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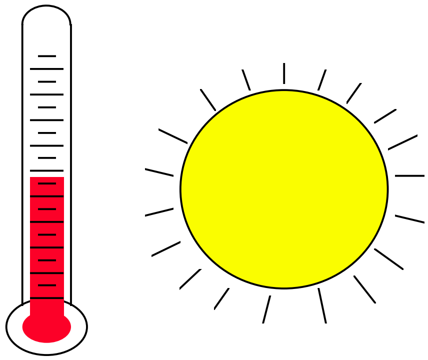

Oceanographic Conditions in the Gulf of St. Lawrence in 1996

Summary

Highlights for 1996: 1) the winter was rather mild, with air temperatures close to normal in the western Gulf, but about 3°C above normal in the eastern Gulf; 2) the ice cover was slightly smaller than the 1962-1987 median areal extent, with sparser ice than in recent years; 3) freshwater discharges were generally above average, with the strongest positive anomaly recorded in July 1996 during the Saguenay region floods; 4) the core temperature of the cold intermediate layer warmed up slightly, but remained below normal; 5) in the southern Gulf, the area with bottom temperature below 0°C or 1°C decreased relative to 1995, but still remained above the 1971-1996 mean; 6) the temperature of the deeper layers remained stable relative to 1995. In the 100-200 m layer, the temperature was 0.6°C below normal in 1996, whereas in the 200-300 m layer, the temperature was normal; 7) the dissolved oxygen content of the 200-300 m layer was normal at the standard hydrographic sections of Cabot Strait and Honguedo Strait in 1996.

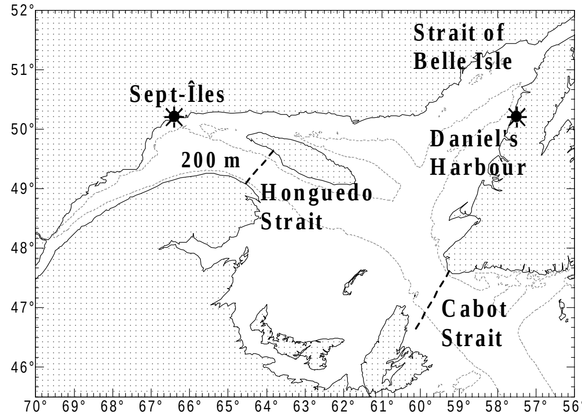

Figure 1. Map of the Gulf of St. Lawrence showing the location of sites mentioned in the text and the 200 m isobath.

Introduction

The waters of the Gulf of St. Lawrence are subject to seasonal, interannual and inter-decadal variations in temperature and salinity. These fluctuations are attributable to two main factors: (1) interactions with the atmosphere (heat exchange, precipitation, 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). The temperature fluctuations undoubtedly affect the different commercial fish and invertebrate stocks of the Gulf of St. Lawrence to a variable extent, although little is as yet known about the effects on most species.

An overview of the meteorological and oceanographic conditions that prevailed in the Gulf of St. Lawrence (Figure 1) in 1996 is presented, based on a few key climatic indices. In view of the important ocean-atmosphere interactions that affect the Gulf's climate, air temperature data, winter ice cover maps, and freshwater discharges are included. Information is also provided on water temperatures in several depth strata: surface layer (0 to 30 m), cold intermediate layer (30 to 100 m) and deep layers (100 to 200 m and 200 to 300 m). Lastly, dissolved oxygen data are presented for the 200 to 300 m layer, which has the lowest oxygen content of the entire water column and hence the greatest potential impact on the metabolism of resident species.

Air temperature

The monthly mean air temperatures presented here are taken from the Canadian Climate Summary, published monthly by the Atmospheric Environment Service of Environment Canada. In the western Gulf, at Sept-Îles (Figure 2), the monthly mean air

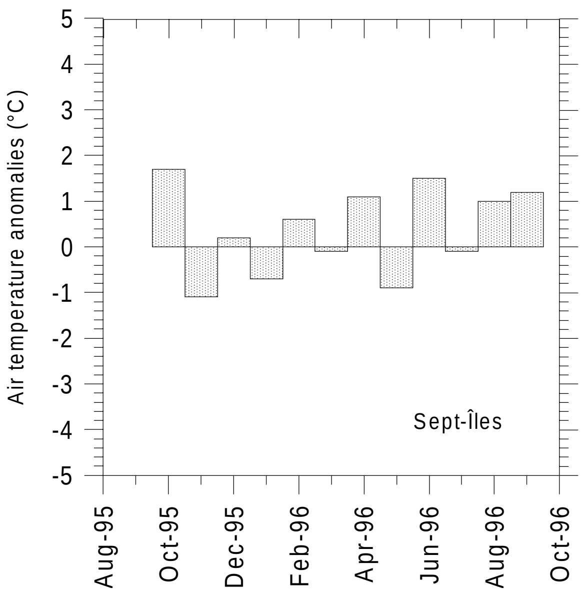

Figure 2. Deviations from the 1961-1990 mean of the monthly averaged air temperature at Sept-Îles.

temperatures remained fairly close to the climatological normals throughout 1996. However, in the eastern Gulf, at Daniel’s Harbour (Figure 3), air temperatures were well above normal from February to April 1996, with positive anomalies of 4.4°C in February, 1.6°C in March, and 3.3°C in April. The mild winter temperatures in the eastern part of the Gulf are linked to a

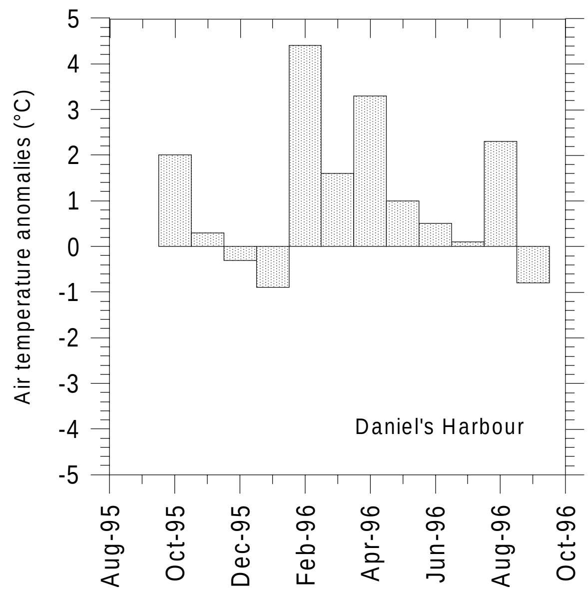

Figure 3. Deviations from the 1961-1990 mean of the monthly averaged air temperature at Daniel's Harbour.

change in the large-scale atmospheric circulation patterns. In fact, the North Atlantic Oscillation index (difference between sea-level air pressure measured over the Azores and Iceland) was negative in 1996 for the first time after seven consecutive years of strong positive values (Drinkwater et al. 1997). The month of August was also very warm, with a temperature 2.3°C above normal at Daniel’s Harbour.

Sea ice

We used the weekly ice charts produced by the Canadian Ice Service of Environment Canada to locate the ice edge at various times during the winter. Air temperatures were close to normal in December 1995 (Figure 2 and Figure 3), resulting in near-normal ice cover at the beginning of the ice season, December 31, 1995 (Figure 4). In January, the ice cover grew at a normal pace, so the ice edge was still close to the long-

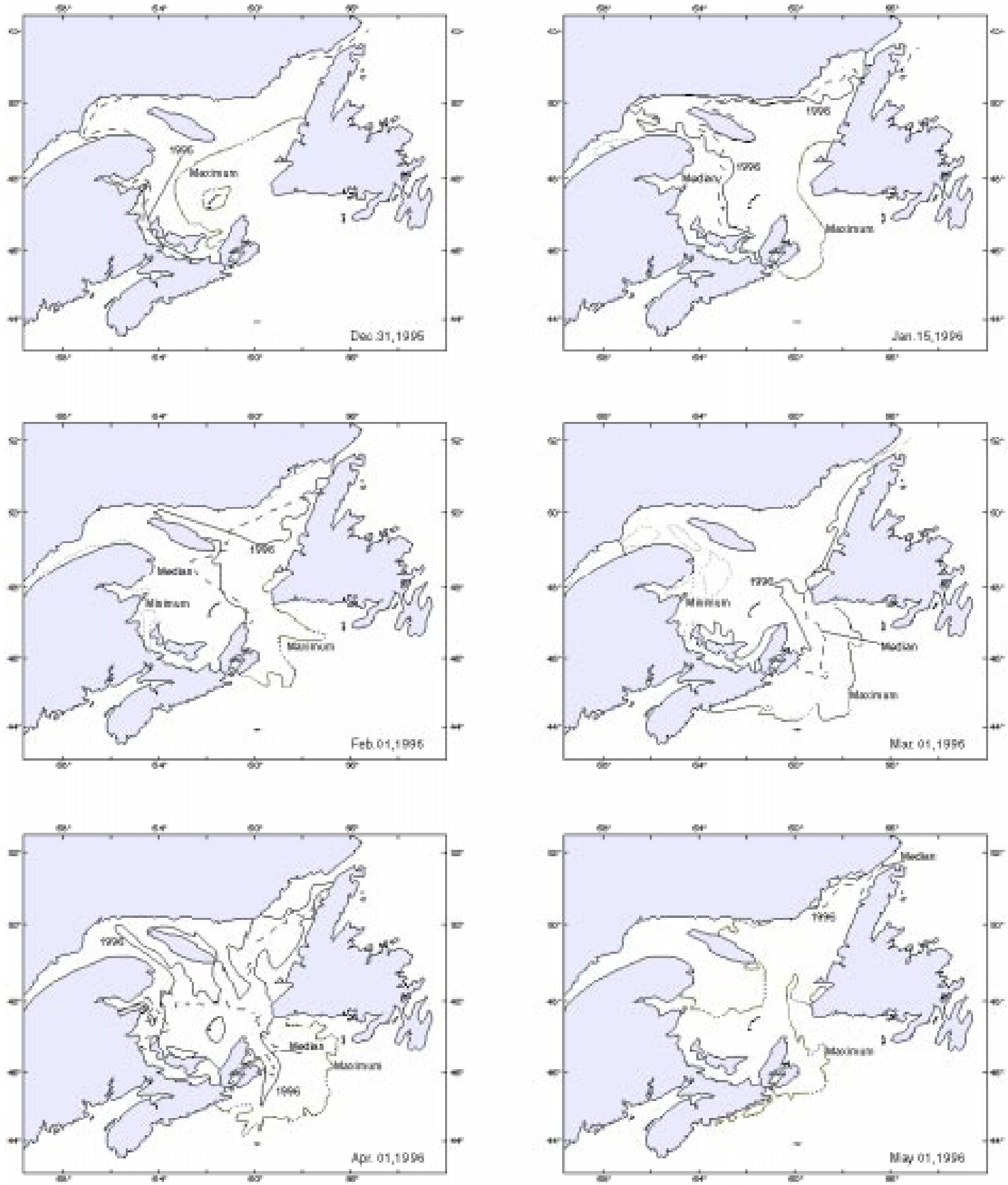

Figure 4. Location of the 1996 ice edge (thick continuous line) relative to the 1962-1987 minimum, median and maximum ice edge positions, from December 31, 1995, to May 01, 1996.

term median extent on February 1, although the ice was sparser than usual.

In February, however, the mild air temperatures in the eastern Gulf delayed ice production, such that on March 1 the ice edge was behind the 1962-1987 median extent and situated farther north. At that time, the ice was still thin and sparse compared with previous years. On April 1, the ice edge was near-normal, although the ice remained thin and sparse. April's warmer-than-average temperatures caused the remaining ice to melt rapidly, so that there was almost no ice left in the Gulf on May 1.

In short, the ice cover was slightly below normal during winter 1996. Total ice duration was 1 to 4 weeks shorter than usual throughout the Gulf (Drinkwater et al. 1997), with the greatest deviations observed around the Strait of Belle Isle and Cabot Strait (Figure 1).

Freshwater discharges

Without a shadow of a doubt, the torrential rainfall that hit the Saguenay, Charlevoix and Haute Côte Nord regions in July 1996 was the most spectacular meteorological event last year. This is reflected in the RIVSUM index, which is the sum of the freshwater discharges of the St. Lawrence River, the Ottawa River and the Saguenay River, as measured at various dam sites along the waterways.

During 1996, freshwater discharges were generally above average, with the greatest deviation recorded in July 1996 (Figure 5). A more detailed picture of the discharges during the July floods is presented in Figure 6, which shows that the discharge from the Saguenay at the outlet of Lac St Jean more than doubled in less than 24 hours between July 19 and 20. The discharge from the Saguenay at the Isle Maligne dam located in Alma remained exceptionally high until July 23, and then gradually returned to more normal values.

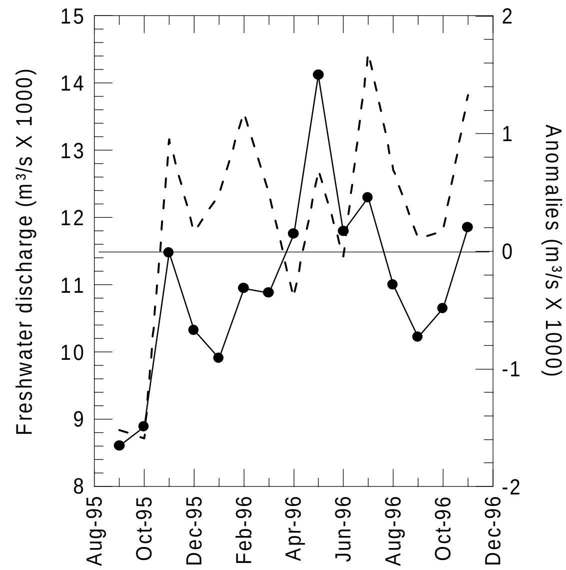

Figure 5. Sum of the freshwater discharges of the St. Lawrence, Ottawa and Saguenay Rivers (RIVSUM index, continuous line), from September 1995 to November 1996. The deviations with respect to the 1961-1990 mean are indicated by the dashed line.

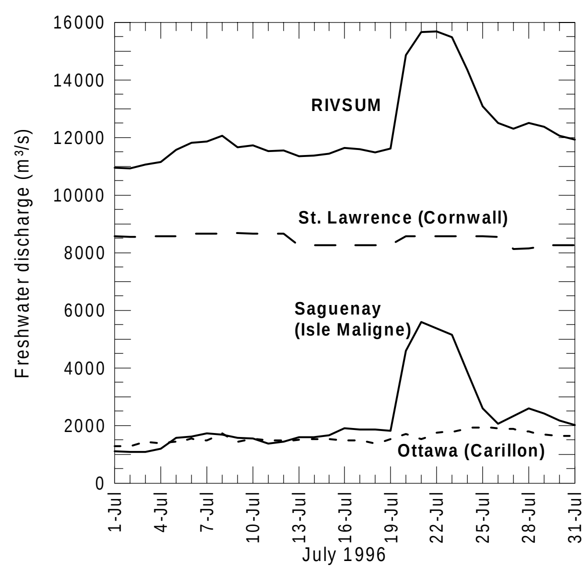

Figure 6. Daily values of the freshwater discharges of the St. Lawrence, the Ottawa and the Saguenay Rivers, together with their sum (RIVSUM index) during July 1996.

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. The cold intermediate layer (CIL) is a layer of cold water, extending roughly from a depth of 30 to 100 m, with warmer water both above and below it. Gilbert and Pettigrew (1997) have documented the temperature variations recorded since 1948 in the core of the CIL, which features the lowest temperature of the entire water column (Figure 7). From this figure, it can be seen that the CIL is subject to temperature variations in the order of ± 1°C on decadal time scales. CIL core temperatures have been below normal since 1984, with the five consecutive years from 1990 to 1994 marked by near-record cold temperatures.

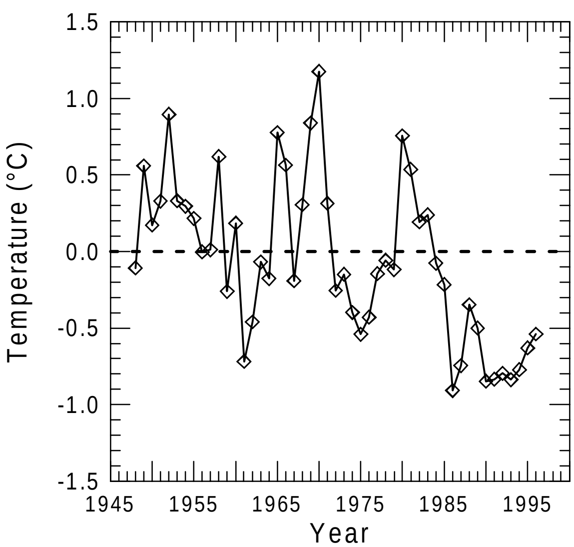

Figure 7. Composite index of CIL core temperature anomaly in the Gulf of St. Lawrence (normal = 0.08°C).

A slight warming of the CIL likely began in 1995 and continued into 1996. In summer 1996, the thickness of the subzero layer decreased by 10 to 20 m everywhere in the Gulf relative to 1995, whereas the thickness of the layer with a temperature below 3°C barely changed.

September bottom temperature in the southern Gulf

The Gulf region most likely to be affected by low CIL temperatures is the southern portion, where a large expanse of the sea bed lies within the depth range of this cold layer. In September 1996, the bottom temperature was lowest in the central region of the Magdalen Shallows and increased shoreward and with depth along the Laurentian Channel, as is typical. Estimated bottom temperature in the southern Gulf was below 1°C over 36,000 km^2 and below 0°C over 15,000 km^2 (Figure 8).

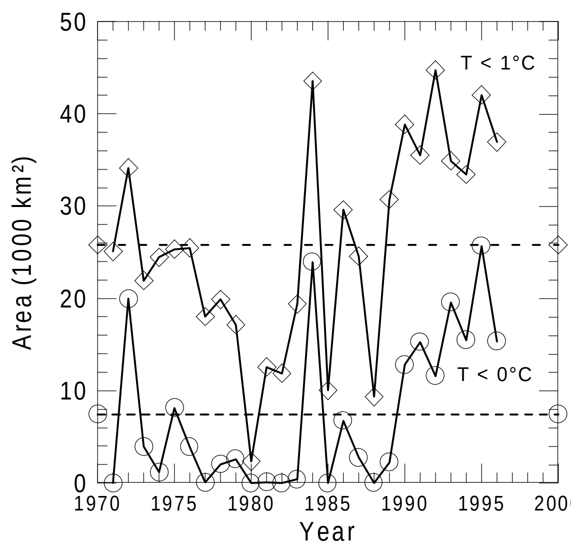

Figure 8. Bottom area with T < 0°C (circles) and T < 1°C (diamonds) in September in the southern Gulf of St. Lawrence. The dashed lines represent the 1971-1996 averages.

The area with a bottom temperature below 1°C declined by nearly 15% relative to 1995, while the area of subzero bottom temperatures decreased by 40%. An appreciable warming thus occurred in the Magdalen

Shallows region, although the areal extent of cold water temperatures still exceeds the long-term normal (Figure 8).

Layer-averaged temperatures

To simplify our analyses of the XBT and CTD observations collected aboard the Lady Hammond and the Alfred Needler during the 1985 to 1996 groundfish trawl surveys, we divided the water column into four layers: a warm upper layer (0 to 30 m deep), a cold intermediate layer (30 to 100 m deep), and two deep layers (100 to 200 m and 200 to 300 m deep). The Gulf-wide average temperatures given below were calculated by assigning to each of the 21 subregions of Petrie et al. (1996) a weight that is proportional to its area. This calculation method differs from that of Gilbert (1996), who used simple arithmetic means for his overall temperature indices.

The Gulf-wide average temperature of the 0-30 m layer during the August-September 1996 survey was 10.1°C, about 0.2°C above normal (9.93°C). In the 30-100 m layer, the average temperature was 0.3°C, more than 1°C colder than usual (1.47°C), continuing the trend of colder-than-normal temperatures of the past few years (Figure 9). In the 100-200 m layer, the water temperature barely changed over the past year, in contrast with the sharp drop in temperature noted between 1994 and 1995 (Figure 9). The average temperature of that layer in 1996 was 1.82°C, some 0.6°C below normal (2.44°C). However, even colder temperatures were observed in the 100-200 m layer in 1991 and 1992 (Figure 9). Lastly, the 200-300 m layer had an average temperature of 4.85°C in 1996, which is on a par with 1995 and very close to normal (4.80°C).

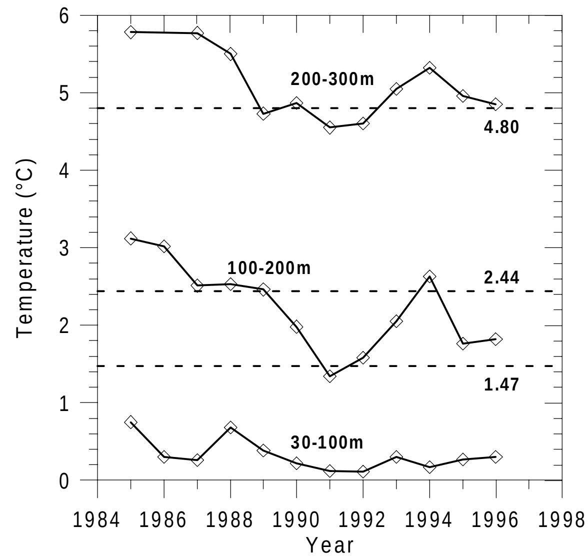

Figure 9. Layer-averaged temperatures for the whole Gulf of St. Lawrence in August-September. The dashed lines indicate the long-term averages based on the climatological atlas of Petrie et al. (1996). The mean temperatures from the 21 subregions of the Gulf of Petrie et al. (1996) were weighted according to their respective areas in the Gulf-wide indices.

To obtain a longer-term perspective of the temperature changes that have occurred in the 200-300 m layer over the last few decades, we may look at data from the standard Cabot Strait section, where temperature measurements have been made on a regular basis since the early 1950s (Figure 10). The average temperature of the 200-300 m layer in Cabot Strait reached record low values in the mid-1960s, followed by relatively warm conditions right until about 1988. Rapid cooling then marked the period through 1991, followed by equally rapid warming in 1992 and 1993. In fall 1996, the temperature was 0.2°C above normal in the 200-300 m layer at Cabot Strait.

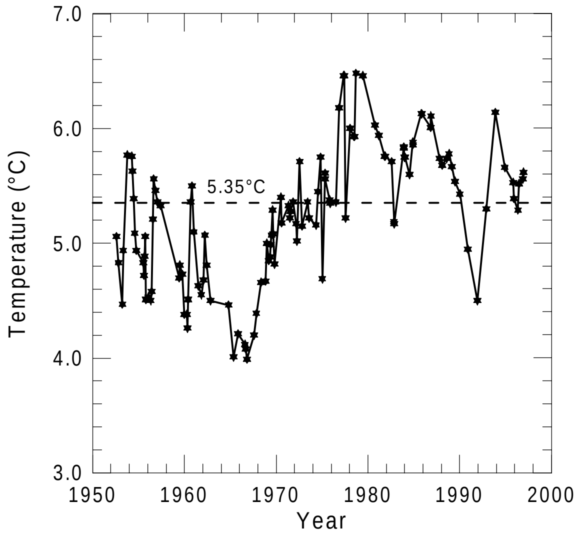

Figure 10. Average temperature of the 200-300 m layer at the standard Cabot Strait section. The dashed line indicates the 1961-1990 mean.

Dissolved oxygen

Below a depth of about 150 m, the waters of the Gulf of St. Lawrence are a mixture of Labrador Sea water and continental slope water. 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 oxidation of the organic matter that sinks from the surface layer.

Monitoring data gathered in late fall since 1981 at standard sections along the Laurentian Channel show that, at Cabot Strait, the dissolved oxygen content of the 200-300 m layer may fluctuate between about 45% and 70% saturation (Figure 11). In Honguedo Strait (Figure 1), the dissolved oxygen content of the 200-300 m layer typically ranges from about 25% to 40% saturation (Figure 11). As described above, the older age of the waters in Honguedo Strait explains the lower oxygen values observed there as compared with Cabot Strait. In 1996, the dissolved oxygen content of the 200-300 m layer was very close to the 1981-1996 average in both straits.

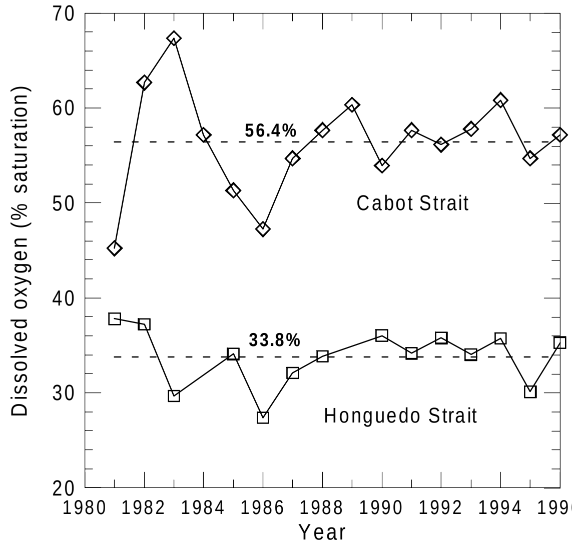

Figure 11. Dissolved oxygen concentration at two sections along the Laurentian Channel (Figure 1). The dashed lines indicate the 1981-1996 averages.

For more information:

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