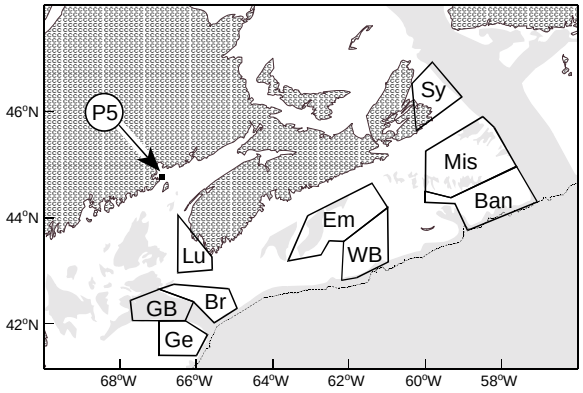
Fisheries and Oceans / Pêches et Océans
Maritimes Region

DFO Science
Stock Status Report G3-01(1999)

1998 State of the Ocean: Scotian Shelf, Bay of Fundy and Gulf of Maine



Sy -Sydney Bight
Mis-Misaine Bank
Ban-Banquereau
Em -Emerald Basin
WB-Western Bank
P5 - Prince 5
Lu - Lurcher Shoals
Br - Browns Bank
GB - Georges Basin
Ge - Georges Bank

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 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. 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.

Summary

- Annual air temperatures over the region were warmer-than-normal in 1998.
- Sea-ice arrived late and left early resulting in the 3rd lowest areal coverage in the 37-year record.
- Sea surface temperatures were generally warmer than usual.
- On the northeastern Scotian Shelf, subsurface temperatures were below normal but approaching their long-term means.
- Over the rest of the Scotian Shelf and in the outer Gulf of Maine, near bottom waters cooled to their lowest levels since the 1960s.
- The source of this cold water was offshore Labrador Slope Water.

May, 1999

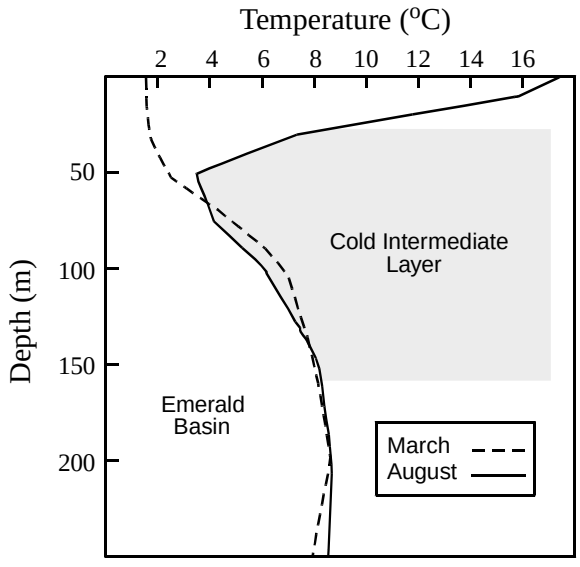
Canada

Average Conditions

Temperature and salinity conditions within the Scotian Shelf, Bay of Fundy and Gulf of Maine vary spatially due to complex bottom topography, transport from upstream sources such as the Gulf of St. Lawrence, melting of sea-ice in spring, and exchange with the adjacent, offshore slope waters. Water properties are also characterized by large seasonal cycles, depth differences and horizontal east-west and inshore-offshore gradients.

The seasonal temperature range of the waters over the Scotian Shelf decreases with depth. At the surface, the range is about 16°C but there is little or no seasonal change at depths greater than approximately 150 to 200 m. In the shallow regions of the Gulf of Maine, such as Lurcher Shoals, the Bay of Fundy and Georges Bank, the seasonal cycle shows much less change with depth due to vertical mixing by the strong tidal currents.

In the winter, the water column in deep regions of the Scotian Shelf consists of two layers separated by a transition zone, as can be seen in the plot below of temperature as a function of depth in Emerald Basin.



The upper layer is mixed by the winter winds and contains cold, low salinity water. The bottom layer has relatively warm and salty water. The latter originates from the offshore slope region and enters the Shelf through deep channels or gullies. In summer, seasonal heating forms a thin (30-40 m) warm upper layer. The winter-cooled waters form a cold intermediate layer (CIL; 40-150 m) and the warm bottom layer remains unchanged. Variation in this vertical structure occurs over the shelf. The warm offshore waters do not penetrate onto the eastern Scotian Shelf and hence waters typical of the CIL (temperatures less than 5°C) extend to the bottom. Further, throughout the Scotian Shelf where depths are shallower than 150 m, there is no warm bottom layer. In areas of strong tidal currents, such as off southwest Nova Scotia, the waters even in summer are vertically well mixed.

Temperatures and salinities generally increase from east to west and from inshore to offshore due to the influences of the warmer, more saline offshore waters and the outflow of the fresher water from the Gulf of St. Lawrence. For example, in the summer within the CIL, the 50 m temperatures typically range from 0-3°C over the eastern Scotian Shelf, 3-8°C over much of the central shelf and 6-9°C over the western Scotian Shelf, eastern Gulf of Maine and Bay of Fundy. The one exception to the general trend in horizontal distributions is the surface temperatures in summer, when they increase from west to east due to the warm surface outflow from the Gulf of St. Lawrence.

The near-bottom temperatures display similar ranges to those at 50 m discussed above, except over the central shelf where the range increases to 3-9°C, the slightly higher temperatures being caused by the intrusion of the offshore waters.

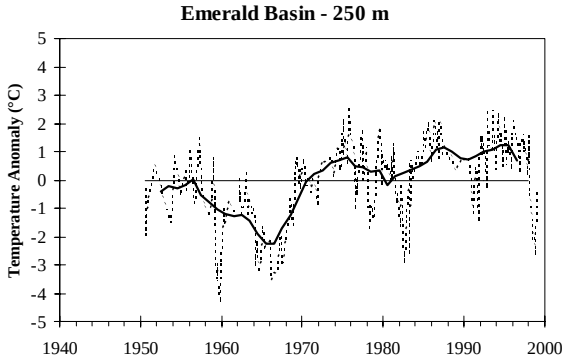
Long-Term Time Trends

Year-to-year changes in the water temperatures on the Scotian Shelf and in the Gulf of Maine are among the most variable in the North Atlantic Ocean. Information on ocean climate variability is derived from several sources. Long-term coastal sea surface temperatures are available at Halifax and St. Andrews. The only long-term hydrographic offshore monitoring site within the region is Prince 5 (P5, see map on page 1), located at the mouth of the Bay of Fundy, however, temperature time series have been constructed for several areas from data collected during fisheries surveys and oceanographic studies.

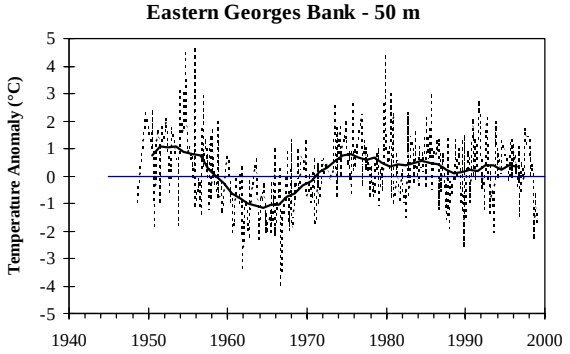
In order to detect time trends in temperature, the seasonal cycle is removed by calculating deviations (anomalies) of temperatures from the long-term (1961-90) monthly means for each area. Inter-annual variability is also expressed as anomalies. With the exception of the Prince 5 series, the data from most areas are sparse prior to 1950.

In general, the temperature records are characterized by short period spikes, superimposed on long period (10-30 year) trends with amplitudes of 1-2°C. While the spikes often represent "noise" due in large part to limited amounts of data and usually show little similarity from area to area, the long-period trends show strong similarity over much of the Scotian Shelf and the Gulf of Maine. In the time series plots in this section, the dashed lines indicate monthly means and the solid lines are the 5-year running means of the annual averages.

The temperature pattern in Emerald Basin is representative of the long-period trends in the deep waters throughout the central and western shelf and in the Gulf of Maine. Temperatures were near or above average in the 1950s and declined to below average in the 1960s. The extended period with the lowest temperatures occurred during the mid-1960s. Temperatures rose rapidly in the late 1960s and from the 1970s to 1997 generally remained warmer-than-average. Indeed, the highest sustained temperature anomalies in the approximate 50-year record were observed in the 1990s. Temperature events in 1998 are discussed in the next section.

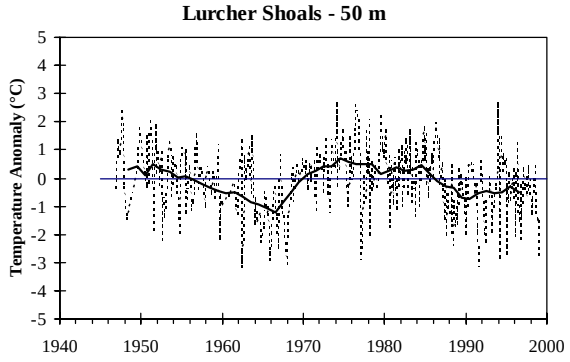


In shallower waters over the shelf, temperature trends were similar to those in the deep waters until the mid-1980s. Temperatures on eastern Georges Bank, which are representative of the offshore banks including Browns and Western, tended to be above average through most of the 1970s and 1980s but declined slightly in the late 1980s. Since then they have remained above normal except in 1998.

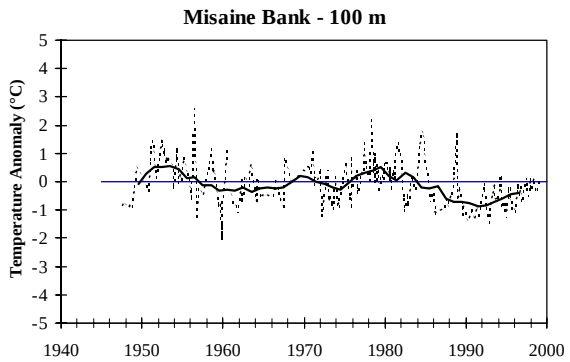


Temperatures in the shallow inshore areas of southwest Nova Scotia (Lurcher Shoals) show a clear decline from the mid-1980s to the early 1990s, reaching levels comparable

to those in the cold period of the 1960s. Temperatures have generally remained below average since the mid-1980s.



In intermediate and deep waters of the eastern shelf, as exemplified by Misaine Bank, the amplitude of the long-period temperature trend is smaller (order 1°C) than for the rest of the shelf. Also, the low temperature anomalies during the 1960s were not as cold as elsewhere on the Scotian Shelf such as in Emerald Basin or over Lurcher Shoals. From the late-1960s to the mid-1970s, temperatures at Misaine Bank oscillated near or above average. They rose above normal around 1980 but by the mid-1980s, temperatures fell sharply. Throughout most of the water column, temperatures have generally remained colder-than-normal during the past decade although in recent years they have been rising. The long-term temperature trends over the eastern inshore areas (e.g. Sydney Bight) and offshore banks (e.g. Banquereau) are similar to those in the Misaine area.

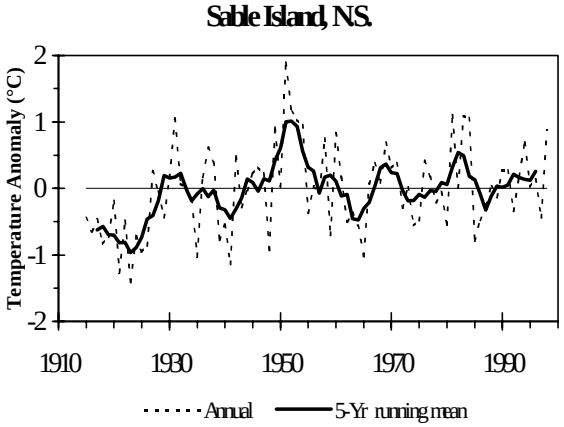


In the deep waters of Cabot Strait, temperatures were coldest during the 1960s but have been above or near average in recent years.

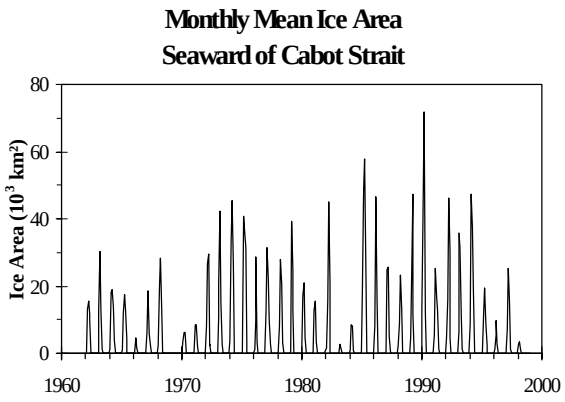
The general temperature trends described above are reflected in the time series of the summer research vessel stratified mean near-bottom temperatures for the Bay of Fundy (4X) as well as the western (4X), central (4W) and eastern (4Vs) Scotian Shelf.

Conditions in 1998

Annual mean air temperatures over the Scotian Shelf, Bay of Fundy and the Gulf of Maine during 1998 were approximately 1°C above normal and increased relative to 1997. The highest temperature deviations from the long-term mean occurred during the winter and spring but almost all months recorded warmer-than-normal conditions.

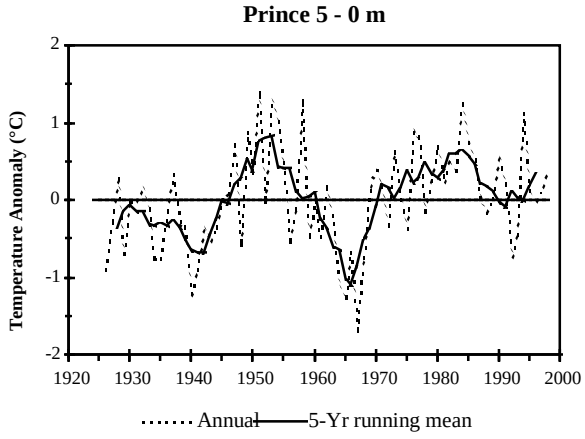


No significant amount of sea ice reached the Scotian Shelf in 1998, resulting in smaller ice coverage than in 1997. The small amount of ice that did extend seaward of Cabot Strait was largely confined to the Sydney Bight region. The ice coverage in 1998 seaward of Cabot was the third lowest in the 37-year record.



Ocean temperature conditions depend upon location and depth. Monthly mean coastal sea surface temperatures in the Gulf of Maine and the Bay of Fundy during 1998 were generally warmer-than-normal and continue a pattern that has persisted since mid-1994. At Halifax, warmer-than-usual temperatures also dominated the monthly means, which is in contrast to the cold conditions of the last several years.

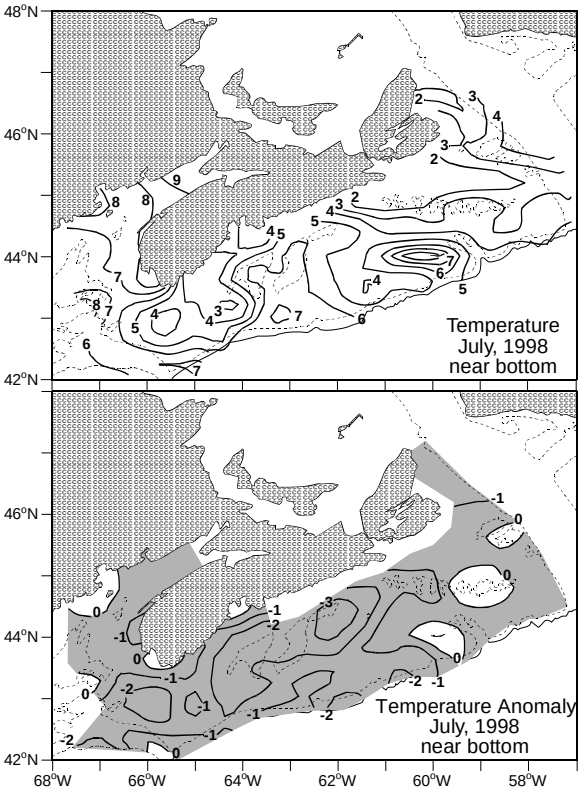
At Prince 5, monthly mean temperatures were predominantly warmer-than-normal during the winter and early spring and colder-than-normal during the second half of the year. The annual mean temperature was slightly warmer than normal at the surface and normal near bottom (90 m). Salinity anomalies at Prince 5 were fresher-than-normal and fell relative to 1997 values but were above the record low salinities of 1996.

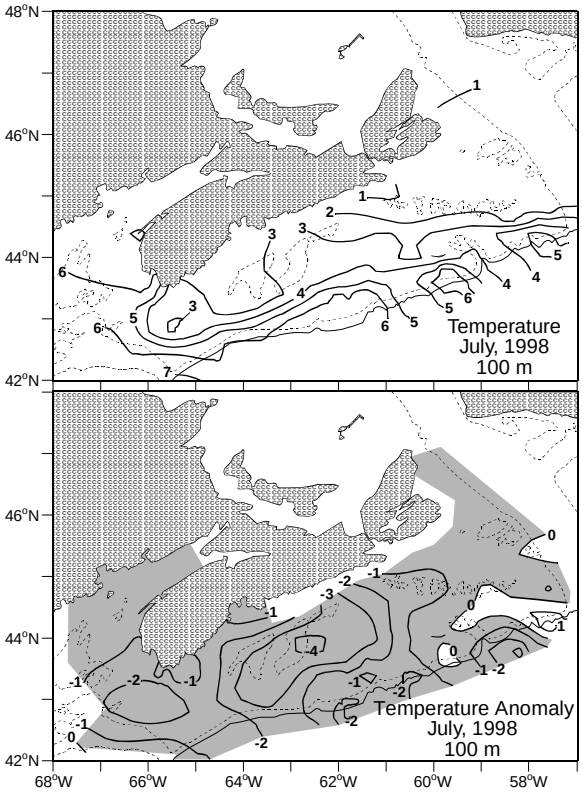


In the Laurentian Channel to the east of the Scotian Shelf, deep (200-300 m) waters at Cabot Strait generally remained slightly above their long-term mean value, and near last year's temperatures. These were both below the maximum recorded in 1993 of 1°C above normal.

Temperature of the bottom waters over the northeastern Scotian Shelf and along the Atlantic coast of Nova Scotia continued to remain below normal in 1998, conditions that have persisted since the mid-1980s. However, during the past several years, temperatures have been on the rise in at least the northeastern region of the Shelf.

During the autumn of 1997, very cold waters of Labrador Current origin were observed along the continental slope of the Scotian Shelf at depths of 100 to 300 m as far south as Emerald Basin. They replaced Warm Slope Water that had occupied this region over most of the past 30 years. By December, these cold waters were beginning to penetrate into Emerald Basin and by February, they occupied the deep layers of the basin. Temperatures in the basin fell by 2°C and salinities by 0.5 between mid-December 1997 and mid-February 1998. By mid-April, temperatures had decreased another 1°C. By the time the summer groundfish survey was conducted in July, these cold waters had spread throughout much of the central and southwestern Scotian Shelf resulting in colder-than-normal temperatures by over 3°C in the area of Emerald Basin. Indeed, the 1998 temperatures in 4X and 4W from the groundfish survey were the coldest recorded since the survey began in 1970.





The cold Labrador Slope Water also pushed southward along the continental slope, extending the entire length of the Scotian Shelf by January 1998. At this time, these waters began to enter the Gulf of Maine through the Northeast Channel. By February, they occupied the southern flank of Georges Bank and by March moved even further westward to lay at the offshore entrance to the Great South Channel. In the Gulf of Maine, the cold waters flushed Georges Basin by April but did not penetrate the inner basins of the Gulf until the summer. At that time, it appeared as if they had mixed with the warmer resident waters rather than replace them, as had occurred in Emerald and Georges basins. The effects of this cold water were not limited to the deep basins but were also observed in some shallower areas as well, e.g. on Georges Bank.

The temperatures within the Cold Intermediate Layer, as represented by 100 m data, show a similar pattern to that observed near bottom, i.e. below normal temperatures throughout most of the Scotian Shelf. The largest differences compared to the long-term mean temperatures (colder than 4°C below normal) were recorded over Emerald Basin. This is attributed to the presence of the cold Labrador Slope Water. On the other hand, the colder-than-normal temperatures in the northeastern shelf were not associated with the slope waters but are thought to be primarily due to outflow of colder-than-normal CIL waters from the Gulf of St. Lawrence, possibly coupled with intense local atmospheric cooling in winter.

Based on the reports from fishers, the intrusion of the cold Slope Water on the shelves affected the catchability of some species. For example, lobster catches on Georges Bank and shark catches in Emerald

Basin both decreased sharply with the arrival of the cold water.

In the ocean, lighter water lays over top of heavier, denser waters due to differences in the temperature and salinity characteristics. The difference in density with depth is referred to as density stratification. From the early 1990s to present, the vertical density stratification in the top 50 m over the Scotian Shelf has increased significantly. Since the mid-1990s, it has been at or near its maximum in the approximately 50-year record. No increase in density stratification has been observed in the Gulf of Maine, however. The primary cause of changes in the Scotian Shelf stratification has been a freshening of the near surface waters. As the stratification increases in the upper layers, vertical mixing is reduced, which in turn can decrease nutrient replenishment to the surface waters. This can ultimately reduce primary production and lead to changes in species composition of plankton.

For more Information

Contact:

Ken Drinkwater
Bedford Institute of Oceanography
P.O. Box 1006
Dartmouth, Nova Scotia
B2Y 4A2

TEL: (902) 426-2650
FAX: (902) 426-7827
EMAIL: drinkwaterk@mar.dfo-mpo.gc.ca

References

Drinkwater, K.F., R.G. Pettipas, and W.M. Petrie. 1999. Overview of meteorological and sea ice conditions off eastern Canada in 1998. DFO Can. Stock Assessment Sec. Res. Doc. 98/51, 28 p.

Drinkwater, K.F., R.G. Pettipas, and W.M. Petrie. 1999. Physical oceanographic conditions on the Scotian Shelf and in the Gulf of Maine during 1998. DFO Can. Stock Assessment Sec. Res. Doc. 99/52, 35 p.

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
Phone number: 902-426-7070
e-mail address: MyraV@mar.dfo-mpo.gc.ca

Internet address: http://www.dfo-mpo.gc.ca/csas
ISSN: 1480-4913

La version française est disponible à l'adresse ci-dessus.

Correct citation for this publication

DFO, 1999. 1998 State of the Ocean: Scotian Shelf, Bay of Fundy and Gulf of Maine. DFO Science Stock Status Report G3-01(1999).