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Newfoundland and Labrador Region **Ecosystem Status Report 2004/001**

Research vessel CCGS Teleost

2003 State of the Ocean: Physical Oceanographic Conditions in the Newfoundland and Labrador Region

Background

The physical oceanographic environment influences the yield (growth, reproduction, survival), and behaviour (distribution, catchability, availability) of marine organisms as well as the operations of the fishing industry. Changes in this environment may contribute directly to variations in food source (plankton), resource yield, reproductive potential, catchability, year-class size (recruitment) and spawning biomass as well as influencing the perception of the resource status and the efficiency and profitability of the industry.

Physical oceanographic conditions are therefore measured during research vessel resource surveys and regularly at fixed sites as part of the ***Atlantic Zonal Monitoring Program (AZMP)****. Additional hydrographic, meteorological and sea ice data are obtained from a variety of sources, research studies, ships-of-opportunity, fishing vessels, and remote sensing (satellites). All of the hydrographic data are edited and archived in Canada's national Marine Environmental Data Service (MEDS) database. A working copy is maintained in a zonal database at the Northwest Atlantic Fisheries Centre in St. John's, Newfoundland and Labrador.*

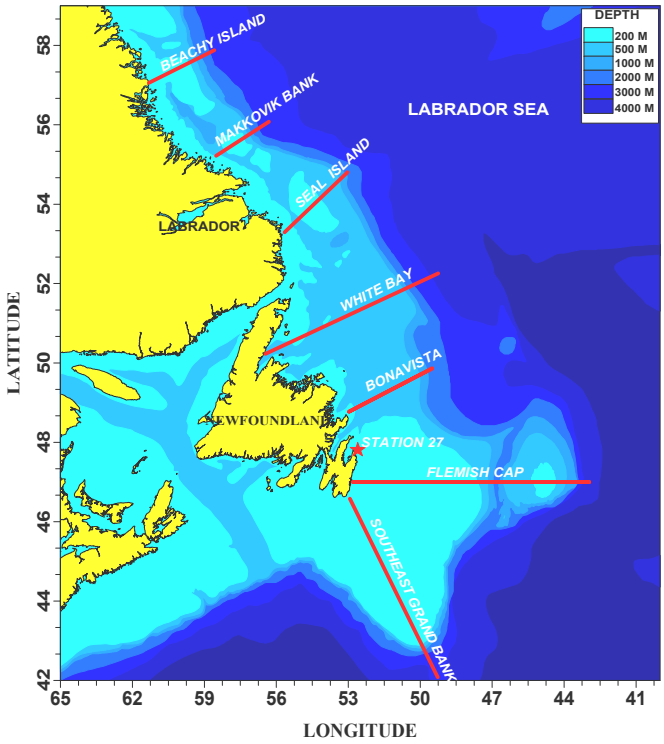

Fig. 1. Location Map showing the positions of standard sections and the fixed AZMP monitoring site (Station 27) in the Newfoundland and Labrador Region.

Summary

- Annual air temperatures ranged from 1.2°C above normal at Cartwright Labrador to 0.7°C above normal at St. John's in southern Newfoundland during 2003.
- The Newfoundland Shelf ice extent increased compared to that of 2002 but remained below normal for the 8th consecutive year.
- The depth-averaged annual water temperature off St. John's was above normal during 2003.
- Annual surface and bottom water temperatures at Station 27 were above normal by 0.7°C and 0.2°C respectively during 2003.

- Salinities off St. John's were above normal in the upper water column for the second year.
- The area of <0°C (CIL) water on the eastern Newfoundland Shelf during 2003 was below normal for the 9th consecutive year.
- Bottom temperatures on the Newfoundland Shelf during 2003 were generally below normal in the spring and above normal in the fall, except for the extreme southeast Grand Bank where they remained below normal.

Introduction

The ocean environment on the Newfoundland Shelf is influenced by several factors, including the Labrador Current, cross-shelf exchange with warmer continental slope water and bottom topography. Superimposed are large seasonal and inter-annual variations in solar heat input, ice cover and storm-forced mixing. The resulting water mass on the shelf is characterised by large annual cycles with strong horizontal and vertical temperature and salinity gradients. Water properties are monitored extensively by fisheries assessment and oceanographic research surveys throughout the year (Fig. 1). Some of these observations are expressed as differences from their average or anomalies. Where possible, the long-term averages are standardised to a base period from 1971-2000.

Conditions in 2003

Newfoundland and Labrador monthly air temperatures were below normal during most of the winter and spring months of 2003 (Fig. 2a). During the remainder of the year however, they increased to above normal values reaching near-record highs by late-summer and early fall. Since the 1960s annual air temperature anomalies at Cartwright (Fig. 2b) show large variations, superimposed on a general downward trend through to the early 1990s. This was followed by a general rise in air temperatures through to the end of the 1990s and into the early 2000s.

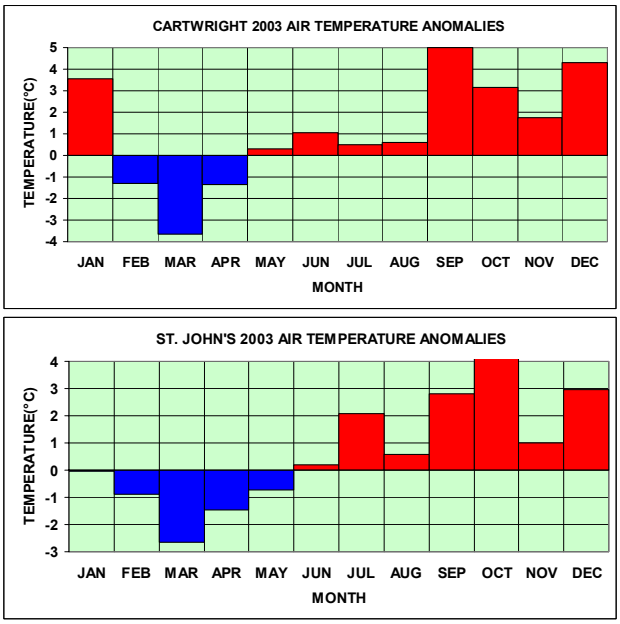

Fig 2a. Departures from normal monthly mean air temperatures at Cartwright and St. John's for 2003.

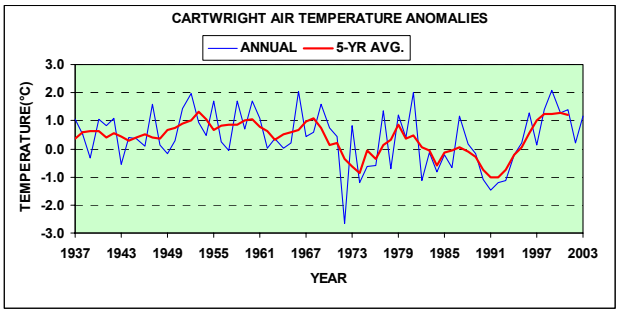

Fig. 2b. Departures from normal annual mean air temperature (dashed line) and the 5 year means at Cartwright on the Labrador Coast.

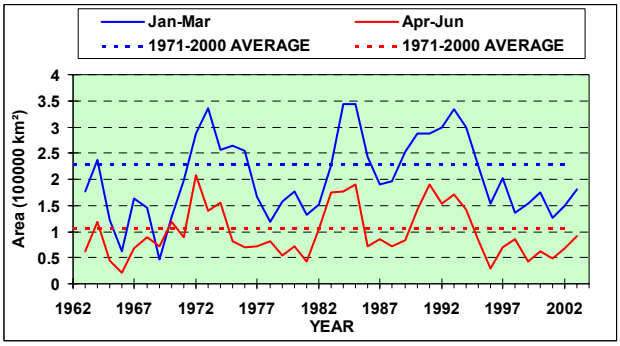

Fig. 3. Time series of annual sea-ice areas off Newfoundland and southern Labrador for the winter (Jan.-Mar.) and spring (Apr.-June).

During 1999 for example, temperature anomalies of 1.9°C above normal set historical highs at St. John's (126-year record) and Cartwright (65-year record). Air temperatures during 2003 increased over 2002 values at Cartwright to 1.2°C above normal and at St. John's to 0.7°C above normal.

The peak extent of sea ice area during 2003 increased slightly over 2002 to the highest since 1997. The duration of the ice season was shorter than normal however and this was the 8th consecutive year with below normal ice extent on the Newfoundland Shelf (Fig. 3).

Station 27 Temperature and Salinity

Upper layer temperatures at Station 27, located in the inshore branch of the Labrador Current (Fig. 1), were generally less than 0°C from January to mid-April and from approximately 0° to -1°C throughout the year near the bottom (175 m).

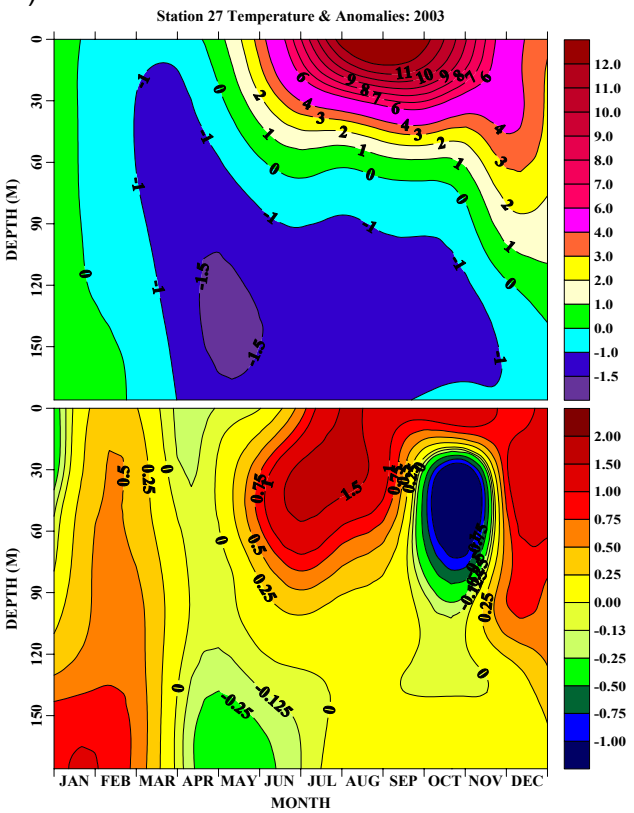

Fig. 4. Monthly temperature (top) and their departures from normal (bottom) at Station 27 as a function of depth for 2003.

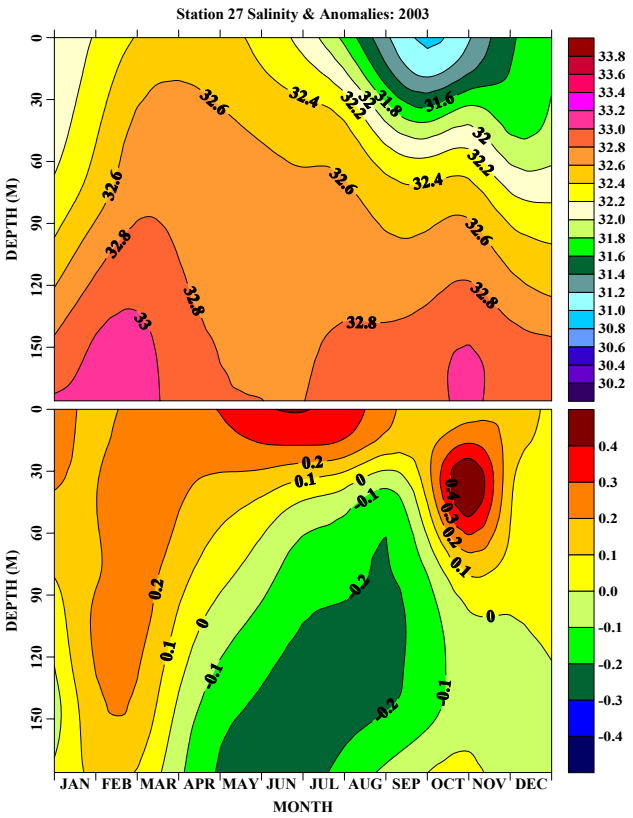

Fig. 5. Monthly salinity (top) and their departures from normal (bottom) at Station 27 as a function of depth for 2003.

By mid-May upper layer temperatures had warmed to 2°C and to above 13°C by August, after which the fall cooling commenced. Temperatures were about 0.25°-0.5°C above normal during the winter months over most of the water column but decreased to below normal values in the spring. Upper layer temperatures during the summer and fall were warmer-than-normal. A colder-than-normal anomaly occurred at mid-water depths during fall (Fig. 4). The annual surface and bottom temperature anomalies at Station 27 were 0.7°C and 0.2°C above normal respectively.

Surface salinities (Fig. 5) were >32.2 during January and decreased to values <31.2 by September. The water was saltier than normal over all depths during the winter and upper layer values were above normal throughout the year. Near-bottom salinities were slightly below normal for most of the year.

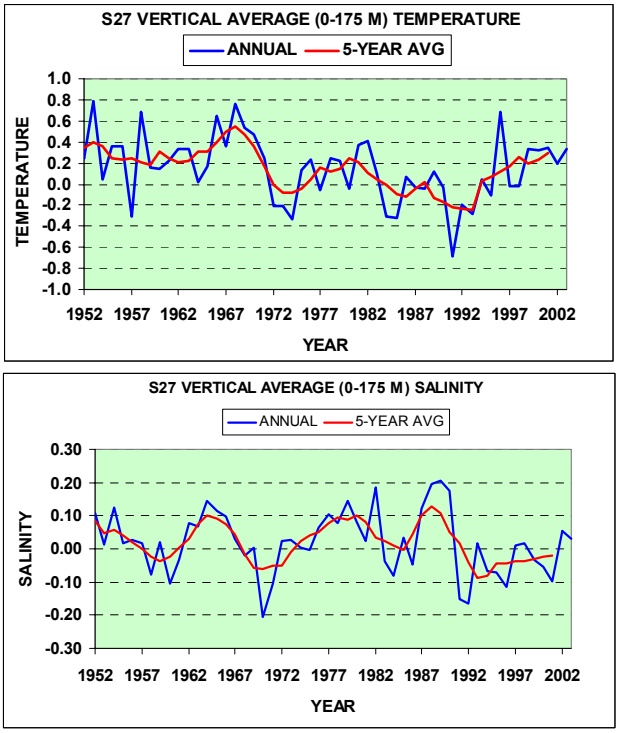

Fig. 6. Departures from normal depth averaged (0-176 m) Station 27 temperature (in °C) and salinity. The red lines are the 5-year means.

Station 27 depth-averaged annual temperature (which is proportional to the heat content of the water column) shows large fluctuations at near decadal time scales, with cold periods during the early 1970s, mid-1980s and early 1990s (Fig. 6). From 1950 to the late 1960s the heat content of the water column was generally above the long-term mean. Recently, the heat content of the water column varied from a record low in 1991, to a near record high during 1996 and was above the long-term mean from 1999 to 2003. The 2003 value increased over 2002 to 0.3°C above the long-term mean.

The depth-averaged annual salinity anomalies show similar patterns as the heat content with fresher-than-normal periods generally corresponding to the colder-than-normal conditions (Fig. 6). Since the fresh conditions of the early 1990s, salinities have ranged from near normal to below normal. During 2002 summer salinities on the Newfoundland Shelf increased to the highest values in about 12 years. The 2003 value remained very similar to the 2002, slightly above normal.

Temperature Trends on St Pierre and Hamilton Banks and on Flemish Cap

Annual near-bottom temperature anomalies from 1950 to 2003 on St. Pierre Bank are displayed in Fig. 7. The temperature trends are characterised by large annual variations greater than 1°C about the mean. During the cold period beginning around 1984, near-bottom temperatures on St. Pierre Bank decreased by up to 1°C and continued below normal until about 1997. From 1998 to 2000 temperatures at 75 m depth on St. Pierre Bank were above normal but returned to below normal values during 2001 and continued to decrease during 2002 and 2003 to the lowest values since 1995. On Hamilton Bank near bottom temperatures also decreased during the early 1980s from the above normal values of the 1960s and 1970s. Throughout most of the 1980s and into the early 1990s temperatures were about 0.5°C below normal. By the mid-1990s, they increased to above normal values that continued into 2002, although the 2003 value decreased over 2002. Bottom temperatures on the Flemish Cap show similar trends to that on the Newfoundland Shelf, with colder-than-normal values during the early to mid-1990s. Annual temperatures on the Flemish Cap during 2000 to 2002 decreased to about normal compared to the warm values of 1999 but increased to about 0.5°C above normal in 2003.

The Newfoundland Shelf Cold Intermediate Layer (CIL)

A common feature of the temperature structure on the Newfoundland and Labrador continental shelf is the layer of cold <0°C water, commonly referred to as the Cold Intermediate Layer (CIL). This winter cooled water remains trapped during the summer and early fall months between the seasonally heated surface layer and warmer near bottom water originating from the continental slope region.

On average along the Bonavista section during the summer this cold layer extends offshore to

over 200 km, with a maximum vertical extent of about 200 m.

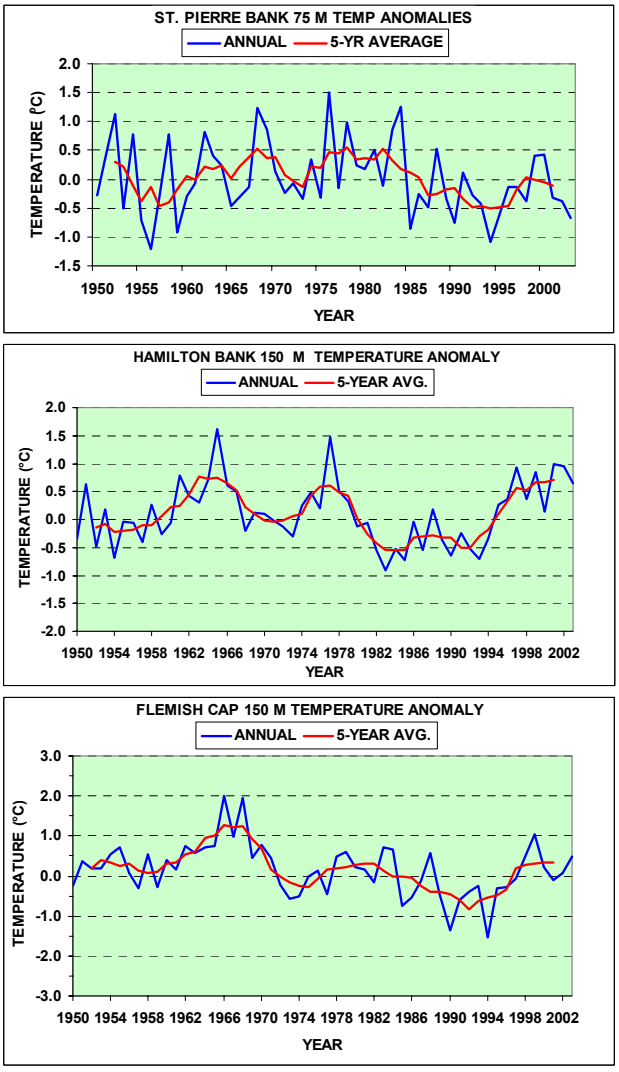

Fig. 7. Departures from normal annual near bottom temperatures on St. Pierre and Hamilton Banks and on the Flemish Cap. The red lines are the 5-year means.

The time series of CIL area anomalies for the Seal Island, Bonavista and Flemish Cap sections (Fig. 1) are displayed in Fig. 8. In these plots, negative anomalies or below normal CIL areas correspond to warm oceanographic conditions. The CIL area during 2003 was below the long-term mean along all three sections but increased slightly over 2002. Along the Bonavista section the CIL was below normal for the 9th consecutive year. These values are in sharp contrast to the near record high values measured during the early 1990s, which was a very cold period on the Newfoundland Shelf.

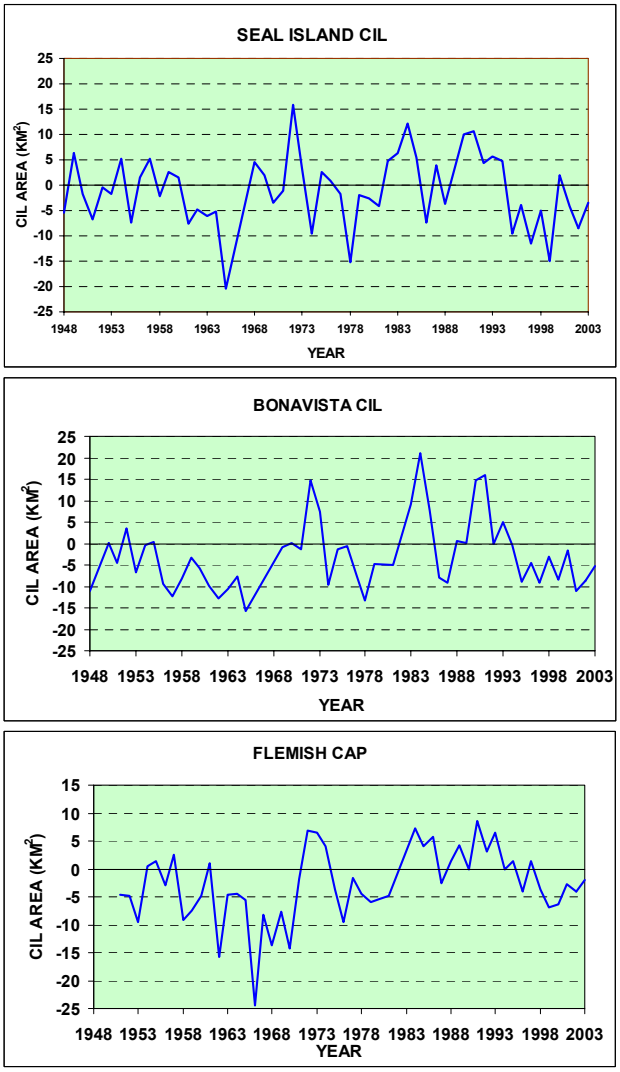

Fig. 8. Time series of CIL area anomalies along the standard sections across the Newfoundland Shelf shown in Fig. 1.

Bottom Temperatures

Spring

Bottom temperatures are routinely measured by trawl mounted Seabird CTDs during the multi-species surveys in the Newfoundland Region during both spring and fall. The bottom temperature fields based on these measurements for NAFO Divisions 3P and 3LNO during the spring of 2003 are displayed in Fig. 9. Bottom temperatures over most of St.

Pierre Bank ranged from -1° to 1°C, which were below the long-term mean and a significant decrease over 2002 values in this area. In general, the area of the bottom covered by below normal temperatures increased during the spring of 2003 compared to 2002 as a result below normal values existed throughout most of the 3P area, except for the deeper waters of the Laurentian Channel and the southwest Grand Bank where they were above normal.

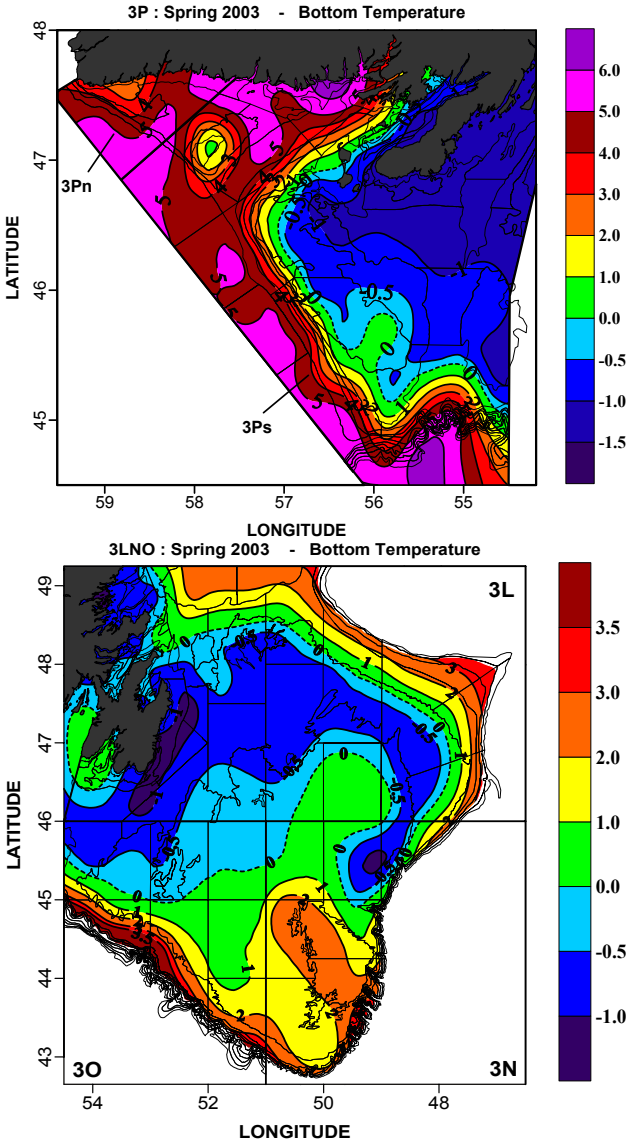

Fig. 9. Bottom temperature maps (in ℃) for the spring of 2003 for NAFO Divisions 3P and 3LNO.

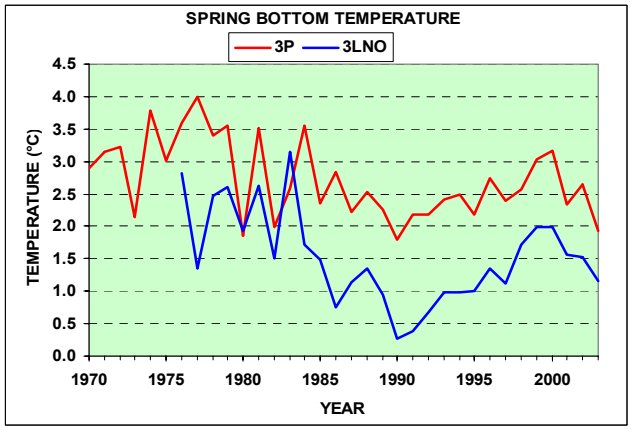

Fig. 10. Annual mean bottom temperatures during the spring for NAFO Divisions 3Pand 3LNO.

The spatially averaged bottom temperature (Fig. 10) of the surveyed area in Division 3P ranged between 2° to 4°C from 1970 to 1984 and decreased to between 2° to 2.5°C from 1985 to 1997. During 1999 and 2000 the average near-bottom temperature increased to over 3°C but decreased to near 2.5°C in 2001 and 2002. During the spring of 2003 the mean bottom temperature decreased by 0.5°C over 2002.

Spring bottom temperatures in Div. 3L ranged from <0°C in the inshore regions of the Avalon Channel and over most of the shallow northern Grand Bank to >3°C at the shelf edge. Over the central and southern areas bottom temperatures ranged from 1°C to 2°C on the Southeast Shoal and to 4°to 5°C along the southwest slopes of the Grand Bank in Div. 3O. During the spring of 2003, <0°C water was mostly restricted to Div. 3L, although there was an increase in the amount of <0C water in the northern portions of 3NO. In general, temperatures were mostly above normal in northern areas and below normal in southern regions. From 1998 to 2000 the areal extent of <0°C bottom water on the Grand Bank decreased and as a result the spatially averaged bottom temperature increased significantly over the lows of the early 1990s. The mean bottom temperature during the spring of 1999 and 2000 reached to 2°C but has decreased to about 1.5°C during the spring of 2001 and 2002. It has further decreased to just above 1°C during the spring of 2003 (Fig. 10).

Fall

Bottom temperature maps for the fall of 2003 in NAFO Divisions 2J, 3K and 3LNO are displayed in Fig. 11. Bottom temperatures during the fall of 2003 in Div. 2J ranged from <1°C inshore, to >3.5°C offshore at the shelf break.

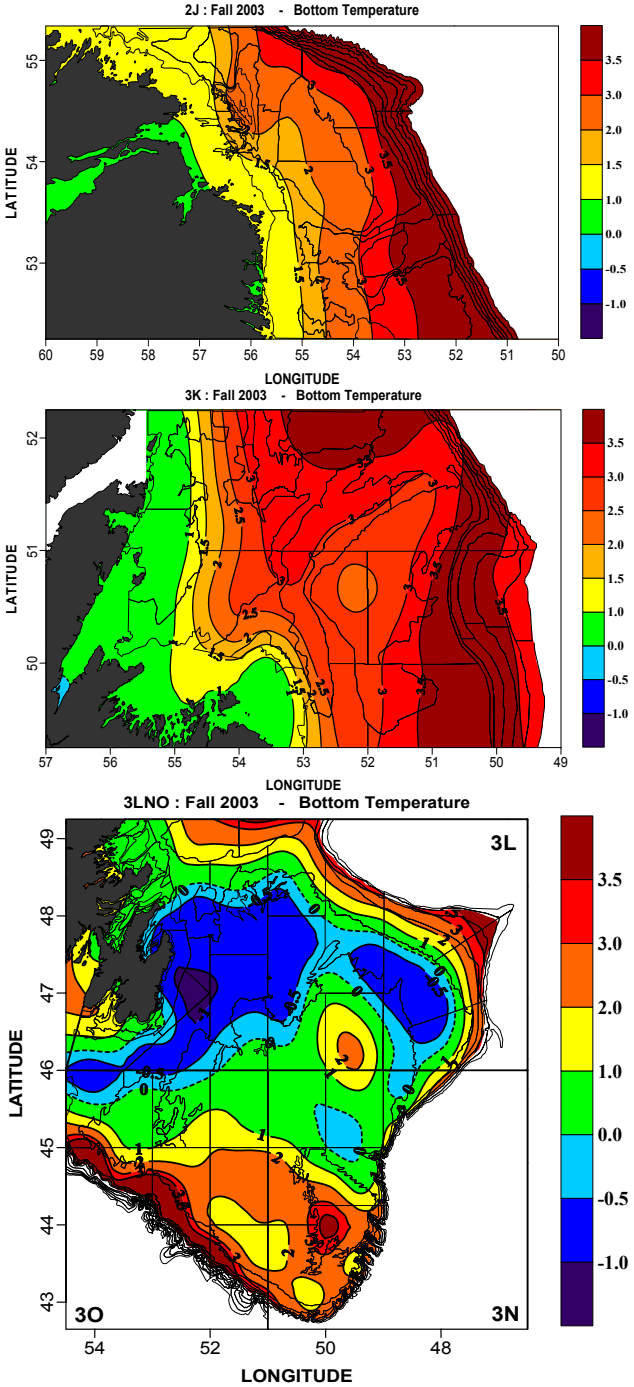

Fig. 11. Bottom temperature maps (in °C) for the fall of 2003 in NAFO Divisions 2J, 3K and 3LNO.

Over Hamilton Bank they ranged from <2°C on the inshore portion of the bank to near 3°C on the southern and eastern portion. These were about 1°to 2°C above normal on Hamilton Bank and about normal along the edge of the shelf (Fig. 11). Since 1996 the area of the bottom on Hamilton Bank covered with <0°C water decreased to <10%. Bottom temperatures during the fall in Div. 2J generally average about 2°C but during the latter half of the 1990s they increased to about 2.5°C. During the fall of 2003 mean bottom temperatures increased over 2002 values to near 3.0°C (Fig. 12).

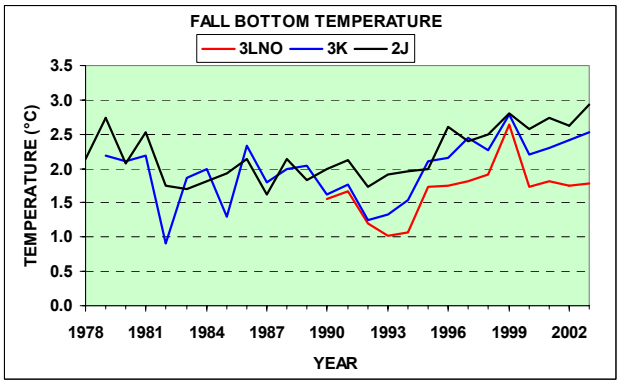

Fig. 12. Annual mean bottom temperatures during the fall for NAFO Divisions 2J, 3K and 3LNO.

Most of the 3K region is deeper than 200-m, as a result relatively warm slope water floods through the deep troughs between the northern Grand Bank and southern Funk Island Bank and between northern Funk Island Bank and southern Belle Isle Bank. Bottom temperatures on these banks during the fall of 2003 ranged between 2° to 3°C, which were about 0.5° to 1°C above their long-term means. Near the edge of the continental shelf in water depths below 500 m temperatures were generally near normal around 3.5°C. The time series of the average bottom temperature in Div. 3K (Fig. 12) during the fall ranged from 1°C in 1982 to 2.3°C in 1986 with an overall average of about 2°C. From 1995 to 1999 they increased to above-average values reaching about 2.7°C during 1999. During the fall of 2000 to 2003 bottom temperatures were lower than in 1999 but remained relatively warm between 2.2° to 2.5°C.

Fall bottom temperatures in Divs. 3LNO generally ranged from <0°C on the northern

Grand Bank and in the Avalon Channel to 3°C along the shelf edge. Over the central and southern areas bottom temperatures ranged from 1° to 2°C during 2003 on the Southeast Shoal and to >3°C along the edge of the Grand Bank. During 2003 bottom temperatures were predominately above normal in northern areas and below normal as much as 2°C over the southeast shoal. The average bottom temperature in Divs. 3LNO during the fall decreased from approximately 1.5°C during 1990 to 1°C during 1993 and 1994 then increased to approximately 1.8°C during 1995. These remained relatively constant up to 1998 but then increased beyond 2.5°C during 1999, the highest in the 10 year record. During the fall of 2000 to 2003 the mean bottom temperature decreased by nearly 1°C over the 1999 values, but was still above the cold condition of the early 1990s (Fig. 12).

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