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Physical Oceanographic Conditions in the Gulf of St. Lawrence in 2008

Conditions d'océanographie physique dans le golfe du Saint-Laurent en 2008

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ABSTRACT

An overview of physical oceanographic conditions in the Gulf of St. Lawrence in 2008 is presented. Air temperatures were close to normal when averaged from January to March, contributing to an ice cover volume that was also close to the climatological mean. 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 2008, but consisted of above-average runoff in summer compensated later by lower runoff in the fall. The high summer runoff contributed to higher-than-normal stratification. Near-surface water temperatures were generally above normal throughout the Gulf for the months of May, July and November and were also above-normal on the Magdalen Shallows in June and in the northern Gulf from August to October. In August the northern parts of the Gulf saw positive anomalies while the southern parts experienced negative anomalies. This lead to the unusual occurrence that the waters around Prince Edward Island and in Northumberland Strait had higher temperature in July than in August 2008. On the Magdalen Shallows, a large area of the bottom was covered by water with temperatures < 0°C in September 2008, similar to the cold period observed in the 1990s and in contrast to conditions in September 2005, 2006 and 2007 when such cold waters were not observed. Maximum sea-ice volume within the Gulf and on the Scotian Shelf was 81 km^3, a value now considered about normal using updated ice volume estimates for 1971-2000. Ice first appeared early in the season and stayed later than normal (later by about 8 days later on the Magdalen Shallows). Winter inflow of cold and saline water from the Labrador Shelf occupied the Mécatina Trough from top to bottom in winter 2008. The spread of the intrusion was confined a bit closer to the coast compared to 2007 conditions, leading to an overall smaller volume of 1850 km^3, which is similar to 2001 and 2006 observations. The winter cold mixed layer volume was 13 700 km^3, a value higher than the 1996–2008 average by 0.8 SD, and corresponded to 41% of the total water volume of the Gulf. The summer CIL (cold intermediate layer) index for 2008 was -0.70°C, comparable to the very cold conditions observed in 2003 and a large decrease (by 0.47°C) from the previous summer. Regional patterns of the August and September CIL show that the layers for T < 1°C and < 0°C were much thicker in most parts of the Gulf in 2008 than in 2007 and had a generally lower core temperature throughout the Gulf. In the Northern Gulf, the area covered by water of low temperature (from < -1°C through < 1°C) increased in August 2008 relative to August 2007. Temperatures in the water column in June 2008 were characterized by a very thick and cold CIL in most regions except the Estuary and by warm deep waters in the Estuary and the northwest Gulf. This overall pattern persisted in the August–September mean conditions. By October and into November, CIL conditions were still thick and cold, while waters above the CIL were anomalously warm. Overall, temperature and salinity were generally normal from 150 m to 300 m, with the exception of slightly lower than normal (by 0.6 SD) temperature at 150 m. Temperature and salinity in this depth range decreased for a second consecutive year. The near-normal Gulf-wide water temperatures at 300 m were composed of warmer waters in the Estuary, near-normal temperatures in the northwest and central, and colder waters flowing into the Gulf at Cabot Strait.

RÉSUMÉ

Le présent document donne un aperçu des conditions d'océanographie physique qui ont prévalu dans le golfe du Saint-Laurent en 2008. 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 près de la moyenne 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 2008, mais a été supérieur à la moyenne au cours de l'été et inférieur à la moyenne à l'automne. L'apport important d'eau douce en été a contribué à une stratification supérieure à la normale. Les températures de l'eau près de la surface ont été en général supérieures à la normale dans l'ensemble du golfe au cours des mois de mai, de juillet et de novembre, sur le Plateau madelinien au mois de juin ainsi que dans le nord du golfe du mois d'août au mois d'octobre. En août, les secteurs situés dans le nord du golfe ont affiché des anomalies positives, tandis que ceux situés dans le sud ont présenté des anomalies négatives. Cela a provoqué l'occurrence inhabituelle de températures plus élevées en juillet qu'en août dans les eaux entourant l'Île-du-Prince-Édouard et celles du détroit de Northumberland, en 2008. Sur le Plateau madelinien, une grande proportion du fond a été couverte par des eaux de température < 0 °C en septembre 2008, ce qui rappelle la période froide observée dans les années 1990 et contraste avec les conditions enregistrées en septembre 2005, 2006 et 2007, alors que de telles eaux froides étaient absentes. Le volume maximal des glaces dans le golfe et sur le Plateau néo-écossais s'est établi à 81 km^3, une valeur près de la normale selon de nouvelles estimations de volumes de glace pour la période s'étendant de 1971 à 2000. La glace est apparue tôt en saison et est demeurée plus tard que la normale (environ huit semaines de plus sur le Plateau madelinien). Les arrivées hivernales d'eaux froides et salées du plateau du Labrador ont rempli entièrement la fosse de Mécatina au cours de l'hiver 2008. La propagation de cette intrusion s'est davantage limitée près de la côte comparativement aux conditions observées en 2007, se traduisant par un volume global plus faible (1850 km^3), similaire aux valeurs observées en 2001 et en 2006. Le volume de la couche mélangée d'eau froide d'hiver s'est établi à 13 700 km^3, une valeur supérieure de 0,8 fois l'écart type à la moyenne de la période 1996-2008, et correspondait à 41 % du volume d'eau total présent dans le golfe. L'indice de la CIF (couche intermédiaire froide) d'été pour 2008 s'est établi à - 0,70 °C, ce qui est comparable aux conditions très froides observées en 2003 et représente une forte diminution (de 0,47 °C) par rapport à l'été 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 épaisses dans la plupart des parties du golfe en 2008 comparativement à 2007 et que la température minimale était en général inférieure dans l'ensemble du golfe. Dans le nord du golfe, la superficie couverte par des eaux de faibles températures (de < -1 °C à < 1 °C) s'est accrue en août 2008 par rapport à août 2007. Les températures dans la colonne d'eau observées en juin 2008 ont été caractérisées par une CIF très épaisse et froide dans la plupart des régions, sauf dans l'estuaire, et par des eaux profondes chaudes dans l'estuaire et le nord-ouest du golfe. Ce profil global s'est maintenu en août et en septembre. En octobre et novembre, la CIF était toujours épaisse et froide, tandis que les eaux situées au-dessus de la CIF étaient anormalement chaudes. Dans l'ensemble, les températures et la salinité ont été généralement normales à une profondeur allant de 150 à 300 m, exception faite des températures légèrement inférieures à la normale (de 0,6 fois l'écart type) observées à 150 m attribuables à l'épaisseur accrue de la CIF. Les températures et la salinité dans cette gamme de profondeurs ont diminué pour une deuxième année consécutive. Les températures de l'eau étaient près de la normale dans l'ensemble du golfe à 300 m, composées d'eaux plus chaudes dans l'estuaire, à des températures près de la normale dans les secteurs du nord-ouest et du centre et à des eaux plus froides s'écoulant dans le golfe depuis le détroit de Cabot.

INTRODUCTION

This paper examines the physical oceanographic conditions in the Gulf of St. Lawrence (Fig. 1) in 2008 and related atmospheric forcing. 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 2007 (Galbraith et al. 2008).

AIR TEMPERATURE

The monthly air temperature anomalies for several stations around the Gulf are shown in Fig. 2 for 2007 and 2008. While air temperatures were generally normal (i.e., within ±0.5 SD) or higher than normal for the greater part of 2008, the southern and eastern parts of the Gulf experienced higher anomalies than the northwest. March was exceptionally cold (by 2.5^{o}C on average) at nearly all stations. Fig. 2 also shows the air temperatures and anomalies averaged for all nine stations. If an annual cycle resembles an oscillation, the winter portion appeared broadened (extending both earlier and later in time, with cold months of December 2007 and March 2008) and clipped (the minimum much less pronounced than normal in January and February). Air temperatures were in general either normal or above normal for the remainder of the year except at Blanc-Sablon in 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 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 2008 by 1 SD. 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 normal in 2008. Winter air temperatures were above normal at the three southern stations and normal to below normal at the six others to the north. Fig. 3 shows the annual mean air temperature anomalies averaged over the nine stations since 1945 as well as seasonal means. Again, this shows that the above-normal 2008 annual conditions were made up of normal winter temperatures and warmer than normal conditions for the rest of the year, by 1 SD for the spring and fall and 2 SD for the summer. A warming trend in the annual air temperature since 1971 does not persist when the time series is considered back to 1945. Thus the warming since 1971 could be due to inter-decadal variability.

PRECIPITATION AND FRESHWATER RUNOFF

Runoff data were obtained from the OSL (*Observatoire du Saint-Laurent* / St. Lawrence Observatory web site, www.osl.gc.ca), where they are updated monthly by D. Lefaivre (Institut Maurice-Lamontange, DFO) using the water level method from Bourgault & Koutitonsky (1999). The monthly averaged runoff measured at Québec City was close to normal overall in 2008 (Fig. 4), but consisted of above-normal runoff in summer, especially in August, compensated later by lower-than-normal runoff in the fall. The higher than normal runoff and its associated low salinity, contributed to higher-than-normal stratification and a strong toxic algae bloom in the St. Lawrence estuary in August,

SURFACE LAYER

The surface layer conditions of the Gulf are monitored by various complementary methods. The shipboard thermosalinograph network 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 along the main shipping route only and that semi-weekly ship tracks are irregular both in time interval and in the position where each longitude is crossed. The thermograph network is inexpensive and provides a growing record of near-surface temperatures at fixed stations and at short time intervals, but not (for the most part) in real-time nor during winter months. It is very helpful in providing information for the southern Gulf and the northeast in areas that are not sampled by the thermosalinograph network. It also provides station climatologies based on longer time spans than the thermosalinograph network. NOAA satellite remote sensing is the third tool and now provides 1-km spatial resolution coverage of ice-free waters with archived data back to 1985.

Shipboard thermosalinographs

The shipboard thermosalinographs were described by Galbraith et al. (2002) and by Gilbert et al. (2004). To summarize, thermosalinographs (SBE-21; Sea-Bird Electronics Inc., Bellevue, WA) have been installed on various ships starting with the commercial ship *Cicero* of Oceanex Inc. in 1999 (retired in 2006) and now on the *Cabot* since 2006. Oceanex ships sail year-round between Montréal, QC, and St. John's, NL, making a return trip once per week. Near-surface (3 m) water temperature and salinity are sampled using the shipboard thermosalinographs. The data are presented in near real-time on the St. Lawrence Observatory website (www.osl.gc.ca).

Fig. 5 shows a mean annual cycle of water temperature at a depth of 3 m along the Montréal to St. John’s shipping route based on data collected from 2000 to 2008. Data were used from any instrumented ship within the main shipping route area to fill data gaps. The data were averaged for each day of the year at intervals of 0.1 degree of longitude to create a composite along the ship track. The most striking feature is the area at the head of the Laurentian Trough (69.5°W), where strong vertical mixing leads to cold summer water temperatures (around 5 to 6°C and sometimes lower) and winter temperatures that are always above freezing (Galbraith et al. 2002). The progression to winter conditions is shown to first reach near-freezing temperatures in the Estuary and then progress eastward with time, usually just reaching Cabot Strait by the end of the winter.

Fig. 5 also shows the water temperature composite for 2008 and its anomaly. Unfortunately, the *Cabot* was in dry-dock during the early winter, so winter coverage begins only in mid-February. Nevertheless, the data show that near-surface water temperatures were normal to below normal in late winter until the end of April. The Estuary near-surface waters were much warmer than normal in May and June and again in August and September, as were the Gulf waters in May and again from July (or August, depending on the region) to September.

Temperature anomaly time series and 2000–2008 climatologies were constructed for selected sections that are crossed by the ship. Although the anomalies are quite similar between the two sections, Table 2 shows how different the near-surface temperature climatologies are at Tadoussac (head of the Laurentian Trough) compared to those nearby in the Estuary, as noted above. Winter temperatures are on average 0.7°C warmer at the Tadoussac section; the maximum monthly mean temperature in summer is only 6.9°C compared to 8.5°C at the nearby Estuary section and up to 13.1°C at the Mont-Louis section. The table provides a quick look at the inter-annual near-surface temperature variations at the selected sections as well as monthly averages for the year in review. The table highlights the same patterns described from Fig. 5.

Thermograph network

The thermograph network was described in a previous report (Gilbert et al. 2004) with updates described in Galbraith et al. (2007). The network consists of 23 stations with moored instruments measuring and logging water temperature every 30 minutes. 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. Twenty stations (Fig. 6) that collected data in 2008 have sufficiently long time series to permit the calculation of daily climatologies with standard deviations. The raw data from the thermograph network and various figures are available from the St. Lawrence Observatory (www.osl.gc.ca). This year, data from Shediac station acquired by DFO's Gulf Region are also shown.

In order to compare the 2008 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. 7, 8 and 9, along with daily climatologies (± 1 SD; shown in blue). Monthly average temperatures are also shown, with the severity of their anomaly colour-coded. Table 3 repeats these average monthly temperatures for each station at shallow sampling depths (< 20 m) for 2007 and 2008. The colour-coding of the scorecard is done according to the normalized anomalies using each station's climatology for individual months. May and July to September near-surface waters were generally above normal everywhere in the Gulf and much warmer in 2008 than in 2007, but they were variable in June and October. 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.

Table 4 shows similar information as Table 3, but for thermograph sensors moored deeper than 20 m. The deep (> 300 m) waters of the Gulf show below average temperatures from May to September 2008. The bottom (82 m) temperatures at Shediac Valley station were also cooler than normal for the same period.

Table 5 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 a greater perspective. In 2008, near-surface temperatures were generally normal to above normal during summer months, but much less remarkably than in 2006 when very warm conditions were present.

NOAA satellite SST

The 2008 quasi-monthly mean sea-surface temperatures are shown in Fig. 10 as colour-coded maps, and temperature anomalies with respect to the 1985-2008 monthly climatology are shown in Fig. 11. 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 2008). 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 April to November when coverage is complete, because ice cover biases the results for the other months, but April is only included for completeness as it is only usually ice-free in the Estuary and Northwest Gulf.

Fig. 11 is in relative agreement with the thermosalinograph and thermograph measurements that have climatologies spanning different numbers of years. The NOAA SST information is summarized on Table 6, showing the 2007 and 2008 monthly surface temperature anomalies spatially averaged over the eight regions of the Gulf delimited by the areas shown in Fig. 12. Near-surface water temperatures in the Gulf were above normal everywhere in May, July and November and were also above-normal on the Magdalen Shallows in June and in the northern Gulf from August to October. It is unusual for the waters around Prince Edward Island and in Northumberland Strait to have higher temperatures in July, as seen in 2008, than in August, which is typically when the warmest temperatures in the Southern Gulf (e.g. Ouellet et al., 2003).

Table 7 and Table 8 show the full 1985-2008 time series of monthly surface temperature anomalies spatially averaged over the Gulf of St. Lawrence and over the eight regions of the Gulf. Note that the intersection of regions 3, 4 and 5 (Fig. 12) was altered this year after the Canadian Hydrographic Service surveyed the area and mapped the saddle point between Mécatina Trough and Esquiman Channel. Table 7 and Table 8 show that, over the spatial scale of the Gulf, the warm anomalies observed in 2006 are still exceptional along with the 1999 observations. Nevertheless, 2008 stands out as an anomalously warm year: there are no below-normal monthly anomalies when averaged over the entire Gulf and only two when considering the eight Gulf regions separately.

One might wonder about the apparent shift from cold to warm anomalies that occured around 1993, which could cast doubt on the SST data. However, the air temperature data shown in Table 1 show a similar transition in 1993 as does the thermograph network water temperature data from Île Shag at 10 m (although a little later here, in 1995) (Table 5).

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 9 along with averages for the Manicouagan Marine Protected Area (MPA), the St. Lawrence Estuary MPA and the Saguenay – St. Lawrence Marine Park (Fig. 13). 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 1°C warmer than for the Estuary as a whole. The common feature among regions for 2008 is the strong positive anomaly in August.

The Magdalen Shallows, excluding Northumberland Strait, are divided into western and eastern areas as mapped on Fig. 14. 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 feature among regions is the strong positive anomaly in July followed by the strong negative anomaly in August.

SEA ICE

The ice volume is estimated partially using a different database than in last year's report (Galbraith et al, 2008). This year, it is estimated from the same gridded database of weekly ice cover and ice categories (Drinkwater et al. 1999) only up to 1969, then completed from weekly composites extracted from ice charts using ArcGIS up to 1999, and further updated to include daily sea-ice conditions up to 2008. The new data lead to considerably higher estimates of ice volumes than previously reported for 1970 onwards.

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 combined Gulf and Scotian Shelf ice volume shown in the top panel of Fig. 15 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 volume shown on the bottom panel of Fig. 15 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. 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 1999.

In 2008, the Gulf and Shelf maximum ice volume was 81 km^3, near the 1971-2000 climatological mean and consistent with the normal air-temperature winter-severity index (the January to March air temperature average). The highest ice volumes of the time series occurred in 1993 and 2003. The maximum ice volume reached during each winter is repeated in Table 12. The correlation between annual maximum ice volume and the air-temperature winter-severity, introduced in Table 1 and also repeated in Table 12, accounts for 63% of the variance using the 1970-2008 time series, and up to 82% of the variance when considering only the daily data from 2000 to 2008. The correlation between the ice volume used in last year's report (Galbraith et al., 2008) and the air-temperature winter-severity index yielded only 42% of the variance accounted for when using the period 1970-1999.

The 2007-08 ice season was anomalously long. The first occurrence of ice was typically 15 to 20 days earlier than normal and the last occurrence of ice was also later than normal in almost every region, e.g. by 8 days on the Magdalen Shallows. More detailed information on large scale meteorological conditions and sea-ice cover in the Gulf of St. Lawrence are presented by Petrie et al. in an annually published research (e.g., Petrie et al. 2008).

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 Gilbert et al. (2004) and in Galbraith et al. (2006).

Eighty-seven stations were sampled during the 3–13 March 2008 survey using 41.5 flight hours. Fig. 16 and Fig. 17 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 2007 and 2008. The surface mixed layer is usually very close (within 0.1^{o}C) to the freezing point in many regions of the Gulf in March, and this was the case in 2008 except for an area extending from the northeast side of Cabot Strait northward to Esquiman Channel. Indeed, relatively warm water (~ 0°C to -1°C) entered the Gulf on the northeast side of Cabot Strait, similar to previous years, and flowed northward along the west coast of Newfoundland. However, the inflow was warmer than in 2007 and its volume and area were much larger.

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. 16 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) and occupied the area north of Anticosti Island as well as Esquiman Channel. Lower salinities (fresher water) are observed in Chaleur Bay and on the north side of the Gaspé Peninsula. These lower salinities are not associated with increased runoff as the freshwater runoff at Québec City was near-normal in January-February 2008, but perhaps greater-than-normal ice cover inhibited wind-forced mixing and kept the fresher waters concentrated in the upper layer.

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 and a large area northeast of Anticosti Island. An estimate of the thickness of this intrusive layer is shown in the top panels of Fig. 17. It occupied the Mécatina Trough from top to bottom again in winter 2008 (up to 235 m depth); however, its spread was confined slightly closer to the coast compared to 2007 conditions, leading to an overall smaller volume. The recent history of Labrador Shelf water intrusions is shown in Fig. 18 where its volume is shown as well as the fraction it represents of all the cold water volume in the Gulf. Both of these quantities were normal in March 2008 (1850 km³ and 13%) and similar to the 2001 and 2006 values.

The cold (< -1°C) mixed layer depth typically reaches about 75 m in the Gulf, but in 2008 this layer was thicker than usual (see middle panels of Fig. 17). 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. The previously noted large warm-water intrusion present on the northeast part of Cabot Strait decreased the overall cold-water volume in the Gulf, with a local cold layer thickness of 0 m. Integrating the cold layer depth over the area of the Gulf yields a cold-water volume of 13 700 km³, higher than the 1996–2008 average by 0.8 SD. This is perhaps surprising considering the near-normal winter air temperatures, but air temperatures were also below-normal in December 2007. This cold-water volume corresponded to 41% of the total water volume of the Gulf (34 000 km³). The time series of winter cold water volume is shown in Table 12.

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 2008 is shown in Fig. 19. The above-normal volume of cold water (13 700 km³) observed in March 2008 led to a CIL minimum temperature index forecast of -0.47°C based on the correlation between the winter cold-water volume and the summertime CIL index for 1996–2007 (excluding 1998). 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 1850 km³ intrusion accounts for a 0.3°C cooling of the CIL index. The CIL forecast of -0.47°C, published in last year's report (Galbraith et al, 2008), would have been a decrease of 0.24°C from the observed 2007 index of -0.23°C.

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 temperature and depth of the temperature minimum in each cast. 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.

Fig. 20 shows the gridded interpolation of the CIL thickness < 1°C and < 0°C and the CIL minimum temperature for August–September 2007 and 2008. It is apparent that the CIL thickness < 1°C and < 0°C was much larger in most parts of the Gulf in 2008 than in 2007 and had a generally lower 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. The time series of the regional CIL volumes are shown in Fig. 21 (for < 0°C and < 1°C) and in Table 12 (for < 1°C). These volumes were all recalculated since last year's report because of the small change in the position of the intersection between regions 3, 4 and 5 (Fig. 12). All regions except Anticosti Channel show an increased CIL (<1°C) volume in 2008 compared to 2007, although this increase was very slight in the northwestern Gulf. Fig. 22 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. 20). The CIL volume as defined by either temperature increased significantly compared to 2007 conditions. Both were close to volumes previously observed during the cold year 2003.

The time series of the CIL regional average core temperatures are shown in Fig. 23 (also recalculated since last year's report). All regions show a decrease in core temperature. The 2008 average temperature minimum over the entire interpolated grid was -0.54°C and is shown in Fig. 22 (bottom panel, blue line). This is a decrease of 0.4°C since 2007. The overall 2008 CIL water mass properties were similar to those observed in 1998 and 2003.

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. 22, 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.

The Gilbert & Pettigrew (1997) CIL index for summer 2008 was -0.70°C. The decrease from the summer of 2007 CIL index of -0.23°C is consistent with the sharp increase in CIL volume observations between August 2007 and 2008 discussed above. This large decrease of the index returned it to cold values similar to those observed in 2003 and most of the 1990s. The index is colder than the prediction of -0.47°C based on the March 2008 observations of the volume of cold water (Fig. 19). The difference is likely caused by the very cold air temperatures that prevailed in March after the winter survey that delayed ice melt and spring warming in the Gulf, combined with increased summertime stratification that limited the erosion of the CIL by mixing.

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 others from Northumberland Strait to obtain a quasi-complete picture of the southern Gulf temperatures at that time of the year. Bottom temperatures typically range from <1°C to >18°C and are mostly depth-dependent (Fig. 24). 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 slightly negative over most of the southern Gulf deeper waters, and positive near the coast of New Brunswick and Prince Edward Island (Fig. 25 and also later Fig. 28 using a higher-resolution anomaly scale). Waters significantly cooler than normal were present in the areas surrounding Îles-de-la-Madeleine. 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 2008 and are likely not artefacts.

Relative to 2007, bottom temperatures during the 2008 multi-species survey were significantly cooler over the Magdalen Shallows while some coastal areas were warmer (Fig. 26). Time series of the bottom area covered by various temperature intervals were estimated from the gridded temperature data (Fig. 27). Unlike conditions in September 2005, 2006 and 2007 a large bottom area was covered by water with temperatures < 0°C in 2008, similar to the cold period observed in the 1990s. 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. While waters colder than 0°C and 1°C covered more of the bottom in 2008 than normal, the coverage of waters colder than 2°C and 3°C was near normal. The cold anomaly was also found consistently throughout the summer at the 82 m thermistor at the Shediac Valley station of the thermograph network (Table 4).

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 and 40 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 on Fig. 14. This analysis again shows that while surface waters were warmer than normal in 2008, the anomalies were not as significant as in 1999 and 2006. In contrast bottom waters were anomalously cold in 2008 similar to the cold period of 1987-1994.

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. 28), which is similar to Fig. 24 for the southern Gulf. Again, bottom temperature contours are very much dependent on 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. 29 shows the bottom water temperature anomaly referenced to the 1971–2000 climatology. Because the temperature variability differs greatly with depth, it is difficult to produce such a map to illustrate the variability everywhere using a single scale. Fig. 28 and Fig. 29 show Mécatina Trough, Beaugé Bank and the bank east of Anticosti Island to have very cold bottom water. The cold anomaly was also observed throughout the summer months at the Beaugé Bank station of the thermograph network (Table 3). Most of the (shallow) coastal waters of the Gulf had a tendency for warmer than normal conditions during the late summer of 2008, based on this analysis.

Fig. 30 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. 24). The figure shows compression of the 5°C to 6°C bottom habitat in 1992. Although this figure shows much less variability than on the Magdalen Shallows (Fig. 27), a strong increase in the area covered by cold water was observed in 2008 for temperatures < -1°C and < 0°C, with a slight increase of the area < 1°C.

SEASONAL AND REGIONAL AVERAGES OF TEMPERATURE PROFILES

In order to show the seasonal progression of temperature profiles, regional averages are shown in Fig. 31 through Fig. 34 for 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 87 conductivity-temperature-depth (CTD) casts in March, 79 casts in June, 126 casts in August, 191 in September and 129 in October–November were obtained. More casts than usual were done in the Estuary during the October–November 2008 survey. Fig. 32 and Fig. 33 also include data from other summertime surveys, most notably in the southern Gulf.

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. 12. Again, these time series and climatologies were recalculated for this year’s report because of the change of regions 3, 4 and 5. 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 in Fig. 31 through Fig. 34.

The March water temperature conditions were discussed at length in earlier sections and are included here for completeness (Fig. 31), but caution is needed in interpreting the results. 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 2007 Esquiman Channel regional average was caused because the last few bins of the deepest cast used in the average contained a mixture of the Labrador Shelf intrusion.

Temperatures in June 2008 (Fig. 32) were characterized by a very thick and cold CIL in most regions except the Estuary, and by warm deep waters in the Estuary and the northwest Gulf, although the CIL was thinner than in 2007 in Anticosti Channel. This overall pattern persisted in the August–September mean conditions (Fig. 33). The discontinuities near 200 m in the 2007 average temperature profile for Mécatina Trough are caused by the large horizontal gradient in deep water properties in the Trough, sampled by only three deep casts that end at different depths. By October–November (Fig. 34), CIL conditions were still thick and cold while waters above the CIL were anomalously warm. Average discrete-depth layer conditions are summarized for the months of the 2007 and 2008 AZMP surveys in Table 14.

YEARLY LAYER AVERAGES OF DEEP (> 150 m) TEMPERATURE AND SALINITY

The aforementioned reconstructed temperature and salinity climatologies for 1971–2000 provide 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 observation 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 average are shown for 200, 250 and 300 m in Table 15 as well as in Fig. 35 for temperature and Fig. 36 for salinity.

In 2008, the temperature and salinity were generally normal from 150 m to 300 m, with the exception that temperature was slightly low (by 0.6 SD) at 150 m, associated with the thicker than normal CIL. Temperature and salinity in this depth range decreased for a second consecutive year, from 2007 to 2008. The near-normal Gulf-wide water temperatures at 300 m were composed of warmer waters in the Estuary (region 1), near-normal temperatures in the northwest and centre (regions 2 and 6), and colder waters coming into the Gulf at Cabot Strait (region 7). This cold anomaly is expected to propagate inward during the next few years, as it appears to be from the decrease in average temperature from 150 m to 300 m between 2007 and 2008.

MONITORING HYPOXIA IN THE ST. LAWRENCE ESTUARY

The deeper waters of the Laurentian Channel are not ventilated during winter and are slowly advected toward the heads of the Laurentian, Esquiman and Anticosti Channels. Therefore, the dissolved oxygen concentrations and saturations are lowest at the Channel heads, and in particular at the head of the longer Laurentian Channel. Fig. 37 is an update of the Gilbert et al. (2005) oxygen time series and provides the mean dissolved oxygen value at depths greater than or equal to 295 m in the St. Lawrence Estuary, expressed as a percentage of saturation at surface pressure. Dissolved oxygen decreased very slightly in 2008 compared with 2007 observations but have remained relatively stable since 2001. In the 1930s and early 1970s, oxygen levels were above the hypoxic threshold of 30% saturation. 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.

TIME SERIES OF TEMPERATURE AND SALINITY PROFILES AT FIXED AZMP STATIONS

Sampling by the Maurice Lamontagne Institute began in 1996 at two stations (Fig. 38) 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. 38). 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. 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, and 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. 39. Similar figures are provided for the Gaspé Current station (Fig. 40), the Anticosti Gyre station (Fig. 41) and the Shediac Valley station (Fig. 42). The scorecard climatologies are calculated from all available data at all stations except for Shediac, where the time series since 1971 is considered (1971-2008).

At the Rimouski station (Fig. 39), salinity at 10 m was below normal from April to September, with the largest anomaly occurring in July in partial agreement with above average freshwater runoff around that time. Spring warming was early and the CIL was thinner than normal in late winter but normal by May. Summertime temperatures were above normal at 10 m, consistent with the enhanced stratification caused by low surface salinity. However, there was no warm anomaly throughout the water column similar to observations of 2006 and 2007.

There is no consistent pattern in water temperature at the Gaspé Current station (Fig. 40) or for the Anticosti Gyre station (Fig. 41) except that the CIL core temperature was either normal or colder than normal. Deep-water salinities were either normal or higher than normal at the Gaspé Current station. The high August runoff resulted in lower than normal salinities at 10 and 30 m in August at both stations, but the extension of lower-than-normal salinities down to 250 m at the Anticosti Gyre station suggests an episodic change in the rotation strength of the gyre, resulting in less doming of the isohalines

At the Shediac Valley station (Fig. 42), there was a strong temperature gradient with waters much warmer than normal near the surface and colder than normal near the bottom in August and September. The near-bottom cold conditions persisted throughout the year at 75 m and until August at 50 m. Near-surface salinities were very low, coincident with the high summer runoff. The strong salinity stratification was favourable to near-surface warming and thermal insulation of the cold bottom waters through reduced vertical mixing.

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 only above normal in 2008 at the Shediac Valley station, the salinity of the top

50 meters was below normal at both the Rimouski station and the Shediac Valley station, but the stratification was the highest of the record at all four stations.

OUTLOOK FOR 2009

The March 2009 winter survey provides an outlook for CIL conditions expected for the remainder of 2009. Fig. 43 shows the surface mixed layer temperature, salinity, and thickness (at $T < -1°C$), as well as the thickness and extent of the cold and saline layer ($S > 32.35$ and $T < -1°C$) that has intruded into the Gulf from the Labrador shelf. The waters were near-freezing almost everywhere. In recent winters warm water ($T > -1°C$) has entered the Gulf on the eastern side of Cabot Strait, but no such warm intrusion occurred in March 2009. The intrusion of cold and saline water from the Labrador Shelf through the Strait of Belle Isle occupied a slightly smaller area closer the coast in March 2009 compared to 2008. It extended to the surface again. Its volume of 1460 km^3 was down from 1850 km^3 in March 2008 and closer to the 1620 km^3 recorded in March 2006. The cold layer (< -1°C) was thicker than usual and its overall volume increased slightly from March 2008 conditions to 14.6×10^3 km^3, making it the second largest volume recorded in 14 years after the 2003 maximum of 14.9×10^3 km^3. The relation between the cold water volume and the CIL index (Galbraith, 2006) forecasts cool summertime CIL conditions in 2009 with an index of -0.58ºC. However, this would be a temperature increase from the -0.70ºC index of 2008 despite a larger winter cold water volume than in 2008. The CIL was colder than expected in 2008 likely because of the late spring warming and high summertime stratification. The high ice cover observed in March 2009 may lead to similar late warming and to a CIL index below -0.58ºC.

SUMMARY

- Air temperatures were close to normal when averaged from January to March, contributing to an ice cover volume that was also close to the climatological mean. Air temperatures were in general either normal or above normal for the remainder of the year.
- The monthly averaged runoff measured at Québec City was normal overall in 2008 but consisted of above-average runoff in summer compensated later by lower runoff in the fall. The high summer runoff contributed to higher-than-normal stratification.
- Near-surface water temperatures were generally above normal throughout the Gulf for the months of May, July and November and were also above-normal on the Magdalen Shallows in June and in the northern Gulf from August to October. In August the northern parts of the Gulf saw positive anomalies while the southern parts experienced negative anomalies. This lead to the unusual occurrence that the waters around Prince Edward Island and in Northumberland Strait had higher temperature in July than in August 2008.
- On the Magdalen Shallows, a large bottom area was covered by water with temperatures < 0°C in September 2008, similar to the cold period observed in the 1990s and in contrast to conditions present in September 2005, 2006 and 2007 when no such waters were observed.
- Maximum sea-ice volume within the Gulf and on the Scotian Shelf was 81 km^3, a value now considered about normal using updated ice volume estimates for 1971-2000.
- Winter inflow of cold and saline water from the Labrador Shelf occupied the Mécatina Trough from top to bottom in winter 2008 (up to 235 m in depth). The spread of the

intrusion was confined a bit closer to the coast compared to 2007 conditions, leading to an overall smaller volume of 1850 km^3, which is similar to the 2001 and 2006 observations.

- The winter cold mixed layer volume was 13 700 km^3, a value higher than the 1996–2008 average by 0.8 SD. This cold-water volume corresponded to 41% of the total water volume of the Gulf.
- The Gilbert & Pettigrew (1997) CIL index for summer 2008 was -0.70°C, which is comparable to the very cold conditions observed in 2003. This was a large decrease in the index of 0.47°C since the summer of 2007. The index was colder than that predicted following the March 2008 survey of the cold mixed layer water volume in the Gulf. This is likely attributable to the very cold air temperatures in March 2008, late ice melt and delayed spring warming. Higher than normal summer stratification may also have played a role.
- Regional patterns of the August and September CIL show that the layers for T < 1°C and < 0°C were much thicker in most parts of the Gulf in 2008 than in 2007 and had a generally lower core temperature everywhere.
- In the northern Gulf, the area covered by low temperature water (bins from < -1°C through 0°C to 1°C) increased in 2008 relative to 2007 conditions.
- Seasonal and regional patterns observed in water column temperatures are summarized as follows: Temperatures in June 2008 were characterized by a very thick and cold CIL in most regions except the Estuary and by warm deep waters in the Estuary and the northwest Gulf. This overall pattern persisted in the August–September mean conditions. By October–November, CIL conditions were still thick and cold, and waters above the CIL were anomalously warm.
- Overall, temperature and salinity were generally normal from 150 m to 300 m, with the exception that temperature was slightly lower (by 0.6 SD) at 150 m due to the thick CIL. Temperature and salinity in this depth range decreased for a second consecutive year, from 2007 to 2008. The near-normal Gulf-wide water temperatures at 300 m were composed of warmer waters in the Estuary, near-normal temperatures in the northwest and centre, and colder waters coming into the Gulf at Cabot Strait.

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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 satndardized anomalies.

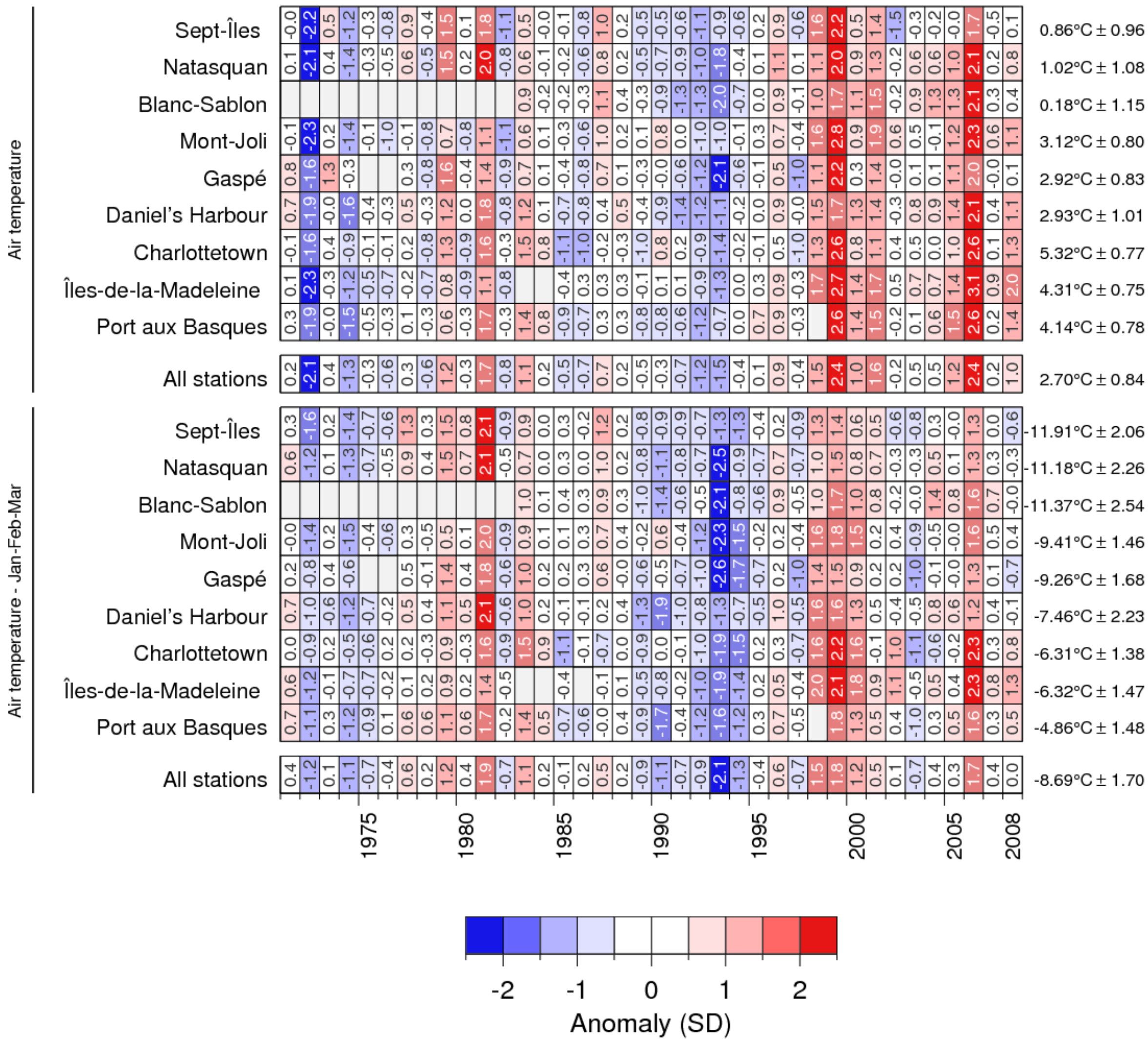

Table 2. Thermosaligraph near-surface temperature monthly anomalies for various sections along the main shipping lane. The numbers on the right are the 2000–2008 climatological means and standard deviations. The numbers in the boxes are normalized anomalies. The map shows all TSG data sampled in 2008. Those drawn in colour are within the main shipping corridor and are used in this report. Monthly average anomalies of temperatures measured close to the indicated blue section lines are shown in the other scorecard panels.

Tadoussac

	2000	2001	2002	2003	2004	2005	2006	2007	2008	
J	-0.5	-0.2	1.0	1.4	-1.5	0.4	-0.6			-0.23°C ± 0.44
F	-0.6	0.0	-1.1	1.6	0.1	-0.8	-0.6	1.4		-0.25°C ± 0.54
M	0.5	0.2	0.2	1.8	-1.1	-1.2	0.4	0.2	-1.2	0.04°C ± 0.51
A	-0.4	0.2	1.9	-0.2	-1.6	-0.6	0.8	-0.6	0.5	1.24°C ± 0.41
M	-0.3	1.8	0.1	-0.8	-1.6	-0.2	0.8	-0.6	0.8	3.57°C ± 0.92
J	-1.9	1.0	-0.1	-1.1	-0.1	-0.4	0.8	0.8	0.9	5.66°C ± 1.09
J			0.9	-1.0	0.6	-1.4	0.3	-0.6	1.2	6.47°C ± 0.51
A		-0.0	-0.3	-0.7		-0.3	0.1	-0.8	2.1	6.94°C ± 1.09
S	-0.1	-0.5		-1.3	0.1	2.1	0.5	-0.7	-0.2	5.36°C ± 0.93
O	-0.8	0.4	-0.4	-1.2	0.7			1.7	-0.4	3.87°C ± 0.55
N	0.4	-0.5	-1.1	-1.2	0.8	-0.1	2.0	-0.0	-0.2	2.70°C ± 0.65
D	0.6	0.7	-0.4	-1.7	-0.5	0.1	1.9	-0.1	-0.6	0.79°C ± 0.67

Estuary / Estuaire

	2000	2001	2002	2003	2004	2005	2006	2007	2008	
J	-0.4	0.1	1.8	-0.3	-1.5	0.2	0.2			-0.87°C ± 0.23
F	-0.4	0.7	-0.6	1.4	-1.0	-0.8	-0.7	1.3		-0.97°C ± 0.19
M	1.7	0.0	0.4	0.9	-0.9	-1.2	0.5	-0.0	-1.4	-0.26°C ± 0.41
A	-0.7	0.4	1.6	-0.1	-1.5	-0.6	1.0	-0.8	0.7	1.52°C ± 0.44
M	0.1	1.2	-0.3	-0.7	-1.4	-0.7	0.7	-0.6	1.7	4.12°C ± 0.70
J	-0.9	1.4	-0.4	-1.2	-0.9	-0.3	0.9	0.1	1.4	6.73°C ± 1.03
J			1.5	-0.7	0.3	1.1	-0.4	-1.1	-0.7	8.33°C ± 0.91
A		-0.5	0.7	-0.5		-0.1	-0.4	-1.1	1.9	8.55°C ± 1.11
S	-0.7	-0.1		-0.4	-0.9	2.1	-0.1	-0.8	0.7	6.01°C ± 0.56
O	-0.8	0.2	0.2	-1.3	0.4			1.8	-0.5	4.19°C ± 0.48
N	0.6	-0.3	-1.2	-1.4	0.8	-0.0	1.9	-0.2	0.0	2.52°C ± 0.68
D	-0.1	0.9	-0.2	-1.4	-0.4	0.3	2.1	-0.7	-0.5	0.39°C ± 0.61

Mont-Louis

	2000	2001	2002	2003	2004	2005	2006	2007	2008	
J	0.9	0.7	-0.2	0.3	-0.7	-1.9	0.9			-1.17°C ± 0.15
F	-0.6	-0.3	-0.7	-0.6	0.7	-0.9	0.5	1.9		-1.52°C ± 0.11
M	1.3	1.0	-0.8	-0.5	-0.7	-0.7	1.4	0.3	-1.2	-1.25°C ± 0.26
A	-0.8	0.7	1.2	-1.5	-0.6	-0.7	1.4	-0.1	0.3	0.55°C ± 0.46
M	-0.5	1.8	-1.0	-0.1	-1.1	-0.8	0.4	-0.0	1.3	4.07°C ± 1.03
J	0.0	1.8	-0.7	0.1	-1.3	-0.2	1.2	-0.9	-0.1	8.73°C ± 0.76
J		-1.2	-0.3	-0.5	0.4	1.9	0.7	0.1	-1.0	13.07°C ± 1.07
A		0.6	1.3	0.1	-0.9	-1.8	0.4	-0.6	0.8	12.65°C ± 0.80
S	-0.9	0.9	0.4	-0.6	-0.8	-0.1	-0.1	-0.9	2.1	9.81°C ± 1.09
O	-1.2	0.4	-1.5	0.1	1.2			0.1	0.9	5.88°C ± 0.64
N	-0.1	-0.5	-1.3	-1.3	0.9	1.4	1.2	-0.3	-0.1	3.61°C ± 1.13
D	1.2	0.0	-0.7	-1.5	0.2	0.0	1.8	-0.8	-0.1	0.74°C ± 0.46

Centre

	2000	2001	2002	2003	2004	2005	2006	2007	2008	
J	-0.2	0.4	-0.6	-1.3	0.2	-1.2	1.2	1.4		-0.38°C ± 0.44
F	-0.4	0.2	-0.5	-1.0	0.3	-0.9	2.1	0.3		-1.43°C ± 0.22
M	0.6	0.1	-0.6	-1.2	-0.4	-0.4	2.1	0.6	-1.1	-1.41°C ± 0.17
A	0.5	0.1	-0.5	-1.4	0.1	-0.4	2.3	-0.2	-0.4	-0.26°C ± 0.50
M	-0.6	1.3		-1.2	-0.8	-0.7	1.3	-0.2	0.9	3.33°C ± 1.35
J	-0.8	1.4	-0.6	-0.4	-1.3		1.5	0.2	-0.1	8.10°C ± 1.59
J			-0.9	-1.0	-0.6		1.6	0.3	0.6	14.14°C ± 1.58
A		-0.9	-0.9	-0.1			-0.2	0.2	1.8	15.39°C ± 1.10
S	0.7	-0.6		0.6	-0.5		0.5	-1.8	1.1	12.40°C ± 1.11
O	-1.0	1.1	-1.1	1.4	0.6			-0.7	-0.3	8.08°C ± 0.76
N	0.6	-0.8	-1.8	-1.0	0.2	0.7	1.4	-0.1	0.7	4.56°C ± 0.75
D	0.7	-0.0	-1.1	-1.0	0.1	0.6	1.9	-1.1	-0.0	1.83°C ± 0.60

Cabot Strait / Détroit de Cabot

	2000	2001	2002	2003	2004	2005	2006	2007	2008	
J	0.4	-0.3	0.1	-1.8	-0.0	0.2	1.9	-0.3		1.42°C ± 0.61
F	-0.7	0.3	0.3	-1.7	-0.1	1.0	1.4	-0.6		-0.10°C ± 0.86
M	0.4	0.4	-0.3	-2.3	0.6	1.4	0.2	-0.6	0.1	-0.50°C ± 0.51
A	0.4	0.4	-0.8	-2.3	0.1	0.8	1.1	0.1	0.1	0.29°C ± 0.64
M	-0.7	0.5		-1.0	-0.7	-0.2	2.1	-0.4	0.5	3.20°C ± 0.80
J	0.1	0.9	-0.7	-0.7	-1.5		1.8	0.1	-0.1	7.36°C ± 1.13
J			-1.3	-0.5	-0.5		1.3	0.2	0.9	13.03°C ± 1.29
A		1.3	-0.1	-1.2			0.3	-1.1	0.8	16.28°C ± 0.99
S	-0.3	0.9		-1.2	-0.7		0.8	-0.8	1.3	13.15°C ± 1.18
O	-0.4	1.2	-1.5	1.0	0.2	0.7		-1.2	-0.1	9.18°C ± 1.63
N	0.4	0.2	-2.0	-0.5	0.7		1.1	-0.7	0.8	6.22°C ± 1.46
D	0.4	0.1	-1.9	-0.6	-0.1	0.8	1.0	-0.9	1.1	3.68°C ± 0.91

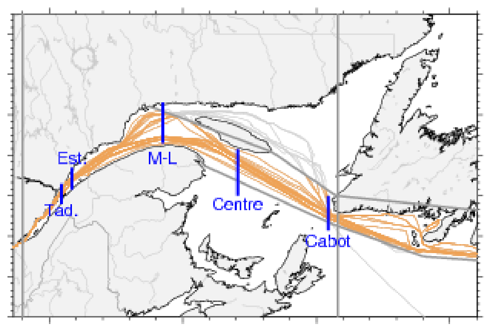

Table 3. Monthly mean temperatures at all shallow sensors of the Maurice Lamontagne Institute thermograph network in 2007 and 2008, as well as at Shediac station from DFO Gulf Region. The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month.

Estuary and NW Gulf / Estuaire et NO du Golfe

		2007												2008											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Tadoussac	1 m					4.4	8.8	8.8	7.6	6.4	5.1	3.2						5.4	9.0	12.4	12.7	8.0	4.4	3.3	
Bic	1 m					4.4	6.7	7.7	7.1	5.5	4.9							5.6	7.0	8.9	10.3	6.9	4.1		
	2 m					4.1	6.4	7.4	6.8	5.4	4.8							5.3	6.7	8.5	10.0	6.7	4.0		
	5.8 m					1.3	2.3	2.8	3.1	2.9								1.9	3.1	3.5	5.2	3.3	2.5		
Rimouski	0.5 m					4.8	9.2	11.2	10.4	6.7	5.5							6.5	8.4	11.4	12.1	8.4	5.0		
IML	0.5 m					5.3	8.4	11.0	10.3	7.3	5.6							6.3	8.0	11.8	12.3	8.7	4.7		
	13.5 m	-0.2	-1.0	-0.8	0.9	3.0	5.6	7.1	7.1	5.8	4.8	2.4	-0.7	-0.8	-1.3	-1.3	1.1	4.0	5.3	7.8	9.4	6.5	4.0	2.1	
Baie-Comeau	1 m					5.3	10.1	10.9	9.8	7.0	6.2							6.5	9.9	12.8	14.6	10.5	5.7		
Gaspé Current	0.5 m						10.6	12.7	11.8	7.8	5.7								9.4	13.2	13.0	11.3	5.6		
Mont-Louis	0.5 m					4.4	9.7	14.0	12.7	8.9	6.1	3.0						5.4	9.5	13.9	14.3	12.2	6.1		
Anticosti Gyre	0.5 m					5.8	9.9	13.8	13.1	8.7	6.2							7.0	9.4	13.8	15.5	12.1	6.4		
Sept-Îles	1 m					4.8	11.3	14.0	12.4	8.1	5.1							7.5	10.3	15.2	16.7	11.4	6.2		
	2 m					4.5	10.5	13.3	12.1	7.8	5.0							7.3	9.8	14.5	16.5	11.2	6.1		
Port-Menier	2 m					2.9	9.1	11.9	10.0	6.9	5.0							5.7	8.5	14.0	14.8	10.1	4.9		
	12.8 m					1.9	5.9	6.0	5.7	4.1	3.6							0.8	4.9	7.9	11.2	5.9	3.7		

Lower North Shore / Basse Côte Nord

		2007												2008											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Rivière-au-Tonnerre	1 m					3.7	7.3	10.2	8.2	5.8	4.8							5.5	8.0	12.6	14.7	9.5	5.7		
	16 m					1.4	3.9	5.0	4.7	3.9	4.3							2.7	5.2	6.0	10.9	6.9	5.0		
Havre-Saint-Pierre	0.5 m					3.1	7.2	12.1	9.9	6.3	5.8							5.5	8.1	12.1	16.4	11.2	7.1		
	1 m					3.0	7.2	12.1	9.9	6.3	5.7							5.3	8.1	11.9	16.4	11.2	7.0		
Natashquan	1 m					4.7	10.8	15.1	12.8	9.2	6.9							7.3	9.5	16.4	16.7	12.0	7.3		
	7.5 m					0.9	5.4	7.5	7.4	6.3	6.2							2.7	5.9	8.4	13.5	8.7	5.3		
La Romaine	1 m					1.9	6.6	11.6	12.8	9.5	7.2							4.0	6.4	12.9	15.0	10.8	8.1		
	2 m					1.8	6.5	11.4	12.7	9.5	7.2							3.9	6.2	12.7	14.9	10.7	8.1		
	14 m					0.4	0.8	1.0	2.8	4.1	6.3							2.2	3.4	2.3	6.9	4.6	7.1		
Beaugé	0.5 m					2.3	7.2	12.8	15.8	11.4	8.2							4.3	8.1	14.1	16.8	13.3	8.6		
	1 m					2.1	7.2	12.7	15.8	11.4	7.7							4.0	8.0	14.1	16.8	13.3	8.1		
La Tabatière	1 m						5.5	8.8	12.0	9.1	6.5								7.0	9.1	13.8	11.0	8.3		
Blanc-Sablon	1 m						2.2	9.4	11.2	8.7	3.8								3.2	9.4	12.0	10.1	6.2		

Southern Gulf / Sud du Golfe

		2007												2008											
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Grande-Rivière	2 m					4.8	10.3	14.9	15.5	11.5	7.6							7.6	10.5	15.0	15.0	14.0	7.9		
	7 m					4.2	7.7	11.9	13.7	10.4	7.3							6.1	8.0	11.3	12.9	13.1	7.5		
Shediac Valley	0.5 m					4.8	10.3	15.8	15.7	13.1								7.5	10.8	15.8	16.7	14.8	10.2		
Île Shag	0.5 m					5.8	10.0	14.8	17.2	14.0								5.2	10.1	16.3	17.8	15.4			
	10 m	-0.5	-1.7	-1.5	-0.0	4.4	8.9	13.3	15.9	13.1	10.6	6.6	1.0	-1.4	-1.7	-1.6	0.2	4.4	9.1	14.6	16.9	14.3			
Shediac	5 m				2.6	7.4	14.2	17.9	19.1	17.2	13.1	6.4	-0.7					6.3	11.9	15.1	17.1	16.3	12.2	7.4	2.1

Table 4. Monthly mean temperatures at all sensors deeper than 20 m of the Maurice Lamontagne Institute thermograph network in 2007 and 2008, as well as at Shediac station from DFO Gulf Region. The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month.

Estuary and NW Gulf / Estuaire et NO du Golfe

		2007												2008										
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Tadoussac	30 m					1.3	3.3	3.4	3.5	2.8	3.2	2.4						1.6	3.7	3.7	6.2	3.6	2.4	2.3
Rimouski	330 m					5.224	5.195	5.172	5.244	5.255	5.205							5.138	5.122	5.102	5.103	5.128	5.121	
Baie-Comeau	80 m	1.9	2.2	-0.2	-0.7	-0.3	0.0	0.3	0.6	0.8	1.2	1.8	1.3	0.6	0.1	-0.1	0.4							
Mont-Louis	30 m					-0.3	0.2	0.2	0.5									-0.5	-0.3	-0.3	-0.1	0.3	1.6	
Anticosti Gyre	337 m					5.433	5.446	5.446	5.447	5.446	5.450							5.407	5.396	5.394	5.395	5.400	5.403	
Sept-Îles	25 m					0.4	3.6	3.5	3.3	3.2	3.5							1.3	3.9	4.2	8.1	4.6	4.2	

Lower North Shore / Basse Côte Nord

		2007												2008										
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Havre-Saint-Pierre	100 m					-0.3	-0.3	-0.3	-0.1	0.1	0.9							-0.0	0.3	0.5	0.7	0.8	1.1	
Beaugé	100 m					-1.3	-0.8	-0.4	-0.1	0.2	0.7							-1.2	-0.7	-0.5	-0.4	-0.0	0.4	
La Tabatière	36 m						-0.0	1.1	3.9	5.1	5.2								2.1	2.3	5.7	5.8	7.0	
Blanc-Sablon	22 m																		2.9	6.1	9.2	8.2	5.9	

Southern Gulf / Sud du Golfe

		2007												2008										
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
Shediac Valley	82 m					0.1	0.3	0.4	0.5	0.7	0.9							-0.6	-0.6	-0.4	-0.1	0.0	0.4	

Table 5. 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.

		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	
Natashquan - 1 m	M								-0.9	1.3	-0.0			0.7		-1.4	0.3	6.80°C ± 1.53
	J		-0.7	-0.6	0.2		0.1	0.9	-0.1	-0.3	-1.5	0.1	-0.9	0.7	2.7	0.2	-0.7	10.52°C ± 1.33
	J		-0.4	0.5	-0.2		-0.2	-1.7	0.5	-1.1	0.1	-0.7	1.2	-0.9	-0.3	0.8	2.2	14.30°C ± 0.98
	A		-0.4	-0.9	1.0		-1.2	0.7	1.4	-0.1	0.4	0.8	-0.8	-1.5	-0.5	-0.5	1.7	13.73°C ± 1.73
	S		-0.4	-0.1	0.3		1.1	1.6	-1.5	-0.1	-0.2	-0.8	-1.6	1.3	0.1	-0.8	0.9	10.46°C ± 1.65
	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	6.82°C ± 1.32
Beaugé - 1 m	M									0.5	-0.9			-0.0	1.2	-1.4	0.6	3.43°C ± 0.95
	J						-0.2	0.6	-1.0	1.2	-0.8	0.2	-2.0	0.7	1.3	-0.4	0.3	7.65°C ± 1.15
	J						-0.4	0.4	-0.9	-0.0	-1.1	-1.0	-0.2	0.0	2.3	-0.3	1.1	13.04°C ± 1.00
	A						-1.6	-1.0	0.7	-0.6	-0.4	-0.4	1.5	-0.7	0.7	0.5	1.4	15.29°C ± 1.13
	S						-1.1	1.4	0.6	0.1	-1.5	-0.3	-0.6	0.2	1.5	-0.9	0.8	12.41°C ± 1.14
	O						-1.9	0.4	-0.8	0.5	-1.6	0.4	0.6	0.8	1.2	-0.1	0.4	7.73°C ± 0.99
La Tabatière - 1 m	J										-0.8	-0.6	-0.9	1.4	0.7	-0.8	1.0	6.12°C ± 0.85
	J										-1.3	1.2	-0.9	0.0	1.4	-0.4	-0.0	9.13°C ± 0.92
	A										-0.4	0.7	-1.2	-1.1	0.4	-0.1	1.7	12.12°C ± 1.02
	S										-0.8	0.1	0.2	1.3	0.6	-1.8	0.2	10.79°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							1.4	0.9	-0.5	-0.1	-0.8	-1.5	0.6	1.3	-1.1	-0.1	3.31°C ± 1.02
	J							0.3	-0.1	-0.7	-0.2	0.2	-2.1	-0.5	1.8	0.7	0.6	8.60°C ± 1.19
	A							0.4	1.2	-0.4	-1.0	-1.3	1.4	-1.0	0.9	-0.5	0.3	11.73°C ± 0.97
	S							0.3	1.1	-0.7	-1.9	-0.0	-0.9	1.1	0.0	-0.3	1.3	8.94°C ± 0.89
	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		-1.6	-0.5	-0.3	-1.1	1.3	1.6	-0.1	1.3	-0.6	-1.1	-0.7	-0.1	1.4	0.2	0.5	8.67°C ± 1.00
	J		-0.3	-0.0	-0.3	-0.8	-0.3	1.7	0.7	0.9	-1.0	-1.8	-0.9	-0.2	1.6	-0.3	1.1	13.61°C ± 0.93
	A		-0.3	0.4	0.5	-0.4	-1.2	0.1	1.1	1.6	-0.9	-1.9	0.6	1.1	-1.1	-0.4	0.8	16.22°C ± 0.78
	S		-0.2	-1.5	0.9	0.1	-1.4	1.2	0.5	1.4	0.2	0.2	-1.0	1.1	0.5	-1.5	-0.4	14.70°C ± 1.03
	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									-0.1	0.3	-1.1	0.8	-1.0	1.8	0.1	-0.8	7.24°C ± 1.22
	J									-0.8	0.5	-0.7	0.3	-1.6	1.4	1.1	-0.2	12.33°C ± 1.74
	J									-1.8	0.7	-0.4	1.1	-0.6	0.6	1.0	-0.6	16.15°C ± 1.82
	A									-1.9	0.9	-0.6	1.2	0.1	0.3	0.5	-0.5	18.05°C ± 1.91
	S									-2.4	0.5	0.3	0.0	0.8	0.5	0.4	-0.2	16.59°C ± 1.44
	O									-2.1	-0.4	1.1	0.1	0.7	0.1	0.7	-0.2	12.35°C ± 1.03
	N										-1.6	0.3	-1.1	1.1	0.6	0.0	0.7	6.44°C ± 1.38
	D											0.2	-0.9	1.1	0.5	-1.5	0.7	1.23°C ± 1.29

Table 6. NOAA SST May to November monthly anomalies averaged over the eight regions of the Gulf for 2007 and 2008 (April also shown for the Estuary and Northwest Gulf). The scorecards are colour-coded according to the monthly standardized anomalies based on the 1985-2008 climatologies for each month, but the numbers are the monthly average temperatures in ºC.

	2007 A	2007 M	2007 J	2007 J	2007 A	2007 S	2007 O	2007 N	2007 D	2008 J	2008 F	2008 M	2008 A	2008 M	2008 J	2008 J	2008 A	2008 S	2008 O	2008 N
1 - Estuary	1.1	4.8	9.4	10.6	9.7	6.8	5.9	2.1					1.6	6.5	8.9	11.2	12.6	8.7	4.6	2.4
2 - Northwest Gulf	0.6	3.6	9.2	13.3	12.7	8.8	6.5	3.3					0.9	6.1	9.0	13.3	14.9	11.9	6.7	3.7
3 - Anticosti Channel		1.7	6.8	12.8	13.7	10.2	7.4	3.8						4.0	7.2	13.2	15.0	12.5	8.2	5.2
4 - Mécatina Trough		1.1	6.0	10.3	12.1	10.0	5.6	3.2						2.8	6.1	11.0	13.2	11.6	7.9	4.5
5 - Esquiman Channel		2.3	7.9	12.9	14.5	11.8	8.0	4.6						3.4	7.4	13.1	15.2	13.1	8.8	5.4
6 - Central Gulf		2.4	7.8	13.8	15.2	11.7	8.5	4.7						4.2	7.7	14.6	16.0	13.4	8.9	5.2
7 - Cabot Strait		2.7	8.6	13.4	15.4	12.9	9.1	6.0						3.3	8.0	14.7	15.0	13.9	9.8	7.1
8 - Magdalen Shallows		4.3	10.6	16.1	16.8	14.3	10.9	6.3						5.5	10.7	17.2	15.5	14.5	10.5	6.5

Table 7. NOAA SST May to November monthly anomalies averaged over the Gulf of St. Lawrence and over the first four regions of the Gulf. 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. 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	Mean ± SD
GSL SST	M	-1.0	0.2	-0.4	0.0	-1.0	-1.5	-1.2	-1.0	-0.6	-0.2	0.5	-0.2	-1.0	1.5	2.0	0.0	1.1	-0.6	-0.1	-0.3	0.2	2.2	-0.1	1.2	3.21°C ± 1.17
	J	-1.7	-1.4	0.3	-1.0	0.2	-1.6	-0.7	-0.8	-0.5	0.0	0.7	1.0	-0.5	0.9	1.7	0.2	1.3	-0.3	-0.1	-0.9	0.5	2.0	0.5	0.4	8.18°C ± 1.11
	J	-0.7	-1.5	0.4	-0.7	0.2	-1.1	-1.5	-2.3	-1.4	1.2	1.0	-0.3	0.0	0.6	1.3	0.4	0.2	-0.3	0.4	0.4	0.5	1.4	0.6	1.1	12.98°C ± 1.25
	A	-0.5	-1.7	-0.5	0.3	-1.2	-0.8	-1.5	-2.5	0.7	0.6	0.7	1.6	-0.3	-0.2	0.8	1.3	0.7	0.7	0.7	1.0	-0.3	0.7	-0.4	0.2	14.93°C ± 0.84
	S	0.0	-1.6	-1.1	-1.2	-1.9	-0.4	-1.2	0.0	0.2	0.2	-0.4	1.1	0.2	0.5	2.3	0.7	0.9	-0.6	0.4	-0.6	1.3	1.0	-0.8	0.8	12.36°C ± 0.91
	O	-0.2	-1.1	0.0	-1.2	-3.0	-0.3	0.2	-1.1	-0.7	1.0	0.9	0.1	0.4	-0.8	0.6	0.1	1.4	-0.7	1.3	0.6	0.7	1.1	0.1	0.4	8.35°C ± 0.88
	N	-0.7	-1.3	-1.1	-0.9	-0.9	-2.0	0.6	-1.3	-0.6	1.3	1.3	0.7	0.2	-0.1	-0.1	0.3	0.4	-0.9	-0.0	0.5	1.3	1.8	0.4	1.2	4.39°C ± 0.86
	M-N	-0.9	-1.4	-0.3	-0.8	-1.2	-1.4	-1.0	-1.6	-0.6	0.7	0.8	0.6	-0.2	0.5	1.6	0.5	1.1	-0.5	0.4	0.1	0.7	1.9	0.1	1.0	9.20°C ± 0.80
1 - Estuary	A		1.4	1.0	-0.4	-0.5	-1.0	-1.9	-1.7	-0.3	-0.5	0.8	-0.5	-0.1	1.4	1.5	-0.3	-0.4	0.9	-0.9	-0.8	0.0	1.7	-0.3	0.5	1.29°C ± 0.56
	M	-0.7	0.3	-0.6	0.1	-1.9	-0.4	-1.7	-0.6	-0.1	0.8	0.6	-0.0	-0.7	0.5	2.1	0.4	1.5	-0.3	0.0	-1.0	-1.3	1.3	-0.0	1.6	4.80°C ± 1.05
	J	-1.4	-2.5	-0.7	-0.5	-1.0	-1.2	-0.3	-0.4	1.1	1.0	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	8.43°C ± 0.91
	J	-1.2	-1.4	-0.1	0.6	0.1	-2.0	-1.9	-1.1	1.8	0.8	1.1	-0.3	-0.3	-0.1	-0.8	1.0	-0.6	1.0	0.5	0.7	1.0	0.8	-0.1	0.5	10.67°C ± 1.15
	A	-0.5	-0.8	-0.2	0.4	-1.9	-0.1	-0.1	-1.9	1.7	0.1	0.6	0.5	-0.7	-1.3	0.2	1.4	0.1	0.9	1.2	-0.6	-0.7	0.3	-0.6	1.8	10.42°C ± 1.20
	S	0.2	-1.3	-1.4	-1.7	-1.1	-0.7	-1.1	-0.1	0.6	-0.1	-0.5	1.4	1.0	1.9	1.7	-0.3	0.2	0.8	-0.1	-0.3	0.8	0.4	-1.0	0.9	7.75°C ± 1.03
	O	0.3	-0.5	-0.5	-1.3	-2.7	-0.8	-0.5	-1.2	-1.4	1.9	0.9	-0.1	0.5	-0.2	0.7	-0.2	0.7	0.5	0.2	0.5	1.2	0.7	1.3	0.0	4.59°C ± 1.02
	N	-0.3	-1.3	-0.8	-0.3	-1.3	-1.4	0.1	-1.5	-1.2	2.4	0.0	0.1	0.3	0.2	0.3	0.3	0.5	-0.4	-0.7	0.9	1.3	1.9	0.3	0.5	1.89°C ± 0.95
2 - Northwest Gulf	A		2.2	0.7	-0.5	-0.8	-0.5	-0.4	-0.1	-0.2	-1.3	0.0	0.1	0.1	1.0	2.6	-0.3	-0.7	-0.4	-1.2	-0.6	-1.4	1.1	0.1	0.6	0.54°C ± 0.60
	M	-0.9	0.9	-0.7	0.2	-1.1	-1.0	-1.5	-0.7	-0.3	0.2	0.8	-0.4	-0.8	1.4	2.1	-0.2	1.3	-0.7	0.4	-0.9	-0.6	1.5	-0.3	1.6	4.03°C ± 1.33
	J	-1.0	-2.2	-0.2	-1.0	0.5	-1.4	-0.9	-0.9	0.4	0.8	1.3	1.4	-0.2	0.9	1.1	-0.1	0.9	-0.8	0.1	-1.0	0.5	1.7	0.2	0.1	8.92°C ± 1.08
	J	-0.7	-1.8	-0.1	0.1	0.4	-1.7	-2.2	-1.8	0.3	1.0	1.6	-0.1	-0.1	0.4	0.4	0.7	-0.4	-0.3	0.2	0.3	1.3	1.2	0.5	0.5	12.73°C ± 1.23
	A	-0.1	-0.9	-1.0	0.8	-1.8	-0.0	-0.5	-2.2	2.0	-0.3	0.8	0.8	-0.5	-0.1	0.5	1.5	-0.2	0.6	0.8	-0.1	-0.8	0.0	-0.7	1.4	13.45°C ± 1.11
	S	0.7	-1.3	-1.3	-1.7	-1.1	-0.6	-0.3	0.2	0.3	-0.5	0.0	1.3	1.2	1.7	1.8	-0.0	0.3	-0.4	-0.0	-0.8	0.8	-0.0	-1.4	1.3	10.38°C ± 1.12
	O	0.2	-0.5	-0.4	-1.1	-2.8	-0.8	-0.1	-1.3	-1.2	2.1	0.4	0.5	1.0	-0.2	1.1	-0.3	0.4	-0.5	0.8	0.7	0.9	0.5	0.2	0.3	6.33°C ± 1.11
	N	-0.4	-1.3	-1.1	-0.7	-1.3	-1.4	0.7	-1.3	-1.1	1.9	0.1	0.3	0.4	0.4	-0.0	0.3	0.1	-0.4	-0.6	1.2	1.6	1.8	0.3	0.6	3.01°C ± 1.11
3 - Anticosti Channel	M	-0.8	0.0	-0.3	-0.1	-0.9	-1.4	-1.2	-0.9	-0.4	-0.4	0.5	-0.1	-1.0	1.4	2.2	-0.2	0.9	-0.5	-0.6	-0.0	0.8	2.1	-0.4	1.4	2.24°C ± 1.28
	J	-1.6	-1.4	0.5	-0.6	0.5	-2.1	-0.8	-0.9	-0.1	-0.2	0.6	1.2	-0.4	0.9	1.1	-0.3	1.0	-0.2	-0.1	-0.6	1.2	2.2	-0.1	0.2	6.98°C ± 1.37
	J	-0.8	-1.3	0.5	-0.5	0.7	-1.7	-2.0	-1.6	-1.4	0.4	0.9	-0.0	0.1	0.8	0.7	0.3	-0.2	-0.1	0.1	0.6	0.9	1.6	1.0	1.3	11.65°C ± 1.22
	A	-1.0	-0.7	-0.3	0.1	-1.4	-1.3	-0.9	-1.9	1.0	-0.5	0.2	1.5	-0.1	-0.5	0.8	1.3	0.1	0.7	1.3	0.3	-1.2	0.7	0.3	1.6	13.42°C ± 1.01
	S	0.2	-0.9	-0.2	-1.6	-1.0	-1.7	-1.1	-0.5	-1.1	0.1	0.3	1.4	0.6	0.7	2.1	0.1	0.7	-0.3	-0.2	-0.5	1.1	1.1	-0.7	1.3	10.98°C ± 1.16
	O	-0.7	-0.4	0.3	-0.8	-2.4	-0.3	-0.1	-0.8	-2.4	1.1	1.0	-0.1	0.7	-0.5	0.9	-0.5	1.0	-0.6	0.4	1.0	1.2	1.0	0.1	0.7	7.29°C ± 1.18
	N	-1.2	-1.6	-0.8	-0.2	-0.8	-1.3	0.6	-1.2	-1.2	0.8	1.3	0.3	0.3	-0.7	-0.3	0.3	0.6	-0.6	-0.3	0.8	1.4	2.1	0.1	1.4	3.72°C ± 1.01
4 - Mécatina Trough	M	-0.4	-0.3	0.5	0.7	-1.4	-2.0	-0.8	-0.4	-0.7	-0.2	-0.3	0.4	-0.9	0.4	1.2	-0.2	0.3	-0.4	-0.4	-0.2	1.4	2.9	-0.3	1.1	1.50°C ± 1.14
	J	-1.0	-1.3	1.1	-0.7	-0.3	-1.9	-2.1	-0.9	-0.6	-0.4	0.5	0.8	0.0	0.9	1.0	0.6	0.6	0.3	0.0	-0.6	1.5	1.6	0.4	0.5	5.43°C ± 1.38
	J	-0.9	-0.6	0.5	-0.5	0.1	-0.1	-2.0	-2.5	-1.9	0.7	0.3	-0.4	0.6	0.8	1.1	0.8	0.2	0.0	0.6	0.3	0.1	1.4	0.5	1.0	9.49°C ± 1.56
	A	-1.1	-0.5	0.5	-0.2	-0.3	-0.8	-1.7	-2.6	-1.3	-0.3	0.9	1.2	0.1	-0.2	1.4	1.0	0.9	0.0	0.7	0.6	-0.1	1.2	-0.0	0.7	12.13°C ± 1.52
	S	-0.6	-0.8	0.2	-0.5	-1.5	-0.0	-2.5	-0.6	-0.6	0.1	-0.6	0.1	-0.6	-0.7	1.9	1.1	1.1	0.0	1.0	0.5	1.2	1.2	-0.1	1.0	10.09°C ± 1.52
	O	-0.9	-1.7	0.4	-0.7	-1.2	1.2	-0.1	-0.2	-0.1	-0.3	1.0	-1.2	0.0	-1.1	0.3	0.7	1.1	-1.5	1.9	0.2	0.7	1.2	-0.9	1.2	6.62°C ± 1.12
	N	-1.8	-1.2	-0.1	0.3	-0.6	-1.4	0.3	-0.9	0.1	0.9	2.2	-0.1	-0.6	-0.8	-0.0	-0.2	0.8	-1.5	1.1	0.3	0.3	1.1	0.3	1.5	2.89°C ± 1.02

Table 8. NOAA SST May to November monthly anomalies averaged over the remaining four regions of the Gulf. 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	Mean ± SD
5 - Esquiman Channel	M	-0.6	-0.1	0.1	0.2	-1.3	-1.5	-0.9	-1.2	-0.7	-0.5	0.2	-0.2	-1.3	1.1	1.6	0.1	1.1	-0.7	-0.1	-0.1	1.0	2.4	0.1	1.0	2.22°C ± 1.10
	J	-1.6	-1.0	0.7	-0.6	0.1	-1.9	-1.2	-1.0	-0.5	-0.4	0.7	0.4	-0.6	1.1	1.2	0.1	1.6	-0.2	-0.1	-1.1	1.0	1.7	0.8	0.5	6.79°C ± 1.36
	J	-0.4	-0.6	0.9	-0.7	0.5	-0.7	-1.4	-2.2	-2.4	0.2	0.5	-0.5	0.1	0.8	1.5	0.1	0.4	-0.2	0.3	0.6	0.1	1.5	0.8	1.0	11.59°C ± 1.54
	A	-1.0	-0.9	0.1	0.3	-0.7	-1.0	-1.1	-2.6	-1.1	0.6	0.3	1.4	-0.4	-0.5	0.6	1.4	0.8	0.1	0.7	1.4	-0.2	1.0	0.0	0.7	14.47°C ± 1.07
	S	-0.2	-1.4	0.1	-0.1	-1.9	0.0	-1.5	-0.3	-0.4	0.5	-0.8	0.7	-0.5	-0.7	1.9	1.5	0.7	-1.2	1.1	-0.4	0.8	1.4	-0.3	0.9	12.09°C ± 1.14
	O	-0.2	-1.3	0.3	-0.7	-2.3	0.1	-0.6	-0.8	-0.2	0.6	0.9	-0.4	-0.2	-1.0	1.1	0.5	1.1	-1.5	2.1	0.2	0.1	1.3	-0.1	0.7	8.10°C ± 0.99
	N	-1.2	-0.9	-0.4	-0.3	-0.7	-1.8	0.8	-1.5	-0.2	1.1	2.0	0.5	-0.4	0.1	0.1	-0.2	0.2	-1.9	0.5	0.3	0.8	1.5	0.4	1.2	4.25°C ± 0.99
6 - Central Gulf	M	-1.2	0.2	0.0	-0.0	-1.0	-1.4	-0.9	-1.0	-0.5	-0.6	0.8	-0.5	-1.0	1.6	1.4	0.1	1.1	-1.0	-0.4	-0.2	0.7	2.3	-0.0	1.4	2.49°C ± 1.25
	J	-1.7	-0.9	1.0	-1.1	0.5	-1.6	-0.6	-0.6	-0.4	-0.6	1.0	0.6	-0.5	0.8	1.7	-0.1	1.5	-0.4	-0.3	-1.1	0.6	2.0	0.3	0.2	7.47°C ± 1.19
	J	-0.3	-1.4	0.6	-0.9	0.3	-1.4	-1.4	-1.8	-1.6	0.9	1.0	-0.1	0.0	0.7	1.6	0.2	0.5	-0.5	-0.4	0.3	0.4	1.4	0.6	1.2	12.93°C ± 1.35
	A	0.1	-1.5	-1.0	0.7	-0.9	-1.8	-1.4	-2.2	0.5	0.6	0.5	1.4	-0.1	-0.0	0.2	1.5	0.7	0.4	0.3	1.3	-0.0	0.8	-0.4	0.4	15.58°C ± 0.93
	S	0.2	-1.0	-0.6	-0.7	-2.6	-0.5	-0.8	-0.0	0.2	0.4	-0.4	1.4	0.2	0.4	2.0	1.0	0.5	-1.0	0.6	-0.7	0.5	1.4	-1.1	0.5	12.90°C ± 1.04
	O	-0.7	-0.6	0.1	-0.8	-3.3	-0.4	0.4	-0.9	-0.4	1.0	0.7	0.4	0.5	-1.1	0.4	0.2	1.1	-0.8	1.1	0.7	0.4	1.5	-0.0	0.4	8.58°C ± 0.87
	N	-0.6	-1.3	-1.0	-0.8	-0.8	-2.3	0.7	-1.0	-0.4	0.5	1.6	0.7	0.2	-0.3	-0.3	0.3	0.0	-0.5	-0.3	0.7	1.0	2.3	0.3	1.0	4.38°C ± 0.83
7 - Cabot Strait	M	-1.3	0.2	-0.2	0.2	-0.6	-1.8	-1.2	-1.2	-0.3	-0.4	0.5	-0.2	-1.1	1.3	1.8	0.5	1.1	-0.6	-0.1	-0.2	0.9	2.3	-0.2	0.4	2.88°C ± 1.23
	J	-2.1	-0.8	-0.2	-1.0	-0.1	-1.2	-1.2	-0.4	-0.6	0.4	0.3	0.4	-0.6	0.7	2.5	0.5	1.1	0.1	-0.3	-0.8	0.5	1.7	0.9	0.3	7.55°C ± 1.22
	J	-0.7	-1.4	0.5	-1.1	-0.0	-0.8	-0.9	-2.4	-1.5	1.4	0.2	-0.0	-0.1	0.5	1.7	0.5	0.6	-0.5	0.5	0.5	0.1	1.2	0.4	1.2	12.85°C ± 1.53
	A	-0.5	-1.2	0.2	-0.3	-0.5	-1.2	-1.9	-1.8	0.0	1.6	0.1	1.4	-0.4	0.5	1.2	1.3	0.7	0.8	0.1	1.3	-0.3	0.2	-0.5	-0.8	15.91°C ± 1.04
	S	-0.2	-1.2	0.1	-0.7	-2.1	0.2	-1.6	0.9	0.5	0.8	-0.7	0.6	-0.1	0.5	2.3	0.4	1.0	-1.0	-0.4	-0.8	1.5	0.7	-0.7	0.2	13.68°C ± 1.07
	O	-0.5	-1.0	0.2	-0.7	-2.8	0.2	0.5	-1.3	0.9	0.8	0.8	0.5	0.2	-0.2	0.0	0.1	1.8	-1.4	1.5	-0.1	0.4	0.9	-0.7	-0.0	9.88°C ± 1.12
	N	-0.5	-0.8	-1.5	-1.2	-0.3	-2.2	-0.3	-0.8	-0.0	0.4	1.4	0.7	0.3	0.7	-0.2	1.0	0.6	-1.8	-0.1	0.6	1.1	1.3	0.1	1.2	5.86°C ± 1.00
8 - Magdalen Shallows	M	-1.1	0.2	-0.6	-0.2	-0.5	-1.5	-0.9	-1.1	-0.9	-0.0	0.2	0.1	-0.9	1.8	2.2	0.1	0.8	-0.3	-0.1	-0.1	-0.4	2.2	0.1	1.0	4.18°C ± 1.28
	J	-1.9	-1.1	0.2	-1.3	0.0	-1.0	0.2	-0.6	-1.2	0.1	0.5	1.1	-0.8	0.5	2.2	0.5	1.3	-0.3	-0.1	-0.8	-0.3	1.8	0.5	0.6	10.04°C ± 1.12
	J	-0.8	-1.6	-0.0	-1.0	-0.1	-0.7	-0.8	-2.4	-1.3	1.9	1.1	-0.3	0.1	0.4	1.4	0.4	0.5	-0.4	0.7	0.0	0.2	1.2	0.5	1.2	15.51°C ± 1.39
	A	-0.0	-2.6	-0.4	0.1	-0.6	0.0	-1.4	-1.2	0.9	1.3	0.8	1.4	0.0	-0.1	0.3	-0.1	1.2	0.6	-0.0	1.0	0.5	0.5	-0.5	-1.7	17.22°C ± 0.98
	S	-0.3	-1.8	-2.4	-1.1	-1.3	0.1	-0.5	0.3	0.9	0.3	-0.2	0.6	-0.3	0.1	1.9	0.7	1.3	-0.1	0.5	-0.3	1.5	0.7	-0.3	-0.2	14.62°C ± 0.95
	O	0.4	-1.4	-0.2	-1.7	-2.6	-0.3	1.1	-1.0	-0.1	-0.2	0.8	0.3	0.0	-1.1	-0.1	0.3	1.9	0.3	1.1	0.6	0.6	0.7	0.7	0.2	10.33°C ± 0.89
	N	-0.2	-1.3	-1.3	-1.8	-0.6	-2.2	0.7	-1.0	-0.3	1.3	1.1	1.2	0.5	-0.4	-0.2	0.1	0.5	-0.4	0.3	-0.3	1.1	1.3	0.8	1.0	5.63°C ± 0.85

Table 9. 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.

		1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Mean ± S.D.
Estuary	A		1.4	1.0	-0.4	-0.5	-1.0	-1.9	-1.7	-0.3	-0.5	0.8	-0.5	-0.1	1.4	1.5	-0.3	-0.4	0.9	-0.9	-0.8	0.0	1.7	-0.3	0.5	1.29°C ± 0.56
	M	-0.7	0.3	-0.6	0.1	-1.9	-0.4	-1.7	-0.6	-0.1	0.8	0.6	-0.0	-0.7	0.5	2.1	0.4	1.5	-0.3	0.0	-1.0	-1.3	1.3	-0.0	1.6	4.80°C ± 1.05
	J	-1.4	-2.5	-0.7	-0.5	-1.0	-1.2	-0.3	-0.4	1.1	1.0	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	8.43°C ± 0.91
	J	-1.2	-1.4	-0.1	0.6	0.1	-2.0	-1.9	-1.1	1.8	0.8	1.1	-0.3	-0.3	-0.1	-0.8	1.0	-0.6	1.0	0.5	0.7	1.0	0.8	-0.1	0.5	10.67°C ± 1.15
	A	-0.5	-0.8	-0.2	0.4	-1.9	-0.1	-0.1	-1.9	1.7	0.1	0.6	0.5	-0.7	-1.3	0.2	1.4	0.1	0.9	1.2	-0.6	-0.7	0.3	-0.6	1.8	10.42°C ± 1.20
	S	0.2	-1.3	-1.4	-1.7	-1.1	-0.7	-1.1	-0.1	0.6	-0.1	-0.5	1.4	1.0	1.9	1.7	-0.3	0.2	0.8	-0.1	-0.3	0.8	0.4	-1.0	0.9	7.75°C ± 1.03
	O	0.3	-0.5	-0.5	-1.3	-2.7	-0.8	-0.5	-1.2	-1.4	1.9	0.9	-0.1	0.5	-0.2	0.7	-0.2	0.7	0.5	0.2	0.5	1.2	0.7	1.3	0.0	4.59°C ± 1.02
	N	-0.3	-1.3	-0.8	-0.3	-1.3	-1.4	0.1	-1.5	-1.2	2.4	0.0	0.1	0.3	0.2	0.3	0.3	0.5	-0.4	-0.7	0.9	1.3	1.9	0.3	0.5	1.89°C ± 0.95
PMSSL	A		0.2	1.2	-0.4				-2.2	0.1	-0.0	-0.1	-0.8	-0.7	1.7	-0.1	0.1	-0.4	1.4	-1.4	-1.1	0.6	1.6	0.3	-0.2	1.09°C ± 0.39
	M	-1.5	0.3	-0.1	0.1	-1.6	-0.2	-1.1	-0.6	-0.1	0.8	1.0	0.0	-1.9	0.7	1.4	0.5	1.9	-0.6	0.3	-1.0	-1.0	1.4	0.4	1.0	4.35°C ± 0.93
	J	-1.2	-1.9	-0.8	-1.0	-1.2	-1.1	-0.4	-1.3	0.3	1.4	0.6	0.4	-0.7	0.8	1.4	0.1	1.4	-0.3	0.2	-0.5	0.6	1.7	0.8	0.6	7.86°C ± 1.04
	J	0.0	-2.3	-0.3	-0.0	-0.6	-1.6	-1.7	-1.4	1.6	1.5	0.7	0.0	-0.4	0.2	-0.1	0.4	0.1	0.9	-0.5	0.9	0.6	1.1	-0.0	1.0	9.83°C ± 1.06
	A	-0.6	-0.8	-0.6	-0.2	-2.1	-0.3	-0.5	-1.7	1.2	0.2	0.8	0.9	-0.3	-1.0	-0.1	1.2	0.7	1.3	1.2	-0.4	-0.5	0.5	-0.7	1.9	9.80°C ± 0.90
	S	-0.5	-2.2	-0.8	-1.8	-1.0	-1.3	-1.1	-0.1	0.8	0.3	-0.9	1.4	1.4	0.9	1.4	-0.3	0.4	1.0	0.3	0.5	0.8	0.1	-0.1	0.4	7.41°C ± 0.89
	O	0.4	-0.8	-0.8		-2.5	-1.0	-0.6	-0.9	-1.1	1.8	1.2	-0.5	0.7	-0.2	0.1	0.2	0.7	0.1	-0.1	0.1	1.4	0.4	1.5	-0.2	4.61°C ± 0.99
	N							-0.9			2.0		-1.3	0.4	-1.1	0.4	-0.6	0.6		-1.3	0.1	0.1	1.4	-0.3	0.7	2.17°C ± 0.67
St. Lawrence Estuary MPA	A		0.8	1.7	-0.1	-0.9	-1.2	-1.4	-1.8	-0.5	-0.4	0.5	-0.8	-0.6	1.5	0.9	-0.1	-0.1	1.4	-0.8	-0.5	0.7	1.8	-0.3	0.1	1.37°C ± 0.55
	M	-0.8	-0.3	-0.6	0.3	-2.4	-0.1	-1.3	-0.1	-0.1	0.5	0.6	0.1	-1.1	0.6	1.7	0.6	1.7	-0.1	0.0	-0.7	-1.4	1.3	-0.1	1.5	4.99°C ± 0.91
	J	-1.4	-2.2	-0.9	-0.7	-1.1	-1.0	-0.2	-0.8	0.8	1.6	0.4	0.5	-0.7	1.3	0.5	0.0	1.5	-0.0	-0.1	-0.5	-0.0	1.6	0.8	0.5	8.39°C ± 0.91
	J	-0.8	-1.8	0.1	0.3	0.2	-1.6	-1.9	-1.4	1.8	1.3	0.5	-0.2	-0.5	0.2	-0.7	0.7	-0.4	1.4	-0.1	0.7	0.6	0.9	-0.1	0.7	10.42°C ± 1.00
	A	-0.6	-1.0	-0.6	0.3	-1.9	-0.1	-0.3	-1.8	1.7	0.4	0.7	0.8	-0.5	-1.2	-0.1	1.2	0.0	1.0	1.0	-0.6	-0.1	0.5	-0.5	1.9	10.28°C ± 1.04
	S	-0.1	-1.5	-1.7	-1.8	-1.0	-1.1	-0.9	-0.1	0.6	-0.1	-0.4	1.4	1.1	1.4	1.6	-0.2	0.4	0.9	0.3	0.0	0.9	0.2	-0.6	0.8	7.91°C ± 0.84
	O	0.3	-0.4	-0.6	-1.2	-2.7	-1.0	-0.5	-0.9	-1.4	1.5	1.0	-0.3	0.4	0.0	0.3	0.1	0.6	0.6	0.0	0.6	1.3	0.7	1.6	0.0	4.92°C ± 0.95
	N	-0.3	-1.4	-0.7	-0.5	-1.3	-1.4	-0.2	-1.4	-1.1	2.5	0.2	0.1	0.8	-0.1	0.6	0.2	0.7	-0.6	-0.5	0.9	0.7	1.9	0.3	0.6	1.99°C ± 0.88
Manicouagan MPA	A		1.8	0.5	-0.5	0.1	-1.2	-1.9	-1.4	-0.1	-0.6	0.9	0.2	-0.2	1.5	1.8	-0.4	-0.6	0.2	-0.6	-0.9	-0.4	1.5	-0.2	0.5	1.63°C ± 0.76
	M	-0.5	0.5	-0.6	-0.0	-1.7	-0.5	-1.8	-0.5	-0.2	0.9	0.7	-0.2	-0.3	0.4	2.4	0.2	1.3	-0.4	-0.3	-1.1	-1.0	1.0	0.2	1.7	5.27°C ± 1.15
	J	-0.8	-2.6	-0.4	-0.3	-0.7	-1.3	-0.2	-0.2	1.6	0.4	-0.3	0.6	0.3	1.1	0.0	-0.8	1.4	-0.2	-0.4	-0.3	-0.6	1.6	1.6	0.6	9.20°C ± 0.97
	J	-1.2	-0.9	-0.2	0.9	-0.0	-2.0	-1.8	-0.9	1.7	0.8	0.9	-0.6	-0.4	-0.1	-1.0	1.3	-0.7	0.7	1.0	0.7	0.9	0.8	0.1	0.2	11.65°C ± 1.52
	A	-0.4	-0.8	0.2	0.4	-1.8	0.3	0.6	-1.9	1.7	-0.4	0.5	0.2	-0.6	-1.1	-0.0	1.8	-0.1	0.5	1.2	-1.0	-0.8	0.2	-0.6	1.7	11.31°C ± 1.36
	S	0.4	-1.1	-1.3	-1.8	-1.3	-0.3	-1.1	-0.1	0.6	0.2	-0.3	1.5	0.9	2.2	1.4	-0.4	-0.3	0.7	-0.2	-0.2	1.0	0.2	-1.2	0.7	8.38°C ± 1.19
	O	-0.2	-0.6	-0.6	-1.1	-2.6	-0.8	-0.2	-1.3	-1.5	2.0	1.0	0.1	0.5	-0.4	1.1	-0.2	0.6	0.5	0.4	0.5	1.1	0.6	1.0	0.2	5.06°C ± 1.15
	N	-0.3	-1.3	-0.9	-0.2	-1.1	-1.4	0.0	-1.5	-1.3	2.5	-0.2	0.0	0.3	0.5	0.2	1.0	0.5	-0.5	-0.6	0.9	1.1	1.8	0.3	0.2	2.05°C ± 1.00

Table 10. 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	Mean ± S.D.
Magdalen Shallows	M	-1.1	0.2	-0.6	-0.2	-0.5	-1.5	-0.9	-1.1	-0.9	-0.0	0.2	0.1	-0.9	1.8	2.2	0.1	0.8	-0.3	-0.1	-0.1	-0.4	2.2	0.1	1.0	4.18°C ± 1.28
	J	-1.9	-1.1	0.2	-1.3	0.0	-1.0	0.2	-0.6	-1.2	0.1	0.5	1.1	-0.8	0.5	2.2	0.5	1.3	-0.3	-0.1	-0.8	-0.3	1.8	0.5	0.6	10.04°C ± 1.12
	J	-0.8	-1.6	-0.0	-1.0	-0.1	-0.7	-0.8	-2.4	-1.3	1.9	1.1	-0.3	0.1	0.4	1.4	0.4	0.5	-0.4	0.7	0.0	0.2	1.2	0.5	1.2	15.51°C ± 1.39
	A	-0.0	-2.6	-0.4	0.1	-0.6	0.0	-1.4	-1.2	0.9	1.3	0.8	1.4	0.0	-0.1	0.3	-0.1	1.2	0.6	-0.0	1.0	0.5	0.5	-0.5	-1.7	17.22°C ± 0.98
	S	-0.3	-1.8	-2.4	-1.1	-1.3	0.1	-0.5	0.3	0.9	0.3	-0.2	0.6	-0.3	0.1	1.9	0.7	1.3	-0.1	0.5	-0.3	1.5	0.7	-0.3	-0.2	14.62°C ± 0.95
	O	0.4	-1.4	-0.2	-1.7	-2.6	-0.3	1.1	-1.0	-0.1	-0.2	0.8	0.3	0.0	-1.1	-0.1	0.3	1.9	0.3	1.1	0.6	0.6	0.7	0.7	0.2	10.33°C ± 0.89
	N	-0.2	-1.3	-1.3	-1.8	-0.6	-2.2	0.7	-1.0	-0.3	1.3	1.1	1.2	0.5	-0.4	-0.2	0.1	0.5	-0.4	0.3	-0.3	1.1	1.3	0.8	1.0	5.63°C ± 0.85
Eastern Magdalen Shelf	M	-1.2	0.3	-0.7	0.2	-0.3	-1.5	-1.0	-1.3	-0.8	0.1	0.0	-0.0	-1.2	1.7	2.2	0.2	0.7	-0.4	0.2	-0.1	0.1	2.3	-0.1	0.7	3.21°C ± 1.33
	J	-1.9	-0.9	0.2	-1.5	-0.2	-1.1	-0.4	-0.5	-1.2	0.0	0.2	0.9	-0.7	0.8	2.2	0.4	1.4	-0.0	-0.4	-0.6	-0.1	1.7	0.7	0.6	8.92°C ± 1.21
	J	-1.0	-1.3	0.1	-1.1	-0.1	-0.5	-0.6	-2.2	-1.6	1.6	0.7	-0.5	0.0	0.4	1.6	0.5	0.7	-0.2	0.5	0.2	-0.1	1.4	0.2	1.3	14.89°C ± 1.63
	A	0.2	-2.2	-0.1	-0.2	-0.3	-0.8	-1.5	-1.3	-0.0	1.8	0.4	1.5	-0.3	-0.1	0.8	0.1	1.3	0.6	0.2	1.3	0.4	0.3	-0.6	-1.6	17.28°C ± 1.05
	S	-0.3	-1.7	-1.4	-0.9	-1.4	-0.1	-0.9	0.5	1.0	0.8	-0.7	0.3	-0.6	-0.1	2.2	1.0	1.5	-0.2	0.5	-0.5	1.5	0.7	-0.7	-0.3	14.85°C ± 0.91
	O	-0.4	-1.3	0.2	-1.4	-2.5	-0.8	1.3	-1.0	0.5	0.0	0.5	0.6	0.2	-1.2	-0.5	0.4	2.0	-0.4	1.2	0.7	0.3	0.6	0.4	0.3	10.61°C ± 0.89
	N	-0.4	-1.1	-1.5	-1.6	0.1	-2.6	0.2	-0.6	0.1	0.6	0.9	1.4	0.3	-0.3	-0.3	1.1	0.5	-0.5	0.2	-0.5	0.8	1.0	0.9	1.4	5.88°C ± 0.91
Western Magdalen Shelf	M	-0.9	0.2	-0.2	-0.5	-0.9	-1.2	-1.1	-1.2	-0.7	-0.4	0.3	-0.2	-0.8	2.0	2.0	0.0	0.6	-0.3	-0.1	-0.1	-0.4	2.2	0.1	1.4	3.70°C ± 1.30
	J	-1.7	-1.1	0.7	-1.4	0.3	-1.3	0.2	-0.4	-1.3	-0.3	0.7	1.1	-0.7	0.7	2.0	0.2	1.4	-0.3	-0.2	-0.8	-0.3	1.6	0.3	0.5	9.60°C ± 1.16
	J	-0.6	-1.5	0.1	-0.9	0.1	-0.9	-1.3	-2.1	-1.4	1.6	1.3	-0.4	0.1	0.5	1.4	0.5	0.4	-0.4	0.5	0.0	0.4	1.2	0.6	1.0	15.14°C ± 1.39
	A	0.1	-2.4	-0.6	0.6	-1.1	-0.4	-1.5	-1.7	1.2	0.9	0.9	1.4	0.1	-0.1	0.2	0.4	0.9	0.5	-0.1	0.8	0.6	0.8	-0.6	-1.2	16.82°C ± 0.98
	S	-0.2	-1.7	-2.0	-0.9	-1.9	0.2	-0.5	0.0	0.9	0.1	-0.2	1.1	0.4	0.3	1.7	0.6	1.1	-0.5	0.3	-0.7	1.6	0.8	-0.8	0.2	14.00°C ± 0.96
	O	0.6	-1.4	-0.2	-1.8	-3.0	-0.0	0.8	-1.1	-0.2	-0.2	0.7	0.6	0.3	-0.8	-0.2	0.3	1.5	0.4	1.1	0.6	0.7	0.7	0.3	0.2	9.55°C ± 0.93
	N	0.0	-1.2	-1.4	-1.8	-1.0	-1.8	1.1	-0.9	-0.5	1.4	1.1	1.5	0.5	-0.5	-0.3	0.1	0.0	-0.1	-0.0	0.0	1.2	1.3	0.5	0.7	5.01°C ± 0.88

Table 11. First and last day of ice occurrence 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. 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.

				1965					1970					1975					1980					1985
First occurrence of ice	1 - Estuary	1	-13	-13	-13	8	-13	-13	-6	-13	-13	-20	-6	-8	-9	-16	1	-21	-11	-10	-9	-12	-4	-1
	2 - Northwest Gulf	1	-13	-13	-6	8	1	-6	-13	-6	-6	-20	-6	-8	-9	-16	1	-21	-11	-10	7	-5	-11	-1
	3 - Anticosti Channel	29	1	15	1	8	-13	15	22	8	1	-13	-6	6	-2	-9	1	-21	-11	-10	7	-12	-4	-1
	4 - Mécatina Trough	15	1	15	1	8	-13	-13	22	1	1	-20	8	6	-9	-9	1	-28	-11	-10	21	-12	-4	-8
	5 - Esquiman Channel	29	8	15	8	22	15	-13	29	8	8	-13	8	13	5	0	8	-14	15	20	28	-12	3	-8
	6 - Central Gulf	22	1	22	1	22	15	43	22	22	8	-6	8	13	5	-9	8	0	15	-1	14	2	15	-1
	7 - Cabot Strait	43	15	22	50	43	15		29	22	22	10	15	31	19	5	29	21	29	8	28	30	15	20
	8 - Magdalen Shallows	1	-6	-13	1	1	-13	-6	-13	-6	-6	-13	-6	-8	-2	-16	1	-21	-11	-10	7	9	-4	-1
Last occurrence of ice	1 - Estuary	78	93	92	78	92	93	78	85	85	107	85	99	76	89	88	99	84	78	50	71	100	92	83
	2 - Northwest Gulf	85	100	92	92	106	107	99	92	92	121	113	113	90	96	95	113	112	99	78	92	100	106	97
	3 - Anticosti Channel	134	114	155	106	99	86	78	106	78	142	127	162	132	96	102	127	112	92	85	140	114	134	90
	4 - Mécatina Trough	141	149	162	127	141	156	134	148	134	142	127	176	160	131	158	141	133	141	113	154	114	134	111
	5 - Esquiman Channel	134	128	155	106	141	156	99	120	134	128	120	176	146	117	151	134	112	106	85	147	100	113	111
	6 - Central Gulf	120	100	106	85	106	107	78	78	99	135	99	113	118	96	95	106	105	85	78	105	86	120	97
	7 - Cabot Strait	127	135	141	99	141	107		106	106	136	127	113	127	105	116	113	105	113	76	105	100	94	107
	8 - Magdalen Shallows	127	135	141	106	148	107	99	120	106	142	127	113	125	96	116	120	119	113	78	112	121	141	111

						1990					1995					2000					2005				Mean ± S.D.
First occurrence of ice	1 - Estuary	-16	-17	-4	-16	-6	-5	-13	-18	-4	2	-20	-1	-16	-7	-8	-21	2	-26	-21	-16	-17	-9	-28	-10 ± 6
	2 - Northwest Gulf	-16	-10	-4	-9	-6	-5	-13	-18	-4	2	-20	6	-16	-8	-8	-21	2	-25	-21	-15	-17	-12	-28	-8 ± 7
	3 - Anticosti Channel	-9	-17	3	-9	1	-5	-6	-18	-4	2	15	6	-2	-1	-2	-21	2	-26	-20	-4	-17	-9	-21	-4 ± 8
	4 - Mécatina Trough	-9	-17	3	-2	1	-5	-6	-18	-4	2	-13	6	-2	-1	-2	-21	2	-26	-20	-1	-17	-2	-20	-5 ± 10
	5 - Esquiman Channel	-9	-10	3	5	1	1	-6	-17	-4	2	8	20	12	-1	8	-4	7	-1	8	4	-7	-4	-20	3 ± 11
	6 - Central Gulf	5	-10	10	-2	-6	-5	1	4	3	9	8	6	-2	3	1	8	17	-2	7	-3	-2	1	-21	4 ± 8
	7 - Cabot Strait	12	33	17	19	1	15	22	11	10	30	22	34	26	5	29	5	35	16	15	25	3	32	18	20 ± 9
	8 - Magdalen Shallows	-9	-10	-4	-9	-6	-5	-6	-18	-4	-12	-25	6	-16	-11	-7	-21	2	-26	-21	-16	-17	-9	-28	-7 ± 8
Last occurrence of ice	1 - Estuary	82	81	73	82	71	85	93	92	101	100	78	83	96	86	93	84	90	107	100	89	85	97	93	86 ± 12
	2 - Northwest Gulf	110	109	136	96	99	113	114	120	108	121	92	97	103	105	93	103	99	153	119	117	93	92	122	104 ± 12
	3 - Anticosti Channel	138	117	136	96	148	133	128	123	157	142	113	153	103	110	93	124	144	158	128	130	115	115	107	121 ± 23
	4 - Mécatina Trough	145	117	136	131	162	133	135	134	157	149	113	146	131	138	103	137	144	153	135	131	119	158	151	137 ± 17
	5 - Esquiman Channel	145	117	108	131	162	127	135	134	157	142	113	146	124	138	89	134	110	157	125	110	117	153	147	128 ± 21
	6 - Central Gulf	110	95	94	117	127	120	121	120	122	121	100	118	103	102	90	107	99	118	105	101	79	96	109	107 ± 14
	7 - Cabot Strait	110	130	104	117	120	120	135	123	115	121	100	132	96	115	96	118	99	115	123	115	92	95	130	113 ± 14
	8 - Magdalen Shallows	117	130	136	117	106	127	135	134	122	121	113	132	110	117	102	124	109	126	123	120	107	104	127	119 ± 14

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 bottom 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.

Year	Air temp. (JFM)	CIL Index	(Winter cold layer volume)	(Max sea-ice volume)	(LSh intrusion volume)	(Mécatina Aug volume < 0°C)	August volume < 1°C: (1 - Estuary)	(2 - Northwest Gulf)	(3 - Anticosti Channel)	(4 - Mécatina Trough)	(5 - Esquiman Channel)	(6 - Central Gulf)	(7 - Cabot Strait)	(8 - Magdalen Shallows)	(All regions)	Magdalen Shallows bottom area: (Area, T < 0°C)	(Area, T < 1°C)	(Area, T < 2°C)	(Area, T < 3°C)
1971	0.4	1.2		-0.4			-1.3						-1.7	-0.3		-1.0	-1.2	-0.7	0.1
1972	-1.2	0.3		1.3									-0.5	1.0		0.0	0.5	0.3	-0.2
1973	0.1	0.1		0.5			-1.5						-0.0	-0.0		-0.3	-0.3	0.2	0.3
1974	-1.1	-0.4		0.5		1.2	-0.8	-0.1	-0.1	0.6	-1.2	0.2	-0.7	-0.7	-1.0	-0.9	0.3	0.6	0.8
1975	-0.7	-0.2		0.7										0.4		0.4	0.1	-0.7	-0.5
1976	-0.4	-0.3		0.5			-2.3							-0.2		1.2	1.0	1.3	1.6
1977	0.6	0.2		0.8					-2.5		-0.7	-1.9	-0.5	-1.4		-1.2	-1.5	-1.1	-1.1
1978	0.2	-0.0		-0.2		-0.8		-2.1		-0.9				0.7		-0.5	0.0	-0.6	-0.8
1979	1.2	1.7		0.3			-0.7				-2.8		-0.4	-0.4		-0.6	-0.0	-0.8	-0.9
1980	0.4	3.3		-1.2			-1.5				-1.9			-2.0		-1.1	-0.9	-1.6	-1.7
1981	1.9	1.3		-1.5				-2.7			-1.8			-0.6		-1.2	-1.6	-1.8	-2.1
1982	-0.7	0.9		-0.1			-0.6							-2.7		-1.2	-2.6	-1.1	-0.7
1983	1.1	1.1		-1.6							-0.9			-0.8		-0.9	-1.2	-1.0	-0.4
1984	0.2	-0.0		-0.8					0.7		-0.7			1.9		1.8	1.2	1.7	1.9
1985	-0.1	0.1		-0.2		-0.5		-1.2	0.8	-1.1	0.2	-0.5	0.4	-0.2	-0.6	-1.1	0.2	0.2	-0.0
1986	0.2	-1.1		-0.1				0.2	-0.1		0.5	-0.2	0.7	-0.0	-0.0	-0.0	0.1	-1.1	-0.9
1987	0.5	-0.8		-0.3			0.9	0.4	0.8		0.7	0.8	0.7	0.5	0.6	-0.3	-0.2	0.3	0.2
1988	0.2	-0.3		-0.3			-0.0	-0.0	-0.1		0.1	-0.3		-1.2	-0.5	-1.0	-1.0	1.3	0.7
1989	-0.9	-0.6		-0.2				-0.0	0.1		0.6	0.2	0.8	0.7	0.2	0.6	0.9	0.3	0.4
1990	-1.1	-1.1		1.4			-0.3	-0.1	0.2		0.6	0.3		-0.4	-0.1	0.4	0.6	0.3	0.8
1991	-0.7	-1.1		-0.3			1.7	1.4	1.8		1.1	1.5	1.5	-0.0	1.6	0.6	0.6	-0.0	-0.5
1992	-0.9	-1.0		0.7			0.7	1.5	1.2		1.1	1.2	0.8	2.0	1.5	1.6	1.5	1.9	2.1
1993	-2.1	-0.8		2.1			0.2	0.8	0.6		0.6	1.0	0.8	0.3	0.7	1.5	0.5	-0.2	-0.8
1994	-1.3	-1.0		1.7		-0.3	0.8	0.5	0.7	-0.9	0.5	0.1	0.7	0.9	0.4	1.2	0.7	0.3	0.1
1995	-0.4	-0.9		1.1		0.1	1.2	1.0	0.2	-0.9	1.2	1.4	1.5	1.5	1.3	1.8	1.4	1.0	0.6
1996	0.6	-0.6	0.7	-0.4		0.8	1.1	1.0	0.4	0.7	0.8	1.0	0.8	0.1	0.9	0.6	0.7	1.0	0.7
1997	-0.7	-0.4	0.7	0.3	-0.8	0.4	0.3	0.3	-0.6	-0.2	1.0	-0.3	0.3	0.2	0.1	0.2	0.6	0.8	0.9
1998	1.5	-0.8	-0.2	-1.6	-0.7	0.2	1.0	0.5	-0.2	1.1	0.7	0.2	-0.2	2.1	0.5	0.8	1.1	0.9	0.9
1999	1.8	0.2	-0.2	-0.9	-0.4	-1.3	0.6	-0.0	-2.0	-1.3	-0.5	-1.4	-1.7	0.6	-1.3	-1.1	-0.6	-0.7	-0.3
2000	1.2	0.8	-1.7	-1.8	-1.2	-1.4	-0.2	-0.7	-1.8	-1.1	-1.0	-2.1	-1.7	-0.6	-2.1	-0.4	-1.0	-1.2	-1.1
2001	0.5	0.2	-0.4	-1.0	0.4	1.4	-0.4	-0.0	0.3	1.5	0.8	0.6	0.1	0.0	0.2	-1.2	0.1	0.2	0.1
2002	0.1	0.2	0.6	-0.8	-0.4	-0.8	-0.4	-0.7	-0.4	-0.3	0.2	-0.8	-0.5	-0.7	-0.9	-1.1	-0.8	-1.1	-1.2
2003	-0.7	-0.9	1.6	2.1	2.3	1.1	1.3	0.7	0.8	0.5	0.6	1.1	1.7	0.4	1.0	0.6	0.4	-0.3	-0.8
2004	0.4	0.1	0.5	-0.4	0.9	0.6	0.9	0.5	0.2	1.3	-0.0	-0.3	-0.9	0.4	-0.1	-0.3	-0.1	-0.4	-1.0
2005	0.3	0.5	-0.8	-0.4	-1.0	-1.3	0.6	0.2	-0.8	-0.4	-0.3	-1.1	-1.3	-0.6	-1.0	-1.2	-0.7	-0.1	0.5
2006	1.7	1.0	-1.9	-2.2	-0.1	-0.8	-1.1	-1.8	-1.5	-1.1	-0.6	-1.4	-1.4	-0.5	-2.1	-1.2	-1.1	-0.2	-0.5
2007	0.4	0.2	0.4	-1.3	0.9	-0.4	-0.5	0.2	0.8	0.7	0.3	-0.0	-0.2	-0.7	-0.1	-1.2	-0.4	-0.7	-1.4
2008	0.0	-0.7	0.8	0.1	0.1	1.7	0.4	0.4	0.5	1.6	0.7	0.8	0.9	0.5	0.7	1.2	0.7	0.3	-0.1
	-8.69°C ± 1.70	-0.32°C ± 0.53	12.6 km^3 ± 1.5	79.4 km^3 ± 24.1	1710 km^3 ± 1213	334 km^3 ± 113	285 km^3 ± 123	1995 km^3 ± 637	1777 km^3 ± 289	462 km^3 ± 82	1920 km^3 ± 676	1996 km^3 ± 478	489 km^3 ± 270	617 km^3 ± 198	10.1 ± 1.9 (x10^3 km^3)	12.2 ± 10.2 (x10^3 km^2)	35.6 ± 7.7 (x10^3 km^2)	46.6 ± 3.9 (x10^3 km^2)	52.1 ± 3.2 (x10^3 km^2)

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 10. The colour-coding of the 0 to 40 m lines are according to standardized anomalies based on the 1971-2000 climatologies, but the numbers are anomalies in ºC. The SST colour-coding is based on the climatology of the entire time series and the numbers are mean temperatures in ºC.

Year	Eastern Shelf SST June	Eastern Shelf 0 m temp.	Eastern Shelf 10 m temp.	Eastern Shelf 20 m temp.	Eastern Shelf 30 m temp.	Eastern Shelf 40 m temp.	Western Shelf SST June	Western Shelf 0 m temp.	Western Shelf 10 m temp.	Western Shelf 20 m temp.	Western Shelf 30 m temp.	Western Shelf 40 m temp.
1965		-1.9	-1.3	-0.4	-0.1	-0.2		-2.3	-1.6	-0.7	-0.4	-0.2
1966		0.2	0.0	-0.3	0.0	0.6		-0.3	-0.7	-1.4	-1.1	-0.4
1967		-4.2	-3.7	-3.0	-0.4	0.1		-2.7	-2.7	-1.6	-0.6	-0.0
1968		1.0	0.8	0.2	0.4	0.5		-0.4	-0.6	-0.7	-1.0	-0.6
1969		0.2	0.4	0.2	0.7	1.0		-1.1	-0.7	-0.4	-0.4	-0.1
1970		1.1	2.0	2.0	2.1	2.0		0.1	1.1	1.5	1.3	1.4
1971		1.1	1.2	0.7	0.5	0.3		0.5	0.6	0.2	-0.0	0.3
1972		-2.8	-2.7	-2.3	-1.6	-1.1		-1.6	-1.7	-1.6	-1.1	-0.8
1973		-2.1	-0.8	-1.0	-0.7	-0.3		-3.7	-1.9	-1.2	-1.2	-0.8
1974		-1.6	-1.3	-0.5	0.2	0.5		-2.9	-2.4	-1.4	-0.8	-0.2
1975		-0.4	-0.8	-0.1	0.4	0.4		-0.9	-0.7	-0.4	-0.1	0.3
1976		-0.5	-0.4	-0.4	-0.8	-1.0		0.0	-0.1	0.0	-0.7	-0.9
1977		-0.6	-1.0	-1.5	-0.6	-0.1		-0.3	-1.0	-1.3	-0.6	-0.4
1978												
1979												
1980		-2.3	-1.3	1.6	2.4	0.3		-1.3	-0.6	0.7	0.3	0.4
1981												
1982		-1.0	0.3	2.2	1.7			-0.6	1.1	0.2	0.9	-0.7
1983												
1984												
1985	6.6						7.6					
1986	7.8						8.4					
1987	9.2	0.3	0.3	-1.6	-2.6	-1.9	10.4	0.8	1.7	0.4	-1.1	-1.3
1988	7.1	-1.8	-0.7	-0.1	0.6	0.7	8.0	-1.4	-0.5	-0.7	-0.8	-0.9
1989	8.7	0.2	-0.6	-2.6	-2.3	-1.2	9.9	2.0	0.8	-0.4	-1.0	-1.0
1990	7.6	-0.5	-0.2	-0.4	0.5	0.7	8.1	-0.5	-0.3	-0.4	0.3	0.4
1991	8.5	-0.9	-0.6	0.3	0.2	-0.2	9.9	0.3	-0.6	0.4	0.7	-0.5
1992	8.3	-0.7	-1.5	-2.2	-1.6	-1.3	9.1	0.8	-0.3	-0.7	-0.8	-0.9
1993	7.5	-1.5	-1.5	-0.7	-1.3	-1.6	8.1	-0.8	-0.9	0.6	-0.1	-1.5
1994	8.9	-1.3	-0.7	-0.4	-0.3	-0.6	9.2	-0.1	-0.1	-1.0	-1.0	-1.0
1995	9.1						10.4					
1996	10.1						10.9					
1997	8.1	-2.4	-2.2	-1.6	-0.6	0.3	8.8	-1.2	-1.0	-0.8	0.2	-0.4
1998	9.9	1.0	0.3	-0.9	-1.2	-0.8	10.4	1.3	1.1	-1.4	-2.2	-1.6
1999	11.6	1.6	2.0	1.8	1.7	1.2	11.9	2.7	1.4	0.2	-0.2	-0.3
2000	9.4	-1.1	-0.6	0.8	2.0	1.4	9.9	0.4	0.4	0.4	0.4	-0.1
2001	10.6	1.3	0.6	-0.9	-1.0	-0.2	11.2	2.2	0.1	-1.5	-1.3	-0.7
2002	8.9	-0.9	-0.4	-0.1	0.1	0.0	9.2	-1.0	-0.2	-0.1	-0.6	-0.4
2003	8.5	-1.6	-0.9	-1.3	-0.8	-0.6	9.3	-0.5	-0.5	-0.8	-0.6	-0.6
2004	8.2	-1.8	-0.8	0.4	1.6	0.6	8.6	-1.4	-0.5	0.5	0.6	0.3
2005	8.8	-1.1	-0.8	-0.9	0.1	0.2	9.3	-1.0	-0.6	-1.6	-0.8	-0.4
2006	11.0	3.1	2.0	-1.9	-1.6	-0.4	11.5	2.9	2.2	-0.5	-1.0	-0.3
2007	9.8	-0.2	-0.9	-2.3	-0.9	-0.3	10.0	-0.0	0.3	0.6	-0.2	-0.1
2008	9.7	0.9	0.2	-0.6	-1.2	-1.7	10.1	0.9	-0.2	-0.8	-1.3	-1.1
SST climatology	8.92°C ± 1.21						9.60°C ± 1.16					

Table 14. Depth-layer monthly average temperature summary for months corresponding to the eight Gulf-wide oceanographic surveys in 2007 and 2008. 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 2008.

1 - Estuary / Estuaire

	2007				2008			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
0 m	-0.41	8.6	9.4	4.0	-1.39	7.9	11.7	4.1
10 m	-0.19	6.0	7.0	4.0	-1.35	6.0	10.8	4.1
20 m	0.1	3.1	4.4	3.7	-0.92	3.8	8.7	3.9
30 m	0.9	2.0	3.0	3.5	-0.54	2.3	6.3	3.4
50 m	0.4	1.0	1.1	2.5	0.1	0.7	1.7	2.4
75 m	1.2	-0.0	0.8	1.1	0.8	-0.2	0.2	1.1
100 m	1.7	0.6	1.6	0.8	2.0	0.3	0.9	0.8
150 m	3.9	2.6	3.2	3.0	3.4	2.6	2.9	2.0
200 m	4.8	4.0	4.2	4.3	4.1	3.8	4.1	3.7
250 m		4.7	4.8	4.9		4.6	4.8	4.6
300 m		5.1	5.2	5.2		5.1	5.1	5.0
350 m		5.2	5.2			5.1	5.2	5.1

2 - Northwest Gulf / Nord-ouest du Golfe

	2007				2008			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	-1.46	10.8	10.8	4.8	-1.62	10.1	15.6	4.0
10 m	-1.45	8.2	9.2	4.7	-1.64	6.8	12.8	4.0
20 m	-1.38	3.9	4.5	4.7	-1.63	2.5	7.8	3.9
30 m	-1.27	2.2	2.5	4.3	-1.61	0.9	5.2	3.2
50 m	-0.47	0.4	0.7	2.4	-1.04	-0.1	1.2	1.2
75 m	0.9	0.3	0.3	1.1	-0.20	-0.1	0.0	0.7
100 m	2.0	1.0	0.8	1.1	1.0	0.8	0.6	1.1
150 m	4.4	3.3	3.0	3.2	3.4	3.0	2.7	2.8
200 m	4.9	4.6	4.5	4.5	4.4	4.4	4.2	4.4
250 m		5.3	5.2	5.2		5.2	5.1	5.1
300 m		5.4	5.4	5.4		5.4	5.4	5.4
350 m		5.4	5.4	5.4		5.4	5.4	5.4
400 m		5.5	5.4				5.4	5.4

3 - Anticosti Channel / Chenal Anticosti

	2007				2008			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	-1.73	7.1	13.4	4.3	-1.70	7.3	16.8	6.1
10 m	-1.72	6.0	12.8	4.3	-1.71	6.2	15.8	6.1
20 m	-1.72	2.7	6.0	4.3	-1.71	3.5	8.1	6.0
30 m	-1.72	1.2	2.2	4.2	-1.70	1.7	4.2	6.0
50 m	-1.70	-0.7	0.2	3.2	-1.68	0.4	0.5	2.0
75 m	-1.07	-1.0	-0.3	1.3	-1.43	-0.6	-0.4	0.7
100 m	0.2	-1.0	-0.4	0.5	-0.98	-0.8	-0.3	0.5
150 m	2.2	-0.3	1.5	2.4	1.5	0.9	1.6	1.3
200 m	4.7	3.2	4.8	4.7	3.9	3.4	4.4	3.9
250 m			5.8	5.7			5.4	5.4

4 - Mécatina Trough / Cuvette de Mécatina

	2007				2008			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	-1.77	5.9	12.1	3.5	-1.74		15.0	4.7
10 m	-1.77	4.5	11.4	3.5	-1.75		14.8	4.7
20 m	-1.77	0.8	8.2	3.5	-1.75		9.0	4.7
30 m	-1.77	0.4	4.4	3.3	-1.75		4.7	4.7
50 m	-1.77	-0.7	1.7	2.9	-1.75		1.0	3.7
75 m	-1.77	-1.1	0.3	2.4	-1.74		-0.5	3.5
100 m	-1.77	-1.3	-0.5	1.8	-1.75		-0.9	3.2
150 m	-1.78	-0.9	-0.4	0.7	-1.77		-0.6	-0.3
200 m	-1.77	-0.1	0.9	1.3	-1.78		-0.5	-0.2

5 - Esquiman Channel / Chenal Esquiman

	2007				2008			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	-1.71	8.1	15.0	5.1	-1.43	8.1	16.7	6.4
10 m	-1.71	8.0	14.1	5.1	-1.45	7.2	13.8	6.4
20 m	-1.71	4.1	8.4	5.0	-1.46	4.2	6.0	6.2
30 m	-1.70	1.4	2.6	4.6	-1.45	1.4	2.0	5.6
50 m	-1.62	0.0	0.4	2.6	-1.41	-0.5	-0.3	1.1
75 m	-1.07	-0.0	-0.0	0.6	-1.09	-0.5	-0.5	-0.1
100 m	-0.10	0.1	0.3	0.5	-0.32	-0.5	-0.2	0.1
150 m	2.3	2.5	2.7	2.2	1.9	1.0	2.2	2.0
200 m	3.9	4.9	4.9	4.7	3.9	3.6	4.4	4.3
250 m		5.6	5.7	5.6		5.4	5.3	5.3
300 m			5.7	5.7			5.4	5.4

6 - Central Gulf / Centre du Golfe

	2007				2008			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	-1.66	9.6	15.4	5.1	-1.49	8.2	17.8	6.6
10 m	-1.66	8.4	13.5	5.0	-1.48	7.9	16.5	6.5
20 m	-1.66	6.0	6.0	5.0	-1.46	5.0	7.8	6.4
30 m	-1.66	3.4	2.7	5.0	-1.44	1.7	2.5	6.1
50 m	-1.57	0.4	0.7	2.3	-1.43	-0.3	0.1	1.0
75 m	-0.26	0.2	0.2	0.4	-1.19	-0.7	-0.6	0.1
100 m	1.3	1.1	0.3	0.6	0.2	-0.1	-0.2	0.4
150 m	3.2	3.4	2.5	3.0	2.7	2.1	1.7	2.3
200 m	5.0	5.1	4.7	4.8	4.6	4.3	4.1	4.4
250 m		5.6	5.6	5.5		5.2	5.3	5.4
300 m		5.6	5.6	5.5		5.4	5.5	5.5
350 m		5.4	5.4	5.4		5.4	5.3	5.3
400 m		5.3	5.2	5.3		5.2	5.2	5.2
450 m		5.1	5.1	5.1				5.1

7 - Cabot Strait / Détroit de Cabot

	2007				2008			
	Mar	June	Aug	Nov	Mar	June	Jul	Nov
0 m	-1.39	10.2	17.0	7.4	-1.22	10.1	17.6	8.7
10 m	-1.43	9.1	13.1	7.3	-1.18	8.3	15.0	8.6
20 m	-1.40	4.2	6.1	7.0	-1.16	5.3	7.9	8.3
30 m	-1.38	2.2	3.2	6.6	-1.13	1.8	3.4	7.7
50 m	-1.33	0.9	1.3	4.5	-1.12	-0.1	0.6	2.5
75 m	-0.95	0.7	0.9	2.3	-0.50	0.5	0.5	1.4
100 m	-0.44	1.1	0.9	1.3	1.0	0.9	0.7	1.1
150 m	2.8	2.7	3.2	3.0	3.8	2.8	2.9	2.1
200 m	4.8	4.5	4.9	4.8	5.4	4.7	4.8	4.4
250 m		5.4	5.5	5.4		5.5	5.5	5.6
300 m		5.5	5.4	5.5		5.5	5.5	5.6
350 m		5.3	5.2	5.3		5.3	5.3	5.4
400 m		5.1	5.1	5.2		5.0	5.1	5.1
450 m		4.9	4.9	5.0		5.0	5.0	5.0
500 m			4.8	4.9			5.0	5.0

8 - Magdalen Shallows / Plateau madelinien

	2007				2008			
	Mar	June	Sep	Nov	Mar	June	Sep	Nov
0 m	-1.60	11.8	14.3	7.1	-1.60	12.9	15.9	7.6
10 m	-1.62	9.9	14.1	7.0	-1.67	9.3	15.8	7.5
20 m	-1.63	5.7	12.8	7.0	-1.68	4.7	12.0	7.1
30 m	-1.65	2.3	8.0	6.7	-1.68	1.1	6.2	5.8
50 m	-1.59	0.3	1.3	4.1	-1.63	-0.6	0.6	2.3
75 m	-1.56	-0.0	0.6	1.1	-1.34	-0.7	-0.2	0.2
100 m							0.4	

Table 15. Deep layer temperature and salinity. Gulf averages are shown for 200, 250 and 300 m and regional averages are shown for 200 and 300 m.

						1975					1980					1985					1990					1995					2000					2005			2008	
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	0.4	0.4	1.2	0.8	0.8	0.6	-0.6	-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	4.44°C ± 0.52
	250 m	-1.1	-1.0	-0.5	-0.7	-1.1	-0.7	0.3	0.7	1.2	2.2	1.5	0.2	-0.4	0.0	0.8	1.6	1.0	1.1	0.5	-0.4	-1.8	-1.9	-0.7	0.7	-0.6	-1.1	0.4	-0.2	0.2	0.1	0.4	0.8	0.7	0.5	0.1	0.5	0.5	-0.2	5.32°C ± 0.34
	300 m	-2.0	-1.8	-1.1	-1.3	-0.9	-0.2	0.3	0.7	1.0	2.6	1.1	0.2	-0.4	0.1	0.6	1.4	0.8	0.7	0.3	-0.1	-1.0	-1.2	-0.3	0.8	0.0	-0.1	0.5	-0.4	-0.1	0.1	0.3	0.5	0.7	0.6	0.1	0.1	0.1	-0.2	5.49°C ± 0.30
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	-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	3.73°C ± 0.51
	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	-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	4.25°C ± 0.43
	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	-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	4.22°C ± 0.58
	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	0.6	-0.5	-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	4.61°C ± 0.62
	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	0.3	-0.8	-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	4.57°C ± 0.65
	7 - Cabot Strait	0.1	-0.1	-0.2	-0.1	-1.3	-0.7	1.8	0.8	1.6	1.4	-0.3	-0.7	-0.6	0.6	1.1	1.3	0.3	0.5	-0.2	-0.6	-2.3	-1.5	-0.1	0.7	-1.5	-1.1	0.6	-0.4	1.0	0.4	0.4	1.1	-0.3	-0.2	0.6	0.7	-0.3	-0.3	4.96°C ± 0.70
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	-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	4.85°C ± 0.37
	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	-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	5.23°C ± 0.32
	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	0.2	-0.3	-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	5.57°C ± 0.33
	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	-0.4	-0.5	-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	5.67°C ± 0.31
Gulf Avg S	200 m	0.6	-0.2	-0.5	0.1	-1.7	0.2	0.2	0.7	0.8	1.8	1.4	-0.7	0.2	0.4	0.2	0.0	1.2	1.2	1.6	-0.6	-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	34.09 ± 0.12
	250 m	0.6	-1.0	-1.2	-0.3	-1.7	-0.4	0.0	-0.2	2.1	1.8	1.7	0.8	-0.2	-0.3	-0.1	0.8	1.4	1.2	0.6	-0.8	-1.4	-1.1	-0.3	0.7	-0.8	-1.9	-0.2	-0.2	0.1	-0.3	-0.2	0.7	0.6	0.1	0.1	1.1	0.4	-0.2	34.48 ± 0.09
	300 m	1.5	-1.8	-0.8	-0.7	-1.5	1.5	-0.8	0.0	-0.5	1.3	1.7	1.5	-0.5	-0.5	-0.3	1.0	1.8	1.7	0.7	-0.7	-1.0	-0.2	0.0	0.5	-0.2	-1.0	0.0	-0.3	0.0	-0.5	-0.2	0.7	0.7	0.5	0.3	1.3	0.3	-0.3	34.65 ± 0.06
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	1.2	-0.4	-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	33.98 ± 0.19
	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	1.8	-1.6	-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	34.09 ± 0.11
	3 - Anticosti Channel	1.2	0.1	0.8	-0.1	-0.7	-0.4					1.0	-0.2	-0.9	1.6	-0.9	-0.3	1.1	0.6	1.9	-0.6	-0.9	-1.6	-0.9	1.3	-0.4	-1.7	0.1	-0.9	0.4	0.5	-0.9	0.8	-0.1	-1.8	-0.6	1.4	0.6	-0.9	33.98 ± 0.16
	4 - Mécatina Trough	0.8			1.1	-1.2			1.0																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	32.80 ± 0.26
	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	1.4	-0.2	-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	34.12 ± 0.18
	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	0.7	0.3	-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	34.09 ± 0.17
	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	0.9	-0.4	-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	34.15 ± 0.18
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				-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	0.3	34.43 ± 0.11
	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	1.0	-1.4	-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	34.61 ± 0.07
	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	0.0	-0.3	-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	34.68 ± 0.07
	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	0.6	-1.3	-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	34.69 ± 0.07

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.

Variable	Station	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	Mean ± SD
T [0-100 m]	Rimouski	2.23	1.73	2.18	1.17	2.24	2.40	1.29	2.39	3.11	2.83	3.14	3.05	2.31	1.42	2.43	2.72	2.33	2.31	2.29°C ± 0.59
	Gaspé Current						2.67	2.05	2.91	2.44	2.27	2.64	3.08	2.28		2.67	3.14		2.43	2.60°C ± 0.35
	Anticosti Gyre						1.78	1.85	1.22	1.39	2.02	2.23	2.39	1.79		1.59	1.83		1.91	1.82°C ± 0.34
	Shediac Valley		7.53					5.53		7.96	7.91	7.90	6.87	6.42	5.73	5.60	6.43	8.49	8.59	7.24°C ± 1.22
S [0-50 m]	Rimouski	0.8	-0.7	-1.3	-0.1	0.5	-1.8	-1.1	-0.7	0.9	0.7	0.8	1.4	1.5	-0.3	-0.7	0.1	1.1	-1.1	29.25 ± 0.42
	Gaspé Current						0.4	-1.2	-1.9	1.3	0.1	0.3	0.4	1.6		-0.1	-0.3		-0.3	29.76 ± 0.33
	Anticosti Gyre						-1.5	-0.7	-1.1	0.9	0.3	0.4	1.5	1.4		-1.0	-0.1		-0.3	31.45 ± 0.19
	Shediac Valley		0.0							0.0	0.0	0.2	1.0	2.0	-0.9	-0.6	-0.1	1.0	-1.6	29.96 ± 0.30
$\Delta\sigma_t$ [0,50 m]	Rimouski	3.71	4.71	4.97	4.79	4.05	5.51	5.44	4.02	3.33	4.53	3.66	4.10	3.94	4.67	4.44	4.59	4.54	5.59	4.48 kg m^{-3} ± 0.65
	Gaspé Current						3.74	4.83	4.14	3.92	4.45	4.07	4.98	4.42			3.79		5.33	4.37 kg m^{-3} ± 0.54
	Anticosti Gyre						3.31	2.96	2.92	2.78	2.92	3.36	2.83	2.89		2.77	2.95		3.68	3.03 kg m^{-3} ± 0.29
	Shediac Valley		3.61							3.45	3.75	3.34	3.49	3.61	3.69	3.85	3.88	3.29	5.08	3.70 kg m^{-3} ± 0.47

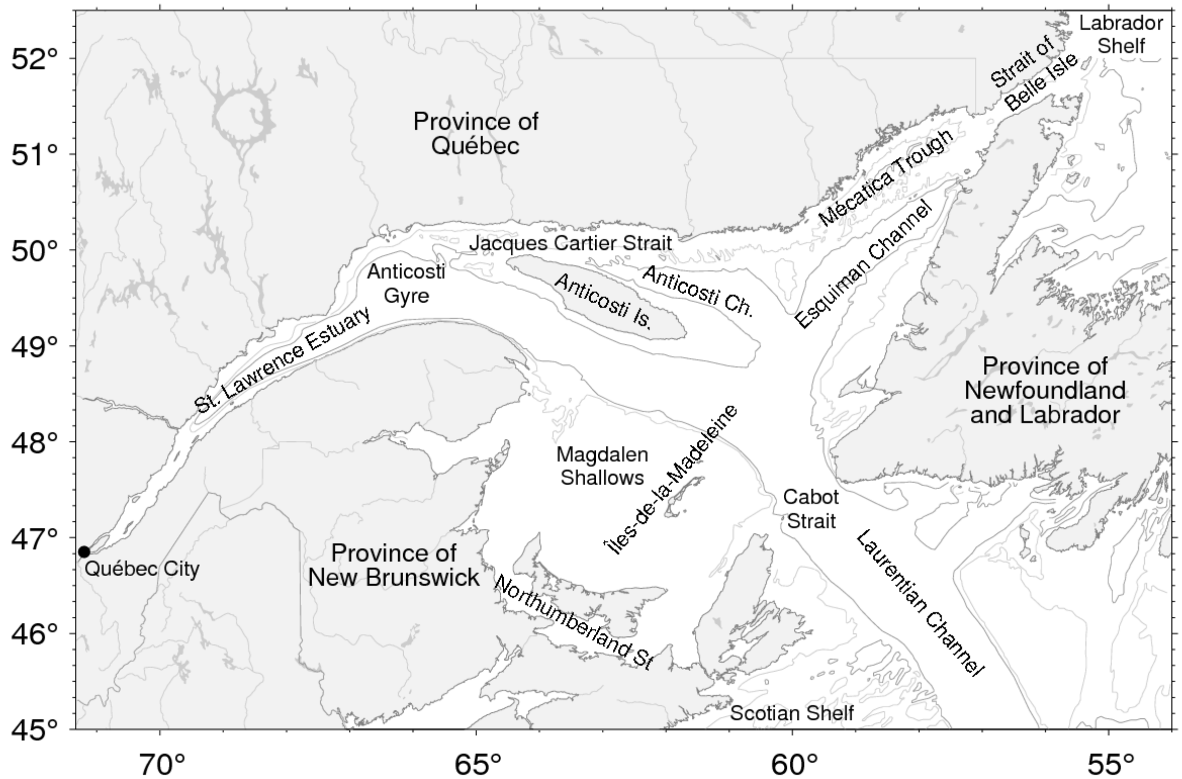

Fig. 1. The Gulf of St. Lawrence, with the100 and 200 m isobaths. Locations discussed in the text are indicated.

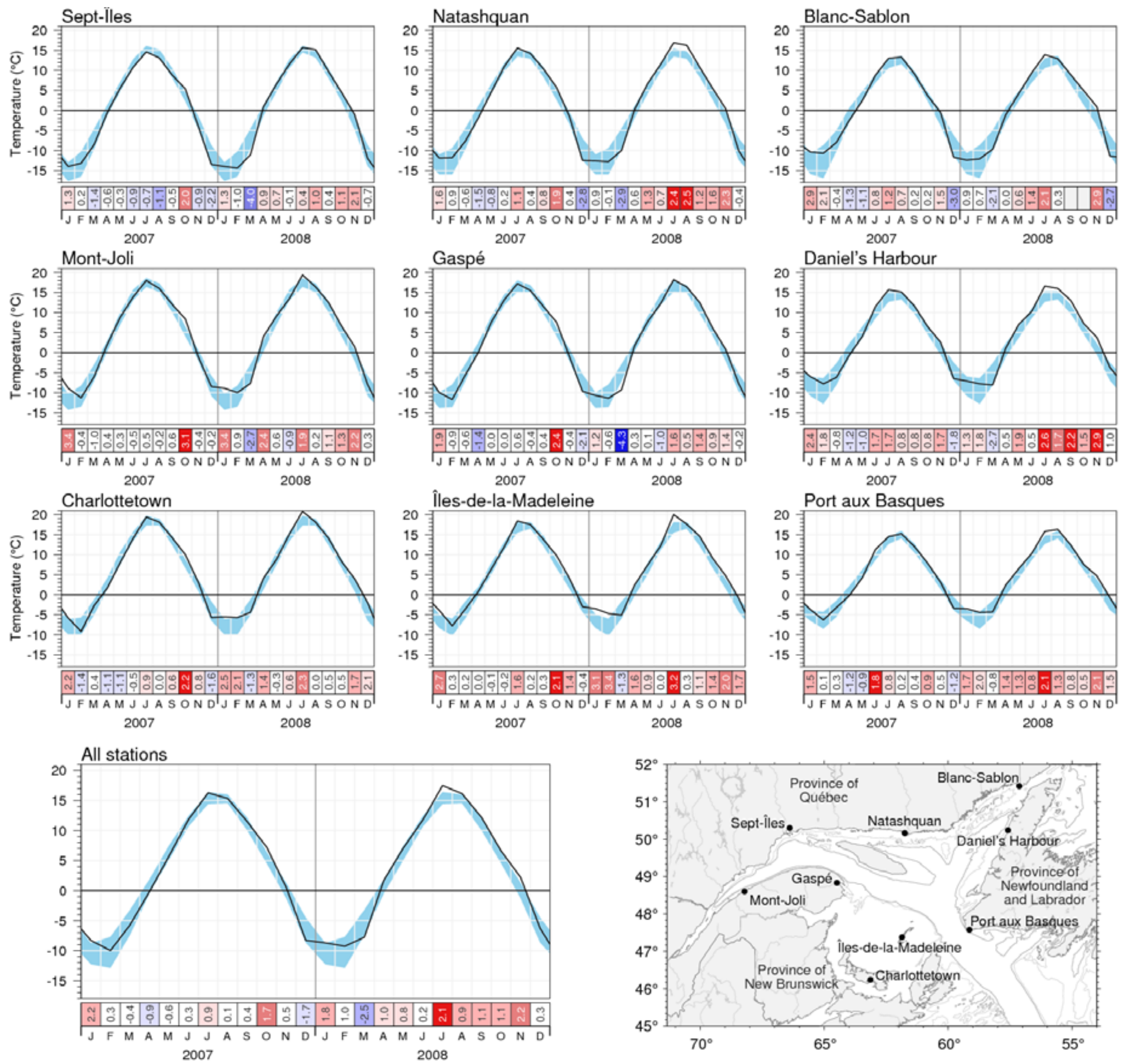

Fig. 2. Monthly air temperatures and anomalies for 2007 and 2008 at nine selected stations around the Gulf as well as the average for all nine stations. The blue area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation. The bottom scorecards are colour-coded (see 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.

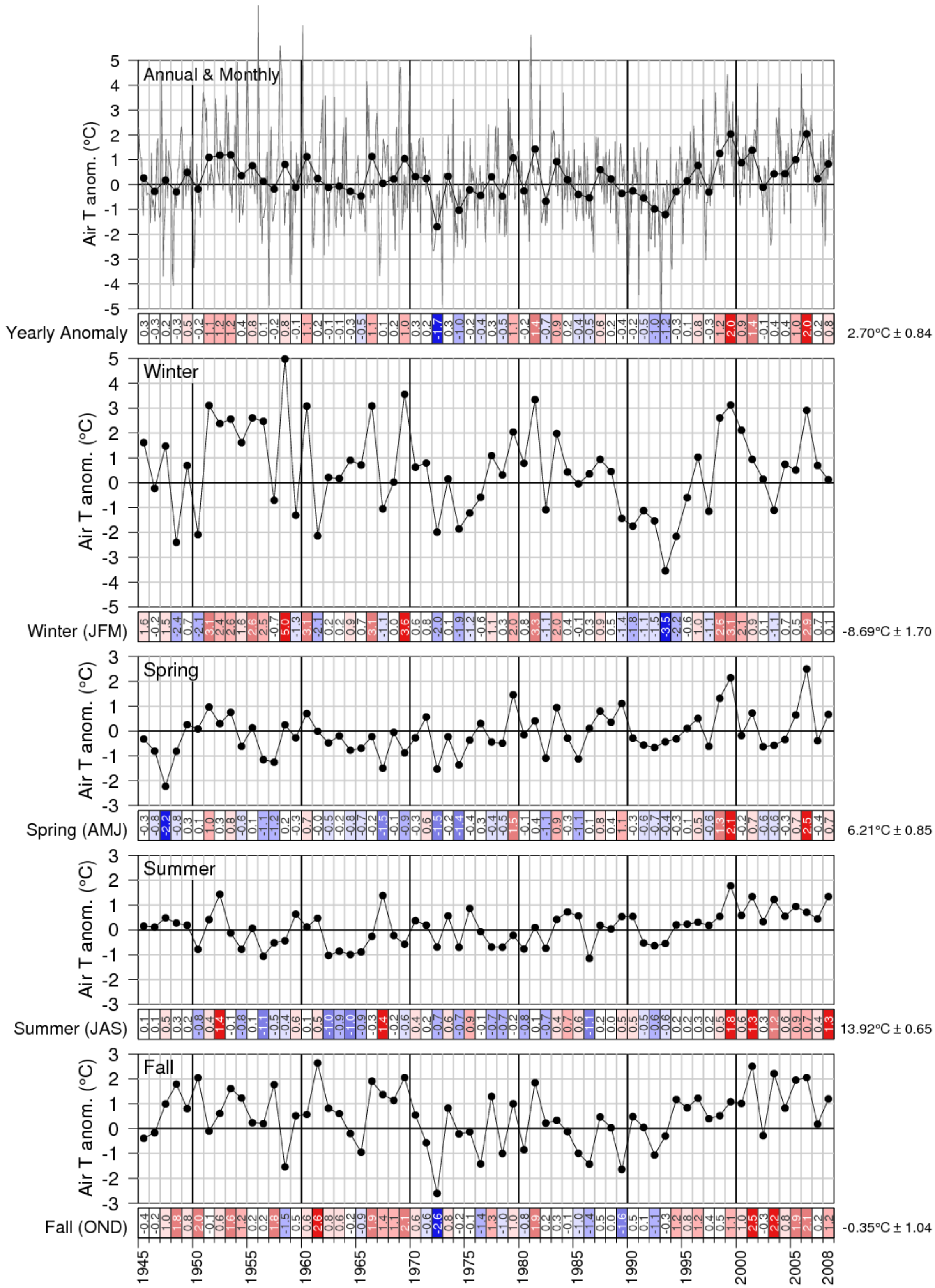

Fig. 3. Annual and seasonal mean air temperature anomalies averaged for the nine selected stations around the Gulf. The bottom scorecards are colour-coded according to the standardized anomalies based on the 1971–2000 climatology, but the numbers are the anomalies in ºC.

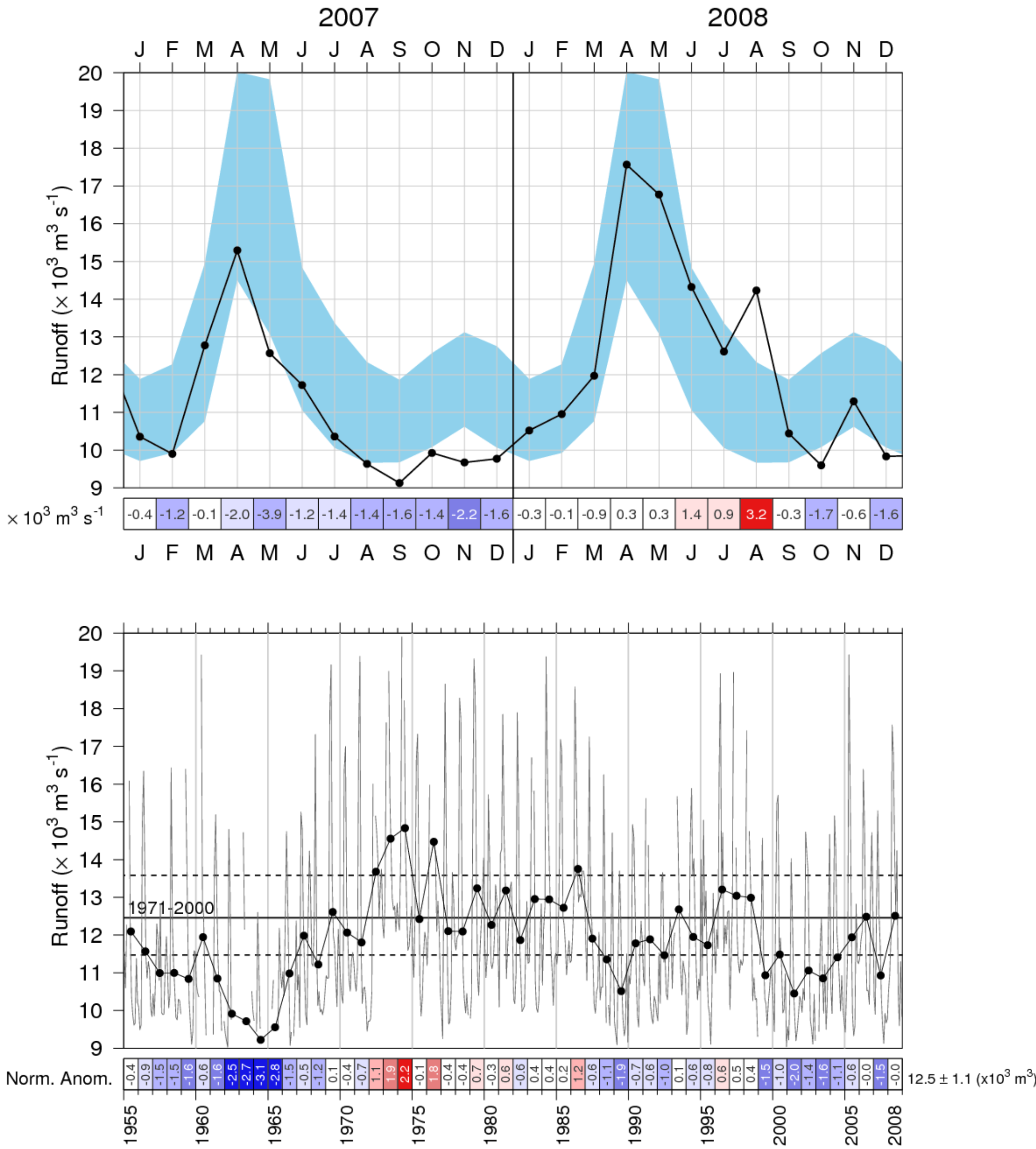

Fig. 4. Monthly (top panel) and annual (bottom panel) mean freshwater flow of the St. Lawrence River at Québec City. The 1971–2000 climatological mean, plus and minus one standard deviation, is shown for each month in the top panel (blue shading) and as horizontal lines for the annual time series in 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 $\times 10^3$ m^3 s^{-1}. The bottom-panel scorecard shows numbered standardized anomalies for which the mean and standard deviation are indicated on the right side.

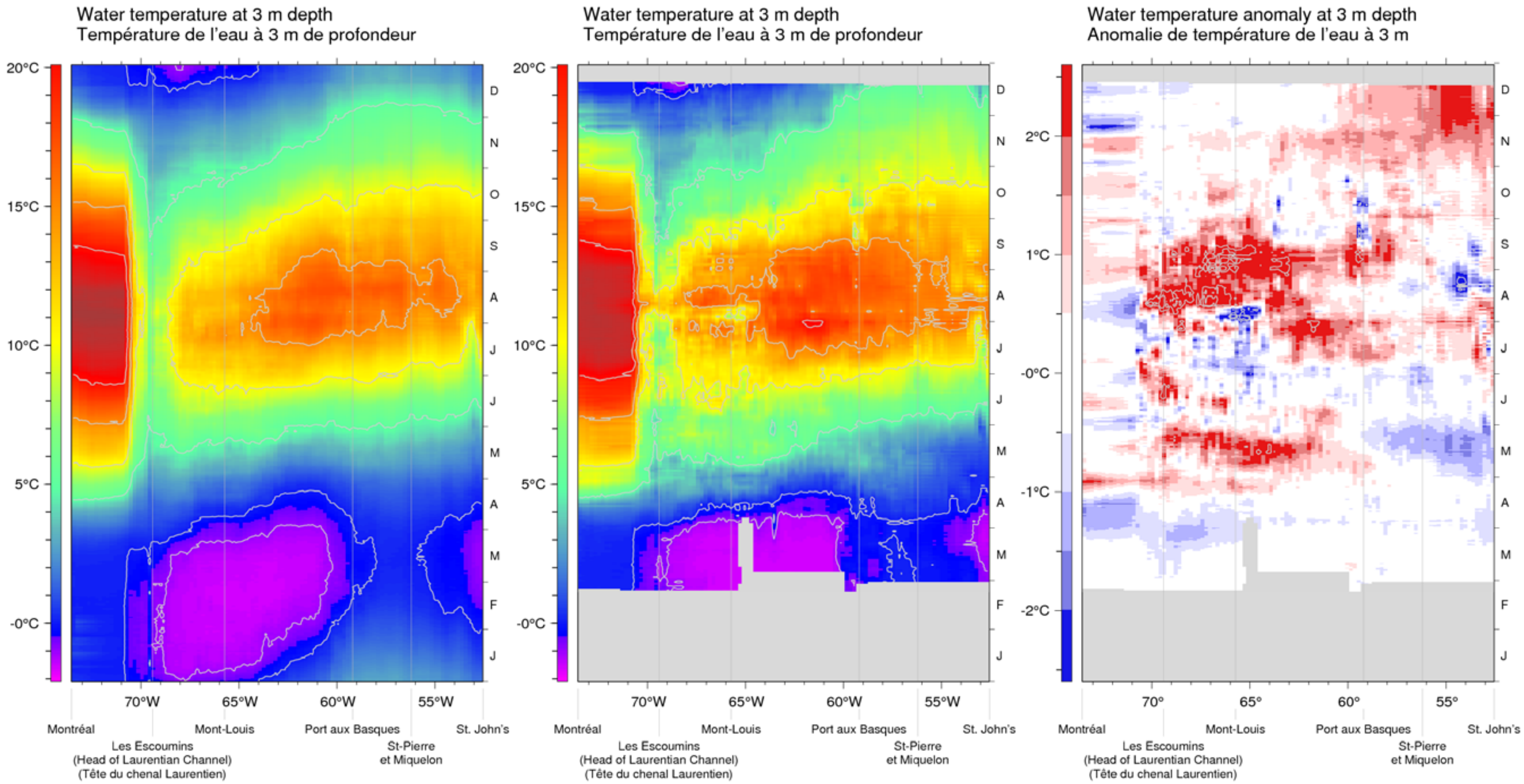

Fig. 5. Thermosalinograph data at 3 m depth along the Montréal to St. John's shipping route: composite mean annual cycle of the water temperature for the 2000–2008 period (left panel), composite annual cycle of the water temperature for 2008 (middle panel) and water temperature anomaly for 2008 relative to the 2000–2008 composite (right panel).

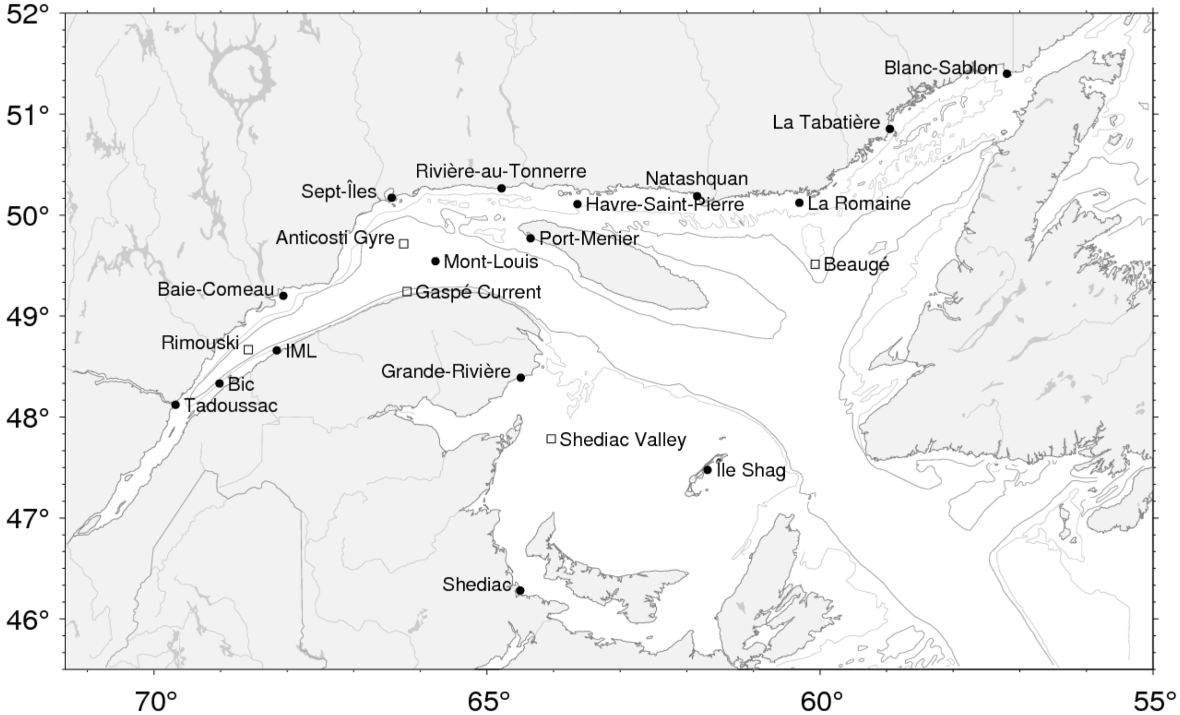

Fig. 6. Locations of the Maurice Lamontagne Institute thermograph network stations in 2008, including regular stations where data are logged internally and recovered at the end of the season (filled circles) and oceanographic buoys that transmit data in real time (open squares). Shediac station from DFO Gulf Region is also shown.

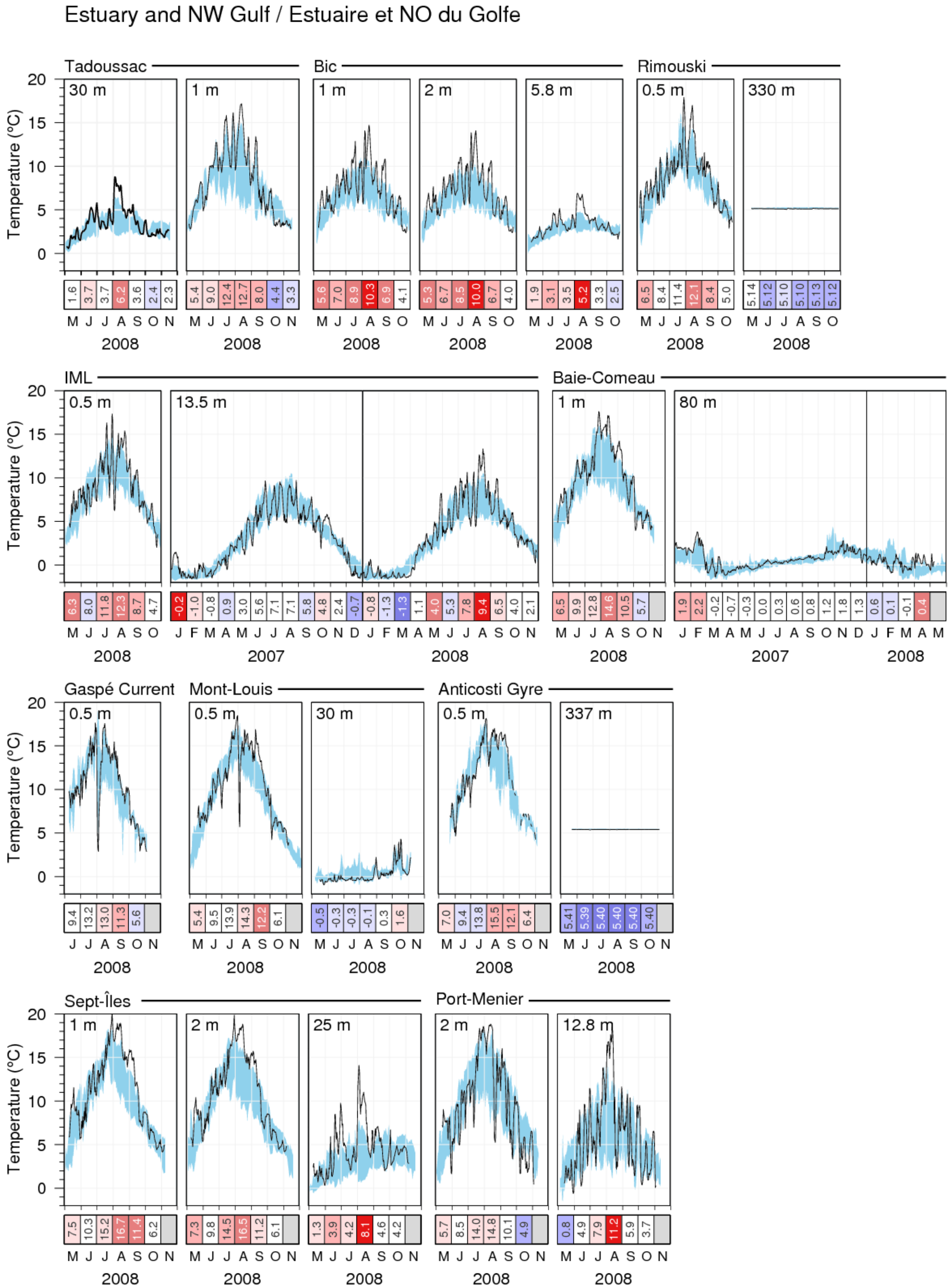

Fig. 7. Thermograph network data. Daily mean 2008 temperatures compared with the daily climatology (daily averages plus and minus one standard deviation; blue areas) computed from all available stations in the Estuary and northwestern Gulf. Score cards show monthly average temperature. Data from 2007 are included if they were not all shown in the previous report (Galbraith et al. 2008).

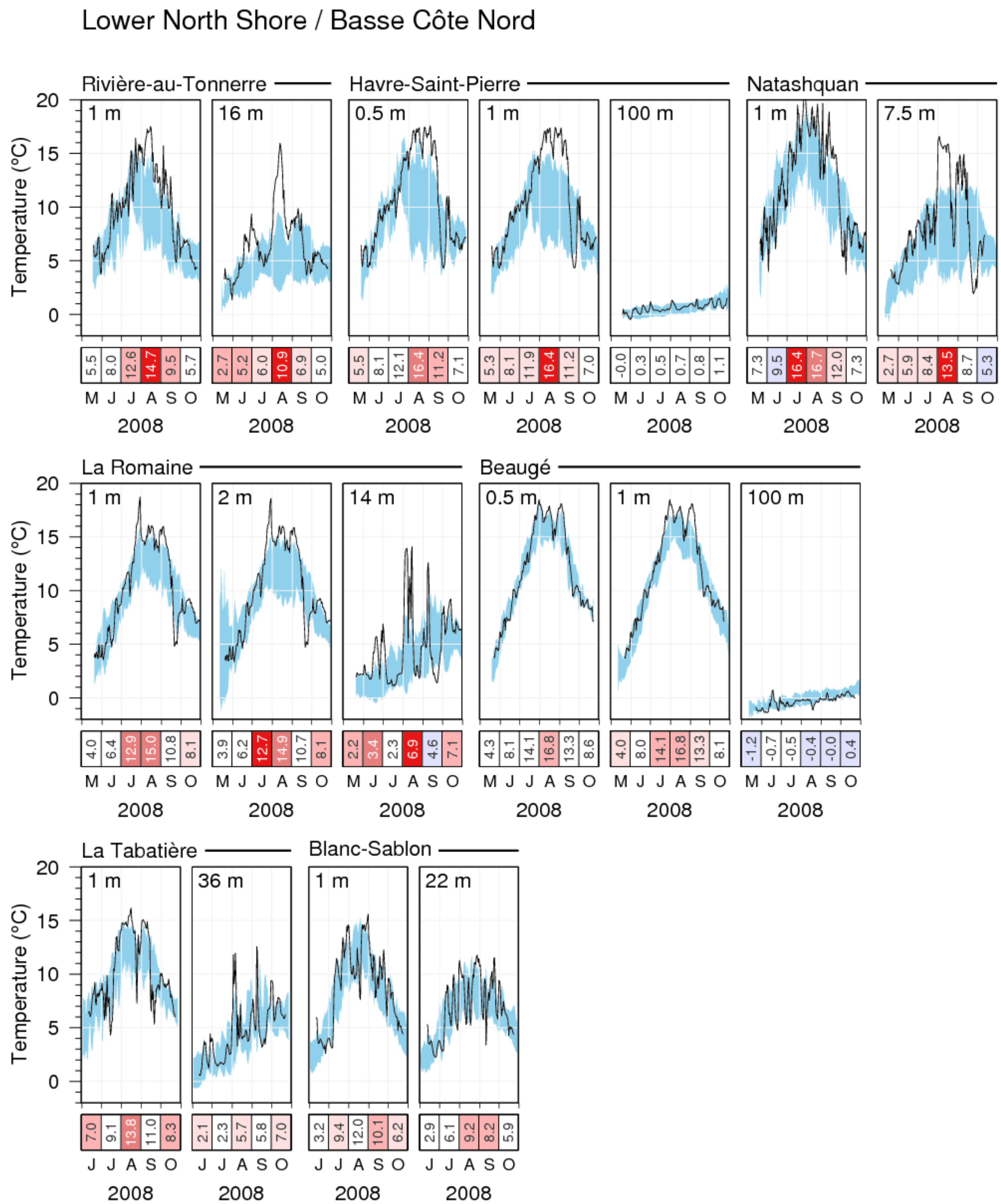

Fig. 8. Thermograph network data. Daily mean 2008 temperatures compared with the daily climatology (daily averages plus and minus one standard deviation; blue areas) computed from all available stations of the lower north shore.

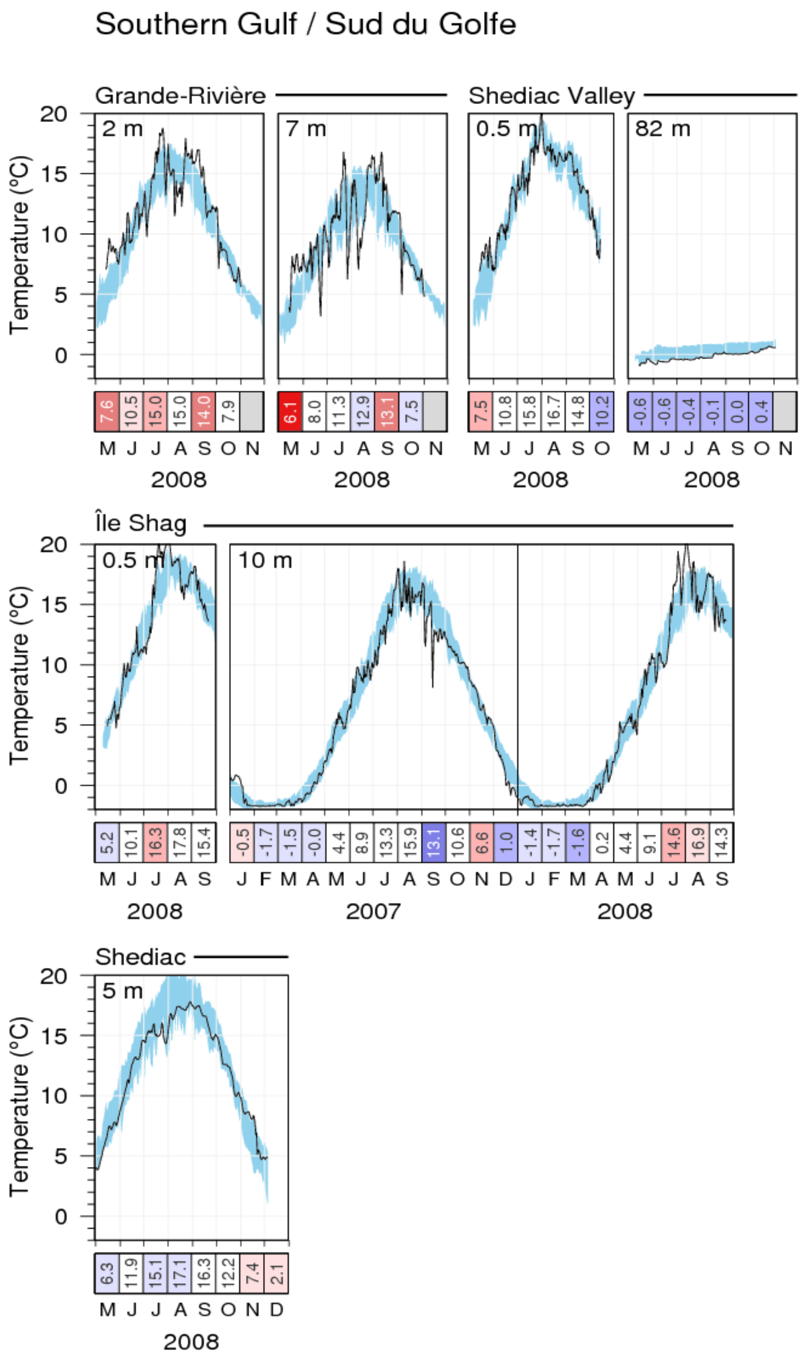

Fig. 9. Thermograph network data. Daily mean 2008 temperatures compared with the daily climatology (daily averages plus and minus one standard deviation; blue area) computed from all available stations of the southern Gulf. Shediac station from DFO Gulf Region is also shown.

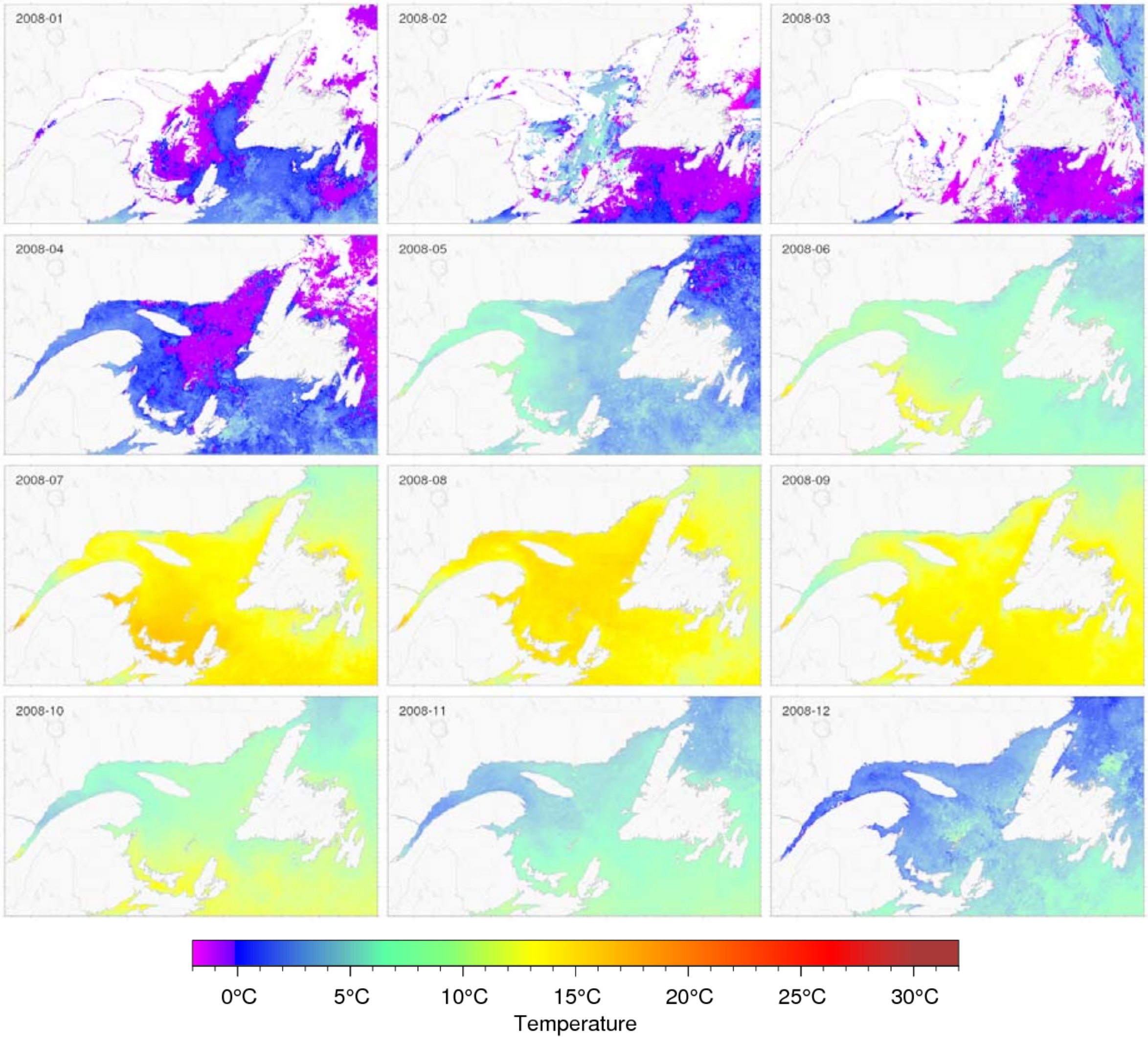

Fig. 10. Sea-surface temperature averages for the first 28 days of each month of 2008 as observed with NOAA AVHRR remote sensing. White areas have no data for the period due to ice cover.

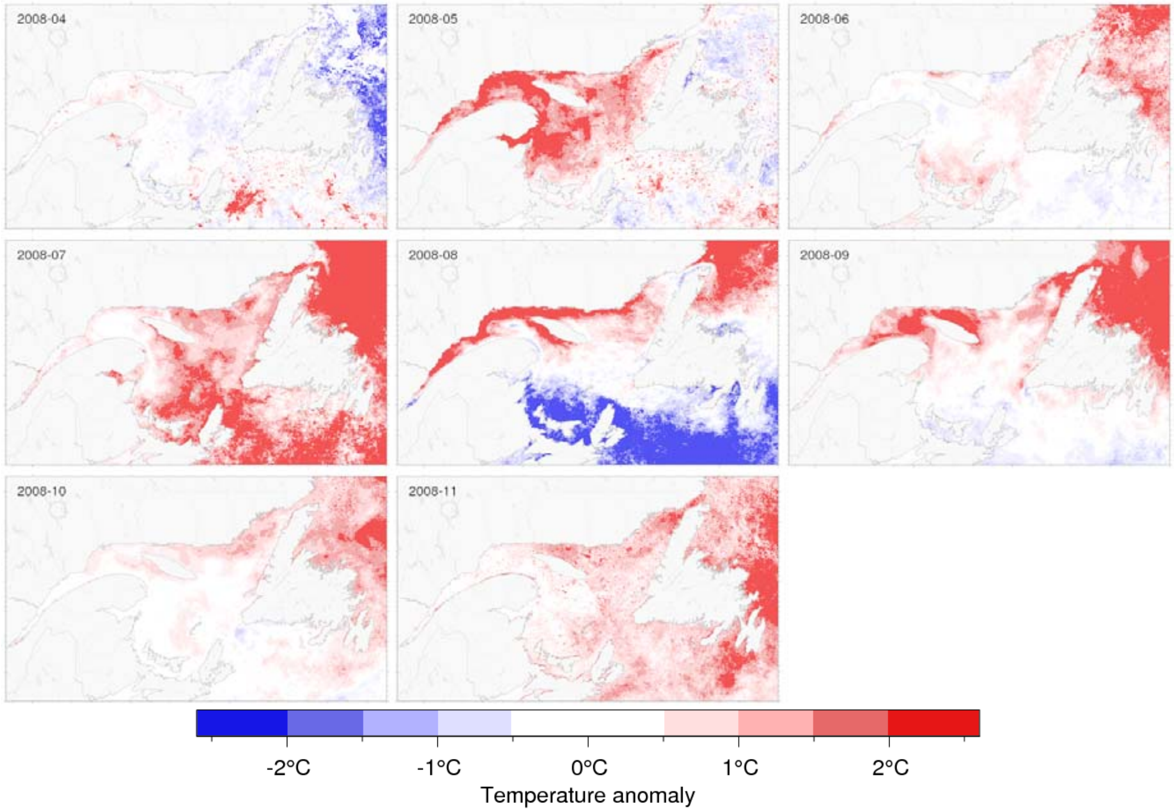

Fig. 11. Sea-surface temperature anomalies for the first 28 days of April through November 2008 based on monthly climatologies calculated for the 1985–2008 period observed with NOAA AVHRR remote sensing. Only ice-free months are shown.

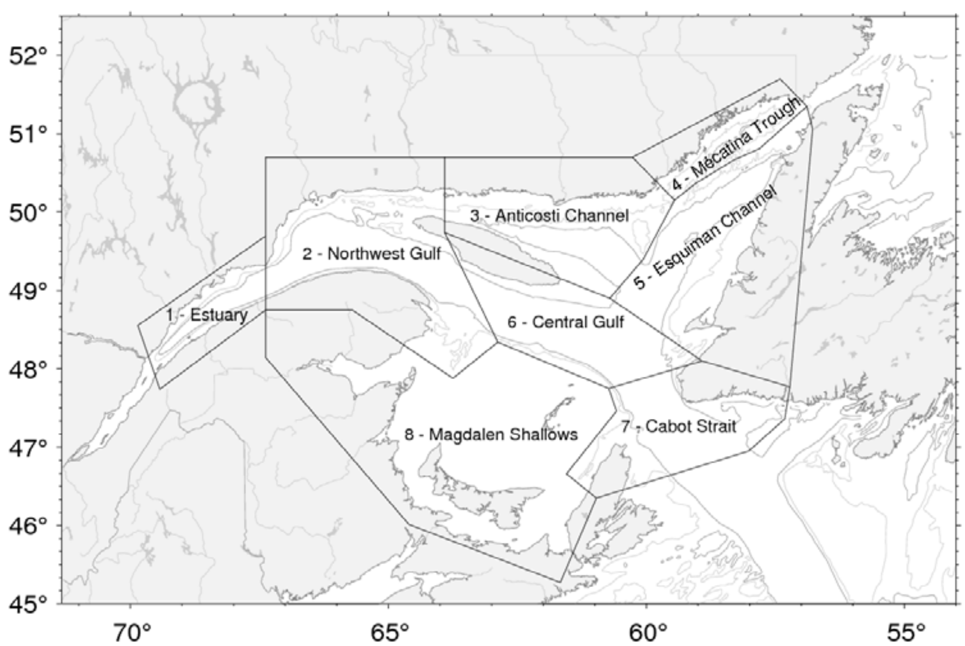

Fig. 12. Gulf of St. Lawrence divided into eight oceanographic regions. The intersection of regions 3, 4 and 5 has been altered since the previous annual report.

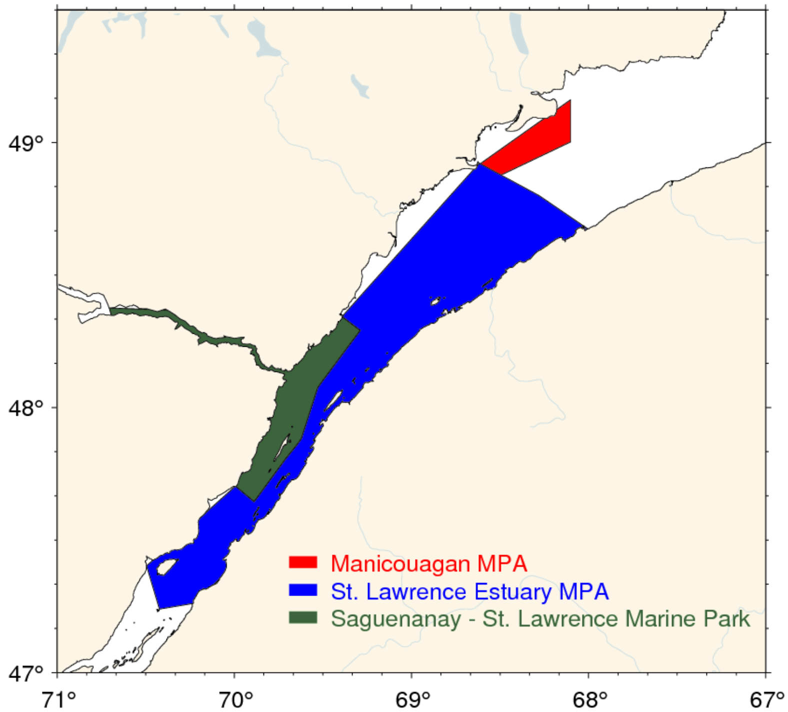

Fig. 13. Areas delimiting the Manicouagan MPA, the St. Lawrence Estuary MPA and the Saguenay – St. Lawrence Marine Park for the purpose of SST extraction from NOAA imagery.

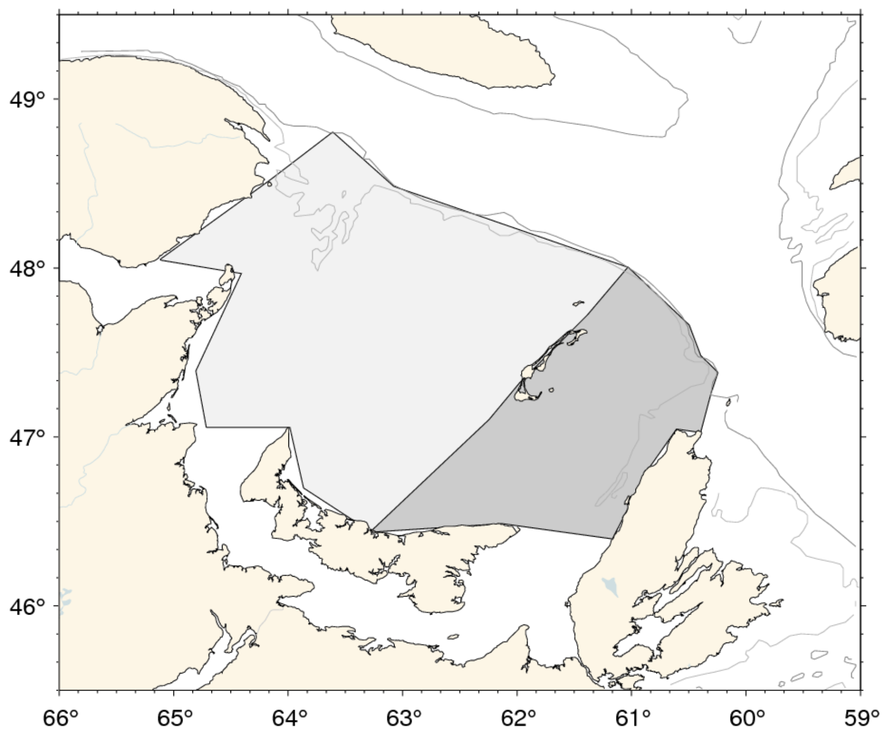

Fig. 14. Areas delimiting western and eastern Magdalen Shallows.

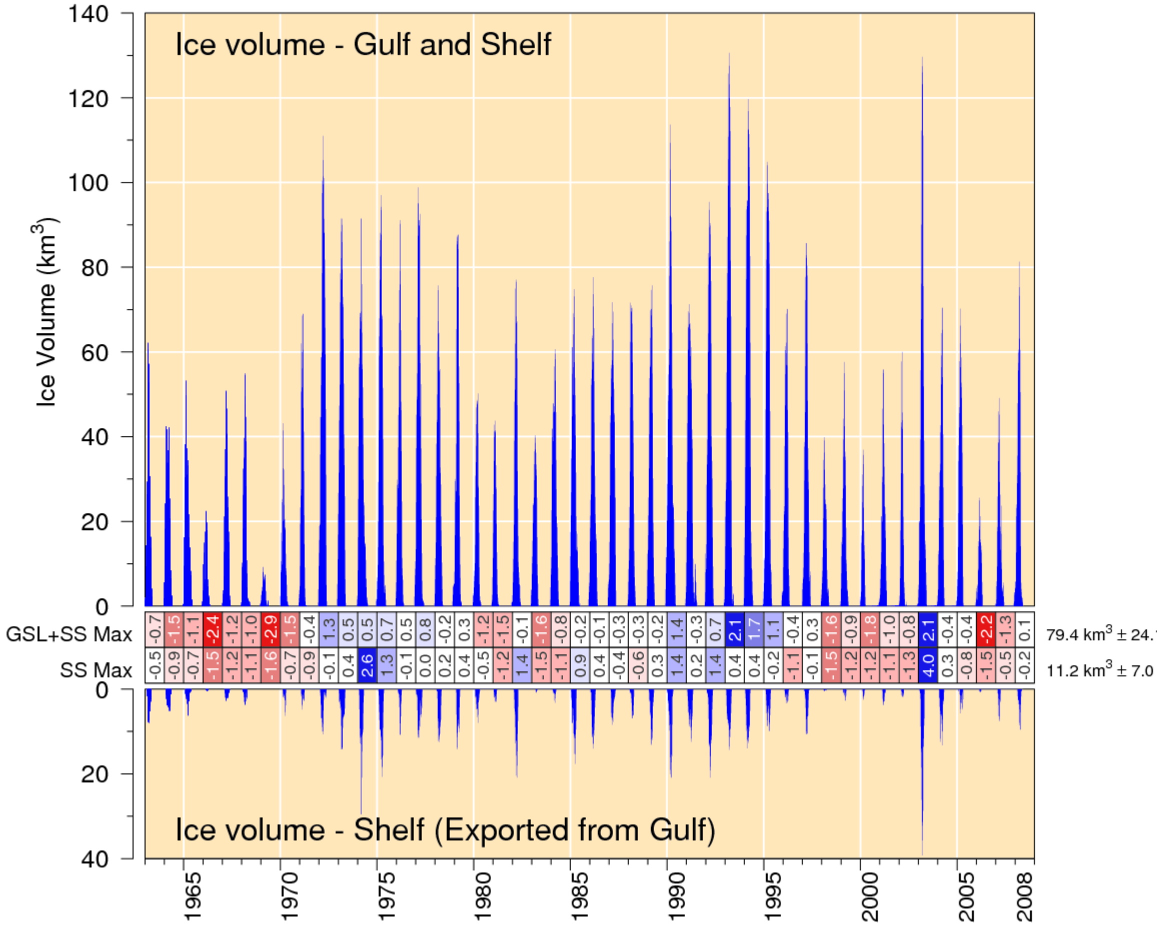

Fig. 15. Estimated ice volume in the Gulf of St. Lawrence and on the Scotian Shelf seaward of Cabot Strait (upper panel) and on the Scotian Shelf only (lower panel). Scorecard show numbered standardized anomalies for the combined Gulf and Shelf volume and the Shelf-only volume. The mean and standard deviation are indicated on the right side using the 1971-2000 climatology.

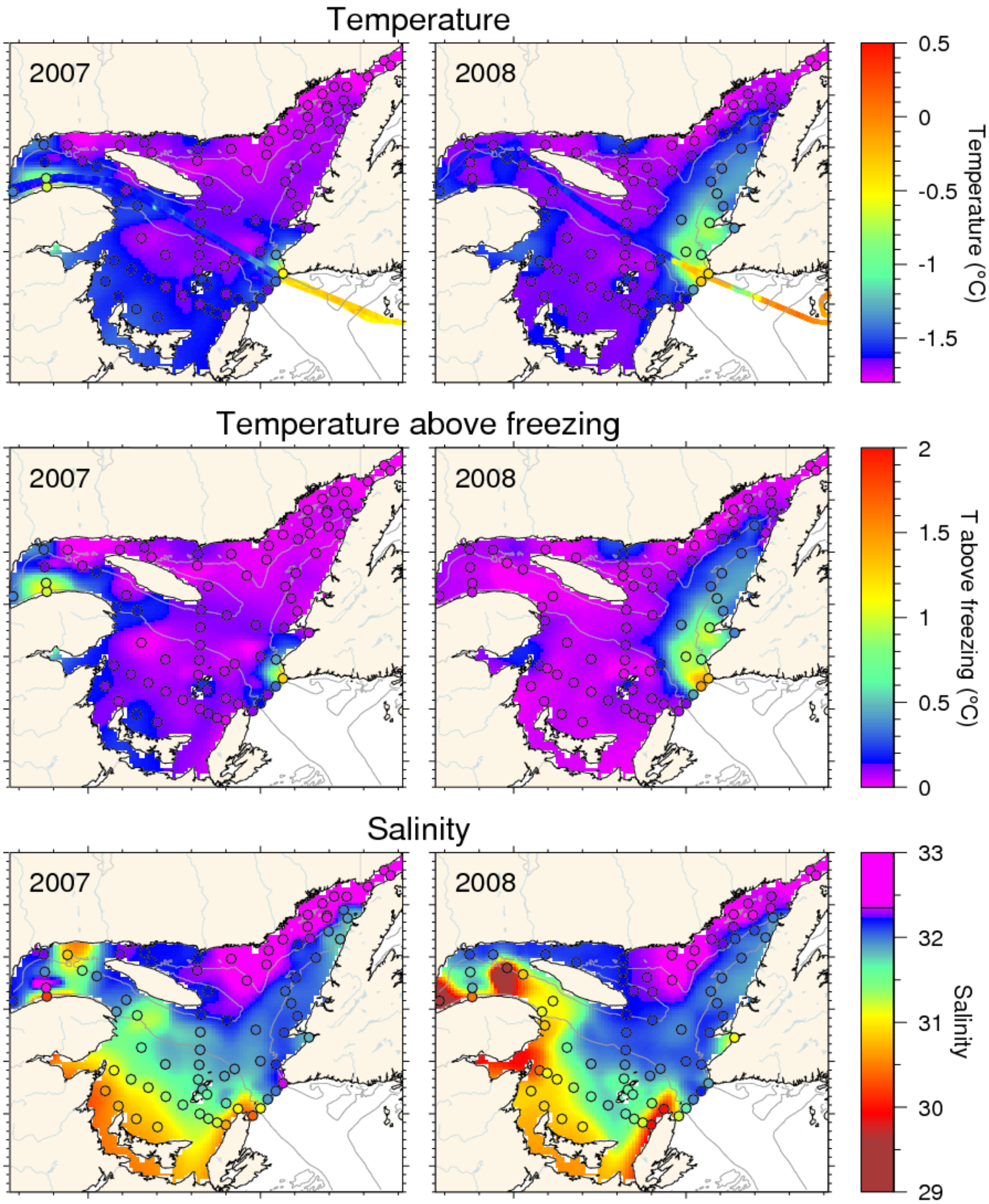

Fig. 16. Winter surface layer characteristics from the March 2007 and 2008 helicopter surveys. Surface water temperature (upper panel), temperature difference between surface water temperature and the freezing point (middle panel) and salinity (lower panel). The temperature measurements from shipboard 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.

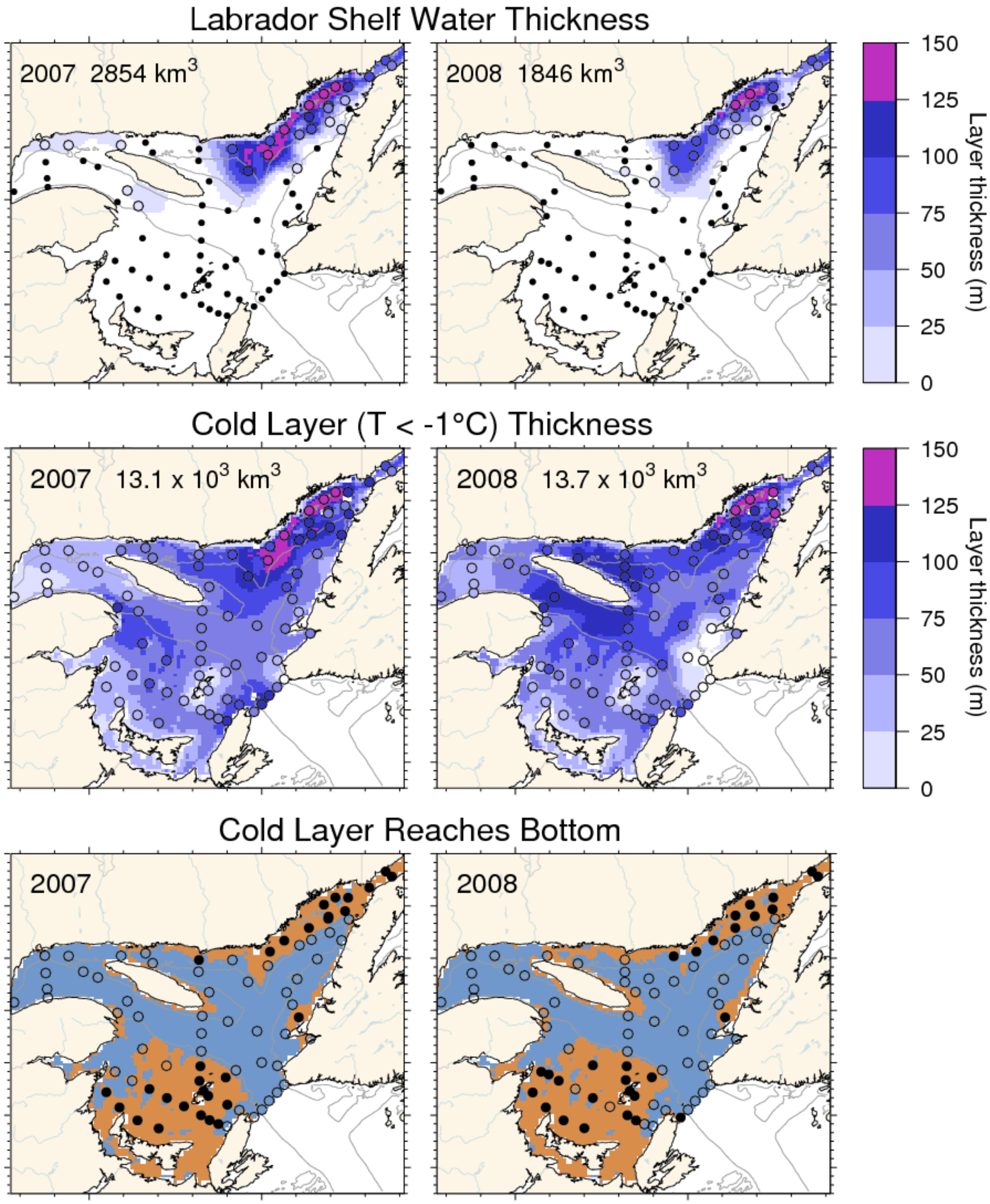

Fig. 17. Winter surface layer characteristics from the March 2007 and 2008 helicopter surveys. Estimates of the thickness of the Labrador Shelf water intrusion (upper panels), cold layer (T < -1°C) thickness (middle panels), and maps indicating where the cold layer reaches the bottom (in brown; lower panels). Station symbols are coloured according to the observed values as in Fig. 16. For the lower panels, the stations where the cold layer reached bottom are indicated with filled circles while open circles represent stations where the layer did not reach to the bottom.

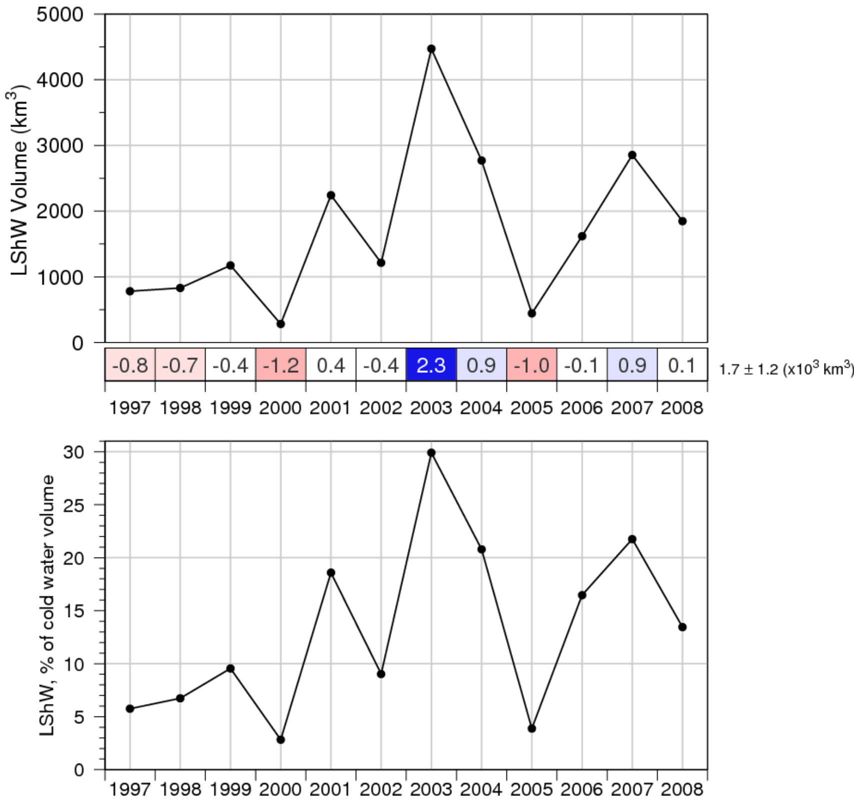

Fig. 18. Estimated volume of cold and saline Labrador Shelf water that flowed into the Gulf over the winter through the Strait of Belle Isle.

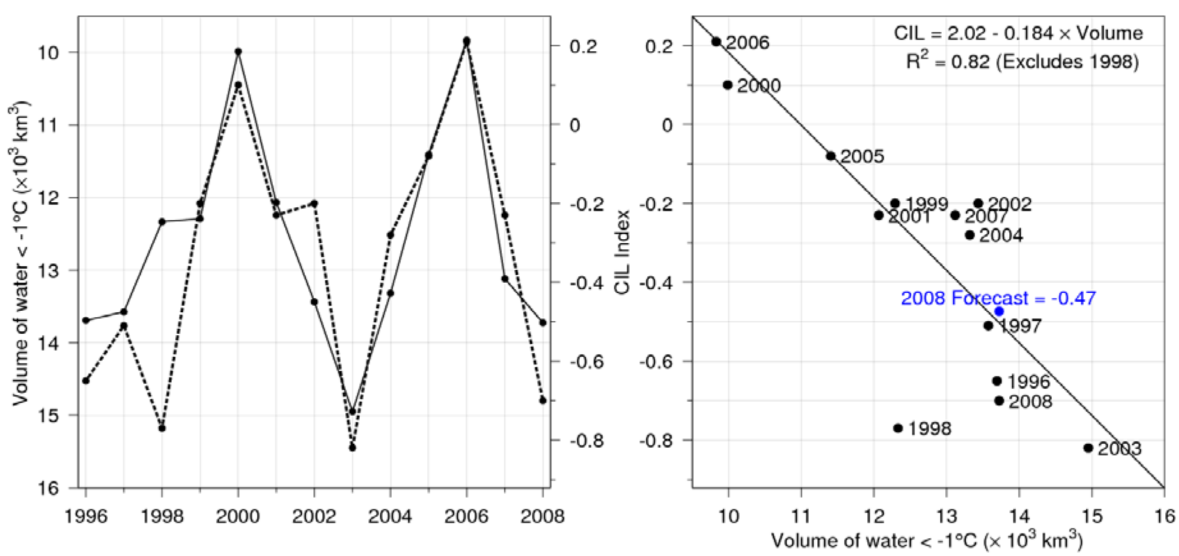

Fig. 19. Left panel: winter surface cold (T < -1°C) layer volume time series (solid line) and summer CIL index (dashed line). Right panel: Relation between summer CIL index and winter cold water volume (regression excludes 1998 data pair; see Galbraith 2006). Note that the volume scale in the left panel is reversed. The volume observed in March 2008 forecasted a CIL index of -0.47ºC (in blue) for summer 2008. The actual 2008 CIL index observed later in the year is also indicated (in black).

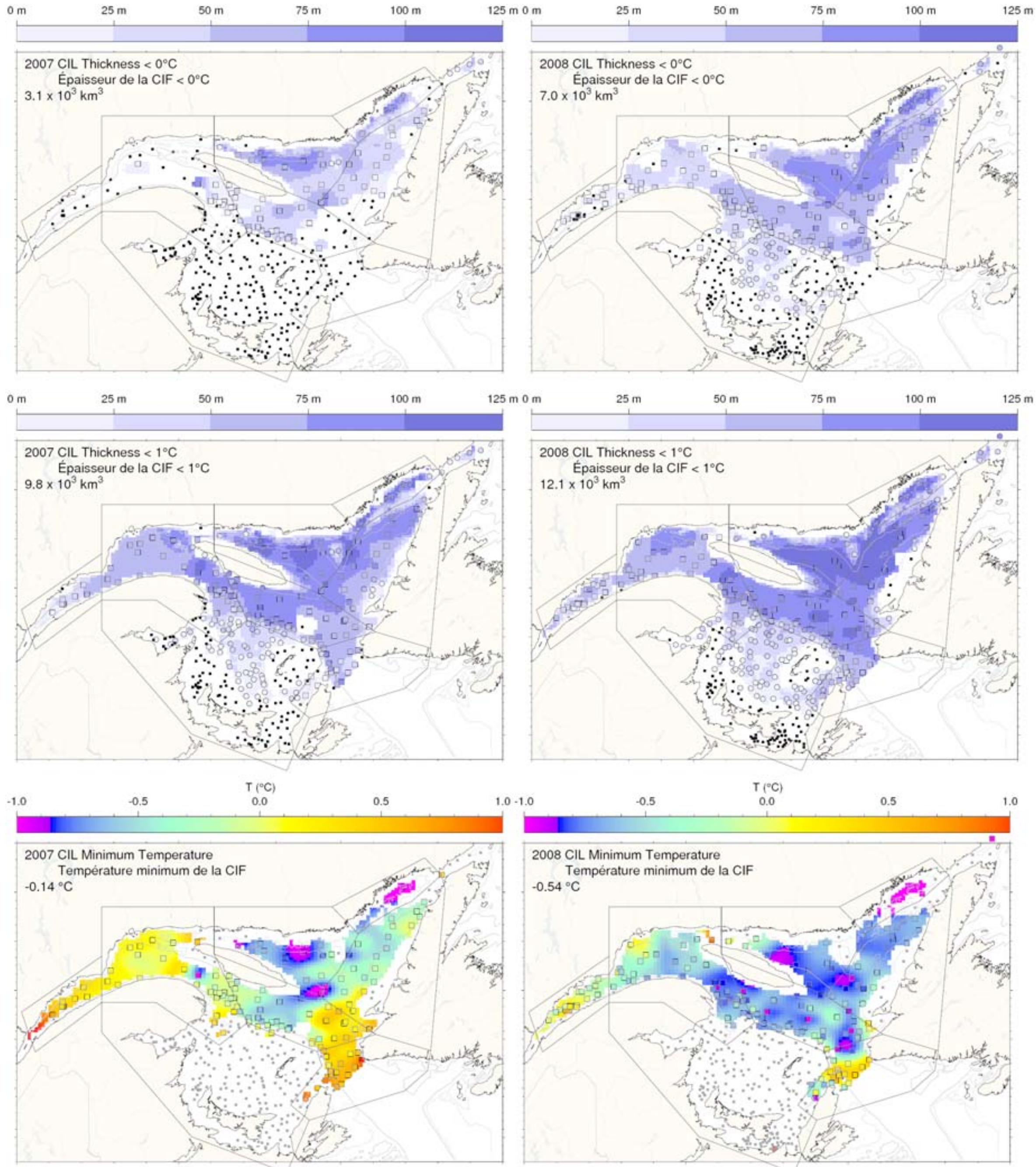

Fig. 20. Cold intermediate layer thickness (T < 0ºC, top panels; T < 1ºC, middle panels) and minimum temperature (bottom panels) in August and September 2007 (left) and 2008 (right).

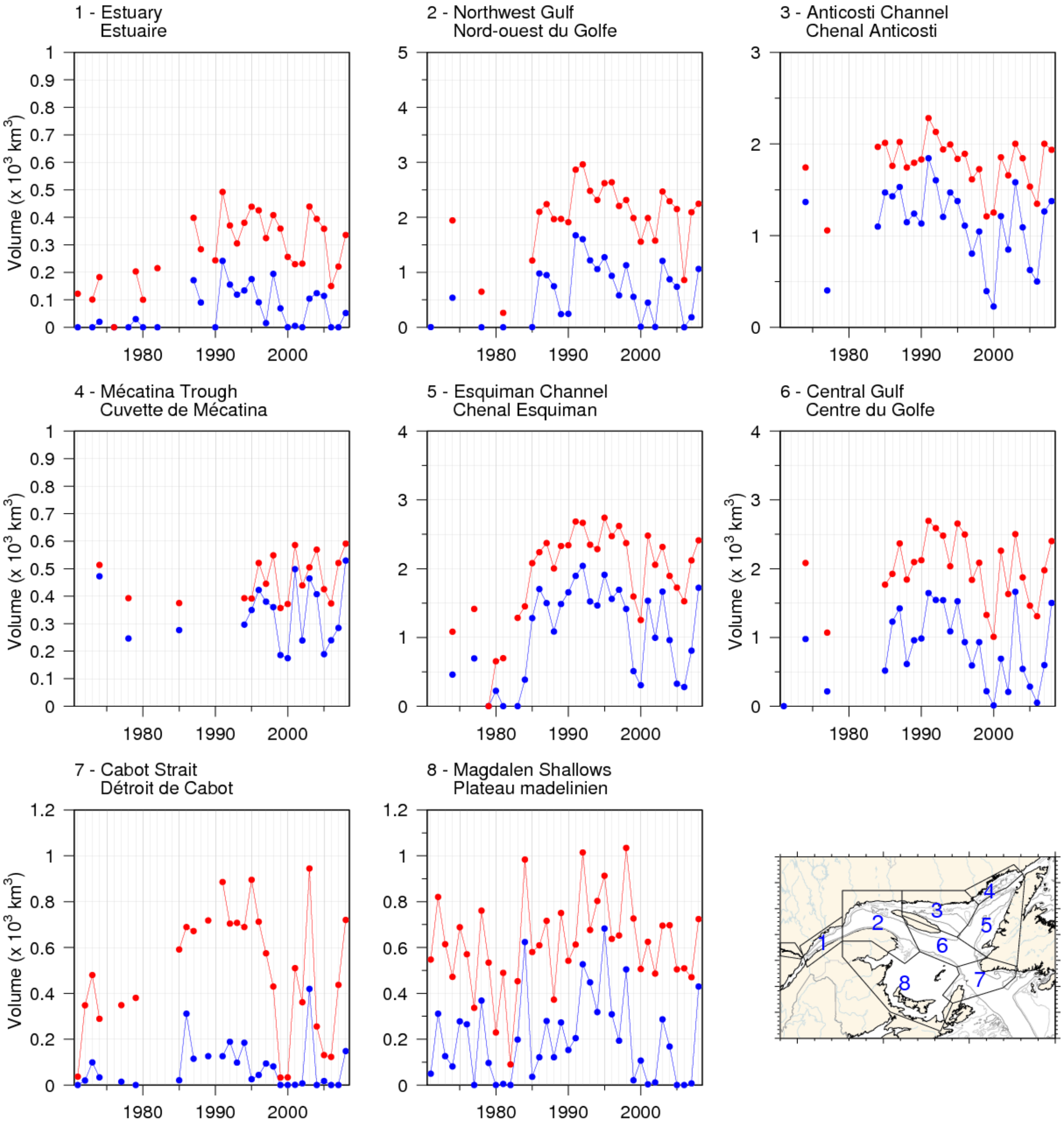

Fig. 21. Volume of the CIL colder than 0ºC (blue) and colder than 1ºC (red) in August and September (mostly region 8 in September).

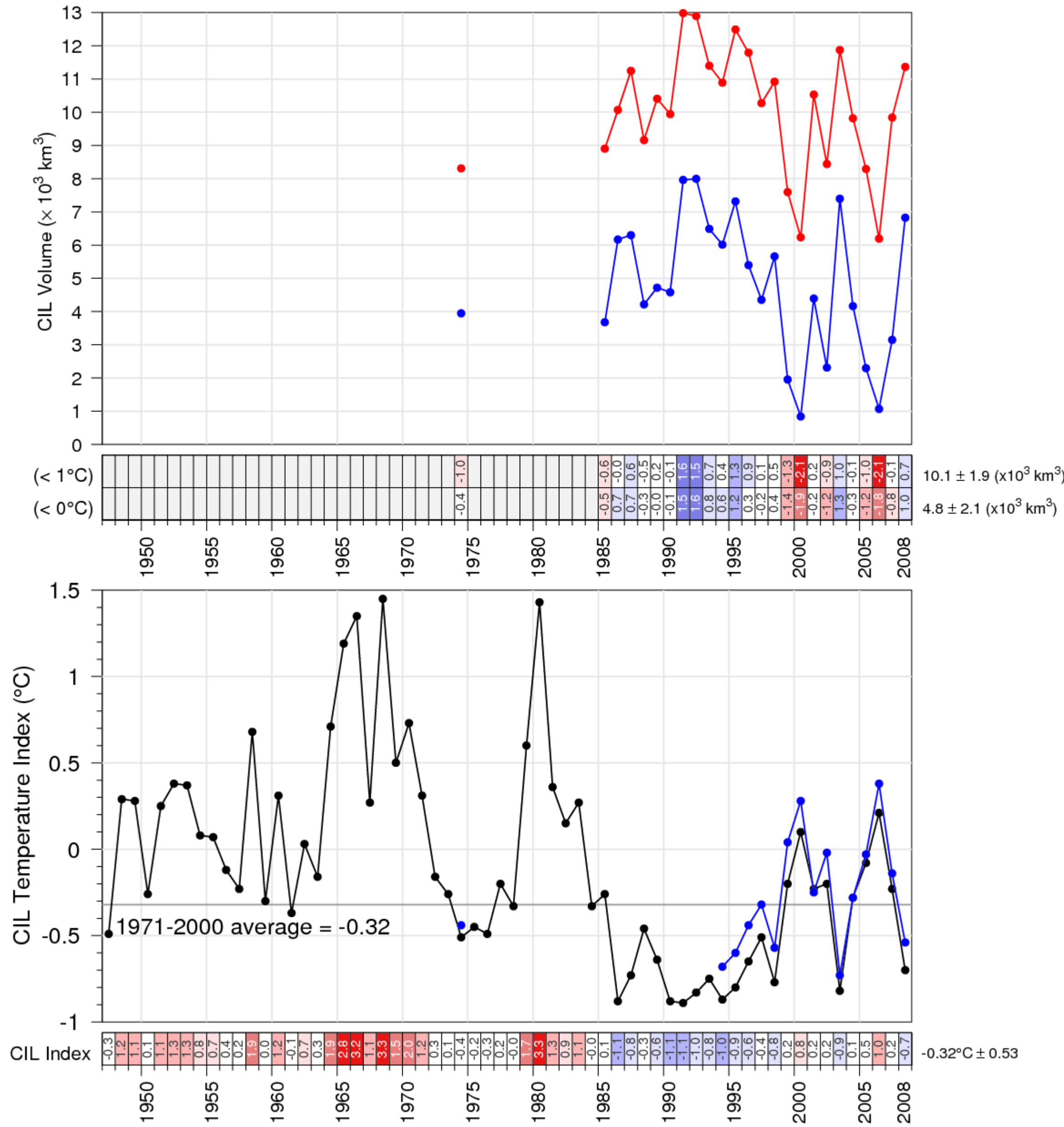

Fig. 22. CIL volume (top panel), delimited by the over- and underlying 0ºC (in blue) and 1ºC (in red) isotherms, and minimum temperature index (bottom panel) in the Gulf of St. Lawrence. The volumes are integrals of each of the annual interpolated thickness grids such as those shown in the top panels of Fig. 20. 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. 20.

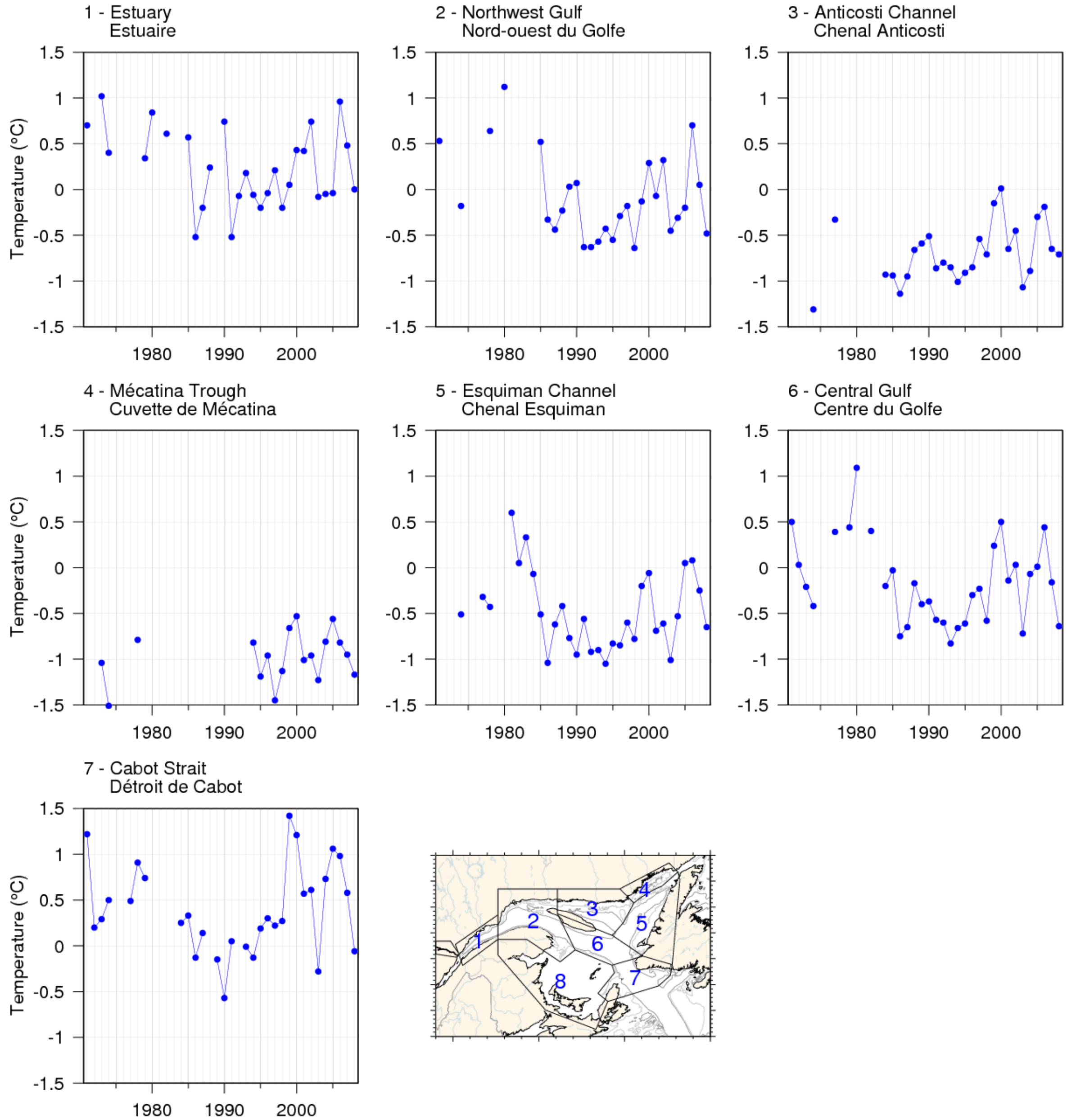

Fig. 23. Temperature minimum of the CIL spatially averaged for the seven areas where the CIL was found.

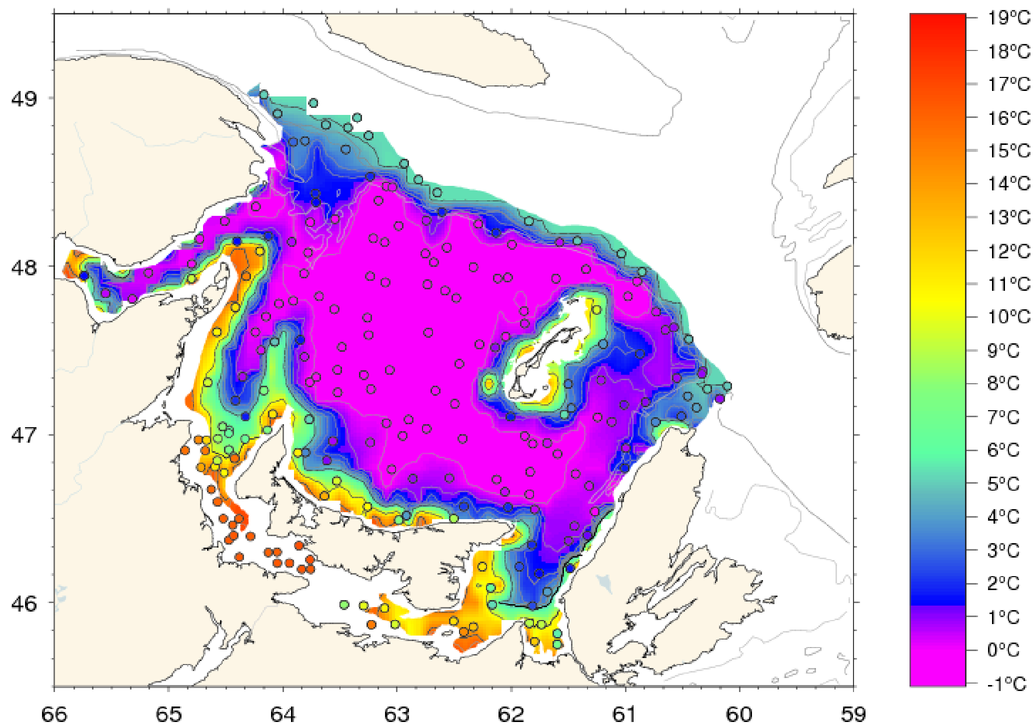

Fig. 24. Near-bottom temperatures during the 2008 September multi-species survey.

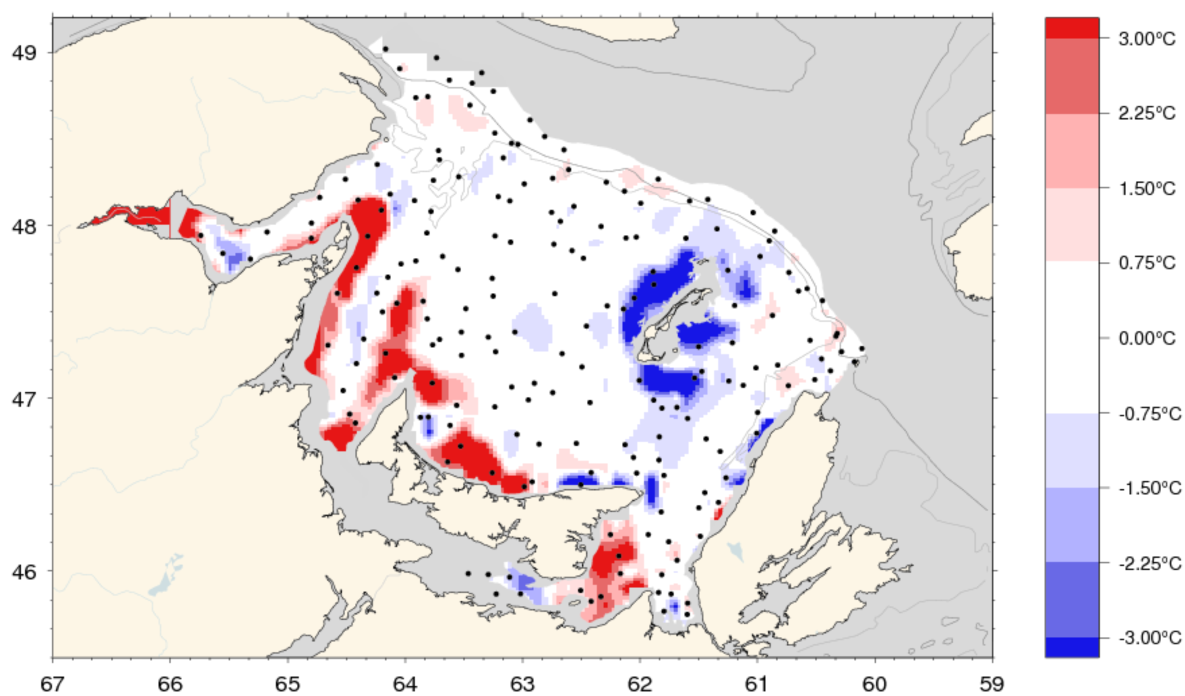

Fig. 25. Near-bottom temperature anomalies based on the 1971–2000 climatology in the southern Gulf of St. Lawrence during the 2008 September multi-species survey.

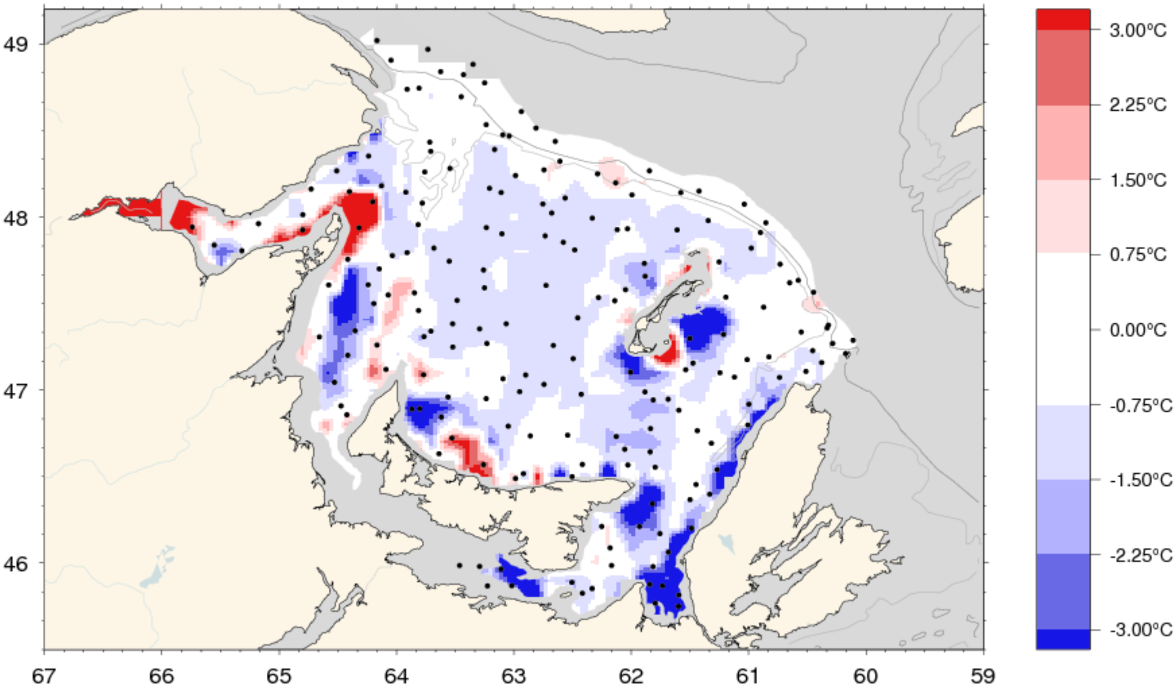

Fig. 26. The difference between the 2008 and 2007 bottom temperature fields in the southern Gulf of St. Lawrence for the September surveys.

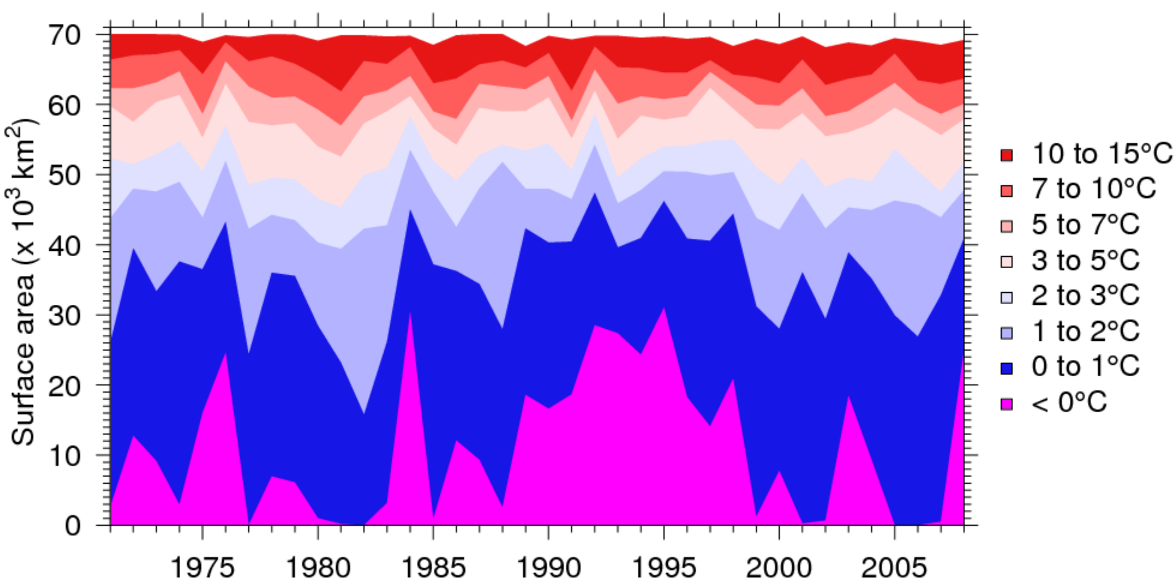

Fig. 27. Time series of the areas of the Magdalen Shallows covered by different temperature bins in September.

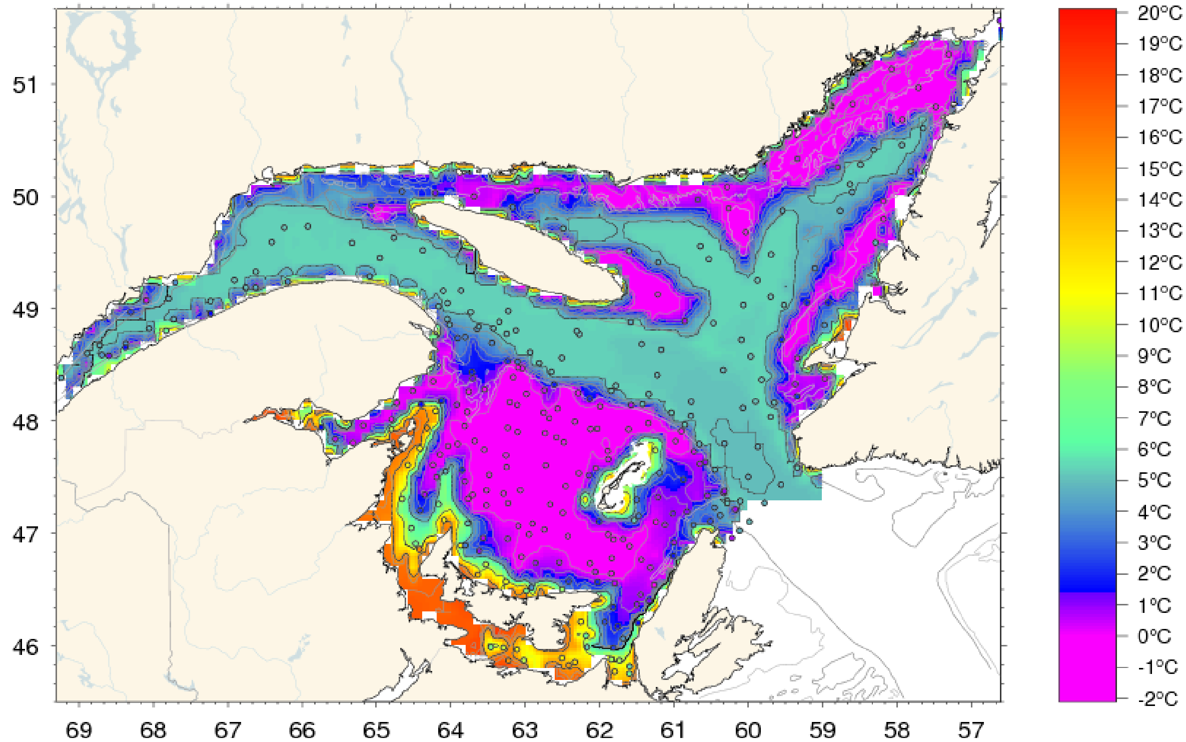

Fig. 28. Near-bottom temperatures during the 2008 August and September multi-species surveys in the northern and southern Gulf respectively.

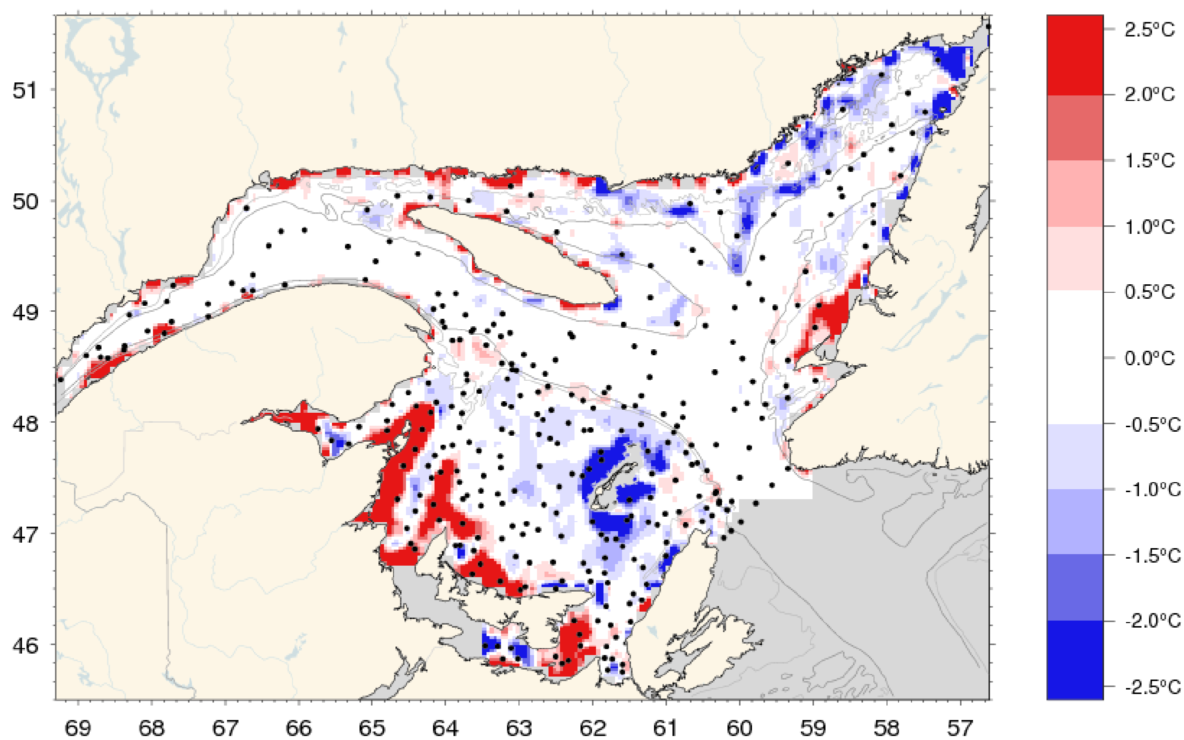

Fig. 29. Near-bottom temperature anomalies based on the 1971–2000 climatology in the Gulf of St. Lawrence during the 2008 August and September multi-species surveys.

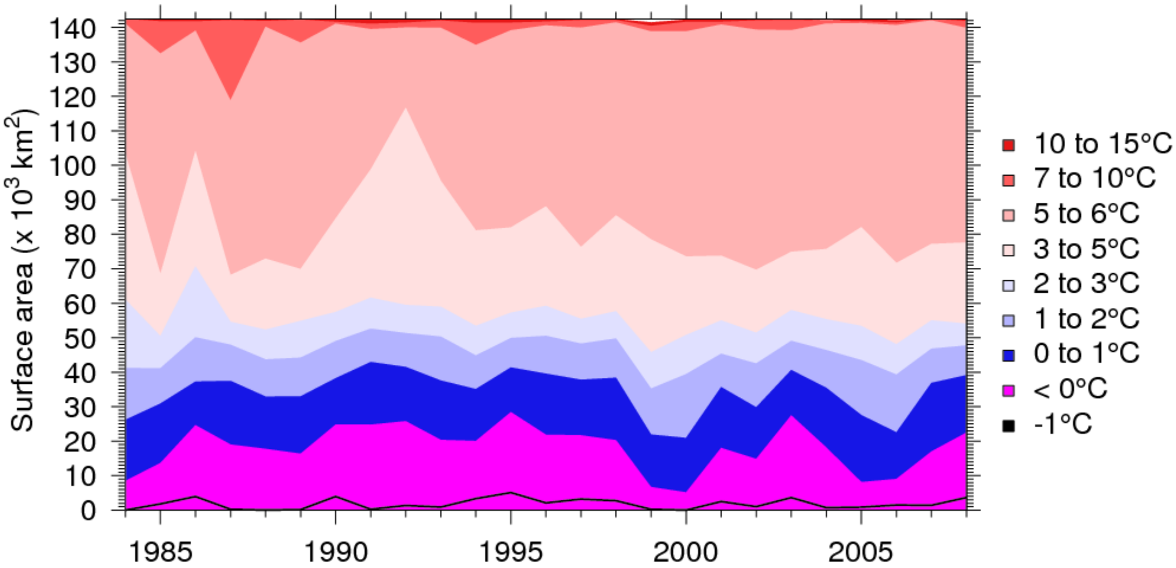

Fig. 30. Time series of the bottom areas covered by different temperature bins in August in the northern Gulf of St. Lawrence (i.e., the area of the Gulf that is not covered in Fig. 24).

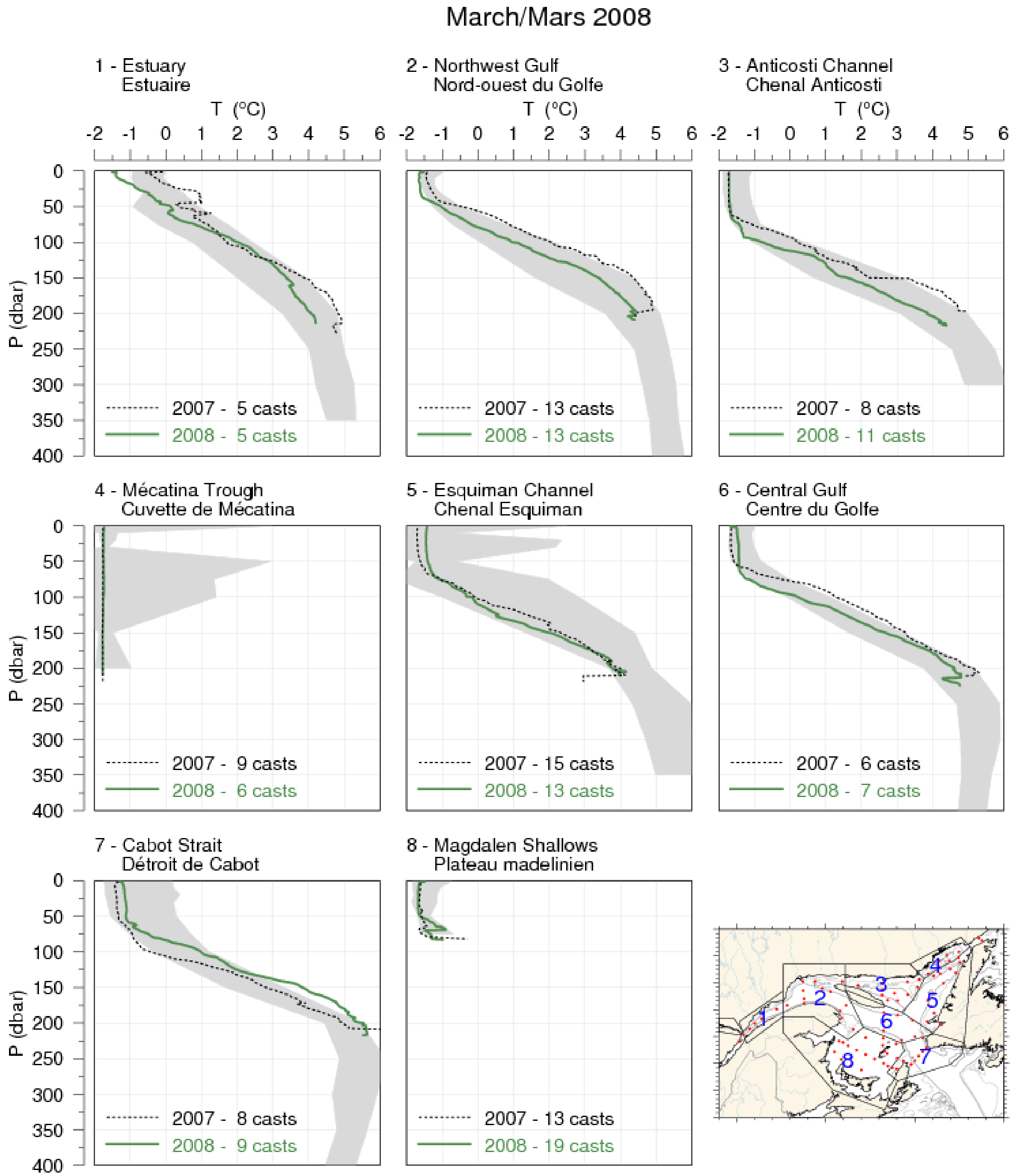

Fig. 31. Mean temperature profiles observed in each region of the Gulf during the March helicopter survey. The shaded area represents the 1971–2008 (but mostly 1996–2008) climatological monthly mean plus and minus one standard deviation. Mean profiles for the 2007 survey are also shown for comparison.

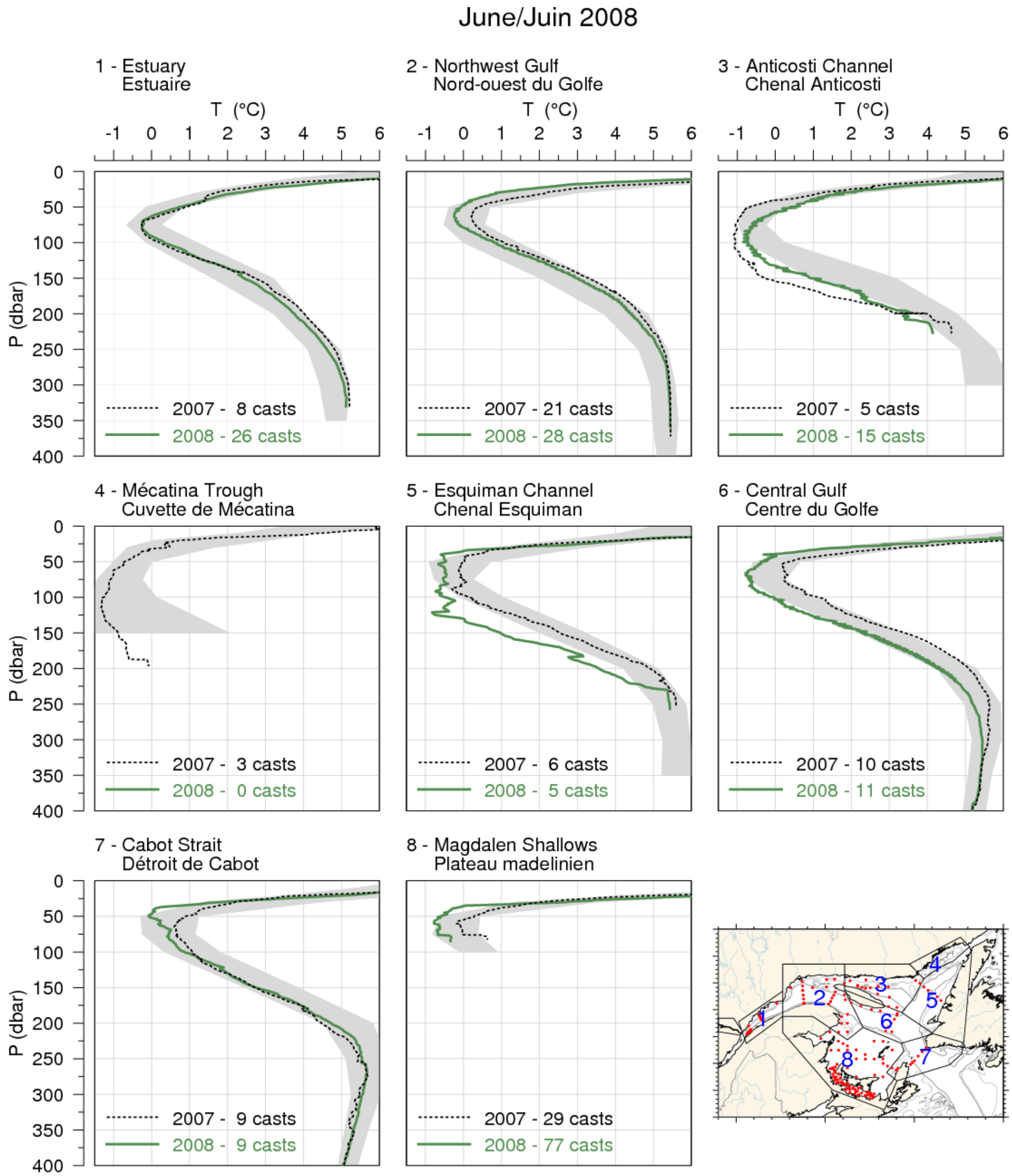

Fig. 32. Mean temperature profiles observed in each region of the Gulf during June. The shaded area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation. Mean profiles for the 2007 survey are also shown for comparison.

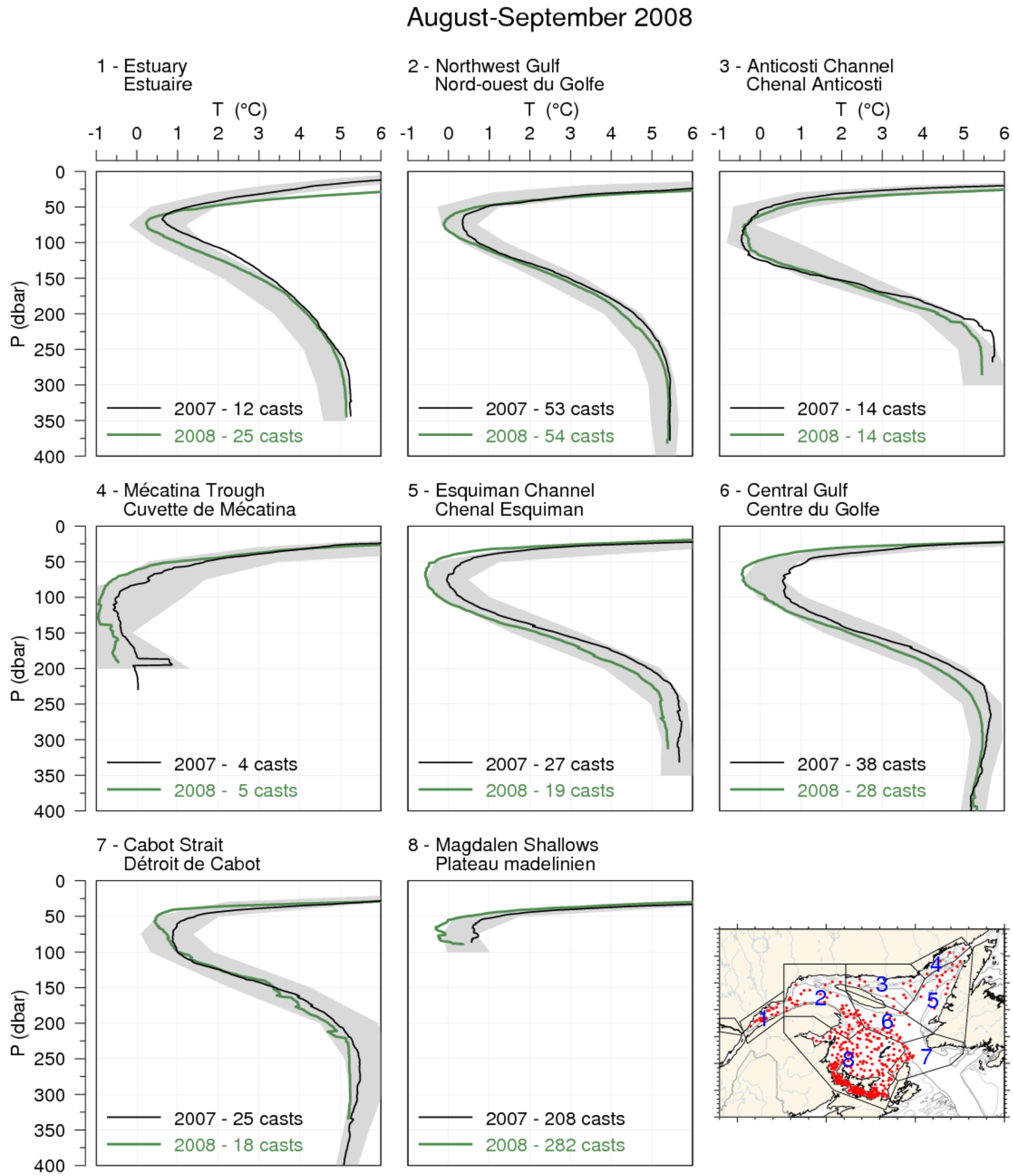

Fig. 33. Mean temperature profiles observed in each region of the Gulf during August and September. The shaded area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation for August for regions 1 through 7, and for September for region 8. Mean profiles for the 2007 survey are also shown for comparison.

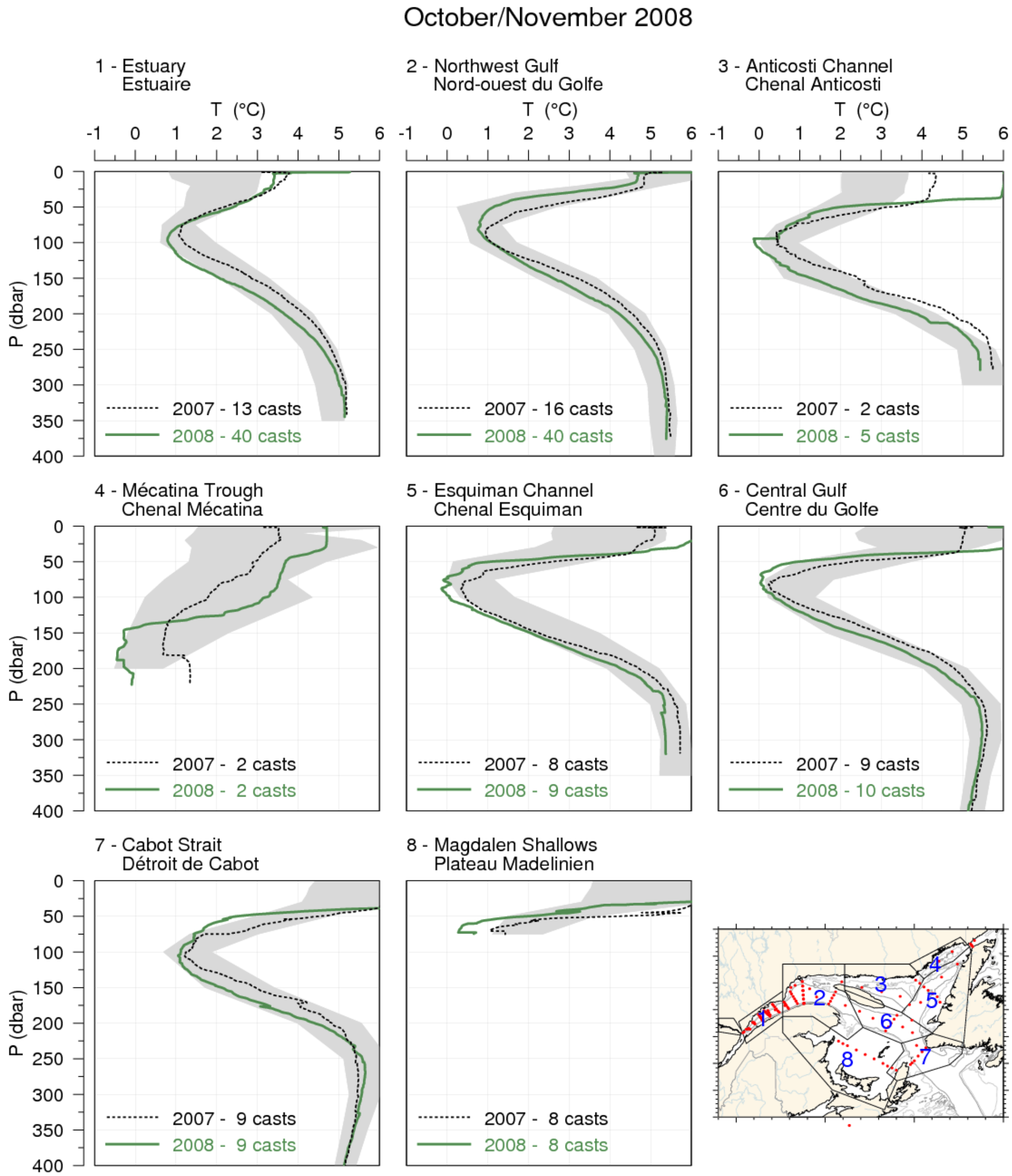

Fig. 34. Mean temperature profiles observed in each region of the Gulf during the November AZMP survey. The shaded area represents the 1971–2000 climatological monthly mean plus and minus one standard deviation. Mean profiles for the 2007 survey are also shown for comparison. Region 2 was mostly sampled during October, so the October monthly climatology is shown for that region while the others show the climatology for November.

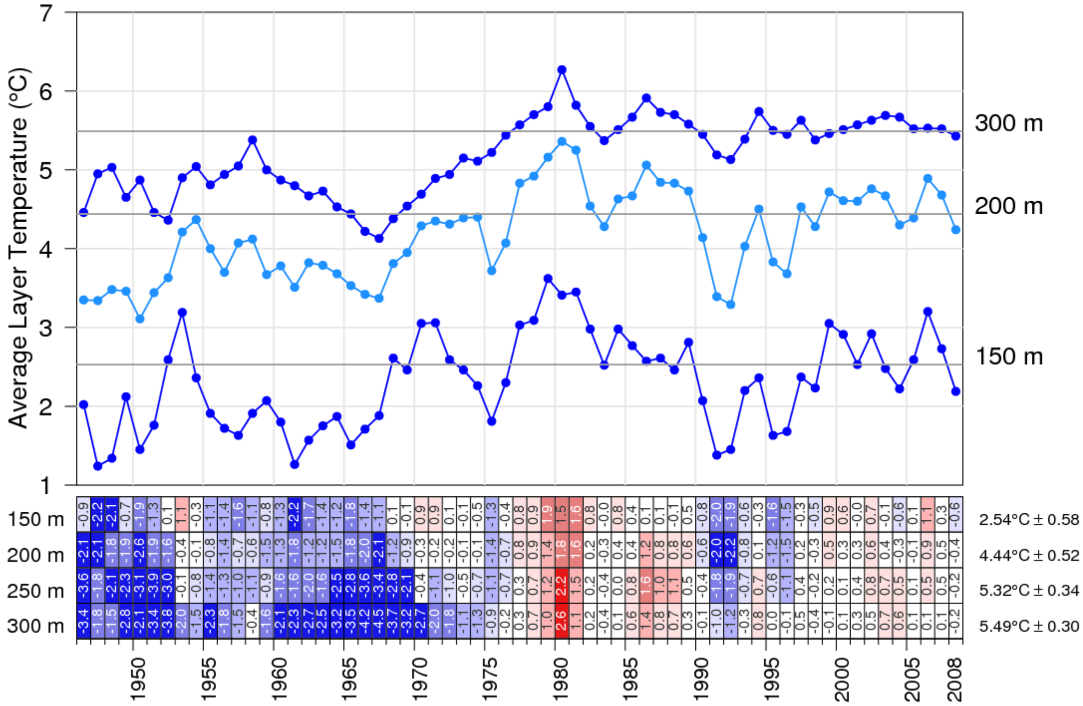

Fig. 35. Layer-averaged temperature time series for the Gulf of St. Lawrence. The graph shows the 150 m, 200 m and 300 m depth averages. The scorecard panel shows the time series of the same depths as well as the 250 m layer. The anomalies are calculated based on the 1971–2000 period.

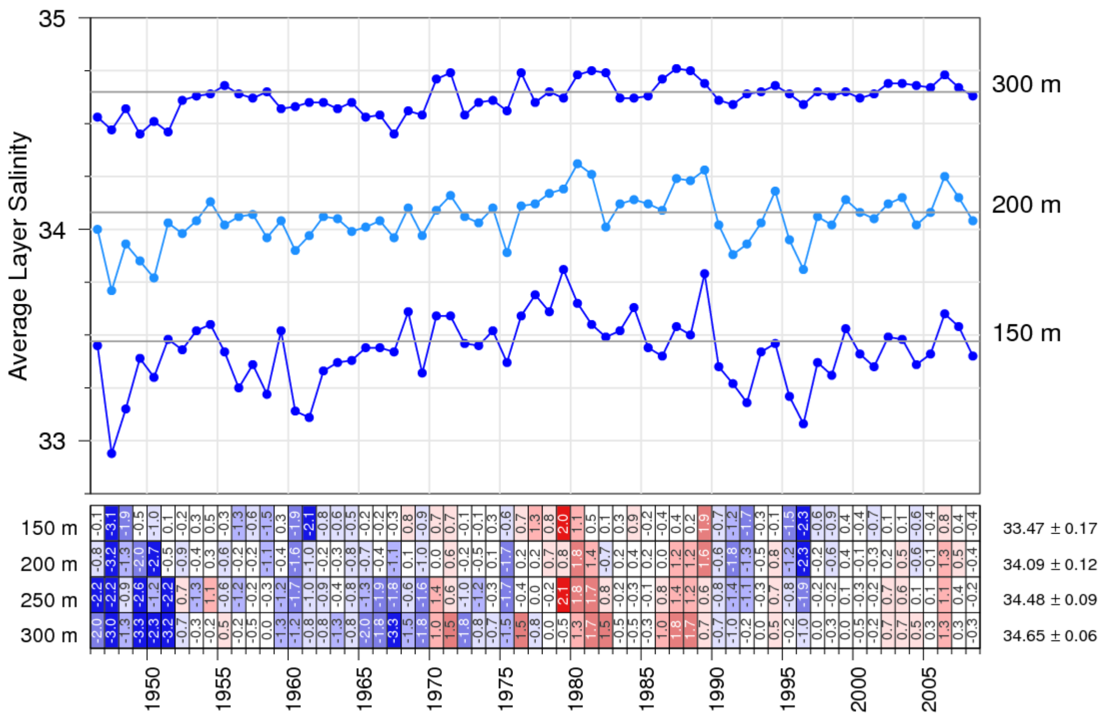

Fig. 36. Layer-averaged salinity time series for the Gulf of St. Lawrence. Other details are given in the legend of Fig. 35.

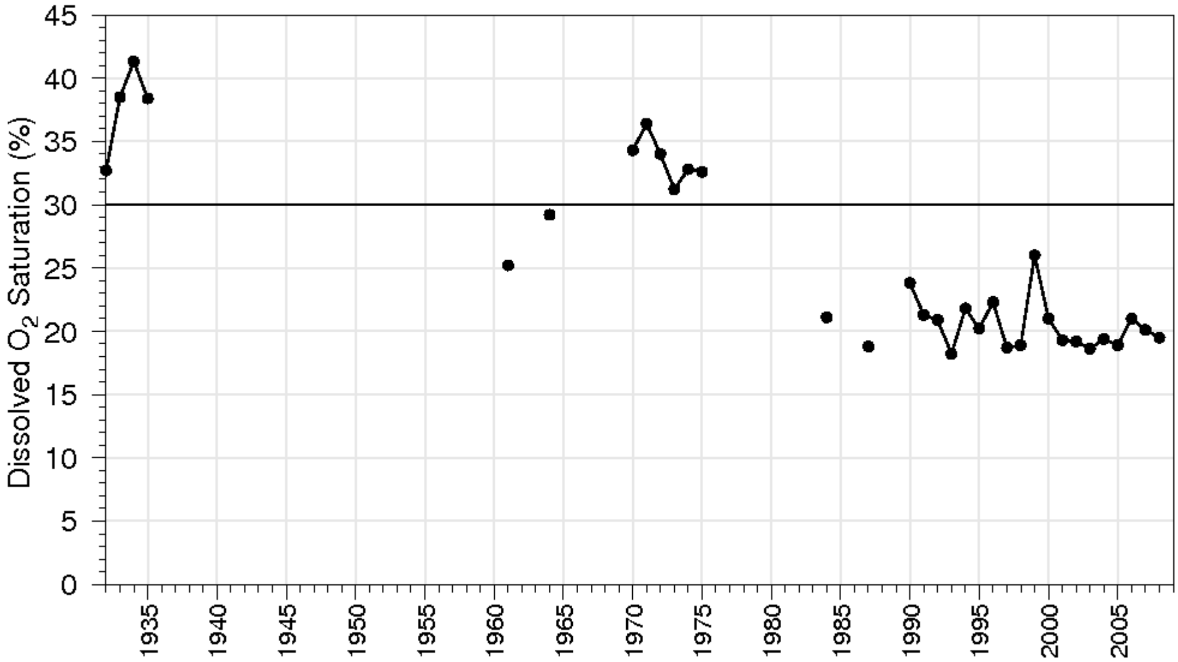

Fig. 37. Dissolved oxygen saturation between 295 m and the bottom in the deep central basin of the St. Lawrence Estuary. The horizontal line at 30% saturation marks the threshold of hypoxic conditions.

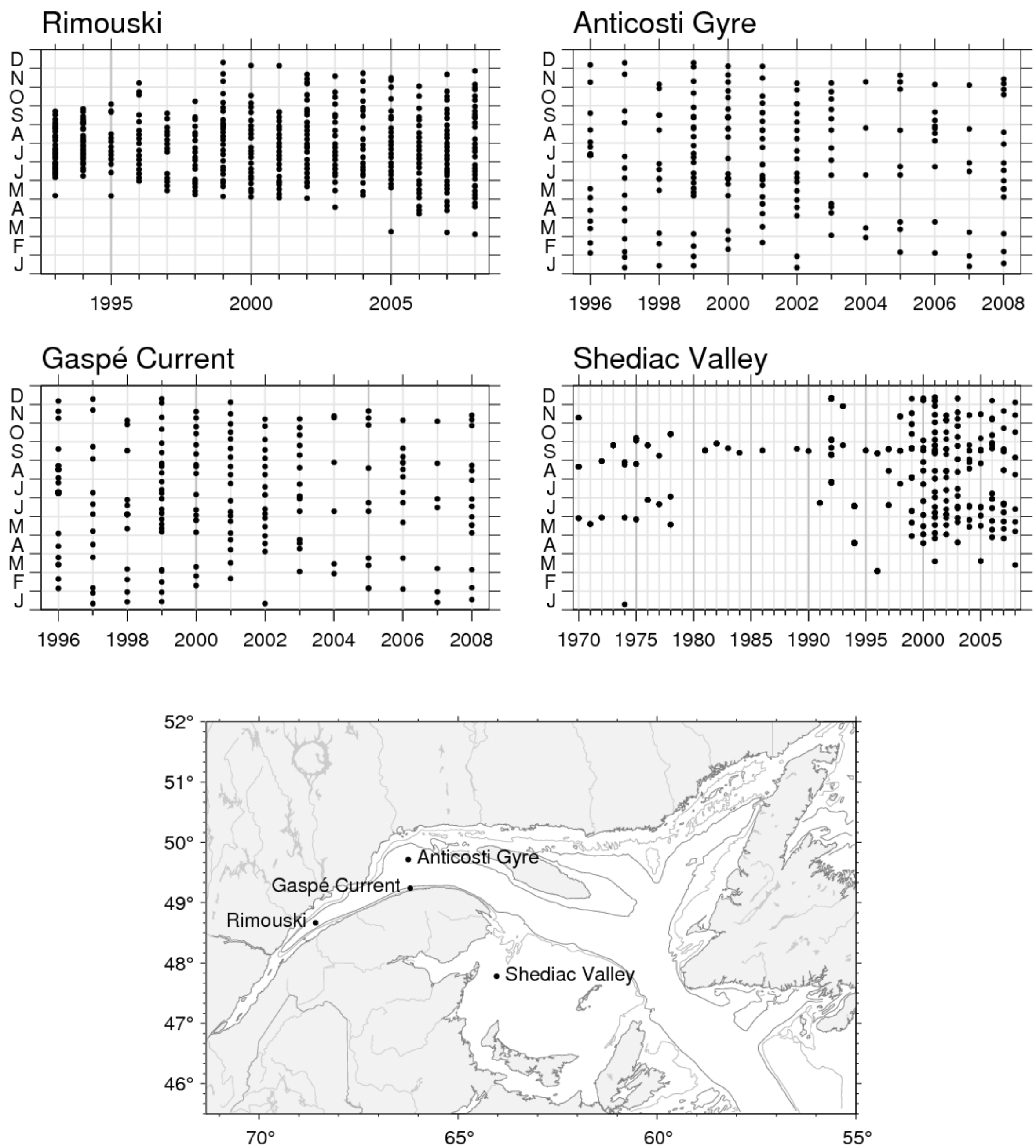

Fig. 38. Sampling frequency and positions of the AZMP stations (Rimouski, Anticosti Gyre, Gaspé Current and Shediac Valley).

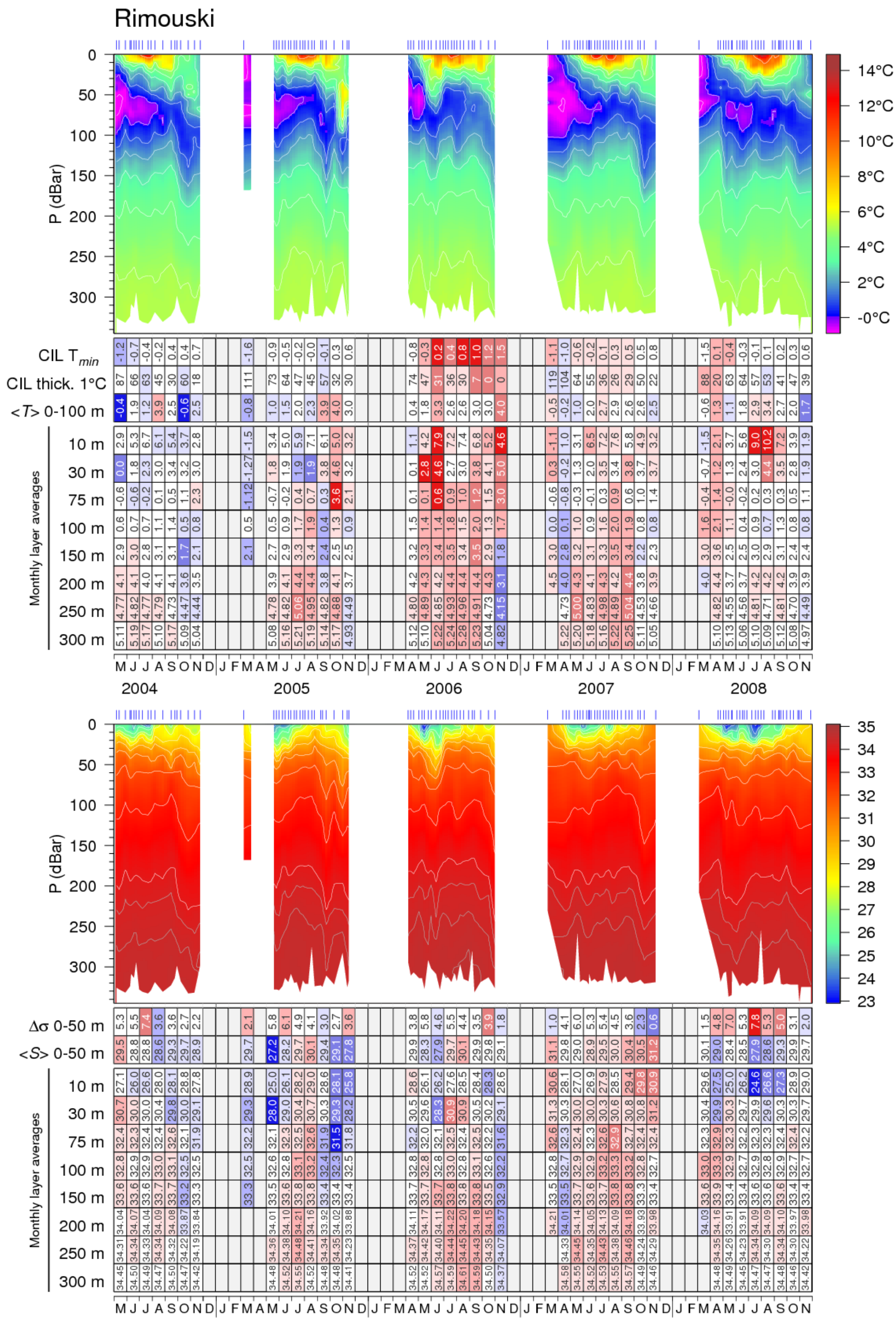

Fig. 39. Isotherm (top) and isohaline (bottom) time series at the Rimouski station; tick marks above indicate sample dates. The scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the monthly climatology for the station (yearly climatology for 250 m and deeper).

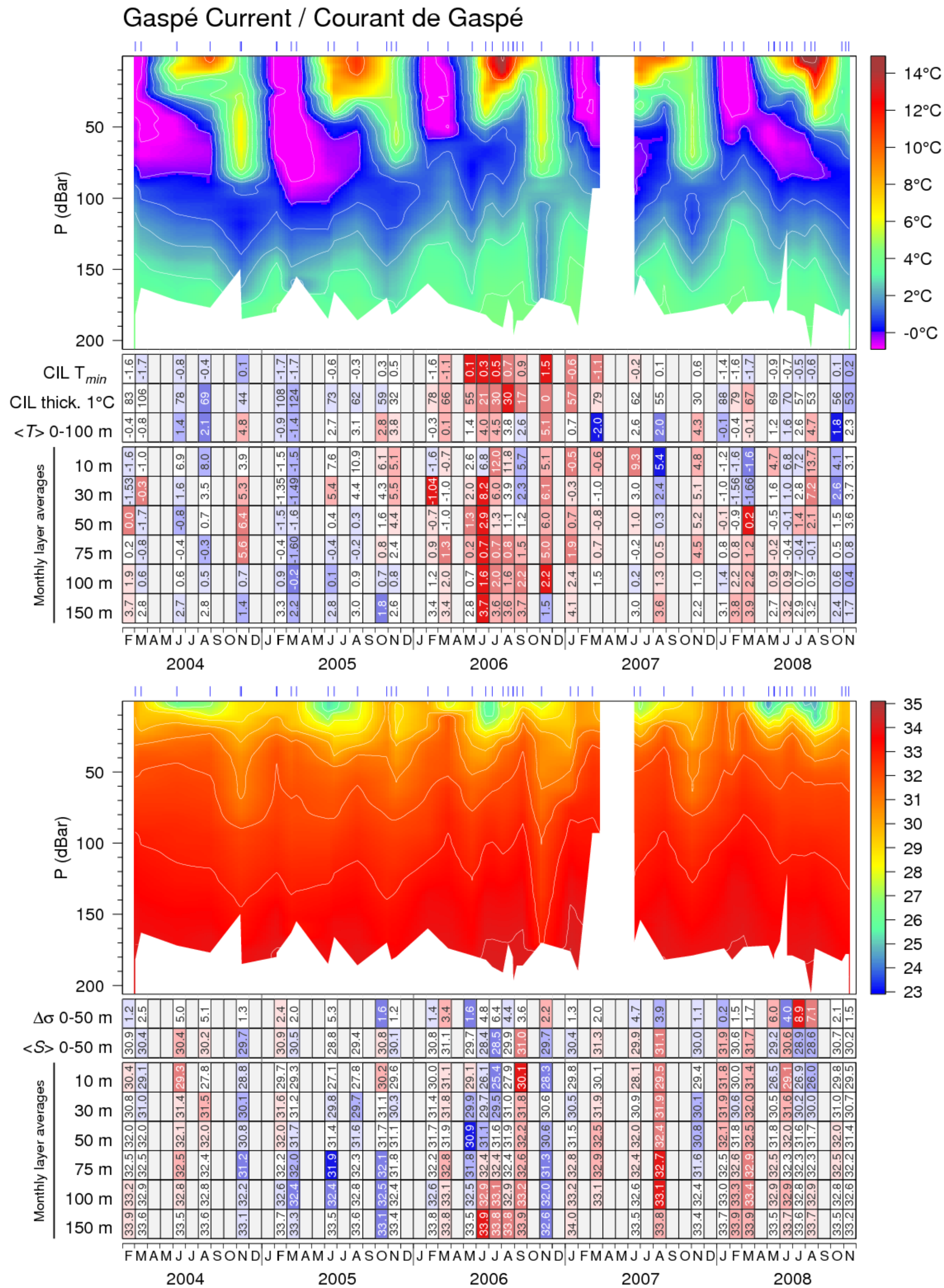

Fig. 40. Isotherm (top) and isohaline (bottom) time series at the Gaspé Current station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the monthly climatology for the station.

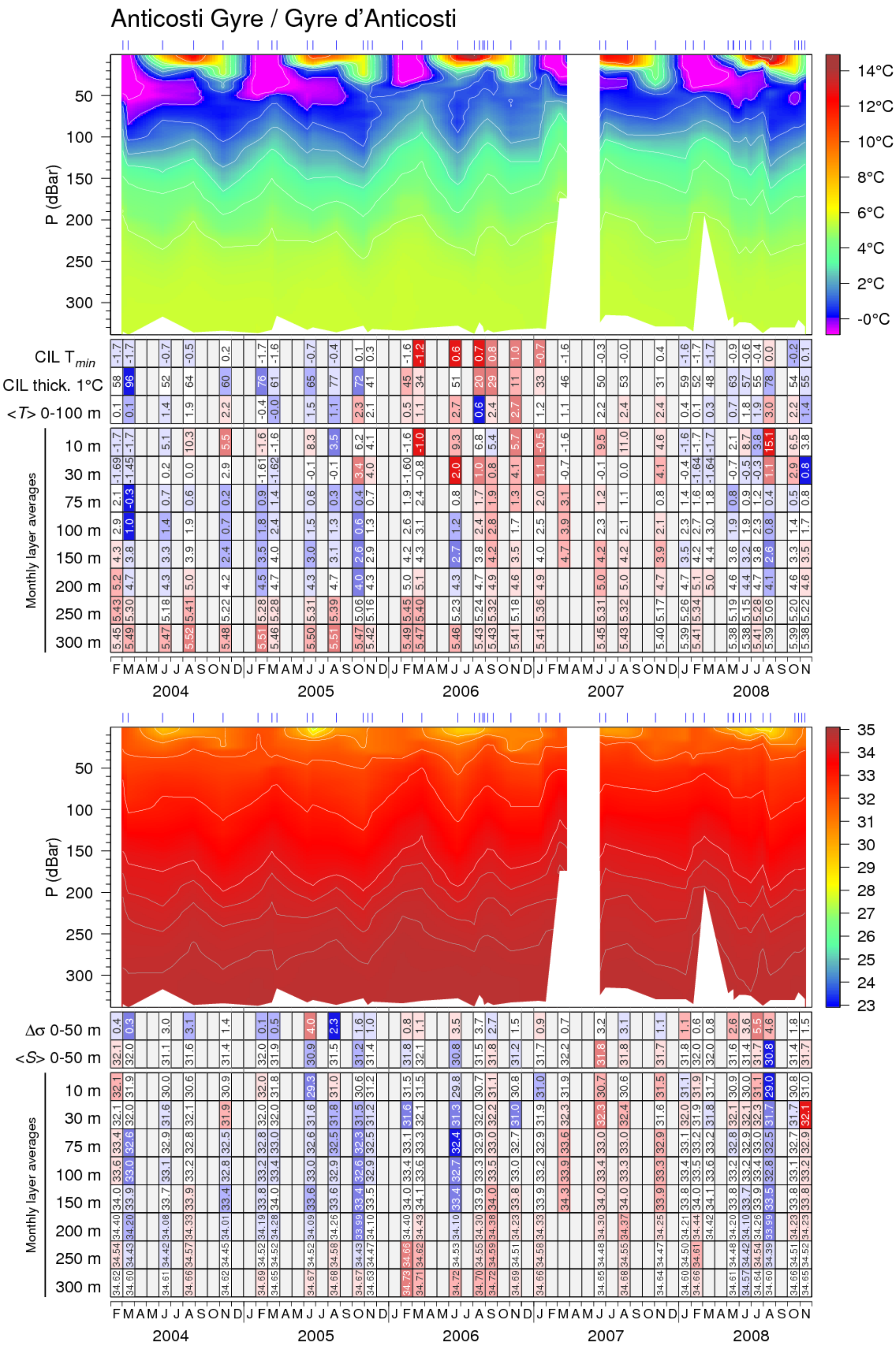

Fig. 41. Isotherm (top) and isohaline (bottom) time series at the Anticosti Gyre station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the monthly climatology for the station (yearly climatology for 250 m and deeper).

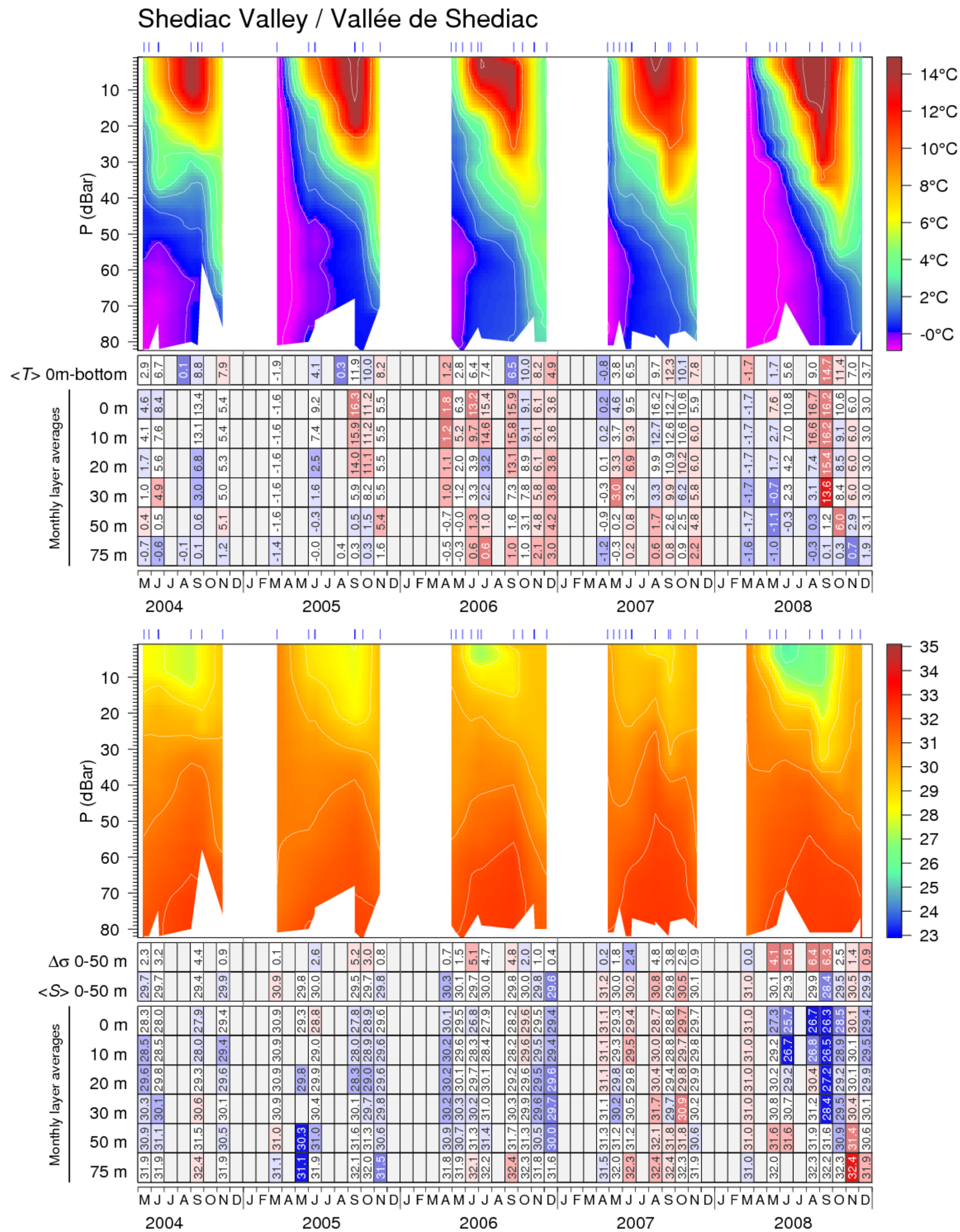

Fig. 42. Isotherm (top) and isohaline (bottom) time series at the Shediac Valley station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the monthly climatology for the station.

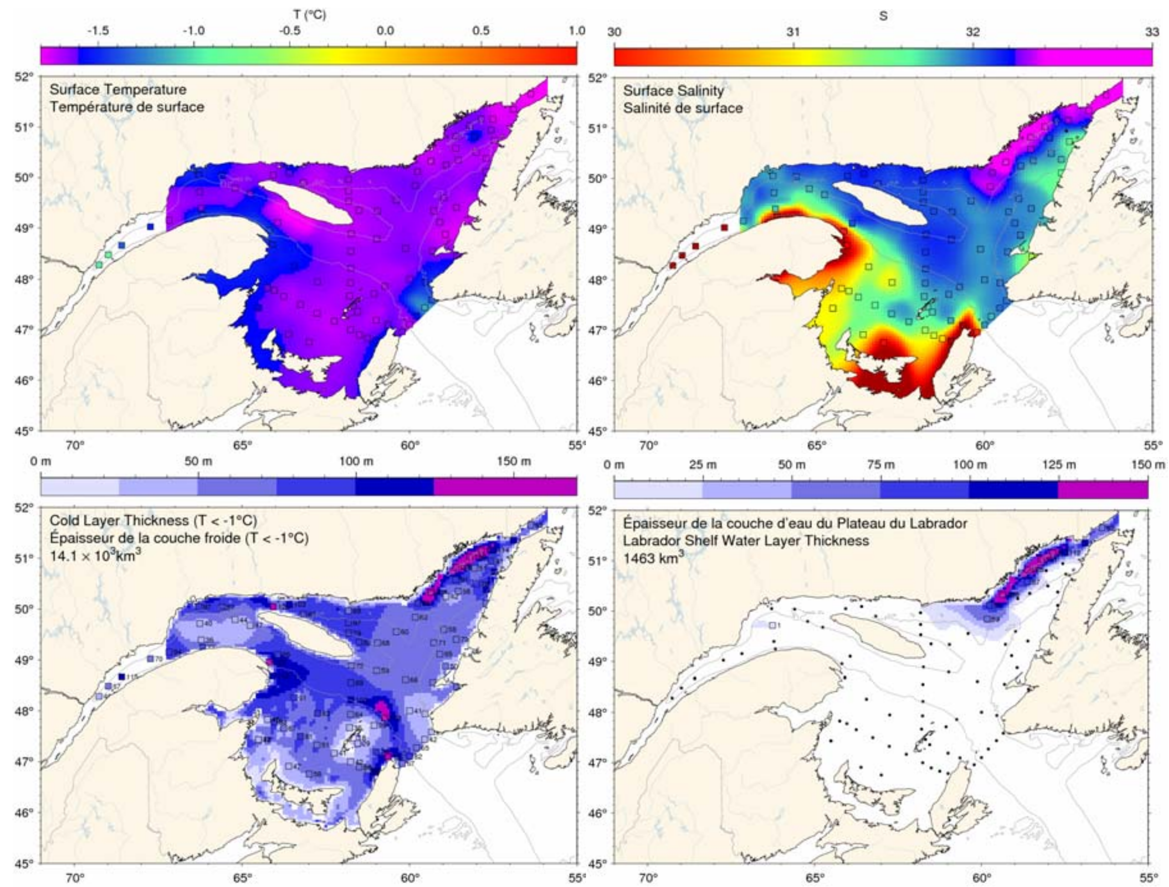

Fig. 43. Surface water temperature (upper left), salinity (upper right), cold layer (T < -1°C) thickness (lower left) and estimate of the thickness of the Labrador Shelf water intrusion (lower right) for the March 2009 survey. The symbols are coloured according to the value observed at the station, using 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.