Researh vessel CCGS Martha L. Black

Oceanographic Conditions in the Gulf of St. Lawrence during 1999

Background

The waters of the Gulf of St. Lawrence are subject to variations in physical properties such as temperature and salinity. These fluctuations occur at various space and time scales in response to variations in the physical processes. Interaction between the atmosphere and the ocean (heat exchange, precipitation, evaporation, transport) has a major influence on the variability of the physical environment which, in turn, may affect directly or indirectly the distribution, growth and reproduction of fish and invertebrate stocks in the Gulf of St. Lawrence.

*Physical oceanographic conditions (temperature and salinity) are measured during research vessel surveys as part of the **Atlantic Zone Monitoring Program (AZMP)**. These data are used, with additional hydrographic and meteorological data obtained from a variety of sources, to produce an annual overview of the environmental state of the Gulf of St. Lawrence. This report presents the information for 1999.*

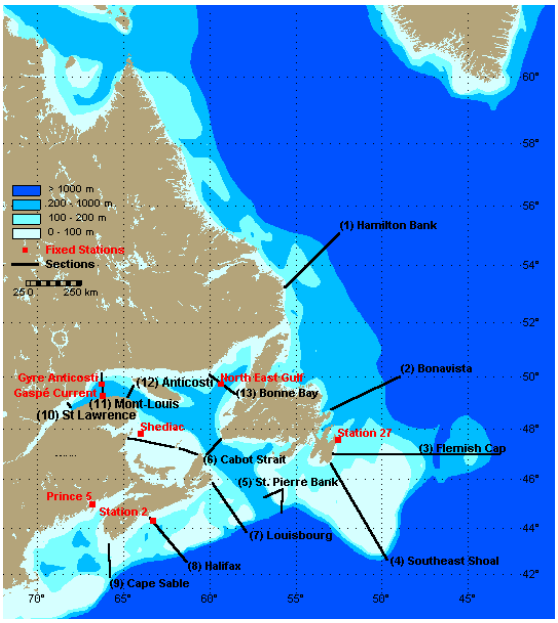

Figure 1. The Atlantic Zone Monitoring Program map showing the positions of standard transects and fixed oceanographic sites.

Summary

- Mean annual air temperature over the Gulf was warmer than average
- Mean annual precipitation was at an average value, but with a strong seasonal heterogeneity
- The areal extent of the ice cover was slightly above average in January and February while in March and April, it was below the average.
- The mean flow of the St. Lawrence river at Quebec City was below average
- The percentage of cold temperature profiles collected during the August groundfish survey decreased from 95 % in 1998 to 78 % in 1999. Similarily, the minimum temperature within the cold intermediate layer (CIL) warmed by 0.6 ^{o}C relative to 1998, but remained below average. The CIL thickness decreased by 20 m from the 1998 value.
- In the southern Gulf, the area with bottom temperature below 0 ^{o}C decreased.

Air temperature

Mean annual air temperature (Environment Canada; www.msc-smc.ec.gc.ca/ccrm/bulletin/index.html) over the Gulf was about 1.5 ^{o}C above the 1951-1980 average. During winter (December 1998 to February 1999), the departures varied between 0.5 ^{o}C and 1.5 ^{o}C higher than average. In spring (March to May), air temperature were 2.5 ^{o}C above average over the central part of the Gulf while in the northwestern and northeastern regions, the departures were as high as 3 ^{o}C above average. Air temperature remained warmer than average during summer (June to August) and autumn (September to November), but the anomalies were less important during these two last seasons.

Precipitation

The mean annual precipitation (Environment Canada; www.msc-smc.ec.gc.ca/ccrm/bulletin/index.html) over the Gulf was average but there was a strong seasonal heterogeneity. During winter, the area west of Anticosti Island was dryer than average while about 20 % more precipitation than average were observed over Newfoundland. In spring and summer, the situation was more complex but the western region was still dryer than average. During autumn, precipitation was about 30 % greater than average over most of Eastern Canada.

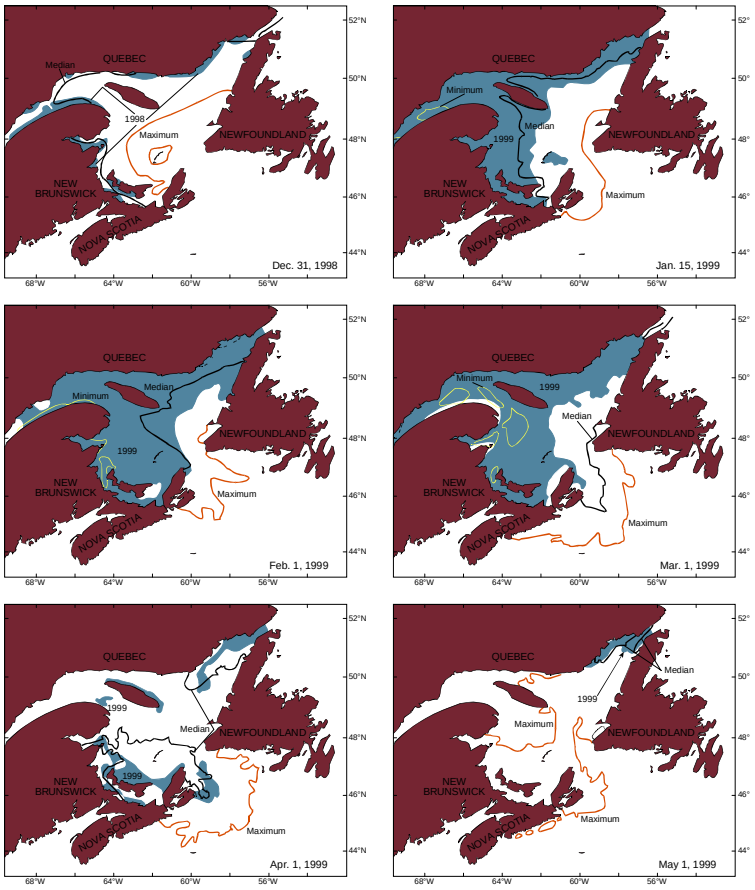

Figure 2. Ice-covered regions (shaded) in the Gulf of St. Lawrence at the dates shown on the maps. The minimum, median and maximum ice edge positions at these dates for the 1962-1987 period are also shown for reference. (Source: K. Drinkwater).

Sea ice

During the 1999 ice season, the areal extent of the ice cover (Drinkwater *et al*, 2000) was well below the 1962-1987 maximum conditions (Figure 2). On January 15 and February 1, the ice edge position was slightly downstream of the median position. By March 1, the ice edge position was upstream of the median position and the ice cover remained below the 1962-1987 median value for the rest of the season. By May 1, the ice cover had disappeared everywhere except in the Strait of Belle Isle. The earlier retreat of the ice cover during spring is consistent with the warmer-than-average air temperature observed during this season.

Freshwater discharge

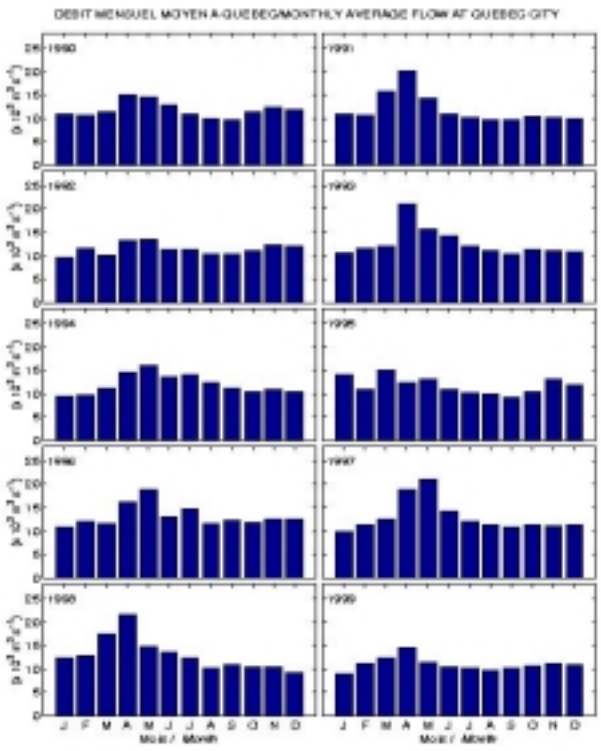

Figure 3. Monthly average flow of the St. Lawrence River at Quebec City for the 1990-1999 period. (Source: D. Bourgault and V. G. Koutitonsky).

The mean annual flow of the St. Lawrence river at Quebec City (Bourgault, D. and V. G. Koutitonski, 1999) was below average during 1999 (Figure 3). The decrease is mostly apparent in the spring period. In April, there was a reduction of 32 % relative to 1998 which is consistent with the less-than-average amounts of precipitation observed in the western regions of the drainage basin during winter and spring.

Cold intermediate layer

A prominent feature of the waters of the Gulf of St. Lawrence is the presence of a cold intermediate layer (CIL) which persists throughout the summer. Vertical profiles of temperature collected during the August shrimp and groundfish survey were used to document this layer. The minimum temperature within the CIL (Gilbert and Pettigrew, 1997) is subject to variations of about plus or minus 1 ^{o}C on decadal time scales (Figure 4).

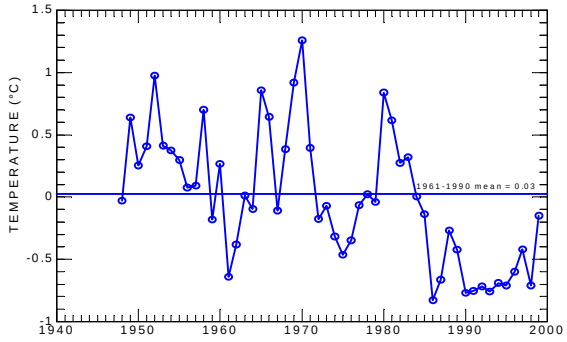

Figure 4. Composite index of CIL core temperature anomaly in the Gulf of St. Lawrence (1961-1990 mean = 0.03 ^{o}C). (Source: D. Gilbert).

Below average CIL minimum temperatures have been recorded since 1985, the six consecutive years from 1990 to 1995 being among the coldest on record (DFO, 1999). A slight warming of the CIL took place in 1996 and 1997, but the CIL minimum

temperature returned within the range of very cold values in 1998. During 1999, the CIL minimum temperature warmed by 0.6 °C relative to 1998, but remained below average.

The most striking feature is that the thickness of CIL waters (D. Gilbert, Fishries and Oceans Canada, Mont-Joli, pers. comm.) with temperature below 0 °C decreased in all sub-area of the Gulf, except in the Cabot Strait where no change was observed. The average thickness of the CIL decreased from 41 m in 1998 to 18 m in 1999, a change of 23 m.

Frequency of cold profiles

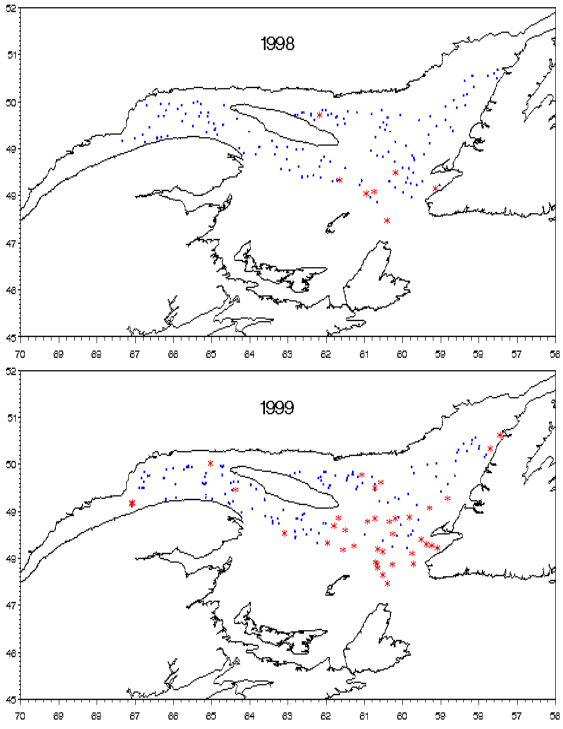

Figure 5. Spatial distribution of cold (dots; Tmin < 0 °C) and warm (stars; Tmin > 0 °C) temperature profiles collected during the August shrimp and groundfish surveys of 1998 and 1999. (Source: J. Plourde)

A recent unpublished study (Plourde, J. and J.-C. Therriault, in prep.) suggests that the inter-annual variability of the properties of the CIL, which is formed during winter, largely reflects climate variability in the Gulf of St. Lawrence. Vertical profiles of temperature for which the lower boundary of the CIL could be detected, were classified as cold profiles if their minimum temperature were below 0 °C. A retrospective analysis of historical data suggested the existence of a large inter-annual variability in the frequency of cold profiles for the period 1947-1994. Since 1995, temperature profiles collected within the model domain during the August shrimp and groundfish survey were used to update the time series. In 1998, 95 % of the temperature profiles were cold while the frequency of cold profiles collected in 1999 decreased to 78 % (Figure 5). The average minimum temperature computed from these profiles warmed from –0.70 °C in 1998 to –0.14 °C in 1999. The area north of the Cabot Strait up to the eastern point of Anticosti Island had a major contribution to this warming.

The time series of the frequency of cold profiles for the period 1947-1999 show the existence of alternating cold and warm periods (Figure 6).

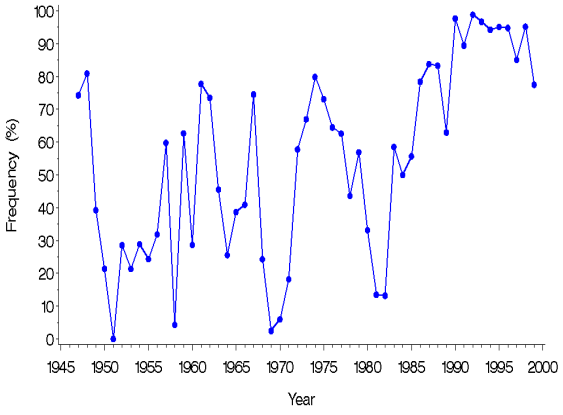

Figure 6. Time series of the frequency of cold temperature profiles (Tmin < 0 °C) for the 1947-1999 period. (Source: J. Plourde).

Over the last three decades, two warm and three cold periods could be identified. Less than 30 % of the profiles were cold during the 1968-1971 and 1981-1982 periods.

During the periods 1974-1975, 1986-1988 and 1990-1999, more than 70 % of the profiles were cold. The nine largest frequencies of cold profiles were consecutively observed from 1990 to 1998, and 1999 was the only one single year having a frequency of cold profiles less than 80 % since 1990.

Bottom temperature in the southern Gulf

In the southern Gulf, a large expanse of the sea bed lies within the depth range of the cold intermediate layer. In September 1999, the area (K. Drinkwater, Fisheries and Oceans Canada, Dartmouth, pers. comm.) with bottom temperature lower than 0 °C and 1 °C decreased relative to 1998 (Figure 7). Notable warming was thus observed in the Magdalen Shallows region in 1999, interrupting the colder-than-average conditions established in the early 90's.

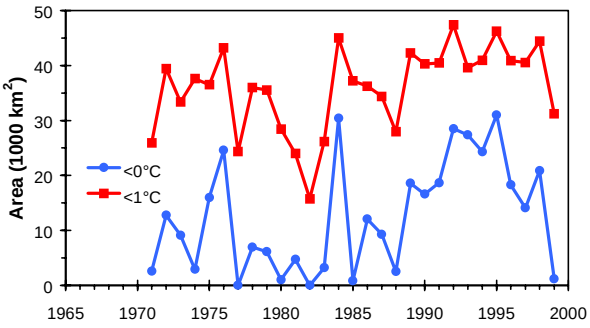

Figure 7. Area with bottom temperature lower than 0 °C (circle) and 1 °C (square) in September in the southern Gulf of St. Lawrence. (Source: K. Drinkwater).

Layer-averaged temperatures

The temperature measurements from the shrimp and groundfish survey were analysed by dividing the water column into four layers:1) warm upper layer (0 to 30 m), 2) cold intermediate layer (30 to 100 m), 3) transition layer (100 to 200 m), 4) warm and salty deep layer (200 to 300 m). Average temperatures within these layers (Figure 8) were calculated for the Gulf as a whole (D. Gilbert, Fishries and Oceans Canada, Mont-Joli, pers. comm.). All of these layers were slightly warmer in 1999 relative to 1998. The mean temperature of the 30-100 m layer remained below the 1961-1990 average while in the three other layers, the mean temperatures were slightly above average.

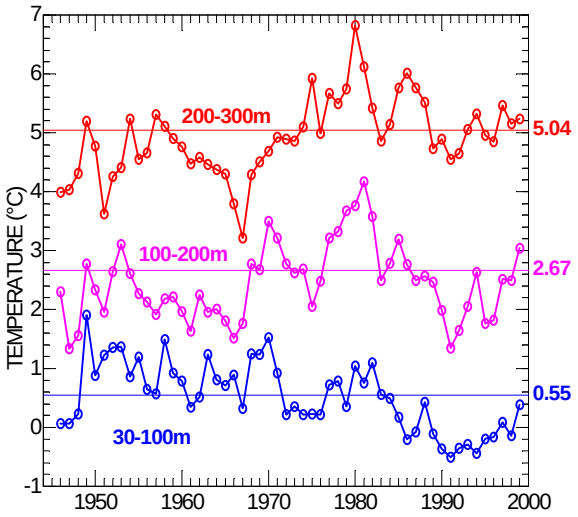

Figure 8. Layer-averaged temperatures for the whole Gulf of St. Lawrence. The horizontal lines indicate the 1961-1990 means. (Source: D. Gilbert)

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Correct citation for this publication

DFO, 2000. Oceanographic Conditions in the Gulf of St. Lawrence during 1999. DFO Science Stock Status Report G4-01 (2000).

This report is available from the:

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ISSN 1480-4913

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