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Newfoundland and Labrador Region **Ecosystem Status Report 2003/003**

Research vessel CCGS Teleost

2002 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.

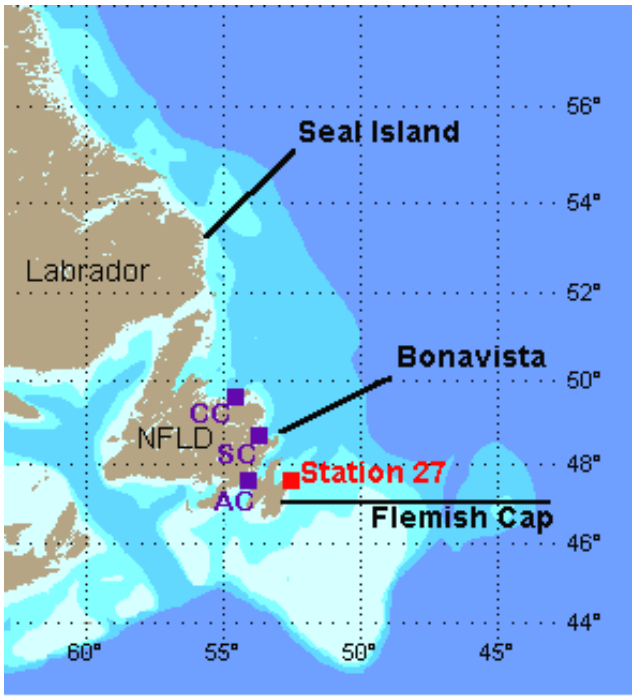

Fig. 1. Location Map showing the positions of standard sections and fixed oceanographic monitoring sites in the Newfoundland and Labrador Region.

Summary

- Annual air temperatures ranged from 0.2°C above normal at Cartwright Labrador to near normal at St. John's in southern Newfoundland during 2002.
- The Newfoundland Shelf ice extent increased slightly compared to 2001 but remained below normal for the 7th consecutive year. Except for the mid-Labrador Shelf sea ice duration was also shorter than normal during 2002.
- The depth-averaged water temperature off St. John's was above normal during 2002.
- Near-bottom water temperatures at Station 27 were about 0.2°C above normal during 2002.

- Salinities off St. John's were above normal in the upper water column and about normal near bottom throughout the year.

- The area of <0°C (CIL) water on the Newfoundland and southern Labrador Shelves during 2002 was below normal for the 8th consecutive year.

- Bottom temperatures on the Newfoundland Shelf during 2002 were generally above normal (+1°C in some areas). The main exception was the southeast shoal of the Grand Bank during the fall, where they were as low as 2°C 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 interannual 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 2002

Newfoundland and Labrador annual air temperatures were slightly above normal during 2002 (Fig. 2a). 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 temperature.

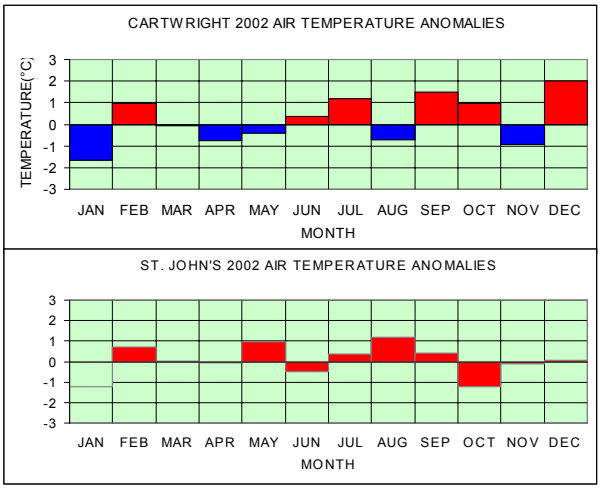

Fig 2a. Departures from normal monthly mean air temperatures at Cartwright and St. John's for 2002.

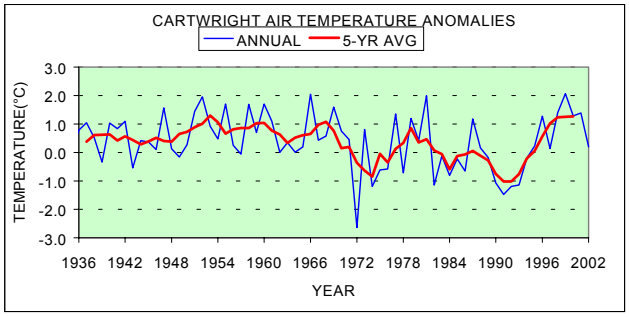

Fig. 2b. Departures from normal annual mean air temperature (dashed line) and the 5 year means at Cartwright on the Labrador Coast.

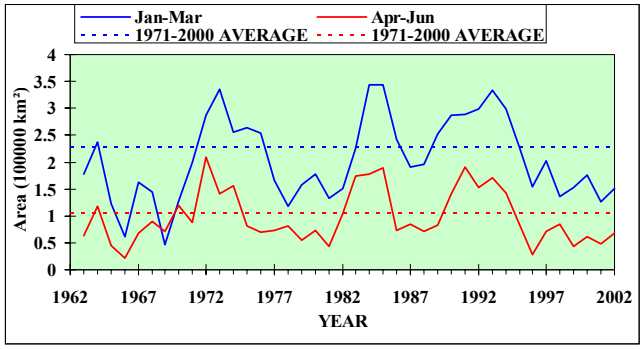

Fig. 3. Time series of annual sea-ice areas off Newfoundland and southern Labrador for the winter (Jan.-Mar.) and spring (Apr.-June).

During 1999 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 2002 decreased over 2001 values at Cartwright to 0.2°C above normal and at St. John's to near normal.

The peak extent of sea ice area during 2002 increased slightly over 2001 with a shorter duration than normal, except on the mid-Labrador Shelf, where sea ice was present at the end of July. This was the 7th 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).

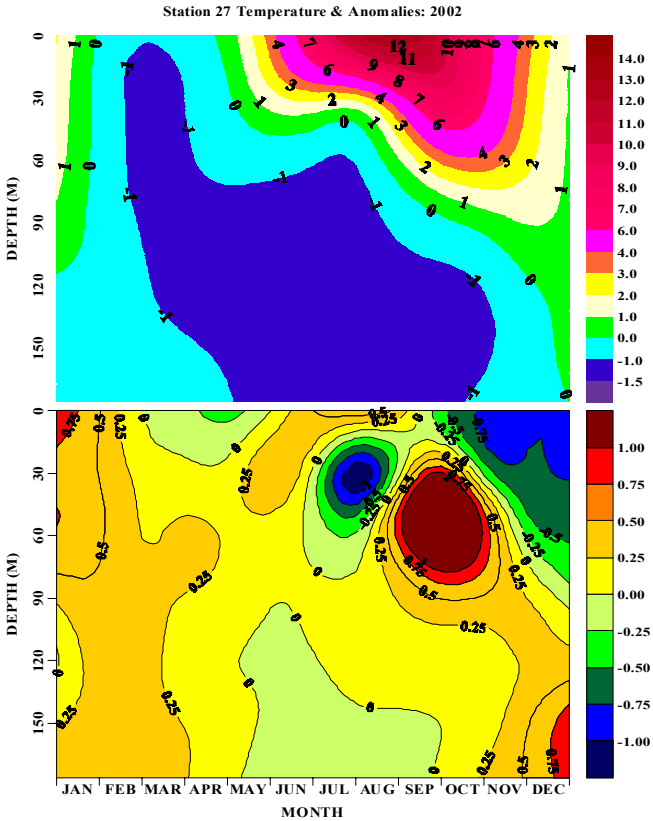

Fig. 4. Monthly temperature (top) and their departures from normal (bottom) at Station 27 as a function of depth for 2002.

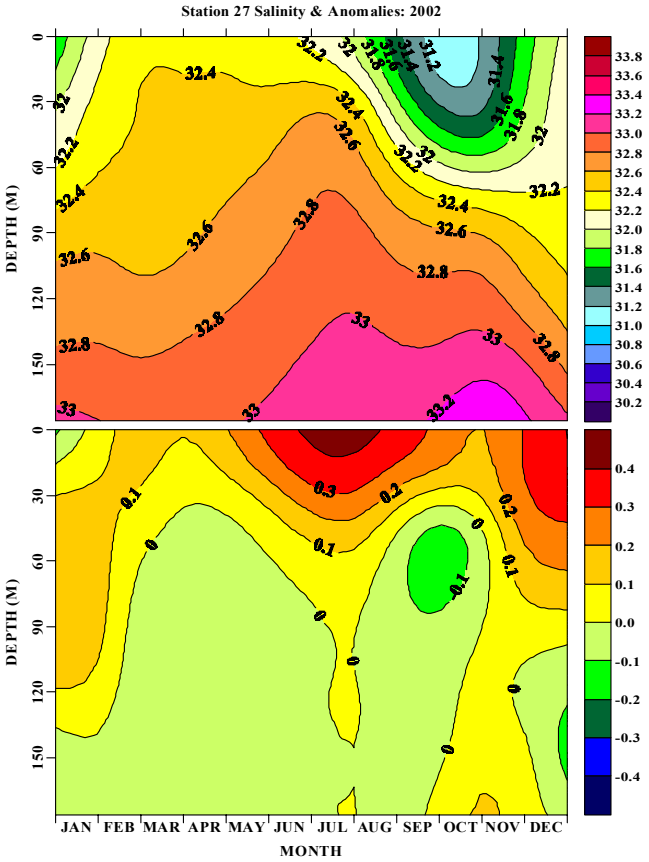

Fig. 5. Monthly salinity (top) and their departures from normal (bottom) at Station 27 as a function of depth for 2002.

By mid-May upper layer temperatures had warmed to 2°C and to above 12°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 in the spring near the surface. Upper layer temperatures during the summer were warmer-than-normal but fell to below normal from September to December. Bottom temperatures averaged throughout the year were about 0.2°C above normal (Fig. 4).

Surface salinities (Fig. 5) were >32.2 by mid-February and decreased to values <31.2 by September. Upper layer values were above normal throughout the year, while near-bottom salinities were near normal.

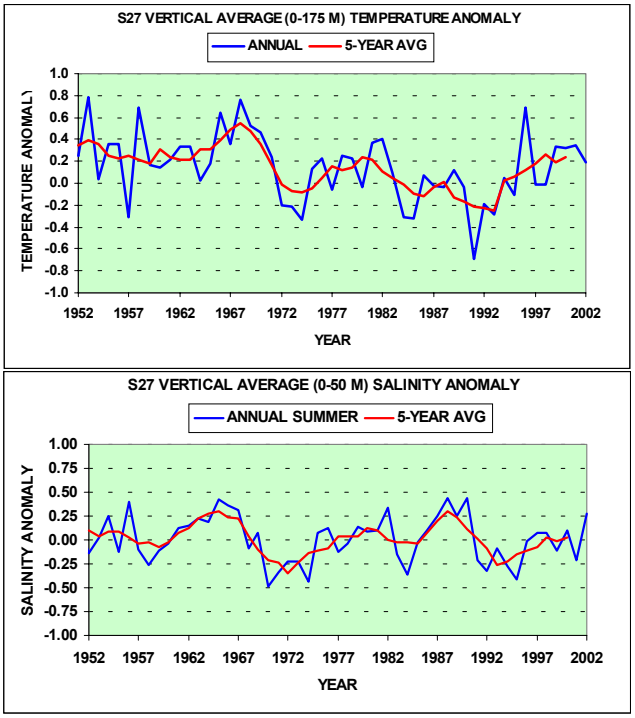

Fig. 6. Departures from normal depth averaged (0-176 m) Station 27 temperature (in °C) and upper layer (0-50 m) averaged summer (July-Sept) salinity. The red lines are the 5-year means.

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 2002, although the 2002 value decreased over 2001.

The depth-averaged (0-50 m) summer (July-September) 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.

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

Annual near-bottom temperature anomalies from 1952 to 2002 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. 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. Bottom temperatures on the Flemish Cap show similar trends as 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.

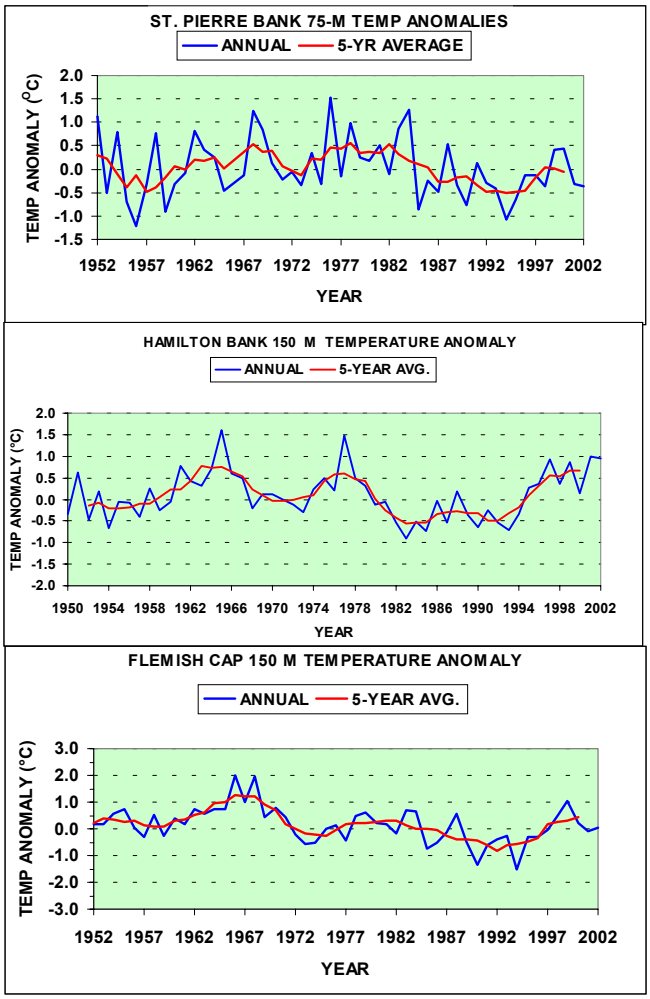

Fig. 7. Departures from normal annual near bottom temperatures on St. Pierre and Hamilton Banks and on the Flemish Cap. The red lines are the 5-year means.

Inshore Temperature Time Series

Annual temperature anomalies from long-term inshore monitoring sites at Comfort Cove in Notre Dame Bay, Stock Cove in Bonavista Bay and at Arnold's Cove in Placentia Bay (Fig. 1) at 10-m depth are displayed in Fig. 8. Temperatures at Comfort Cove were mostly below normal during the early 1990s and above normal from 1998 to 2002. Temperatures during the past 2 years, however, decreased from the highs experienced during 1999-2000 when values exceeded 1°C above normal. At Stock Cove temperatures were also below normal during most of the early 1990s and above normal during 1998 to 2002, by up to 0.5°-1°C.

At Arnold's Cove on the south coast of Newfoundland, temperature trends were similar to those on the east and northeast coast, with values below normal from 1991 to 1995. During 1998-2002 temperatures were above normal, reaching 1.5°C above normal in 1999, the highest value of the time series. Similar to other regions, inshore temperatures in Placentia Bay have decreased during the past 2-years.

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).

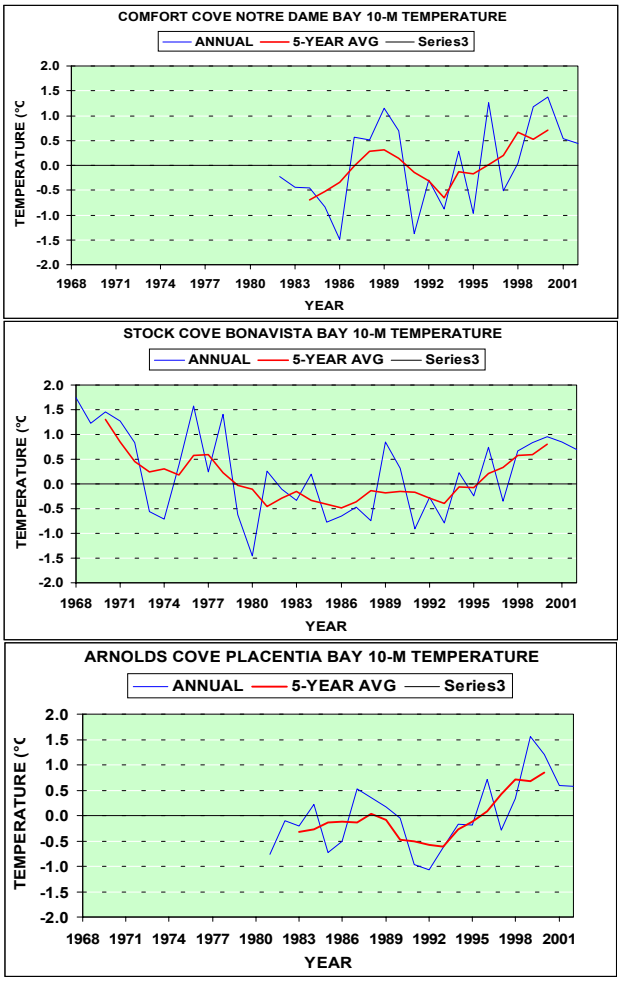

Fig. 8. Departures from normal annual temperatures at 10 m depth at Comfort Cove in Notre Dame Bay, Stock Cove in Bonavista Bay and for Arnold's Cove in Placentia Bay.

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.

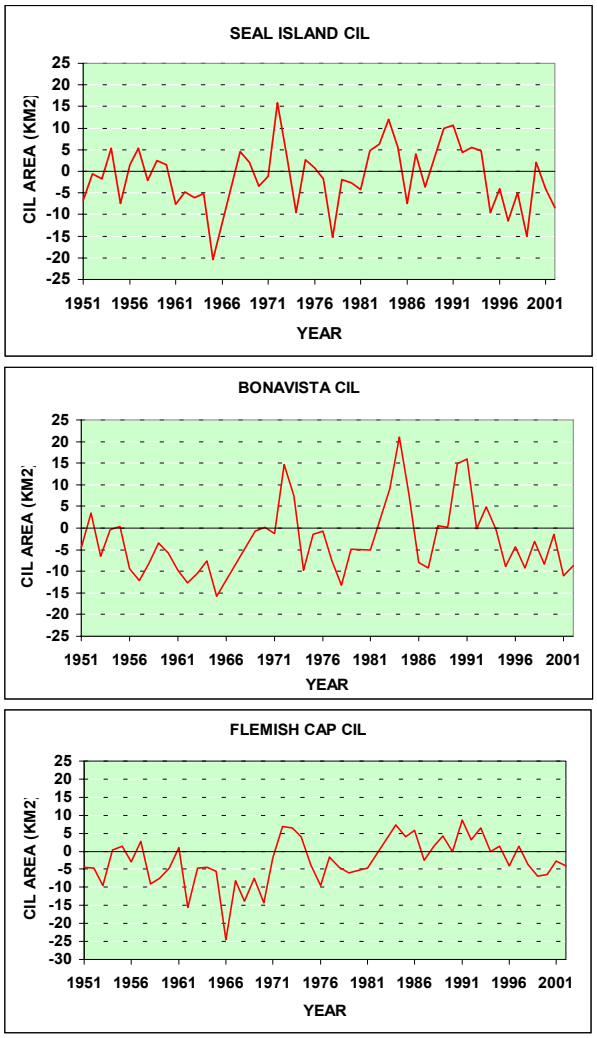

Fig. 9. Time series of CIL area anomalies along the standard sections across the Newfoundland Shelf shown in Fig. 1.

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. The time series of CIL area anomalies for the Seal Island, Bonavista and Flemish Cap sections (Fig. 1) are displayed in Fig. 9. In these plots, negative anomalies or below normal CIL areas correspond to warm oceanographic conditions. The CIL area during 2002 was below the long-term mean along all three sections. Off Bonavista, the CIL area was very similar to 2001, below normal for the 8th consecutive year and among the lowest observed since the late 1970s. 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.

Bottom Temperatures

Spring

Bottom temperature anomalies for NAFO Divisions 3P and 3LNO during the spring of 2002 are displayed in Fig. 10.

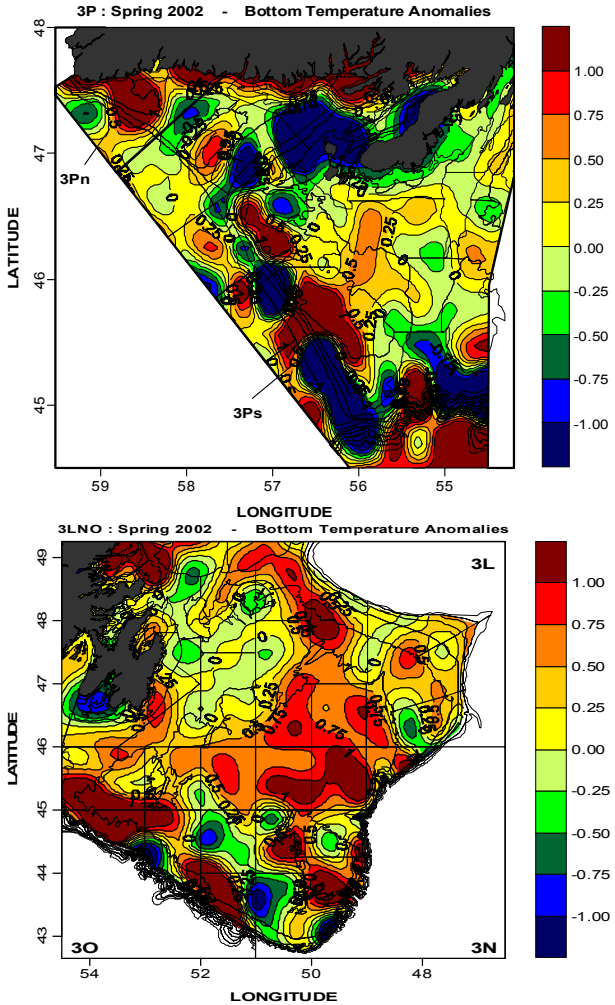

Fig. 10. Bottom temperature anomalies (in °C) for the spring of 2002 for NAFO Subdivisions 3Pn and 3Ps and Divisions 3LNO.

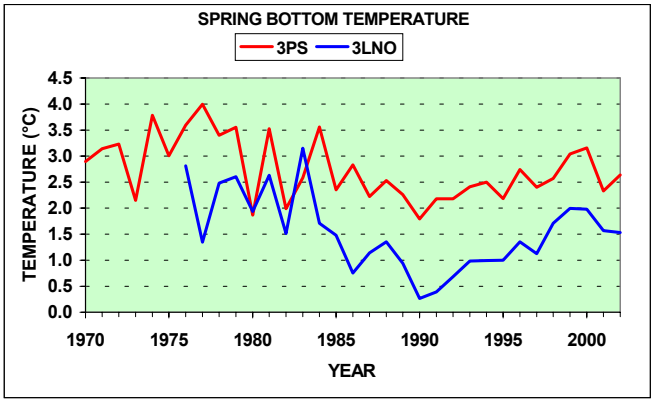

Fig. 11. Annual mean bottom temperatures during the spring for NAFO Subdivisions 3Pn and 3Ps and Divisions 3LNO.

Bottom temperature anomalies during the spring of 2002 in NAFO Subdivisions 3Ps and 3Pn are displayed in Fig. 10. Temperatures were above average over Burgeo and Rose Blanche banks, while Hermitage Channel bottom temperatures were mostly below normal. Bottom temperatures over most of St. Pierre Bank ranged from 0° to 3°C, which were mostly below normal around the edges of the bank to above normal over the central portions of the bank (Fig. 10). In general, the area of the bottom covered by below normal temperatures decreased during the spring of 2002 compared to 2001. The average bottom temperature of the surveyed area in Division 3P ranged between 2° - 4°C from 1970 to 1984 and decreased to between 2° - 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. During the spring of 2002 the mean bottom temperature increased slightly over 2001 (Fig. 11).

During the spring on the Grand Bank in Div. 3L, temperature anomalies varied considerably from slightly below normal in the inshore to 0.75°C above normal in the offshore regions. In Divs. 3NO again temperatures varied but were mostly above normal. In the western regions of Div. 3O bottom temperatures reached 1°C above normal. From 1998 to 2000 the areal extent of <0°C bottom water on the Grand Bank decreased and as a result the average bottom temperature increased significantly over the lows of the early 1990s. The mean bottom temperature during the spring of 1999 and 2000 reached 2°C but has decreased to about 1.5°C during the spring of 2001 and 2002 (Fig. 11).

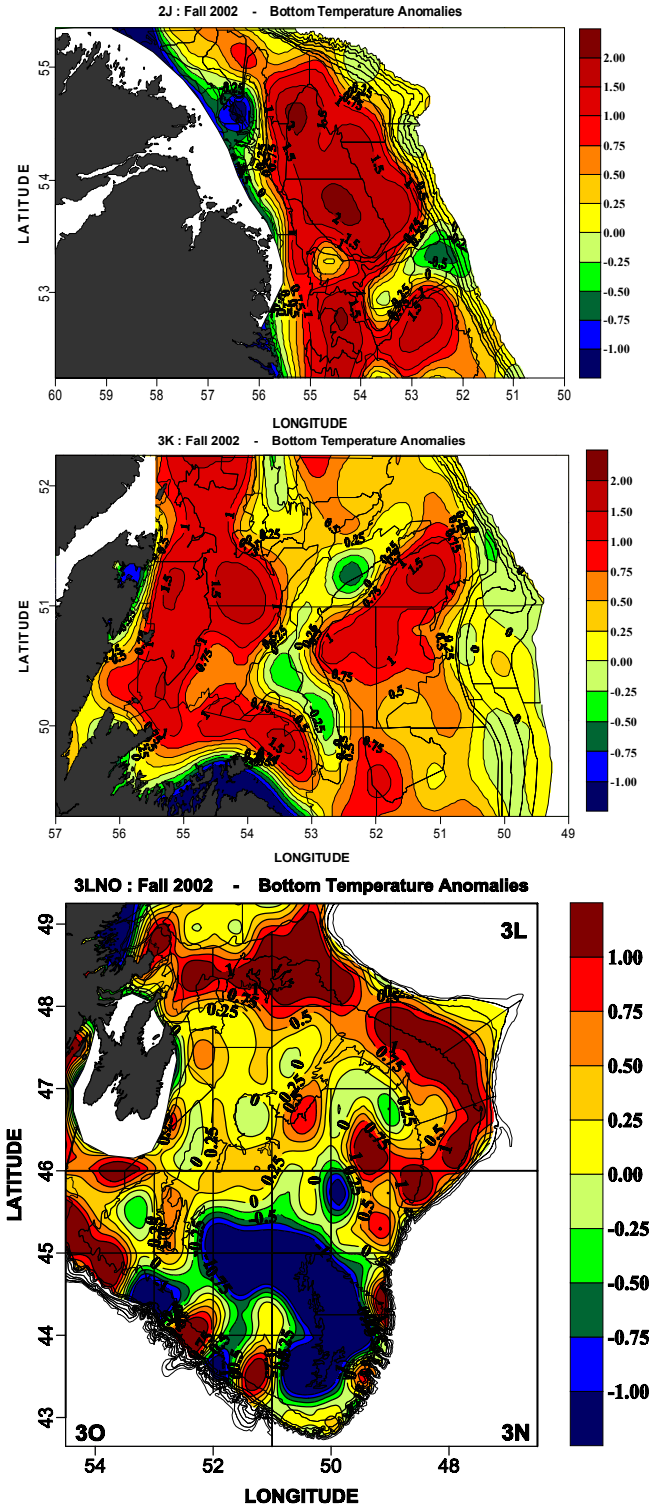

Fig. 12. Bottom temperature anomalies (in °C) for the fall of 2002 for NAFO Divisions 2J, 3K and 3LNO.

Fall

Bottom temperature anomalies for the fall of 2002 in NAFO Divisions 2J, 3K and 3LNO are displayed in Fig. 12. Bottom temperatures during the fall of 2002 in Div. 2J ranged from <1°C inshore, to >3.5°C offshore at the shelf break. Over Hamilton Bank they ranged from <2°C on the inshore portion of the bank to near 3°C on the southern portion. These were about 1°-2°C above normal on Hamilton Bank and about normal along the edge of the shelf (Fig. 12). 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 2001 and 2002 mean bottom temperatures continued above 2.5°C (Fig. 13).

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 2002 ranged between 2°-3°C, which were about 0.5°-1°C above their long-term means. Near the edge of the continental shelf in water depths below 500-m temperatures were generally around 3.5°C, which was about normal. The time series of the average bottom temperature in Div. 3K (Fig. 13) 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 2002 bottom temperatures were lower than in 1999 but remained relatively warm between 2.2° to 2.4°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 3°C during 2002 on the Southeast Shoal and to >3°C along the edge of the Grand Bank. During 2002 bottom temperatures were predominately above normal, except for the southeast shoal where they were up to 2°C below normal. 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 to over 2.5°C during 1999, the highest in the 10 year record. During the fall of 2000 to 2002 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. 13).

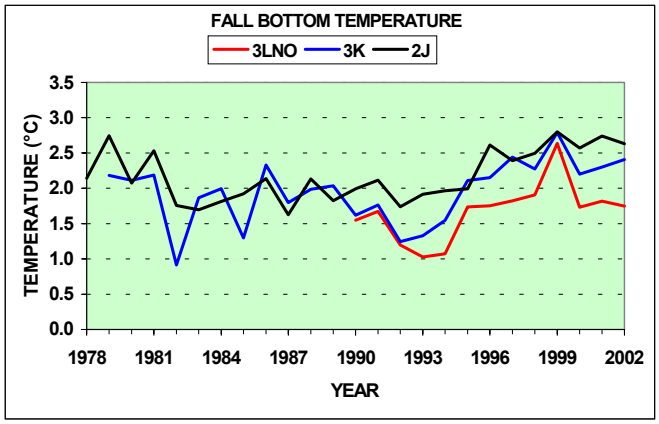

Fig. 13. Annual mean bottom temperatures during the fall for NAFO Divisions 2J, 3K and 3LNO.

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