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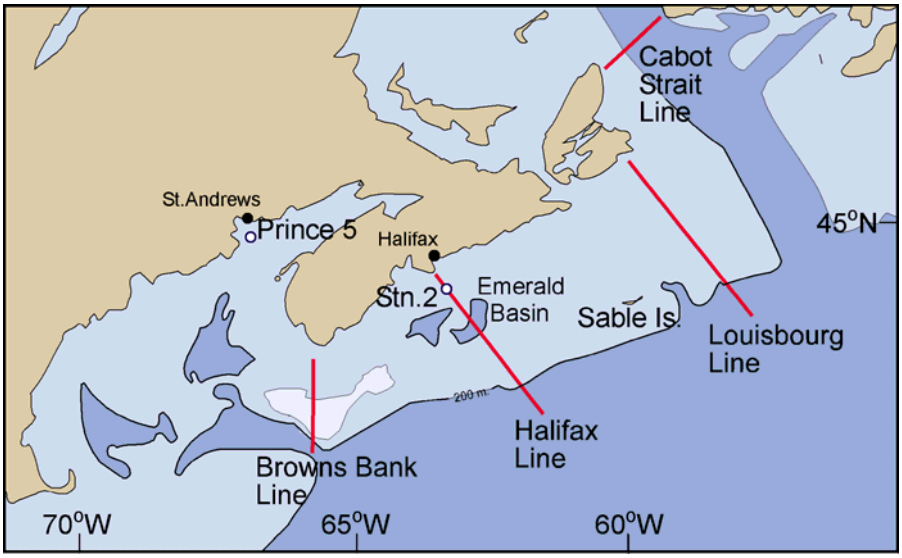
Canadian Science Advisory Secretariat
Science Advisory Report 2005/039

STATE OF THE OCEAN 2004: PHYSICAL OCEANOGRAPHIC CONDITIONS ON THE SCOTIAN SHELF, BAY OF FUNDY AND GULF OF MAINE



Context

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 influence the perception of the resource status and the efficiency and profitability of the industry.

*Physical oceanographic conditions (mainly water temperature and salinity) are therefore measured during research vessel resource surveys and regularly at fixed sites as part of the **Atlantic Zone Monitoring Program (AZMP)**. Additional hydrographic, meteorological and sea ice data are obtained from a variety of sources, including standard monitoring stations, 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 Northwest Atlantic database at the Bedford Institute of Oceanography.

Canada

SUMMARY

- Annual air temperatures in 2004 over the Scotian Shelf, Bay of Fundy and eastern Gulf of Maine were 0.2°C to 0.8°C below normal, similar to 2003.

- Sea ice cover seaward of Cabot Strait was less than normal in January-May 2004 and substantially less than coverage in 2003.

- Sea-surface temperatures were 0.3-1.1°C below normal for the Scotian Shelf and eastern Gulf of Maine, similar to 2003.

- Colder than normal conditions prevailed in subsurface waters over the Scotian Shelf and eastern Gulf of Maine, slightly colder overall in 2004 compared to 2003.

- Bottom temperatures during the July 2004 groundfish survey were about 1.3°C below normal, the coldest in 35 years, and 0.8°C colder than in 2003.

- Vertical stratification (0-50m) for the Scotian Shelf was lower than average, spatially variable and weaker than in 2003.

DESCRIPTION OF THE ISSUE

Temperature and salinity conditions in the Scotian Shelf, Bay of Fundy and Gulf of Maine regions are determined by heat transfer between the ocean and atmosphere, inflow from the Gulf of St. Lawrence supplemented by flow from the Newfoundland Shelf, exchange with offshore slope waters, freshwater runoff, direct precipitation and melting of sea-ice. Water properties have large seasonal cycles, variations with depth, and east-west and inshore-offshore gradients (Petrie et al. 1996). Temperature and salinity may be modified by diffusion, mixing and currents. Shelf topography is a major factor affecting the circulation.

The reference period used for climate normals is 1971-2000.

Conditions in 2004

Annual air temperatures over the Scotian Shelf and eastern Gulf of Maine were about 0.2°C-0.8°C below normal in 2004. The monthly anomalies were dominated by an extremely cold January when air temperatures varied from 2.9°C below normal at Sable Island to 4.7°C below normal at Saint John (N. B.) Sable Island temperatures continued to decline since the long-term high of 1999 (Figure 1).

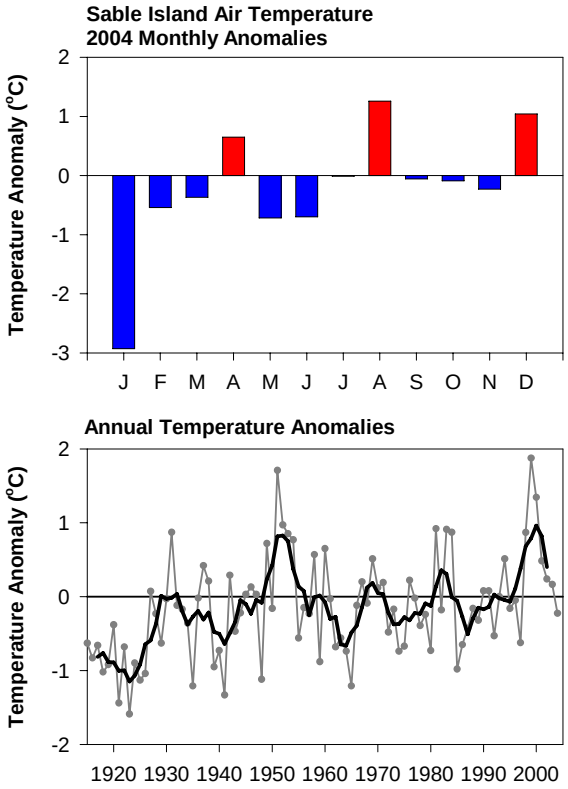


Figure 1. Sable Island monthly temperature anomalies for 2004 relative to the 1971-2000 long-term means (top panel). Time series of annual temperature anomalies (grey line and dots) and 5 year running means (heavy, black line; bottom panel).

The Jan-May 2004 sea ice cover seaward of Cabot Strait was below normal and substantially less than in 2003 (Figure 2). The coverage was 66% of the normal ice cover; 2004 ranked 19th of 43 years of observations when ordering the years from least to greatest cover.

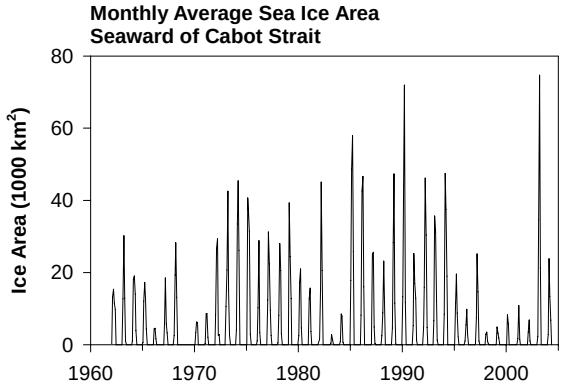


Figure 2. Time series of monthly average sea ice area seaward of Cabot Strait.

The annual average sea-surface temperature in 2004 at St. Andrews, N.B. was 0.8°C below normal making it the 14th coldest in 84 years. At Halifax, the annual anomaly was 1.0°C below normal, making 2004 the 9th coldest in 79 years.

At Prince 5, monthly average temperatures at all depths were dominated by colder than average values leading to annual anomalies of 0.9°C below normal. Temperatures decreased by about 0.6°C relative to 2003. The monthly salinity anomalies were above normal for the first half of 2004

and below normal during the second half. Annual values were 0.13 above normal at 0 m and 0.12 below normal at 90 m (Figure 3).

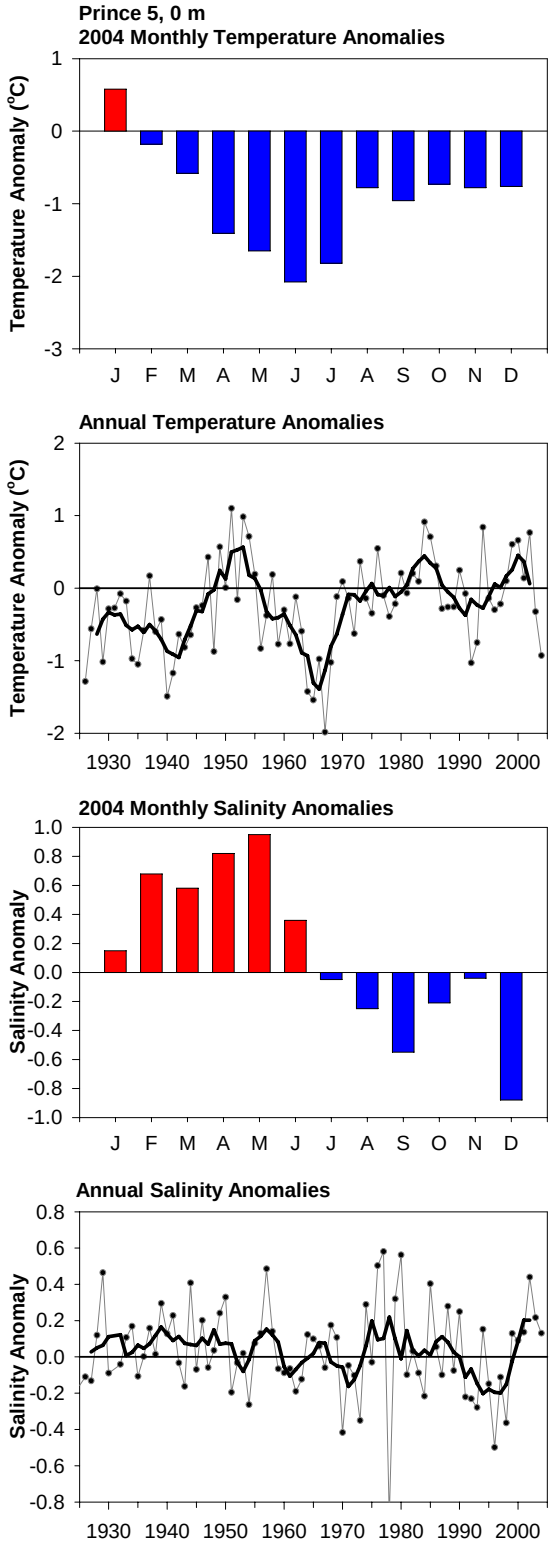


Figure 3. Monthly surface temperature anomalies for 2004 relative to the 1971-2000 long-term means for the Prince 5 station at the mouth of the Bay of Fundy (top panel). Time series of annual temperature anomalies (grey line and dots) and 5 year running means (heavy, black line; second panel). Monthly surface salinity anomalies for 2004 (third panel) and the time series of annual salinity anomalies (grey line and dots) and 5 year running means (heavy, black line; bottom panel).

In the Laurentian Channel to the east of the Scotian Shelf, temperatures in the deep (200-300 m) waters at Cabot Strait were 0.16°C above the long-term mean, the same value as in 2003.

In 2004, the temperatures in the upper 20 m and from 50 to 175 m in Emerald Basin were below normal throughout most of the year (Figure 4). The largest negative anomaly was at 100 m with an annual value (dot in figure) of -1.9°C, 3.7 standard errors below normal (±1 standard error is shown by the horizontal bar). From ~200 m to the bottom, temperatures were slightly warmer than normal. The change from below to above normal values marks the separation between two different water types: shallow, shelf waters flowing from the eastern shelf, and the deeper slope water that moves onto the shelf from the Scotian Slope.

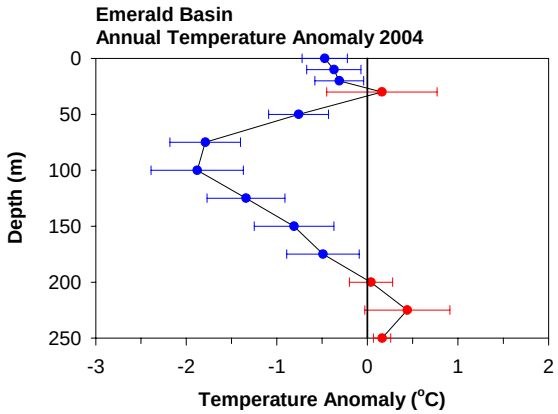


Figure 4. Depth profile of the annual temperature anomalies based on averages of the monthly anomalies for Emerald Basin, 2004. Horizontal bars are estimates of the standard error.

Temperature anomalies over the Scotian Shelf and eastern Gulf of Maine during the 2004 July groundfish survey varied with depth (Figure 5). At the surface, temperatures were above normal by 0-3°C along the Laurentian Channel and the eastern, outer edge of the Scotian Shelf. Surface temperatures were 0-2°C below normal along the outer half of the western Scotian Shelf and in the eastern Gulf of Maine and the Bay of Fundy. Temperatures 1-3°C below normal prevailed at 50 m, 100 m and at the bottom. These anomalies were generally larger towards the outer half of the shelf. This indicates that the subsurface layer of cold water on the shelf was even more extensive and colder than the exceptionally well-developed layer of 2003.

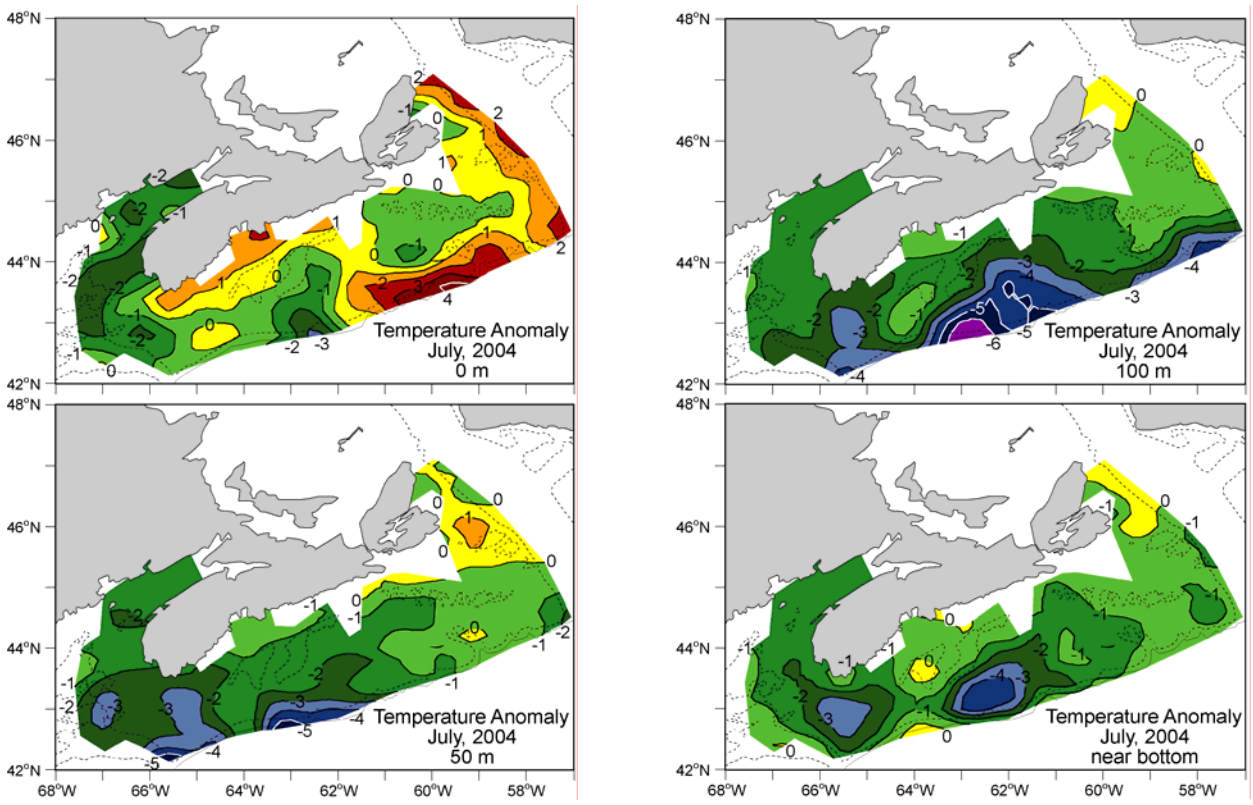


Figure 5. Plan views of the temperature anomalies at 0, 50, 100m and near the bottom for the Scotian Shelf in July 2004. The anomalies are based on observations collected during the annual groundfish survey.

The average bottom temperature for the area covered in the 2004 July groundfish survey was about 4.5°C, about 1.3°C below the 1971-2000 mean temperature and the coldest value in the 35 years of the survey (Figure 6). Bottom temperatures in NAFO fishing areas 4W and 4X were especially cold.

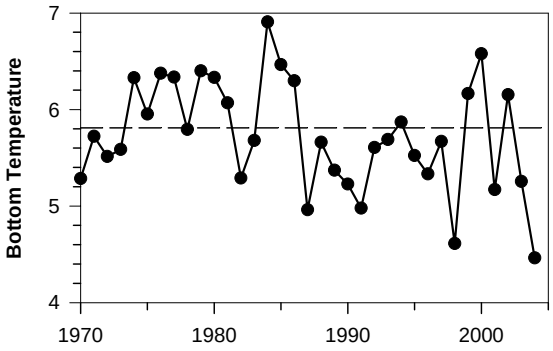


Figure 6. Time series of the average bottom temperature for the Scotian Shelf based on data from the annual July groundfish survey.

The cold, subsurface temperature conditions were also seen in the spring and October surveys on the Scotian Shelf. In October, the cold water was evident on the Louisbourg Line as a distinct layer, from 50 m to the bottom, that extended from the coast to the continental slope. On the Halifax Line, the layer was found from about 50 to 100 m across the entire section. The cold,

subsurface layer was also about 50 m thick on Browns Bank Line but showed some evidence of mixing with offshore waters near the shelf break (Figure 7).

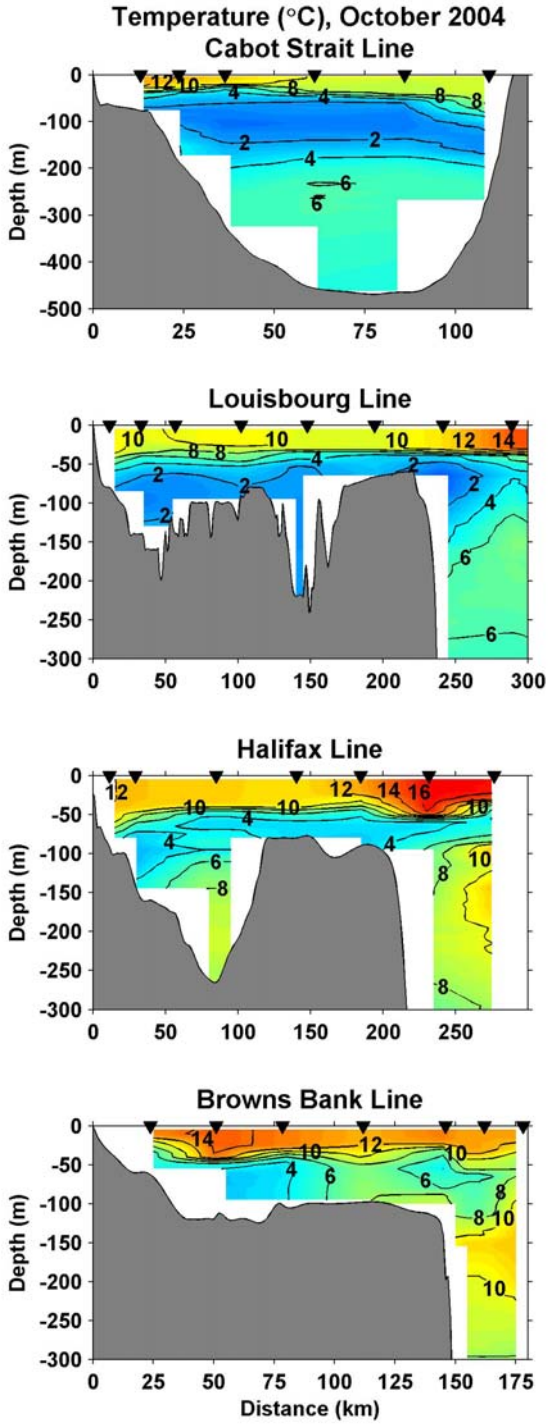


Figure 7. Fall 2004 temperature sections from the Biological Ocean Science section's fall survey of the Scotian Shelf.

Year to year, water temperatures on the Scotian Shelf and in the Gulf of Maine are among the most variable in the North Atlantic Ocean. A major inflow of Labrador Slope water in the early to mid-1960s produced below average temperatures throughout much of the region. The last two decades have seen variations between warmer and colder than normal conditions. In 2004,

temperatures on the Scotian Shelf, Lurcher Shoals off western Nova Scotia and eastern Georges Bank were 0.3-1.6°C below normal. On the other hand, near bottom temperatures in Emerald Basin and the 200 m temperatures in Georges Basin were slightly above or near normal.

Density depends on temperature, salinity and pressure and increases with depth in the ocean. The density difference between waters at two depths is referred to as the density stratification. The density stratification divided by the depth difference is called the stratification index. In the 1990s, the average, 0 to 50 m index over the Scotian Shelf increased significantly. From the mid to late 1990s, the index was at or near its maximum over the 50-year record (Figure 8).

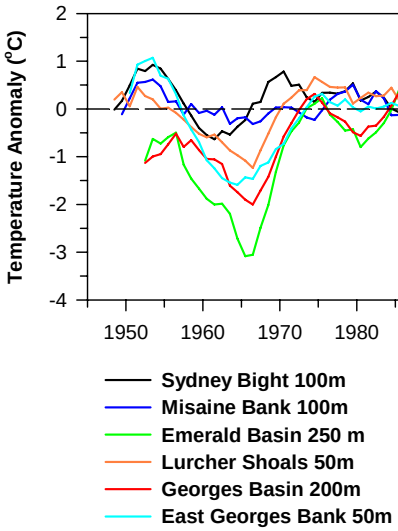


Figure 8. Time series of annual temperature anomalies from various sites on the Scotian Shelf and in the Gulf of Maine.

Increased stratification inhibits vertical mixing, can decrease nutrient fluxes to the surface waters and thus affect phytoplankton production. In 2004, stratification was slightly lower than average; however, there was considerable spatial variability over the Scotian Shelf (Figure 9).

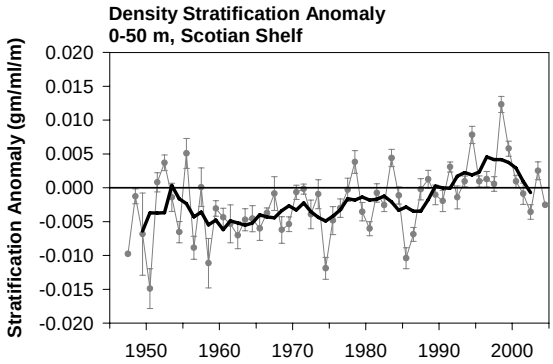


Figure 9. Time series of the density stratification anomaly over the Scotian Shelf.

The average positions of the temperature boundary between shelf and slope waters (Shelf/Slope front) and between slope and Gulf Stream waters in 2004 were seaward of their long-term means by about 19 km.

SOURCES OF INFORMATION

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FOR MORE INFORMATION

Contact: Brian Petrie
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

TEL.: (902) 426-3809
FAX: (902) 426-6927
EMAIL: petrieb@mar.dfo-mpo.gc.ca

This report is available from the:

Maritimes Regional Advisory Process
Department of Fisheries and Oceans
P.O. Box 1006, Stn. B203
Dartmouth, Nova Scotia
Canada B2Y 4A2

Telephone: (902) 426-7070
Fax: (902) 426-5435
E-Mail: myrav@mar.dfo-mpo.gc.ca
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