Research vessel CCGS Teleost

Environmental Conditions in the Newfoundland Region during 1999

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 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.

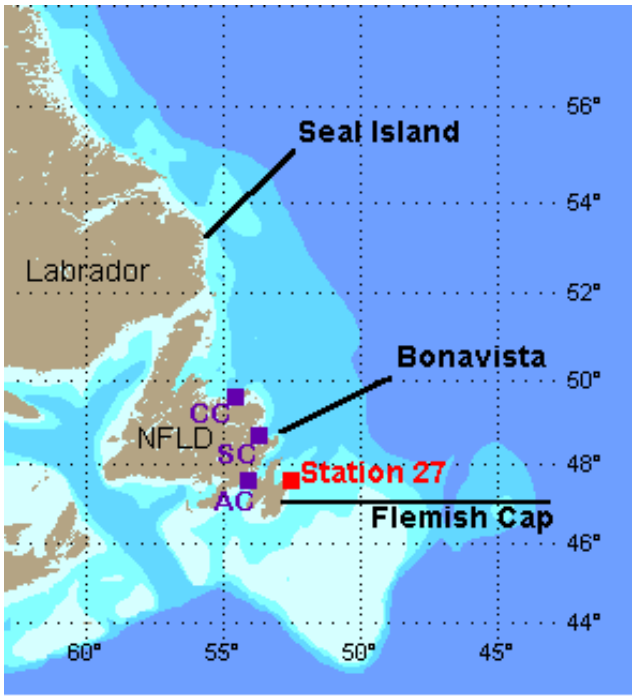

Fig. 1. Location Map showing the positions of standard transects and fixed oceanographic monitoring sites in the Newfoundland Region.

Summary

- Annual air temperatures were up to 2°C above normal during 1999, breaking a 126-year record at St. John's.
- The Newfoundland Shelf ice extent was below normal and the ice duration was shorter than normal during 1999.
- Mid-summer surface water temperature off St. John's reached over 2°C above normal during 1999.
- Bottom temperatures throughout the year at Station 27 were up to 0.5°C above normal.
- Salinities off St. John's were above normal during the winter months and below normal during the rest of the year.

- The volume of sub-zero °C water on the Newfoundland and southern Labrador Shelves during 1999 was below normal, continuing a trend established in 1995.

- Bottom temperatures on the Grand Bank during the spring and fall ranged between 1-3°C above the long-term average over most areas.

- On St. Pierre Bank bottom temperatures were above the long-term average during the spring of 1999.

- The percentage area of sub-zero°C water covering all major banks in the Newfoundland Region during 1999 had decreased to near 0% from highs near 80-100% during the early 1990s.

- In general, ocean temperatures during 1999 continued the above normal trend established in 1996.

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 1961-1990.

Conditions in 1999

Newfoundland and Labrador air temperatures were mostly above normal during 1999 (Fig 2a).

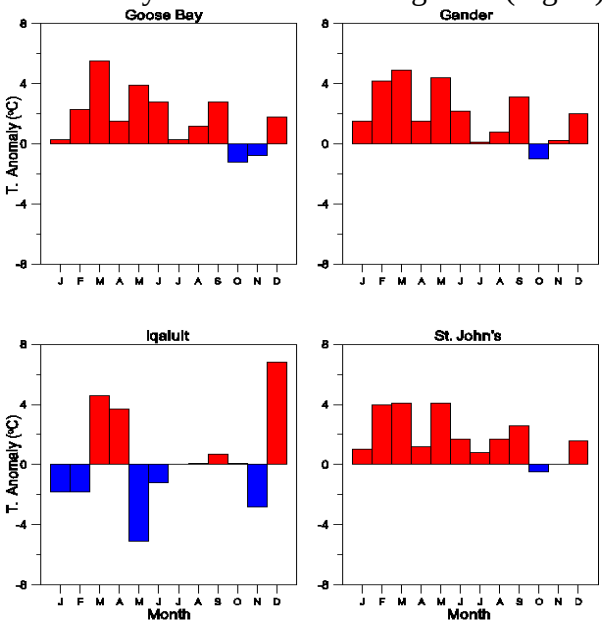

Fig 2a. Departures from normal mean air temperatures at four sites in the Northwest Atlantic for 1999.

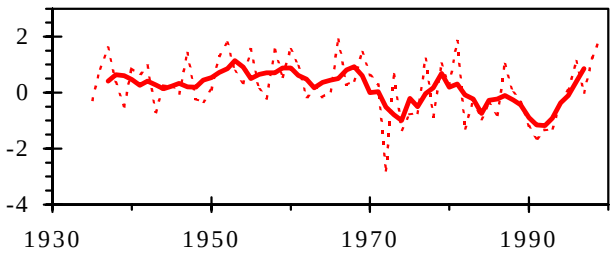

Fig. 2b. Departures from normal mean air temperature (dashed line) and the 5 year means at Cartwright on the Labrador Coast.

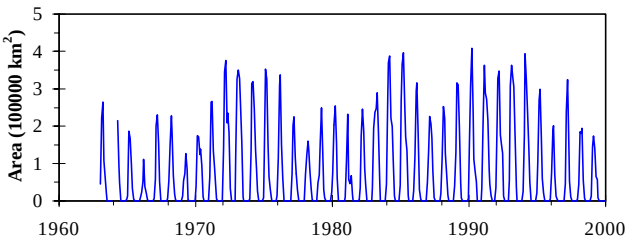

Fig. 3. Time series of ice areas off Newfoundland and southern Labrador.

The air temperature time series at Cartwright (Fig. 2b) since the 1960s show large variations, superimposed on a general downward trend up to the early 1990s. Recently, however air temperatures have been above normal. 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. The peak extent of ice area on the Newfoundland and Southern Labrador Shelves during 1999 decreased over 1998 values and was 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 near constant at about 0 °C from January to early April and from approximately 0 to -1°C

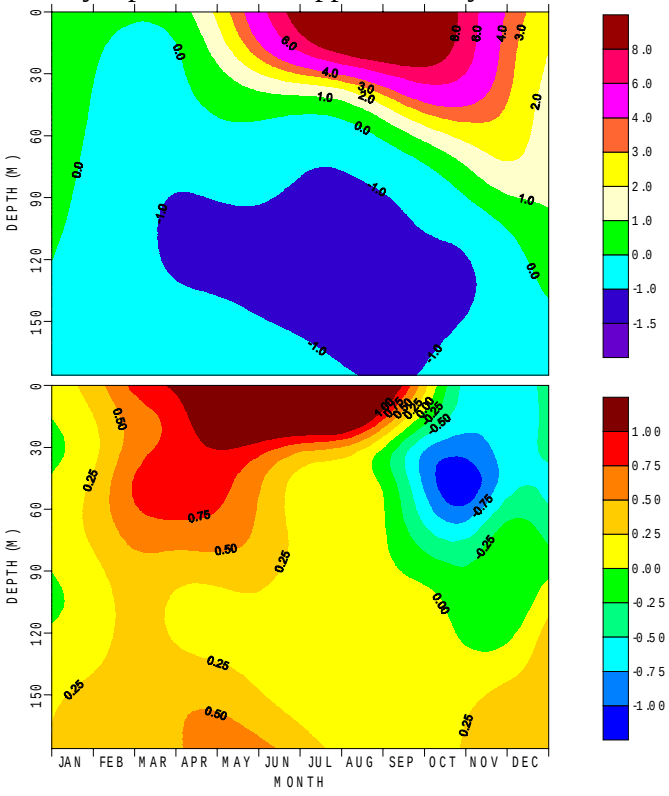

Fig. 4. Monthly temperature (top) and their departures from normal (bottom) at Station 27 as a function of depth for 1999.

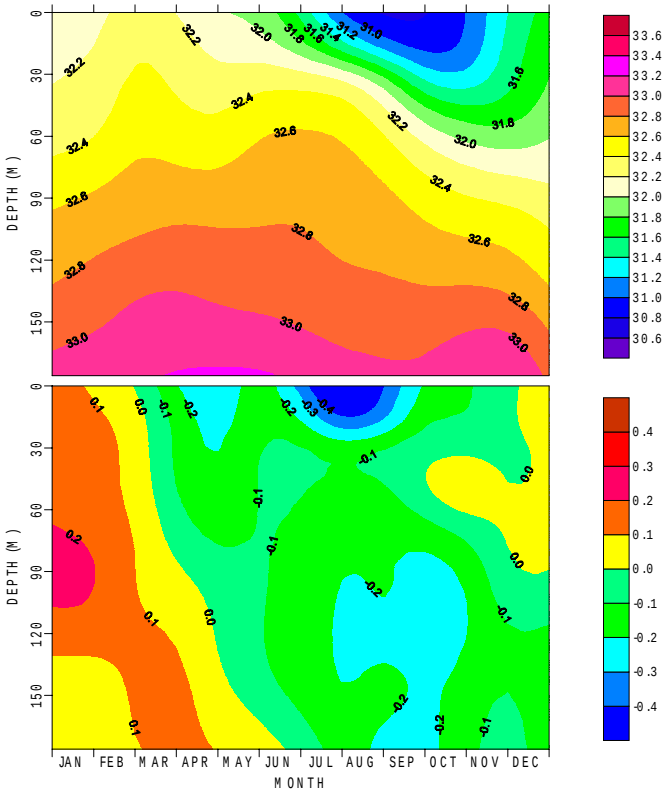

Fig. 5. Monthly salinity (top) and their departures from normal (bottom) at Station 27 as a function of depth for 1999.

throughout the year near the bottom at about 175-m depth. By early May the upper layer temperature had warmed to 3°C and to above 14°C by August at the surface, after which the fall cooling commenced. These temperatures ranged from 0.3° to 0.75°C above normal for the winter months over most of the water column. By mid-Summer temperatures increased to over 2°C above normal at the surface. Fall temperatures over the upper 100-m of the water column were below normal by about 0.5°C. Bottom temperatures throughout the year were above normal by up to 0.5°C (Fig. 4). Surface salinities (Fig. 5) reached a maximum of 32.2 in mid-March and decreased to a minimum of 30.5 by late August, these values were below the long term mean by up to 0.5. Below 50-m depth, salinities generally ranged from 32.4 to 33.0. There was a slight positive anomaly during the winter months, but values were generally below normal throughout the year.

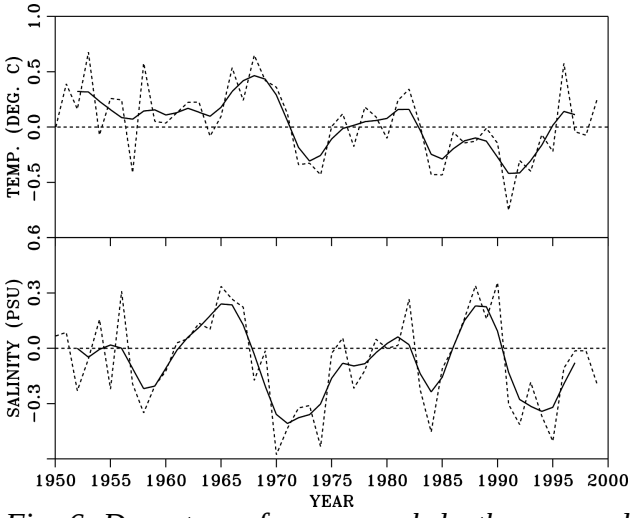

Fig. 6. Departures from normal depth averaged (0-176 m) Station 27 temperature and upper layer (0 to 50 m) averaged summer (July-Sept) salinity. The heavy lines are the three-year running means.

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. During the time period 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 in 1999. The depth-averaged (0-50 m) summer (July-September) salinity anomalies (Fig. 6) show similar behaviour to the heat content with less saltier than normal periods generally corresponding to the colder than normal conditions. During 1995 summer salinities started to increase and were near normal during 1996 to 1998 but fell to below normal values again during 1999.

St. Pierre Bank (Subdivision 3Ps)

The time series of temperature anomalies from 1950 to 1999 on St. Pierre Bank are shown in Fig. 7 at standard depths of 0, 20, 50 and 75 m. This record was smoothed to suppress the monthly variations, which are shown as the

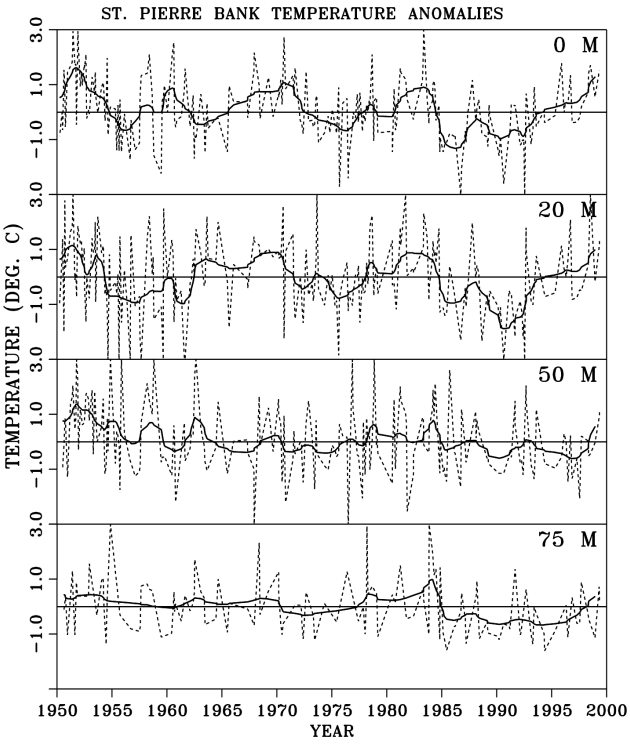

Fig. 7. Departures from normal monthly temperature at standard depths on St. Pierre Bank in Subdivision 3Ps. The heavy line represents the long-term trends.

dashed lines in the figure. The temperature trends are characterised by large variations greater than 1°C above and below normal with periods between 5 to 10 years. During the cold period beginning around 1984 temperatures decreased by up to 2°C in the upper water column and by 1°C in the lower water column and continued below normal until about 1993. From 1993 to 1999 temperatures warmed over the top 20-m of the water column but remained well below average at 75-m depth until at least 1996. From 1996 to 1998 at 50 and 75-m depth temperature anomalies fluctuated considerably but appeared to be moderating and were above normal during most of 1999.

Inshore Temperature Time Series

Temperature time series from 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 for 1998 and 1999 are displayed in Fig. 8. Temperatures at Arnold's Cove were above normal during the first 8

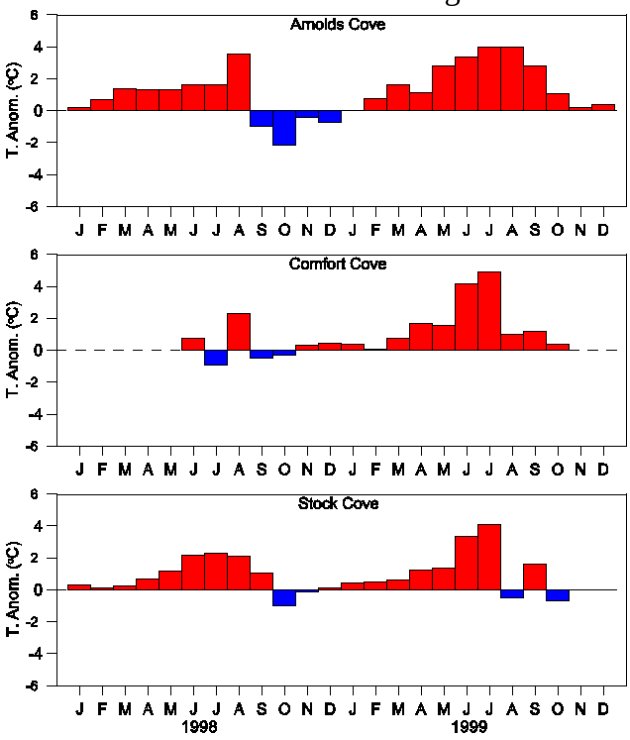

Fig. 8. Departures from normal monthly temperatures at 10 m depth during 1998 and 1999 at Comfort Cove, Notre Dame Bay, Stock Cove, Bonavista Bay and for Arnold's Cove, Placentia Bay.

months of 1998, below normal during the rest of the year but warmed to above normal values during 1999 reaching near 4°C above normal during the summer months. During the latter half of 1998 temperatures at Comfort Cove fluctuated above and below normal but increased to above normal values from May to October of 1999, reaching over 4°C above normal during July. At Stock Cove temperatures were above normal during most of 1998, except during the fall months and above normal from January to July of 1999. The negative anomaly in August at Stock Cove was due to upwelling of colder water in response to strong offshore winds.

The Newfoundland Shelf Cold Intermediate Layer (CIL)

A common feature of the temperature structure on the Newfoundland Continental Shelf is the layer of cold sub-zero °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

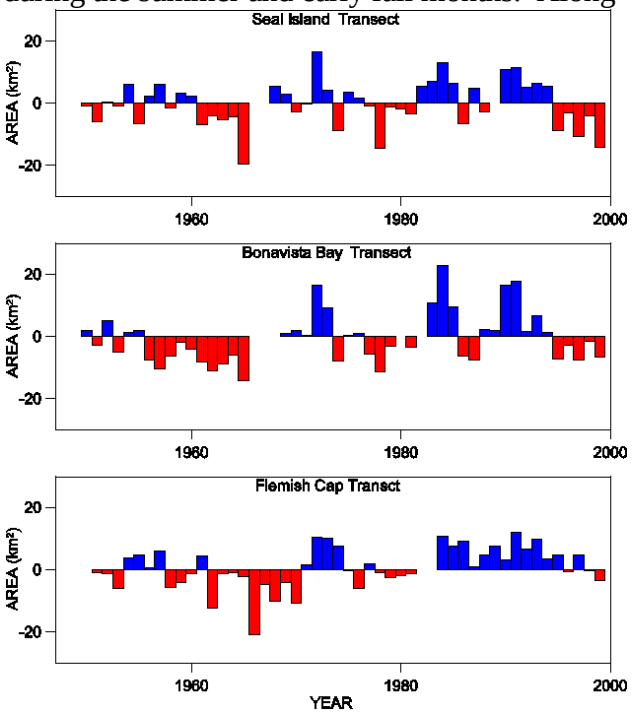

Fig.9. Time series of CIL area anomalies along the standard transects across the Newfoundland Shelf shown in Fig. 1.

the Bonavista transect during the summer of 1999 this cold layer extended offshore to about 190 km, with a maximum thickness of about 175 m corresponding to a cross-sectional area of about 20 km^2, compared to the 1961-90 average of 27 km^2. 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. Low values of CIL areas correspond to warm oceanographic conditions. During the summer of 1999 the CIL area off Bonavista was about 25% below normal compared to 5% below normal in 1998 and 28% below normal in 1997. The CIL area along the Seal Island transect was also below normal by about 49% during 1999, 15% in 1998 and 38% during 1997. During the cold years from 1990 to 1994 the CIL was above normal reaching a peak of more than 60% in 1991. On the Grand Bank along the Flemish Cap transect the CIL was 14% below normal during 1999 compared to about normal values in 1998.

Bottom Temperatures

Spring

Bottom temperature anomalies on the Grand Bank during the spring of 1999 are displayed in Fig. 10. During 1999 sub-zero °C was restricted to a small area in the Avalon Channel and above normal conditions persisted over the entire Northern Grand Bank with temperatures up to 1°C above average. Over the central and southern areas of the Grand Bank bottom temperatures ranged from 1-3°C above the long-term mean. 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 1999 the extent of sub-zero ^{o}C water decreased further to near 0% (Fig. 12). Bottom temperature anomalies during the spring of 1999 in NAFO Subdivisions 3Ps and 3Pn are shown in Fig. 11. Bottom temperatures were above average over Burgeo Bank and Burgeo Channel. Hermitage Channel temperatures were near normal while those over most of St. Pierre Bank were above normal by up to 2^{o}C. In general, bottom temperatures over most of the area were above normal continuing the trend established in 1998.

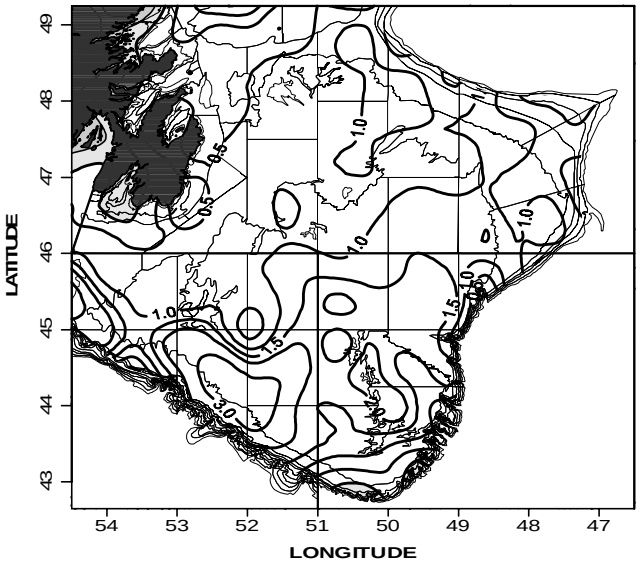

Fig. 10. Bottom temperature anomalies (in °C) for the spring of 1999 for NAFO Divisions 3LNO.

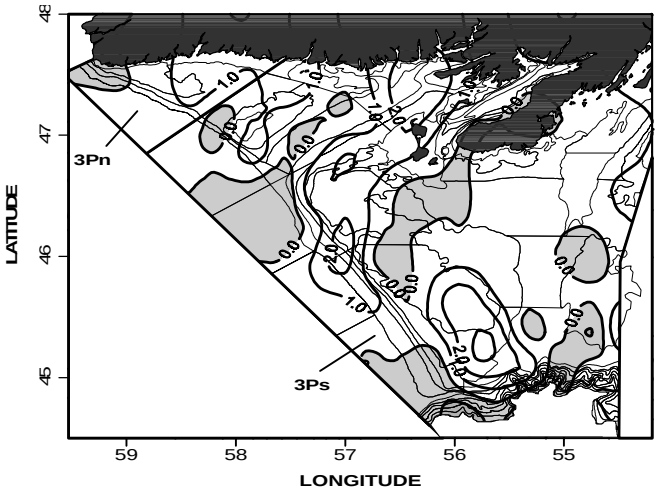

Fig. 11. Bottom temperature anomalies (in °C) for the spring of 1999 for NAFO Subdivisions 3Pn and 3Ps.

The areal extent of sub-zero ^{o}C bottom water covering the banks in this region shows a dramatic increase since the mid-1980s, very low values in 1998 and a complete disappearance in 1999 (Fig. 12). The extent of bottom water with temperatures above 1^{o}C was about 50% of the total area of the banks during 1998 the first significant amount since 1984 and this increased

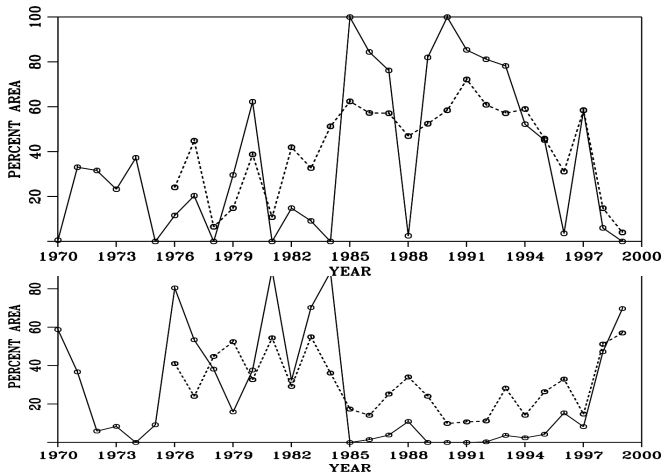

Fig. 12. The percentage area of NAFO Divisions 3LNO (dashed line) and Subdivision 3Ps (solid line) covered by sub-zero ^{o}C water (top) and by water greater than 1^{o}C (bottom) for areas with water depths less than 100-m.

to 70% in 1999 (Fig.12). In general, temperature conditions in this region are highly variable (Fig. 7) but it appears that the cold trend on St. Pierre Bank has moderated during 1998 and 1999.

Autumn

Bottom temperature anomalies for the fall of 1999 in NAFO Divisions 2J, 3K and 3LNO are shown in Figs. 13 to 15. Bottom temperatures ranged from 1-1.5^{o}C above normal on the major banks in Divisions 2J and 3K. During the fall of 1999 bottom temperatures over all the surveyed area in Divisions 3LNO were above normal reaching up to 3-4^{o}C above normal on the shallow Southeast Grand Bank. During the fall of 1999 the area of sub-zero ^{o}C water covering the bottom on all major banks in the Newfoundland Region had decreased to near 0% (Fig. 16). The areal extent of bottom water with temperatures above 1 ^{o}C increased significantly during the fall of 1999 reaching about 80% of the total area on all major banks in the region (Fig.16). In general ocean temperatures in the Newfoundland Region during both 1998 and 1999 were above their long-term mean in almost all areas.

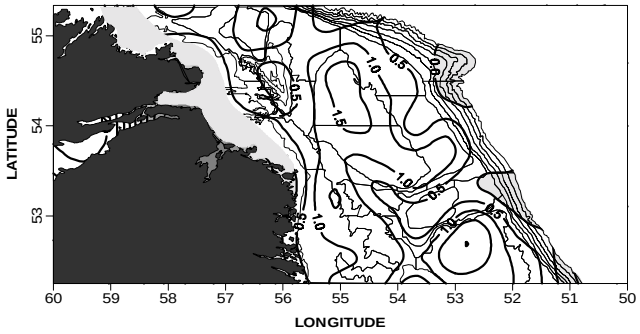

Fig. 13. Bottom temperature anomalies (in ^{o}C) for the fall of 1999 in NAFO Division 2J.

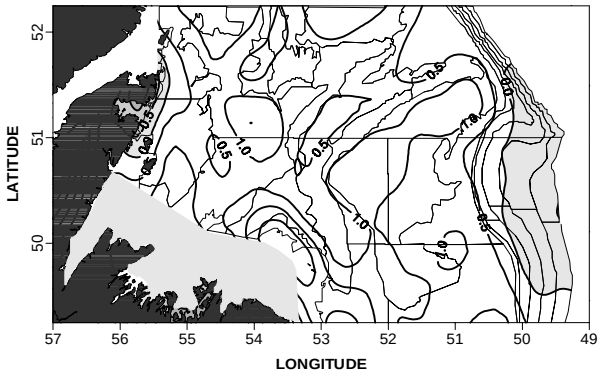

Fig. 14. Bottom temperature anomalies (in ^{o}C) for the fall of 1999 in NAFO Division 3K.

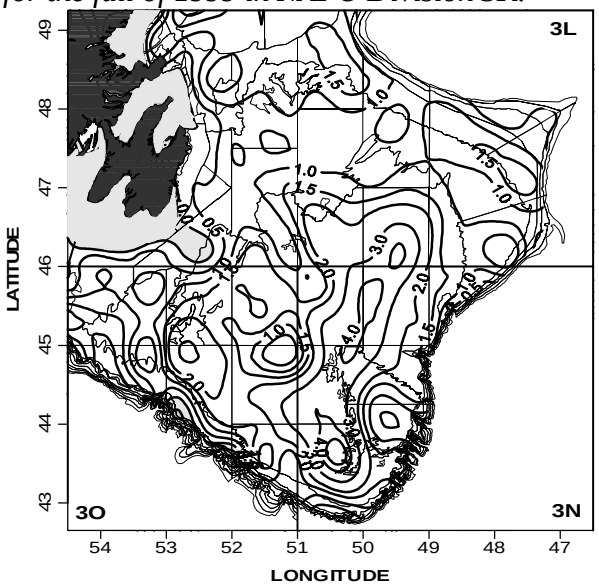

Fig. 15. Bottom temperature anomalies (in ^{o}C) for the fall of 1999 in NAFO Divisions 3LNO.

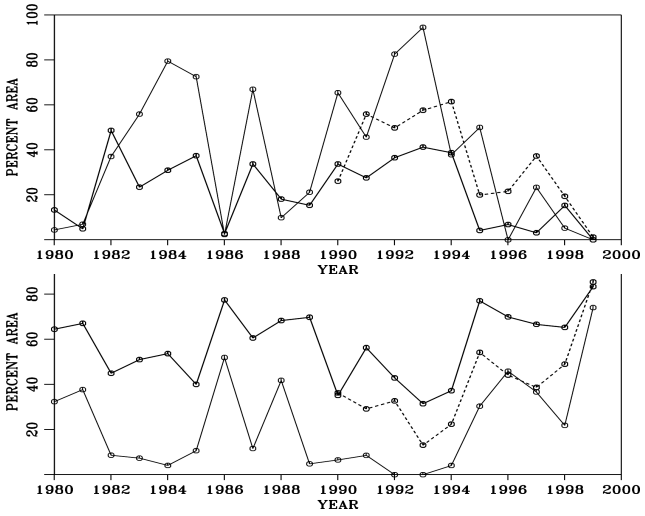

Fig. 16. The percentage area of NAFO Division 2J with water depths ≤200-m (light solid line), Division 3K with water depths ≤300-m (heavy solid line) and Divisions 3LNO with water depths ≤100-m (dashed line) covered by sub-zero ^{o}C (top) and by water with temperatures greater than 1^{o}C (bottom).

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