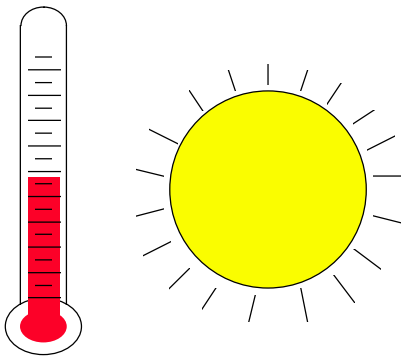

# Oceanographic Conditions in the Gulf of St. Lawrence in 1997

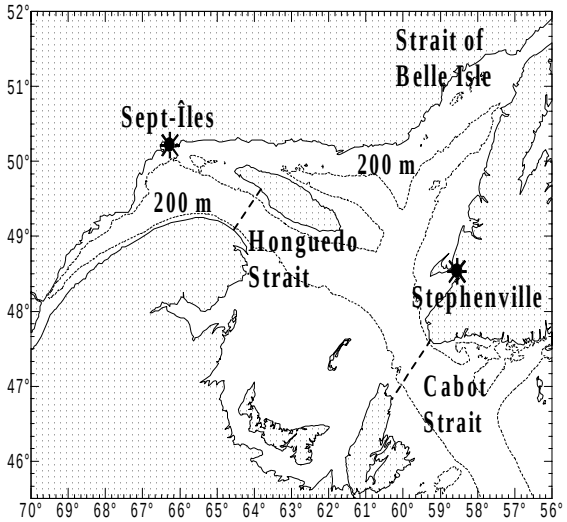


*Figure 1. Map of the Gulf of St. Lawrence showing the location of sites mentioned in the text and the 200 m isobath.*

***Background***

*The waters of the Gulf of St. Lawrence are subject to seasonal, interannual and interdecadal variations in temperature and salinity. 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 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.*

## *Summary*


- Air temperatures over the Gulf were warmer than normal at the beginning of the 1996-1997 winter, but then dropped below normal in February and March 1997.
- As a result, ice formed later than usual but also melted later than usual.
- The RIVSUM freshwater runoff index was above normal throughout the year.
- The temperature of the cold intermediate layer was warmer than in 1996, but still remains slightly colder than normal.
- In the southern Gulf, the bottom area where the temperature was lower than 0°C or 1°C decreased relative to 1996, but remains slightly above the 1971-1997 average.
- The temperature of the deep layers increased by approximately 0.6°C compared to 1996. In the 100-200 m layer, the 1997 temperature was close to normal, while in the 200-300 m layer, the 1997 temperature was 0.6°C warmer than normal.
- Dissolved oxygen saturation in the 200-300 m layer in 1997 was normal at the Cabot Strait hydrographic section, but was 3 % below normal at the Honguedo Strait section.


## *Air temperature*

The monthly mean air temperatures presented here are taken from the Canadian Climate Summary, published monthly by the Atmospheric Environment Service of Envi-

ronment Canada. In the northwestern Gulf, in Sept-Îles (Figure 2), the monthly average air temperature was 4°C warmer than normal at the beginning of the winter, in December 1996. January 1997 was normal, but was followed by temperatures 3°C and 4°C colder than normal in February and March 1997 respectively. The remainder of 1997 was then close to normal, except for December (2°C above normal). In the southeastern Gulf, at Stephenville (Figure 3), the temperature anomalies resembled those of Sept-Îles in 1997. This situation contrasts with 1996 when we observed notable differences between the eastern and western parts

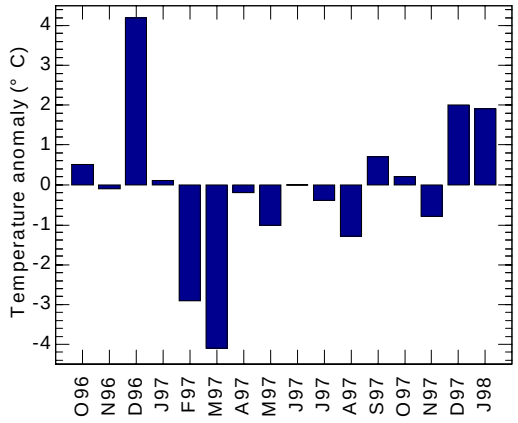


*Figure 2. Deviations from the 1951-1980 mean (anomalies) of the monthly averaged air temperature at Sept-Îles.*

of the Gulf during the winter.

## *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. The much warmer than normal air temperatures observed in December 1996 (Figures 2 and 3) led to the total absence of ice at the beginning of the ice season, on December 31, 1996 (Figure 4). In January, the close to normal air temperatures allowed the ice cover to start to grow, but the ice edge nevertheless re-

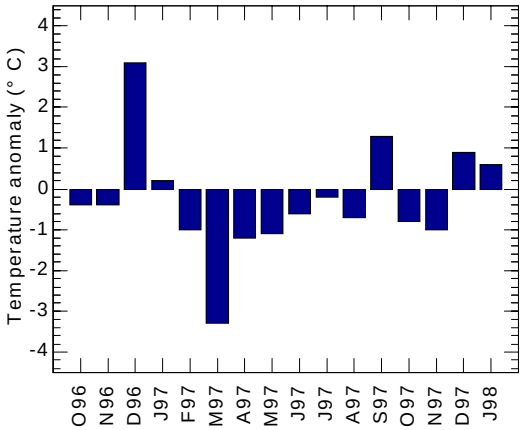


*Figure 3. Deviations from the 1951-1980 mean (anomalies) of the monthly averaged air temperature at Stephenville.*

mained behind the long-term normal until February 1. One month later, the 3°C colder than normal air temperatures of February caused accelerated ice growth, so that the ice edge had reached the 1962-1987 normal by March 1. The cold spell continued in March, so that on April 1, the ice edge was generally beyond the 1962-1987 normal (Figure 4). On May 1, ice had completely melted everywhere except east of Prince Edward Island and in the northeastern Gulf. Overall, we could summarize the situation by saying that the ice cover formed later than normal, but also left later than normal. The total ice cover duration was a little shorter than normal in the estuary and the northern part of the Magdalen Shallows, but was ten days longer than normal in the eastern Gulf and the southern part of the Magdalen Shallows.

## *Freshwater discharge*

The index we use to represent the freshwater flow entering the estuary and the Gulf of St. Lawrence is commonly referred to as RIVSUM. The RIVSUM index is defined as 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. RIV-

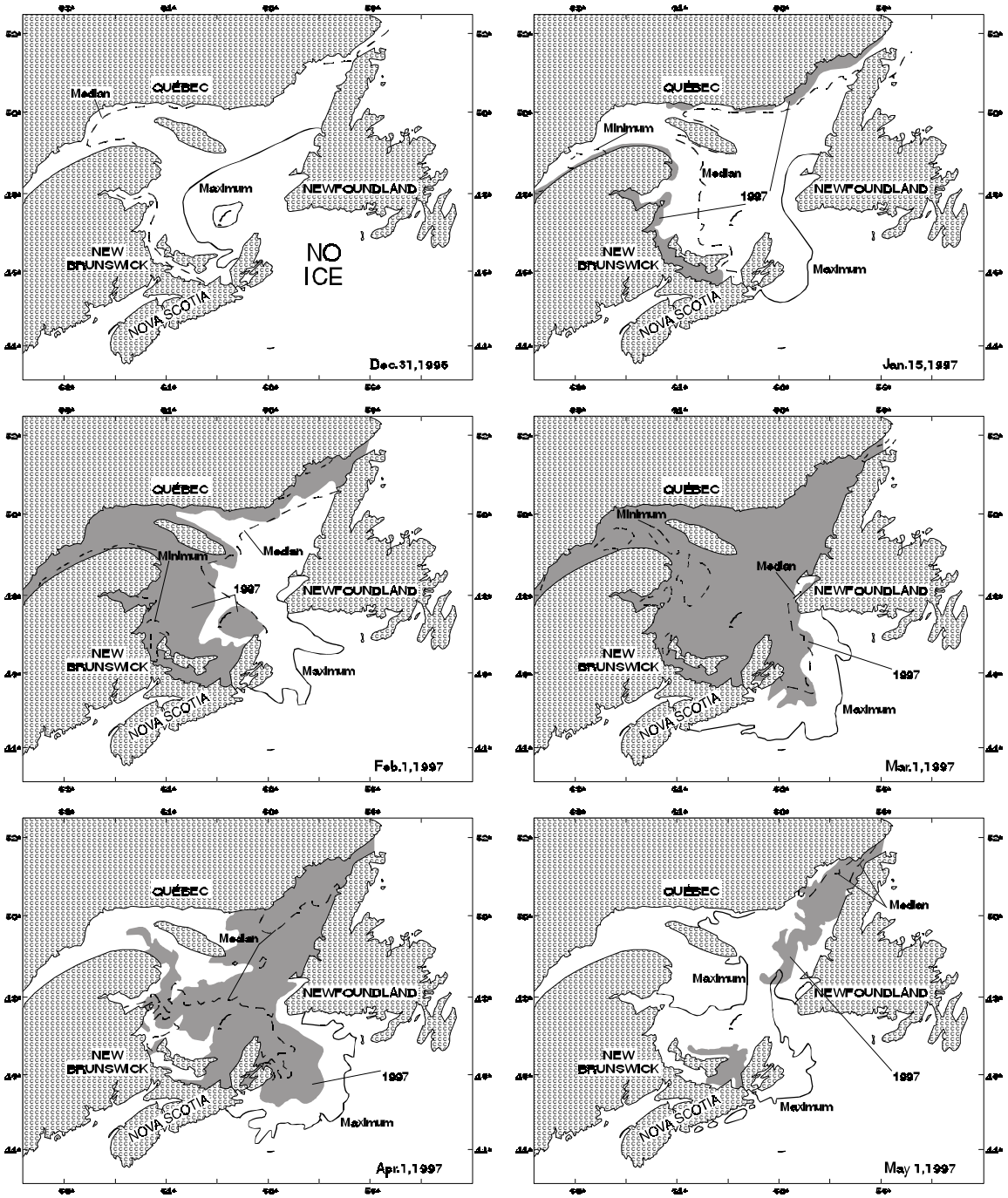


*Figure 4. Ice-covered regions (shaded) in the Gulf of St. Lawrence at the dates shown on the maps. The minimum, median and maximum ice edge positions at these dates for the 1962-1987 period (Côté 1989) are also shown for reference.*

SUM remained higher than normal throughout 1997, the greatest departures from normal being recorded in the spring (Figure 5).

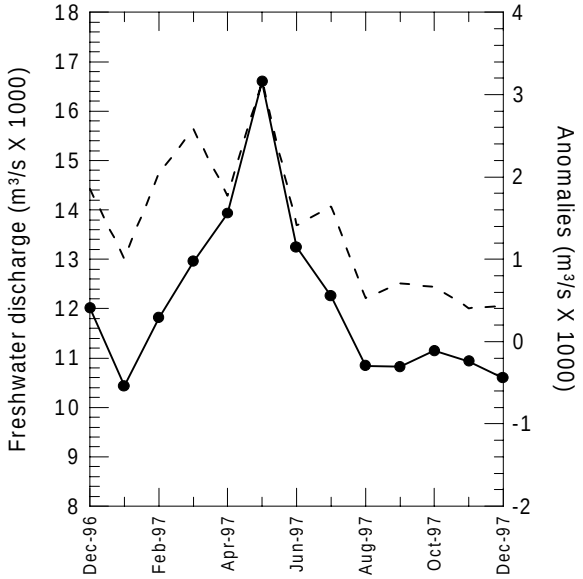


*Figure 5. Sum of the freshwater discharges of the St. Lawrence, Ottawa and Saguenay Rivers from December 1996 to December 1997 (RIVSUM index, continuous line, left scale). The deviations with respect to the 1961-1990 mean (anomalies) are indicated by the dashed line (right scale).*

## *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), located roughly between 30 and 125 m depth. The minimum temperature within this layer is subject to variations of about plus or minus 1°C on decadal time scales (Figure 6). Temperatures below normal have been recorded there since 1984, the five consecutive years from 1990 to 1994 being among the coldest of the entire period for which we have data. A slight warming of the CIL began in 1995 and continued in 1996 and 1997. In the summer of 1997, the thickness of the water layer with temperatures lower than 0°C had decreased by approximately ten meters virtually everywhere in the Gulf relative to 1996. This amount of thinning is considerable, as the thickness of the layer with temperatures below 0°C varied between 5 m and 60 m in the various regions of the Gulf in August 1997. A substantial 10 to 30 m thinning relative to 1996 was also observed in the layer of water with temperatures below 3°C, the amplitude of the thinning being greater in some regions than in others.

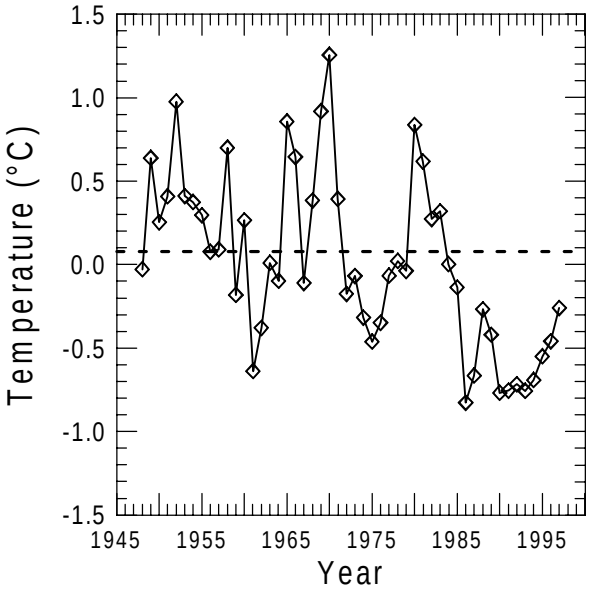


*Figure 6. Composite index of CIL core temperature anomaly in the Gulf of St. Lawrence (normal = 0.08°C).*

## *September bottom temperature in the southern Gulf*

The region of the Gulf where bottom temperatures are most likely to be affected by the cold intermediate layer is the southern Gulf, where a large expanse of the sea bed lies within the depth range of this cold layer. In September 1997, we estimated that the bottom temperature was lower than 1°C over an area of 32 800 km$^2$, and lower than 0°C over an area of 9 200 km$^2$ in the southern

Gulf (Figure 7). The bottom area with a temperature lower than 1°C decreased by almost 10 % compared to 1996, whereas the bottom area with a temperature lower than 0°C decreased 40 %. Notable warming was thus observed in the Magdalen Shallows region, although the bottom areas covered by cold water still remain a little higher than normal (Figure 7).

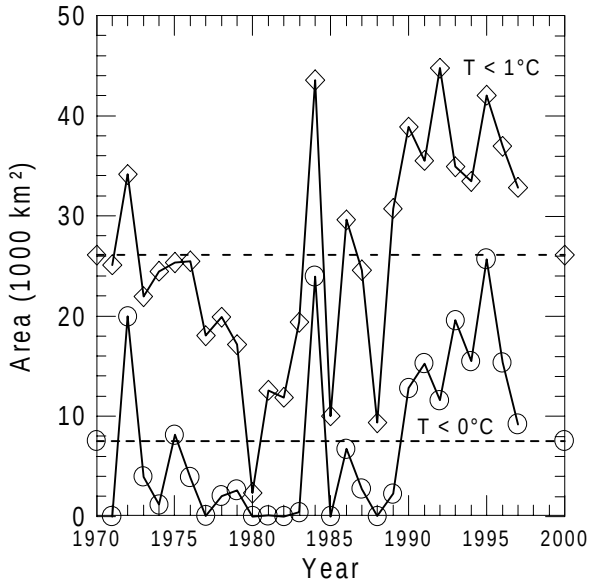


*Figure 7. Bottom area with T < 0°C (circles) and T < 1°C (diamonds) in September in the southern Gulf of St. Lawrence. The dashed lines represent the 1971-1997 averages.*

## *Layer-averaged temperatures*

To simplify our analyses of the temperature and salinity measurements carried out during the 1985 to 1997 shrimp and groundfish trawl surveys, we divided 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). We then calculated temperature averages for 21 areas of the Gulf, and from these calculated global indices of temperature for the whole Gulf by allotting to each of the 21 areas a weight proportional to its area.

The Gulf-wide average temperature of the 0-30 m layer during the 1997 August-September survey was 10.23°C, some 0.3°C above normal (9.93°C). In the 30-100 m layer, the average temperature was 0.55°C, almost 1°C colder than normal (1.47°C). This shows a continuation of the period with lower than normal temperatures observed for several years in this layer, although a slight warming of 0.25°C occurred in 1997 compared to 1996 (Figure 8). In the 100-200 m layer, temperature increased by 0.7°C relative to 1996, reaching 2.52°C, which is near normal (2.44°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 rose by 0.6°C compared to 1996 in the 200-300 m layer. The temperature of this layer was 5.46°C in 1997, which is 0.66°C warmer than normal (4.80°C).

A longer-term perspective of the tempera-

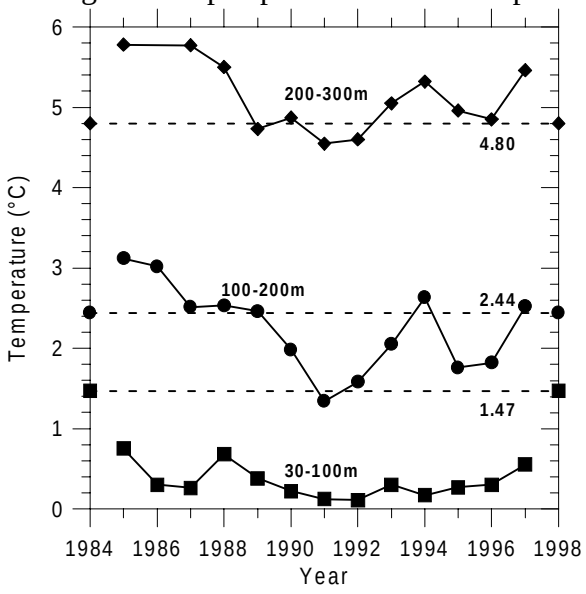


*Figure 8. Layer-averaged temperatures for the whole Gulf of St. Lawrence in August-September. The dashed lines indicate the long-term averages based on the climatological atlas of Petrie et al. (1996).*

ture changes that have occurred in the 200-300 m layer over the last few decades can be seen in the data from the standard Cabot Strait section, where temperature measurements have been made on a regular basis since the early 1950s (Figure 9). The average temperature of the 200-300 m layer at 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. According to measurements made 15 days apart during the fall of 1997, the temperature of the 200-300 m layer in Cabot Strait was between 0.15°C and 0.6°C warmer than normal in 1997.

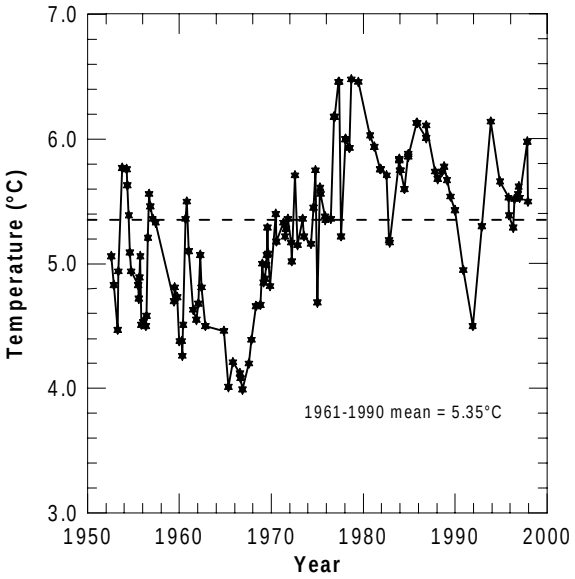


*Figure 9. Average temperature of the 200-300 m layer in the standard Cabot Strait section. The dashed line indicates the 1961-1990 mean.*

## *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 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 and affect the metabolism of other resident species.

Oceanographic monitoring data gathered in late fall since 1981 at standard sections along the Laurentian Channel show that, in Cabot Strait, the dissolved oxygen content of the 200-300 m layer (Figure 10) may fluctuate 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

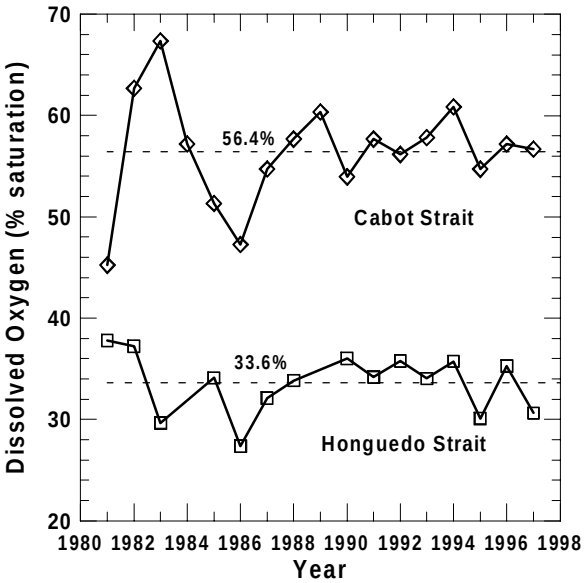


*Figure 10. Dissolved oxygen concentration at two sections along the Laurentian Channel (Figure 1). The dashed lines indicate the 1981-1997 averages.*

dissolved oxygen content of the 200-300 m layer typically ranges from about 25 % to 40 % saturation (Figure 10). 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 1997, the dissolved oxygen content of the 200-300 m layer was very close to the 1981-1997 average in Cabot Strait, and 3 % below average in Honguedo Strait (Figure 10).

## *Outlook for 1998*

The beginning of 1998 was extremely mild throughout Canada because of the ENSO (El-Niño-Southern Oscillation) episode of record amplitude taking place in the area of the equatorial Pacific Ocean. Over the Gulf of St. Lawrence, although departures from normal air temperatures were not as large as in the central and northwestern parts of the country, we experienced a warmer winter (December to February) than normal by 0.5 to 2.0°C, and a warmer spring (March to May) than normal by 1.5 to 2.0°C. The greatest deviations from normal air temperature occurred in February (3 to 4°C) and in May (2 to 3°C). This mild winter was also characterized by less ice than usual in the Gulf of the St. Lawrence. It can thus be expected that the cold intermediate layer should continue its warming trend in 1998. This should result in a further reduction of the bottom area bathed by waters with temperature below 1°C and 0°C in the entire Gulf. In deeper water (100-200 m and 200-300 m layers), temperature measurements taken in the Laurentien channel off Saint-Pierre Bank in 1997 indicate that temperatures will likely remain above normal in the Gulf in 1998.

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