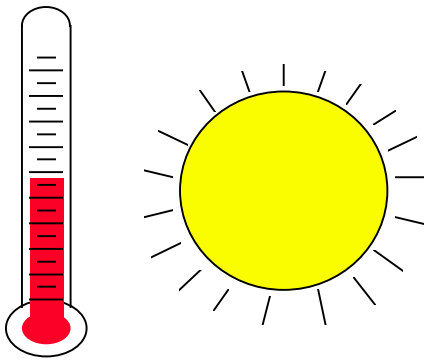

Oceanographic Conditions in the Gulf of St. Lawrence in 1998: physical oceanography

Background

The waters of the Gulf of St. Lawrence are subject to seasonal, interannual and interdecadal variations in physical properties such as temperature, salinity and ice cover. These fluctuations are attributable to two main factors: (1) interactions with the atmosphere (heat exchange between water and air, rain, evaporation, ice formation), and (2) water mass exchanges between the Gulf and the Atlantic Ocean through Cabot Strait and the Strait of Belle Isle (Figure 1). Such fluctuations in oceanographic conditions on short, medium and long time scales may potentially affect the distribution, growth, physiological condition and reproduction of commercial fish and invertebrate stocks in the Gulf of St. Lawrence.

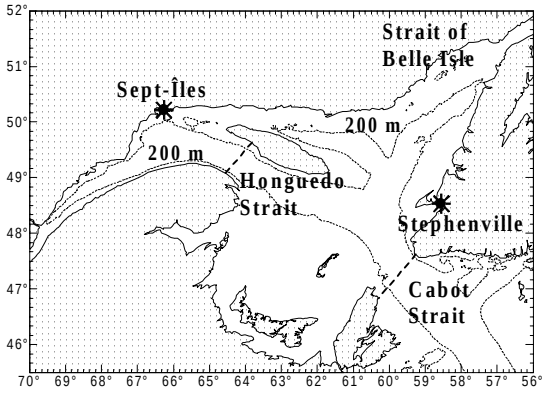

Figure 1. Map of the Gulf of St. Lawrence showing the location of sites mentioned in the text and the 200 m isobath.

Summary

- Air temperatures over the Gulf were warmer than normal during all of 1998.
- As a result, ice formed later than normal and melted earlier than normal, leading to a shorter than normal ice season.
- The RIVSUM freshwater runoff index was well above normal in March and April due to earlier than normal snow melting. Conversely, RIVSUM values were much below normal later in the year, from October to December.
- The minimum temperature within the cold intermediate layer (CIL) unexpectedly dropped by 0.3 °C relative to 1997, thus returning to the range of much colder than normal values observed from 1990 to 1995. Moreover, the thickness and volume of CIL waters with temperature below 0°C both increased relative to 1997.
- In the southern Gulf, the bottom area where temperature was lower than 0°C or 1°C in 1998 increased by 71% and 14% respectively compared with 1997.
- The temperature of the deep layers did not change much relative to 1997. The 1998 temperatures were close to normal

in both the 100-200 m layer and the 200-300 m layer.

- Dissolved oxygen saturation in the 200-300 m layer was normal at the Cabot Strait hydrographic section in 1998, but was slightly below normal at the Honguedo Strait section.

Air temperature

In the northwest Gulf, at Sept-Îles (Figure 2), the monthly mean air temperature was 2°C warmer than normal at the beginning of winter, in December 1997. January 1998 was 1.9°C warmer than normal, and was followed by temperatures 4.4°C and 0.6°C warmer than normal in February and March 1998, respectively. Spring temperatures were also very mild being 2.9°C and 2.2°C above normal in April and May 1998. Temperatures remained relatively warm for the rest of 1998, with the largest anomaly (2.1°C) in September. In the southeast Gulf, at Stephenville (Figure 3), temperatures were also warmer than normal during 1998 although less so than at Sept-Îles, particularly in early winter. The largest positive temperature anomalies at Stephenville were observed in February (3.1°C), March (2.5°C) and May (2.6°C). November was the only month of 1998 with colder than normal air temperature at Stephenville, with an anomaly of -0.4°C.

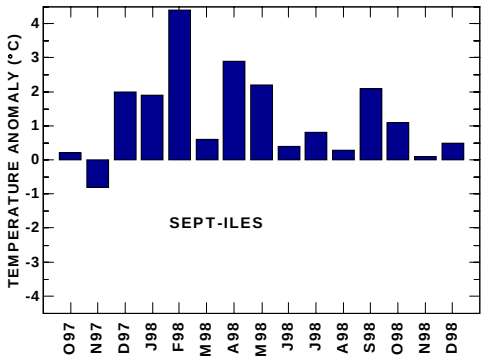

Figure 2. Deviations from the 1961-1990 mean (anomalies) of the monthly averaged air temperature at Sept-Îles.

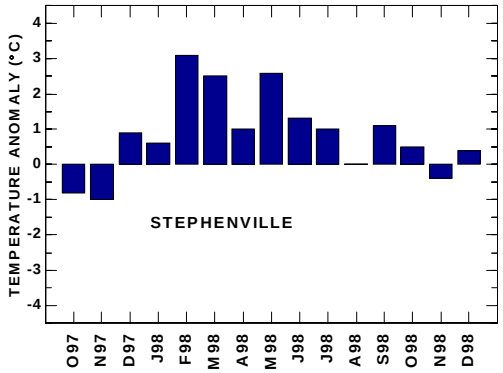

Figure 3. Deviations from the 1961-1990 mean (anomalies) of the monthly averaged air temperature at Stephenville.

Sea ice

The warmer than normal air temperatures observed in December 1997 (Figure 2) lead to less extensive ice cover than normal through to January 15, 1998 (Figure 4). By February 1, 1998, the ice edge had temporarily caught up with the 1962-1987 median despite the relatively mild conditions of January, but the ice was thinner than usual. The extremely warm air temperatures throughout the Gulf in February (3°C to 4°C warmer than normal) prevented further ice growth and even caused a retreat of the ice edge on the Magdalen Shallows, so that on March 1, 1998, the ice cover area was much less than normal. Continuing warm air temperatures during the spring kept the ice edge position behind the 1962-1987 median. By May 1, 1998, ice had disappeared everywhere except very close to the Strait of Belle Isle. In summary, the 1998 ice cover in the Gulf of St. Lawrence formed later than normal, disappeared earlier than normal, and the ice cover duration was much shorter than usual.

Freshwater discharge

RIVSUM is the sum of the freshwater flows of the St. Lawrence River at the Cornwall dam, the Ottawa River at the Carillon dam

and the Saguenay River at the Isle Maligne dam. The warmer than normal air temperatures observed in the winter and spring caused earlier than usual snow melt in the drainage basins of these rivers. This in turn lead to much larger than normal RIVSUM values in March and April 1998 (Figure 5), so much so that the 1998 flow

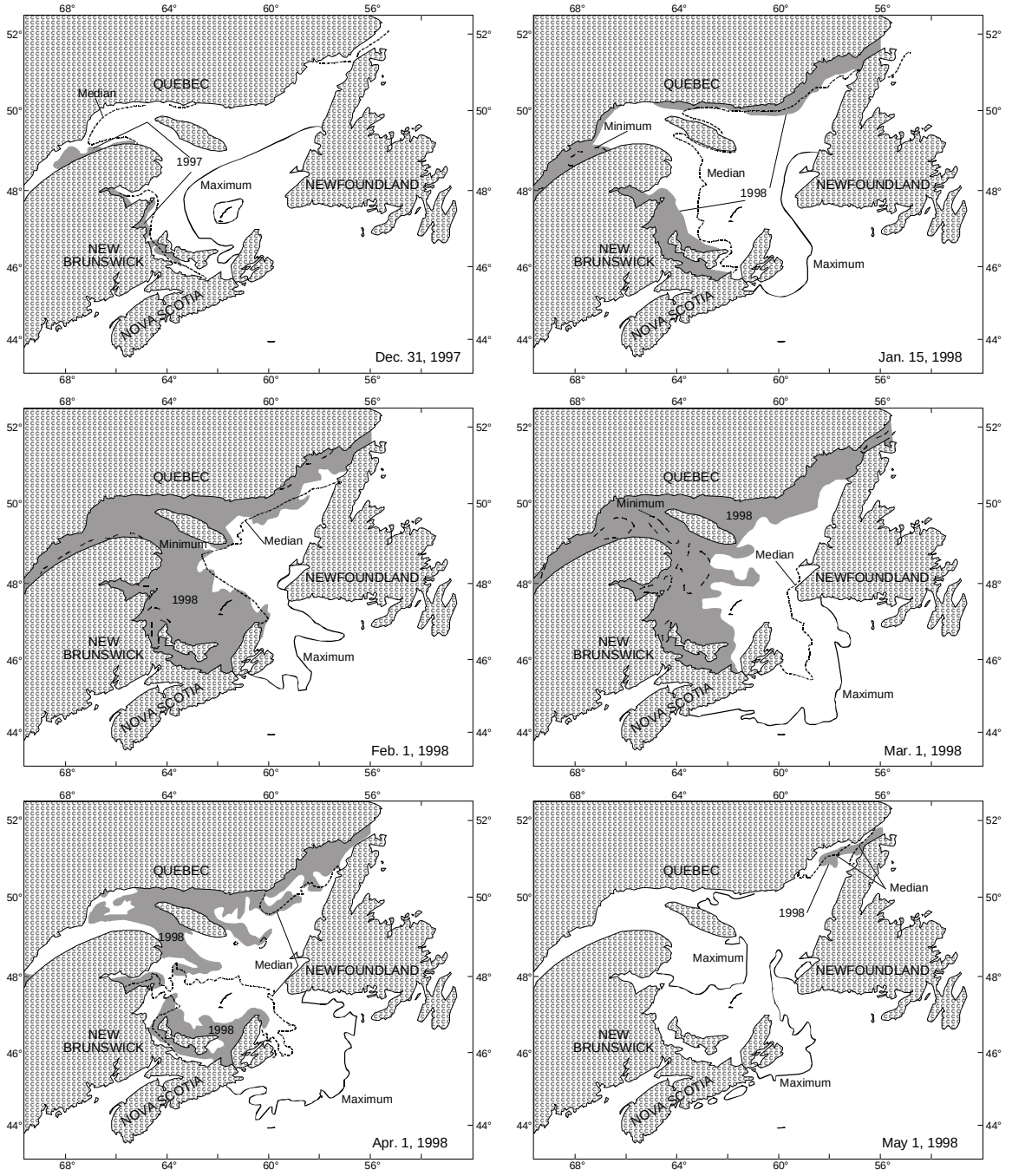

Figure 4. Ice-covered regions (shaded) in the Gulf of St. Lawrence at the dates shown on the maps. The minimum, median and maximum ice edge positions at these dates for the 1962-1987 period (Côté 1989) are also shown for reference.

peaked in April instead of the usual May. During summer, RIVSUM values were close to normal, but by autumn less than normal amounts of precipitation caused RIVSUM flows to fall below normal.

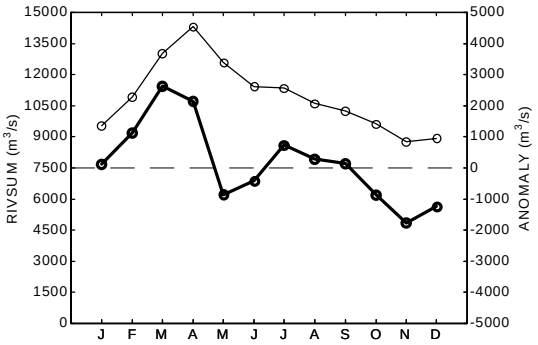

Figure 5. Sum of the monthly averaged freshwater discharges of the St. Lawrence, Ottawa and Saguenay Rivers from January to December 1998 (RIVSUM index, thin line, left scale). The deviations with respect to the 1961-1990 mean (anomalies) are indicated by the thick line (right scale).

Cold intermediate layer

Vertical profiles of temperature and salinity collected during the August-September shrimp and groundfish stock assessment surveys were used to compile information on the cold intermediate layer (CIL), roughly located between 30 and 125 m depth in the Gulf of St. Lawrence. The minimum temperature within this layer is subject to variations of about plus or minus 1°C on decadal time scales (Figure 6). Below normal CIL minimum temperatures have been recorded since 1985, the six consecutive years from 1990 to 1995 being among the coldest on record. A slight warming of the CIL took place in 1996 and 1997. Surprisingly, warming did not continue into 1998 despite the mild winter air temperatures and reduced ice cover. The 1998 CIL minimum temperature was 0.3°C lower than in 1997, thus returning to the range of very cold values observed from 1990 to 1995.

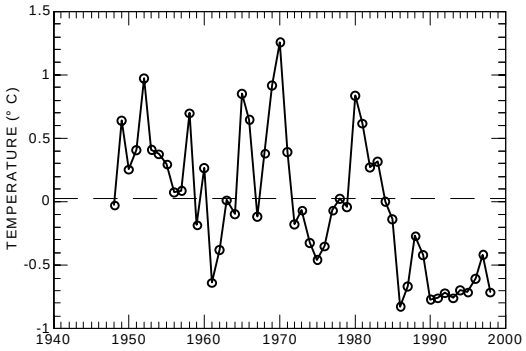

Figure 6. Composite index of CIL core temperature anomaly in the Gulf of St. Lawrence (1961-1990 mean = 0.03°C).

Moreover, in the summer of 1998 the thickness of CIL waters with temperature below 0°C increased by an overall average of approximately 8 m compared with 1997. This increase is considerable, given the thickness of CIL waters with temperature below 0°C varied between 10 m and 65 m throughout the Gulf in August 1998. In the Estuary, northwest Gulf, and Laurentian Channel adjacent to the Magdalen Shallows, the CIL thickness increased by as much as 10 to 30 m whereas the CIL thickness decreased by similar amounts on the Newfoundland side of the Esquiman and Laurentian Channels. However, the areas of CIL thinning in the East were not as extensive as the areas of CIL thickening in the West. The total volume of CIL waters with temperature less than 0°C increased by 18 % compared with 1997, whereas the total volume of water with temperature less than 1°C increased by a more modest 2%. The total volumes of water with temperature less than 2°C and 3°C showed no significant change compared with 1997.

September 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 1998, the bottom area with temperatures lower than 0°C and 1°C increased by 71% and 14% respectively compared to 1997 (Figure 7). Notable cooling was thus observed in the Magdalen Shallows region in 1998, prolonging the colder than normal conditions established in 1990.

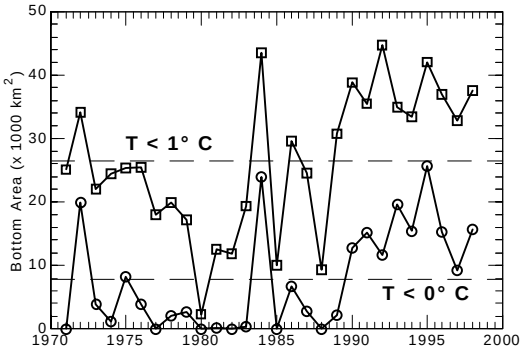

Figure 7. Bottom area with T < 0°C (circles) and T < 1°C (squares) in September in the southern Gulf of St. Lawrence. The horizontal lines represent the 1971-1998 averages.

Layer-averaged temperatures

The temperature and salinity measurements from the 1985 to 1998 shrimp and groundfish trawl surveys were analyzed by dividing the water column into four layers: 1) warm upper layer (0 to 30 m deep), 2) cold intermediate layer (30 to 100 m deep), 3) transition layer (100 to 200 m deep), 4) warm and salty deep layer (200 to 300 m deep). Average temperatures within these layers were calculated for the Gulf as a whole.

The Gulf-wide average temperature of the 0-30 m layer during the 1998 August-September survey was 10.43°C, 0.5°C above normal (9.93°C). In the 30-100 m layer, the average temperature was 0.32°C, about 0.2°C colder than in 1997. To allow a comparison of this result with a mid-summer time series starting in 1946, the August-September value was extrapolated to July 15, yielding -0.29°C for the 30-100 m layer. This is 0.84°C colder than the 1961-1990 average (0.55°C), thus indicating a continuation of the period with lower than normal temperatures observed over the last ten years (Figure 8). In the 100-200 m layer, temperature remained stable relative to 1997 reaching 2.49°C, which is close to the 1961-1990 normal (2.67°C). Very cold temperatures were observed in 1991 and 1992, as well as in 1995 and 1996 in the 100-200 m layer (Figure 8). Lastly, temperature in the 200-300 m layer dropped by 0.3°C compared to 1997. The temperature of this layer was 5.15°C in 1998, 0.11°C warmer than the 1961-1990 normal (5.04°C).

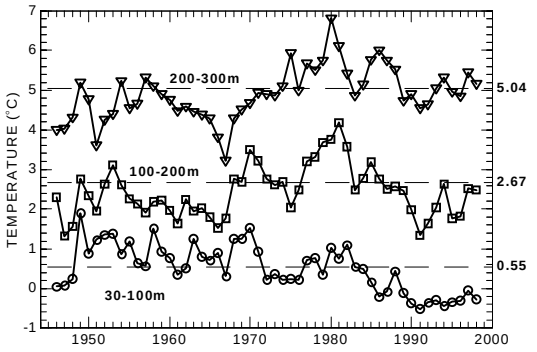

Figure 8. Layer-averaged temperatures for the whole Gulf of St. Lawrence based on May to September data. For the 30-100m layer, the data were extrapolated to July 15. The horizontal lines indicate the 1961-1990 means.

At the entrance to the Gulf in Cabot Strait, the average temperature of the 200-300 m layer reached record low values in the mid-1960s, followed by relatively warm conditions until about 1988 (Figure 9). Rapid cooling marked the period through 1991, followed by equally rapid warming in 1992 and 1993. Since then, the observed

temperatures have generally been close to or slightly above normal, except for mid-April 1998 that was 0.53°C below normal.

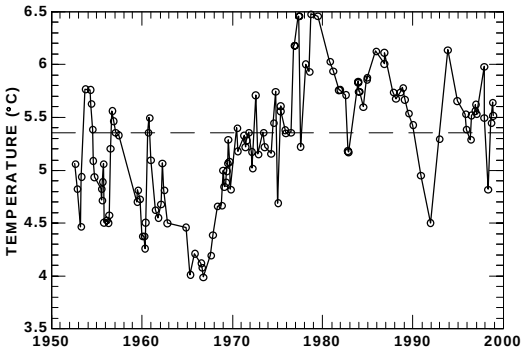

Figure 9. Average temperature of the 200-300 m layer at the standard Cabot Strait section. The horizontal line indicates the 1961-1990 mean (5.35 °C).

Dissolved oxygen

Below a depth of 150 m, the waters of the Gulf of St. Lawrence are a mixture of Labrador Shelf and Slope Water and Western North Atlantic Water in varying proportions. These water masses enter the mouth of the Laurentian Channel at the shelf break, some 400 km southeast of Cabot Strait. They then make a journey which takes several years towards the heads of the Laurentian, Anticosti and Esquiman channels. As the waters move toward the head of each channel, their dissolved oxygen content is progressively consumed through decomposition of organic matter that sinks from the surface layer. In certain parts of the Gulf (particularly in the St. Lawrence Estuary at depths of 250 m or more), the dissolved oxygen concentrations are sufficiently weak to limit the presence of certain species (e.g. cod) and affect the metabolism of other resident species.

At Cabot Strait, the dissolved oxygen content of the 200-300 m layer (Figure 10) fluctuates between about 45% and 70% saturation (100% saturation corresponds to the maximum dissolved oxygen concentration possible for a given temperature and salinity when this water mass was at the surface). At Honguedo Strait (Figure 1), the dissolved oxygen content of the 200-300 m layer typically ranges from about 25% to 40% saturation (Figure 10). The older age of the waters in Honguedo Strait explains the lower oxygen values observed there as compared with Cabot Strait. In 1998, the dissolved oxygen content of the 200-300 m layer was identical to the 1981-1998 average at Cabot Strait, and slightly below average at Honguedo Strait (Figure 10).

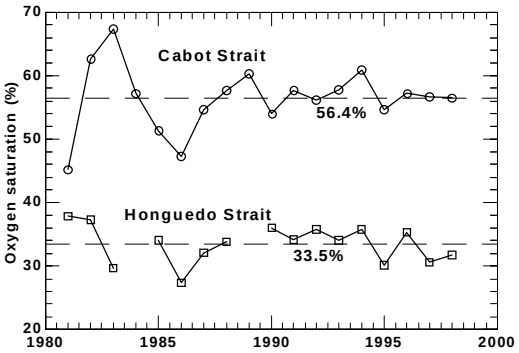

Figure 10. Dissolved oxygen concentration at the Cabot Strait section (circles) and the Honguedo Strait section (squares). The horizontal lines indicate the 1981-1998 averages.

For more information:

Drinkwater, K.F., R. Pettipas and L. Petrie. 1999. Overview of meteorological and sea ice conditions off Eastern Canada during 1998. Can. Stock Ass. Sec. Res. Doc. 99/xx, xxp (in preparation).

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