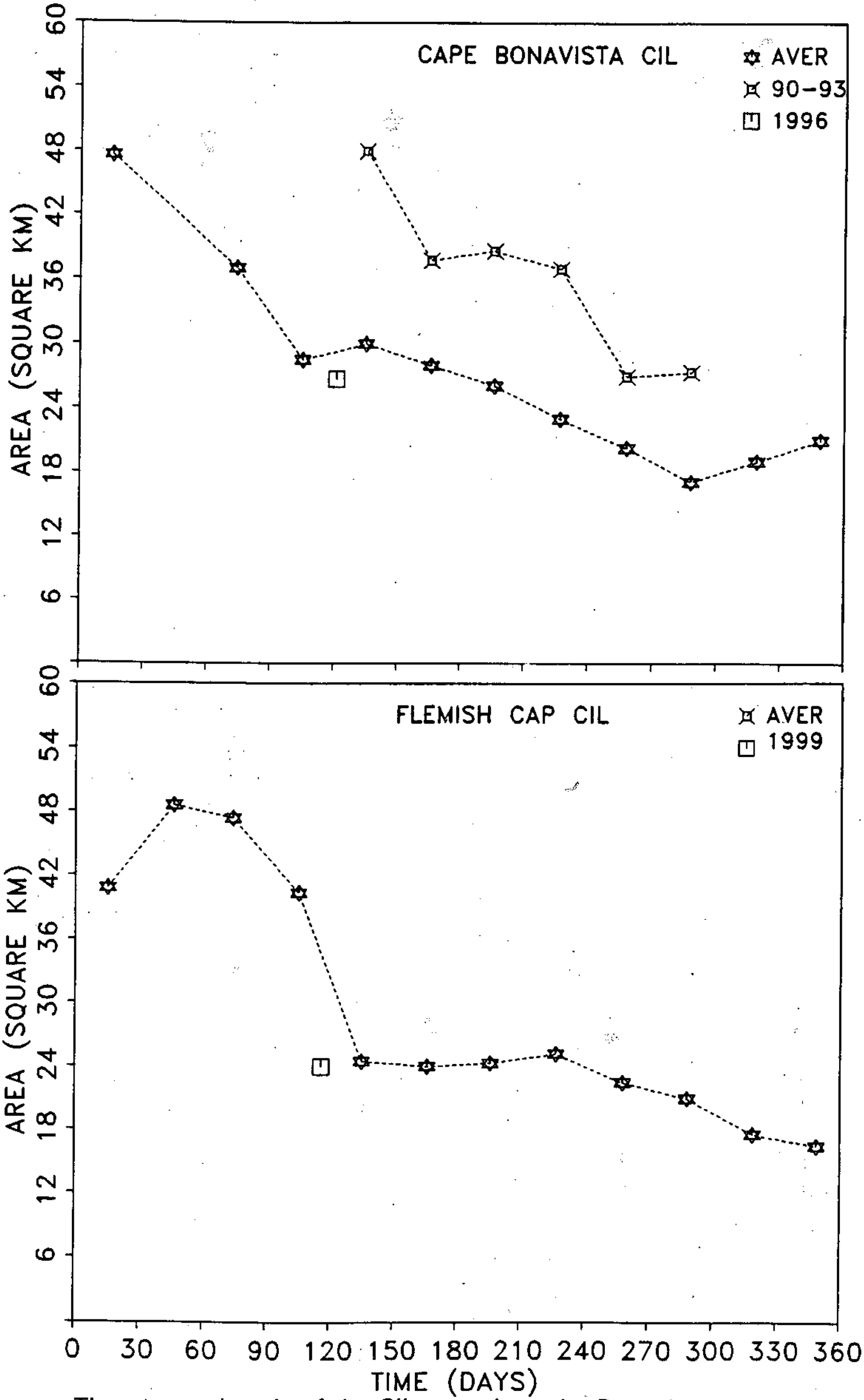

Fig. 9. The seasonal cycle of the CIL area along the Bonavista and Flemish Cap transects obtained from the monthly average of all temperature observations along each transect (Colbourne and Senciall, 1993, 1996).