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# A comparison of the 1961-1990 and the 1971-2000 means for selected oceanographic data sets in the Newfoundland Region

# Comparaison des moyennes de certaines données océanographiques dans la région de Terre-Neuve entre les périodes 1961-1990 et 1971-2000

By / Par

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## Abstract

A comparison of the 1961-1990 and 1971-2000 monthly means of temperature and salinity at several sites in Newfoundland waters including St. Pierre Bank, Station 27 and the Flemish Cap are presented. In addition, seasonal and annual oceanographic indices derived from annual oceanographic and fish assessment surveys are also presented for the two time periods. The 30-year time period of 1961-1990 included data from the warm-salty 1960s and the two cold-fresh periods of the early 1970s and mid-1980s, whereas the new standard (1971-2000) covers three cold-fresh periods of the early 1970s, mid-1980s and the early 1990s. As a result ocean temperatures in Newfoundland waters were generally colder during the 1971-2000 time period compared to 1961-1990. The most significant temperature anomalies occurred in the upper water column where some of the largest monthly mean differences were observed. Although the deeper waters of the cold intermediate layer (>75-m) were also colder during the 1971-2000 time period during all months of the year. Salinities were generally lower during 1971-2000 compared to the 1961-1990 base period. Again the most significant salinity anomalies and monthly mean differences over the two time periods were restricted to the upper water column, where the freshening effects of sea ice melt dominates. As a result of the changing standards for computing long-term means, time series of temperature and salinity anomalies on the Newfoundland Shelf during the past several decades will appear warmer and saltier referenced to the new base period compared to the previous.

## Résumé

Ce document présente une comparaison des moyennes mensuelles de température et de salinité entre les périodes 1961-1990 et 1971-2000, à divers sites dans les eaux de Terre-Neuve, y compris le banc de St-Pierre, la station 27 et le Bonnet Flamand. Des indices océanographiques annuels et saisonniers, établis à l'aide des relevés océanographiques et halieutiques annuels, sont également présentés pour ces deux périodes. La période allant de 1961 à 1990 couvre les années 1960 aux eaux chaudes et salées et deux périodes d'eaux froides et relativement douces (début des années 1970 et milieu des années 1980). La nouvelle période de référence (1971-2000) comprend, quant à elle, les deux périodes d'eaux froides et douces susmentionnées en plus de celle du début des années 1990. La température des eaux océaniques de Terre-Neuve était donc en général plus basse au cours de la période 1971-2000 que de 1961 à 1990. Les anomalies de température les plus importantes se sont produites dans la colonne d'eau supérieure, où quelques-unes des plus grandes variations de moyennes mensuelles ont été observées. Les eaux les plus profondes de la couche intermédiaire froide (>75 m) étaient également plus froides à tous les mois de l'année au cours de la période 1971-2000. La salinité était généralement plus basse entre 1971 et 2000 qu'entre 1961 et 1990. Pour les deux périodes, les anomalies et les variations de moyennes mensuelles de la salinité les plus importantes étaient également limitées à la colonne d'eau supérieure, où l'effet de dilution de la salinité dû à la fonte de la glace de mer domine. Comme les moyennes à long terme seront calculées sur une nouvelle période de référence (1971-2000), les anomalies de température et de salinité observées lors des dernières décennies sur la plate-forme de Terre-Neuve paraîtront plus chaudes et plus salées que lorsqu'elles étaient calculées par rapport à l'ancienne période de référence.

## Introduction

To facilitate the comparability of climate indices among different regions of the world, the International Meteorological Committee in 1872 established a 30-year interval in which to summarize the “normal” climate. The World Meteorological Organization (WMO), which succeeded the International Meteorological Committee, defines normals as "period averages computed for a uniform and relatively long period comprising at least three consecutive 10-year periods" (WMO, 1984). The WMO has defined the climatological standard base periods for the following consecutive periods of 30 years: January 1, to December 31 of the years 1901-1930, 1931-1960, 1961-1990, etc. (WMO, 1984). To keep up with on-going climate change and any major climatic events, individual member countries of the WMO re-compute the climatological normals every decade. In the United States for example, climatological normals have been computed for periods 1971-2000, 1961-1990, 1951-1980, 1941-1970, 1931-1960, and 1921-1950 time periods. A coordinated international effort to compile global standard normals however, is undertaken only once every 30 years (Guttman, 1989). The latest global standard normal period is 1961-1990, which will be updated in 2021.

During the past couple of decades, oceanographers in Atlantic Canada have attempted to follow the meteorological standards insofar as the data sets will allow. For example, oceanographic climate indices computed during the last decade (1990s) which were presented to the Fisheries Oceanography Committee (FOC), the Northwest Atlantic Fisheries Organisation (NAFO) and other interest groups were referenced to the 1961-1990 base period (Drinkwater et al. 1999, Colbourne 2001a, 2001b). For the review of environmental conditions in Atlantic Canada during 2001, the new 1971-2000 base period was adopted as the standard, consistent with the meteorological service of Environment Canada. It is noted that for many sites oceanographic data are not always available over the full base period. With the advancement of the base period to 1971-2000 however, more data will be available than in the pervious period, which will allow a more representative mean to be computed. In this paper we present and compare monthly, seasonal and annual means and anomalies for oceanographic data collected at several sites in Newfoundland waters for the 1961-1990 and the 1971-2000 time periods.

## Methods

Station 27 ($47^{o}$ $32.8^{'}$ N, $52^{o}$ $35.2^{'}$ W) is a standard hydrographic monitoring station located off St. John's Newfoundland (Colbourne and Fitzpatrick 1994, Huyer and Verney 1975). First occupied in 1946, it is located about 8 km directly off St. John's harbor Newfoundland, in a water depth of 176 m thus making it an ideal location for departing and arriving research vessels. In recent years the station has been occupied on a regular basis primarily by oceanographic and fisheries research vessels at a frequency of about 2-4 times per month. The Station 27 oceanographic data set therefore is one of the most widely used time series in the Northwest Atlantic

for providing indices of ocean climate change. In addition, historical oceanographic data collected by various oceanographic surveys, fisheries assessment surveys and from ships of opportunity enables one to construct time series at several key locations on the Newfoundland Shelf. The annual data coverage in most regions is sufficient to construct annual cycles at most depths during both the 1961-1990 and the 1971-2000 standard reference period, however, data are not available for all months and in some cases monthly estimates may be based on only one measurement. In recent reviews of oceanographic conditions in this region temperature and salinity time series were constructed for Hamilton Bank, St. Pierre Bank and the Flemish Cap (Colbourne 2000).

In this report we have taken all available monthly averages and determined the monthly means over all years within both the 1961-1990 and the 1971-2000 base periods. For Station 27 we present plots of the annual cycles for both time periods at 9 standard depths together with the numerical value of the monthly means. In addition, we present the corresponding differences between the monthly means for the two base periods. For the other sites we present data only for the surface and near bottom depths. At all sites we include a time series of temperature and salinity (except salinity on St. Pierre Bank) anomalies referenced to both base periods. Finally, we include as examples, average bottom temperature maps for the Grand Banks and a temperature cross section along the standard Bonavista transect for the two base periods.

## Results

### *Temperature and salinity time series*

The differences in the annual temperature cycles at Station 27 based on the monthly means for the 1961-1990 and the 1971-2000 time periods are displayed in Figs. 1a to 1c. In the top 50-m of the water column temperatures were generally colder during the 1971-2000 period for the winter, later summer and fall months with maximum differences reaching near 0.5$^{o}$C at 50-m depth. Differences during March to June were smaller and probably not significant. In the depth range of 75 m to near-bottom at 175-m again temperatures were generally colder during the 1971-2000 time period with negative differences in all months reaching maximum values of about 0.2$^{o}$C. The time series of annual and inter-annual temperature anomalies based on the two reference periods were very similar at the surface but appear significantly warmer near bottom based on the 1971-2000 time period (Figs.2a and 2b).

The differences in the annual salinity cycles at Station 27 based on the monthly means for the 1961-1990 and the 1971-2000 time periods are displayed in Figs. 3a to 3c. Salinities were generally fresher during the 1971-2000 period compared to 1961-1990 over most months with the most significant differences in the upper water column. For example, maximum differences at the surface reached over 0.2 during mid-summer but were only about 0.05 near-bottom. At mid depths

between 50-100 m differences were generally smaller and more varied. These differences are reflected in the annual and inter-annual time series of salinity anomalies based on the two reference periods, which show significantly saltier conditions at the surface during the 1971-2000 time period (Figs.4a and 4b).

The differences in the annual temperature cycles on St. Pierre Bank based on the monthly means for the 1961-1990 and the 1971-2000 time periods are displayed in Figs. 5a and 5b. Surface temperatures were colder during the 1971-2000 period for 6 out of 12 months with a significant positive difference during September. The time series of annual surface temperature anomalies computed from the monthly values for the two time periods exhibit significant differences during some years. Unlike Station 27 where we have good annual coverage, data are not available for all months on St. Pierre Bank and in fact some annual estimates may be based on as few as two measurement. As a result differences in the anomaly time series will exhibit large variations. Near bottom on St. Pierre Bank however, differences appear to be more consistently negative (except for August and September) as a result temperature anomalies appear to be slightly warmer referenced to the 1971-2000 time period.

On the Flemish Cap differences in the annual temperature cycles for the two time periods displayed in Figs. 6a and 6b indicate generally colder conditions during the 1971-2000 period compared to 1961-1990. Again differences are more consistently negative near the bottom at 150 m depth. Temperature anomalies for both the surface and near bottom are warmer for the 1971-2000 base period compared to 1961-1990. Similar to Station 27, salinity differences on the Flemish Cap both at the surface and at 150 m depth indicate that conditions were fresher over the 1971-2000 time period compared to 1961-1990. As a result the time series of salinity anomalies reflect this difference, however, as on St. Pierre Bank this data set is incomplete with many missing months.

***Standard monitoring sections***

Since the late 1940s the occupation of cross shelf sections has been a regular component of oceanographic monitoring on the Newfoundland Shelf. Three of the most frequently monitored sections include the Seal Island section on the southern Labrador Shelf, the Bonavista section off the east coast of Newfoundland and the Flemish Cap section which crosses the Grand Bank at 47°N and continues eastward across the Flemish Cap (Anon. 1978). One of the most commonly used climate indices for examining ocean climate and its effects on fish production is derived from these surveys, the so called cold-intermediate-layer (CIL) (Pertie et al. 1988). The CIL area is a summer-time measurement of the remnants of the winter chilled shelf water, usually defined by water $<0^{o}C$ for the Newfoundland Shelf. During the annual reviews of oceanographic conditions presented to FOC and NAFO anomalies of T/S cross-sections and the area of CIL water are presented referenced to the WMO standard base period.

An examination of the average summer temperature cross-section along the Bonavista section reveals significant differences for the two time periods (Fig. 7). During the 1961-1990 time period near-surface temperatures ranged from 8-10$^{o}$C compared to 6-8$^{o}$C during the 1971-2000 period. At intermediate depths, typically 50-225-m, the areal extent of water with temperatures <0$^{o}$C is more extensive during the 1971-2000 period extending in the offshore direction to about 225-km. Near-bottom temperatures over most of the Northeast Newfoundland Shelf in water depths typically >250-m ranged from about 1$^{o}$-3$^{o}$C during both averaging time periods. As a consequence cross-sectional anomalies referenced to the new 1971-2000 base period will appear warmer and the time series of CIL anomalies will be offset by the differences in the mean of the two periods. This offset appears to be the smallest for the Seal Island transect and maximum along the Flemish Cap transect across the shallow Grand Bank where most of the water column is influenced by the CIL.

***Spatial temperature maps***

Spatial temperature and temperature anomaly contour maps are routinely included in the annual reviews of oceanographic conditions presented to FOC and NAFO. The anomalies are normally referenced to all data collected within the WMO standard base period. The main data source for this analysis is from the stratified random multi-species trawl surveys that have been conducted in NAFO Sub-areas 2 and 3 since the 1970s.

An examination of the average spring near-bottom temperature in NAFO Divs. 3LNO reveals only minor differences for the two time periods (Fig. 10). The only noticeable difference between the two time periods, apart from minor features, is the slightly more extensive area of sub-zero $^{o}$C water, particularly at temperatures below –0.5$^{o}$C. The main reason for the similarity is the lack of comprehensive surveys during the 1960s. Furthermore, during the decade of the 1990s both the very cold early 1990s averaged out the very warm conditions experienced during the latter part of the decade. Hence differences between the two time periods in this case are minor.

## Summary and conclusions

During the past several decades' ocean climate conditions on the Newfoundland Shelf have been characterized by several extremes. Most of the 1960s were very warm and salty. Cold-fresh ocean conditions prevailed during the early 1970s, mid-1980s and early 1990s and the very warm but generally fresh conditions occurred during the latter half of the 1990s. The annual time series of temperature, salinity, CIL and other oceanographic and meteorological indices clearly show these near-decadal oscillations in the physical environmental in the Northwest Atlantic (Colbourne et al. 1994, Drinkwater et al. 1996). The 30-year time period of 1961-1990 included the warm, salty 1960s and the two cold-fresh periods

of the early 1970s and mid-1980s, whereas the new standard will include three cold-fresh periods of the past three decades. As a result ocean temperatures in Newfoundland waters were generally colder over 1971-2000 time period compared to 1961-1990. The most significant temperature anomalies occurred in the upper water column where some of the largest monthly mean differences were observed. The deeper waters of the CIL (>75-m) were also colder over the 1971-2000 time period during all months of the year. Salinities were generally lower during 1971-2000 compared to the 1961-1990 base period. The most significant salinity anomalies and monthly mean differences over the two time periods were restricted to the upper water column, where the freshening effects of sea ice melt dominate. In conclusion, the net result of the changing standards for computing long-term means will be that the time series of temperature and salinity anomalies during the past several decades will appear warmer and saltier referenced to the new base period compared to the previous.

## Acknowledgements

We thank P. Stead of the oceanography section at NAFC for data quality control and D. Senciall for computer software support. We also thank the many scientists and technicians at the Northwest Atlantic Centre (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.

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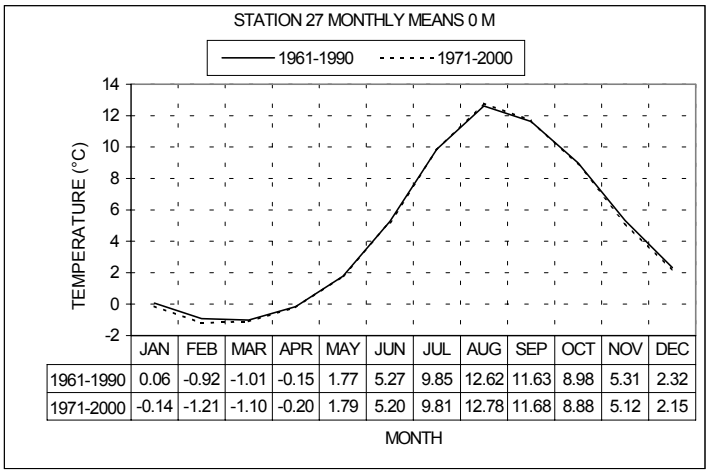


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| 1971-2000 | -0.14 | -1.21 | -1.10 | -0.20 | 1.79 | 5.20 | 9.81 | 12.78 | 11.68 | 8.88 | 5.12 | 2.15 |

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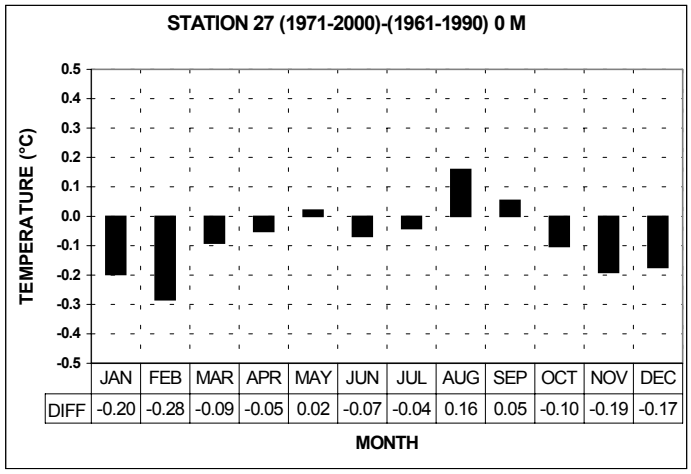


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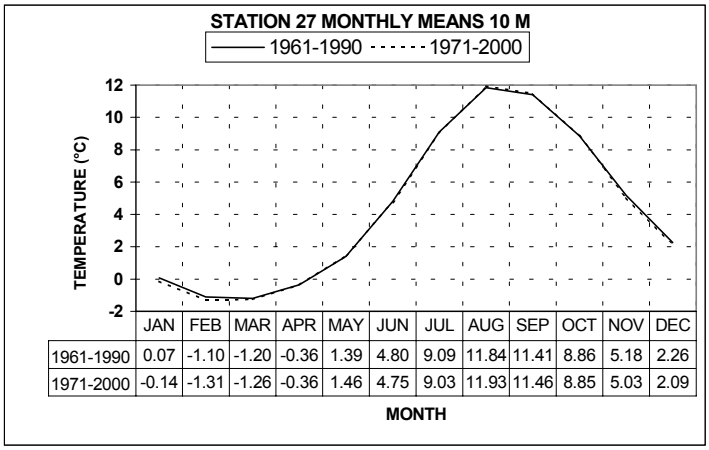


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| 1961-1990 | 0.07 | -1.10 | -1.20 | -0.36 | 1.39 | 4.80 | 9.09 | 11.84 | 11.41 | 8.86 | 5.18 | 2.26 |
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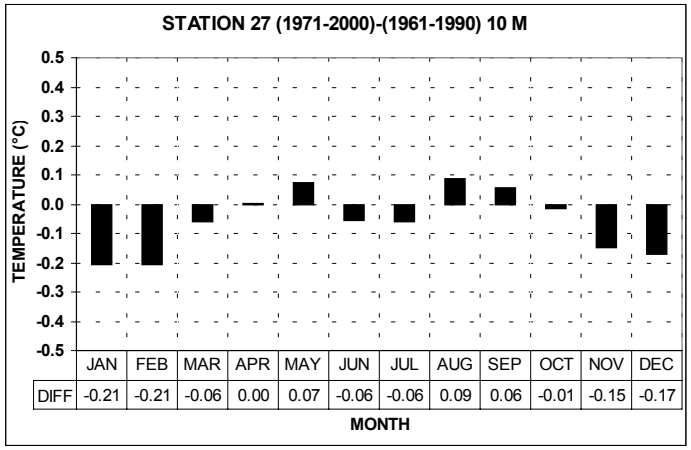


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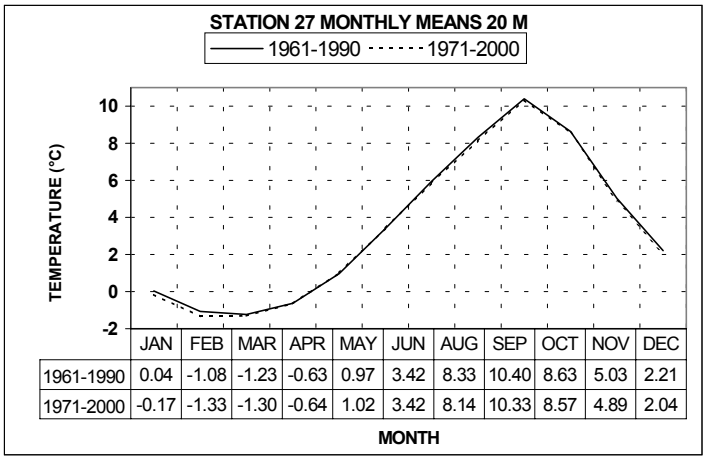
MONTH

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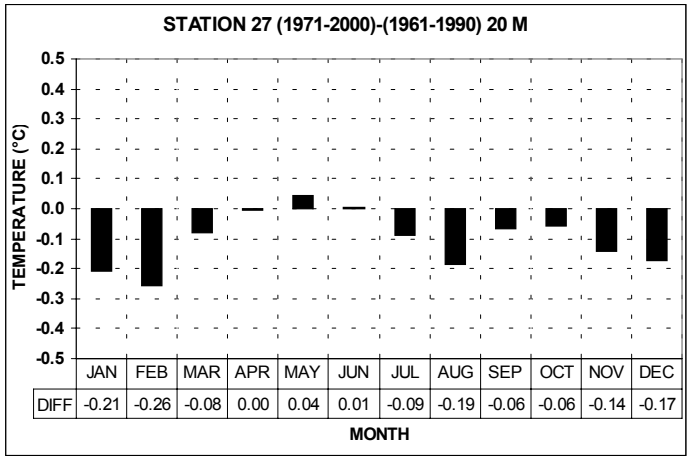
| 1961-1990 | 0.04 | -1.08 | -1.23 | -0.63 | 0.97 | 3.42 | 8.33 | 10.40 | 8.63 | 5.03 | 2.21 |
| 1971-2000 | -0.17 | -1.33 | -1.30 | -0.64 | 1.02 | 3.42 | 8.14 | 10.33 | 8.57 | 4.89 | 2.04 |

MONTH

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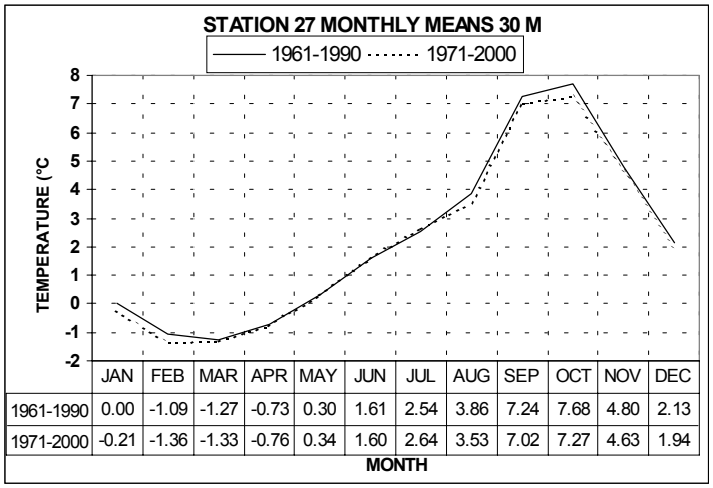
MONTH

Fig. 1a. Monthly means (left panels) and differences (right panels) of temperature at Station 27 for the periods 1961-1990 and 1971-2000 at standard depths.

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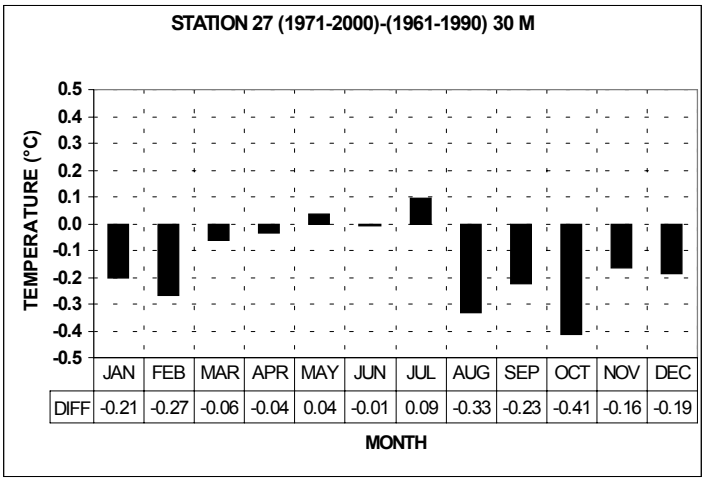
| 1961-1990 | 0.00 | -1.09 | -1.27 | -0.73 | 0.30 | 1.61 | 2.54 | 3.86 | 7.24 | 7.68 | 4.80 | 2.13 |
| 1971-2000 | -0.21 | -1.36 | -1.33 | -0.76 | 0.34 | 1.60 | 2.64 | 3.53 | 7.02 | 7.27 | 4.63 | 1.94 |

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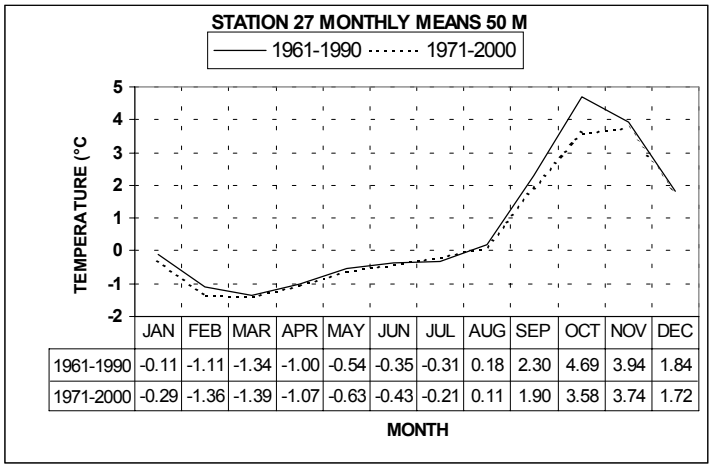
| DIFF | -0.21 | -0.27 | -0.06 | -0.04 | 0.04 | -0.01 | 0.09 | -0.33 | -0.23 | -0.41 | -0.16 | -0.19 |

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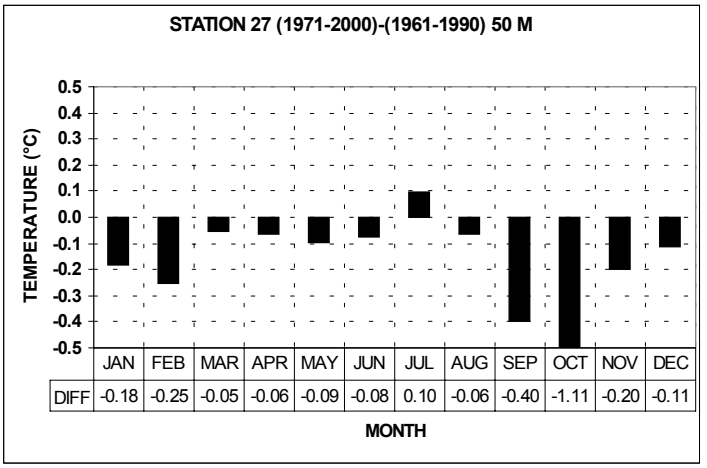
| 1961-1990 | -0.11 | -1.11 | -1.34 | -1.00 | -0.54 | -0.35 | -0.31 | 0.18 | 2.30 | 4.69 | 3.94 | 1.84 |
| 1971-2000 | -0.29 | -1.36 | -1.39 | -1.07 | -0.63 | -0.43 | -0.21 | 0.11 | 1.90 | 3.58 | 3.74 | 1.72 |

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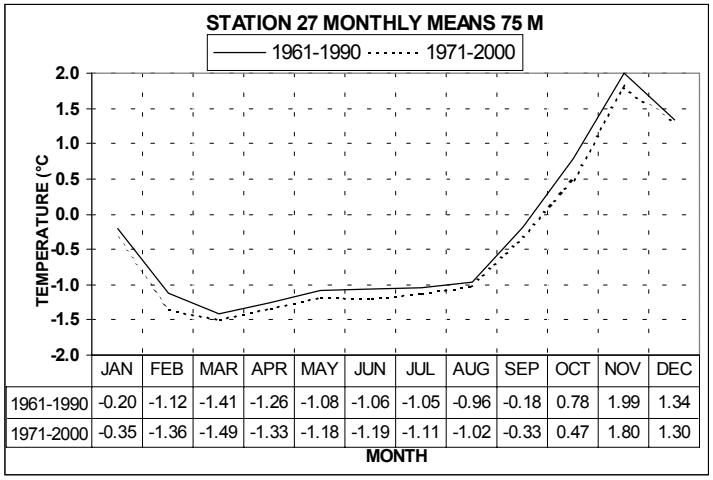


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| 1961-1990 | -0.20 | -1.12 | -1.41 | -1.26 | -1.08 | -1.06 | -1.05 | -0.96 | -0.18 | 0.78 | 1.99 | 1.34 |
| 1971-2000 | -0.35 | -1.36 | -1.49 | -1.33 | -1.18 | -1.19 | -1.11 | -1.02 | -0.33 | 0.47 | 1.80 | 1.30 |

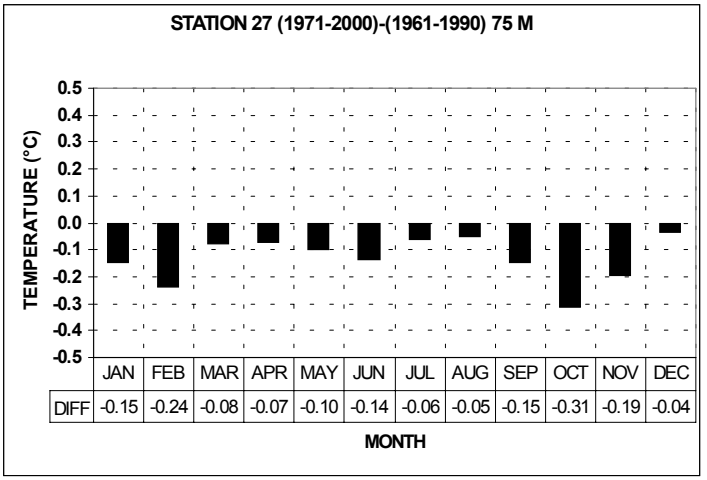


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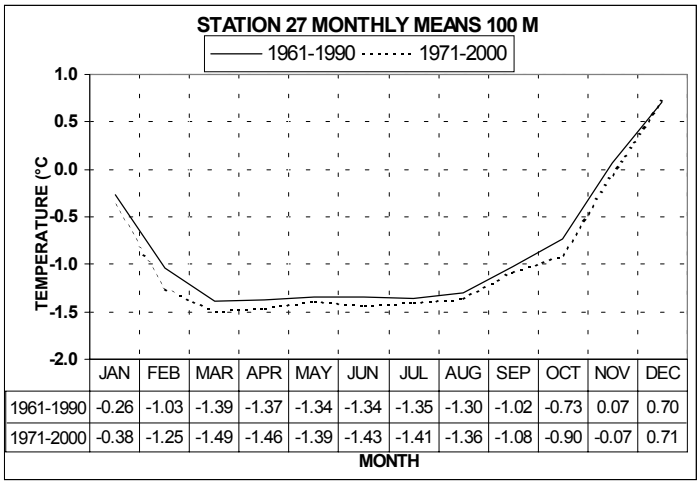
Fig. 1b. Monthly means (left panels) and differences (right panels) of temperature at Station 27 for the periods 1961-1990 and 1971-2000 at standard depths.

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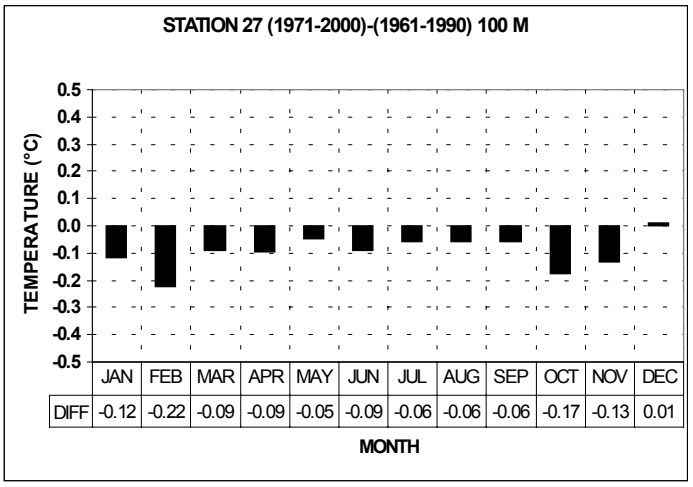
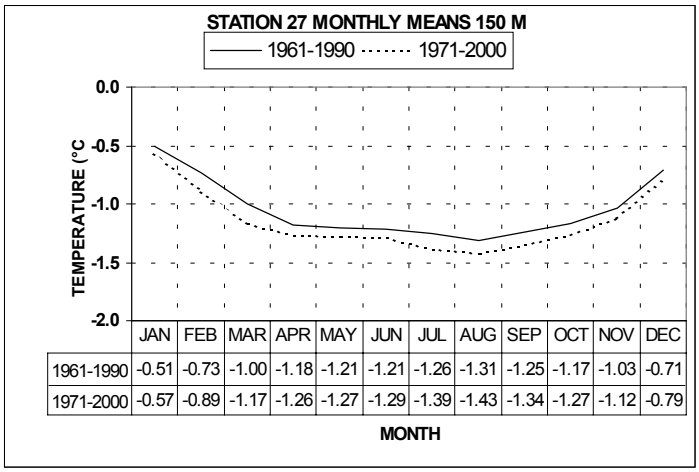
| 1961-1990 | -0.26 | -1.03 | -1.39 | -1.37 | -1.34 | -1.34 | -1.35 | -1.30 | -1.02 | -0.73 | 0.07 | 0.70 |
| 1971-2000 | -0.38 | -1.25 | -1.49 | -1.46 | -1.39 | -1.43 | -1.41 | -1.36 | -1.08 | -0.90 | -0.07 | 0.71 |

MONTH



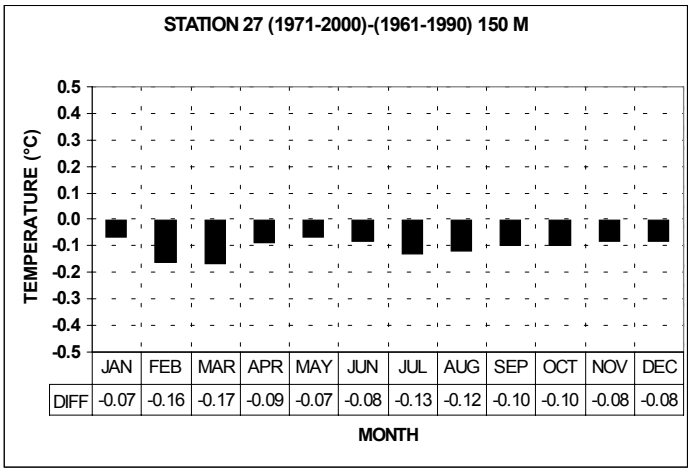

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.12 | -0.22 | -0.09 | -0.09 | -0.05 | -0.09 | -0.06 | -0.06 | -0.06 | -0.17 | -0.13 | 0.01 |

MONTH



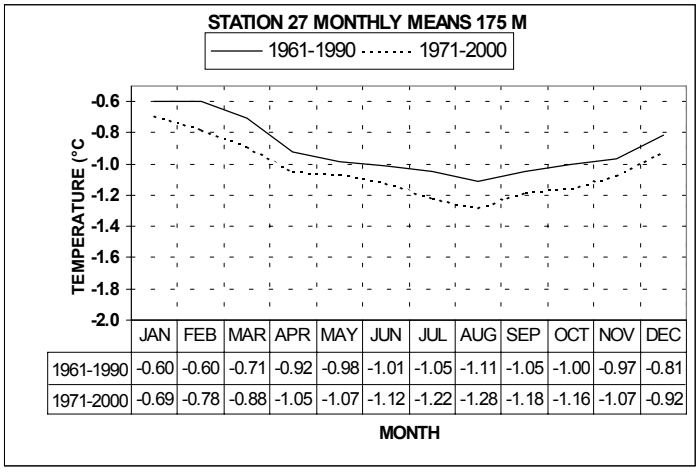

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | -0.51 | -0.73 | -1.00 | -1.18 | -1.21 | -1.21 | -1.26 | -1.31 | -1.25 | -1.17 | -1.03 | -0.71 |
| 1971-2000 | -0.57 | -0.89 | -1.17 | -1.26 | -1.27 | -1.29 | -1.39 | -1.43 | -1.34 | -1.27 | -1.12 | -0.79 |

MONTH



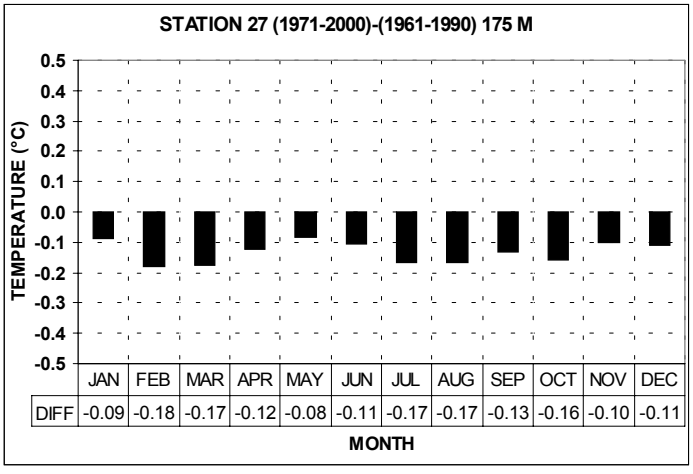

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.07 | -0.16 | -0.17 | -0.09 | -0.07 | -0.08 | -0.13 | -0.12 | -0.10 | -0.10 | -0.08 | -0.08 |

MONTH




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | -0.60 | -0.60 | -0.71 | -0.92 | -0.98 | -1.01 | -1.05 | -1.11 | -1.05 | -1.00 | -0.97 | -0.81 |
| 1971-2000 | -0.69 | -0.78 | -0.88 | -1.05 | -1.07 | -1.12 | -1.22 | -1.28 | -1.18 | -1.16 | -1.07 | -0.92 |

MONTH




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.09 | -0.18 | -0.17 | -0.12 | -0.08 | -0.11 | -0.17 | -0.17 | -0.13 | -0.16 | -0.10 | -0.11 |

MONTH

Fig. 1c. Monthly means (left panels) and differences (right panels) of temperature at Station 27 for the periods 1961-1990 and 1971-2000 at standard depths.

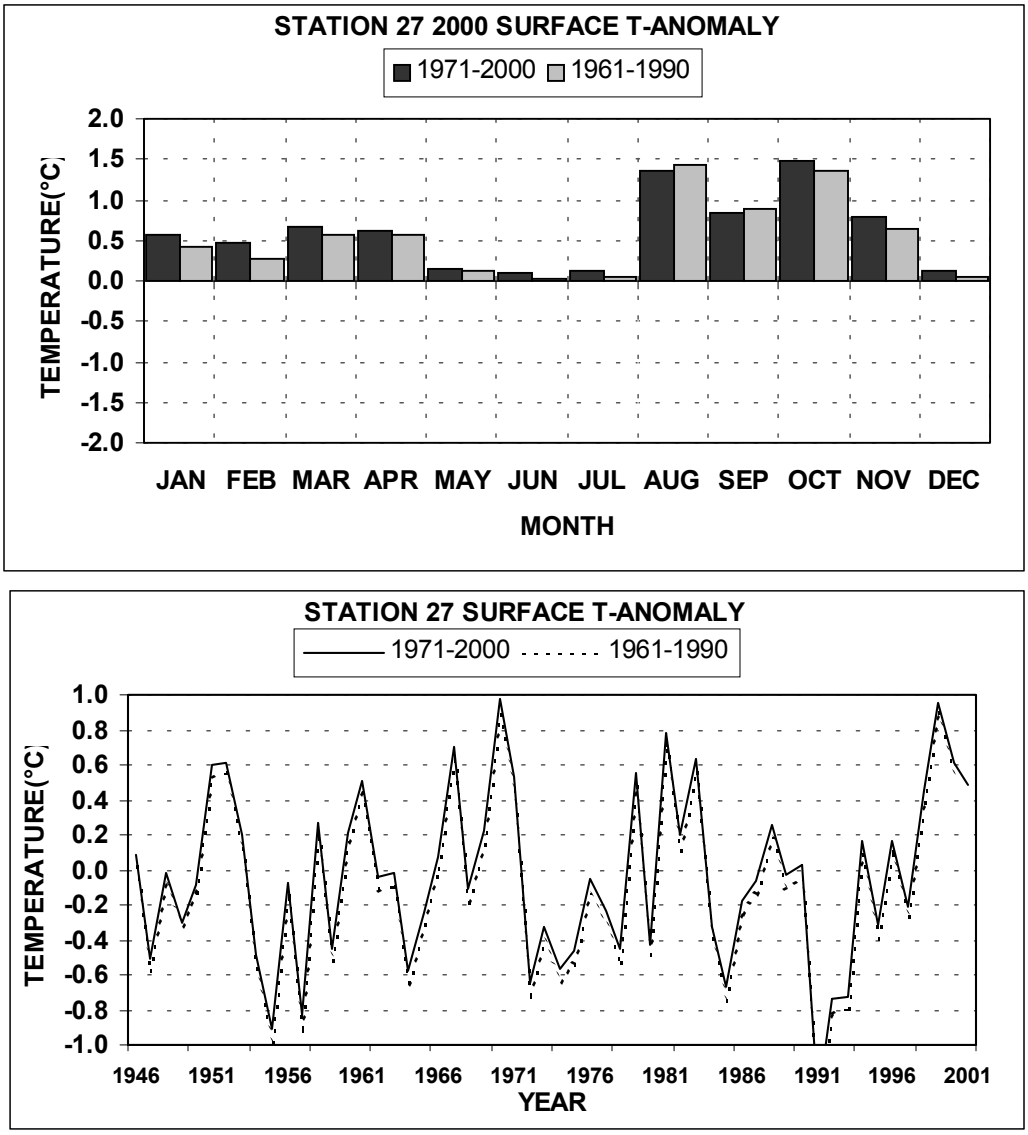



Fig. 2a. Monthly means (top panel) of surface temperature during 2000 and the annual anomalies (bottom panel) at Station 27 referenced to the periods 1961-1990 and 1971-2000.

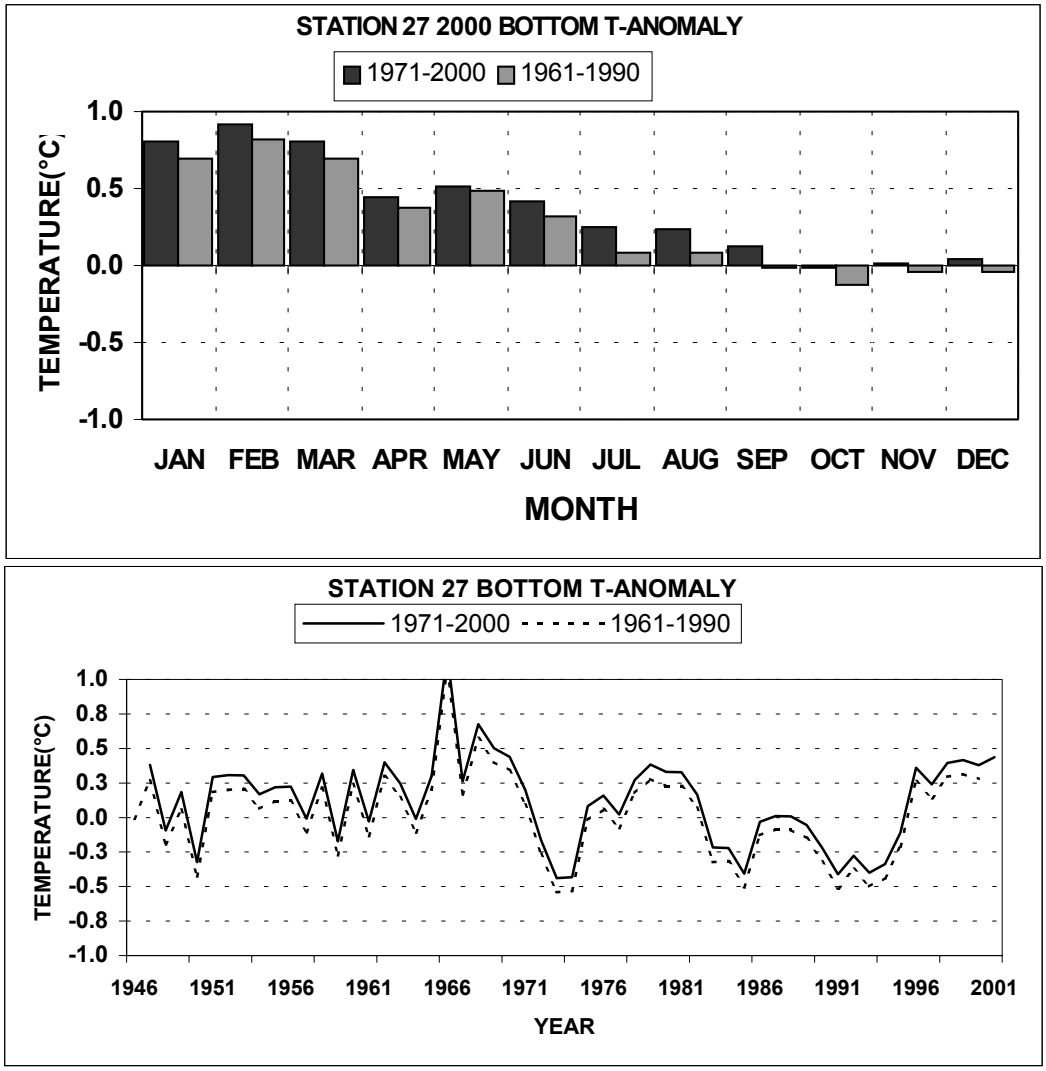
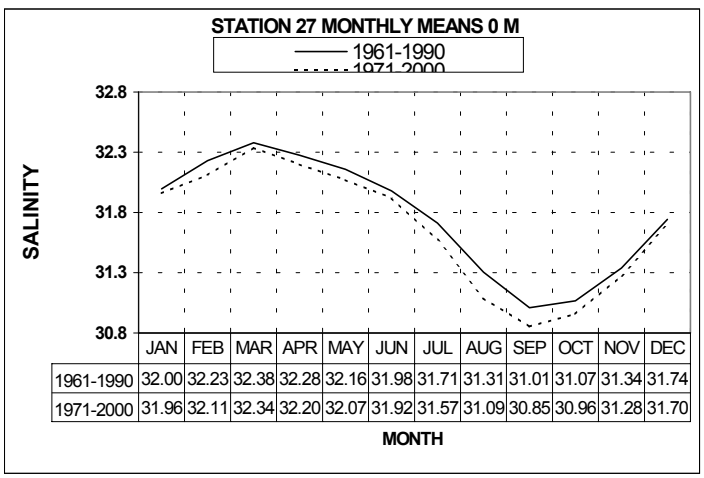
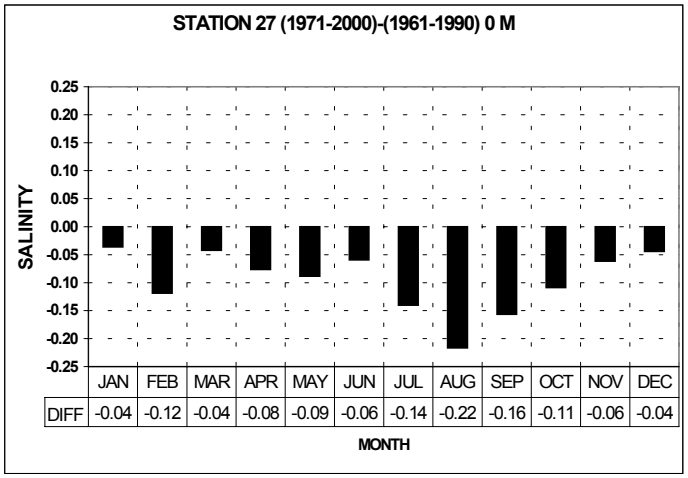


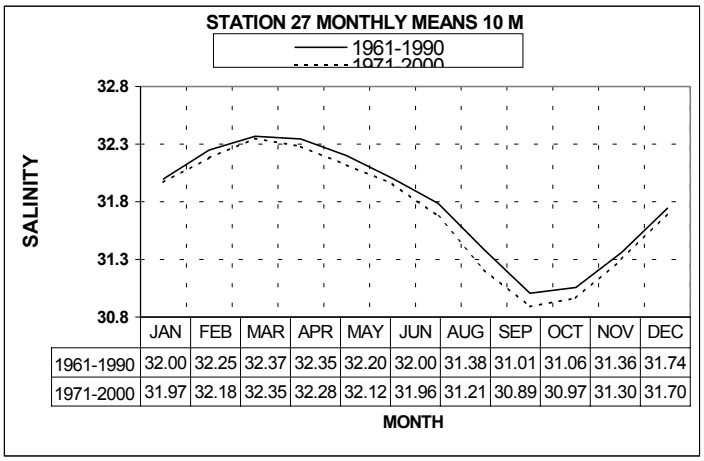

Fig. 2b. Monthly means (top panel) of bottom temperature during 2000 and the annual anomalies (bottom panel) at Station 27 referenced to the periods 1961-1990 and 1971-2000.



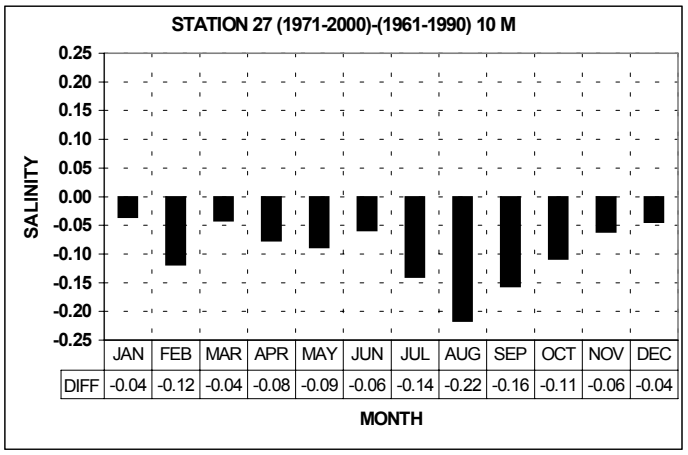

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.00 | 32.23 | 32.38 | 32.28 | 32.16 | 31.98 | 31.71 | 31.31 | 31.01 | 31.07 | 31.34 | 31.74 |
| 1971-2000 | 31.96 | 32.11 | 32.34 | 32.20 | 32.07 | 31.92 | 31.57 | 31.09 | 30.85 | 30.96 | 31.28 | 31.70 |



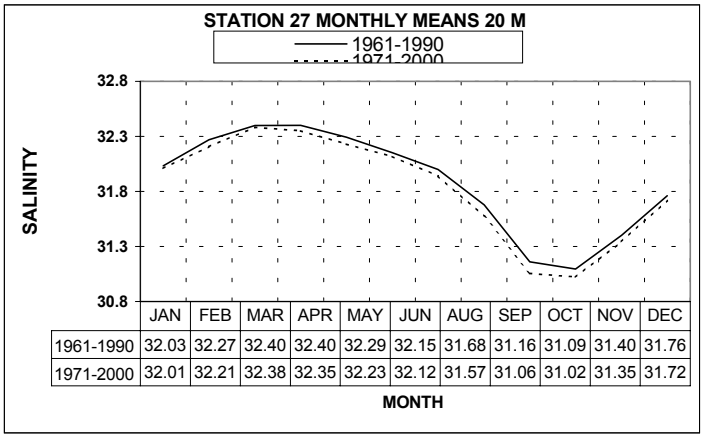

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.04 | -0.12 | -0.04 | -0.08 | -0.09 | -0.06 | -0.14 | -0.22 | -0.16 | -0.11 | -0.06 | -0.04 |



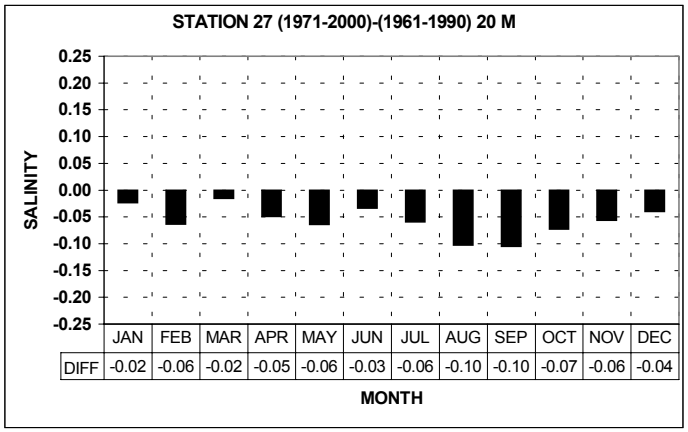

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.00 | 32.25 | 32.37 | 32.35 | 32.20 | 32.00 | 31.38 | 31.01 | 31.06 | 31.36 | 31.74 | |
| 1971-2000 | 31.97 | 32.18 | 32.35 | 32.28 | 32.12 | 31.96 | 31.21 | 30.89 | 30.97 | 31.30 | 31.70 | |




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.04 | -0.12 | -0.04 | -0.08 | -0.09 | -0.06 | -0.14 | -0.22 | -0.16 | -0.11 | -0.06 | -0.04 |

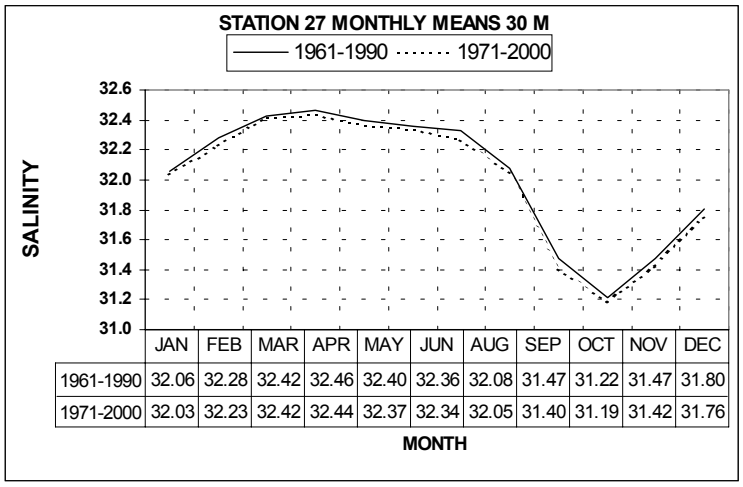



| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.03 | 32.27 | 32.40 | 32.40 | 32.29 | 32.15 | 31.68 | 31.16 | 31.09 | 31.40 | 31.76 | |
| 1971-2000 | 32.01 | 32.21 | 32.38 | 32.35 | 32.23 | 32.12 | 31.57 | 31.06 | 31.02 | 31.35 | 31.72 | |



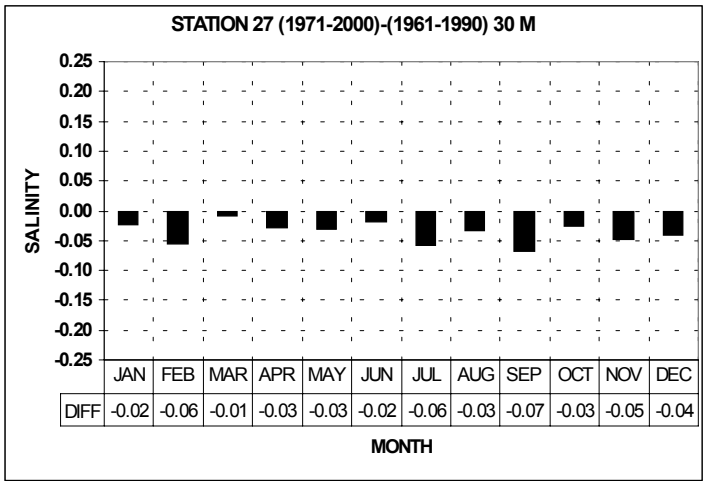

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.02 | -0.06 | -0.02 | -0.05 | -0.06 | -0.03 | -0.06 | -0.10 | -0.10 | -0.07 | -0.06 | -0.04 |

Fig. 3a. Monthly means (left panels) and differences (right panels) of salinity at Station 27 for the periods 1961-1990 and 1971-2000 at standard depths.



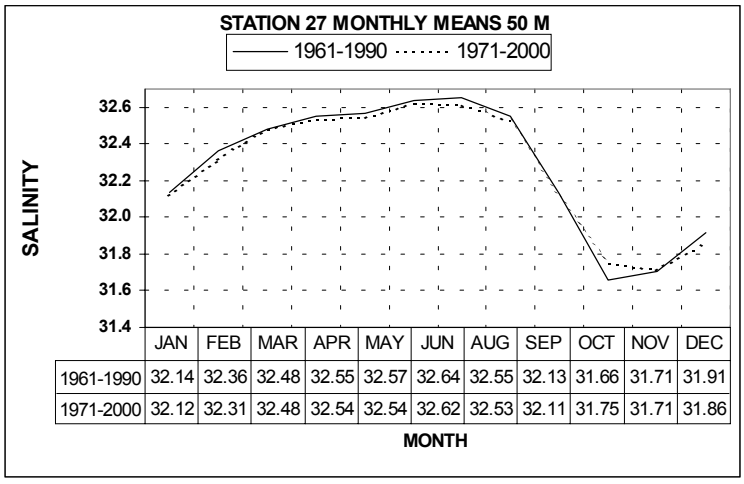

| | JAN | FEB | MAR | APR | MAY | JUN | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.06 | 32.28 | 32.42 | 32.46 | 32.40 | 32.36 | 32.08 | 31.47 | 31.22 | 31.47 | 31.80 |
| 1971-2000 | 32.03 | 32.23 | 32.42 | 32.44 | 32.37 | 32.34 | 32.05 | 31.40 | 31.19 | 31.42 | 31.76 |

MONTH



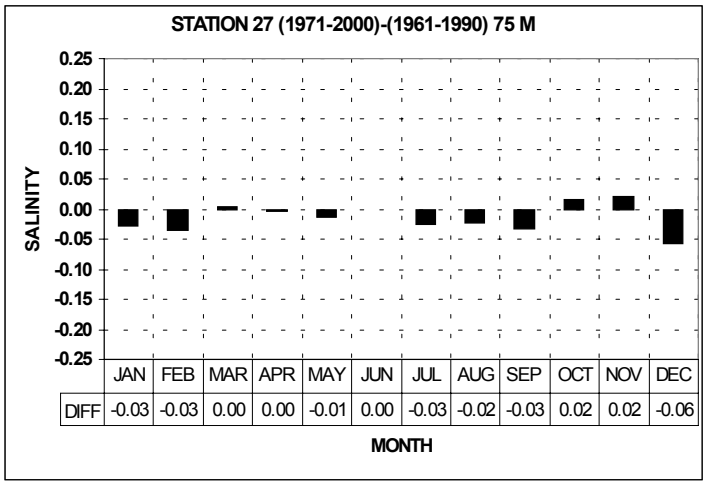

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.02 | -0.06 | -0.01 | -0.03 | -0.03 | -0.02 | -0.06 | -0.03 | -0.07 | -0.03 | -0.05 | -0.04 |

MONTH



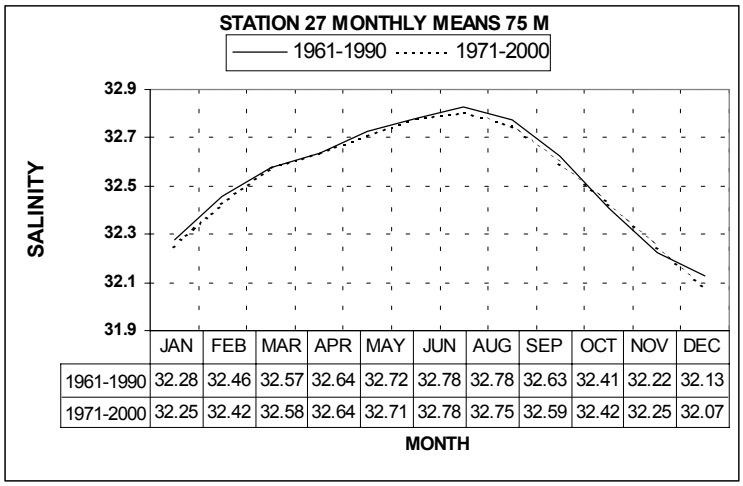

| | JAN | FEB | MAR | APR | MAY | JUN | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.14 | 32.36 | 32.48 | 32.55 | 32.57 | 32.64 | 32.55 | 32.13 | 31.66 | 31.71 | 31.91 |
| 1971-2000 | 32.12 | 32.31 | 32.48 | 32.54 | 32.54 | 32.62 | 32.53 | 32.11 | 31.75 | 31.71 | 31.86 |

MONTH



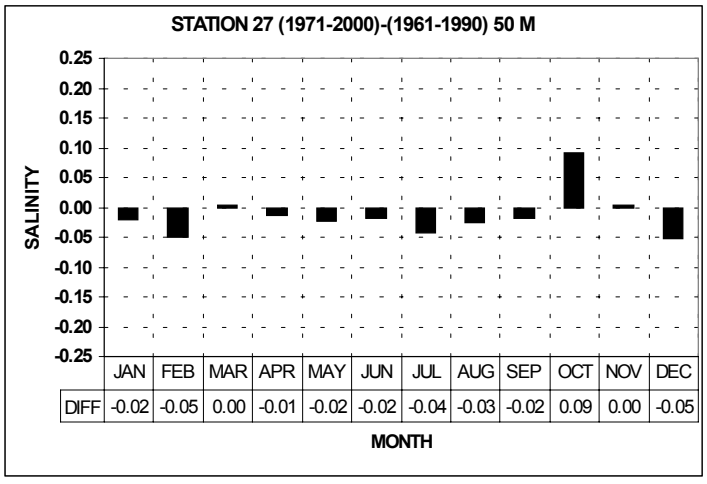

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.03 | -0.03 | 0.00 | 0.00 | -0.01 | 0.00 | -0.03 | -0.02 | -0.03 | 0.02 | 0.02 | -0.06 |

MONTH




| | JAN | FEB | MAR | APR | MAY | JUN | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.28 | 32.46 | 32.57 | 32.64 | 32.72 | 32.78 | 32.78 | 32.63 | 32.41 | 32.22 | 32.13 |
| 1971-2000 | 32.25 | 32.42 | 32.58 | 32.64 | 32.71 | 32.78 | 32.75 | 32.59 | 32.42 | 32.25 | 32.07 |

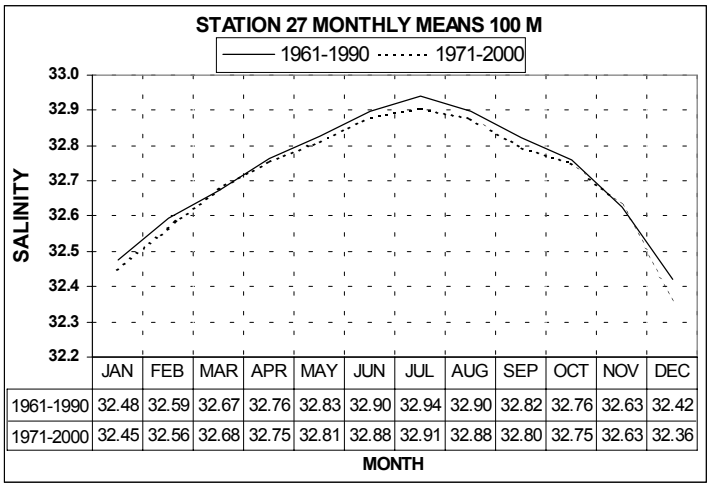
MONTH




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.02 | -0.05 | 0.00 | -0.01 | -0.02 | -0.02 | -0.04 | -0.03 | -0.02 | 0.09 | 0.00 | -0.05 |

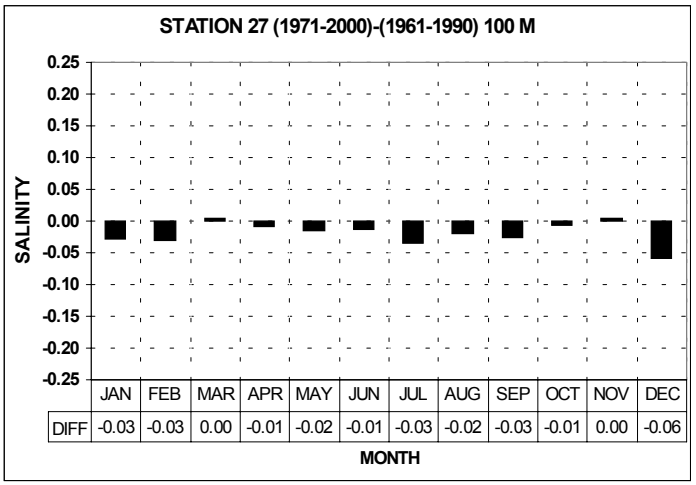
MONTH

Fig. 3b. Monthly means (left panels) and differences (right panels) of salinity at Station 27 for the periods 1961-1990 and 1971-2000 at standard depths.



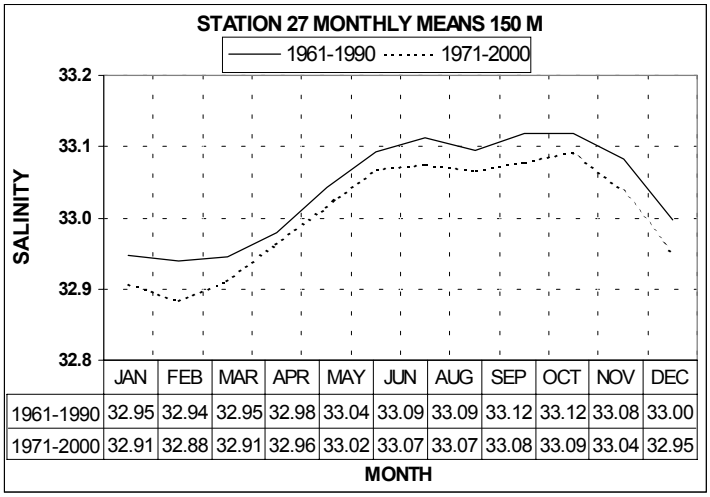

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.48 | 32.59 | 32.67 | 32.76 | 32.83 | 32.90 | 32.94 | 32.90 | 32.82 | 32.76 | 32.63 | 32.42 |
| 1971-2000 | 32.45 | 32.56 | 32.68 | 32.75 | 32.81 | 32.88 | 32.91 | 32.88 | 32.80 | 32.75 | 32.63 | 32.36 |

MONTH



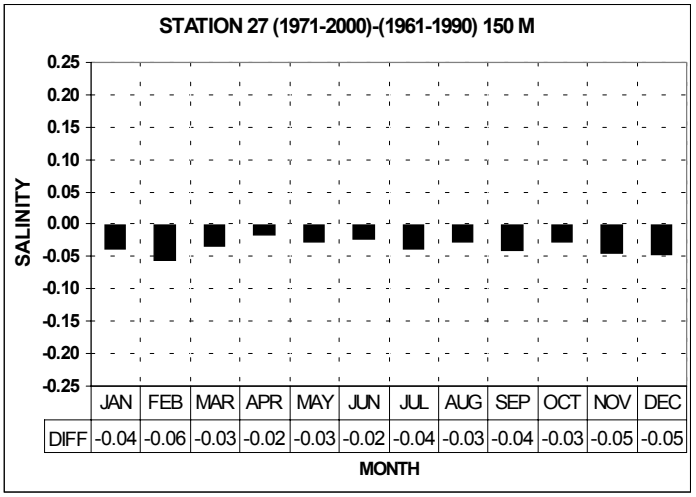

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.03 | -0.03 | 0.00 | -0.01 | -0.02 | -0.01 | -0.03 | -0.02 | -0.03 | -0.01 | 0.00 | -0.06 |

MONTH



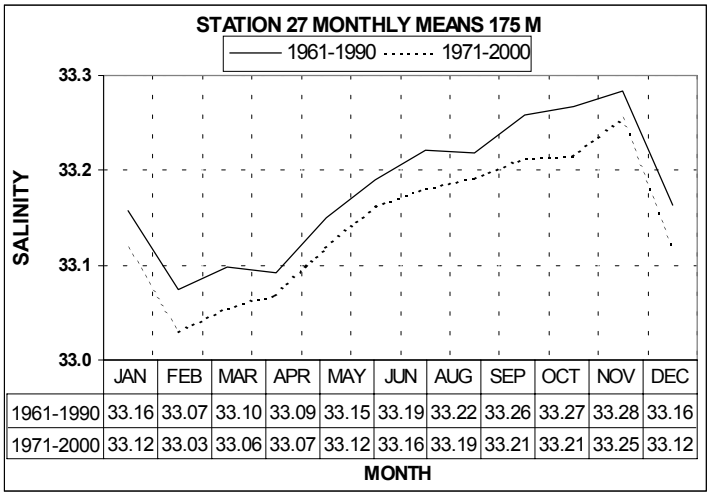

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 32.95 | 32.94 | 32.95 | 32.98 | 33.04 | 33.09 | 33.09 | 33.12 | 33.12 | 33.08 | 33.00 | |
| 1971-2000 | 32.91 | 32.88 | 32.91 | 32.96 | 33.02 | 33.07 | 33.07 | 33.08 | 33.09 | 33.04 | 32.95 | |

MONTH



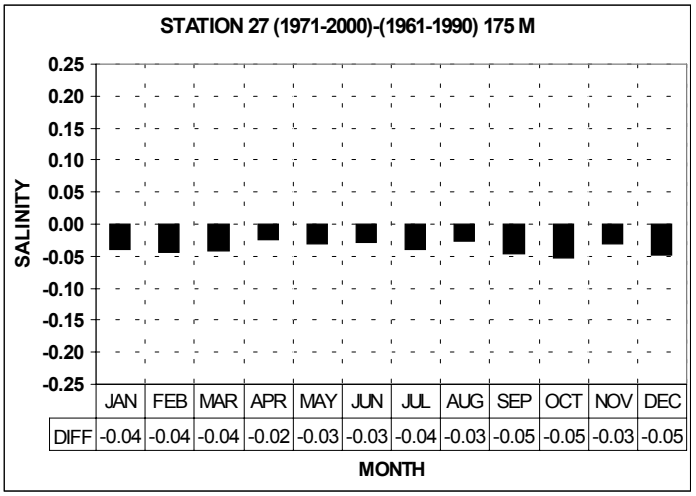

| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.04 | -0.06 | -0.03 | -0.02 | -0.03 | -0.02 | -0.04 | -0.03 | -0.04 | -0.03 | -0.05 | -0.05 |

MONTH




| | JAN | FEB | MAR | APR | MAY | JUN | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 33.16 | 33.07 | 33.10 | 33.09 | 33.15 | 33.19 | 33.22 | 33.26 | 33.27 | 33.28 | 33.16 |
| 1971-2000 | 33.12 | 33.03 | 33.06 | 33.07 | 33.12 | 33.16 | 33.19 | 33.21 | 33.21 | 33.25 | 33.12 |

MONTH




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.04 | -0.04 | -0.04 | -0.02 | -0.03 | -0.03 | -0.04 | -0.03 | -0.05 | -0.05 | -0.03 | -0.05 |

MONTH

Fig. 3b. Monthly means (left panels) and differences (right panels) of salinity at Station 27 for the periods 1961-1990 and 1971-2000 at standard depths.

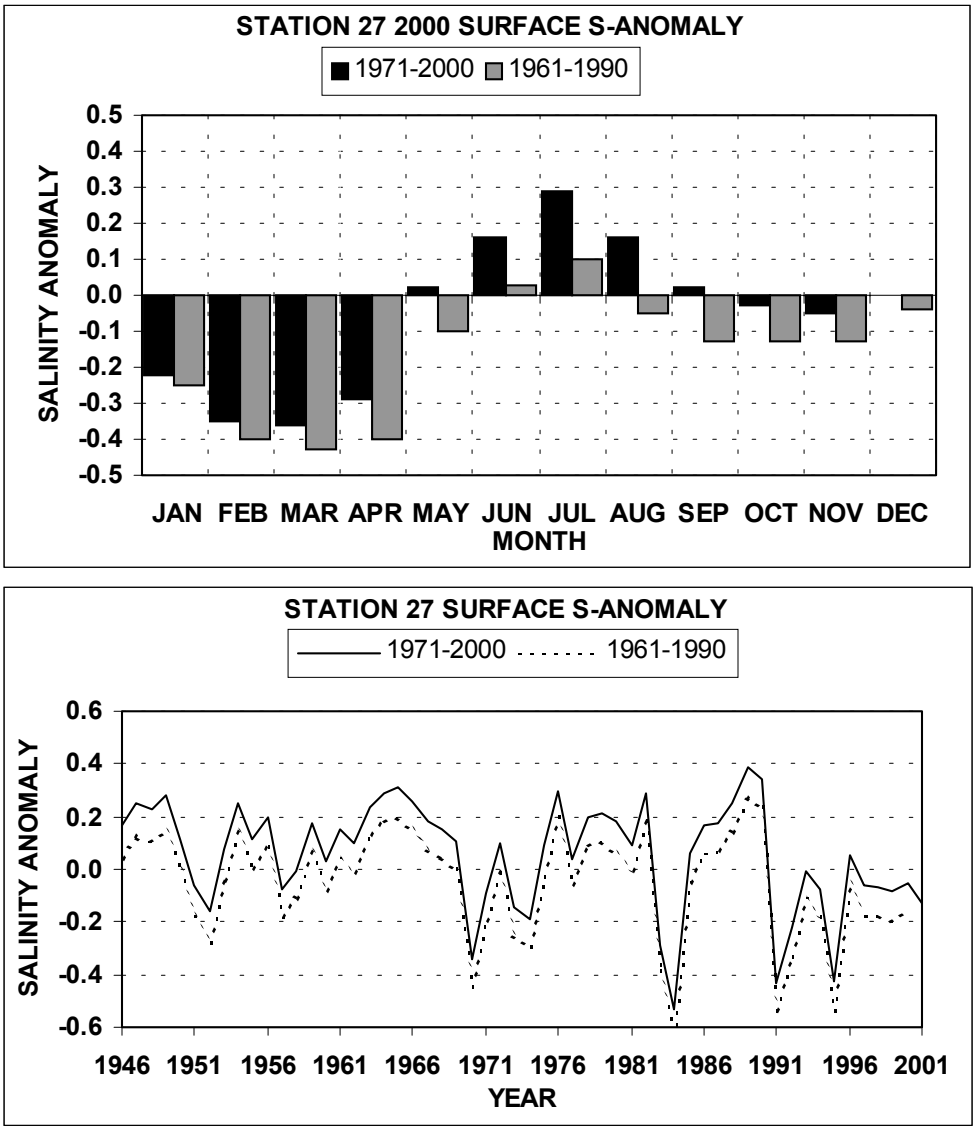



Fig. 4a. Monthly means (top panel) of surface salinity during 2000 and the annual anomalies (bottom panel) at Station 27 referenced to the periods 1961-1990 and 1971-2000.

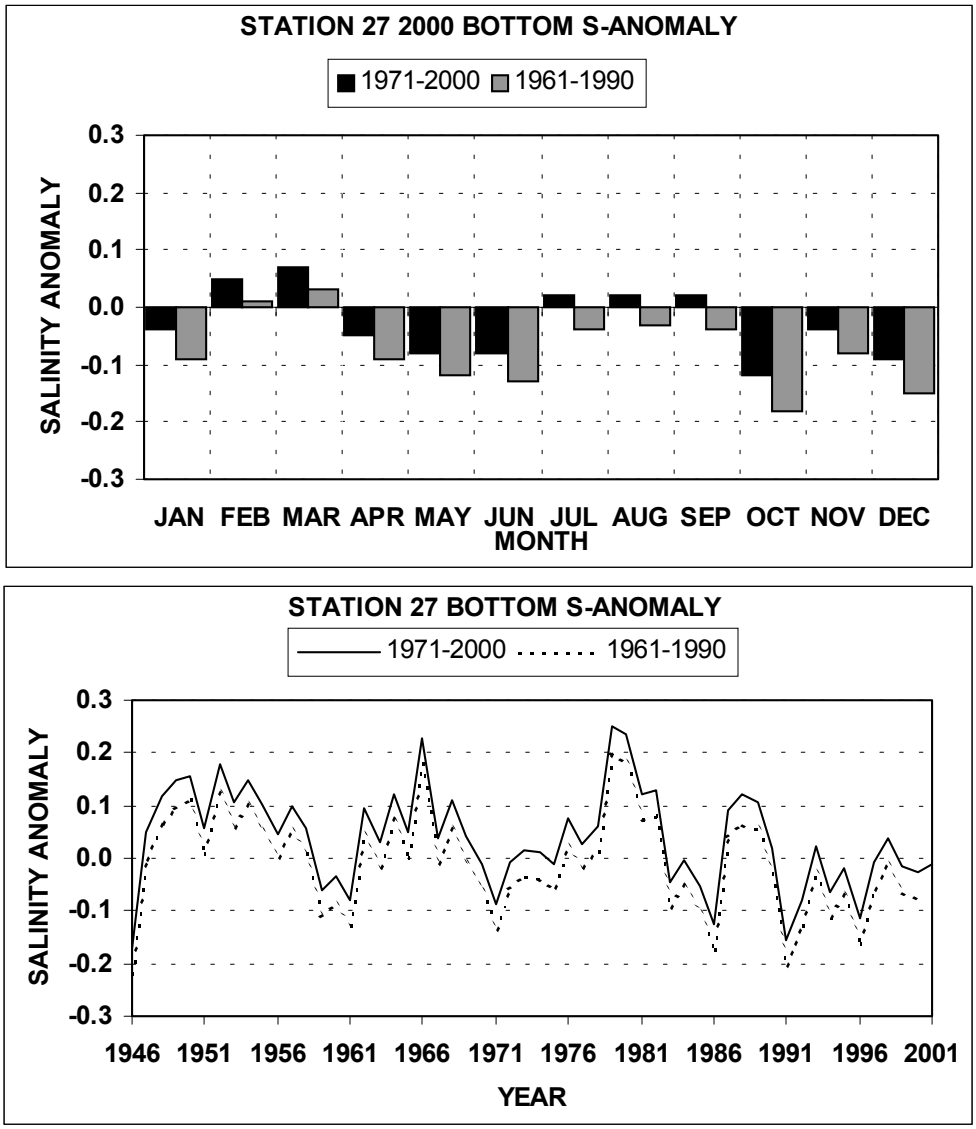
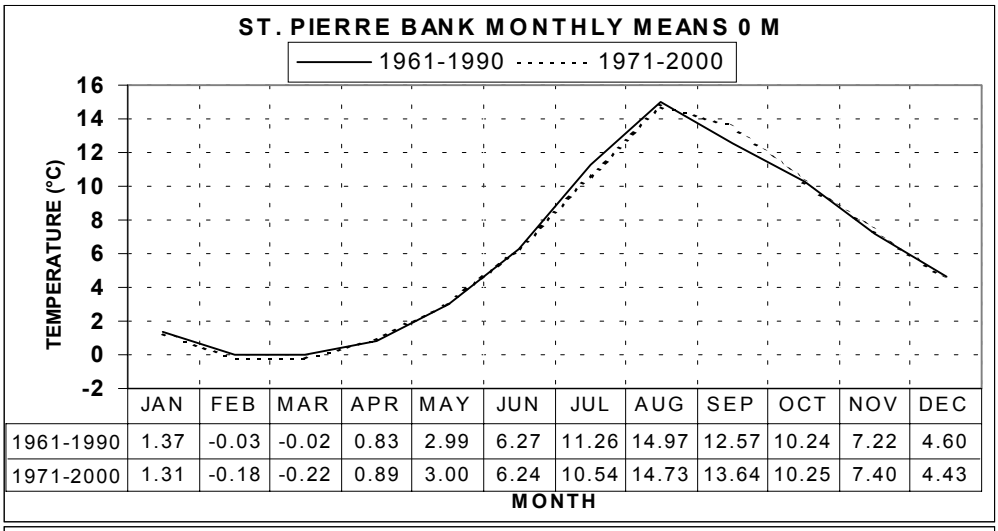
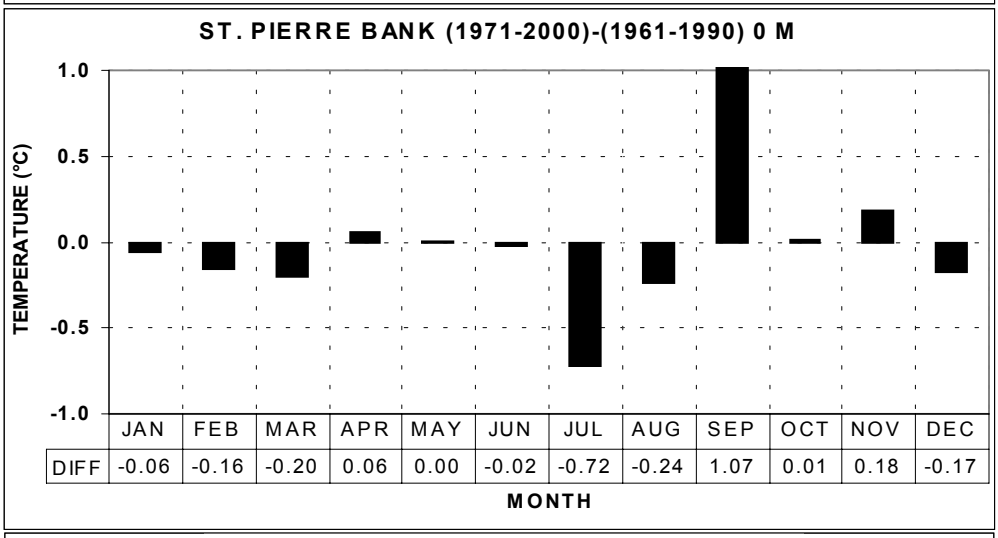



Fig. 4b. Monthly means (top panel) of bottom salinity during 2000 and the annual anomalies (bottom panel) at Station 27 referenced to the periods 1961-1990 and 1971-2000.




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 1.37 | -0.03 | -0.02 | 0.83 | 2.99 | 6.27 | 11.26 | 14.97 | 12.57 | 10.24 | 7.22 | 4.60 |
| 1971-2000 | 1.31 | -0.18 | -0.22 | 0.89 | 3.00 | 6.24 | 10.54 | 14.73 | 13.64 | 10.25 | 7.40 | 4.43 |




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.06 | -0.16 | -0.20 | 0.06 | 0.00 | -0.02 | -0.72 | -0.24 | 1.07 | 0.01 | 0.18 | -0.17 |

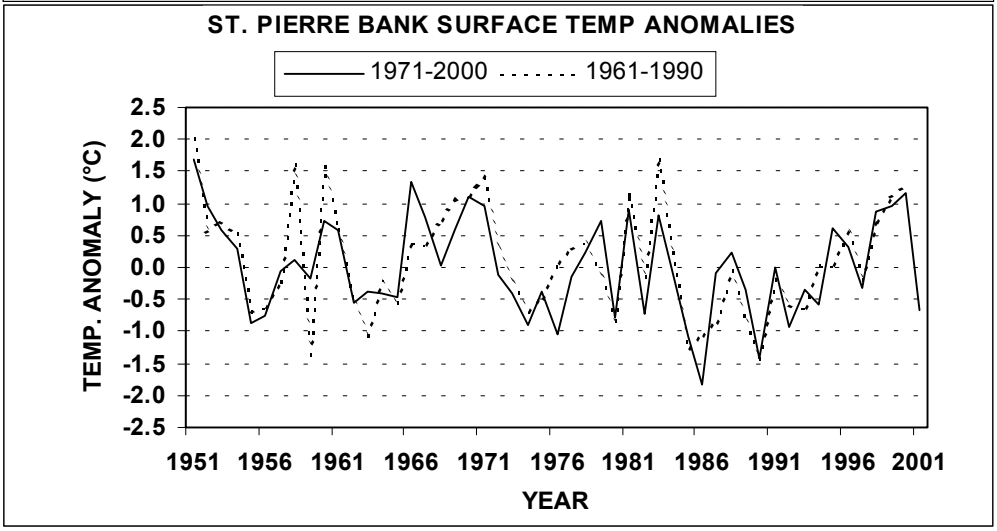



Fig. 5a. Monthly means (top panel), differences (centre panel) and annual anomalies (bottom panel) of surface temperatures on St. Pierre Bank for the periods 1961-1990 and 1971-2000.

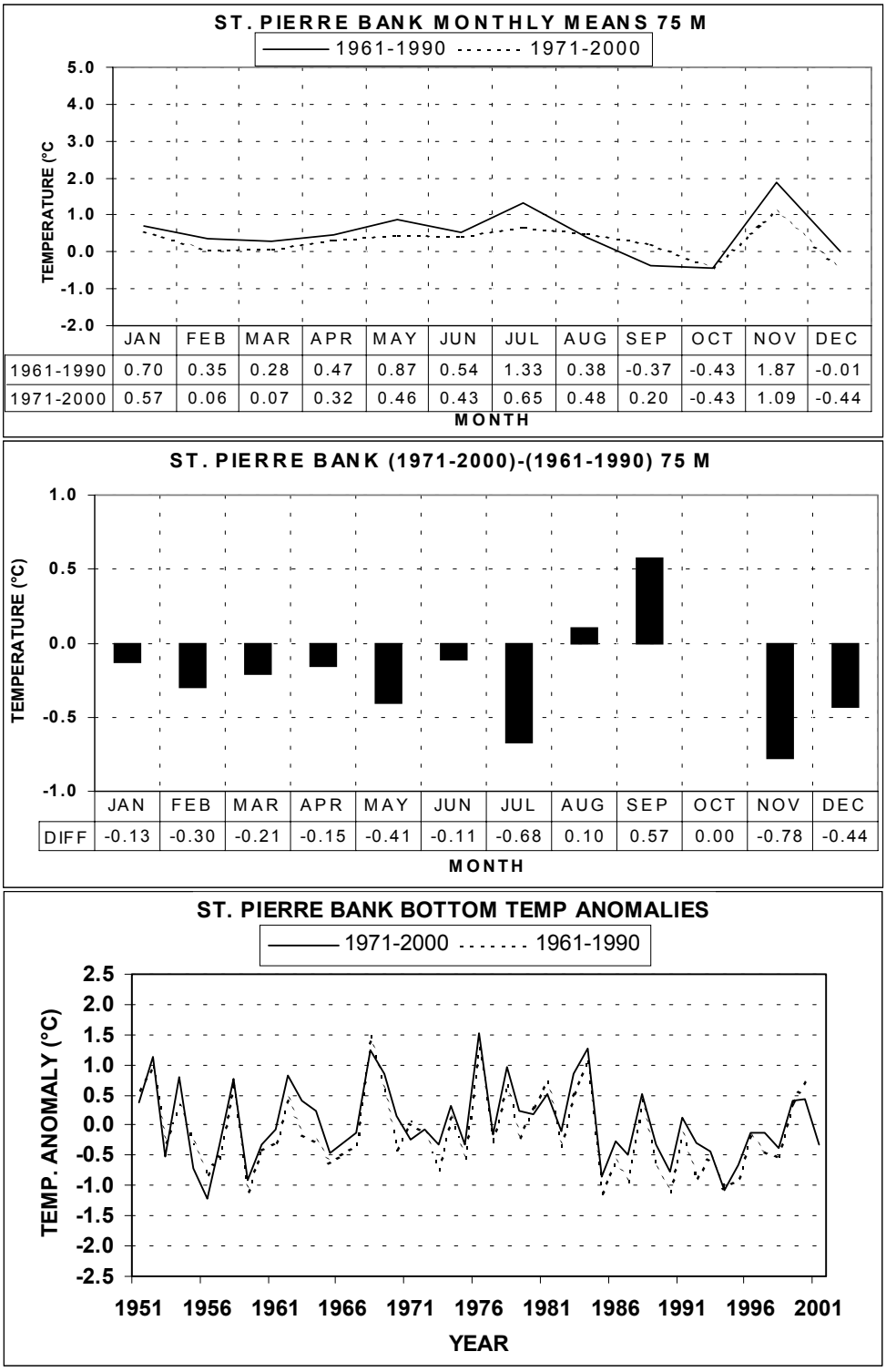



Fig. 5b. Monthly means (top panel), differences (centre panel) and annual anomalies (bottom panel) of near bottom temperatures on St. Pierre Bank for the periods 1961-1990 and 1971-2000.

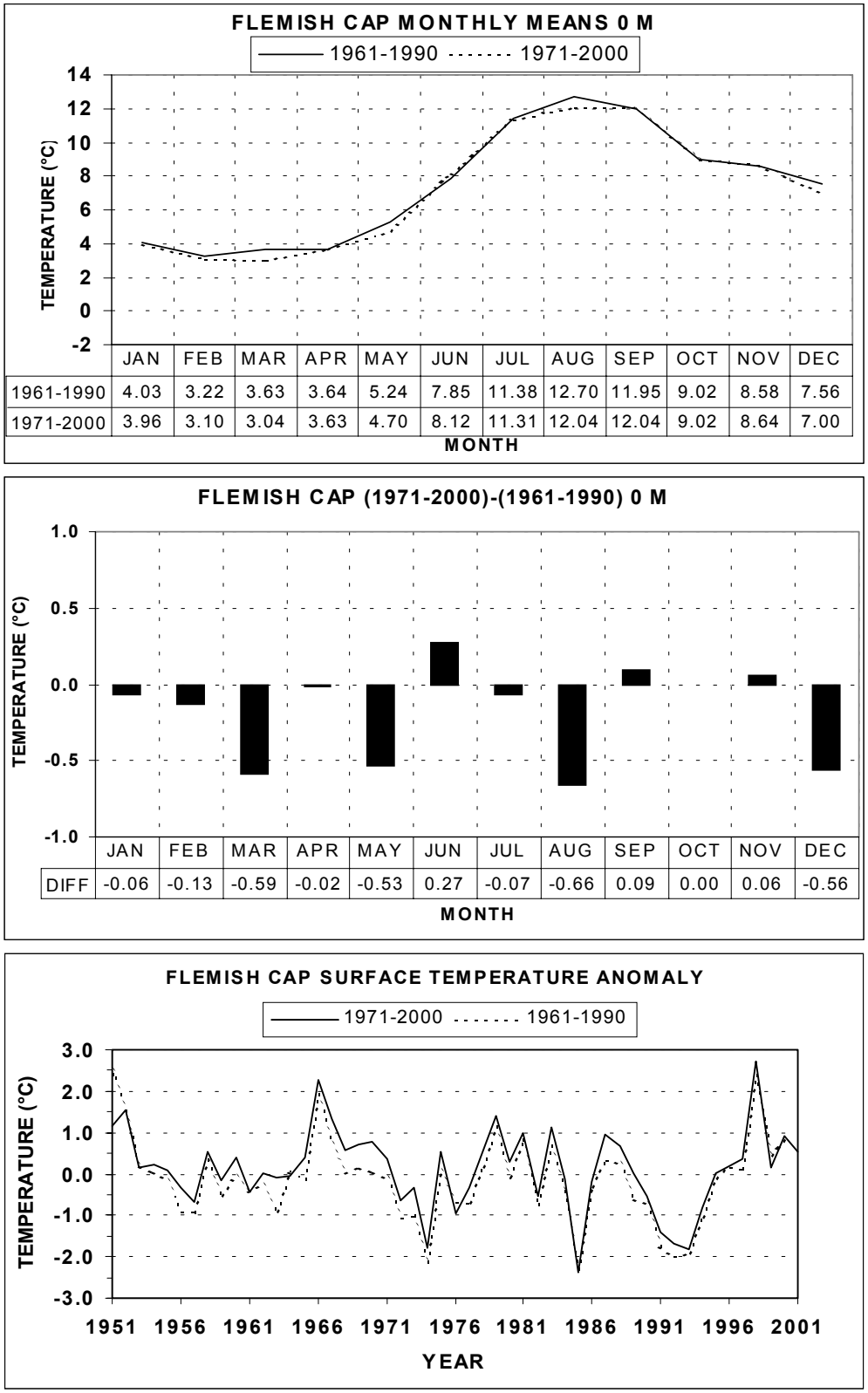
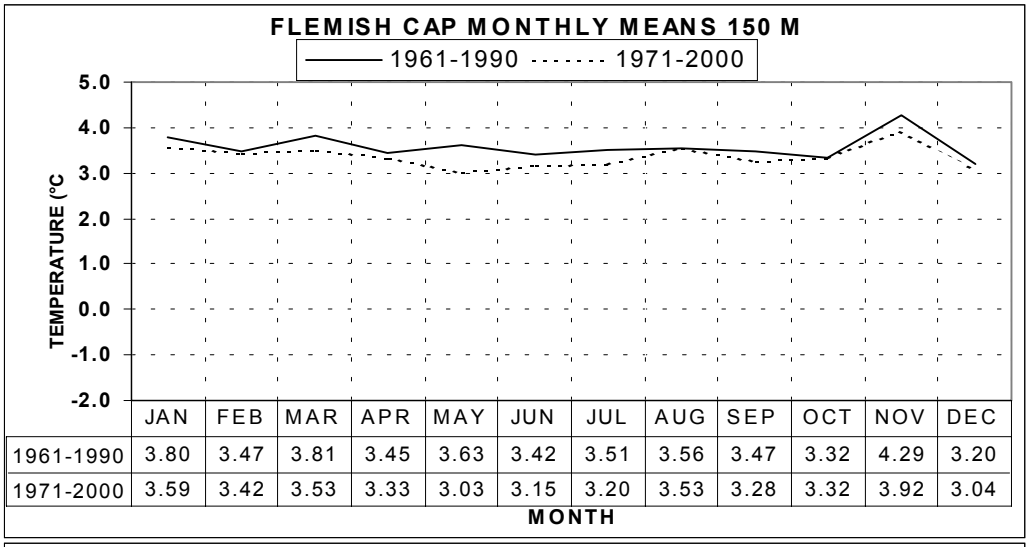
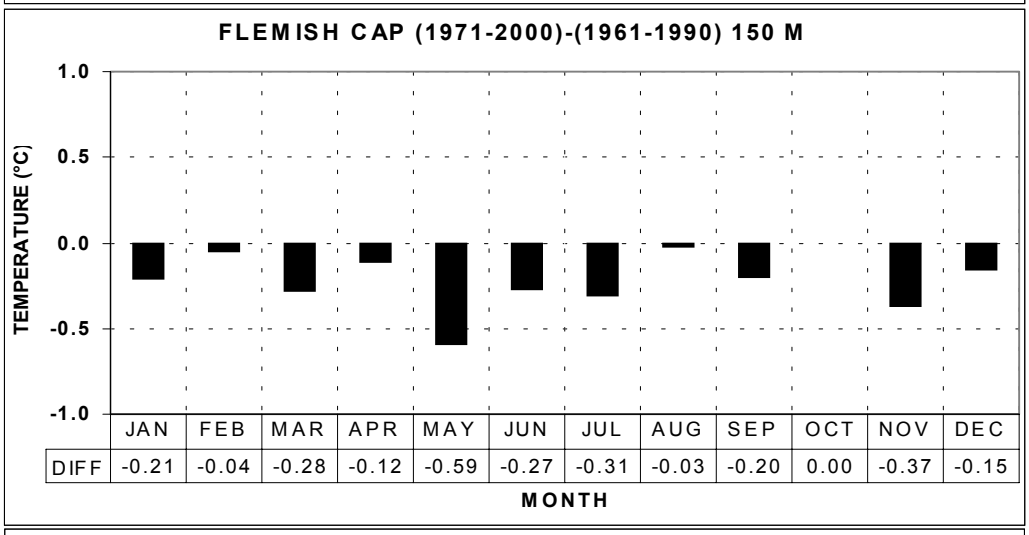



Fig. 6a. Monthly means (top panel), differences (centre panel) and annual anomalies (bottom panel) of surface temperatures on the Flemish Cap for the periods 1961-1990 and 1971-2000.




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 3.80 | 3.47 | 3.81 | 3.45 | 3.63 | 3.42 | 3.51 | 3.56 | 3.47 | 3.32 | 4.29 | 3.20 |
| 1971-2000 | 3.59 | 3.42 | 3.53 | 3.33 | 3.03 | 3.15 | 3.20 | 3.53 | 3.28 | 3.32 | 3.92 | 3.04 |




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | -0.21 | -0.04 | -0.28 | -0.12 | -0.59 | -0.27 | -0.31 | -0.03 | -0.20 | 0.00 | -0.37 | -0.15 |

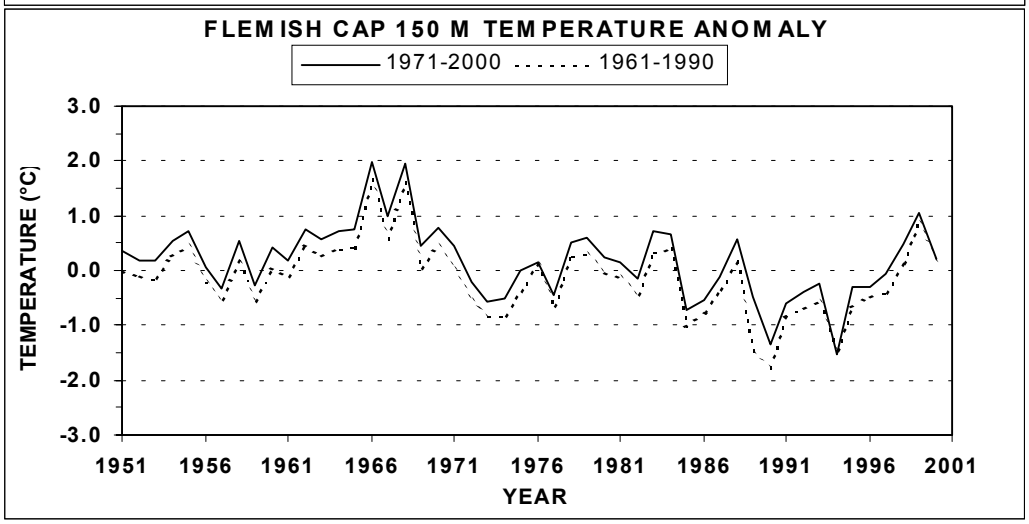
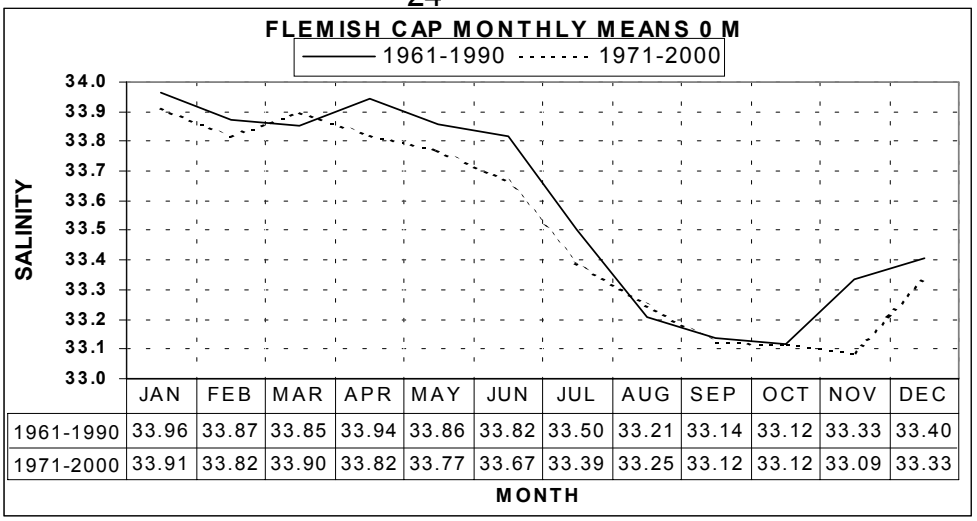
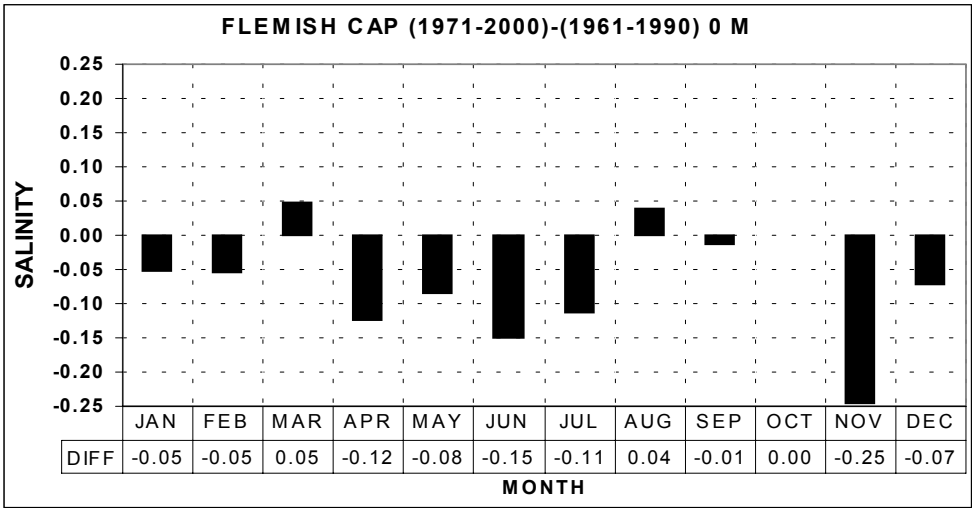



Fig. 6b. Monthly means (top panel), differences (centre panel) and annual anomalies (bottom panel) of near bottom temperatures on the Flemish Cap for the periods 1961-1990 and 1971-2000.



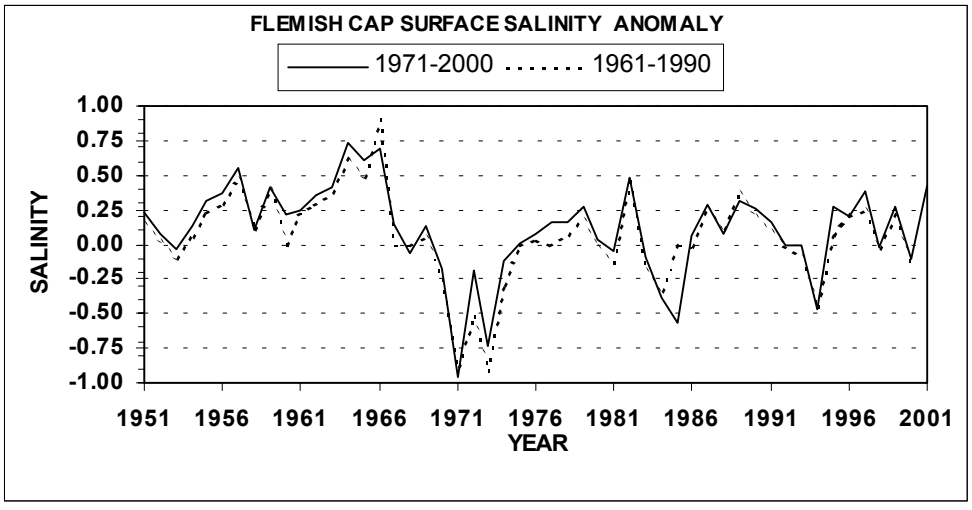
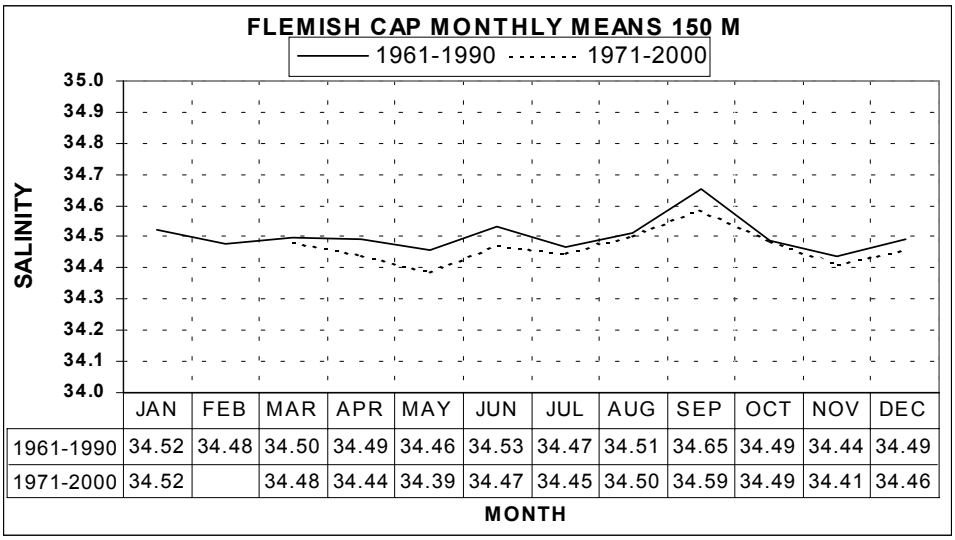
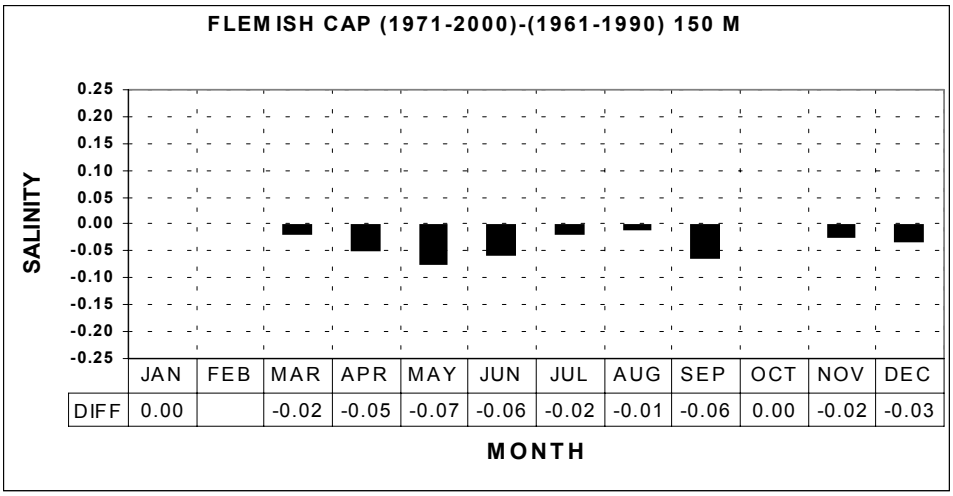




Fig. 7a. Monthly means (top panel), differences (centre panel) and annual anomalies (bottom panel) of surface salinity on the Flemish Cap for the periods 1961-1990 and 1971-2000.




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1961-1990 | 34.52 | 34.48 | 34.50 | 34.49 | 34.46 | 34.53 | 34.47 | 34.51 | 34.65 | 34.49 | 34.44 | 34.49 |
| 1971-2000 | 34.52 | | 34.48 | 34.44 | 34.39 | 34.47 | 34.45 | 34.50 | 34.59 | 34.49 | 34.41 | 34.46 |




| | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DIFF | 0.00 | | -0.02 | -0.05 | -0.07 | -0.06 | -0.02 | -0.01 | -0.06 | 0.00 | -0.02 | -0.03 |

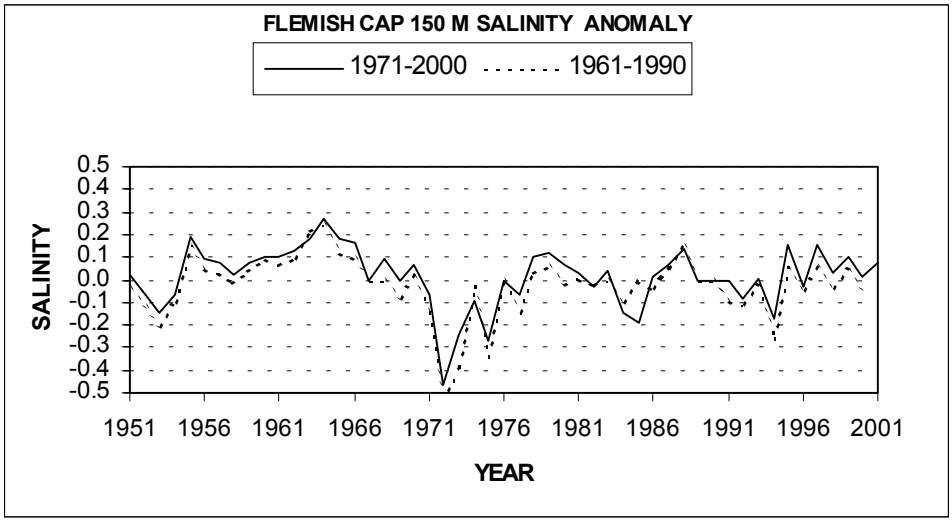



Fig. 7b. Monthly means (top panel), differences (centre panel) and annual anomalies(bottom panel) of near bottom salinity on the Flemish Cap for the periods 1961-1990 and 1971-2000.

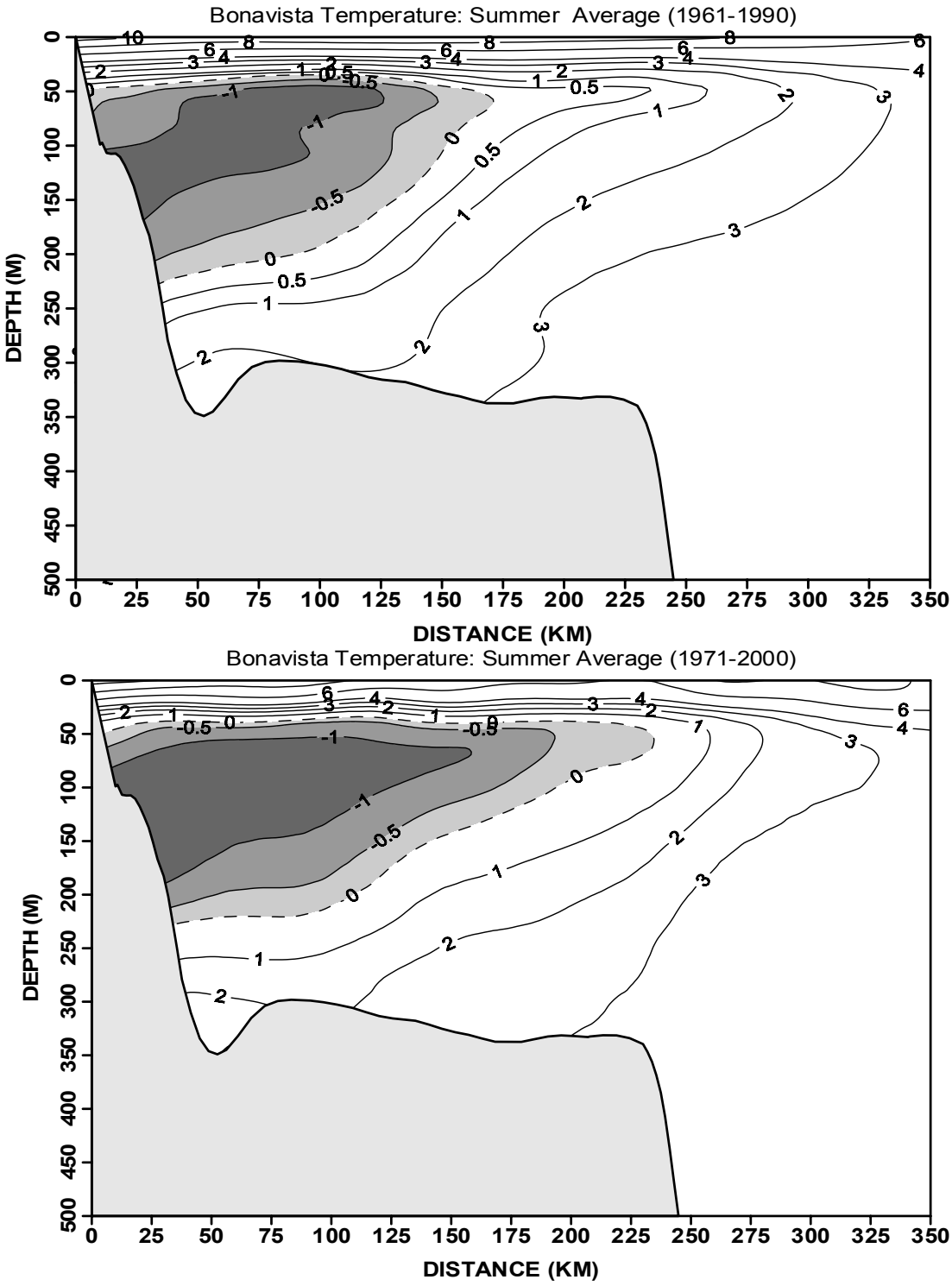



Fig. 8. Cross-sectional temperature contours along the standard Bonavista transect during the summer based on all data collected during the 1961-1990 and the 1971-2000 time periods.

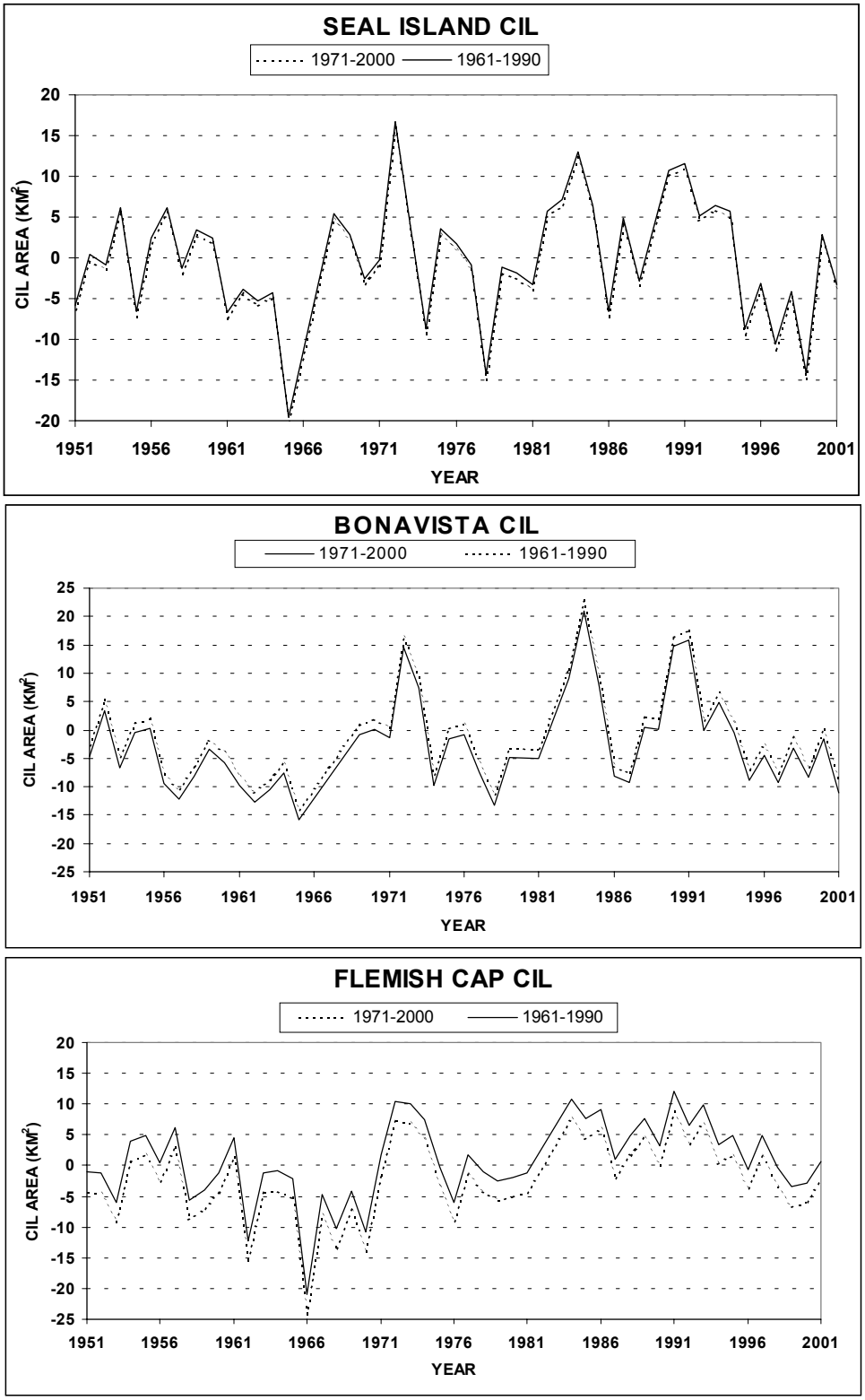



Fig. 9. Annual CIL anomalies along the standard Seal Island, Bonavista and Flemish Cap transects, referenced to the 1961-1990 and the 1971-2000 time periods.

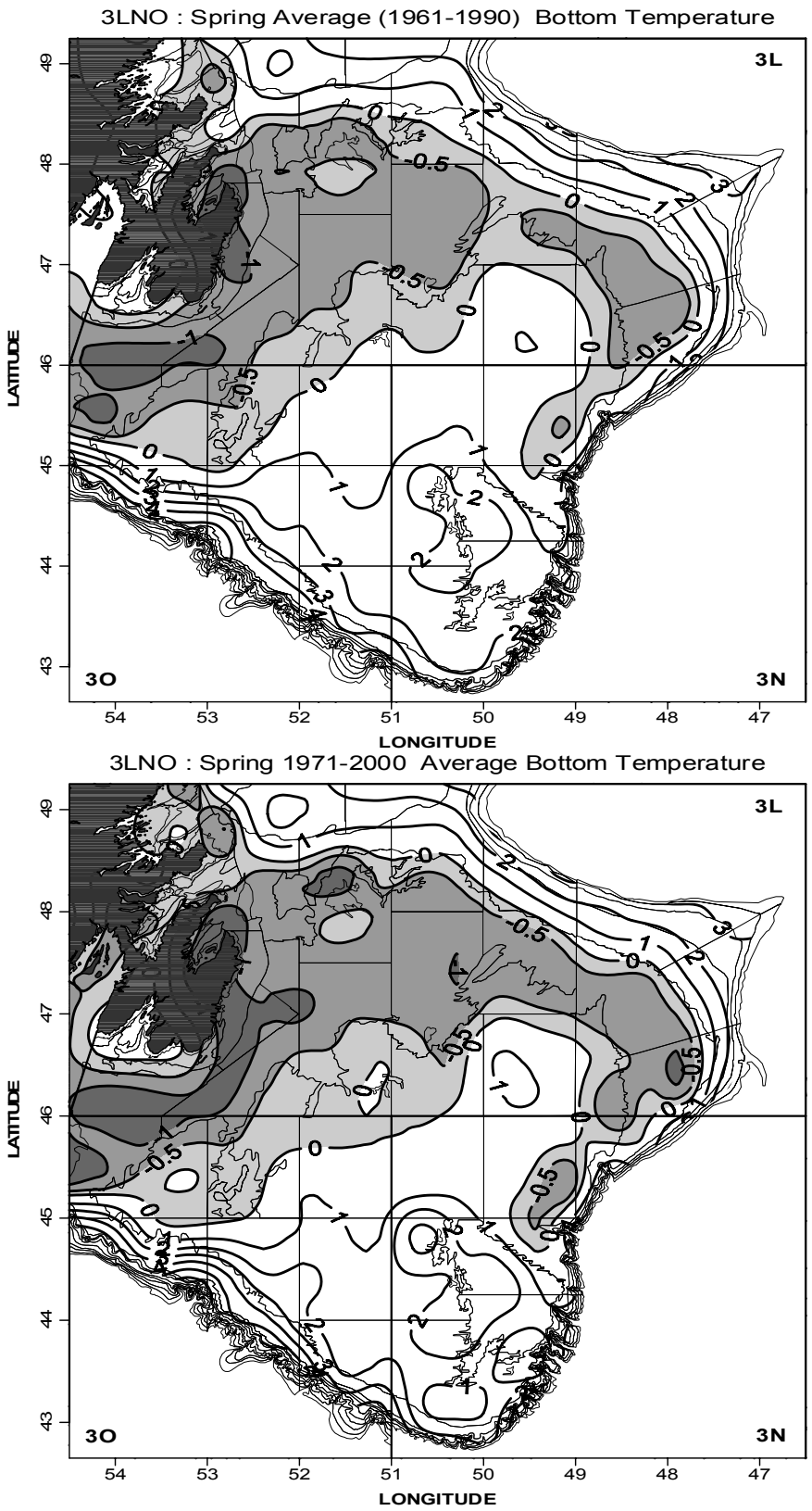



Fig. 10. Bottom temperature contours for the spring in NAFO Divs. 3LNO based on data collected during the 1961-1990 and the 1971-2000 time periods.