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OCEANOGRAPHIC CONDITIONS IN NAFO SUBDIVISIONS 3Pn AND 3Ps, WITH COMPARISONS TO THE LONG-TERM AVERAGE

by

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ABSTRACT

Historical water temperature data from NAFO subdivisions 3Pn and 3Ps are compared to data from the area during the winter from 1990 to 1993 and during the spring of 1993 and 1994. The data is presented in several ways, as vertical transects across the major banks and channels, horizontal bottom temperature maps of the area and as a time series of temperature anomalies at standard oceanographic depths. Analysis indicates the anomalous cold period that started in the mid 1980s has moderated in some areas during the early 1990s but large areas with below normal temperatures still exist, particularly on the eastern portions of St. Pierre Bank, Placentia Bay and on the continental slope areas.

RÉSUMÉ

On compare les données historiques sur la température dans les sous-divisions 3Pn et 3Ps de l'OPANO à celles qui portaient sur les températures hivernales de 1990 à 1993 et printanières de 1993 et 1994 dans la même région. Ces données sont présentées de diverses manières, sous forme notamment de transects verticaux dans les principaux bancs et chenaux, de cartes horizontales des températures du fond et de séries chronologiques des anomalies de température aux profondeurs océanographiques standard. Les analyses révèlent que le froid anormal qui a commencé à se manifester au milieu des années 1980 s'est modéré dans certaines régions au début des années 1990, mais que les températures restent inférieures à la normale dans de vastes régions, en particulier dans les secteurs est du banc de St. Pierre, de la baie de Placentia et sur le talus continental.

INTRODUCTION

This report summarizes recent oceanographic conditions in NAFO subdivisions 3Pn and 3PS with a comparison to average conditions. The report relies mainly on temperature data collected with XBTs at the end of each fishing set during Canadian assessment surveys during February, March and April since 1973. Since the winter of 1990, water temperatures on groundfish assessment surveys were measured for the most part using trawl-mounted Seabird 19 CTD systems. In addition to this data all other data available in the area dating back to 1915 were used to determine the average conditions.

The vertical distribution of temperature is examined along a transect from near shore at Rose Blanche on the south coast of Newfoundland in a southeasterly direction crossing Burgeo Bank, Hermitage Channel and St. Pierre Bank and offshore to the edge of the continental shelf on the Southwestern Grand Bank (Fig. 1, Box A). In addition, spatially averaged time series of temperature anomalies mainly on St. Pierre Bank (Fig. 1, Box B) are examined together with bottom temperatures over the entire 3Pn and 3PS area.

The general circulation in the 3Ps region consist of modified Labrador current water, the inshore branch of which flows through the Avalon Channel around the Avalon Peninsula westward north of St. Pierre Bank and to the south between Green Bank and Whale Bank. Additionally, part of the offshore branch of the Labrador current flows around the tail of the Grand Bank, westward along the continental slope where it is influenced by the Gulf Stream and slope waters, to the Laurentian Channel and into the Gulf of St. Lawrence.

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. 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 (Colbourne et al., 1994, Drinkwater et al., 1992, Narayanan et al., 1994).

The extent to which these oceanographic anomalies may have propagated into the 3Ps area are documented by several studies (Hutchings and Myers 1994, Moguedet and Mahe 1991, Battaglia and Poulard 1987, Forest and Poulard 1981). Drinkwater and Trites (1986) have also compiled monthly averaged temperature and salinity over much of the 3Ps area. The main purpose of this report is to provide an updated more general presentation of the data with reference to the longer term average.

VERTICAL TEMPERATURE FIELD

The vertical section (depth versus horizontal distance from the shore along the transect) of the average temperature field for the period February 1 to March 31, based on all available historical data from 1915 to 1993 is shown in Fig. 2. No attempts were made to adjust this average for possible temporal or spatial biasing arising from variations in the number of observations within the time interval or within the area. An examination of the data indicates that the observations are well distributed geographically across the complete transect, however temporally, most of the data have been collected since the early 1970s.

The average temperature for this time period ranges from -0.5 °C near the coast to 0.0 °C near the edge of the continental shelf over a depth range of 0 to 100 m. In deeper water (100 m to the bottom between 175 to 425 m) the temperature ranged from 0.0 to 5.0 °C in Hermitage Channel between St. Pierre Bank and Burgeo Bank and beyond the shelf edge in the continental slope region. Near the edge of the continental shelf on the Southwestern Grand Bank the temperature field is marked by a strong front separating the warmer slope water from the Labrador current water over St. Pierre Bank. In this region temperatures increase from 0.0 °C at 125 m depth to between 5.0 to 6.0 °C at about 175 m depth, a temperature gradient of 1.0 °C per 10 m depth change.

The vertical temperature distribution during the winter (February-March) of 1990 and 1991 is shown in Fig. 3. Data were absent beyond the middle of St. Pierre

Bank in 1990. During 1990 temperatures ranged from -0.5 to -1.0 °C in the upper water column from the coast and across most of St. Pierre Bank, about 0.5 °C below average and from 0.0 to 5.0 °C from 100 m to the bottom at about 425 m depth, near average.

In the winter of 1991 upper layer temperatures ranged from 0.0 °C near the coast to -0.25 °C across St. Pierre Bank to 1.0 °C at the edge of the shelf and from 1.0 to 5.0 °C from 100 m to the bottom, near average over most areas except at the shelf edge where it was up to 1.0 °C below average. In both 1992 and 1993 (Fig. 4) the average upper layer temperatures ranged from 0.0 to -1.0 °C, about 0.5 °C below normal and from 1.0 to 7.0 °C in deeper water, somewhat warmer than average.

The average (1915-1993) temperature for April (Fig. 5) ranges from 1.0 °C near the coast and over St. Pierre Bank to 2.0 °C beyond the shelf edge in the upper 100 m of the water column. In the deeper water of Burgeo and Hermitage Channels and on the continental slope region the temperature ranges from 2.0 °C at approximately 125 m depth to 5.0 to 6.0 °C near the bottom. During April 1993 (Fig. 6) temperatures ranged from -0.25 to 0.0 °C near the coast and over St. Pierre Bank to -1.0 to 1.0 °C at the edge of the shelf, generally about 1.0 °C below average. In April 1994 temperatures ranged from -1.0 to 0.0 °C in the upper 100 m over Burgeo and Hermitage Channels, up to 2.0 °C below average and from 0.5 to 1.0 °C over St. Pierre Bank, near average. Deep water temperatures on the continental slope were similar to 1993 values, about 1.0 °C below average.

BOTTOM TEMPERATURES

The average winter (February and March) bottom temperatures (Fig. 7) ranged from 5.0 °C in the Laurentian (200 to 400 m depth), Burgeo and Hermitage Channels (200 to 300 m depth) to about 3.0 to 4.0 °C on Rose Blanche Bank (100 to 200 m depth) in subdivision 3Pn and on Burgeo Bank (100 to 200 m depth) and from -0.5 to 1.0 °C on St. Pierre Bank (60 to 100 m depth). In general the bottom isotherms follow the bathymetry around the Laurentian Channel and the Southwestern Grand Bank decreasing from 2.0 °C at 200 m depth to 5.0 °C in the deeper water. These horizontal bottom temperature maps were contoured from all available bottom of the profile temperature measurements, rejecting values for which the profile depths were not within 10 % of the water depth.

During 1991 (Fig. 7) winter bottom temperatures on Rose Blanche Bank in subdivision 3Pn and on Burgeo Bank ranged from 2.0 to 3.0 °C, about 1.0 °C below average and from 0.0 to 1.5 °C over most of St. Pierre Bank, about 0.5 °C above average. In 1992 winter bottom temperatures were slightly below average over most areas and about average in 1993 (Fig 7).

The average (1915-1993) April bottom temperatures (Fig. 8) ranged from 5.0 °C in the Laurentian, Burgeo and Hermitage Channels to about 3.0 to 4.0 °C on Rose Blanche Bank and on Burgeo Bank very similar to the winter average and from -0.5 °C on the eastern side of St. Pierre Bank to 2.0 °C on the western side. In April 1991 data was limited to the eastern side of St. Pierre bank where conditions appeared near average. In April 1993 conditions were near average over most areas with the exception of the eastern side of St. Pierre Bank where temperatures were about 0.5 °C below average. During April 1994 temperatures were up to 1.0 °C above average over Burgeo Bank and Hermitage Channel, near average on the western side of St. Pierre Bank and about 0.5 °C below average on the eastern side.

TEMPORAL ANOMALIES IN TEMPERATURE

To examine the low frequency temperature variations during the last several decades, the historical data set for region B in Fig. 1 was examined. This region encompasses most of St. Pierre Bank in a depth range of 0 to 75 m. The historical data set for this area for all years were sorted by day of the year to determine the seasonal cycle. Following the general methods of Akenhead (1987) and Myers et al. (1990), the seasonal cycle in the temperature field at selected water depths were determined by fitting a least-squares regression to the mean and a sum of 4 sine and cosine pairs representing 4 harmonics.

Temperature measurements for all years at standard depths of 0, 20, 50, and 75 m for the area show the temporal distribution of the data throughout the year as well as the scatter from the fitted seasonal cycle (Fig. 9). These plots indicate sufficient data to adequately define the seasonal cycle over all depths considered. As usual the largest seasonal cycle in the water temperature occurs in the upper layers where the strongest coupling to the annual solar flux exists. The amplitude of the cycle for temperature decreases with depth and is not significant below 75 m depth. The phase of the temperature cycle increases with depth at a rate of approximately 1.0 day/m in the upper water column.

Time series of temperature anomalies were formed by taking each observation and subtracting the least squares fitted value of the seasonal cycle for the same day of the year. Observations made on the same day within the same area were averaged. The time series of the anomalies were then low pass filtered to suppress the high frequency variations at seasonal scales, (ie. the higher amplitude seasonal variations are not considered here). Time series of temperature anomalies were referenced to a 1950-1994 average. Unlike the time series at fixed points (eg. Station

27) these time series are based on a smaller data set distributed over a wider geographical area, hence the anomalies may be subject to larger spatial and temporal biasing.

The time series of temperature anomalies at standard depths of 0, 20, 50 and 75 m (Fig. 10) are characterized by large variations with amplitudes ranging from ± 1.0 °C and with periods between 5 to 10 years with some higher frequency variations in the upper water column. The cold periods of the mid 1970s and the mid 1980s are coincident with severe meteorological and ice conditions in the Northwest Atlantic and colder and fresher oceanographic anomalies over most of the Canadian continental shelf (Findlay and Deptuch-Stapf 1991). The cold period beginning in 1984 when overall temperatures decreased by up to 1.0 °C continued below normal until 1990. During 1991 temperatures moderated over the top 50 m of the water column but remained well below average at 75 m depth. During 1992 and 1993 the sign of the temperatures anomalies changed at 20 and 50 m depth but remained negative at the surface and at 75 m depth.

SUMMARY

Time series of temperature anomalies in the 3PS area show anomalous cold periods in the mid 1970s and since the mid 1980s, similar to conditions on the continental shelf along the east coast of Newfoundland. The most recent cold period, which started around 1984, continued to the early 1990s with temperatures up to 1.0 °C below average over all depths and up to 2.0 °C below the warmer temperatures of the late 1970s and early 1980s in the surface layers. Since 1991, temperatures have moderated somewhat in some areas from the lows experienced from the mid to late 1980s and 1990 but large spatial areas with negative temperature anomalies are continuing into the spring of 1994, particularly on the eastern portion of St. Pierre Bank and on the continental slope areas.

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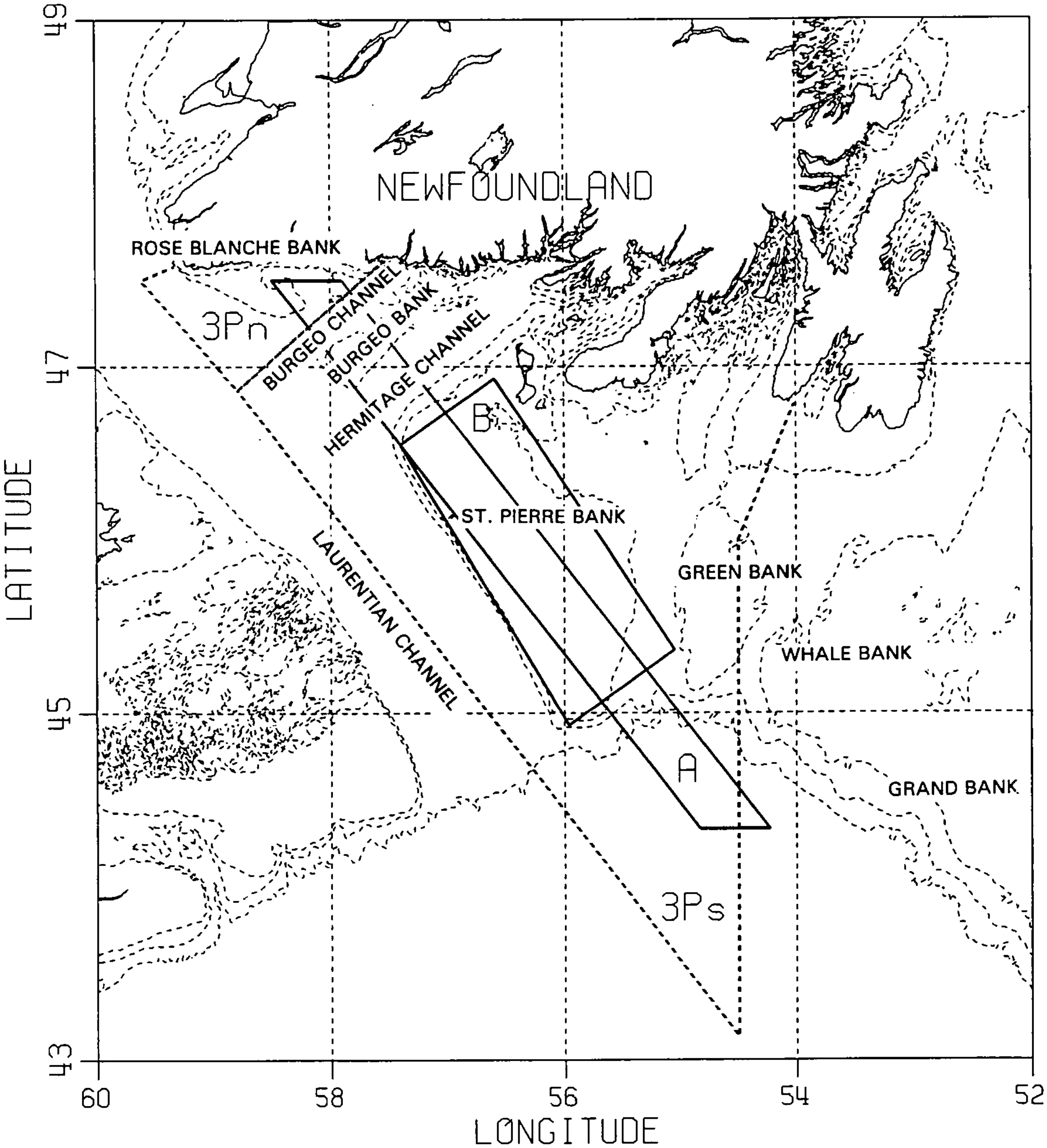


Fig. 1. Location map showing the 3Pn and 3Ps subdivisions and the areas A and B from which data were examined. The bathymetry lines are 100, 200 and 1000 m.

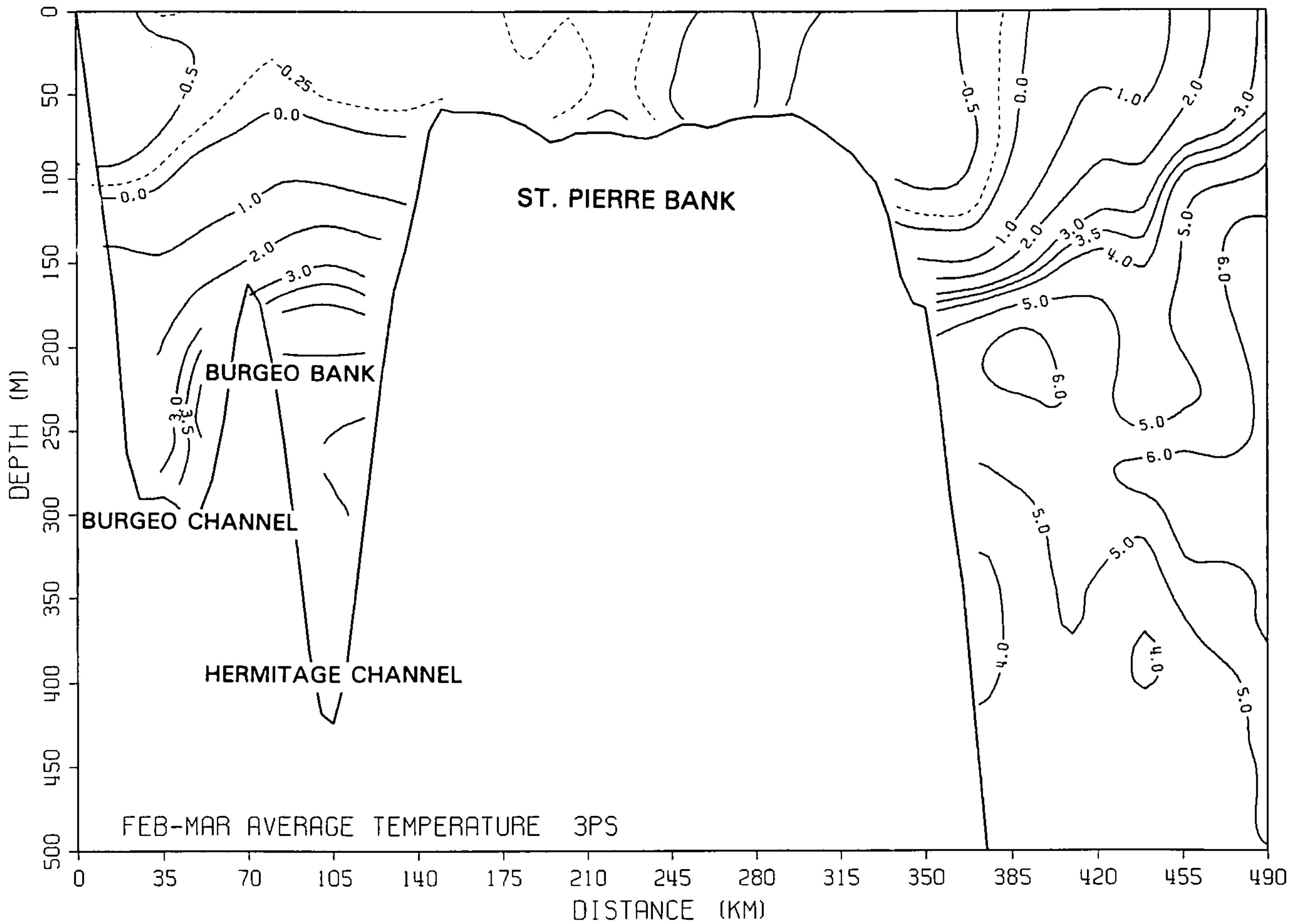
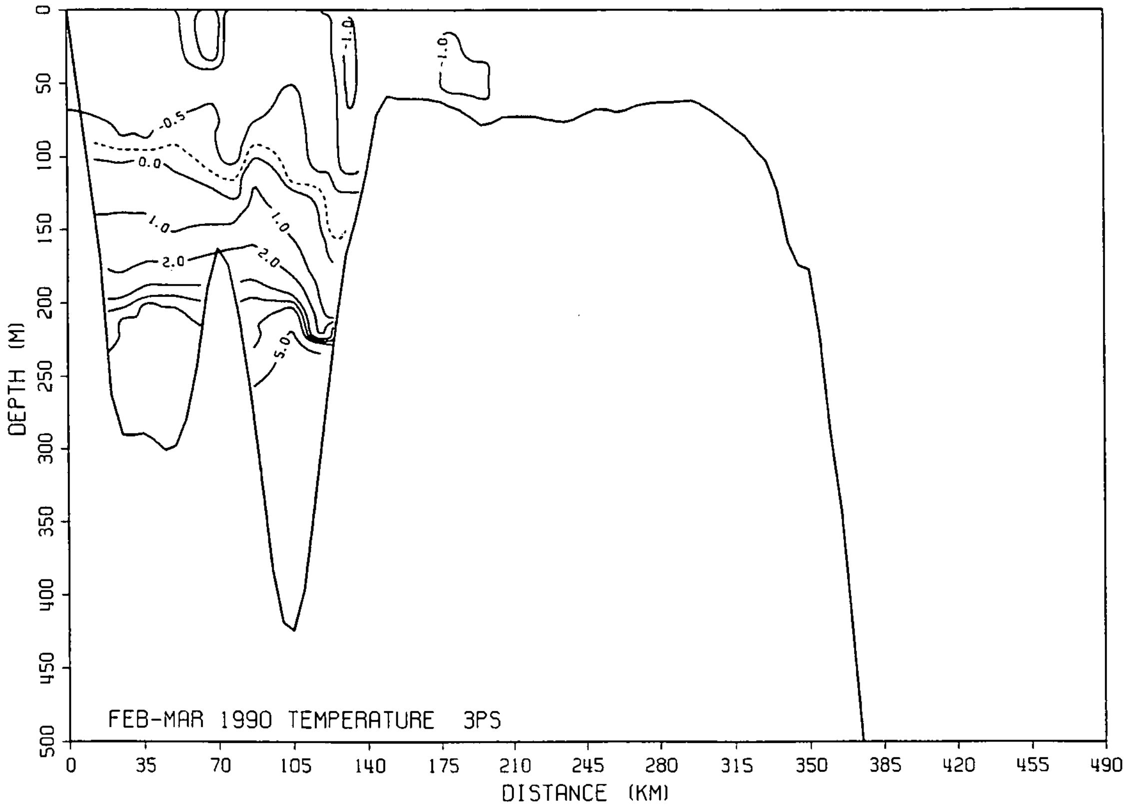


Fig. 2. The 1915 to 1993 average winter (February-March) temperature along the transect shown in Fig. 1 for NAFO subdivisions 3Pn and 3Ps.



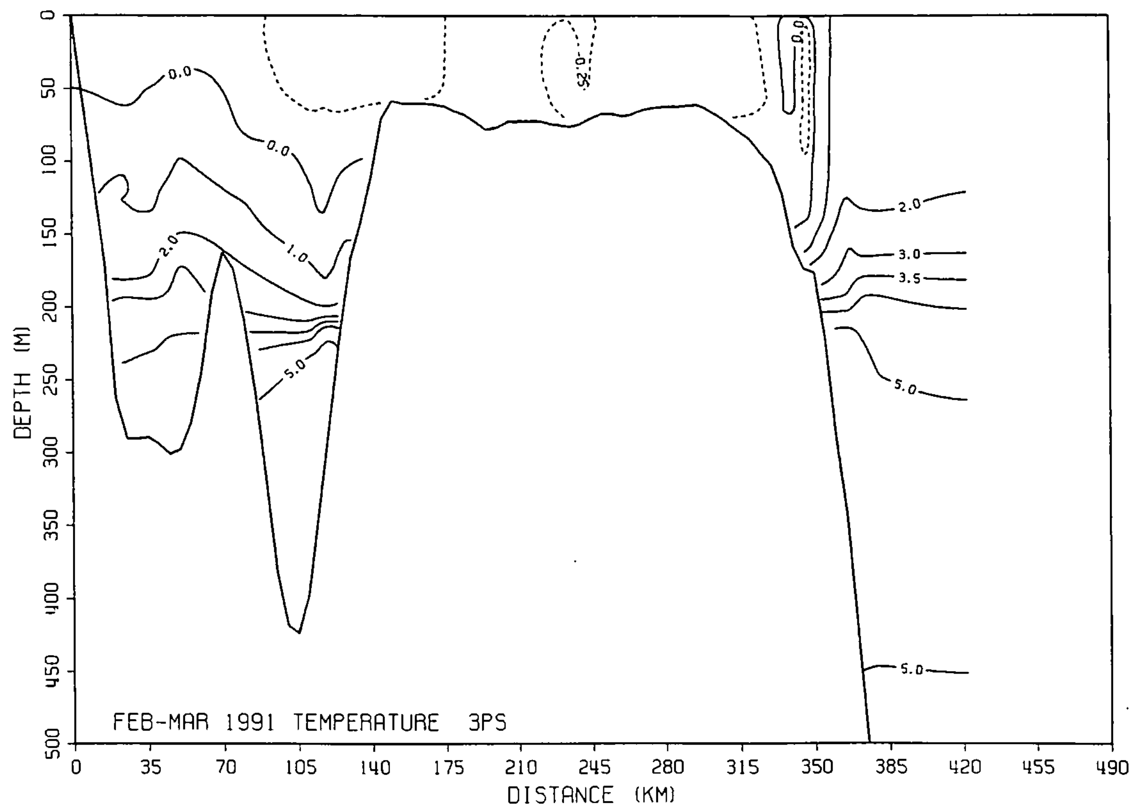


Fig. 3. The 1990 and 1991 winter temperature along the transect shown in Fig. 1 for NAFO subdivisions 3Pn and 3Ps.

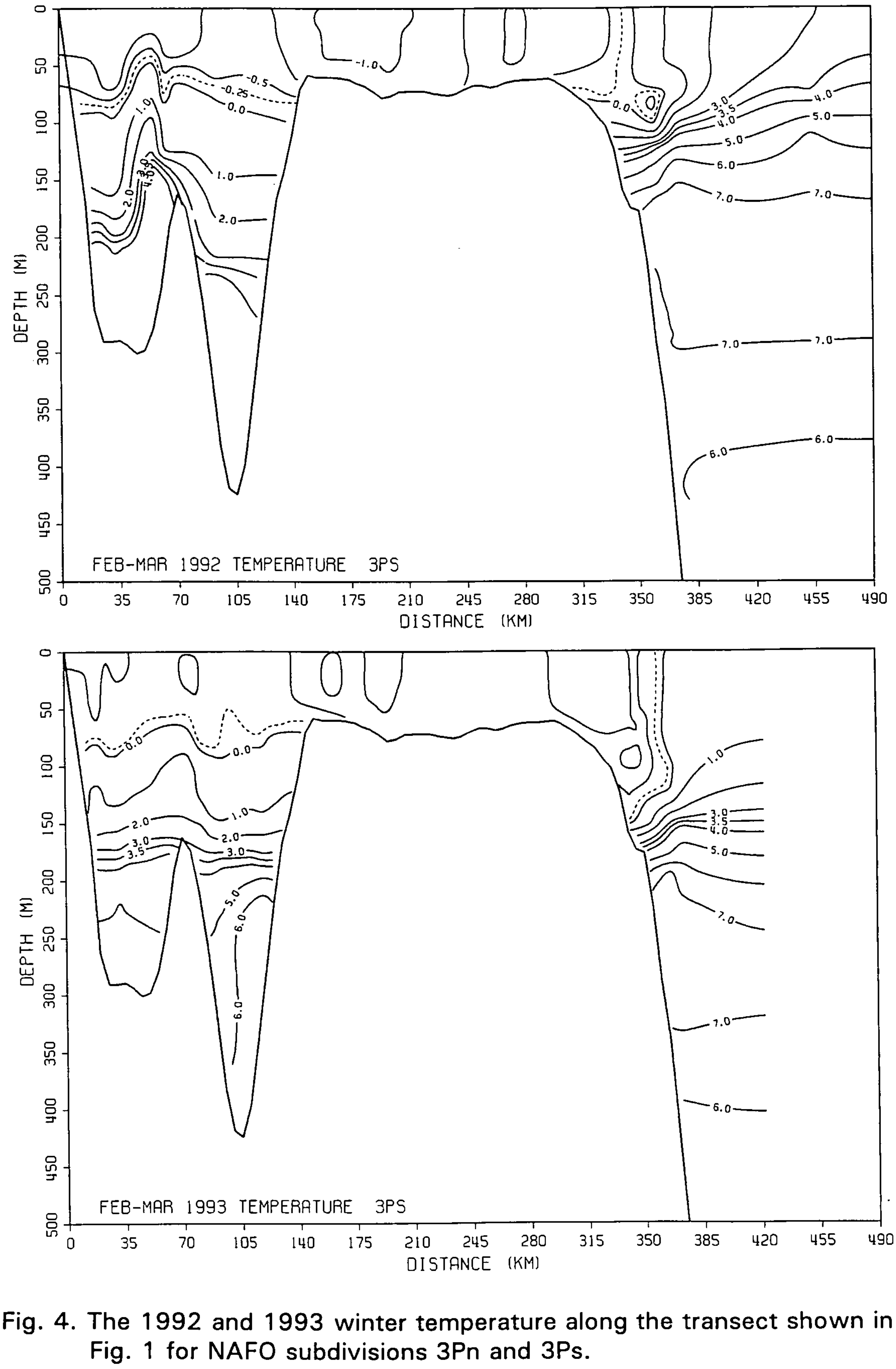


Fig. 4. The 1992 and 1993 winter temperature along the transect shown in Fig. 1 for NAFO subdivisions 3Pn and 3Ps.

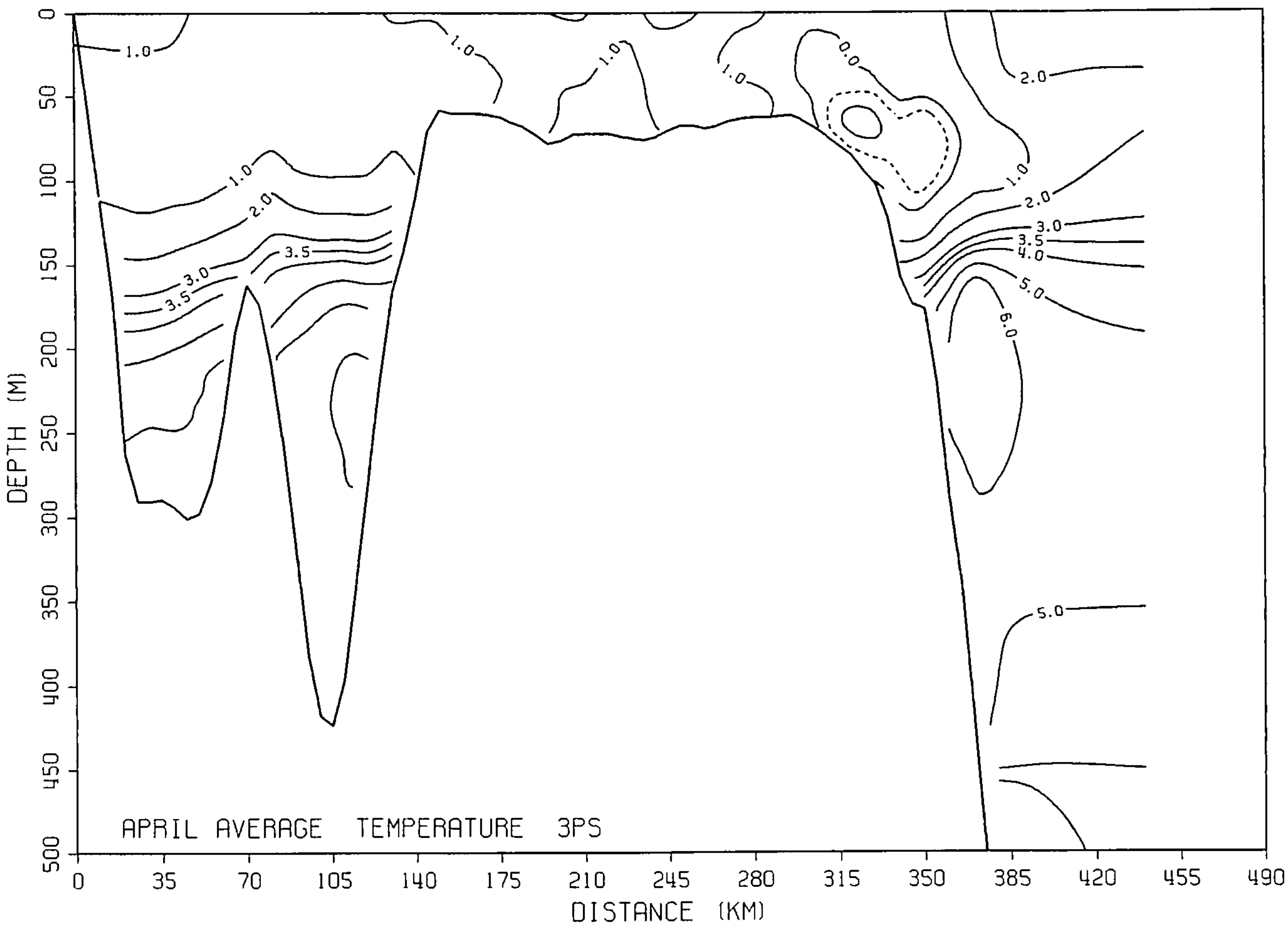


Fig. 5. The 1915 to 1993 average April temperature along the transect shown in Fig. 1 for NAFO subdivisions 3Pn and 3Ps.

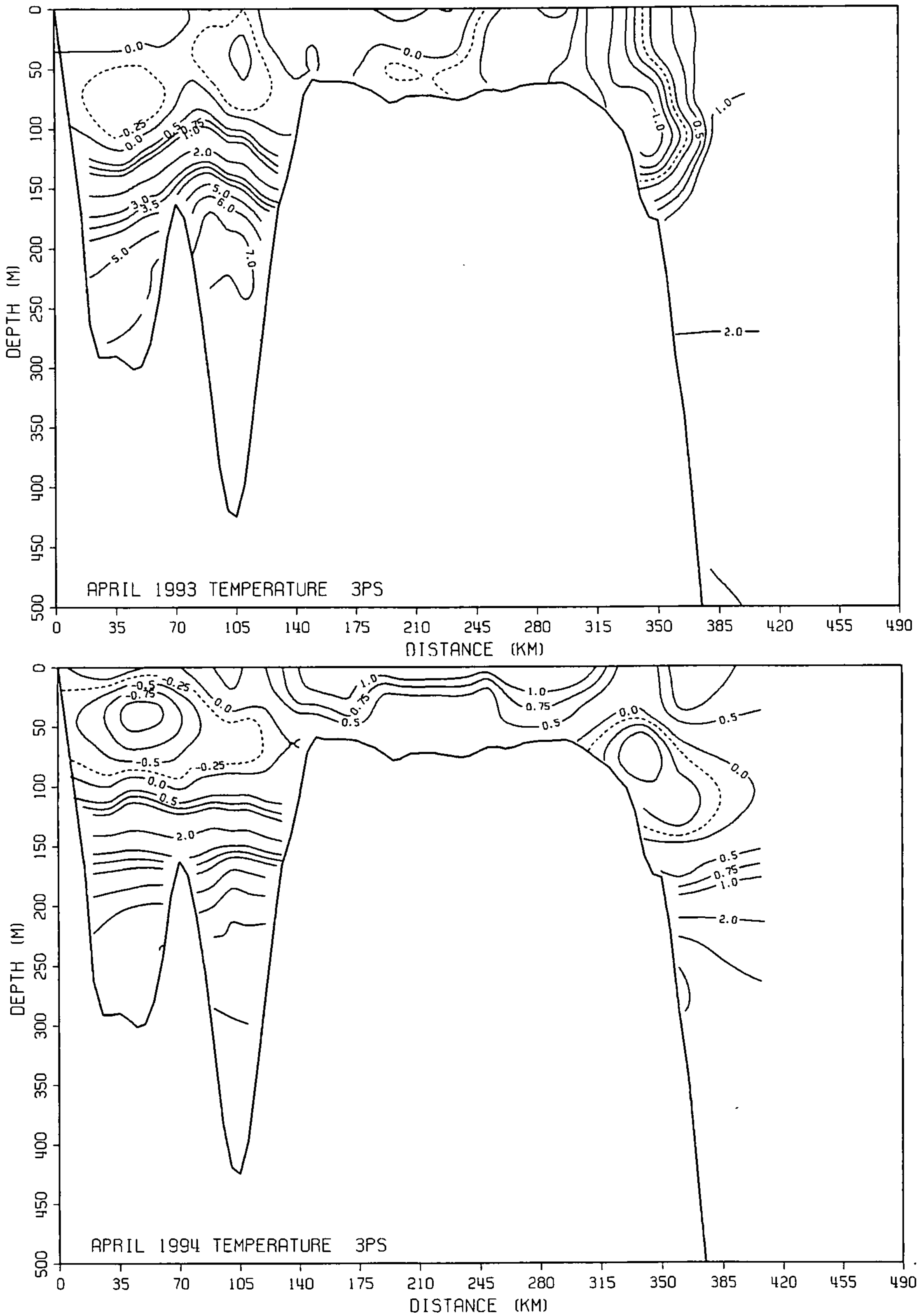


Fig. 6. The 1993 and 1994 April temperature along the transect shown in Fig. 1 for NAFO subdivisions 3Pn and 3Ps.

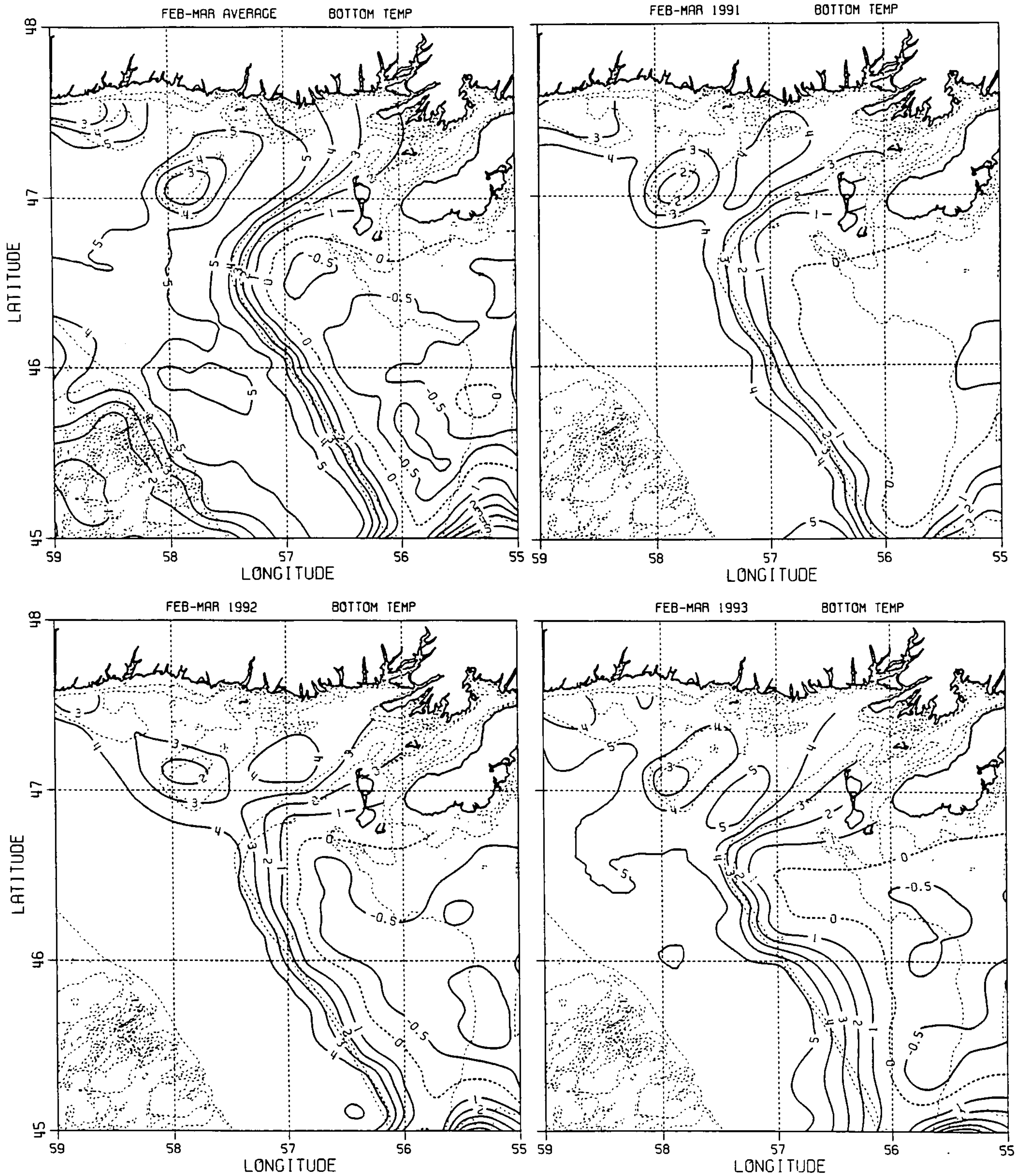


Fig. 7. Horizontal bottom temperature maps for the 1915 to 1993 winter average, winter 1991, 1992 and 1993 in NAFO subdivisions 3Pn and 3Ps.

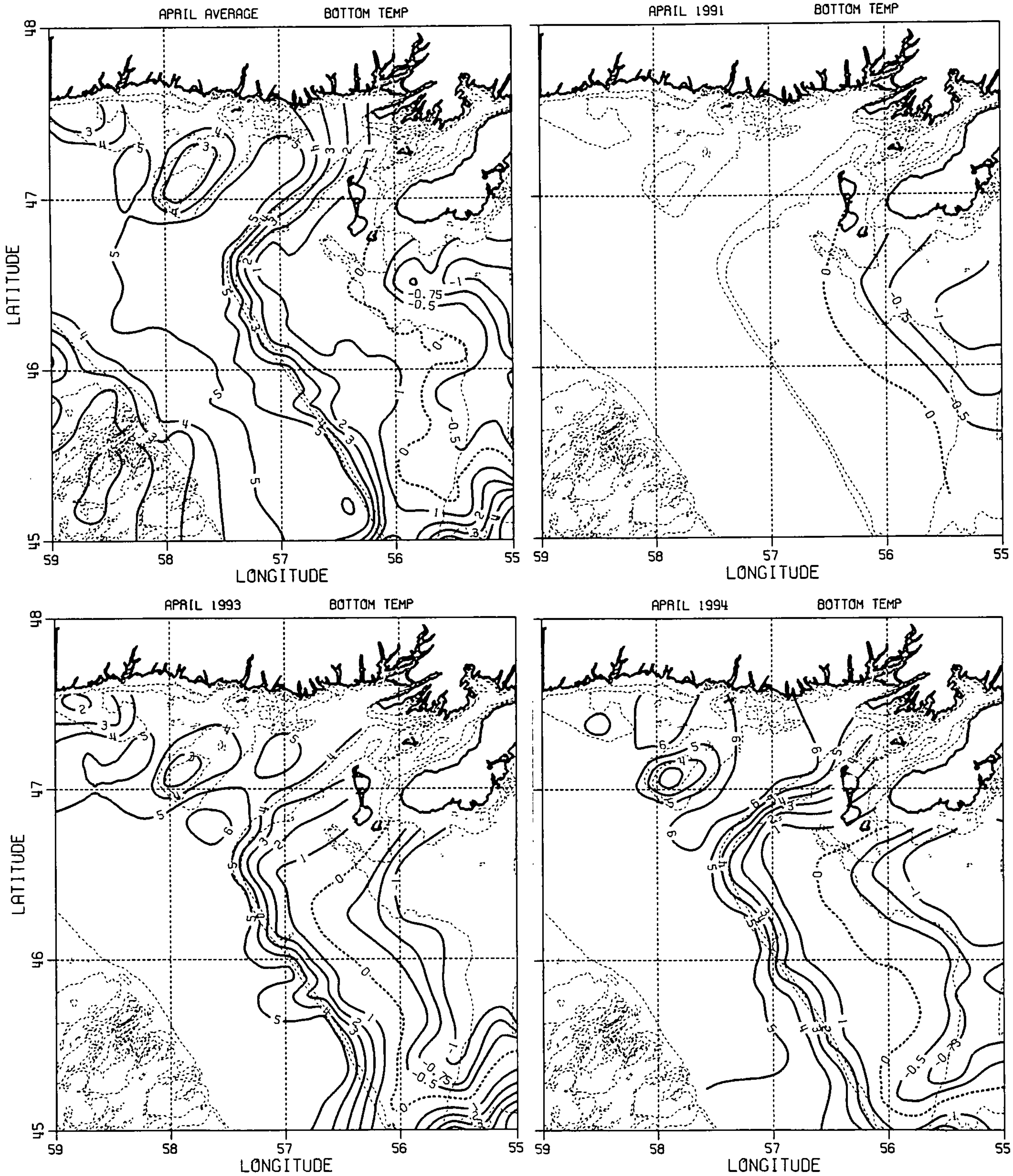


Fig. 8. Horizontal bottom temperature maps for the 1915 to 1993 April average, April 1991, 1993 and 1994 in NAFO subdivisions 3Pn and 3Ps.

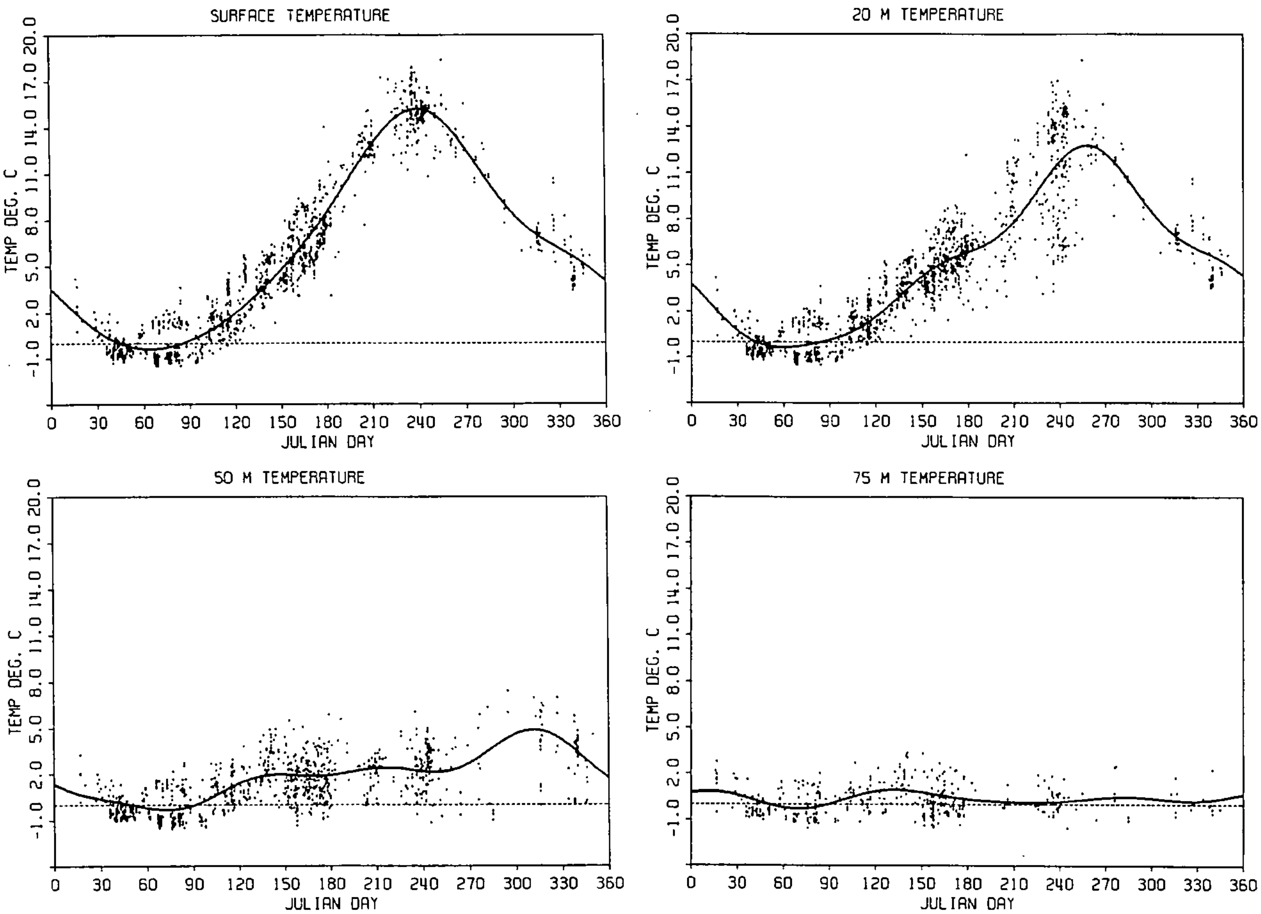


Fig. 9. Temperature measurements for all years at depths of 0.0 20.0, 50.0 and 75.0 m for box B in Fig. 1, together with the fitted regression curves.

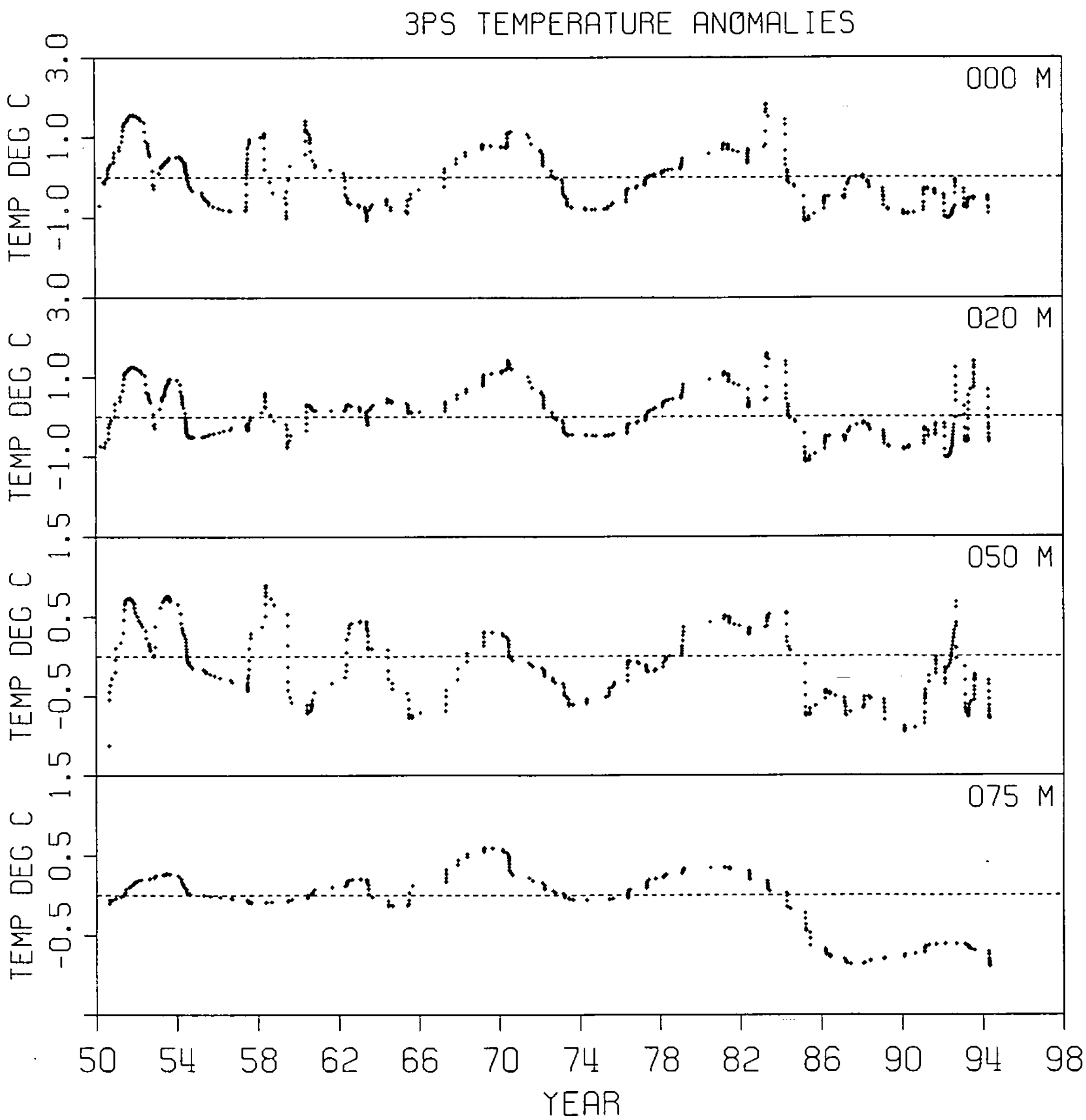


Fig. 10. Temperature anomaly time series at standard depths of 0.0 20.0, 50.0 and 75.0 m for box B in Fig. 1.