Northwest Atlantic Fisheries Organization

Serial No. N2770 NAFO SCR Doc. 96/87

SCIENTIFIC COUNCIL MEETING - SEPTEMBER 1996

# OCEANOGRAPHIC CONDITIONS ON THE FLEMISH CAP DURING THE SUMMER OF 1996, WITH COMPARISONS TO THE PREVIOUS YEAR AND THE 1961-1990 AVERAGE

by

E. Colbourne

Science Branch, Department of Fisheries and Oceans
P.O. Box 5667 St. John's, Newfoundland A1C 5X1

## ABSTRACT

Oceanographic data from the summer of 1996 on the Flemish Cap are examined and compared to the long-term (1961-1990) average and to conditions during the summer of 1995. The results indicate that the colder than normal temperatures experienced over the continental shelf and on the Flemish Cap since the late 1980s continued into 1996 with some improvement over values experienced in 1993 and 1995, particularly in the depth range of 50 m to the bottom. In the near surface layer, temperatures were up to 0.5 to 1.5 °C below normal in 1995 and slightly cooler at 0.5 to 2.5 °C below normal in 1996. Upper layer (top 50 m) salinities were above the long-term mean (by 0.2-0.5 psu) in both 1995 and 1996, otherwise about normal. Chlorophyll measurements show higher summer values in the upper 50 m of the water column over the Cap compared to the Grand Bank where a weaker maximum was observed somewhat deep in the water column. Dissolved oxygen levels indicate a well oxygenated water column over the Cap in 1996 similar to values in 1993 and 1995. Additionally, current measurements using ADCPs continue to show the presence of a general anticyclonic circulation around the Cap.

## 1. INTRODUCTION

This report describes oceanographic conditions on the Flemish Cap during the summer of 1996 with a comparison to 1995 conditions and to the long-term mean based on all available historical data. The normal has been defined as the 30 year period from 1961-1990 in accordance with the convention of the World Meteorological Organization and recommendations of the NAFO Scientific Council. The 1995 and 1996 observations were made by the Department of Fisheries and Oceans on oceanographic surveys in mid July aboard the Canadian Scientific Ship Parizeau. During these surveys oceanographic observations were made along the standard NAFO Flemish Cap transect (47° N) as well as several stations along a transect across the northwestern portion of the bank (Fig. 1). Measurements included vertical profiles of currents, temperature, salinity, chlorophyll and dissolved oxygen.

The monthly mean temperature and salinity along the standard Flemish Cap Section have been published by Keeley, 1981 and includes observations from 1910 to 1980. Spatially averaged temperature and salinity from all available bottle data from 1910 to 1982 over the Flemish Cap area were published by Drinkwater and Trites, 1986. Numerous reviews and studies of the physical oceanography around the Flemish Cap were conducted during the Flemish Cap Project of the late 1970s and early 1980s (Hays et al. 1978; Bailey 1982; Akenhead 1981). More recent reviews of oceanographic conditions in the region compared 1993 and 1995 observations with

the long-term mean and also presented time series of temperature and salinity anomalies at various depths around the Cap (Colbourne 1993; Colbourne 1995). This review presents an update to the 1995 report by including data up to the summer of 1996.

Since the early 1970s the oceanographic, meteorological, and ice conditions of the Northwest Atlantic have been dominated by three anomalous periods: early 1970s, mid 1980s and the early 1990s (Colbourne et al. 1994). During these periods strong positive winter North Atlantic Oscillation (NAO) index anomalies were mainly responsible for colder than normal air temperatures over the Northwest Atlantic resulting in increased ice cover and eventually colder and fresher than normal oceanographic conditions over most of the continental shelf in Atlantic Canada (Drinkwater et al. 1992). An examination of the temperature and salinity anomaly time series from 1970 to 1993 indicated similar conditions existed in the Flemish Cap region as on the adjacent continental shelf (Colbourne 1993).

## 2. AVERAGE TEMPERATURE AND SALINITY

The vertical distribution (depth versus horizontal distance from the Avalon Peninsula) of the average temperature and salinity over the Flemish Cap along the standard NAFO transect for the period July 1 to July 31, based on all available historical data from 1961-1990 is shown in Fig. 2. An examination of the data distribution for July indicates a bias in the observations towards the latter half of the month. No attempts were made here to adjust the mean for possible temporal biasing arising from variations in the number of observations within the time interval.

The average temperature for July (Fig. 2, upper panel) based on this analysis in the upper water column ranges from 4.0 °C at 50 m depth to about 10 to 11 °C near the surface. In deeper water (50 m to the bottom) the temperatures ranges from 2.0 to 3.5 °C in the Flemish Pass area, in the offshore branch of the Labrador current and from 3.5 to 5.0 °C offshore of the Cap where the influence of the Gulf Stream is evident. The corresponding average salinities (Fig. 2 bottom panel) generally ranges from 33.5 psu near the surface to 34.75 psu near the bottom over the Flemish Cap in water depths of about 300 m. In water depths greater than 300 m salinities are generally greater than 34.75 psu.

## 3. 1995 AND 1996 TEMPERATURE AND SALINITY

The vertical temperature distribution in July of 1996 along the standard NAFO transect shows temperatures ranging from about 5.0 °C at 50 m depth to about 9 °C near the surface, slightly cooler than 1995 values (Fig. 3). In the depth range of 50-100 m temperatures ranged from 5.0 to 2.8 °C along the Flemish Pass in the offshore branch of the Labrador current and about 5.0 to 3.5 °C on the Cap. In the depth range of 100 m to the bottom over the Cap temperatures ranged from 3.0 to 3.5 °C. Temperatures along the transect running across the northwest section of the Cap show similar values as along 47° N but slightly warmer than the corresponding 1995 values (Fig. 4).

The vertical distribution of temperature anomalies for 1995 and 1996 over the Flemish Cap are shown in Fig. 5. These anomalies were calculated by subtracting the gridded averaged 1961-1990 data from the current transect data (collected on July 18) without any adjustment for temporal biasing arising from variations in the number of observations throughout the month. An examination of the historical data distribution for July shows that about 40 % of the data were collected before July 20 with a median date of July 25. An examination of the annual temperature cycle over the Flemish Cap indicates that the temperature normally changes by approximately 0.5 °C in the time interval from July 18 to 25 in the near surface layers (0 to 20 m) and about 0.1 °C at 50 m depth. This indicates that in near surface areas, where the annual cycle is the strongest, the temperature anomalies may be biased low, assuming normal atmospheric heat flux.

During 1996, near surface temperature anomalies ranged from -1.0 to -2.5 °C in the Flemish Pass and generally around -1.0 °C over the Cap and the offshore portion of the continental slope (Fig. 5, bottom panel). These values were slightly

cooled that the 1995 values (Fig. 5 top panel). Below the surface layer temperatures ranged from 0.3 to 0.5 °C below normal, similar to 1995 values except for an area of positive anomalies directly over the Cap in the depth range of 25 to 90 m. These surface anomalies are similar to 1993 value and are probably due to reduced solar heat input during spring.

The corresponding salinities (Fig. 6) show values ranging from less than 33.5 psu near the surface in the Flemish Pass, where the influence of the Labrador current is felt, to between 33.75 to 34.0 psu across the Cap in the upper 50 m. In the depth range of 50 m to the bottom salinities ranged from 34.0 to 34.75 psu with very small horizontal gradients across the Cap.

The corresponding salinities anomalies in both 1995 and 1996 were similar, with a saltier than normal (by 0.2 to 0.4 psu) surface layer (0 to 50 m thick) across the Cap and near normal values over the rest of the water column (Fig. 7). In contrast 1993 salinities in the upper layer over the Cap were slightly fresher than normal by 0.2 to 0.3 psu.

## 4. 1995 AND 1996 CHLOROPHYLL AND DISSOLVED OXYGEN

The vertical distributions of chlorophyll and dissolved oxygen saturation for 1995 and 1996 along the standard NAFO transect across the Flemish Cap are shown in Figs. 8 and 9. These data were collected in conjunction with the temperature and salinity data using a YSI type polarographic element dissolved oxygen sensor and a fluorometer interfaced to a Seabird-9 CTD system. The oxygen sensor was factory calibrated at zero and air-saturated water oxygen levels and also field calibrated by taking water samples at standard depths. The oxygen levels of the samples were determined by semi-automated analytical chemistry using a modified Winkler titration technique. The sensor readings were then corrected by using a least-squares fit of the titration measurements to the electronic sensor measurements. The chlorophyll measurements are uncalibrated.

The July chlorophyll concentrations show relatively high values (between 2.0 to 2.5 mg/l) over the Flemish Cap during both years which were confined to a surface layer from 0 to about 50 m depth (Fig. 8). These values were much higher than values over the adjacent Grand Bank (0.75 to 1.0 mg/l, not shown) along the same transect and may indicate a delayed or extended offshore plankton bloom relative to the Newfoundland Shelf areas.

Dissolved oxygen levels during 1995 and 1996 were about 7.0 ml/l in the upper 100 m of the water column over the Flemish Pass area and from 7.0 to 6.5 in water depths from 100 m to the bottom over the bank. The corresponding oxygen saturations (Fig. 9) ranged from 97.5 to 100 % from the surface to about 50 m depth and from 82.5 to 90 % in the depth range of 50 m to the bottom. These levels are slightly lower than during 1995 (top panel), however these values indicate a well oxygenated water column during both years.

## 5. CIRCULATION

The general circulation in the Flemish Cap region consists of the offshore branch of the Labrador Current which flows through the Flemish Pass more or less trapped to the Grand Bank side of the continental slope area and a jet that flows to the east, north of the bank. To the south the Gulf stream flows to the northeast merging with the Labrador current to form the North Atlantic current. In the absence of strong wind forcing the circulation over the Flemish Cap is dominated by a topographically induced anticyclonic gyre over the central portion of the bank (Kudlo et al. 1984; Ross 1981). The stability of this circulation pattern may influence the retention of ichthyoplankton on the bank and is probably a factor in determining the year-class strength of various fish species such as cod and redfish (Kudlo and Borovkov 1977; Kudlo and Boytsov 1979); this hypothesis however has yet to be confirmed.

Since 1993 currents on the Flemish Cap have been measured with hull-mounted 150 kHz RDI acoustic Doppler current profilers (ADCP) at a spatial resolution of 4.0 m vertically by approximately 1.5 km horizontally. Measurements were only available in water depths less than 500 where bottom referencing is possible. The useful range of the 150 kHz ADCP for current measurements in this area is about 10 to 275 m. Figures 10 and 11 shows the vertical distribution of the currents over the Flemish Cap during July of 1996 along 47° N and along the northwest transect shown in Fig. 1. In these plots negative values correspond to southward and westward flowing water.

Evidence of anticyclonic circulation around the Flemish Cap is evident in the 1993, 1995 and the 1996 measurements. In 1996 along 47° N measurements show a northward component ranging from 5 to 20 cm/s over the shoreward portion of the Cap in the Flemish Pass area and generally southward currents over the Cap in the upper layer with speeds ranging from 5 to 30 cm/s. The east-west current velocities show a strong westerly component over the inshore portion of the cap and a easterly component over the outer portion. The upper layer (10 to 50 m) average current vectors shown in Fig. 12 indicate maximum current speeds in excess of 1 knot (50 cm/s).

## ACKNOWLEDGEMENTS

I like thank C. Fitzpatrick, D. Senciall, P. Stead and J. Walpert of the oceanography section at NWAFC for a professional job in data collection and processing and for the computer software support. I would also like to thank the captain and crew of the CSS Parizeau for field support.

## REFERENCES

Akenhead, S. 1981. Local Sea-surface temperature and Salinity on the Flemish Cap. *NAFO SCR Doc. 87/66, Ser. No. N426* 20 p.

Bailey, W.B., 1982. A Time-series of Sea-surface Temperature on the Flemish Cap, 1962-81. NAFO SCR Doc. 82/4, Ser. No. N489 7 p.

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

Colbourne, E. 1993. Oceanographic Conditions on the Flemish Cap During the Summer of 1993, *with Comparisons to the Long-Term Average. NAFO SCR* Doc. 93/107, Ser. No. N2300 36p.

Colbourne, E. 1995. Oceanographic Conditions on the Flemish Cap During the Summer 1995, with Comparisons to the 1961-1990 Average. NAFO SCR Doc. 95/102, Ser. No. N2625 12p.

Drinkwater, K. F., and R. W. Trites. 1986. Monthly means of temperature and salinity in the Grand Banks region. Can. Tech. Rep. Fish. Aquat. Sci. 1450:iv + 111 p.

Drinkwater, K. F., B. Petrie and S. Narayanan. 1992. Overview of Environmental Conditions in the Northwest Atlantic in 1991. NAFO SCR Doc. 92/73, 36p.

Hays, R. M., D.G. Mountain, and T.C. Wolford. 1978. Physical oceanography and the abiotic influence on cod recruitment in the Flemish Cap region. ICNAF Res. Doc. 77/54, Ser. No. 5107, 33p.

Keeley, J.R., 1981. Mean conditions of potential temperature and salinity along the standard Flemish Cap Section. Mar. Environ. Data Serv. Tech. Rep. No. 9: 148 pp.

Kudlo, B.P., V.A. Borovkov and N.G. Sapronetskaya. 1984. Water Circulation Patterns on the Flemish Cap from Observations in 1977-82. NAFO Sci. Coun. Studies, 7:27-37.

Kudlo, B.P., and V.A. Borovkov. 1977. Hydrological regime of the Labrador current and reproduction of commercial fishes. Syezd Sovetskikh Okeanologov, Tezisy Dokladov, Moskva vyp. ii:133-134.

Kudlo, B.P., and V. D. Boytsov. 1979. The effect of water dynamics on year-class strength of cod on Flemish Cap. ICNAF Sel. Papers, 5: 7-9.

Ross, C.K., 1981. Drift of Satellite-tracked Buoys on the Flemish Cap, 1970-80. NAFO Sci. Counc. Studies, No. 1: p47-50.

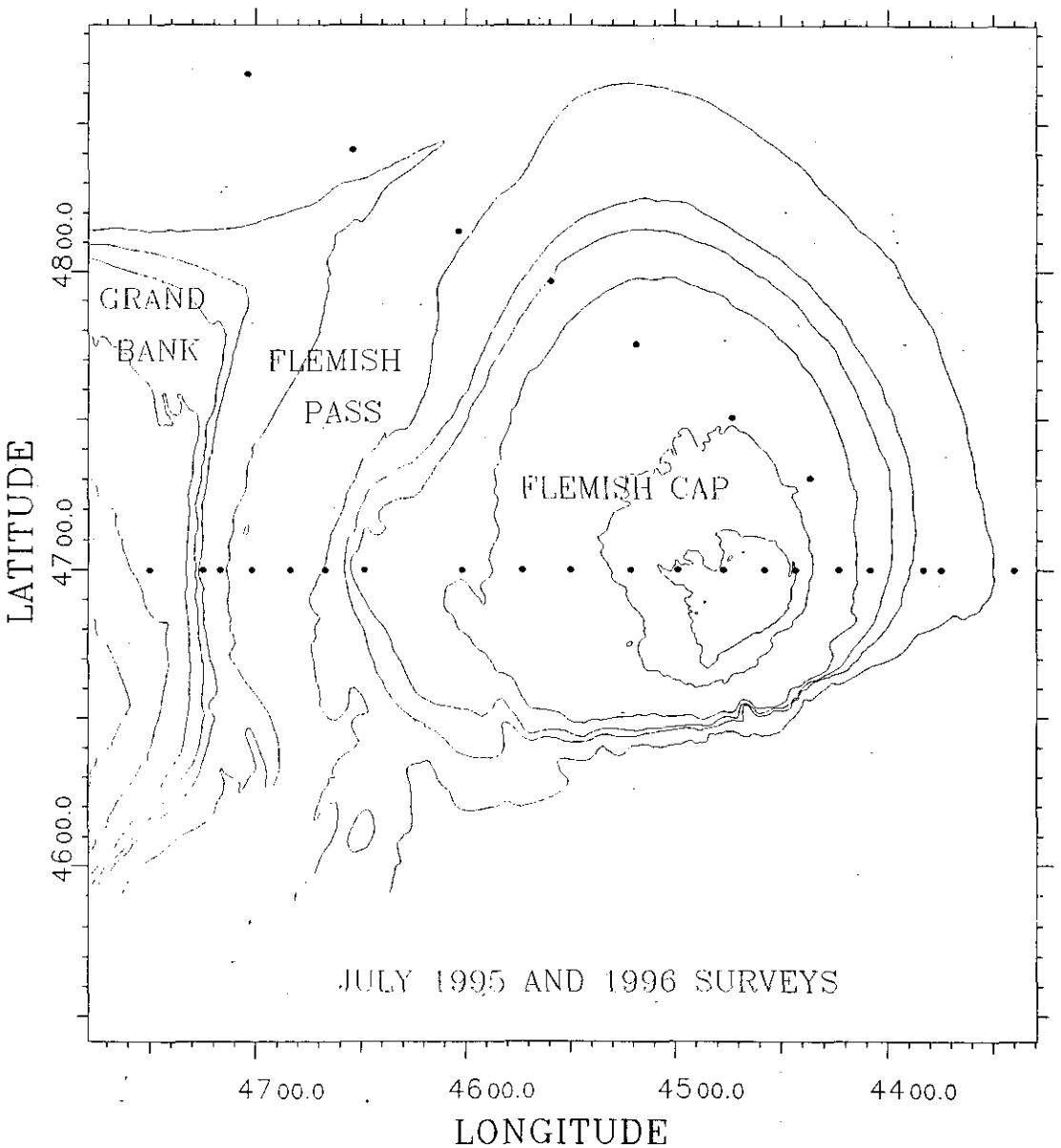


Fig. 1. Location map of the Flemish Cap area showing the stations occupied during the summer of 1995 and 1996. Bathymetry lines are 1000, 500, 400, 300, 200 and 150 m.

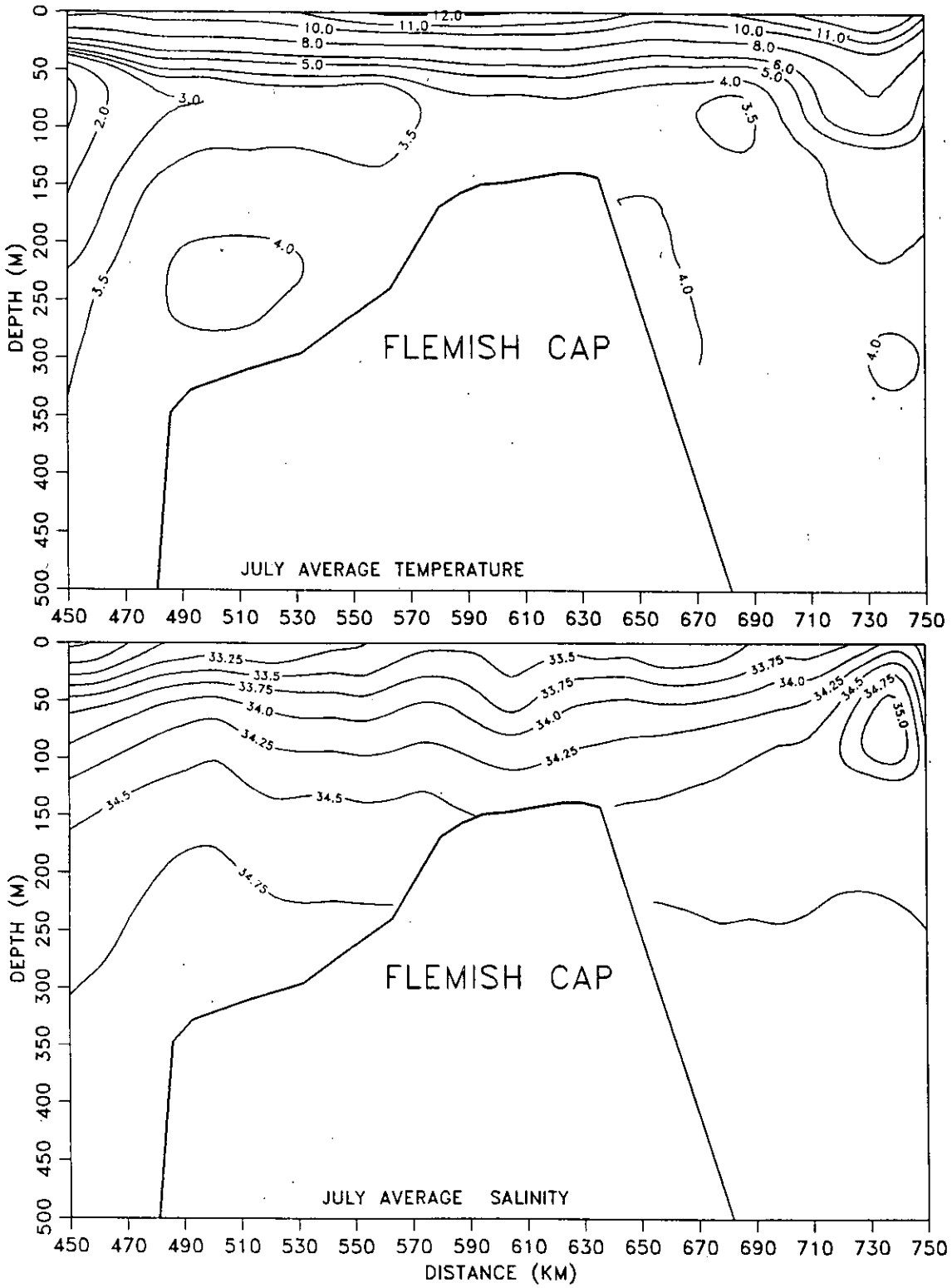


Fig. 2. The vertical distribution of the average temperature and salinity over the Flemish Cap based on all available historical data from 1961-1990.

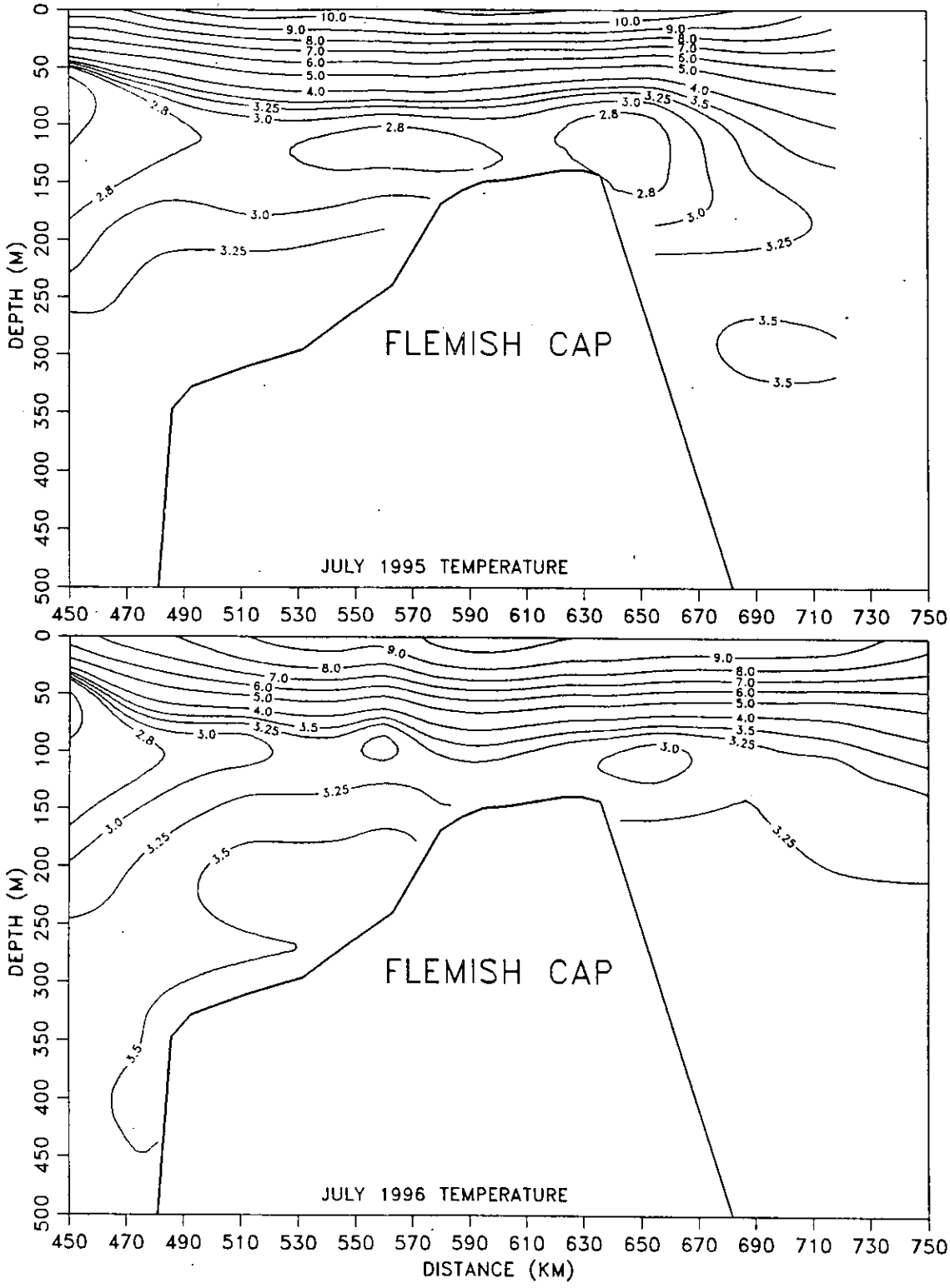


Fig. 3 The vertical distribution of temperature over the Flemish Cap (along 47°N) for July of 1995 and 1996.

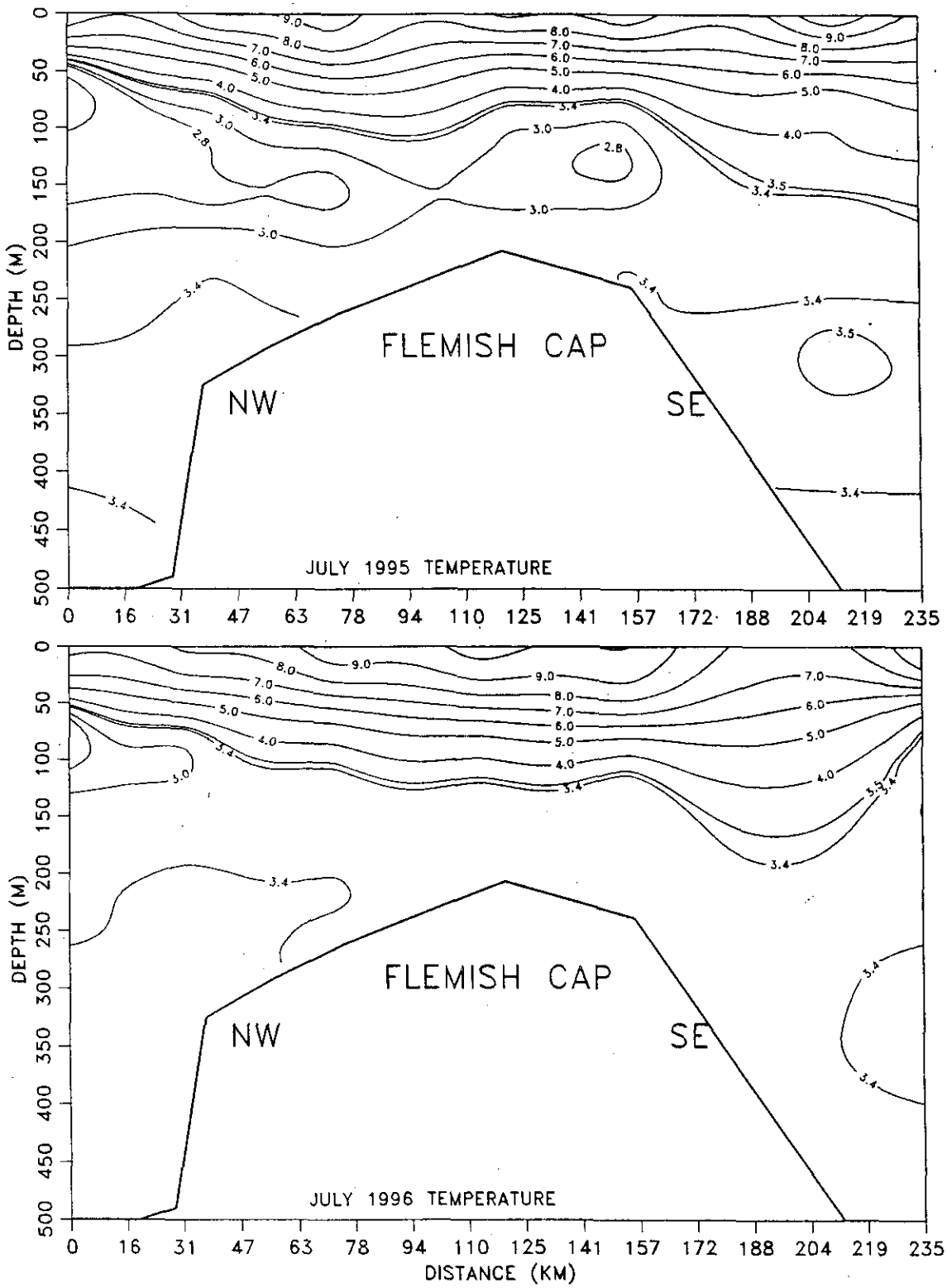


Fig. 4. The vertical distribution of temperature along a transect across the northwest Flemish Cap (Fig. 1) for July of 1995 and 1996.

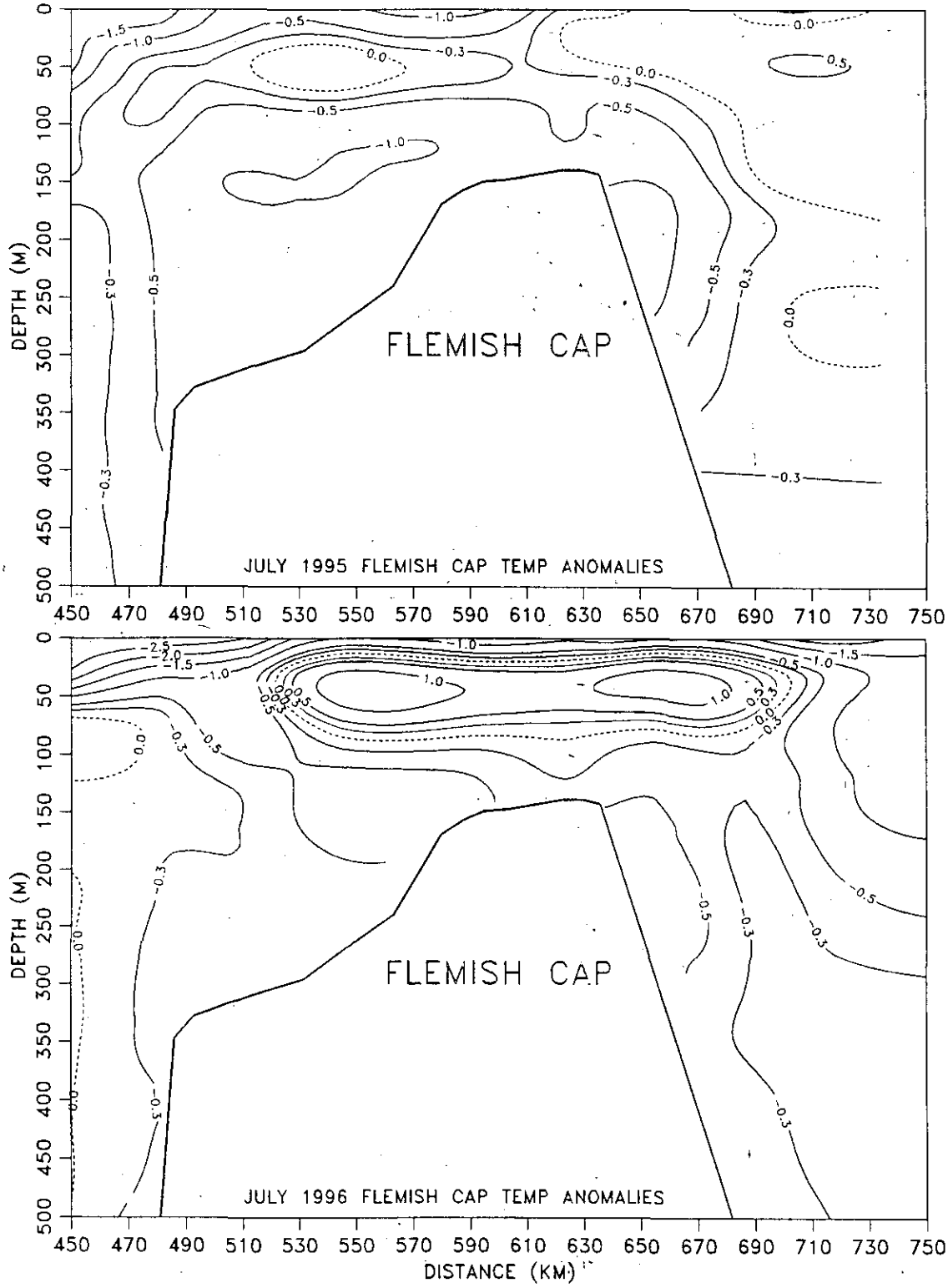


Fig. 5. The vertical distribution of temperature anomalies over the Flemish Cap (along 47° N) for July of 1995 and 1996.

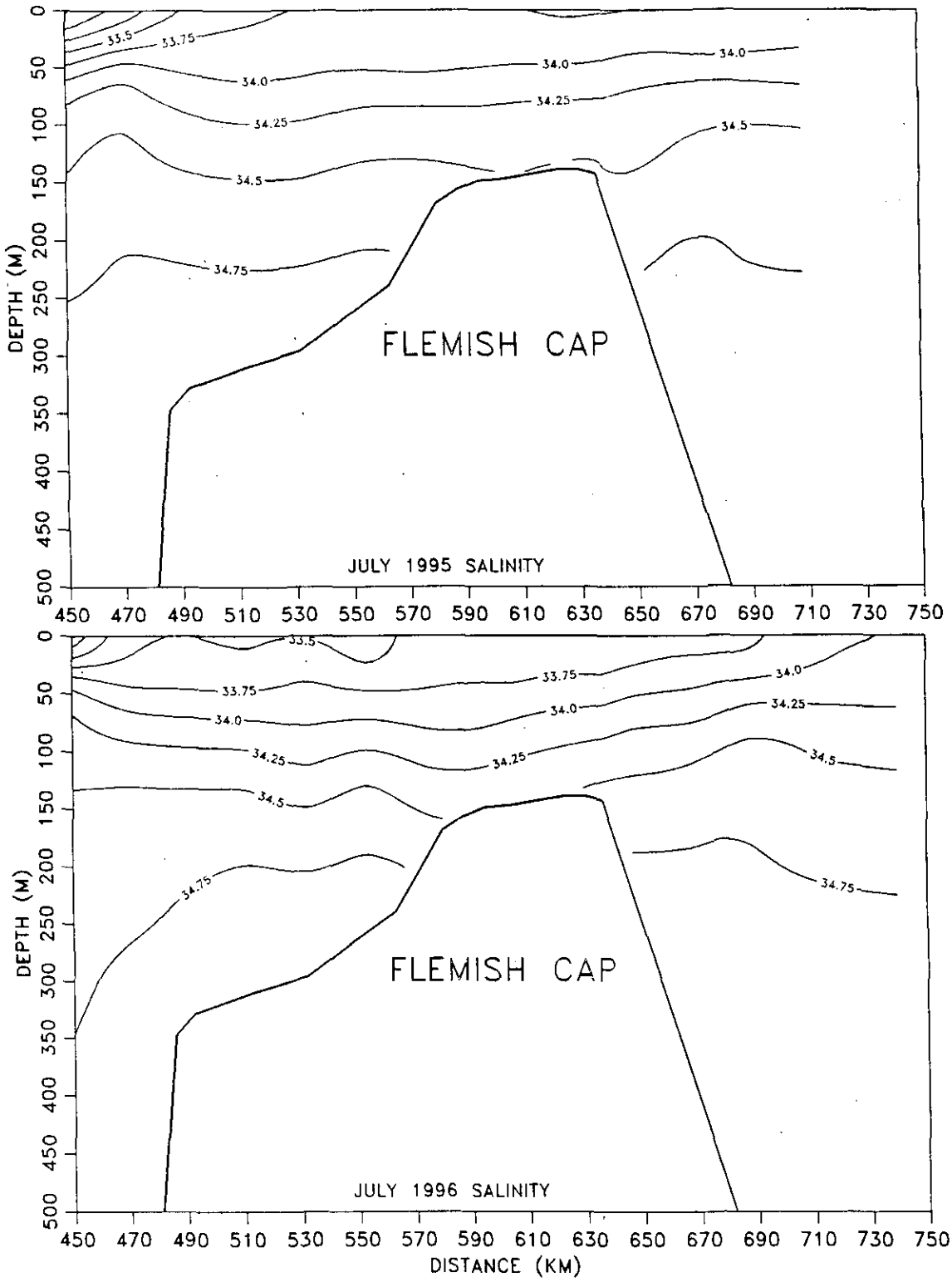


Fig. 6 The vertical distribution of salinity over the Flemish Cap (along 47°N) for July of 1995 and 1996.

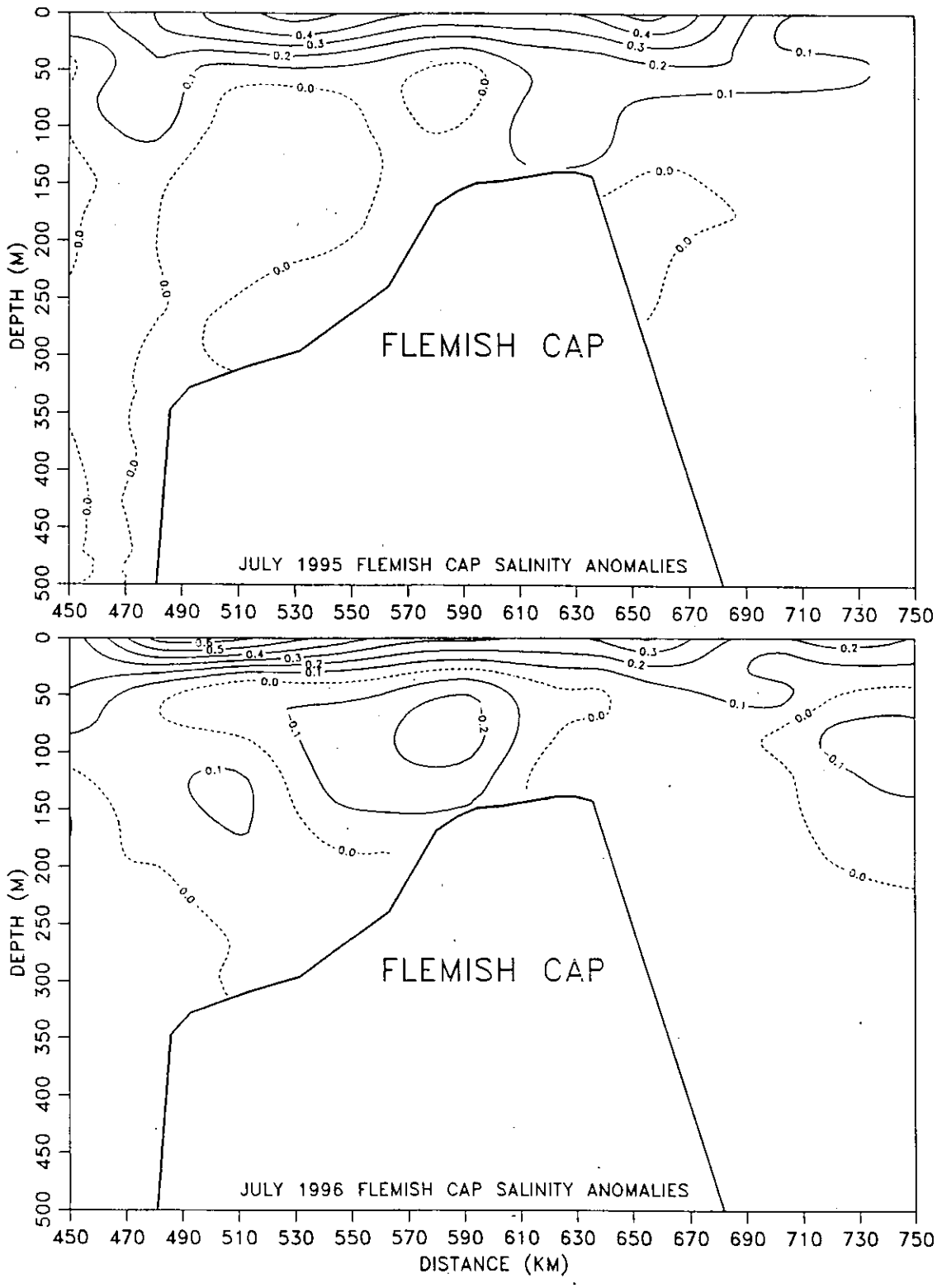


Fig. 7. The vertical distribution of salinity anomalies over the Flemish Cap (along 47° N) for July of 1995 and 1996.

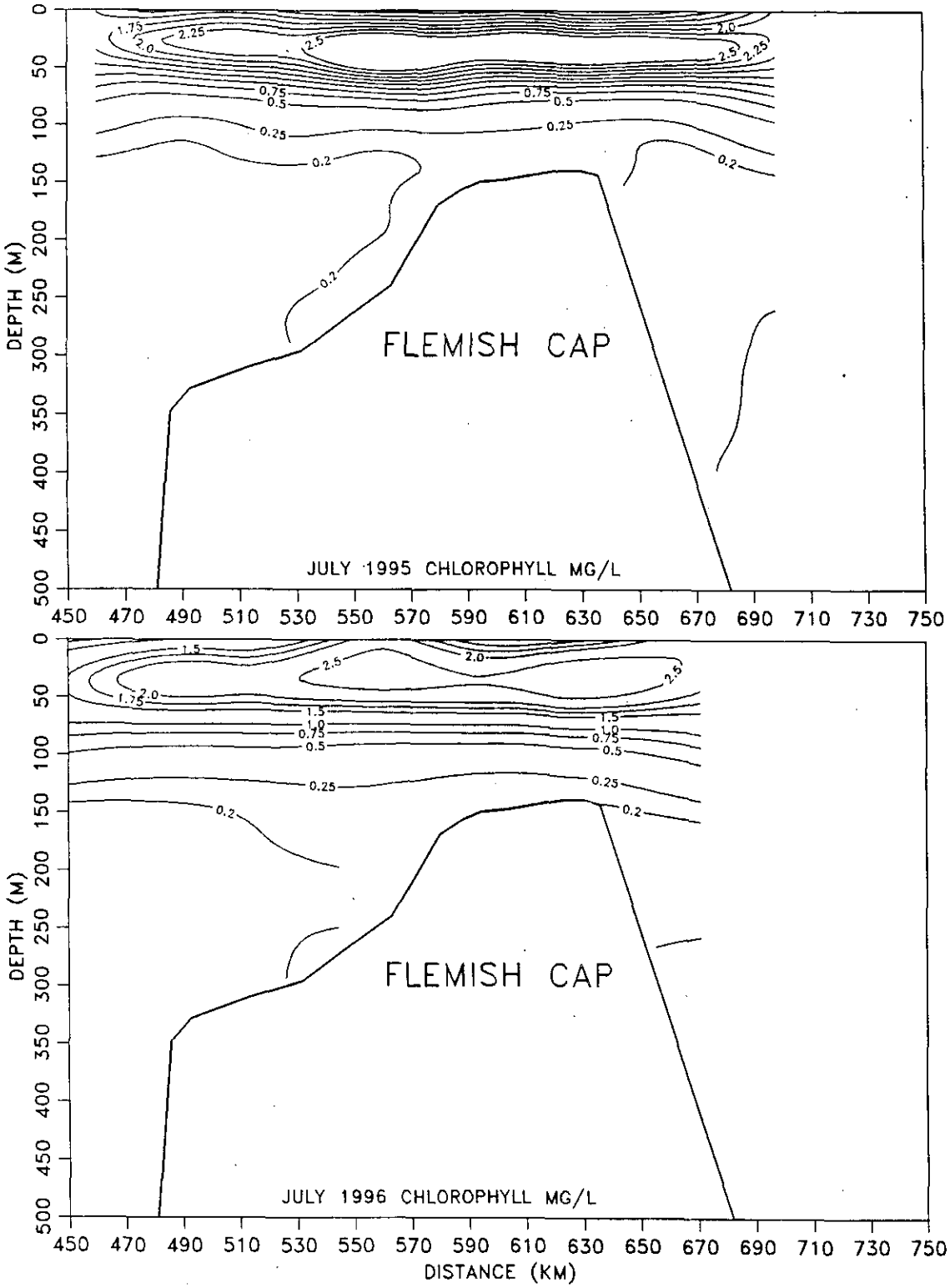


Fig. 8. The vertical distribution of chlorophyll concentrations over the Flemish Cap (along 47 °N) for July of 1995 and 1996.

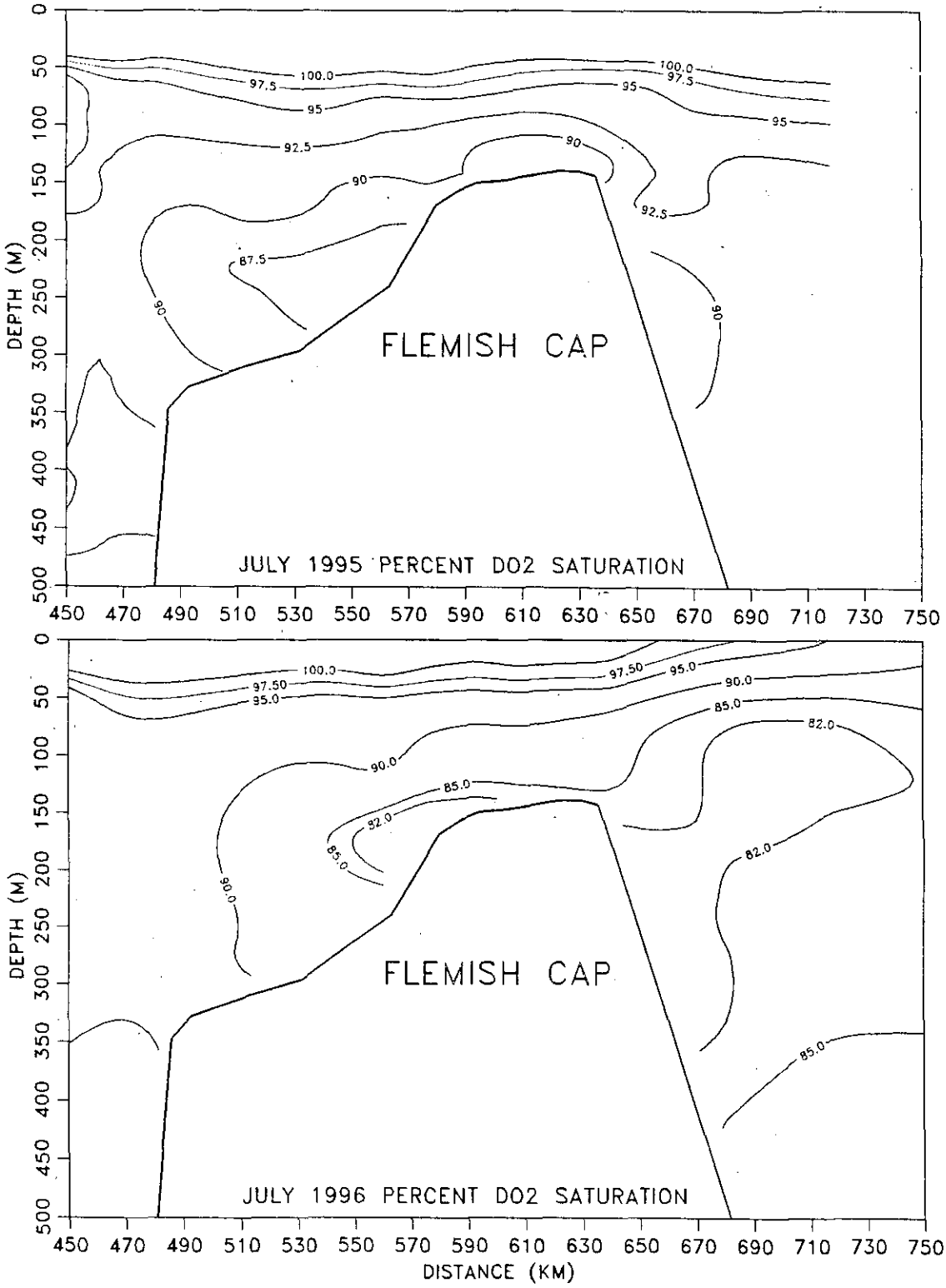


Fig. 9. The vertical distribution of dissolved oxygen percent saturation over the Flemish Cap (along 47° N) for July of 1995 and 1996.

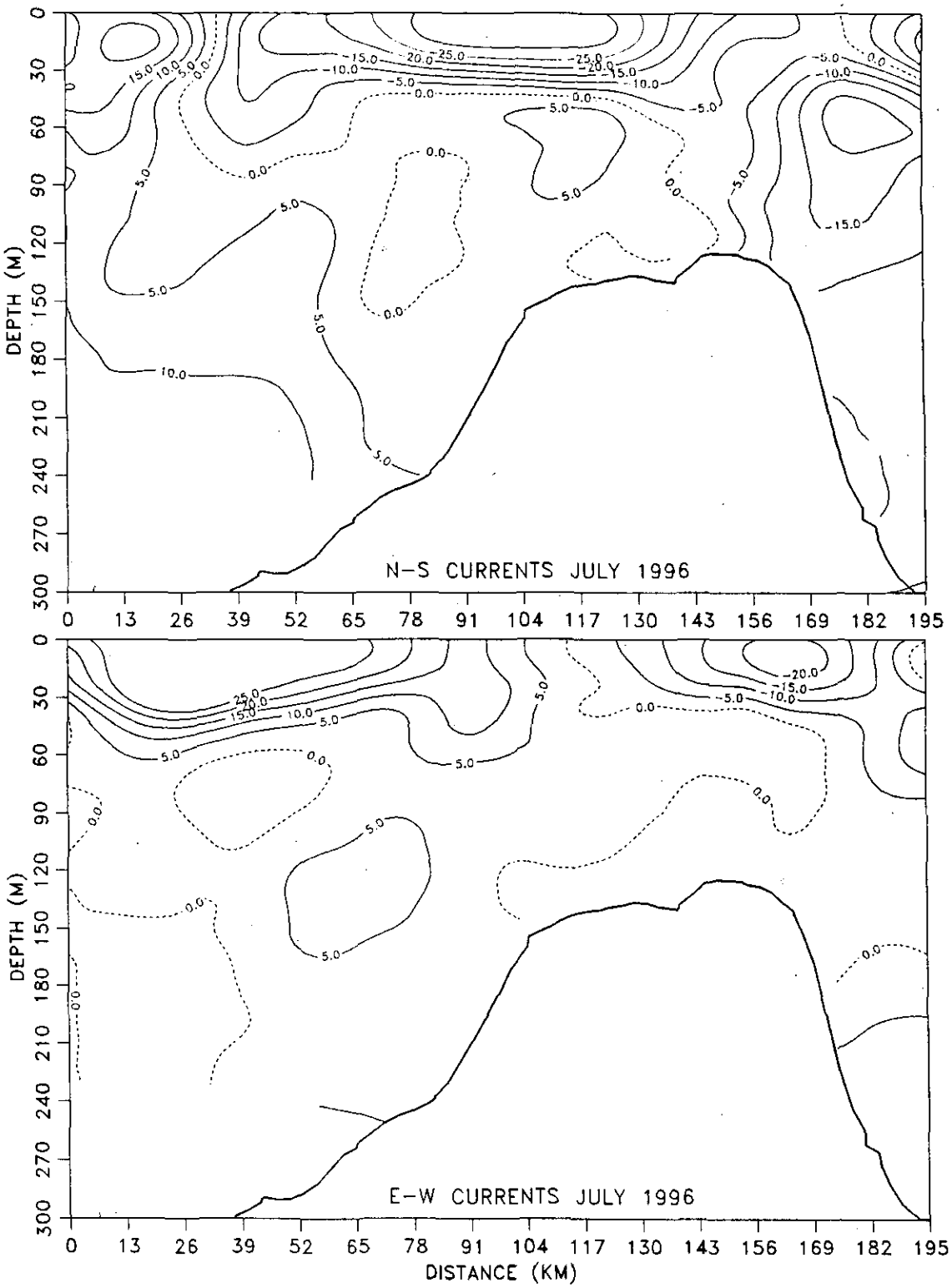


Fig. 10. The vertical distribution of the N-S and E-W current field over the Flemish Cap (along 47° N) during July 1996 from a 150 kHz ADCP. Negative currents are southward and westward.

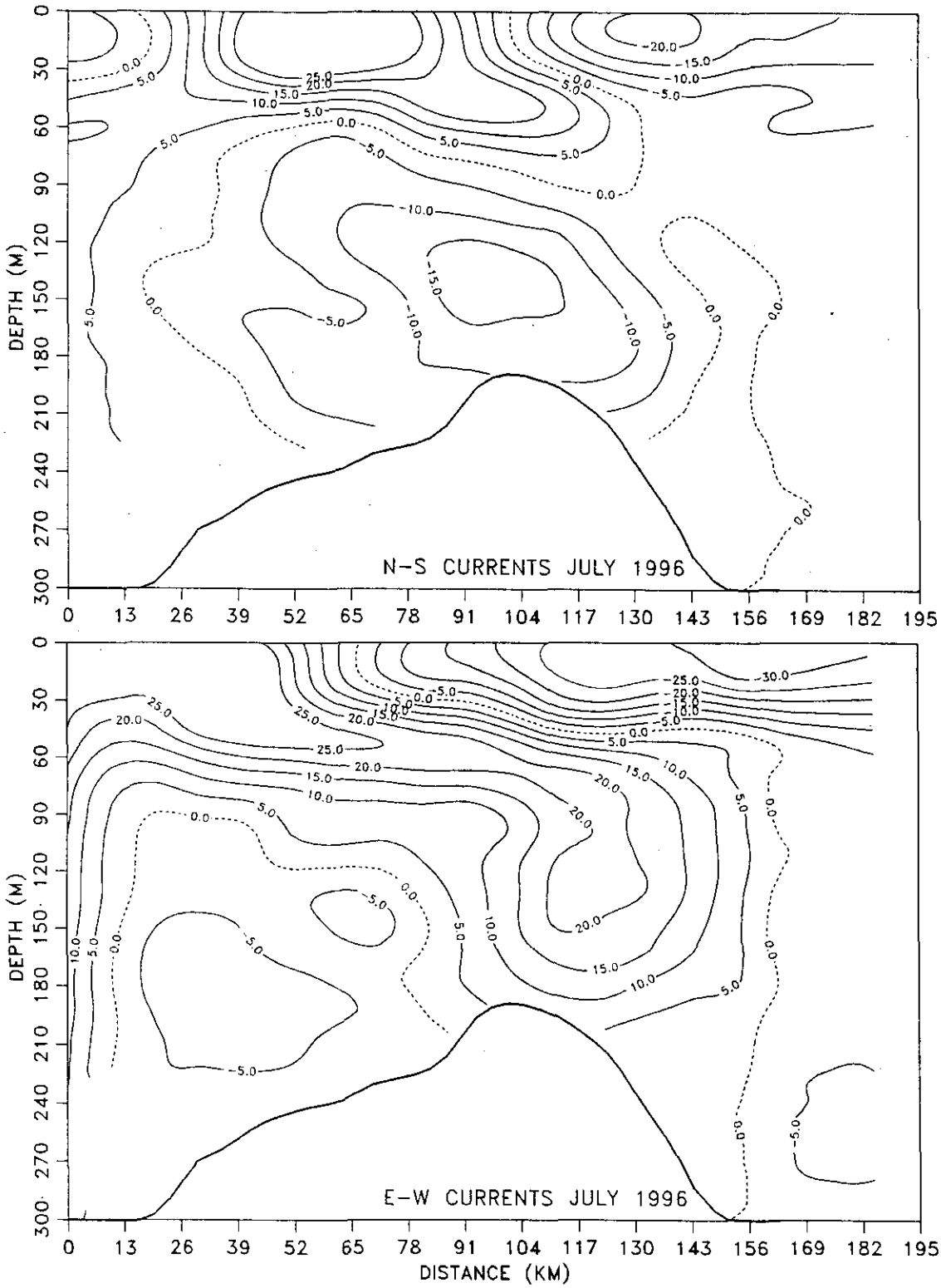


Fig. 11. The vertical distribution of the N-S and E-W current field over the Flemish Cap (northwest transect Fig. 1) during July 1996 from a 150 kHz ADCP. Negative currents are southward and westward.

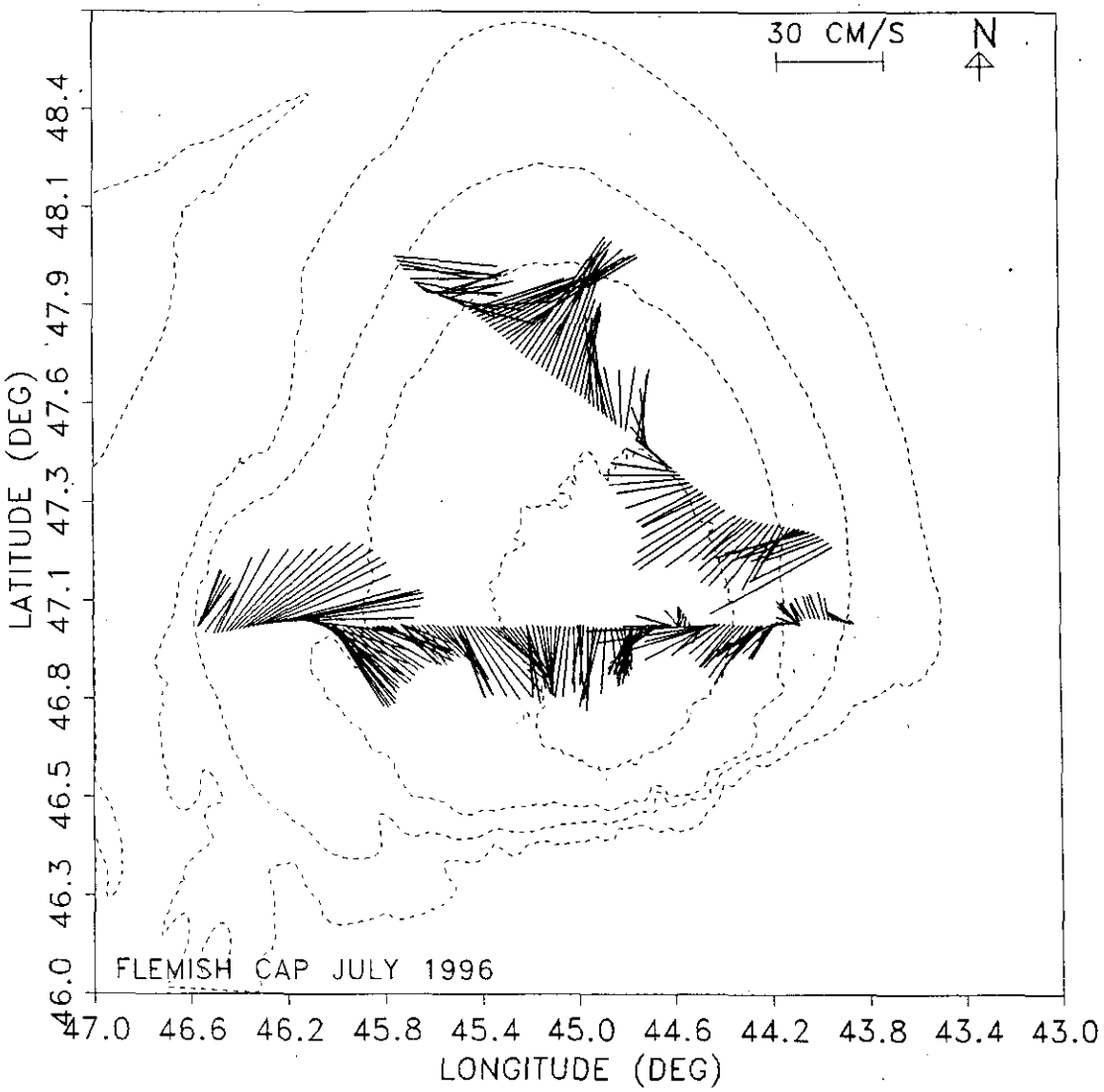


Fig. 12. The upper layer (0-50 m) circulation around the Flemish Cap during July of 1996 from a 150 kHz ADCP.