Fisheries and Oceans Canada / Pêches et Océans Canada
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Research Document 2010/035 / **Document de recherche 2010/035**

Physical Oceanographic Conditions in the Gulf of St. Lawrence in 2009

Conditions d'océanographie physique dans le golfe du Saint-Laurent en 2009

P.S. Galbraith[1], R.G. Pettipas[4], J. Chassé[2], D. Gilbert[1], P. Larouche[1], B. Pettigrew[1], A. Gosselin[3], L. Devine[3], C. Lafleur[3]

[1] Ministère des Pêches et Océans, Région du Québec
Direction des sciences océaniques et environnementales, Institut Maurice-Lamontagne
C.P. 1000, Mont-Joli, Québec, G5H 3Z4

[2] Ministère des Pêches et Océans, Région du Golfe

[3] Ministère des Pêches et Océans, Région du Québec
Direction des avis, informations et soutien scientifique, Institut Maurice-Lamontagne
C.P. 1000, Mont-Joli, Québec, G5H 3Z4

[4] Ministère des Pêches et Océans, Région des Maritimes

ISSN 1499-3848 (Printed / Imprimé)
ISSN 1919-5044 (Online / En ligne)

Correct citation for this publication:

Galbraith, P.S., Pettipas, R.G., Chassé, J., Gilbert, D., Larouche, P., Pettigrew, B., Gosselin, A., Devine, L. and Lafleur, C. 2010. Physical Oceanographic Conditions in the Gulf of St. Lawrence in 2009. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/035. iv + 73 p.

ABSTRACT

An overview of physical oceanographic conditions in the Gulf of St. Lawrence in 2009 is presented. Air temperatures were close to normal when averaged from January to March. Air temperatures were in general either normal or above normal for the remainder of the year. The monthly averaged freshwater runoff measured at Québec City was normal overall in 2009 but consisted of above-average runoff in July compensated later by lower runoff in the fall. Near-surface water temperatures in the Gulf were above normal in all regions except the Northwest Gulf and the Estuary in June and in every region in August. Maximum sea-ice volume within the Gulf and on the Scotian Shelf was 65 km³, a value that is below normal using updated ice volume estimates for 1971-2000. The duration of the 2008-09 ice season was longer than normal in the Estuary, normal in the central Gulf and Cabot Strait, and shorter elsewhere. This was mostly associated with the variability of the first occurrence of ice. Winter inflow of cold and saline water from the Labrador Shelf occupied the Mécatina Trough over the entire column in winter 2009. The spread of the intrusion was confined a bit closer to the coast compared to 2008 conditions, leading to an overall smaller volume of 1270 km³, which is similar to the 2002 observations. The winter cold mixed layer volume in the Gulf, excluding the Estuary, was 14 000 km³, a value higher than the 1996–2009 average by 0.7 SD. This cold-water volume corresponded to 42% of the total water volume of the Gulf. The cold intermediate layer (CIL) index for summer 2009 was -0.42°C, which is similar to observations in 2002, 2004, 2005 and 2007. This is an increase of 0.32°C since 2008. On the Magdalen Shallows, almost none of the bottom area was covered by water with temperatures < 0°C in September 2009, similar to conditions in 2005, 2006 and 2007. Regional patterns of the August and September CIL show that the layers for T < 1°C and < 0°C were much thinner in most parts of the Gulf in 2009 than in 2008 and had a generally higher core temperature everywhere. In the northern Gulf, the area covered by low temperature water (< 1°C) decreased in 2009 relative to 2008 conditions. Temperatures in March 2009 were characterized by a very thick cold layer, including a thick intrusion of Gulf CIL waters into the Estuary. By June 2009, CIL temperatures returned to normal with a warming trend that continued into August, especially on the Magdalen Shallows. By October–November, CIL conditions were normal in most regions except the estuary and Northwest Gulf, where the CIL and the surface mixed layer were anomalously deep. Overall, temperature and salinity were generally normal from 150 m to 200 m, and slightly lower than normal at 250 and 300 m. Temperature and salinity at 300 m decreased for a third consecutive year, from 2008 to 2009. The lower-than-normal Gulf-wide water temperatures at 300 m were composed of normal waters in the Estuary and northwest and colder waters in the centre and coming into the Gulf at Cabot Strait. This cold anomaly has propagated inward in the last few years and is expected to continue toward the Estuary during the next few years.

RÉSUMÉ

Le présent document donne un aperçu des conditions d'océanographie physique qui ont prévalu dans le golfe du Saint-Laurent en 2009. La moyenne des températures de l'air établie pour la période allant de janvier à mars a été près de la normale, ce qui a contribué à la formation d'une couverture de glace qui est demeurée juste sous la normale climatologique. En général, les températures de l'air ont été normales ou supérieures à la normale pendant le reste de l'année. L'apport d'eau douce mensuel moyen mesuré à Québec a été normal pour l'ensemble de l'année 2009, mais a été supérieur à la moyenne au cours du mois de juillet et inférieur à la normale à l'automne. Les températures de l'eau près de la surface ont été en général supérieures à la normale dans l'ensemble du golfe à l'exception du nord-ouest du Golfe et de l'Estuaire au cours des mois de juin, et partout en août. Le volume maximal des glaces dans le Golfe et sur le Plateau néo-écossais s'est établi à 65 km³, une valeur sous la normale selon de nouvelles estimations de volumes de glace pour la période s'étendant de 1971 à 2000. La durée de la saison de glace a été plus longue que la normale dans l'Estuaire, normale dans le centre du Golfe et le détroit de Cabot, et plus courte ailleurs. Ceci était associée à une variabilité dans la date d'englacement, la fin de la saison étant normale partout. Les entrées hivernales d'eaux froides et salées du plateau du Labrador ont rempli entièrement la cuvette de Mécatina au cours de l'hiver 2009. La propagation de cette intrusion s'est davantage limitée près de la côte comparativement aux conditions observées en 2008, se traduisant par un volume global plus faible (1270 km³), similaire aux valeurs observées en 2002. Le volume de la couche mélangée d'eau froide d'hiver s'est établi à 14 000 km³, une valeur supérieure de 0,7 fois l'écart type à la moyenne de la période 1996-2009, et correspondait à 42 % du volume d'eau total présent dans le Golfe. L'indice de la CIF (couche intermédiaire froide) d'été pour 2009 s'est établi à - 0,42 °C, ce qui est comparable aux conditions très froides observées en 2002, 2004, 2005 et 2007 et représente une forte augmentation (de 0,32 °C) par rapport à l'été 2008. Sur le Plateau madelinien, presque qu'aucune proportion du fond a été couverte par des eaux de température < 0 °C en septembre 2009, telle qu'observé aussi en 2005, 2006 et 2007. Les profils régionaux de la CIF d'août et de septembre indiquent que les couches où T < 1 °C et < 0 °C ont été beaucoup plus minces dans la plupart des parties du Golfe en 2009 comparativement à 2008 et que la température minimale était en général supérieure dans l'ensemble du Golfe. Dans le nord du Golfe, la superficie couverte par des eaux de faibles températures (< 1 °C) a diminuée en août 2009 par rapport à août 2008. Les températures dans la colonne d'eau observées en mars 2009 ont été caractérisées par une couche de surface froide très épaisse dans la plupart des régions, et particulièrement par une épaisse intrusion des eaux froides du Golfe dans l'Estuaire. Dès le mois de juin, l'épaisseur de la CIF s'était amincie vers des conditions normales et la tendance au réchauffement s'est maintenue jusqu'en août, plus particulièrement sur le Plateau madelinien. En octobre-novembre, les conditions de la CIF était normales presque partout, sauf dans l'Estuaire et le nord-ouest du Golfe où la CIF était profonde ainsi que la couche de surface mélangée. Dans l'ensemble, les températures et la salinité ont été généralement normales à une profondeur allant de 150 à 200 m, et sous la normale à 250 et 300 m. Les températures et la salinité à 300 m ont diminué pour une troisième année consécutive pour atteindre des valeurs sous la normale, composées d'eaux de température normale dans l'Estuaire et le nord-ouest du Golfe et à des températures plus froides dans le centre et s'écoulant dans le Golfe depuis le détroit de Cabot. Cette anomalie froide poursuivra son cours vers l'Estuaire dans les prochaines années.

INTRODUCTION

This paper examines the physical oceanographic conditions and related atmospheric forcing in the Gulf of St. Lawrence in 2009 (Fig. 1). Specifically, it discusses air temperature, freshwater runoff, sea-ice volume, surface water temperature and salinity, winter water mass conditions (e.g., the near-freezing mixed layer volume, the volume of dense water that entered through the Strait of Belle Isle), the summertime cold intermediate layer (CIL), and the temperature, salinity and dissolved oxygen of the deeper layers. It uses data obtained from the Department of Fisheries and Oceans' (DFO) Atlantic Zone Monitoring Program (AZMP), other DFO surveys and other sources. Environmental conditions are usually expressed as anomalies, i.e., deviations from their long-term mean or normal conditions calculated for the 1971–2000 reference period when possible. Furthermore, because these series have different units (^{o}C, m^3, m^2, etc.), each anomaly time series is normalized by dividing by its standard deviation (SD), which is also calculated using data from 1971–2000 when possible. This allows a more direct comparison of the various series. Missing data are represented by grey cells, values within 0.5 SD of the average as white cells, and conditions corresponding to warmer than normal (higher temperatures, reduced ice volumes, reduced cold water volumes or areas) by more than 0.5 SD as red cells, with more intense reds corresponding to increasingly warmer conditions. Similarly, blue represents colder than normal conditions. Higher than normal freshwater inflow and stratification are shown as red, but do not necessarily correspond to warmer than normal conditions. The last detailed report of physical oceanographic conditions in the Gulf of St. Lawrence was produced for the year 2008 (Galbraith et al. 2009).

The summertime water column in the Gulf of St. Lawrence consists of three distinct layers: the surface layer, the cold intermediate layer (CIL) and the deeper water layer (Fig. 2). Surface temperatures typically reach maximum values in mid-July to mid-August. Gradual cooling occurs thereafter, and wind mixing during the fall leads to a progressively deeper and cooler mixed layer, eventually encompassing the CIL. During winter, the surface layer thickens partly because of buoyancy loss (cooling and reduced runoff) and brine rejection associated with sea–ice formation, but mostly from wind–driven mixing prior to ice formation (Galbraith 2006). The surface winter layer extends to an average depth of 75 m and up to 150 m in places by the end of March (intruding waters from the Labrador Shelf at the Strait of Belle Isle may extend to the bottom (>200 m) in Mécatina Trough) and exhibit temperatures near freezing (–1.8 to 0ºC) (Galbraith 2006). During spring, surface warming, sea–ice melt waters and continental runoff produce a lower–salinity and higher–temperature surface layer, below which cold winter waters are partly isolated from the atmosphere and become known as the summer Cold Intermediate Layer (CIL). This layer will persist until the next winter, gradually warming up and deepening during summer (Gilbert and Pettigrew 1997) and more rapidly during the fall as vertical mixing intensifies.

This report considers these three layers in turn. First, a significant driver of the surface layer, the air temperature, is examined, followed by the fresh water runoff. The winter sea ice and winter oceanographic conditions are described, which force the summer CIL that is presented next. The deeper waters, mostly isolated from exchanges with the surface, are presented last along with a summary of major oceanographic surveys.

AIR TEMPERATURE

The monthly air temperature anomalies for several stations around the Gulf are shown in Fig. 3 for 2008 and 2009. Air temperature varied about the mean from January to September without sustained trends. The month of October 2009 was consistently cold at all stations, especially at Daniel's Harbour, and it was followed by a warm month of November, most especially at Mont-Joli and Sept-Îles, and a warm month of December.

The annual mean temperature time series are shown in Table 1 for the nine stations along with their 1971-2000 average. Annual mean air temperatures in 2009 were either normal or above normal at all stations. The average of the nine stations provides an overall temperature index for the entire Gulf which was above normal in 2009 by +0.8 (±0.3) SD. The last negative annual anomaly occurred in 2002, and the last negative anomaly greater than 0.5 SD occurred in 1993.

A bulk air-temperature winter-severity index is also shown in Table 1. This index, which was constructed by averaging the air temperatures of all stations sampled from January to March of each year, was near-normal in 2009 and made up of near-normal values at all but one station. Temporally, it was composed of a cold anomaly for the month of January, warm for February and cold again for March. Air temperatures were almost as cold in March (-6.1^{o}C) as they were in February (-7.3^{o}C) in absolute terms.

Fig. 4 shows the annual and seasonal mean air temperature anomalies averaged over the nine stations since 1945. Again, this shows that the above-normal 2009 annual conditions resulted from near-normal winter temperatures, slightly warmer than normal spring and summer values and warmer than normal values during fall. A warming trend in the annual air temperature since 1971 does not persist when the time series is considered back to 1945, however a warming trend is found for Pointe-au-Père and Charlottetown between the 1880s and the early 1950s (not shown) of 0.8 to 2 ^{o}C per 100 years.

PRECIPITATION AND FRESHWATER RUNOFF

Runoff data were obtained from the St. Lawrence Global Observatory (http://ogsl.ca/en/runoffs/data/tables.html), where they are updated monthly (D. Lefaivre Institut Maurice-Lamontange, DFO) using the water level method from Bourgault & Koutitonsky (1999). The annual average runoff measured at Québec City was close to normal overall in 2009 (Fig. 5), but consisted of above-normal runoff in July, compensated later by lower-than-normal runoff in the fall. This pattern resembled observations of 2008, but to a lesser degree. The much-higher than normal runoff that occurred in summer 2008 (and its associated low salinity), contributed to higher-than-normal stratification and a strong toxic algae bloom in the St. Lawrence estuary in August (M. Scarratt, IML, pers. comm.).

SURFACE LAYER

The May to November expected cycle of weekly averaged surface temperature is illustrated in Fig. 6 using a 1985-2008 climatology based on AVHRR remote sensing data for ice-free months, complemented by 2001-2008 thermosalinograph data for the winter months. Maximum temperatures are reached on average during the second week of

August, but can vary by up to several weeks from year to year. The maximum surface temperature averages 15.1ºC over the Gulf, but there are spatial differences; temperatures on the Magdalen Shallows are the warmest of the Gulf, averaging 17.4ºC over the area, and the coolest are at the head of the St. Lawrence estuary and upwelling areas along the lower North Shore. Thermosalinograph data (not shown) have demonstrated that the cooling of offshore surface waters of the Gulf during fall and winter first reaches near-freezing temperatures in the Estuary, then progresses eastward with time, usually just reaching Cabot Strait by the end of the winter. The exception is the head of the St. Lawrence estuary (Fig. 6); the upwelling and mixing of the CIL in the surface layer in this area keep the waters cool in summer and well above freezing in winter.

The surface layer conditions of the Gulf are monitored by various complementary methods. The shipboard thermosalinograph network typically provides year-round, near real-time coverage and is especially useful for monitoring the winter freeze-up and the evolution of the spring thaw. Its drawbacks are that it provides data only along the main shipping route and that semi-weekly ship tracks are irregular both in time and in the position where each longitude is crossed. No thermosalinograph data are available for 2009. The second data source is from the thermograph network (Fig. 7). It provides an inexpensive, growing record of near-surface temperatures at fixed stations and at short sampling intervals, but not (for the most part) in real-time nor during winter months. However, its coverage of the southern and northeastern Gulf, areas not sampled by the thermosalinograph network, is very informative. It also provides station climatologies based on more years of data than the thermosalinograph network. NOAA satellite remote sensing, the third tool, provides 1-km spatial resolution of ice-free waters with data back to 1985.

THERMOGRAPH NETWORK

The thermograph network, described in detail in previous reports (Gilbert et al. 2004, Galbraith et al. 2008), consists of a number of stations with moored instruments recording water temperature every 30 minutes (Fig. 7). Most instruments are installed on Coast Guard buoys that are deployed in the ice-free season, but a few stations are occupied year-round. The data are typically only available after the instruments are recovered except for the five oceanographic buoys that transmit data in real-time. Data from Shediac station acquired by the DFO Gulf Region are also shown.

In order to compare the 2009 observations to temperature measurements from previous years, climatological daily average temperatures were calculated using all available data for each day of the year at each station and depth. Daily averages for all stations are shown in Fig. 8, 9 and 10, along with daily climatologies (± 1 SD; shown in blue). Monthly average temperatures are also shown, with the magnitude of their anomaly colour-coded. Table 2 repeats these average monthly temperatures for each station at shallow sampling depths (< 20 m) for 2008 and 2009. The colour-coding of the scorecard is done according to the normalized anomalies using each station's climatology for individual months.

Monthly anomalies were fairly consistent across all stations of each of the three regions listed in Table 2. May to July near-surface water temperatures were generally below normal in the Estuary and northwest Gulf, and above normal in August and October. Near-surface waters at the lower north shore stations were also below normal in May and September, but they were normal to above-normal from June to August. Except for normal temperatures in May conditions at the southern Gulf stations were similar to those of the Estuary. The warmest anomalies occurred in August in the Estuary, the northwest Gulf and the lower north shore, but during the same month near-surface anomalies were normal or below-normal in the southern Gulf. Overall, summer temperatures were much cooler than during the summer of 2008.

Table 3 shows similar information as Table 2, but for thermograph sensors moored deeper than 20 m. The deep (> 300 m) waters of the Estuary and northwest Gulf show below average temperatures in 2009 compared to normal values in 2008. The bottom (82 m) temperatures at Shediac Valley station show a return to normal temperatures after very cold conditions in 2008.

Table 4 shows the history of monthly averaged temperature anomalies for selected stations both in the northeastern and southern Gulf. The cold period from 1993 to 1998 (except 1996) is evident at Île Shag (as it was for air temperature in Table 1), and this long record helps to put the current year into perspective. In the summer of 2009, near-surface temperatures were variable without a consistent pattern throughout the period.

NOAA SATELLITE SST

The 2009 quasi-monthly mean sea-surface temperatures are shown in Fig. 11 as colour-coded maps, and temperature anomalies with respect to the 1985-2009 monthly climatology are shown in Fig. 12. These maps are generated using National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer (AVHRR) satellite images available from the Maurice Lamontagne Institute sea surface temperature processing facility. The raw data acquired by the three DFO and four NOAA satellite receiving stations are processed using the Terascan software to detect clouds, correct navigation errors and project the results onto a national geo-referenced grid of 1 km resolution covering all Canadian waters. The processing also includes a temporal consistency check using sequences of individual images. Mean sea surface temperatures at each grid node are then calculated for every averaging period of 1, 3, 5 and 7 days (and also for a period of 15 days for data acquired in 2009). Here, the area covering the Gulf is extracted from four successive 7-day-mean images for each month and are averaged together to produce a mean for the first 28 days of each month, hence the quasi-monthly mean. The anomalies are shown only for the months of May to November when coverage is complete, because ice cover biases the results for the other months. April is included only for the usually ice-free Estuary and Northwest Gulf.

Fig. 12 is in relative agreement with the thermograph measurements that have climatologies spanning fewer years. The NOAA SST information is summarized on Table 5, showing the 2008 and 2009 monthly surface temperature anomalies spatially averaged over the Gulf and over each of the eight regions delimited by the areas shown in Fig. 13, and further into sub-regions of the Estuary as shown in Fig. 14. Near-surface water temperatures in the Gulf were above normal in all regions except the Northwest Gulf and the Estuary in June and in every region in August. Some warm anomalies during July along the lower north shore were confined close (Fig. 12) to shore and were also observed at coastal thermograph stations (Table 2); they were presumably caused by less frequent than normal cold upwelling events. Water temperatures were below normal in Mécatina Trough and Esquiman Channel in October, consistent with well below normal air temperatures at Blanc Sablon and Daniel’s Harbour. Air temperature in November was exceptionally warm throughout the Gulf yet surface water temperatures were only above-normal in the western half of the Gulf. This is consistent with the October surface water temperature cold anomaly in eastern areas of the Gulf that had to be warmed to reach positive anomalies.

Table 6 and Table 7 show the full 1985-2009 time series of monthly surface temperature anomalies spatially averaged over the Gulf of St. Lawrence and over the eight regions of the Gulf. These results show that, over the spatial scale of the Gulf, the warm anomalies observed in 1999 and 2006 are still exceptional. While none of the regions exhibited outstanding conditions in 2009, they each only had only one month with below-normal surface temperatures, several with above-normal conditions and two to four months of near-normal conditions.

Sea-surface temperature monthly climatologies and time series were also extracted for more specific regions of the Gulf. The monthly average SST for the St. Lawrence Estuary as a whole (region 1) is repeated in Table 8 along with averages for the Manicouagan Marine Protected Area (MPA), the St. Lawrence Estuary MPA and the Saguenay – St. Lawrence Marine Park (Fig. 14). The overall pattern is similar across regions, but there are differences associated with episodic local events such as eddies and upwelling. The climatology averages also differ. For example, the Manicouagan maximum monthly average temperature is 0.8°C warmer than for the Estuary as a whole. The common feature among most regions for 2009 is the positive anomaly in August.

The Magdalen Shallows, excluding Northumberland Strait, are divided into western and eastern areas as mapped on Fig. 15. The monthly average SST for the Magdalen Shallows as a whole (region 8) is repeated in Table 9 along with averages for the western and eastern areas. Climatologies differ by roughly 0.5°C between the western and eastern regions. The common features among regions are the positive anomalies in May and June, negative in July, followed by a positive anomaly in August, normal conditions for Sep and Oct, and positive anomalies in Nov.

An interesting new product this year is the number of weeks in the year that the mean weekly temperature is above 10°C for each pixel (Fig. 16, Table 10). Summer surface temperature conditions are integrated here into a single chart. The anomalies for 2009 are shown in Fig. 17. The Estuary had near-normal to below-normal summer surface temperature conditions while the rest of the Gulf experienced a near-normal to above-normal number of weeks with mean surface temperatures above 10°C.

SEA ICE

The ice volume is estimated using a different database than in last year's report (Galbraith et al. 2009). This year, it is estimated from a gridded database of ice cover and ice categories obtained from the Canadian Ice Service, consisting of weekly files for 1969-1997 and daily files thereafter. Standard average thicknesses are attributed to each ice category to estimate the volume. The new data lead to similar estimates of ice volumes as reported in last year's review, with small differences in volumes calculated for the 1970s.

Sea ice is typically produced in the northern parts of the Gulf and drifts towards the Îles-de-la-Madeleine and Cabot Strait during the ice season. The maximum ice thickness that occurred in 2009 is shown in *Fig. 18* and compared with minimum and maximum conditions observed in 1969 and 2003. The combined Gulf and Scotian Shelf ice volume shown in the top panel of Fig. 19 is indicative of the total volume of ice produced in the Gulf, including the advection out of the Gulf, but it also includes the thicker sea ice that drifts into the Gulf from the Strait of Belle Isle. The highest ice volumes of the time series occurred in 1993 and 1994. The volume shown on the bottom panel of Fig. 19

corresponds to that found seaward of Cabot Strait and represents the volume of ice exported from the Gulf (although not the total export since it melts on the Shelf before the end of the ice season). Table 11 shows the day of first and last occurrence of ice in each of the regions of the Gulf of St. Lawrence, extracted from the same database, as well as duration of the ice season and maximum observed volume during each season. Caution should be used in over interpreting the table since the database from which it is produced is coarse in time resolution (weekly) up to 1997.

The correlation between annual maximum ice volume and the air-temperature winter-severity, both repeated in Table 12, accounts for 63% of the variance using the 1970-2009 time series.

In 2009, the Gulf and Shelf maximum ice volume was 65 km³, 0.5 SD below the 1971-2000 climatological mean and fairly consistent with the -0.2 SD near-normal air-temperature winter-severity index (the January to March air temperature average). The duration of the 2008-09 ice season was longer than normal in the Estuary, normal in the central Gulf and Cabot Strait, and shorter elsewhere. This was mostly associated with the variability of the first occurrence of ice (Table 11).

WINTER WATER MASSES

A wintertime survey of the Gulf of St. Lawrence waters (0–200 m) has been undertaken in early March since 1996 using a Canadian Coast Guard helicopter. This has added a considerable amount of data to the previously very rare winter data for the region. The survey, sampling methods and results concerning the cold-water volume formed in the Gulf and the estimate of the water volume advected into the Gulf via the Strait of Belle Isle over the winter are described in Galbraith (2006) and in Galbraith et al. (2006). Ninety stations were sampled during the 9–17 March 2009 survey using 41.5 flight hours. Fig. 20 and Fig. 21 show gridded interpolations of near-surface temperature, temperature above freezing, salinity, cold layer thickness and where it contacts the bottom, and thickness of the Labrador Shelf intrusion for 2008 and 2009. Interpolations for all years were reanalyzed for this report using the new 500-m resolution bathymetry grid and now include the Estuary.

The surface mixed layer is usually very close (within 0.1°C) to the freezing point in many regions of the Gulf in March, and this was the case in 2009. During winter, slightly warmer water (~ 0°C to -1°C) may enter the Gulf on the northeast side of Cabot Strait and flow northward along the west coast of Newfoundland. However, this inflow affected only a small area in 2009.

Near-freezing waters with salinities of around 32 are responsible for the (local) formation of the CIL since that is roughly the salinity at the temperature minimum during summer. These are coded in blue in the salinity panel of Fig. 20 and are typically found to the north and east of Anticosti Island. These waters were displaced by higher-salinity waters intruding into Mécatina Trough (see below). Surface salinities were generally high in Anticosti Gyre and Honguedo Strait, with the low salinity Gaspé Current restricted to the proximity of the Gaspé Peninsula.

Near-freezing waters with salinity >32.35 (colour-coded in violet) are considered to be too saline to have been formed from waters originating within the Gulf (Galbraith 2006) and are presumed to have been advected from the Labrador Shelf through the Strait of Belle

Isle. These waters occupied the surface over the Mécatina Trough. An estimate of the thickness of this intrusive layer is shown in the top panels of Fig. 21. It occupied the Mécatina Trough from top to bottom again in winter 2009 (up to 235 m depth); however, its spread was confined slightly even closer to the coast compared to 2008 conditions, leading to an overall smaller volume. The recent history of Labrador Shelf water intrusions is shown in Fig. 22 where its volume is shown as well as the fraction it represents of all the cold water volume in the Gulf. Volumes calculated with the bathymetry used in last year's report (Galbraith et al. 2009) are also shown, differing slightly with the new calculations. The volume and percentage were near but below normal in March 2009 at 1270 km³ (-0.4 SD) and 9% (-0.5 SD), similar to the 2002 values.

The cold (< -1°C) mixed layer depth typically reaches about 75 m in the Gulf, but in 2009 this layer was thicker than usual (see middle panels of Fig. 21). The cold surface layer is the product of local convection as well as cold waters advected from the Labrador Shelf, and can consist either of a single water mass or of layers of increasing salinity with depth. Integrating the cold layer depth over the area of the Gulf (excluding the Estuary) yields a cold-water volume of 14 000 km³, higher than the 1996–2009 average by 0.7 SD. This is somewhat surprising considering the near-normal winter air temperatures. This volume of cold water corresponds to 42% of the total water volume of the Gulf (33 300 km³, excluding the Estuary). The time series of winter cold water volume observed in the Gulf, excluding the estuary, is shown in Table 12.

Of particular note for 2009 is the very thick cold layer observed in the Estuary. Winter surface waters formed within the Estuary have lower salinity than those formed in the Gulf (Galbraith, 2006). Below this surface layer, and separated by a thin warm layer, a thick cold layer was observed. It had salinities associated with the winter cold surface layer of the Gulf and was presumably being advected upstream by estuarine circulation. This type of intrusion towards the head of the Channel normally occurs later in the spring. The high volume observed in the Estuary brings the overall cold water volume to 14 500 km³.

COLD INTERMEDIATE LAYER

PREDICTION FROM THE MARCH SURVEY

The summer CIL minimum temperature index (Gilbert & Pettigrew, 1997) has been found to be highly correlated with the total volume of cold water (< -1°C) measured the previous March (Galbraith, 2006). This is expected because the CIL is the remnant of the winter cold surface layer. A measurement of the volume of cold water present in March is therefore a valuable tool for forecasting the coming summer CIL conditions. The updated relation for 2009 is shown in Fig. 23 and uses volumes recalculated this year with the new bathymetry grid. The above-normal volume of cold water (14 000 km³, excluding the Estuary) observed in March 2009 gives a CIL minimum temperature index forecast of -0.5°C based on the correlation between the winter cold-water volume and the summertime CIL index for 1996–2009 (excluding 1998). This is a fairly significant revision from the prediction of -0.58°C published in Galbraith et al. 2009, and is a result of the volume recalculations using the new bathymetry grid. Part of the CIL index variability is associated with the volume of the Labrador Shelf water intrusion. Indeed, the linear relation between winter cold-water volume and the summer CIL index implies that the 1270 km³ intrusion accounts for a 0.2°C cooling of the CIL index.

UPDATE OF THE AUGUST CIL TIME SERIES BASED ON THE MULTI-SPECIES SURVEY

The CIL minimum temperature and the CIL thickness and volume for T < 0°C and <1°C were estimated using temperature profiles from all sources for the months of August and September. The majority of the data come from the multi-species surveys in September for the Magdalen Shallows and August for the rest of the Gulf. The CIL minimum temperature grid was calculated by first finding the minimum temperature and its depth for each profile. Each cast must have at least some data between 30 and 120 m to be considered. The temperature minimum is defined as simply the lowest recorded temperature for casts with data >100 m. For shallower casts, a temperature minimum is considered only if the temperature rises by at least 0.5°C below the minimum. The CIL minimum temperatures and core depths are then interpolated to a regular grid, and a mask of where a CIL core was found is also interpolated. This interpolated minimum temperature grid is then checked at every grid point. Interpolated minimum temperatures are removed (and blanked) from the grid if the interpolated core depth is deeper than local bathymetry, or if the interpolated core-presence mask implies that there should be no CIL core at the location.

The CIL thickness was calculated by interpolating both the over and underlying CIL isotherms on a regular grid and then checking the bathymetry at every grid point to see if the interpolated isotherms reach the bottom. If so, the thickness at the grid point was reduced appropriately. Again, the thicknesses shown for prior years differ from those in last year's report because of the change in bathymetry used in calculations to the the 500-m nominal resolution grid provided by DFO's Canadian Hydrographic Service..

Fig. 24 shows the gridded interpolation of the CIL thickness < 1°C and < 0°C and the CIL minimum temperature for August–September 2008 and 2009. Except for Mécatina Trough, it is apparent that the CIL thickness < 1°C and < 0°C was thinner in 2009 than in 2008 and had a generally warmer core temperature. Similar maps were produced for all years back to 1971 (although some years have no data in some regions), allowing the calculation of volumes for each region for each year. All maps and volumes were recalculated this year to account for the new bathymetry data, but only minor differences occur in the results. The time series of the regional CIL volumes are shown in Fig. 25 (for < 0°C and < 1°C) and in Table 12 (for < 1°C). All regions show an increased CIL (<1°C) volume in 2009 compared to 2008, although this increase was very slight in the Estuary and Mécatina Trough. Fig. 26 shows the average CIL core temperature and the total volume of CIL water (< 0°C and < 1°C) of the August–September interpolated grids (e.g., Fig. 24). The CIL volume as defined by either temperature decreased significantly compared to 2008 conditions to reach lower than normal volumes.

The time series of the CIL regional average core temperatures are shown in Fig. 27 (also recalculated since last year's report to account for the intersection of the CIL with the bottom). All regions show an increase in core temperature. The 2009 average temperature minimum over the entire interpolated grid was -0.20°C and is shown in Fig. 26 (bottom panel, blue line). This is an increase of 0.35°C since 2008. The overall 2009 CIL water mass properties were similar to those observed in 2002, 2004, 2005 and 2007.

NOVEMBER CIL CONDITIONS IN THE ST. LAWRENCE ESTUARY

The AZMP November survey provides a high resolution conductivity-temperature-depth (CTD) sampling grid in the St. Lawrence estuary since 2006. This allows the finer display of the CIL thickness and minimum temperature in the Estuary (Fig. 28), showing the CIL erosion and warming spatially towards the head of the channel, and temporally since the August survey (*Fig. 24*). The overall volumes and average minimum temperature are shown in Fig. 25 and Fig. 27, as well as in Table 12. The CIL was thinner and much warmer in November 2009 than in 2008. Fig. 25 in particular shows the fairly rapid decrease of the CIL volume occurring between August and November 2009, although CIL conditions were normal in November 2009.

UPDATE OF THE GILBERT & PETTIGREW (1997) CIL INDEX BASED ON ALL AVAILABLE DATA

The Gilbert & Pettigrew (1997) CIL index is defined as the mean of the CIL minimum core temperatures observed between 1 May and 30 September of each year, adjusted to 15 July. It was updated using all available temperature profiles measured within the Gulf between May and September inclusively since 1947 (black line of the bottom panel of Fig. 26, and Table 12). As expected, the CIL core temperature interpolated to 15 July is almost always colder than the estimate based on August and September data for which no temporal corrections were made. This is because the CIL is eroded over the summer and therefore its core warms over time.

This CIL index for summer 2009 was -0.42°C. The 0.32°C increase from the summer of 2008 CIL index of -0.70°C is consistent with the sharp decrease in CIL volume between August 2008 and 2009 discussed above, and the increase of 0.35°C in the areal average of the minimum temperature in August. This large increase of the index returned it to a near-normal value.

It may seem very surprising that the winter conditions were slightly colder in 2009 than in 2008, with a higher volume of water colder than -1°C, yet the summer CIL conditions were much warmer in 2009 than in 2008. However, the 2008 summertime CIL was unexpectedly cold relative to the prediction based on March 2008 observations. It was hypothesized in Galbraith et al. (2009) that the difference was likely caused by the very cold air temperatures that prevailed in March 2008 after the winter survey, delaying ice melt and spring warming in the Gulf, combined with increased 2008 summertime stratification that limited the erosion of the CIL by mixing. Therefore, we may consider that it was the 2008 summer CIL conditions that were anomalously cold and the 2009 conditions closer to expectations.

Nevertheless, the more rapid warming and thinning of the CIL in the summer of 2009 (as observed above most noticeably on the Magdalen Shallows) might be due to increased exchanges between the Gulf and adjoining areas; a possible mechanism to investigate is whether cold water left the Gulf through the Strait of Belle Isle, compensated by warmer inflow through Cabot Strait. This hypothesis is supported by the anomalously large estuarine intrusion of Gulf winter waters into the Estuary as early as March, indicating enhanced circulation in the Gulf.

BOTTOM WATER TEMPERATURES AFFECTED BY THE CIL

MAGDALEN SHALLOWS

Measurements from the September multi-species survey (1971–present) on the Magdalen Shallows were combined with other available data from the same area to map bottom temperature. Bottom temperatures typically range from <1°C to >18°C and are mostly depth-dependent (*Fig. 29*). The deeper areas (50–80 m) are typically covered by waters with temperatures <1°C, which have slowly warmed since the previous winter.

Bottom temperature anomalies were only slightly negative close to the Îles-de-la-Madeleine, normal in deeper parts of the Shallows and above normal to the west and south in shallower waters (Fig. 25 and also later Fig. 33 using a higher-resolution anomaly scale). The coastal anomalies must be viewed with caution because of high temporal variability of bottom temperatures at depths close to the thermocline. At these depths, the mixed layer may extend to the bottom one day and not on the next, perhaps in response to wind forcing. However, the anomalies are spatially uniform in 2009 and are likely not artefacts.

Relative to 2008, bottom temperatures during the 2009 multi-species survey were significantly warmer over the Magdalen Shallows while some coastal areas were cooler (Fig. 31). Time series of the bottom area covered by various temperature intervals were estimated from the gridded temperature data (Fig. 32). Unlike the very cold conditions observed on the bottom in 2008, almost none of the bottom was covered by water with temperatures < 0°C in 2009, similar to conditions in 2005, 2006 and 2007. The time series of areas of the Magdalen Shallows covered by water colder than 0, 1, 2 and 3°C are also shown in Table 12. Waters colder than these thresholds covered less of the bottom than normal in 2009. This pattern was consistent with the return of normal temperatures throughout the summer at the 82 m thermistor at the Shediac Valley station of the thermograph network (Table 3) after cold anomalies in the summer of 2008.

Another longstanding assessment survey covering the Magdalen Shallows takes place in June for mackerel. Temperature profiles from these surveys have been objectively interpolated on a regular grid. Table 13 shows the time series of depth-layer temperature averages over the interpolation grids at 0, 10, 20, 30, 50 and 75 m for all years when interpolation was possible, as well as SST June averages since 1985, for both western and eastern regions of the Magdalen Shallows as shown in Fig. 15. This analysis again shows that near-bottom waters were warmer in 2009 than in 2008, although still near-normal in June. Anomalies were warmer in the eastern shelf than on the western shelf.

NORTHERN GULF

Bottom temperatures are obtained for all regions of the Gulf by combining the CTD surveys for the northern Gulf in August and for the Magdalen Shallows in September. An objective analysis interpolation is used to produce a map of bottom water temperatures for the entire Gulf based on these surveys (Fig. 33), which is similar to Fig. 29 for the southern Gulf. Again, bottom temperature contours generally follow the bathymetry, but the Mécatina Trough nevertheless stands out with very cold bottom waters in a wider range of water depth due to the intrusion of cold Labrador Shelf waters. Fig. 34 shows the bottom water temperature anomaly referenced to the 1971–2000 climatology. The reader is cautioned that temperature variability is much lower in the deeper waters such that the white areas in the Laurentian channel may not all represent normal temperatures even though they are within 0.5°C of the mean climatology. Fig. 33 and Fig. 34 show Mécatina Trough, parts of Beaugé Bank and the Jacques Cartier Strait to have anomalously cold bottom water, while the bank east of Anticosti Island was covered by above-normal bottom waters. However the cold anomaly was not observed at the Beaugé Bank station of the thermograph network throughout the summer months (Table 2).

Fig. 35 shows the time series of the bottom area covered by various temperature intervals in the northern Gulf (the Gulf, excluding the region already covered by Fig. 29). The figure shows compression of the bottom habitat area in the temperature range of 5°C to 6°C in 1992. Although this figure shows much less variability than on the Magdalen Shallows (Fig. 32), a decrease in the area covered by cold water was observed in 2009 for temperatures < 0°C (33% decrease from 22.5 to 15.1 $\times 10^3$ km²) and < 1°C (17% decrease from 39.1 to 32.3 $\times 10^3$ km²).

SEASONAL AND REGIONAL AVERAGES OF TEMPERATURE PROFILES

In order to show the seasonal progression of temperature profiles, regional averages are shown in Fig. 36 through Fig. 39 based on the data collected during the March helicopter survey, the June AZMP survey, the August multi-species survey (September survey for region 8) and the November AZMP survey. The temperature scale was adjusted to highlight the CIL and deep water features; the display of surface temperature variability is best suited to other tools such as remote sensing and thermographs. During the surveys, a total of 85 CTD casts in March, 88 casts in June, 109 casts in August, 157 in September and 121 in October–November were obtained. More casts than usual were done in the Estuary during the October–November 2009 survey. Fig. 37 and Fig. 38 also include data from other summertime surveys, most notably in the southern Gulf in June.

Monthly temperature and salinity climatologies for 1971–2000 were constructed for various depths using a method similar to that used by Petrie et al. (1996) but using the new geographical regions shown in Fig. 13. All available data obtained during the same month within a region and close to each depth bin are first averaged together for each year. Monthly averages from all available years and their standard deviations are then computed. This two-fold averaging avoids the bias that occurs when the numbers of profiles in any given year are different. The temperature climatologies are shown in grey as the mean value plus and minus one standard deviation (Fig. 36-39).

The March water temperature conditions were discussed at length in earlier sections and are included here for completeness (Fig. 36), but caution is needed in interpreting the mean profiles. Indeed, regional averaging of winter profiles does not work very well in the northeast Gulf (regions 4 and 5) because very different water masses can be averaged together: the cold Labrador Shelf intrusion with saltier and warmer deeper waters of Esquiman Channel. For example, the sudden temperature decrease near the bottom of the Esquiman Channel for the 2009 regional average was resulted from the last few bins of the deepest cast used in the average which contained a mixture of the Labrador Shelf intrusion. Large changes near 200 m are due to our usual sampling cutoff near 200 m for the March airborne survey and some casts being slightly deeper than others. In particular, the unusual temperature between 200 and 300 m in the mean profile for the Northwest Gulf (region 2) appears because only one station, the Anticosti Gyre AZMP station, is sampled beyond 200 m. The highlight of March water temperatures shown in Fig. 36 is the previously discussed thick near-surface cold layer in the Estuary, well beyond the climatological values.

Temperatures in June 2009 (Fig. 37) were characterized by a return to normal CIL conditions, even thin in the Estuary; furthermore, near-normal CIL conditions prevailed elsewhere, in stark contrast to June 2008 conditions. Warm deep waters persisted in the Estuary, but temperatures were normal in northwest Gulf after being above-normal there a year earlier. This overall pattern persisted in the August–September mean conditions (Fig.

38) with an enhanced warming of the CIL in the northwest Gulf and on the Magdalen Shallows. The discontinuities near 175 m in the 2009 average temperature profile for Mécatina Trough are caused by the large horizontal gradient in deep water properties there, sampled by only three deep casts that end at different depths. By October–November (Fig. 39), CIL conditions were normal in most regions except the Estuary and Northwest Gulf, where the CIL and the surface mixed layer were anomalously deep. Average discrete-depth layer conditions are summarized for the months of the 2008 and 2009 AZMP surveys in Table 14. The deep surface mixed layer and deep CIL of the Estuary and Northwest Gulf result in strong positive temperature anomalies in the top 50 to 75 m.

DEEP WATERS (> 150 m)

The deeper water layer (>150 m) below the CIL originates at the entrance of the Laurentian Channel at the continental shelf and circulates towards the heads of the Laurentian, Anticosti and Esquiman Channels without much exchange with the upper layers. The layer from 150 to 540 m is characterised by temperatures between 2 and 6°C and salinities between 32.5 and 35 (Fig. 40). Inter–decadal changes in temperature, salinity and dissolved oxygen of the deep waters entering the Gulf at the continental shelf are related to the varying proportion of the source cold-fresh and high-dissolved-oxygen Labrador Current Water and warm-salty, low-dissolved-oxygen Slope Water (McLellan 1957, Lauzier and Trites 1958, Gilbert et al. 2005). These waters travel from Cabot Strait to the Estuary in roughly three to four years (Gilbert 2004), decreasing in dissolved oxygen from in-situ respiration and oxidation of organic material as they progress to the channel heads. The lowest levels of dissolved oxygen are therefore found in the deep waters at the head of the Laurentian Channel in the Estuary.

TEMPERATURE AND SALINITY

The calculation of monthly temperature and salinity climatologies mentioned earlier using a method similar to that of Petrie et al. (1996) also provides time series of monthly averaged values. These were averaged into regional yearly time series that are presented in *Table 15* for 200 and 300 m. The 300 m observations in particular suggest that temperature anomalies are advected up-channel from Cabot Strait to the northwestern Gulf in two to three years, consistent with the findings of Gilbert (2004). The regional averages are weighted into a Gulf-wide average in accordance to the surface area of each region at the specified depth. These Gulf-wide averages are shown for 200, 250 and 300 m in *Table 15* as well as for 150, 200 and 300 m in Fig. 40.

In 2009, the temperature and salinity were generally normal from 150 to 200 m, and slightly below normal at 250 and 300 m. Temperature and salinity at 300 m decreased for a second consecutive year. The now lower-than-normal Gulf-wide water temperatures at 300 m were composed of normal waters in the Estuary (region 1) and northwest (region 2) and colder waters in the centre (region 6) and coming into the Gulf at Cabot Strait (region 7). This cold anomaly has propagated inward in the last few years and is expected to continue toward the Estuary during the next few years. Waters flowing into Cabot Strait are also progressively cooler. The cooling observed in deep waters of the Estuary is consistent with deep observations of the thermograph network at the Rimouski and Anticosti Gyre stations.

DISSOLVED OXYGEN AND HYPOXIA IN THE ST. LAWRENCE ESTUARY

Fig. 40 shows an update of the Gilbert et al. (2005) oxygen time series, providing the mean dissolved oxygen value at depths ≥295 m in the St. Lawrence Estuary, expressed as a percentage of saturation at surface pressure. Since some of the variability is associated with changing water masses, the temperature at 300 m in the Estuary is also shown.

Table 15 shows regional averages at 300 m since 2000 based on fall CTD data with a dissolved oxygen sensor calibrated against Winkler titrations. These are mostly from the surveys known as Ice Forecast Cruises.

The deep waters of the Estuary were briefly hypoxic in the early 1960s and have consistently been hypoxic at about 19-21% saturation since 1984 (Fig. 40). Dissolved oxygen increased very slightly in 2009 compared with 2008 observations but has remained relatively stable since 2001. The inflow of colder waters to the Estuary ameliorates the hypoxic conditions since these colder waters are typically richer in dissolved oxygen. This is seen from the regional timeseries of *Table 15*, where an overall tendency towards increasing dissolved oxygen during the last decade is observed broadly throughout the Gulf, associated with the change in temperature from the water mixture richer in Labrador Water.

TIME SERIES OF TEMPERATURE AND SALINITY PROFILES AT FIXED AZMP STATIONS

Sampling by the Maurice Lamontagne Institute began in 1996 at two stations (Fig. 41) that were to become part of the AZMP program (Therriault et al., 1998) in the northwest Gulf of St. Lawrence: the Anticosti Gyre (49° 43.0' N, 66°15.0' W) and the Gaspé Current (49° 14.5' N, 66° 12.0' W). Both stations were to be sampled at 15-day intervals, but logistical problems have often led to less frequent sampling (Fig. 41). The AZMP station in the Shediac Valley (47° 46.8' N, 64° 01.8' W) is sampled on a regular basis by the Bedford Institute of Oceanography as well as occasionally by the Maurice Lamontagne Institute during their Gulf-wide surveys. This station has been sampled since 1947, nearly every year since 1957 and more regularly in summer month since 1999 when the AZMP program began. However, prior to 1999 the observations were mostly of temperature and salinity. A station offshore of Rimouski (48° 40' N 68° 35' W) has also been sampled since 1991, typically once a week during summer, less often during spring and fall, but almost never in winter. Of the four stations, the Rimouski station has been sampled with regularity in summertime for the longest period, since 1993.

Isotherms and isohalines as well as monthly averages of layer temperature and salinity, stratification, and CIL core temperature and thickness at <1°C are shown for the Rimouski station in Fig. 42. Similar figures are provided for the Gaspé Current station (Fig. 43), the Anticosti Gyre station (Fig. 44) and the Shediac Valley station (Fig. 45). The scorecard climatologies are calculated from all available data at all stations except for Shediac, where the time series since 1971 is considered (1971-2009).

At the Rimouski station (Fig. 42), the CIL was very thick and cold in March, reaching 150 m depth, but quickly thinned and warmed during the month to reach positive anomalies by June. Salinity in the CIL depth range also started out low and increased to above-normal as early as May, except at 10 to 30 m in July and August where strong summer runoff presumably kept salinity low.

The evolution of the CIL was similar at the Gaspé Current station (Fig. 43), very thick and cold in March, but eroding quickly to reach a normal thickness by May. The thickness remained normal thereafter but the layer average temperatures on the top 75 m continued to increase to positive anomalies by the fall.

The Anticosti Gyre station (Fig. 44) do not experience the same temperature cycle as the other two stations. Although the CIL stayed cooler than normal for most of the summer, its thickness was typically normal. In October, the CIL warmed but thickened to above normal values that increased further in November. Temperature and salinity below 75 m was lower than normal in October and November.

At the Shediac Valley station (Fig. 45), waters were initially cold in March but warmed to near-normal temperatures by May. While temperatures and salinity were variable throughout the year, the overall water column monthly temperature anomalies ranged from near-normal to below-normal.

Table 16 shows the inter-annual variability of some bulk layer averages from May to October for the four stations. From this perspective, the temperature of the top 100 meters was above normal in 2009 at the Rimouski and Gaspé Current stations. Salinity was well below-normal at Rimouski station yet stratification remained normal (indicating that the salinity anomaly extended deeper than 50 m), but was higher than normal at both the Gaspé Current and Anticosti Gyre stations with matching lower-than-normal stratification. The quick progression of the CIL from thick and cold early in the season to thin and warm led to near-normal May to October average CIL indices.

OUTLOOK FOR 2010

Winter 2010 air temperatures were very mild over the Gulf of St. Lawrence, likely caused by a combination of a moderate-to-strong El Niño event and a strongly negative NAO index which both tend to favour warmer-than-normal air circulation over eastern Canada. The January to March average air temperature anomaly over the nine stations of Fig. 3 reached +5.1°C; that broke the record of +5.0°C set in 1958 for this time series that started in 1945. This led to the almost complete absence of sea-ice cover and an anomalously warm winter surface layer, the latter measured during the March 2010 survey (Fig. 46). While the surface mixed layer is usually close to freezing almost everywhere in the Gulf during winter (e.g. Fig. 20), its temperature in March 2010 was approximately 0.7°C to 2°C above freezing everywhere except within the cold intrusion of Labrador Shelf water in Mécatina Trough. It was the first time in the 15 years of the winter survey that such warm conditions were observed. Even if winter conditions return to more typical conditions in 2011, the physical oceanographic conditions observed in 2010 may be typical of the future state of the Gulf under a warming climate scenario.

The volume of near-freezing water is usually a good predictor for the following summer's CIL minimum temperature index (i.e. Fig. 23). During most winters, the bulk of these cold waters have temperatures fairly close to the freezing point and a threshold of -1°C works well to calculate the cold layer volume. This is because waters with temperatures in the vicinity of -1°C are rare; the mixed layer is typically much colder and the waters underneath much warmer. But in March 2010 the mixed layer was generally warmer than this threshold. Only a small water volume of 2800 km^3 had temperatures lower than -1°C (Fig. 46, lower left) and most of it corresponded with or was adjacent to the waters of the Labrador Shelf intrusion into the Gulf that typically occupies Mécatina Trough (Fig. 46, middle right). This indicated that some mixing had likely already occurred between the waters of the intrusion with those locally formed in the Gulf.

In previous mild winters such as 2006, the winter mixed layer was still near-freezing but its thickness was smaller than normal. In 2010, the winter mixed layer was much warmer than normal, but extended over a large thickness. In fact, if waters colder than 0°C are considered, the volume of 14 600 km^3 observed in 2010 is almost equivalent to that measured in 2009 (16 000 km^3, not shown). One hypothesis is that the mixed layer deepened normally in late-fall and early-winter, but heat was not removed sufficiently fast for the layer to reach near-freezing temperatures before the end of the winter. Another possibility is that the early absence of a protective ice cover also allowed more wind energy transfer to mix up heat from the deeper waters into the surface mixed layer. There is some evidence that the stratification was also weaker than normal down to 200 m in the northwest Gulf and in Anticosti Channel.

Therefore, considering that the surface layer was thick in spite of being warmer than normal, the CIL prediction for summer 2010 is based on the volume of the mixed layer and a temperature difference offset to account for the head-start in spring warming. The water volume of 14 600 km^3 would lead to a CIL prediction of -0.6°C, assuming it was the volume of water colder than -1°C. Using that initial guess and the difference between the mean temperature of the mixed winter layer in 2010 and 2009 of approximately 1°C, a prediction of the summer 2010 CIL index of +0.4°C is obtained. If this CIL index materializes, it would be the warmest CIL since 1980 (Fig. 26). Note, however, that while a warm CIL is usually a thin CIL, there is no indication that this will be the case in 2010 since the winter mixed layer was very thick. In fact, this combination of warm yet thick CIL in past summertime oceanographic conditions might be an indicator of previous similarly mild winters, sometime that will be investigated further.

SUMMARY

- Winter air temperatures (Jan.-Mar.) were close to normal (-0.2 SD), fairly consistently with the just below normal (-0.5 SD) maximum ice volume. Air temperatures were in general either normal or above normal for the remainder of the year.

- The annual average runoff measured at Québec City was normal overall in 2009 but consisted of above-average runoff in July compensated later by lower runoff in the fall.

- Near-surface water temperatures were above normal by more than 1 SD in June in all regions of the Gulf except the Northwest Gulf and the Estuary, and in all regions in August.

- Maximum sea-ice volume within the Gulf and on the Scotian Shelf was 65 km^3, a value 0.5 SD below normal using updated ice volume estimates for 1971-2000. The duration of the 2008-09 ice season was longer than normal in the Estuary, normal in the central Gulf and Cabot Strait, and shorter elsewhere. This was mostly associated with the variability of the first occurrence of ice.

- Winter inflow of cold and saline water from the Labrador Shelf occupied the Mécatina Trough over the entire water column in winter 2009 (up to 235 m in depth). The spread of the intrusion was confined slightly closer to the coast compared to 2008 conditions, leading to an overall smaller volume of 1270 km^3, which is similar to the 2002 observations.

- The winter cold mixed layer volume in the Gulf, excluding the Estuary, was 14 000 km^3, a value higher than the 1996–2009 average by 0.7 SD. This layer accounted for 42% of the total water volume of the Gulf.

- The CIL index for summer 2009 was -0.42°C, which is similar to observations in 2002, 2004, 2005 and 2007. This is an increase of 0.32°C since 2008.

- On the Magdalen Shallows, almost none of the bottom area was covered by water with temperatures < 0°C in September 2009, similar to conditions in 2005, 2006 and 2007.

- Regional patterns of the August and September CIL (T < 1°C and < 0°C) were much thinner in most parts of the Gulf in 2009 than in 2008 and had a generally higher core temperature throughout.

- In the northern Gulf, the area covered by low temperature water (< -1°C, < 0°C, < 1°C) decreased in 2009 relative to 2008 conditions.

- March temperatures were characterized by a very thick cold layer, including a thick intrusion of Gulf CIL waters into the Estuary.

- CIL temperatures returned to normal in June with a warming trend that continued into August, especially on the Magdalen Shallows. By October–November, CIL conditions were normal in most regions except the estuary and Northwest Gulf, where the CIL and the surface mixed layer was anomalously deep.

- Overall, temperature and salinity were generally normal from 150 m to 200 m and slightly low at 250 and 300 m. Temperature and salinity at 300 m decreased for a second consecutive year. The lower-than-normal Gulf-wide water temperatures at 300 m were composed of normal conditions in the Estuary and northwest and colder waters in the central region and entering the Gulf at Cabot Strait. This cold anomaly has propagated inward in the last few years and is expected to continue toward the Estuary during the next few years.

ACKNOWLEDGEMENTS

We are grateful to the people responsible for CTD data acquisition during the surveys used in this report:

- Fixed station monitoring: Chief scientist Roger Pigeon and Yves Gagnon scientific personnel Rémi Desmarais, Sylvain Cantin, Marie-Lyne Dubé, Caroline Lafleur, Line McLauglin.
- Rimouski station monitoring: Chief scientist Pierre Joly; scientific personnel Stéphane Plourde, Jean-François St-Pierre, Laure Devine, Caroline Lafleur, Geneviève Perrin, Norman Robinson, Yves Gosselin et Joannie Ferland.
- March 2009 helicopter survey: Chief scientist Peter Galbraith; scientific personnel Rémi Desmarais; helicopter pilot Robert Delisle and aircraft technician Bertran Murray.
- AZMP transects in June: Chief scientist Alain Gagné; scientific personnel Sylvain Cantin, Yves Gagnon, Rémi Desmarais, Marie-Lyne Dubé; the officers and crew of the CCGS *Teleost*.
- Multi-species survey in August: Chief scientists Diane Archambault and Philippe Schwab; scientific personnel Daniel Thibeault, Line McLauglin, Caroline Lafleur, Bernard Pettigrew; the officers and crew of the CCGS *Teleost*.
- AZMP transects in October–November (Ice Forecast Cruise): Alain Gagné and Jacques Gagné ; scientific personnel Daniel Thibeault, Rémi Desmarais; Marie-Lyne Dubé, Laure Devine, Bernard Pelchat, Line McLauglin the officers and crew of the CCGS *Hudson*
- Multi-species survey in September: Tom Hurlbut for providing the CTD data.
- Northumberland Strait survey: Chief scientists Mark Hanson and Joël Chassé.

Data from the following sources are also gratefully acknowledged:

- Runoff at Québec City : Denis Lefaivre.
- Thermograph network: Bernard Pettigrew, Rémi Desmarais, Daniel Thibeault.
- NOAA remote sensing: Pierre Larouche, André Gosselin, Bernard Pettigrew.
- Dissolved oxygen: Alain Gagné, Laure Devine, Pierre Joly, Marie-Lyne Dubé.

All tables and figure were illustrated using the free software Gri (Kelley & Galbraith 2000).

We are grateful to Brian Petrie and Eugene Colbourne for reviewing the manuscript and providing insightful comments.

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Table 1. Mean air temperature standardized anomalies: annual (top) and January-February-March (bottom) averages. The numbers on the right are the 1971–2000 climatological means and standard deviations. The numbers in the boxes are standardized anomalies.

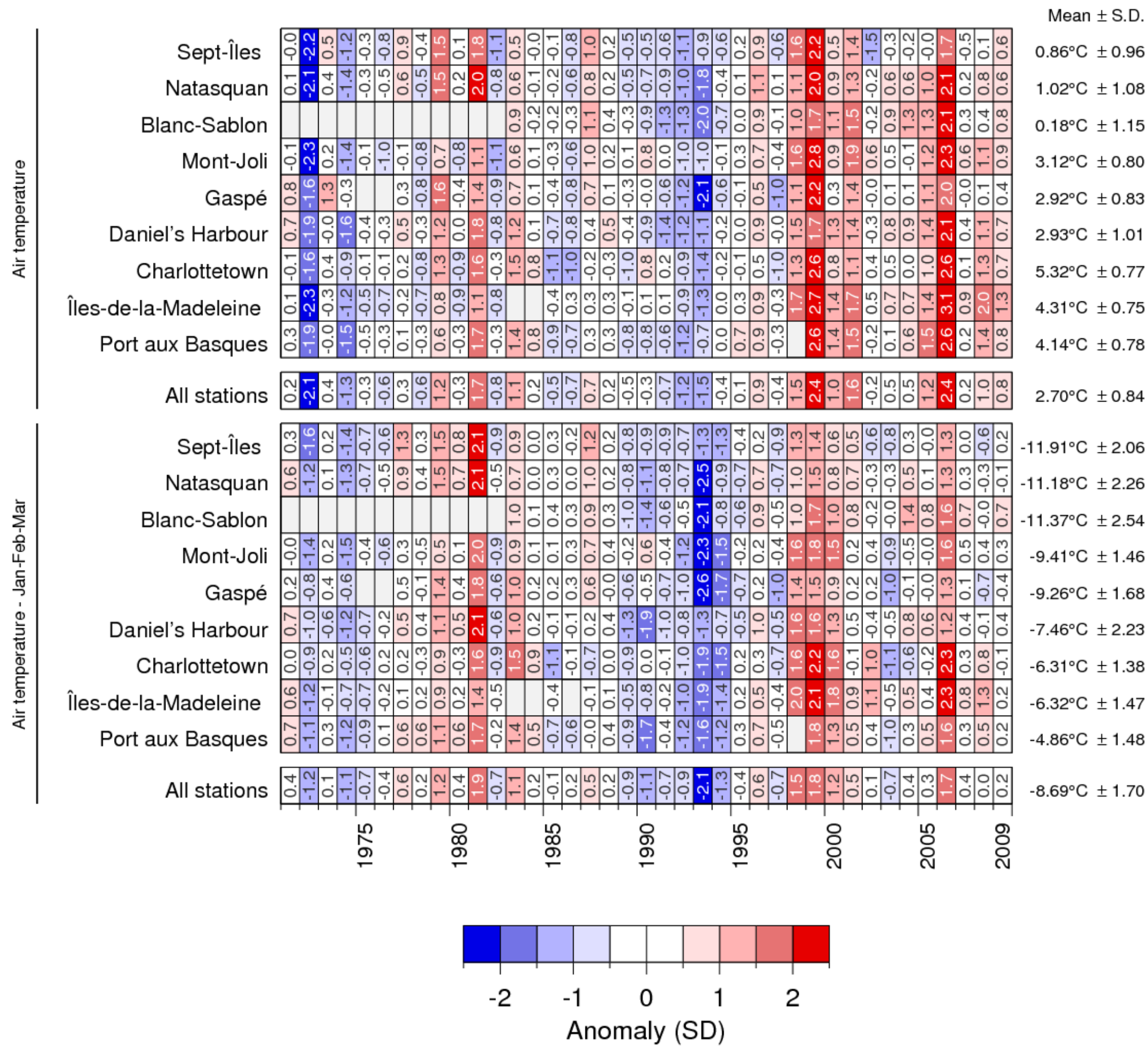

Table 2. Monthly mean temperatures at all shallow sensors of the Maurice Lamontagne Institute thermograph network in 2008 and 2009, as well as at Shediac station from DFO Gulf Region. The number of years that each station and depth has been monitored is indicated on the far right. The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month. Numbers are monthly average temperatures.

Estuary and NW Gulf / Estuaire et NO du Golfe

		2008 J	F	M	A	M	J	J	A	S	O	N	D	2009 J	F	M	A	M	J	J	A	S	O	N	D	
Tadoussac	2 m																	3.4	6.3	10.2	9.5	6.1	5.0			12 y
Bic	1 m					5.6	7.0	8.9	10.3	6.9	4.1							3.7	5.7	8.6	8.6	5.9	4.5			13 y
	2 m					5.3	6.7	8.5	10.0	6.7	4.0							3.5	5.4	8.3	8.3	5.7	4.4			16 y
Rimouski	0.5 m					6.3	8.4	11.4	12.1	8.4	4.9							5.0	7.8	10.0	10.8	7.1	5.3			8 y
IML	0.5 m					6.3	8.0	11.8	12.3	8.7	4.7							5.0	7.1	9.4	12.6	8.2	4.6			16 y
	11.6 m	-0.8	-1.3	-1.3	1.1	4.0	5.3	7.8	9.4	6.5	4.0	2.1	-0.3	-1.3	-1.0	-1.0	1.2	3.2	4.8	7.4	8.4	6.2	4.2			16 y
Baie-Comeau	1 m					6.5	9.9	12.8	14.6	10.5	5.7							4.5	9.2	12.8	12.1	7.5	6.9			11 y
Gaspé Current	0.5 m					7.9	8.9	13.2	13.0	11.3	5.6							6.5	9.4	12.1	14.1	8.9	5.9			5 y
Mont-Louis	0.35 m																	3.9	9.1	12.3	14.8	10.2	6.6			10 y
	0.5 m					5.4	9.5	13.9	14.3	12.2	6.1							3.7	9.1	12.3	14.8	10.2	6.6			16 y
	1.1 m																	3.9	9.0	12.2	14.8	10.2	6.6			11 y
	2.1 m																	3.8	8.9	12.1	14.6	10.2	6.6			11 y
Anticosti Gyre	0.5 m					7.1	9.4	13.8	15.5	12.1	6.4							4.2	8.5	12.9						5 y
Sept-Îles	2 m					7.1	9.8	14.5	16.5	11.2	6.1							3.8	10.1	15.0	14.5	8.2	7.2			14 y
Port-Menier	2 m					5.8	8.5	14.0	14.8	10.1	4.9							3.0	9.9	14.3	12.0	7.6	6.6			15 y
	12.8 m					0.7	4.9	7.9	11.2	5.9	3.7							1.8	6.7	10.2	6.3	5.3	6.3			11 y

Lower North Shore / Basse Côte Nord

		2008 J	F	M	A	M	J	J	A	S	O	N	D	2009 J	F	M	A	M	J	J	A	S	O	N	D	
Rivière-au-Tonnerre	1 m					5.1	8.0	12.6	14.7	9.5	5.7							2.9	6.9	13.2	10.9	6.4				11 y
	16 m					2.5	5.2	6.0	10.9	6.9	5.0							0.7	3.5	11.1	7.7	5.1				14 y
Havre-Saint-Pierre	0.5 m					5.3	8.1	12.1	16.4	11.2	7.1							2.6	7.5	13.4	12.7	8.8				6 y
	1 m					4.5	8.1	11.9	16.4	11.2	7.0							2.3	7.3	13.4	12.7	8.7				13 y
Natashquan	1 m					6.8	9.5	16.4	16.7	12.0	7.3							5.5	12.0	15.8	14.1	8.9				15 y
	5.4 m					2.8	5.9	8.4	13.5	8.7	5.4							0.0	4.6	11.4	7.5	6.2				14 y
La Romaine	1 m					3.3	6.4	12.9	15.0	10.8	8.1							1.6	7.9	12.5	13.1	9.7				12 y
	2 m					3.7	6.2	12.7	14.9	10.7	8.1							1.4	7.7	12.5	13.1	9.7				16 y
Beaugé	0.5 m					3.7	8.1	14.1	16.8	13.3	8.6							1.9	8.2	13.3	16.0	11.9				5 y
La Tabatière	1 m						6.9	9.1	13.8	11.0	8.3							2.9	7.3	11.8	11.4	9.7				8 y
Blanc-Sablon	1 m						3.2	9.4	12.0	10.1	6.2								4.6	7.0	11.1	7.7				11 y

Southern Gulf / Sud du Golfe

		2008 J	F	M	A	M	J	J	A	S	O	N	D	2009 J	F	M	A	M	J	J	A	S	O	N	D	
Grande-Rivière	2 m					7.6	10.5	15.0	15.0	14.0	7.9							5.1	9.5	13.3	16.2	13.0				16 y
	10 m					6.2	8.0	11.3	12.9	13.1	7.5							4.2	7.2	10.4	14.8	12.1				14 y
Shediac Valley	0.5 m					7.5	10.8	15.8	16.7	14.8	10.2							5.7	11.3	15.7						6 y
Île Shag	0.5 m					5.3	10.1	16.3	17.8	15.4								5.9	10.2	14.3	18.3	14.8				12 y
	10 m	-1.4	-1.7	-1.6	0.2	4.4	9.1	14.6	16.9	14.3									9.2	12.8	15.9	14.4				17 y
Shediac	5 m					6.3	11.9	15.1	17.1	16.3	12.2	7.4	2.1					9.0	13.9	18.0	17.9	16.2	10.7	6.0		9 y

Table 3. Monthly mean temperatures at all sensors deeper than 20 m of the Maurice Lamontagne Institute thermograph network in 2008 and 2009, as well as at Shediac station from DFO Gulf Region. The number of years that each station and depth has been monitored is indicated on the far right. The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month. Numbers are monthly average temperatures.

Estuary and NW Gulf / Estuaire et NO du Golfe

		2008 J	F	M	A	M	J	J	A	S	O	N	D	2009 J	F	M	A	M	J	J	A	S	O	N	D	
Tadoussac	36.6 m					1.6	3.7	3.7	6.2	3.6	2.4	2.3						0.7	2.5	5.3	3.9	2.4	4.0			10 y
Bic	30.5 m					1.9	3.1	3.5	5.2	3.3	2.5							1.2	2.2	4.4	3.6	2.9	3.3			14 y
Rimouski	330 m					5.131	5.121	5.101	5.102	5.125	5.120							5.187	5.143	5.116	5.086	5.082	5.020			5 y
Baie-Comeau	82.3 m	0.6	0.1	-0.1	0.4	-0.0	-0.1	0.1	0.5	0.6	1.0	1.5	1.2	1.1	0.5	-0.1	-0.6									9 y
Gaspé Current	165 m						3.7	3.8	3.7	3.9	3.9								3.8	3.5	3.7	3.8	2.6			5 y
Mont-Louis	30 m					-0.5	-0.3	-0.3	-0.1	0.3	1.6							-0.8	-0.6	-0.4	2.5	1.3	0.6			5 y
Anticosti Gyre	337 m					5.417	5.395	5.395	5.401	5.404	5.399							5.357	5.356	5.342	5.327	5.324	5.322			5 y
Sept-Îles	21.9 m					1.3	3.9	4.2	8.1	4.6	4.2							-0.3	2.4	9.2	4.9	3.8	7.4			12 y

Lower North Shore / Basse Côte Nord

		2008 J	F	M	A	M	J	J	A	S	O	N	D	2009 J	F	M	A	M	J	J	A	S	O	N	D	
Havre-Saint-Pierre	120 m					-0.1	0.3	0.5	0.7	0.8	1.1							0.1	0.1	0.2	0.6	0.6				12 y
La Romaine	21.9 m					1.7	3.4	2.3	6.9	4.6	7.1							-0.9	0.7	6.1	3.3	6.1				13 y
Beaugé	97 m					-1.1	-0.7	-0.5	-0.4	-0.0	0.4							-0.1	-0.4	0.0	0.4	0.5				11 y
La Tabatière	39 m						2.1	2.3	5.7	5.8	7.0							-0.4	1.0	4.4	3.5	6.6				7 y
Blanc-Sablon	22 m						2.9	6.1	9.2	8.2	5.9								3.5	5.5	7.3	6.7				10 y

Southern Gulf / Sud du Golfe

		2008 J	F	M	A	M	J	J	A	S	O	N	D	2009 J	F	M	A	M	J	J	A	S	O	N	D	
Shediac Valley	82 m					-0.7	-0.6	-0.4	-0.1	0.0	0.4							0.0	0.2	0.4	0.5	0.7				5 y

Table 4. History of the monthly averaged temperature anomalies for selected stations of the thermograph network. The monthly numbers are the standardized anomalies (monthly mean minus climatological mean, divided by the standard deviation of the climatology). The mean and standard deviation are indicated for each month on the right side of the table.

Station	Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± SD
Natashquan - 1 m	M								-1.0	1.2	0.1			1.0		-1.3	0.6	-0.5	6.12°C ± 1.16
	J		-0.7	-0.7	0.1		0.0	0.8	-0.2	-0.3	-1.6	-0.0	-0.9	0.6	2.6	0.1	-0.8	1.0	10.61°C ± 1.34
	J		-0.5	0.4	-0.3		-0.3	-1.7	0.4	-1.1	-0.0	-0.7	1.1	-1.0	-0.3	0.7	2.0	1.4	14.40°C ± 1.02
	A		-0.4	-0.9	1.1		-1.3	0.7	1.4	-0.2	0.4	0.8	-0.9	-1.5	-0.5	-0.6	1.8	0.2	13.75°C ± 1.67
	S		-0.4	-0.0	0.4		1.2	1.7	-1.4	-0.0	-0.2	-0.7	-1.6	1.4	0.2	-0.7	1.0	-0.9	10.36°C ± 1.63
	O		0.7	0.1	-0.4		-1.4	0.2	-1.7	0.2	-1.8	1.1	0.9	1.3	0.5	0.0	0.4		6.81°C ± 1.32
La Tabatière - 1 m	M										-0.9					-0.2		1.1	1.93°C ± 0.88
	J										-0.9	-0.9	-1.0	1.2	0.5	-0.9	0.8	1.2	6.25°C ± 0.90
	J										-1.2	0.6	-0.9	-0.2	0.8	-0.5	-0.3	1.8	9.46°C ± 1.26
	A										-0.3	0.8	-1.1	-1.0	0.5	-0.0	1.8	-0.6	12.04°C ± 0.97
	S										-0.6	0.3	0.4	1.5	0.8	-1.6	0.3	-0.9	10.66°C ± 0.98
	O											-0.2	-0.6	0.4	0.8	-1.5	1.2		7.51°C ± 0.66
Blanc-Sablon - 1m	J							1.2	0.8	-0.6	-0.2	-0.9	-1.6	0.5	1.1	-1.1	-0.2	1.1	3.42°C ± 1.05
	J							0.4	-0.0	-0.6	-0.1	0.3	-1.9	-0.3	1.8	0.8	0.7	-1.2	8.46°C ± 1.23
	A							0.5	1.3	-0.3	-1.0	-1.3	1.5	-1.0	1.0	-0.5	0.4	-0.6	11.67°C ± 0.94
	S							0.4	1.2	-0.5	-1.7	0.1	-0.8	1.2	0.2	-0.2	1.4	-1.3	8.82°C ± 0.93
	O							-0.3	-0.3	1.0	-1.7	1.4	-0.7	0.4	0.7	-1.2	0.6		5.41°C ± 1.40
Île Shag - 10 m	J		-1.3	-0.6	-1.0	0.4	-0.9	-1.1	0.7	0.5	0.7	0.3	0.4	-0.7	2.4	0.9	-0.6		-1.02°C ± 0.57
	F		-1.2	-0.5	-0.8	-0.7	-0.5	-0.9	1.0	1.5	1.2	1.5	-0.1	-0.6	1.5	-0.7	-0.7		-1.57°C ± 0.19
	M		-1.3	-0.5	-0.8	-0.8	0.6	-0.2	1.6	1.8	0.1	0.3	-0.6	-0.3	1.6	-0.6	-1.1		-1.31°C ± 0.30
	A		-1.1	-1.5	-0.3	-1.2	0.7	0.7	2.0	0.4	0.5	-0.4	-0.3	-0.4	1.8	-0.5	-0.3		0.34°C ± 0.71
	M		-1.3	-1.6	-0.1	-0.9	1.6	0.1	0.5	0.6	-0.7	-0.7	0.2	-0.0	2.2	0.1	0.0		4.35°C ± 0.90
	J		-1.7	-0.6	-0.4	-1.1	1.3	1.6	-0.2	1.3	-0.6	-1.1	-0.8	-0.1	1.4	0.2	0.4	0.5	8.70°C ± 0.97
	J		-0.3	0.0	-0.2	-0.7	-0.2	1.8	0.8	1.0	-0.9	-1.8	-0.9	-0.1	1.7	-0.3	1.2	-0.8	13.56°C ± 0.92
	A		-0.3	0.5	0.6	-0.4	-1.2	0.1	1.2	1.7	-0.9	-1.9	0.6	1.1	-1.1	-0.4	0.9	-0.4	16.20°C ± 0.76
	S		-0.2	-1.6	0.9	0.1	-1.5	1.3	0.6	1.4	0.3	0.2	-1.0	1.2	0.6	-1.6	-0.4	-0.2	14.68°C ± 0.99
	O	-0.7	-1.9	-0.1	0.2	0.1	-1.7	-0.7	0.3	1.4	-0.5	1.7	0.6	1.0	0.3	-0.0			10.63°C ± 0.90
	N	-1.1	-0.6	0.8	0.9	-0.2	-1.2	-1.5	1.5	1.1	-1.3	0.4	-0.8	0.9	0.1	1.0			6.04°C ± 0.57
	D	-0.5	-1.2	-1.0	1.1	-1.0	-1.0	1.7	0.5	0.7	-0.2	0.6	-0.6	0.7	1.3	-1.2			1.96°C ± 0.75
Shediac - 5 m	M									-0.3	0.1	-1.2	0.6	-1.1	1.6	-0.0	-0.9	1.2	7.43°C ± 1.29
	J									-0.9	0.4	-0.8	0.2	-1.7	1.3	1.0	-0.4	0.8	12.50°C ± 1.71
	J									-1.9	0.6	-0.5	1.0	-0.7	0.5	0.9	-0.7	0.9	16.36°C ± 1.81
	A									-2.1	0.9	-0.6	1.3	0.1	0.3	0.6	-0.5	-0.1	18.03°C ± 1.79
	S									-2.5	0.6	0.3	0.1	0.8	0.6	0.5	-0.2	-0.2	16.55°C ± 1.35
	O									-1.8	-0.2	1.2	0.3	0.8	0.3	0.8	0.0	-1.3	12.16°C ± 1.12
	N										-1.7	0.4	-1.1	1.2	0.7	0.0	0.8	-0.3	6.38°C ± 1.29
	D											0.2	-0.9	1.1	0.5	-1.5	0.7		1.23°C ± 1.29

Table 5. NOAA SST May to November monthly anomalies averaged over the Gulf, the eight regions of the Gulf and management regions of the St. Lawrence Estuary, for 2008 and 2009 (April also shown for the Northwest Gulf, the Estuary and its regions). The scorecards are colour-coded according to the monthly standardized anomalies based on the 1985-2009 climatologies for each month, but the numbers are the monthly average temperatures in ºC.

	A 2008	M 2008	J 2008	J 2008	A 2008	S 2008	O 2008	N 2008	D 2008	J 2009	F 2009	M 2009	A 2009	M 2009	J 2009	J 2009	A 2009	S 2009	O 2009	N 2009
GSL		4.6	8.6	14.4	15.1	13.1	8.7	5.4						3.3	9.3	12.7	16.2	11.9	8.2	4.8
1 - Estuary	1.6	6.5	8.9	11.2	12.6	8.7	4.6	2.4					1.9	4.5	8.1	9.7	11.3	7.3	5.0	3.1
2 - Northwest Gulf	0.9	6.1	9.0	13.3	14.9	11.9	6.7	3.7					0.7	3.5	8.9	12.4	14.6	9.6	7.3	4.0
3 - Anticosti Channel		4.0	7.2	13.2	15.0	12.5	8.2	5.2						1.8	8.6	12.0	14.8	10.3	7.3	3.5
4 - Mécatina Trough		2.8	6.1	11.0	13.2	11.6	7.9	4.5						1.0	7.5	10.3	13.3	9.9	5.1	2.2
5 - Esquiman Channel		3.4	7.4	13.1	15.2	13.1	8.8	5.4						1.9	8.3	12.1	16.0	11.8	6.8	4.1
6 - Central Gulf		4.2	7.7	14.6	16.0	13.4	8.9	5.2						2.4	8.9	12.9	16.9	12.8	8.5	5.0
7 - Cabot Strait		3.3	8.0	14.7	15.0	13.9	9.8	7.1						3.8	9.3	13.2	17.3	13.1	9.6	6.2
8 - Magdalen Shallows		5.5	10.7	17.2	15.5	14.5	10.5	6.5						5.2	11.2	13.9	18.4	14.4	10.2	6.4
PMSSL (Saguenay)	0.7	3.4	9.7	13.7	12.8	9.1	4.3	3.4					0.9	3.9	10.7	11.2	14.1	10.1	2.4	2.1
PMSSL (Estuary)	1.1	5.8	8.2	10.2	11.2	7.5	4.5	2.4					1.6	4.3	7.1	8.9	10.0	6.9	4.2	3.0
St. Lawrence Estuary MPA	1.4	6.4	8.9	11.0	12.3	8.5	4.8	2.4					2.1	5.0	8.1	9.4	11.2	7.6	4.7	3.1
Manicouagan MPA	1.8	6.8	9.7	11.9	13.4	9.0	5.2	2.4					1.9	4.7	8.5	10.7	11.7	7.6	5.9	3.2

Table 6. NOAA SST May to November monthly anomalies averaged over the Gulf of St. Lawrence and over the first four regions of the Gulf. The scorecards are colour-coded according to the monthly standardized anomalies based on the 1985-2009 climatologies for each month, but the numbers are the monthly average temperatures in ºC. The mean and standard deviation are indicated for each month on the right side of the table. April anomalies are included for the Estuary and the Northeast Gulf because those regions are typically ice-free by then. The May to November average is included for the Gulf of St. Lawrence (top panel).

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± SD
GSL SST Anomaly	M	2.0	3.5	2.8	3.2	2.1	1.5	1.9	2.0	2.5	3.0	3.8	3.0	2.0	5.0	5.6	3.2	4.5	2.5	3.1	2.9	3.5	5.8	3.1	4.6	3.3	3.21°C ± 1.14
	J	6.2	6.6	8.6	7.0	8.4	6.4	7.3	7.3	7.7	8.2	9.0	9.2	7.6	9.2	10.1	8.4	9.7	7.8	8.0	7.2	8.8	10.3	8.7	8.6	9.3	8.23°C ± 1.11
	J	12.1	11.2	13.4	12.1	13.3	11.6	11.1	10.1	11.3	14.4	14.2	12.7	13.0	13.7	14.6	13.5	13.3	12.6	13.4	13.4	13.6	14.8	13.8	14.4	12.7	12.97°C ± 1.23
	A	14.5	13.5	14.6	15.2	13.9	14.2	13.7	12.9	15.5	15.5	15.5	16.2	14.7	14.7	15.6	16.0	15.6	15.5	15.5	15.7	14.7	15.5	14.6	15.1	16.2	14.98°C ± 0.87
	S	12.4	10.9	11.4	11.3	10.7	12.0	11.3	12.4	12.5	12.6	12.0	13.4	12.5	12.8	14.5	13.0	13.2	11.8	12.7	11.8	13.5	13.2	11.6	13.1	11.9	12.34°C ± 0.90
	O	8.2	7.4	8.4	7.3	5.7	8.1	8.6	7.3	7.8	9.2	9.1	8.4	8.7	7.6	8.9	8.4	9.6	7.7	9.5	8.9	9.0	9.3	8.5	8.7	8.2	8.34°C ± 0.86
	N	3.8	3.3	3.5	3.6	3.6	2.6	4.9	3.3	3.9	5.5	5.5	5.0	4.6	4.3	4.3	4.6	4.7	3.6	4.4	4.9	5.5	6.0	4.7	5.4	4.8	4.41°C ± 0.85
	M-N	8.4	8.1	8.9	8.5	8.2	8.1	8.4	7.9	8.7	9.8	9.9	9.7	9.0	9.6	10.5	9.6	10.1	8.8	9.5	9.2	9.8	10.7	9.3	10.0	9.5	9.21°C ± 0.78
1 - Estuary	A		2.0	1.9	1.0	1.0	0.7	0.2	0.3	1.1	1.0	1.8	1.0	1.3	2.1	2.1	1.1	1.1	1.8	0.8	0.8	1.3	2.3	1.1	1.6	1.9	1.31°C ± 0.56
	M	4.1	5.1	4.2	4.9	2.8	4.4	3.0	4.2	4.7	5.7	5.5	4.8	4.1	5.3	7.0	5.3	6.4	4.5	4.8	3.8	3.5	6.1	4.8	6.5	4.5	4.79°C ± 1.03
	J	7.2	6.2	7.8	8.0	7.5	7.3	8.1	8.1	9.4	9.4	8.6	9.0	8.3	9.6	8.8	8.2	9.9	8.4	8.3	8.0	8.2	9.9	9.4	8.9	8.1	8.42°C ± 0.89
	J	9.3	9.0	10.6	11.3	10.8	8.4	8.5	9.4	12.7	11.6	11.9	10.3	10.3	10.5	9.8	11.8	10.0	11.8	11.3	11.4	11.8	11.6	10.6	11.2	9.7	10.63°C ± 1.15
	A	9.9	9.4	10.2	10.9	8.1	10.3	10.3	8.1	12.5	10.5	11.2	11.1	9.6	8.9	10.7	12.1	10.5	11.5	11.9	9.7	9.5	10.8	9.7	12.6	11.3	10.45°C ± 1.19
	S	8.0	6.4	6.3	6.0	6.6	7.0	6.6	7.7	8.3	7.6	7.3	9.2	8.8	9.7	9.5	7.4	8.0	8.5	7.7	7.4	8.6	8.1	6.8	8.7	7.3	7.73°C ± 1.02
	O	4.9	4.1	4.1	3.3	1.8	3.8	4.1	3.4	3.2	6.5	5.5	4.5	5.1	4.4	5.3	4.4	5.3	5.0	4.8	5.1	5.8	5.3	5.9	4.6	5.0	4.61°C ± 1.00
	N	1.6	0.6	1.2	1.6	0.7	0.6	2.0	0.5	0.8	4.2	1.9	2.0	2.2	2.1	2.2	2.2	2.4	1.5	1.3	2.7	3.1	3.7	2.1	2.4	3.1	1.94°C ± 0.96
2 - Northwest Gulf	A		1.9	0.9	0.3	0.1	0.3	0.3	0.5	0.4	-0.2	0.6	0.6	0.6	1.2	2.1	0.4	0.1	0.3	-0.2	0.2	-0.3	1.2	0.6	0.9	0.7	0.55°C ± 0.59
	M	2.8	5.2	3.1	4.2	2.5	2.6	2.1	3.1	3.6	4.3	5.0	3.5	3.0	5.9	6.8	3.8	5.7	3.1	4.5	2.9	3.3	6.0	3.6	6.1	3.5	4.01°C ± 1.30
	J	7.8	6.5	8.7	7.9	9.4	7.4	8.0	7.9	9.4	9.8	10.3	10.4	8.7	9.9	10.1	8.8	9.9	8.0	9.0	7.8	9.4	10.8	9.2	9.0	8.9	8.92°C ± 1.06
	J	11.9	10.6	12.6	12.9	13.3	10.7	10.1	10.6	13.2	14.0	14.7	12.7	12.6	13.3	13.2	13.6	12.2	12.3	13.0	13.0	14.4	14.2	13.3	13.3	12.4	12.72°C ± 1.21
	A	13.3	12.4	12.3	14.4	11.5	13.4	12.8	11.0	15.7	13.1	14.3	14.3	12.9	13.4	14.0	15.1	13.2	14.2	14.3	13.4	12.6	13.5	12.7	14.9	14.6	13.49°C ± 1.11
	S	11.1	8.9	8.9	8.5	9.2	9.7	10.0	10.6	10.8	9.9	10.4	11.8	11.7	12.2	12.3	10.3	10.7	10.0	10.4	9.4	11.3	10.3	8.8	11.9	9.6	10.34°C ± 1.11
	O	6.5	5.8	5.8	5.1	3.2	5.5	6.3	4.9	5.0	8.7	6.8	6.8	7.4	6.2	7.6	6.0	6.8	5.8	7.2	7.1	7.4	6.9	6.5	6.7	7.3	6.36°C ± 1.11
	N	2.6	1.6	1.8	2.2	1.6	1.4	3.7	1.6	1.8	5.2	3.2	3.3	3.5	3.4	3.0	3.4	3.1	2.6	2.3	4.3	4.8	5.0	3.3	3.7	4.0	3.05°C ± 1.10
3 - Anticosti Channel	M	1.2	2.2	1.8	2.1	1.1	0.4	0.8	1.1	1.7	1.7	2.9	2.1	1.0	4.0	5.1	1.9	3.4	1.6	1.4	2.2	3.3	5.0	1.7	4.0	1.8	2.23°C ± 1.26
	J	4.8	5.1	7.7	6.2	7.7	4.1	5.9	5.7	6.9	6.7	7.7	8.7	6.4	8.2	8.5	6.6	8.3	6.7	6.8	6.1	8.7	10.0	6.8	7.2	8.6	7.04°C ± 1.38
	J	10.7	10.0	12.2	11.0	12.5	9.6	9.2	9.8	9.9	12.1	12.8	11.6	11.8	12.6	12.4	12.0	11.4	11.5	11.8	12.4	12.7	13.6	12.8	13.2	12.0	11.67°C ± 1.20
	A	12.4	12.8	13.1	13.6	12.0	12.1	12.5	11.5	14.5	12.9	13.7	14.9	13.3	12.9	14.2	14.8	13.5	14.1	14.8	13.7	12.2	14.1	13.7	15.0	14.8	13.48°C ± 1.02
	S	11.2	10.0	10.7	9.2	9.8	9.0	9.7	10.4	9.7	11.0	11.4	12.6	11.7	11.8	13.5	11.1	11.8	10.6	10.7	10.4	12.3	12.3	10.2	12.5	10.3	10.95°C ± 1.14
	O	6.4	6.8	7.7	6.4	4.5	6.9	7.2	6.4	4.5	8.6	8.4	7.2	8.1	6.7	8.4	6.7	8.5	6.6	7.8	8.5	8.7	8.5	7.4	8.2	7.3	7.29°C ± 1.15
	N	2.5	2.1	2.9	3.5	2.9	2.4	4.4	2.5	2.5	4.5	5.0	4.0	4.0	3.0	3.4	4.0	4.4	3.1	3.4	4.5	5.1	5.8	3.8	5.2	3.5	3.71°C ± 0.99
4 - Mécatina Trough	M	1.1	1.2	2.0	2.3	-0.0	-0.8	0.6	1.0	0.7	1.2	1.2	2.0	0.5	2.0	2.9	1.3	1.9	1.0	1.1	1.3	3.1	4.8	1.1	2.8	1.0	1.48°C ± 1.12
	J	4.1	3.6	6.9	4.5	5.1	2.7	2.5	4.2	4.6	4.9	6.1	6.5	5.5	6.7	6.8	6.3	6.3	5.8	5.5	4.6	7.5	7.6	6.0	6.1	7.5	5.51°C ± 1.42
	J	8.0	8.6	10.3	8.6	9.6	9.4	6.4	5.5	6.5	10.5	10.0	8.8	10.4	10.7	11.2	10.8	9.8	9.5	10.4	10.0	9.7	11.7	10.3	11.0	10.3	9.53°C ± 1.54
	A	10.4	11.4	12.8	11.9	11.7	10.9	9.6	8.1	10.1	11.6	13.5	13.9	12.3	11.8	14.2	13.6	13.5	12.2	13.2	13.0	12.0	14.0	12.1	13.2	13.3	12.18°C ± 1.51
	S	9.2	8.8	10.3	9.3	7.8	10.0	6.3	9.2	9.2	10.2	9.2	10.3	9.1	9.0	12.9	11.8	11.7	10.1	11.6	10.8	11.9	11.9	10.0	11.6	9.9	10.09°C ± 1.49
	O	5.6	4.8	7.1	5.9	5.2	7.9	6.5	6.3	6.5	6.3	7.8	5.2	6.7	5.4	6.9	7.4	7.9	5.0	8.8	6.9	7.4	7.9	5.6	7.9	5.1	6.56°C ± 1.13
	N	1.0	1.7	2.8	3.2	2.2	1.5	3.2	2.0	3.0	3.8	5.2	2.8	2.3	2.1	2.9	2.7	3.8	1.4	4.0	3.2	3.2	4.0	3.2	4.5	2.2	2.87°C ± 1.01

Table 7. NOAA SST May to November monthly anomalies averaged over the remaining four regions of the Gulf. The scorecards are colour-coded according to the monthly standardized anomalies based on the 1985-2009 climatologies for each month, but the numbers are the monthly average temperatures in ºC. The mean and standard deviation are indicated for each month on the right side of the table.

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± SD
5 - Esquiman Channel	M	1.6	2.2	2.3	2.5	0.8	0.6	1.2	0.9	1.5	1.7	2.5	2.0	0.8	3.4	4.0	2.3	3.5	1.5	2.1	2.1	3.3	4.9	2.3	3.4	1.9	2.20°C ± 1.08
	J	4.7	5.5	7.7	6.0	6.9	4.2	5.2	5.5	6.1	6.2	7.8	7.3	6.0	8.3	8.5	7.0	8.9	6.5	6.7	5.3	8.1	9.2	7.9	7.4	8.3	6.85°C ± 1.36
	J	10.9	10.6	13.0	10.5	12.3	10.5	9.4	8.2	8.0	11.9	12.3	10.8	11.7	12.8	13.9	11.7	12.1	11.3	12.0	12.6	11.7	13.9	12.9	13.1	12.1	11.61°C ± 1.51
	A	13.4	13.5	14.6	14.8	13.7	13.4	13.2	11.7	13.3	15.1	14.8	15.9	14.0	13.9	15.2	16.0	15.4	14.6	15.2	16.0	14.3	15.5	14.5	15.2	16.0	14.53°C ± 1.09
	S	11.8	10.5	12.2	12.0	9.9	12.1	10.3	11.7	11.7	12.6	11.2	12.9	11.6	11.3	14.3	13.8	12.9	10.8	13.3	11.7	13.0	13.7	11.8	13.1	11.8	12.07°C ± 1.12
	O	7.9	6.8	8.4	7.4	5.8	8.2	7.5	7.3	7.9	8.7	9.0	7.7	7.9	7.1	9.2	8.6	9.2	6.7	10.2	8.3	8.2	9.4	8.0	8.8	6.8	8.05°C ± 1.00
	N	3.1	3.4	3.9	3.9	3.6	2.5	5.0	2.7	4.1	5.3	6.2	4.8	3.8	4.3	4.3	4.1	4.4	2.4	4.8	4.5	5.1	5.7	4.6	5.4	4.1	4.24°C ± 0.97
6 - Central Gulf	M	1.1	2.8	2.5	2.5	1.2	0.8	1.4	1.2	1.9	1.8	3.5	1.9	1.3	4.5	4.2	2.6	3.9	1.2	2.0	2.3	3.3	5.3	2.4	4.2	2.4	2.49°C ± 1.22
	J	5.4	6.3	8.7	6.2	8.0	5.6	6.8	6.7	7.0	6.8	8.7	8.2	6.8	8.4	9.5	7.3	9.2	7.0	7.1	6.2	8.1	9.8	7.8	7.7	8.9	7.53°C ± 1.20
	J	12.5	11.1	13.8	11.7	13.4	11.0	11.0	10.5	10.8	14.1	14.3	12.8	13.0	13.9	15.1	13.2	13.6	12.3	12.4	13.3	13.4	14.8	13.8	14.6	12.9	12.92°C ± 1.32
	A	15.7	14.2	14.7	16.2	14.7	13.9	14.2	13.5	16.0	16.1	16.0	16.9	15.5	15.5	15.8	17.0	16.2	15.9	15.8	16.8	15.5	16.4	15.2	16.0	16.9	15.63°C ± 0.95
	S	13.1	11.8	12.3	12.2	10.2	12.4	12.1	12.9	13.1	13.3	12.5	14.4	13.1	13.3	14.9	14.0	13.5	11.8	13.6	12.1	13.4	14.4	11.7	13.4	12.8	12.90°C ± 1.01
	O	8.0	8.1	8.7	7.9	5.8	8.2	8.9	7.8	8.2	9.5	9.2	8.9	9.0	7.6	9.0	8.7	9.5	7.9	9.6	9.2	8.9	9.9	8.5	8.9	8.5	8.57°C ± 0.85
	N	3.9	3.3	3.6	3.8	3.7	2.5	5.0	3.6	4.1	4.8	5.7	4.9	4.6	4.1	4.1	4.6	4.4	4.0	4.1	5.0	5.2	6.3	4.7	5.2	5.0	4.41°C ± 0.82
7 - Cabot Strait	M	1.3	3.1	2.6	3.2	2.1	0.7	1.4	1.5	2.5	2.4	3.5	2.6	1.6	4.4	5.1	3.5	4.2	2.1	2.8	2.6	4.0	5.7	2.7	3.3	3.8	2.91°C ± 1.22
	J	5.0	6.6	7.3	6.3	7.5	6.1	6.1	7.1	6.8	8.0	7.9	8.1	6.8	8.4	10.5	8.2	8.9	7.7	7.2	6.6	8.1	9.6	8.6	8.0	9.3	7.62°C ± 1.25
	J	11.8	10.7	13.6	11.2	12.8	11.7	11.4	9.2	10.5	15.0	13.2	12.8	12.6	13.7	15.5	13.6	13.8	12.1	13.7	13.6	13.0	14.7	13.4	14.7	13.2	12.86°C ± 1.50
	A	15.4	14.6	16.1	15.6	15.4	14.7	13.9	14.0	15.9	17.6	16.1	17.4	15.5	16.5	17.2	17.3	16.7	16.8	16.0	17.2	15.6	16.1	15.4	15.0	17.3	15.97°C ± 1.05
	S	13.5	12.4	13.8	12.9	11.4	13.9	12.0	14.6	14.2	14.6	12.9	14.3	13.6	14.2	16.1	14.1	14.7	12.6	13.2	12.8	15.3	14.5	12.9	13.9	13.1	13.66°C ± 1.05
	O	9.3	8.8	10.1	9.1	6.8	10.1	10.4	8.4	10.8	10.8	10.7	10.4	10.1	9.6	9.9	10.0	11.9	8.4	11.6	9.8	10.3	10.9	9.1	9.8	9.6	9.87°C ± 1.09
	N	5.4	5.0	4.4	4.7	5.5	3.7	5.6	5.1	5.8	6.3	7.3	6.6	6.2	6.6	5.7	6.9	6.4	4.1	5.8	6.5	7.0	7.2	6.0	7.1	6.2	5.87°C ± 0.98
8 - Magdalen Shallows	M	2.7	4.4	3.4	3.9	3.5	2.2	3.0	2.7	3.1	4.1	4.4	4.3	3.0	6.5	7.0	4.3	5.1	3.8	4.1	4.0	3.7	7.0	4.3	5.5	5.2	4.22°C ± 1.27
	J	8.0	8.8	10.2	8.6	10.1	8.9	10.3	9.3	8.7	10.1	10.6	11.3	9.2	10.6	12.5	10.6	11.5	9.7	9.9	9.2	9.7	12.0	10.6	10.7	11.2	10.09°C ± 1.12
	J	14.4	13.3	15.5	14.2	15.3	14.6	14.4	12.2	13.7	18.1	17.0	15.0	15.6	16.1	17.4	16.1	16.2	15.0	16.5	15.5	15.7	17.1	16.1	17.2	13.9	15.45°C ± 1.40
	A	17.2	14.6	16.8	17.3	16.6	17.2	15.9	16.0	18.1	18.5	18.0	18.6	17.2	17.1	17.5	17.1	18.4	17.9	17.2	18.2	17.7	17.8	16.8	15.5	18.4	17.27°C ± 0.99
	S	14.3	12.9	12.3	13.6	13.3	14.7	14.2	14.9	15.5	14.9	14.4	15.2	14.4	14.8	16.4	15.3	15.9	14.6	15.1	14.3	16.0	15.2	14.3	14.5	14.4	14.62°C ± 0.93
	O	10.7	9.1	10.2	8.8	8.0	10.0	11.3	9.4	10.2	10.2	11.0	10.6	10.4	9.3	10.2	10.6	12.0	10.6	11.3	10.9	10.8	11.0	10.9	10.5	10.2	10.32°C ± 0.87
	N	5.5	4.5	4.5	4.1	5.2	3.8	6.2	4.8	5.4	6.7	6.5	6.7	6.1	5.3	5.5	5.7	6.0	5.3	5.8	5.4	6.6	6.8	6.3	6.5	6.4	5.67°C ± 0.85

Table 8. NOAA SST April to November monthly anomalies averaged over the Estuary (region 1 of the Gulf) and subregions for the Saguenay St. Lawrence Marine Park (PMSSL), the St. Lawrence Estuary Marine Protected Area (MPA) and the Manicouagan MPA. The monthly numbers are the standardized anomalies (monthly mean minus climatological mean, divided by the standard deviation of the climatology). The mean and standard deviation are indicated for each month on the right side of the table.

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± S.D.
Estuary	A		1.3	1.0	-0.5	-0.5	-1.0	-1.9	-1.7	-0.4	-0.5	0.8	-0.5	-0.1	1.4	1.5	-0.3	-0.4	0.8	-0.9	-0.9	-0.0	1.7	-0.3	0.4	1.1	1.31°C ± 0.56
	M	-0.7	0.3	-0.6	0.1	-2.0	-0.4	-1.7	-0.6	-0.1	0.9	0.7	-0.0	-0.7	0.5	2.1	0.5	1.5	-0.3	0.0	-1.0	-1.3	1.3	0.0	1.6	-0.3	4.79°C ± 1.03
	J	-1.4	-2.5	-0.8	-0.5	-1.0	-1.2	-0.3	-0.4	1.1	1.1	0.2	0.7	-0.1	1.3	0.5	-0.2	1.6	-0.1	-0.2	-0.5	-0.3	1.6	1.1	0.5	-0.4	8.42°C ± 0.89
	J	-1.1	-1.4	-0.0	0.6	0.2	-2.0	-1.8	-1.1	1.8	0.9	1.1	-0.3	-0.3	-0.1	-0.7	1.1	-0.6	1.0	0.6	0.7	1.0	0.8	-0.0	0.5	-0.8	10.63°C ± 1.15
	A	-0.5	-0.9	-0.2	0.4	-2.0	-0.1	-0.1	-2.0	1.7	0.1	0.6	0.5	-0.7	-1.3	0.2	1.4	0.1	0.8	1.2	-0.6	-0.8	0.3	-0.6	1.8	0.7	10.45°C ± 1.19
	S	0.3	-1.3	-1.4	-1.7	-1.1	-0.7	-1.1	-0.1	0.6	-0.1	-0.5	1.5	1.0	1.9	1.7	-0.3	0.2	0.8	-0.0	-0.3	0.8	0.4	-1.0	0.9	-0.4	7.73°C ± 1.02
	O	0.3	-0.5	-0.5	-1.3	-2.8	-0.8	-0.5	-1.2	-1.4	1.9	0.9	-0.1	0.5	-0.2	0.7	-0.2	0.7	0.4	0.2	0.5	1.2	0.7	1.3	0.0	0.4	4.61°C ± 1.00
	N	-0.4	-1.4	-0.8	-0.4	-1.3	-1.4	0.1	-1.5	-1.2	2.3	-0.1	0.0	0.2	0.1	0.2	0.3	0.5	-0.5	-0.7	0.8	1.2	1.8	0.2	0.4	1.2	1.94°C ± 0.96
PMSSL (Saguenay)	A		-0.6	1.3	-1.1	-2.4	-0.5	-1.4	-0.7	1.3	1.5	-0.0	-0.3	0.4	1.6	0.1	0.7	0.2	-0.1	-0.5	-1.4	0.1	-0.1	1.0	0.3	0.6	0.51°C ± 0.63
	M	-2.1	0.4	0.2	-0.5	-0.7	-1.0	-1.0	0.7	0.8	1.1	1.3	0.3	-1.8	0.6	0.8	0.4	1.8	-0.6	1.0	-1.1	-1.0	1.0	0.5	-0.6	-0.3	4.38°C ± 1.62
	J	-1.0	-2.0	-0.7	-1.1	-0.8	-0.4	0.3	-0.8	0.8	1.9	1.0	0.3	-1.2	-0.1	1.8	0.9	0.6	-1.1	0.4	-1.1	1.0	1.0	0.2	-0.2	0.3	10.13°C ± 1.85
	J	0.5	-2.0	-0.4	0.5	-0.7	-0.5	-0.5	-1.4	1.5	1.9	2.2	-0.5	-0.7	-0.8	0.4	-0.3	-0.4	-0.6	-0.5	0.4	1.0	1.1	-0.1	0.7	-0.9	12.65°C ± 1.61
	A	-0.7	-1.6	-1.6	-0.9	-1.0	0.6	-0.4	-0.6	1.5	0.4	1.8	1.3	-0.7	-0.8	-0.4	0.0	1.1	0.9	1.4	-0.3	-0.2	0.0	-1.3	0.1	1.2	12.65°C ± 1.21
	S	-1.0	-2.8	-1.9	-0.7	-0.6	-0.6	-0.9	-0.0	0.0	0.3	-0.9	1.0	1.2	-0.1	1.4	-0.2	1.0	0.8	1.1	0.8	0.6	0.3	0.1	0.2	0.9	8.79°C ± 1.54
	O	-0.5	-1.1	-0.5	-1.7	-1.5	-1.1	0.2	-0.6	-0.5	1.7	1.8	-0.4	0.7	-0.2	-0.6	0.9	1.2	-0.3	0.7	0.4	1.1	-0.0	1.6	-0.1	-1.2	4.39°C ± 1.61
	N	-0.5	-1.4	-1.1	0.7	-0.4	1.3	-0.6	-1.1	-0.8	0.3	-0.3	-0.7	1.5	-0.7	2.1	-0.1	1.3	-0.8	-0.7	-0.9	0.1	0.3	-0.4	1.8	0.8	1.07°C ± 1.29
PMSSL (Estuary)	A		0.6	1.1	0.1	-1.1	-1.2	-1.6	-1.9	-0.1	-0.3	0.1	-0.5	-0.6	1.4	0.1	0.1	-0.2	1.7	-1.0	-0.5	1.0	2.0	0.2	-0.1	1.0	1.14°C ± 0.47
	M	-1.0	0.2	-0.3	0.4	-1.9	0.2	-0.9	-1.1	-0.5	0.6	0.7	-0.1	-1.7	0.6	1.6	0.6	1.7	-0.5	-0.1	-0.9	-0.9	1.4	0.3	1.7	-0.1	4.35°C ± 0.84
	J	-1.1	-1.7	-0.8	-0.8	-1.3	-1.4	-0.7	-1.4	0.1	1.0	0.3	0.4	-0.3	1.3	1.1	-0.2	1.6	0.2	-0.0	-0.2	0.2	1.8	1.0	1.0	-0.2	7.30°C ± 0.90
	J	-0.1	-2.2	-0.1	-0.2	-0.5	-1.9	-2.0	-1.2	1.5	1.2	0.0	0.2	-0.2	0.6	-0.3	0.6	0.2	1.5	-0.4	1.1	0.3	0.9	-0.0	1.0	-0.1	9.09°C ± 1.02
	A	-0.5	-0.5	-0.3	0.0	-2.2	-0.6	-0.5	-1.9	0.9	0.0	0.3	0.6	-0.2	-1.0	-0.1	1.4	0.4	1.2	1.0	-0.5	-0.6	0.5	-0.5	2.3	1.0	9.13°C ± 0.91
	S	-0.2	-1.7	-0.2	-2.2	-1.1	-1.5	-1.0	-0.0	1.1	0.2	-0.8	1.5	1.3	1.4	1.3	-0.3	0.1	1.0	-0.1	0.2	0.8	0.1	-0.2	0.6	-0.2	7.08°C ± 0.78
	O	0.8	-0.5	-0.7	-1.1	-2.6	-0.8	-0.9	-0.9	-1.1	1.8	0.9	-0.3	0.8	-0.0	0.5	0.0	0.5	0.5	-0.2	0.1	1.5	0.7	1.5	-0.1	-0.4	4.59°C ± 0.91
	N	-0.3	-1.7	-0.6	-0.7	-1.3	-1.1	-0.1	-1.3	-1.2	2.4	0.1	-0.4	0.4	-0.2	0.2	0.1	0.7	-0.5	-0.4	0.9	0.7	2.0	0.4	0.5	1.2	1.92°C ± 0.86
St. Lawrence Estuary MPA	A		0.8	1.5	-0.2	-0.9	-1.2	-1.5	-1.9	-0.5	-0.4	0.4	-0.8	-0.6	1.5	0.9	-0.2	-0.2	1.2	-0.9	-0.5	0.6	1.8	-0.3	0.1	1.4	1.38°C ± 0.56
	M	-0.9	-0.1	-0.8	0.2	-2.4	-0.0	-1.3	-0.2	-0.1	0.6	0.7	0.1	-1.0	0.7	1.8	0.6	1.7	-0.2	-0.0	-0.8	-1.3	1.3	-0.1	1.6	0.0	4.97°C ± 0.91
	J	-1.2	-2.2	-0.9	-0.8	-1.1	-1.1	-0.3	-0.8	0.9	1.5	0.4	0.5	-0.6	1.4	0.5	-0.0	1.6	-0.1	-0.1	-0.5	0.0	1.7	1.0	0.6	-0.3	8.35°C ± 0.89
	J	-0.9	-1.7	0.0	0.4	0.0	-1.7	-1.8	-1.3	1.9	1.3	0.6	-0.1	-0.4	0.3	-0.7	0.9	-0.4	1.4	-0.0	0.9	0.7	0.9	-0.1	0.6	-1.0	10.35°C ± 1.02
	A	-0.6	-1.0	-0.5	0.2	-2.0	-0.2	-0.3	-1.9	1.6	0.3	0.6	0.7	-0.5	-1.4	-0.0	1.3	0.0	1.0	0.9	-0.7	-0.2	0.4	-0.5	1.9	0.8	10.25°C ± 1.06
	S	-0.1	-1.5	-1.6	-1.8	-1.1	-1.2	-1.0	-0.1	0.7	-0.0	-0.4	1.5	1.1	1.5	1.7	-0.3	0.4	1.0	0.3	0.0	0.9	0.1	-0.6	0.8	-0.2	7.80°C ± 0.87
	O	0.3	-0.4	-0.6	-1.3	-2.7	-1.0	-0.4	-1.0	-1.4	1.6	1.0	-0.3	0.5	-0.0	0.4	0.0	0.6	0.5	-0.0	0.6	1.3	0.7	1.7	0.1	-0.2	4.80°C ± 0.94
	N	-0.4	-1.4	-0.8	-0.5	-1.3	-1.4	-0.2	-1.4	-1.1	2.4	0.1	0.1	0.7	-0.1	0.5	0.2	0.7	-0.7	-0.6	0.8	0.7	1.9	0.2	0.5	1.2	1.99°C ± 0.89
Manicouagan MPA	A		1.6	0.4	-0.7	-0.2	-1.4	-1.8	-1.6	-0.2	-0.4	0.5	0.2	-0.1	1.8	2.0	-0.1	-0.6	0.2	-0.7	-0.9	-0.5	1.6	0.0	0.3	0.5	1.56°C ± 0.70
	M	-0.8	0.6	-0.9	-0.2	-1.7	-0.7	-1.8	-0.4	0.1	1.1	0.9	0.0	-0.2	0.6	2.2	0.2	1.3	-0.6	-0.2	-1.0	-1.1	1.2	0.1	1.6	-0.3	5.05°C ± 1.16
	J	-0.8	-2.7	-0.6	-0.7	-1.0	-1.3	-0.2	-0.1	1.7	0.7	-0.1	0.6	0.2	1.2	0.3	-0.5	1.1	-0.5	0.0	-0.5	-0.1	1.7	1.5	0.7	-0.5	9.04°C ± 0.98
	J	-1.3	-1.2	-0.1	0.9	-0.2	-2.0	-1.7	-1.0	1.9	1.1	1.0	-0.3	-0.5	-0.1	-0.8	1.3	-0.6	0.7	0.6	0.6	0.9	1.0	0.1	0.3	-0.6	11.45°C ± 1.37
	A	-0.6	-0.8	-0.0	0.3	-1.9	0.2	0.4	-1.9	1.8	-0.1	0.5	0.3	-0.7	-1.2	0.0	1.6	0.0	0.7	1.3	-0.9	-0.7	0.0	-0.6	1.8	0.4	11.22°C ± 1.22
	S	0.2	-1.4	-1.4	-1.8	-1.3	-0.5	-1.2	-0.1	0.6	0.4	-0.2	1.5	0.9	2.0	1.6	-0.3	-0.1	0.8	-0.1	0.0	0.9	0.3	-0.9	0.6	-0.5	8.24°C ± 1.18
	O	-0.0	-0.9	-0.7	-1.3	-2.6	-0.8	-0.1	-1.3	-1.3	1.7	1.0	-0.1	0.6	-0.5	0.8	-0.2	0.7	0.3	0.4	0.6	1.2	0.6	1.1	0.2	0.8	4.95°C ± 1.16
	N	-0.4	-1.4	-1.0	-0.3	-1.1	-1.5	-0.0	-1.4	-1.2	2.2	-0.2	-0.1	0.6	0.4	0.1	1.0	0.4	-0.6	-0.7	0.7	1.1	1.7	0.1	0.4	1.2	2.01°C ± 0.97

Table 9. NOAA SST May to November monthly anomalies averaged over the Magdalen Shallows (region 8 of the Gulf) and subregions Eastern and Western Magdalen Shallows. The monthly numbers are the standardized anomalies (monthly mean minus climatological mean, divided by the standard deviation of the climatology). The mean and standard deviation are indicated for each month on the right side of the table.

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± S.D.
Magdalen Shallows	M	-1.2	0.1	-0.7	-0.3	-0.6	-1.6	-1.0	-1.2	-0.9	-0.1	0.2	0.1	-0.9	1.8	2.2	0.0	0.7	-0.3	-0.1	-0.1	-0.4	2.2	0.1	1.0	0.7	4.22°C ± 1.27
	J	-1.9	-1.2	0.1	-1.4	-0.0	-1.0	0.2	-0.7	-1.2	0.0	0.5	1.1	-0.8	0.5	2.1	0.4	1.3	-0.4	-0.2	-0.8	-0.3	1.7	0.4	0.5	0.9	10.09°C ± 1.12
	J	-0.7	-1.5	0.0	-0.9	-0.1	-0.6	-0.7	-2.3	-1.2	1.9	1.1	-0.3	0.1	0.4	1.4	0.4	0.5	-0.3	0.7	0.1	0.2	1.2	0.5	1.2	-1.1	15.45°C ± 1.40
	A	-0.1	-2.7	-0.5	0.0	-0.7	-0.0	-1.4	-1.3	0.8	1.3	0.7	1.4	-0.0	-0.1	0.3	-0.1	1.1	0.6	-0.1	1.0	0.4	0.5	-0.5	-1.8	1.2	17.27°C ± 0.99
	S	-0.3	-1.9	-2.5	-1.1	-1.4	0.1	-0.5	0.3	0.9	0.3	-0.2	0.6	-0.3	0.2	1.9	0.7	1.4	-0.1	0.5	-0.3	1.5	0.7	-0.3	-0.2	-0.2	14.62°C ± 0.93
	O	0.4	-1.4	-0.1	-1.8	-2.7	-0.3	1.1	-1.0	-0.1	-0.1	0.8	0.3	0.1	-1.1	-0.1	0.3	1.9	0.3	1.1	0.6	0.6	0.8	0.7	0.2	-0.2	10.32°C ± 0.87
	N	-0.3	-1.3	-1.4	-1.8	-0.6	-2.2	0.7	-1.0	-0.3	1.3	1.0	1.2	0.5	-0.5	-0.2	0.0	0.4	-0.4	0.2	-0.3	1.1	1.3	0.7	1.0	0.9	5.67°C ± 0.85
Eastern Magdalen Shelf	M	-1.2	0.3	-0.7	0.1	-0.3	-1.6	-1.0	-1.3	-0.8	0.1	-0.0	-0.1	-1.2	1.6	2.1	0.2	0.7	-0.4	0.2	-0.2	0.1	2.3	-0.2	0.6	0.8	3.25°C ± 1.32
	J	-1.9	-0.9	0.2	-1.5	-0.2	-1.1	-0.4	-0.5	-1.2	-0.0	0.1	0.9	-0.7	0.8	2.2	0.3	1.3	-0.1	-0.4	-0.6	-0.2	1.7	0.7	0.6	1.1	8.97°C ± 1.22
	J	-1.0	-1.3	0.1	-1.0	-0.1	-0.5	-0.6	-2.2	-1.5	1.7	0.7	-0.5	0.1	0.4	1.7	0.5	0.7	-0.2	0.6	0.2	-0.1	1.4	0.3	1.3	-0.8	14.84°C ± 1.62
	A	0.1	-2.2	-0.1	-0.3	-0.3	-0.8	-1.5	-1.3	-0.1	1.8	0.4	1.5	-0.3	-0.1	0.7	0.1	1.2	0.6	0.1	1.2	0.3	0.3	-0.6	-1.7	1.2	17.34°C ± 1.06
	S	-0.3	-1.7	-1.4	-1.0	-1.4	-0.1	-0.9	0.5	1.0	0.8	-0.8	0.3	-0.6	-0.1	2.2	1.0	1.5	-0.2	0.6	-0.5	1.6	0.7	-0.7	-0.3	-0.1	14.85°C ± 0.89
	O	-0.4	-1.3	0.2	-1.5	-2.5	-0.8	1.3	-1.0	0.6	0.0	0.6	0.7	0.2	-1.2	-0.5	0.5	2.1	-0.4	1.3	0.7	0.3	0.6	0.5	0.4	-0.4	10.59°C ± 0.87
	N	-0.4	-1.2	-1.6	-1.6	0.1	-2.7	0.2	-0.7	0.1	0.6	0.8	1.4	0.2	-0.3	-0.3	1.0	0.4	-0.6	0.2	-0.5	0.8	1.0	0.9	1.3	0.7	5.91°C ± 0.90
Western Magdalen Shelf	M	-1.0	0.1	-0.2	-0.5	-0.9	-1.2	-1.1	-1.2	-0.8	-0.5	0.3	-0.2	-0.9	2.0	2.1	0.0	0.6	-0.3	-0.1	-0.2	-0.5	2.2	0.1	1.4	0.6	3.73°C ± 1.28
	J	-1.8	-1.1	0.7	-1.4	0.3	-1.3	0.2	-0.5	-1.4	-0.4	0.7	1.1	-0.7	0.7	2.0	0.2	1.3	-0.3	-0.3	-0.9	-0.3	1.6	0.3	0.4	0.9	9.64°C ± 1.15
	J	-0.6	-1.4	0.2	-0.9	0.1	-0.9	-1.2	-2.1	-1.4	1.7	1.3	-0.3	0.1	0.5	1.4	0.5	0.4	-0.4	0.5	0.0	0.4	1.2	0.6	1.1	-1.0	15.09°C ± 1.39
	A	0.1	-2.5	-0.6	0.6	-1.2	-0.5	-1.6	-1.7	1.1	0.9	0.8	1.4	0.1	-0.1	0.1	0.3	0.9	0.4	-0.1	0.8	0.6	0.8	-0.6	-1.2	1.2	16.87°C ± 0.99
	S	-0.2	-1.7	-2.0	-0.9	-1.9	0.2	-0.5	0.0	0.9	0.1	-0.2	1.2	0.4	0.3	1.7	0.6	1.1	-0.5	0.3	-0.7	1.7	0.8	-0.8	0.2	-0.3	13.99°C ± 0.94
	O	0.6	-1.4	-0.2	-1.8	-3.0	-0.1	0.8	-1.1	-0.2	-0.2	0.7	0.6	0.3	-0.8	-0.2	0.3	1.6	0.4	1.1	0.6	0.7	0.7	0.3	0.2	0.1	9.56°C ± 0.91
	N	0.0	-1.2	-1.5	-1.9	-1.0	-1.8	1.0	-0.9	-0.6	1.4	1.1	1.4	0.4	-0.5	-0.3	0.1	0.0	-0.1	-0.1	-0.0	1.1	1.3	0.4	0.7	1.1	5.05°C ± 0.88

Table 10. Yearly number of weeks with mean weekly surface temperature > 10°C, averaged for the entire Gulf and each region of the Gulf. The scorecards are colour-coded according to the standardized anomalies based on the 1985-2009 timeseries, but the numbers are the average number of weeks above 10°C for each year.

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± S.D.
Gulf of St. Lawrence	11.4	10.4	13.0	11.0	12.1	12.0	11.7	10.7	12.4	14.0	14.8	14.7	13.6	14.3	16.1	14.1	15.5	12.6	14.7	13.1	14.1	16.2	13.8	14.3	14.1	13.4 w ± 1.6
1 - Estuary	4.9	3.4	5.1	6.6	5.4	5.4	5.0	5.2	10.1	6.9	7.4	8.1	7.6	7.9	8.2	8.0	7.8	8.0	6.8	5.7	6.6	9.0	6.6	8.7	6.2	6.8 w ± 1.6
2 - Northwest Gulf	11.0	8.0	9.0	9.2	10.7	10.0	9.6	9.4	13.0	12.6	13.6	14.9	12.6	14.6	15.1	12.2	13.1	11.0	12.6	10.5	12.6	13.7	11.5	12.9	11.8	11.8 w ± 1.9
3 - Anticosti Channel	9.5	8.8	11.5	8.9	11.4	7.3	7.7	8.9	9.4	11.4	12.5	13.4	12.0	12.9	15.1	11.3	12.8	11.3	11.8	10.7	12.9	14.5	10.7	11.9	12.6	11.2 w ± 2.0
4 - Mécatina Trough	4.6	5.4	9.0	6.7	5.9	7.7	2.9	2.8	4.2	8.3	7.7	7.8	8.7	8.3	12.4	11.6	10.6	7.9	11.7	9.5	9.7	11.6	8.5	10.2	9.8	8.1 w ± 2.7
5 - Esquiman Channel	9.9	9.4	13.0	10.8	10.9	10.9	8.9	8.2	9.2	12.9	13.1	11.8	12.4	12.5	15.5	13.5	14.4	10.0	15.2	11.7	12.5	16.6	13.0	13.2	13.2	12.1 w ± 2.1
6 - Central Gulf	12.3	10.9	14.2	11.3	12.4	12.2	12.6	11.8	12.8	14.6	15.5	15.4	13.9	14.1	16.7	14.2	16.1	12.4	15.3	13.3	13.8	17.1	13.1	13.9	14.8	13.8 w ± 1.6
7 - Cabot Strait	11.6	11.1	15.0	11.8	12.6	14.4	13.6	11.3	14.1	16.1	16.8	16.1	14.6	15.6	17.2	15.3	18.0	12.5	16.2	13.9	15.5	17.3	15.3	15.3	15.7	14.7 w ± 2.0
8 - Magdalen Shallows	14.7	14.4	16.6	14.1	15.5	16.3	17.5	15.1	16.0	17.4	18.7	18.1	16.7	17.3	18.5	17.6	19.6	17.3	18.0	17.7	17.7	19.3	18.5	18.0	17.5	17.1 w ± 1.5

Table 11. First and last day of ice occurrence, ice duration and season maximum ice volume, by region. The time when ice was first and last seen in days from the beginning of each year is indicated for each region and the colour code expresses the anomaly based on the 1971-2000 climatology, with blue representing earlier first occurrence and later last occurrence. The threshold is 5% of the largest ice volume ever recorded in the region. Numbers in the table are the actual day of the year rather than the anomaly, but the colour coding is according to standardized anomalies based on the climatology of each region.

Variable	Region	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
First occurrence of ice	1 - Estuary	17	12	-10	0	-12	-3	-8	-5	-14		-21	-6	-24	-9	-5	3	2	-13	-14	-8	-5
	2 - Northwest Gulf	17	12	15	0	-12	-3	8	-5	-14		-21	8	-1	14	9	3	2	-6	-7	-1	-5
	3 - Anticosti Channel	57	12	15	0	-2	9	15	9	7	8	14	-6	22	14	-5	15	2	8	-14	24	2
	4 - Mécatina Trough	80	12	15	0	-12	9	8	-5	-7	8	-28	1	-1	21	-12	3	2	-13	-14	3	-5
	5 - Esquiman Channel	80	58	15	14	-2	16	29	37	16	36	14	29	36	28	44	15	2	8	7	17	9
	6 - Central Gulf		37	15	21	3	23	29	16	16	22	14	36	15	42	23	15	23	15	21	24	16
	7 - Cabot Strait		30	29	28	15	23	29	37	16	29	42	36	15	35	51	43	23	22	35	31	30
	8 - Magdalen Shallows	17	12	-1	0	-12	9	8	9	-14	8	-21	8	-1	14	9	3	2	-6	-14	-1	-5
Last occurrence of ice	1 - Estuary	80	84	64	101	71	72	71	93	86	99	84	80	55	77	100	99	79	78	84	87	79
	2 - Northwest Gulf	80	77	78	108	85	93	85	100	86	99	91	80	62	77	100	99	79	85	112	80	86
	3 - Anticosti Channel	57	98	71	136	99	149	127	121	100	127	105	92	83	140	93	129	128	134	119	129	86
	4 - Mécatina Trough	132	119	92	122	134	177	162	142	121	134	133	120	90	140	114	143	156	141	119	136	128
	5 - Esquiman Channel	80	119	85	129	120	163	141	121	128	134	77	99	62	119	86	129	149	127	119	108	121
	6 - Central Gulf		70	85	136	99	107	113	100	93	106	98	80	69	99	79	99	93	106	91	94	107
	7 - Cabot Strait		98	92	136	127	107	127	100	114	106	98	106	62	105	100	87	107	106	126	101	114
	8 - Magdalen Shallows	94	105	106	136	127	107	127	100	114	113	112	106	83	105	114	136	107	113	126	108	107
Duration of ice season	1 - Estuary	64	73	75	102	84	76	80	99	101	110	106	87	80	87	106	97	78	92	99	96	85
	2 - Northwest Gulf	64	66	64	109	98	97	78	106	101	105	113	73	64	64	92	97	78	92	120	82	92
	3 - Anticosti Channel	1	87	57	137	102	141	113	113	94	120	92	99	62	127	99	115	127	127	134	106	85
	4 - Mécatina Trough	53	108	78	123	147	169	155	148	129	127	162	120	92	120	127	141	155	155	134	134	134
	5 - Esquiman Channel	1	62	71	116	123	148	113	85	113	99	64	71	27	92	43	115	148	120	113	92	113
	6 - Central Gulf		34	71	116	97	85	85	85	78	85	85	45	55	58	57	85	71	92	71	71	92
	7 - Cabot Strait		69	64	109	113	85	99	64	99	78	57	71	48	71	50	45	85	85	92	71	85
	8 - Magdalen Shallows	78	94	108	137	140	99	120	92	129	106	134	99	85	92	106	134	106	120	141	110	113
Maximum ice volume (km^3)	1 - Estuary	1.6	1.6	1.9	2.2	2.3	2.0	2.5	1.7	2.1	2.1	5.3	1.2	2.6	2.6	2.4	2.0	2.1	1.6	2.4	2.2	1.9
	2 - Northwest Gulf	4	7	13	13	9	9	9	9	11	12	12	5	9	6	9	11	7	7	10	13	8
	3 - Anticosti Channel	1	4	7	13	8	8	6	7	8	5	8	4	3	4	3	7	5	6	7	5	6
	4 - Mécatina Trough	1	3	3	6	6	6	5	5	6	6	5	5	2	6	4	6	8	8	6	5	7
	5 - Esquiman Channel	1	4	7	17	13	18	19	20	18	8	12	6	4	13	4	9	15	15	14	16	18
	6 - Central Gulf	0	4	9	13	8	6	10	10	11	7	9	5	8	6	1	7	6	7	5	7	7
	7 - Cabot Strait	0	3	5	10	7	11	11	9	8	8	10	6	5	9	1	3	7	8	5	7	7
	8 - Magdalen Shallows	10	18	23	35	31	19	28	23	30	27	31	19	18	22	18	24	25	24	33	25	20
	Scotian Shelf	0	6	4	10	13	25	18	9	10	10	12	7	3	19	1	3	19	14	9	7	14
	GSL + Scotian Shelf	17	42	65	99	83	84	85	82	88	66	82	46	42	69	40	61	75	78	70	72	74

Variable	Region	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± S.D.
First occurrence of ice	1 - Estuary	-21	0	-12	-17	-4	2	-20	6	-9	0	2	-5	5	-21	-21	-8	-12	14	-15	-19	-8 ± 8
	2 - Northwest Gulf	-21	7	-5	-3	3	16	8	6	3	3	16	12	19	8	3	3	2	24	6	7	1 ± 10
	3 - Anticosti Channel	-21	7	2	4	-4	9	29	34	9	9	16	26	18	5	28	17	31	29	7	19	8 ± 12
	4 - Mécatina Trough	-21	-11	-5	-3	3	2	-20	20	6	2	15	5	17	-2	25	10	-3	14	0	18	-1 ± 12
	5 - Esquiman Channel	8	7	23	4	24	16	15	41	17	14	41	23	25	15	43	23	31	29	21	27	19 ± 13
	6 - Central Gulf	8	14	23	11	10	30	22	34	29	13	29	36	35	19	15	26	52	37	26	18	20 ± 9
	7 - Cabot Strait	8	21	23	25	17	44	36	41	40	35	39	50	41	25	25	31	60	37	46	25	30 ± 10
	8 - Magdalen Shallows	-21	-7	-5	-3	3	2	-13	6	-2	2	15	4	17	7	10	5	33	18	1	5	-1 ± 10
Last occurrence of ice	1 - Estuary	57	98	79	81	87	100	71	83	85	86	80	82	85	82	88	86	76	85	93	86	82 ± 12
	2 - Northwest Gulf	92	91	100	109	101	121	92	97	91	90	84	79	85	93	93	98	78	84	101	83	92 ± 12
	3 - Anticosti Channel	148	168	128	116	157	142	106	153	105	115	84	118	91	157	101	98	115	113	105	113	120 ± 24
	4 - Mécatina Trough	155	182	149	158	157	149	120	146	126	137	114	135	109	152	128	111	118	154	147	129	137 ± 21
	5 - Esquiman Channel	155	119	135	133	143	142	100	125	120	123	80	132	96	149	118	106	107	127	116	115	120 ± 24
	6 - Central Gulf	120	119	121	116	115	107	92	118	106	94	82	85	95	114	101	89	64	84	103	98	101 ± 15
	7 - Cabot Strait	113	119	135	116	108	121	100	132	91	114	79	114	91	115	111	115	85	88	114	104	108 ± 17
	8 - Magdalen Shallows	106	119	135	123	115	121	113	125	108	109	90	114	92	107	116	113	87	89	109	106	114 ± 12
Duration of ice season	1 - Estuary	79	99	92	99	92	99	92	78	95	87	79	88	81	104	110	95	89	72	109	106	91 ± 10
	2 - Northwest Gulf	114	85	106	113	99	106	85	92	89	88	69	68	67	86	91	96	77	61	96	77	92 ± 16
	3 - Anticosti Channel	170	162	127	113	162	134	78	120	97	107	69	93	74	153	74	82	85	85	99	95	113 ± 28
	4 - Mécatina Trough	177	194	155	162	155	148	141	127	121	136	100	131	93	155	104	102	122	141	148	112	139 ± 24
	5 - Esquiman Channel	148	113	113	130	120	127	86	85	104	110	40	110	72	135	76	84	77	99	96	89	101 ± 31
	6 - Central Gulf	113	106	99	106	106	78	71	85	78	82	54	50	61	96	87	64	13	48	78	81	82 ± 18
	7 - Cabot Strait	106	99	113	92	92	78	65	92	52	80	41	65	51	91	87	85	26	52	69	80	79 ± 21
	8 - Magdalen Shallows	128	127	141	127	113	120	127	120	111	108	76	111	76	101	107	109	55	72	109	102	116 ± 17
Maximum ice volume (km^3)	1 - Estuary	1.4	1.6	2.6	2.5	2.5	3.4	2.0	1.4	1.4	1.1	1.6	1.2	2.9	1.3	2.0	2.1	1.1	0.9	1.4	1.7	2.2 km^3 ± 0.8
	2 - Northwest Gulf	11	9	14	18	12	16	13	12	6	8	6	7	10	7	4	11	5	4	17	8	10.2 km^3 ± 3.0
	3 - Anticosti Channel	10	9	8	12	14	17	6	7	4	9	3	4	6	6	4	6	2	4	7	5	7.3 km^3 ± 3.3
	4 - Mécatina Trough	11	6	6	5	10	8	4	7	4	6	2	9	5	10	5	4	6	6	4	4	5.7 km^3 ± 1.9
	5 - Esquiman Channel	36	16	18	21	25	15	10	17	5	9	2	8	8	30	10	4	4	9	13	8	14.0 km^3 ± 7.2
	6 - Central Gulf	10	8	11	17	18	14	11	10	3	5	6	3	6	17	2	10	2	4	8	7	8.4 km^3 ± 3.7
	7 - Cabot Strait	12	7	10	14	11	11	5	11	2	5	5	5	3	22	9	5	2	4	7	8	7.6 km^3 ± 3.0
	8 - Magdalen Shallows	25	22	30	61	48	43	29	30	17	26	18	34	20	41	33	33	11	16	32	33	27.4 km^3 ± 9.5
	Scotian Shelf	21	14	20	14	14	10	3	11	1	3	2	5	2	42	9	4	1	6	7	14	10.7 km^3 ± 6.5
	GSL + Scotian Shelf	117	71	96	134	120	106	72	86	41	57	37	59	60	139	63	68	25	38	76	65	76.6 km^3 ± 23.7

Table 12. CIL and related properties. The top block shows the scorecard time series for winter air temperature averaged over eight stations, the Gilbert & Pettigrew (1997) CIL index, March cold layer (< -1°C) volume, yearly maximum sea-ice volume, volume of Labrador Shelf Water intrusion in the Gulf observed in March, and the August–September volume of cold water (< 0°C) observed in the Mécatina Trough. Titles in parentheses have their colour coding reversed (blue for high values). The middle block shows scorecard time series for August–September CIL volumes (<1°C) for all eight regions and for the entire Gulf when available. The following block shows the scorecard time series for the bottom areas of the Magdalen Shallows covered by waters colder than 0, 1, 2 and 3°C during the September survey. The last block shows the November survey CIL volume (<1°C) and average CIL minimum temperature in the Estuary.

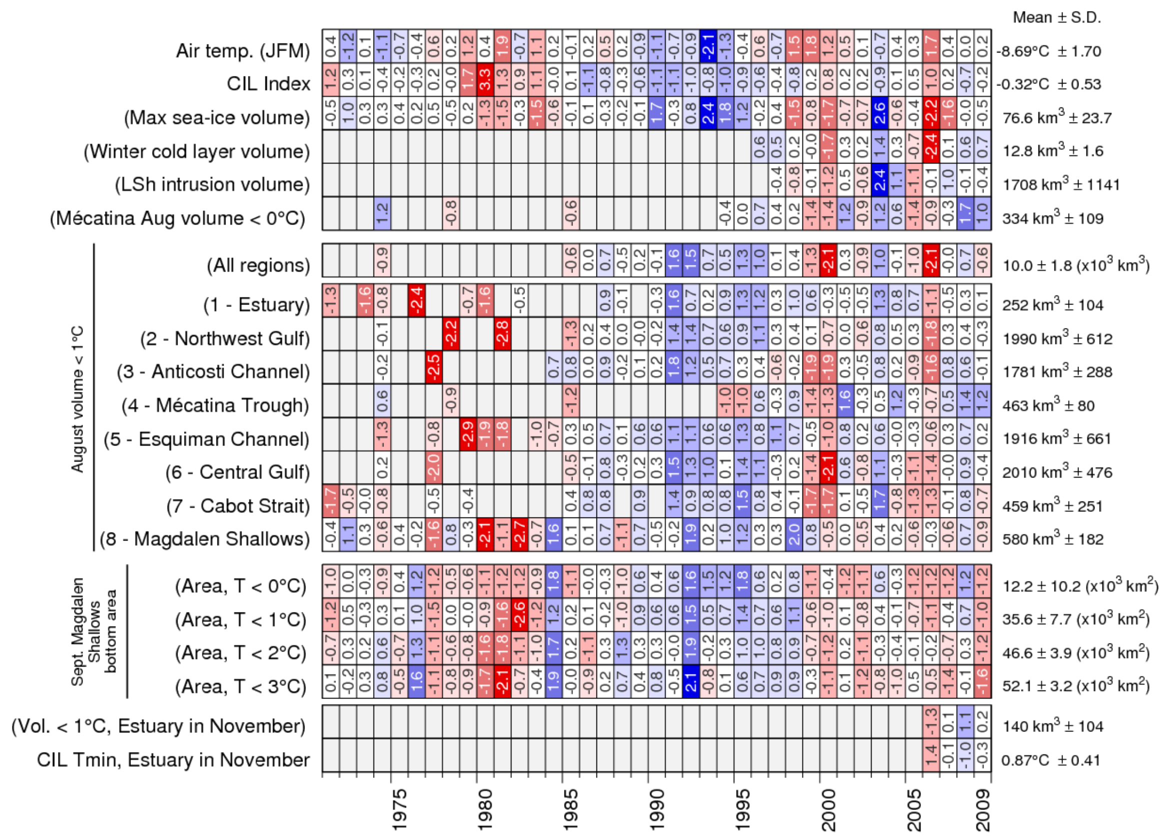

Table 13. Depth-layer average temperature anomalies for western and eastern Magdalen Shallows for the June mackerel survey. The SST data are from June averages from NOAA remote sensing repeated from Table 9. The colour-coding of the 0 to 75 m lines are according to standardized anomalies based on the 1971-2000 climatologies, but the numbers are mean temperatures in ºC. The SST colour-coding is based on the climatology of the entire time series and the numbers are mean temperatures in ºC.

		1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Eastern Shelf	SST June																				
	0 m temp.	5.8	9.1	10.1	10.0	10.5	8.6	7.8	11.3	6.8		6.5	11.1	9.8	11.5		11.4		9.7		
	10 m temp.	5.6	7.8	6.5	9.5	8.8	8.1	6.9	8.3	5.7		5.6	9.5	7.9			10.0		8.6		
	20 m temp.	4.5	4.9	2.4	5.7	5.9	6.8	3.6	3.2	4.1		3.6	6.0	4.3			7.7		5.3		
	30 m temp.	1.6	2.2	0.8	2.2	4.1	5.0	1.9	0.8	1.9		1.4	2.1	2.0			4.6		2.2		
	50 m temp.	0.2	0.8	0.3	0.1	1.6	2.0	-0.4	-0.2	0.3		0.1	-0.7	0.9			1.1		0.7		
	75 m temp.	-0.9	0.6		1.1	1.7	2.1	0.0	1.5	1.3		0.2	-0.5	2.1			0.7		0.9		
Western Shelf	SST June																				
	0 m temp.	5.9	8.8	7.6	10.2	9.5	8.0	8.2	11.6			9.1	11.8	9.2	11.2		11.7		10.8		
	10 m temp.	5.4	6.8	5.8	9.5	7.4	6.9	7.0	8.3			7.5	10.0	7.1	9.6		10.4		9.8		
	20 m temp.	4.0	3.3	3.4	6.2	4.6	4.6	4.5	2.6			4.9	6.2	4.0	6.7		7.6		5.5		
	30 m temp.	2.2	1.6	2.0	2.4	2.6	2.9	3.2	0.3			2.2	2.5	2.5	4.1		4.6		2.4		
	50 m temp.	0.3	0.3	0.5	-0.2	0.8	1.3	0.2	-0.3			0.0	-0.4	0.7	0.7		1.5		0.9		
	75 m temp.	-0.2	0.0	0.2	-0.1	0.8	1.7	0.5				-0.3	-0.3	0.3	0.2		0.4		0.2		

		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
Eastern Shelf	SST June	6.6	7.8	9.2	7.1	8.7	7.6	8.5	8.3	7.5	8.9	9.1	10.1	8.1	9.9	11.6	9.4	10.6	8.9	8.5	8.2	8.8	11.0	9.8	9.7	10.3	8.97°C ± 1.22
	0 m temp.			10.9	10.2	12.1	10.4	8.7	11.0	9.6	11.1		11.9	6.9	11.1	12.2	11.7	10.3	8.7	8.2	8.6	9.0	15.9	11.1	12.3	10.1	10.16°C ± 1.76
	10 m temp.			9.2	9.7	9.7	9.1	7.6	8.6	7.9	9.6		10.7	6.0	9.2	10.9	10.2	8.4	7.9	7.5	8.0	7.8	11.4	9.1	10.2	9.6	8.61°C ± 1.56
	20 m temp.			4.6	6.4	4.0	5.3	5.8	4.2	5.3	6.0		6.1	3.8	4.8	7.4	7.2	4.5	5.3	4.5	6.1	4.7	4.5	4.6	6.2	6.8	5.17°C ± 1.33
	30 m temp.			1.6	2.9	0.7	3.0	2.8	1.1	0.8	2.0		2.2	2.0	1.5	4.2	4.6	1.5	2.6	1.8	4.2	2.6	1.6	2.0	2.1	3.7	2.20°C ± 1.14
	50 m temp.			-0.1	0.2	-0.2	-0.1	-0.3	-0.7	-1.4	-0.6		0.2	0.6	-0.4	1.4	1.0	0.1	0.7	-0.4	0.8	0.8	0.7	0.4	-0.4	0.2	0.07°C ± 0.71
	75 m temp.			0.1	1.2				0.3				0.3	0.2	-0.4	0.9	1.0	0.4	0.9	-0.4	0.3	1.0		0.8	0.3	0.9	0.62°C ± 0.72
Western Shelf	SST June	7.6	8.4	10.4	8.0	9.9	8.1	9.9	9.1	8.1	9.2	10.4	10.9	8.8	10.4	11.9	9.9	11.2	9.2	9.3	8.6	9.3	11.5	10.0	10.1	10.7	9.64°C ± 1.15
	0 m temp.			11.7	10.1	13.4	10.0	11.3	12.2	9.2	9.8		11.9	9.2	11.6	13.5	11.9	11.4	9.2	9.9	9.1	9.4	14.2	11.2	12.0	10.9	10.92°C ± 1.44
	10 m temp.			10.9	8.8	10.2	8.6	8.5	9.5	7.5	7.9		10.4	7.8	9.8	10.4	10.1	8.3	8.2	8.3	8.4	8.2	10.6	10.0	9.3	9.1	9.06°C ± 1.23
	20 m temp.			5.7	5.1	5.4	5.3	6.1	5.4	5.5	4.4		5.0	4.6	4.0	5.6	6.6	3.7	5.2	4.6	5.9	3.8	4.7	6.6	5.0	5.1	5.27°C ± 1.08
	30 m temp.			1.8	2.5	2.0	3.3	3.6	2.3	2.2	2.0		2.2	3.1	0.5	2.6	3.7	1.6	2.2	2.3	3.5	2.1	2.6	2.9	1.8	2.3	2.55°C ± 1.02
	50 m temp.			-0.5	-0.2	-0.0	0.3	-0.2	-0.3	-1.3	-0.5		-0.2	0.1	-0.5	0.3	0.3	0.1	0.2	-0.3	0.3	0.3	0.6	0.4	-0.3	0.0	0.02°C ± 0.60
	75 m temp.			-0.1	-0.3			-0.4	-0.3		-0.5		-0.7	-0.6		-0.2	-0.1	-0.4	-0.0	-0.6	-0.7	-0.1	0.6	0.1	-0.5	-0.1	-0.15°C ± 0.36

Table 14. Depth-layer monthly average temperature summary for months corresponding to the eight Gulf-wide oceanographic surveys in 2008 and 2009. The colour-coding is according to the temperature anomaly relative to the monthly 1971-2000 climatology of each region, except for March for which the climatology extends to 2009.

1 - Estuary / Estuaire

	2008				2009			
	Mar	Juin	Août	Oct	Mar	Juin	Août	Oct
0 m	-1.39	7.9	11.9	4.2	-1.07	7.4	8.5	4.3
10 m	-1.35	6.0	10.6	4.0	-1.25	5.0	6.8	4.3
20 m	-0.92	3.9	8.7	3.8	-1.07	2.8	4.6	4.5
30 m	-0.54	2.3	6.0	3.3	-0.76	1.7	3.3	4.5
50 m	0.1	0.8	1.6	2.3	-0.98	0.2	1.0	4.2
75 m	0.8	-0.2	0.3	1.1	-0.68	0.2	0.4	2.1
100 m	2.0	0.4	0.9	0.8	0.4	1.2	1.3	1.1
150 m	3.4	2.6	2.9	2.1	2.2	2.9	3.0	2.0
200 m	4.1	3.8	4.2	3.8	3.6	3.9	4.1	3.5
250 m		4.6	4.8	4.7	4.7	4.7	4.8	4.4
300 m		5.1	5.1	5.1	5.1	5.0	5.0	4.9
350 m		5.1	5.2	5.1		5.1	5.1	5.0

2 - Northwest Gulf / Nord-ouest du Golfe

	2008				2009			
	Mar	Juin	Août	Nov	Mar	Juin	Août	Nov
0 m	-1.62	10.1	15.5	4.0	-1.56	9.5	13.4	4.4
10 m	-1.64	6.8	13.1	4.0	-1.62	7.5	11.1	4.4
20 m	-1.63	2.5	8.7	3.9	-1.65	4.1	5.2	4.4
30 m	-1.61	0.9	6.1	3.2	-1.65	1.6	3.0	3.8
50 m	-1.04	-0.1	1.4	1.2	-1.20	-0.0	0.7	2.1
75 m	-0.20	-0.1	0.0	0.7	-0.43	0.2	0.4	1.0
100 m	1.0	0.8	0.6	1.1	0.3	1.2	1.1	0.7
150 m	3.4	3.0	2.7	2.8	3.1	3.1	3.0	2.3
200 m	4.4	4.4	4.2	4.4	4.4	4.5	4.3	3.9
250 m		5.2	5.1	5.1	5.3	5.1	5.0	4.8
300 m		5.4	5.4	5.4	5.4	5.3	5.3	5.2
350 m		5.4	5.4	5.4		5.3	5.3	5.3
400 m			5.4	5.4			5.3	5.3

3 - Anticosti Channel / Chenal Anticosti

	2008				2009			
	Mar	Juin	Août	Nov	Mar	Juin	Août	Nov
0 m	-1.70	7.3	16.8	6.1	-1.66	6.2	15.7	3.4
10 m	-1.71	6.2	15.8	6.1	-1.69	5.5	13.3	3.5
20 m	-1.71	3.5	8.1	6.0	-1.70	3.3	5.5	3.4
30 m	-1.70	1.7	4.2	6.0	-1.70	1.7	2.3	3.4
50 m	-1.68	0.4	0.5	2.0	-1.65	-0.5	0.3	3.0
75 m	-1.43	-0.6	-0.4	0.7	-1.12	-0.7	-0.2	1.4
100 m	-0.98	-0.8	-0.3	0.5	-0.00	-0.5	-0.1	0.8
150 m	1.5	0.9	1.6	1.3	2.3	1.6	1.8	1.1
200 m	3.9	3.4	4.4	3.9	4.4	3.4	3.6	3.1
250 m			5.4	5.4			5.1	4.9

4 - Mécatina Trough / Cuvette de Mécatina

	2008				2009			
	Mar	Juin	Août	Nov	Mar	Juin	Août	Nov
0 m	-1.74		15.0	4.7	-1.68	6.1	13.3	2.0
10 m	-1.75		14.8	4.7	-1.69	5.9	12.0	2.0
20 m	-1.75		9.0	4.7	-1.70	3.7	3.9	2.1
30 m	-1.75		4.7	4.7	-1.71	1.1	2.3	2.1
50 m	-1.75		1.0	3.7	-1.61	0.0	0.5	2.1
75 m	-1.74		-0.5	3.5	-1.53	-0.9	-0.6	2.0
100 m	-1.75		-0.9	3.2	-1.56	-1.2	-0.6	1.9
150 m	-1.77		-0.6	-0.3	-1.77	-1.2	-0.1	0.7
200 m	-1.78		-0.5	-0.2	-1.77	-1.0	-0.1	-0.1

5 - Esquiman Channel / Chenal Esquiman

	2008				2009			
	Mar	Juin	Août	Nov	Mar	Juin	Août	Nov
0 m	-1.43	8.1	16.7	6.4	-1.68	5.7	17.1	3.8
10 m	-1.45	7.2	13.8	6.4	-1.69	5.5	16.0	3.8
20 m	-1.46	4.2	6.0	6.2	-1.69	4.8	9.1	3.7
30 m	-1.45	1.4	2.0	5.6	-1.68	2.0	4.3	3.6
50 m	-1.41	-0.5	-0.3	1.1	-1.52	0.6	0.7	1.9
75 m	-1.09	-0.5	-0.5	-0.1	-0.44	-0.2	-0.0	0.5
100 m	-0.32	-0.5	-0.2	0.1	0.6	0.3	0.4	0.7
150 m	1.9	1.0	2.2	2.0	2.2	2.6	2.1	2.1
200 m	3.9	3.6	4.4	4.3	3.9	4.5	4.0	4.0
250 m		5.4	5.3	5.3		5.2	5.0	4.9
300 m			5.4	5.4			5.2	5.1

6 - Central Gulf / Centre du Golfe

	2008				2009			
	Mar	Juin	Août	Nov	Mar	Juin	Août	Nov
0 m	-1.49	8.2	17.8	6.6	-1.67	8.7	17.1	5.4
10 m	-1.48	7.9	16.5	6.5	-1.68	8.0	15.3	5.4
20 m	-1.46	5.0	7.8	6.4	-1.68	5.6	9.0	5.4
30 m	-1.44	1.7	2.5	6.1	-1.67	2.6	4.9	5.4
50 m	-1.43	-0.3	0.1	1.0	-1.45	-0.2	1.2	2.8
75 m	-1.19	-0.7	-0.6	0.1	-0.66	0.0	0.1	1.1
100 m	0.2	-0.1	-0.2	0.4	0.3	0.8	0.4	0.7
150 m	2.7	2.1	1.7	2.3	2.3	3.3	2.3	2.5
200 m	4.6	4.3	4.1	4.4	4.1	4.8	4.2	4.3
250 m		5.2	5.3	5.4		5.3	5.1	5.1
300 m		5.4	5.5	5.5		5.4	5.3	5.3
350 m		5.4	5.3	5.3		5.3	5.3	5.3
400 m		5.2	5.2	5.2		5.2	5.2	5.2
450 m				5.1		5.1	5.1	5.1

7 - Cabot Strait / Détroit de Cabot

	2008				2009			
	Mar	Juin	Juil	Nov	Mar	Juin	Août	Nov
0 m	-1.22	10.1	17.6	8.7	-1.52	9.4	17.2	6.8
10 m	-1.18	8.3	15.0	8.6	-1.52	8.3	14.9	6.8
20 m	-1.16	5.3	7.9	8.3	-1.52	4.9	7.9	6.8
30 m	-1.13	1.8	3.4	7.7	-1.48	2.9	4.0	6.5
50 m	-1.12	-0.1	0.6	2.5	-1.01	0.5	1.0	5.4
75 m	-0.50	0.5	0.5	1.4	-0.17	0.5	0.7	2.3
100 m	1.0	0.9	0.7	1.1	0.5	1.2	1.1	1.6
150 m	3.8	2.8	2.9	2.1	3.0	3.7	3.4	2.8
200 m	5.4	4.7	4.8	4.4	4.9	5.0	4.9	5.0
250 m		5.5	5.5	5.6		5.3	5.3	5.6
300 m		5.5	5.5	5.6		5.3	5.3	5.4
350 m		5.3	5.3	5.4		5.3	5.3	5.3
400 m		5.0	5.1	5.1		5.1	5.2	5.2
450 m		5.0	5.0	5.0		5.0	5.1	5.1
500 m			5.0	5.0			5.0	5.0

8 - Magdalen Shallows / Plateau madelinien

	2008				2009			
	Mar	Juin	Sep	Nov	Mar	Juin	Sep	Nov
0 m	-1.60	13.2	16.1	7.5	-1.66	10.6	14.7	6.4
10 m	-1.67	11.3	16.0	7.4	-1.67	9.4	14.7	6.4
20 m	-1.68	7.5	12.7	7.0	-1.68	5.0	13.4	6.4
30 m	-1.68	3.5	6.4	5.8	-1.69	2.0	8.6	6.4
50 m	-1.63	-0.6	0.6	2.4	-1.68	-0.2	1.5	4.3
75 m	-1.34	-0.7	-0.2	0.4	-1.59	-0.3	0.5	1.6
100 m			0.4				1.2	

Table 15. Deep layer temperature, salinity and dissolved oxygen. Gulf averages for temperature and salinity are shown for 200, 250 and 300 m and regional averages are shown for 200 and 300 m. Only recent regional averages at 300 m are shown for dissolved oxygen, with an inverted colour scheme. The numbers on the right are the 1971–2000 climatological means and standard deviations. The numbers in the boxes are standardized anomalies.

		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Gulf Avg T	200 m	-0.2	-0.2	-0.1	-0.1	-1.4	-0.7	0.8	0.9	1.4	1.8	1.6	0.2	-0.3	0.3	0.4	1.2	0.8	0.8	0.6	-0.6
Gulf Avg T	250 m	-1.2	-1.0	-0.5	-0.7	-1.2	-0.7	0.3	0.7	1.2	2.2	1.5	0.2	-0.4	0.1	0.8	1.6	1.0	1.1	0.5	-0.4
Gulf Avg T	300 m	-2.0	-1.8	-1.2	-1.3	-1.0	-0.3	0.3	0.6	1.0	2.6	1.2	0.3	-0.3	0.1	0.6	1.4	0.7	0.7	0.3	-0.1
200-m Temperature	1 - Estuary	-0.1	-0.7	0.1	0.0	-0.7	-0.2	-2.0	0.9	1.2	0.9		1.8		1.2	-2.4		0.2	1.1	1.3	0.2
200-m Temperature	2 - Northwest Gulf	-0.6	-1.1	0.2	0.2	-1.5	-1.2	-0.1	0.7	1.2	1.7	2.2	0.9	0.8	0.4	0.7	0.3	0.6	0.9	0.9	-0.7
200-m Temperature	3 - Anticosti Channel	0.1	-0.3	0.3	-0.5	-1.0	-0.6	1.2	0.7	1.4	1.1	1.4	-0.5	-1.5	-0.1	1.0	1.0	1.2	0.9	0.5	0.3
200-m Temperature	5 - Esquiman Channel	-0.1	-0.0	-0.3	-0.1	-1.0	-0.7	1.3	0.5	0.8	1.7	1.2	0.7	-0.1	0.3	-0.6	1.0	1.3	0.8	0.7	-0.5
200-m Temperature	6 - Central Gulf	-0.1	0.4	-0.3	0.0	-1.4	-0.3	0.6	1.3	1.4	1.8	1.4	-0.4	-0.8	0.2	0.8	1.4	0.4	0.4	0.4	-0.8
200-m Temperature	7 - Cabot Strait	0.1	-0.2	-0.2	-0.1	-1.3	-0.7	1.8	0.7	1.6	1.4	-0.3	-0.7	-0.6	0.6	1.1	1.2	0.3	0.5	-0.2	-0.6
300-m Temperature	1 - Estuary	-1.6	-1.4	-1.4	-0.6	-1.5	-0.6		0.6	1.5	2.0		1.4		0.7			0.2	1.1	1.2	0.8
300-m Temperature	2 - Northwest Gulf	-2.1	-1.6	-1.3	-1.0	-1.2	-1.1	-0.8	0.2	0.8	2.4	1.9	0.9	0.2	0.8	0.0	0.4	0.9	1.2	0.9	0.5
300-m Temperature	6 - Central Gulf	-1.8	-1.7	-1.2	-1.1	-0.7	0.3	0.3	0.8	1.0	3.1	0.5	0.0	-0.5	-0.2	0.5	1.5	0.5	0.5	0.1	-0.3
300-m Temperature	7 - Cabot Strait	-1.5	-1.8	-0.2	-1.6	-0.5	-0.3	1.3	1.1	1.1	0.4	1.0	-0.8	-0.9	0.1	1.5	1.8	0.6	-0.0	-0.3	-0.5
Gulf Avg S	200 m	0.6	-0.2	-0.5	0.1	-1.8	0.2	0.2	0.7	0.9	1.8	1.4	-0.8	0.2	0.4	0.2	0.0	1.2	1.1	1.4	-0.6
Gulf Avg S	250 m	0.7	-0.9	-1.1	-0.2	-1.6	-0.4	0.0	-0.2	2.1	1.9	1.8	0.9	-0.1	-0.2	0.0	0.9	1.4	1.3	1.0	-0.8
Gulf Avg S	300 m	1.2	-2.0	-1.0	-0.8	-1.5	1.2	-0.8	-0.2	-0.5	1.3	1.5	1.3	-0.5	-0.5	-0.5	0.8	1.5	1.3	0.8	-1.0
200-m Yearly Salinity	1 - Estuary	0.7	-1.4	-0.2	-0.4	0.5	-0.2	-1.8	1.0	1.3	0.8		1.0		1.2			0.4	0.8	1.3	-0.4
200-m Yearly Salinity	2 - Northwest Gulf	1.0	-0.8	-0.9	0.6	-0.8	-0.9		0.7	0.9	1.5	1.3	0.6	0.5	0.5	0.1	-1.0	0.9	0.8	1.6	-1.6
200-m Yearly Salinity	3 - Anticosti Channel	1.3	0.1	0.9	-0.1	-0.7	-0.4					1.1	-0.2	-0.9	1.8	-0.9	-0.3	1.2	0.7	1.3	-0.6
200-m Yearly Salinity	4 - Mécatina Trough	0.8			1.1	-1.2			1.0												
200-m Yearly Salinity	5 - Esquiman Channel	-0.8	0.1	-0.9	-0.4	-1.0	1.7		1.2			1.4	0.6	0.6	-0.1	0.4	0.1	1.3	1.6	1.1	-0.2
200-m Yearly Salinity	6 - Central Gulf	0.9	0.2	-0.1	0.2	-2.1	-0.3	1.0	-0.1		1.2	1.5	-2.6	0.2	0.1	0.4	0.5	0.9	0.5	1.0	0.3
200-m Yearly Salinity	7 - Cabot Strait	0.6	-0.2	0.1	0.8	-1.6	0.9	-1.1			2.6	-1.3	0.2	-0.1	0.2	0.3	0.7	0.7	1.1	0.8	-0.4
300-m Yearly Salinity	1 - Estuary	0.2	-0.8	-0.8	-0.6	0.6	-1.1		0.9	1.5			1.4		0.8			-0.3	0.5	1.5	0.1
300-m Yearly Salinity	2 - Northwest Gulf	0.4	-1.3	-0.9	-0.7	-1.6	1.3		-0.3	0.1	0.6	1.0	0.7	0.3	0.0	-1.1	-0.1	1.6	1.3	1.1	-1.4
300-m Yearly Salinity	6 - Central Gulf	1.9	-1.7	-0.7	-0.7	-1.6	1.1	-1.7	-0.1		1.0	1.4	1.3	-0.6	-0.9	-0.3	0.9	1.4	1.3	0.6	-0.3
300-m Yearly Salinity	7 - Cabot Strait	0.1	-1.6	-0.6	0.1	-1.0	1.3	0.7			1.6	0.9	1.3	-2.0	-0.3	0.1	1.4	1.1	1.0	-0.3	-1.3
300-m Yearly Oxygen	(1 - Estuary)																				
300-m Yearly Oxygen	(2 - Northwest Gulf)																				
300-m Yearly Oxygen	(6 - Central Gulf)																				
300-m Yearly Oxygen	(7 - Cabot Strait)																				

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Mean ± S.D.
Gulf Avg T	200 m	-2.0	-2.2	-0.8	0.1	-1.2	-1.5	0.2	-0.3	0.5	0.3	0.3	0.6	0.4	-0.3	-0.1	0.9	0.5	-0.4	-0.5	4.44°C ± 0.52
Gulf Avg T	250 m	-1.7	-1.9	-0.7	0.6	-0.6	-1.1	0.4	-0.1	0.2	0.1	0.4	0.8	0.7	0.5	0.1	0.5	0.5	-0.2	-0.7	5.30°C ± 0.34
Gulf Avg T	300 m	-1.0	-1.2	-0.4	0.7	0.0	-0.2	0.4	-0.3	-0.1	0.0	0.2	0.4	0.6	0.6	0.1	0.1	0.1	-0.2	-0.6	5.46°C ± 0.30
200-m Temperature	1 - Estuary	-1.2	-0.6	-0.9	-0.4	-0.4	-0.8	0.2	0.2	0.6	0.5	0.6	0.6	0.7	0.1	0.6	0.7	1.1	0.5	0.3	3.73°C ± 0.51
200-m Temperature	2 - Northwest Gulf	-1.4	-1.5	-1.2	-0.6	-1.4	-1.0	-0.1	-0.2	0.9	0.4	0.6	1.0	1.1	0.4	0.2	0.9	1.0	0.3	-0.2	4.25°C ± 0.43
200-m Temperature	3 - Anticosti Channel	-1.8	-2.2	-1.3	0.3	-0.6	-1.2	0.1	-0.7	0.5	0.7	-0.1	1.0	0.1	-1.6	-0.6	1.1	0.4	-1.1	-1.0	4.22°C ± 0.58
200-m Temperature	5 - Esquiman Channel	-2.2	-2.6	-0.2	0.4	-0.9	-1.7	-0.2	-0.2	0.2	0.3	0.1	-0.5	0.5	-0.4	-0.3	0.7	0.0	-0.7	-0.8	4.61°C ± 0.62
200-m Temperature	6 - Central Gulf	-1.9	-2.3	-0.7	0.3	-0.9	-1.4	0.5	-0.3	0.3	0.1	0.3	0.8	0.2	-0.2	-0.2	0.8	0.6	-0.4	-0.3	4.57°C ± 0.65
200-m Temperature	7 - Cabot Strait	-2.4	-1.5	-0.2	0.6	-1.5	-1.2	0.6	-0.4	1.0	0.4	0.4	1.1	-0.3	-0.2	0.6	0.7	-0.3	-0.3	-0.0	4.97°C ± 0.70
300-m Temperature	1 - Estuary	-0.4	-0.4	-0.8	-0.9	-0.4	-0.4	0.0	0.0	0.6	0.2	0.2	0.6	0.9	0.7	0.8	0.7	0.9	0.6	0.5	4.85°C ± 0.37
300-m Temperature	2 - Northwest Gulf	-0.2	-0.8	-0.9	-0.2	-0.2	-0.2	0.2	0.3	0.2	-0.0	0.2	0.5	0.8	0.8	0.8	0.6	0.6	0.4	0.1	5.23°C ± 0.32
300-m Temperature	6 - Central Gulf	-1.0	-1.2	-0.3	1.1	0.1	-0.1	0.6	-0.5	-0.3	0.0	0.2	0.3	0.5	0.5	-0.2	-0.1	0.0	-0.3	-0.8	5.57°C ± 0.33
300-m Temperature	7 - Cabot Strait	-1.5	-1.1	0.8	1.4	0.3	0.1	0.4	-0.8	0.3	0.2	0.3	0.6	0.8	0.5	-0.1	-0.1	-0.7	-0.6	-1.1	5.67°C ± 0.31
Gulf Avg S	200 m	-1.8	-1.3	-0.5	0.8	-1.2	-2.3	-0.2	-0.6	0.4	-0.1	-0.3	0.2	0.5	-0.6	-0.1	1.3	0.5	-0.4	-0.2	34.09 ± 0.12
Gulf Avg S	250 m	-1.3	-1.0	-0.2	0.7	-0.8	-1.9	-0.1	-0.2	0.2	-0.3	-0.2	0.7	0.7	0.2	0.2	1.2	0.6	-0.1	-0.6	34.47 ± 0.09
Gulf Avg S	300 m	-1.0	-0.2	-0.2	0.3	-0.3	-1.2	-0.2	-0.7	-0.2	-0.7	-0.3	0.5	0.5	0.3	0.2	1.2	0.2	-0.5	-0.8	34.65 ± 0.06
200-m Yearly Salinity	1 - Estuary	-0.4			-0.4	-0.9	-2.7	-0.1	-0.3	0.4	-0.1	-0.1	0.1	0.4	-0.2	0.3	0.3	0.8	0.2	0.2	33.98 ± 0.19
200-m Yearly Salinity	2 - Northwest Gulf	-0.8	-0.8	0.0	0.1	-1.9	-1.3	0.0	-0.7	1.5	0.1	0.4	1.0	1.4	0.2	0.3	1.5	1.1	0.4	0.0	34.09 ± 0.11
200-m Yearly Salinity	3 - Anticosti Channel	-0.9	-1.6	-0.9	1.5	-0.4	-1.7	0.1	-0.9	0.5	0.6	-0.9	0.9	0.0	-1.8	-0.6	1.6	0.7	-0.9	-0.5	33.97 ± 0.15
200-m Yearly Salinity	4 - Mécatina Trough				0.4	0.4	-2.2	-0.6	-0.1	0.3	-0.1	-0.7	0.2	-0.3	-0.9	-0.6	0.1	0.4	-0.1	-0.0	32.80 ± 0.26
200-m Yearly Salinity	5 - Esquiman Channel	-1.7	-1.2	-0.6	0.7	-0.4	-1.9	-0.7	-0.2	-0.3	-0.2	-0.6	-1.6	0.4	-0.5	-0.3	0.7	-0.4	-0.7	-0.7	34.12 ± 0.18
200-m Yearly Salinity	6 - Central Gulf	-1.5	-0.9	-0.3	1.0	-0.5	-1.8	0.1	-0.2	0.2	-0.2	-0.1	0.7	0.3	-0.2	0.0	1.2	0.6	-0.3	0.1	34.09 ± 0.17
200-m Yearly Salinity	7 - Cabot Strait	-1.7	-1.0	-0.6	0.7	-1.3	-1.3	0.3	-0.2	0.7	0.1	0.0	1.1	0.0	-0.2	0.6	1.1	0.1	0.1	0.3	34.15 ± 0.18
300-m Yearly Salinity	1 - Estuary				-1.7	-1.1	-1.2	-0.4	-0.7	0.9	-0.3	-0.5	0.4	0.8	0.3	0.6	0.8	0.9	0.2	0.4	34.43 ± 0.11
300-m Yearly Salinity	2 - Northwest Gulf	-0.6	-0.7	-0.6	1.7	-0.6	-0.7	-0.3	-1.0	0.6	-0.7	-0.4	0.3	0.9	0.0	0.7	1.3	0.4	-0.1	-0.1	34.61 ± 0.07
300-m Yearly Salinity	6 - Central Gulf	-0.9	0.0	0.0	-0.1	0.0	-1.1	0.1	-0.1	-0.4	-0.4	-0.1	0.4	0.1	0.6	0.0	1.0	0.1	-0.6	-0.9	34.68 ± 0.07
300-m Yearly Salinity	7 - Cabot Strait	-2.0	-0.7	0.1	0.1	0.3	-0.6	0.1	-0.4	0.1	-0.3	0.0	0.9	1.1	0.7	0.4	0.9	0.1	-0.3	-0.9	34.69 ± 0.07
300-m Yearly Oxygen	(1 - Estuary)										1.7	0.4	-1.1	-1.4	-0.4	-1.1	1.0	0.4	0.1	0.3	64 µM ± 6
300-m Yearly Oxygen	(2 - Northwest Gulf)										-0.6	2.4	0.4	-0.4	0.2	-0.2	-0.6	0.5	-0.6	-1.2	82 µM ± 6
300-m Yearly Oxygen	(6 - Central Gulf)										-1.4	0.0	1.0	-1.9	-0.6	1.0	0.4	0.8	0.7	0.3	129 µM ± 5
300-m Yearly Oxygen	(7 - Cabot Strait)										-1.7	0.8	0.2	-1.4	-0.7	0.0	0.2	1.3	0.9	0.2	153 µM ± 10

Table 16. May to October temperature and salinity layer averages for the fixed monitoring stations, as well as stratification expressed as the density difference between 0 and 50 m. Numbers in the temperature and stratification panels are monthly average values and numbers in the salinity panel are standardized anomalies. Three months of anomaly data, between May and October, are required in order to show an average anomaly for any given year.

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	
T [0-100 m]	Rimouski	2.2	1.7	2.2	1.2	2.2	2.4	1.3	2.4	3.1	2.8	3.2	3.0	2.3	1.4	2.4	2.7	2.3	2.3	2.8	2.32°C ± 0.58
	Gaspé Current						2.7	2.0	2.8	2.4	2.3	2.6	3.1	2.3		2.6	3.2		2.5	2.9	2.62°C ± 0.35
	Anticosti Gyre						1.8	1.9	1.2	1.4	2.0	2.2	2.4	1.8		1.6	1.8		1.9	1.9	1.82°C ± 0.32
	Shediac Valley		7.6					5.5		7.9	7.9	7.9	6.9	6.4	5.7	5.6	6.4	8.5	8.8	6.7	7.22°C ± 1.20
S [0-50 m]	Rimouski	0.8	-0.6	-1.2	-0.1	0.6	-1.6	-1.0	-0.5	0.9	0.7	0.8	1.5	1.6	-0.2	-0.6	0.2	1.1	-1.0	-1.4	29.21 ± 0.44
	Gaspé Current						0.3	-1.5	-1.9	1.3	0.0	0.3	0.3	1.6		-0.2	-0.4		-0.5	0.7	29.79 ± 0.30
	Anticosti Gyre						-1.5	-0.8	-1.2	0.9	0.3	0.3	1.4	1.4		-1.1	-0.1		-0.4	0.8	31.46 ± 0.19
	Shediac Valley		0.0							0.0	0.0	0.2	1.0	2.1	-0.8	-0.6	-0.1	1.0	-1.7	-0.1	29.96 ± 0.30
$\Delta\sigma_t$ [0,50 m]	Rimouski	3.7	4.7	5.0	4.8	4.0	5.5	5.4	4.0	3.3	4.5	3.7	4.1	3.9	4.7	4.4	4.6	4.5	5.6	4.7	4.48 kg m^{-3} ± 0.63
	Gaspé Current						3.7	4.8	4.1	3.9	4.5	4.1	5.0	4.5			3.8		5.3	3.7	4.31 kg m^{-3} ± 0.55
	Anticosti Gyre						3.3	3.0	2.9	2.8	2.9	3.4	2.8	2.9		2.8	2.9		3.7	2.7	3.00 kg m^{-3} ± 0.29
	Shediac Valley		3.6							3.5	3.8	3.3	3.5	3.6	3.7	3.9	3.9	3.3	5.0	3.8	3.71 kg m^{-3} ± 0.45
T [CIL min]	Rimouski	-0.71	-0.56	-0.59	-0.29	-0.66	-0.21	-0.19	-0.63	-0.21	0.08	0.27	0.35	-0.27	-0.29	-0.22	0.53	0.10	-0.05	-0.05	-0.19°C ± 0.35
	Gaspé Current						-0.38	-0.27	-0.68	-0.34	0.03	-0.20	0.13	-0.45		-0.29	0.54		-0.44	-0.24	-0.22°C ± 0.32
	Anticosti Gyre						-0.33	-0.47	-0.67	-0.46	0.07	-0.10	0.03	-0.60		-0.41	0.49		-0.38	-0.45	-0.27°C ± 0.33
CIL thick. < 1°C	Rimouski	91		83	59	73	60	50	60	49	50	32	36	69	59	53	32	43	54	47	56 m ± 16
	Gaspé Current						72	62	65	65	52	57	48	75		68	29		58	59	59 m ± 12
	Anticosti Gyre						60	69	70	54	40	42	36	53		71	34		61	56	54 m ± 13

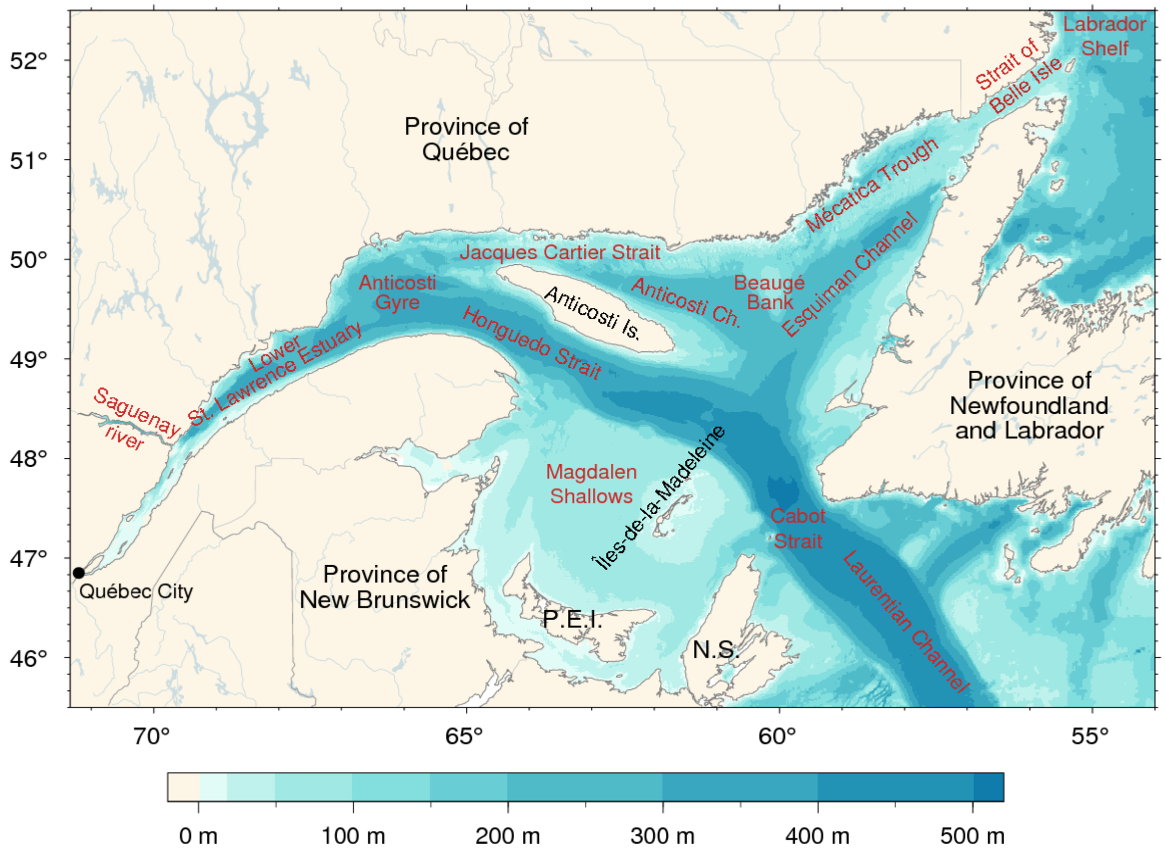

Fig. 1. The Gulf of St. Lawrence, with 500-m horizontal resolution bathymetry provided by the Canadian Hydrographic Service. Locations discussed in the text are indicated.

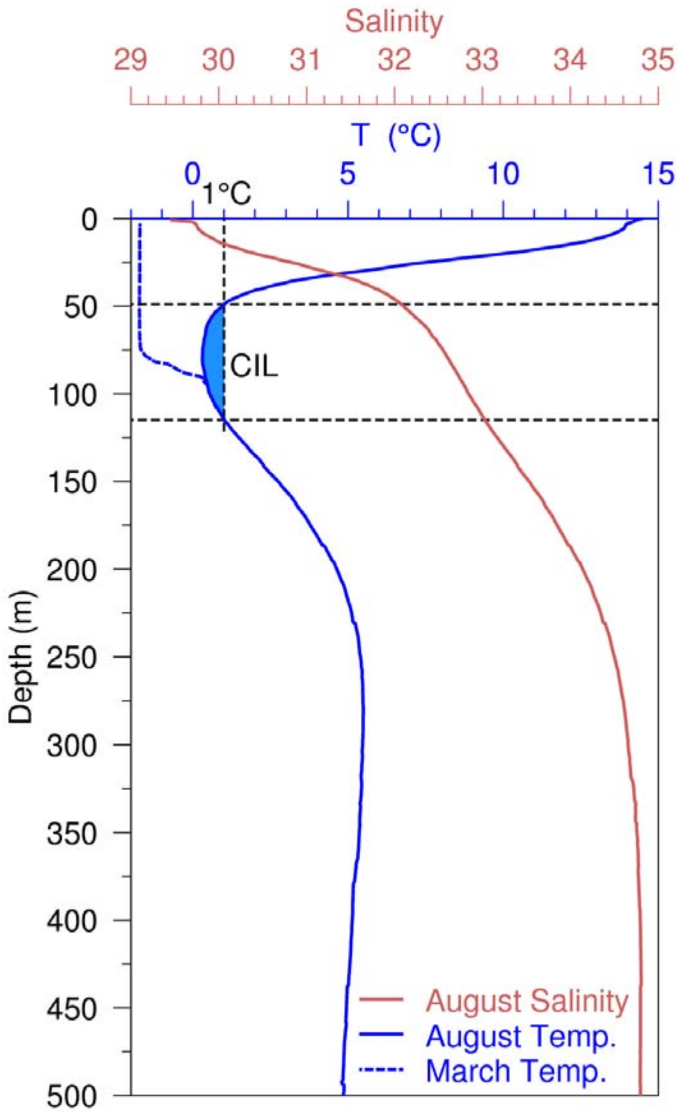

Fig. 2. Typical depth profile of temperature and salinity observed during the summer in the Gulf of St. Lawrence. Profiles are averages observed in August 2007 in the northern Gulf. The cold intermediate layer (CIL) is defined as the part of the water column that is colder than 1°C, although some authors use a different temperature threshold. The dashed line at left shows a winter temperature profile measured in March 2008, with near–freezing temperatures in the top 75 m.

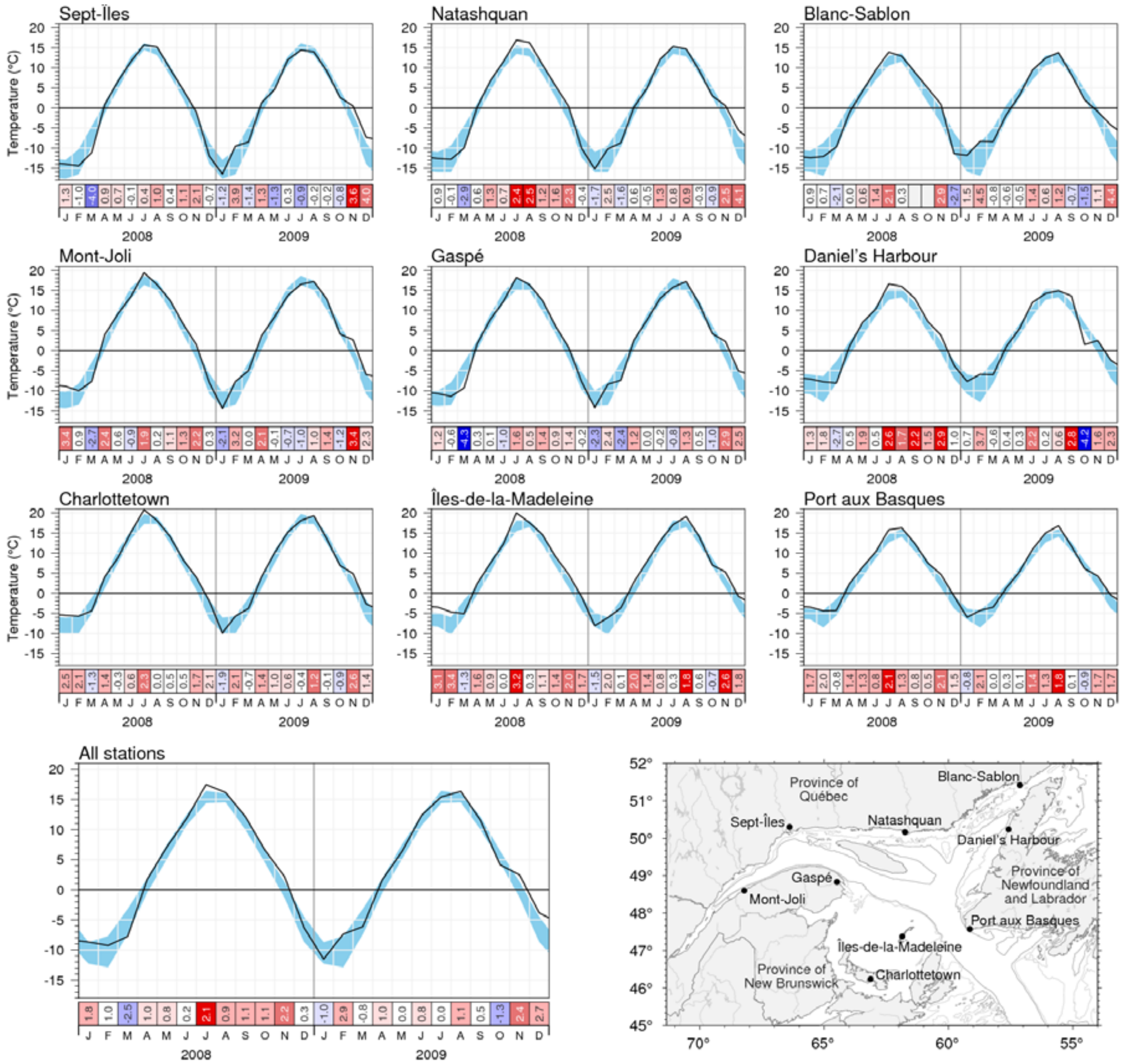

Fig. 3. Monthly air temperatures and anomalies for 2008 and 2009 at nine selected stations around the Gulf as well as the average for all nine stations. The blue area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation. The bottom scorecards are colour-coded (see Table 1) according to the monthly standardized anomalies based on the 1971-2000 climatologies for each month, but the numbers are the monthly anomalies in ºC.

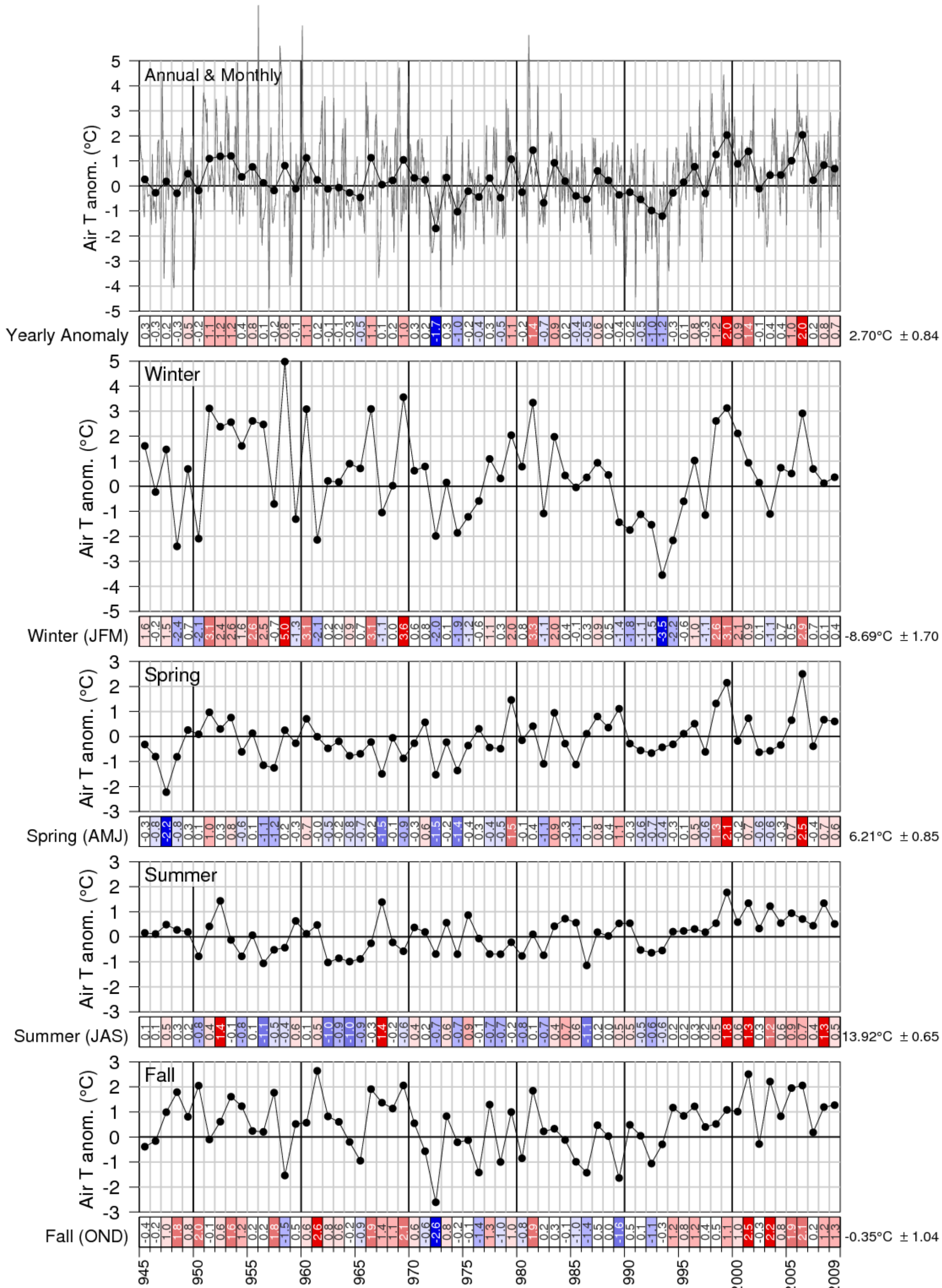

Fig. 4. Annual and seasonal mean air temperature anomalies averaged for the nine selected stations around the Gulf. The bottom scorecards are colour-coded according to the standardized anomalies based on the 1971–2000 climatology, but the numbers are the anomalies in ºC.

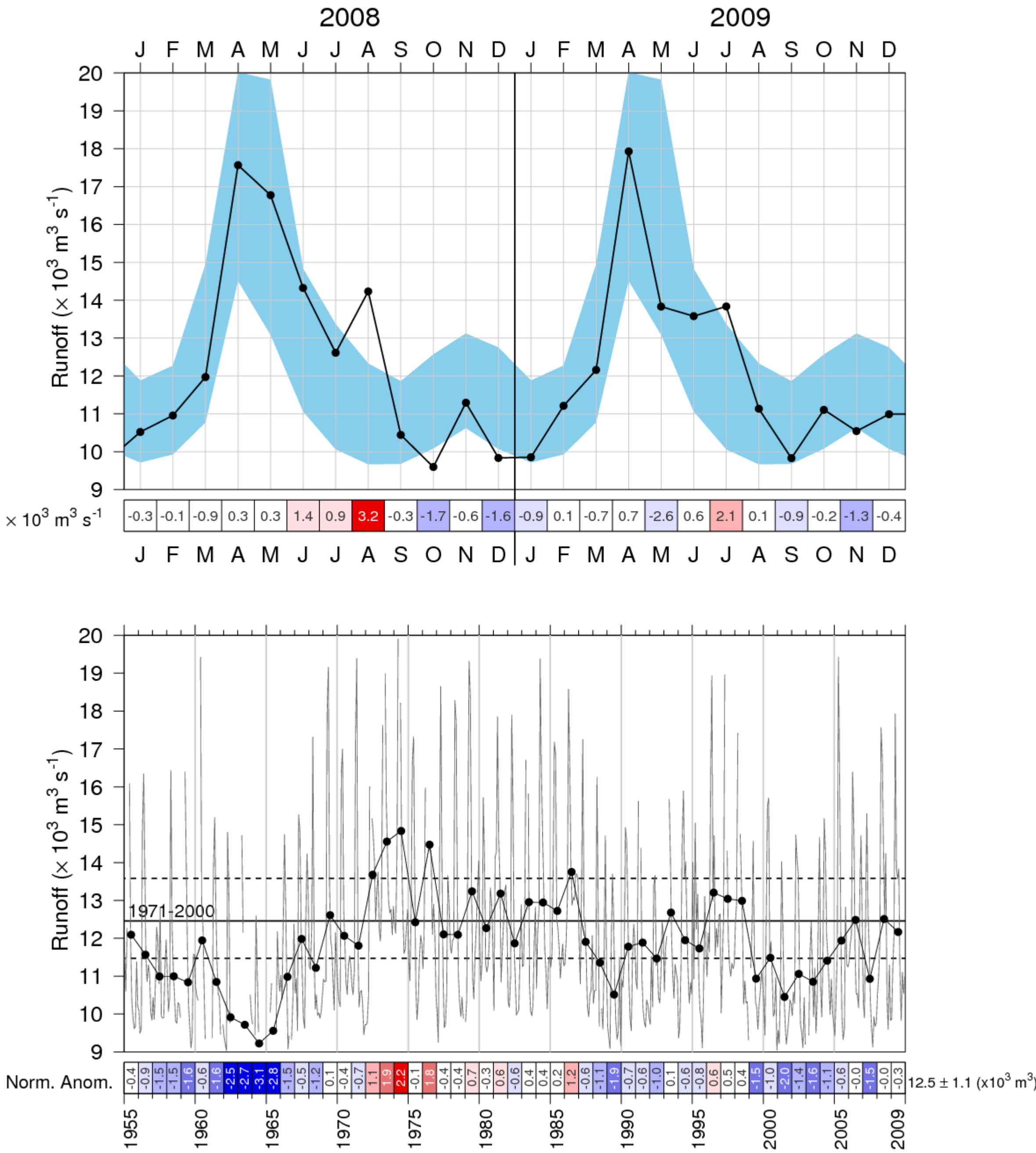

Fig. 5. Monthly (top panel) and annual (bottom panel) mean freshwater flow of the St. Lawrence River at Québec City. The 1971–2000 climatological mean (plus and minus one standard deviation) is shown for each month in the top panel (blue shading) and as horizontal lines for the annual time series in the bottom panel. The top-panel scorecard is colour-coded according to the monthly anomalies standardized for each month of the year, but the numbers are the actual monthly anomalies in 10^3 m^3 s^{-1}. The bottom-panel scorecard shows numbered and colour-coded standardized anomalies for which the mean and standard deviation are indicated on the right side.

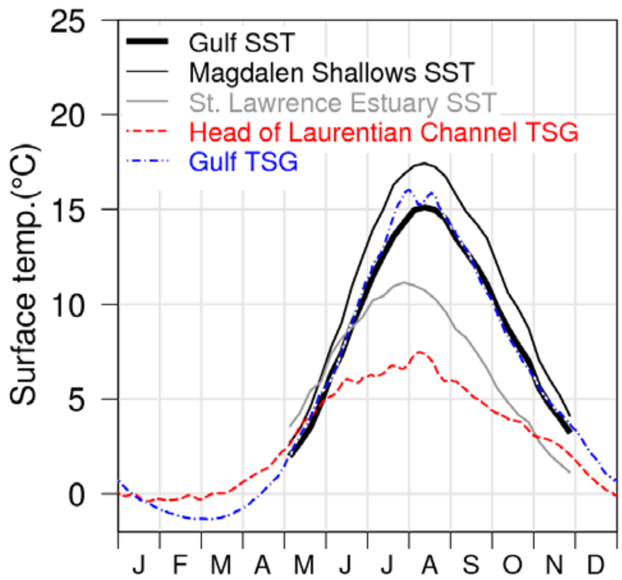

Fig. 6. Sea surface temperature climatological seasonal cycle in the Gulf of St. Lawrence. NOAA AVHRR temperature weekly averages for the years 1985 to 2008 are shown from May to November (ice-free months) for the entire Gulf (thick black line), the warmer Magdalen Shallows (black line) and the cooler St. Lawrence Estuary (grey line). Thermosalinograph (TSG) data averages for the years 2000 to 2008 are shown for the head of the Laurentian Channel (69.5°W, red line) and for the average over the Gulf waters along the main shipping route between 66°W and 59°W (blue line).

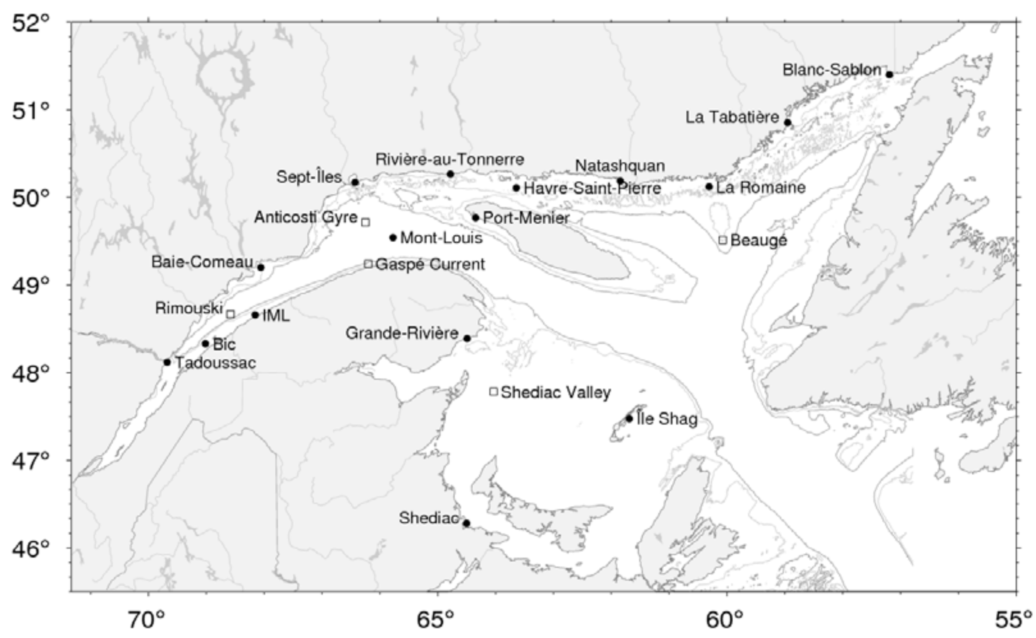

Fig. 7. Locations of the Maurice Lamontagne Institute thermograph network stations in 2009, including regular stations where data are logged internally and recovered at the end of the season (filled circles) and oceanographic buoys that transmit data in real time (open squares). Shediac station from DFO Gulf Region is also shown.

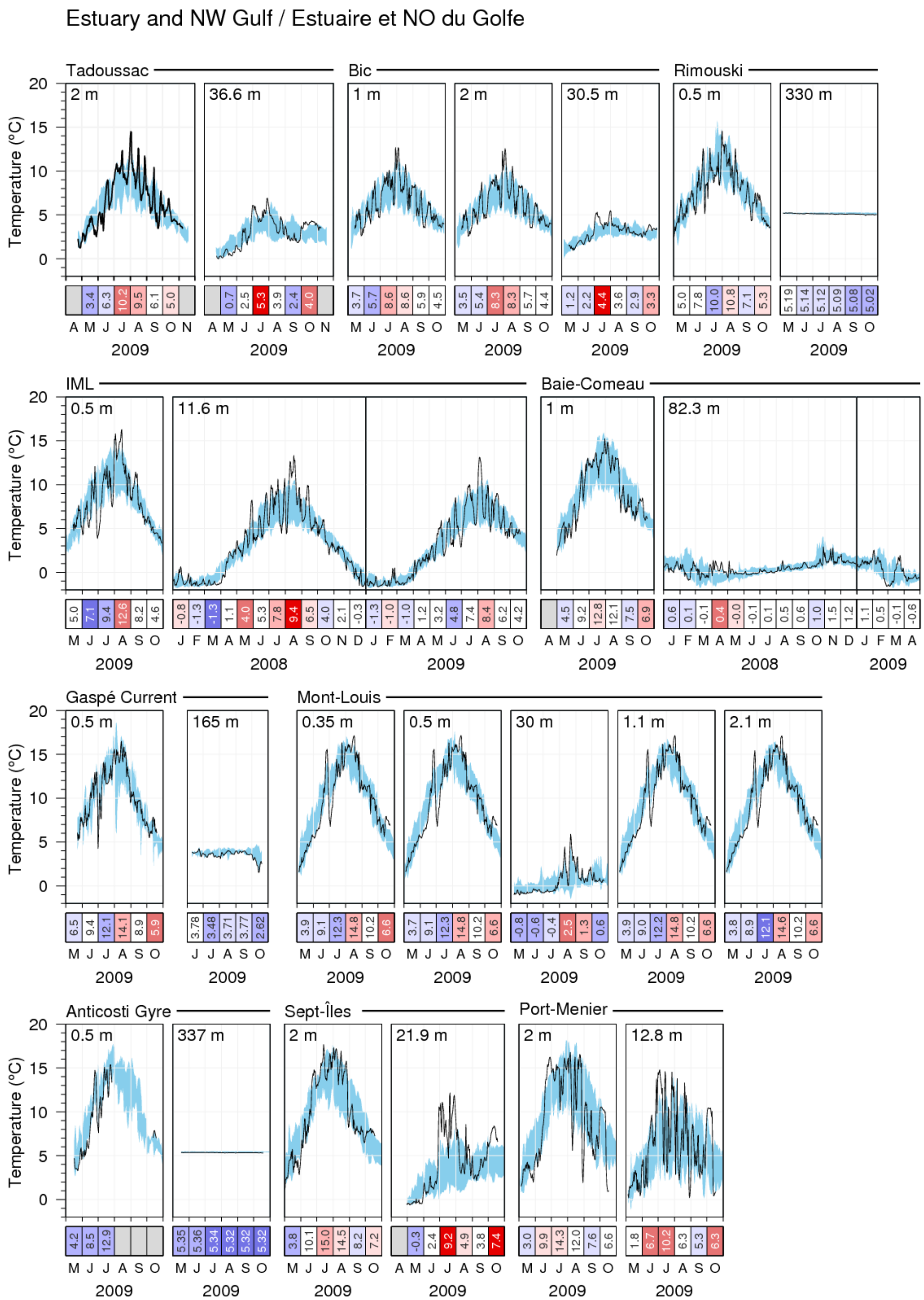

Fig. 8. Thermograph network data. Daily mean 2009 temperatures compared with the daily climatology (daily averages plus and minus one standard deviation; blue areas) computed from all available stations in the Estuary and northwestern Gulf. Score cards show monthly average temperature. Data from 2008 are included if they were not all shown in the previous report (Galbraith et al. 2009).

Lower North Shore / Basse Côte Nord

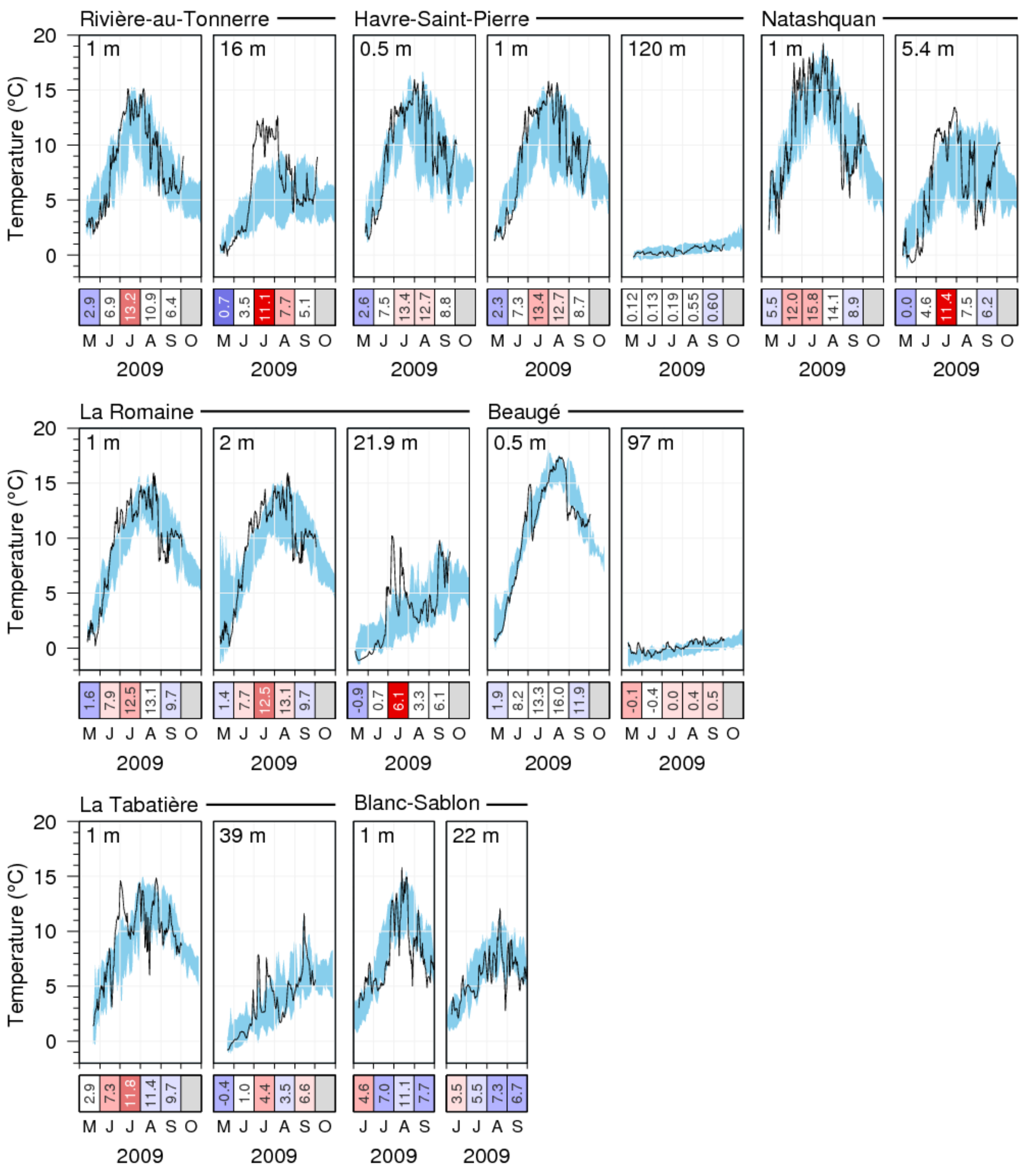

Fig. 9. Thermograph network data. Daily mean 2009 temperatures compared with the daily climatology (daily averages plus and minus one standard deviation; blue areas) computed from all available stations of the lower north shore.

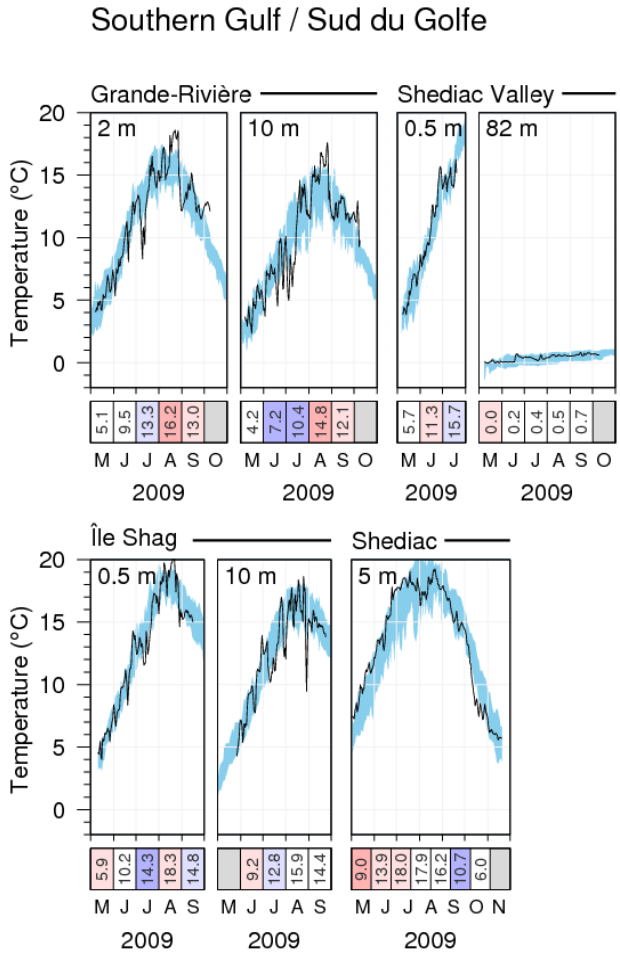

Fig. 10. Thermograph network data. Daily mean 2009 temperatures compared with the daily climatology (daily averages plus and minus one standard deviation; blue area) computed from all available stations of the southern Gulf. Shediac station from DFO Gulf Region is also shown.

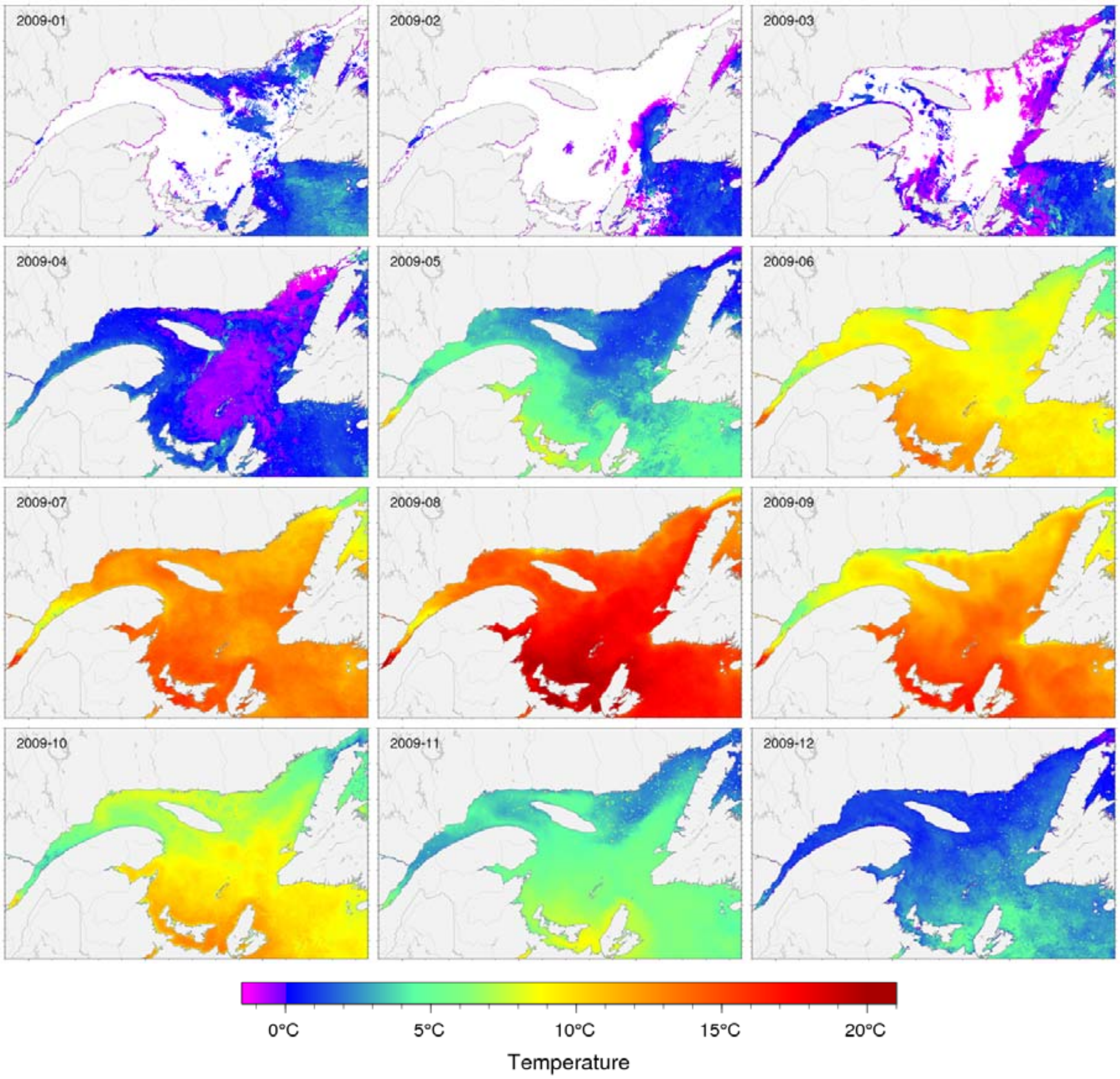

Fig. 11. Sea-surface temperature averages for the first 28 days of each month of 2009 as observed with NOAA AVHRR remote sensing. White areas have no data for the period due to ice cover.

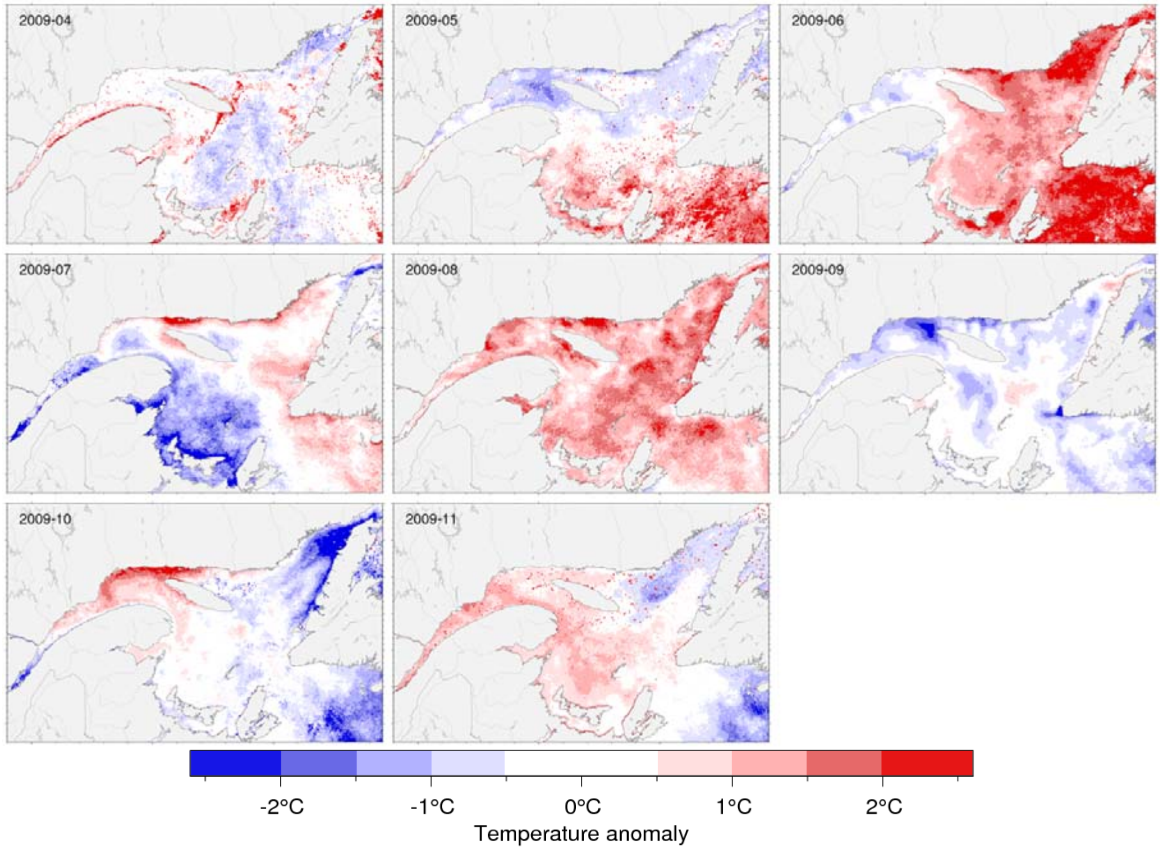

Fig. 12. Sea-surface temperature anomalies for the first 28 days of April through November 2009 based on monthly climatologies calculated for the 1985–2009 period observed with NOAA AVHRR remote sensing. Only ice-free months are shown.

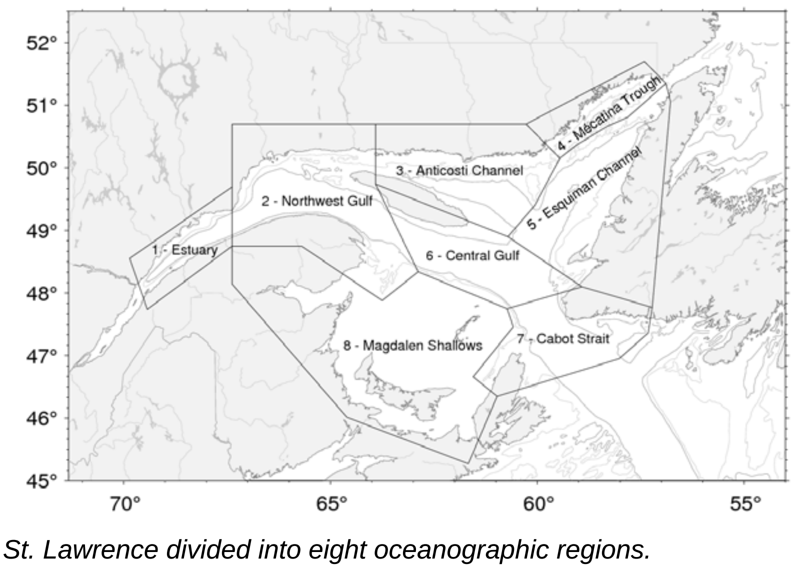

Fig. 13. Gulf of St. Lawrence divided into eight oceanographic regions.

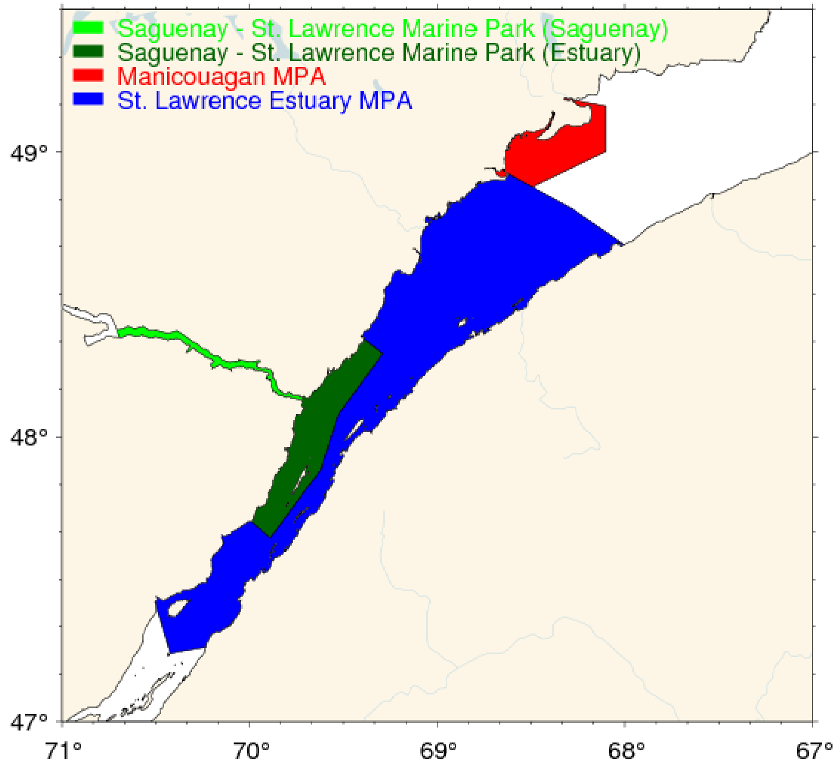

Fig. 14. Areas delimiting the Manicouagan MPA, the St. Lawrence Estuary MPA and the Saguenay – St. Lawrence Marine Park for the purpose of SST extraction from NOAA imagery.

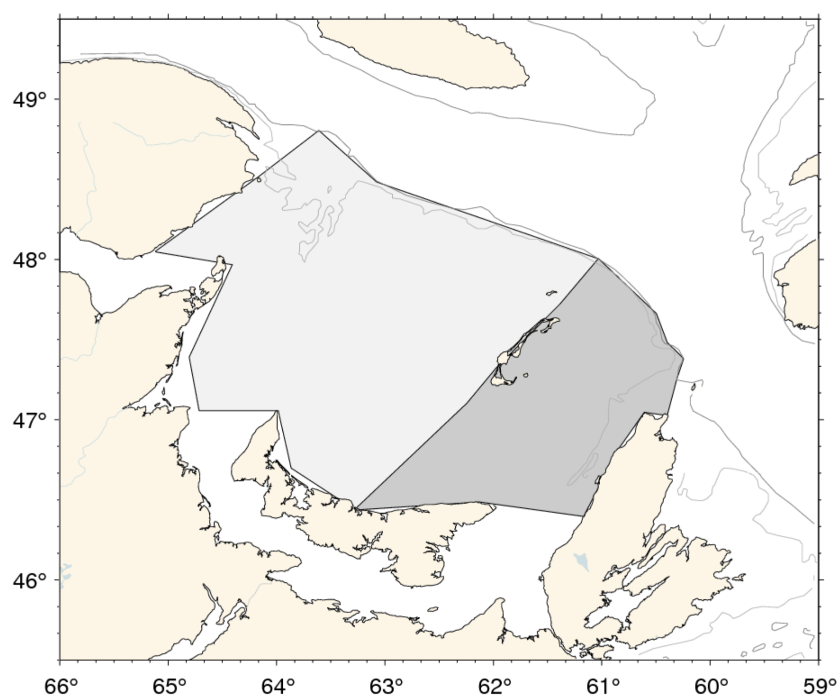

Fig. 15. Areas delimiting western and eastern Magdalen Shallows.

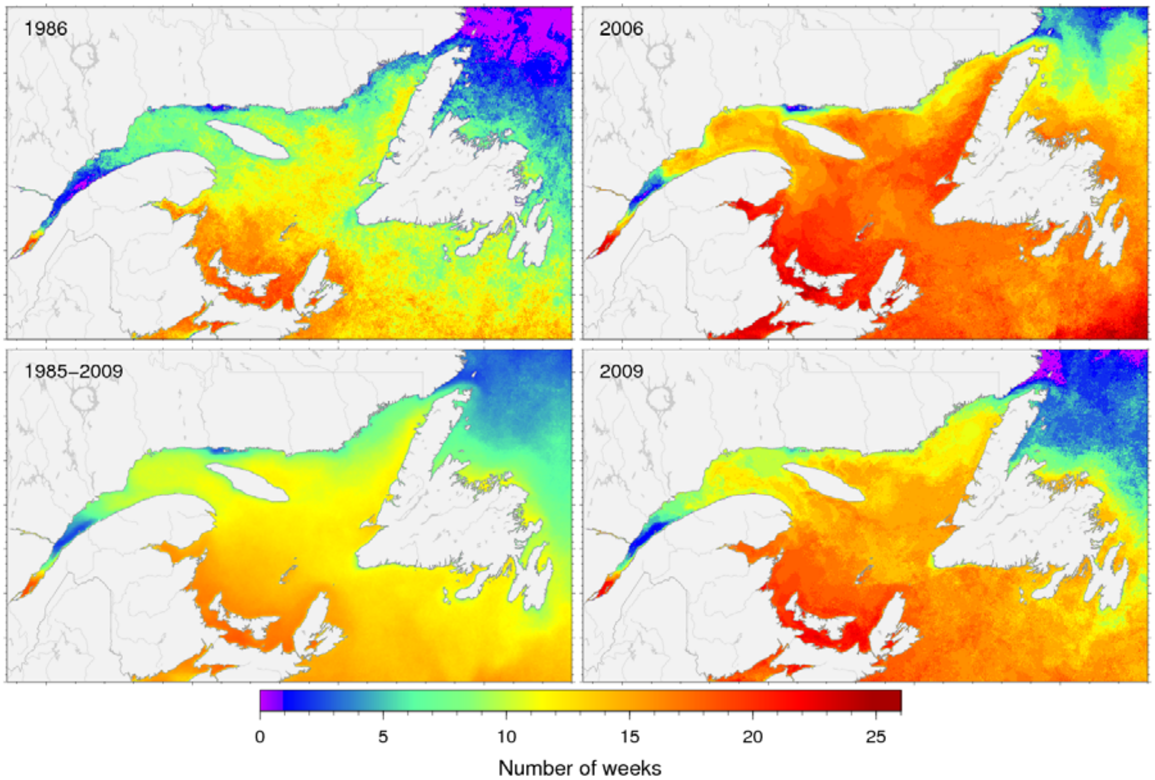

Fig. 16. Yearly number of weeks with mean weekly surface temperature > 10°C. Years with minimum (1986, top left) and maximum (2006, top right) number of weeks are shown, as well as the 1985-2009 climatological average (lower left) and the chart for 2009.

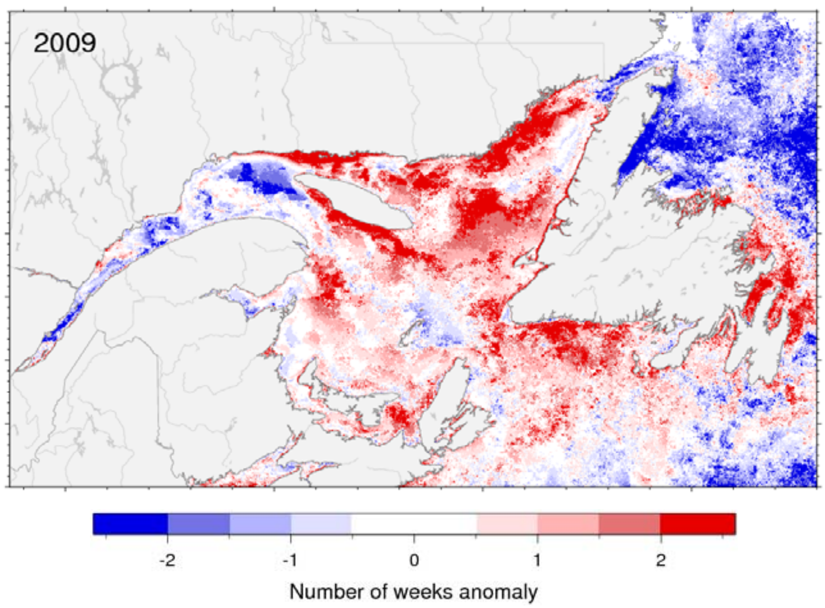

Fig. 17. Anomaly of the number of weeks in 2009 with mean weekly surface temperature > 10°C, using the 1985-2009 climatological average from Fig. 16.

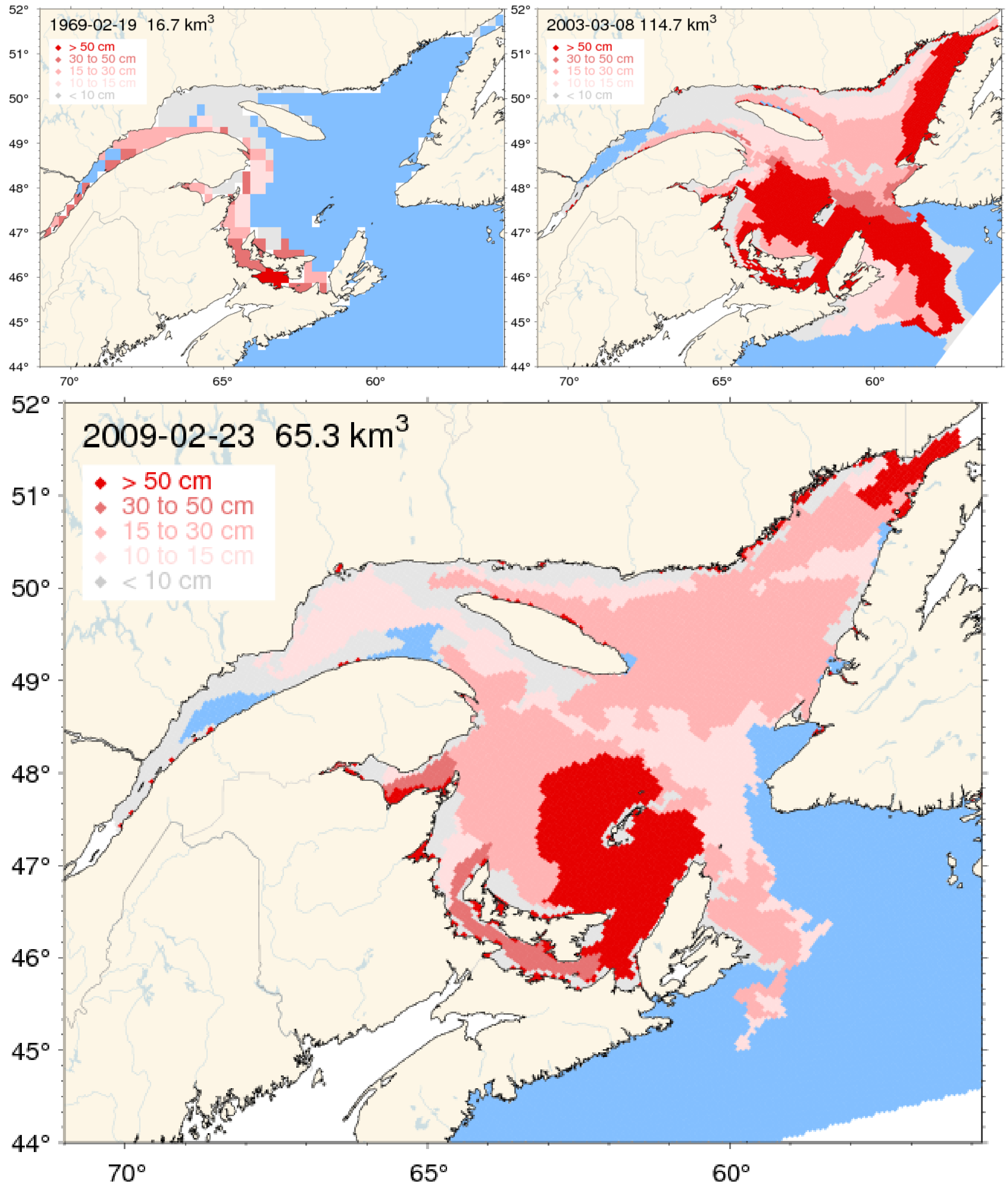

Fig. 18. Ice thickness map for 2009 for day of the year with maximum annual volume (lower panel) and for weeks of maximum ice cover in 1969 and 2003, the years with the smallest and largest annual ice volumes respectively.

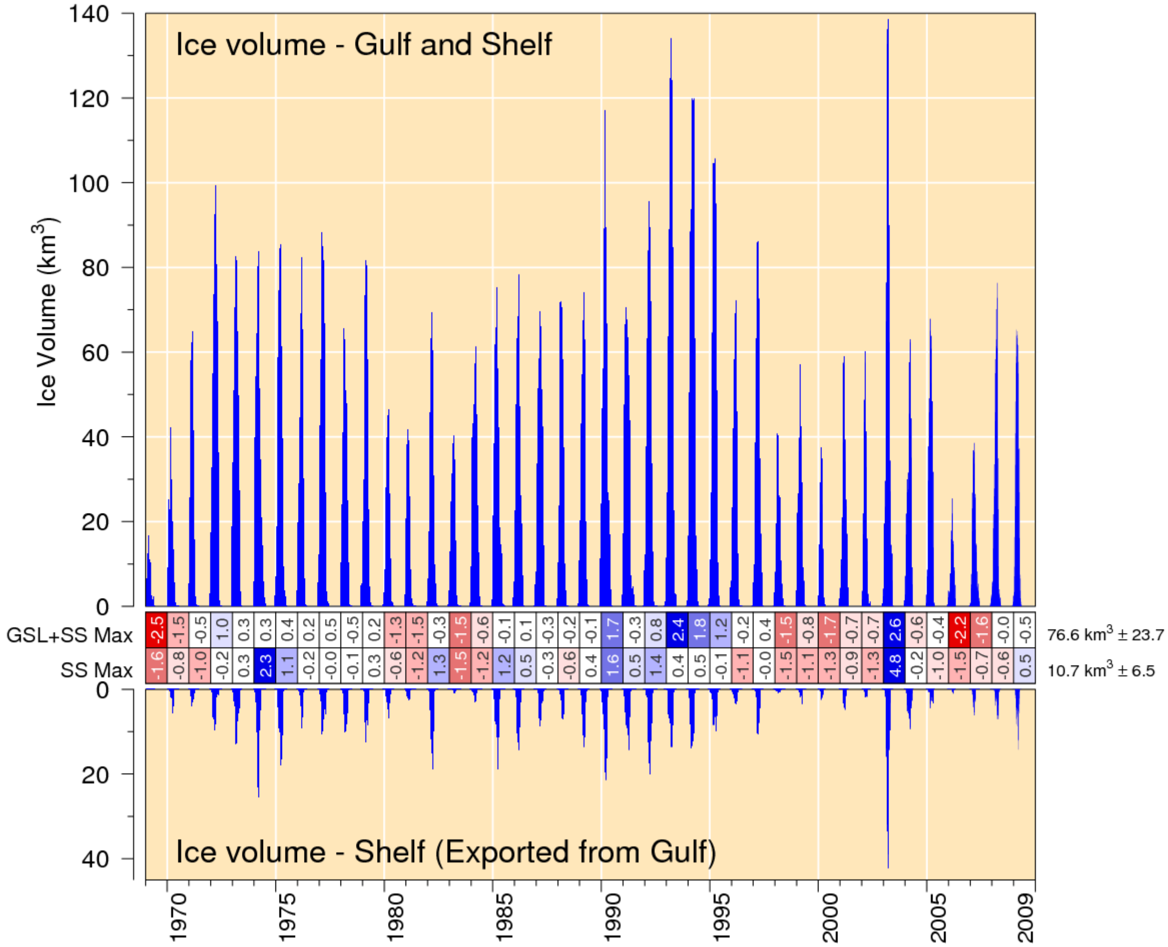

Fig. 19. Estimated ice volume in the Gulf of St. Lawrence and on the Scotian Shelf seaward of Cabot Strait (upper panel) and on the Scotian Shelf only (lower panel). Scorecards show numbered standardized anomalies for the combined Gulf and Shelf and Shelf-only annual maximum volumes. The mean and standard deviation are indicated on the right side using the 1971-2000 climatology.

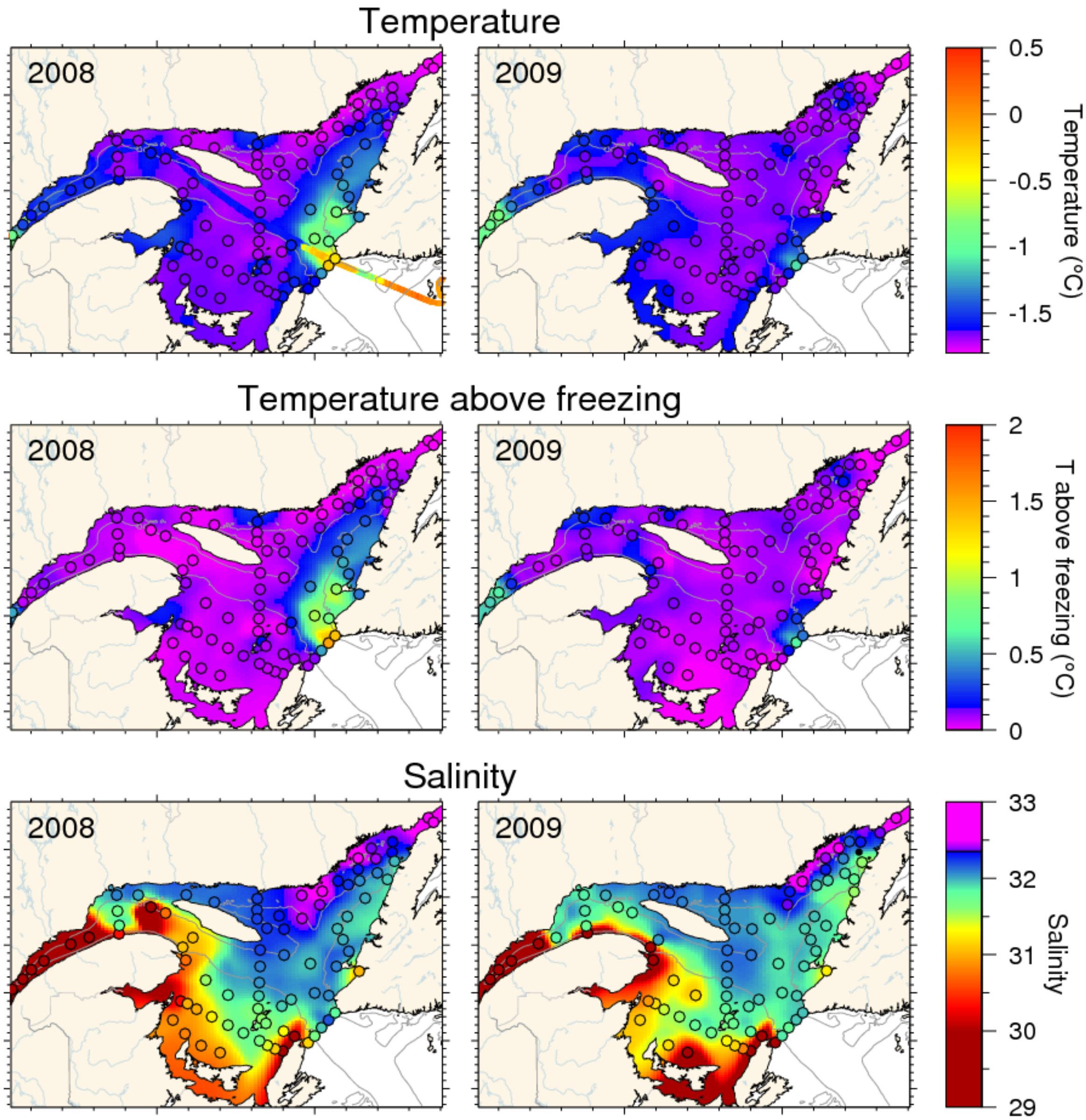

Fig. 20. Winter surface layer characteristics from the March 2008 and 2009 helicopter surveys. Surface water temperature (upper panel), temperature difference between surface water temperature and the freezing point (middle panel) and salinity (lower panel). The temperature measurements from shipboard thermosalinographs taken during the survey are also shown in the upper panels. The symbols are coloured according to the value observed at the station, using the same colour palette as the interpolated image. A good match is seen between the interpolation and the station observations where the station colours blend into the background.

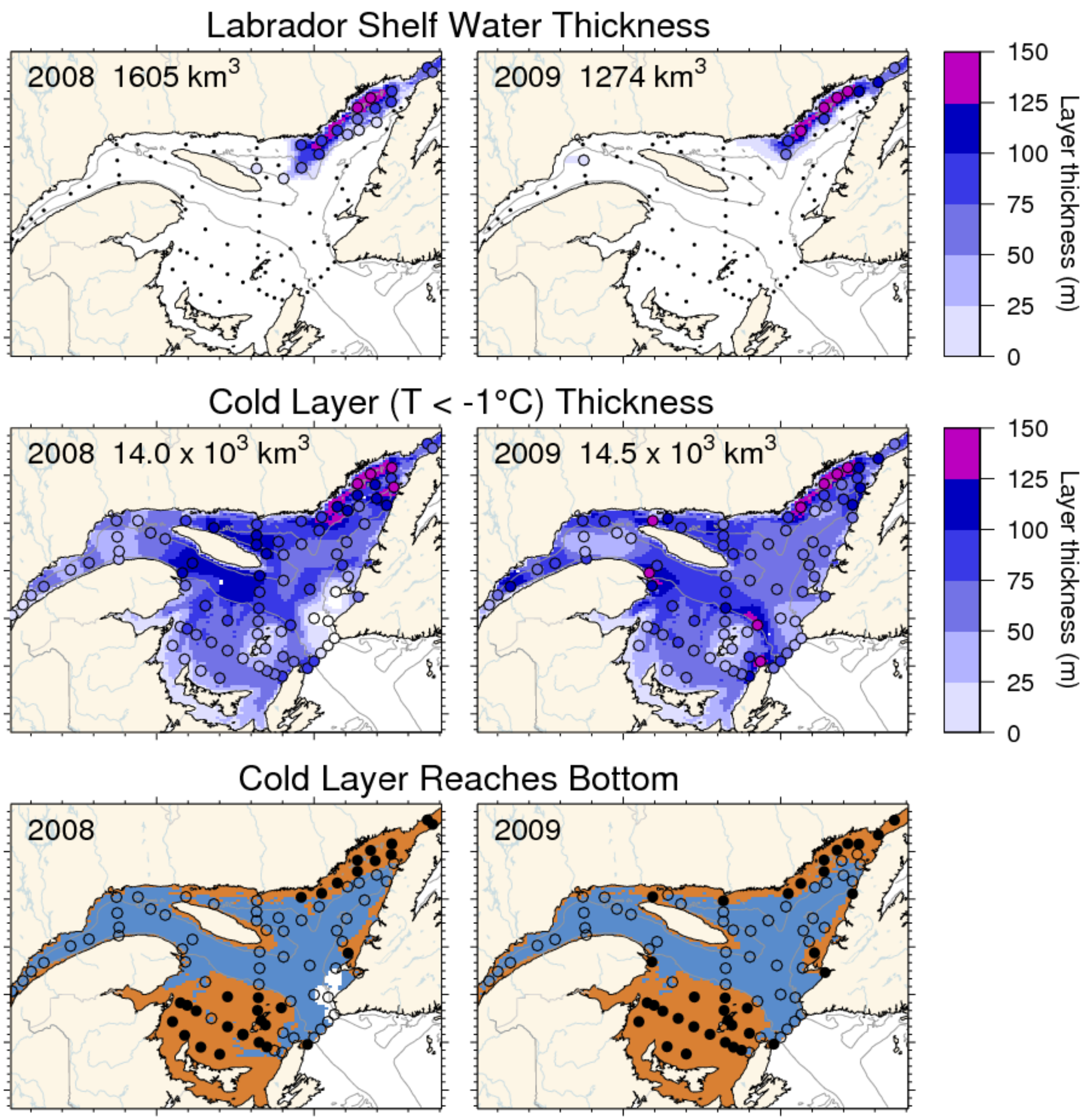

Fig. 21. Winter surface layer characteristics from the March 2008 and 2009 helicopter surveys. Estimates of the thickness of the Labrador Shelf water intrusion (upper panels), cold layer (T < -1°C) thickness (middle panels), and maps indicating where the cold layer reaches the bottom (in brown; lower panels). Station symbols are coloured according to the observed values as in Fig. 20. For the lower panels, the stations where the cold layer reached the bottom are indicated with filled circles while open circles represent stations where the layer did not reach to the bottom.

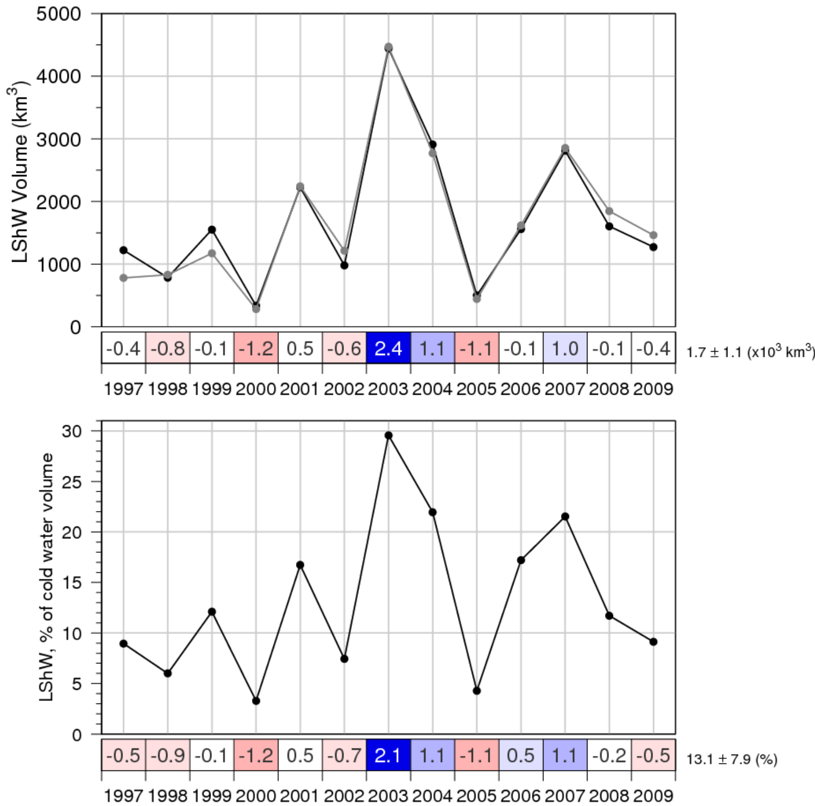

Fig. 22. Estimated volume of cold and saline Labrador Shelf water that flowed into the Gulf over the winter through the Strait of Belle Isle. The grey line shows the volume calculated using the bathymetry used in Galbraith et al. 2009. The bottom panel shows the volume as a percentage of total cold water volume (< -1ºC). The numbers in the boxes are standardized anomalies.

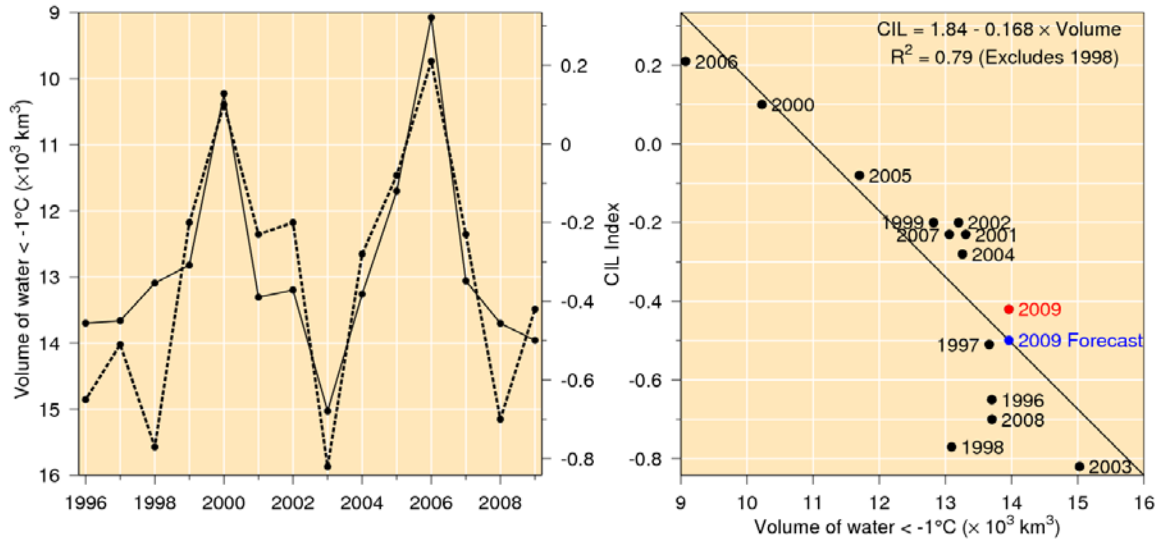

Fig. 23. Left panel: winter surface cold (T < -1°C) layer volume time series (solid line) and summer CIL index (dashed line). Right panel: Relation between summer CIL index and winter cold water volume (regression excludes 1998 data pair; see Galbraith 2006). Note that the volume scale in the left panel is reversed. Winter volumes exclude waters in the Estuary. The volume observed in March 2009 would forecast a CIL index of -0.50ºC (in blue) for summer 2009. The actual 2009 CIL index observed later in the year is also indicated (in red).

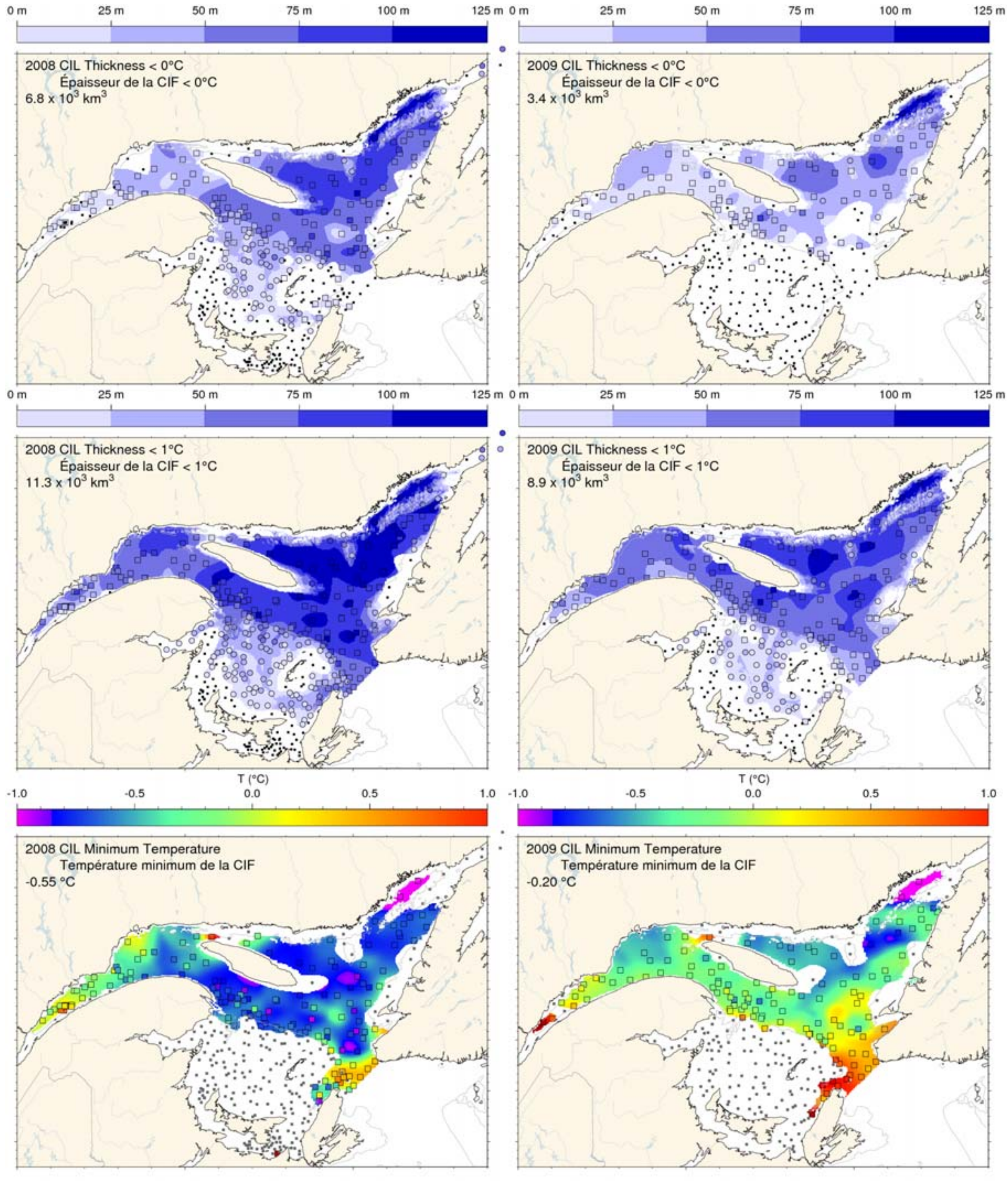

Fig. 24. Cold intermediate layer thickness (T < 0ºC, top panels; T < 1ºC, middle panels) and minimum temperature (bottom panels) in August and September 2008 (left) and 2009 (right).

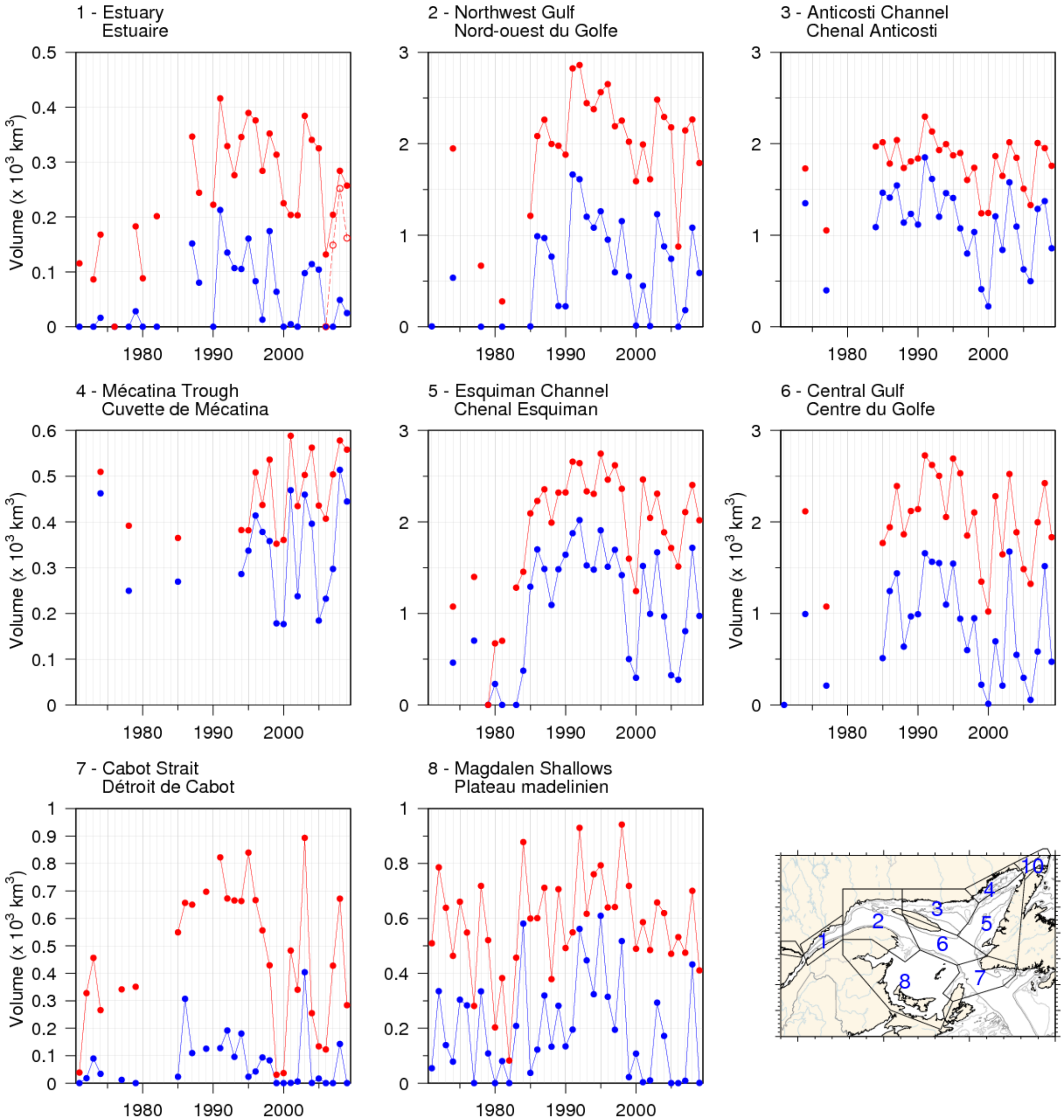

Fig. 25. Volume of the CIL colder than 0ºC (blue) and colder than 1ºC (red) in August and September (mostly region 8 in September). The volume of the CIL colder than 1ºC in November since 2006 is also shown for the St. Lawrence estuary (dashed line).

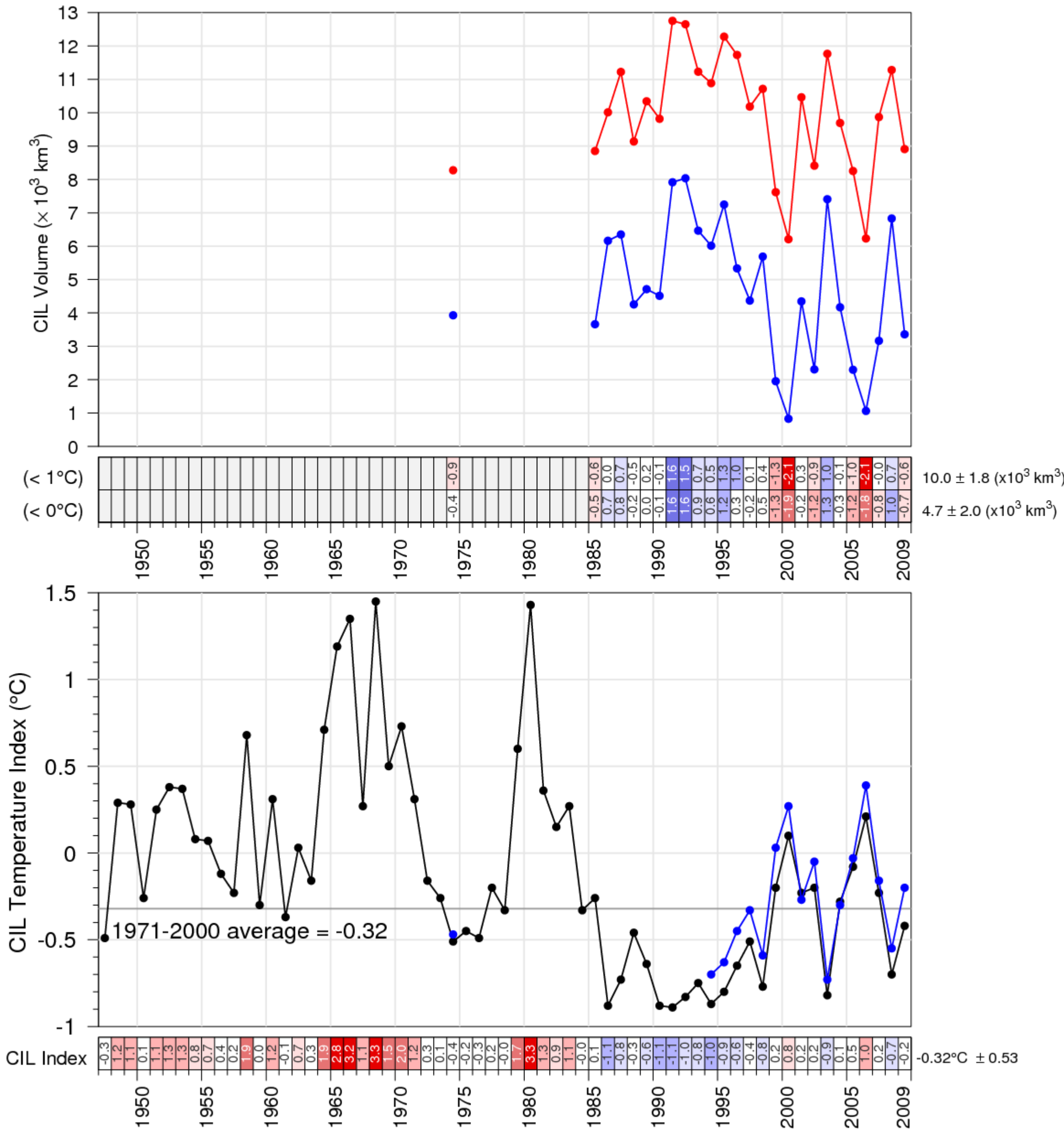

Fig. 26. CIL volume (top panel), delimited by the over- and underlying 0ºC (in blue) and 1ºC (in red) isotherms, and minimum temperature index (bottom panel) in the Gulf of St. Lawrence. The volumes are integrals of each of the annual interpolated thickness grids such as those shown in the top panels of Fig. 24. In the lower panel, the black line is the updated Gilbert & Pettigrew (1997) index interpolated to 15 July and the blue line is the spatial average of each of the annual interpolated grid such as those shown in the two bottom panels of Fig. 24. The numbers in the boxes are standardized anomalies.

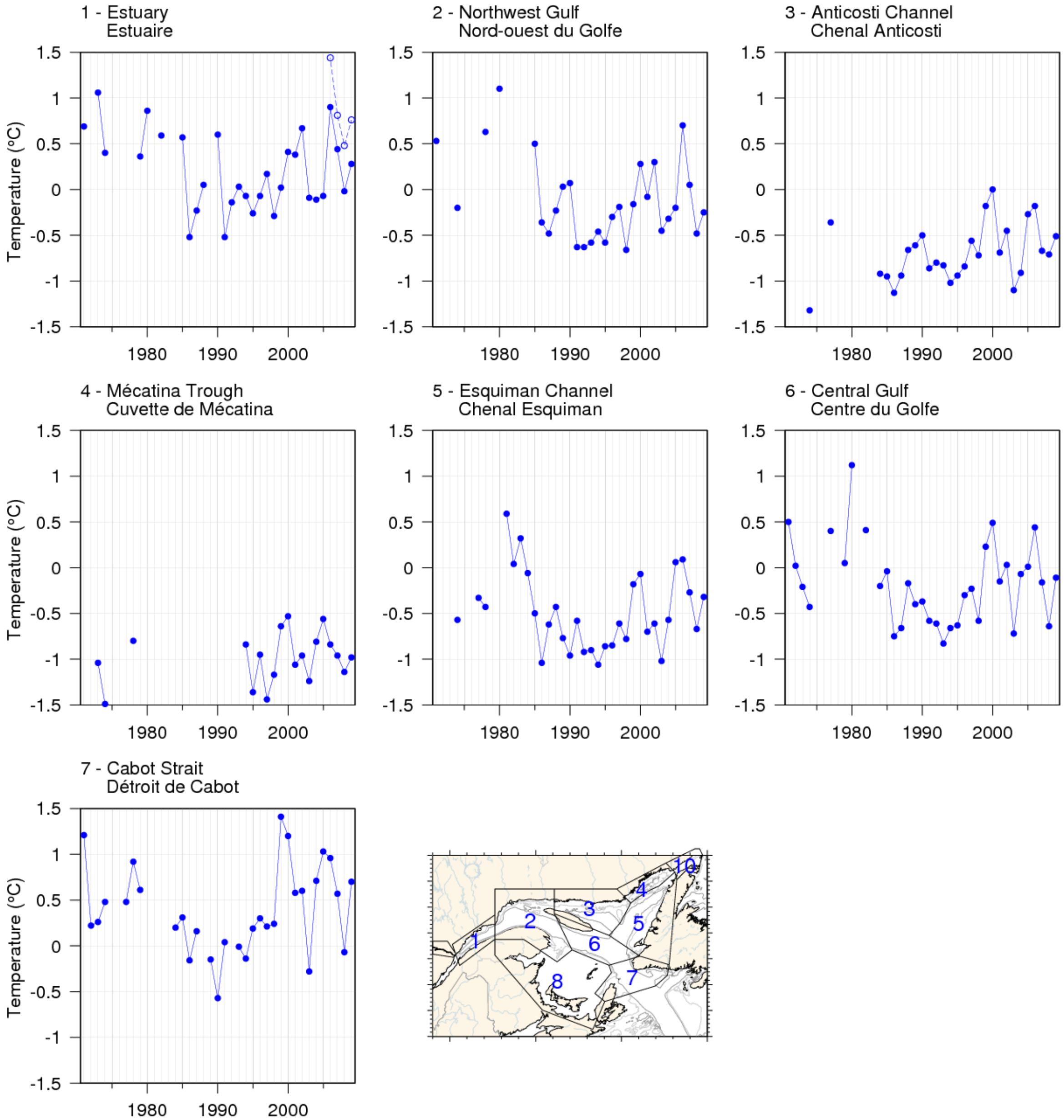

Fig. 27. Temperature minimum of the CIL spatially averaged for the seven areas where the CIL minimum temperature can be clearly identified (i.e. deeper than 100 m). The volume of the CIL colder than 1ºC in November since 2006 is also shown for the St. Lawrence estuary (dashed line).

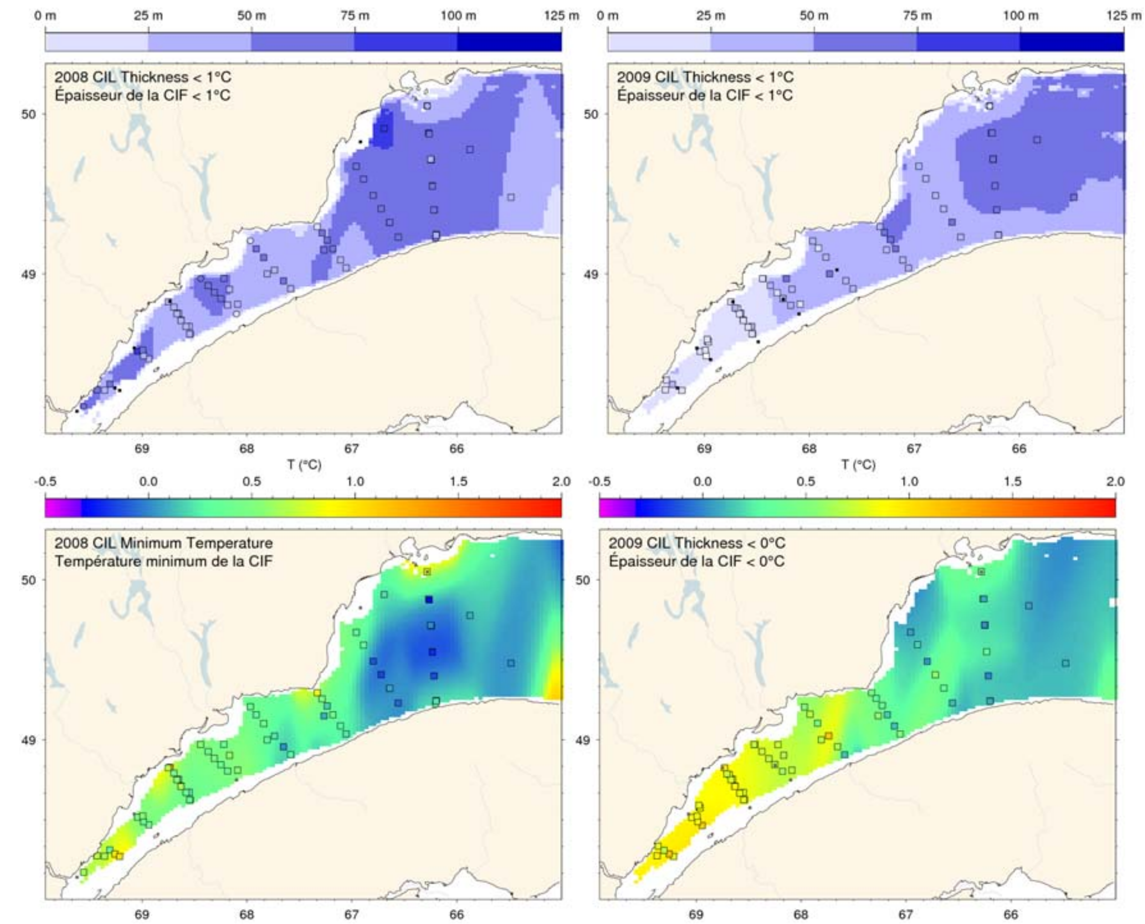

Fig. 28. Cold intermediate layer thickness (T < 1ºC, top panels) and minimum temperature (bottom panels) in November 2008 (left) and 2009 (right) in the St. Lawrence Estuary.

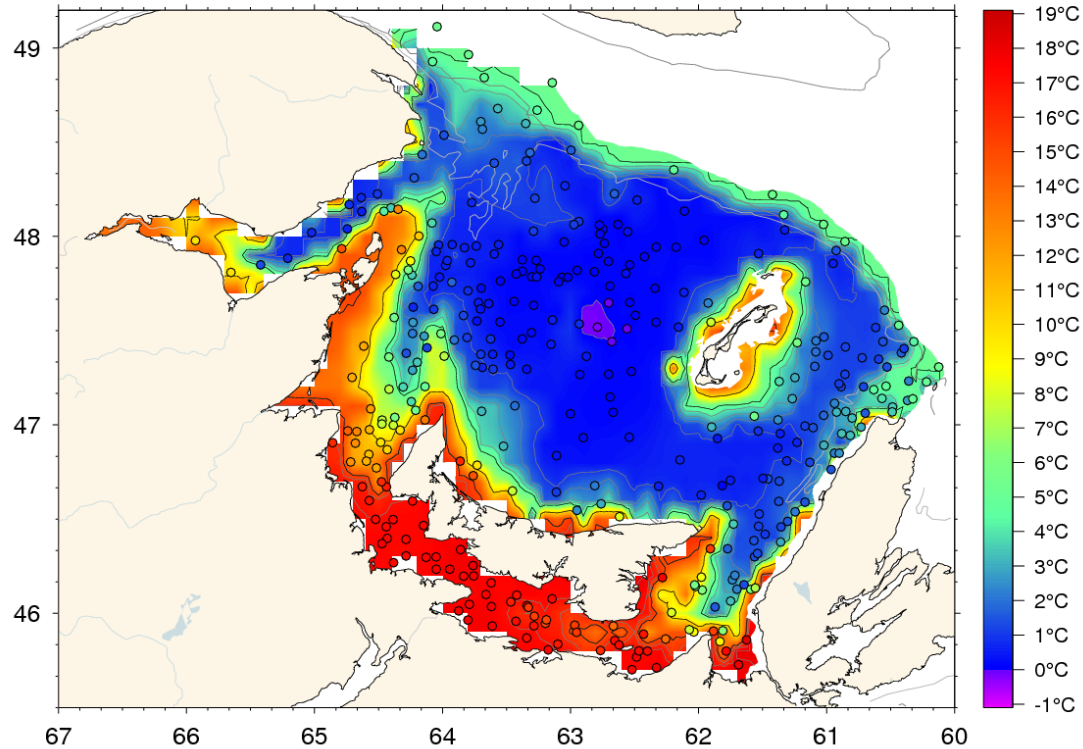

Fig. 29. Near-bottom temperatures during the 2009 September multi-species survey.

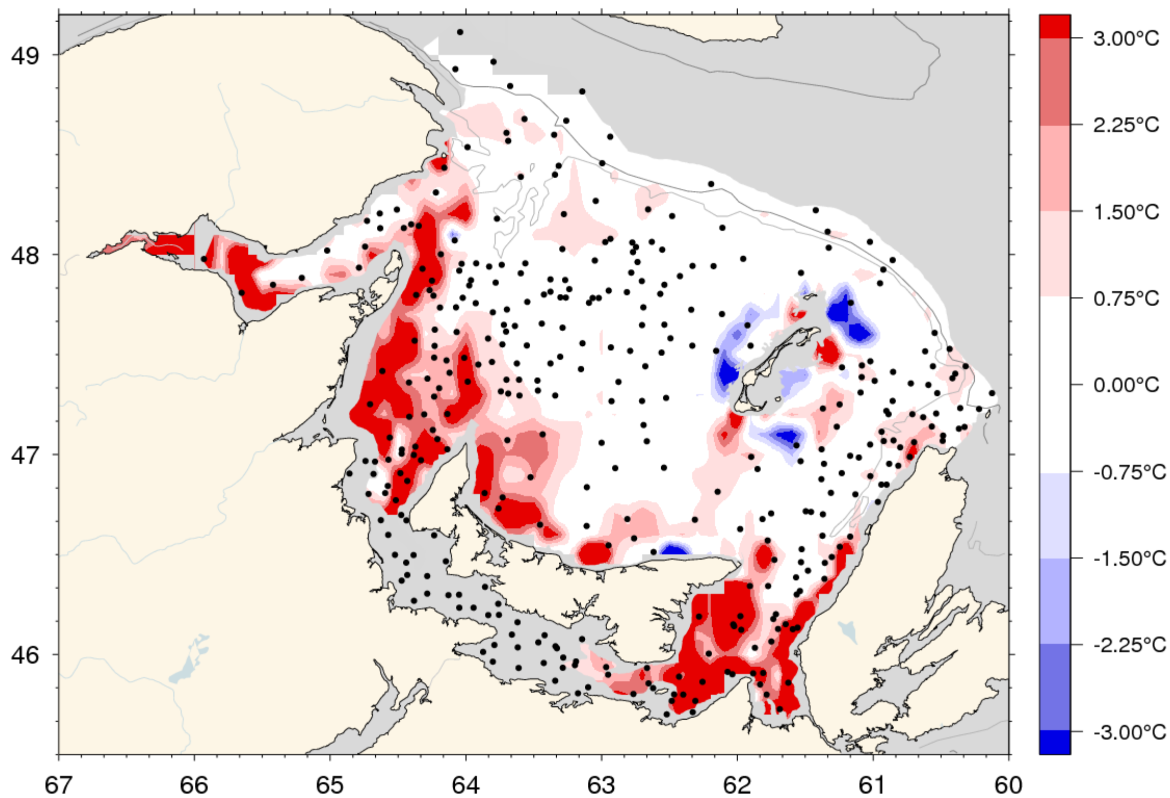

Fig. 30. Near-bottom temperature anomalies based on the 1971–2000 climatology in the southern Gulf of St. Lawrence during the 2009 September multi-species survey.

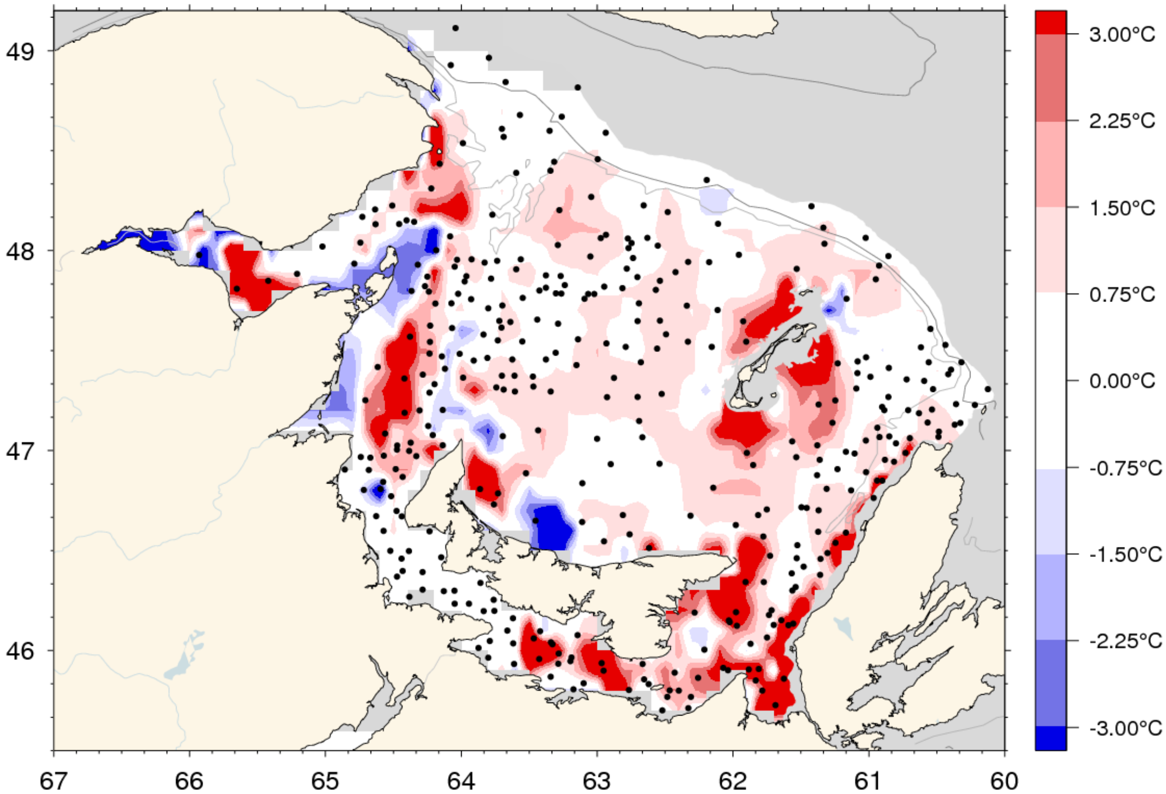

Fig. 31. The difference between the 2009 and 2008 bottom temperature fields in the southern Gulf of St. Lawrence for the September surveys.

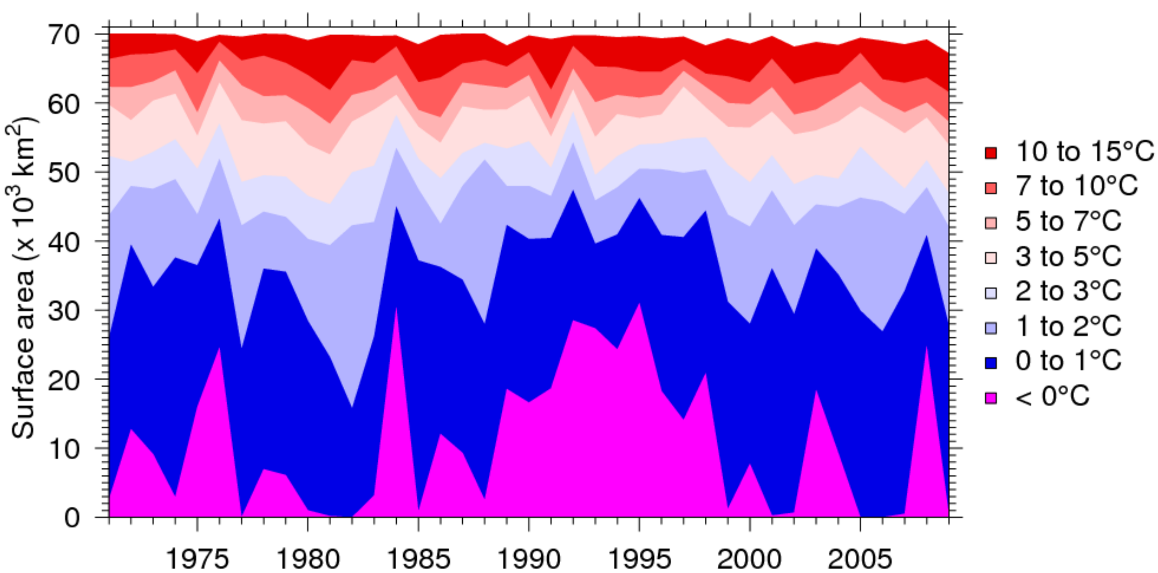

Fig. 32. Time series of the areas of the Magdalen Shallows covered by different temperature bins in September.

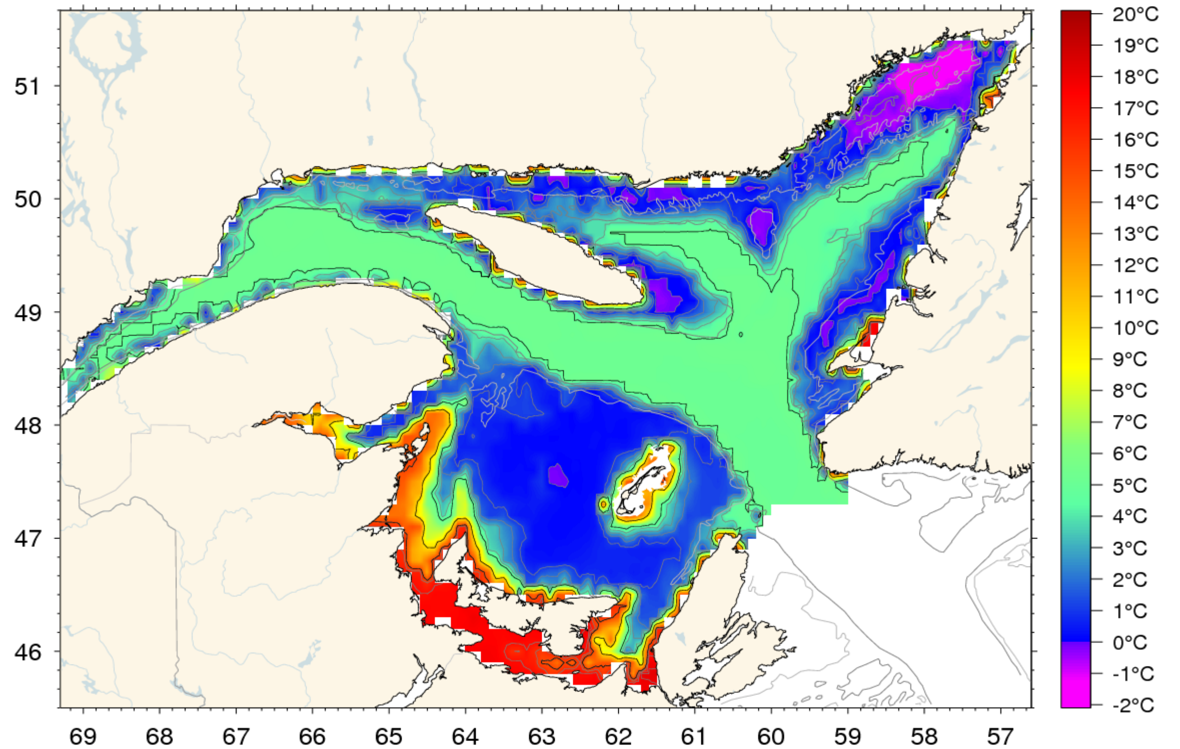

Fig. 33. Near-bottom temperatures during the 2009 August and September multi-species surveys in the northern and southern Gulf.

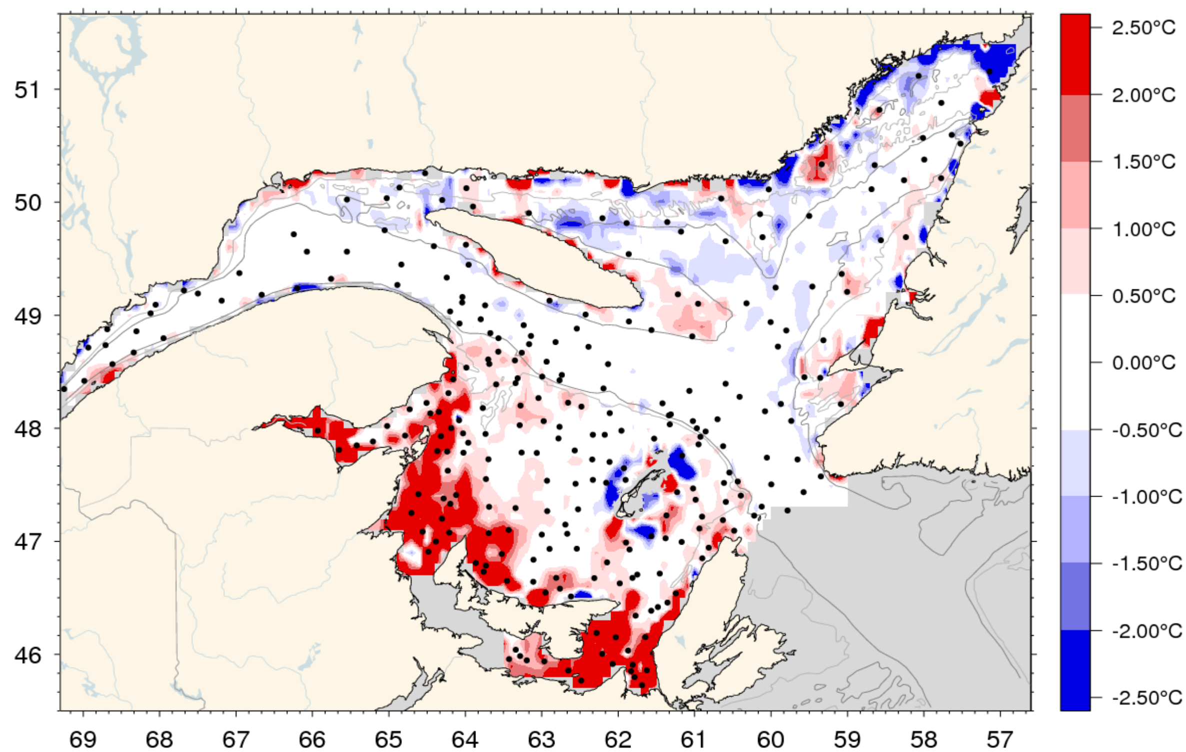

Fig. 34. Near-bottom temperature anomalies based on the1971–2000 climatology in the Gulf of St. Lawrence during the 2009 August and September multi-species surveys.

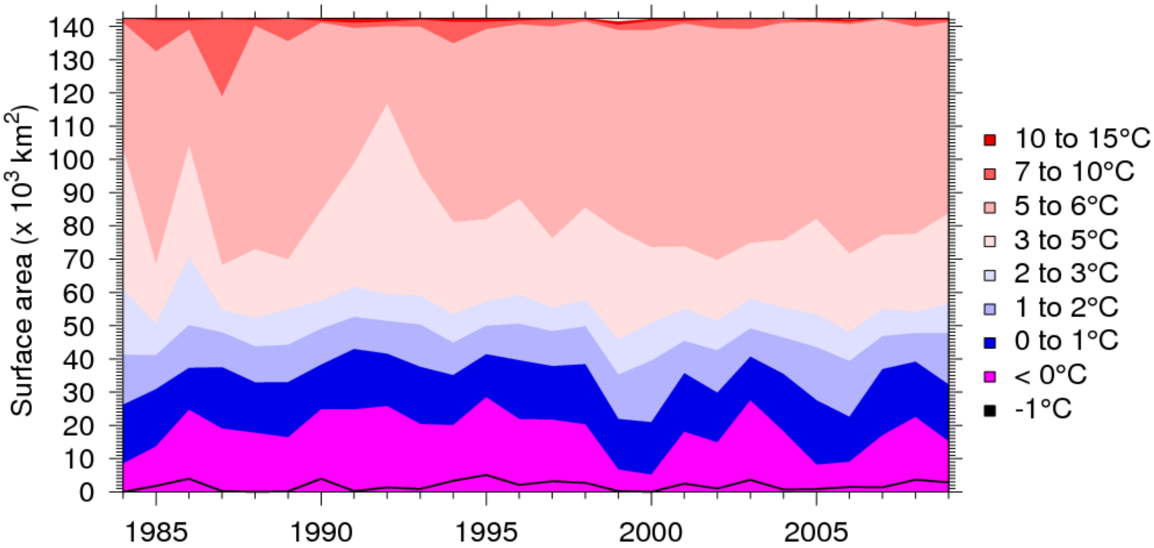

Fig. 35. Time series of the bottom areas covered by different temperature bins in August in the northern Gulf of St. Lawrence (i.e., the area of the Gulf that is not covered in Fig. 29).

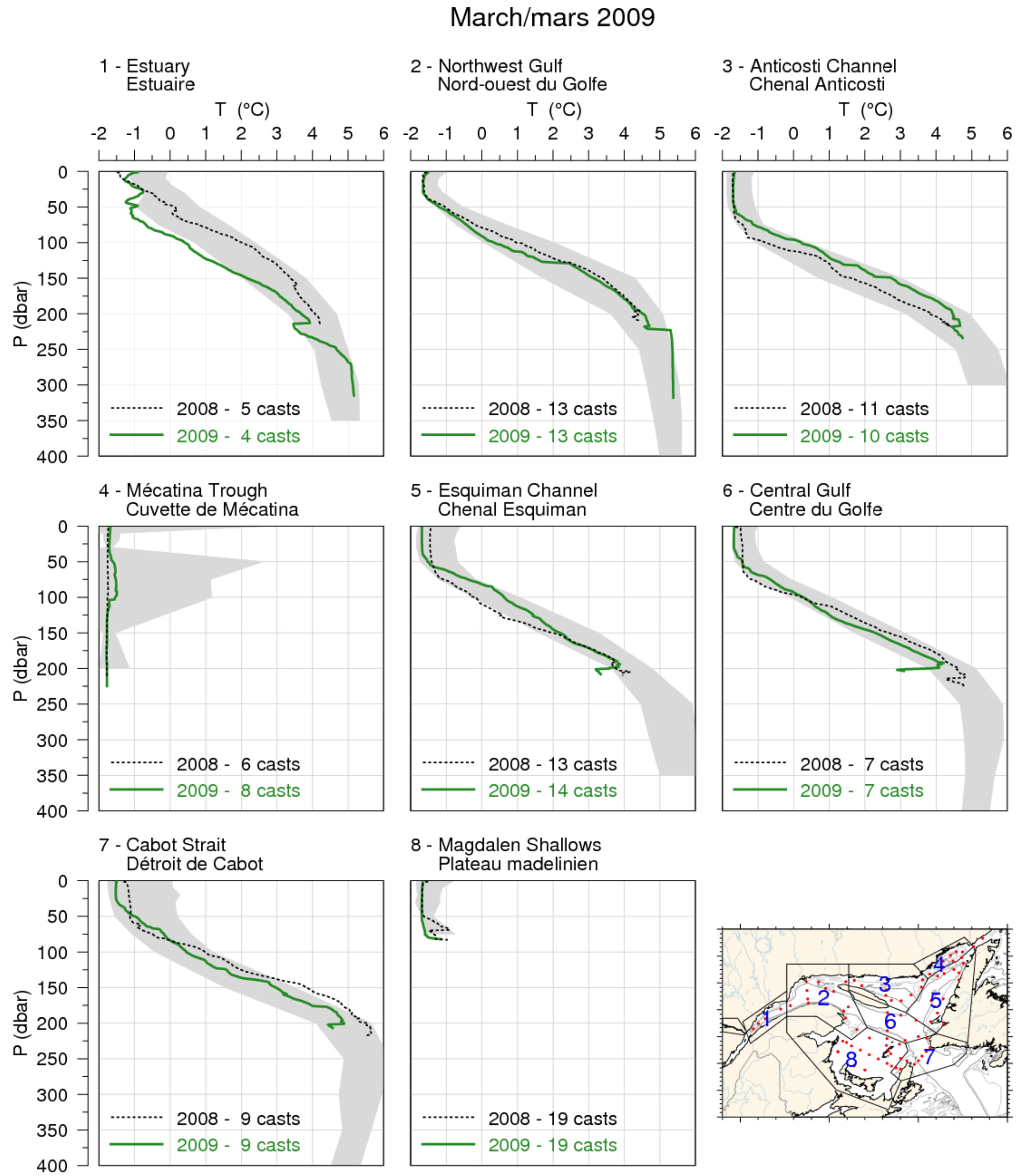

Fig. 36. Mean temperature profiles observed in each region of the Gulf during the March helicopter survey. The shaded area represents the 1971–2009 (but mostly 1996–2009) climatological monthly mean plus and minus one standard deviation. Mean profiles for the 2008 survey are also shown for comparison.

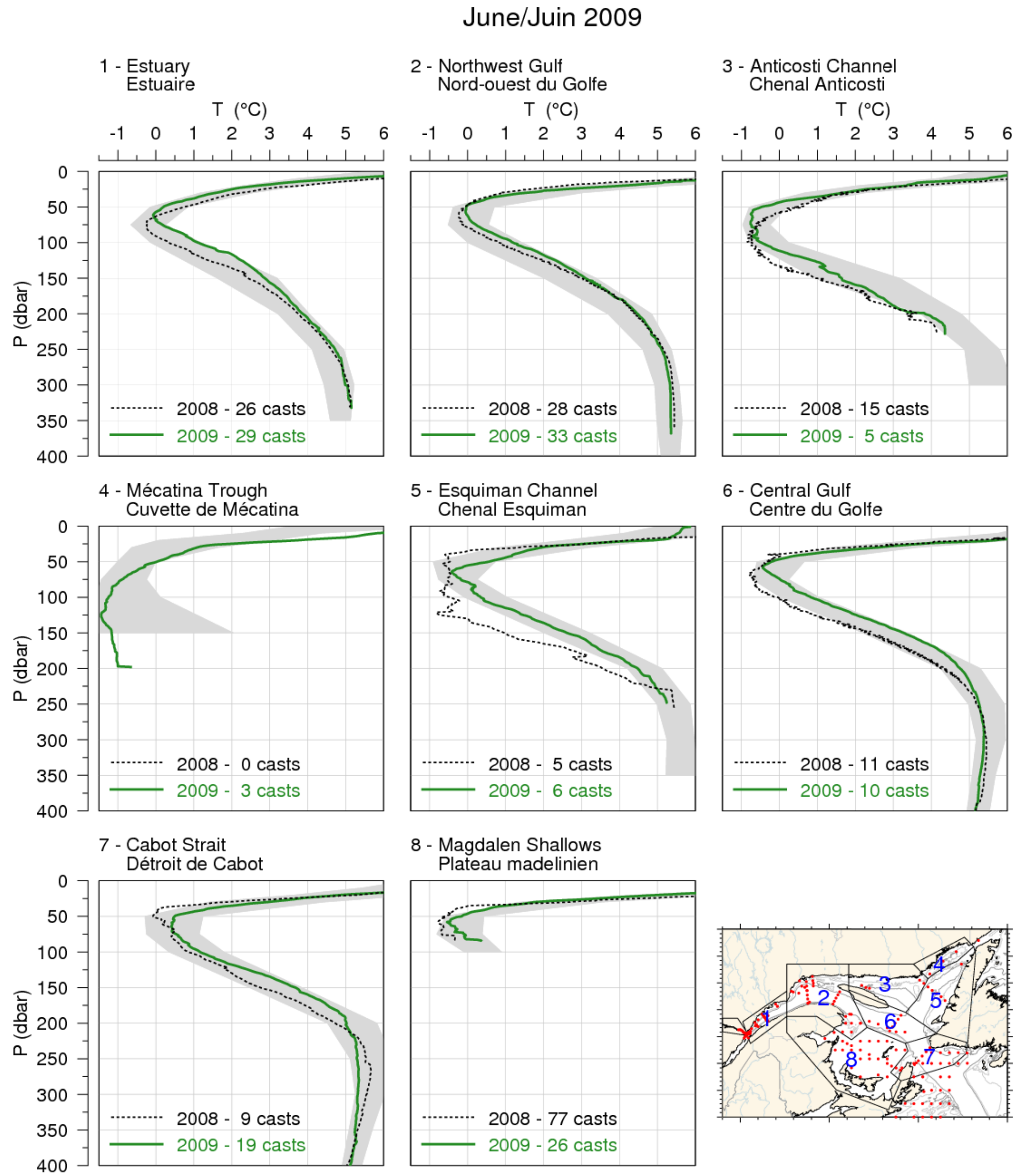

Fig. 37. Mean temperature profiles observed in each region of the Gulf during June. The shaded area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation. Mean profiles for the 2008 survey are also shown for comparison.

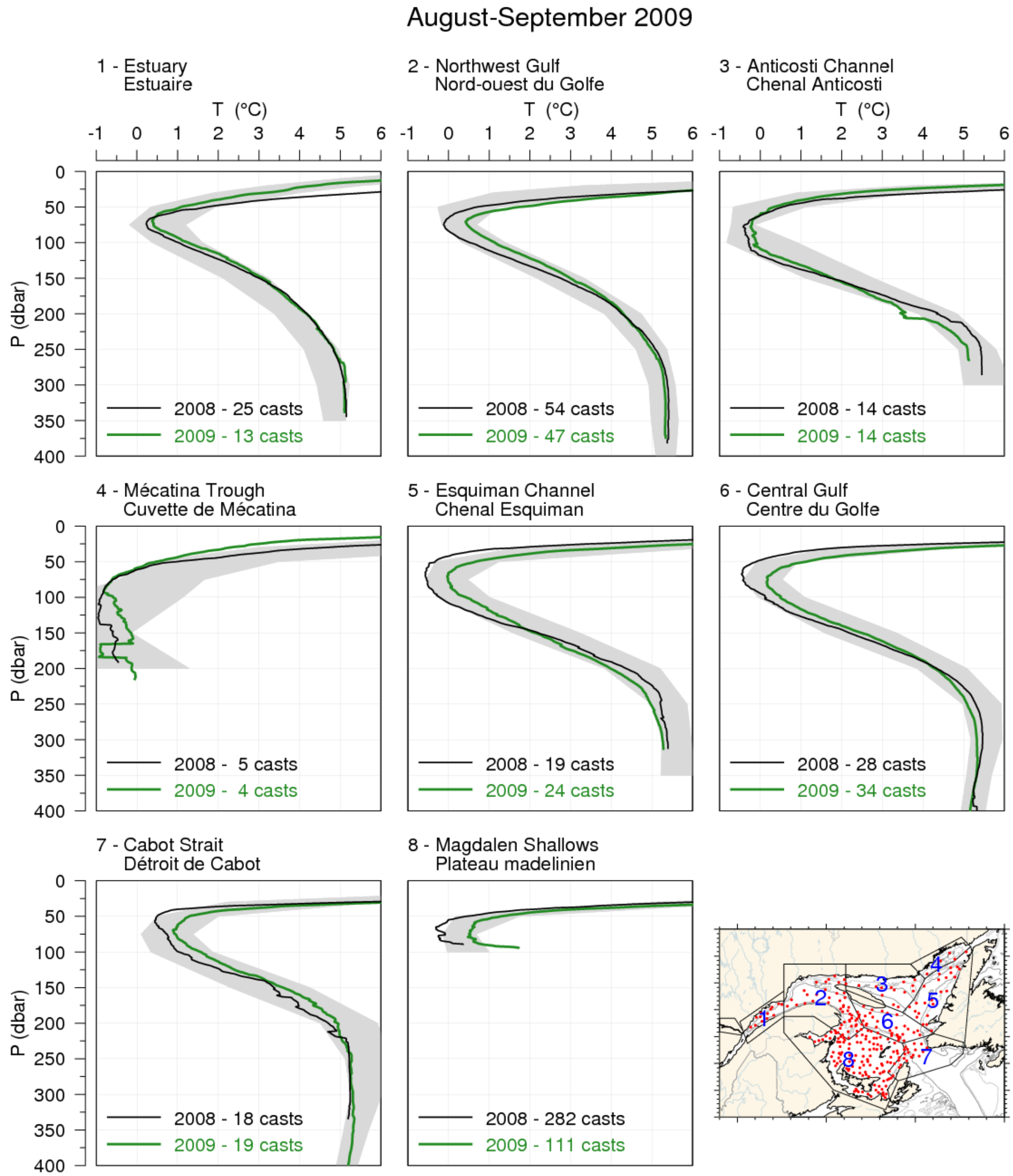

Fig. 38. Mean temperature profiles observed in each region of the Gulf during August and September. The shaded area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation for August for regions 1 through 7, and for September for region 8. Mean profiles for the 2008 survey are also shown for comparison.

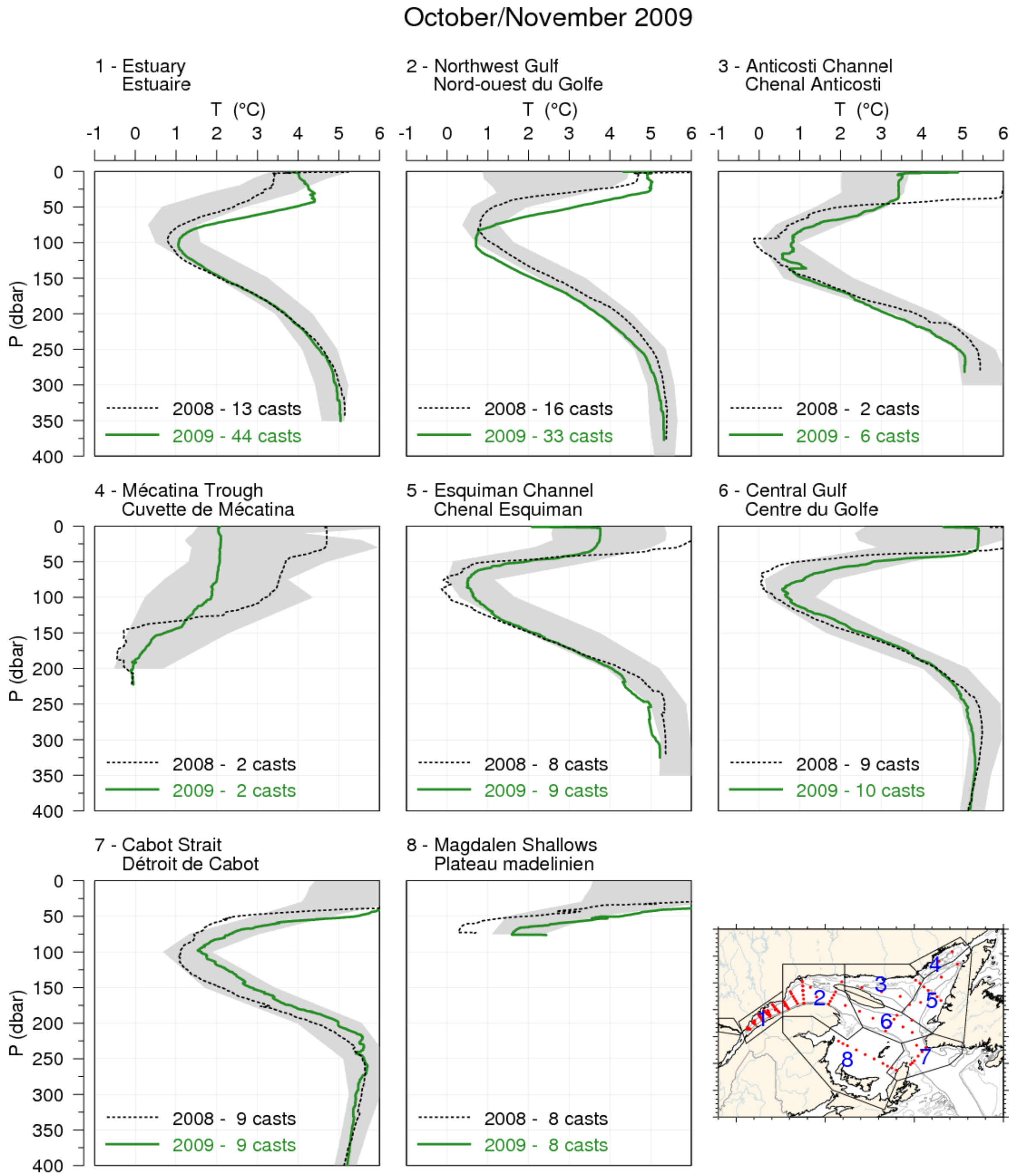

Fig. 39. Mean temperature profiles observed in each region of the Gulf during the November AZMP survey. The shaded area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation. Mean profiles for the 2008 survey are also shown for comparison. Region 1 was mostly sampled during October, so the October monthly climatology is shown for that region while the others show the climatology for November.

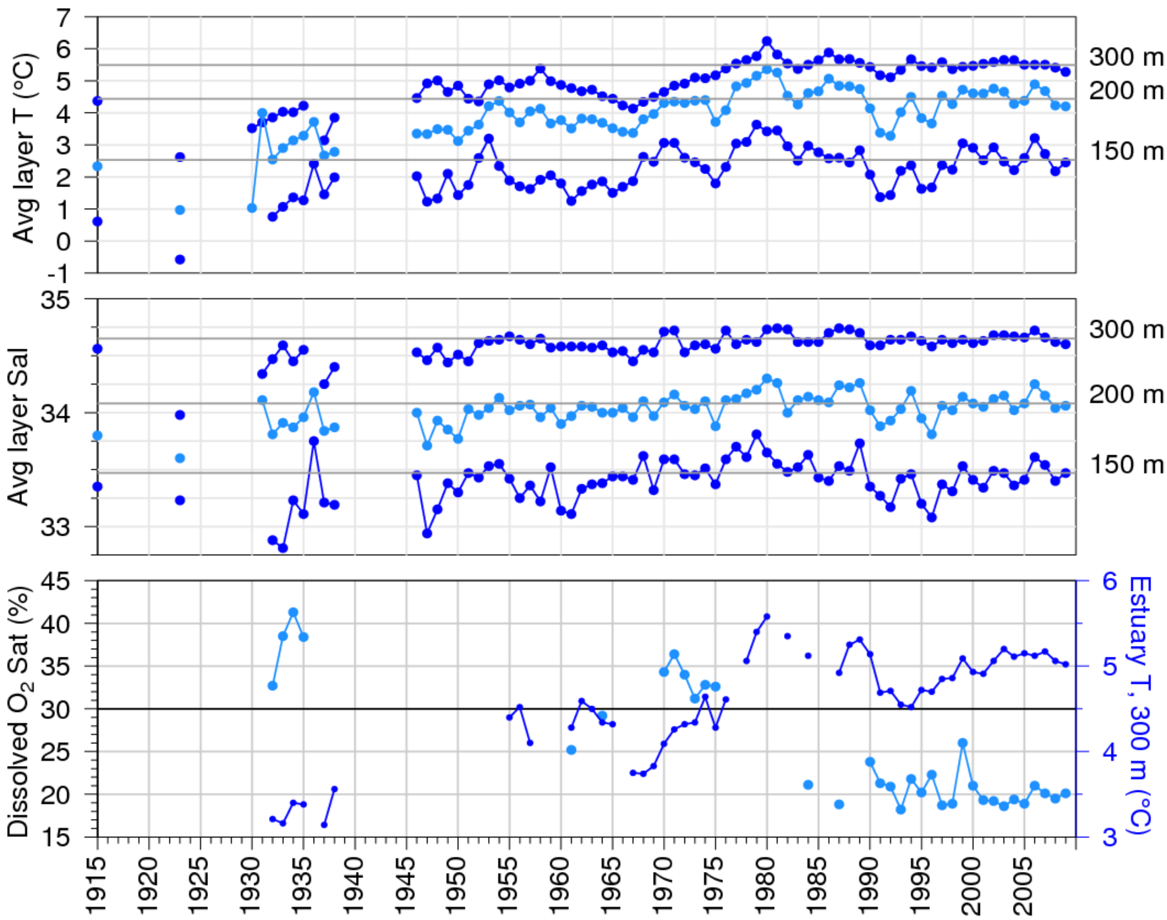

Fig. 40. Layer-averaged temperature and salinity time series for the Gulf of St. Lawrence and dissolved oxygen saturation between 295 m and the bottom in the deep central basin of the St. Lawrence Estuary. The temperature and salinity panels show the 150 m, 200 m and 300 m averages and the horizontal lines are 1971-2000 averages. The horizontal line in the oxygen panel at 30% saturation marks the threshold of hypoxic conditions. In addition to the oxygen percent saturation time series (light blue), the lower panel also shows temperature (dark blue) at 300 m in the Estuary.

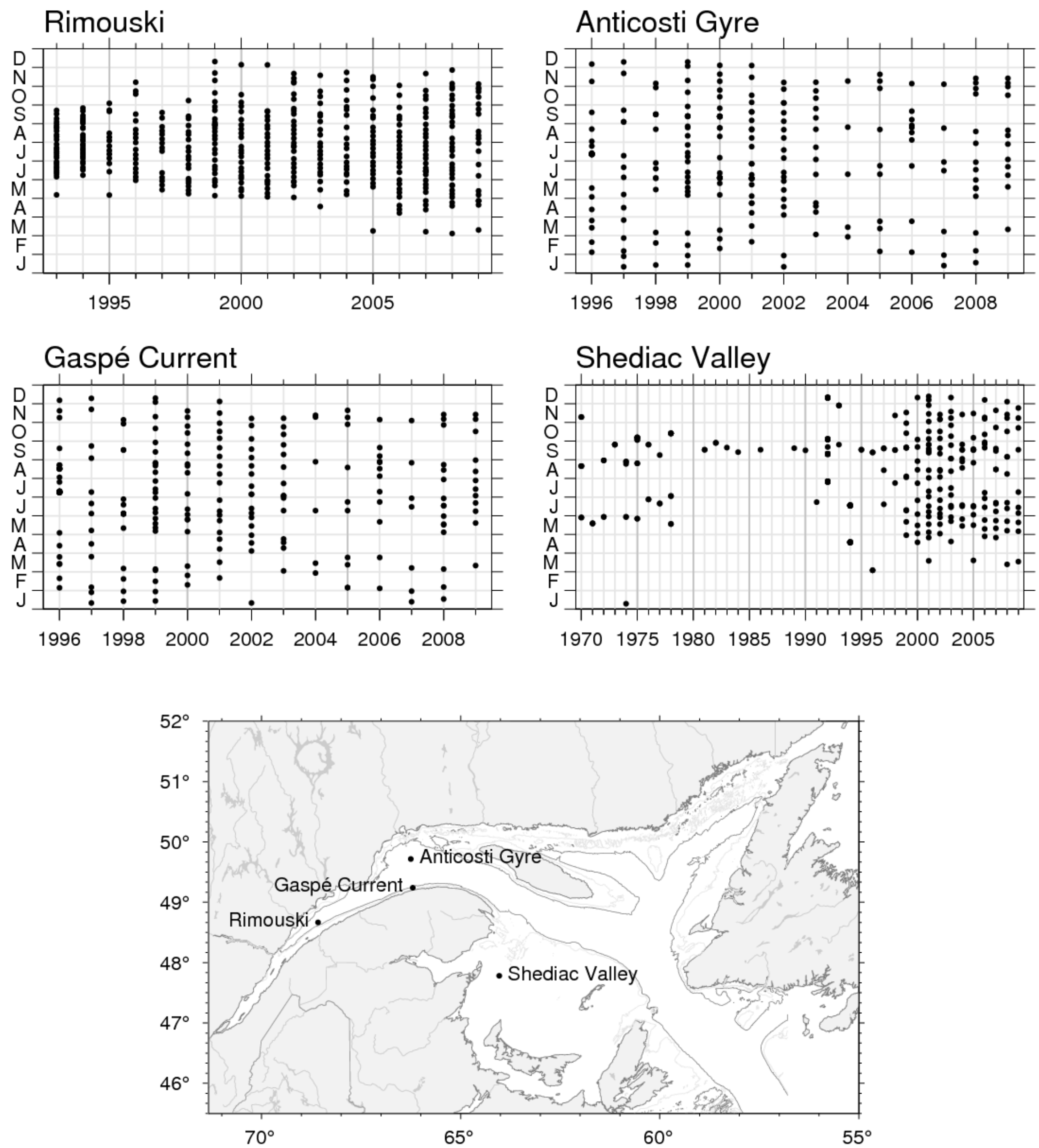

Fig. 41. Sampling frequency and positions of the AZMP stations (Rimouski, Anticosti Gyre, Gaspé Current and Shediac Valley).

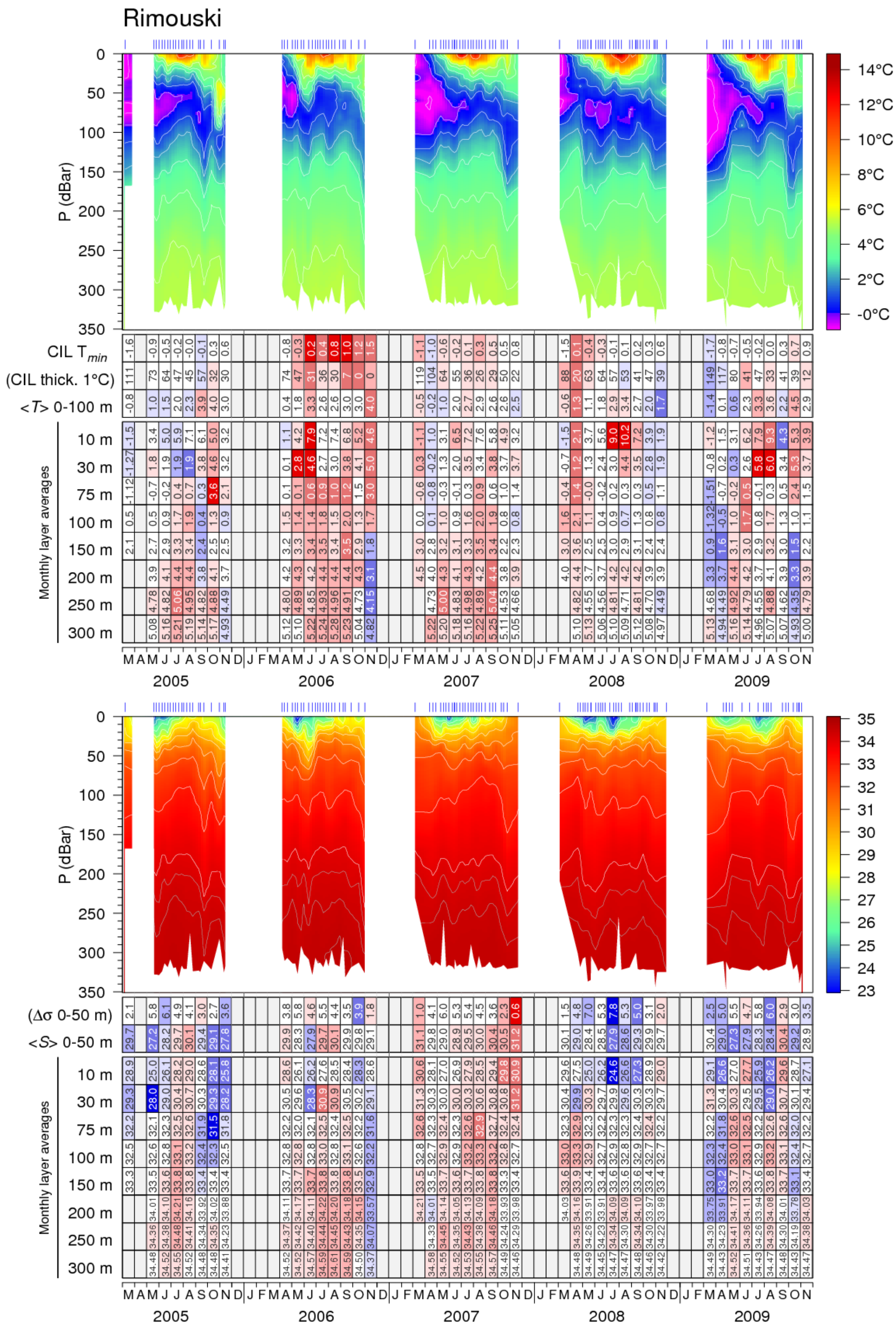

Fig. 42. Isotherm (top) and isohaline (bottom) time series at the Rimouski station; tick marks above indicate sample dates. The scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1993-2009 monthly climatology for the station (yearly climatology for 250 m and deeper).

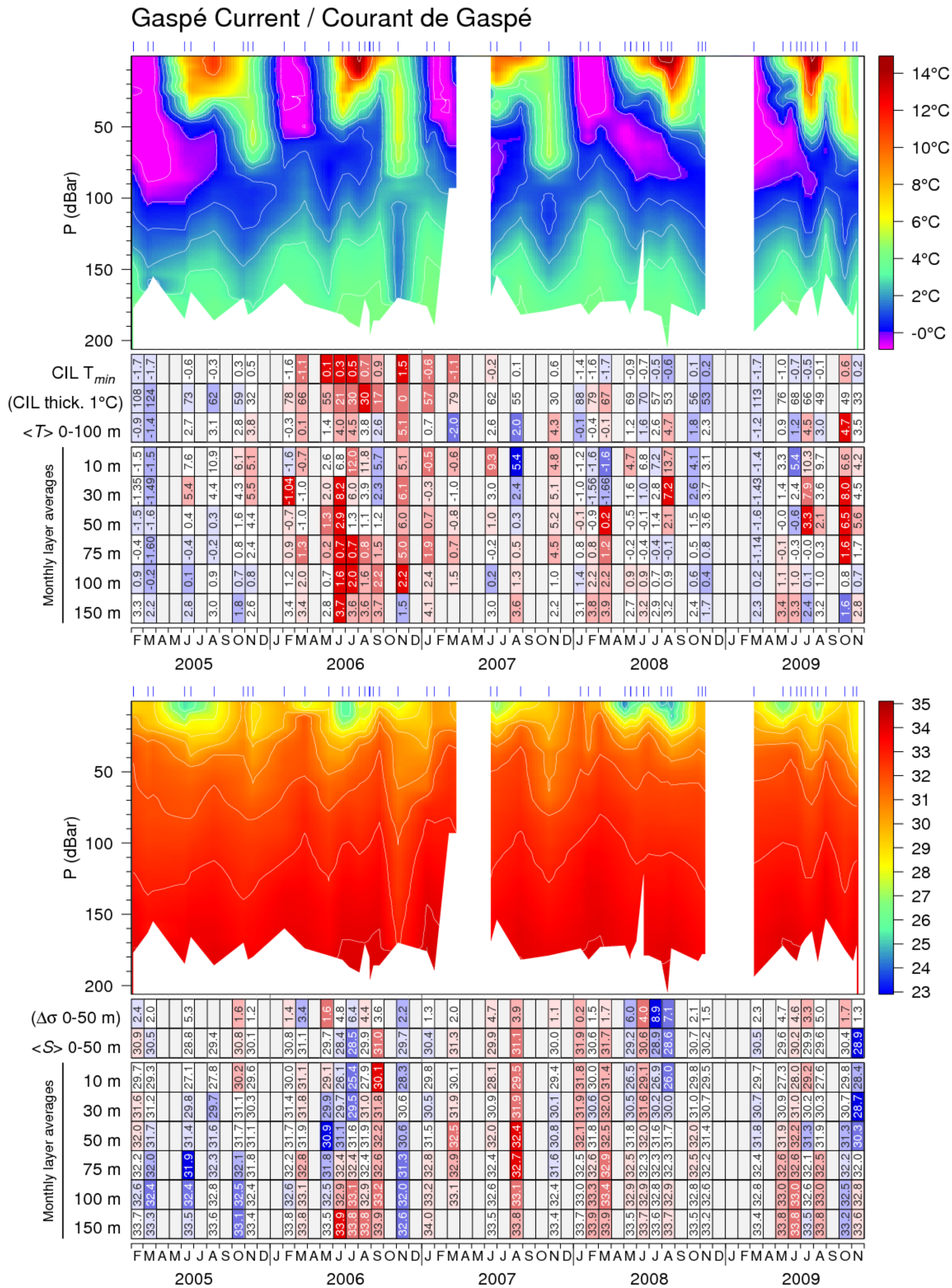

Fig. 43. Isotherm (top) and isohaline (bottom) time series at the Gaspé Current station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1996-2009 monthly climatology for the station.

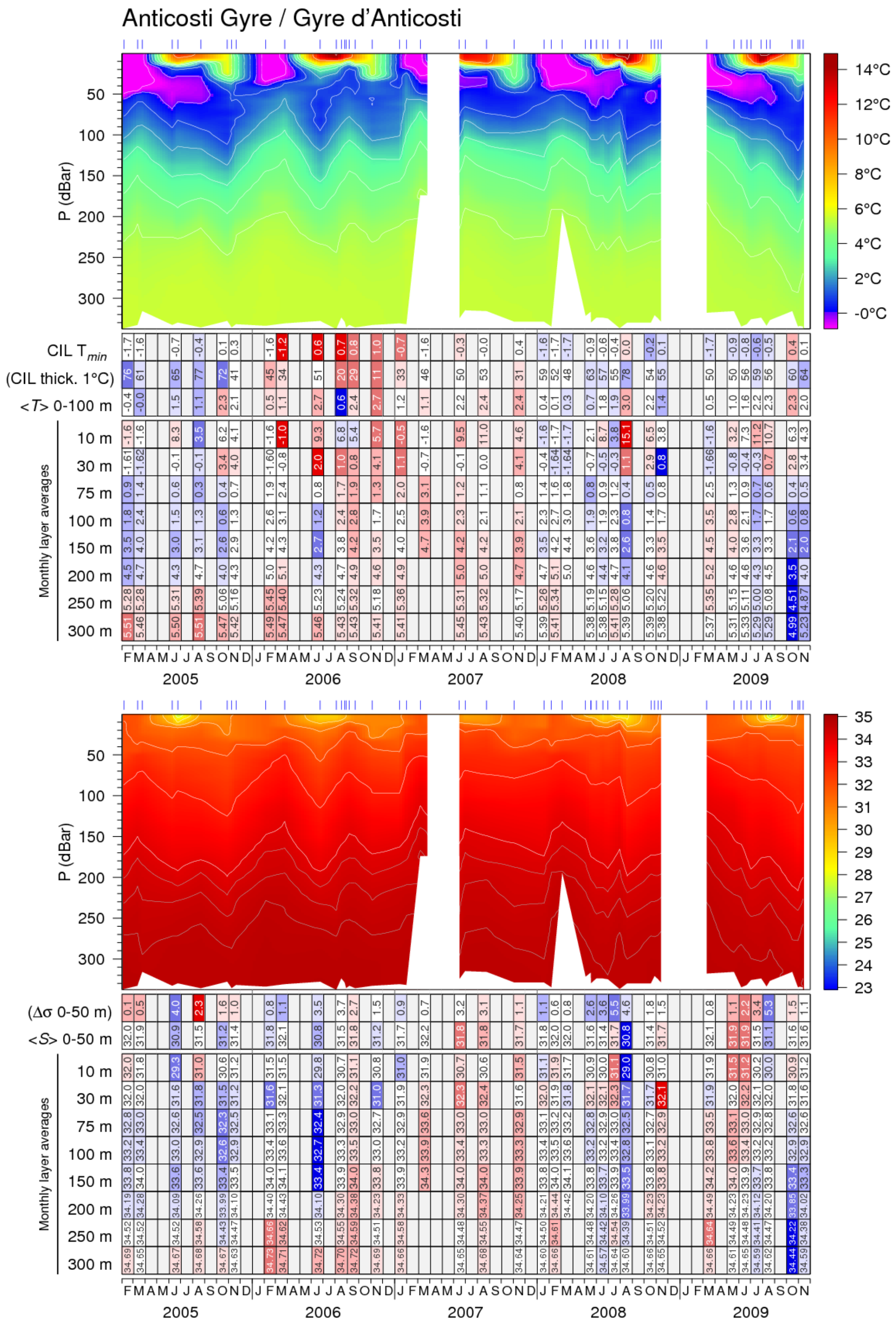

Fig. 44. Isotherm (top) and isohaline (bottom) time series at the Anticosti Gyre station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1996-2009 monthly climatology for the station (yearly climatology for 250 m and deeper).

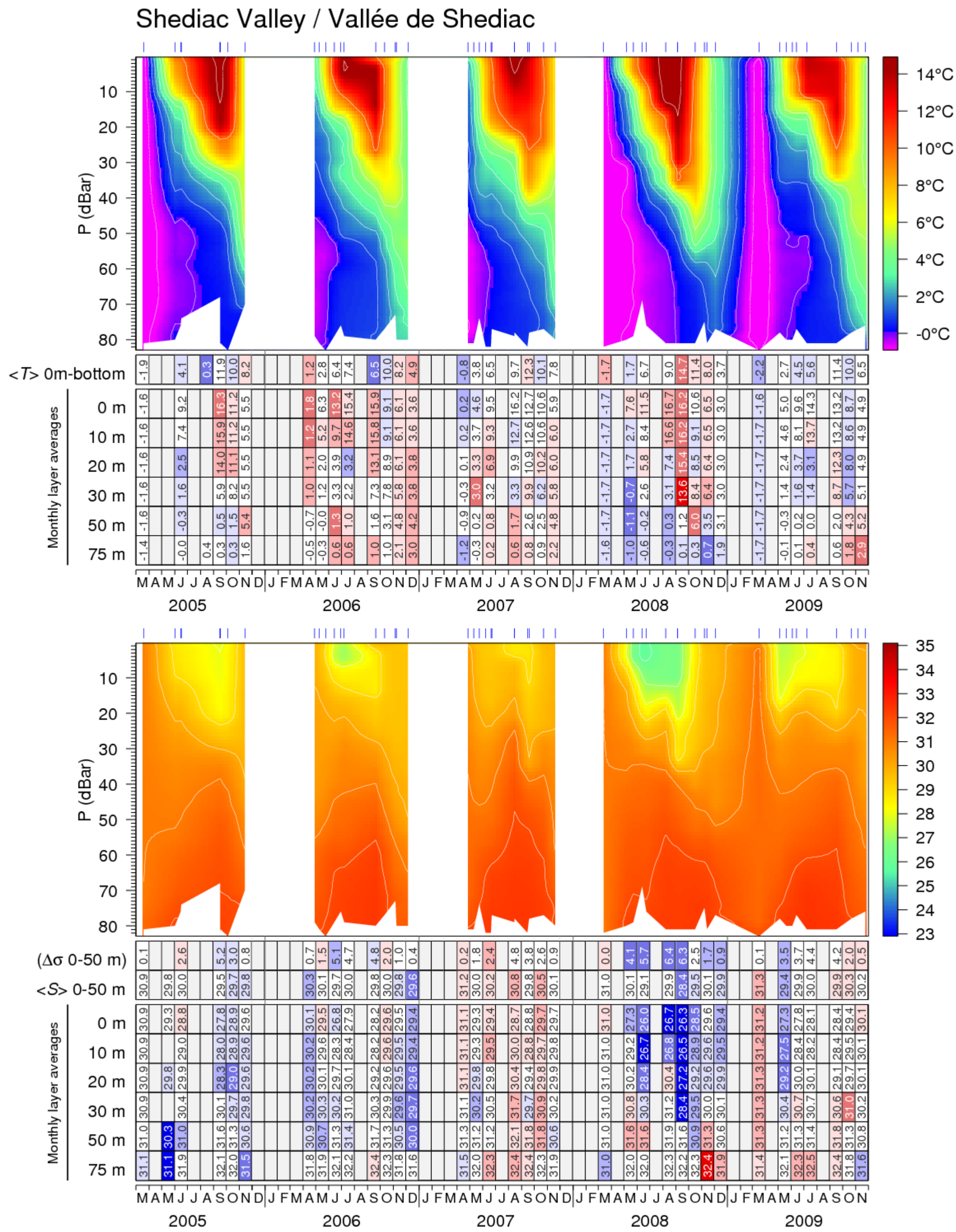

Fig. 45. Isotherm (top) and isohaline (bottom) time series at the Shediac Valley station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1971-2009 monthly climatology for the station.

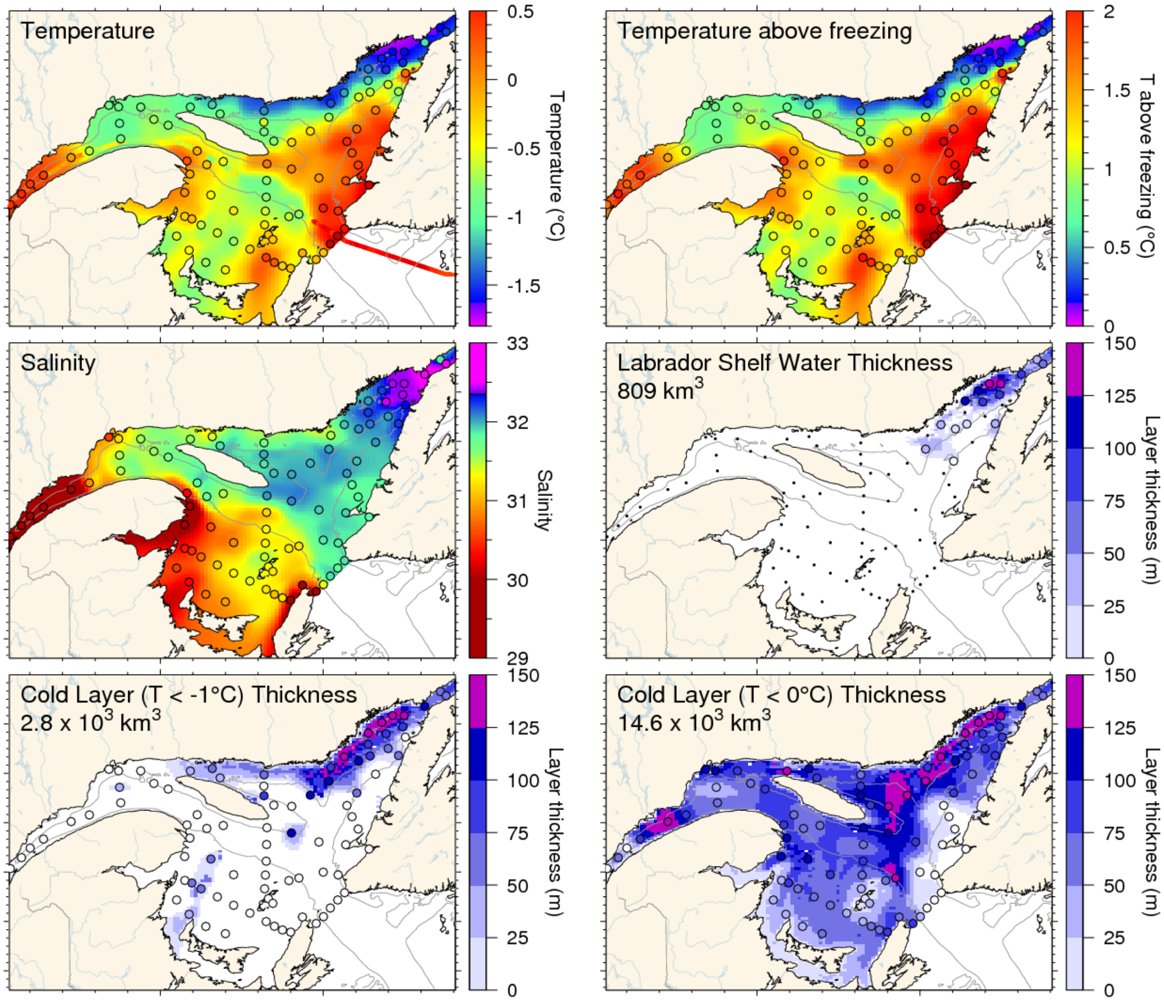

Fig. 46. March 2010 surface cold layer characteristic: surface water temperature (upper left), temperature difference above freezing point (upper right), salinity (middle left), estimate of the thickness of the Labrador Shelf water intrusion (middle right) and cold layer (T < -1°C and < 0°C) thicknesses (lower left and right). The symbols are coloured according to the value observed at the station, using the same colour palette as the interpolated image. A good match is seen between the interpolation and the station observations where the station colours blend into the background. The temperature panel also has a shipboard thermosalinograph data track drawn over the interpolated grid.