Research vessel CCGS Teleost

2001 State of the Ocean: Physical Oceanographic Conditions in the Newfoundland 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.

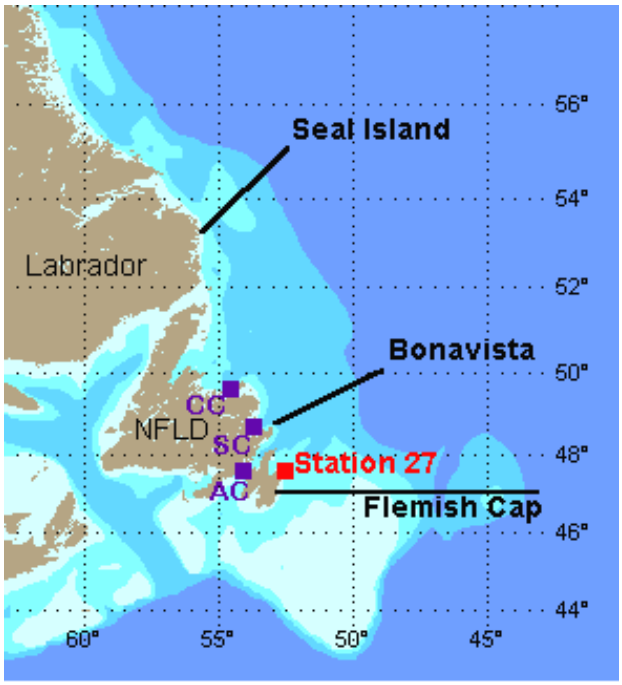


Fig. 1. Location Map showing the positions of standard transects and fixed oceanographic monitoring sites in the Newfoundland Region.

Summary

- Annual air temperatures ranged from 1.4°C above normal at Cartwright Labrador to 0.5°C at St. John's in southern Newfoundland during 2001.
- The Newfoundland Shelf ice extent decreased slightly compared to 2000 remaining below normal for the 4th consecutive year. Sea ice duration was also shorter than normal during 2001.
- The annual surface water temperature off St. John's was about 0.5°C above normal during 2001.
- Annual bottom water temperature at Station 27 was about 0.4°C above normal during 2001.

- Salinities off St. John's were about normal during the winter months but fresher than normal during the rest of the year.

- The volume of sub-zero °C water on the Newfoundland and southern Labrador Shelves during 2001 was below normal in all areas reaching a 24-year low off Bonavista.

- Bottom temperatures during 2001 were up to 1°C above the long-term average over many areas except the southern Grand Banks and St. Pierre Bank.

- The percentage area of sub-zero°C water covering the banks in the Newfoundland Region during the spring of 2001 increased slightly over 2000 values but remained low in most areas during the fall.

- In general, ocean temperatures during 2001 were similar to 2000, slightly cooler than 1999 but continuing above normal in most areas. The main exception was in Subdivision 3Ps where temperatures decreased significantly over 2000 values.

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 mean or anomalies. Where possible, the long-term means are standardised to a base period from 1971-2000.

Conditions in 2001

Newfoundland and Labrador air temperatures were mostly above normal during 2001 (Fig 2a).

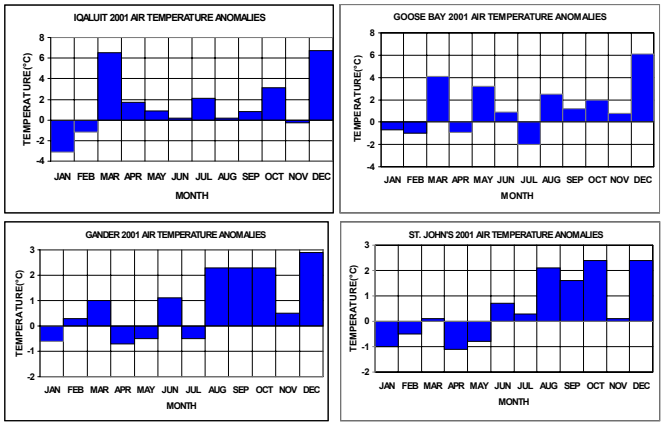


Fig 2a. Departures from normal mean air temperatures at four sites in the Northwest Atlantic for 2001.

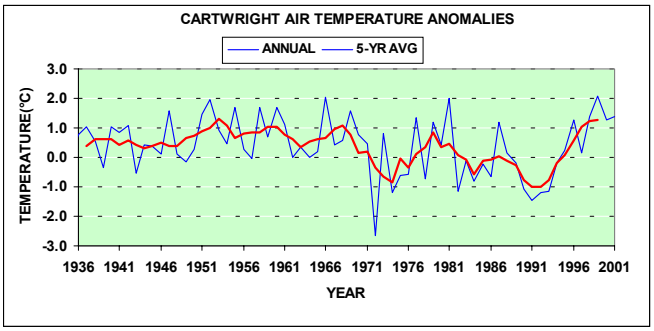


Fig. 2b. Departures from normal mean air temperature (dashed line) and the 5 year means at Cartwright on the Labrador Coast.

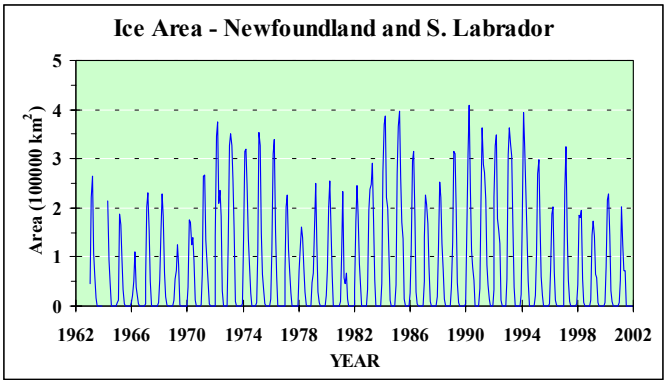


Fig. 3. Time series of monthly sea-ice areas off Newfoundland and southern Labrador.

Air temperature at Cartwright (Fig. 2b) since the 1960s show large variations, superimposed on a general downward trend up to the early 1990s. During 1999 record highs were recorded at St. John's with temperatures 1.9°C above normal, a 126-year record and at Cartwright 1.9°C above normal, a 65-year record. Air temperatures during 2001 continued warm increasing slightly over 2000 values at Cartwright to 1.4°C above normal. At St. John's air temperatures decreased over 2000 values but were 0.6°C above normal. The peak extent of sea ice area during 2001 decreased slightly over 2000 with a shorter duration than normal. This was the 4th consecutive year with below normal ice extent, which was only about ½ the peak extent of the heavy ice years of the early 1990s (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 late April and from approximately 0 to -1°C throughout the year near the bottom at about 175 m depth. By mid-May upper layer temperatures had warmed to 1°C and to above 13°C by August at the surface, after which the fall cooling commenced. These temperatures were about 1/4°C above normal for the winter months over most of the water column but decreased to 0.5°C below normal by mid spring. Upper layer temperatures during the summer were warmer-than-normal which continued to the end of the year. Fall temperatures at mid-depths were below normal, while bottom values remained above normal throughout the year (Fig. 4). Surface salinities (Fig. 5) reached a maximum of >32.2 by mid-February and decreased to a minimum of <30.8 by September. These values

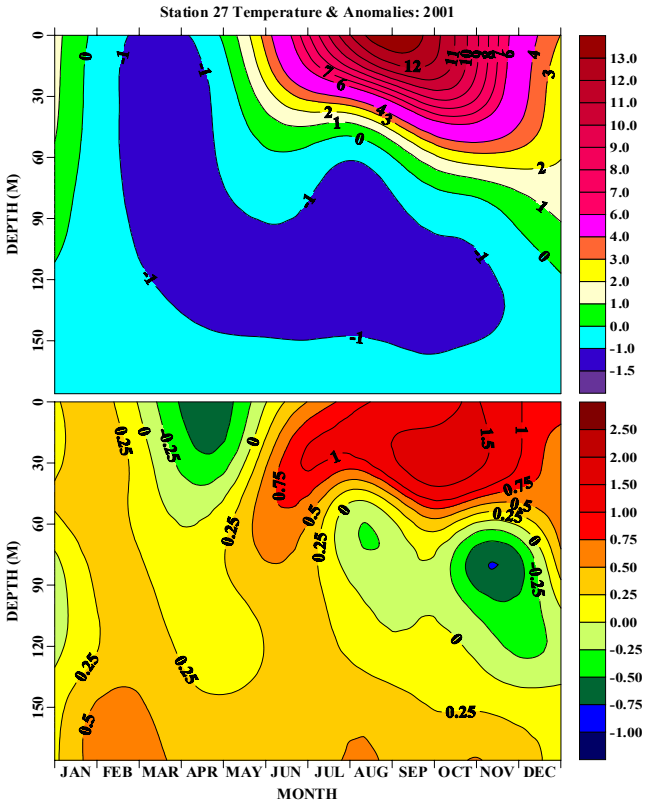


Fig. 4. Monthly temperature (top) and their departures from normal (bottom) at Station 27 as a function of depth for 2001.

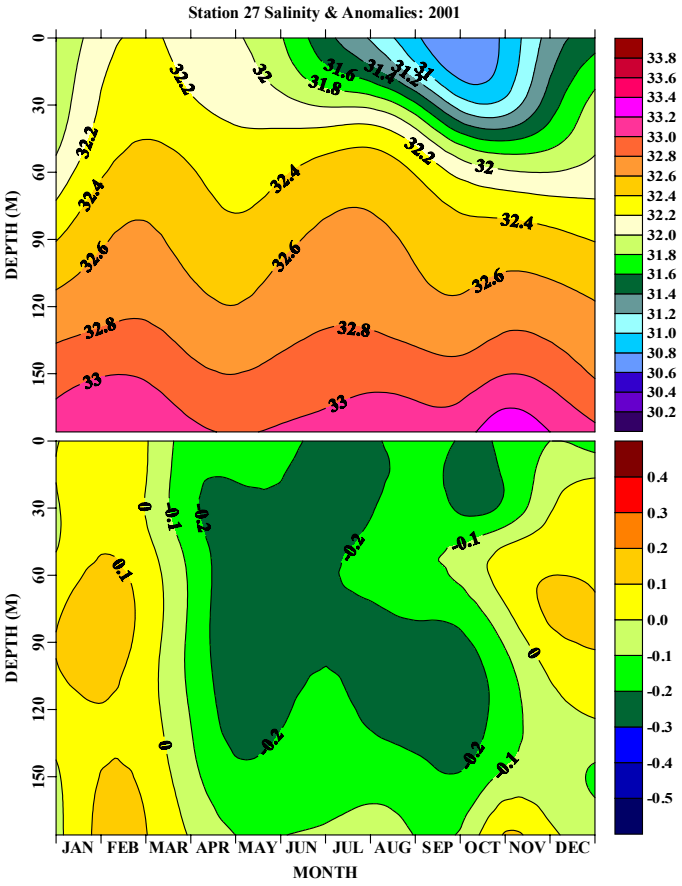


Fig. 5. Monthly salinity (top) and their departures from normal (bottom) at Station 27 as a function of depth for 2001.

were about normal during the winter and late fall months over most of the water column. Below 100-m depth, salinities generally ranged from 32.6 to 33 near the bottom. Except for the winter and fall values salinities were generally below normal during the rest of the year over all depths.

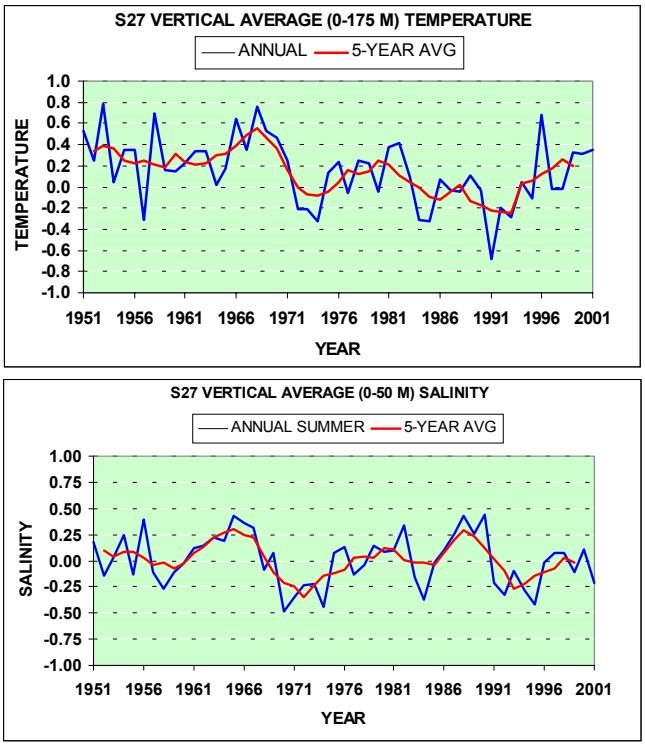


Fig. 6. Departures from normal depth averaged (0-176 m) Station 27 temperature and upper layer (0-50 m) averaged summer (July-Sept) salinity. The red lines are the 5-year means.

The station 27 depth-averaged annual temperature (which is proportional to the heat content of the water column) (Fig. 6) shows large fluctuations at near decadal time scales, with cold periods during the early 1970s, mid-1980s and early 1990s. 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 2001. The depth-averaged (0-50 m) summer (July-September) salinity anomalies (Fig. 6) show similar patterns as the heat content with fresher-than-normal periods generally corresponding to the colder-than-normal conditions. During 1995 summer salinities started to increase and were near normal from 1996 to 2000, but decreased to below normal in 2001.

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

Annual near bottom temperature anomalies from 1951 to 2001 on St. Pierre Bank are displayed in Fig. 7. The temperature trends are characterised

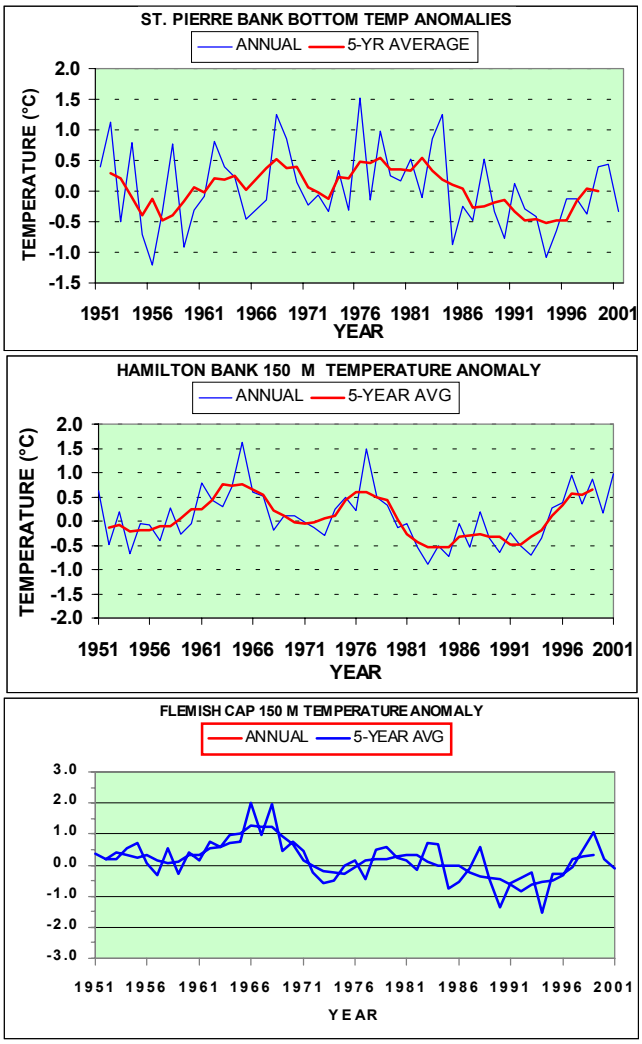


Fig. 7. Departures from normal annual near bottom temperatures on St. Pierre and Hamilton Banks and on the Flemish Cap. The red lines are the 5-year means.

by large annual variations greater than 1°C about the mean. During the cold period beginning around 1984 temperatures near bottom on St. Pierre Bank decreased by up to 1°C and continued below normal until about 1997. From 1998 to 2000 temperatures on St. Pierre Bank were above normal but returned to below normal values during 2001. 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 ½°C below normal, By the mid-1990s they increased to above normal values that continued into 2001. 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 during 2000 and 2001 decreased over the warm values of 1999 to about normal values.

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 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 2001. Temperatures during 2001, however, decreased over 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 2001, by up to 0.5°-1°C. At Arnold's Cove on the south coast of Newfoundland temperature trends were similar to the east and northeast coast, with values below normal from 1991 to 1995 and above normal during 1998-2000 reaching 1.5°C above normal in 1999, the highest value of the time series. Data were not available for 2001 at Arnold's Cove.

The Newfoundland Shelf Cold Intermediate Layer (CIL)

A common feature of the temperature structure on the Newfoundland Continental Shelf is the layer of cold less than 0°C water, commonly referred to as the Cold Intermediate Layer or CIL. This winter cooled water remains trapped between the seasonally heated surface layer and warmer continental slope near bottom water during the summer and early fall months. Along

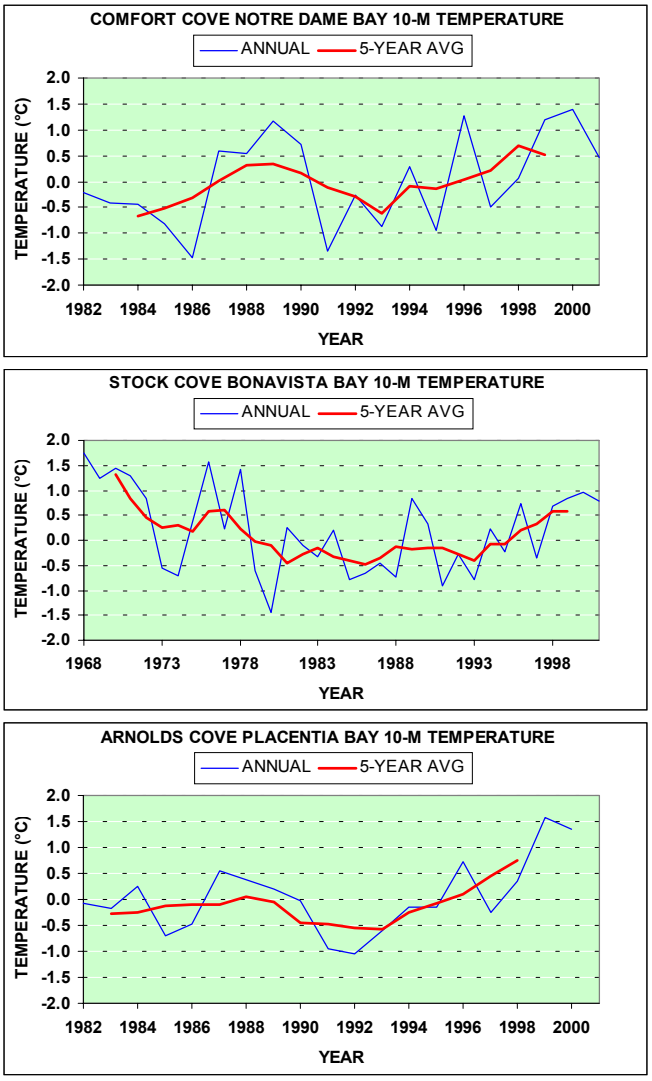


Fig. 8. Departures from normal annual temperatures at 10 m depth at Comfort Cove, Notre Dame Bay, Stock Cove, Bonavista Bay and for Arnold's Cove, Placentia Bay.

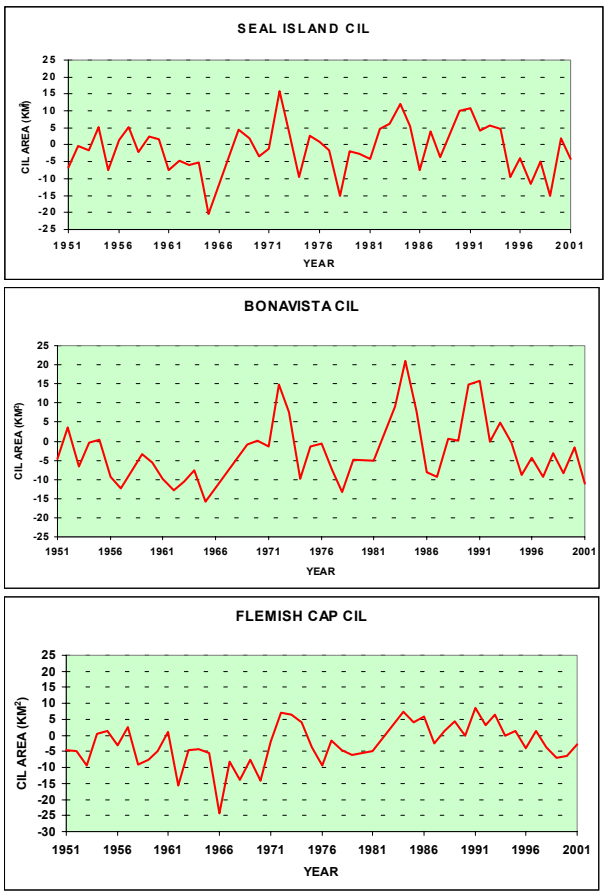


Fig.9. Time series of CIL area anomalies along the standard transects across the Newfoundland Shelf shown in Fig. 1.

the Bonavista transect during the summer for example, this cold layer extended offshore to over 200 km, with a maximum vertical extent of about 200 m. Figure 9 shows the time series of the CIL area for the Seal Island, Bonavista and Flemish Cap transects, the positions of which are shown in Fig. 1. In these plots negative or below normal CIL areas correspond to warm oceanographic conditions. Along the Flemish Cap transect during the summer of 2001 the CIL area was below it's 1971-2000 mean, similar to conditions observed during the past 3-years but a slight increase over 2000. Off Bonavista the CIL area decreased to the lowest value observed since 1978 continuing the trend of below normal values observed since 1994. Similarly along the Seal Island transects the area of sub-zero ^{o}C water decreased over 2000 values continuing the recent below normal trend. This is in 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 on the Grand Bank during the spring of 2001 are displayed in

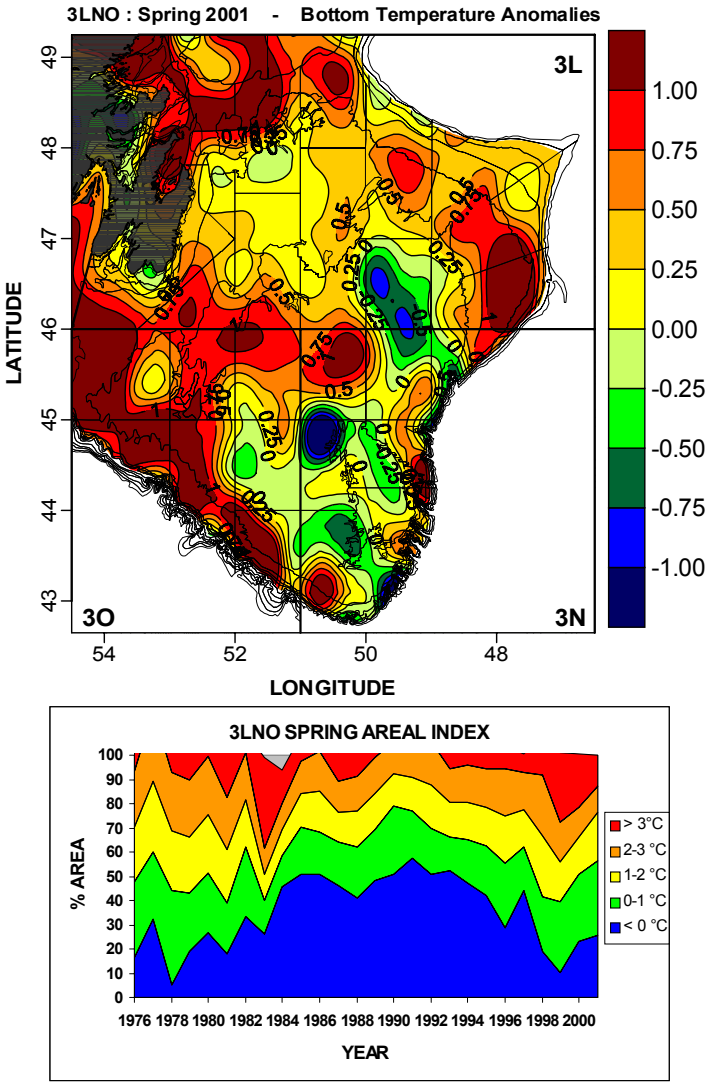


Fig. 10. Bottom temperature anomalies (in °C) for the spring of 2001 for NAFO Divisions 3LNO and the percentage area of the bottom covered by water in various temperature bins.

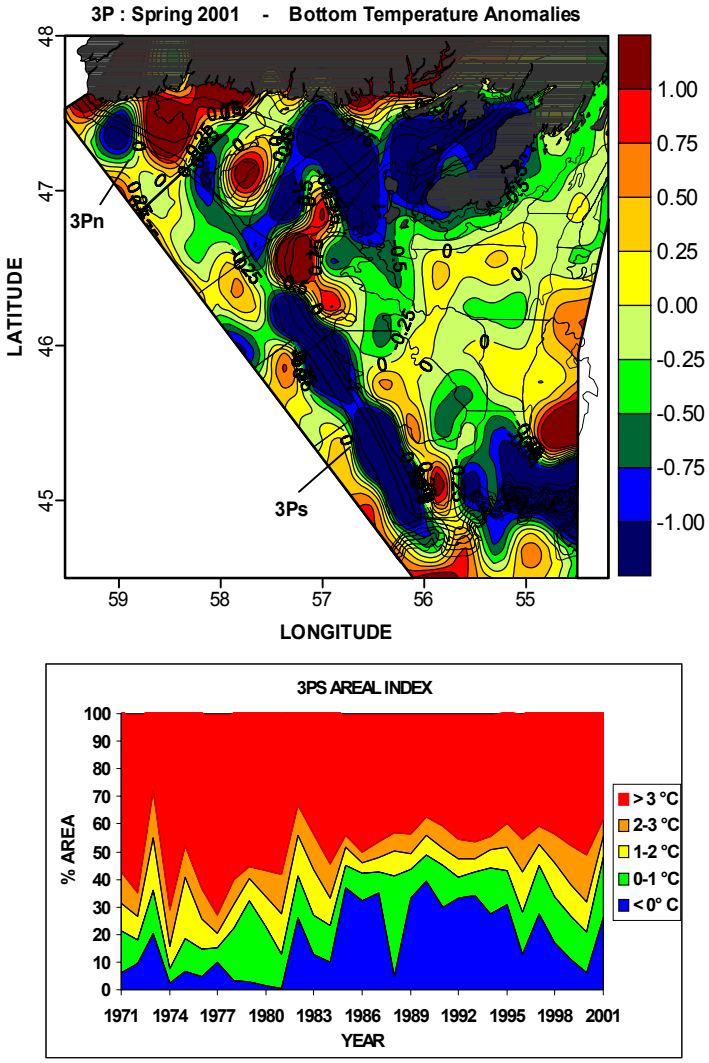


Fig. 11. Bottom temperature anomalies (in °C) for the spring of 2001 for NAFO Subdivisions 3Pn and 3Ps and the percentage area of the bottom covered by water in various temperature bins.

Fig. 10. During the spring on the Grand Bank sub-zero °C was mostly restricted to Div. 3L where temperatures were above normal by ½ to 1°C in most areas. In Div 3N temperatures were mostly below normal., particularly on the southeast shoal of the Grand Bank. In the western regions of Div. 3O bottom temperatures reached 1°C above normal. The areal extent of bottom water in different temperature bins reveals a significant decrease in the extent of sub-zero ^{o}C water with a corresponding increase in the extent of water above 1^{o}C during the spring of 1998 and 1999 compared to 1997. During the spring of 2001 the extent of sub-zero ^{o}C water increased slightly over 2000 values (Fig. 10). Bottom temperature anomalies during the spring of 2001 in NAFO Subdivisions 3Ps and 3Pn are displayed in Fig. 11. Except for small isolated areas bottom temperatures were below normal over most areas with values ranging from 0.5-1^{o}C below normal. These values are a significant decrease over 2000 values. The areal extent of sub-zero ^{o}C bottom water in this region shows a dramatic increase in the mid-1980s that continued up to 1997 after which it decreased to about 10% in 1999 and 2000 (Fig. 11). During 2001 it again increased to relatively high values. The extent of bottom water with temperatures above 1^{o}C was about 60% of the total area during 1995 and this increased to about 80% during the spring of 2000 and decreased to near 50% during 2001 (Fig. 11).

Autumn

Bottom temperature anomalies for the fall of 2001 in NAFO Divisions 2J, 3K and 3LNO are shown in Figs. 12 to 14. Bottom temperatures were up to 2^{o}C above normal on Hamilton Bank in Div. 2J and from 0.5-1^{o}C above normal on Belle Isle and Funk Island Banks in Div. 3K with near-normal values along the shelf edge. During

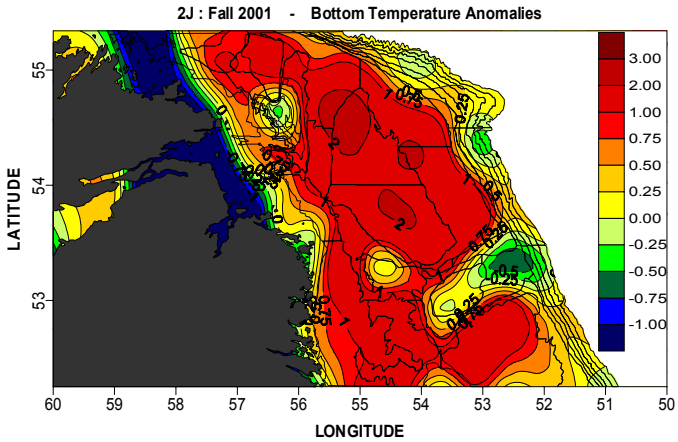


Fig. 12a. Bottom temperature anomalies (in °C) for the fall of 2001 for NAFO Division 2J.

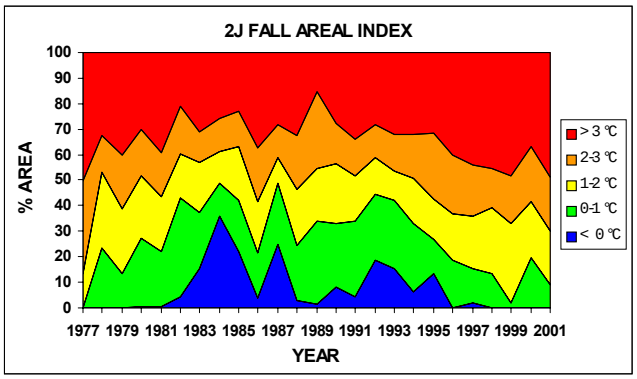
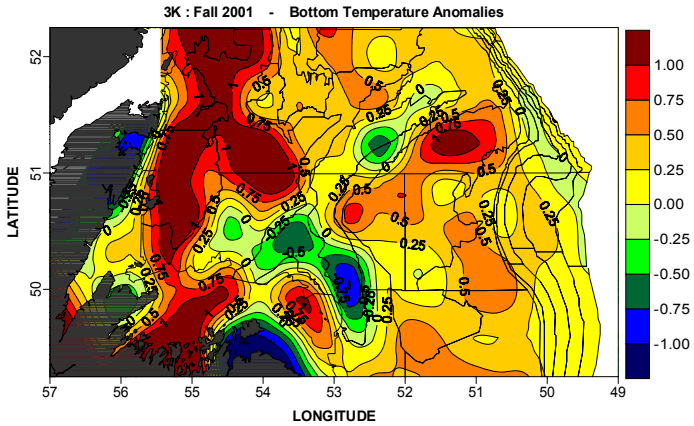


Fig. 12b. The percentage area of the bottom covered by water in various temperature bins for the fall of 2001 for NAFO Division 2J.



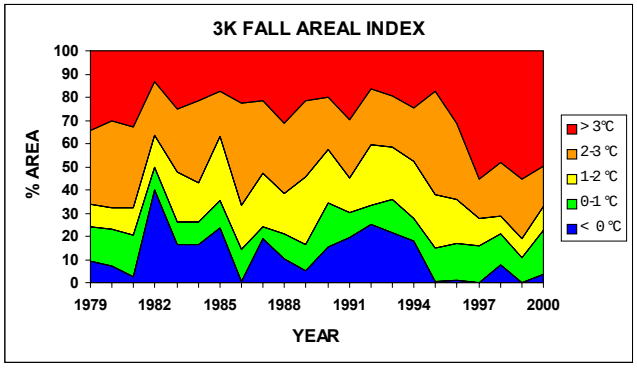
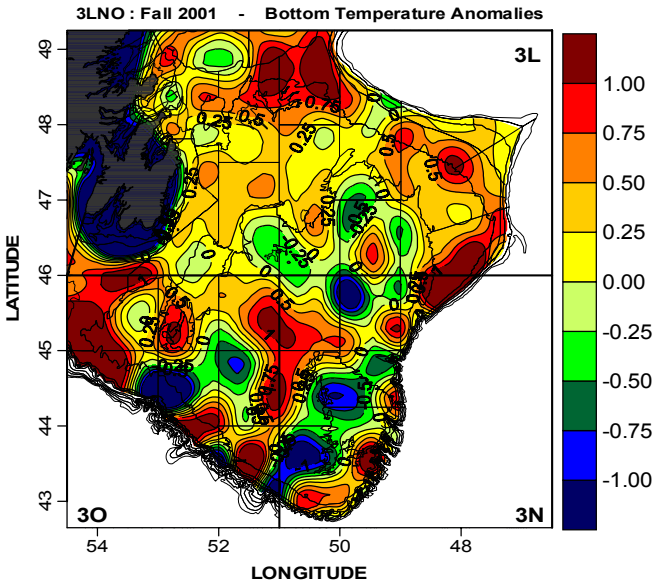


Fig. 13. Bottom temperature anomalies (in °C) for the fall of 2001 for NAFO Division 3K and the percentage area of the bottom covered by water in various temperature bins.

the fall of 2001 bottom temperatures were above normal on the northern Grand Bank in Div. 3L and along the edge of the banks. In Divs. 3NO bottom temperatures were quite variable fluctuating by 1°C about the mean.

In general, bottom temperatures during the fall were above normal in most areas except areas of the southern Grand Banks. During the fall of 2001 the area of sub-zero °C water covering the bottom in Divisions 3LNO decreased slightly over 2000 values to about 30%. There was very little or no sub-zero °C water in Divs. 2J and 3K since the mid 1990s (Figs 12b and 13, bottom panel). The areal extent of bottom water with temperatures above 1°C increased significantly during the fall of 1999 reaching 70-80% of the total area on all major banks in the region. During 2000 and 2001 this area has decreased somewhat, however, in most areas particularly north of the Grand Banks relatively warm water dominated.



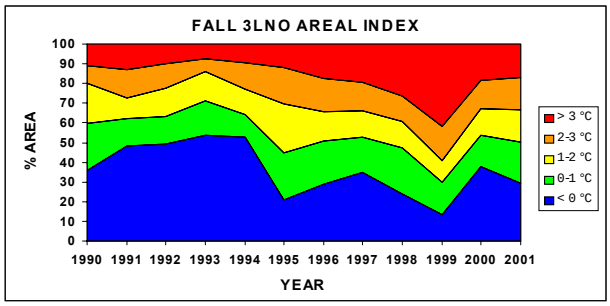


Fig. 14. Bottom temperature anomalies (in °C) for the fall of 2001 for NAFO Divisions 3LNO and the percentage area of the bottom covered by water in various temperature bins.

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