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Physical Oceanographic Conditions in the Gulf of St. Lawrence in 2011

Conditions océanographiques physiques dans le golfe du Saint-Laurent en 2011

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ABSTRACT

An overview of physical oceanographic conditions in the Gulf of St. Lawrence in 2011 is presented. Both winter and annual air temperatures were above normal by 1.7°C (+0.9 SD) and 0.7°C (+0.7 SD), respectively. The annual runoff measured at Québec City was above normal in 2011 (+1.4 SD), seventh highest since 1955, with May having the fourth largest monthly runoff since 1955. Near-surface water temperatures were above normal in winter and typically normal for the remainder of all year until November, when they were above normal. Maximum sea-ice volume within the Gulf was 14 km³, close to the record low of 11 km³ recorded a year earlier, consistent with the above-normal mixed layer temperatures and with very warm air temperatures in December 2010 and January 2011. The duration of the 2010–11 ice season was much shorter than normal, beginning later than normal. No ice was exported onto the Scotian Shelf. Winter inflow of cold and saline water from the Labrador Shelf occupied the Mécatina Trough over the entire water column during the winter. Its volume was above normal in March, at 2200 km³ (+0.5 SD), and the percentage of cold water it represented was 29% (+1.5 SD), higher than normal. The winter cold mixed layer volume (T < 0°C) in the Gulf, excluding the Estuary, was 13 300 km³. While this matches the lowest volume recorded since 1996, it still corresponded to 40% of the total water volume of the Gulf. However, it was very warm, on average about 0.5 to 1°C above the freezing point. This is the second time in 16 years of winter surveys that such high temperatures were recorded. The cold intermediate layer (CIL) minimum temperature index for summer 2011 was +0.17°C, similar to observations in 2006 and the warmest since 1983. On the Magdalen Shallows, none of the bottom area was covered by water with temperatures < 0°C in September 2011, similar to conditions in 2005-07, 2009-2010. In other regions of the Gulf, very few areas had bottom temperatures below 0°C. Regional patterns of the August and September CIL show that the layers for T < 1°C and < 0°C were much thinner in most parts of the Gulf in 2011 than in 2010 and had a generally higher core temperature everywhere. Conditions in March 2011 were characterized by a thin and warm mixed layer. The CIL remained below normal in thickness and above-normal in minimum temperature throughout the remainer of the year, especially in the Estuary and Central Gulf. The CIL at Rimouski station was, overall, the thinnest and warmest recorded since monitoring began there in 1991. The deep waters in the Estuary were colder and fresher than normal in 2011. Very warm and saline waters occupied Cabot Strait all year at 250 m, the depth of the temperature maximum. Gulf-wide average temperatures were above normal at 150 m and normal at 200 to 300 m and salinity averages were normal from 150 to 250 m and above normal at 300 m. Temperature at 300 m increased significantly when averaged over the Gulf (by 1.3 SD). At Cabot Strait the 300 m temperature anomaly was positive by 1.2 SD; the highest since 1994. Salinity at 200 m and 300 m increased overall by 0.9 and 2.4 SD respectively, but increased at Cabot Strait to reach +1.2 SD at 200 m and +1.5 SD at 300 m, the latter being a high since 1986. Salinities in Central Gulf changed from -1.6 SD in 2010 to +1.2 SD in 2011, an increase of 2.8 SD. The 300 m waters of the Estuary were expected to cool between 2010 and 2011 but instead they warmed slightly. The warm anomaly present since 2010 at Cabot Strait should progress up the channel towards the Estuary in the next two years. By November the surface mixed layer was anomalously thick but more importantly very warm, warmer in fact than that observed during fall 2010 which were preconditions of the low ice cover of winter 2011.

RÉSUMÉ

Le présent document donne un aperçu des conditions d'océanographie physique qui ont prévalu dans le golfe du Saint-Laurent en 2011. Les températures de l'air moyennées de janvier à mars, étaient supérieures à la normale (+1,7 °C, + 0,9 ET ou écart-type), ainsi qu'annuellement (+0,7 °C, +0,7 ET). L'apport d'eau douce mensuel moyen mesuré à Québec a été supérieur à la normale pour l'ensemble de l'année 2011 (+1,4 ET), le septième débit annuel le plus élevé depuis 1955, avec le quatrième débit mensuel le plus élevé survenu en mai. Les températures de l'eau près de la surface ont été supérieures à la normale en hiver, suivi de conditions normales jusqu'en novembre quand elles sont redevenues supérieures à la normale. Le volume maximal des glaces dans le golfe s'est établi à 14 km³, une valeur près du minimum depuis 1969 observé un an plus tôt, et en accord avec les températures élevées de la couche de surface mélangée hivernale ainsi qu'avec des températures de l'air élevées en décembre 2010 et janvier 2011. La durée de la saison de glace 2010-2011 a été plus courte que la normale et était associée à une prise tardive. Aucune glace n'a été exportée vers le plateau Néo-écossais. Les entrées hivernales d'eaux froides et salées du plateau du Labrador ont rempli entièrement la cuvette de Mécatina au cours de l'hiver 2011. Le volume de ces entrées d'eaux était de 2200 km³ (+0,5 ET), et représente 29 % (+1,5 ET) de toutes les eaux froides sous -1 °C. Le volume de la couche de surface mélangée hivernale, sélectionnée avec un critère moins strict de la température, sous 0 °C au lieu de – 1 °C, était de 13 300 km³ (excluant l'estuaire). Bien que cela égale le volume le plus faible enregistré depuis 1996, ceci correspond néanmoins à 40 % du volume d'eau total présent dans le golfe. Cependant, la couche de surface hivernale était chaude, autour de 0,5 à 1 °C au-dessus du point de congélation. Ce fut la seconde fois en 16 ans de monitorage hivernal que de telles conditions ont été observées. L'indice de la CIF (couche intermédiaire froide) d'été pour 2011 s'est établi à +0,17 °C, ce qui est comparable aux conditions observées en 2006, l'année la plus chaude depuis 1983. Sur le plateau madelinien, aucune partie du fond n'était couverte par des eaux de température < 0 °C en septembre 2011, tel qu'observé aussi en 2005 à 2007, 2009 et 2010. Les profils régionaux de la CIF d'août et de septembre indiquent que les couches où T < 1 °C et < 0 °C ont été beaucoup plus minces dans la plupart du golfe en 2011 comparativement à 2010 et que la température minimale était en général supérieure dans l'ensemble du golfe. Les températures dans la colonne d'eau observées en mars 2011 ont été caractérisées par une couche de surface mince et chaude. La CIF est demeurée sous la normale en épaisseur et au-dessus de la normale en température pour le reste de l'année, et ce en particulier dans l'estuaire et le centre du golfe; à la station Rimouski, son épaisseur et sa température minimale ont atteint des records depuis le début de son monitorage en 1991. Les eaux profondes de l'estuaire étaient plus froides et moins salées que la normale en 2011. Des eaux très chaudes occupaient le détroit de Cabot durant toute l'année à 250 m, la profondeur du maximum de température. Dans l'ensemble, la température a été généralement au-dessus de la normale à 150 m, et normale aux profondeurs allant de 200 à 300 m, tandis que la salinité était normale de 150 à 250 m et au-dessus de la normal à 300 m. Les températures à 300 m ont globalement augmenté de façon significative (par 1,3 ET). Au détroit de Cabot, l'anomalie à 300 m atteignait +1,2 ET, la valeur la plus élevée depuis 1994. La salinité à 200 m et 300 m a augmenté globalement de 0,9 et 2,4 ET respectivement, mais a augmenté au détroit de Cabot pour atteindre +1,2 ET à 200 m et +1,5 ET à 300 m, cette dernière valeur étant un record depuis 1986. La salinité dans la région du centre a augmenté de 2,8 ET entre 2010 et 2011, passant de -1,6 à +1,2 ET. Les eaux profondes de l'estuaire qui auraient dû se refroidir en 2011 se sont plutôt réchauffées. Durant les deux prochaines années, l'anomalie chaude présente depuis 2010 dans le détroit de Cabot devrait remonter le chenal Laurentien vers l'estuaire. La couche de surface était épaisse et très chaude en novembre 2011, plus chaude même que les conditions de novembre 2010 qui étaient précurseures de l'hiver faible en couvert de glace de 2011.

INTRODUCTION

This paper examines the physical oceanographic conditions and related atmospheric forcing in the Gulf of St. Lawrence in 2011 (Fig. 1). Specifically, it discusses air temperature, freshwater runoff, sea-ice volume, surface water temperature and salinity, winter water mass conditions (e.g., the near-freezing mixed layer volume, the volume of dense water that entered through the Strait of Belle Isle), the summertime cold intermediate layer (CIL), and the temperature, salinity, and dissolved oxygen of the deeper layers. Some of the variables are spatially averaged over distinct regions of the Gulf (Fig. 2). The report 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 1981–2010 reference period when possible. Furthermore, because these series have different units (oC, m3, m2, etc.), each anomaly time series is normalized by dividing by its standard deviation (SD), which is also calculated using data from 1981–2010 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 is shown as red, but does not necessarily correspond to warmer-than-normal conditions. Higher than normal stratification is shown in blue because it usually corresponds to lower salinity. The last detailed report of physical oceanographic conditions in the Gulf of St. Lawrence was produced for the year 2010 (Galbraith et al. 2011).

The summertime water column in the Gulf of St. Lawrence consists of three distinct layers: the surface layer, the cold intermediate layer (CIL), and the deeper water layer (Fig. 3). Surface temperatures typically reach maximum values in mid-July to mid-August. Gradual cooling occurs thereafter, and wind mixing during the fall leads to a progressively deeper and cooler mixed layer, eventually encompassing the CIL. During winter, the surface layer thickens partly because of buoyancy loss (cooling and reduced runoff) and brine rejection associated with sea-ice formation, but mostly from wind-driven mixing prior to ice formation (Galbraith 2006). The surface winter layer extends to an average depth of 75 m and up to 150 m in places (and even more in the northeast, where intruding waters through the Strait of Belle Isle from the Labrador Shelf may extend from the surface to the bottom [>200 m] in Mécatina Trough) by the end of March when temperatures decrease to near freezing (-1.8 to 0ºC) (Galbraith 2006). During spring, surface warming, sea-ice melt waters, and continental runoff produce a lower-salinity and higher-temperature surface layer, below which cold waters from the previous winter are partly isolated from the atmosphere and form the summer CIL. This layer will persist until the next winter, gradually warming up and deepening during summer (Gilbert and Pettigrew 1997; Cyr et al. 2011) and more rapidly during the fall as vertical mixing intensifies.

This report considers these three layers in turn. First, air temperature is examined because it is a significant driver of the surface layer, followed by the freshwater runoff. The winter sea ice and winter oceanographic conditions are described; these force the summer CIL, which is presented next. The deeper waters, mostly isolated from exchanges with the surface, are presented last along with a summary of major oceanographic surveys. Quantities are often averaged over regions of the Gulf depicted in Fig. 2.

AIR TEMPERATURE

The monthly air temperature anomalies for several stations around the Gulf are shown in Fig. 4 for 2010 and 2011. Only the January anomaly had a consistent sign at all stations, in this case above-normal. Averaged over the Gulf, air temperature was above the 1981–2010 normal between October 2010 and January 2011, then normal until July, above normal between August and November and normal again in December 2011.

The annual mean temperature time series are shown in Table 1 for the nine stations along with their 1981–2010 average. Annual mean air temperatures in 2011 were still above normal at all stations except Sept-Îles and Blanc-Sablon after the record highs of 2010. The average of the nine stations provides an overall temperature index for the entire Gulf, which was above normal in 2011 by 0.7°C (+0.7 SD) and ninth warmest since 1945. The last below-normal (< -0.5 SD) annual anomaly occurred in 2002.

A bulk winter air temperature 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 above normal in 2011 by 1.7°C (+0.9 SD). Temporally, it was composed of the seventh-warmest anomaly since 1945 for the month of January (4.0°C, +2.0 SD) followed by normal conditions in February and March.

Fig. 5 shows the annual and seasonal mean air temperature anomalies averaged over the nine stations since 1945, with record-high annual and winter conditions in 2010. In 2011 winter and fall anomalies were above-normal (1.7°C and +0.9 SD in winter; 1.2°C and +1.0 SD in fall) and normal in spring and summer.

A warming trend in the annual air temperature since 1971 does not persist when the time series is considered back to 1945; however, a warming trend of 0.9°C per century is found between 1873 and 2011 (Galbraith et al, 2012).

PRECIPITATION AND FRESHWATER RUNOFF

Runoff data for the St. Lawrence River were obtained from the St. Lawrence Global Observatory (http://ogsl.ca/en/runoffs/data/tables.html), where they are updated monthly (Modelling and Operational Oceanography Division, Canadian Hydrographic Service, Maurice Lamontagne Institute, Fisheries and Oceans Canada) using the water level method from Bourgault and Koutitonsky (1999). The annual average runoff measured at Québec City was above normal in 2011 (Fig. 6) at 13 200 m^3s^{-1} (+1.4 SD), seventh highest since 1955. It consisted of above-normal monthly averages between May and October. In fact, the May freshet had the fourth largest monthly runoff in the time series and was the highest since 1976.

A hydrological watershed model was used to estimate the monthly runoff since 1948 for all major rivers flowing into the Gulf of St. Lawrence, with discharge locations as shown in Fig. 7. The precipitation data (NCEP reanalysis, six hourly intervals) used as input in the model were obtained from the NOAA-CIRES Climate Diagnostics Center (Boulder, Colorado, USA; Kalnay et al. 1996). The data were interpolated to a ¼° resolution grid and the water routed to river mouths using a simple algorithm described here. When air temperatures were below freezing, the water was accumulated as snow in the watershed and later melted as a function of warming temperatures. Water regulation is modelled for three rivers that flow into the estuary (Saguenay, Manicouagan, Outardes) for which the annual runoff is redistributed following the climatology of the true regulated runoffs for 12 months thereafter.

Runoffs were summed for each region shown and the climatology established for the 1981–2010 period. Monthly anomalies of the summed runoffs for 2010 and 2011 are shown in Table 2. Rivers other than the St. Lawrence contribute about 5 000 m3s-1 runoff to the Estuary, the equivalent of 40% of the St. Lawrence River, while the other tributaries distributed along the border of the GSL provide an additional 3 500 m^3s^{-1} in freshwater runoff to the system. The 2011 data show that rivers on the western side of the Gulf (regions 1, 2 and 8) behaved similarly to the St. Lawrence River, with higher-than-normal runoff in summer and lower than normal in the fall, although the pattern was different for rivers on the eastern side (regions 3, 4 and 5). The persistently strong fall runoff in region 1 is attributable to the regulated redistribution of the strong spring freshet. The long term time series are shown, summed by large basins, in *Fig. 8*. Broad longterm patterns of runoff over the large basins were similar to that of the St. Lawrence River. In 2011 the runoff had positive anomalies in all regions except in the Northeast which was within normal conditions.

SURFACE LAYER

The surface layer conditions of the Gulf are monitored by various complementary methods. The shipboard thermosalinograph network typically provides year-round, near real-time coverage and is especially useful for monitoring the winter freeze-up and the evolution of the spring thaw. Its limitations are that it only provides data only along the main shipping route and that semi-weekly ship tracks are irregular both in time and in the position where each longitude is crossed. The second data source is the thermograph network. It provides an inexpensive, growing record of near-surface temperatures at fixed stations and at short sampling intervals, but not (for the most part) in real-time nor during winter months. However, its coverage of the southern and northeastern Gulf, areas not sampled by the thermosalinograph network, is very informative. It also provides station climatologies based on more years of data than the thermosalinograph network. NOAA satellite remote sensing, the third data source, provides 1 km spatial resolution of ice-free waters with data back to 1985.

Before showing results specific to 2011, we examine the climatology expected for the region. The expected May to November cycle of weekly averaged surface temperature is illustrated in Fig. 9 using a 1985–2010 climatology based on AVHRR remote sensing data for ice-free months complemented by 2001–2010 thermosalinograph data for the winter months. Galbraith et al (2012) have shown that Gulf-averaged air temperature and SST monthly climatologies match up quite well with SST lagging air temperature by half a month. Maximum sea-surface temperatures are reached on average during the second week of August but can vary by up to several weeks from year to year. The maximum surface temperature averages 15.6ºC over the Gulf during the second week of August (1985–2010 average), but there are spatial differences: temperatures on the Magdalen Shallows are the warmest of the Gulf, averaging 18.1ºC over the area, and the coolest are at the head of the St. Lawrence Estuary and upwelling areas along the lower North Shore. Thermosalinograph data (see below) have demonstrated that the cooling of offshore surface waters of the Gulf during fall and winter first reaches near-freezing temperatures in the Estuary, then progresses eastward with time, usually reaching Cabot Strait by the end of the winter. The exception is the head of the St. Lawrence Estuary (*Fig. 9*), where upwelling and mixing of the CIL to the surface layer keep the waters cool in summer (around 5°C to 6°C and sometimes lower) and well above freezing in winter (Galbraith et al. 2002, Galbraith et al. 2012).

SHIPBOARD THERMOSALINOGRAPHS

The shipboard thermosalinographs were described by Galbraith et al. (2002). 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 and sample near-surface (3 m) water temperature and salinity along their route. Oceanex ships sail year-round between Montréal, QC, and St. John's, NL, making a return trip once per week. Figure 10 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 2011. 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 and winter temperatures that are always above freezing as mentioned above. The progression to winter conditions first reaching near-freezing temperatures in the Estuary and then progressing eastward with time, usually reaching Cabot Strait by the end of the winter, also appears in this climatology. Figure 10 also shows the water temperature composite for 2011 and its anomaly. Unfortunately, the Cabot was in dry-dock during part of the winter, so winter coverage ends in mid-February. Nevertheless, the data show that near-surface water temperatures were above normal in winter and again from May to late-June. The Gulf near-surface waters in January and February were significantly above normal with anomalies between +0.5°C and +2°C, where normal is usually near freezing at this time of year. This was followed by a brief colder-than-normal period until late August except for warmer conditions in the Estuary. Next, most of the waters along the ship track in the Estuary and Gulf experienced warmer-than-normal conditions until the end of 2011, notwithstanding missing data between mid-September and early-November. The existence of warm anomalies of over 1°C in December is a substantial preconditioning of the winter mixed layer if the fall mixed layer is thick.

Temperature anomaly time series and 2000–2011 climatologies were constructed for selected sections that are crossed by the ship. Although the anomalies are quite similar between the two sections, Table 3 shows how different the near-surface temperature climatologies are at Tadoussac (head of the Laurentian Trough) compared with those nearby in the Estuary, as noted above. Winter temperatures are on average 0.6°C warmer at the Tadoussac section; the maximum monthly mean temperature in summer is only 7.1°C compared with 8.7°C at the nearby Estuary section and up to 13.2°C at the Mont-Louis section. The table provides a quick look at the interannual 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 above with below normal anomalies only occurring in July and August at the Cabot Strait section.

THERMOGRAPH NETWORK

The thermograph network, described in detail in previous reports (Gilbert et al. 2004, Galbraith et al. 2008), consists of a number of stations with moored instruments recording water temperature every 30 minutes (Fig. 11). Most instruments are installed on Coast Guard buoys that are deployed in the ice-free season, but a few stations are monitored year-round. The data are typically only available after the instruments are recovered except for the five oceanographic buoys that transmit data in real-time. Data from Shediac station acquired by the DFO Gulf Region are also shown.

In order to compare the 2011 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 12, 13, and 14 along with daily climatologies (± 1 SD; shown in blue). Monthly average temperatures are also shown, with the magnitude of their anomaly colour-coded. The average monthly temperatures for each station at shallow sampling depths (< 20 m) for 2010 and 2011 are also shown in Table 4.

Monthly anomalies were fairly consistent across all stations of each of the three regions listed in Table 4. May to October near-surface water temperatures were generally normal to above normal in the Estuary and northwest Gulf (top panel). They were typically normal to above-normal from May through August on the Lower North Shore, then normal to below normal in September and October. They were typically normal to above normal in the Southern Gulf except in July and August (bottom panel). The three stations recording winter temperatures showed strongly above-normal temperatures in January, consistent with the high air temperatures.

Table 5 shows information similar to Table 4, but for thermograph sensors moored deeper than 20 m. The deep (>300 m) waters of the Estuary show below-average temperatures in 2011, but a warming occurs in the northwest Gulf (Anticosti Gyre station) between July and October.

Table 6 shows the history of monthly averaged temperature anomalies for selected stations both in the northeastern and southern Gulf. The cold period from 1993 to 1998 (except 1996) is evident at Île Shag (as it was for air temperature in *Table 1*), and this long record helps to put the current year into perspective.

NOAA SATELLITE SST

The 2011 monthly mean sea-surface temperatures are shown in Fig. 15 as colour-coded maps, and the corresponding temperature anomalies maps referenced to the 1985–2010 monthly climatology are shown in Fig. 16. 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 (details in Galbraith and Larouche, 2011). New for this year, true monthly composites are used as in Galbraith *et al.* (2012) whereas the first 28 days of each month were used in prior reports. The anomalies are shown only for the months of May to November when coverage is complete, because ice cover biases the results for the other months (even though December has been ice-free in recent years, it would be difficult to construct a valid climatology). April is included but is only accurate for the usually ice-free Northwest Gulf. The NOAA SST information is summarized in *Table 7*, showing the 2010 and 2011 monthly surface temperature anomalies spatially averaged over the Gulf and over each of the eight regions delimited by the areas shown in *Fig. 2*, and further into sub-regions of the Estuary as shown in Fig. 17.

Near-surface water temperatures in the Estuary were above normal except in April and May. Elsewhere in the Gulf, temperatures were typically normal except from June to August in Cabot Strait and over the Magdalen Shallows when they were below normal, and in November when they were above normal everywhere but in the northeast.

Table 8 and Table 9 show the full 1985–2011 time series of monthly surface temperature anomalies spatially averaged over the Gulf of St. Lawrence and over the eight regions of the Gulf. These results show that temperatures in 2011 were close to normal, similar to conditions observed in 2007 and 2009.

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 10 along with averages for the Manicouagan Marine Protected Area (MPA), the St. Lawrence Estuary MPA, and the Saguenay – St. Lawrence Marine Park (Fig. 17). The overall pattern is similar across regions, but there are differences associated with episodic local events such as eddies and upwellings. The climatology averages also differ, for example the Manicouagan maximum monthly average temperature is 1.0°C warmer than for the Estuary as a whole. The common features among most regions for 2011 are the negative anomalies in April and positive in October and November.

The Magdalen Shallows, excluding Northumberland Strait, is divided into western and eastern areas as mapped on Fig. 18. The monthly average SST for the Magdalen Shallows as a whole (region 8) is also shown in Table 11 along with averages for the western and eastern areas. Climatologies differ by roughly 0.5°C to 1°C between the western and eastern regions. The common features among most regions for 2011 are the negative anomalies in July, normal in September and October, and strongly positive in November.

The number of weeks in the year that the mean weekly temperature is above 10°C for each pixel (Fig. 19, Table 12) integrates summer surface temperature conditions into a single map displaying the length of the warm season. The anomalies of the number of weeks for 2011 are shown in Fig. 20. The Estuary, Northwest Gulf and Baie des Chaleurs area had above-normal summer surface temperature conditions (matching conditions of 2006 in the Estuary) while the rest of the Gulf experienced a mix of conditions averaging to a normal number of weeks with mean surface temperatures above 10°C.

SEA ICE

Ice volume is estimated from a gridded database of ice cover and ice categories obtained from the Canadian Ice Service, consisting of weekly files for 1969–1997 and daily files thereafter. Standard average thicknesses are attributed to each ice category to estimate the volume. Offshore sea ice is typically produced in the northern parts of the Gulf and drifts towards Îles-de-la-Madeleine and Cabot Strait during the ice season. The maximum ice thickness that occurred in 2011 is shown in and compared with previous minimum and maximum conditions observed in 2010 and 2003. The combined Gulf and Scotian Shelf ice volume shown in the top panel of Fig. 22 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. 22 corresponds to that found seaward of Cabot Strait. It would represent the volume of ice exported from the Gulf provided that no melt had already occurred. Table 13 shows the day of first and last occurrence of ice in each of the regions of the Gulf of St. Lawrence, extracted from the same database, as well as duration of the ice season and maximum observed volume during each season. Caution should be used in over interpreting the table since the database from which it is produced is coarse in time resolution (weekly) up to 1997.

The correlation between annual maximum ice volume and the winter air temperature index (i.e. January-March average), both repeated in Table 14, accounts for 68% of the variance using the 1969–2011 time series. The correlation increases to 72% of the variance accounted-for (and accounts for the low ice volume of 2011 introduced below) when using the December-January-February average air temperature anomaly for stations located in the western Gulf (Sept-Îles, Mont-Joli, Gaspé, Charlottetown and Îles-de-la-Madeleine).

In 2011, the Gulf and Shelf maximum ice volume was 14 km³, slightly higher than the record low of the 1969–2010 time series observed just a year earlier (11 km³ in 2010). No ice was exported from the Gulf of St. Lawrence onto the Scotian Shelf for the second consecutive year. This near-record-low maximum ice volume is consistent with the Dec-Jan-Feb western Gulf air temperature anomaly of +2.9°C, the third highest since 1873 after 2010 and 1958. The duration of the 2010–11 ice season was much shorter than normal in all regions, mostly due to late ice formation (Table 13), again consistent with warm air temperatures in early winter. The duration was not defined for the Central Gulf region because ice never exceeded 5% of the largest volume recorded in that region.

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 sparse winter data for the region. The survey, sampling methods, and results concerning the cold-water volume formed in the Gulf and the estimate of the water volume advected into the Gulf via the Strait of Belle Isle over the winter are described in Galbraith (2006) and in Galbraith et al. (2006). Ninety-three stations were sampled during the 8–17 March 2011 survey. Fig. 23 and Fig. 24 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 water intrusion for 2010 and 2011. Interpolations for all years were reanalyzed for this report using the 500 m resolution bathymetry grid corrected in Baie des Chaleurs and some areas of the Magdalen Shallows.

During previous winters, the surface mixed layer was usually very close (within 0.1°C) to the freezing point in most regions of the Gulf and it was the layer thickness that varied, leading to variability in the cold-water volume between mild and severe winters. This was not the case in 2010 for the first time since the inception of this winter survey, when the mixed layer was on average 1°C above freezing. Similar conditions, although not quite as warm, were observed in March 2011. During typical winters, surface waters in the temperature range of ~ 0°C to -1°C are only found on the northeast side of Cabot Strait, entering the Gulf and flowing northward along the west coast of Newfoundland. This inflow was again much warmer than usual in 2011 and affected a very large area, reaching Anticosti Island. Careful analysis will need to be done to confirm that these are warm waters that have entered the Gulf during winter and not local waters that have simply not cooled close to freezing; a different scenario not previously considered.

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. 23 and are typically found to the north and east of Anticosti Island but occupied less area in 2011 because surface salinities were generally lower than usual in the Gulf. Salinities were also unusually low over the Magdalen Shallows.

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 were absent at the surface in March 2011 and were only found below the surface at the Strait of Belle Isle station. A second criterion from Galbraith (2006) was used to identify intruding waters in a T-S diagram that have exhibited no evidence of mixing with warm and saline deep Gulf water. These waters occupied all of the Mécatina Trough in March 2011 (top-right panel of Fig. 24). The recent history of Labrador Shelf water intrusions is shown in Fig. 25, where its volume is shown as well as the fraction it represents of all the cold-water volume in the Gulf. This volume was above normal in March 2011, at 2200 km³ (+0.5 SD), and the percentage of cold water it represents was high, at 29% (+1.5 SD).

The cold mixed layer depth typically reaches about 75 m in the Gulf and is usually delimited by the -1°C isotherm because the mixed layer is typically near-freezing and deeper waters are much warmer, such that little water has temperatures in the vicinity of -1°C. But in 2011 (as in 2010, but to a lesser degree) much of this layer was warmer than -1°C such that the criterion of T<0°C was also used (see middle panels of Fig. 24). The cold surface layer is the product of local convection as well as cold waters advected from the Labrador Shelf, and can consist either of a single water mass or of layers of increasing salinity with depth. Integrating the cold layer depth over the area of the Gulf (excluding the Estuary) yields a <-1°C cold-water volume of 7 500 km³, the second lowest value after 2010 since 1996. The mixed layer volume increases to 13 600 km³ when water temperatures <0°C are considered, about the same as the record low value recorded in 2000. The T<0°C volume is 13 300 km³ when the waters present in the Estuary are excluded. This volume of cold water corresponds to 40% of the total water volume of the Gulf (33 300 km³, excluding the Estuary). The time series of winter cold-water (<-1°C) volume observed in the Gulf (excluding the estuary) is shown in Table 14 and Fig. 26.

COLD INTERMEDIATE LAYER

PREDICTION FROM THE MARCH SURVEY

The summer CIL minimum temperature index (Gilbert and Pettigrew 1997) has been found to be highly correlated with the total volume of cold water (<-1°C) measured the previous March in conditions when much of the mixed layer is near-freezing (Galbraith 2006, updated relation in right panel of Fig. 26). 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. Unfortunately, the winter mixed layer was not near-freezing in March 2011 so this relation cannot be used (it failed to predict the summer CIL conditions for the similar case of 2010). Based on similarities to the T<0°C volumes recorded in 2000 and 2006, we predicted in last year's report that the Gilbert and Pettigrew (1997) index would be between +0.2 and 0°C in 2011, a good prediction as seen below.

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 August and September. Most data come from the multi-species surveys in September for the Magdalen Shallows and August for the rest of the Gulf. The CIL minimum temperature grid was calculated by first finding the minimum temperature and its depth for each profile. Each cast must have at least some data between 30 and 120 m to be considered. The temperature minimum is defined as simply the lowest recorded temperature for casts with data >100 m. For shallower casts, a temperature minimum is considered only if the temperature rises by at least 0.5°C at depths greater than that of the minimum. The CIL minimum temperatures and core depths are then interpolated to a regular grid; 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.

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 reached the bottom. If so, the thickness at the grid point was reduced appropriately.

Fig. 27 shows the gridded interpolation of the CIL thickness <1°C and <0°C and the CIL minimum temperature for August–September 2010 and 2011. Interpolations for all years were reanalyzed for this report using the 500 m resolution bathymetry grid corrected in Baie des Chaleurs and some areas of the Magdalen Shallows. The CIL thickness <1°C and <0°C was generally less in 2011 than in 2010 and had a generally warmer core temperature. Similar maps were produced for all years back to 1971 (although some years have no data in some regions), allowing the calculation of volumes for each region for each year. The time series of the regional CIL volumes are shown in Fig. 28 (for <0°C and <1°C) and in Table 14 (for <1°C). All regions show a decreased CIL (<1°C) volume in 2011 compared to 2010, except for a small increase on the Magdalen Shallows. Fig. 29 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. 27). The CIL volume as defined by T<1°C decreased significantly compared to 2010 conditions and reached a record-low value. In the case of the volume delimited by 0°C, there was only a slight decrease compared to the already near-record low 2010 conditions.

The time series of the CIL regional average minimum core temperatures are shown in Fig. 30. All regions show an increase in core temperature for the third consecutive year except in Mécatina Trough. The 2011 average temperature minimum over the entire interpolated grid was +0.39°C and is shown in Fig. 29 (bottom panel, blue line). This is an increase of 0.3°C since 2010, of 0.6°C since 2009 and of 0.9°C since 2008. The overall 2011 CIL water mass properties were similar to those observed in 2006, matching that record since at least 1985.

NOVEMBER CIL CONDITIONS IN THE ST. LAWRENCE ESTUARY

The AZMP November survey provides a high resolution conductivity-temperature-depth (CTD) sampling grid in the St. Lawrence estuary since 2006. This allows the finer display of the CIL thickness and minimum temperature in the Estuary (*Fig. 31*), showing the CIL erosion and warming spatially towards the head of the channel, and temporally since the August survey (Fig. 27). The overall volumes and average minimum temperature are shown in Fig. 28 and Fig. 30, as well as in Table 14. The CIL was thinner and much warmer in November 2011 than in 2009 (the previous sampled year). Fig. 28 in particular shows the fairly rapid decrease of the CIL volume occurring between August and November 2011.

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

The Gilbert and 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. 29, and Table 14). As expected, the CIL core temperature interpolated to 15 July is almost always colder than the estimate based on August and September data for which no temporal corrections were made. This is because the CIL is eroded over the summer and therefore its core warms over time.

This CIL index for summer 2011 was +0.17°C. The 0.21°C increase from the summer 2010 CIL index of -0.04°C is consistent with the sharp decrease in CIL volume between August 2010 and 2011 discussed above albeit smaller than the increase of 0.27°C in the areal average of the minimum temperature in August. This increase of the index makes it above normal by 1.5 SD. The warm winter conditions of 2010 and 2011 led to CIL indices that were still far below the record high observed in the 1960s and 1980. These earlier CIL temperature minimums should be re-examined to make sure that they were calculated using data with sufficient vertical resolution to correctly resolve the core minimum temperature.

BOTTOM WATER TEMPERATURES

Bottom temperatures are obtained for all regions of the Gulf by combining all available CTD data from August and September, thus including the multispecies surveys for the northern Gulf in August and for the Magdalen Shallows in September. An interpolation scheme is used to estimate temperature at each 1 m depth interval on a 2 km resolution grid; bottom temperature is then estimated at each point by looking up the interpolated temperature at the depth level corresponding to a bathymetry grid provided by the Canadian Hydrographic Service. The method is fully described in Tamdrari et al. (2012). A climatology was constructed by averaging all temperature grids since 1985, when coverage of the entire Gulf became regularly adequate for such a calculation; suitable data are available since 1971 for the Magdalen Shallows.

Bottom temperatures typically range from <0°C to >18°C and are mostly depth dependent. The Mécatina Trough nevertheless stands out, with very cold bottom waters in a wider range of water depth down to 235 m due to the intrusion of cold Labrador Shelf waters (Fig. 32). The coldest areas are those covered by the CIL (<1°C) which has slowly warmed since the previous winter. These areas typically occur in the 50–120 m range. This includes the Magdalen Shallows, where bottom temperature anomalies were generally positive (*Fig. 33*).

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. The reader is also cautioned that temperature variability is much lower in the deeper waters, meaning that the white areas in the Laurentian Channel on *Fig. 33* may not all represent normal temperatures even though they are within 0.5°C of the mean climatology. In spite of this, the deep bottom waters were warmer than normal in Central Gulf in 2011.

Time series of the bottom area covered by water in various temperature intervals were estimated from the gridded data (Fig. 34 and Fig. 35). Unlike the very cold conditions observed on the bottom in 2008, none of the bottom of the Magdalen Shallows was covered by water with temperatures <0°C in 2011; this condition is similar to those in 2005-07, and 2009-10. 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 14. Waters in these temperature intervals covered less of the bottom than normal in 2011.

In many other regions of the Gulf, no bottom area was covered by waters colder than 0°C in 2011 (Fig. 34 and Fig. 35). Even in the Anticosti Channel and Mécatina Trough—areas affected by the winter intrusion of cold Labrador Shelf water—bottom areas with this temperature range were considerably reduced compared to previous years. The figures also show compression of the bottom habitat area in the temperature range of 5–6°C in 1992, but there was no similar remarkable event in 2011. Because deep water temperature variability is much lower than near surface layers, the bottom water temperature map from Fig. 32 was redone in Fig. 36 using the deep water temperature scale used for Fig. 34. This highlights deep variability, for example in Esquiman Channel.

Another long-standing 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 15 shows the time series of depth-layer temperature averages over the grids at 0, 10, 20, 30, 50 and 75 m for all years when interpolation was possible, as well as SST June averages since 1985, for both western and eastern regions of the Magdalen Shallows as shown in Fig. 18. On the Eastern Shelf, all depth levels except 75 m were colder in 2011 than in 2010, while on the Western Shelf all levels 20 m and deeper were colder. Generally, shallow waters (≤10 m) were colder than normal while waters were warmer than normal at 75m depth.

SEASONAL AND REGIONAL AVERAGES OF TEMPERATURE PROFILES

In order to show the seasonal progression of temperature profiles, regional averages are shown in Fig. 37 through Fig. 41 based on the data collected during the March helicopter survey, the June AZMP and mackerel surveys, the August multi-species survey (September survey for region 8), and the November AZMP survey and including all additional archived CTD data for those months. An additional survey was done in October 2011 and is summarized in Fig. 40. 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 93 CTD casts in March, 138 casts in June, 152 casts in August, 159 in September, 114 in October and 81 in November were obtained. The discontinuities near 175 m in the August 2011 average temperature profile for Mécatina Trough are caused by the large horizontal gradient in deep water properties there, sampled by only three deep casts that end at different depths.

Monthly temperature and salinity climatologies for 1981–2010 were constructed for various depths using a method similar to that used by Petrie et al. (1996) but using the geographical regions shown in Fig. 2. 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 ± 1 SD (Fig. 37–40).

The March water temperature conditions were discussed at length in earlier sections and are included here for completeness (Fig. 37), but caution is needed in interpreting the mean profiles. Indeed, regional averaging of winter profiles does not work very well in the northeast Gulf (regions 4 and 5) because very different water masses are present in the area such as the cold Labrador Shelf intrusion with saltier and warmer deeper waters of Esquiman Channel. For example, the sudden temperature decrease near the bottom of Mécatina Trough for the 2010 and 2011 regional averages resulted from the deepest cast used in each of the averages, which contained colder Labrador Shelf intrusion water. Large changes near 200 m are due to our usual sampling cutoff near 200 m for the March airborne survey, with some casts being slightly deeper than others. In particular, the unusual shift in temperature below 200 m in the mean profiles for the Estuary (region 1) and Northwest Gulf (region 2) appears because only one station in each region, the Rimouski and Anticosti Gyre AZMP stations, respectively, is sampled beyond 200 m. The highlights of March water temperatures shown in Fig. 37 are the previously discussed winter mixed layer, with temperatures atypically well above freezing, although not as pronounced as in 2010. Temperatures at ≥200 m in Cabot Strait were above normal.

Temperatures in June 2011 (Fig. 38) were characterized by CIL conditions that were below normal in thickness and above-normal in minimum temperature. Deep waters were colder than normal in the Estuary and above-normal in Cabot Strait, in particular at the depth of the temperature maximum (250 m). Cold waters were also observed by the deep (> 300 m) stations of the thermograph network at the Rimouski station, while deep temperatures at Anticosti Gyre station were below normal from May through August and were above normal by October (Table 5). The warm deep waters were still present in Cabot Strait in August and November. The CIL remained warmer than normal throughout the year, especially in the Estuary and Central Gulf, as well as in Cabot Strait in August. By November the surface mixed layer was anomalously thick but, more importantly, very warm. This winter mixed layer is even milder than that observed during fall 2010 in most regions. Average discrete-depth layer conditions are summarized for the months of the 2010 and 2011 AZMP surveys in Table 16 for temperature, and (new in this year's report) in Table 17 for salinity and 0-50 m stratification. The deep warm waters in Cabot Strait had above-normal salinity while the deep cold waters in the Estuary had below-normal salinity

DEEP WATERS (>150 m)

The deeper water layer (>150 m) below the CIL originates at the entrance of the Laurentian Channel at the continental shelf and circulates towards the heads of the Laurentian, Anticosti, and Esquiman channels without much exchange with the upper layers. The layer from 150 to 540 m is characterized by temperatures between 1 and 6.5°C and salinities between 32.5 and 35 (e.g. Fig. 42). Interdecadal changes in temperature, salinity, and dissolved oxygen of the deep waters entering the Gulf at the continental shelf are related to the varying proportion of the source cold–fresh/high dissolved oxygen Labrador Current water and warm–salty/low dissolved oxygen slope water (McLellan 1957, Lauzier and Trites 1958, Gilbert et al. 2005). These waters travel from the mouth of the Laurentian Channel to the Estuary in roughly three to four years (Gilbert 2004), decreasing in dissolved oxygen from in situ respiration and oxidation of organic material as they progress to the channel heads. The lowest levels of dissolved oxygen are therefore found in the deep waters at the head of the Laurentian Channel in the Estuary.

TEMPERATURE AND SALINITY

The calculation of monthly temperature and salinity climatologies mentioned earlier using a method similar to that of Petrie et al. (1996) also provides time series of monthly averaged values. These monthly averages were further averaged into regional yearly time series that are presented in Table 18 for 200 and 300 m. The 300 m observations in particular suggest that temperature anomalies are advected up-channel from Cabot Strait to the northwestern Gulf in two to three years, consistent with the findings of Gilbert (2004). The regional averages are weighted into a Gulf-wide average in accordance to the surface area of each region at the specified depth. These Gulf-wide averages are shown for 200 and 300 m in Table 18 as well as for 150, 200, and 300 m in Fig. 42.

In 2011, the gulf-wide average temperatures were above normal at 150 m and normal at 200 to 300 m and salinity averages were normal from 150 to 250 m and above normal at 300 m. Temperature at 300 m increased significantly overall (by 1.3 SD) but less so at Cabot Strait (increase of 0.6 SD), where the 2011 anomaly is positive by 1.2 SD; the highest since 1994. Salinity at 200 m and 300 m increased overall by 0.9 and 2.4 SD respectively, but increased at Cabot Strait to reach +1.2 SD at 200 m and +1.5 SD at 300 m, the latter being a high since 1986. Salinities in Central Gulf changed from -1.6 SD in 2010 to +1.2 SD in 2011, a large increase of 2.8 SD. The 300 m waters of the Estuary were expected to cool between 2010 and 2011 (based on the colder deep waters present in the northwest Gulf in 2010) and instead they warmed slightly. The warm anomaly present since 2010 at Cabot Strait should progress up the channel towards the Estuary in the next two years; already the temperature in Central Gulf has increased substantially (from -1.2 SD to +0.3 SD).

DISSOLVED OXYGEN AND HYPOXIA IN THE ST. LAWRENCE ESTUARY

Fig. 42 shows an update of the Gilbert et al. (2005) oxygen time series, providing the mean dissolved oxygen value at depths ≥295 m in the St. Lawrence Estuary expressed as a percentage of saturation at surface pressure. Since some of the variability is associated with changing water masses, the temperature at 300 m in the Estuary is also shown. The deep waters of the Estuary were briefly hypoxic in the early 1960s and have consistently been hypoxic at about 19–21% saturation since 1984 (Fig. 42). Dissolved oxygen increased slightly in 2011 compared with 2010 observations but has remained relatively stable since 2001.

Inflow of colder (warmer) waters to the Estuary should ameliorate (deteriorate) the hypoxic conditions since these colder waters are typically richer (poorer) in dissolved oxygen (McLellan 1957, Lauzier and Trites 1958, Gilbert et al 2005). This is seen in the regional time series shown in Table 18, where an overall tendency towards increasing dissolved oxygen during the last decade is observed broadly throughout the Gulf, associated with the change in temperature from the water mixture richer in Labrador Water. However, it is surprising that the warming (cooling) observed in 2011 in the deep waters of the Estuary (Cabot Strait) did not coincide with an decrease (increase) in dissolved oxygen, but rather an increase (decrease) (Table 18 and Fig. 42). This suggests that interannual variability in respiration is the cause.

CURRENTS AND TRANSPORTS

Currents and transports are derived from a numerical model of the Gulf of St. Lawrence, Scotian Shelf, and Gulf of Maine. The model is prognostic, i.e., it allows for evolving temperature and salinity fields. It has a spatial resolution of 1/12° with 46 depth-levels in the vertical. The atmospheric forcing is taken from the Global Environmental Multiscale (GEM) model run at the Canadian Meteorological Center (CMC). Freshwater runoff is taken from observed data and the hydrological model, as discussed in the freshwater runoff section. A simulation was run for 2006–2011 from which transports were calculated. The reader is cautioned that the results outlined below are not measurements but simulations and that improvement in the model may lead to changes in the transport values.

Fig. 43–44 show seasonal depth-averaged currents for 0–20 m, 20–100 m, and 100 m to the bottom for 2011. Currents are strongest in the surface mixed layer, generally 0–20 m, except in winter months when the 20–100 m averages are almost as strong and when even the deep (100 m to the bottom) averages are very high (note the different scale for this depth). Currents are also strongest along the slopes of the deep channels. The Anticosti Gyre is always evident but strongest during winter months, when it even extends strongly into the bottom-average currents.

Monthly averaged transports across seven sections of the Gulf of St. Lawrence are shown in Table 19 and Table 20. The first table shows transports related to estuarine circulation. The net transport integrates both up and downstream circulation and corresponds to freshwater runoff at the Pointe-des-Monts section. The outflow transport integrates all currents heading toward the ocean, while the estuarine ratio corresponds to the outflow divided by the net transports. Table 20 shows only net transports for sections within the Gulf. Transports were variable in 2011.

Transports on sections under the direct estuarian influence of the St. Lawrence River (e.g., Pointe-des-Monts) have a more direct response to change in freshwater runoff while others (e.g., Cabot Strait, Bradelle Bank) have a different response, presumably due to redistribution of circulation in the GSL under varying runoff. The estuarine circulation ratio is determined by the mixing intensities within the estuary and is greatly influenced by stratification. It is greatest during winter months and weakest during the spring freshet. In fact, it is sufficiently reduced in spring that the overall outward transport at Pointe-des-Monts reaches its minimum value in June even though this month corresponds to the third highest net transport of the year, i.e. the estuary becomes sufficiently stratified that fresh water runoff tends to slip on top of the salty waters underneath.

TIME SERIES OF TEMPERATURE AND SALINITY PROFILES AT FIXED AZMP STATIONS

Sampling by the Maurice Lamontagne Institute began in 1996 at two stations (Fig. 46) that were to become part of the AZMP (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. 46). 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 during the summer months since 1999, when the AZMP program began. However, observations were mostly of temperature and salinity prior to 1999. A station offshore of Rimouski (48° 40' N 68° 35' W) has also been sampled since 1991, typically once a week during summer and 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. The sampling activities at the Rimouski station are described in Plourde et al. (2009)

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. 47. Similar figures are provided for the Gaspé Current station (Fig. 48), the Anticosti Gyre station (Fig. 49), and the Shediac Valley station (Fig. 50). The scorecard climatologies are calculated from all available data at all stations except for Shediac, where the time series since 1981 is considered (1981–2011).

At the Rimouski station (Fig. 47), the CIL was thin with normal temperatures in March 2011, reaching only 50 m in thickness. Its thickness was about constant until June but thinned quickly thereafter and disappeared completely (using the <1°C definition) by October. While this would indicate quick erosion, the minimum temperature evolution indicates the opposite: it was well above normal at 0.3°C (+2.4 SD) in May, warmed to 1.0°C by September (+1.8 SD) and only to 1.1°C by November (+0.9 SD). Temperatures were typically above normal in the top 100 m and below normal at 300 m. Stratification was typically above normal, consistent with below normal near-surface salinities and with the above normal summer runoff (Fig. 6). The limited number of sorties to the Gaspé Current and Anticosti Gyre stations limits our interpretation of these data. The CIL was thick and warm throughout the year at the Gaspé Current station while salinities were below normal in the top 100 m (Fig. 48). At the Anticosti Gyre station (Fig. 49), the summer CIL was warm, and waters 100 m and deeper had temperatures and salinities below normal in February and March. At the Shediac Valley station (Fig. 50), salinities were typically well below normal, especially in March (see also the results of the March winter survey showing low mixed layer salinity over all the Magdalen Shallows).

Table 21 shows the interannual variability of some bulk layer averages from May to October for the four stations. The data were not sufficient to calculate indices for the Gaspé Current and Anticosti Gyre stations again in 2011. The CIL at Rimouski station was the thinnest and warmest recorded since monitoring began there in 1991. Bulk surface layer temperature and stratification were above normal at Rimouski station with record-low surface layer salinity, while surface layer temperature and stratification were normal at Shediac Valley station in spite of the below normal surface layer salinity.

OUTLOOK FOR 2012

Air temperatures in January and February 2012 were slightly above normal throughout the Gulf, but were near-normal in the ice-producing regions of the northwest. This was the setting for the March 2012 survey which provides an outlook for CIL conditions expected for the remainder of 2012. Fig. 51 shows the surface mixed layer temperature, salinity, and thickness (at T<-1°C and T<0°C), as well as the thickness and extent of the cold and saline layer that has intruded into the Gulf from the Labrador shelf. After the previous two very mild winters in 2010 and 2011, the winter surface mixed layer returned to closer-to-normal conditions, as observed prior to 2010, whereby waters were near-freezing at the end of winter over a large portion of the Gulf. The exception was the area offshore of the west coast of Newfoundland, extending nearly to the eastern tip of Anticosti Island. The conditions of the mixed layer, including temperature, salinity, volume and area with T<-1°C and T<0°C, were all similar to conditions observed in March 2000. Based on the updated relation between the cold water volume (T<-1°C) and the CIL index (Galbraith, 2006) that excludes the warm winters of 2010 and 2011, we can forecast warm summertime CIL conditions in 2012 with an index of +0.13ºC, similar to conditions in 2000 but also similar to the CIL minimum temperature index observed in 2011.

SUMMARY

Fig. 52 shows three annual composite index time series (Petrie et al. 2007) constructed as the sum of various standardized anomalies, representing the state of different parts of the system, with each time series contribution shown as stacked bars. The first sum anomalies representing the entire water column, whereas the second and third sum anomalies representing the state of the shallow and deep parts of the water column, which are decoupled. Here, the CIL is grouped as a shallow feature since it is generated by the winter surface mixed layer. These composite indices measure the overall state of the climate system with positive values representing warm conditions and negative representing cold conditions. The plot also indicates the degree of correlation between the various measures of the environment. For May-November SST, the April-November air temperature proxy from Galbraith et al (2012) is used prior to 1985. The record high occurred in 1980 for both shallow and deep anomalies, leading to a strongly positive overall anomaly sum +3.2 SD above normal. The record low occurred in 1993, again combining records in both shallow and deep anomalies. In 2011, the shallow index is warm (above normal by +1.6 SD), the deep index is near-normal and all components are in phase, leading to an overall index of +1.1 SD.

- Winter air temperatures (January–March) were above normal with an average anomaly of +1.7°C (+0.9 SD). Annual air temperatures were above normal by +0.7°C (+0.7 SD).

- The annual average runoff measured at Québec City was above normal in 2011 (+1.4 SD), seventh highest since 1955, with above-normal monthly averages between May and October. The May freshet had the fourth largest monthly runoff of the time series and was the highest since 1976.

- Near-surface water temperatures in the Gulf were above normal in winter and typically normal for the remainder of all year until November, when they were above normal. The winter mixed layer, although not as unusually warm as during the winter of 2010, still had large areas with temperatures around 0.5°C to >1°C above the freezing point.

- Maximum sea-ice volume within the Gulf was 14 km^3, close to the record low (since 1969) of 11 km^3 recorded in 2010. This is consistent with the above-normal mixed layer temperatures. The duration of the 2010–11 ice season was much shorter than normal, beginning later than normal and consistent with very warm December 2010 and January 2011 air temperatures. No ice was exported onto the Scotian Shelf.

- Winter inflow of cold and saline water from the Labrador Shelf occupied the Mécatina Trough over the entire water column in winter 2011 (up to 235 m in depth). The volume was above normal in March 2011, at 2200 km³ (+0.5 SD), and the percentage of cold water it represents was above normal (+1.5 SD) at 29%.

- The winter cold mixed layer volume (T<0°C) in the Gulf, excluding the Estuary, was 13 300 km³ matching the record low of 2000. This layer accounted for 40% of the total water volume of the Gulf. It was very warm, on average about 0.5 to 1°C above the freezing point. Usually, the criterion used to calculate the winter mixed layer volume is temperature lower than -1°C, but in 2011 only 7 500 km³ of water met this criterion

- The CIL index for summer 2011 was +0.17°C, an increase of 0.21°C since 2010 making it above normal by 1.5 SD. The overall 2011 CIL water mass properties were similar to those observed in 2006, matching that record since at least 1983.

- The CIL volume as defined by T<1°C decreased significantly compared to 2010 conditions and reached a record-low value. In the case of the volume delimited by 0°C, there was only a slight decrease compared to the already near-record low 2010 conditions.

- On the Magdalen Shallows, none of the bottom area was covered by water with temperatures <0°C in September 2011, similar to conditions in 2005-07, 2009-2010. In many other regions of the Gulf, no bottom area was covered by water colder than 0°C in 2011. Even in the Anticosti Channel and Mécatina Trough, which are regions affected by the cold Labrador Shelf water, bottom areas covered by cold water were considerably reduced compared with previous years.

- March temperatures were characterized by a thin and warm surface mixed layer. CIL conditions remained below normal in thickness throughout the year, especially in the Estuary and Central Gulf, as well as in Cabot Strait in August. At the Rimouski station, the T<1°C CIL thickness diminished quickly to disappear by October, however the minimum temperature warmed more slowly than normal: 0.3°C (+2.4 SD) in May, 1.0°C by September (+1.8 SD) and 1.1°C by November (+0.9 SD). The CIL at Rimouski station was, overall, the thinnest and warmest recorded since monitoring began there in 1991.

- The deep waters in the Estuary were colder and fresher than normal in 2011. Very warm and saline waters occupied Cabot Strait all year at 250 m, the depth of the temperature maximum. By November the surface mixed layer was anomalously thick but more importantly very warm, warmer in fact than that observed during fall 2010 which were preconditions of the low ice cover of winter 2011.

- Gulf-wide average temperatures were above normal at 150 m and normal at 200 to 300 m and salinity averages were normal from 150 to 250 m and above normal at 300 m. Temperature at 300 m increased significantly overall (by 1.3 SD). At Cabot Strait the 300 m temperature anomaly is positive by 1.2 SD; the highest since 1994.

- Salinity at 200 m and 300 m increased overall by 0.9 and 2.4 SD respectively, but increased at Cabot Strait to reach +1.2 SD at 200 m and +1.5 SD at 300 m, the latter being a high since 1986. Salinities in Central Gulf changed from -1.6 SD in 2010 to +1.2 SD in 2011, a large increase of 2.8 SD.

- The 300 m waters of the Estuary were expected to cool between 2010 and 2011 and instead they warmed slightly. The warm anomaly present since 2010 at Cabot Strait should progress up the channel towards the Estuary in the next two years.

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Table 1. Normalized mean air temperature anomalies: annual (top) and January–February–March (bottom) averages. The numbers on the right are the 1981–2010 climatological means and standard deviations. The numbers in the boxes are normalized anomalies. The colour palette used for this and subsequent tables is shown at the bottom. Numbers within 1.5 SD of normal are in black font and stronger anomalies are typeset in white.

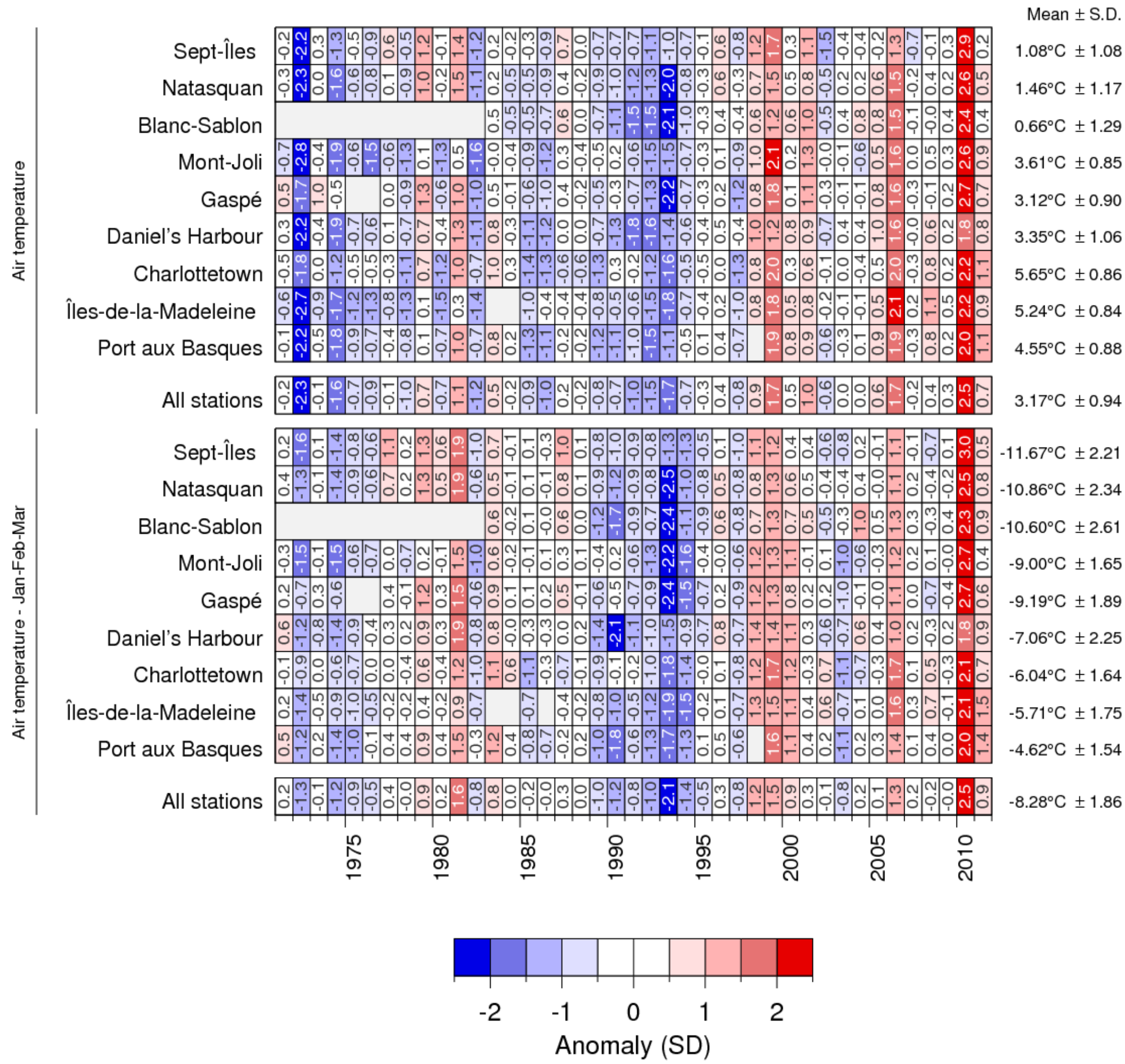

Table 2. Monthly anomalies of the St. Lawrence River runoff and sums of all other major rivers draining into separate Gulf regions for 2010 and 2011. The scorecards are colour-coded according to the monthly normalized anomalies based on the 1981–2010 climatologies for each month, but the numbers are the monthly average runoffs in $m^3 s^{-1}$. Numbers on the right side are annual climatological means. Runoff regulation is simulated for three rivers that flow into the Estuary (Saguenay, Manicouagan, Outardes)

	2010												2011												
	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	
St. Lawrence	11001	11957	13894	13612	10635	10083	9933	9680	10629	12766	11864	14244	11576	10708	12843	16197	21925	15707	12364	13115	11290	12001	10213	10714	12034 $m^3 s^{-1}$
1 - Estuary	4168	4155	4062	5114	8007	5093	3548	3274	4139	4553	3985	3852	3457	3335	3415	4507	8381	8281	6609	6303	5100	5382	5217	4757	4978 $m^3 s^{-1}$
2 - Northwest Gulf	131	110	130	943	2392	2468	1827	1059	1168	1447	1314	1205	340	53	196	563	2456	4894	2699	1595	894	781	831	352	1129 $m^3 s^{-1}$
3 - Anticosti Channel	218	160	223	1177	2727	3192	1893	866	831	1553	1442	1027	319	127	367	719	2304	4256	1892	962	741	743	1094	729	1234 $m^3 s^{-1}$
4 - Mécatina Trough	113	86	85	467	1449	2357	1343	395	346	871	756	489	169	55	133	253	951	2018	790	236	256	421	523	313	597 $m^3 s^{-1}$
5 - Esquiman Channel	92	36	54	230	318	123	34	43	99	115	120	205	155	77	101	252	397	279	113	32	85	235	239	180	162 $m^3 s^{-1}$
8 - Magdalen Shallows	327	196	524	1322	1180	385	129	217	683	732	1062	1323	457	238	618	1459	2269	823	569	753	234	318	546	581	617 $m^3 s^{-1}$

Table 3. Thermosaligraph near-surface temperature monthly anomalies for various sections along the main shipping lane. The numbers on the right are the 2000–2011 climatological means and standard deviations. The numbers in the boxes are normalized anomalies. The map shows all TSG data sampled in 2011. 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

Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
J	-0.7	-0.5	0.4	0.7	-1.6	-0.1	-0.8	1.7				0.9	0.05°C ± 0.56
F	-0.9	-0.2	-1.4	1.5	-0.0	-1.0	-0.8	1.3	-0.2		0.8	0.8	-0.12°C ± 0.50
M	0.5	0.1	0.1	1.8	-1.2	-1.3	0.3	0.1	-1.3		0.9		0.09°C ± 0.50
A	-0.5	0.1	1.7	-0.3	-1.7	-0.7	0.7	-0.7	0.4		1.1		1.29°C ± 0.43
M	-0.4	1.8	0.0	-0.9	-1.8	-0.3	0.8	-0.7	0.8		-0.0	0.8	3.71°C ± 0.86
J	-1.8	0.9	-0.2	-1.1	-0.2	-0.5	0.6	0.6	0.8		-0.7	1.6	5.97°C ± 1.17
J	-0.5		0.5	-1.1	0.2	-1.4	0.0	-0.8	0.8		0.3	2.0	6.78°C ± 0.60
A		0.1	-0.1	-0.5	-1.5	-0.1	0.2	-0.5	1.8		-0.9	1.5	7.08°C ± 1.41
S	-0.3	-0.6		-1.5	-0.1	2.1	0.4	-0.8	-0.3		0.3	0.9	5.55°C ± 0.89
O	-0.9	-0.1	-0.6	-1.2	0.2		2.0	0.9	-0.6		0.4		4.13°C ± 0.77
N	0.4	-0.5	-1.2	-1.3	0.8	-0.1	2.1	-0.1	-0.3			0.1	2.74°C ± 0.62
D	0.3	0.5	-0.6	-1.9	-0.7	-0.2	1.8	-0.3	-0.8		1.1	0.7	0.99°C ± 0.68

Mont-Louis

Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
J	-0.1	-0.1	-0.4	-0.2	-0.5	-0.9	-0.1	-0.3				2.6	-0.80°C ± 0.55
F	-0.6	-0.5	-0.6	-0.6	-0.2	-0.7	-0.2	0.2	-0.7		1.6	2.3	-1.32°C ± 0.36
M	0.7	0.4	-0.8	-0.6	-0.8	-0.8	0.8	-0.0	-1.1		2.1		-1.16°C ± 0.36
A	-0.8	0.3	0.7	-1.3	-0.7	-0.8	0.9	-0.3	0.0		2.0		0.68°C ± 0.61
M	-0.7	1.4	-1.2	-0.3	-1.3	-1.0	0.1	-0.2	1.0		1.4	0.6	4.40°C ± 1.11
J	-0.2	1.3	-0.8	-0.1	-1.3	-0.4	0.8	-1.0	-0.3		2.0	0.0	8.93°C ± 0.91
J	-0.4	-1.5	-0.4	-0.7	0.3	2.0	0.7	0.1	-1.2		0.8	0.3	13.19°C ± 0.94
A		0.3	1.0	-0.2	-1.1	-1.9	0.1	-0.8	0.5		0.9	1.1	12.96°C ± 0.83
S	-1.0	0.8	0.2	-0.8	-1.0	-0.3	-0.3	-1.1	1.9		1.0	0.7	10.06°C ± 1.07
O	-0.8	0.2	-1.0	0.0	0.6		-1.4	-0.0	0.4		1.9		5.96°C ± 1.05
N	-0.2	-0.6	-1.4	-1.4	0.8	1.4	1.2	-0.4	-0.2			0.8	3.82°C ± 1.12
D	0.7	-0.2	-0.8	-1.4	-0.1	-0.2	1.1	-0.8	-0.5		2.1	0.3	0.96°C ± 0.60

Cabot Strait / Détroit de Cabot

Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
J	0.1	-0.5	-0.2	-1.7	-0.2	-0.1	1.3	-0.4				1.7	1.78°C ± 0.75
F	-0.9	0.3	0.3	-2.0	-0.2	1.0	1.4	-0.8	-0.4		0.4	0.9	0.04°C ± 0.77
M	0.2	0.2	-0.4	-2.2	0.4	1.1	0.1	-0.7	-0.1		1.5		-0.41°C ± 0.57
A	0.2	0.2	-0.8	-2.1	-0.1	0.5	0.8	-0.1	-0.1		1.7		0.43°C ± 0.75
M	-0.7	0.7	-1.3	-1.0	-0.7	-0.4	2.0	-0.4	0.5		0.4	1.1	3.31°C ± 0.82
J	0.2	1.1	-0.7	-0.6	-1.5		2.0	0.2	0.0		-0.7	0.1	7.28°C ± 1.03
J			-1.2	-0.3	-0.3		1.6	0.4	1.2		-0.4	-0.9	12.58°C ± 1.20
A		1.5	-0.1	-1.3	-0.1		0.2	-1.2	0.8		1.0	-0.9	16.16°C ± 0.93
S	-0.5	0.8		-1.4	-0.9		0.8	-1.0	1.3		0.9	0.0	13.32°C ± 1.09
O	-0.6	1.2	-1.8	1.0	0.1	0.6	0.5	-1.4	-0.2		0.7		9.39°C ± 1.50
N	0.3	0.1	-2.2	-0.6	0.6	0.8	1.1	-0.9	0.7			0.1	6.43°C ± 1.34
D	0.2	-0.1	-2.0	-0.8	-0.3	0.5	0.7	-1.0	0.6		1.7	0.4	3.98°C ± 0.99

Estuary / Estuaire

Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
J	-0.7	-0.3	1.0	-0.6	-1.5	-0.3	-0.2	1.2				1.5	-0.68°C ± 0.31
F	-0.6	-0.1	-0.7	0.3	-0.9	-0.8	-0.8	0.2	-0.1		2.4	1.1	-0.77°C ± 0.39
M	1.2	-0.1	0.1	0.6	-1.0	-1.2	0.2	-0.2	-1.4		1.6		-0.17°C ± 0.48
A	-0.8	0.2	1.4	-0.2	-1.6	-0.7	0.8	-0.9	0.5		1.2		1.58°C ± 0.45
M	-0.0	1.1	-0.5	-0.9	-1.6	-0.9	0.5	-0.9	1.5		0.9	0.7	4.29°C ± 0.68
J	-1.1	1.2	-0.6	-1.4	-1.1	-0.5	0.7	-0.0	1.2		0.5	1.1	7.02°C ± 1.01
J	-0.3		1.6	-0.9	0.2	1.1	-0.6	-1.4	-0.9		0.2	1.1	8.56°C ± 0.80
A		-0.5	0.7	-0.4	-0.8	-0.1	-0.4	-1.0	1.8		-0.9	1.5	8.74°C ± 1.19
S	-1.0	-0.4	0.6	-0.7	-1.2	1.9	-0.4	-1.1	0.4		1.1	0.7	6.20°C ± 0.55
O	-1.0	-0.1	-0.2	-1.4	0.0		0.6	1.2	-0.7		1.7		4.38°C ± 0.58
N	0.5	-0.3	-1.3	-1.5	0.7	-0.0	1.9	-0.3	-0.1			0.5	2.62°C ± 0.67
D	-0.3	0.6	-0.4	-1.5	-0.6	0.0	1.7	-0.9	-0.7		1.3	0.8	0.62°C ± 0.67

Centre

Month	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
J	-0.4	0.0	-0.6	-1.1	-0.1	-1.0	0.6	0.6				2.1	0.01°C ± 0.67
F	-0.6	-0.3	-0.7	-0.9	-0.3	-0.8	0.7	-0.3			1.0	2.3	-1.18°C ± 0.44
M	0.0	-0.2	-0.6	-0.8	-0.5	-0.5	0.7	0.0	-0.8		2.6		-1.31°C ± 0.36
A	0.1	-0.1	-0.6	-1.2	-0.2	-0.5	1.3	-0.4	-0.5		2.2		-0.08°C ± 0.73
M	-0.6	1.6	-0.9	-1.3	-0.8	-0.8	1.4	-0.2	1.0		0.3	0.3	3.34°C ± 1.23
J	-0.9	1.5	-0.7	-0.5	-1.5		1.6	0.2	-0.1		-0.0	0.5	8.27°C ± 1.42
J	0.0		-1.1	-1.2	-0.7		2.0	0.4	0.8		0.2	-0.2	14.10°C ± 1.25
A		-1.2	-1.3	-0.3	0.3		-0.4	0.1	1.9		0.8	0.1	15.57°C ± 0.94
S	0.7	-0.7		0.5	-0.6		0.4	-2.0	1.1		1.0	-0.4	12.46°C ± 1.05
O	-1.0	1.3	-1.2	1.6	0.7		0.2	-0.8	-0.3		-0.5		8.04°C ± 0.68
N	0.4	-0.9	-1.8	-1.1	0.0	0.6	1.2	-0.3	0.4			1.4	4.84°C ± 0.83
D	0.3	-0.3	-1.2	-1.1	-0.1	0.2	1.3	-1.2	-0.5		1.8	0.6	2.10°C ± 0.71

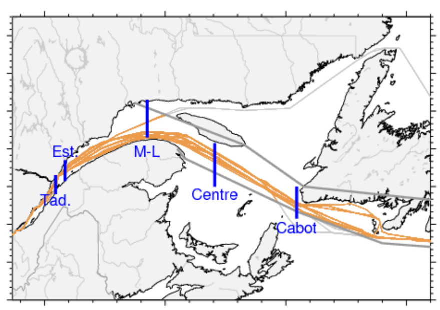

Table 4. Monthly mean temperatures at all shallow sensors of the Maurice Lamontagne Institute thermograph network in 2009 and 2010 as well as at Shediac station from DFO Gulf Region. The number of years that each station and depth has been monitored is indicated on the far right. The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month. Numbers are monthly average temperatures.

Estuary and NW Gulf / Estuaire et NO du Golfe

Station	Depth	2010 J	F	M	A	M	J	J	A	S	O	N	D	2011 J	F	M	A	M	J	J	A	S	O	N	D	Years
Tadoussac	1 m					4.7	6.6	8.1	7.6	8.0	5.6	3.1						4.7	9.4	10.1	12.0	8.9	5.7			6 y
	2 m																	4.4	8.7	8.8	10.8	7.6	5.2			13 y
Bic	1 m					4.7	5.9	7.8	7.5	6.6	4.7							4.6	7.6	9.1	9.5	7.5	4.9			15 y
	2 m					4.3	5.5	7.3	7.0	6.4	4.7							4.4	7.2	8.7	9.2	7.1	4.9			18 y
Rimouski	0.5 m					6.6	9.1	9.8	10.8	7.9	5.1	3.2						5.0	8.9	11.4	12.1	8.6	5.6			10 y
IML	0.5 m					6.9	9.5	11.0	10.8	8.2	5.2							4.7	8.2	12.5	11.0	9.7	5.4			18 y
	10.8 m	-0.7	-0.8	0.3	1.8	3.9	5.6	7.5	7.3	6.9	4.8	2.7	1.4	-0.1	-0.7	-0.2	1.9	3.3	5.6	8.4	8.7	7.4				18 y
Baie-Comeau	1 m					6.4	9.8	12.3	11.9	10.3	6.2							5.3	10.0	12.7	14.2	9.3	7.2			13 y
Gaspé Current	0.5 m					7.9	10.6	13.8	13.2	9.9								4.9	9.6	13.9	13.7	10.8	6.7			7 y
Mont-Louis	0.35 m																	5.3	9.9	13.7	14.5	11.3	8.0			11 y
	0.5 m					6.0	11.3	14.9	14.8	11.0	6.8	2.9						5.2	9.9	13.6	14.4	11.3	8.0			18 y
	1.1 m					6.2	11.3	14.8	14.8	11.1	6.8	2.9						5.4	9.9	13.6	14.4	11.3	8.0			13 y
	2.1 m					6.1	11.2	14.7	14.6	11.0	6.8	2.9						5.2	9.6	13.5	14.2	11.2	8.0			13 y
Anticosti Gyre	0.5 m					5.9	11.0	14.7	14.8	11.1	6.7							5.2	9.7	14.4	14.8	11.6	7.3			7 y
Sept-Îles	1 m					5.8	10.0	15.2	13.5	11.5	5.7							6.0	10.7	16.0	16.3	10.4	6.7			10 y
	2 m					5.6	9.8	14.4	13.1	11.3	5.7							5.4	10.2	15.5	16.0	10.2	6.7			16 y
Port-Menier	2 m					2.2	8.2	13.3	12.7	9.7	5.7							5.0	9.4	13.2	15.2	9.3	7.2			17 y
	12.8 m					1.1	4.8	6.3	8.6	7.2	4.4							3.2	6.6	8.2	11.1	6.2	6.3			13 y

Lower North Shore / Basse Côte Nord

Station	Depth	2010 J	F	M	A	M	J	J	A	S	O	N	D	2011 J	F	M	A	M	J	J	A	S	O	N	D	Years
Rivière-au-Tonnerre	1 m					3.5	7.3	10.6	9.9	10.2	5.7							4.2	8.1	12.0	14.5	7.1	4.9			13 y
	16 m					1.6	3.9	6.6	5.9	7.9	5.0							2.1	4.8	6.8	9.4	4.5	4.0			16 y
Havre-Saint-Pierre	0.5 m					3.6	7.4	10.7	11.8	11.8	7.6							3.4	7.8	11.8	14.2	8.3	5.8			8 y
	1 m					3.5	7.4	10.6	11.6	11.7	7.6							3.3	7.7	11.6	14.1	8.2	5.6			15 y
Natashquan	1 m					5.7	9.7	14.2	15.0	12.0	7.3							5.6	10.4	14.9	17.0	9.5	5.1			17 y
	5.4 m					2.7	4.6	7.3	7.8	9.8	6.7							1.8	6.2	8.5	12.4	4.5	4.3			16 y
La Romaine	1 m					3.3	5.4	9.9	14.8	12.1	7.7							2.7	7.0	12.4	14.4	7.8	6.8	5.9		14 y
	2 m					3.4	5.4	9.8	14.7	12.1	7.7							2.6	6.9	12.3	14.4	7.8	6.8	5.9		18 y
Beaugé	0.5 m					3.6	6.1	11.7	16.4	12.7	8.0							2.3	6.5	11.8	16.2	12.7				7 y
	1 m					3.6	6.1	11.7	16.4	12.7	7.9							2.3	6.4	11.8	16.3	12.7				13 y
La Tabatière	1 m					3.0	4.6	9.2	12.3	11.1	7.1							3.6	7.6	9.6	11.9	7.9	7.3			10 y
Blanc-Sablon	1 m					0.9	2.2	6.4	10.3	7.9	5.9							2.0	2.9	5.0	10.7	10.1	4.9			13 y

Southern Gulf / Sud du Golfe

Station	Depth	2010 J	F	M	A	M	J	J	A	S	O	N	D	2011 J	F	M	A	M	J	J	A	S	O	N	D	Years
Grande-Rivière	2 m					6.0	10.8	14.8	16.2	13.1	9.2							4.8	10.7	14.5	14.7	13.8	9.6			18 y
	10 m					5.1	9.1	12.2	14.0	11.8	9.1							3.9	8.4	11.8	11.4	13.0	9.0			16 y
Borden	1 m	-0.7	-0.8	1.0	5.5	11.1	15.4	19.0	19.6	17.8	11.7	6.5	3.2	-0.9	-1.5	-1.1	3.3	8.5	13.4	16.3	19.7	18.1	13.0			14 y
Irving Whale	0.5 m					5.4	10.0	17.2	18.9	15.0	9.5	5.7						3.4	9.4	16.0	18.2	14.4	10.8	7.1	4.7	12 y
Île Shag	1 m					6.4	10.2	15.9	19.0	16.5								5.6	10.0	14.1	17.3	15.6				14 y
	10 m	-0.1	-1.2		2.8	6.0	9.6	14.6	17.6	14.4	10.7	6.9	4.0	1.2	-1.5	-1.0	1.3	5.1	9.5	12.4	15.8	15.0				19 y
La Perle	1 m					5.1	9.0	15.5	18.9	15.2	10.7	7.0						4.4	8.5	13.8	17.4	15.1	11.4	7.2		16 y
Shediac	5 m					9.4	13.9	19.0	19.8	17.5	12.3	7.5						7.5	12.6	17.3	19.6	17.6	12.4	6.6	2.5	11 y

Table 5. Monthly mean temperatures at all sensors deeper than 20 m of the Maurice Lamontagne Institute thermograph network in 2009 and 2010 as well as at Shediac station from DFO Gulf Region. The number of years that each station and depth has been monitored is indicated on the far right. The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month. Numbers are monthly average temperatures, with greater number of significant digits included when variance is lower.

Estuary and NW Gulf / Estuaire et NO du Golfe

Station	Depth	J 2010	F 2010	M 2010	A 2010	M 2010	J 2010	J 2010	A 2010	S 2010	O 2010	N 2010	D 2010	J 2011	F 2011	M 2011	A 2011	M 2011	J 2011	J 2011	A 2011	S 2011	O 2011	N 2011	D 2011	Years
Tadoussac	36.6 m					1.8	2.9	3.8	3.9	4.4	3.1	2.4						1.8	3.5	4.1	5.7	3.3	3.4			12 y
Bic	30.5 m					1.7	2.5	3.6	3.8	4.0	3.2							1.8	3.3	3.9	4.9	3.7	3.3			16 y
Rimouski	330 m					4.791	4.748	4.740	4.829	4.837	4.833	4.836						4.828	4.804	4.801	4.842	4.910	4.884			7 y
Baie-Comeau	82.3 m	0.8	0.4	-0.2	-0.3	-0.1	0.2	0.5	0.7	1.4	1.2	1.9	2.6	2.3	1.6	0.7	0.4									11 y
Gaspé Current	165 m					3.0	3.0	3.2	3.4	3.3	3.5							3.2	3.3	3.5	3.7	3.9	3.7			7 y
Mont-Louis	30 m					-0.1	0.0	0.2	0.3	1.6	2.4	1.3						0.1	0.2	0.7	3.9	6.4	4.0			16 y
Anticosti Gyre	337 m					5.205	5.177	5.176	5.185	5.179	5.163							5.290	5.252	5.255	5.269	5.316	5.414			7 y
Sept-Îles	21.9 m					0.9	2.6	4.6	4.0	5.8	3.7							1.7	4.3	4.6	7.4	2.8	3.9			15 y

Lower North Shore / Basse Côte Nord

Station	Depth	J 2010	F 2010	M 2010	A 2010	M 2010	J 2010	J 2010	A 2010	S 2010	O 2010	N 2010	D 2010	J 2011	F 2011	M 2011	A 2011	M 2011	J 2011	J 2011	A 2011	S 2011	O 2011	N 2011	D 2011	Years
Havre-Saint-Pierre	120 m					0.0	0.4	0.8	0.9	1.4	1.6							0.3	0.5	0.9	1.0	1.4	1.5			14 y
La Romaine	21.9 m					1.1	1.9	2.8	3.9	7.4	5.7							0.7	3.4	3.5	3.0	2.4	6.1	4.9		15 y
La Tabatière	39 m					-0.1	1.1	3.1	4.1	7.1	5.9							0.5	2.3	2.0	2.2	3.4	5.6			10 y
Blanc-Sablon	22 m					0.3	1.7	5.4	6.1	6.9	5.5							0.4	2.5	4.0	6.7	7.9	4.7			12 y
Belle Isle	71 m	-0.8					0.6	0.7	0.1	2.2	3.3	2.8	1.8	0.6	-1.4	-1.7	-1.5	-0.4								5 y

Southern Gulf / Sud du Golfe

Station	Depth	J 2010	F 2010	M 2010	A 2010	M 2010	J 2010	J 2010	A 2010	S 2010	O 2010	N 2010	D 2010	J 2011	F 2011	M 2011	A 2011	M 2011	J 2011	J 2011	A 2011	S 2011	O 2011	N 2011	D 2011	Years
Irving Whale	67 m					-0.5	-0.0	0.3	0.4	0.6	1.2	1.3						-0.5	-0.0	0.3	0.5	0.6	0.8	1.2		10 y

Table 6. Time series of the monthly averaged temperature anomalies for selected stations of the thermograph network. The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month. Numbers are monthly average temperatures. The mean and standard deviation are indicated for each month on the right side of the table.

Station	Month	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
Natashquan - 1 m	M								4.8	7.4	6.0			7.0		4.6	6.6	5.3	5.7	5.6	5.89°C ± 0.96
	J		9.6	9.7	10.8		10.6	11.7	10.3	10.1	8.5	10.6	9.4	11.4	14.1	10.8	9.5	12.0	9.7	10.4	10.54°C ± 1.27
	J		13.9	14.8	14.1		14.1	12.7	14.8	13.3	14.4	13.6	15.5	13.4	14.1	15.1	16.4	15.8	14.2	14.9	14.42°C ± 0.97
	A		13.0	12.3	15.5		11.6	14.9	16.1	13.5	14.4	15.0	12.3	11.2	12.9	12.8	16.7	14.1	15.0	17.0	14.02°C ± 1.76
	S		9.7	10.3	11.0		12.3	13.1	8.0	10.3	10.1	9.2	7.8	12.7	10.7	9.2	12.0	8.9	12.0	9.5	10.40°C ± 1.60
	O		7.8	6.9	6.2		4.9	7.0	4.6	7.1	4.4	8.2	8.0	8.6	7.5	6.9	7.4		7.3	5.1	6.75°C ± 1.31
La Tabatière - 1 m	M										0.6					1.3		2.1	3.0	3.6	2.13°C ± 1.23
	J										5.4	5.6	5.4	7.3	6.7	5.5	7.0	7.3	4.6	7.6	6.24°C ± 1.06
	J										7.9	10.2	8.3	9.1	10.4	8.8	9.1	11.8	9.2	9.6	9.46°C ± 1.12
	A										11.7	12.8	10.9	11.0	12.5	12.0	13.8	11.4	12.3	11.9	12.05°C ± 0.86
	S										10.0	10.9	11.0	12.1	11.4	9.1	11.0	9.7	11.1	7.9	10.43°C ± 1.26
	O											7.3	7.0	7.6	7.9	6.3	8.1		7.1	7.3	7.33°C ± 0.56
Blanc-Sablon - 1m	M										0.6								0.9	2.0	1.14°C ± 0.77
	J							4.7	4.3	2.9	3.2	2.6	1.8	3.9	4.6	2.2	3.3	4.6	2.2	2.9	3.32°C ± 1.01
	J							9.0	8.4	7.8	8.4	8.8	6.2	8.1	10.7	9.4	9.4	7.0	6.4	5.0	8.03°C ± 1.55
	A							12.1	12.9	11.3	10.8	10.4	13.1	10.7	12.6	11.2	12.0	11.1	10.3	10.7	11.49°C ± 0.96
	S							9.2	9.9	8.3	7.3	8.9	8.1	9.9	9.0	8.7	10.1	7.6	7.9	10.1	8.85°C ± 0.96
	O							5.0	5.0	6.8	3.0	7.5	4.5	6.0	6.4	3.8	6.3		5.9	4.9	5.43°C ± 1.29
Irving Whale - 0.5 m	M						6.0			3.8	3.9		3.3	1.9	6.9	3.7			5.4	3.4	4.27°C ± 1.55
	J						11.4	12.8	10.5	12.2	10.1	9.3	9.1	9.1	12.6	10.0			10.0	9.4	10.54°C ± 1.35
	J						16.9	17.5	16.5	16.9	15.9	16.8	16.0	16.7	17.7	17.0			17.2	16.0	16.77°C ± 0.60
	A						16.3	16.7	19.2	18.6	17.7	17.3	18.3	18.3	17.8	16.9			18.9	18.2	17.85°C ± 0.90
	S						15.1	15.3	14.7	15.9	13.6	14.8	14.1	16.6	15.4	14.0			15.0	14.4	14.91°C ± 0.83
	O						9.0	8.7	9.8	11.7	10.6	11.2	11.3	11.2	11.3	11.2			9.5	10.8	10.52°C ± 1.01
	N						4.5	5.1		5.4	5.1	4.8				6.0			5.7	7.1	5.48°C ± 0.83
	D						2.3	3.8												4.7	3.60°C ± 1.23
Île Shag - 10 m	J		-1.7	-1.3	-1.6	-0.8	-1.5	-1.7	-0.6	-0.8	-0.6	-0.9	-0.8	-1.4	0.3	-0.5	-1.4		-0.1	1.2	-0.83°C ± 0.78
	F		-1.8	-1.7	-1.7	-1.7	-1.7	-1.7	-1.4	-1.3	-1.4	-1.3	-1.6	-1.7	-1.3	-1.7	-1.7		-1.2	-1.5	-1.54°C ± 0.20
	M		-1.7	-1.5	-1.5	-1.5	-1.1	-1.4	-0.8	-0.8	-1.3	-1.2	-1.5	-1.4	-0.8	-1.5	-1.6			-1.0	-1.30°C ± 0.30
	A		-0.4	-0.7	0.1	-0.5	0.8	0.8	1.7	0.6	0.7	0.1	0.2	0.1	1.6	0.0	0.2		2.8	1.3	0.55°C ± 0.91
	M		3.2	2.9	4.3	3.5	5.8	4.5	4.8	4.9	3.7	3.8	4.5	4.3	6.3	4.4	4.4		6.0	5.1	4.49°C ± 0.95
	J		7.0	8.2	8.4	7.6	9.9	10.2	8.5	9.9	8.1	7.6	7.9	8.6	10.0	8.9	9.1	9.2	9.6	9.5	8.80°C ± 0.96
	J		13.3	13.6	13.4	12.9	13.4	15.2	14.3	14.4	12.7	11.9	12.7	13.4	15.1	13.3	14.6	12.8	14.6	12.4	13.56°C ± 0.95
	A		16.0	16.6	16.6	15.9	15.3	16.3	17.1	17.5	15.5	14.8	16.7	17.1	15.3	15.9	16.9	15.9	17.6	15.8	16.26°C ± 0.79
	S		14.5	13.1	15.6	14.8	13.2	16.0	15.2	16.1	14.9	14.9	13.7	15.9	15.3	13.1	14.3	14.6	14.4	15.0	14.69°C ± 0.94
	O	10.1	9.0	10.5	10.8	10.7	9.1	10.0	10.9	11.9	10.2	12.2	11.1	11.5	10.9	10.6		10.4	10.7		10.62°C ± 0.84
	N	5.4	5.7	6.5	6.6	5.9	5.4	5.2	6.9	6.6	5.3	6.3	5.6	6.5	6.1	6.6		5.9	6.9		6.08°C ± 0.58
	D	1.6	1.1	1.2	2.8	1.2	1.2	3.2	2.3	2.5	1.8	2.4	1.5	2.5	2.9	1.0		2.8	4.0		2.12°C ± 0.87
Shediac - 5 m	M									7.2	7.7	6.0	8.3	6.0	9.5	7.4	6.3	9.1	9.4	7.5	7.66°C ± 1.28
	J									11.0	13.2	11.1	12.9	9.6	14.8	14.2	11.9	13.9	13.9	12.6	12.63°C ± 1.58
	J									12.9	17.5	15.4	18.1	15.1	17.2	17.9	15.1	18.0	19.0	17.3	16.69°C ± 1.82
	A									14.3	19.7	17.0	20.4	18.2	18.6	19.1	17.1	17.9	19.8	19.6	18.33°C ± 1.73
	S									13.2	17.3	17.0	16.6	17.7	17.4	17.2	16.3	16.2	17.5	17.6	16.73°C ± 1.27
	O									10.1	11.9	13.5	12.5	13.1	12.4	13.1	12.2	10.7	12.3	12.4	12.19°C ± 1.00
	N										4.2	6.9	4.9	8.0	7.3	6.4	7.4	6.0	7.5	6.6	6.51°C ± 1.19
	D											1.6	0.0	2.6	1.9	-0.7	2.3			2.5	1.45°C ± 1.30

Table 7. NOAA SST May to November monthly anomalies averaged over the Gulf, the eight regions of the Gulf, and management regions of the St. Lawrence Estuary for 2010 and 2011 (April results are also shown for the Northwest Gulf, the Estuary, and its regions). The scorecards are colour-coded according to the monthly normalized anomalies based on the 1985–2010 climatologies for each month, but the numbers are the monthly average temperatures in ºC.

	2010									2011										
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
GSL		4.1	8.3	14.2	16.4	13.0	9.3	5.3						3.5	8.2	13.0	15.4	12.6	8.6	5.5
1 - Estuary	2.2	6.0	9.0	11.1	10.6	8.5	5.6	2.5					1.2	4.6	8.9	11.6	11.4	8.0	5.3	3.0
2 - Northwest Gulf	1.2	5.0	9.8	14.3	14.2	11.4	7.4	4.0					0.5	4.0	9.3	13.5	14.2	10.6	7.4	4.3
3 - Anticosti Channel		3.4	7.0	12.3	15.0	12.2	8.4	4.9						2.0	7.1	12.3	14.6	10.6	7.1	4.6
4 - Mécatina Trough		1.8	4.3	10.7	13.8	10.5	7.4	3.8						1.8	5.8	9.9	12.7	9.9	6.2	2.5
5 - Esquiman Channel		3.1	6.6	12.4	16.2	12.6	9.0	5.4						2.4	6.7	11.5	15.2	12.5	7.1	3.9
6 - Central Gulf		3.3	7.5	13.9	17.3	13.6	9.8	5.5						2.7	7.5	12.4	15.8	13.5	9.2	6.2
7 - Cabot Strait		3.5	7.2	14.2	17.8	14.4	11.1	6.9						3.8	7.1	12.1	15.6	14.3	10.0	7.0
8 - Magdalen Shallows		5.2	10.5	17.0	18.7	14.8	10.9	6.3						4.9	9.7	15.3	17.4	14.8	10.8	7.4
PMSSL (Saguenay)	0.5	6.2	10.1	13.8	12.5	7.3	3.6	0.6					0.2	3.3	10.2	13.2	12.3	9.7	5.2	2.4
PMSSL (Estuary)	2.0	4.7	7.2	9.3	8.8	7.6	5.4	2.4					1.2	4.6	8.1	10.0	10.0	7.6	5.1	3.0
St. Lawrence Estuary MPA	2.3	5.8	8.6	10.5	10.1	8.3	5.6	2.5					1.3	4.8	8.9	11.2	11.2	8.2	5.3	3.1
Manicouagan MPA	2.4	6.5	9.6	11.9	11.7	9.1	5.9	2.6					1.3	4.9	9.6	12.4	11.9	8.3	6.0	3.1

Table 8. NOAA SST May to November monthly anomalies averaged over the Gulf of St. Lawrence and over the first four regions of the Gulf. The scorecards are colour-coded according to the monthly normalized anomalies based on the 1985–2010 climatologies for each month, but the numbers are the monthly average temperatures in ºC. The 1985-2010 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, also only in recent years in the Estuary. The May to November average is also included.

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
GSL SST Anomaly	M	2.5	3.7	2.9	3.4	2.3	1.9	2.3	2.6	2.5	3.6	3.8	3.2	2.8	4.7	4.0	3.4	4.5	2.9	2.7	2.6	3.6	5.6	3.2	4.2	3.4	4.1	3.5	3.31°C ± 0.86
	J	7.0	6.8	8.7	7.2	8.8	7.0	7.7	7.3	7.9	8.7	9.4	9.4	7.8	9.4	9.8	8.3	9.8	8.2	8.4	7.4	8.9	10.4	8.6	8.5	9.0	8.3	8.2	8.43°C ± 0.97
	J	12.2	12.1	13.7	13.1	13.6	11.9	12.2	11.5	12.3	14.4	14.7	13.6	13.3	14.1	14.9	14.1	14.2	13.3	13.6	13.9	14.0	15.2	14.1	14.7	13.3	14.2	13.0	13.54°C ± 1.00
	A	14.9	14.2	14.8	15.3	14.5	14.7	14.2	13.5	15.5	15.6	15.9	16.2	15.0	15.2	15.8	16.5	15.9	15.7	15.4	15.9	15.0	15.7	14.8	15.9	16.2	16.4	15.4	15.35°C ± 0.74
	S	12.4	11.3	12.1	11.9	11.2	12.4	11.3	12.3	12.5	12.8	12.1	13.7	12.9	12.9	14.0	13.0	13.4	12.1	12.8	11.7	13.6	13.2	11.6	13.1	12.2	13.0	12.6	12.52°C ± 0.77
	O	7.8	7.3	8.3	7.3	5.9	8.7	8.5	7.5	8.3	8.9	9.1	8.6	8.6	7.8	8.8	8.4	9.5	8.2	9.9	8.9	9.2	9.7	8.4	8.7	7.8	9.3	8.6	8.43°C ± 0.87
	N	3.8	3.4	3.4	3.7	3.7	3.2	4.7	3.3	4.0	5.3	5.4	4.9	4.8	4.6	4.4	4.6	4.4	3.5	4.0	4.5	5.1	5.6	5.0	5.4	4.7	5.3	5.5	4.41°C ± 0.75
	M-N	8.7	8.4	9.1	8.8	8.6	8.5	8.7	8.3	9.0	9.9	10.1	9.9	9.3	9.8	10.3	9.8	10.2	9.1	9.6	9.3	9.9	10.8	9.4	10.1	9.5	10.1	9.5	9.43°C ± 0.67
1 - Estuary	A			2.2					1.5	1.7		2.4	1.9				1.9		2.6	0.7	1.0	1.3	2.1	1.1	1.7	1.6	2.2	1.2	1.73°C ± 0.52
	M		5.3	4.7	5.2	3.5	4.6		3.9	4.4	6.5	4.9	4.8	4.7	5.6	6.1	4.9	6.7	4.6	4.1	4.0	3.9	5.7	5.0	5.5	4.1	6.0	4.6	4.95°C ± 0.86
	J	7.6	6.2	7.5	8.0	7.9	7.4	8.1	7.4	9.0	9.0	8.5	8.8	8.2	9.7	8.6	8.0	9.7	8.5	8.1	7.9	8.2	9.7	9.1	8.7	8.1	9.0	8.9	8.34°C ± 0.81
	J	9.2	9.2	10.4	11.3	10.2	9.1	9.2	9.4	12.6	11.5	12.2	11.3	10.2	10.2	10.0	11.9	10.8	11.3	11.2	11.6	11.2	11.3	11.0	11.2	10.5	11.1	11.6	10.74°C ± 0.98
	A	9.8	9.1	9.8	10.6	8.1	9.7	10.1	8.5	11.8	10.3	11.1	10.6	9.5	9.0	10.4	11.5	10.4	10.6	11.2	9.5	9.5	10.7	9.6	11.9	11.0	10.6	11.4	10.20°C ± 0.95
	S	8.2	6.5	6.7	6.4	6.5	7.4	6.3	6.8	7.8	7.7	7.1	8.9	8.4	9.0	9.0	7.3	7.5	8.2	7.2	6.9	8.1	8.0	6.5	8.0	7.2	8.5	8.0	7.55°C ± 0.84
	O	4.2	3.8	4.2	3.4	2.4	3.8	3.5	3.3	3.7	5.7	4.9	4.0	5.0	4.2	5.3	4.2	4.8	5.0	4.7	4.8	5.6	5.2	5.4	4.4	4.7	5.6	5.3	4.46°C ± 0.82
	N	1.6	1.3	1.2	1.2	0.9	0.8	2.3	1.0	1.1	3.8	2.2	1.6	2.5	2.1	2.2	2.2	2.3	1.6	1.4	2.5	2.9	3.3	2.5	2.4	3.0	2.5	3.0	2.02°C ± 0.77
	M-N		5.9	6.3	6.6	5.6	6.1		5.8	7.2	7.8	7.3	7.2	6.9	7.1	7.4	7.2	7.5	7.1	6.8	6.7	7.0	7.7	7.0	7.5	7.0	7.6	7.5	6.93°C ± 0.59
2 - Northwest Gulf	A		0.7	1.3	0.1	0.4	0.6	0.4	0.6	0.5	0.1	1.2	0.8	0.6	1.2	1.6	0.7	0.5	0.7	0.1	0.2	-0.2	1.5	0.6	1.1	0.7	1.2	0.5	0.69°C ± 0.46
	M	2.7	5.4	3.7	4.3	2.9	3.2	2.7	3.6	3.6	4.8	4.7	3.8	3.9	5.9	5.0	3.7	5.9	3.5	4.0	3.0	3.9	5.8	3.8	5.3	3.4	5.0	4.0	4.14°C ± 0.99
	J	8.4	6.8	8.7	7.8	9.8	8.0	8.2	8.1	9.5	10.1	10.5	10.5	8.8	10.2	10.1	8.8	10.1	8.6	9.3	8.1	9.8	10.8	8.9	8.8	9.2	9.8	9.3	9.14°C ± 1.00
	J	12.2	11.4	12.8	13.8	13.2	11.4	11.4	11.2	13.4	13.8	15.1	13.3	12.9	13.5	13.5	14.1	13.4	13.0	13.0	13.8	14.3	14.5	13.7	13.6	13.1	14.3	13.5	13.22°C ± 1.01
	A	13.4	12.7	12.3	14.0	12.1	13.3	13.0	11.5	15.3	13.0	14.6	13.9	13.1	13.5	14.0	15.1	13.3	13.8	14.0	13.5	12.8	13.4	12.8	14.9	14.5	14.2	14.2	13.54°C ± 0.92
	S	11.2	9.0	9.2	9.1	9.3	10.1	9.6	10.2	10.5	10.0	10.3	11.7	11.5	12.2	11.9	10.2	10.5	9.9	10.2	9.1	10.9	10.3	8.7	11.4	9.7	11.4	10.6	10.31°C ± 0.97
	O	5.6	5.4	5.7	5.1	3.9	5.7	5.9	5.1	5.3	8.1	6.7	6.5	7.4	6.3	7.4	6.1	6.6	6.0	7.4	7.0	7.2	7.0	6.4	6.4	6.8	7.4	7.4	6.32°C ± 0.95
	N	2.5	1.9	1.9	2.1	1.9	1.8	3.6	1.9	2.2	4.8	3.3	3.2	3.4	3.7	3.1	3.2	2.9	2.5	2.3	4.0	4.3	4.6	3.8	3.6	3.9	4.0	4.3	3.10°C ± 0.91
	M-N	8.0	7.5	7.8	8.0	7.6	7.7	7.8	7.4	8.6	9.2	9.3	9.0	8.7	9.3	9.3	8.7	9.0	8.2	8.6	8.3	9.0	9.5	8.3	9.2	8.6	9.4	9.1	8.54°C ± 0.67
3 - Anticosti Channel	M	1.9	2.5	1.9	2.4	1.4	0.5	1.4	1.6	1.6	2.5	3.0	2.8	1.6	3.7	2.8	2.1	3.5	2.1	1.4	1.8	2.7	4.9	1.9	3.5	2.0	3.4	2.0	2.35°C ± 0.92
	J	5.7	5.0	7.9	6.3	8.2	4.7	6.1	6.0	7.0	7.1	8.0	8.7	7.0	8.5	8.4	6.6	8.7	7.5	7.3	6.5	8.7	9.7	6.9	7.4	8.4	7.0	7.1	7.28°C ± 1.24
	J	11.0	10.9	12.4	11.5	12.4	10.0	10.5	10.3	10.9	12.2	13.1	12.5	12.0	12.8	12.8	12.7	12.3	12.2	12.0	13.0	12.8	13.9	13.0	13.3	12.2	12.3	12.3	12.12°C ± 0.98
	A	13.1	13.1	13.2	13.6	12.5	12.5	12.6	12.0	13.8	13.3	13.9	14.7	13.4	13.2	14.2	15.1	13.8	14.2	14.6	13.9	12.4	14.1	13.8	15.3	14.6	15.0	14.6	13.69°C ± 0.88
	S	11.3	10.1	10.8	9.8	10.2	10.0	9.6	10.3	10.1	11.4	11.3	12.5	11.8	11.9	13.2	10.8	11.8	10.8	10.7	10.3	12.3	12.2	10.0	12.0	10.4	12.2	10.6	11.07°C ± 0.99
	O	6.2	6.5	7.5	6.5	4.8	7.2	7.1	6.6	5.7	8.3	8.2	7.4	8.0	6.9	7.9	6.8	8.5	7.0	8.0	8.3	8.5	8.7	7.4	8.0	6.8	8.4	7.1	7.35°C ± 0.96
	N	2.5	2.3	2.8	3.3	2.8	2.8	4.0	2.9	2.8	4.5	4.9	4.0	3.9	3.2	3.3	3.8	4.0	3.1	3.5	4.2	5.1	5.5	4.0	5.2	3.4	4.9	4.6	3.72°C ± 0.89
	M-N	7.4	7.2	8.1	7.6	7.5	6.8	7.3	7.1	7.4	8.4	8.9	8.9	8.3	8.6	8.9	8.3	8.9	8.2	8.2	8.3	8.9	9.9	8.1	9.2	8.3	9.0	8.3	8.22°C ± 0.76
4 - Mécatina Trough	M	1.6	1.4	1.4	2.4	0.2	-0.5	1.1	1.2	0.9	1.7	1.5	2.1	1.2	1.6	2.3	2.0	2.8	1.3	1.6	1.2	3.1	4.0	1.3	2.0	1.5	1.8	1.8	1.64°C ± 0.88
	J	5.2	3.7	6.9	4.6	5.6	3.8	4.6	4.5	5.0	6.2	6.3	5.8	5.5	6.5	6.8	6.6	5.8	6.4	5.7	5.4	7.2	7.3	5.7	5.5	7.5	4.3	5.8	5.71°C ± 1.06
	J	8.2	9.3	10.7	8.9	9.9	9.4	8.5	7.0	7.9	10.7	11.0	10.2	10.4	10.7	11.2	11.3	10.1	9.9	10.5	10.0	10.1	12.0	10.6	11.4	10.1	10.7	9.9	10.03°C ± 1.17
	A	11.3	11.8	12.9	12.0	12.0	11.3	10.6	9.7	10.7	12.1	13.4	14.1	12.5	12.0	14.4	13.9	13.5	12.9	13.3	13.2	12.3	14.2	12.7	13.7	13.1	13.8	12.7	12.60°C ± 1.22
	S	9.3	8.9	10.2	10.2	8.3	10.5	7.4	9.3	9.2	10.6	9.6	10.8	9.4	8.7	12.5	11.5	12.0	10.0	11.6	10.5	11.7	11.5	10.0	11.8	10.1	10.5	9.9	10.23°C ± 1.24
	O	5.4	4.7	6.7	5.8	4.7	7.8	6.2	6.0	6.5	5.7	7.5	5.0	6.2	5.4	6.5	7.5	7.8	5.1	8.8	6.6	7.5	8.1	5.2	7.5	4.0	7.4	6.2	6.37°C ± 1.23
	N	1.3	1.9	2.8	3.3	1.8	1.8	2.6	2.2	3.0	3.9	4.6	2.5	2.2	2.3	2.8	2.5	3.2	1.5	3.7	3.0	3.0	3.5	3.0	4.2	2.1	3.8	2.5	2.79°C ± 0.85
	M-N	6.0	5.9	7.4	6.7	6.1	6.3	5.9	5.7	6.2	7.3	7.7	7.2	6.8	6.7	8.1	7.9	7.9	6.7	7.9	7.1	7.8	8.7	7.0	8.0	6.9	7.5	7.0	7.05°C ± 0.81

Table 9. NOAA SST May to November monthly anomalies averaged over the remaining four regions of the Gulf. The scorecards are colour-coded according to the monthly normalized anomalies based on the 1985–2010 climatologies for each month, but the numbers are the monthly average temperatures in ºC. The 1985-2010 mean and standard deviation are indicated for each month on the right side of the table. The May to November average is also included.

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± SD
5 - Esquiman Channel	M	2.0	2.4	2.1	2.8	0.8	0.9	1.5	1.5	1.5	2.6	2.7	2.3	1.6	3.0	3.0	2.6	3.3	1.7	1.8	1.8	3.2	4.6	2.4	3.1	1.9	3.1	2.4	2.31°C ± 0.84
	J	5.8	5.4	7.6	6.1	7.2	5.0	5.8	5.7	6.3	6.5	8.1	7.5	6.4	8.6	8.5	7.0	8.8	7.0	7.3	5.8	8.0	9.1	7.8	7.4	8.1	6.6	6.7	7.06°C ± 1.13
	J	11.1	11.7	13.1	10.8	12.8	10.6	10.8	10.0	9.8	12.1	12.9	12.0	12.0	13.1	14.4	12.4	12.8	12.1	12.3	12.9	12.3	14.5	13.1	13.7	12.1	12.4	11.5	12.22°C ± 1.18
	A	14.6	14.3	15.1	15.0	14.3	13.9	13.6	12.8	13.8	15.4	15.4	16.1	14.6	14.7	15.4	16.6	15.7	15.5	15.3	16.2	14.7	16.0	14.9	15.9	16.0	16.2	15.2	15.08°C ± 0.92
	S	11.7	10.9	12.5	12.5	10.6	12.5	10.5	11.8	11.8	12.9	11.4	13.7	12.1	11.4	14.1	13.8	13.3	11.5	13.4	12.0	13.5	13.5	11.8	13.2	12.0	12.6	12.5	12.35°C ± 1.01
	O	7.9	6.8	8.3	7.3	5.7	8.5	7.5	7.4	8.2	8.6	8.8	7.7	7.6	7.2	9.1	8.7	9.2	7.0	10.5	8.2	8.2	10.0	8.0	8.6	6.5	9.0	7.1	8.10°C ± 1.05
	N	3.1	3.6	3.7	4.1	3.4	2.9	4.9	3.0	3.9	5.0	5.9	4.7	4.1	4.7	4.3	4.1	4.0	2.7	4.4	4.3	4.7	5.3	4.5	5.4	3.9	5.4	3.9	4.23°C ± 0.82
	M-N	8.0	7.9	8.9	8.4	7.8	7.8	7.8	7.5	7.9	9.0	9.3	9.2	8.3	8.9	9.8	9.3	9.6	8.2	9.3	8.7	9.2	10.4	8.9	9.6	8.6	9.3	8.4	8.76°C ± 0.75
6 - Central Gulf	M	1.8	3.1	2.5	2.5	1.6	1.1	1.8	1.7	2.0	2.2	3.4	2.2	2.1	3.8	2.9	2.7	3.6	1.8	1.8	1.9	3.1	5.2	2.6	3.7	2.4	3.3	2.7	2.57°C ± 0.90
	J	6.2	6.3	8.7	6.3	8.5	6.0	6.8	6.8	7.1	7.3	9.3	8.5	7.2	8.7	9.0	7.2	9.4	7.2	7.4	6.3	8.2	9.8	7.7	7.7	7.9	7.5	7.5	7.66°C ± 1.07
	J	12.5	12.1	14.0	12.8	13.9	11.2	12.0	11.8	11.7	13.9	14.7	13.7	13.3	14.3	15.3	13.9	14.4	13.0	12.7	14.0	14.0	15.6	14.0	14.8	13.5	13.9	12.4	13.49°C ± 1.13
	A	16.0	15.0	15.0	16.3	15.5	14.9	14.4	14.2	15.9	16.3	16.6	17.0	15.9	16.0	16.1	17.4	16.7	16.2	15.8	17.0	15.8	16.6	15.4	16.8	16.9	17.3	15.8	16.03°C ± 0.85
	S	13.1	12.3	13.0	12.8	11.0	12.7	12.1	13.0	13.0	13.6	12.5	14.6	13.6	13.5	14.6	13.9	13.7	12.2	13.6	11.9	13.6	14.3	11.8	13.2	13.0	13.6	13.5	13.08°C ± 0.87
	O	7.8	8.0	8.6	7.5	5.9	8.9	8.8	7.9	8.7	9.3	9.2	9.1	8.8	7.9	8.7	8.6	9.3	8.5	10.0	9.2	8.9	10.3	8.5	8.8	7.9	9.8	9.2	8.67°C ± 0.89
	N	3.8	3.4	3.4	3.7	3.8	3.1	4.7	3.5	4.2	4.6	5.5	5.0	5.0	4.6	4.4	4.8	4.2	3.7	3.9	4.6	5.0	6.0	5.0	5.5	4.9	5.5	6.2	4.44°C ± 0.76
	M-N	8.7	8.6	9.3	8.8	8.6	8.3	8.7	8.4	8.9	9.6	10.2	10.0	9.4	9.8	10.1	9.8	10.2	9.0	9.3	9.3	9.8	11.1	9.3	10.1	9.5	10.1	9.6	9.42°C ± 0.69
7 - Cabot Strait	M	1.9	3.3	2.5	3.2	1.7	1.1	1.7	2.1	2.2	3.0	3.3	2.7	2.1	4.2	3.7	3.6	3.7	2.4	2.3	2.3	3.7	5.3	2.8	3.2	3.3	3.5	3.8	2.88°C ± 0.91
	J	6.3	6.7	7.7	6.5	7.7	6.4	6.3	6.4	6.8	8.1	8.4	8.5	6.8	8.8	9.6	8.1	8.9	7.6	7.6	6.6	8.2	9.5	8.3	7.8	8.2	7.2	7.1	7.67°C ± 0.99
	J	11.7	11.9	14.0	12.6	13.6	11.9	12.1	11.2	11.5	14.8	13.9	13.5	13.1	14.5	15.6	14.3	14.5	13.1	13.4	13.6	13.6	15.3	13.8	14.9	13.7	14.2	12.1	13.47°C ± 1.20
	A	15.9	15.2	16.5	15.9	16.1	15.7	14.9	14.6	16.2	17.6	16.9	17.5	15.9	17.1	17.6	17.8	17.3	17.0	16.2	17.5	16.1	16.5	15.5	16.3	17.2	17.8	15.6	16.50°C ± 0.92
	S	13.5	12.8	14.3	13.3	12.2	14.2	12.2	14.5	14.3	14.8	13.1	14.8	14.0	14.2	15.6	14.3	15.0	13.1	13.5	12.6	15.5	14.4	12.9	14.2	13.4	14.4	14.3	13.89°C ± 0.93
	O	9.1	8.9	10.0	9.2	7.0	10.7	10.6	8.8	11.7	10.6	10.9	10.5	9.7	9.6	10.2	9.7	11.9	8.8	12.0	9.9	10.8	11.5	9.2	9.9	9.5	11.1	10.0	10.07°C ± 1.14
	N	5.7	5.4	4.4	5.4	5.1	4.3	5.5	4.5	6.0	6.2	7.0	6.6	7.0	6.9	5.8	6.6	6.1	4.1	5.4	6.3	6.3	7.0	6.0	7.0	6.0	6.9	7.0	5.90°C ± 0.89
	M-N	9.2	9.2	9.9	9.4	9.1	9.2	9.0	8.9	9.8	10.7	10.5	10.6	9.8	10.7	11.2	10.6	11.1	9.4	10.1	9.8	10.6	11.4	9.8	10.5	10.2	10.7	10.0	10.05°C ± 0.73
8 - Magdalen Shallows	M	3.6	4.4	3.8	3.9	3.9	2.7	3.6	3.5	3.0	4.4	4.7	4.1	3.7	6.2	5.2	4.4	5.3	4.3	3.7	3.7	4.1	7.0	4.6	5.3	5.3	5.2	4.9	4.36°C ± 0.97
	J	8.2	9.2	10.6	8.6	10.6	9.7	10.5	9.5	9.3	11.1	11.3	11.6	9.3	10.9	12.1	10.5	11.9	10.0	10.4	9.4	10.0	12.6	10.4	10.7	10.7	10.5	9.7	10.37°C ± 1.05
	J	14.5	14.2	16.1	15.9	15.9	14.7	15.5	14.2	14.7	18.1	17.6	15.9	15.9	16.6	18.0	16.5	17.1	15.8	16.6	16.0	16.5	17.6	16.6	17.4	15.4	17.0	15.3	16.17°C ± 1.12
	A	17.4	15.9	17.2	17.7	17.2	17.8	16.8	16.4	18.1	18.5	18.5	18.8	17.7	17.9	18.1	18.2	18.9	18.1	17.3	18.6	18.2	17.9	17.1	17.1	18.5	18.7	17.4	17.80°C ± 0.75
	S	14.6	13.4	14.1	14.3	14.0	15.1	14.2	15.0	15.5	15.3	14.5	16.0	15.1	15.2	15.9	15.4	16.1	14.8	15.2	14.2	16.2	15.4	14.3	14.9	14.8	14.8	14.8	14.92°C ± 0.70
	O	10.0	9.3	10.2	8.8	7.8	11.3	11.3	9.5	10.9	10.2	11.1	11.1	10.4	9.6	10.1	10.5	12.0	11.2	11.9	11.0	11.7	11.5	11.0	10.6	9.9	10.9	10.8	10.54°C ± 0.99
	N	5.3	4.4	4.3	4.6	5.4	4.5	6.0	4.4	5.4	6.4	6.5	6.7	6.1	5.5	5.7	6.0	5.8	4.8	5.2	4.9	6.2	6.3	6.8	6.5	6.2	6.3	7.4	5.62°C ± 0.79
	M-N	10.5	10.1	10.9	10.6	10.7	10.8	11.1	10.4	11.0	12.0	12.0	12.0	11.2	11.7	12.2	11.6	12.5	11.3	11.5	11.1	11.9	12.6	11.5	11.8	11.6	11.9	11.5	11.40°C ± 0.66

Table 10. 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 proposed St. Lawrence Estuary Marine Protected Area (MPA), and Manicouagan MPA. The scorecards are colour-coded according to the monthly normalized anomalies based on the 1985–2010 climatologies for each month, but the numbers are the monthly average temperatures in ºC. The 1985-2010 mean and standard deviation are indicated for each month on the right side of the table.

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± S.D.
Estuary	A			2.2					1.5	1.7		2.4	1.9				1.9		2.6	0.7	1.0	1.3	2.1	1.1	1.7	1.6	2.2	1.2	1.73°C ± 0.52
	M		5.3	4.7	5.2	3.5	4.6		3.9	4.4	6.5	4.9	4.8	4.7	5.6	6.1	4.9	6.7	4.6	4.1	4.0	3.9	5.7	5.0	5.5	4.1	6.0	4.6	4.95°C ± 0.86
	J	7.6	6.2	7.5	8.0	7.9	7.4	8.1	7.4	9.0	9.0	8.5	8.8	8.2	9.7	8.6	8.0	9.7	8.5	8.1	7.9	8.2	9.7	9.1	8.7	8.1	9.0	8.9	8.34°C ± 0.81
	J	9.2	9.2	10.4	11.3	10.2	9.1	9.2	9.4	12.6	11.5	12.2	11.3	10.2	10.2	10.0	11.9	10.8	11.3	11.2	11.6	11.2	11.3	11.0	11.2	10.5	11.1	11.6	10.74°C ± 0.98
	A	9.8	9.1	9.8	10.6	8.1	9.7	10.1	8.5	11.8	10.3	11.1	10.6	9.5	9.0	10.4	11.5	10.4	10.6	11.2	9.5	9.5	10.7	9.6	11.9	11.0	10.6	11.4	10.20°C ± 0.95
	S	8.2	6.5	6.7	6.4	6.5	7.4	6.3	6.8	7.8	7.7	7.1	8.9	8.4	9.0	9.0	7.3	7.5	8.2	7.2	6.9	8.1	8.0	6.5	8.0	7.2	8.5	8.0	7.55°C ± 0.84
	O	4.2	3.8	4.2	3.4	2.4	3.8	3.5	3.3	3.7	5.7	4.9	4.0	5.0	4.2	5.3	4.2	4.8	5.0	4.7	4.8	5.6	5.2	5.4	4.4	4.7	5.6	5.3	4.46°C ± 0.82
	N	1.6	1.3	1.2	1.2	0.9	0.8	2.3	1.0	1.1	3.8	2.2	1.6	2.5	2.1	2.2	2.2	2.3	1.6	1.4	2.5	2.9	3.3	2.5	2.4	3.0	2.5	3.0	2.02°C ± 0.77
PMSSL (Saguenay)	A		0.5	0.8	-0.1	-1.1	0.1	-0.3	0.1	0.2	0.5	0.5	0.7	0.8	0.1	0.4	0.6	0.2	0.1	0.1	-0.4	0.5	0.4	0.3	0.8	0.5	0.5	0.2	0.28°C ± 0.42
	M	1.3	5.1	4.6	3.8	2.8	2.8	2.4	3.8	4.5	4.9	4.2	3.6	2.2	4.1	4.9	3.7	6.2	3.6	3.8	2.5	2.6	5.5	3.7	3.1	2.9	6.2	3.3	3.79°C ± 1.23
	J	8.8	6.9	9.2	8.0	9.2	9.4	10.6	8.4	11.0	11.9	11.7	10.7	8.6	10.3	12.9	11.2	11.1	8.7	10.7	8.1	11.1	11.8	10.8	10.0	10.4	10.1	10.2	10.06°C ± 1.44
	J	13.8	10.8	12.2	13.9	11.6	12.9	12.4	10.9	14.7	15.3	15.9	12.2	11.9	12.0	13.5	12.6	13.4	11.1	12.6	14.1	13.4	14.2	13.7	14.3	11.9	13.8	13.2	13.03°C ± 1.33
	A	11.9	11.1	10.8	11.5	11.1	13.4	12.8	12.1	13.5	13.2	14.0	13.3	11.9	11.9	12.5	12.3	13.9	13.3	13.6	12.0	12.4	12.2	11.3	13.4	13.7	12.5	12.3	12.53°C ± 0.94
	S	7.3	5.8	6.5	8.4	7.8	7.9	6.6	8.4	8.4	9.6	7.5	10.6	10.0	8.2	10.4	8.7	9.1	8.9	9.7	9.2	9.6	8.8	8.7	9.2	9.8	7.3	9.7	8.56°C ± 1.22
	O	3.0	2.4	3.6	1.6	1.8	2.6	3.2	3.0	3.1	5.5	6.5	2.7	5.1	3.0	3.1	4.1	5.6	3.4	5.8	4.2	6.2	4.5	6.1	4.0	1.9	3.6	5.2	3.82°C ± 1.44
	N	0.4	-0.7	-0.3	1.8	0.5	1.3	0.4	-0.4	-0.5	1.0	0.5	-0.1	2.4	0.2	1.3	0.8	2.1	0.1	0.1	-0.2	0.8	0.6	0.5	3.5	1.6	0.6	2.4	0.71°C ± 0.97
PMSSL (Estuary)	A								1.6	1.3		1.9	2.3				2.2		2.7	0.8	1.1	1.4	2.0	1.2	1.6	1.7	2.0	1.2	1.71°C ± 0.51
	M		4.5	4.6	4.9	3.8	4.3		3.2	3.7	5.1	4.1	4.4	3.8	5.2	5.0	4.5	6.2	4.0	3.1	3.9	3.9	5.0	4.3	4.9	3.8	4.7	4.6	4.36°C ± 0.70
	J	6.6	5.5	6.9	6.4	6.3	5.9	6.4	5.6	7.3	7.8	7.3	7.0	6.7	8.2	7.6	6.8	8.3	7.4	7.0	6.9	7.2	8.6	7.6	7.8	6.8	7.2	8.1	7.03°C ± 0.78
	J	8.7	7.9	8.6	8.7	8.0	7.7	7.2	7.8	10.0	10.2	9.5	9.7	8.7	9.6	8.6	9.9	9.5	9.5	8.4	9.9	8.9	9.4	9.4	9.7	9.3	9.3	10.0	9.00°C ± 0.82
	A	8.6	8.7	8.4	8.7	6.7	8.2	8.5	7.2	9.3	8.8	9.0	9.0	8.6	8.2	8.5	9.9	9.2	9.5	9.1	8.1	8.2	9.4	8.3	10.4	9.3	8.8	10.0	8.72°C ± 0.75
	S	7.1	5.6	6.0	5.7	5.8	6.1	5.9	6.3	7.2	7.5	6.3	7.9	7.7	7.7	7.7	6.7	6.8	7.4	6.3	6.6	7.2	6.8	6.3	6.8	6.6	7.6	7.6	6.75°C ± 0.69
	O	4.5	4.0	4.2	3.5	2.4	3.9	3.5	3.5	3.6	5.9	4.6	3.9	5.1	4.0	4.9	4.4	4.6	4.8	4.1	4.4	5.7	5.0	5.4	4.3	4.2	5.4	5.1	4.37°C ± 0.78
	N	1.9	0.9	1.5	1.1	0.9	1.2	2.2	1.0	1.2	3.6	2.7	1.6	2.7	1.8	2.1	2.0	2.5	1.6	1.4	2.5	2.6	3.3	2.8	2.6	2.8	2.4	3.0	2.03°C ± 0.76
St. Lawrence Estuary MPA	A			2.4					1.6	1.5		2.1	2.1				2.0		2.9	0.9	1.3	1.6	2.2	1.3	1.8	2.0	2.3	1.3	1.87°C ± 0.50
	M		5.0	4.7	5.5	3.6	4.8		4.2	4.5	6.2	5.0	4.8	4.8	5.9	5.9	5.1	6.6	4.7	4.1	4.3	4.1	5.7	5.0	5.7	4.5	5.8	4.8	5.02°C ± 0.74
	J	7.6	6.4	7.4	7.6	7.7	7.2	7.9	7.1	8.8	9.2	8.6	8.4	7.8	9.5	8.5	8.0	9.5	8.3	8.1	7.8	8.2	9.6	8.9	8.7	7.9	8.6	8.9	8.20°C ± 0.78
	J	9.3	8.9	10.1	10.5	9.6	9.2	8.9	9.0	12.0	11.4	11.3	10.9	9.9	10.2	9.7	11.4	10.6	11.1	10.3	11.3	10.6	11.1	10.6	10.9	10.3	10.5	11.2	10.37°C ± 0.86
	A	9.6	9.0	9.4	10.1	8.0	9.5	9.7	8.4	11.2	10.3	10.6	10.6	9.5	9.0	9.9	11.0	10.1	10.5	10.6	9.3	9.8	10.4	9.6	11.7	10.9	10.1	11.2	9.95°C ± 0.84
	S	7.9	6.7	6.8	6.6	6.6	7.2	6.6	6.9	7.8	7.9	7.3	8.9	8.3	8.6	8.7	7.4	7.7	8.2	7.4	7.2	8.1	7.6	7.0	7.8	7.5	8.3	8.2	7.58°C ± 0.68
	O	4.4	4.1	4.3	3.6	2.6	3.9	3.7	3.8	3.8	5.7	5.0	4.2	5.2	4.5	5.1	4.5	4.9	5.1	4.6	5.0	5.8	5.3	5.8	4.6	4.5	5.6	5.3	4.60°C ± 0.78
	N	1.8	1.3	1.3	1.2	1.0	0.8	2.0	1.1	1.2	3.6	2.4	1.7	2.8	1.9	2.2	2.3	2.4	1.5	1.4	2.5	2.5	3.2	2.6	2.6	2.9	2.5	3.1	2.03°C ± 0.75
Manicouagan MPA	A								1.6	2.0		2.3	2.0				2.2		2.4	0.8	1.1	1.3	2.3	1.2	2.0	1.6	2.4	1.3	1.81°C ± 0.55
	M		6.1	4.3	5.3	3.6	4.8		4.3	5.1	7.2	5.5	5.2	5.5	5.9	6.4	5.1	7.1	4.7	4.2	4.0	4.4	6.4	5.5	5.7	4.2	6.5	4.9	5.30°C ± 0.98
	J	8.6	6.5	8.2	8.2	8.6	7.9	8.9	7.9	10.4	9.7	9.0	9.8	9.3	10.5	9.2	8.7	10.2	8.9	8.8	8.4	9.1	10.6	10.3	9.4	8.7	9.6	9.6	9.05°C ± 0.95
	J	9.8	10.0	11.5	12.6	10.9	10.1	10.2	10.3	14.4	12.9	13.4	12.2	10.9	11.2	10.9	13.1	11.8	11.6	12.5	12.6	12.2	12.5	12.0	11.9	11.9	11.9	12.4	11.73°C ± 1.14
	A	10.5	10.1	11.2	11.3	9.1	11.1	11.7	9.2	12.7	11.1	11.8	11.4	10.4	10.0	11.1	12.6	11.3	11.3	12.3	10.0	10.4	11.2	10.5	13.0	11.5	11.7	11.9	11.10°C ± 0.99
	S	8.6	6.5	7.2	6.5	6.8	8.0	6.5	7.4	8.5	8.6	7.9	9.9	9.1	9.9	9.7	8.0	7.8	8.8	7.9	7.5	8.8	8.5	7.0	8.5	7.7	9.1	8.3	8.11°C ± 1.02
	O	4.2	3.7	4.3	3.7	2.6	3.9	4.1	3.5	4.0	5.8	5.7	4.4	5.4	4.1	5.8	4.5	5.1	5.2	5.2	5.3	5.9	5.6	5.7	4.8	5.4	5.9	6.0	4.76°C ± 0.90
	N	1.7	1.4	1.2	1.1	1.1	0.8	2.3	1.2	1.4	3.9	2.1	1.7	2.9	2.4	2.2	2.6	2.4	1.4	1.5	2.5	2.9	3.4	2.3	2.5	3.0	2.6	3.1	2.10°C ± 0.78

Table 11. NOAA SST May to November monthly anomalies averaged over the Magdalen Shallows (region 8 of the Gulf) and the eastern and western subregions of the Magdalen Shallows. . The scorecards are colour-coded according to the monthly normalized anomalies based on the 1985–2010 climatologies for each month, but the numbers are the monthly average temperatures in ºC. The 1985-2010 mean and standard deviation are indicated for each month on the right side of the table.

Region	Month	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± S.D.
Magdalen Shallows	M	3.6	4.4	3.8	3.9	3.9	2.7	3.6	3.5	3.0	4.4	4.7	4.1	3.7	6.2	5.2	4.4	5.3	4.3	3.7	3.7	4.1	7.0	4.6	5.3	5.3	5.2	4.9	4.36°C ± 0.97
	J	8.2	9.2	10.6	8.6	10.6	9.7	10.5	9.5	9.3	11.1	11.3	11.6	9.3	10.9	12.1	10.5	11.9	10.0	10.4	9.4	10.0	12.6	10.4	10.7	10.7	10.5	9.7	10.37°C ± 1.05
	J	14.5	14.2	16.1	15.9	15.9	14.7	15.5	14.2	14.7	18.1	17.6	15.9	15.9	16.6	18.0	16.5	17.1	15.8	16.6	16.0	16.5	17.6	16.6	17.4	15.4	17.0	15.3	16.17°C ± 1.12
	A	17.4	15.9	17.2	17.7	17.2	17.8	16.8	16.4	18.1	18.5	18.5	18.8	17.7	17.9	18.1	18.2	18.9	18.1	17.3	18.6	18.2	17.9	17.1	17.1	18.5	18.7	17.4	17.80°C ± 0.75
	S	14.6	13.4	14.1	14.3	14.0	15.1	14.2	15.0	15.5	15.3	14.5	16.0	15.1	15.2	15.9	15.4	16.1	14.8	15.2	14.2	16.2	15.4	14.3	14.9	14.8	14.8	14.8	14.92°C ± 0.70
	O	10.0	9.3	10.2	8.8	7.8	11.3	11.3	9.5	10.9	10.2	11.1	11.1	10.4	9.6	10.1	10.5	12.0	11.2	11.9	11.0	11.7	11.5	11.0	10.6	9.9	10.9	10.8	10.54°C ± 0.99
	N	5.3	4.4	4.3	4.6	5.4	4.5	6.0	4.4	5.4	6.4	6.5	6.7	6.1	5.5	5.7	6.0	5.8	4.8	5.2	4.9	6.2	6.3	6.8	6.5	6.2	6.3	7.4	5.62°C ± 0.79
Eastern Magdalen Shelf	M	2.4	3.5	2.6	3.0	2.8	1.7	2.2	2.3	2.1	3.7	3.5	3.2	2.6	5.2	3.9	3.6	4.2	3.2	2.9	2.6	3.5	6.2	3.3	4.0	4.2	4.2	4.5	3.33°C ± 0.99
	J	7.1	8.3	9.8	7.3	9.2	8.1	8.6	8.1	7.7	9.8	10.0	10.5	8.0	10.2	11.1	9.3	10.8	9.0	9.0	8.2	8.9	11.5	9.5	9.7	9.6	9.2	8.4	9.17°C ± 1.13
	J	13.5	13.6	15.7	15.1	15.3	14.1	14.7	13.4	13.4	17.6	16.7	15.1	15.3	16.2	18.1	16.1	16.7	15.4	15.8	15.4	15.6	17.7	15.7	17.2	14.7	16.4	14.0	15.56°C ± 1.32
	A	17.7	16.1	17.6	17.4	17.4	17.4	16.6	16.4	17.6	19.2	18.6	19.2	17.6	18.3	18.6	18.5	19.2	18.4	17.6	19.0	18.2	18.0	16.9	17.2	18.7	19.2	17.5	17.95°C ± 0.90
	S	14.6	13.7	14.9	14.6	14.2	15.0	14.2	15.5	15.9	16.0	14.4	16.1	15.3	14.9	16.3	16.0	16.5	15.0	15.4	14.1	16.7	15.5	14.2	15.2	15.0	14.8	15.3	15.14°C ± 0.79
	O	10.2	9.8	10.7	9.7	8.2	11.2	12.1	9.9	12.4	10.5	11.2	11.7	10.8	9.6	10.4	10.7	12.5	11.1	12.3	11.5	12.3	11.7	11.1	11.2	10.0	11.6	10.8	10.94°C ± 1.04
	N	6.2	4.9	4.4	5.3	5.9	4.3	6.1	4.6	6.0	6.3	6.8	7.4	6.8	5.9	5.9	6.9	6.0	5.2	5.5	5.1	6.2	6.3	7.2	7.1	6.4	6.9	8.0	5.99°C ± 0.86
Western Magdalen Shelf	M	3.2	4.0	3.6	3.1	3.4	2.2	3.0	2.9	2.8	3.5	4.3	3.3	3.3	5.8	4.6	3.8	4.7	3.8	3.1	3.3	3.6	6.5	4.0	5.1	4.6	4.5	3.8	3.85°C ± 0.96
	J	8.0	8.6	10.6	8.0	10.5	9.1	10.0	9.4	8.8	10.4	11.1	11.2	9.0	10.6	11.6	9.8	11.7	9.6	9.8	8.8	9.6	11.9	9.8	10.1	10.2	9.8	9.4	9.92°C ± 1.06
	J	14.4	13.9	15.8	15.6	15.7	13.8	14.5	13.8	14.1	17.4	17.6	15.4	15.5	16.3	17.5	16.3	16.7	15.3	16.0	15.8	16.3	17.2	16.3	16.9	15.0	16.4	15.0	15.75°C ± 1.15
	A	17.1	15.4	16.5	17.6	16.7	16.9	16.0	15.6	17.9	17.7	18.1	18.2	17.3	17.3	17.4	18.0	18.3	17.4	16.7	17.9	17.9	17.6	16.4	16.9	18.0	18.3	17.1	17.27°C ± 0.82
	S	13.9	12.7	13.3	13.7	12.8	14.4	13.4	13.9	14.7	14.4	13.8	15.5	14.8	14.8	15.0	14.6	15.3	13.7	14.3	13.2	15.6	14.7	13.1	14.3	14.0	14.2	14.0	14.16°C ± 0.79
	O	9.3	8.4	9.4	7.8	6.8	10.5	10.2	8.6	9.7	9.3	10.3	10.4	9.8	9.0	9.3	9.8	10.9	10.4	11.2	10.2	10.6	10.6	9.8	9.7	9.2	10.1	10.0	9.66°C ± 0.99
	N	4.8	3.9	3.6	3.7	4.5	4.1	5.4	3.9	4.7	6.0	5.8	6.2	5.5	5.0	5.0	5.3	5.0	4.4	4.4	4.6	5.8	5.8	6.1	5.9	5.8	5.6	6.8	5.03°C ± 0.81

Table 12. Yearly number of weeks with mean weekly surface temperature >10°C, averaged for the entire Gulf and each region of the Gulf. The scorecards are colour-coded according to the normalized anomalies based on the 1985–2010 time series, but the numbers are the average number of weeks above 10°C for each year.

Region	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean ± S.D.
Gulf of St. Lawrence	11.4	10.4	13.0	11.0	12.1	12.0	11.8	10.8	12.4	14.0	14.9	14.8	13.7	14.4	16.2	14.1	15.6	12.7	14.8	13.1	14.2	16.3	13.8	14.4	14.2	14.2	13.7	13.5 w ± 1.6
1 - Estuary	4.9	3.5	5.1	6.6	5.4	5.5	5.0	5.2	10.1	6.9	7.4	8.1	7.6	7.9	8.2	8.0	7.8	8.1	6.9	5.8	6.7	9.1	6.6	8.7	6.3	8.8	9.1	6.9 w ± 1.6
2 - Northwest Gulf	11.0	8.0	9.0	9.2	10.7	10.0	9.6	9.4	13.0	12.6	13.6	15.0	12.6	14.6	15.1	12.3	13.1	11.1	12.6	10.5	12.7	13.8	11.6	13.0	11.9	13.9	13.0	11.9 w ± 1.9
3 - Anticosti Channel	9.5	8.8	11.5	8.9	11.4	7.3	7.7	8.9	9.4	11.4	12.6	13.4	12.0	13.0	15.2	11.3	12.9	11.3	11.9	10.8	13.0	14.6	10.7	11.9	12.7	12.5	10.9	11.3 w ± 2.0
4 - Mécatina Trough	4.6	5.4	9.0	6.7	5.9	7.7	2.9	2.8	4.2	8.3	7.8	7.8	8.8	8.4	12.5	11.6	10.7	8.0	11.8	9.5	9.7	11.7	8.6	10.2	9.9	9.1	8.3	8.2 w ± 2.7
5 - Esquiman Channel	9.9	9.4	13.0	10.8	10.9	10.9	8.9	8.2	9.2	12.9	13.1	11.9	12.4	12.6	15.6	13.6	14.5	10.1	15.3	11.8	12.6	16.8	13.1	13.3	13.3	12.6	11.7	12.2 w ± 2.1
6 - Central Gulf	12.3	10.9	14.2	11.3	12.4	12.2	12.6	11.8	12.8	14.6	15.5	15.4	13.9	14.2	16.7	14.2	16.1	12.4	15.3	13.3	13.8	17.2	13.1	13.9	14.9	13.9	13.5	13.8 w ± 1.6
7 - Cabot Strait	11.6	11.1	15.0	11.8	12.6	14.4	13.6	11.3	14.1	16.1	16.9	16.1	14.6	15.6	17.3	15.4	18.1	12.5	16.2	14.0	15.6	17.4	15.4	15.4	15.8	15.0	14.6	14.7 w ± 1.9
8 - Magdalen Shallows	14.8	14.5	16.6	14.1	15.5	16.3	17.6	15.1	16.1	17.5	18.8	18.2	16.8	17.4	18.6	17.6	19.8	17.4	18.1	17.8	17.9	19.5	18.7	18.2	17.7	17.6	17.7	17.2 w ± 1.5

Table 13. First and last day of ice occurrence, ice duration, and maximum seasonal ice volume by region. The time when ice was first and last seen in days from the beginning of each year is indicated for each region, and the colour code expresses the anomaly based on the 1981–2010 climatology, with blue representing earlier first occurrence and later last occurrence. The threshold is 5% of the largest ice volume ever recorded in the region. Numbers in the table are the actual day of the year rather than the anomaly, but the colour coding is according to normalized anomalies based on the climatology of each region.

First occurrence of ice

Year	1 - Estuary	2 - Northwest Gulf	3 - Anticosti Channel	4 - Mécatina Trough	5 - Esquiman Channel	6 - Central Gulf	7 - Cabot Strait	8 - Magdalen Shallows
	17	17	57	80	80			17
1970	12	12	12	12	58	37	30	12
	-10	15	15	15	15	15	29	-1
	0	0	0	0	14	21	28	0
	-12	-12	-2	-12	-2	3	15	-12
	-3	-3	9	9	16	23	23	9
1975	-8	8	15	8	29	29	29	8
	-5	-5	9	-5	37	16	37	9
	-14	-14	7	-7	16	16	16	-14
			8	8	36	22	29	8
	-21	-21	14	-28	14	14	42	-21
1980	-6	8	-6	1	29	36	36	8
	-24	-1	22	-1	36	15	15	-1
	-9	14	14	21	28	42	35	14
	-5	9	-5	-12	44	23	51	9
	3	3	15	3	15	15	43	3
1985	2	2	2	2	2	23	23	2
	-13	-6	8	-13	8	15	22	-6
	-14	-7	-14	-14	7	21	35	-14
	-8	-1	24	3	17	24	31	-1
	-5	-5	2	-5	9	16	30	-5
1990	-21	-21	-21	-21	8	8	8	-21
	0	7	7	-11	7	14	21	-7
	-12	-5	2	-5	23	23	23	-5
	-17	-3	4	-3	4	11	25	-3
	-4	3	-4	3	24	10	17	3
1995	2	16	9	2	16	30	44	2
	-20	8	29	-20	15	22	36	-13
	6	6	34	20	41	34	41	6
	-9	3	9	6	17	29	40	-2
	0	3	9	2	14	13	35	2
2000	2	16	16	15	41	29	39	15
	-5	12	26	5	23	36	50	4
	5	19	18	17	25	35	41	17
	-21	8	5	-2	15	19	25	7
	-21	3	28	25	43	15	25	10
2005	-8	3	17	10	23	26	31	5
	-12	2	31	-3	31	52	60	33
	14	24	29	14	29	37	37	18
	-15	6	7	0	21	26	46	1
	-19	7	19	18	27	18	25	5
2010	-2	19	32	24	36			24
	7	33	59	41	61		65	26
Mean ± S.D.	-8 ± 10	5 ± 9	12 ± 14	3 ± 13	22 ± 12	23 ± 10	33 ± 12	3 ± 11

Last occurrence of ice

Year	1 - Estuary	2 - Northwest Gulf	3 - Anticosti Channel	4 - Mécatina Trough	5 - Esquiman Channel	6 - Central Gulf	7 - Cabot Strait	8 - Magdalen Shallows
	80	80	57	132	80			94
1970	84	77	98	119	119	70	98	105
	64	78	71	92	85	85	92	106
	101	108	136	122	129	136	136	136
	71	85	99	134	120	99	127	127
	72	93	149	177	163	107	107	107
1975	71	85	127	162	141	113	127	127
	93	100	121	142	121	100	100	100
	86	86	100	121	128	93	114	114
	99	99	127	134	134	106	106	113
	84	91	105	133	77	98	98	112
1980	80	80	92	120	99	80	106	106
	55	62	83	90	62	69	62	83
	77	77	140	140	119	99	105	105
	100	100	93	114	86	79	100	114
	99	99	129	143	129	99	87	136
1985	79	79	128	156	149	93	107	107
	78	85	134	141	127	106	106	113
	84	112	119	119	119	91	126	126
	87	80	129	136	108	94	101	108
	79	86	86	128	121	107	114	107
1990	57	92	148	155	155	120	113	106
	98	91	168	182	119	119	119	119
	79	100	128	149	135	121	135	135
	81	109	116	158	133	116	116	123
	87	101	157	157	143	115	108	115
1995	100	121	142	149	142	107	121	121
	71	92	106	120	100	92	100	113
	83	97	153	146	125	118	132	125
	85	91	105	126	120	106	91	108
	86	90	115	137	123	94	114	109
2000	80	84	84	114	80	82	79	90
	82	79	118	135	132	85	114	114
	85	85	91	109	96	95	91	92
	82	93	157	152	149	114	115	107
	88	93	101	128	118	101	111	116
2005	86	98	98	111	106	89	115	113
	76	78	115	118	107	64	85	87
	85	84	113	154	127	84	88	89
	93	101	105	147	116	103	114	109
	86	83	113	129	115	98	104	106
2010	53	55	63	124	48			83
	84	77	74	107	100		83	84
Mean ± S.D.	82 ± 12	90 ± 14	118 ± 25	136 ± 19	117 ± 24	99 ± 15	106 ± 16	109 ± 14

Duration of ice season

Year	1 - Estuary	2 - Northwest Gulf	3 - Anticosti Channel	4 - Mécatina Trough	5 - Esquiman Channel	6 - Central Gulf	7 - Cabot Strait	8 - Magdalen Shallows
	64	64	1	53	1			78
1970	73	66	87	108	62	34	69	94
	75	64	57	78	71	71	64	108
	102	109	137	123	116	116	109	137
	84	98	102	147	123	97	113	140
	76	97	141	169	148	85	85	99
1975	80	78	113	155	113	85	99	120
	99	106	113	148	85	85	64	92
	101	101	94	129	113	78	99	129
	110	105	120	127	99	85	78	106
	106	113	92	162	64	85	57	134
1980	87	73	99	120	71	45	71	99
	80	64	62	92	27	55	48	85
	87	64	127	120	92	58	71	92
	106	92	99	127	43	57	50	106
	97	97	115	141	115	85	45	134
1985	78	78	127	155	148	71	85	106
	92	92	127	155	120	92	85	120
	99	120	134	134	113	71	92	141
	96	82	106	134	92	71	71	110
	85	92	85	134	113	92	85	113
1990	79	114	170	177	148	113	106	128
	99	85	162	194	113	106	99	127
	92	106	127	155	113	99	113	141
	99	113	113	162	130	106	92	127
	92	99	162	155	120	106	92	113
1995	99	106	134	148	127	78	78	120
	92	85	78	141	86	71	65	127
	78	92	120	127	85	85	92	120
	95	89	97	121	104	78	52	111
	87	88	107	136	110	82	80	108
2000	79	69	69	100	40	54	41	76
	88	68	93	131	110	50	65	111
	81	67	74	93	72	61	51	76
	104	86	153	155	135	96	91	101
	110	91	74	104	76	87	87	107
2005	95	96	82	102	84	64	85	109
	89	77	85	122	77	13	26	55
	72	61	85	141	99	48	52	72
	109	96	99	148	96	78	69	109
	106	77	95	112	89	81	80	102
2010	56	37	32	101	13			60
	78	45	16	67	40		19	59
Mean ± S.D.	91 ± 12	86 ± 18	106 ± 32	134 ± 25	96 ± 33	76 ± 22	74 ± 21	107 ± 22

Maximum ice volume (km^3)

Year	1 - Estuary	2 - Northwest Gulf	3 - Anticosti Channel	4 - Mécatina Trough	5 - Esquiman Channel	6 - Central Gulf	7 - Cabot Strait	8 - Magdalen Shallows	Scotian Shelf	GSL + Scotian Shelf
	1.6	4	1	1	1	0	0	10	0	17
1970	1.6	7	4	3	4	4	3	18	6	42
	1.9	13	7	3	7	9	5	23	4	65
	2.2	13	13	6	17	13	10	35	10	99
	2.3	9	8	6	13	8	7	31	13	83
	2.0	9	8	6	18	6	11	19	25	84
1975	2.5	9	6	5	19	10	11	28	18	85
	1.7	9	7	5	20	10	9	23	9	82
	2.1	11	8	6	18	11	8	30	10	88
	2.1	12	5	6	8	7	8	27	10	66
	5.3	12	8	5	12	9	10	31	12	82
1980	1.2	5	4	5	6	5	6	19	7	46
	2.6	9	3	2	4	8	5	18	3	42
	2.6	6	4	6	13	6	9	22	19	69
	2.4	9	3	4	4	1	1	18	1	40
	2.0	11	7	6	9	7	3	24	3	61
1985	2.1	7	5	8	15	6	7	25	19	75
	1.6	7	6	8	15	7	8	24	14	78
	2.4	10	7	6	14	5	5	33	9	70
	2.2	13	5	5	16	7	7	25	7	72
	1.9	8	6	7	18	7	7	20	14	74
1990	1.4	11	10	11	36	10	12	25	21	117
	1.6	9	9	6	16	8	7	22	14	71
	2.6	14	8	6	18	11	10	30	20	96
	2.5	18	12	5	21	17	14	61	14	134
	2.5	12	14	10	25	18	11	48	14	120
1995	3.4	16	17	8	15	14	11	43	10	106
	2.0	13	6	4	10	11	5	29	3	72
	1.4	12	7	7	17	10	11	30	11	86
	1.4	6	4	4	5	3	2	17	1	41
	1.1	8	9	6	9	5	5	26	3	57
2000	1.6	6	3	2	2	6	5	18	2	37
	1.2	7	4	9	8	3	5	34	5	59
	2.9	10	6	5	8	6	3	20	2	60
	1.3	7	6	10	30	17	22	41	42	139
	2.0	4	4	5	10	2	9	33	9	63
2005	2.1	11	6	4	4	10	5	33	4	68
	1.1	5	2	6	4	2	2	11	1	25
	0.9	4	4	6	9	4	4	16	6	38
	1.4	17	7	4	13	8	7	32	7	76
	1.7	8	5	4	8	7	8	33	14	65
2010	1.0	2	2	3	2	0	0	5	0	11
	0.8	2	1	3	2	0	1	8	0	14
Mean ± S.D.	1.9 km^3 ± 0.6	9.3 km^3 ± 3.8	6.4 km^3 ± 3.4	5.9 km^3 ± 2.2	12.6 km^3 ± 8.2	7.5 km^3 ± 4.7	7.0 km^3 ± 4.3	27.2 km^3 ± 11.2	9.7 km^3 ± 8.8	70.8 km^3 ± 30.2

Table 14. CIL and related properties. The top block shows the scorecard time series for winter air temperature averaged over eight stations, the Gilbert and Pettigrew (1997) CIL index, yearly maximum sea-ice volume, winter (March) cold-layer (<-1°C) volume, volume of Labrador Shelf Water intrusion into the Gulf observed in March, and the August–September volume of cold water (<0°C) observed in the Mécatina Trough. Labels in parentheses have their colour coding reversed (blue for high values). The second block shows scorecard time series for August–September CIL volumes (<1°C) for all eight regions and for the entire Gulf when available. The third block shows the scorecard time series for the bottom areas of the Magdalen Shallows covered by waters colder than 0, 1, 2, and 3°C during the September survey. The last block shows the November survey CIL volume (<1°C) and average CIL minimum temperature in the Estuary.

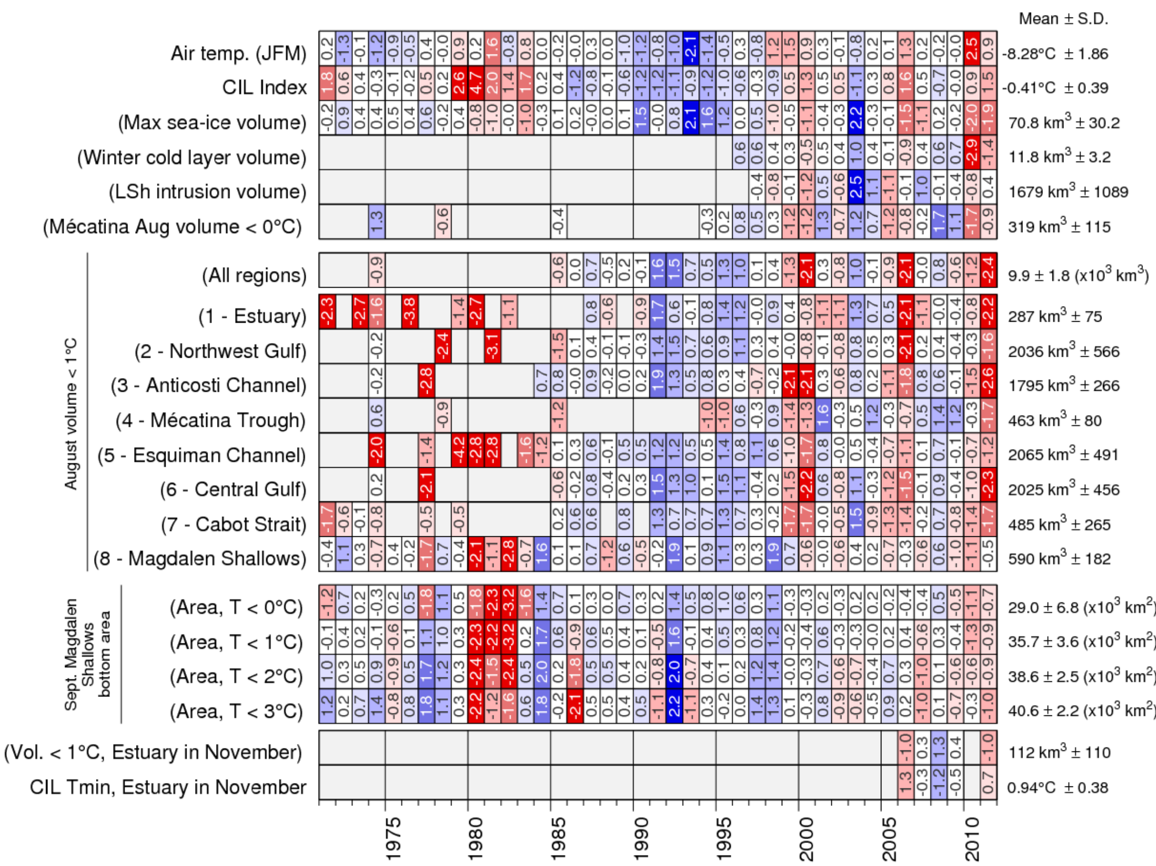

Table 15. Depth-layer average temperature anomalies for western and eastern Magdalen Shallows for the June mackerel survey. The SST data are June averages from NOAA remote sensing repeated from Table 11. The colour-coding of the 0 to 75 m lines are according to normalized anomalies based on the 1981–2010 climatologies, but the numbers are mean temperatures in ºC. The SST colour-coding is based on the climatology of the entire time series and the numbers are mean temperatures in ºC.

Eastern Shelf

Year	SST June	0 m temp.	10 m temp.	20 m temp.	30 m temp.	50 m temp.	75 m temp.
1965		5.8	5.6	4.5	1.6	0.1	-0.9
1966		9.2	7.8	4.9	2.1	0.8	0.6
1967		10.1	6.5	2.4	0.8	0.3	
1968		10.0	9.5	5.7	2.2	0.1	1.1
1969		10.5	8.8	5.9	4.1	1.6	1.7
1970		8.6	8.1	6.8	5.0	1.9	2.1
1971		7.8	6.9	3.6	1.9	-0.4	0.0
1972		11.3	8.3	3.2	0.8	-0.2	1.5
1973		6.8	5.7	4.1	1.9	0.3	1.3
1974							
1975		6.5	5.5	3.6	1.4	0.1	0.2
1976		11.1	9.5	6.0	2.1	-0.7	-0.5
1977		9.8	7.9	4.3	2.0	0.9	2.1
1978		11.5					
1979							
1980		11.4	10.0	7.7	4.6	1.1	0.7
1981							
1982		9.7	8.6	5.3	2.2	0.7	0.9
1983							
1984							
1985	7.1						
1986	8.3						
1987	9.8	10.9	9.2	4.6	1.6	-0.1	0.1
1988	7.3	10.2	9.7	6.4	2.9	0.2	1.2
1989	9.2	12.1	9.7	4.0	0.7	-0.2	
1990	8.1	10.4	9.1	5.3	3.0	-0.1	
1991	8.6	8.7	7.6	5.8	2.8	-0.3	
1992	8.1	11.0	8.6	4.2	1.1	-0.7	0.3
1993	7.7	9.6	7.9	5.3	0.8	-1.4	
1994	9.8	11.1	9.6	6.0	2.0	-0.6	
1995	10.0						
1996	10.5	11.9	10.7	6.1	2.2	0.2	0.3
1997	8.0	6.9	6.0	3.8	2.0	0.6	0.2
1998	10.2	11.1	9.2	4.8	1.5	-0.4	-0.4
1999	11.1	12.2	10.9	7.4	4.2	1.4	0.9
2000	9.3	11.7	10.2	7.2	4.6	1.0	1.0
2001	10.8	10.3	8.4	4.5	1.5	0.1	0.4
2002	9.0	8.7	7.9	5.3	2.6	0.7	0.9
2003	9.0	8.2	7.5	4.5	1.8	-0.4	-0.4
2004	8.2	8.6	8.0	6.1	4.2	0.8	0.3
2005	8.9	9.0	7.8	4.7	2.6	0.8	1.0
2006	11.5	15.9	11.4	4.5	1.6	0.7	
2007	9.5	11.1	9.1	4.6	2.0	0.4	0.8
2008	9.7	12.3	10.2	6.2	2.1	-0.4	0.3
2009	9.6	10.1	9.6	6.8	3.7	0.2	0.9
2010	9.2	9.0	8.7	7.1	5.5	2.9	1.2
2011	8.4	8.2	8.0	5.7	2.7	0.6	2.0
	9.17°C ± 1.13	10.44°C ± 1.83	8.98°C ± 1.25	5.43°C ± 1.06	2.46°C ± 1.21	0.26°C ± 0.85	0.55°C ± 0.49

Western Shelf

Year	SST June	0 m temp.	10 m temp.	20 m temp.	30 m temp.	50 m temp.	75 m temp.
1965		5.9	5.5	4.0	2.2	0.3	-0.2
1966		8.8	6.8	3.3	1.6	0.3	0.0
1967		7.6	5.8	3.4	2.0	0.5	0.2
1968		10.2	9.5	6.2	2.4	-0.2	-0.1
1969		9.5	7.4	4.6	2.6	0.8	0.8
1970		8.0	6.9	4.6	2.9	1.3	1.7
1971		8.2	7.0	4.5	3.2	0.2	0.5
1972		11.6	8.3	2.6	0.3	-0.3	
1973							
1974							
1975		9.1	7.5	4.9	2.2	0.0	-0.3
1976		11.8	10.0	6.2	2.5	-0.4	-0.3
1977		9.2	7.1	4.0	2.5	0.7	0.3
1978		11.2	9.6	6.7	4.1	0.7	0.2
1979							
1980		11.7	10.4	7.6	4.6	1.5	0.4
1981							
1982		10.8	9.8	5.5	2.4	0.8	0.2
1983							
1984							
1985	8.0						
1986	8.5						
1987	10.6	11.7	10.9	5.7	1.8	-0.5	-0.1
1988	8.0	10.1	8.8	5.1	2.5	-0.2	-0.3
1989	10.5	13.4	10.2	5.4	2.0	-0.0	
1990	9.1	10.0	8.6	5.3	3.3	0.3	
1991	10.0	11.3	8.5	6.1	3.6	-0.2	-0.4
1992	9.4	12.2	9.5	5.4	2.3	-0.3	-0.3
1993	8.8	9.2	7.5	5.5	2.1	-1.3	
1994	10.4	9.8	7.9	4.4	2.0	-0.5	-0.5
1995	11.1						
1996	11.2	11.8	10.4	5.0	2.2	-0.2	-0.7
1997	9.0	9.2	7.8	4.6	3.1	0.1	-0.7
1998	10.6	11.6	9.8	4.0	0.5	-0.5	
1999	11.6	13.5	10.4	5.6	2.6	0.3	-0.2
2000	9.8	11.8	10.1	6.6	3.7	0.3	-0.1
2001	11.7	11.4	8.3	3.6	1.6	0.1	-0.4
2002	9.6	9.2	8.2	5.2	2.1	0.2	-0.0
2003	9.8	9.9	8.3	4.6	2.3	-0.3	-0.6
2004	8.8	9.1	8.4	5.9	3.5	0.3	-0.7
2005	9.6	9.3	8.2	3.8	2.1	0.3	-0.1
2006	11.9	14.2	10.6	4.7	2.5	0.7	0.6
2007	9.8	11.2	10.0	6.6	2.9	0.4	0.1
2008	10.1	12.0	9.3	5.0	1.8	-0.3	-0.5
2009	10.2	10.9	9.1	5.1	2.3	0.0	-0.1
2010	9.8	9.5	8.4	6.2	3.8	0.9	0.4
2011	9.4	9.5	8.4	4.9	2.2	0.1	0.3
	9.92°C ± 1.06	10.98°C ± 1.47	9.13°C ± 1.00	5.21°C ± 0.79	2.46°C ± 0.76	0.01°C ± 0.49	-0.22°C ± 0.36

Table 16. Depth-layer monthly average temperature summary for months during which the eight Gulf-wide oceanographic surveys took place in 2010 and 2011. The colour-coding is according to the temperature anomaly relative to the monthly 1981–2010 climatology of each region.

1 - Estuary / Estuaire

	2010				2011			
	Mar	June	Aug	Oct	Mar	June	Aug	Nov
0 m	0.4	7.2	8.9	5.3	-0.95	8.8	11.4	3.5
10 m	0.3	4.8	6.2	5.0	-0.79	5.4	9.4	3.4
20 m	0.2	2.9	4.4	4.3	-0.47	3.2	7.0	3.1
30 m	0.2	2.2	3.1	4.0	-0.13	2.4	5.5	2.9
50 m	-0.15	0.7	1.6	2.7	0.8	1.3	3.1	2.0
75 m	-0.39	0.2	0.9	0.9	1.5	0.7	1.3	1.3
100 m	0.3	0.9	1.3	1.4	1.7	1.1	1.5	1.5
150 m	1.7	2.5	2.8	2.8	2.9	2.7	2.9	2.9
200 m	3.1	3.5	3.8	3.8	3.7	3.8	3.9	4.0
250 m	4.1	4.3	4.4	4.6	4.4	4.3	4.5	4.6
300 m	4.6	4.7	4.7	4.8	4.9	4.7	4.8	4.8
350 m		4.8	4.9			4.9	4.9	4.9

2 - Northwest Gulf / Nord-ouest du Golfe

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	-0.58	9.0	15.7	4.2	-1.45	8.2	14.8	5.5
10 m	-0.60	7.0	12.9	4.3	-1.45	5.9	12.4	5.5
20 m	-0.66	4.1	6.1	4.0	-1.46	2.7	6.4	5.4
30 m	-0.73	2.4	3.1	3.2	-1.45	1.3	3.9	4.8
50 m	-0.50	0.6	1.0	1.7	-0.64	0.5	1.5	2.6
75 m	-0.10	0.3	0.4	1.3	0.6	0.8	0.9	1.3
100 m	0.5	0.6	0.8	1.6	1.2	1.3	1.4	1.5
150 m	2.2	2.1	2.6	2.8	2.8	3.0	2.9	3.0
200 m	3.6	3.6	4.1	4.2	3.9	4.2	4.4	4.3
250 m	4.7	4.7	4.9	4.9	5.0	5.0	5.1	5.1
300 m	5.1	5.1	5.2	5.2	5.1	5.2	5.4	5.4
350 m	5.2	5.2	5.2	5.2		5.3	5.4	5.5
400 m							5.5	

3 - Anticosti Channel / Chenal Anticosti

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
0 m	-0.90	6.5	15.2	5.7	-1.17	5.6	15.8	7.1
10 m	-0.91	5.2	13.7	5.8	-1.19	4.5	13.8	7.1
20 m	-0.90	3.0	5.6	5.7	-1.20	2.8	8.2	7.1
30 m	-0.88	1.4	2.7	5.5	-1.19	1.6	4.5	6.7
50 m	-0.88	0.5	1.0	3.0	-1.13	0.1	1.4	3.7
75 m	-0.81	-0.0	0.2	1.5	-0.89	-0.4	0.0	1.3
100 m	-0.40	0.1	0.0	0.9	-0.11	-0.1	0.5	0.9
150 m	1.9	1.5	2.7	2.0	1.3	2.1	2.8	2.6
200 m	3.4	3.8	4.3	4.2	3.7	4.1	4.6	4.5
250 m			5.2	5.1			5.2	5.4

4 - Mécatina Trough / Cuvette de Mécatina

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
0 m	-1.47	2.5	12.5		-1.70	6.4	14.0	5.1
10 m	-1.50	2.4	12.1		-1.71	5.5	9.1	5.1
20 m	-1.50	2.1	7.0		-1.72	3.6	5.2	5.1
30 m	-1.50	2.0	4.1		-1.73	2.1	3.6	5.0
50 m	-1.53	0.1	2.1		-1.73	0.1	2.3	4.1
75 m	-1.56	-0.3	0.2		-1.74	-0.8	0.7	3.1
100 m	-1.56	-0.4	-0.3		-1.74	-1.1	-0.3	2.3
150 m	-1.52	0.2	0.8		-1.75	-0.9	0.5	1.2
200 m	-1.18	0.3	1.2		-1.50	0.0	1.2	1.2

5 - Esquiman Channel / Chenal Esquiman

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
0 m	-0.10	5.4	15.5	6.5	-0.31	6.4	15.4	7.3
10 m	-0.15	5.1	15.0	6.5	-0.41	5.0	14.2	7.0
20 m	-0.21	4.3	9.0	6.4	-0.45	4.0	9.5	5.7
30 m	-0.24	3.2	4.5	6.3	-0.46	3.2	4.5	4.3
50 m	-0.22	0.4	0.9	2.7	-0.51	0.7	1.2	2.1
75 m	-0.32	-0.2	0.0	0.7	-0.41	0.3	0.4	1.2
100 m	0.7	0.5	0.5	1.1	0.5	0.8	0.8	1.5
150 m	2.6	2.6	2.7	2.8	2.4	2.8	2.7	2.9
200 m	4.4	4.4	4.5	4.4	4.3	4.5	4.6	4.5
250 m		5.1	5.1	5.2		5.1	5.5	5.4
300 m			5.2	5.2			5.7	5.7

6 - Central Gulf / Centre du Golfe

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	-0.31	6.9	17.9	6.3	-0.50	8.7	15.5	8.1
10 m	-0.36	6.6	16.3	6.3	-0.50	7.1	13.5	8.1
20 m	-0.35	5.1	6.9	6.2	-0.51	4.1	10.0	8.1
30 m	-0.33	2.4	3.1	6.1	-0.51	2.0	6.4	8.1
50 m	-0.35	0.3	1.0	2.6	-0.46	0.8	2.0	5.1
75 m	-0.18	0.3	0.5	1.1	0.1	0.7	0.9	2.0
100 m	0.2	0.8	0.7	1.1	1.2	1.1	1.2	1.7
150 m	1.8	2.4	2.5	2.7	2.8	2.9	2.7	2.9
200 m	3.6	4.0	4.4	4.5	4.6	4.5	4.4	4.8
250 m		4.9	5.3	5.4		5.4	5.5	5.9
300 m		5.2	5.5	5.5		5.6	5.7	5.7
350 m		5.3	5.4	5.5		5.5	5.6	5.6
400 m		5.2	5.3	5.3		5.4	5.5	5.4
450 m			5.2	5.4			5.3	5.3

7 - Cabot Strait / Détroit de Cabot

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
0 m	0.1	8.0	17.5	8.4	-0.22	7.4	15.1	8.4
10 m	-0.06	7.9	15.6	8.4	-0.24	7.2	14.7	8.4
20 m	-0.10	6.6	8.1	8.3	-0.23	4.7	13.0	8.1
30 m	-0.06	5.1	4.6	7.8	-0.14	2.0	9.8	7.8
50 m	0.0	2.9	2.5	5.5	0.2	1.7	3.4	4.9
75 m	0.3	1.1	1.4	3.1	0.8	2.0	2.4	2.5
100 m	0.9	1.4	1.3	1.7	1.5	2.4	2.1	2.1
150 m	2.5	3.7	3.1	3.1	3.3	3.8	3.5	4.0
200 m	4.8	5.8	5.9	5.7	5.6	5.8	5.8	5.6
250 m		6.2	6.2	6.2		6.4	6.5	6.1
300 m		5.8	6.0	6.0		6.0	5.9	6.1
350 m		5.2	5.6	5.7		5.7	5.6	5.7
400 m		5.2	5.4	5.4		5.4	5.3	5.4
450 m		5.3	5.4	5.3		5.1	5.2	5.1
500 m			5.4	5.4			5.1	5.1

8 - Magdalen Shallows / Plateau madelinien

	2010				2011			
	Mar	June	Sep	Nov	Mar	June	Sep	Nov
0 m	-0.43	9.8	15.6	6.8	-1.15	9.7	14.7	8.9
10 m	-0.56	8.9	15.4	6.7	-1.21	8.9	14.5	8.9
20 m	-0.67	6.9	12.0	6.6	-1.25	5.5	12.6	8.7
30 m	-0.75	4.7	6.7	6.3	-1.26	2.6	6.7	8.0
50 m	-0.80	1.1	1.9	4.1	-1.12	0.2	1.5	3.0
75 m	-0.92	0.3	0.8	2.2	-0.72	0.3	0.7	1.0
100 m								

Table 17. Depth-layer monthly average stratification and salinity summary for months during which the eight Gulf-wide oceanographic surveys took place in 2010 and 2011. Stratification is defined as the density difference between 50 m and the surface and its colour-coding is reversed (blue for positive anomaly).

1 - Estuary / Estuaire

	2010				2011			
	Mar	June	Aug	Oct	Mar	June	Aug	Nov
Strat.	3.35	3.9	3.4	5.3	2.12	8.0	4.7	3.6
0 m	26.9	27.1	28.2	24.8	28.2	21.7	26.1	27.4
10 m	27.9	28.5	29.3	26.1	28.5	24.3	26.9	28.1
20 m	28.9	29.5	30.1	27.5	29.0	27.4	27.9	29.5
30 m	29.9	30.2	30.8	28.8	29.6	29.1	29.0	30.6
50 m	31.0	31.3	31.6	31.2	30.9	30.9	30.8	31.7
75 m	31.8	32.0	32.3	32.2	32.2	31.8	32.0	32.2
100 m	32.3	32.6	32.8	32.8	32.8	32.4	32.7	32.6
150 m	33.0	33.4	33.5	33.5	33.5	33.3	33.5	33.5
200 m	33.7	33.8	33.9	34.0	33.9	33.9	34.0	34.0
250 m	34.1	34.2	34.2	34.3	34.2	34.2	34.3	34.3
300 m	34.3	34.3	34.3	34.4	34.4	34.4	34.4	34.4
350 m		34.4	34.4			34.4	34.4	34.5

2 - Northwest Gulf / Nord-ouest du Golfe

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
Strat.	0.59	3.2	4.1	1.9	0.70	4.3	4.9	1.7
0 m	31.0	28.8	29.2	29.9	30.7	27.3	27.8	29.6
10 m	31.0	29.6	29.6	30.4	30.8	28.6	28.5	29.6
20 m	31.2	30.5	30.5	31.2	31.2	30.2	30.1	30.0
30 m	31.3	31.2	31.2	31.5	31.3	31.0	30.9	30.5
50 m	31.7	31.8	31.8	32.1	31.6	31.8	31.7	31.4
75 m	32.1	32.2	32.2	32.5	32.1	32.3	32.2	32.2
100 m	32.4	32.5	32.6	32.8	32.5	32.7	32.7	32.6
150 m	33.4	33.3	33.5	33.5	33.5	33.6	33.5	33.5
200 m	33.9	33.9	34.0	34.1	34.0	34.1	34.2	34.1
250 m	34.3	34.3	34.4	34.4	34.5	34.4	34.5	34.5
300 m	34.5	34.5	34.6	34.6	34.5	34.6	34.7	34.7
350 m	34.6	34.6	34.7	34.6		34.7	34.8	34.8
400 m							34.8	

3 - Anticosti Channel / Chenal Anticosti

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
Strat.	0.12	1.9	3.2	1.0	0.09	1.7	3.6	0.9
0 m	31.8	30.1	30.4	30.7	31.8	30.3	29.8	30.9
10 m	31.8	30.6	30.6	30.9	31.8	30.6	30.1	30.9
20 m	31.9	31.2	31.3	31.0	31.8	31.4	30.9	30.9
30 m	31.9	31.5	31.6	31.1	31.9	31.6	31.4	31.0
50 m	32.0	31.8	31.9	31.7	31.9	31.9	31.8	31.6
75 m	32.0	32.0	32.2	32.1	32.0	32.1	32.1	32.0
100 m	32.2	32.2	32.5	32.6	32.2	32.3	32.5	32.3
150 m	33.1	33.0	33.4	33.1	32.8	33.1	33.4	33.3
200 m	33.8	33.9	34.0	34.0	33.8	34.0	34.2	34.1
250 m			34.5	34.5			34.5	34.6

4 - Mécatina Trough / Cuvette de Mécatina

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
Strat.	0.10	0.7	2.6		0.09	1.7	2.7	0.4
0 m	32.2	30.9	30.3		32.0	30.4	30.5	31.4
10 m	32.3	30.9	30.4		32.1	30.6	30.9	31.4
20 m	32.3	31.1	31.2		32.1	31.1	31.4	31.4
30 m	32.3	31.3	31.4		32.1	31.5	31.6	31.5
50 m	32.3	31.6	31.8		32.1	31.9	31.8	31.8
75 m	32.4	31.9	32.1		32.1	32.1	32.0	32.0
100 m	32.4	32.1	32.3		32.2	32.2	32.2	32.1
150 m	32.4	32.7	32.7		32.2	32.5	32.6	32.6
200 m	32.6	32.8	32.9		32.2	32.7	32.8	32.7

5 - Esquiman Channel / Chenal Esquiman

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
Strat.	0.13	1.1	3.1	1.1	0.25	1.1	3.2	1.3
0 m	32.0	31.4	30.7	31.1	31.5	31.1	30.4	31.1
10 m	32.1	31.5	30.8	31.1	31.7	31.3	30.5	31.1
20 m	32.1	31.7	31.3	31.2	31.8	31.4	31.0	31.3
30 m	32.1	31.8	31.6	31.2	31.8	31.5	31.4	31.6
50 m	32.2	32.2	32.0	32.0	31.8	31.8	31.8	32.0
75 m	32.4	32.4	32.3	32.4	31.9	32.0	32.1	32.3
100 m	32.7	32.7	32.6	32.8	32.4	32.4	32.4	32.7
150 m	33.4	33.4	33.4	33.4	33.2	33.4	33.3	33.4
200 m	34.0	34.0	34.1	34.0	34.0	34.1	34.1	34.1
250 m		34.4	34.4	34.4		34.4	34.5	34.5
300 m			34.5	34.4			34.6	34.6

6 - Central Gulf / Centre du Golfe

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
Strat.	0.19	1.1	3.9	1.0	0.06	2.0	4.2	1.0
0 m	31.6	31.4	30.3	31.1	31.6	30.4	29.0	30.8
10 m	31.7	31.4	30.5	31.1	31.6	30.6	29.7	30.8
20 m	31.7	31.5	31.2	31.1	31.6	31.1	30.6	30.8
30 m	31.8	31.7	31.6	31.1	31.7	31.5	31.2	30.8
50 m	31.9	32.0	32.0	31.9	31.7	31.9	31.8	31.6
75 m	32.1	32.4	32.3	32.4	31.9	32.2	32.1	32.2
100 m	32.4	32.7	32.6	32.7	32.5	32.6	32.5	32.5
150 m	33.1	33.3	33.3	33.4	33.4	33.4	33.3	33.3
200 m	33.8	33.9	34.0	34.1	34.1	34.1	34.0	34.1
250 m		34.3	34.4	34.5		34.5	34.5	34.6
300 m		34.5	34.6	34.7		34.7	34.7	34.8
350 m		34.7	34.8	34.8		34.8	34.8	34.9
400 m		34.8	34.8	34.8		34.9	34.9	34.9
450 m			34.8	34.9			34.9	34.9

7 - Cabot Strait / Détroit de Cabot

	2010				2011			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
Strat.	0.44	1.4	3.7	1.2	0.62	1.9	3.2	1.4
0 m	31.1	30.5	30.5	30.2	30.7	30.0	30.3	30.4
10 m	31.4	30.5	30.8	30.2	30.8	30.0	30.7	30.5
20 m	31.5	30.7	31.6	30.3	31.0	30.5	31.2	30.7
30 m	31.5	31.0	31.8	30.6	31.2	30.9	31.5	30.9
50 m	31.7	31.5	32.2	31.3	31.5	31.6	32.1	31.6
75 m	31.9	32.3	32.4	32.2	31.9	32.5	32.4	32.4
100 m	32.4	32.7	32.7	32.7	32.4	32.9	32.6	32.8
150 m	33.3	33.6	33.4	33.5	33.4	33.6	33.4	33.6
200 m	34.0	34.3	34.3	34.3	34.3	34.3	34.3	34.2
250 m		34.6	34.6	34.6		34.7	34.7	34.6
300 m		34.7	34.8	34.7		34.8	34.8	34.8
350 m		34.8	34.8	34.8		34.9	34.9	34.8
400 m		34.8	34.8	34.9		34.9	34.9	34.9
450 m		34.9	34.9	34.9		34.9	34.9	34.9
500 m			34.9	34.9			34.9	34.9

8 - Magdalen Shallows / Plateau madelinien

	2010				2011			
	Mar	June	Sep	Nov	Mar	June	Sep	Nov
Strat.	0.26	2.5	3.9	1.2	0.29	3.3	4.5	2.7
0 m	31.0	29.2	29.1	30.0	30.4	28.2	27.9	28.8
10 m	31.0	29.4	29.1	30.0	30.5	28.7	28.0	28.8
20 m	31.1	29.8	29.6	30.1	30.5	29.5	28.6	29.1
30 m	31.1	30.3	30.4	30.2	30.5	30.2	29.8	29.7
50 m	31.3	31.2	31.5	31.2	30.8	31.1	31.2	31.1
75 m	31.3	31.8	32.1	31.8	31.2	31.9	32.0	31.9
100 m								

Table 18. Deep layer temperature, salinity, and dissolved oxygen. Gulf averages for temperature and salinity are shown for 150, 200, 250, and 300 m, and regional averages are shown for 200 and 300 m. Only recent regional averages at 300 m are shown for dissolved oxygen, with an inverted colour scheme. The numbers on the right are the 1981–2010 climatological means and standard deviations (except for oxygen where 2011 data are included). The numbers in the boxes are normalized anomalies.

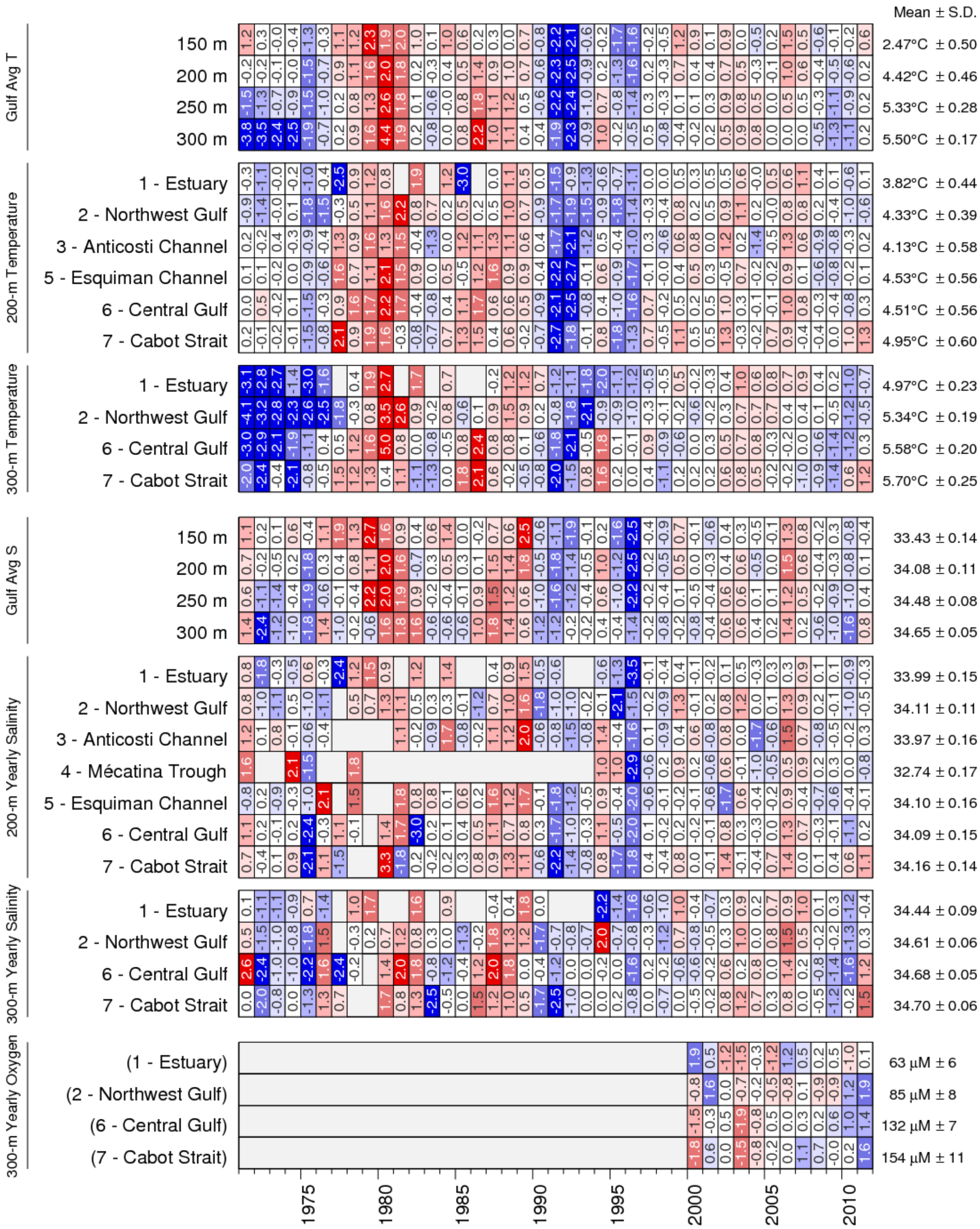

Table 19. Monthly averaged modelled transports and estuarine ratio across sections of the Gulf of St. Lawrence since 2006. The numbers on the right are the 2006–2011 means and standard deviations. The numbers in the boxes are normalized anomalies. Colours indicate the magnitude of the anomaly. Sv (Sverdrup) are units of transport equal to $10^6\ m^3s^{-1}$.

Net Transport

Section	Month	2006	2007	2008	2009	2010	2011	Mean ± SD
Pointe-des-Monts	J	-0.6	0.6	0.0	-1.4	-0.2	1.5	16.97 x10^3 m^3 s^{-1} ± 1.3
	F	1.1	-0.9	-0.7	0.8	0.8	-1.2	16.03 x10^3 m^3 s^{-1} ± 2.1
	M	-1.7	1.0	-0.4	-0.0	0.1	1.0	18.49 x10^3 m^3 s^{-1} ± 1.0
	A	-0.2	-0.7	0.6	1.2	-1.5	0.6	23.05 x10^3 m^3 s^{-1} ± 1.6
	M	-0.2	-0.6	0.6	0.0	-1.3	1.6	24.16 x10^3 m^3 s^{-1} ± 4.2
	J	-0.3	-0.6	0.9	0.4	-1.5	1.1	21.33 x10^3 m^3 s^{-1} ± 3.5
	J	-0.4	-0.8	0.8	0.9	-1.3	0.9	18.44 x10^3 m^3 s^{-1} ± 3.5
	A	-0.3	-1.2	1.1	0.5	-1.1	0.9	17.01 x10^3 m^3 s^{-1} ± 3.0
	S	0.5	-1.6	0.3	-0.5	0.0	1.3	16.49 x10^3 m^3 s^{-1} ± 1.2
	O	1.5	-1.4	-0.6	0.2	0.6	-0.4	16.73 x10^3 m^3 s^{-1} ± 2.3
	N	1.8	-1.0	-0.4	-0.4	0.5	-0.4	17.53 x10^3 m^3 s^{-1} ± 2.2
	D	1.1	-1.4	-0.6	-0.1	1.2	-0.2	16.58 x10^3 m^3 s^{-1} ± 2.7
Honguedo	J	0.5	-1.3	0.5	0.3	1.2	-1.2	0.162 Sv ± 0.035
	F	0.2	-0.9	0.3	0.9	1.0	-1.5	82.15 x10^3 m^3 s^{-1} ± 77.1
	M	0.8	0.4	-1.9	-0.1	0.8	0.1	0.118 Sv ± 0.026
	A	-0.5	0.2	-1.3	1.5	0.8	-0.6	0.146 Sv ± 0.059
	M	-1.0	-1.0	0.6	-0.7	0.9	1.2	0.136 Sv ± 0.044
	J	-1.2	-0.8	1.0	0.6	-0.7	1.1	0.293 Sv ± 0.046
	J	0.1	-1.3	-0.3	1.2	1.1	-0.8	0.447 Sv ± 0.043
	A	0.5	-0.7	1.4	-1.5	0.4	-0.1	0.483 Sv ± 0.047
	S	0.4	0.1	0.6	-0.9	1.3	-1.4	0.462 Sv ± 0.027
	O	0.2	-0.9	0.0	0.4	1.5	-1.2	0.464 Sv ± 0.062
	N	-0.8	1.2	1.3	-0.7	-0.3	-0.8	0.444 Sv ± 0.080
	D	-1.7	-0.3	0.2	1.1	0.8	-0.1	0.323 Sv ± 0.075
Cabot	J	0.3	-1.4	1.2	0.5	0.5	-1.0	0.489 Sv ± 0.049
	F	-0.1	-0.9	-0.2	1.8	-0.9	0.3	0.434 Sv ± 0.031
	M	1.5	-1.0	-0.2	0.9	-0.6	-0.6	0.379 Sv ± 0.032
	A	1.0	-0.0	1.2	0.1	-0.7	-1.5	0.227 Sv ± 0.040
	M	0.1	-0.2	-0.4	-0.4	-1.0	1.9	0.150 Sv ± 0.052
	J	-0.7	-0.2	0.5	-0.0	-1.2	1.7	89.75 x10^3 m^3 s^{-1} ± 37.7
	J	-0.1	-0.8	-0.7	-0.6	0.3	1.9	86.55 x10^3 m^3 s^{-1} ± 23.0
	A	-1.2	-0.5	1.0	-0.2	-0.5	1.4	0.216 Sv ± 0.026
	S	-0.3	-1.9	0.2	0.7	0.9	0.4	0.390 Sv ± 0.032
	O	0.3	-1.4	0.1	1.0	-1.1	1.0	0.526 Sv ± 0.043
	N	-0.2	-0.9	0.3	1.2	0.9	-1.3	0.542 Sv ± 0.033
	D	-1.1	-0.3	-0.0	0.9	1.4	-0.9	0.514 Sv ± 0.046

Outward Transport

Section	Month	2006	2007	2008	2009	2010	2011	Mean ± SD
Pointe-des-Monts	J	-0.4	-1.2	0.5	0.1	1.6	-0.8	0.281 Sv ± 0.038
	F	-1.4	1.6	-0.2	0.5	-0.5	-0.1	0.272 Sv ± 0.047
	M	-1.5	0.5	-0.9	0.4	1.1	0.4	0.227 Sv ± 0.030
	A	-0.7	0.2	0.2	1.8	-1.0	-0.5	0.232 Sv ± 0.040
	M	-0.5	-0.1	-0.9	0.9	-0.9	1.5	0.217 Sv ± 0.044
	J	-0.1	-1.3	-0.3	1.2	-0.6	1.2	0.156 Sv ± 0.030
	J	-0.1	-1.0	-0.3	1.8	0.4	-0.9	0.200 Sv ± 0.046
	A	-0.5	-0.1	1.9	-1.1	-0.0	-0.2	0.221 Sv ± 0.037
	S	0.3	0.0	-0.7	-1.0	1.8	-0.4	0.221 Sv ± 0.019
	O	0.8	1.2	-0.9	-0.8	-1.0	0.7	0.255 Sv ± 0.011
	N	-0.2	1.0	1.1	-0.0	-0.2	-1.6	0.259 Sv ± 0.037
	D	-0.6	-0.6	-0.3	0.4	1.9	-0.8	0.334 Sv ± 0.086
Honguedo	J	-0.8	-0.5	-0.9	1.4	1.1	-0.4	0.775 Sv ± 0.161
	F	-0.9	-0.1	-0.5	1.7	0.6	-0.8	0.613 Sv ± 0.167
	M	-0.8	-0.2	-1.4	1.4	0.3	0.6	0.610 Sv ± 0.089
	A	0.2	-0.6	-1.6	0.7	0.0	1.2	0.599 Sv ± 0.068
	M	-0.2	1.4	-1.4	-0.7	0.2	0.7	0.541 Sv ± 0.075
	J	-1.3	-0.9	0.1	0.6	0.1	1.4	0.550 Sv ± 0.054
	J	-0.0	-1.4	-0.1	1.5	0.6	-0.6	0.560 Sv ± 0.039
	A	0.3	-1.1	1.8	-0.5	-0.2	-0.3	0.641 Sv ± 0.063
	S	0.5	-0.6	-0.2	-1.2	1.7	-0.3	0.684 Sv ± 0.041
	O	0.7	-1.7	0.1	1.2	0.1	-0.3	0.803 Sv ± 0.057
	N	-0.8	0.5	1.5	-0.7	0.6	-1.1	0.879 Sv ± 0.100
	D	-0.7	-0.8	0.8	-0.6	1.6	-0.4	1.102 Sv ± 0.237
Cabot	J	-0.8	0.7	1.4	0.5	-0.6	-1.2	2.012 Sv ± 0.204
	F	-1.2	1.1	0.7	-0.6	0.9	-0.9	2.085 Sv ± 0.108
	M	-0.7	1.6	-0.5	-0.8	-0.5	0.9	2.027 Sv ± 0.295
	A	0.3	0.3	-1.6	1.1	-0.8	0.6	1.978 Sv ± 0.120
	M	-0.6	-1.1	-1.0	0.7	1.3	0.6	1.638 Sv ± 0.178
	J	-0.8	0.1	-0.5	-0.7	1.9	0.1	1.314 Sv ± 0.127
	J	-0.1	-0.1	1.0	-1.3	1.3	-0.7	1.418 Sv ± 0.183
	A	-0.2	1.9	0.3	-0.7	-0.4	-0.9	1.468 Sv ± 0.140
	S	-0.6	1.6	-0.2	-1.2	0.7	-0.3	1.254 Sv ± 0.116
	O	-0.8	0.5	-1.4	0.2	0.2	1.4	1.193 Sv ± 0.269
	N	0.2	1.9	-0.3	-0.7	-0.6	-0.5	1.561 Sv ± 0.135
	D	0.1	1.4	-0.0	0.7	-0.7	-1.4	2.186 Sv ± 0.188

Estuarine ratio

Section	Month	2006	2007	2008	2009	2010	2011	Mean ± SD
Pointe-des-Monts	J	-0.1	-1.1	0.4	0.8	1.3	-1.2	16.67 ± 2.93
	F	-1.3	1.6	0.1	-0.2	-0.7	0.5	17.40 ± 4.52
	M	-1.2	0.1	-1.0	0.6	1.5	-0.0	12.27 ± 1.23
	A	-0.8	0.7	-0.1	1.6	-0.6	-0.9	10.03 ± 1.30
	M	-0.5	0.6	-1.7	1.1	0.4	0.1	9.07 ± 1.43
	J	0.1	-1.1	-1.3	1.0	1.1	0.2	7.37 ± 1.13
	J	0.1	-0.4	-0.8	0.6	1.6	-1.2	11.17 ± 3.12
	A	-0.2	1.0	0.4	-1.3	1.1	-0.9	13.28 ± 2.67
	S	-0.1	1.2	-0.8	-0.5	1.3	-1.1	13.45 ± 1.51
	O	-1.0	1.7	0.2	-0.5	-0.8	0.4	15.52 ± 2.42
	N	-1.0	1.4	0.9	0.2	-0.5	-1.0	15.00 ± 3.20
	D	-1.5	0.5	0.1	0.6	1.2	-0.9	20.26 ± 3.94
Honguedo	J	-1.1	0.9	-1.2	0.8	-0.2	0.9	4.92 ± 1.15
	F	-0.2	1.9	-0.2	-0.2	-0.2	-1.1	10.45 ± 24.89
	M	-1.2	-0.6	1.5	0.8	-0.6	0.1	5.38 ± 1.25
	A	0.4	-0.6	1.3	-1.1	-0.9	0.9	4.66 ± 1.73
	M	0.8	1.5	-1.0	0.1	-0.7	-0.7	4.38 ± 1.69
	J	0.7	0.3	-1.4	-0.5	1.5	-0.4	1.89 ± 0.17
	J	-0.6	0.7	0.4	-0.3	-1.6	0.9	1.26 ± 0.05
	A	-0.4	-0.7	0.6	1.8	-1.0	-0.5	1.33 ± 0.08
	S	0.3	-1.0	-1.2	-0.4	0.6	1.7	1.48 ± 0.06
	O	0.0	-0.1	-0.1	0.2	-1.7	1.5	1.75 ± 0.18
	N	0.5	-1.6	-0.7	0.4	1.2	0.2	2.00 ± 0.18
	D	1.5	-0.6	0.4	-1.4	0.4	-0.4	3.53 ± 0.83
Cabot	J	-0.9	1.9	0.1	0.0	-0.9	-0.2	4.14 ± 0.54
	F	-0.6	1.1	0.4	-1.3	1.0	-0.6	4.83 ± 0.52
	M	-1.0	1.6	-0.3	-0.9	-0.2	0.8	5.42 ± 1.16
	A	-0.7	-0.0	-1.3	0.1	0.3	1.7	9.01 ± 1.96
	M	-0.5	-0.3	-0.2	0.3	1.8	-1.2	11.91 ± 4.25
	J	0.2	-0.1	-0.6	-0.4	1.9	-0.9	17.39 ± 9.31
	J	-0.2	0.7	1.2	-0.2	0.1	-1.7	17.21 ± 4.26
	A	0.8	1.4	-0.6	-0.3	0.0	-1.4	6.91 ± 1.15
	S	-0.2	2.0	-0.3	-0.9	-0.1	-0.4	3.25 ± 0.58
	O	-0.9	1.0	-1.4	-0.2	0.6	0.9	2.28 ± 0.54
	N	0.2	1.8	-0.4	-1.0	-0.8	0.3	2.89 ± 0.37
	D	1.0	1.3	-0.0	-0.3	-1.5	-0.5	4.28 ± 0.49

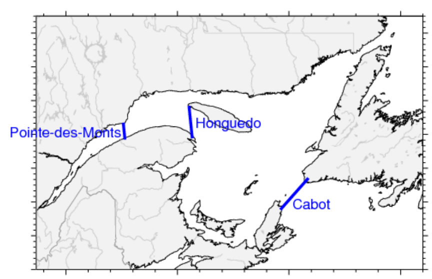

Table 20. Monthly averaged modelled transports across sections of the Gulf of St. Lawrence since 2006. The numbers on the right are the 2006–2011 means and standard deviations, with positive values toward east and north. The numbers in the boxes are normalized anomalies. Colours indicate the magnitude of the anomaly (e.g., negative anomalies are still shown in red when the mean transport is negative across the section).

Jacques-Cartier

Month	2006	2007	2008	2009	2010	2011	Mean ± SD
J	-0.5	1.3	-0.5	-0.4	-1.1	1.2	-0.143 Sv ± 0.037
F	-0.2	0.9	-0.3	-0.9	-1.1	1.5	-65.37 x10^3 m^3 s^{-1} ± 73.9
M	-0.9	-0.3	1.9	0.0	-0.8	0.0	-95.53 x10^3 m^3 s^{-1} ± 25.2
A	0.5	-0.2	1.3	-1.4	-0.8	0.6	-0.118 Sv ± 0.059
M	1.0	1.0	-0.5	0.6	-1.1	-1.0	-0.106 Sv ± 0.042
J	1.3	0.8	-0.9	-0.6	0.6	-1.1	-0.266 Sv ± 0.042
J	-0.2	1.2	0.4	-1.1	-1.2	0.9	-0.424 Sv ± 0.046
A	-0.6	0.6	-1.3	1.5	-0.5	0.2	-0.464 Sv ± 0.047
S	-0.4	-0.2	-0.6	0.9	-1.3	1.5	-0.443 Sv ± 0.027
O	-0.2	0.9	0.0	-0.3	-1.6	1.2	-0.446 Sv ± 0.060
N	0.8	-1.2	-1.3	0.6	0.3	0.8	-0.424 Sv ± 0.081
D	1.8	0.2	-0.2	-1.1	-0.7	0.1	-0.305 Sv ± 0.074

Bradelle

Month	2006	2007	2008	2009	2010	2011	Mean ± SD
J	0.5	-0.4	1.1	-1.3	0.9	-0.8	-0.353 Sv ± 0.082
F	1.8	-0.9	0.1	-0.9	-0.1	-0.1	-0.258 Sv ± 0.043
M	0.4	-1.5	1.0	0.6	0.6	-1.0	-0.201 Sv ± 0.076
A	-0.6	-0.9	1.6	-0.4	0.9	-0.6	-0.166 Sv ± 0.060
M	0.8	-1.1	-0.2	0.7	-1.3	1.1	-0.135 Sv ± 0.056
J	0.4	-0.5	-0.8	1.9	-0.4	-0.6	-80.99 x10^3 m^3 s^{-1} ± 72.8
J	1.3	-1.4	0.0	0.8	0.1	-0.9	-0.114 Sv ± 0.039
A	-0.2	-1.5	-0.5	0.0	0.8	1.4	-0.100 Sv ± 0.039
S	-0.4	-0.2	-0.0	0.6	-1.5	1.5	-0.137 Sv ± 0.057
O	-0.2	0.7	0.3	0.7	-1.9	0.4	-0.184 Sv ± 0.095
N	-0.1	0.4	-1.6	1.4	-0.3	0.2	-0.248 Sv ± 0.063
D	-0.7	0.1	-1.1	-0.7	1.4	0.9	-0.365 Sv ± 0.099

Northumberland

Month	2006	2007	2008	2009	2010	2011	Mean ± SD
J	-0.1	-0.0	-0.5	-1.3	0.2	1.7	4.97 x10^3 m^3 s^{-1} ± 3.4
F	0.1	-1.3	0.6	1.1	0.7	-1.2	-0.75 x10^3 m^3 s^{-1} ± 1.0
M	0.3	-0.1	-1.3	-0.9	1.4	0.6	1.19 x10^3 m^3 s^{-1} ± 2.3
A	0.7	-0.6	-1.7	0.5	1.0	0.2	3.29 x10^3 m^3 s^{-1} ± 4.2
M	-1.8	-0.1	0.2	0.6	1.2	-0.2	3.76 x10^3 m^3 s^{-1} ± 3.8
J	-0.7	-0.5	1.5	-1.1	0.2	0.8	2.81 x10^3 m^3 s^{-1} ± 3.2
J	-0.4	0.1	-0.1	1.3	-1.6	0.7	6.37 x10^3 m^3 s^{-1} ± 2.5
A	-0.5	0.0	1.6	0.5	-1.3	-0.4	3.98 x10^3 m^3 s^{-1} ± 5.3
S	-0.9	-0.2	1.2	-1.3	1.0	0.2	-0.56 x10^3 m^3 s^{-1} ± 2.9
O	0.9	-1.1	-0.9	-0.7	0.7	1.1	-1.05 x10^3 m^3 s^{-1} ± 3.8
N	0.1	-0.7	0.5	-0.9	1.7	-0.7	-0.39 x10^3 m^3 s^{-1} ± 3.9
D	0.6	-0.2	-0.2	0.2	1.3	-1.7	7.65 x10^3 m^3 s^{-1} ± 6.6

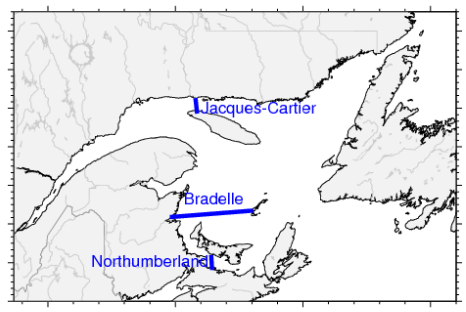

Table 21. May to October temperature and salinity layer averages, stratification expressed as the density difference between 0 and 50 m, and CIL temperature minimum and thickness (T<1°C) for the fixed monitoring stations. Numbers in the temperature and stratification panels are monthly average values and numbers in the salinity panel are normalized anomalies. Three months of anomaly data, between May and October, are required to show an average anomaly for any given year.

Variable	Station	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	Mean
T [0-100 m]	Rimouski	1.6	1.7	2.2	1.1	2.2	2.4	1.3	2.4	3.1	2.8	3.1	3.0	2.3	1.4	2.4	2.7	2.3	2.3	2.8	2.5	3.1	2.33°C ± 0.60
	Gaspé Current						2.6	2.0	2.9	2.4	2.3	2.6	3.1	2.3		2.6	3.2		2.5	2.9			2.62°C ± 0.36
	Anticosti Gyre						1.8	1.9	1.2	1.4	2.0	2.2	2.4	1.8		1.6	1.9		1.9	1.9			1.83°C ± 0.32
	Shediac Valley		7.6					5.4		7.8	7.9	7.9	6.9	6.4	5.6	5.5	6.3	8.4	8.7	6.5	7.8	7.6	7.24°C ± 1.17
S [0-50 m]	Rimouski	0.8	-0.6	-0.9	-0.0	0.6	-1.5	-0.7	-0.4	0.9	0.8	0.8	1.4	1.5	-0.1	-0.4	0.3	1.1	-0.7	-1.1	0.2	-2.2	29.15 ± 0.50
	Gaspé Current						0.4	-1.5	-1.9	1.3	0.0	0.3	0.3	1.5		-0.2	-0.4		-0.5	0.6			29.79 ± 0.31
	Anticosti Gyre						-1.4	-1.1	-1.2	0.9	0.3	0.3	1.4	1.4		-1.0	-0.1		-0.3	0.8			31.46 ± 0.19
	Shediac Valley		-0.0							0.0	0.1	0.3	1.1	2.1	-0.6	-0.5	0.0	1.1	-1.7	0.0	0.7	-1.4	29.95 ± 0.29
$\Delta\sigma_t$ [0,50 m]	Rimouski	3.7	4.7	5.0	4.8	4.0	5.5	5.5	4.0	3.3	4.5	3.7	4.1	3.9	4.7	4.4	4.6	4.5	5.6	4.7	4.3	5.5	4.53 kg m^{-3} ± 0.64
	Gaspé Current						3.7	4.8	4.1	3.9	4.5	4.1	5.0	4.4			3.8		5.3	3.7			4.30 kg m^{-3} ± 0.55
	Anticosti Gyre						3.3	3.0	2.9	2.8	2.9	3.4	2.8	2.9		2.7	2.9		3.7	2.7			3.00 kg m^{-3} ± 0.29
	Shediac Valley		3.5							3.5	3.8	3.3	3.5	3.6	3.7	3.9	3.9	3.3	5.1	3.8	3.3	3.7	3.68 kg m^{-3} ± 0.43
T [CIL min]	Rimouski	-0.70	-0.56	-0.59	-0.29	-0.66	-0.21	-0.19	-0.63	-0.21	0.08	0.26	0.35	-0.27	-0.29	-0.22	0.53	0.10	-0.05	-0.05	0.25	0.68	-0.13°C ± 0.39
	Gaspé Current						-0.37	-0.27	-0.68	-0.34	0.03	-0.20	0.13	-0.45		-0.31	0.54		-0.44	-0.25			-0.22°C ± 0.32
	Anticosti Gyre						-0.32	-0.47	-0.67	-0.46	0.07	-0.10	0.03	-0.61		-0.42	0.46		-0.39	-0.45			-0.28°C ± 0.33
CIL thick. < 1°C	Rimouski	91		83	59	73	60	49	60	49	50	31	36	69	59	53	30	43	54	47	39	23	53 m ± 17
	Gaspé Current						73	62	64	65	52	57	48	75		68	29		58	59			59 m ± 12
	Anticosti Gyre						60	69	70	54	40	42	36	53		71	34		61	56			54 m ± 13

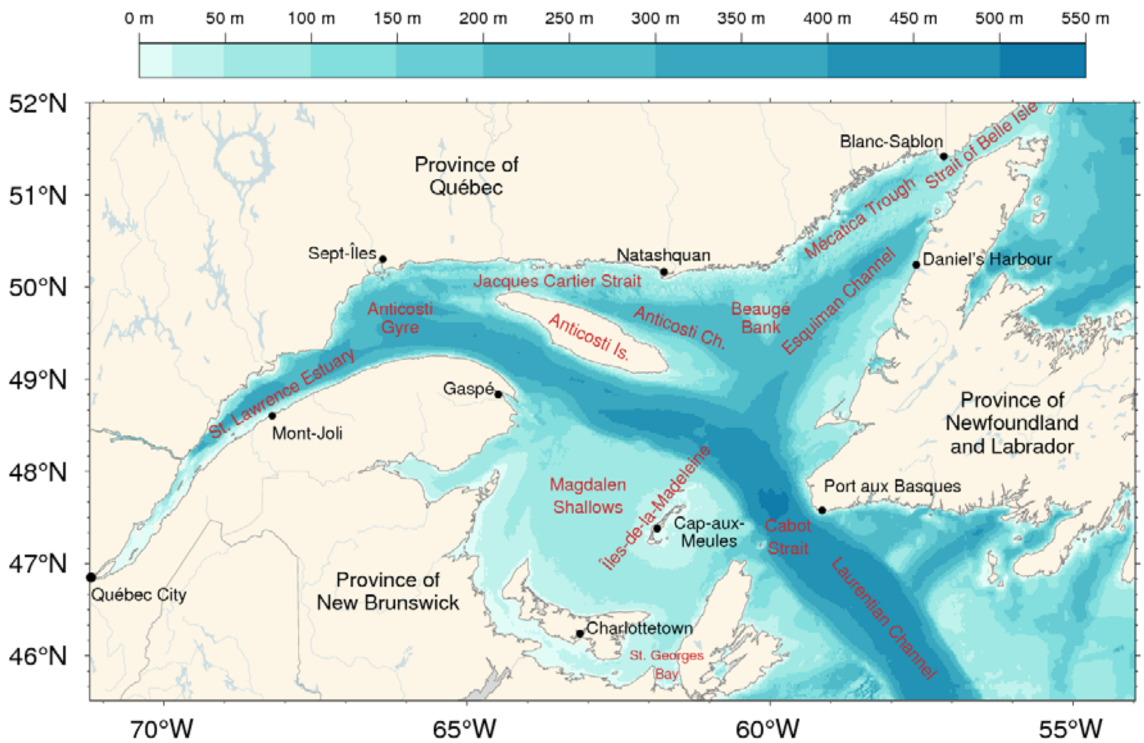

Fig. 1. The Gulf of St. Lawrence. Locations discussed in the text are indicated. Bathymetry datasets used are from the Canadian Hydrographic Service to the west of 56°47' W (with some corrections applied to the baie des Chaleurs and Magdalen Shallows) and TOPEX data to the east.

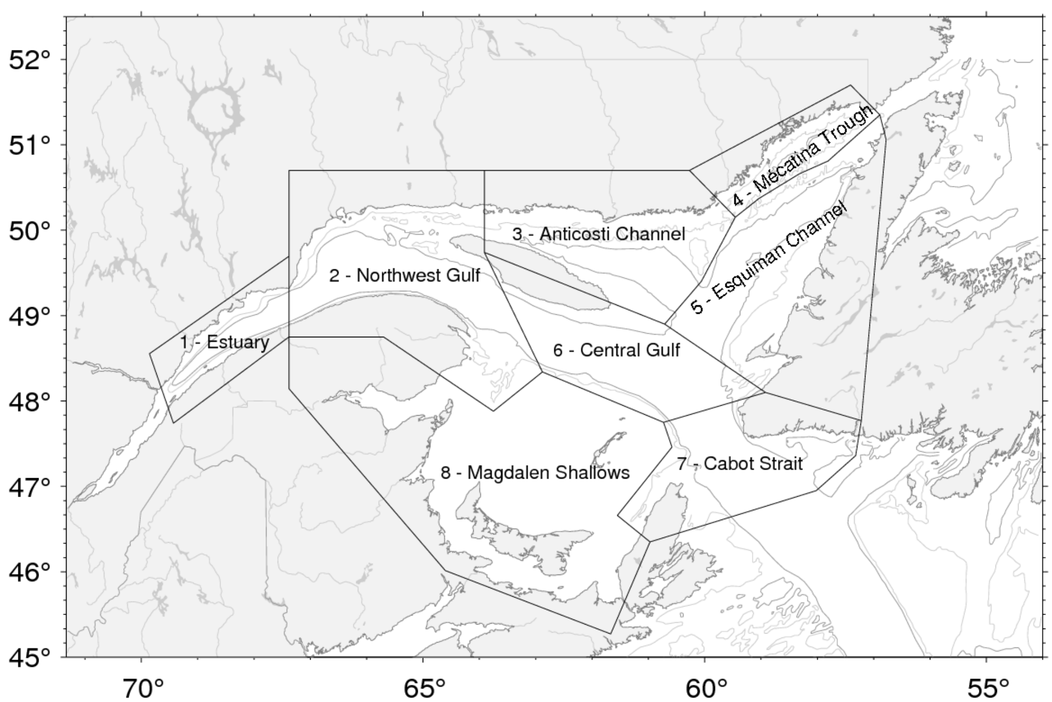

Fig. 2. Gulf of St. Lawrence divided into eight oceanographic regions.

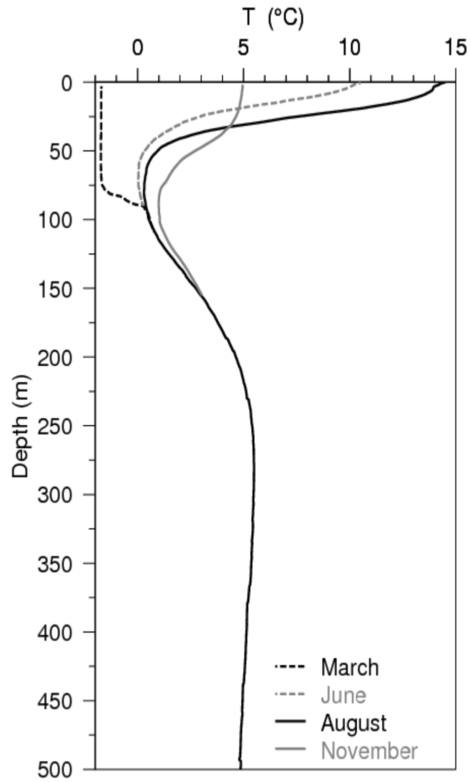

Fig. 3. Typical seasonal progression of the depth profile of temperature observed in the Gulf of St. Lawrence. Profiles are averages of observations in August, June and November 2007 in the northern Gulf. The dashed line at left shows a single winter temperature profile (March 2008), with near-freezing temperatures in the top 75 m. The cold intermediate layer (CIL) is defined as the part of the water column that is colder than 1°C, although some authors use a different temperature threshold. Figure from Galbraith et al. (2012).

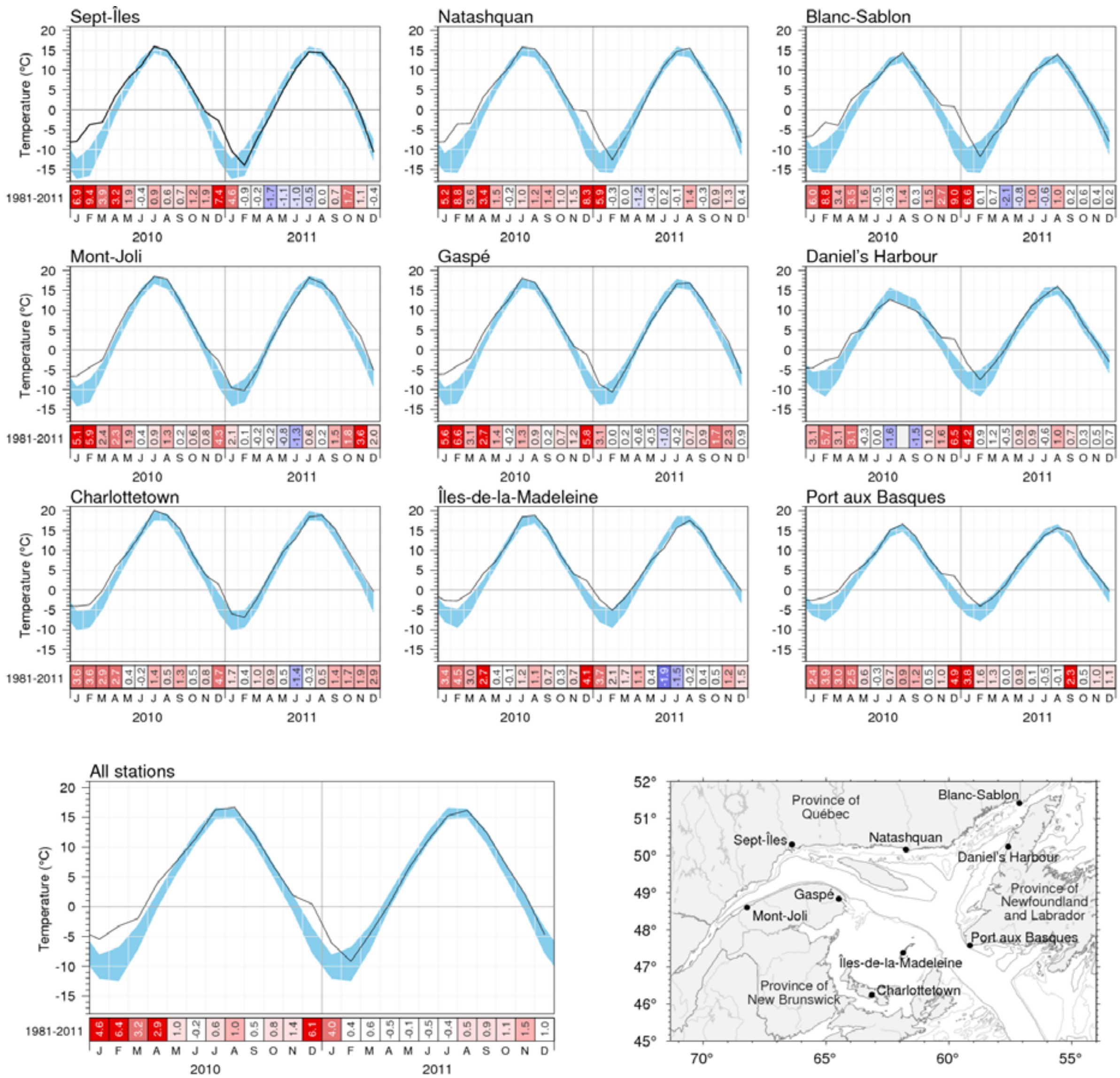

Fig. 4. Monthly air temperatures and anomalies for 2010 and 2011 at nine selected stations around the Gulf as well as the average for all nine stations. The blue area represents the 1981–2010 climatological monthly mean ± 1 SD. The bottom scorecards are colour-coded (see ***Table 1****) according to the monthly normalized anomalies based on the 1981–2010 climatologies for each month, but the numbers are the monthly anomalies in ºC.*

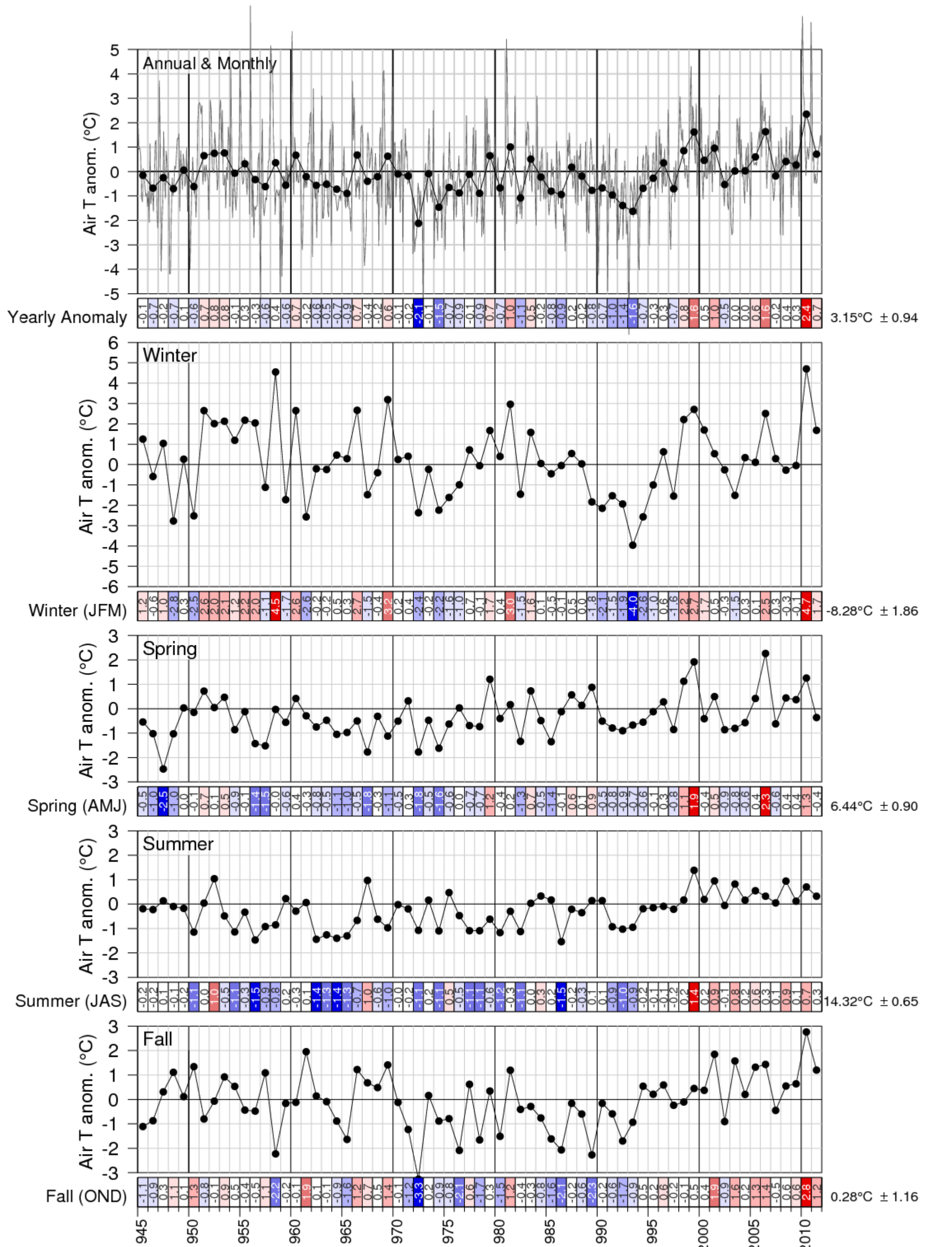

Fig. 5. Annual and seasonal mean air temperature anomalies averaged for the nine selected stations around the Gulf. The bottom scorecards are colour-coded according to the normalized anomalies based on the 1981–2010 climatology, but the numbers are the anomalies in ºC.

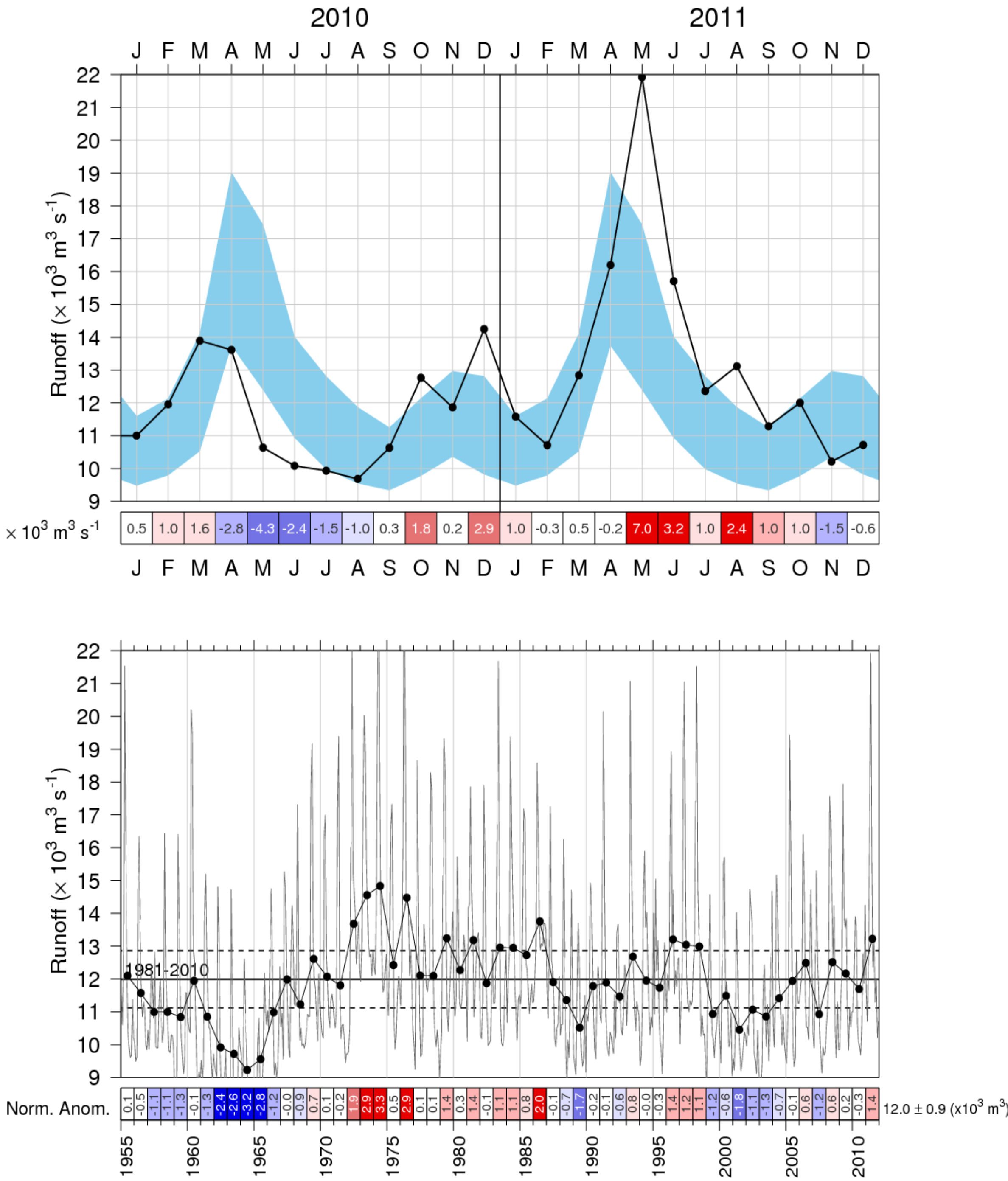

Fig. 6. Monthly (top panel) and annual (bottom panel) mean freshwater flow of the St. Lawrence River at Québec City. The 1981–2010 climatological mean (± 1 SD) is shown for each month in the top panel (blue shading) and as horizontal lines for the annual time series in the bottom panel. The top-panel scorecard is colour-coded according to the monthly anomalies normalized for each month of the year, but the numbers are the actual monthly anomalies in 10^3 m^3 s^{-1}. The bottom-panel scorecard shows numbered and colour-coded normalized anomalies for which the mean and standard deviation are indicated on the right side.

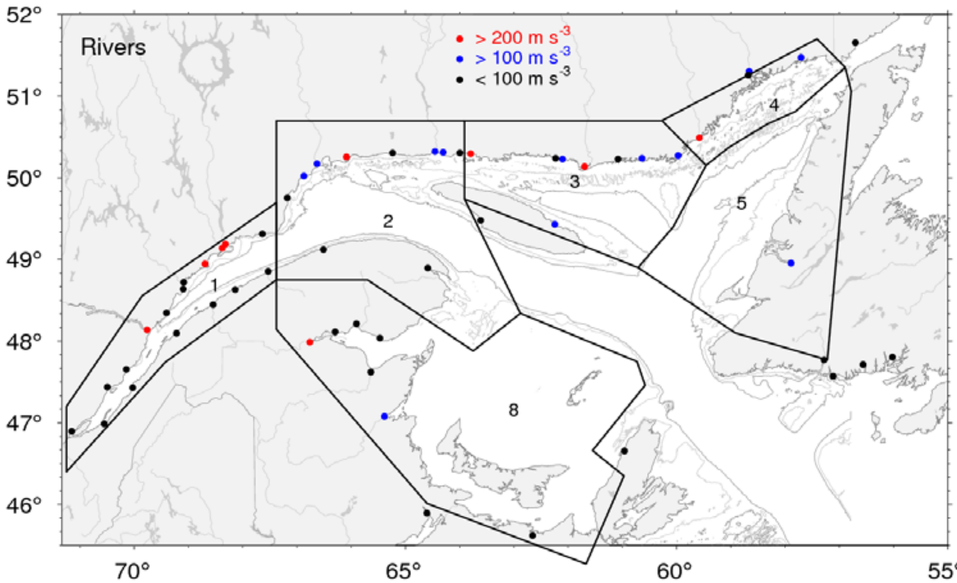

Fig. 7. River discharge locations for the regional sums of runoffs listed in Table 2. Red and blue dots indicate rivers that have climatological mean runoff greater than 200 m s^{-1} and between 100 and 200 m^3 s^{-1}, respectively.

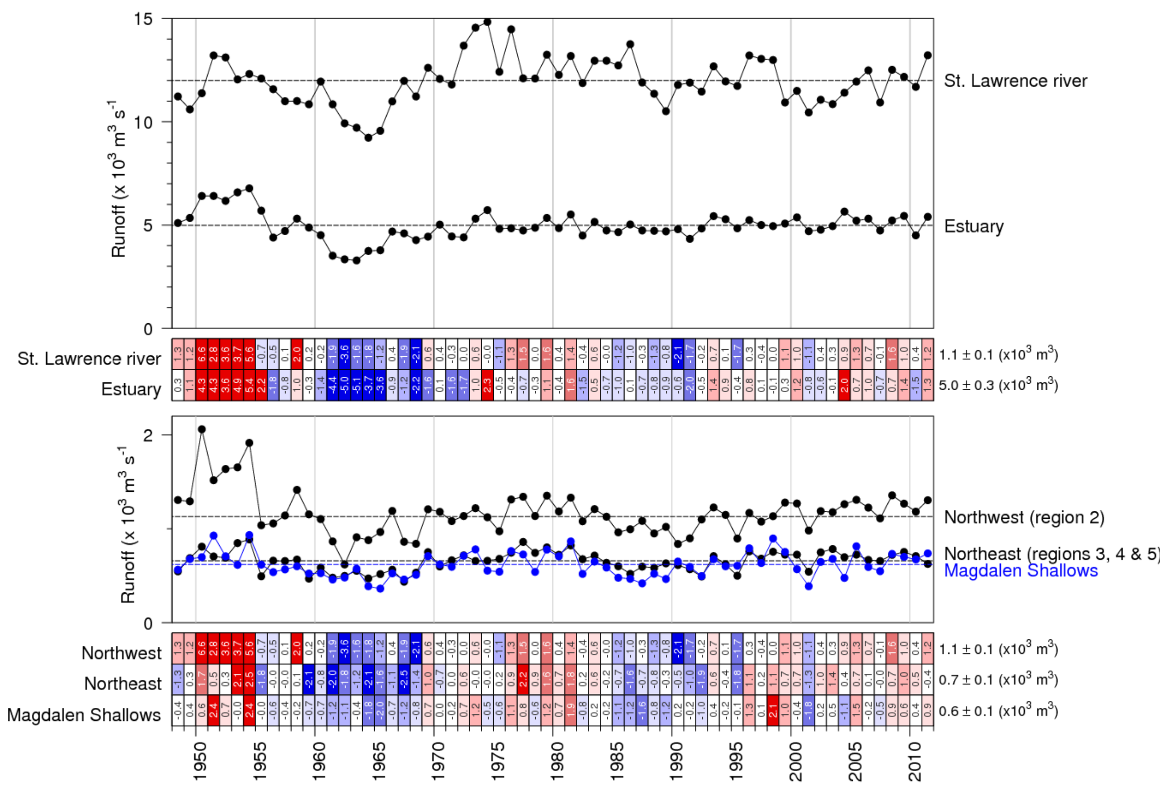

Fig. 8. Annual mean freshwater flow of the St. Lawrence River at Québec City and of the sum of all rivers flowing into regions of the Estuary and Gulf. The 1981–2010 climatological mean is shown as horizontal lines and indicated on the right side of the scorecards. Numbers in scorecards are normalized anomalies.

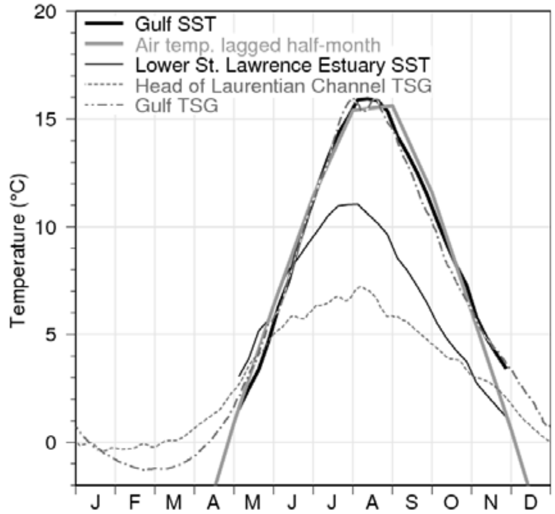

Fig. 9. Sea-surface temperature climatological seasonal cycle in the Gulf of St. Lawrence. NOAA AVHRR temperature weekly averages for 1985 to 2010 are shown from May to November (ice-free months) for the entire Gulf (thick black line) and the cooler Lower St. Lawrence Estuary (thin black line), defined as the area west of the Pointe-des-Monts section and east of approx 69°30'W. Thermosalinograph data averages for 2000 to 2010 are shown for the head of the Laurentian Channel (at 69°30'W, grey dashed line) and for the average over the Gulf waters along the main shipping route between the Pointe-des-Monts and Cabot Strait sections (gray dash-dotted line). Monthly air temperature averaged over eight stations in the Gulf of St. Lawrence are shown offset by 2 weeks into the future (thick grey line; winter months not shown). Figure from Galbraith et al, (2012).

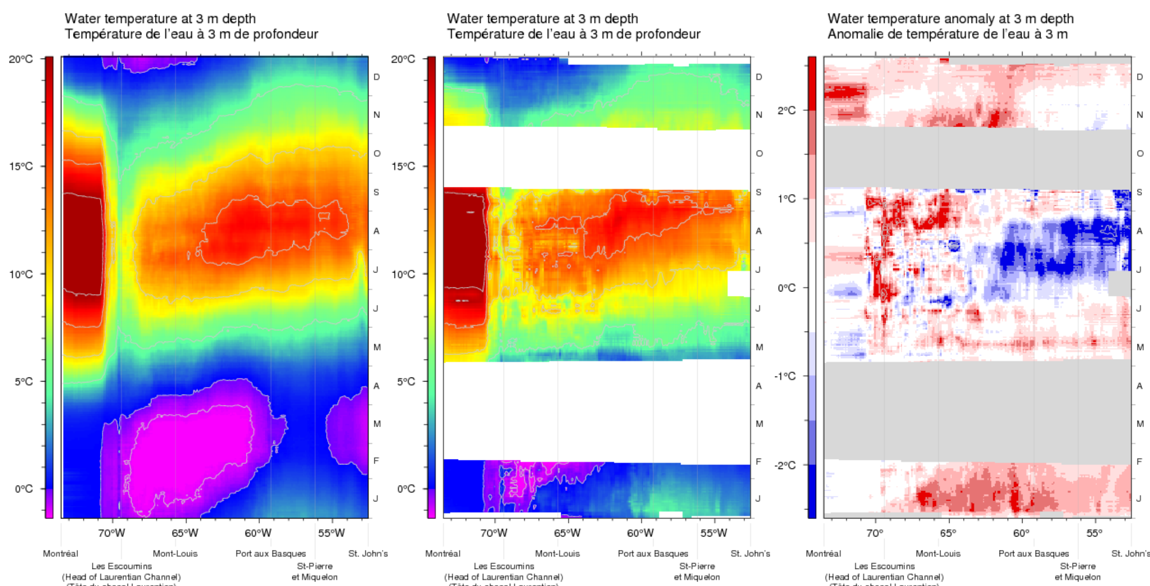

Fig. 10. Thermosalinograph data at 3 m depth along the Montréal to St. John's shipping route: composite mean annual cycle of the water temperature for the 2000–2011 period (left panel), composite annual cycle of the water temperature for 2011 (middle panel), and water temperature anomaly for 2011 relative to the 2000–2011 composite (right panel).

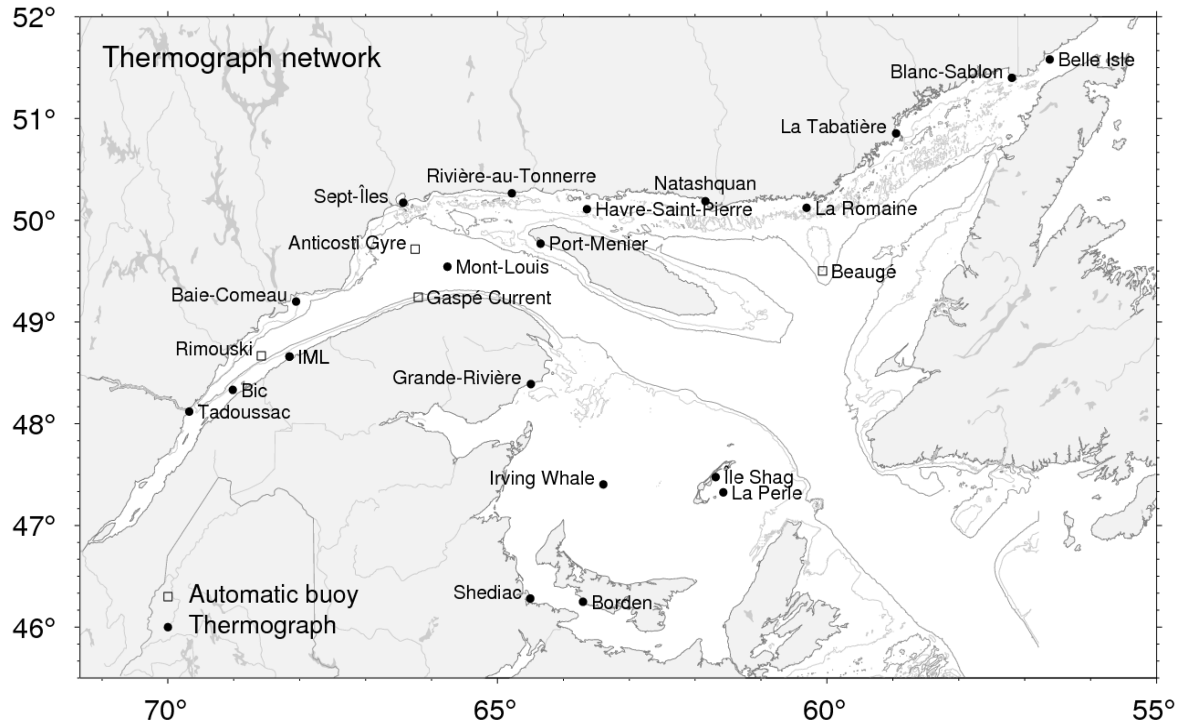

Fig. 11. Locations of the Maurice Lamontagne Institute thermograph network stations in 2011, including regular stations where data are logged internally and recovered at the end of the season (filled circles) and oceanographic buoys that transmit data in real time (open squares). Shediac station from DFO Gulf Region is also shown.

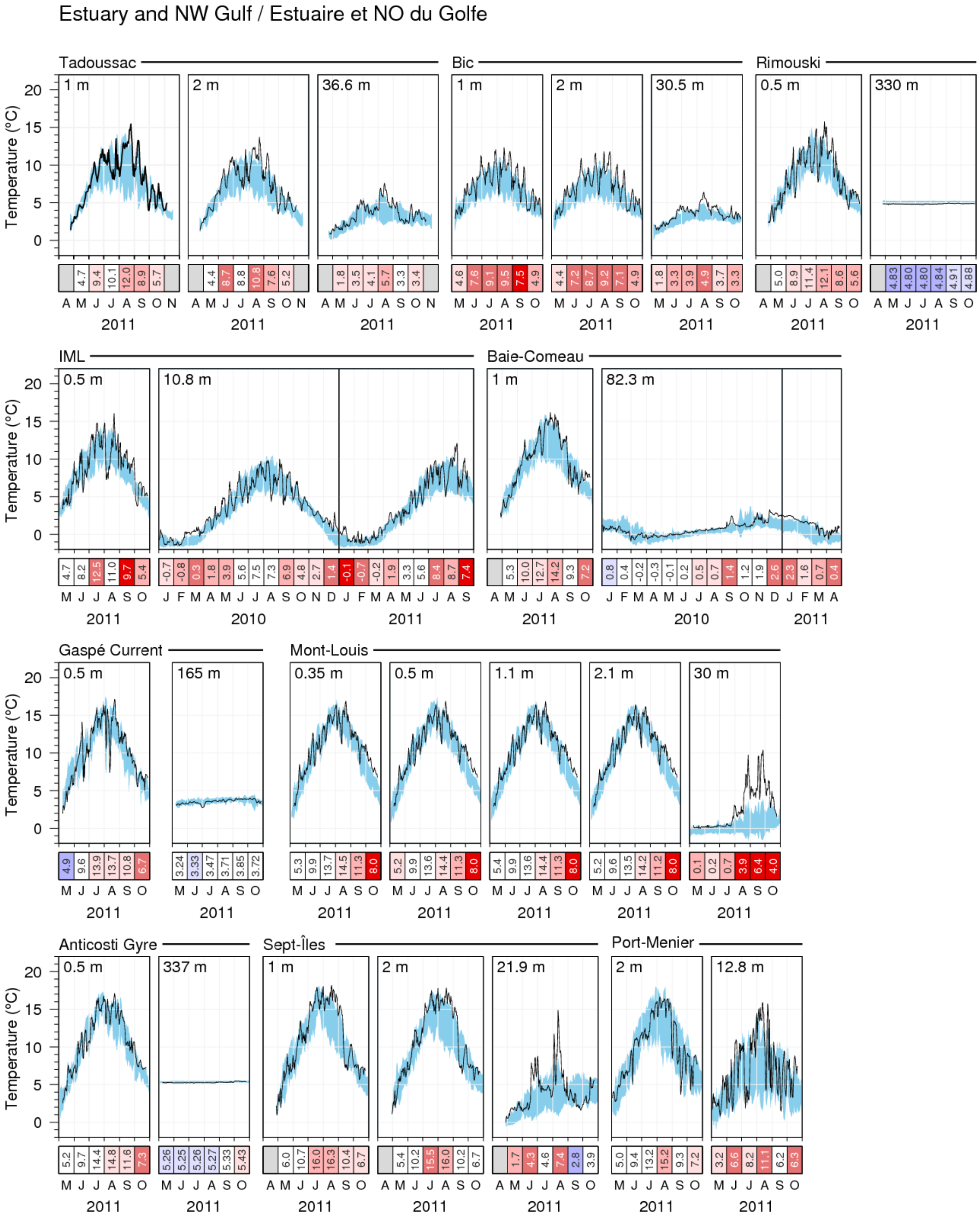

Fig. 12. Thermograph network data. Daily mean 2011 temperatures compared with the daily climatology (daily averages ± 1 SD; blue areas) computed from all available stations in the Estuary and northwestern Gulf. Scorecards show monthly average temperature. Data from 2010 are included if they were not all shown in the previous report (Galbraith et al. 2011).

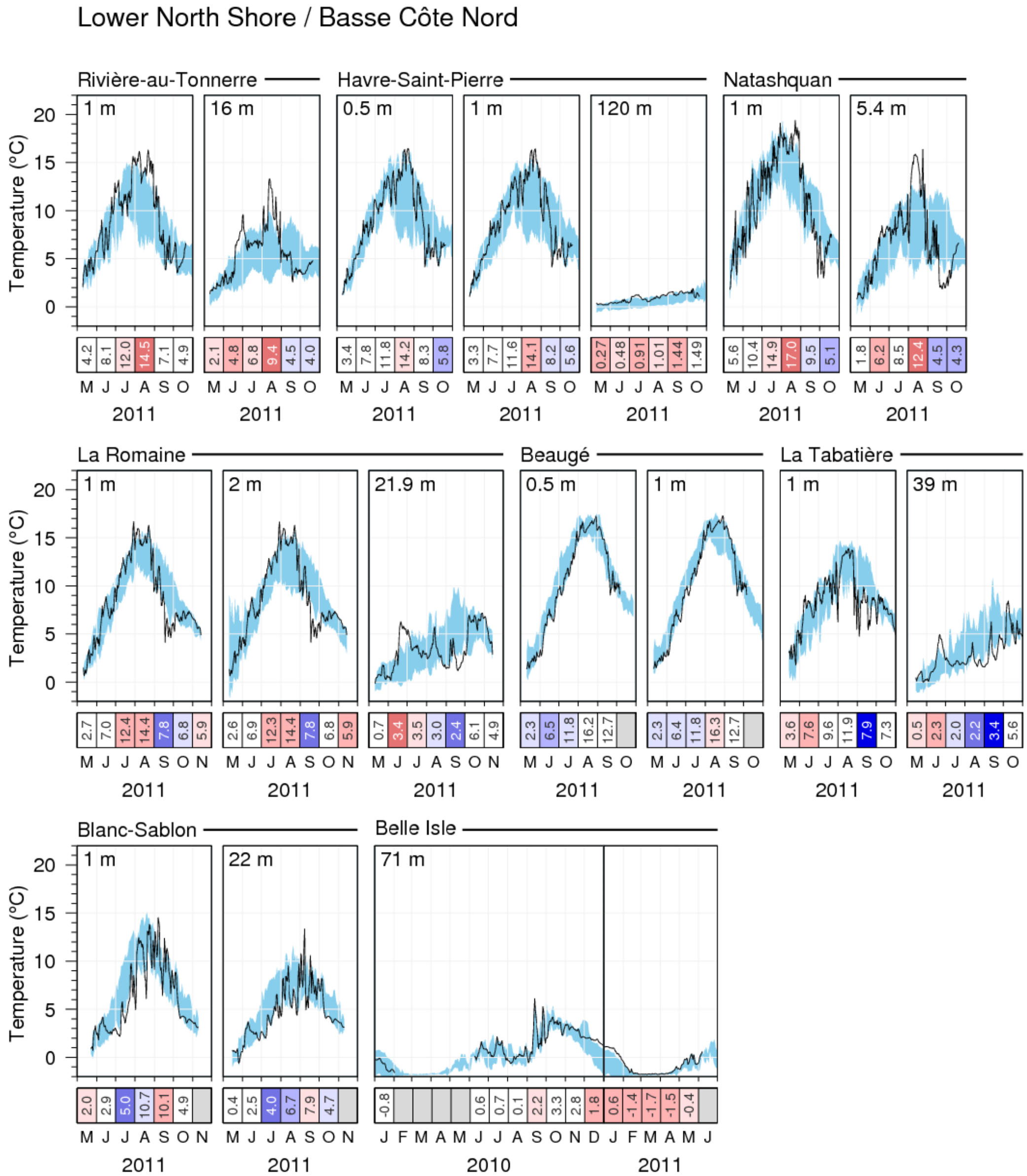

Fig. 13. Thermograph network data. Daily mean 2011 temperatures compared with the daily climatology (daily averages ± 1 SD; blue areas) computed from all available stations of the lower north shore.

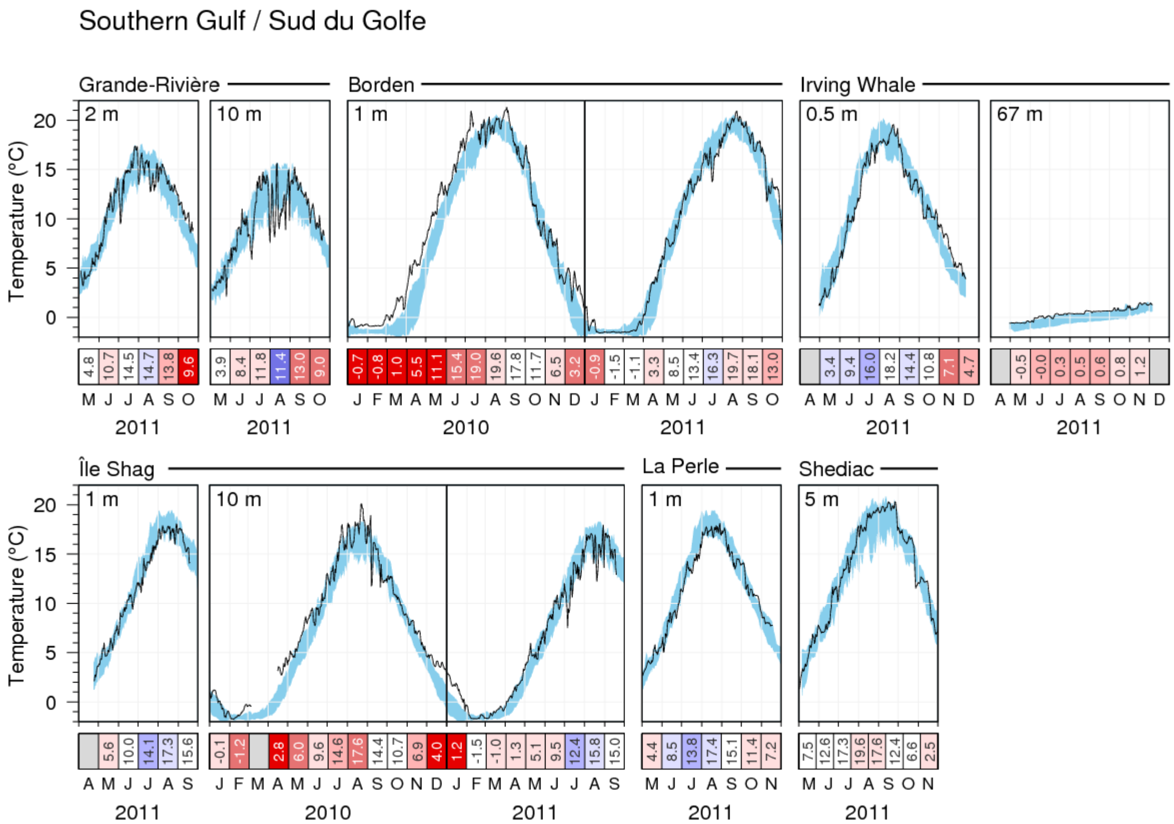

Fig. 14. Thermograph network data. Daily mean 2011 temperatures compared with the daily climatology (daily averages ± 1 SD; blue area) computed from all available stations of the southern Gulf. Shediac station from DFO Gulf Region is also shown.

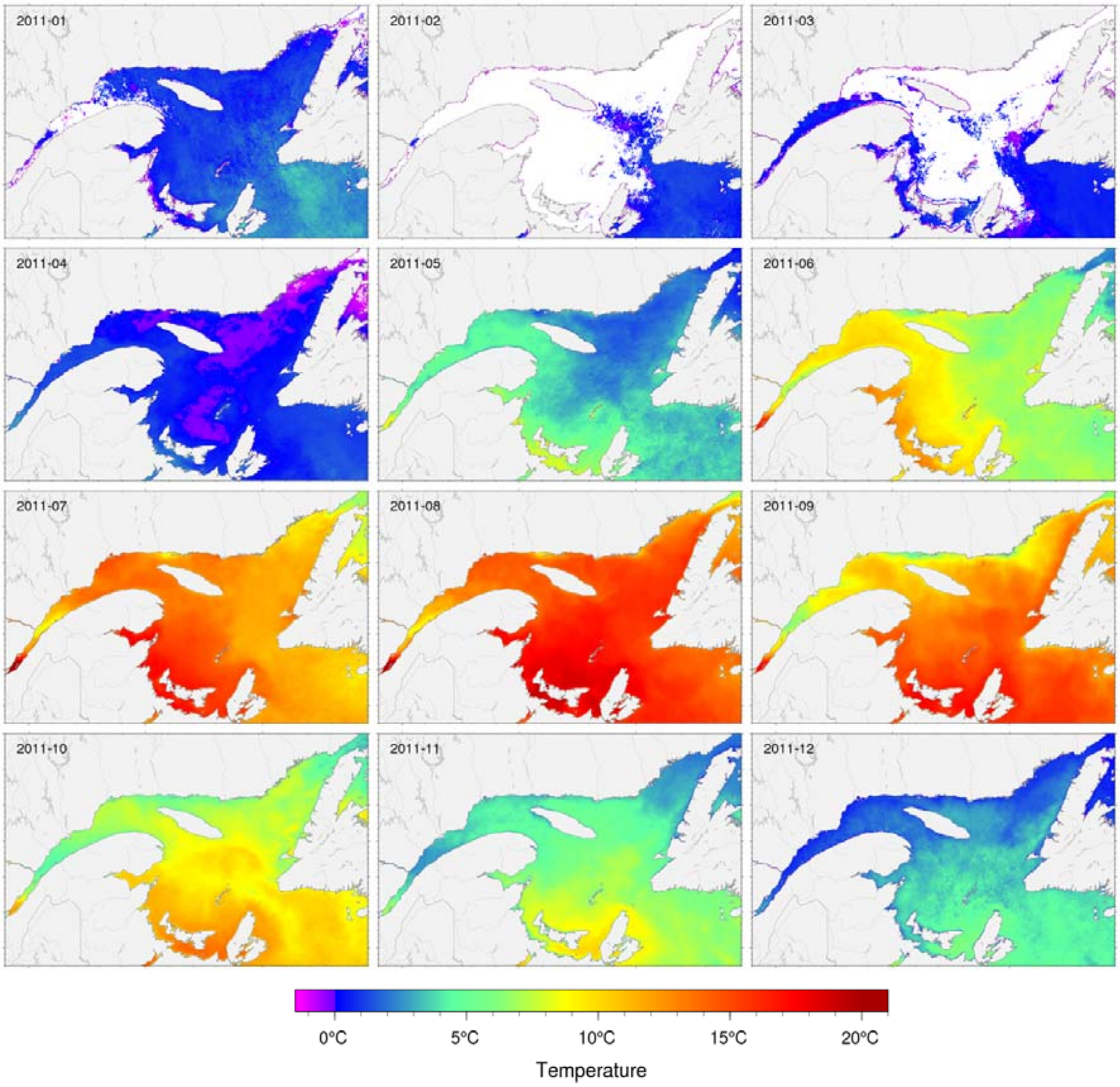

Fig. 15. Sea-surface temperature monthly averages for 2011 as observed with NOAA AVHRR remote sensing. White areas have no data for the period due to ice cover.

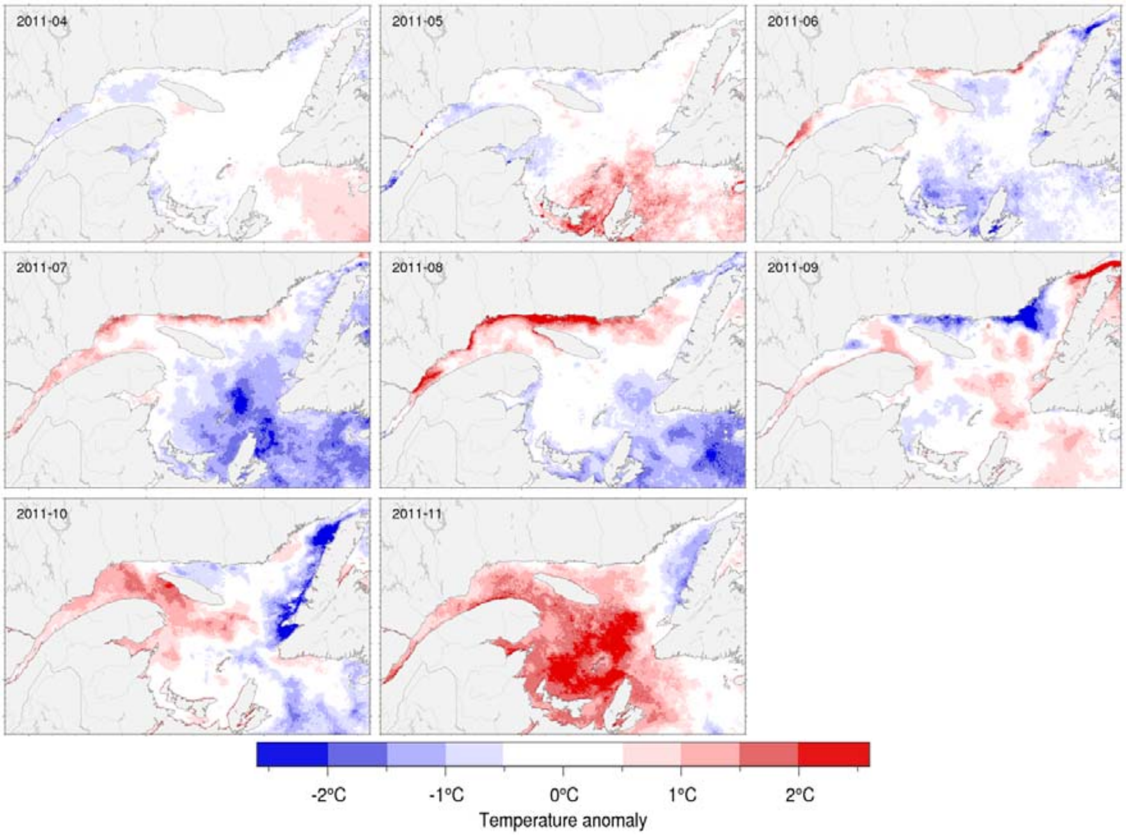

Fig. 16. Sea-surface temperature monthly anomalies for April through November 2011 based on monthly climatologies calculated for the 1985–2010 period observed with NOAA AVHRR remote sensing. Only ice-free months are shown.

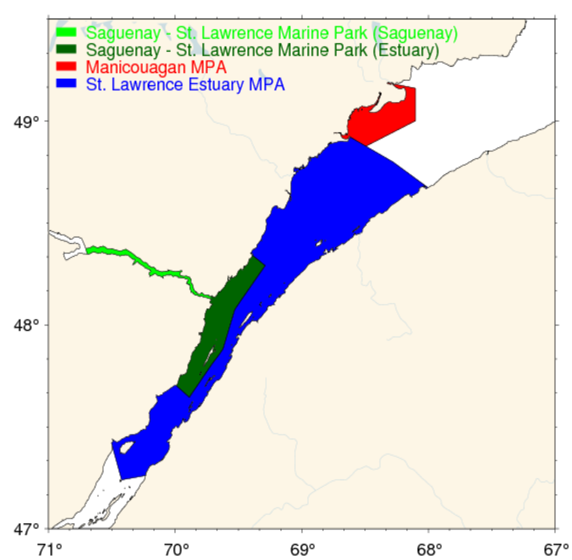

Fig. 17. Map showing the Manicouagan MPA, the St. Lawrence Estuary MPA, and the Saguenay – St. Lawrence Marine Park for the purpose of SST extraction from NOAA imagery.

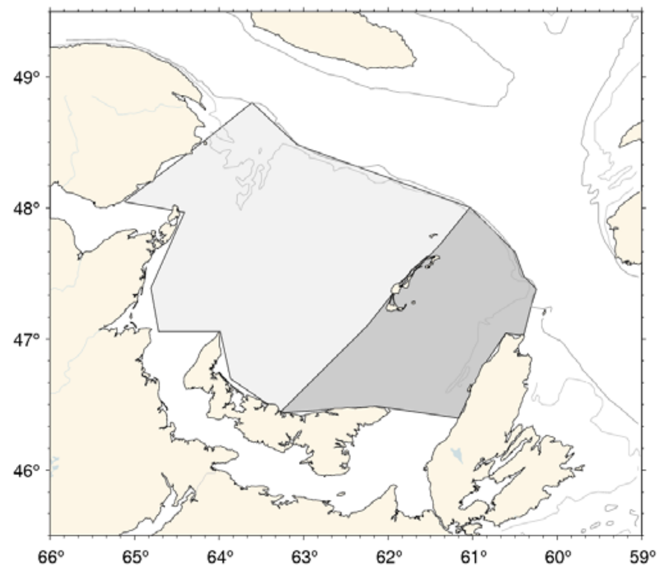

Fig. 18. Areas defined as the western and eastern Magdalen Shallows.

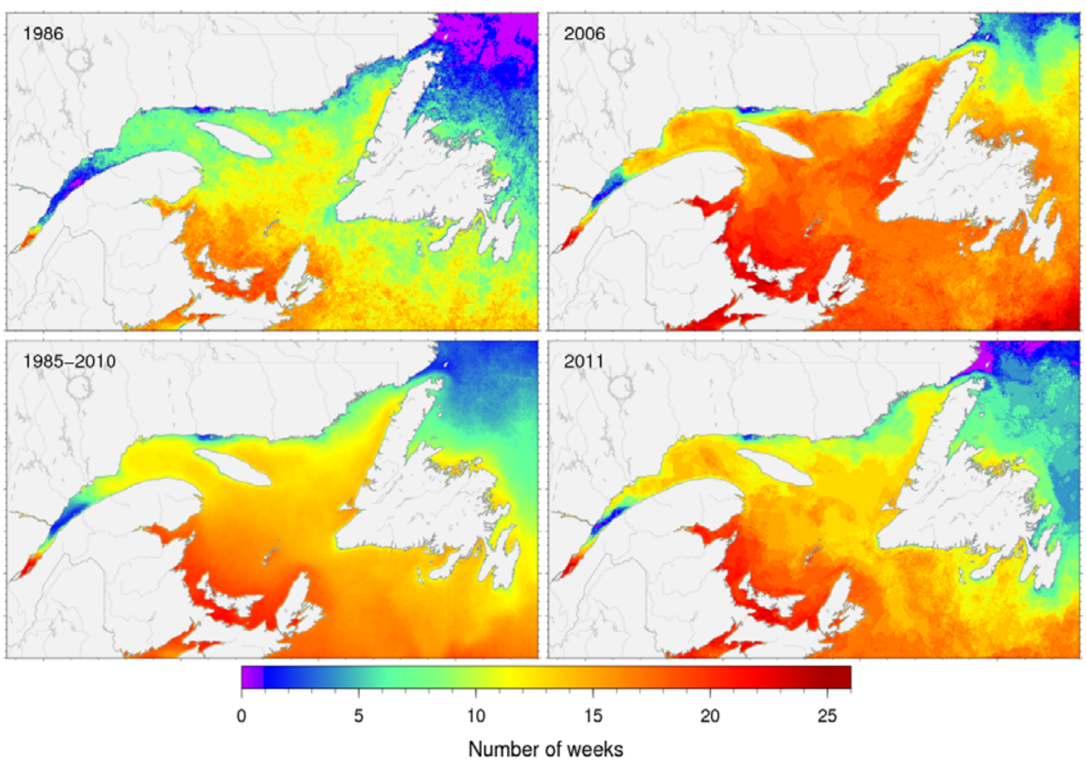

Fig. 19. Yearly number of weeks with mean weekly surface temperature >10°C. Years with the minimum (1986, top left) and maximum (2006, top right) number of weeks are shown along with the 1985–2010 climatological average (lower left) and the chart for 2011.

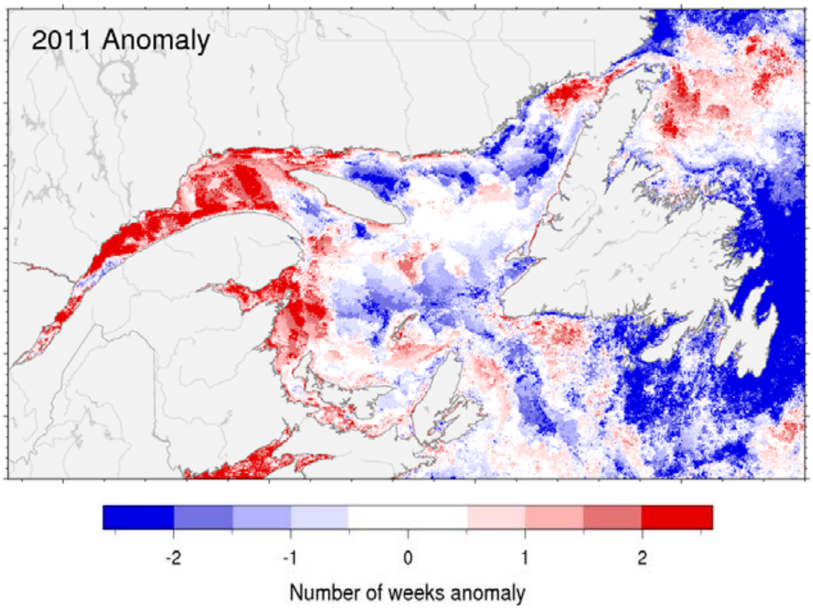

Fig. 20. Anomaly of the number of weeks in 2011 with mean weekly surface temperature >10°C using the 1985–2010 climatological average from Fig. 19.

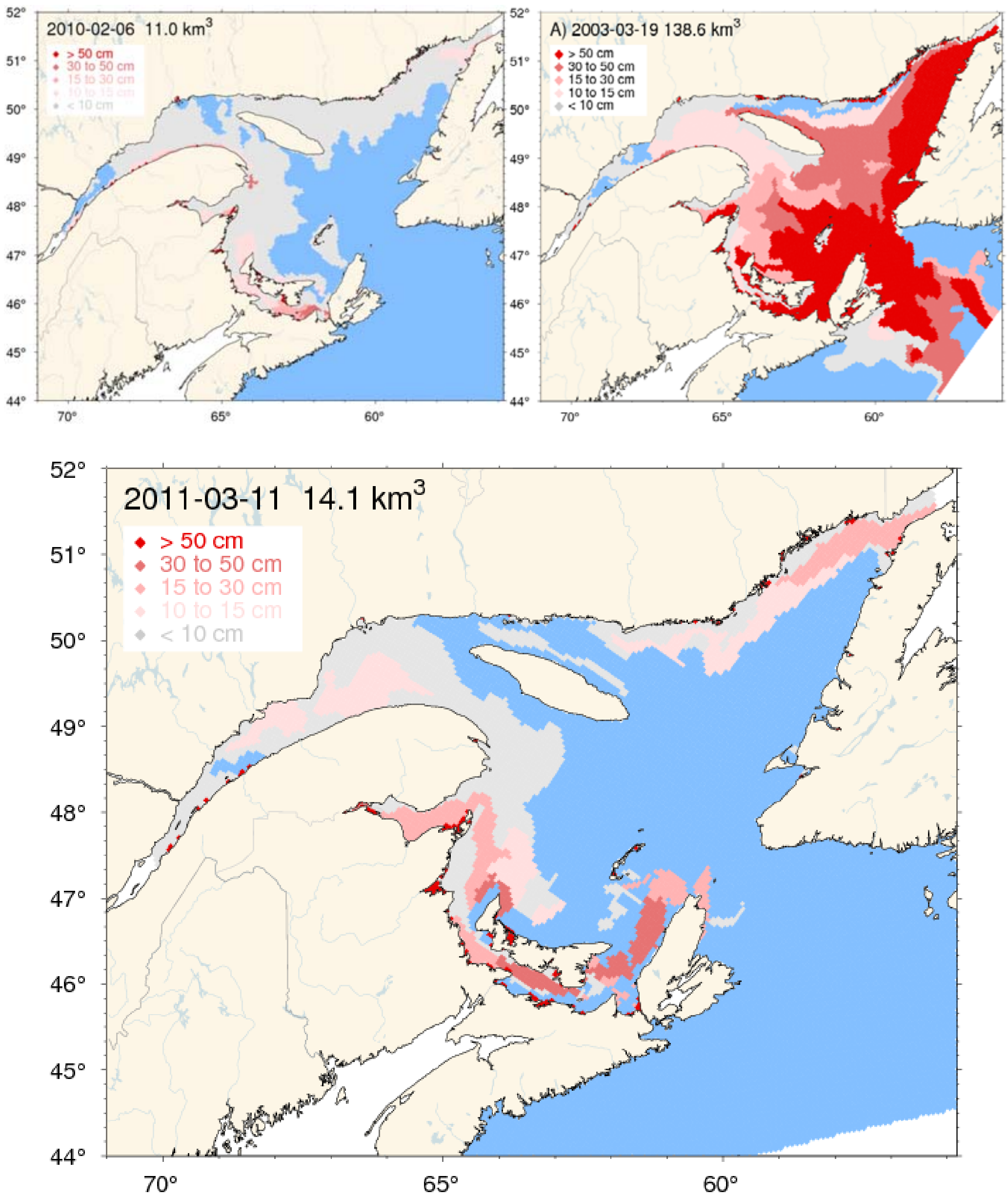

Fig. 21. Ice thickness map for 2011 for the day of the year with the maximum annual volume (lower panel) and similarly for 2010 and 2003, the years with the smallest and largest annual ice volumes, respectively.

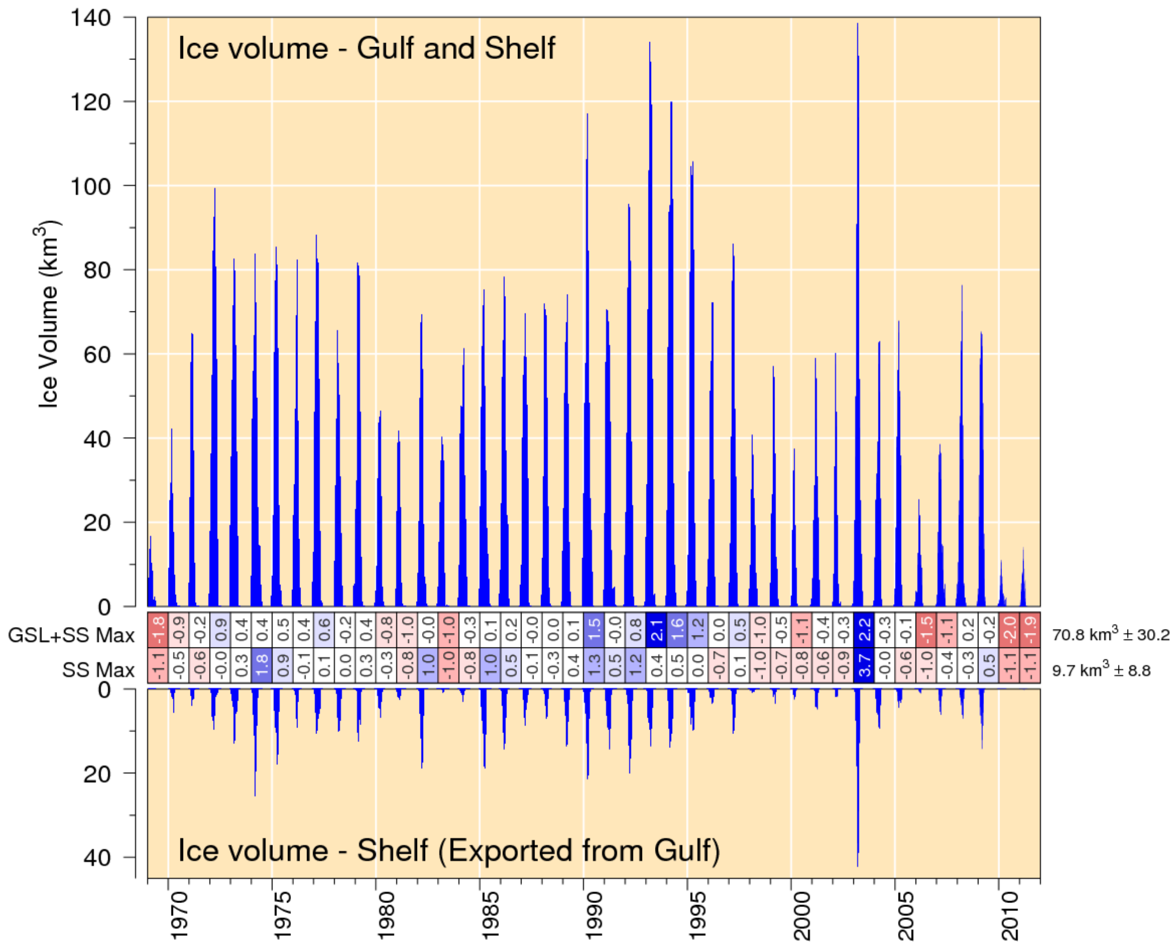

Fig. 22. Estimated ice volume in the Gulf of St. Lawrence and on the Scotian Shelf seaward of Cabot Strait (upper panel) and on the Scotian Shelf only (lower panel). Scorecards show numbered normalized anomalies for the combined Gulf and Shelf and Shelf-only annual maximum volumes. The mean and standard deviation are indicated on the right side using the 1981–2010 climatology.

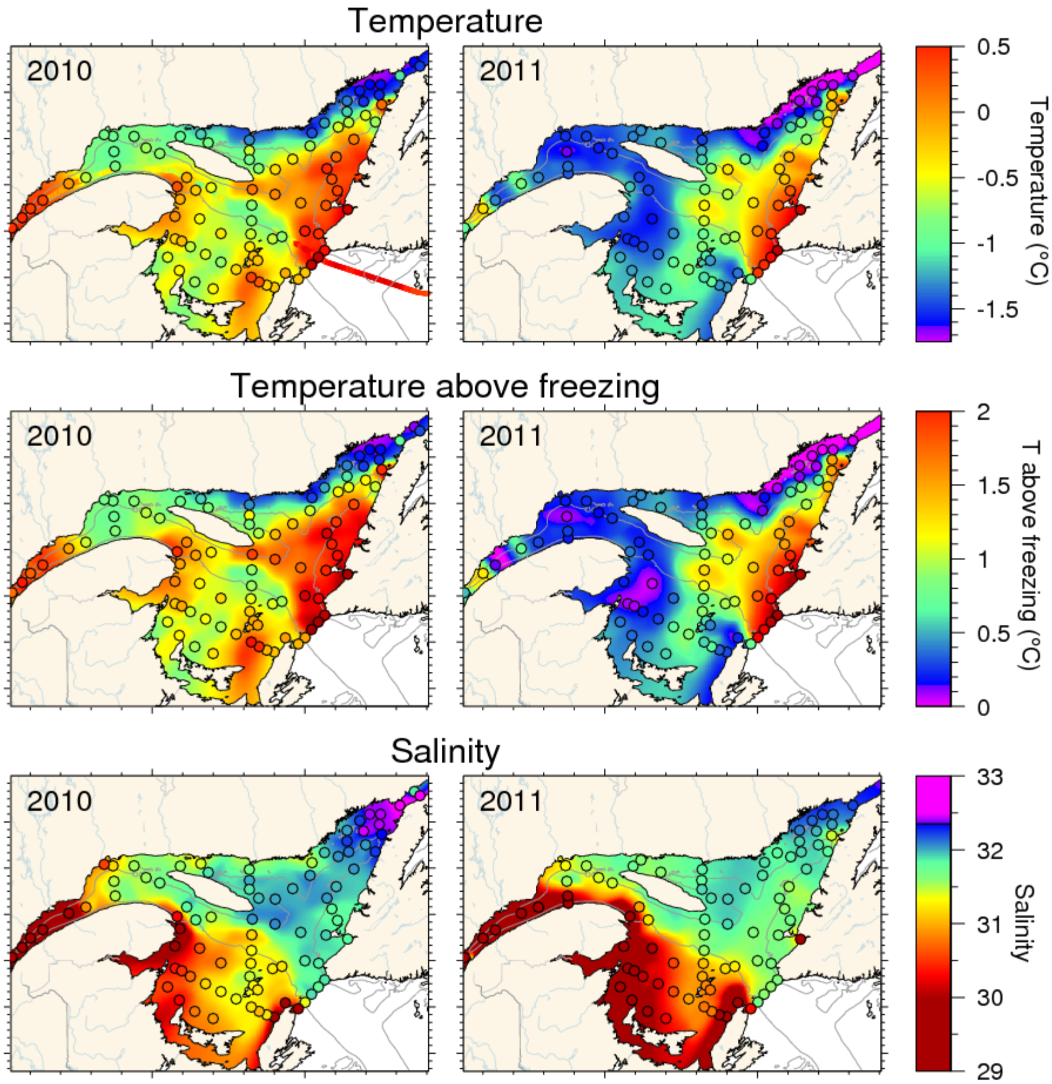

Fig. 23. Winter surface layer characteristics from the March 2010 and 2011 helicopter surveys: surface water temperature (upper panel), temperature difference between surface water temperature and the freezing point (middle panel), and salinity (lower panel). The temperature measurements from shipboard thermosalinographs taken during the 2010 survey are also shown in the upper panel. 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.

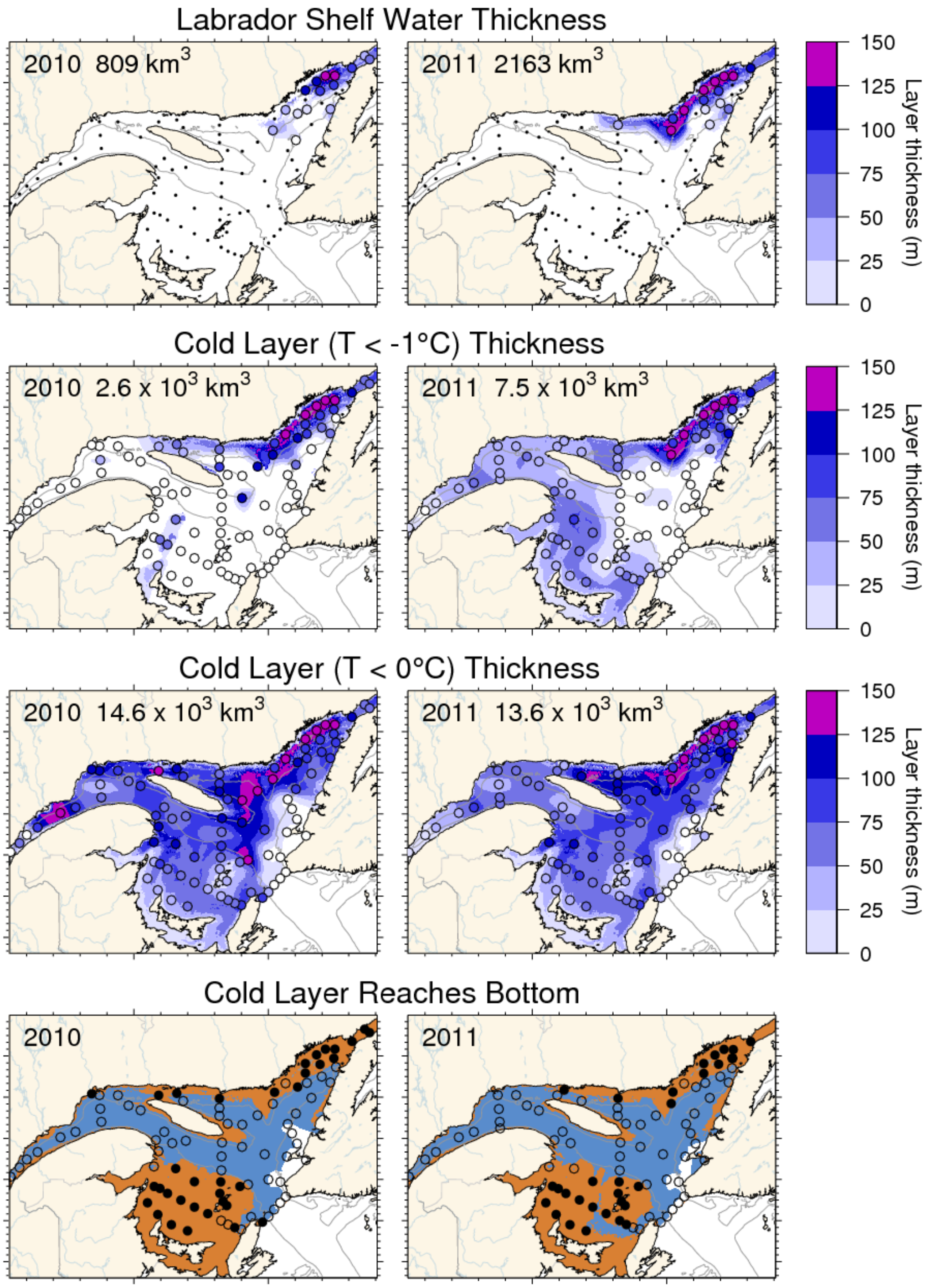

Fig. 24. Winter surface layer characteristics from the March 2010 and 2011 helicopter surveys. Estimates of the thickness of the Labrador Shelf water intrusion (upper panels), cold layer (T<-1°C, T<0°C) thickness (middle panels), and maps indicating where the cold layer (T<0°C) reaches the bottom (in brown; lower panels). Station symbols are coloured according to the observed values as in Fig. 23. For the lower panels, the stations where the cold layer reached the bottom are indicated with filled circles while open circles represent stations where the layer did not reach the bottom. Integrated volumes are indicated for the first six panels.

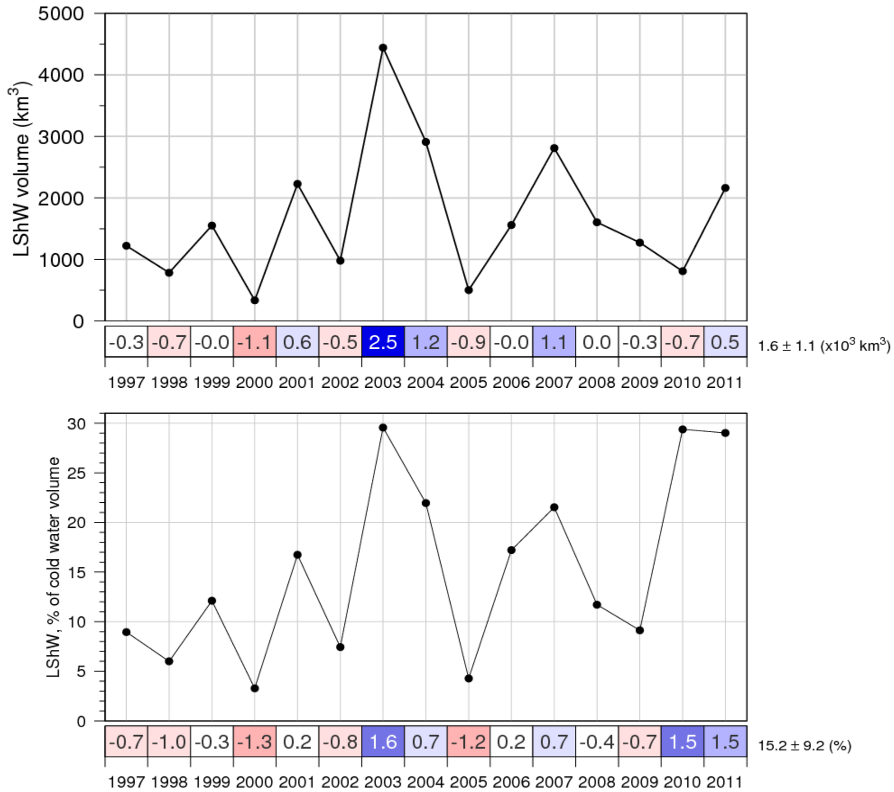

Fig. 25. Estimated volume of cold and saline Labrador Shelf water that flowed into the Gulf over the winter through the Strait of Belle Isle. The bottom panel shows the volume as a percentage of total cold-water volume (<-1ºC). The numbers in the boxes are normalized anomalies.

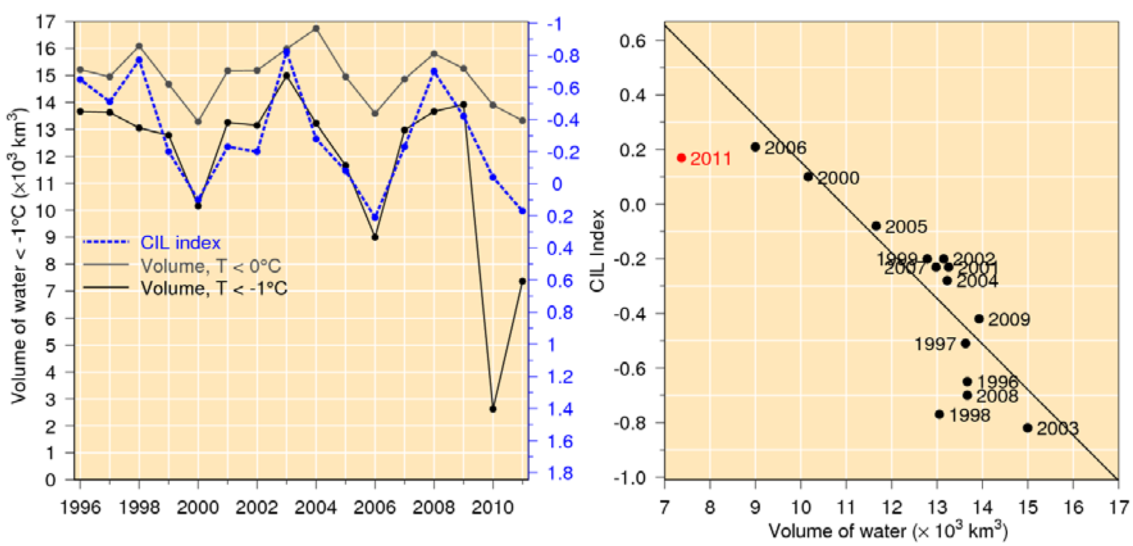

Fig. 26. Left panel: winter surface cold (T<-1°C and T<0°C) layer volume time series (black and grey lines) and summer CIL index (blue dashed line). Right panel: 1997-2009 relation between summer CIL index and winter cold-water volume with T<-1°C excluding the Estuary (regression for 1996-2009 data pairs, excluding 1998; see Galbraith 2006). Note that the CIL scale in the left panel is reversed.

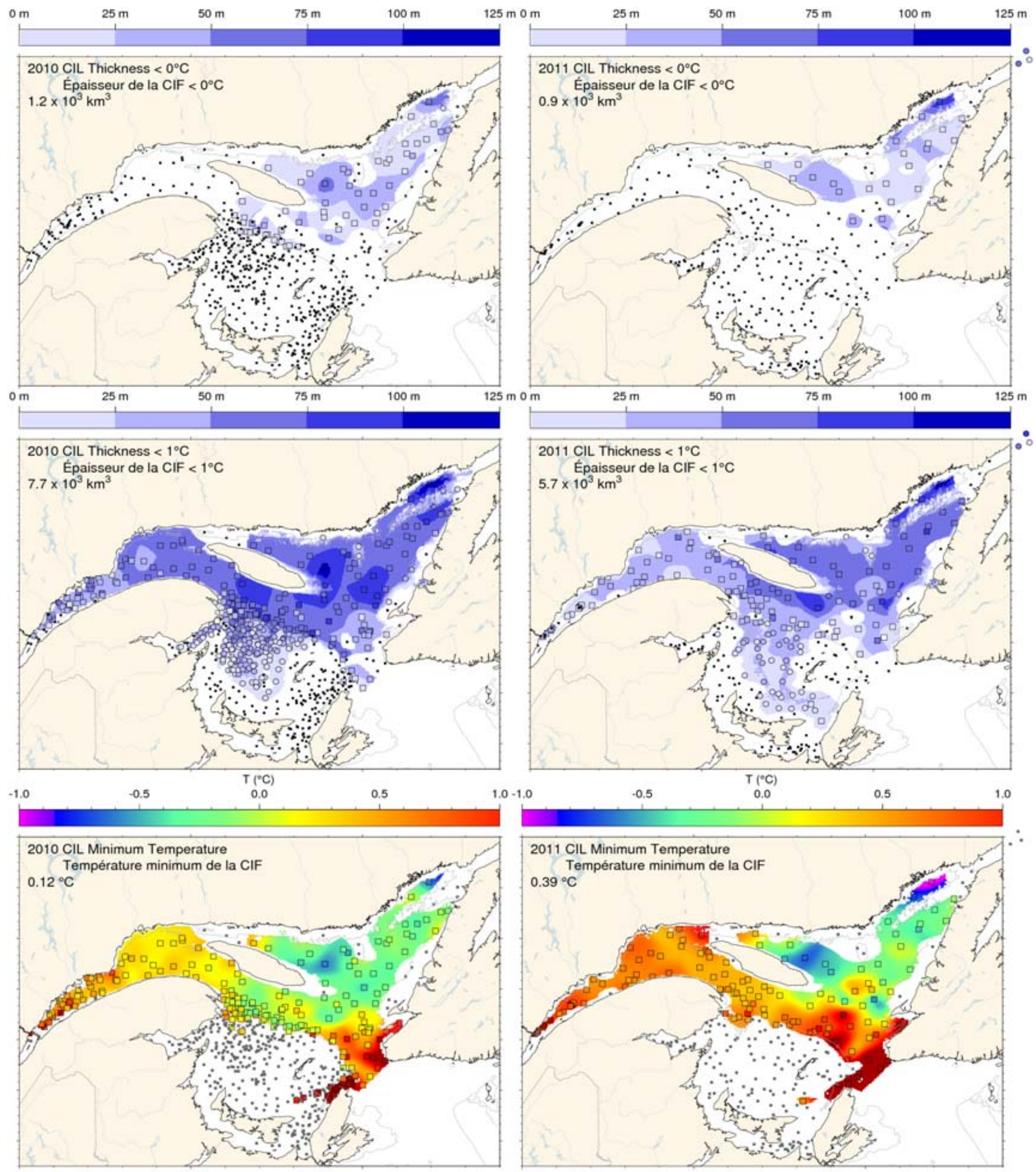

Fig. 27. Cold intermediate layer thickness (T<0ºC, top panels; T<1ºC, middle panels) and minimum temperature (bottom panels) in August and September 2010 (left) and 2011 (right). The colour-coding is according to the temperature anomaly relative to the climatology of each station for each month. Numbers in the upper and middle panels are integrated CIL volumes and in the lower panels are monthly average temperatures.

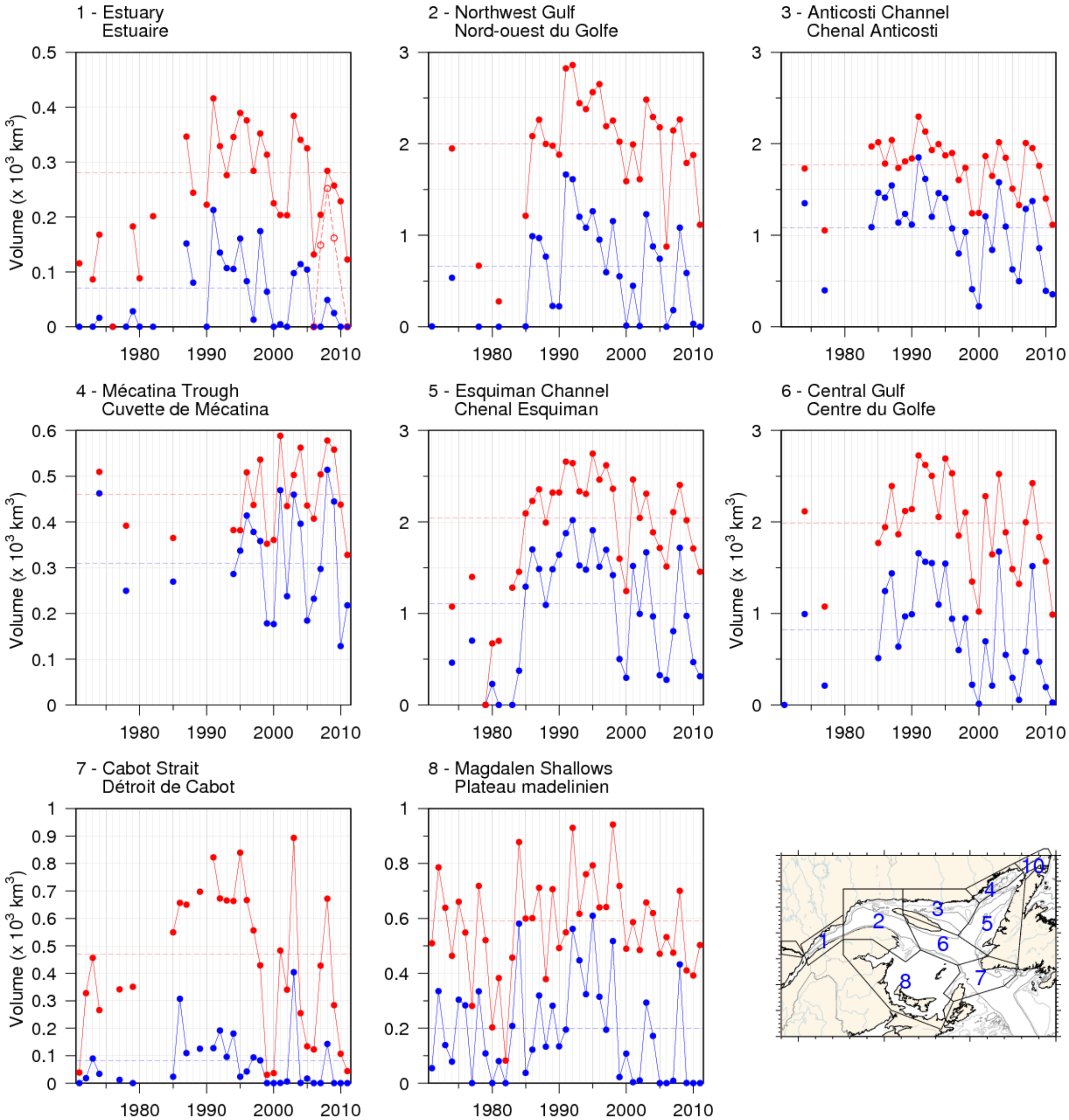

Fig. 28. Volume of the CIL colder than 0ºC (blue) and colder than 1ºC (red) in August and September (primarily region 8 in September). The volume of the CIL colder than 1ºC in November 2006 to 2009 and 2011 is also shown for the St. Lawrence Estuary (dashed line).

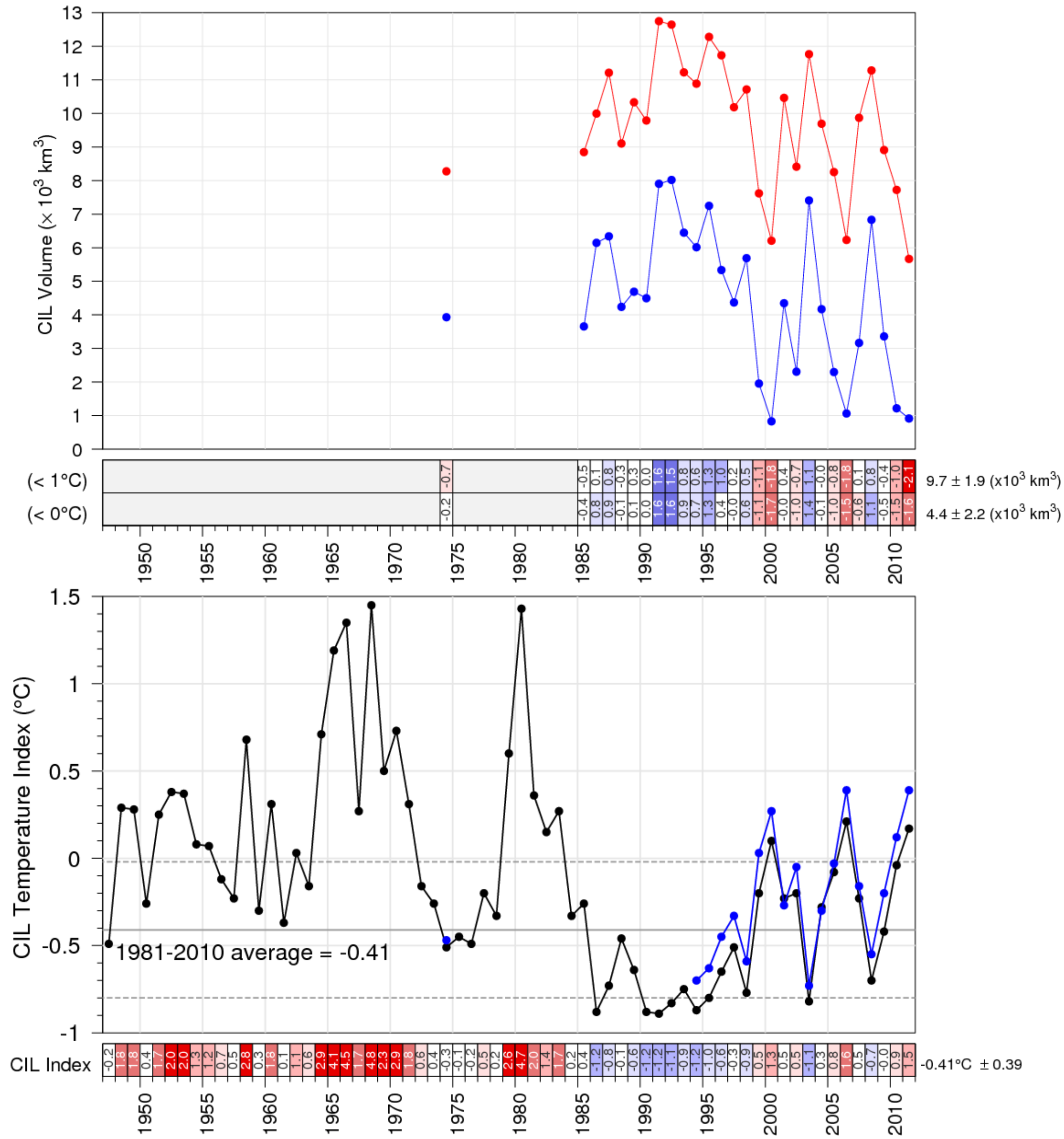

Fig. 29. CIL volume (top panel) delimited by the over- and underlying 0ºC (in blue) and 1ºC (in red) isotherms, and minimum temperature index (bottom panel) in the Gulf of St. Lawrence. The volumes are integrals of each of the annual interpolated thickness grids such as those shown in the top panels of Fig. 27. In the lower panel, the black line is the updated Gilbert and 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. 27. The numbers in the boxes are normalized anomalies.

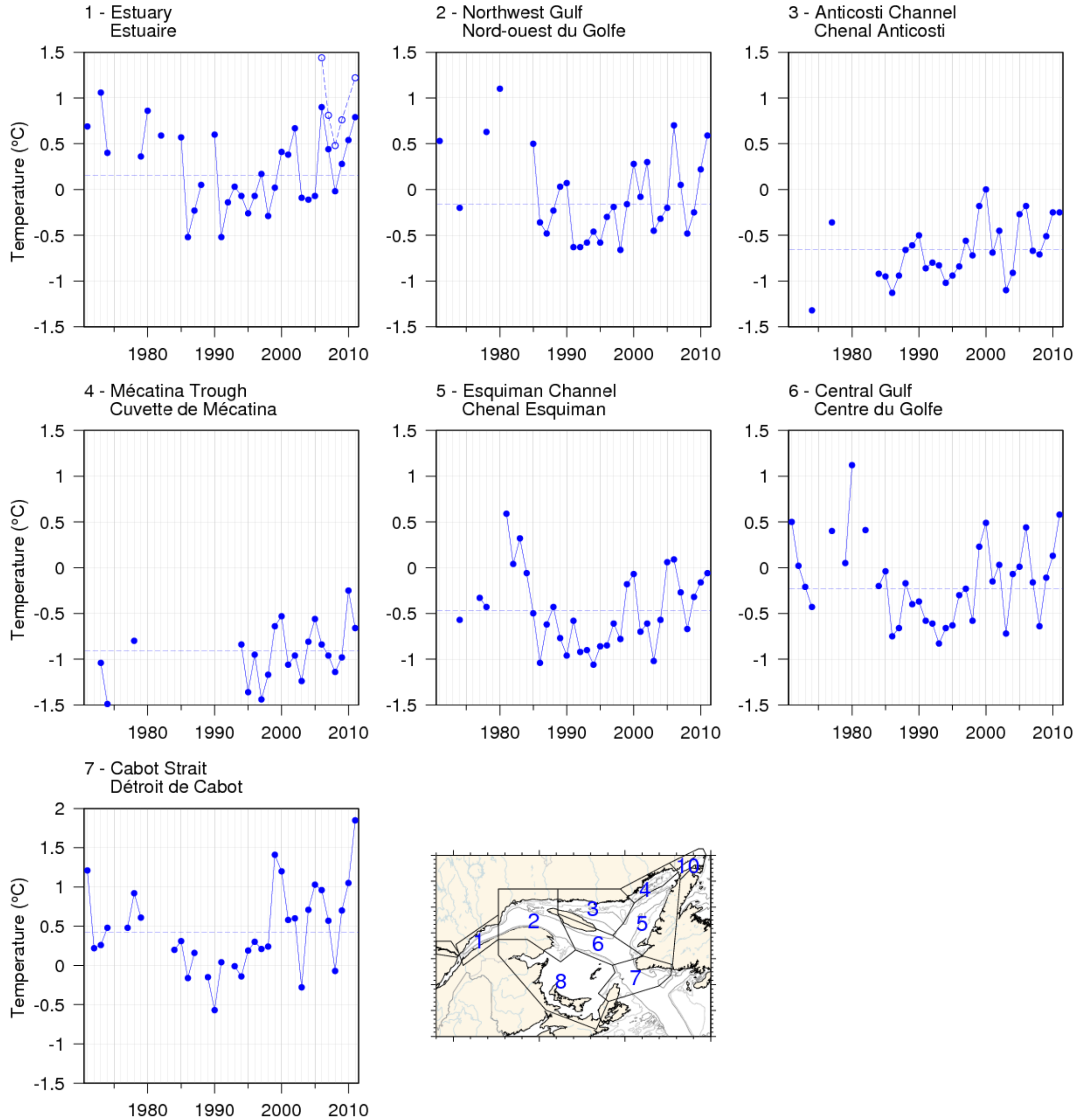

Fig. 30. Temperature minimum of the CIL spatially averaged for the seven areas where the CIL minimum temperature can be clearly identified (i.e., deeper than 100 m). The volume of the CIL colder than 1ºC in November 2006 to 2009 and 2011 is also shown for the St. Lawrence estuary (dashed line).

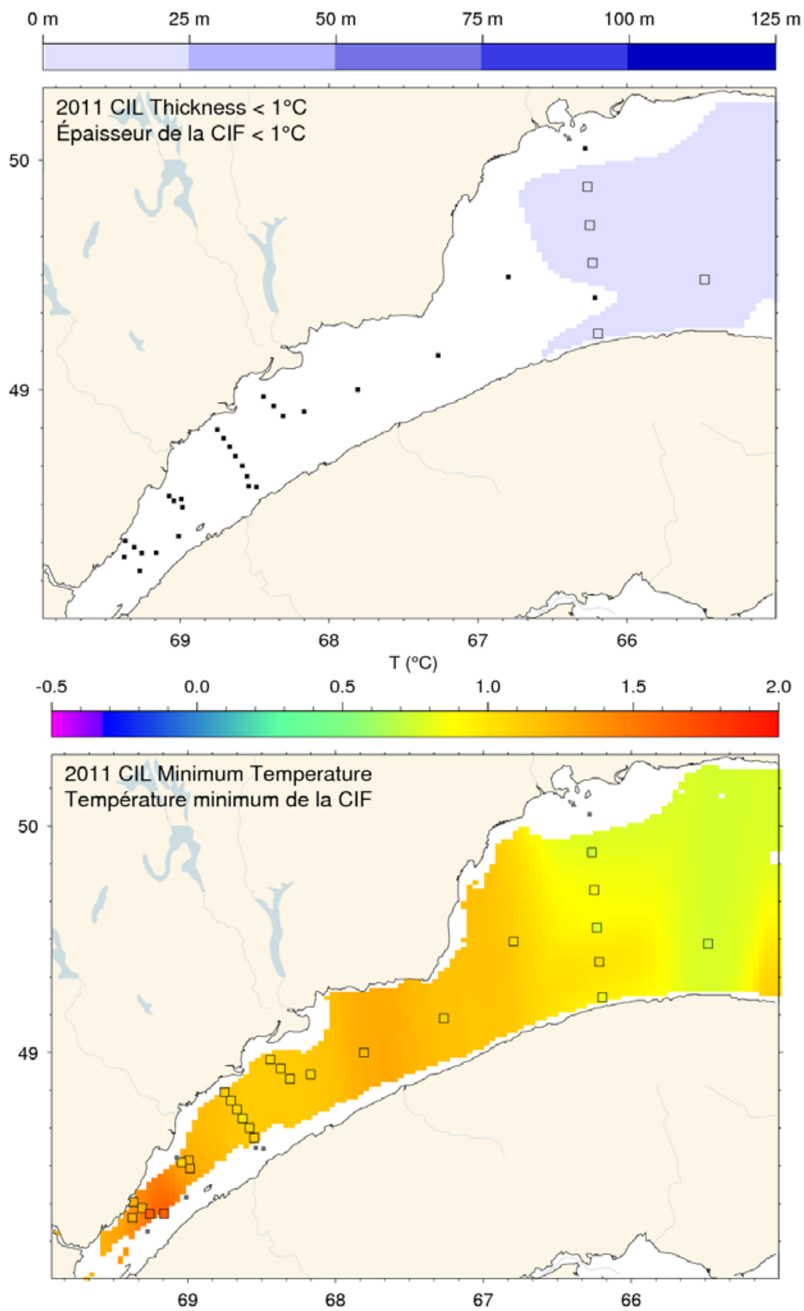

Fig. 31. Cold intermediate layer thickness (T<1ºC, top panel) and minimum temperature (bottom panel) in November 2011 in the St. Lawrence Estuary.

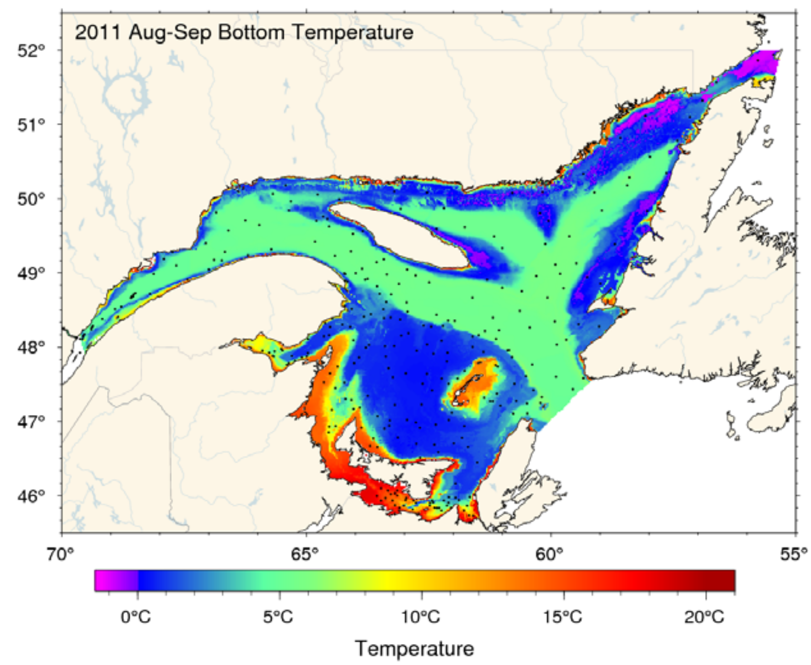

Fig. 32. Near-bottom temperatures during August and September 2011.

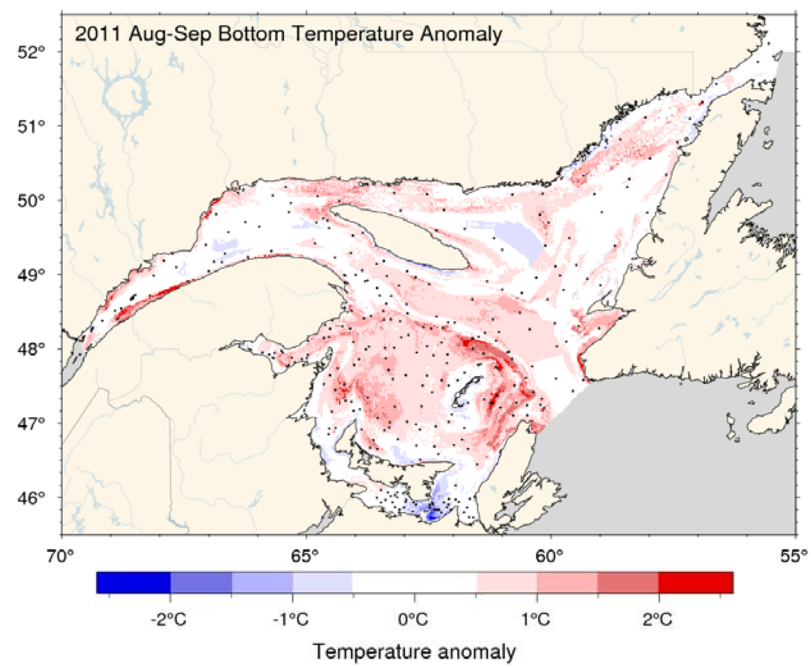

Fig. 33. Near-bottom temperature anomalies based on the 1985–2000 climatology.

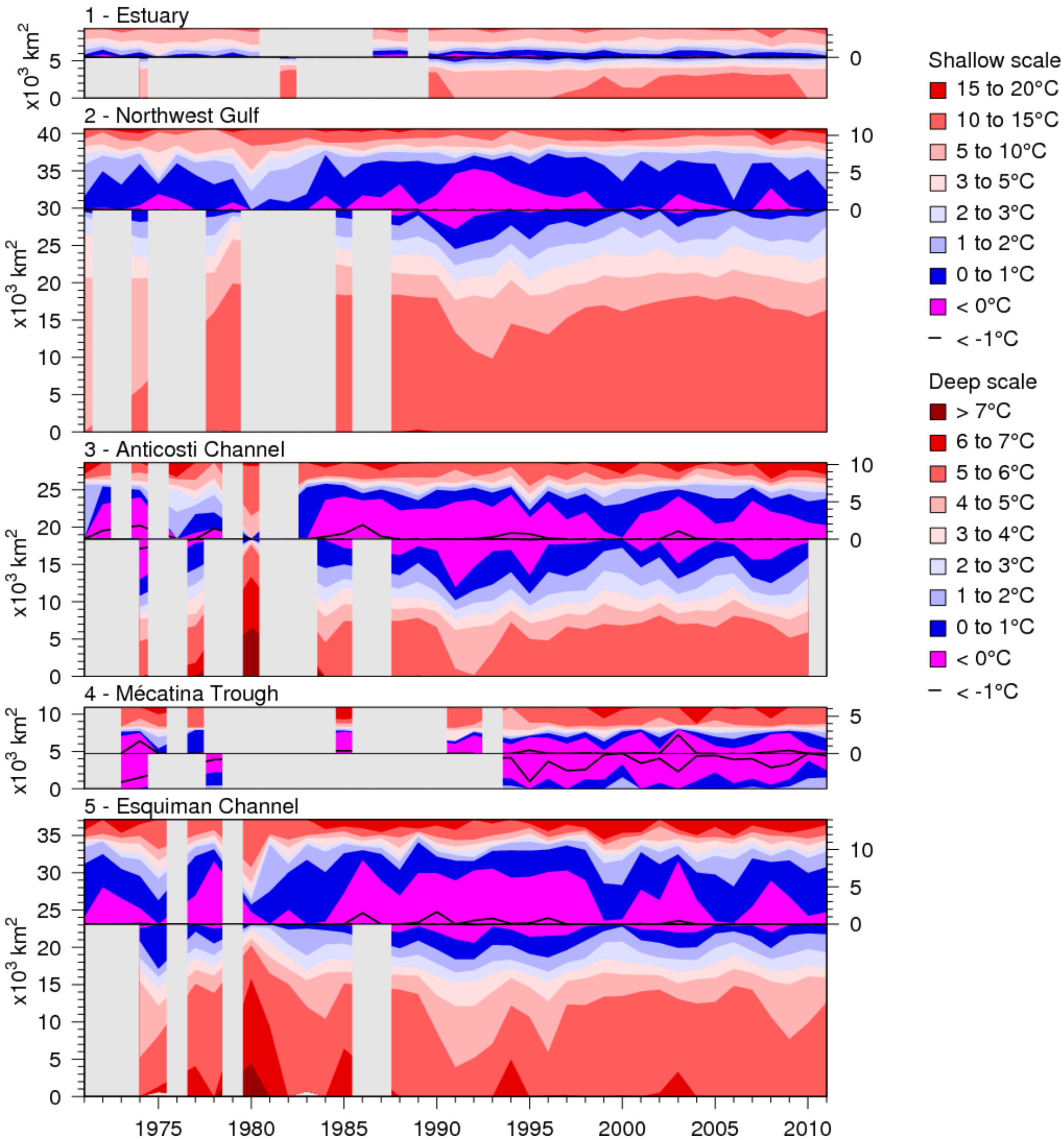

Fig. 34. Time series of the bottom areas covered by different temperature bins in August and September for regions 1 to 5. The panels are separated by the black horizontal line into shallow (<100 m) and deep (>100 m) areas to distinguish between warmer waters above and below the CIL. The shallow areas are shown on top using the area scale on the right-hand side and have warmer waters shown starting from the top end. The deep areas are shown below the horizontal line and have warmer waters starting at the bottom end. The CIL areas above and below 100 m meet near the horizontal line.

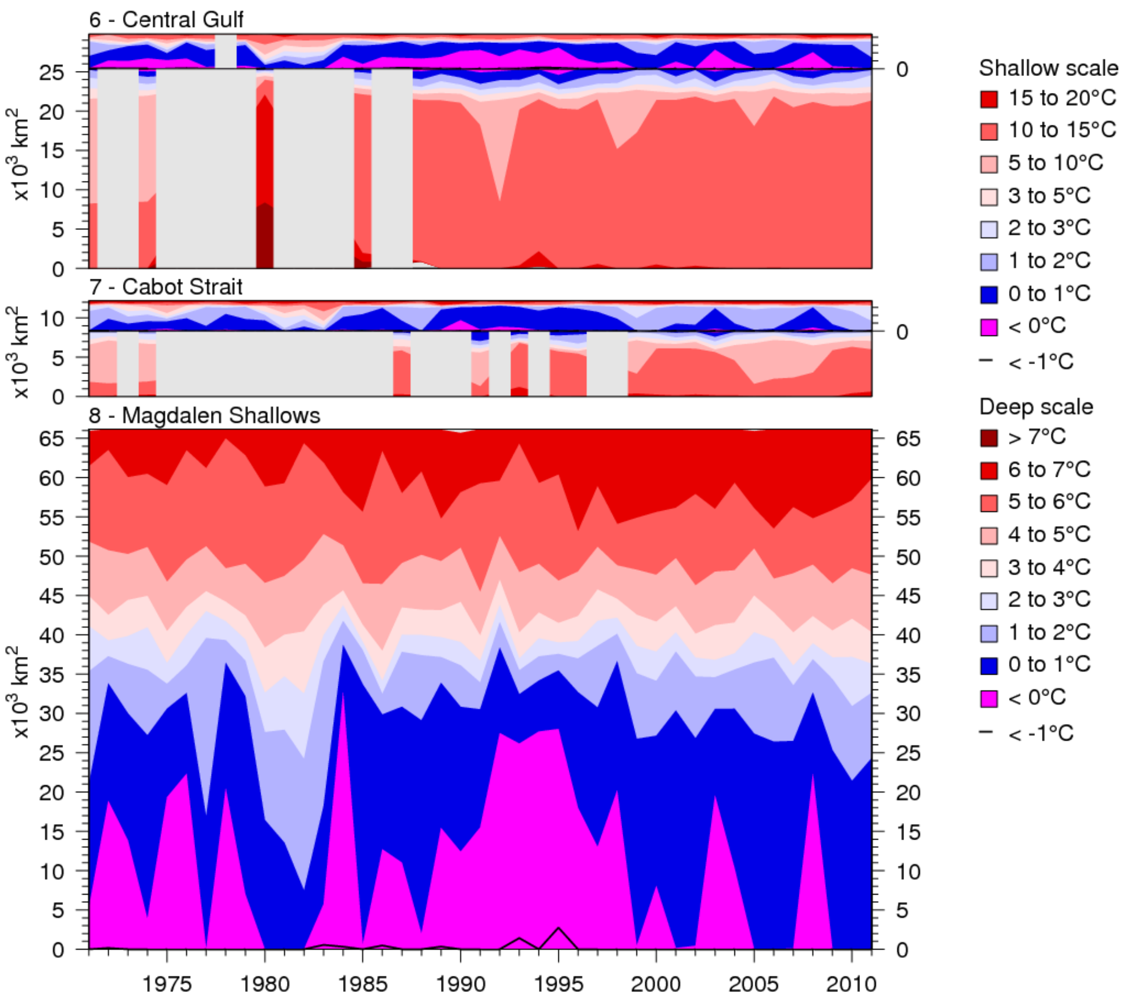

Fig. 35. Time series of the bottom areas covered by different temperature bins in August and September for regions 6 to 8. The panels are separated into shallow (<100 m) and deep (>100 m) areas to distinguish between warmer waters above and below the CIL, except for region 8, which does not have deep waters. See Fig. 34 caption.

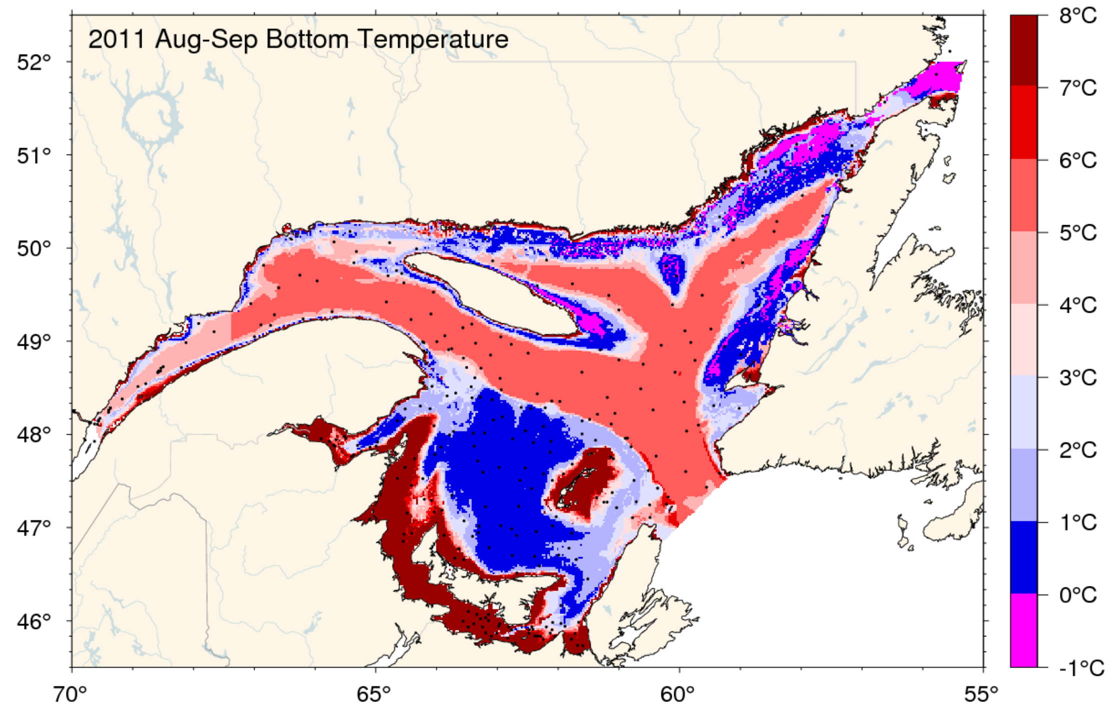

Fig. 36 Near-bottom temperatures during August and September 2011. This figure is the same as Fig. 32 but uses the deepwater scale of Fig. 34 and Fig. 35.

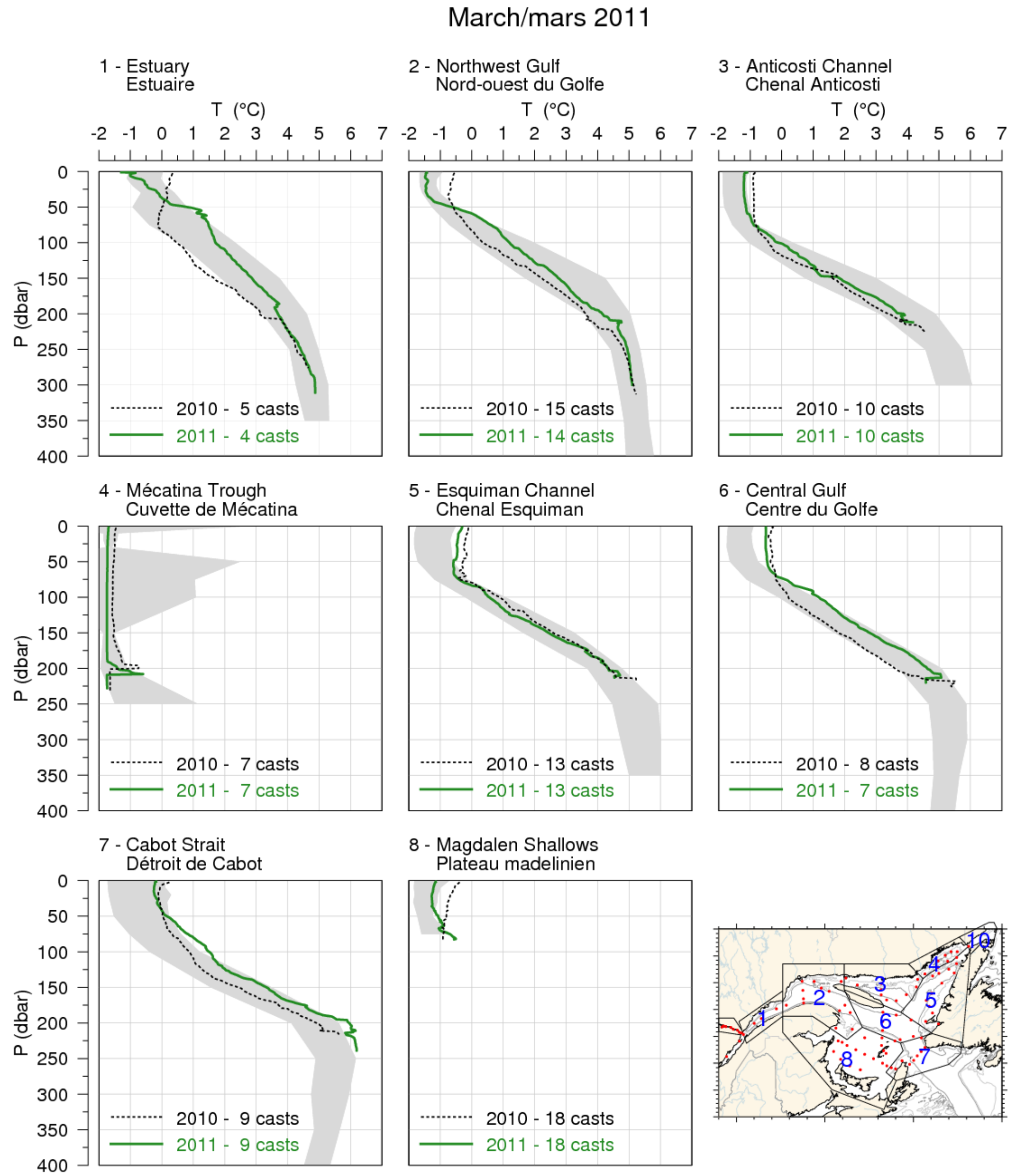

Fig. 37. Mean temperature profiles observed in each region of the Gulf during the March helicopter survey. The shaded area represents the 1981–2010 (but mostly 1996–2010) climatological monthly mean ± 1 SD. Mean profiles for the 2010 survey are also shown for comparison.

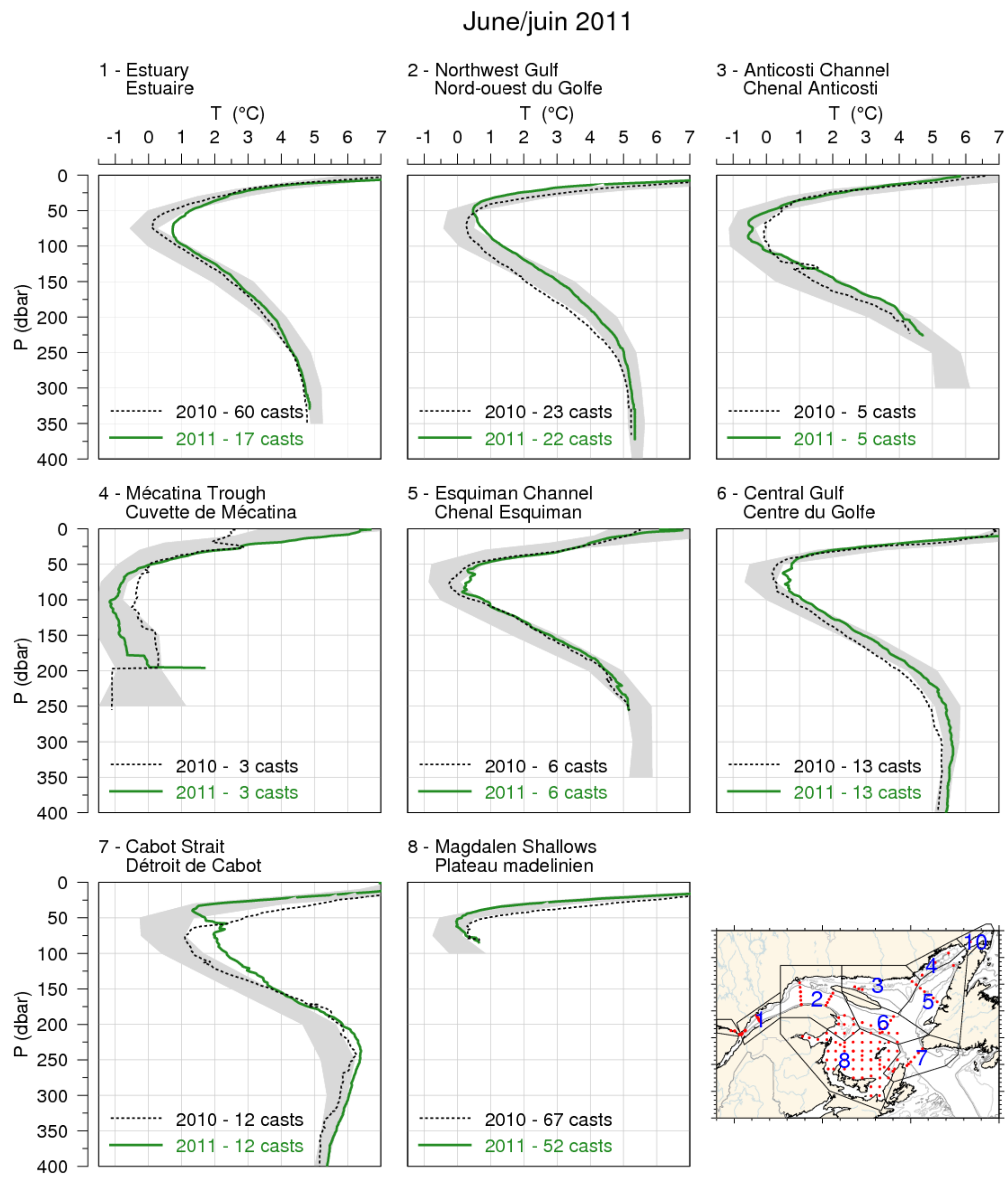

Fig. 38. Mean temperature profiles observed in each region of the Gulf during June. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD. Mean profiles for the 2010 survey are also shown for comparison.

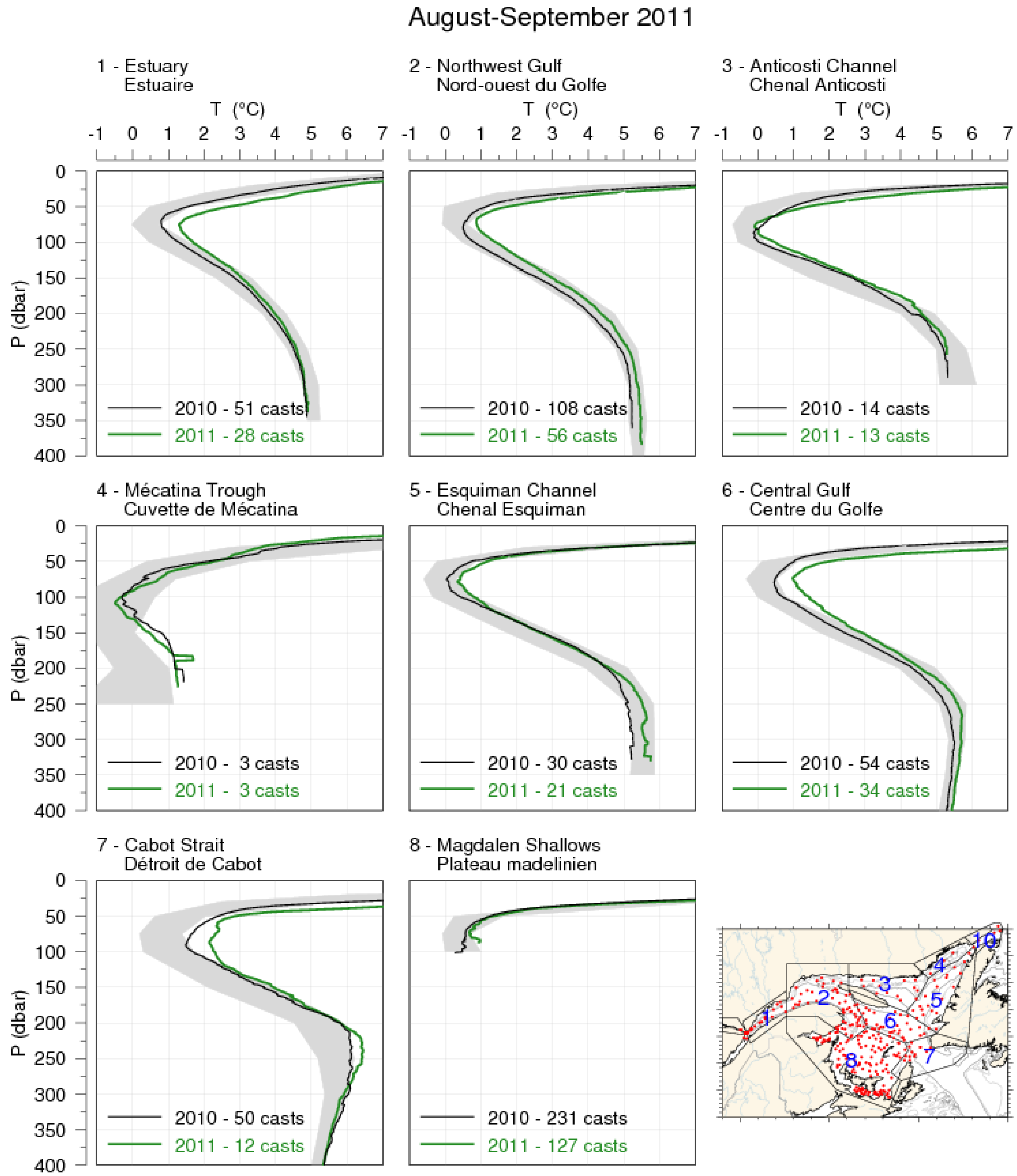

Fig. 39. Mean temperature profiles observed in each region of the Gulf during August and September. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD for August for regions 1 through 7 and for September for region 8. Mean profiles for the 2010 survey are also shown for comparison.

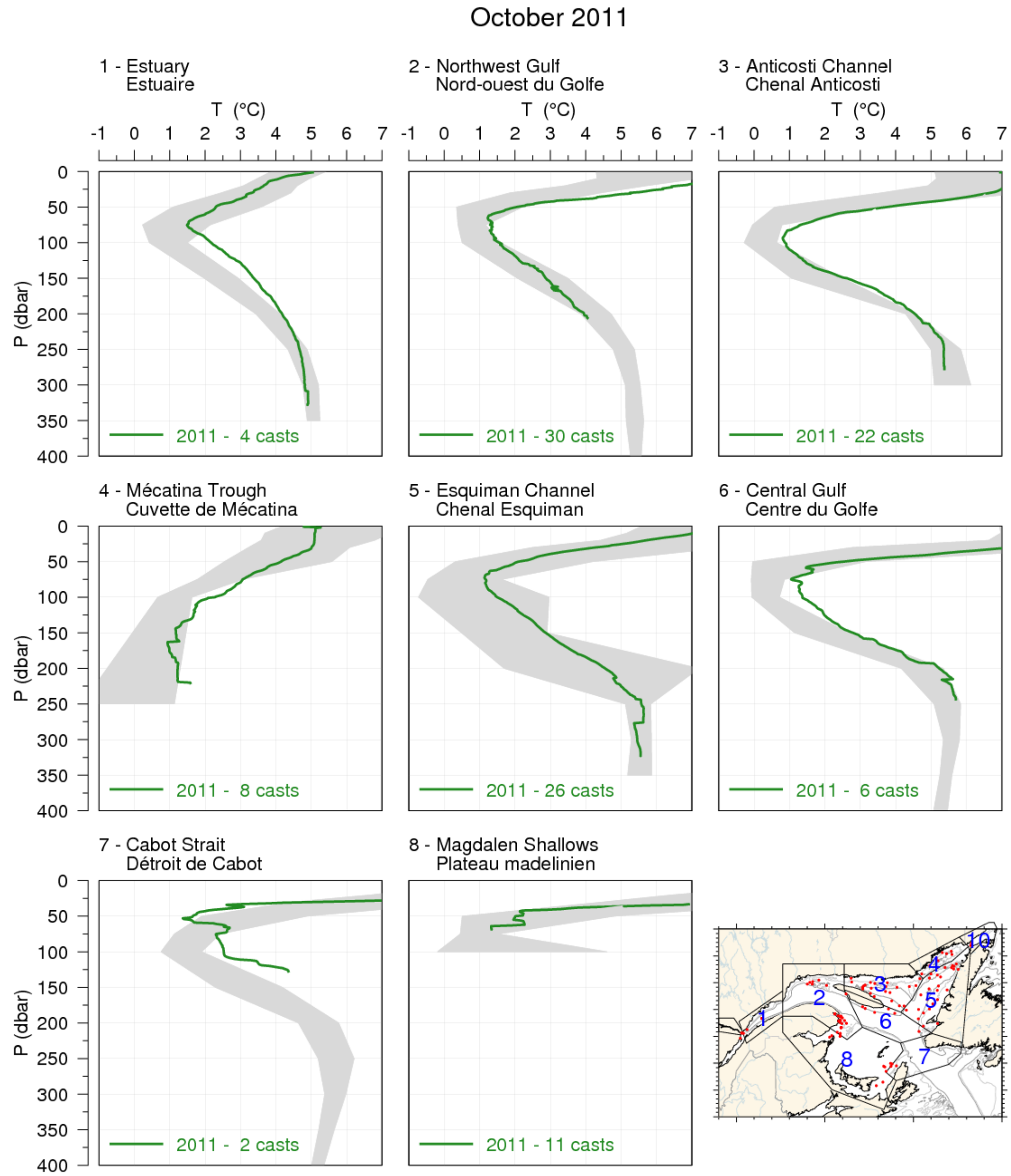

Fig. 40 Mean temperature profiles observed in each region of the Gulf during the October AZMP survey. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD. Mean profiles for the 2010 survey are also shown for comparison.

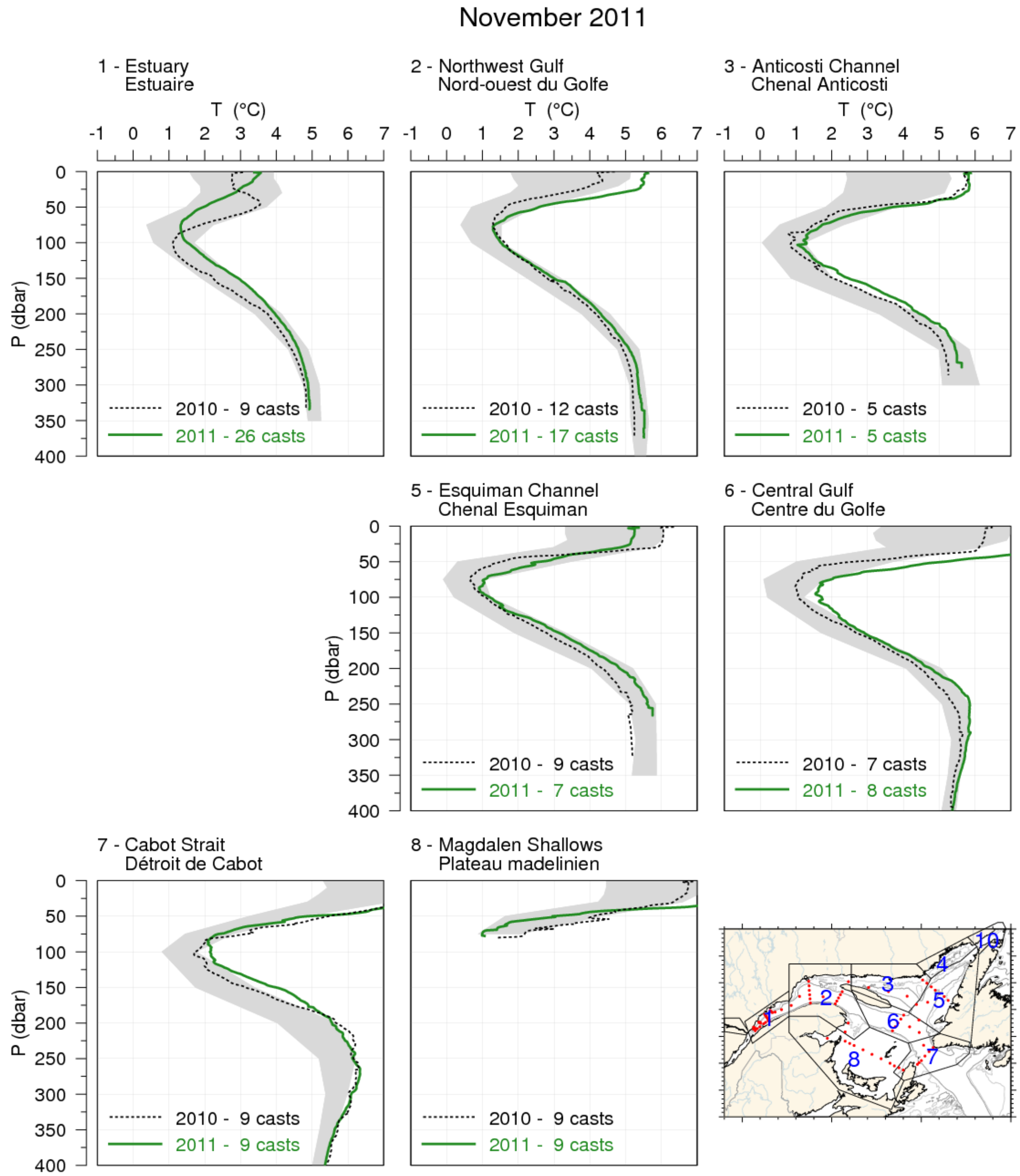

Fig. 41. Mean temperature profiles observed in each region of the Gulf during the November AZMP survey. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD. Mean profiles for the 2010 survey are also shown for comparison.

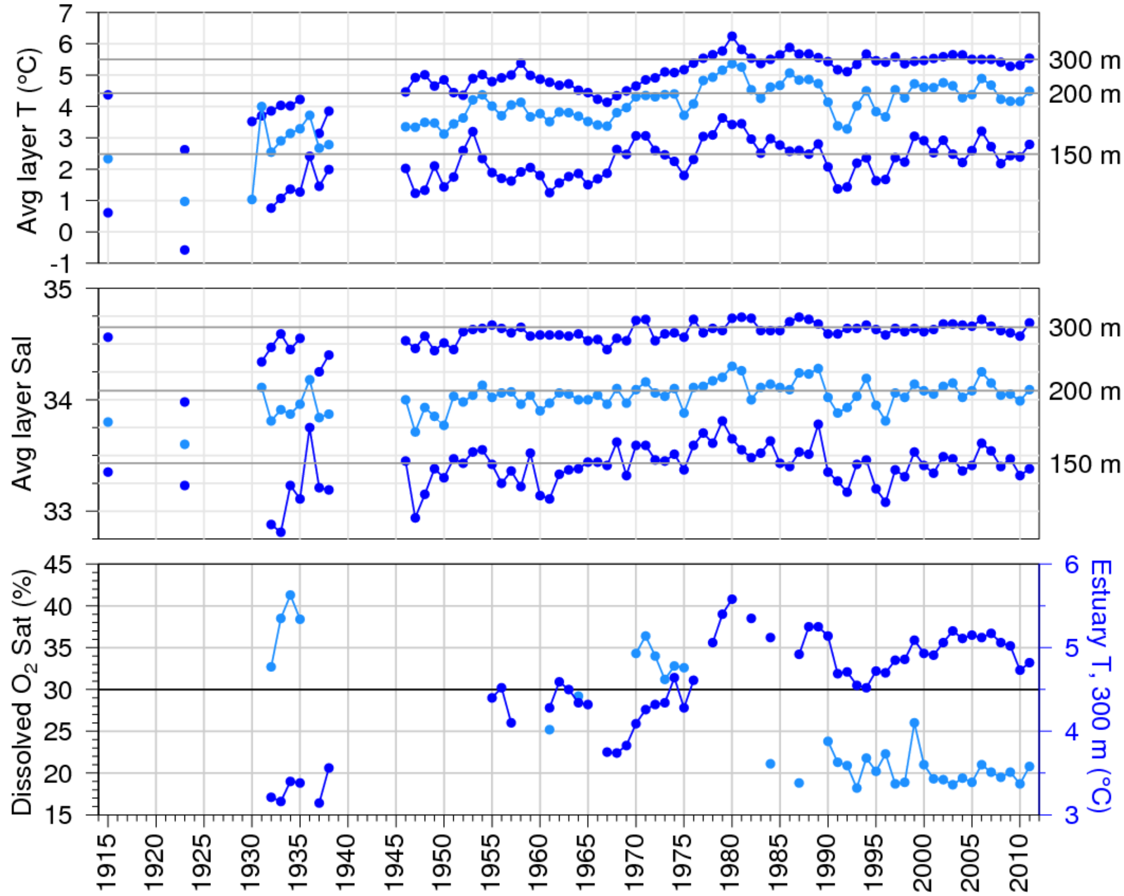

Fig. 42. Layer-averaged temperature and salinity time series for the Gulf of St. Lawrence and dissolved oxygen saturation between 295 m and the bottom in the deep central basin of the St. Lawrence Estuary. The temperature and salinity panels show the 150 m, 200 m, and 300 m annual averages and the horizontal lines are 1981–2010 means. The horizontal line in the oxygen panel at 30% saturation marks the threshold of hypoxic conditions. In addition to the oxygen percent saturation time series (light blue), the lower panel also shows temperature (dark blue) at 300 m in the Estuary.

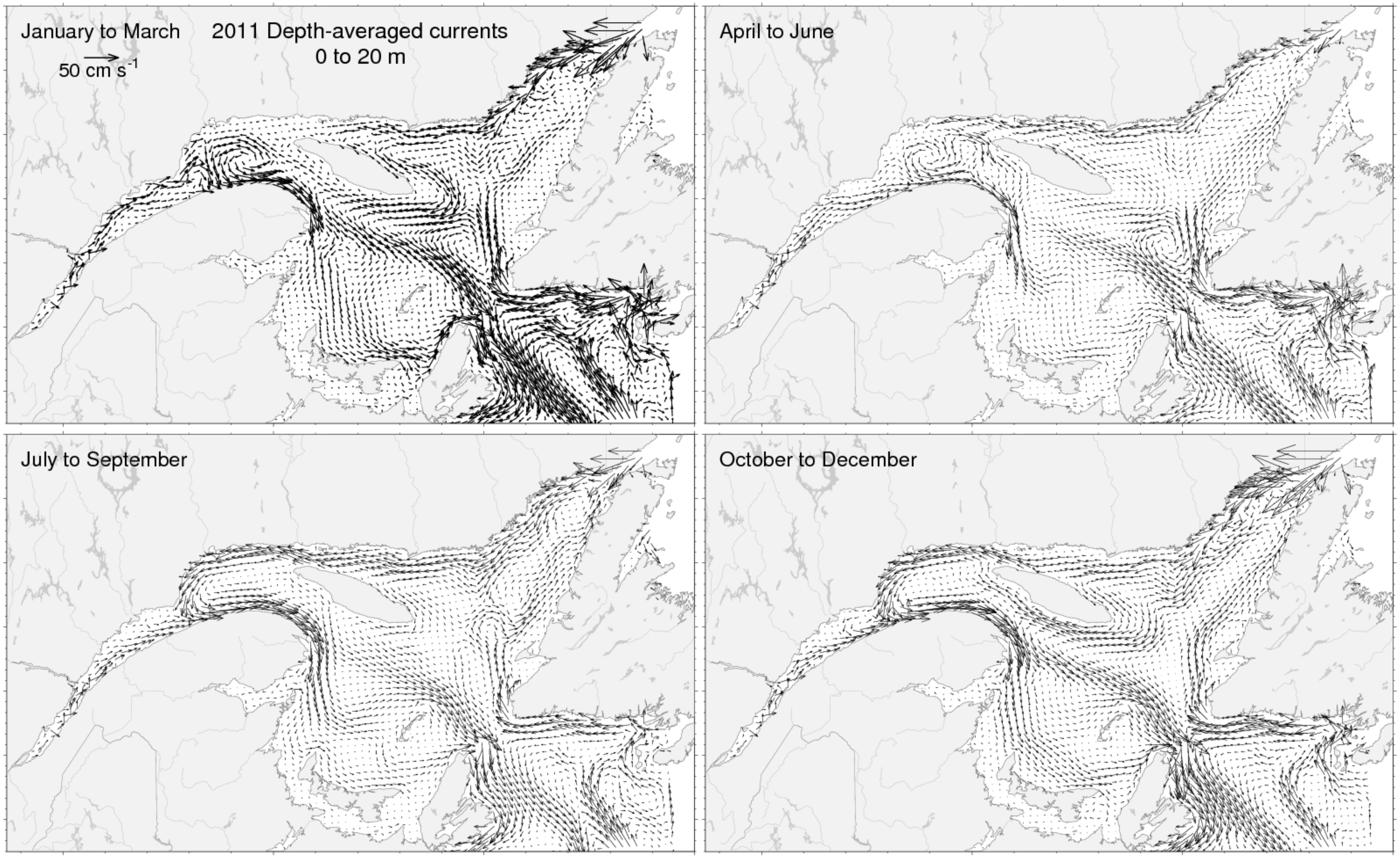

Fig. 43. Depth-averaged currents from 0 to 20 m for each three-month period of 2011.

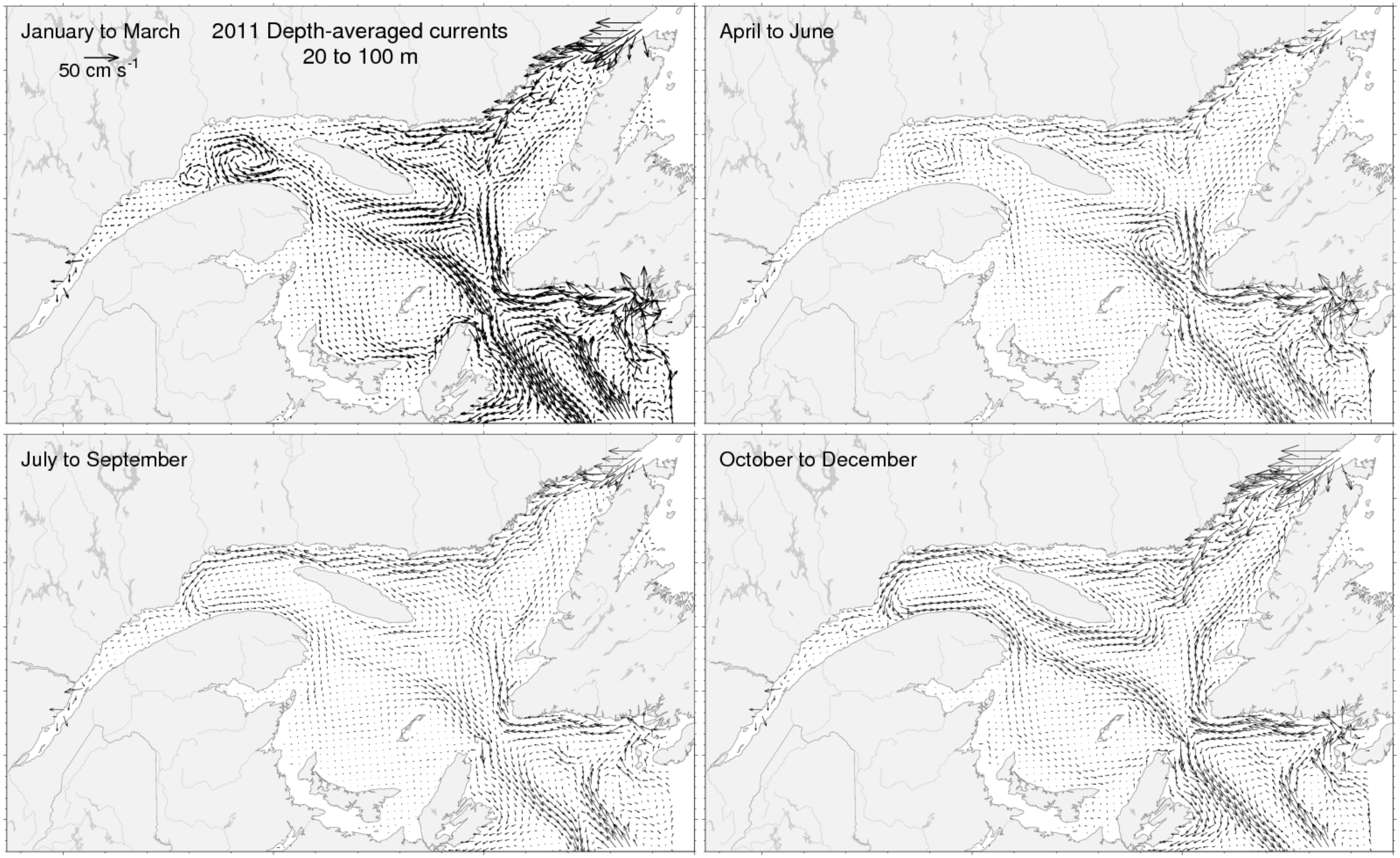

Fig. 44. Depth-averaged currents from 20 to 100 m for each three-month period of 2011.

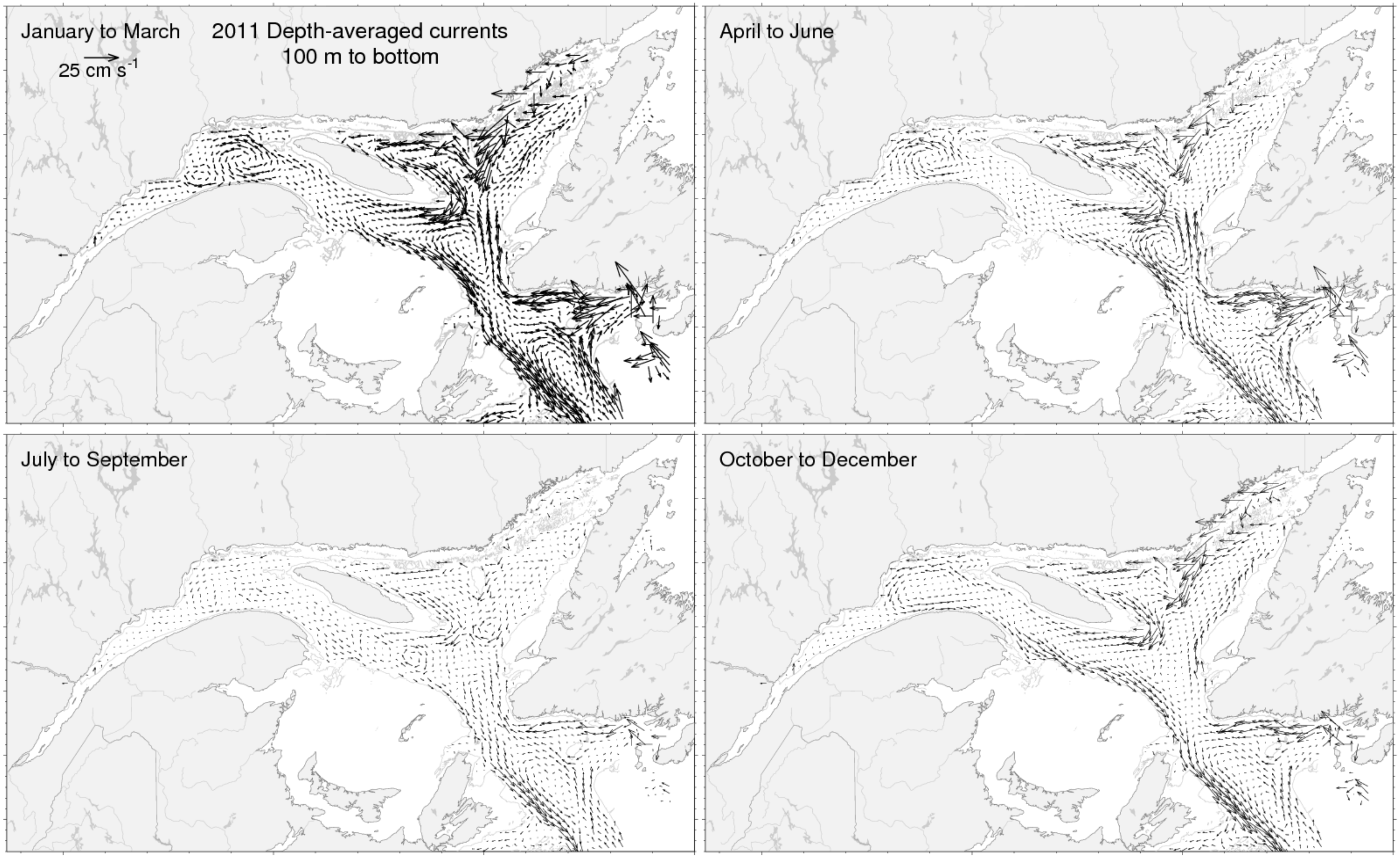

Fig. 45. Depth-averaged currents from 100 m to the bottom for each three-month period of 2011.

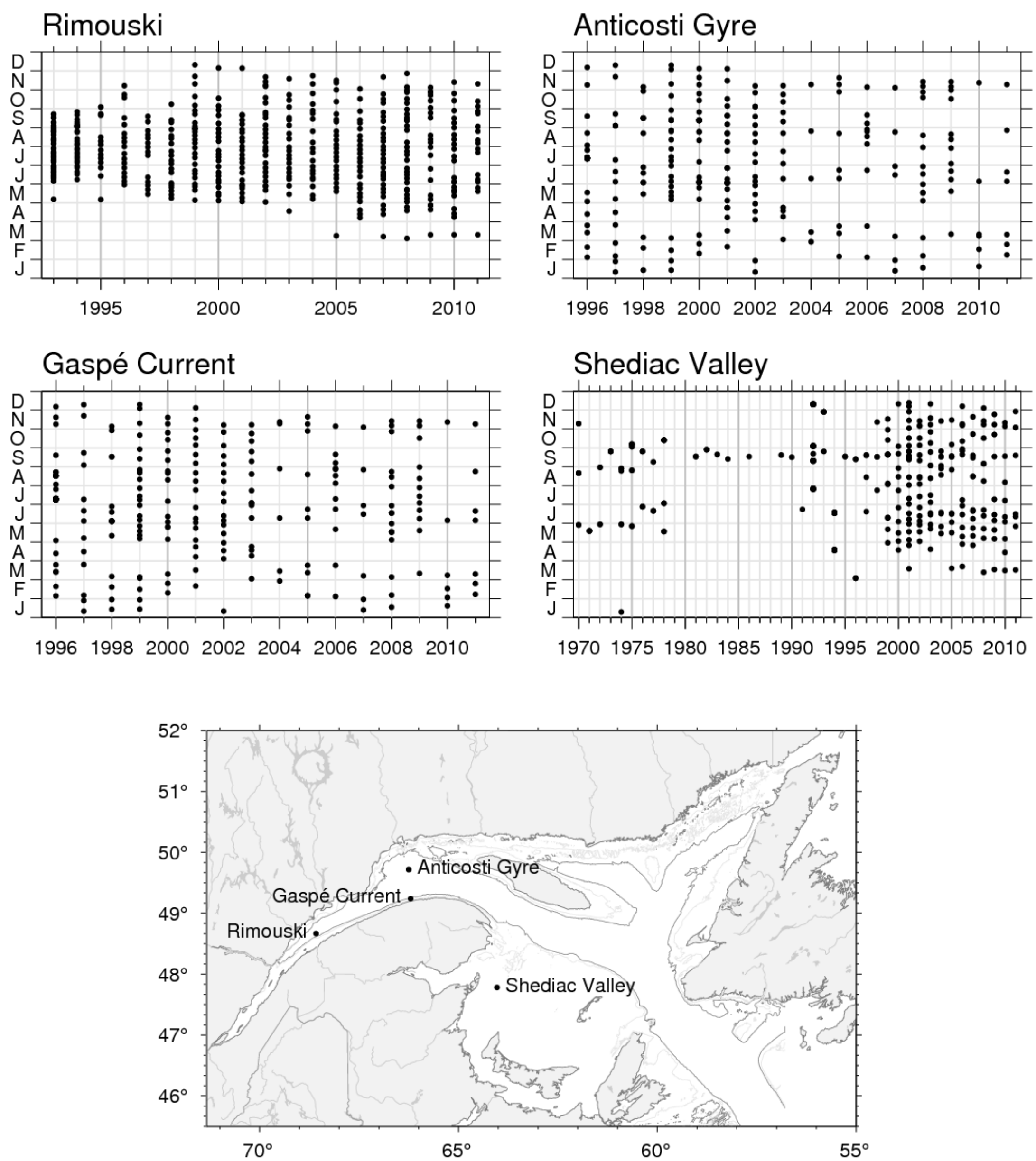

Fig. 46. Sampling frequency and positions of the AZMP stations (Rimouski, Anticosti Gyre, Gaspé Current, and Shediac Valley).

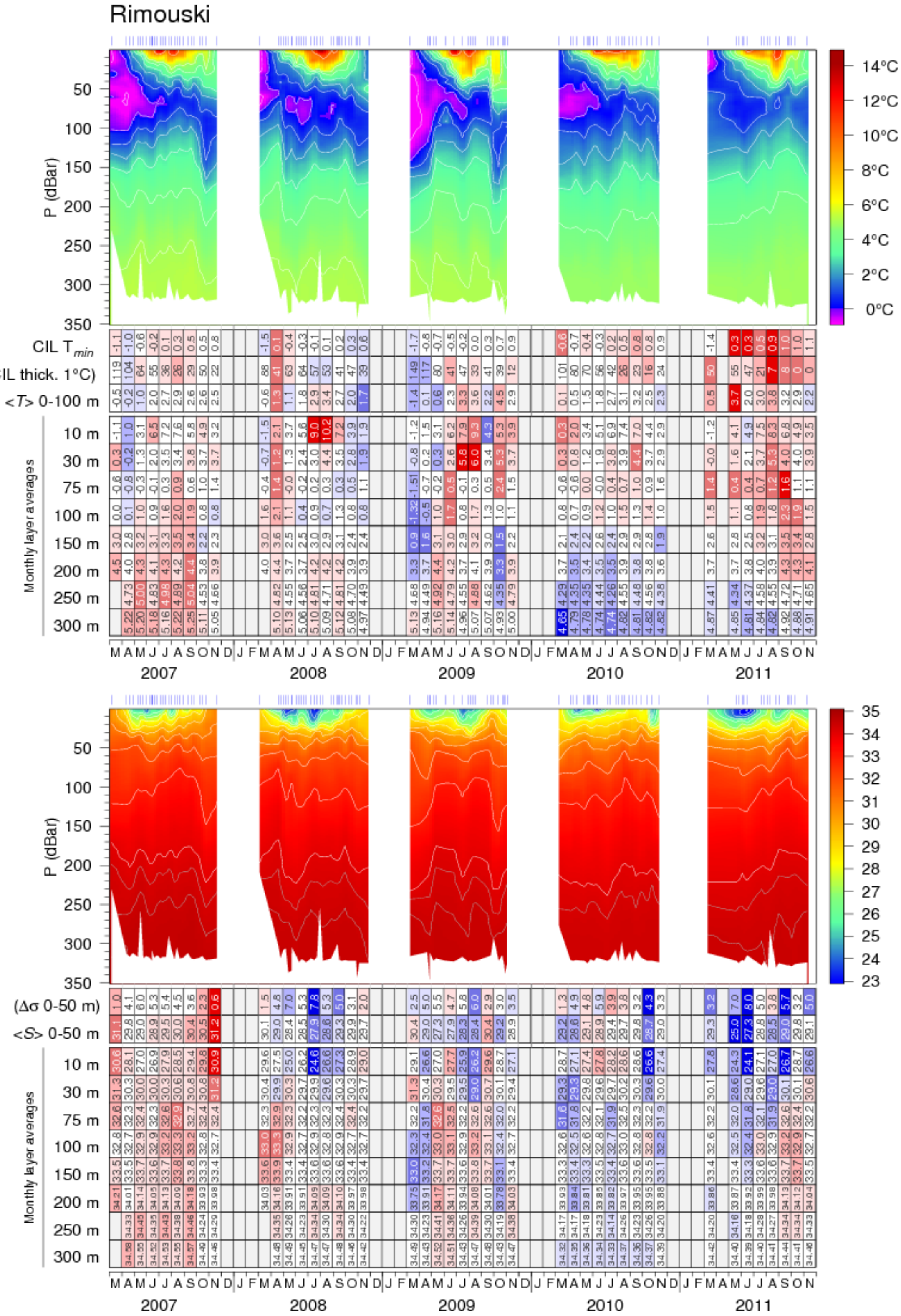

Fig. 47. Isotherm (top) and isohaline (bottom) time series at the Rimouski station; tick marks above indicate sample dates. The scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1993–2010 monthly climatology for the station (yearly climatology for 250 m and deeper). Thickness of the CIL and stratification have reversed colour codes where red indicates thinner CIL (warmer water) and less stratification (higher surface salinity).

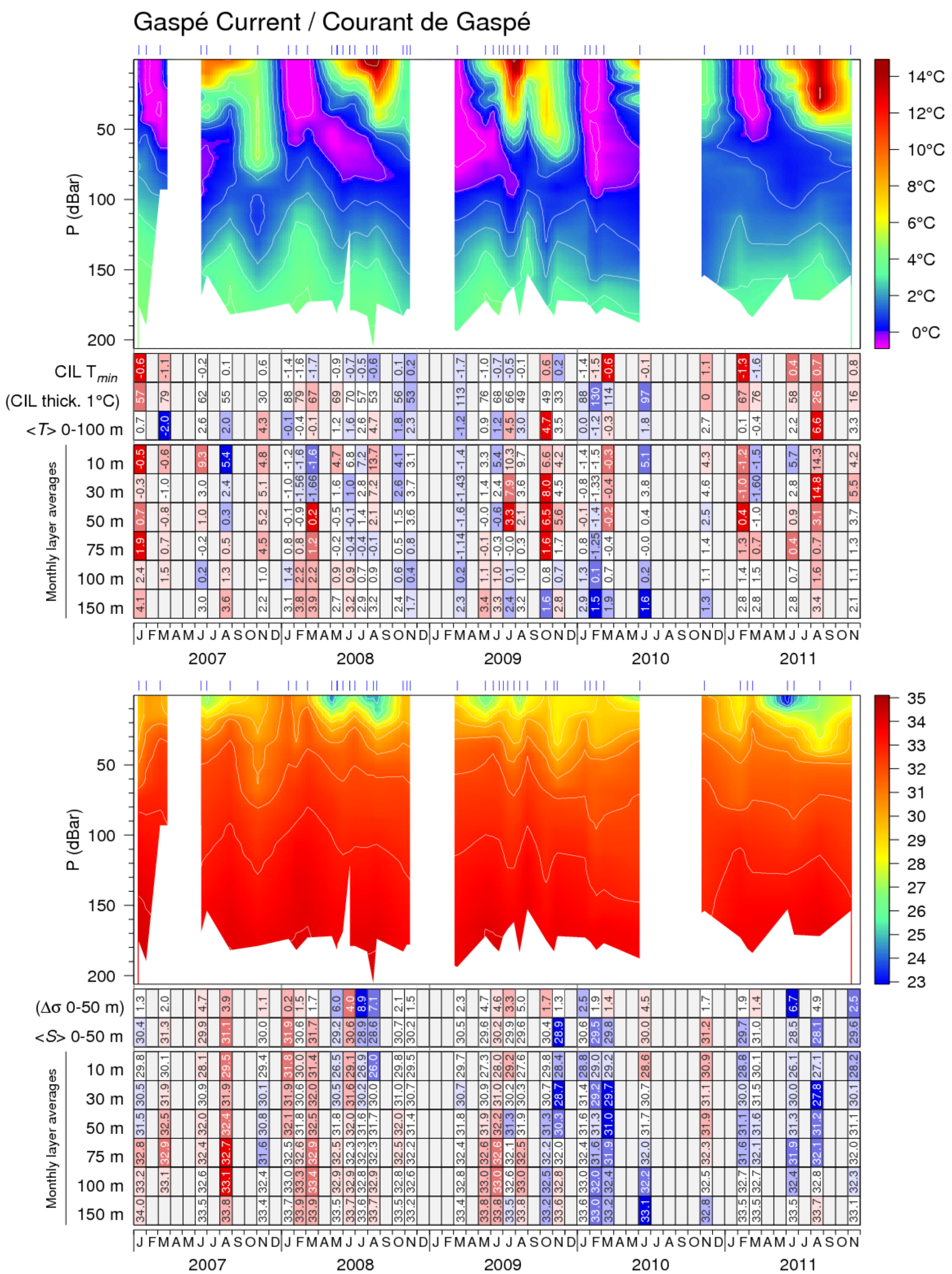

Fig. 48. Isotherm (top) and isohaline (bottom) time series at the Gaspé Current station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1996–2010 monthly climatology for the station.

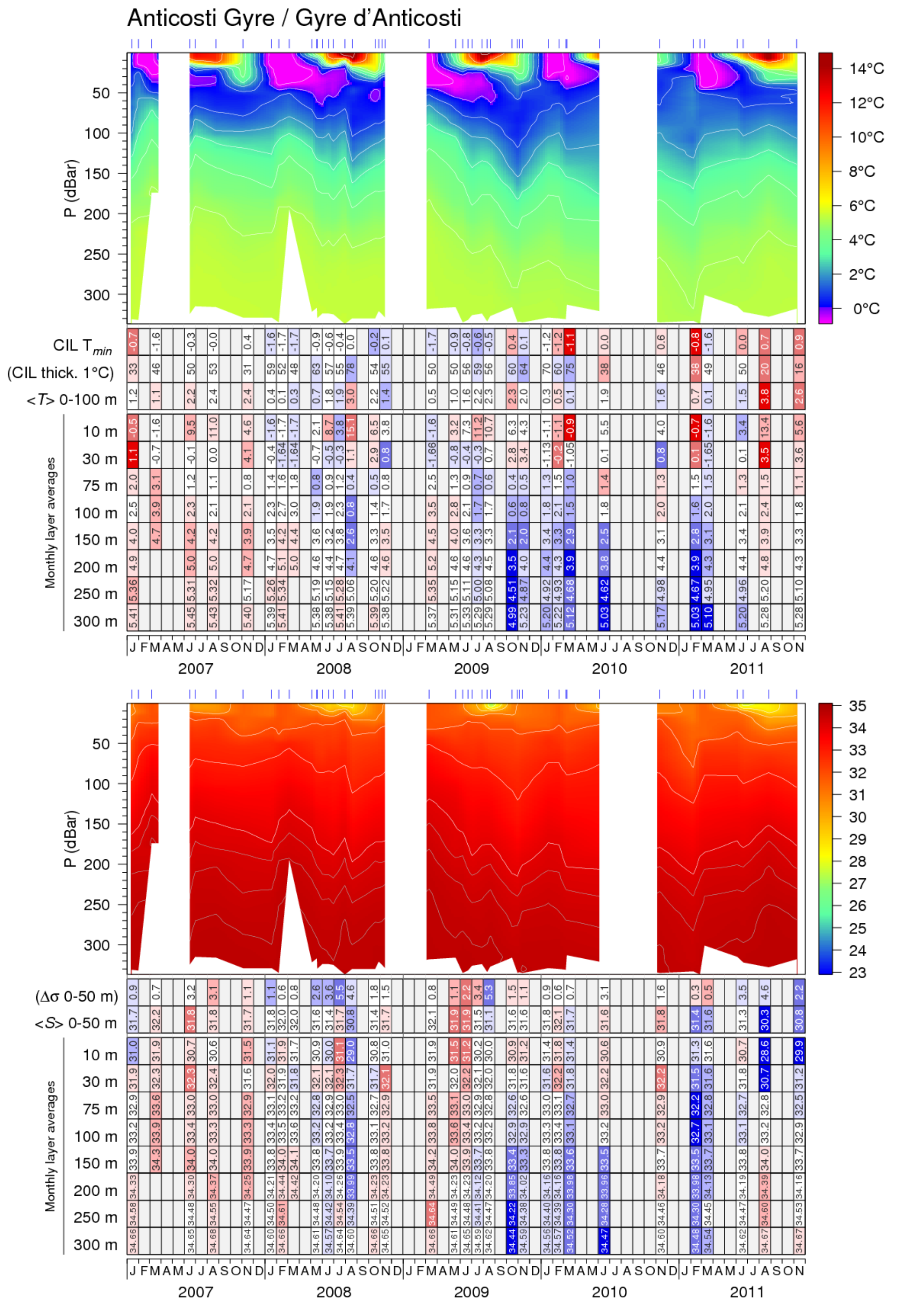

Fig. 49. Isotherm (top) and isohaline (bottom) time series at the Anticosti Gyre station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1996–2010 monthly climatology for the station (yearly climatology for 250 m and deeper).

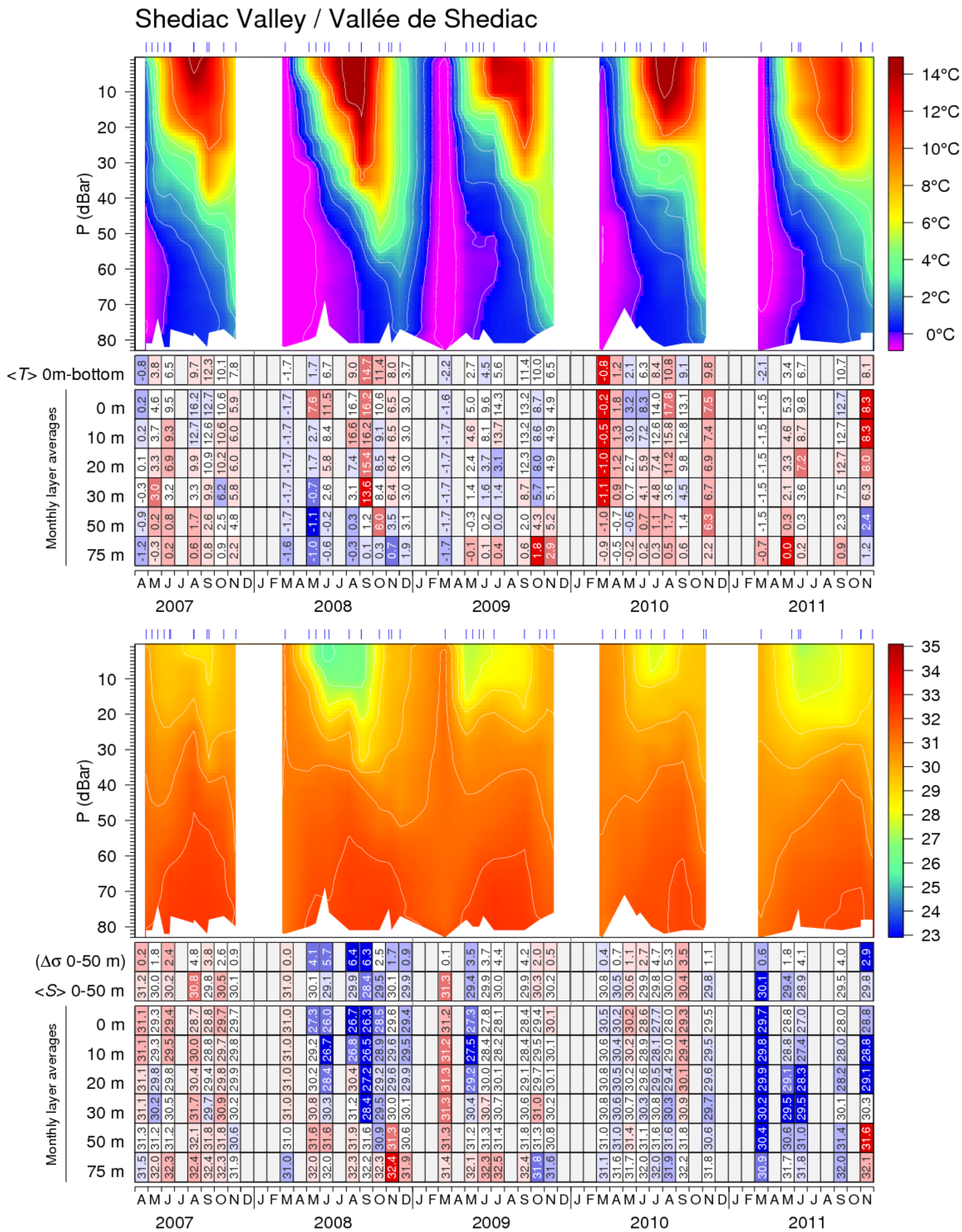

Fig. 50. Isotherm (top) and isohaline (bottom) time series at the Shediac Valley station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1971–2010 monthly climatology for the station.

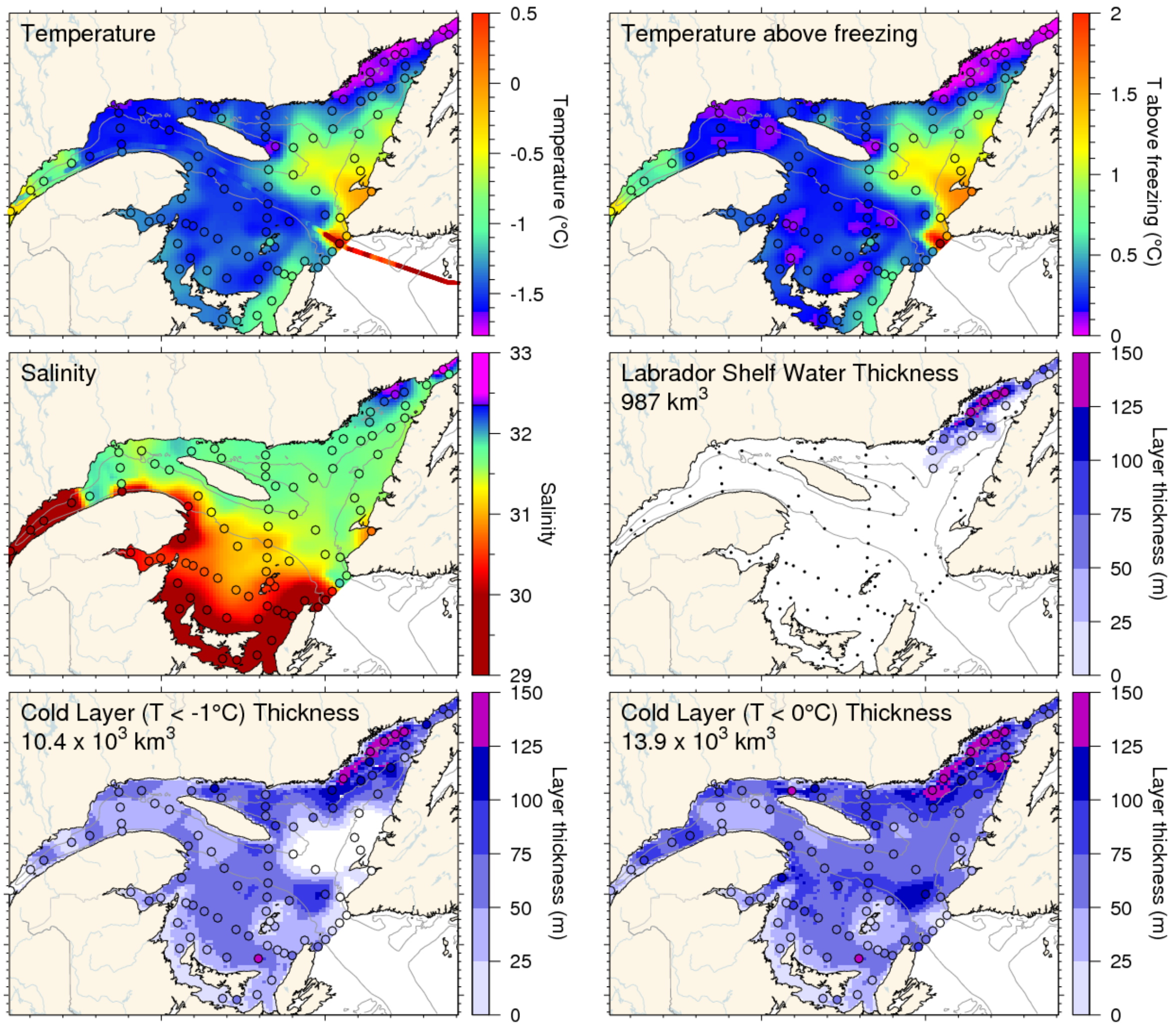

Fig. 51. March 2011 surface cold layer characteristics: surface water temperature (upper left), temperature difference with the freezing point (upper right), salinity (middle left), estimate of the thickness of the Labrador Shelf water intrusion (middle right), and cold layer (T<-1°C and <0°C) thicknesses (lower left and right). The symbols are coloured according to the value observed at the station, using the same colour palette as the interpolated image. A good match is seen between the interpolation and the station observations where the station colours blend into the background.

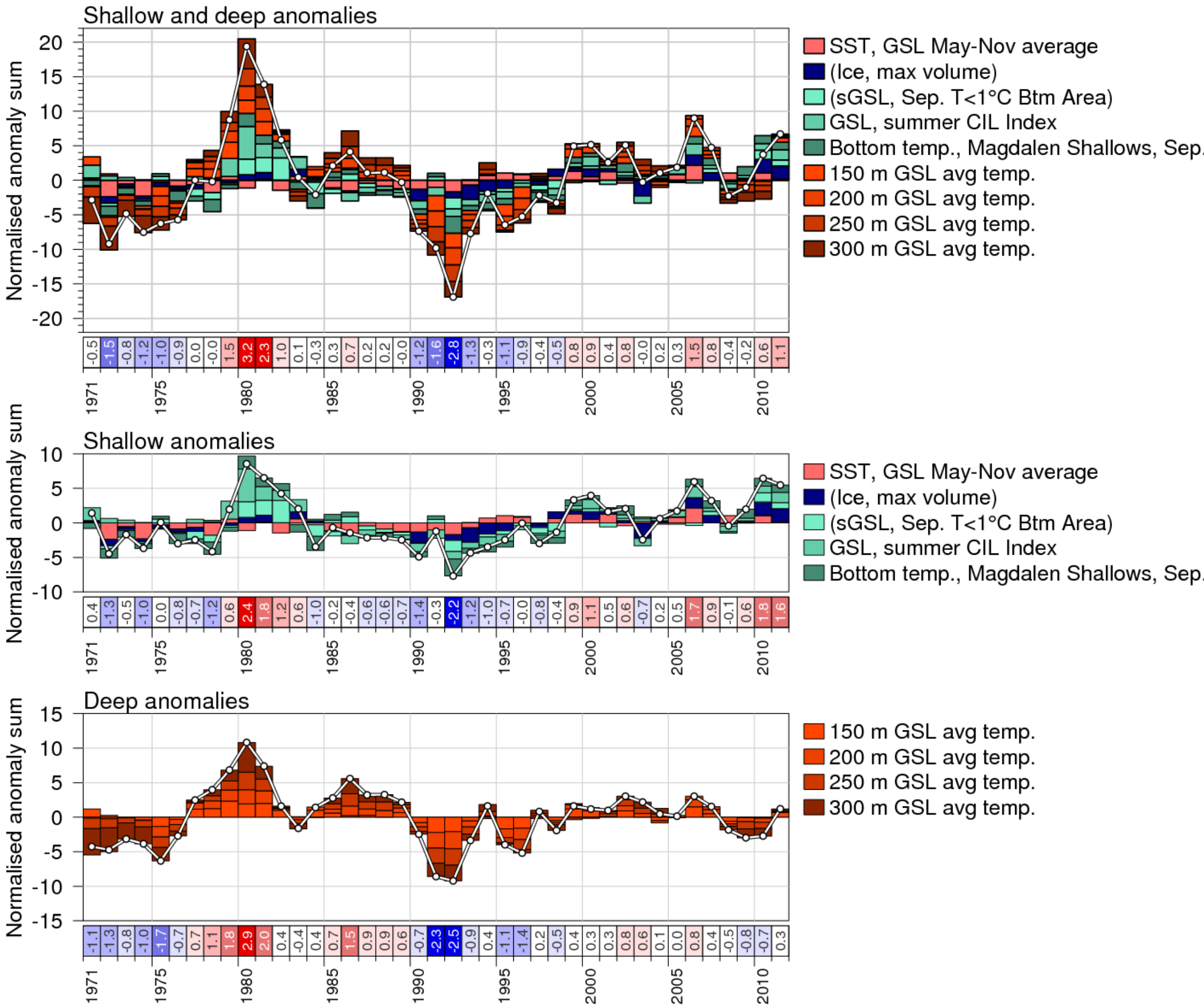

Fig. 52. Composite climate indices (white lines and dots) derived by summing various standardized anomalies from different parts of the environment (colored boxes stacked above the abscissa are positive anomalies, and below are negative). Top panel sums anomalies representing the entire water column, middle panel sums shallow anomalies and bottom panel sums deep anomalies.