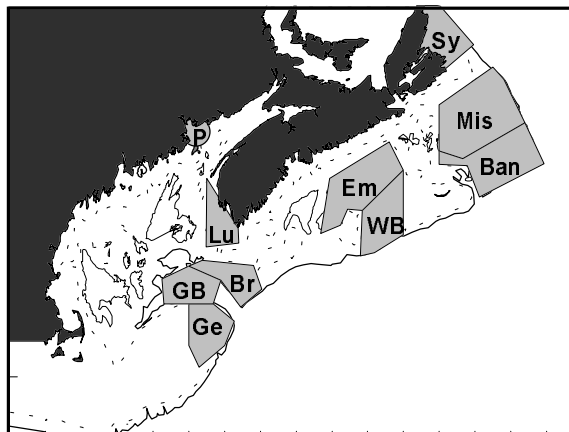




## State of the Ocean: Scotian Shelf, Bay of Fundy and Gulf of Maine



### 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 (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, process oriented 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) data base. A working copy is maintained in a zonal data base at the Bedford Institute of Oceanography.*

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

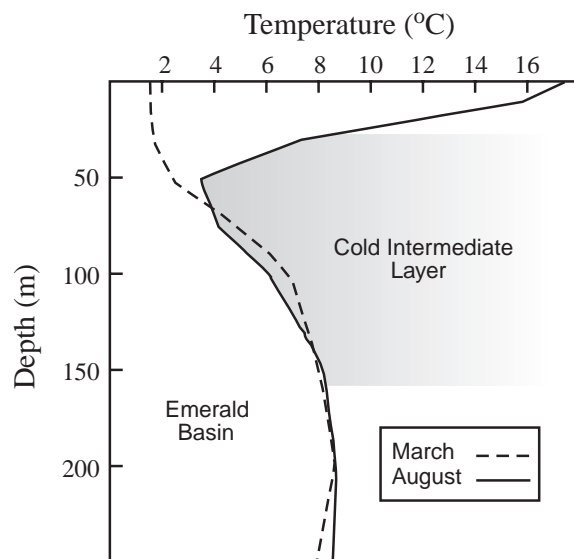
### Mean Conditions

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, 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 temperature range of the

surface waters is reduced and there is little change in the range throughout the water column due to the 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 is shown in the March plot below of the variation in temperature with 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 (see the August plot below). The winter-cooled waters form a cold intermediate layer (CIL) and the warm bottom layer remains unchanged. Variations in this vertical structure occurs over the shelf. The warm offshore waters cannot penetrate onto the eastern Scotian Shelf and hence waters typical of the CIL (temperatures less than 5°C) extend to the bottom. Over banks where depths are shallower than 150 m, there is no warm bottom layer. In areas of strong tidal currents, the waters even in summer are vertically well mixed.



Despite these seasonal differences, the horizontal pattern of temperature and salinity is generally the same throughout the year. Temperatures and salinities 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 at 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.

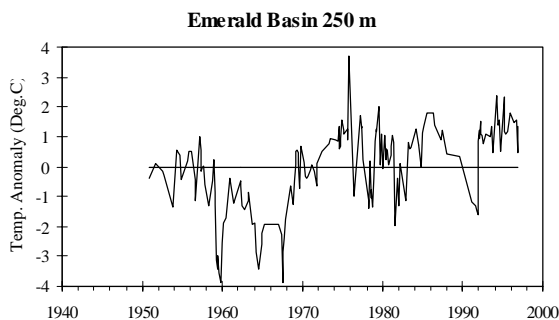
The near-bottom temperatures display similar ranges to that at 50 m except over the central shelf where the range increases to 3-9°C, the higher temperatures being caused by the intrusion of the warm offshore waters.

### *Time Trends*

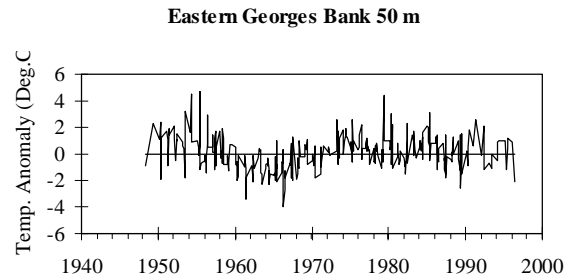
Year-to-year changes in the water temperatures on the Scotian Shelf and in the Gulf of Maine are among the most variable in the North Atlantic Ocean. Information on ocean climate variability is derived from several sources. Long-term coastal sea surface temperatures are available at Halifax and St. Andrews.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

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 very sparse prior to 1950.

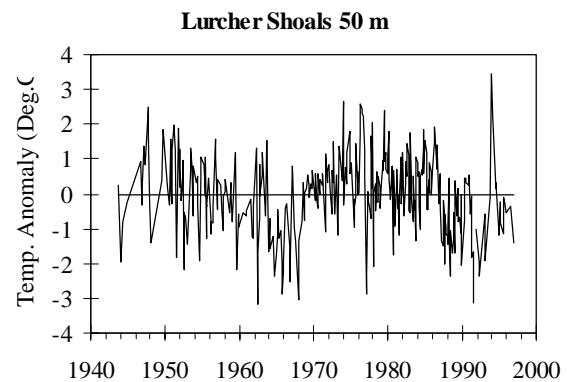
In general, the temperature records are characterized by short period fluctuations, indicated by spikes in the time series, superimposed on long period (10-30 year) trends with amplitudes of 1-2°C. While the spikes often represent “noise” due in large part to limited amounts of data and usually show little similarity from area to area, the long-period trends are highly significant, showing strong similarity over most of the Scotian Shelf and the Gulf of Maine.



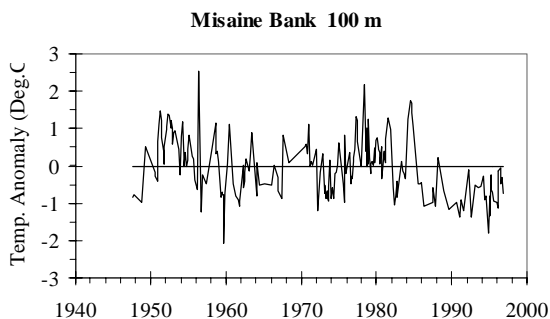
The temperature pattern in Emerald Basin (area Em on the chart at the beginning of this report) is representative of the long-period trends in the deep waters throughout the central and western shelf. Temperatures were near or above average in the 1950s and declined to below average in the 1960s. The extended period with the lowest temperatures occurred during the mid-1960s. Temperatures rose rapidly in the late 1960s and since the 1970s have generally remained warmer-than-average. In shallower waters over the shelf, temperatures trends were similar to those in the deep waters until the mid-1980s. Temperatures on the offshore banks (Georges and Western, areas Ge and WB, respectively) tended to be above average through most of the 1970s and 1980s but declined slightly in the late 1980s and since then have oscillated about normal.



Temperatures on Lurcher Shoals (area Lu) show a clear decline from the mid-1980s to the early 1990s, reaching levels comparable to those in the cold period of the 1960s. Although temperatures have been warming in recent years, they have remained below average, with the exception of a warm anomaly in 1994.



In intermediate and deep waters of the eastern shelf, as exemplified by Misaine (area Mis), the amplitude of the long-period temperature trend is smaller than for the rest of the shelf (order 1°C). For example, the low temperature anomalies during the 1960s were not as cold as elsewhere on the Scotian Shelf such as in Emerald Basin, over Lurcher Shoals, etc. From the late-1960s to the early 1980s temperatures at Misaine oscillated near or above average. In the mid-1980s, temperatures fell below average and, throughout most of the water column, have generally remained colder-than-normal for the past decade.



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

Temperature trends over the eastern inshore areas (e.g. Sydney Bight, area Sy) and offshore banks (e.g. Banquereau, area Ban) are similar to those in the Misaine area, with the exception of a few warm anomalies in the mid-1990s.

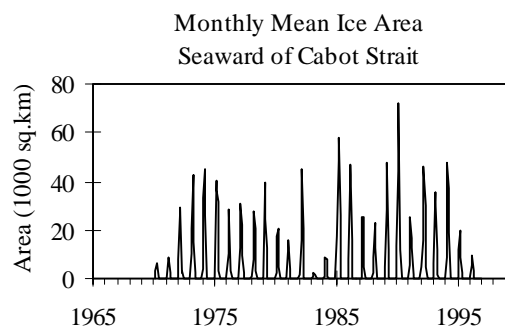
The general temperature trends described above are reflected in the time series of the summer research vessel stratified mean near-bottom temperatures for the Bay of Fundy (4X) as well as the western (4X), central (4W) and eastern (4Vs) Scotian Shelf.

### ***Conditions in 1996***

Annual mean air temperatures over the Scotian Shelf, Bay of Fundy and the Gulf of Maine during 1996 were near normal. Seasonally, early winter air temperatures were cooler-than-normal but rose above average in late winter and through the spring. During the summer and autumn, monthly mean temperatures varied about the normal.

The amount of sea ice that reached the Scotian Shelf was well below normal in 1996 and less than in 1995. The ice extent seaward of Cabot Strait was the lowest recorded in 12 years. Not only was there less ice but its duration was

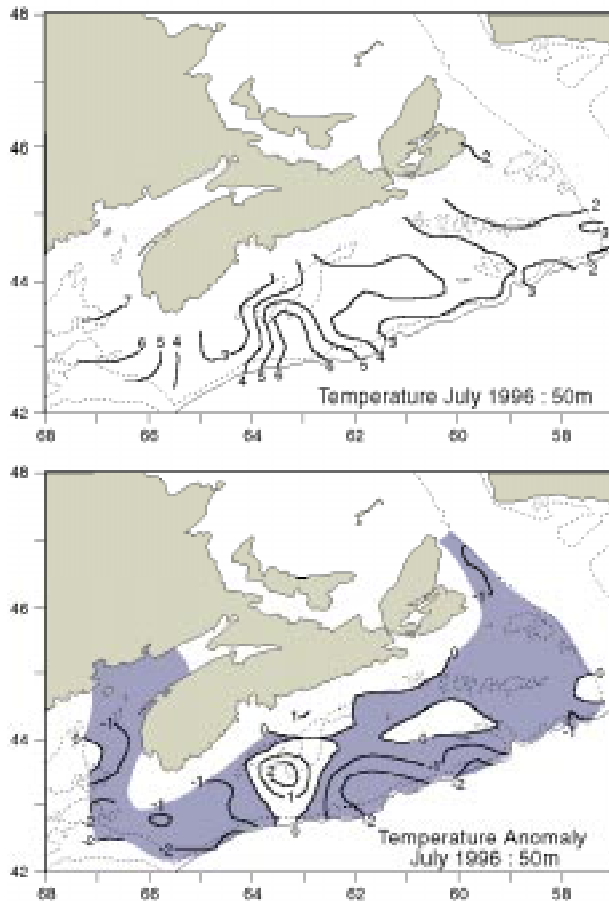
shorter than normal by 2-4 weeks, due to a late arrival and early departure.



As in previous years, the ocean temperature conditions in 1996 depended upon location and depth. Monthly mean coastal sea surface temperatures in the Gulf of Maine and the Bay of Fundy revealed warm conditions in contrast to the colder-than-normal waters that predominated at Halifax. This pattern has persisted since mid-1994. At Prince 5, monthly mean temperatures throughout the water column were predominantly warmer-than-normal with only January and August recording below normal temperatures. Of particular note were the year-round low salinities at Prince 5 resulting in the lowest annual salinity in over 70 years of measurements. Declining salinities have also been reported in the deep waters of the Gulf of Maine.

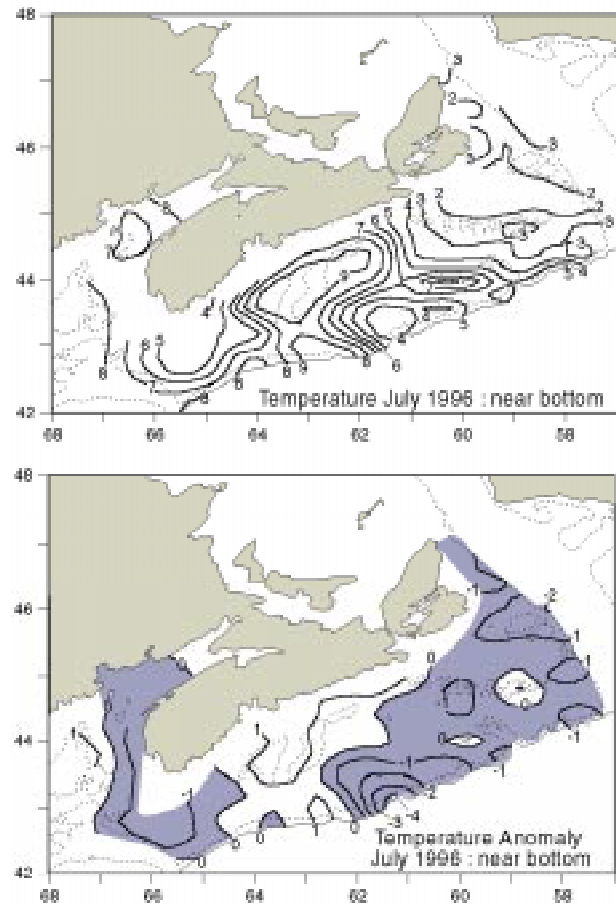
Colder-than-normal temperatures persisted in the bottom waters over the northeastern Scotian Shelf and off southwestern Nova Scotia. This temperature pattern was established in the mid-1980s. In contrast, the waters in the central Scotian Shelf over Emerald Basin and along the continental slope were warmer-than-normal. These conditions are related to the presence of warm slope water offshore which intrudes upon the shelf and is intermittently transported shoreward by cross-shelf exchange processes. In the central Gulf of Maine such as in Georges Basin (area GB), temperatures remained well above normal for

the third year in a row. These conditions are believed to have been initiated by an influx of warm slope water through the Northeast Channel during late 1993. In the Laurentian Channel to the east of the Scotian Shelf, deep (200-300 m) waters at Cabot Strait were near their long-term mean value, similar to last year and down from the maxima recorded in 1993 of 1°C above normal.



The temperatures at shallower depths also varied with location. The temperatures at 50 m over Sydney Bight, Misaine Bank and Lurcher Shoals were below normal throughout much of 1996 whereas temperatures were above normal on Banquereau for the second consecutive year. The latter are due to the influence of warm offshore waters. On Georges and Browns banks, temperatures at 100 m were below normal in the summer but above normal in the autumn. Temperature on

Western Bank varied about its long-term mean throughout the year. Temperatures in the Bay of Fundy were above normal throughout most of the year. These spatial and temporal differences reflect varying degrees of influence of the cold intermediate layer and slope waters.



The temperature conditions during the 1996 groundfish research surveys reflected the above patterns. The temperatures from the 4VW and 5Z spring and 4VWX summer surveys were all within the historical ranges observed during the surveys. The temperatures during the spring surveys were near or above the survey means but these are confounded by interannual variation in the timing of the surveys. During the summer survey, near-bottom temperatures were less than 2°C over a large portion of the northeastern Scotian Shelf, resulting in below

normal temperatures. Colder-than-average temperatures in 1996 were also observed over the western Scotian Shelf and in the Bay of Fundy whereas warmer-than-normal temperatures were found over the central Scotian Shelf and the central Gulf of Maine. Temperatures in the cooler-than-normal areas, did however, warm slightly relative to the 1995 survey whereas the warmer areas cooled. The temperature anomalies at 50 and 100 m show a similar pattern to the near-bottom waters.

### ***For more Information***

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