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Physical Oceanographic Conditions in the Gulf of St. Lawrence in 2012

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Foreword

This series documents the scientific basis for the evaluation of aquatic resources and ecosystems in Canada. As such, it addresses the issues of the day in the time frames required and the documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

Research documents are produced in the official language in which they are provided to the Secretariat.

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ABSTRACT

An overview of physical oceanographic conditions in the Gulf of St. Lawrence in 2012 is presented as part of the Atlantic Zonal Monitoring Program (AZMP). AZMP data as well as data from regional monitoring programs are analysed and presented in relation to long term means. August air temperature was the warmest on record at eight stations around the Gulf of St. Lawrence and the warmest averaged over up to nine stations since at least 1873. Averaged over the entire year, 2012 was 3rd warmest since 1945. May-November sea-surface temperature averaged over the Gulf was second warmest after 2006. Sea ice reached a seasonal volume that was 4th lowest since 1969. The summer cold intermediate layer (CIL) volume was the lowest since at least 1985. The CIL minimum temperature index for the Gulf was the highest since 1980. At Rimouski station, the CIL minimum temperature was at a monthly record-high (since 1993) from July until the end of the sampling season in November. Deep water temperatures and salinities are increasing overall in the Gulf. In Cabot Strait, the warmest temperature on record (since 1915) was observed at 200 m and salinity reached a record high (also since 1915) at 300 m.

Conditions océanographiques physiques dans le golfe du Saint-Laurent en 2012

RÉSUMÉ

Le présent document donne un aperçu des conditions d'océanographie physique qui ont prévalu dans le golfe du Saint-Laurent en 2012 et est un produit du Programme de monitorage de la zone Atlantique (PMZA). Les données du PMZA ainsi que de programmes de monitorage régionaux sont analysées et présentées en relation avec des moyennes à long terme. Les températures de l'air en août étaient les plus chaudes des séries temporelles à huit stations autour du golfe Saint-Laurent. Moyenné sur les données disponibles à neuf stations, le mois d'août a été le plus chaud depuis au moins 1873. Moyenné annuellement, 2012 a été la troisième plus chaude année depuis 1945. Les températures de l'eau près de la surface moyennées de mai à novembre ont été les deuxièmes plus chaudes après 2006. Le volume de glace de mer a atteint un volume qui en fait le quatrième plus faible depuis 1969. Le volume de la CIF (couche intermédiaire froide) d'été était à son niveau le plus faible depuis le début de la série en 1985, tandis que sa température minimale était à son niveau le plus chaud depuis 1980. À la station de monitorage Rimouski, la température minimale de la CIF était à un niveau record de chaleur pour la période de l'année à partir de juillet, et ce jusqu'à la fin de son échantillonnage en novembre. Les températures et salinités des eaux profondes augmentent dans le golfe. Dans le détroit de Cabot, la température à 200 m a été la plus chaude observée depuis 1915, tandis que la salinité a atteint aussi un record maximal depuis 1915 à 300 m.

HIGHLIGHTS

- August air temperature was warmest at eight stations since at least 1945 and the exception, Blanc Sablon, held that record for the month of July. The August average over up to nine stations was the warmest since at least 1873. Averaged over the entire year, 2012 was 3rd warmest since 1945, and the warmest on record (1909) at Port aux Basques.
- May-November sea-surface temperature averaged over the Gulf was second warmest after 2006.
- Sea ice reached a seasonal volume that was 4th lowest since 1969.
- The summer cold intermediate layer (CIL) volume was the lowest since at least 1985. The CIL minimum temperature index for the Gulf was the highest since 1980. At Rimouski station, it was at a monthly record-high (since 1993) from July until the end of the sampling season in November.
- Deep water temperatures and salinities are increasing overall in the Gulf. In Cabot Strait, the warmest temperature on record (since 1915) was observed at 200 m and salinity reached a record high (also since 1915) at 300 m.

INTRODUCTION

This report examines the physical oceanographic conditions and related atmospheric forcing in the Gulf of St. Lawrence in 2012 (Figure 1). It complements similar reviews of the environmental conditions on the Newfoundland and Labrador Shelf and the Scotian Shelf and Gulf of Maine as part of the Atlantic Zone Monitoring Program (AZMP; see Therriault et. al., 1998; Colbourne et al., 2012; Hebert et al., 2012). 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 (Figure 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 (°C, m^3, m^2, etc.), each anomaly time series is normalized by dividing by its standard deviation (SD), which is also calculated using data from 1981–2010 when possible. This allows a more direct comparison of the various series. The results are usually presented in tables with missing data 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 since it is largely due to lower than normal surface salinity.

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 (Figure 3). Surface temperatures typically reach maximum values in mid-July to mid-August after which a gradual cooling occurs during the remainder of the year. Wind mixing during the fall leads to a progressively deeper and cooler mixed layer that eventually encompasses 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 by the end of March when temperatures decrease to near freezing (-1.8 to 0ºC) (Galbraith 2006). In the Mécatina Trough, intruding waters through the Strait of Belle Isle from the Labrador Shelf may extend from the surface all the way to the bottom in water depths exceeding 200 m. 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 Figure 2.

The last detailed report of physical oceanographic conditions in the Gulf of St. Lawrence was produced for the year 2011 (Galbraith et al. 2012a).

AIR TEMPERATURE

The monthly air temperature anomalies for several stations around the Gulf are shown in Figure 4 for 2011–2012. August air temperatures were at record highs at all stations, some dating from the 1870s, except for Blanc-Sablon (3rd warmest) where a record high was reached in July. Averaged over the Gulf, air temperature was at a record high since at least 1945 for the month of August as well as for the summer period of July-August-September.

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 2012 were well above normal at all stations and was a record-high (since 1909) at Port aux Basques. During winter months, air temperatures were closer to normal in northern areas and well above-normal in southern areas.

Figure 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. Air temperatures were above-normal during all seasons of 2012 and at a record-high in summer (+1.9°C, +2.8 SD). The annual average of the nine stations was above normal in 2012 by 1.6°C (+1.7 SD) and third warmest since 1945. The last below-normal (< -0.5 SD) annual anomaly occurred in 2002.

A mean winter air temperature index is also shown at the bottom of Table 1. This index was constructed by averaging the air temperatures of all stations sampled from December of the previous year to February of each year. This differs from previous reports which used a January to March average and was implemented because correlation with ice volume is slightly increased by substituting March air temperature for that of the previous December. The index was above normal in 2012 by 1.5°C (+1.0 SD). Temporally, it was composed of normal conditions for the month of December 2011 followed by above-normal conditions in January and February (Figure 4).

A warming trend of 0.9°C per century is found between 1873 and 2011 in the average April-November air temperature over the Gulf calculated using all stations listed in Figure 4 except for Mont-Joli, forming an index used as a proxy for May-November sea-surface temperature over the Gulf but excluding the estuary (Galbraith et al, 2012b).

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 below normal in 2012 (Figure 6) at 11 300 m^3s^{-1} (-0.8 SD), after an upwards trend since 2001. It consisted of either normal or below-normal monthly averages except for March where an early spring freshet produced a positive anomaly. While the anomaly was positive relative to the climatology of March observations, the combined March-May observations combine to a near-normal freshet (-0.4 SD) indicating a shift to earlier timing of the freshet.

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 Figure 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 2011 and 2012 are shown in Table 2. Rivers other than the St. Lawrence contribute about 5 000 m^3 s^{-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^3 s^{-1} in freshwater runoff to the system. River regulation has a strong impact on the relative contributions of sources. For example, in May 2012 the higher-than-average river runoff into the Estuary (an effect of the heavy precipitation in 2011 and river regulation) was almost as important as the then below-normal St. Lawrence run-off. The 2012 simulation shows that rivers in regions 3, 4, 5 and 8 behaved similarly, with higher-than-normal freshet followed by lower-than-normal runoff. The strong winter and spring runoff in region 1 is attributable to the regulated redistribution of the 2011 anomaly. The long term time series are shown, summed by large basins, in Figure 8. Broad long-term patterns of runoff over the large basins were similar to that of the St. Lawrence River but interannual variability is low in the Northeast basin and Magdalen Shallows basin.

SURFACE LAYER

The surface layer conditions of the Gulf are monitored by various complementary methods. The shipboard thermosalinograph network (Galbraith et al., 2002) consists of temperature-salinity sensors (SBE-21; Sea-Bird Electronics Inc., Bellevue, WA) that 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. They sample near-surface (3 m depth) water temperature and salinity along their year-round route between Montréal, QC, and St. John's, NL, making a return trip once per week. The data are especially useful for monitoring the winter freeze-up and the evolution of the spring thaw. Limitations of the network are that it does not provide data outside of 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 (Gilbert et al. 2004, Galbraith et al. 2008), which consists of a number of stations with moored instruments recording water temperature every 30 minutes (Figure 9). 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 five oceanographic buoys that transmit data in real-time. Data from Shediac station acquired by the DFO Gulf Region are also shown when available, but were not yet available for this report. The network provides an inexpensive, growing record of near-surface temperatures at fixed sites and at short sampling intervals, but usually not in real-time nor during winter months.

The third data source are 1 km resolution monthly composite Sea Surface Temperature (SST) 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, and Galbraith et al. 2012b). These data are available for sea-ice free months with climatologies computed for the months of May to November.

SST SEASONAL CYCLE CLIMATOLOGY

The expected May to November cycle of weekly averaged surface temperature is illustrated in Figure 10 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 (2012b) 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), 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.

Figure 11 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 thermosalinograph data collected from 2000 to 2012. Data were used from all instrumented ships that were within the main shipping route area to fill data gaps. The data were averaged for each day of the year at intervals of 0.1 degree of longitude to create a composite along the ship track. The most striking feature is the area at the head of the Laurentian Trough (69.5°W), where strong vertical mixing leads to cold summer water temperatures (around 5°C to 6°C and sometimes lower) and winter temperatures that are always above freezing (see also Figure 10). The climatology shows 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.

Temperature anomaly time series and 2000–2012 climatologies were constructed for selected sections that are crossed by the ship (Table 3). 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 7.0°C compared with 8.9°C at the nearby Estuary section and up to 13.3°C at the Mont-Louis section. The table provides a quick reference to the interannual near-surface temperature variations at the selected sections as well as monthly averages for the year in review.

SST IN 2012

Figure 11 also shows the thermosalinograph water temperature composite for 2012 and its anomaly. Figure 11 and Table 3 show that near surface water temperatures were normal in winter with early spring warming upstream of the Laurentian Channel, and usually above-normal in the Gulf until at least the end of October, with more pronounced variability in the Estuary.

The 2012 monthly mean sea-surface temperatures from NOAA AVHRR imagery are shown in Figure 12 as colour-coded maps and the corresponding temperature anomaly maps referenced to the 1985–2010 monthly climatology are shown in Figure 13. The anomalies are shown only for the months of May to November, because ice cover biases the climatologies for the other months (even though December has been ice-free in recent years, it would be difficult to construct a valid climatology since 1985). April is included but is only accurate for the usually ice-free Northwest Gulf. The NOAA SST information is summarized in Table 4, showing the 2011 and 2012 monthly surface temperature anomalies spatially averaged over the Gulf and over each of the eight regions delimited by the areas shown in Figure 2, and further into sub-regions of the Estuary as shown in Figure 14. Near-surface water temperatures were above normal almost everywhere from May to November. The only region with below normal temperatures was Anticosti Channel during the month of October.

Tables 5 and 6 show the 1985–2012 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 Gulf-wide May-November averaged temperatures in 2012 were a close second warmest after 2006. While the SST in 2006 were very much above normal in spring, they were normal in August (the warmest month of the annual cycle). In contrast, the SST in August 2012 was by far the warmest of the series, above-normal by nearly 2°C or almost double that of the previous record, leading to record peak values. Since the August air temperature record-high dates back to at least 1945 and likely the 1870s, it suggested that the same holds for this SST record. The August SST anomaly extended throughout the entire Gulf (Figure 13) and in fact extended to the shelf break of the Newfoundland Shelf to the east and of the Scotian Shelf to the south (not shown).

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 7 along with averages for the proposed Manicouagan Marine Protected Area (MPA), the proposed St. Lawrence Estuary MPA, and the Saguenay – St. Lawrence Marine Park (Figure 14). 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 Saguenay fjord SST was normal in August, contrary to everywhere else.

The Magdalen Shallows, excluding Northumberland Strait, is divided into western and eastern areas as shown in Figure 15. The monthly average SST for the Magdalen Shallows as a whole (region 8) is repeated in Table 8 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 2012 are the positive anomalies everywhere except in October and the record-high anomalies in August.

The number of weeks in the year that the mean weekly temperature is above 10°C for each pixel (Figure 16, Table 9) integrates summer surface temperature conditions into a single map displaying the length of the warm season. The anomalies of the number of weeks for 2012 are shown in Figure 17. While not quite as high as in 2006, nearly all areas of the Gulf had a much above-normal number of weeks with mean surface temperatures above 10°C. The exceptions were some areas prone to upwelling along the lower north shore and the area of influence of cold intermediate water mixing at the head of the Laurentian Channel.

Thermograph network observations are compared to daily average temperatures calculated using all available data for each day of the year at each station and depth (Figs. 18-20). Monthly average temperatures are also shown, with the magnitude of their anomaly colour-coded. For the first time, salinities are shown in a similar fashion in Figure 21. The average monthly temperatures for each station at shallow sampling depths (< 20 m) for 2011 and 2012 are also shown in Table 10.

Monthly anomalies were fairly consistent across all stations of each of the three regions listed in Table 10. As with AVHRR data sources and in spite of different climatological periods, the month of October is the only period with many stations showing cold anomalies from Havre-Saint-Pierre to La Romaine. The three stations recording winter temperatures showed near-normal values in mid-winter but shorter cold seasons.

Table 11 shows information similar to Table 10, but for thermograph sensors moored deeper than 20 m. The deep (>300 m) waters of the Estuary show near-normal temperatures in 2012 after below-average temperatures in 2011.

Table 12 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.

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 estimates for 1969–1997 and daily 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 2012 is shown and compared with previous minimum and maximum conditions observed in 2010 and 2003 (Figure 22). The combined Gulf and Scotian Shelf ice volume shown in the top panel of Figure 23 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 Figure 23 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 values since the database from which it is produced is only at weekly resolution prior to 1998.

The correlation between annual maximum ice volume and the December-February air temperature averaged over five Western Gulf stations (Sept-Îles, Mont-Joli, Gaspé, Charlottetown and Îles-de-la-Madeleine), in Table 14, accounts for 72% of the variance using the 1969–2012 time series. In 2012, the Gulf and Shelf maximum ice volume was 22 km³, double the volume of the record low of the 1969–2010 time series observed just two years earlier (11 km³ in 2010), still 1.6 SD below the 71 km³ climatological average. No ice was exported from the Gulf of St. Lawrence onto the Scotian Shelf for the third consecutive year. This low maximum ice volume is somewhat surprising (but not inconsistent with) given the Dec-Feb western Gulf air temperature anomaly of +1.6°C (+1.1 SD). The duration of the 2011–12 ice season was much shorter than normal in all regions, due to late ice formation and early melt (Table 13).

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). One hundred and seven stations were sampled during the 5–17 March 2012 survey, providing much better coverage of the Magdalen Shallows than in prior years. Figure 24 and Figure 25 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 2011 and 2012. Interpolations for all years were recomputed for this report using a bathymetry grid corrected in some areas of the Magdalen Shallows.

During winters prior to 2010, the surface mixed layer was usually very close (within 0.1°C) to the freezing point in most regions of the Gulf but thickness of the surface layer 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 the winter survey, when the mixed layer was on average 1°C above freezing. Similar conditions to those of 2010 were observed in March 2011, although not quite as warm. After the previous two very mild winters in 2010 and 2011, the winter surface mixed layer returned to near-normal conditions, as observed prior to 2010, whereby waters were near-freezing at the end of winter over a large portion of the Gulf. 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. An analysis will need to be done to confirm that these are warm waters that have entered the Gulf during winter as opposed to local waters that have simply not cooled close to freezing. This area of warm water was fairly extensive in 2012, almost reaching Anticosti Island. 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 Figure 24 and are typically found to the north and east of Anticosti Island. Surface salinities were generally lower than usual in this part of the Gulf in winter 2012.

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 only present at the surface on the north shore of the Strait of Belle Isle (Figure 24) and in limited areas of Mécatica Trough in March 2012 where they were found below the surface. A T-S water mass criterion from Galbraith (2006) was used to identify intruding waters that have exhibited no evidence of mixing with warm and saline deep Gulf water. These waters occupied the sub-surface of Mécatina Trough in March 2012 (top-right panel of Figure 25). The recent history of Labrador Shelf water intrusions is shown in Figure 26, where its volume is shown as well as the fraction it represents of all the cold-water volume in the Gulf. This volume was below normal in March 2012, at 1000 km³ (-0.6 SD), as was the percentage of cold water it represents, at 10% (-0.6 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 (Galbraith, 2006). In March 2010 and 2011 much of the mixed layer was warmer than -1°C such that the criterion of T<0°C was also introduced (see middle panels of Figure 25). The cold surface layer is the product of local formation 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 and the Strait of Belle Isle) yields a cold-water (<- 1°C) volume of 10 200 km³, 0.5 SD below the 1996–2012 average. The mixed layer volume increases to 13 400 km³ when water temperatures <0°C are considered, only slightly higher than the record low value recorded in 2000. The T<0°C volume is 13 900 km³ when the waters present in the Estuary are included. This volume of cold water corresponds to 41% of the total water volume of the Gulf (33 500 km³, including 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 Figure 27. In summary, 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.

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 Figure 27). 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. 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 forecasted in last year’s report 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. As shown below, the CIL turned out to be even warmer at +0.42ºC.

AUGUST CIL BASED ON THE MULTI-SPECIES SURVEY

The CIL minimum temperature, 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 using a different method this year in order to be consistent with bottom temperature results presented in another section, and so values for prior years may be slightly different than in last year's report. Using all available temperature profiles, each 1-m depth layer of the Gulf was spatially interpolated for temperature, with the interpolated field bound between the minimum and maximum values observed within each of the different regions of the Gulf (Figure 2) to avoid spurious extrapolations. The CIL thickness at each grid point is simply the sum of depth bins below the threshold temperature, and the CIL minimum temperature is only defined at grid points where temperature rises by at least 0.5°C at depths greater than that of the minimum, or if the grid point minimum temperature is below the CIL spatial average of the Gulf.

Figure 28 shows the gridded interpolation of the CIL thickness <1°C and <0°C and the CIL minimum temperature for August–September 2012 as well their 1985-2010 climatology (1994-2010 for Mécatina Trough). The CIL thickness for both <1°C and <0°C was generally less and core temperatures generally warmer in 2012 than in 2011. 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 (as well as the climatologies shown in Figure 28). The time series of the regional CIL volumes are shown in Figure 29 (for <0°C and <1°C) and in Table 14 (for <1°C). The CIL defined by <0°C all but disappeared except for the Mécatina Trough and its surrounding influence in Anticosti Channel. Most regions show a decreased CIL <1°C volume in 2012 compared to 2011, except for a small increase in Anticosti Channel and a return to a large volume in Mécatina Trough. Record lows were reached in the Estuary as well as in Central Gulf. Figure 30 shows the average CIL core temperature and the total volume of CIL water (<0°C and <1°C) from the August– September interpolated grids (e.g., Figure 28). The CIL volume as defined by T<1°C decreased significantly compared to 2011 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 low 2011 conditions, reaching a new record-low. New in this year's report, the CIL areal minimum temperature average and volume exclude Mécatina Trough (Figure 30) which has very different water masses from the rest of the Gulf, influenced by inflow through the Strait of Belle Isle, and is therefore not indicative of the climate in the rest of the Gulf.

The time series of the CIL regional average minimum core temperatures are shown in Figure 31. All regions show an increase in core temperature for the third consecutive year except in Cabot Strait and the Mécatina Trough. The 2012 average temperature minimum over the deep channels was +0.78°C and is shown in Figure 30 (bottom panel, green line). The overall 2012 CIL water mass properties were warmer than any year recorded since 1980.

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 minimum temperature in the Estuary (Figure 32), showing the CIL erosion and warming spatially towards the head of the channel, and temporally since the August survey (Figure 31). Note that the November CIL thickness with T < 1°C, shown in previous reports, is omitted this year because no waters were observed to be colder than this threshold temperature in the Estuary in

November 2012. The overall volumes (i.e. zero) and average minimum temperature are shown in Figures 29 and 31, as well as in Table 14. The CIL was warmer in November 2012 than in 2011. Figure 31 shows that the fairly rapid increase of the CIL minimum temperature occurring between August and November is fairly constant inter-annually in spite of the differences in August temperature.

GILBERT AND PETTIGREW (1997) CIL INDEX

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 Figure 30 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 2012 was +0.42°C. The 0.25°C increase from the summer 2011 CIL index of +0.17°C is consistent with the sharp decrease in CIL volume between August 2011 and 2012 discussed above and the increase of 0.3°C in the areal average of the minimum temperature in August. This increase of the index makes it above normal by 2.1 SD. The warm winter conditions since 2010 led to CIL indices that were still far below the record high observed in the 1960s and 1980. While these earlier CIL temperature minimums should be re-examined to confirm that they were calculated using data with sufficient vertical resolution to correctly resolve the core minimum temperature, other indicators show some to be warm such as the regional averages recorded in 1980 (Figs. 29 and 31) and bottom temperatures in the June survey (see below). However, it is becoming increasingly clear that the winter mixed layer is not the only factor explaining summertime CIL conditions and that mechanisms having a multi-year cumulative effect are required to explain the interannual autocorrelations observed. For example, this may be linked to the summertime thermocline being shallower than normal, decreasing the thickness of the CIL.

MAGDALEN SHALLOWS JUNE SURVEY

A long-standing assessment survey covering the Magdalen Shallows takes place in June for mackerel and provides good coverage of the temperature conditions that are greatly influenced by the cold intermediate layer that reaches the bottom at roughly half of the surface area at this time of time.

Warming of near-surface waters progresses quickly in June, being mid-way between the winter minimum and the annual maximum in early August. This can introduce a bias if the survey dates are not the same each year. To account for this, the seasonal warming observed at the Shediac Valley AZMP monitoring station was evaluated. A linear regression was performed of temperature versus time for each meter of the water column for each year with monitoring data at Shediac Valley between May and July. Visual inspection showed that the depth-dependent rate was fairly constant for all years and an average was computed for every depth. Warming is maximum at the surface at 20°C per 100 days and decreases almost proportionally with depth to reach 2.7°C per 100 days at 40 m. In spite of some uncertainties between 40 and 55 m, the warming rate is well approximated by a further linear decrease reaching 1°C per 100 days at 82 m.

All available temperature casts taken in June from a given year are binned at 1m depth intervals (or interpolated if the resolution is too coarse) and then adjusted according to the sampling date to offset them to June 15th according to the depth-dependant warming rate extracted from Shediac Valley monitoring data. An interpolation scheme is used to estimate temperature at each 1 m depth layer on a 2 km resolution grid. Figure 33 shows temperatures and anomalies at depth of 10, 20 and 50 m. Table 15 shows 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 of Figure 15. Temperatures were normal to above-normal at 10 and 50 m, but varied about the mean at 20 m (Figure 33). On average, temperatures were normal or above-normal at all depths in both western and eastern regions. Near the surface, temperatures were well below the record-high anomalies of 2006, while at 75 m they were at a high not observed since 1972 on the western Shelf.

BOTTOM WATER TEMPERATURES

Bottom temperature is also estimated at each point of the above grids 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 available temperature grids between 1981 and 2010 and anomaly grids were computed for each year. The June bottom temperature climatology as well as the 2012 reconstructed temperature and anomaly fields are shown in Figure 34. Anomalies are typically greater than +0.5°C in the deeper waters of the western shelf such that the area occupied by waters colder than 0°C is much less than the climatology.

The same method was applied to the entire 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 into a single map (Figure 35). Most of the intermediate depths had above normal temperatures, in some locations by as much as 2°C although more typically between 1 and 1.5°C.

Time series of the bottom area covered by water in various temperature intervals were estimated from the gridded data for the June surveys as well as for the September multispecies survey on the Magdalen Shallows (Figure 36). 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 <-1°C in June 2012 or <0°C in September 2012; these conditions are similar to those in 2005-07, and 2009-11. The time series of areas of the Magdalen Shallows covered by water colder than 0, 1, 2, and 3°C in September are also shown in Table 14. The area covered by water temperatures <1°C reached a low not seen since 1983, but areas with T< 2 and 3°C increased since the same period in 2011.

Time series of the bottom area covered by water in various temperature intervals were also estimated for the other regions of the Gulf based on August-September temperature profile data (Figs. 37 and 38). Anticosti Channel and Mécatina Trough, areas affected by the winter intrusion of cold Labrador Shelf water, were the only regions to have bottom waters colder than 0°C. Bottom waters are colder in Mécatina Trough in 2012 compared to the same period in 2011. Waters colder than 1°C disappeared from the central Gulf region as well as almost from the northwest Gulf region. 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 2012 although the return of >6°C temperatures to the sea floor is noted.

SEASONAL AND REGIONAL AVERAGES OF TEMPERATURE PROFILES

In order to show the seasonal progression of temperature profiles, regional averages are shown in Figs. 39 to 43 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 October-November AZMP survey and including all additional archived CTD data for those months. 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 91 CTD casts in March, 124 casts in June, 283 casts in August, 280 in September, 86 in October and 70 in November were obtained. Average discrete depth layer conditions are summarized for the months of the 2011 and 2012 AZMP surveys in Table 16 for temperature and in Table 17 for salinity and 0-50 m stratification, where for each survey the anomalies are computed relative to monthly temperature and salinity climatologies calculated for each region.

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 Figure 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 (Figs. 39 to 43).

The March water temperature conditions were discussed at length in earlier sections and are included here for completeness (Figure 39), 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 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 Figure 39 are the previously discussed winter mixed layer, with temperatures returning to near-freezing after milder conditions in 2010 and 2011. The thermocline was much shallower than usual in central Gulf and Cabot Strait regions. One cast was sampled beyond 200 m depth on the Newfoundland side of Cabot Strait to sample the inflow into the Gulf; temperatures at ≥200 m were above normal, reaching record levels and its salinity was also above-normal (Table 17).

Temperatures in June 2012 (Figure 40, Table 16) were characterized by CIL conditions that were below normal in thickness and above-normal in minimum temperature, especially in Central Gulf. Deep water temperatures were normal in the Estuary and above-normal in Cabot Strait, in particular at the depth of the temperature maximum (225 m) as was also observed in March. The warm deep anomaly observed at Cabot Strait in 2011 appears to have propagated to Esquiman and central Gulf regions, and has since warmed further at Cabot Strait. By August, the CIL was also anomalously warm in the Estuary, Northwest Gulf, Anticosti Channel and Esquiman Channel (Figure 41, Table 16). By November (Figure 43, Table 16), the average profile in the Estuary had a CIL minimum temperature of approximately 2°C! The surface mixed layer was also very warm everywhere in November, a mild precondition to the winter of 2012-13.

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 7°C and salinities between 32.5 and 35 (except for Mécatina Trough where near-freezing waters may fill the basin to 235 m in winter and persist throughout the summer). 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 Figure 44. Some older values have changed since last year's report because some temperature-salinity profiles were updated from NODC archives.

In 2012, the gulf-wide average temperatures and salinities were above normal at all depths. Temperature at 300 m increased greatly overall for the second year in a row (by 1.3 SD since 2011 and by 2.6 SD since 2010) and the 2012 anomaly is positive by 1.5 SD; the highest since 1986. Temperature at 200 m increased overall by 1.1 SD, but increased at Cabot Strait to reach +2.2 SD, a series record since 1915. The 300 m depth waters of the Estuary warmed between 2011 and 2012 as expected based on the change observed between 2010 and 2011 in the northwest Gulf (see also Table 11 for the deep thermograph at Rimouski station). The warm anomaly present since 2010 at Cabot Strait should progress up the channel towards the Estuary by next year; already the temperature in Central Gulf is above normal (+0.5 SD). Salinity increased overall by 0.7 SD at 200 m and 0.4 SD at 300 m to reach values of +0.8 SD and +1.2 SD respectively. Salinity at Cabot Strait at 300 m is at a record high (since 1915) of +1.8 SD or 34.81.

DISSOLVED OXYGEN AND HYPOXIA IN THE ST. LAWRENCE ESTUARY

Figure 44 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 less than about 25% saturation since 1984 (typically less than 22%). Dissolved oxygen increased slightly in 2012 compared with 2011.

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 should be seen in the regional time series shown in Table 18, where changes in dissolved oxygen would have been expected to be associated with the change in temperature from the water mixture richer in Labrador Water. However, no strong correspondence is observed, suggesting that interannual variability in respiration may be occuring.

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 obtained from observed data and the hydrological model, as discussed in the freshwater runoff section. A simulation was run for 2006–2012 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.

Figures 45–47 show seasonal depth-averaged currents for 0–20 m, 20–100 m, and 100 m to the bottom for 2012. Currents are strongest in the surface mixed layer, generally 0–20 m, except in winter months when the 20–100 m and the 100m to bottom averages are almost as 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 Tables 19 and 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 net transports for sections within the Gulf and shows a high degree of variability in 2012.

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 denser salty waters underneath.

FIXED AZMP STATIONS

Sampling by the Maurice Lamontagne Institute began in 1996 at two stations (Figure 48) 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 (Figure 48). 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 limited to 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 Figure 49 for 2008-2012. Similar figures are provided for the Gaspé Current station (Figure 50), the Anticosti Gyre station (Figure 51), and the Shediac Valley station (Figure 52). The scorecard climatologies are calculated from all available data at all stations except for Shediac Valley, where the time series since 1981 is considered (1981–2012).

At the Rimouski station (Figure 49), the CIL had a normal thickness with below normal temperatures in March 2012. It thinned and warmed rapidly, disappearing completely (using the <1°C definition) by October, and reaching record-high minimum temperature by July with each subsequent month until the end of sampling in November holding the series record high. Temperatures were typically above normal in the top 100 m and switched from below normal to normal at 300 m by May. The limited number of samplings of the Gaspé Current and Anticosti Gyre stations limits our interpretation of these data. The CIL started out at both stations with normal minimum temperatures in February and March, but they were above-normal from June onward. At the Shediac Valley station (Figure 52), 0-10 m temperatures were above-normal in April while salinities were below normal, suggesting the influence of the spring freshet. Near-surface (0-10 m) temperatures were record-highs in August, consistent with the record highs also observed in SST throughout the Gulf. Near-bottom (75 m) temperatures were mostly above-normal.

Table 21 shows the interannual variability of some bulk layer averages from May to October for the four stations. Bulk surface layer temperature was above normal at all stations. Stratification was below normal at Rimouski Station and Gaspé Current, but above normal at Anticosti Gyre and normal at Shediac Valley, providing no clear signal across the Gulf (note however that sampling was fairly sparse at Gaspé Current and Anticosti Gyre). The CIL at Rimouski station was the thinnest and warmest recorded since monitoring began there in 1991, breaking the records set in 2011.

OUTLOOK FOR 2013

Air temperatures in January and February 2013 were slightly above normal throughout the Gulf. This was the setting for the March 2013 survey which provides an outlook for CIL conditions expected for the remainder of 2013. Figure 53 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. While the winter surface layer is usually well mixed and homogenous in temperature and salinity, it was stratified in the northwest Gulf where the warm surface temperatures shown in Figure 53 are not representative of the entire surface layer; colder temperatures were found below as evidenced by the thickness of the layer with T<-1°C. The only areas with very near-freezing surface temperatures were in Mécatina Trough and the southern Gulf around Prince Edward Island. A warm surface layer (T>-1°C) occupied a large area along the west coast of Newfoundland, exceptionally reaching Anticosti Island and almost reaching Îles-de-la-Madeleine; it was nevertheless colder than 0°C.

Based on the similarities of the mixed layer in terms of temperature and volumes colder than 1°C and 0°C with those observed in 2011, we can forecast warm summertime CIL conditions in 2013 with an index of between +0.2ºC and +0.4ºC, similar to conditions in the previous two years.

SUMMARY

A single-figure temperature summary that groups SST, CIL and deep water average temperatures was presented in Benoît et al. (2012) and is updated here (Figure 54). It shows increases in all layers (surface, CIL, deep waters) between 2011 and 2012 and near-record surface temperatures averaged from May to November.

To further summarize the temperature state of the Gulf of St. Lawrence, eight timeseries are chosen to represent surface and deep conditions (Table 22). Here, the CIL is grouped as a shallow feature since it is generated by the winter surface mixed layer. Figure 55 shows three annual composite index time series (Petrie et al. 2007) constructed as the sum of these anomalies, representing the state of different parts of the system, with each time series contribution shown as stacked bars. The first anomaly sum represents the entire water column, whereas the second and third sums represent the state of the shallow and deep parts of the water column, which are decoupled. 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 combined high occurred in 1980 from the record deep anomalies and the near-record shallow anomalies. The record low occurred in 1993, combining records in both shallow and deep anomalies. In 2012, the shallow index is at a record high (above normal by +2.4 SD), the deep index is above-normal at +1.5 SD and all components are in phase, leading to an overall index of +2.4 SD, the highest since 1981 and second highest in the series.

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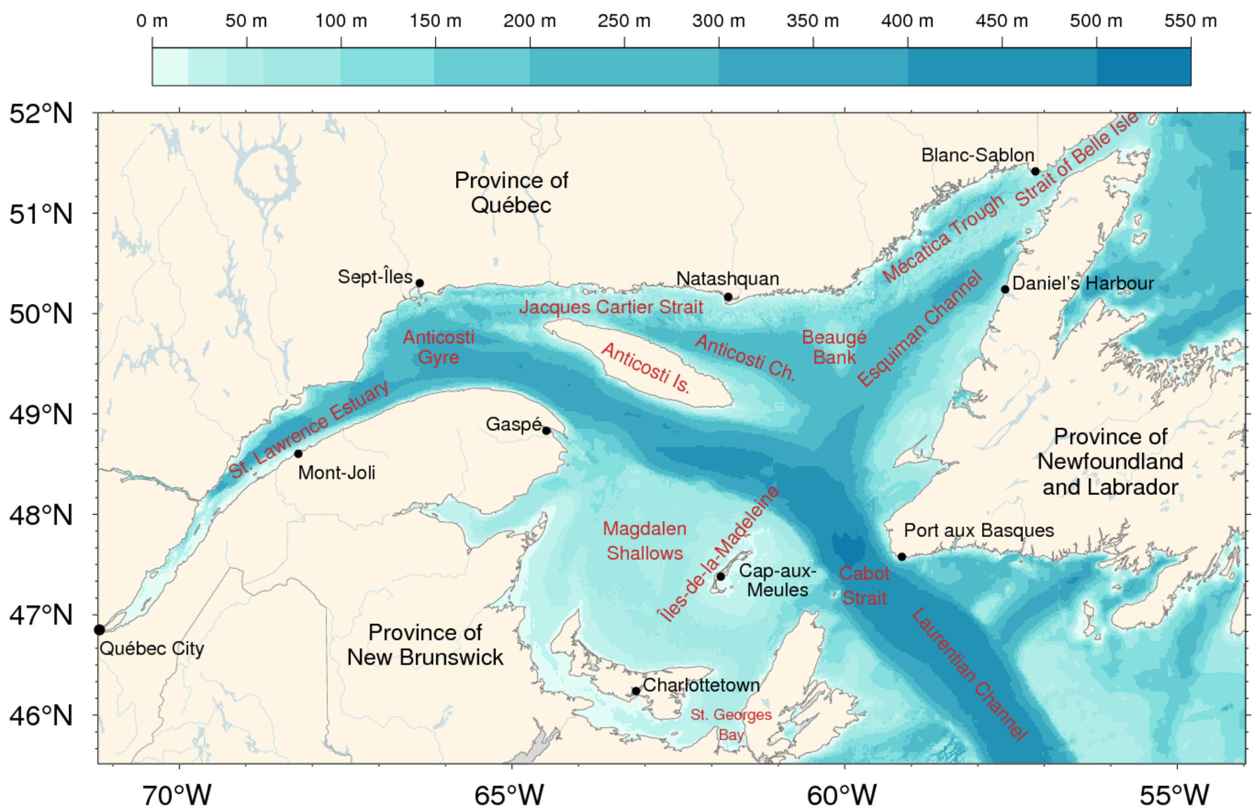


Figure 1. The Gulf of St. Lawrence. Locations discussed in the text are indicated. Bathymetry datasets used are from the Canadian Hydrographic Service to the west of 56°47' W (with some corrections applied to the baie des Chaleurs and Magdalen Shallows) and TOPEX data to the east.

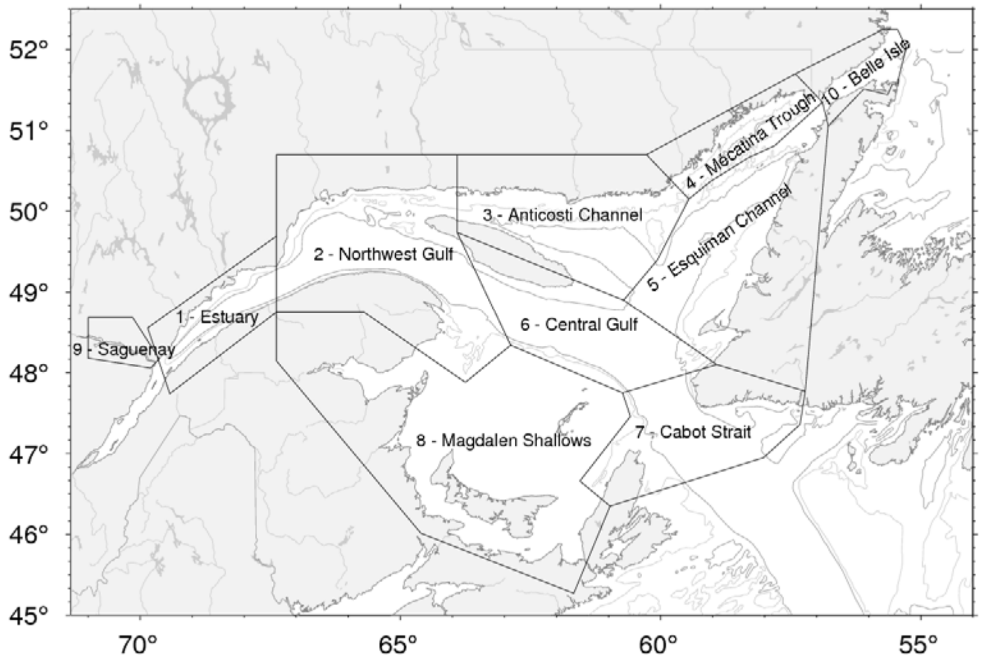


Figure 2. Gulf of St. Lawrence divided into oceanographic regions. The first eight are typically used in this report.

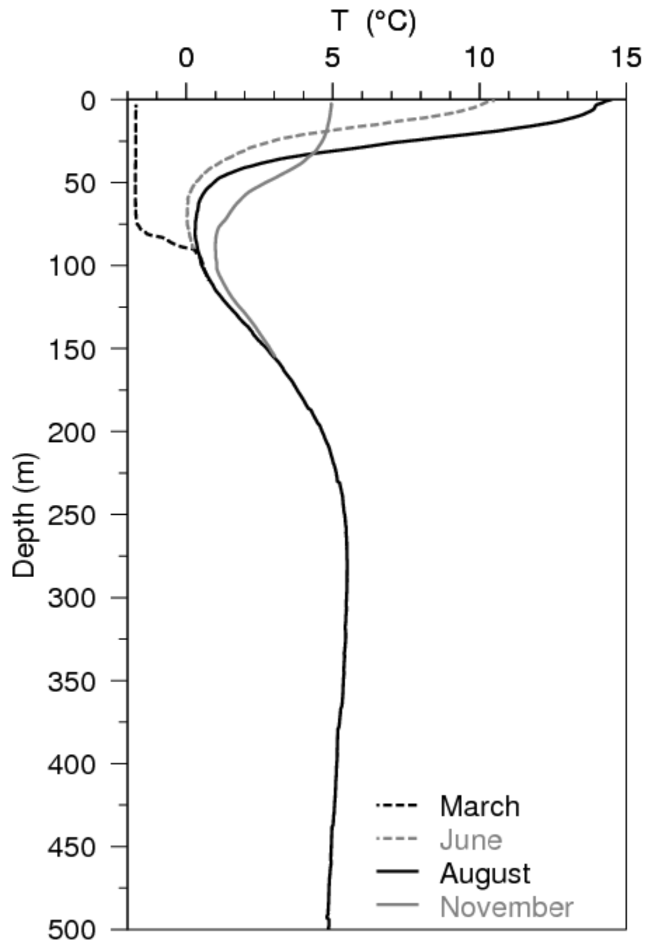


Figure 3. Typical seasonal progression of the depth profile of temperature observed in the Gulf of St. Lawrence. Profiles are averages of observations in August, June and November 2007 in the northern Gulf. The dashed line at left shows a single winter temperature profile (March 2008), with near freezing 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. (2012b).

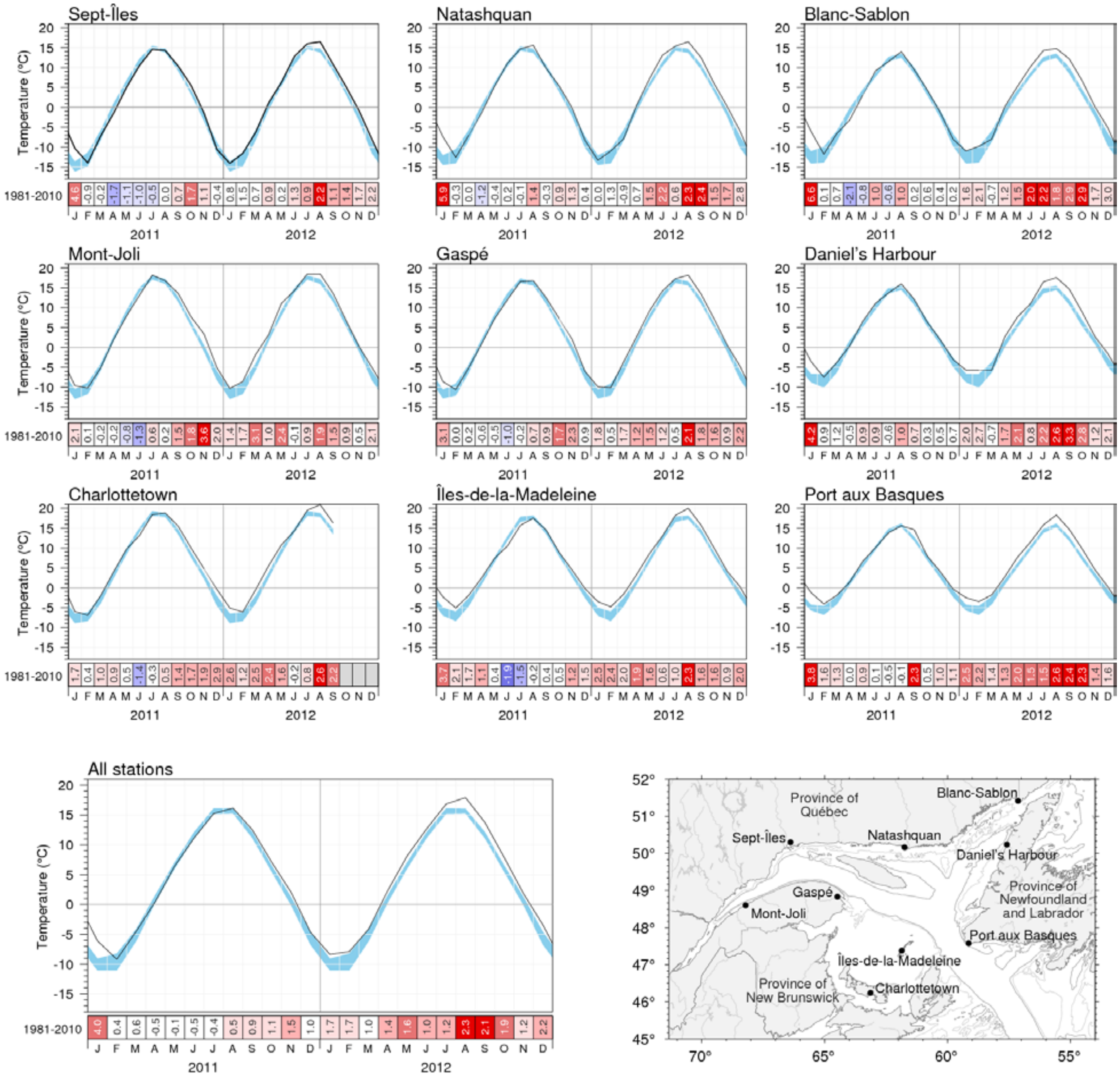
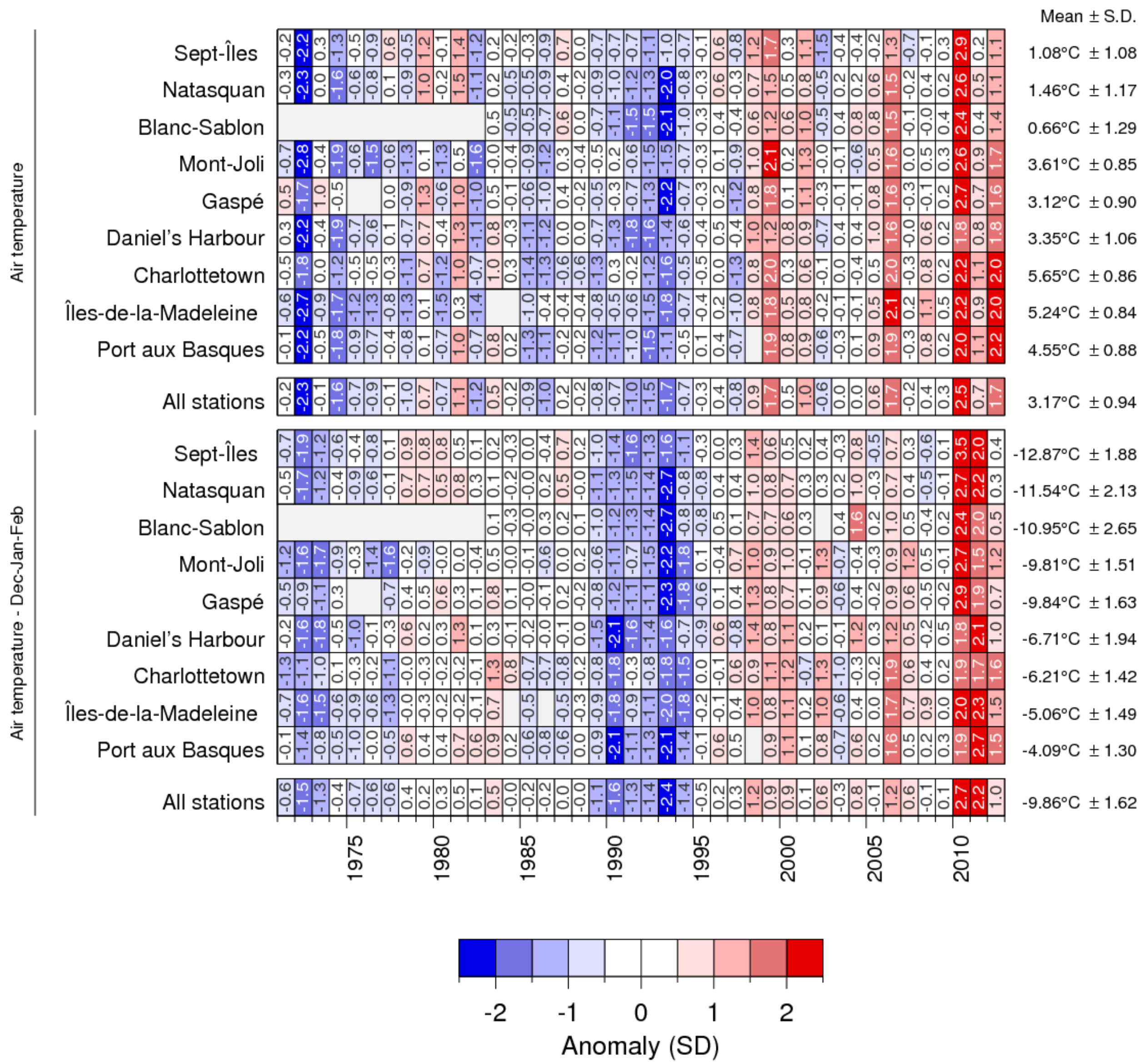


Figure 4. Monthly air temperatures and anomalies for 2011 and 2012 at nine selected stations around the Gulf as well as the average for all nine stations. The blue area represents the 1981–2010 climatological monthly mean ± 0.5 SD. The bottom scorecards are colour-coded (see Table 1) according to the monthly normalized anomalies based on the 1981–2010 climatologies for each month, but the numbers are the monthly anomalies in ºC.

Table 1. Normalized mean air temperature anomalies: annual (top) and December-January–February (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.



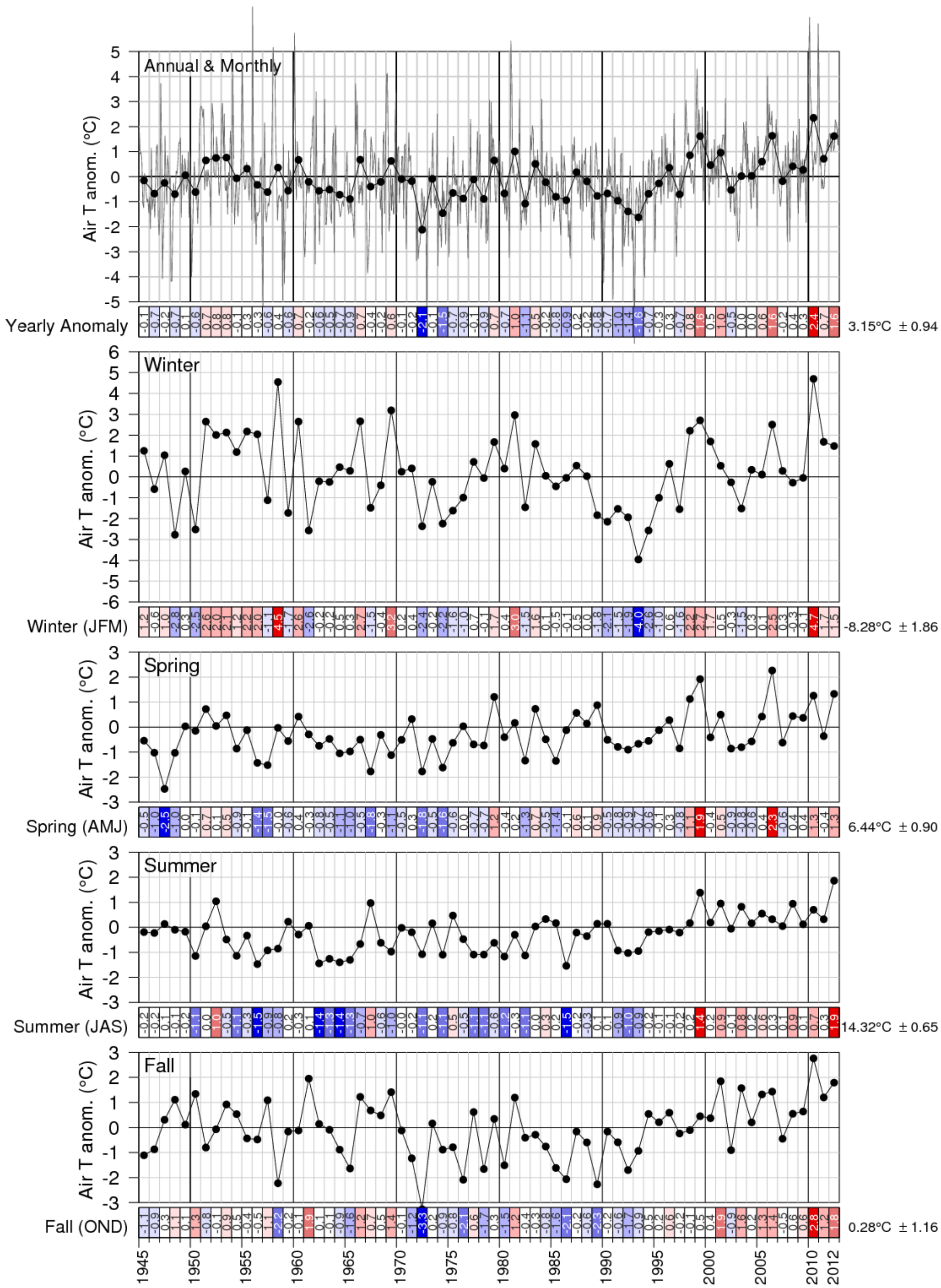


Figure 5. Annual and seasonal mean air temperature anomalies averaged for the nine selected stations around the Gulf. The bottom scorecards are colour-coded according to the normalized anomalies based on the 1981–2010 climatology, but the numbers are the anomalies in ºC.

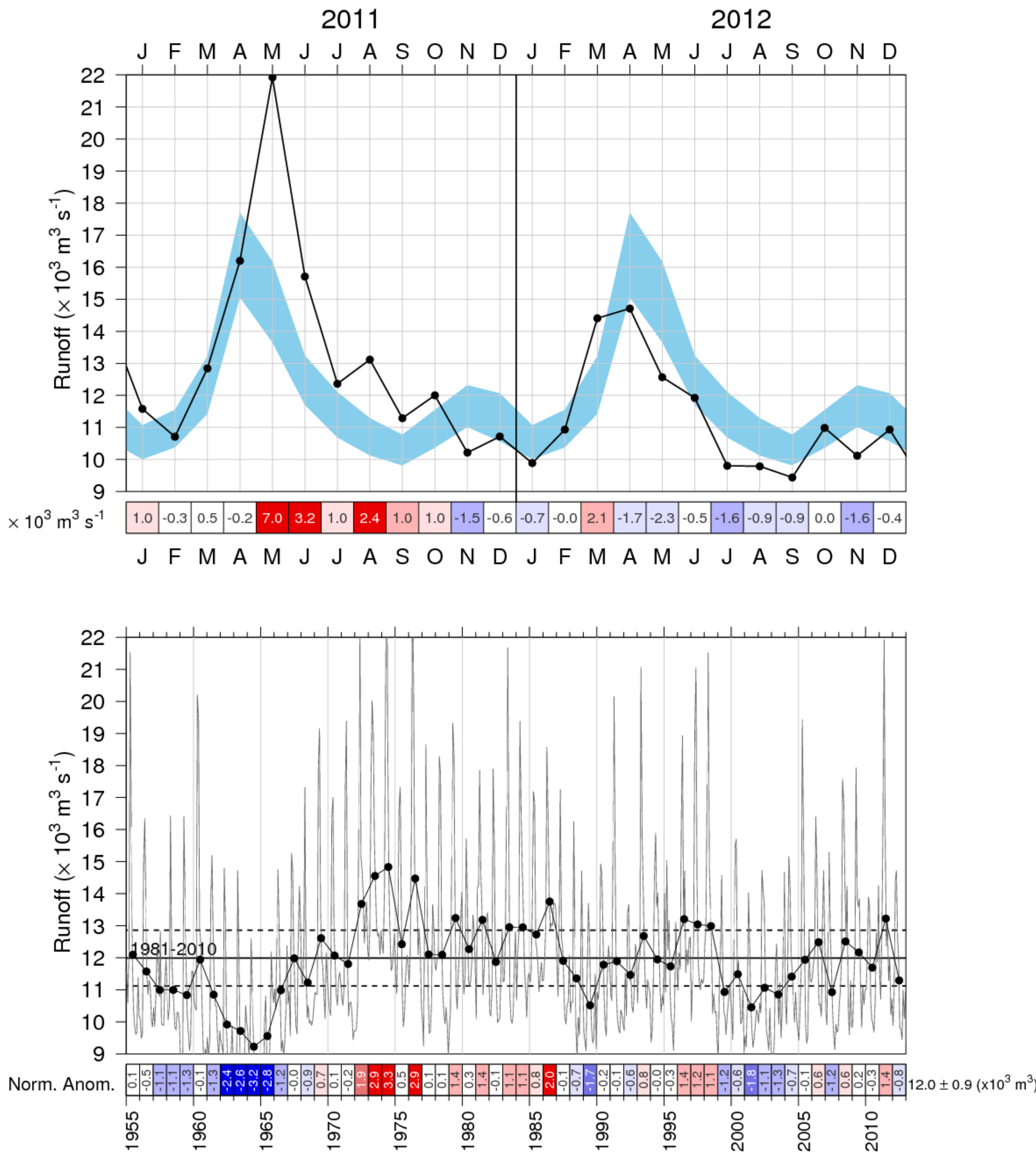


Figure 6. Monthly (top panel) and annual (bottom panel) mean freshwater flow of the St. Lawrence River at Québec City. The 1981–2010 climatological mean (± 0.5 SD) is shown for each month in the top panel (blue shading) and as horizontal lines for the annual time series in the bottom panel. The top-panel 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.

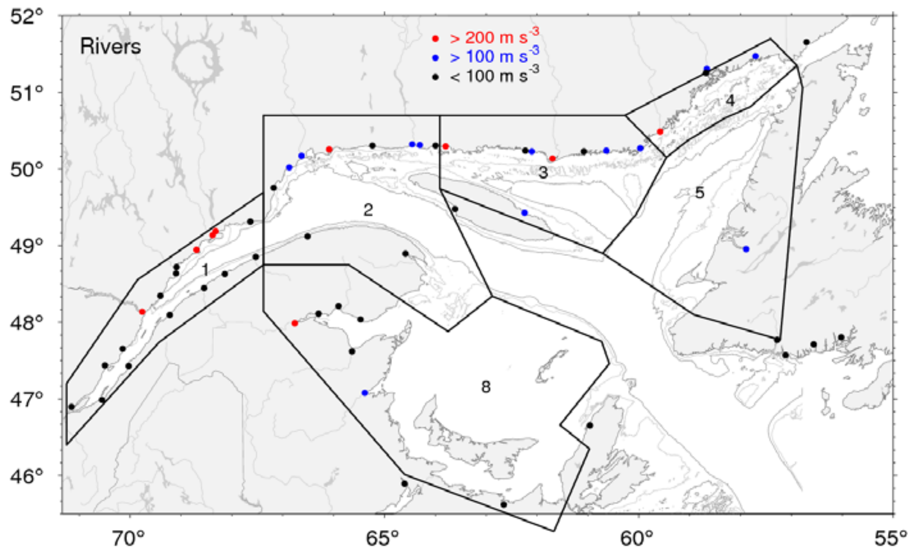


Figure 7. River discharge locations for the regional sums of runoffs listed in Table 2. Red and blue dots indicate rivers that have climatological mean runoff greater than 200 $m^3 s^{-1}$ and between 100 and 200 $m^3 s^{-1}$, respectively.

Table 2. Monthly anomalies of the St. Lawrence River runoff and sums of all other major rivers draining into separate Gulf regions for 2011 and 2012. 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).

	2011												2012												
	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	11576	10708	12843	16197	21925	15707	12364	13115	11290	12001	10213	10714	9886	10932	14407	14712	12567	11923	9805	9787	9439	10984	10114	10933	12011 $m^3 s^{-1}$
1 - Estuary	3457	3335	3415	4507	8381	8281	6609	6303	5100	5382	5217	4769	4671	4725	4960	6400	9758	7119	4734	4306	4486	5185	4543	4040	4978 $m^3 s^{-1}$
2 - Northwest Gulf	340	53	196	563	2456	4894	2699	1595	894	781	831	353	57	43	279	1139	2623	3093	1443	924	1162	1434	845	214	1129 $m^3 s^{-1}$
3 - Anticosti Channel	319	127	367	719	2304	4256	1892	962	741	743	1094	740	225	69	333	1439	3067	3476	1437	665	883	1367	892	458	1234 $m^3 s^{-1}$
4 - Mécatina Trough	169	55	133	253	951	2018	790	236	256	421	523	313	89	40	152	645	1455	1774	680	115	230	579	469	175	597 $m^3 s^{-1}$
5 - Esquiman Channel	155	77	101	252	397	279	113	32	85	235	239	193	125	93	101	314	398	103	11	109	92	27	108	175	162 $m^3 s^{-1}$
8 - Magdalen Shallows	457	238	618	1459	2269	823	569	753	234	318	546	626	386	242	727	1540	924	406	176	166	267	578	494	536	617 $m^3 s^{-1}$

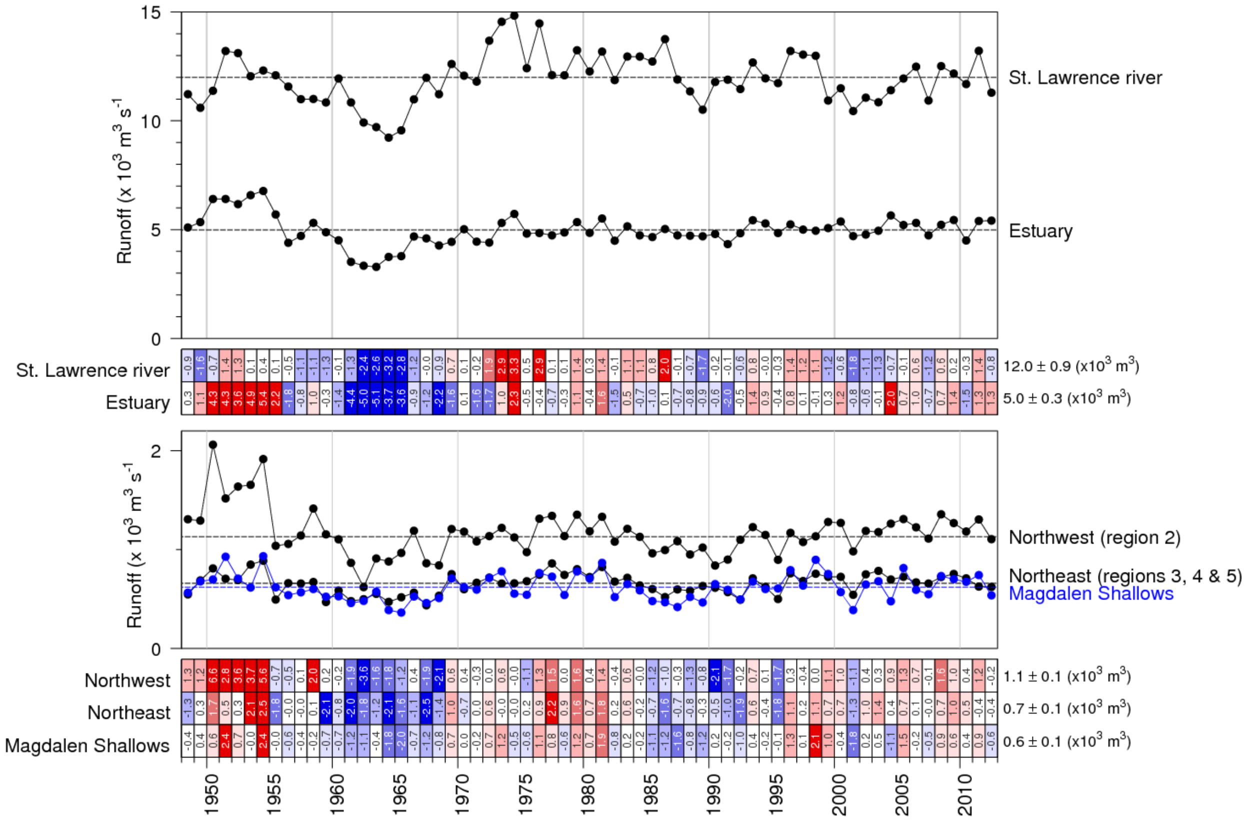


Figure 8. Annual mean freshwater flow of the St. Lawrence River at Québec City and of the sum of all rivers flowing into regions of the Estuary and Gulf. The 1981–2010 climatological mean is shown as horizontal lines and indicated on the right side of the scorecards. Numbers in scorecards are normalized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

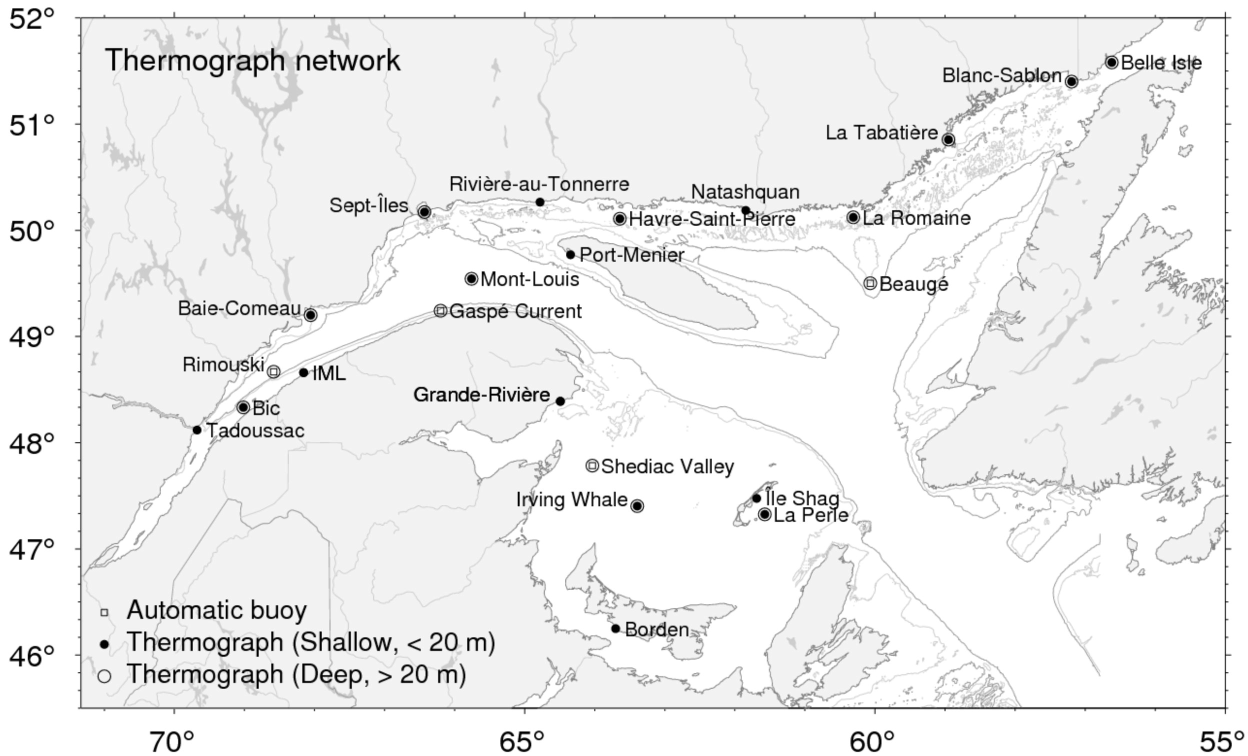


Figure 9. Locations of the Maurice Lamontagne Institute thermograph network stations in 2012, including regular stations where data are logged internally and recovered at the end of the season (circles) and oceanographic buoys that transmit data in real time (open squares).

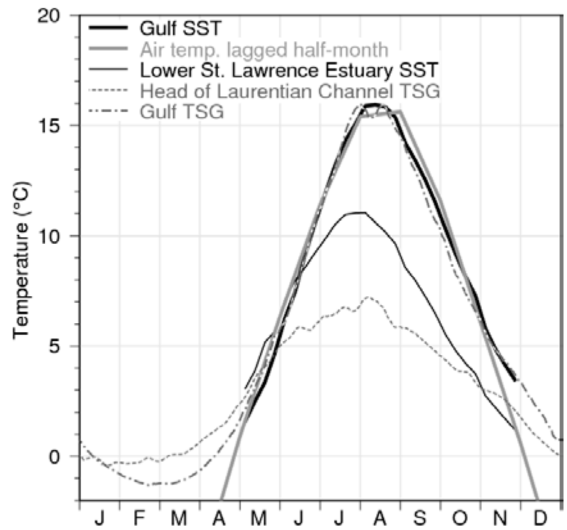


Figure 10. Sea-surface temperature climatological seasonal cycle in the Gulf of St. Lawrence. NOAA AVHRR temperature weekly averages for 1985 to 2010 are shown from May to November (ice-free months) for the entire Gulf (thick black line) and the cooler Lower St. Lawrence Estuary (thin black line), defined 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. (2012b).

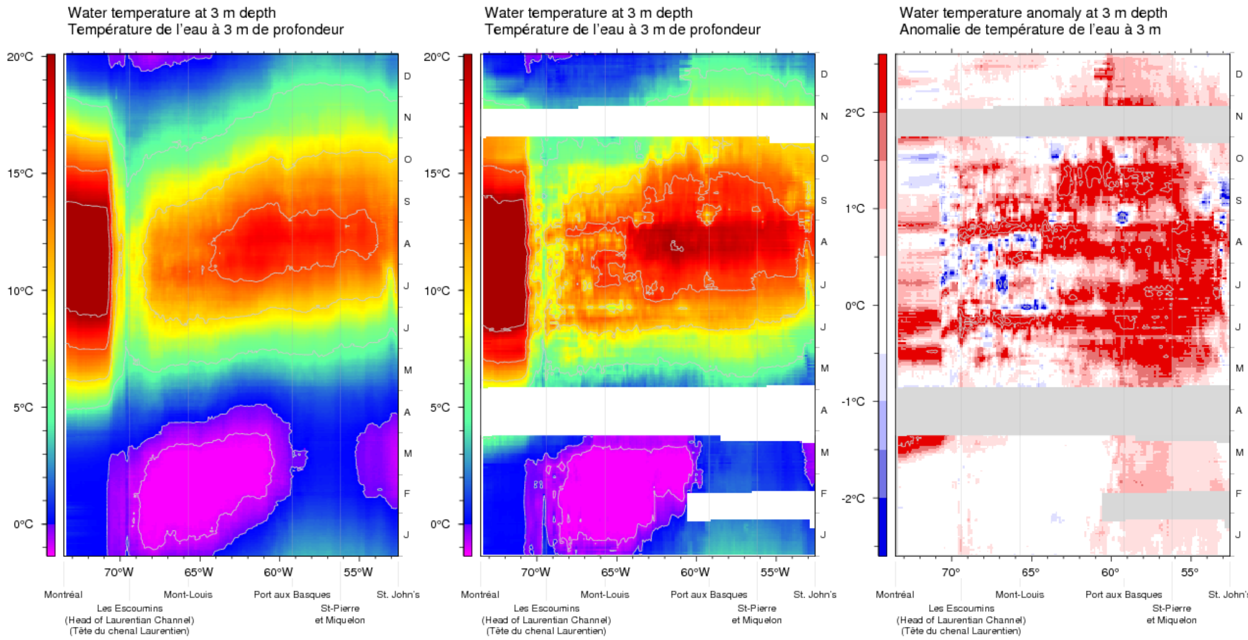


Figure 11. Thermosalinograph data at 3 m depth along the Montréal to St. John's shipping route: composite mean annual cycle of the water temperature for the 2000–2012 period (left panel), composite annual cycle of the water temperature for 2012 (middle panel), and water temperature anomaly for 2012 relative to the 2000–2012 composite (right panel).

Table 3. Thermosaligraph near-surface temperature monthly anomalies for various sections along the main shipping lane. The numbers on the right are the 2000–2012 climatological means and standard deviations. The numbers in the boxes are normalized anomalies. The map shows all TSG data sampled in 2012. Those drawn in colour are within the main shipping corridor and are used in this report. Monthly average anomalies of temperatures measured close to the indicated blue section lines are shown in the other scorecard panels.

Tadoussac

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
J	-0.8	-0.6	0.3	0.6	-1.6	-0.2	-0.9	1.5				0.9	0.9	0.05°C ± 0.59
F	-1.0	-0.2	-1.5	1.5	-0.1	-1.1	-0.9	1.3	-0.1		1.0	0.8	0.2	-0.13°C ± 0.48
M	0.5	0.1	0.1	1.9	-1.3	-1.3	0.3	0.1	-1.4		0.9		0.1	0.09°C ± 0.48
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	-0.5	1.8	-0.0	-1.0	-1.9	-0.4	0.8	-0.8	0.8		-0.1	0.9	0.2	3.66°C ± 0.82
J	-1.7	0.6	-0.3	-1.1	-0.3	-0.6	0.4	0.4	0.5		-0.8	1.4	1.6	5.97°C ± 1.34
J	-1.1		0.5	-1.0	0.2	-1.3	0.0	-0.8	0.7		0.2	2.1	0.6	6.64°C ± 0.64
A		0.1	-0.2	-0.6	-1.5	-0.2	0.1	-0.6	1.7		-1.0	1.6	0.7	7.01°C ± 1.41
S	-0.4	-0.7		-1.6	-0.1	2.1	0.4	-0.9	-0.4		0.3	0.9	0.4	5.59°C ± 0.85
O	-1.0	-0.2	-0.7	-1.3	0.1		1.9	0.8	-0.7		0.3		0.9	4.33°C ± 0.76
N	0.3	-0.7	-1.3	-1.4	0.7	-0.1	2.1	-0.2	-0.4			0.1	0.8	2.80°C ± 0.61
D	0.3	0.4	-0.6	-2.0	-0.7	-0.2	1.7	-0.4	-0.8		1.1	0.8	0.6	1.03°C ± 0.67

Estuary / Estuaire

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
J	-0.8	-0.4	0.7	-0.7	-1.5	-0.4	-0.4	1.0				1.6	0.9	-0.69°C ± 0.35
F	-0.7	-0.1	-0.8	0.2	-1.0	-0.9	-0.8	0.2	-0.1		2.5	1.2	0.1	-0.79°C ± 0.38
M	1.2	-0.2	0.1	0.5	-1.0	-1.3	0.2	-0.3	-1.5		1.7		0.5	-0.15°C ± 0.46
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	-0.1	1.0	-0.6	-1.0	-1.7	-1.0	0.4	-0.9	1.5		0.8	0.7	0.7	4.29°C ± 0.67
J	-1.1	0.9	-0.7	-1.4	-1.1	-0.6	0.4	-0.2	0.8		0.2	0.8	1.9	7.12°C ± 1.20
J	-0.8		1.4	-1.0	0.2	0.9	-0.7	-1.4	-1.0		0.1	1.1	1.0	8.60°C ± 0.84
A		-0.6	0.5	-0.5	-0.9	-0.2	-0.5	-1.1	1.6		-1.0	1.4	1.2	8.87°C ± 1.27
S	-1.0	-0.5	0.4	-0.8	-1.2	1.5	-0.5	-1.1	0.2		0.8	0.5	1.8	6.41°C ± 0.64
O	-1.0	-0.3	-0.3	-1.5	-0.1		0.4	0.9	-0.8		1.4		1.4	4.61°C ± 0.62
N	0.4	-0.4	-1.4	-1.6	0.6	-0.1	1.8	-0.4	-0.1			0.5	0.8	2.66°C ± 0.67
D	-0.4	0.6	-0.5	-1.6	-0.7	-0.0	1.7	-1.0	-0.8		1.3	0.9	0.4	0.62°C ± 0.65

Mont-Louis

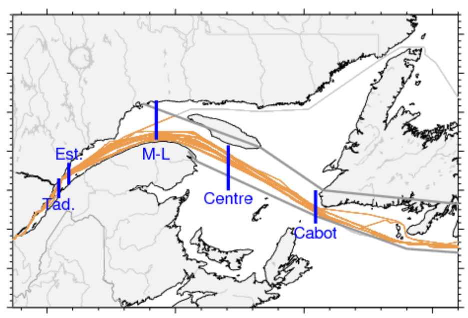
	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
J	-0.1	-0.2	-0.4	-0.3	-0.5	-0.8	-0.1	-0.2				2.8	-0.2	-0.97°C ± 0.59
F	-0.6	-0.5	-0.6	-0.6	-0.2	-0.7	-0.2	0.2	-0.5		1.7	2.4	-0.3	-1.37°C ± 0.37
M	0.7	0.5	-0.8	-0.6	-0.8	-0.8	0.8	-0.0	-1.1		2.2		-0.0	-1.16°C ± 0.35
A	-0.8	0.3	0.7	-1.3	-0.7	-0.8	0.9	-0.3	0.0		2.0			0.68°C ± 0.61
M	-0.7	1.4	-1.3	-0.3	-1.3	-1.1	0.1	-0.3	1.0		1.5	0.7	0.4	4.38°C ± 1.07
J	-0.3	1.1	-0.9	-0.2	-1.4	-0.5	0.6	-1.0	-0.4		1.7	-0.1	1.5	9.06°C ± 0.98
J	-0.5	-1.6	-0.5	-0.8	0.2	1.9	0.6	-0.0	-1.3		0.8	0.3	0.9	13.34°C ± 0.94
A		0.2	0.8	-0.3	-1.1	-2.0	-0.0	-0.9	0.4		0.7	1.0	1.3	13.09°C ± 0.88
S	-1.1	0.7	0.1	-0.9	-1.1	-0.4	-0.4	-1.2	1.8		0.9	0.6	0.9	10.22°C ± 1.07
O	-0.9	0.1	-1.1	-0.0	0.6		-1.5	-0.1	0.4		2.0		0.5	6.07°C ± 1.00
N	-0.2	-0.6	-1.5	-1.4	0.9	1.4	1.2	-0.4	-0.2			0.9	-0.0	3.73°C ± 1.07
D	0.6	-0.3	-0.9	-1.5	-0.2	-0.3	1.0	-0.9	-0.6		2.1	0.4	0.6	0.98°C ± 0.59

Centre

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
J	-0.4	-0.1	-0.6	-1.0	-0.1	-1.0	0.5	0.6				2.4	-0.2	-0.17°C ± 0.74
F	-0.6	-0.4	-0.7	-0.9	-0.3	-0.9	0.6	-0.3			1.1	2.4	-0.0	-1.23°C ± 0.45
M	-0.0	-0.3	-0.6	-0.9	-0.5	-0.5	0.7	-0.0	-0.9		2.6		0.7	-1.29°C ± 0.35
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	-0.7	1.5	-1.0	-1.4	-0.9	-0.9	1.4	-0.3	1.0		0.2	0.3	0.7	3.36°C ± 1.19
J	-1.0	1.3	-0.8	-0.6	-1.6		1.5	0.0	-0.2		-0.1	0.4	1.0	8.34°C ± 1.44
J	-0.1		-1.2	-1.3	-0.8		1.9	0.3	0.7		0.1	-0.3	0.7	14.35°C ± 1.22
A		-1.2	-1.2	-0.4	0.1		-0.5	-0.2	1.3		0.5	-0.2	1.9	16.15°C ± 1.21
S	0.4	-0.8		0.3	-0.7		0.2	-1.9	0.8		0.7	-0.6	1.6	12.96°C ± 1.20
O	-1.0	0.8	-1.1	1.0	0.3		-0.0	-0.8	-0.4		-0.6		1.9	8.46°C ± 0.86
N	0.3	-0.9	-1.8	-1.1	-0.1	0.4	1.0	-0.4	0.3			1.4	1.1	4.84°C ± 0.86
D	0.3	-0.3	-1.3	-1.1	-0.1	0.2	1.4	-1.3	-0.5		1.9	0.6	0.2	2.04°C ± 0.68

Cabot Strait / Détroit de Cabot

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
J	-0.0	-0.6	-0.3	-1.7	-0.3	-0.2	1.1	-0.4				1.9	0.5	1.68°C ± 0.79
F	-1.0	0.1	0.1	-2.0	-0.3	0.9	1.3	-0.9	-0.5		0.2	0.9	1.2	0.08°C ± 0.80
M	0.0	-0.0	-0.5	-2.1	0.1	0.8	-0.1	-0.8	-0.2		1.2		1.6	-0.30°C ± 0.64
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	-0.8	0.3	-1.2	-1.1	-0.8	-0.5	1.6	-0.5	0.2		0.2	0.8	1.8	3.39°C ± 0.93
J	-0.1	0.7	-0.8	-0.7	-1.4		1.4	-0.0	-0.2		-0.8	-0.1	1.9	7.52°C ± 1.26
J			-1.3	-0.4	-0.4		1.4	0.2	1.0		-0.5	-1.1	1.1	13.12°C ± 1.27
A		1.1	-0.2	-1.2	-0.4		0.1	-1.2	0.6		0.8	-1.1	1.5	16.68°C ± 1.05
S	-0.6	0.7		-1.6	-1.0		0.7	-1.1	1.3		0.9	-0.0	0.8	13.52°C ± 1.07
O	-0.7	1.2	-1.9	1.0	0.0	0.6	0.4	-1.5	-0.3		0.6		0.5	9.59°C ± 1.45
N	0.2	-0.0	-2.3	-0.7	0.4	0.7	0.9	-1.0	0.6			0.1	1.2	6.63°C ± 1.40
D	0.0	-0.2	-2.0	-0.9	-0.4	0.4	0.6	-1.1	0.5		1.6	0.4	1.1	4.12°C ± 1.01



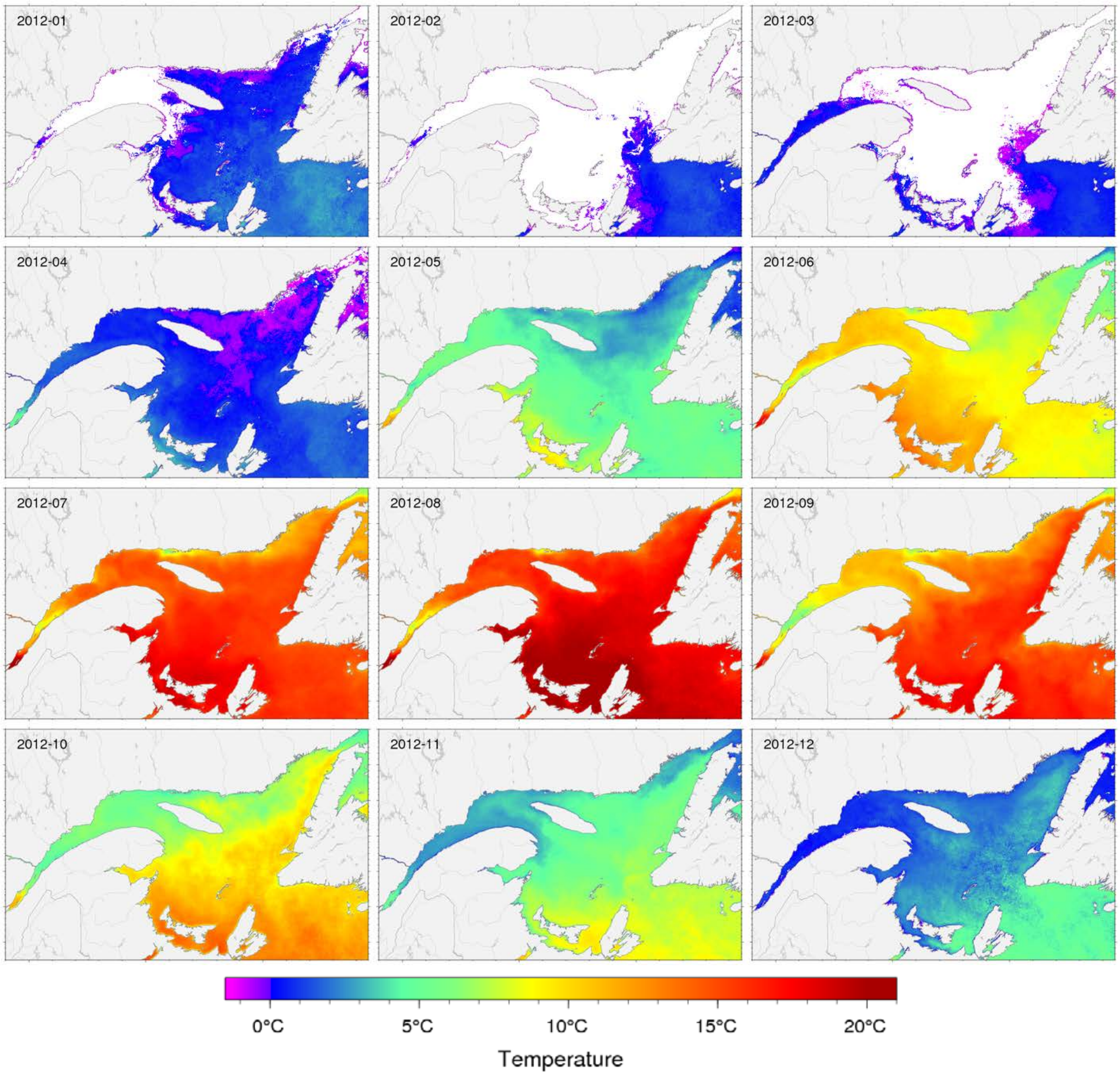


Figure 12. Sea-surface temperature monthly averages for 2012 as observed with NOAA AVHRR remote sensing. White areas have no data for the period due to ice cover.

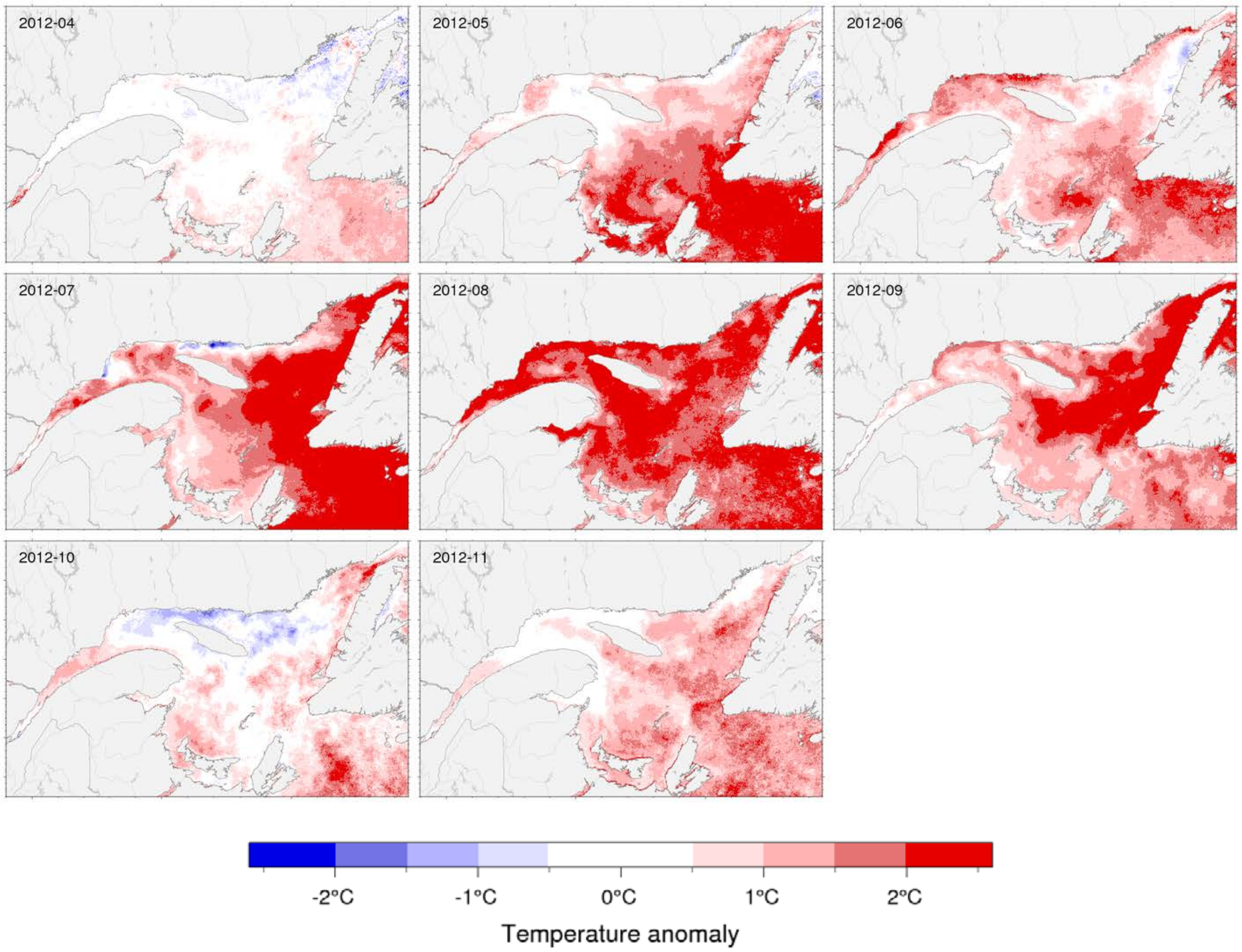


Figure 13. Sea-surface temperature monthly anomalies for April through November 2012 based on monthly climatologies calculated for the 1985–2010 period observed with NOAA AVHRR remote sensing. Only ice-free months are shown.

Table 4. 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 2011 and 2012 (April results are also shown for the Northwest Gulf). The scorecards are colour-coded according to the monthly normalized anomalies based on the 1985–2010 climatologies foreach month, but the numbers are the monthly average temperatures in ºC.

	2011									2012										
	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N
GSL		3.5	8.2	13.0	15.4	12.6	8.6	5.5						4.6	9.4	15.1	17.3	14.0	8.8	5.3
1 - Estuary		4.6	8.9	11.6	11.4	8.0	5.3	3.0						5.5	9.6	12.1	12.3	8.1	5.4	2.6
2 - Northwest Gulf	0.5	4.0	9.3	13.5	14.2	10.6	7.4	4.3					0.8	4.5	10.2	14.3	15.7	11.4	6.3	3.4
3 - Anticosti Channel		2.0	7.1	12.3	14.6	10.6	7.1	4.6						3.1	8.0	13.4	15.7	12.6	6.8	4.5
4 - Mécatina Trough		1.8	5.8	9.9	12.7	9.9	6.2	2.5						2.2	6.7	11.8	14.5	12.1	7.1	3.1
5 - Esquiman Channel		2.4	6.7	11.5	15.2	12.5	7.1	3.9						3.6	7.7	14.5	17.0	14.8	8.6	5.4
6 - Central Gulf		2.7	7.5	12.4	15.8	13.5	9.2	6.2						4.0	8.9	15.6	18.1	15.2	9.0	5.7
7 - Cabot Strait		3.8	7.1	12.1	15.6	14.3	10.0	7.0						5.0	9.3	15.7	18.5	15.2	10.6	7.3
8 - Magdalen Shallows		4.9	9.7	15.3	17.4	14.8	10.8	7.4						6.0	11.3	17.2	19.6	16.0	11.1	6.6
PMSSL (Saguenay)		3.3	10.2	13.2	12.3	9.7	5.2	2.4						5.5	10.7	13.7	12.8	8.8	4.1	0.4
PMSSL (Estuary)		4.6	8.1	10.0	10.0	7.6	5.1	3.0						4.8	8.6	9.9	9.6	7.0	5.1	2.8
St. Lawrence Estuary MPA		4.8	8.9	11.2	11.2	8.2	5.3	3.1						5.8	9.7	11.4	11.6	7.9	5.4	2.7
Manicouagan MPA		4.9	9.6	12.4	11.9	8.3	6.0	3.1						5.6	10.8	12.7	13.5	8.8	5.6	2.5

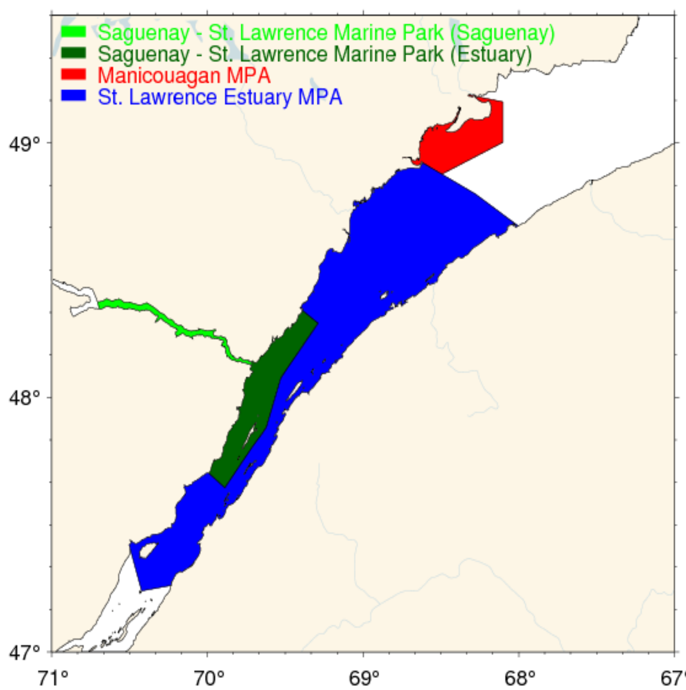


Figure 14. Map showing the proposed Manicouagan MPA, the proposed St. Lawrence Estuary MPA, and the Saguenay – St. Lawrence Marine Park for the purpose of SST extraction from NOAA imagery (Table 4).

Table 5. 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 Northeast Gulf because those regions are typically ice-free by then. 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	2012	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	4.6	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	9.4	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	15.1	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	17.3	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	14.0	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	8.8	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	5.3	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	10.7	9.43°C ±0.67
1 - Estuary	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	5.5	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	9.6	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	12.1	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	12.3	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	8.1	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	5.4	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	2.6	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	7.9	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	0.8	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	4.5	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	10.2	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	14.3	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	15.7	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	11.4	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	6.3	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	3.4	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	9.4	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	3.1	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	8.0	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	13.4	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	15.7	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	12.6	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	6.8	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	4.5	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	9.2	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	2.2	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	6.7	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	11.8	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	14.5	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	12.1	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	7.1	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	3.1	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	8.2	7.05°C ±0.81

Table 6. 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	2012	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	3.6	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	7.7	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	14.5	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	17.0	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	14.8	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	8.6	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	5.4	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	10.2	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	4.0	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	8.9	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	15.6	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	18.1	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	15.2	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	9.0	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	5.7	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	10.9	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	5.0	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	9.3	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	15.7	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	18.5	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	15.2	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	10.6	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	7.3	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	11.7	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	6.0	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	11.3	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	17.2	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	19.6	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	16.0	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	11.1	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	6.6	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	12.5	11.40°C ± 0.66

Table 7. 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	2012	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	4.6	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	9.4	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	15.1	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	17.3	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	14.0	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	8.8	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	5.3	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	10.7	9.43°C ± 0.67
1 - Estuary	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	5.5	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	9.6	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	12.1	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	12.3	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	8.1	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	5.4	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	2.6	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	7.9	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	0.8	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	4.5	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	10.2	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	14.3	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	15.7	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	11.4	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	6.3	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	3.4	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	9.4	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	3.1	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	8.0	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	13.4	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	15.7	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	12.6	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	6.8	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	4.5	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	9.2	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	2.2	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	6.7	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	11.8	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	14.5	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	12.1	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	7.1	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	3.1	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	8.2	7.05°C ± 0.81

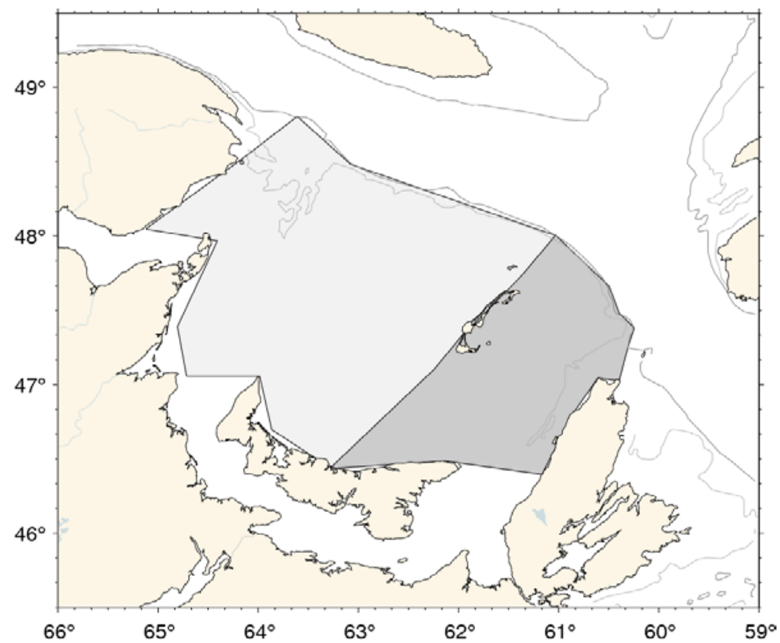


Figure 15. Areas defined as the western and eastern Magdalen Shallows.

Table 8. 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.

		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	2012	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	6.0	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	11.3	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	17.2	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	19.6	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	16.0	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	11.1	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	6.6	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	5.1	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	10.7	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	17.1	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	19.8	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	16.3	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	11.3	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	7.2	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	5.5	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	10.8	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	16.9	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	19.3	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	15.6	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	10.3	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	5.9	5.03°C ± 0.81

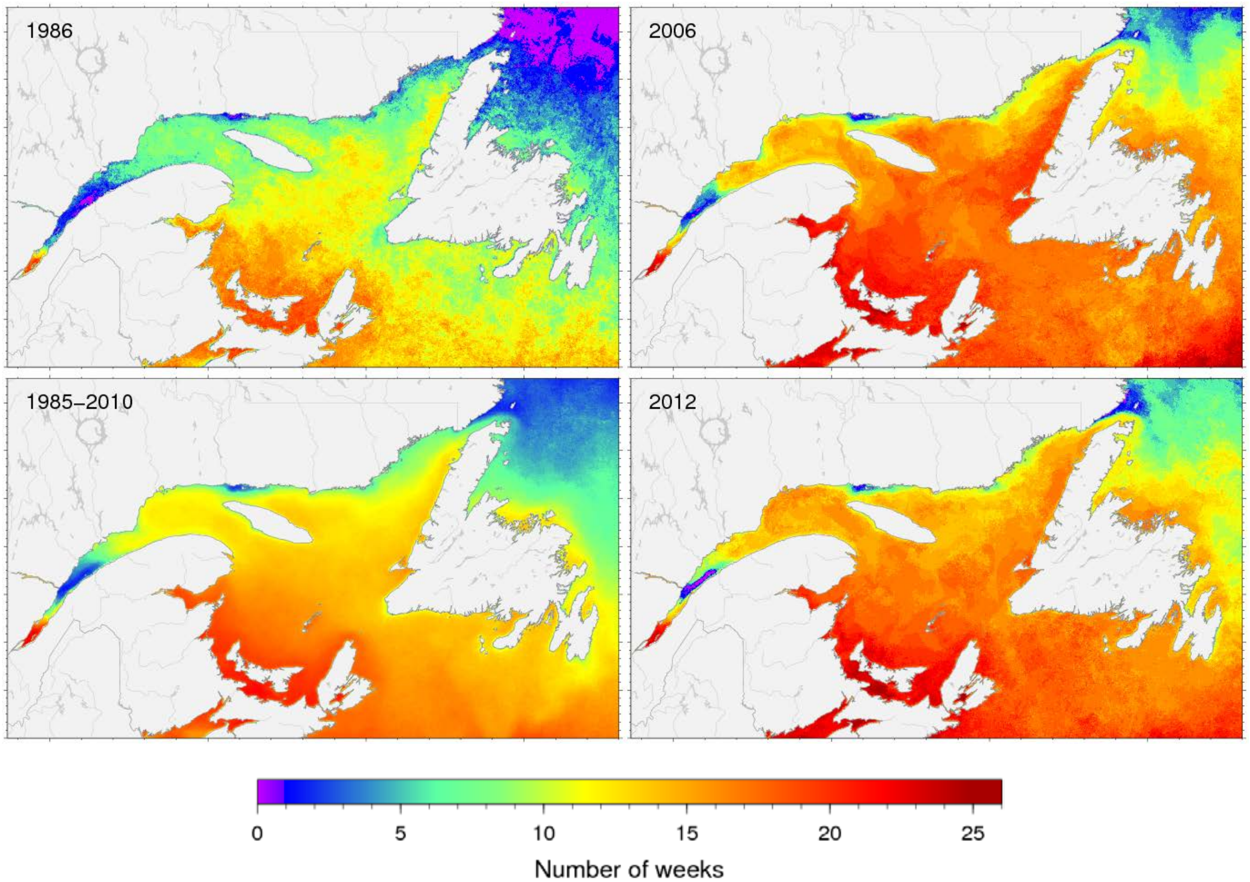


Figure 16. Yearly number of weeks with mean weekly surface temperature >10°C. Years with the minimum (1986, top left) and maximum (2006, top right) number of weeks are shown along with the 1985–2010 climatological average (lower left) and the chart for 2012.

Table 9. 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.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
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
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
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
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
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
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
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
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
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

	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
Gulf of St. Lawrence	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	15.9	13.5 w ± 1.6
1 - Estuary	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	10.3	6.9 w ± 1.6
2 - Northwest Gulf	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	14.6	11.9 w ± 1.9
3 - Anticosti Channel	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	13.2	11.3 w ± 2.0
4 - Mécatina Trough	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	12.0	8.2 w ± 2.7
5 - Esquiman Channel	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	15.2	12.2 w ± 2.1
6 - Central Gulf	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	16.2	13.8 w ± 1.6
7 - Cabot Strait	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	17.4	14.7 w ± 1.9
8 - Magdalen Shallows	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	19.0	17.2 w ± 1.5

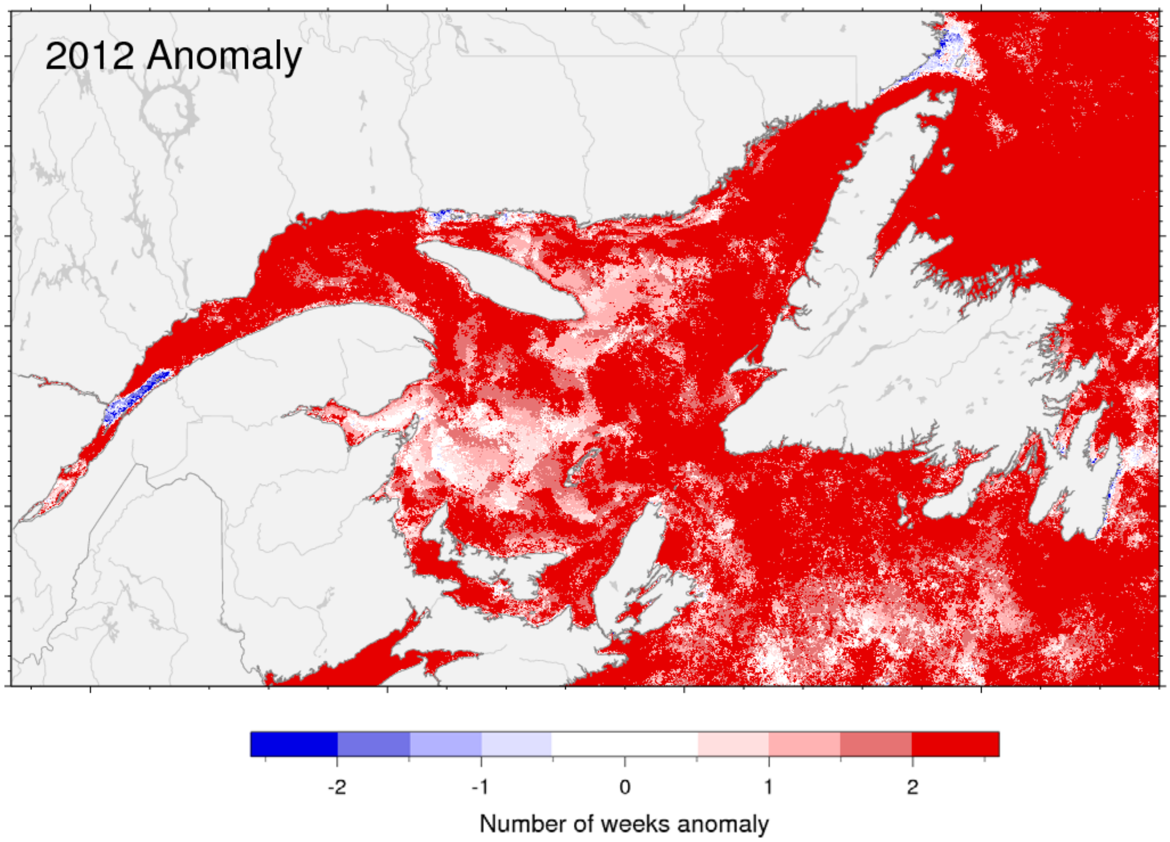


Figure 17. Anomaly of the number of weeks in 2012 with mean weekly surface temperature >10°C using the 1985–2010 climatological average from Figure 16.

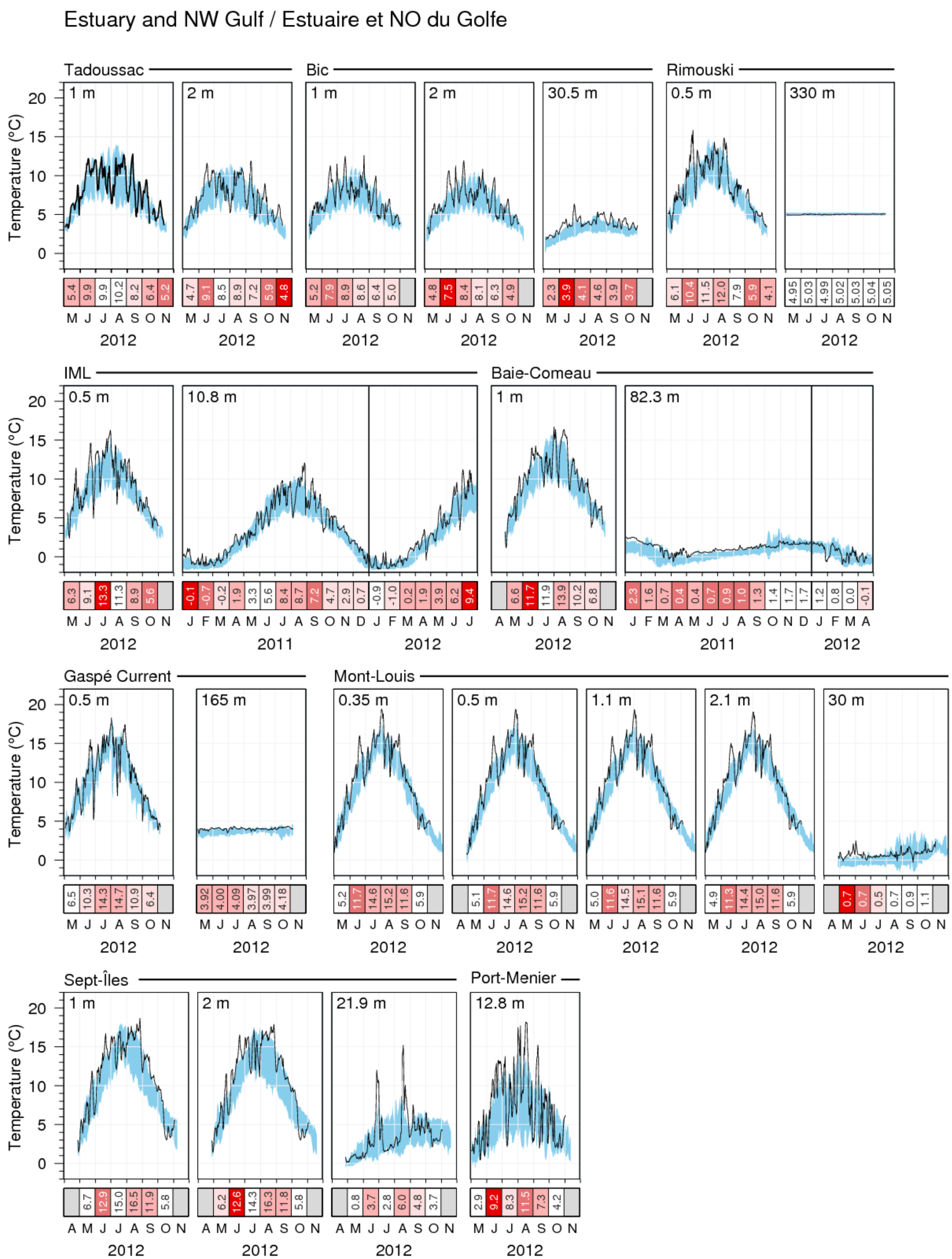


Figure 18. Thermograph network data. Daily mean 2012 temperatures compared with the daily climatology (daily averages ± 1 SD; blue areas) for stations in the Estuary and northwestern Gulf. Scorecards show monthly average temperature. Data from 2011 are included if they were not shown in the previous report.

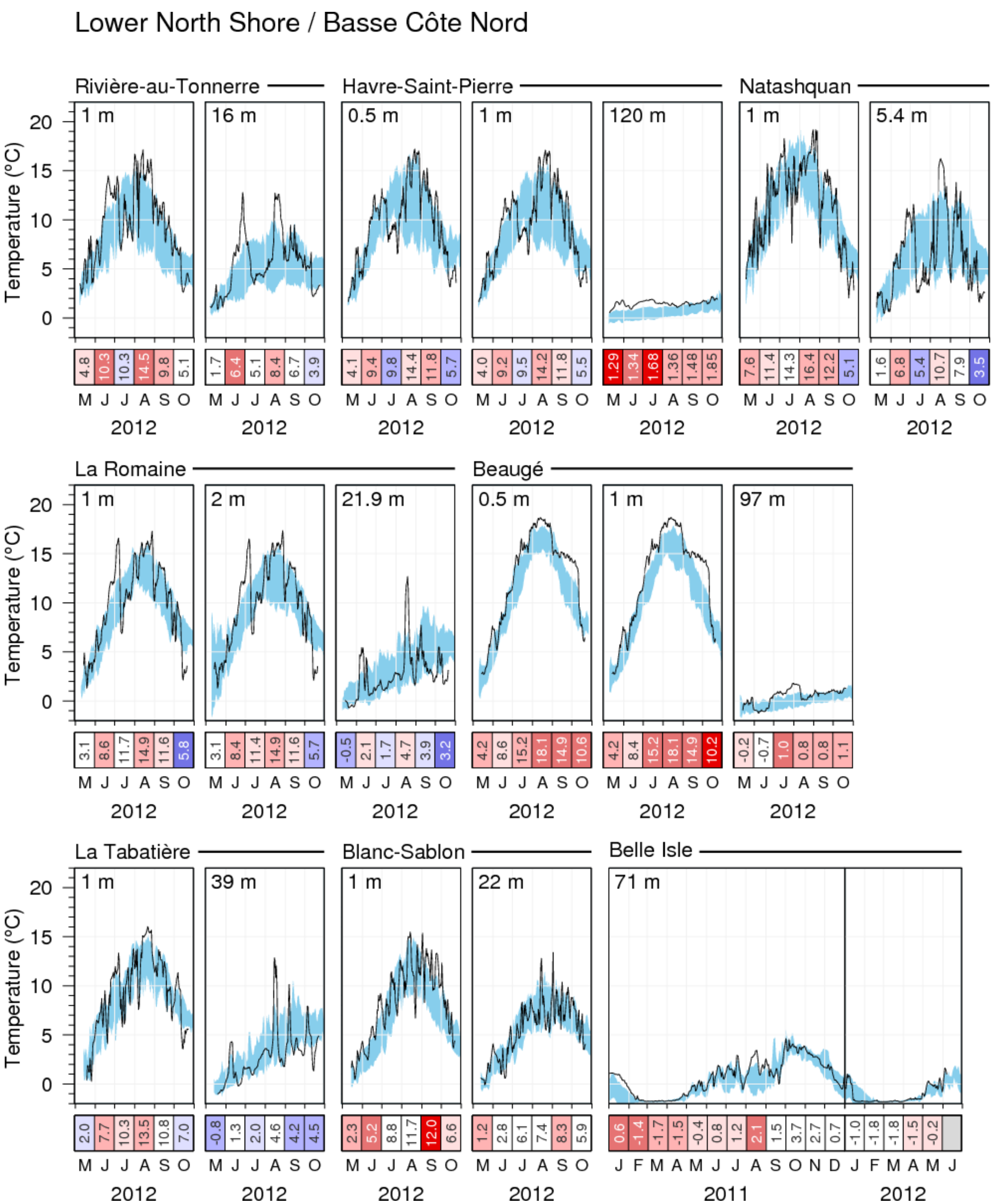


Figure 19. Thermograph network data. Daily mean 2012 temperatures compared with the daily climatology (daily averages ± 1 SD; blue areas) for stations of the lower north shore.

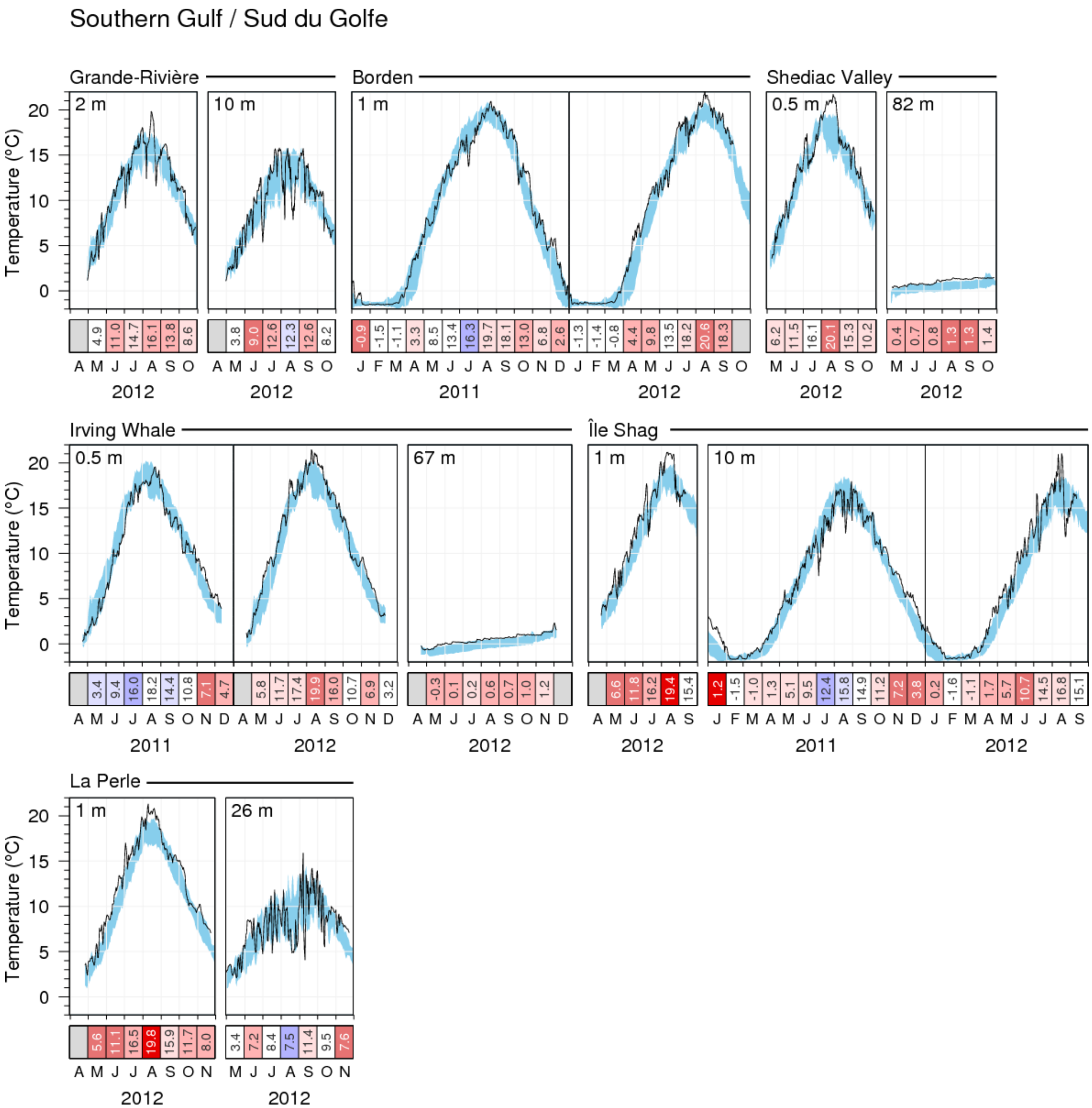


Figure 20. Thermograph network data. Daily mean 2012 temperatures compared with the daily climatology (daily averages ± 1 SD; blue area) for stations of the southern Gulf.

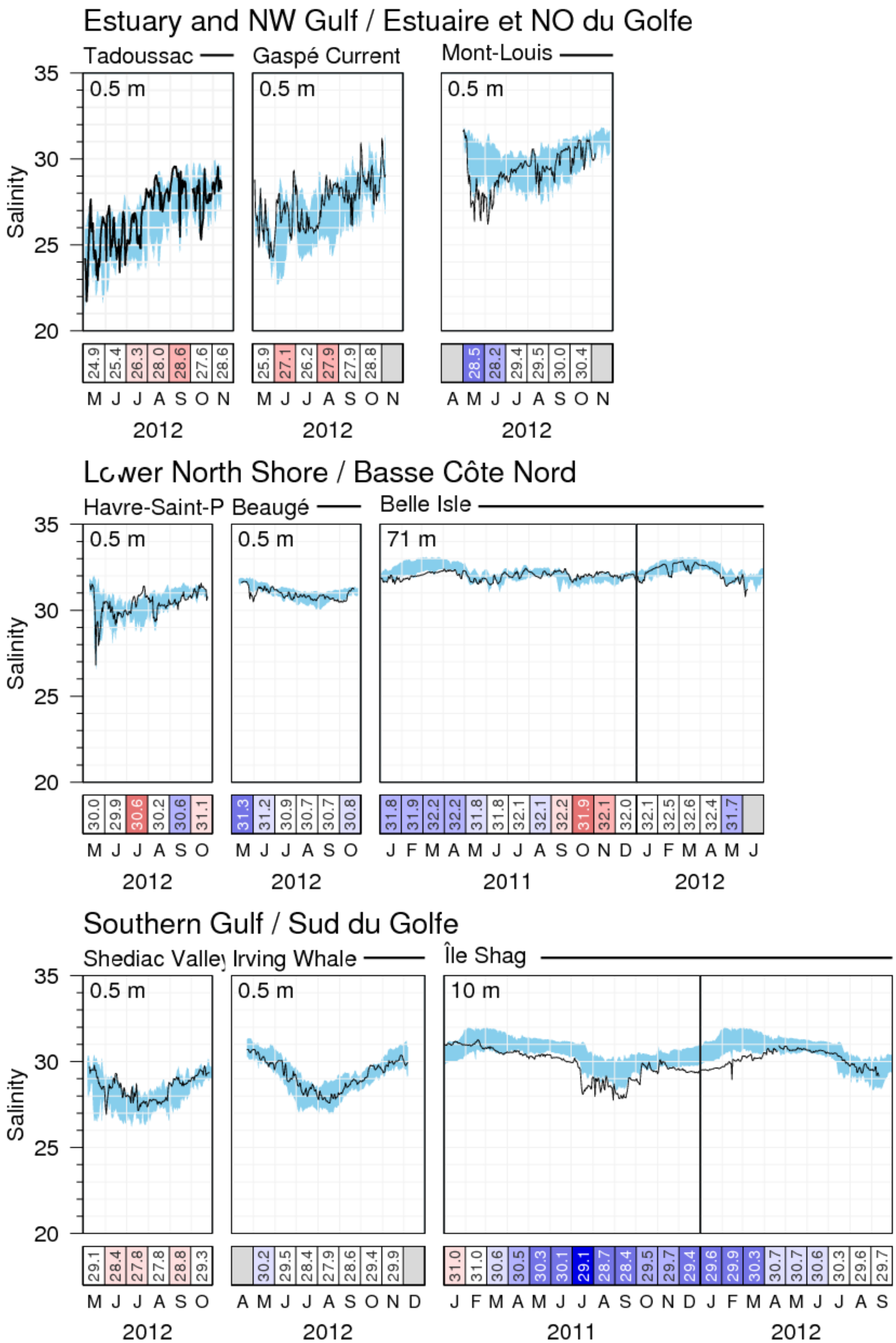


Figure 21. Thermograph network data. Daily mean 2012 salinities compared with the daily climatology (daily averages ± 1 SD; blue area) computed from all available stations.

Table 10. Monthly mean temperatures at all shallow sensors of the Maurice Lamontagne Institute thermograph network in 2011 and 2012. 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

		J 2011	F 2011	M 2011	A 2011	M 2011	J 2011	J 2011	A 2011	S 2011	O 2011	N 2011	D 2011	J 2012	F 2012	M 2012	A 2012	M 2012	J 2012	J 2012	A 2012	S 2012	O 2012	N 2012	D 2012	
Tadoussac	1 m					4.7	9.4	10.1	12.0	8.9	5.7							5.4	9.9	9.9	10.2	8.2	6.4	5.2		7 y
	2 m					4.4	8.7	8.8	10.8	7.6	5.2							4.7	9.1	8.5	8.9	7.2	5.9	4.8		15 y
Bic	1 m					4.6	7.6	9.1	9.5	7.5	4.9							5.2	7.9	8.9	8.6	6.4	5.0			16 y
	2 m					4.4	7.2	8.7	9.2	7.1	4.9							4.8	7.5	8.4	8.1	6.3	4.9			19 y
Rimouski	0.5 m					5.0	8.9	11.4	12.1	8.6	5.6							6.1	10.4	11.5	12.0	7.9	5.9	4.1		12 y
IML	0.5 m					4.6	8.2	12.5	11.0	9.7	5.4							6.3	9.1	13.3	11.3	8.9	5.6			19 y
	10.8 m	-0.1	-0.7	-0.2	1.9	3.3	5.6	8.4	8.7	7.2	4.7	2.9	0.7	-0.9	-1.0	0.2	1.9	3.9	6.2	9.4						19 y
Baie-Comeau	1 m					5.3	10.0	12.7	14.2	9.3	7.2							6.6	11.7	11.9	13.9	10.2	6.8			14 y
Gaspé Current	0.5 m					4.6	9.6	13.9	13.7	10.8	6.7							6.5	10.3	14.3	14.7	10.9	6.4			8 y
Mont-Louis	0.35 m					5.1	9.9	13.7	14.5	11.3	8.0							5.2	11.7	14.6	15.2	11.6	5.9			12 y
	0.5 m					5.2	9.9	13.6	14.4	11.3	8.0							5.1	11.7	14.6	15.2	11.6	5.9			20 y
	1.1 m					5.1	9.9	13.6	14.4	11.3	8.0							5.0	11.6	14.5	15.1	11.6	5.9			14 y
	2.1 m					5.0	9.6	13.5	14.2	11.2	8.0							4.9	11.3	14.4	15.0	11.6	5.9			14 y
Sept-Îles	1 m					6.0	10.7	16.0	16.3	10.4	6.7							6.7	12.9	15.0	16.5	11.9	5.8			11 y
	2 m					5.4	10.2	15.5	16.0	10.2	6.7							6.2	12.6	14.3	16.3	11.8	5.8			17 y
Port-Menier	12.8 m					3.2	6.6	8.2	11.1	6.2	6.3							2.9	9.2	8.3	11.5	7.3	4.2			14 y

Lower North Shore / Basse Côte Nord

		J 2011	F 2011	M 2011	A 2011	M 2011	J 2011	J 2011	A 2011	S 2011	O 2011	N 2011	D 2011	J 2012	F 2012	M 2012	A 2012	M 2012	J 2012	J 2012	A 2012	S 2012	O 2012	N 2012	D 2012	
Rivière-au-Tonnerre	1 m					4.2	8.1	12.0	14.5	7.1	4.9							4.8	10.3	10.3	14.5	9.8	5.1			14 y
	16 m					2.1	4.8	6.8	9.3	4.5	4.0							1.7	6.4	5.1	8.4	6.7	3.9			17 y
Havre-Saint-Pierre	0.5 m					3.4	7.8	11.8	14.2	8.3	5.8							4.1	9.4	9.8	14.4	11.8	5.7			9 y
	1 m					3.3	7.7	11.6	14.1	8.2	5.6							4.0	9.2	9.5	14.2	11.8	5.5			16 y
Natashquan	1 m					5.6	10.4	14.9	17.0	9.5	5.1							7.6	11.4	14.3	16.4	12.2	5.1			19 y
	5.4 m					1.8	6.2	8.5	12.4	4.5	4.4							1.6	6.8	5.4	10.7	7.9	3.5			17 y
La Romaine	1 m					2.7	7.0	12.4	14.4	7.8	6.8	5.9						3.1	8.6	11.7	14.9	11.6	5.8			15 y
	2 m					2.6	6.9	12.3	14.4	7.8	6.8	5.9						3.1	8.4	11.4	14.9	11.6	5.7			19 y
Beaugé	0.5 m					2.3	6.5	11.8	16.2	12.7								4.2	8.6	15.2	18.1	14.9	10.6			8 y
	1 m					2.3	6.4	11.8	16.3	12.8								4.2	8.4	15.2	18.1	14.9	10.2			15 y
La Tabatière	1 m					3.6	7.6	9.6	11.9	7.9	7.3							2.0	7.7	10.3	13.5	10.8	7.0			11 y
Blanc-Sablon	1 m					1.5	2.9	5.0	10.7	10.1	4.9							2.3	5.2	8.8	11.7	12.0	6.6			14 y

Southern Gulf / Sud du Golfe

		J 2011	F 2011	M 2011	A 2011	M 2011	J 2011	J 2011	A 2011	S 2011	O 2011	N 2011	D 2011	J 2012	F 2012	M 2012	A 2012	M 2012	J 2012	J 2012	A 2012	S 2012	O 2012	N 2012	D 2012	
Grande-Rivière	2 m					4.7	10.7	14.5	14.7	13.8	9.6							4.9	11.0	14.7	16.1	13.8	8.6			19 y
	10 m					3.9	8.4	11.8	11.4	13.0	9.0							3.8	9.0	12.6	12.3	12.6	8.2			17 y
Borden	1 m	-0.9	-1.5	-1.1	3.3	8.5	13.4	16.3	19.7	18.1	13.0	6.8	2.6	-1.3	-1.4	-0.8	4.4	9.8	13.5	18.2	20.6	18.3				15 y
Shediac Valley	0.5 m																	6.2	11.5	16.1	20.1	15.3	10.2			8 y
Irving Whale	0.5 m					3.4	9.4	16.0	18.2	14.4	10.8	7.1	4.7					5.8	11.7	17.4	19.9	16.0	10.7	6.9	3.2	14 y
Île Shag	1 m					5.6	10.0	14.1	17.3	15.6								6.6	11.8	16.2	19.4	15.4				15 y
	10 m	1.2	-1.5	-1.0	1.3	5.1	9.5	12.4	15.8	14.9	11.2	7.2	3.8	0.2	-1.6	-1.1	1.7	5.7	10.7	14.5	16.8	15.1				22 y
La Perle	1 m					4.4	8.5	13.8	17.4	15.1	11.4	7.1						5.6	11.1	16.5	19.8	15.9	11.7	8.0		17 y

Table 11. Monthly mean temperatures at all sensors deeper than 20 m of the Maurice Lamontagne Institute thermograph network in 2011 and 2012.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

		2011 J	F	M	A	M	J	J	A	S	O	N	D	2012 J	F	M	A	M	J	J	A	S	O	N	D	
Bic	30.5 m					1.8	3.3	3.9	4.9	3.7	3.3							2.3	3.9	4.1	4.6	3.9	3.7			17 y
Rimouski	330 m					4.827	4.806	4.801	4.845	4.910	4.884							4.952	5.025	4.992	5.020	5.026	5.037	5.047		8 y
Baie-Comeau	82.3 m	2.3	1.6	0.7	0.4	0.4	0.7	0.9	1.0	1.3	1.4	1.7	1.7	1.2	0.8	0.0	-0.1									12 y
Gaspé Current	165 m					3.2	3.3	3.5	3.7	3.9	3.7							3.9	4.0	4.1	4.0	4.0	4.2			8 y
Mont-Louis	30 m					0.1	0.2	0.7	3.9	6.4	4.0							0.7	0.7	0.5	0.7	0.9	1.1			17 y
Sept-Îles	21.9 m					1.7	4.3	4.6	7.4	2.8	3.8							0.8	3.7	2.8	6.0	4.8	3.7			16 y

Lower North Shore / Basse Côte Nord

		2011 J	F	M	A	M	J	J	A	S	O	N	D	2012 J	F	M	A	M	J	J	A	S	O	N	D	
Havre-Saint-Pierre	120 m					0.3	0.5	0.9	1.0	1.4	1.5							1.3	1.3	1.7	1.4	1.5	1.9			15 y
La Romaine	21.9 m					0.7	3.4	3.5	3.0	2.4	6.1	4.9						-0.5	2.1	1.7	4.7	3.9	3.2			16 y
Beaugé	97 m																	-0.2	-0.7	1.0	0.8	0.8	1.1			13 y
La Tabatière	39 m					0.5	2.3	2.0	2.2	3.4	5.6							-0.8	1.3	2.0	4.6	4.2	4.5			11 y
Blanc-Sablon	22 m					0.5	2.5	4.0	6.7	7.9	4.7							1.2	2.8	6.1	7.4	8.3	5.9			13 y
Belle Isle	71 m	0.6	-1.4	-1.7	-1.5	-0.4	0.8	1.2	2.1	1.5	3.7	2.7	0.7	-1.0	-1.8	-1.8	-1.5	-0.2								6 y

Southern Gulf / Sud du Golfe

		2011 J	F	M	A	M	J	J	A	S	O	N	D	2012 J	F	M	A	M	J	J	A	S	O	N	D	
Shediac Valley	82 m																	0.4	0.7	0.8	1.3	1.3	1.4			7 y
Irving Whale	67 m					-0.5	-0.0	0.3	0.5	0.6	0.8	1.2						-0.3	0.1	0.2	0.6	0.7	1.0	1.2		11 y
La Perle	26 m																	3.4	7.2	8.4	7.5	11.4	9.5	7.6		13 y

Table 12. Ti network. The colour- me series of the monthly averaged temperature anomalies for selected stations of the thermograph 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	2012	Mean ± SD
Natashquan - 1 m	M								4.8	7.4	6.0			7.1		4.6	6.6	5.3	5.7	5.6	7.6	6.08°C ± 1.06
	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	11.4	10.59°C ± 1.25
	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	14.3	14.42°C ± 0.94
	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	16.4	14.15°C ± 1.80
	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	12.2	10.50°C ± 1.61
	O		7.8	6.9	6.2		4.9	7.0	4.6	7.1	4.4	8.3	8.0	8.6	7.5	6.9	7.4		7.3	5.1	5.1	6.66°C ± 1.33
La Tabatière - 1 m	M										0.6					1.3		2.1	3.0	3.6	2.0	2.11°C ± 1.09
	J										5.4	5.6	5.4	7.3	6.7	5.5	7.0	7.3	4.6	7.6	7.7	6.38°C ± 1.10
	J										7.9	10.2	8.3	9.1	10.4	8.8	9.1	11.8	9.2	9.6	10.3	9.53°C ± 1.09
	A										11.7	12.8	10.9	11.0	12.5	12.0	13.8	11.4	12.3	11.9	13.5	12.18°C ± 0.92
	S										10.0	10.9	11.0	12.1	11.4	9.1	11.0	9.7	11.1	7.9	10.8	10.46°C ± 1.20
	O											7.2	6.9	7.6	7.9	6.3	8.2		7.1	7.3	7.0	7.27°C ± 0.55
Blanc-Sablon - 1m	M										0.2								0.6	1.5	2.3	1.13°C ± 0.95
	J							4.7	4.2	2.8	3.2	2.5	1.8	3.9	4.6	2.2	3.2	4.6	2.2	2.9	5.2	3.45°C ± 1.10
	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	8.8	8.09°C ± 1.50
	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	11.7	11.51°C ± 0.93
	S							9.2	9.9	8.3	7.3	8.9	8.1	9.9	9.0	8.7	10.1	7.7	7.9	10.1	12.0	9.07°C ± 1.24
	O							5.0	5.0	6.8	2.9	7.4	4.4	6.0	6.4	3.8	6.3		5.9	4.9	6.6	5.50°C ± 1.29
Irving Whale - 0.5 m	M						6.0			3.8	3.9		3.3	1.8	6.9	3.7			5.4	3.4	5.8	4.40°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	11.7	10.62°C ± 1.33
	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	17.4	16.81°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	19.9	18.01°C ± 1.03
	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	16.0	15.00°C ± 0.85
	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	10.7	10.53°C ± 0.97
	N						4.5	5.1		5.4	5.1	4.8				6.0			5.7	7.1	6.9	5.64°C ± 0.91
	D						2.3	3.8												4.7	3.2	3.49°C ± 1.02
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	0.2	-0.78°C ± 0.79
	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	-1.6	-1.54°C ± 0.20
	M		-1.7	-1.5	-1.5	-1.6	-1.1	-1.4	-0.8	-0.8	-1.3	-1.2	-1.5	-1.4	-0.8	-1.5	-1.6			-1.0	-1.1	-1.29°C ± 0.29
	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	1.7	0.62°C ± 0.92
	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	5.7	4.56°C ± 0.96
	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	10.7	8.90°C ± 1.03
	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	14.5	13.61°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	16.8	16.29°C ± 0.78
	S		14.5	13.1	15.6	14.8	13.2	15.9	15.2	16.1	14.9	14.9	13.7	15.9	15.3	13.1	14.3	14.6	14.4	14.9	15.1	14.70°C ± 0.91
	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	11.2		10.65°C ± 0.83
	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	7.2		6.14°C ± 0.62
	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	3.8		2.22°C ± 0.93

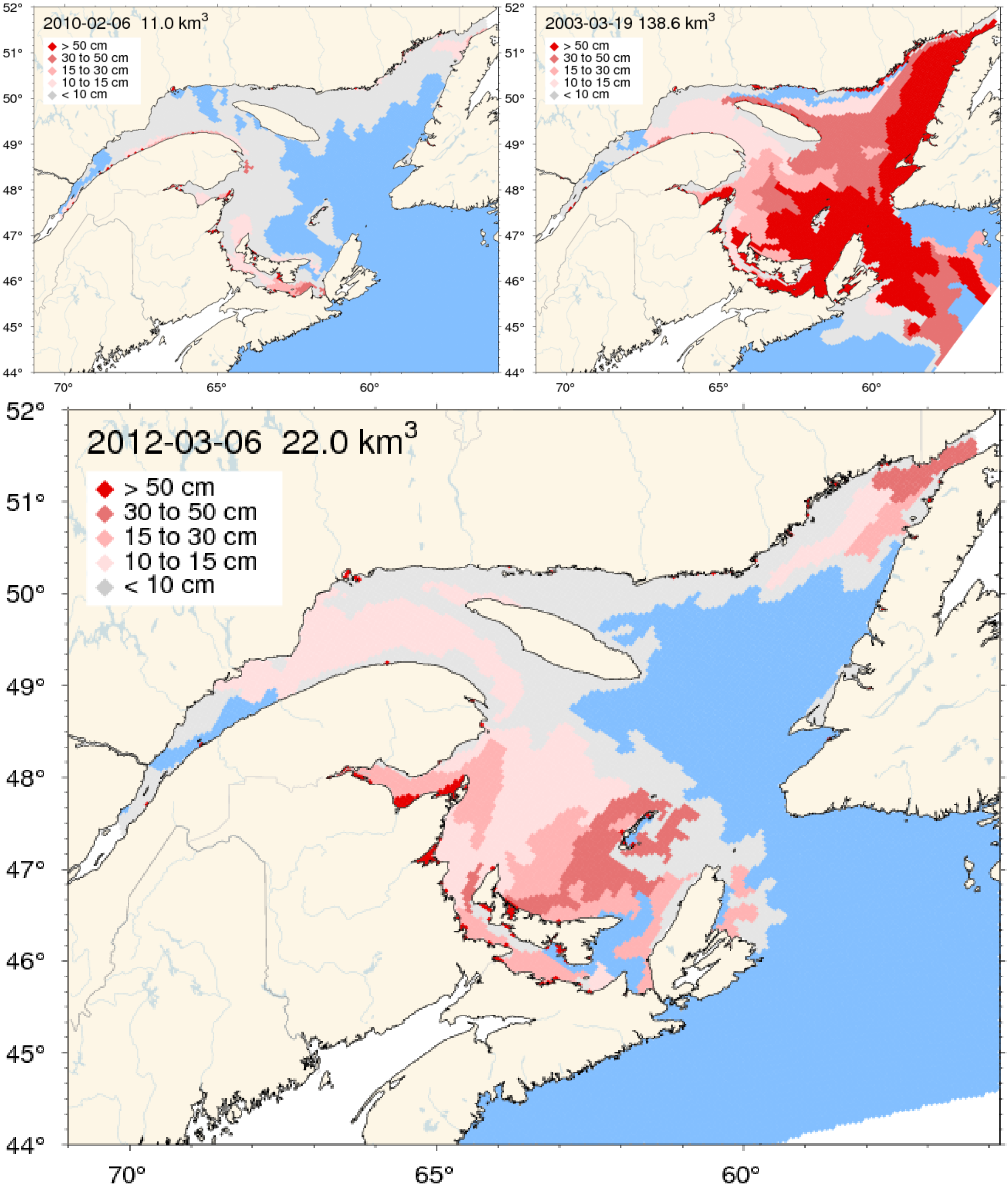


Figure 22. Ice thickness map for 2012 for the day of the year with the maximum annual volume (lower panel) and similarly for 2010 and 2003, the years with the smallest and largest annual ice volumes, respectively.

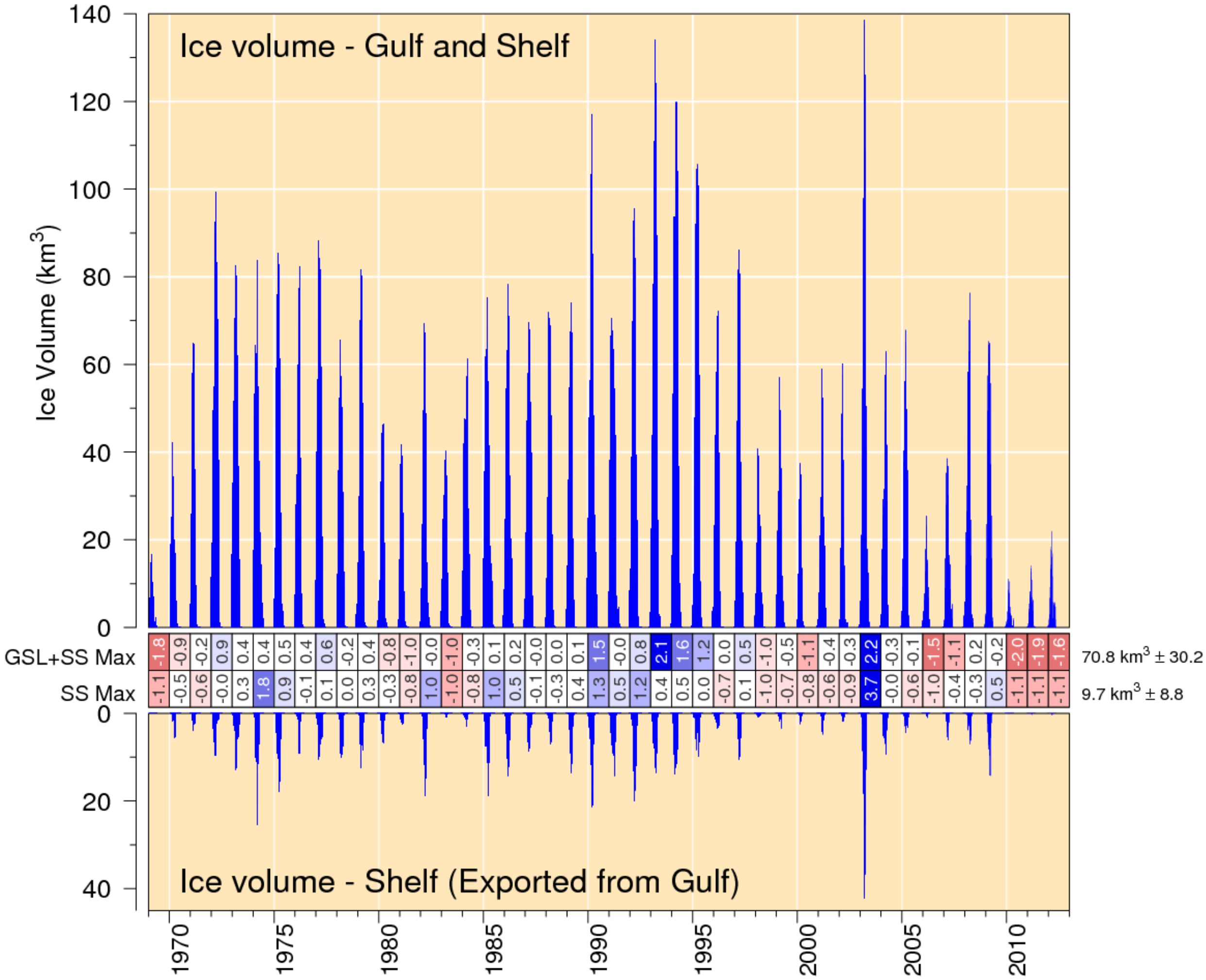


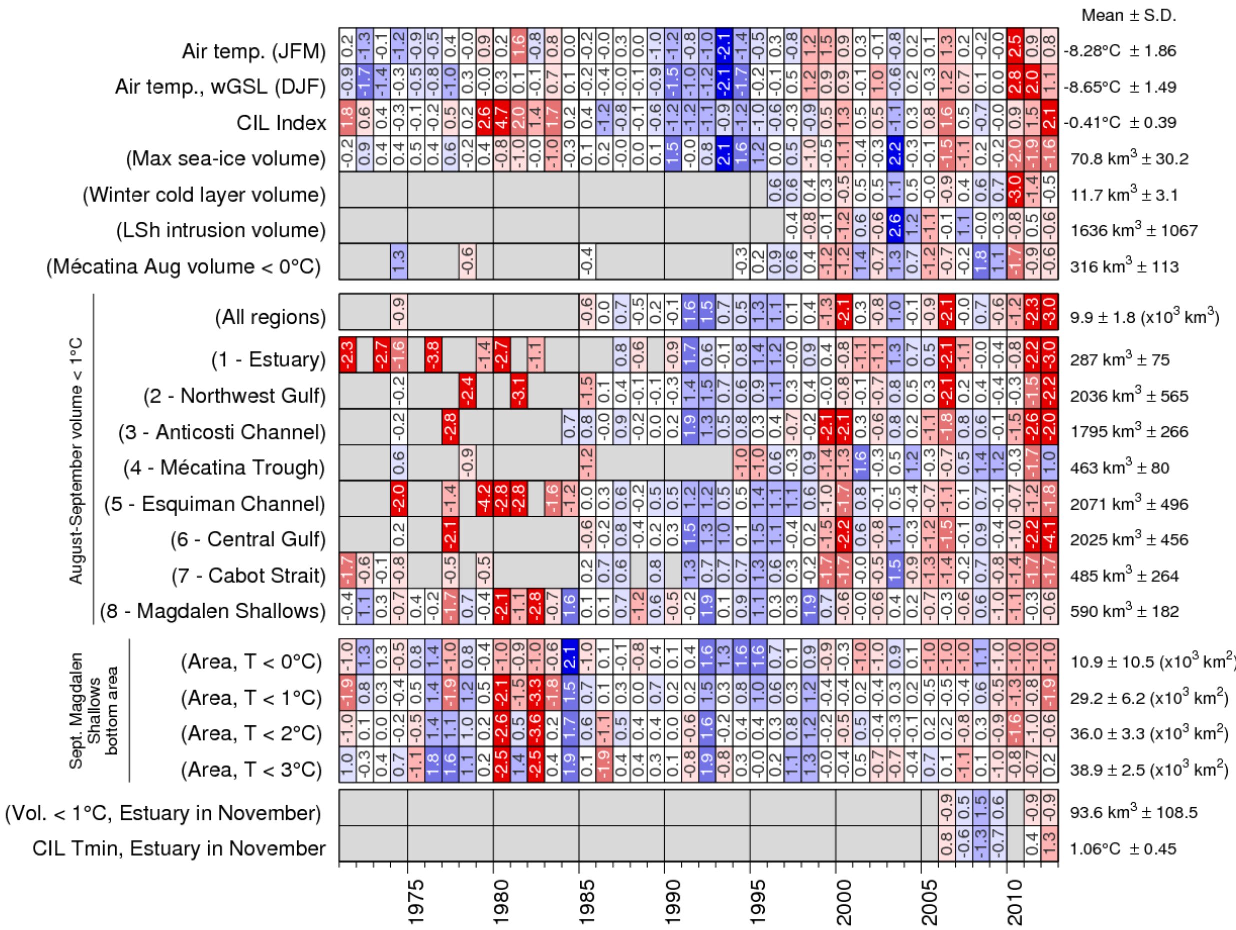
Figure 23. Estimated ice volume in the Gulf of St. Lawrence and on the Scotian Shelf seaward of Cabot Strait (upper panel) and on the Scotian Shelf only (lower panel). Scorecards show numbered normalized anomalies for the combined Gulf and Shelf and Shelf-only annual maximum volumes. The mean and standard deviation are indicated on the right side using the 1981–2010 climatology.

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.

	Region	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
First occurrence of ice	1 - Estuary	17	12	-10	0	-12	-3	-8	-5	-14		-21	-6	-24	-9	-12	3	2	-13	-14	-8	-5	-21
	2 - Northwest Gulf	17	12	15	0	-12	-3	8	-5	-14		-21	8	-15	14	9	3	2	-6	-14	-1	-5	-21
	3 - Anticosti Channel	57	12	15	0	-2	9	15	9	7	8	7	-6	22	14	-5	15	2	8	-14	24	-5	-21
	4 - Mécatina Trough	80	12	15	0	-12	9	8	-5	-7	8	-28	1	-1	21	-12	3	2	-13	-14	3	-5	-21
	5 - Esquiman Channel	80	58	15	14	-2	16	29	37	16	22	14	29	36	28	44	15	2	8	7	17	9	8
	6 - Central Gulf		37	15	21	3	16	29	16	16	22	14	36	8	42	23	15	23	15	21	24	16	1
	7 - Cabot Strait		30	29	28	15	23	29	37	16	29	42	36	15	28	51	36	23	22	35	31	30	8
	8 - Magdalen Shallows	17	12	-1	0	-12	9	8	9	-14	8	-21	8	-1	14	9	3	2	-6	-14	-1	-5	-21
Last occurrence of ice	1 - Estuary	80	84	64	101	71	72	78	93	86	99	84	80	55	77	100	99	79	78	84	87	79	71
	2 - Northwest Gulf	80	77	78	108	85	93	85	100	86	99	91	80	62	77	100	99	79	85	112	80	86	92
	3 - Anticosti Channel	57	98	71	136	99	149	127	121	100	127	105	92	83	140	93	129	128	134	119	129	86	148
	4 - Mécatina Trough	132	119	92	122	134	177	162	142	121	134	133	120	90	140	114	143	156	141	119	136	128	155
	5 - Esquiman Channel	80	119	85	129	120	163	141	121	128	134	77	99	62	119	86	129	149	127	119	108	121	155
	6 - Central Gulf		70	85	136	99	119	113	100	93	106	98	80	76	99	79	99	100	106	112	94	107	120
	7 - Cabot Strait		98	92	136	127	107	127	100	114	106	98	106	62	105	100	136	107	106	126	101	114	113
	8 - Magdalen Shallows	94	105	106	143	127	107	127	100	114	113	112	106	83	105	114	136	107	113	126	108	107	106
Duration of ice season	1 - Estuary	64	73	75	102	84	76	87	99	101	110	106	87	80	87	113	97	78	92	99	96	85	93
	2 - Northwest Gulf	64	66	64	109	98	97	78	106	101	105	113	73	78	64	92	97	78	92	127	82	92	114
	3 - Anticosti Channel	1	87	57	137	102	141	113	113	94	120	99	99	62	127	99	115	127	127	134	106	92	170
	4 - Mécatina Trough	53	108	78	123	147	169	155	148	129	127	162	120	92	120	127	141	155	155	134	134	134	177
	5 - Esquiman Channel	1	62	71	116	123	148	113	85	113	113	64	71	27	92	43	115	148	120	113	92	113	148
	6 - Central Gulf		34	71	116	97	104	85	85	78	85	85	45	69	58	57	85	78	92	92	71	92	120
	7 - Cabot Strait		69	64	109	113	85	99	64	99	78	57	71	48	78	50	101	85	85	92	71	85	106
	8 - Magdalen Shallows	78	94	108	144	140	99	120	92	129	106	134	99	85	92	106	134	106	120	141	110	113	128
Maximum ice volume (km^3)	1 - Estuary	1.6	1.6	1.9	2.2	2.3	2.0	2.5	1.7	2.1	2.1	5.3	1.2	2.6	2.6	2.4	2.0	2.1	1.6	2.4	2.2	1.9	1.4
	2 - Northwest Gulf	4	7	13	13	9	9	9	9	11	12	12	5	9	6	9	11	7	7	10	13	8	11
	3 - Anticosti Channel	1	4	7	13	8	8	6	7	8	5	8	4	3	4	3	7	5	6	7	5	6	10
	4 - Mécatina Trough	1	3	3	6	6	6	5	5	6	6	5	5	2	6	4	6	8	8	6	5	7	11
	5 - Esquiman Channel	1	4	7	17	13	18	19	20	18	8	12	6	4	13	4	9	15	15	14	16	18	36
	6 - Central Gulf	0	4	9	13	8	6	10	10	11	7	9	5	8	6	1	7	6	7	5	7	7	10
	7 - Cabot Strait	0	3	5	10	7	11	11	9	8	8	10	6	5	9	1	3	7	8	5	7	7	12
	8 - Magdalen Shallows	10	18	23	35	31	19	28	23	30	27	31	19	18	22	18	24	25	24	33	25	20	25
	Scotian Shelf	0	6	4	10	13	25	18	9	10	10	12	7	3	19	1	3	19	14	9	7	14	21
	GSL + Scotian Shelf	17	42	65	99	83	84	85	82	88	66	82	46	42	69	40	61	75	78	70	72	74	117

	Region	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Mean ± S.D.
First occurrence of ice	1 - Estuary	0	-12	-17	-4	2	-20	6	-9	-1	2	-5	5	-21	-21	-8	-12	14	-15	-19	-2	7	6	-8 ± 10
	2 - Northwest Gulf	7	-5	-3	3	16	8	6	3	3	11	12	18	8	3	0	2	24	6	7	19	27	13	4 ± 10
	3 - Anticosti Channel	7	2	4	-4	9	15	34	9	9	16	25	18	5	25	6	31	18	7	19	32	59	31	11 ± 13
	4 - Mécatina Trough	-11	-5	-3	3	2	-20	20	6	2	15	5	17	-2	25	10	-3	14	0	18	24	41	27	3 ± 13
	5 - Esquiman Channel	7	23	4	17	16	15	41	9	14	41	23	25	15	41	23	31	25	21	27	36	61	59	21 ± 12
	6 - Central Gulf	14	23	11	10	30	22	34	29	13	25	36	35	19	15	26	50	37	26	18			34	23 ± 11
	7 - Cabot Strait	21	23	25	17	44	36	41	40	34	39	50	41	25	25	31	59	37	46	25		65	45	32 ± 12
	8 - Magdalen Shallows	-7	-5	-3	3	2	-13	6	-2	2	15	4	17	7	10	5	33	18	1	5	24	26	19	3 ± 11
Last occurrence of ice	1 - Estuary	98	86	81	87	100	71	83	85	90	80	82	87	82	88	88	77	85	93	86	53	84	72	83 ± 11
	2 - Northwest Gulf	91	100	109	101	121	92	97	91	90	84	79	85	93	93	98	78	85	101	83	55	77	77	90 ± 14
	3 - Anticosti Channel	168	128	116	157	142	106	153	105	115	84	118	91	157	101	98	115	114	105	113	63	80	76	118 ± 25
	4 - Mécatina Trough	182	149	158	157	149	120	146	126	137	106	135	109	152	128	111	118	154	147	125	124	107	133	135 ± 20
	5 - Esquiman Channel	133	135	133	143	142	100	125	120	123	86	133	96	149	120	106	107	137	116	115	48	100	100	118 ± 24
	6 - Central Gulf	119	121	116	115	107	92	118	106	94	82	85	98	114	101	89	64	84	104	98			71	100 ± 15
	7 - Cabot Strait	119	135	123	108	121	100	132	91	114	79	114	91	115	112	115	85	88	114	104		83	74	108 ± 17
	8 - Magdalen Shallows	119	135	123	115	121	113	125	108	109	90	114	92	107	116	113	87	89	109	106	83	84	82	109 ± 14
Duration of ice season	1 - Estuary	99	99	99	92	99	92	78	95	92	79	88	83	104	110	97	90	72	109	106	56	78	67	92 ± 12
	2 - Northwest Gulf	85	106	113	99	106	85	92	89	88	74	68	68	86	91	99	77	62	96	77	37	51	65	87 ± 18
	3 - Anticosti Channel	162	127	113	162	134	92	120	97	107	69	94	74	153	77	93	85	97	99	95	32	22	46	108 ± 31
	4 - Mécatina Trough	194	155	162	155	148	141	127	121	136	92	131	93	155	104	102	122	141	148	108	101	67	107	134 ± 25
	5 - Esquiman Channel	127	113	130	127	127	86	85	112	110	46	111	72	135	80	84	77	113	96	89	13	40	42	98 ± 33
	6 - Central Gulf	106	99	106	106	78	71	85	78	82	58	50	64	96	87	64	15	48	79	81			38	78 ± 22
	7 - Cabot Strait	99	113	99	92	78	65	92	52	81	41	65	51	91	88	85	27	52	69	80		19	30	77 ± 21
	8 - Magdalen Shallows	127	141	127	113	120	127	120	111	108	76	111	76	101	107	109	55	72	109	102	60	59	64	107 ± 22
Maximum ice volume (km^3)	1 - Estuary	1.6	2.6	2.5	2.5	3.4	2.0	1.4	1.4	1.1	1.6	1.2	2.9	1.3	2.0	2.1	1.1	0.9	1.4	1.7	1.0	0.8	1.1	1.9 km^3 ± 0.6
	2 - Northwest Gulf	9	14	18	12	16	13	12	6	8	6	7	10	7	4	11	5	4	17	8	2	2	5	9.3 km^3 ± 3.8
	3 - Anticosti Channel	9	8	12	14	17	6	7	4	9	3	4	6	6	4	6	2	4	7	5	2	1	1	6.4 km^3 ± 3.4
	4 - Mécatina Trough	6	6	5	10	8	4	7	4	6	2	9	5	10	5	4	6	6	4	4	3	3	5	5.9 km^3 ± 2.2
	5 - Esquiman Channel	16	18	21	25	15	10	17	5	9	2	8	8	30	10	4	4	9	13	8	2	2	2	12.6 km^3 ± 8.2
	6 - Central Gulf	8	11	17	18	14	11	10	3	5	6	3	6	17	2	10	2	4	8	7	0	0	1	7.5 km^3 ± 4.7
	7 - Cabot Strait	7	10	14	11	11	5	11	2	5	5	5	3	22	9	5	2	4	7	8	0	1	1	7.0 km^3 ± 4.3
	8 - Magdalen Shallows	22	30	61	48	43	29	30	17	26	18	34	20	41	33	33	11	16	32	33	5	8	12	27.2 km^3 ± 11.2
	Scotian Shelf	14	20	14	14	10	3	11	1	3	2	5	2	42	9	4	1	6	7	14	0	0	0	9.7 km^3 ± 8.8
	GSL + Scotian Shelf	71	96	134	120	106	72	86	41	57	37	59	60	139	63	68	25	38	76	65	11	14	22	70.8 km^3 ± 30.2

Table 14. Winter and summertime CIL related properties. The top block shows the scorecard time series for winter air temperature averaged over eight stations, the December-January-February air temperature averaged over five Western Gulf 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.



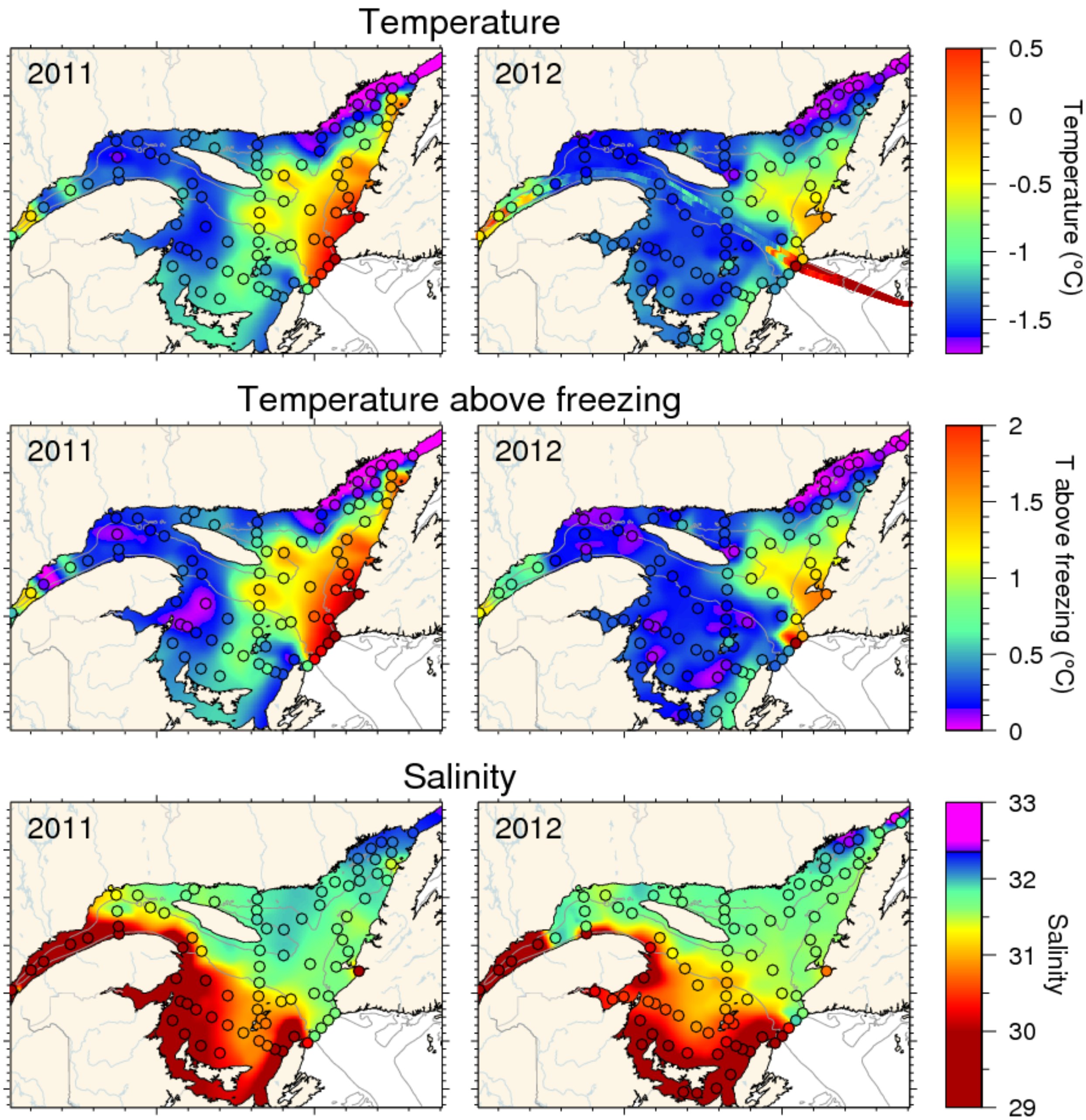


Figure 24. Winter surface layer characteristics from the March 2011 and 2012 helicopter surveys: surface water temperature (upper panel), temperature difference between surface water temperature and the freezing point (middle panel), and salinity (lower panel). The temperature measurements from shipboard thermosalinographs taken during the 2012 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.

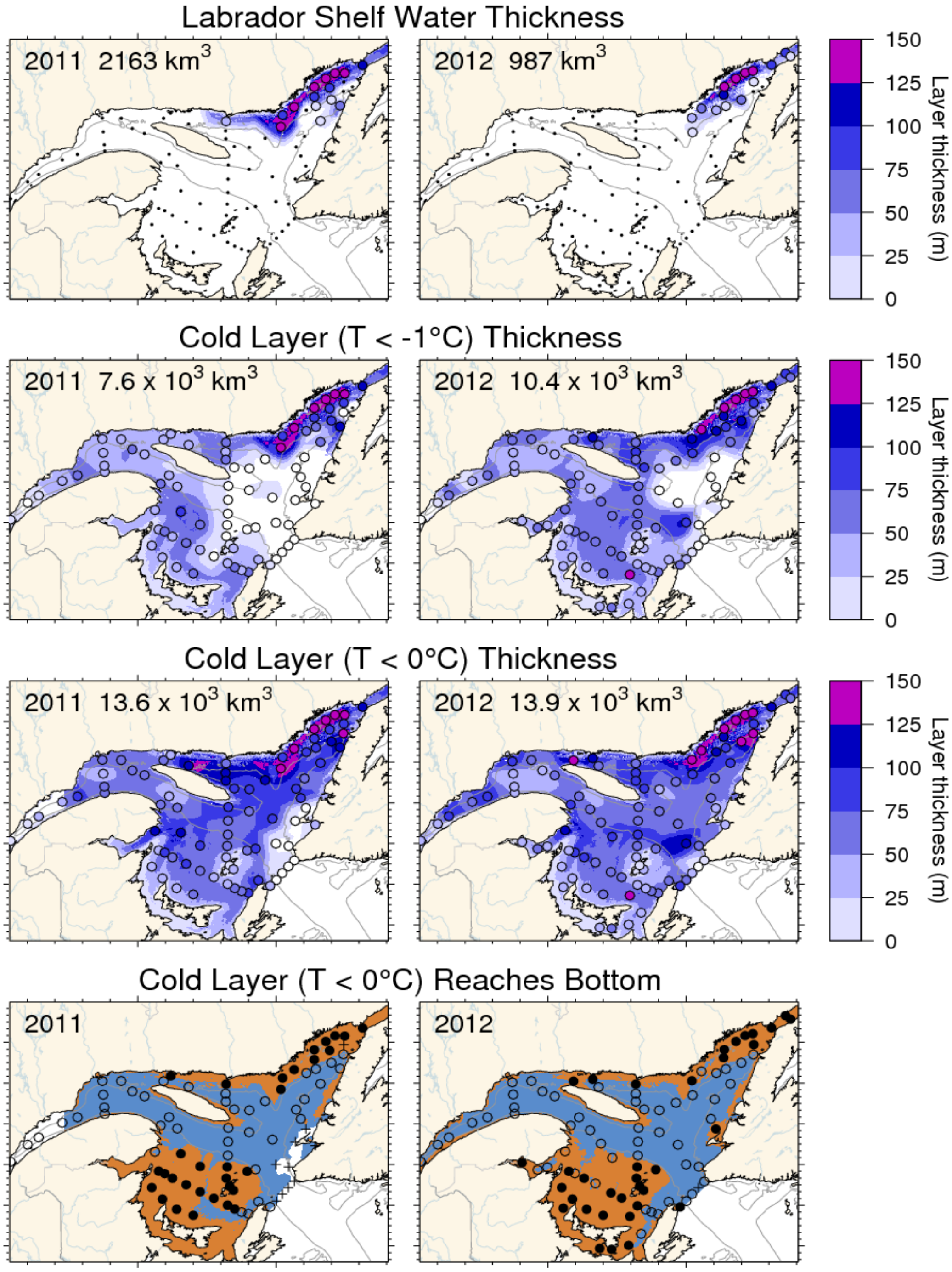


Figure 25. Winter surface layer characteristics from the March 2011 and 2012 helicopter surveys. Estimates of the thickness of the Labrador Shelf water intrusion (upper panels), cold layer (T<-1°C, T<0°C) thickness (middle panels), and maps indicating where the cold layer (T<0°C) reaches the bottom (in brown; lower panels). Station symbols are coloured according to the observed values as in Figure 24. 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 (including the Estuary but excluding the Strait of Belle Isle).

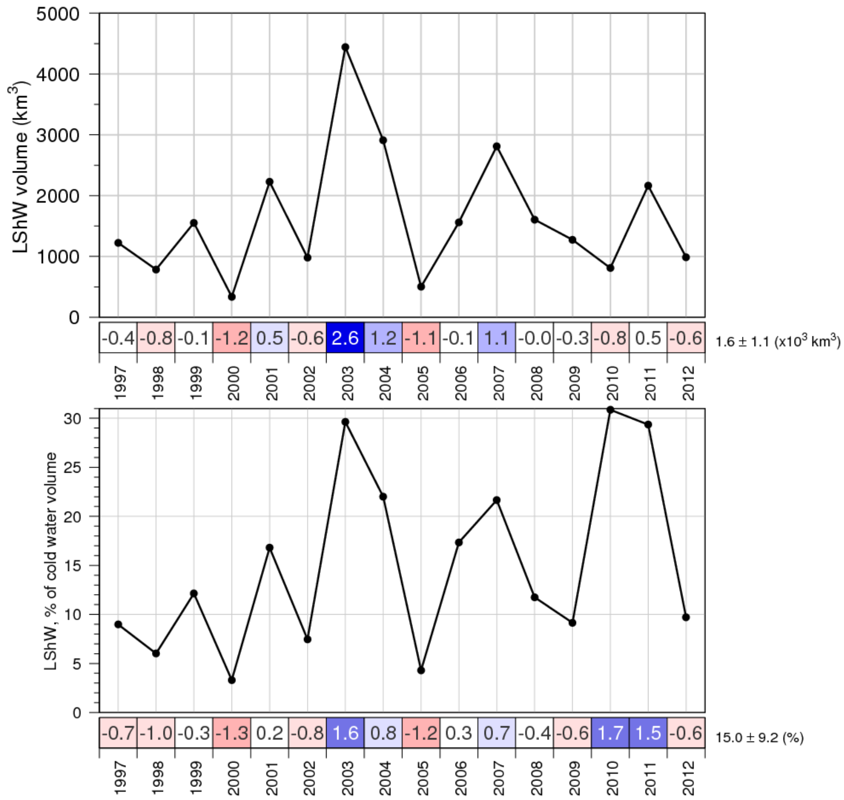


Figure 26. Estimated volume of cold and saline Labrador Shelf water that flowed into the Gulf over the winter through the Strait of Belle Isle. The bottom panel shows the volume as a percentage of total cold-water volume (<-1ºC). The numbers in the boxes are normalized anomalies.

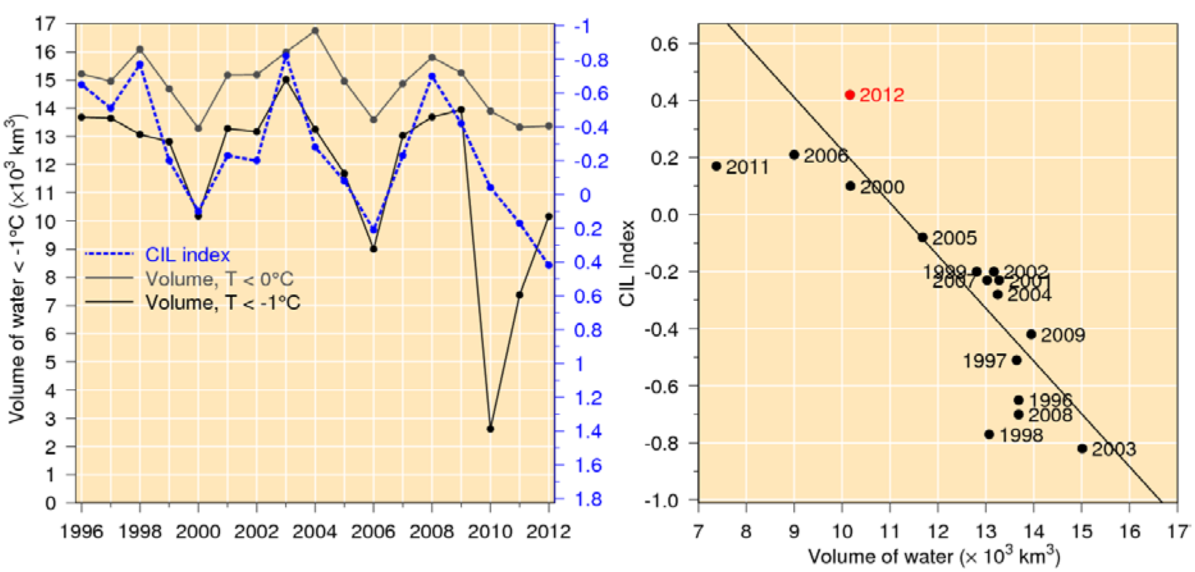


Figure 27. Left panel: winter surface cold (T<-1°C and T<0°C) layer volume (excluding the Estuary and the Strait of Belle Isle) time series (black and grey lines) and summer CIL index (blue dashed line). Right panel: Relation between summer CIL index and winter cold-water volume with T<-1°C (regression for 1996-2009 data pairs, excluding 1998; see Galbraith 2006). Note that the CIL scale in the left panel is reversed.

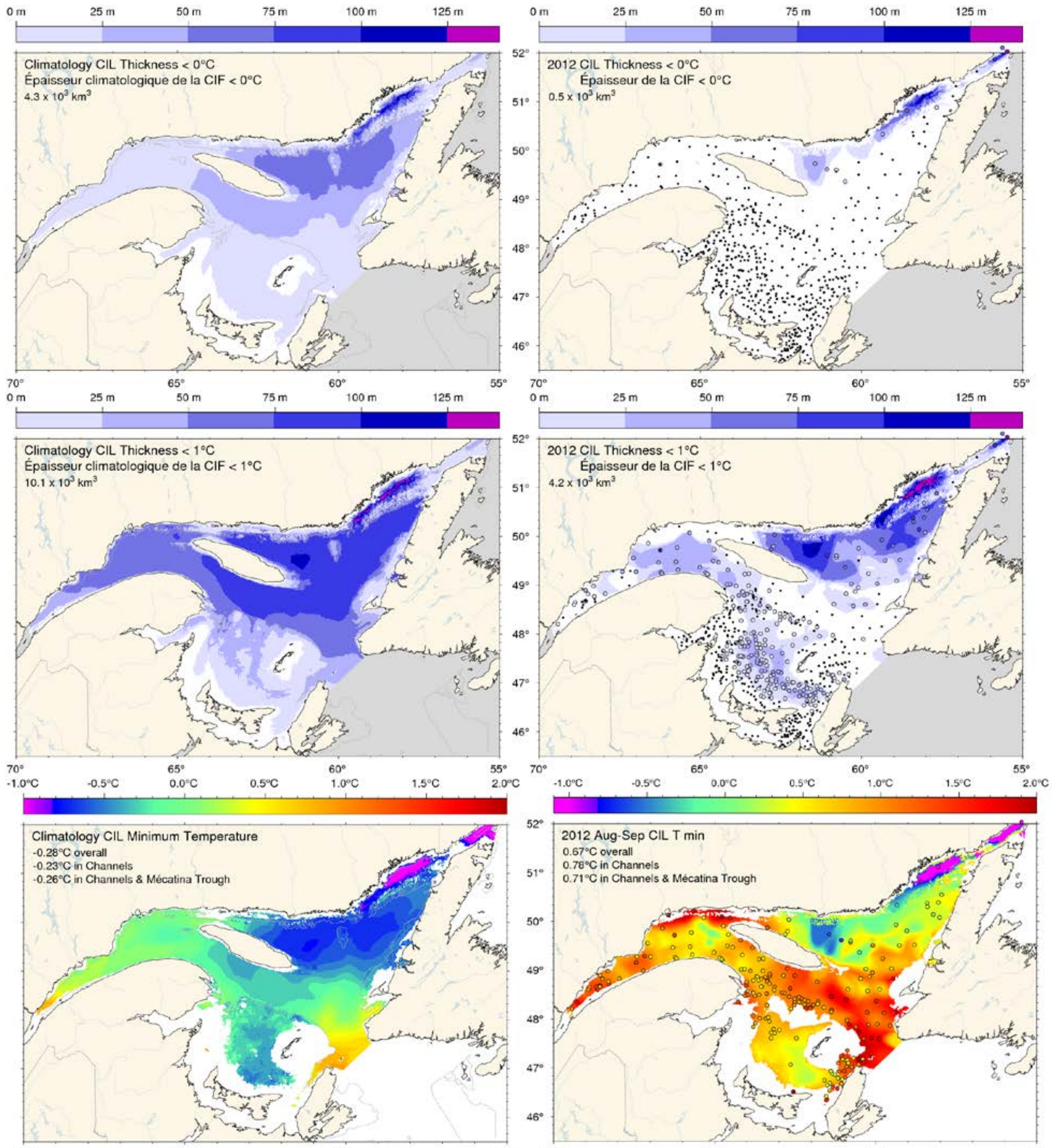


Figure 28. Cold intermediate layer thickness (T<0ºC, top panels; T<1ºC, middle panels) and minimum temperature (bottom panels) in August and September 2012 (right) and 1985-2010 climatology (left). Station symbols are colour-coded according to their CIL thickness and minimum temperature. Numbers in the upper and middle panels are integrated CIL volumes and in the lower panels are monthly average temperatures.

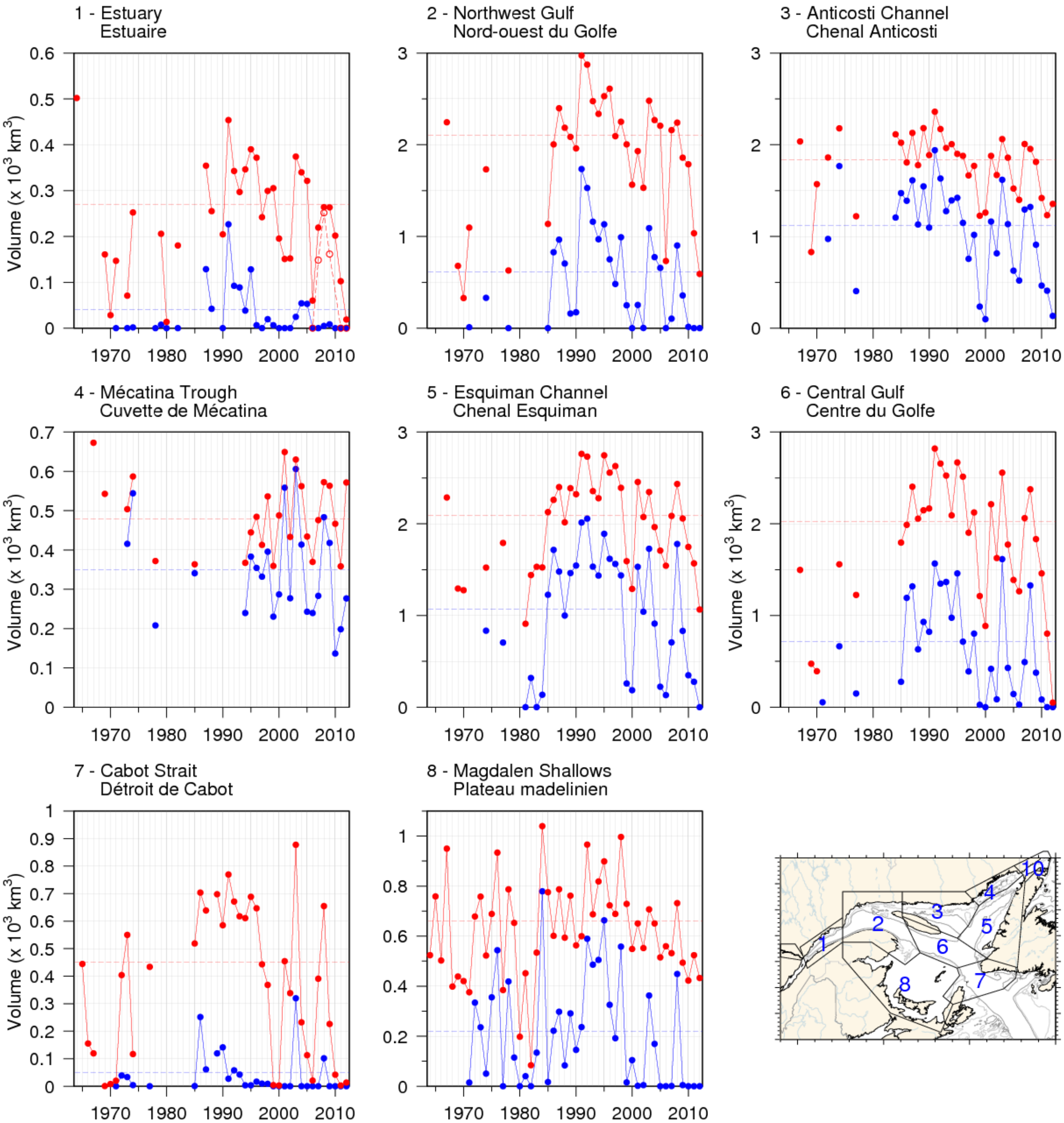


Figure 29. Volume of the CIL colder than 0ºC (blue) and colder than 1ºC (red) in August and September (primarily region 8 in September). The volume of the CIL colder than 1ºC in November for available years since 2006 is also shown for the St. Lawrence Estuary (dashed line).

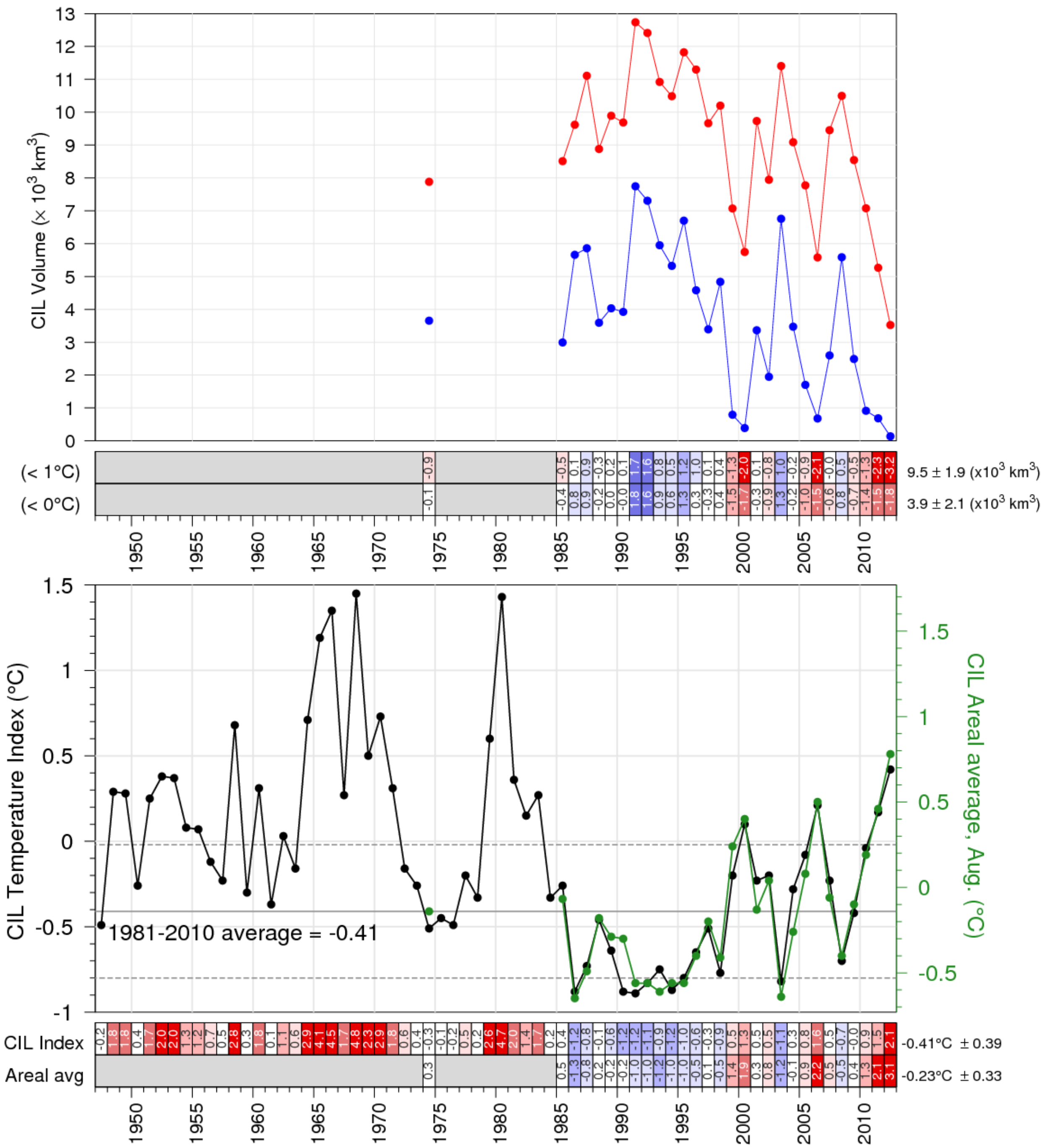


Figure 30. CIL volume (top panel) delimited by the over- and underlying 0ºC (in blue) and 1ºC (in red) isotherms, and minimum temperature index (bottom panel) in the Gulf of St. Lawrence. The volumes are integrals of each of the annual interpolated thickness grids such as those shown in the top panels of Figure 28, excluding Mécatina Trough and the Strait of Belle Isle. In the lower panel, the black line is the updated Gilbert and Pettigrew (1997) index interpolated to 15 July and the green line is the spatial average of each of the annual interpolated grid such as those shown in the two bottom panels of Figure 28, excluding Mécatina Trough and the Magdalen Shallows. The numbers in the boxes are normalized anomalies.

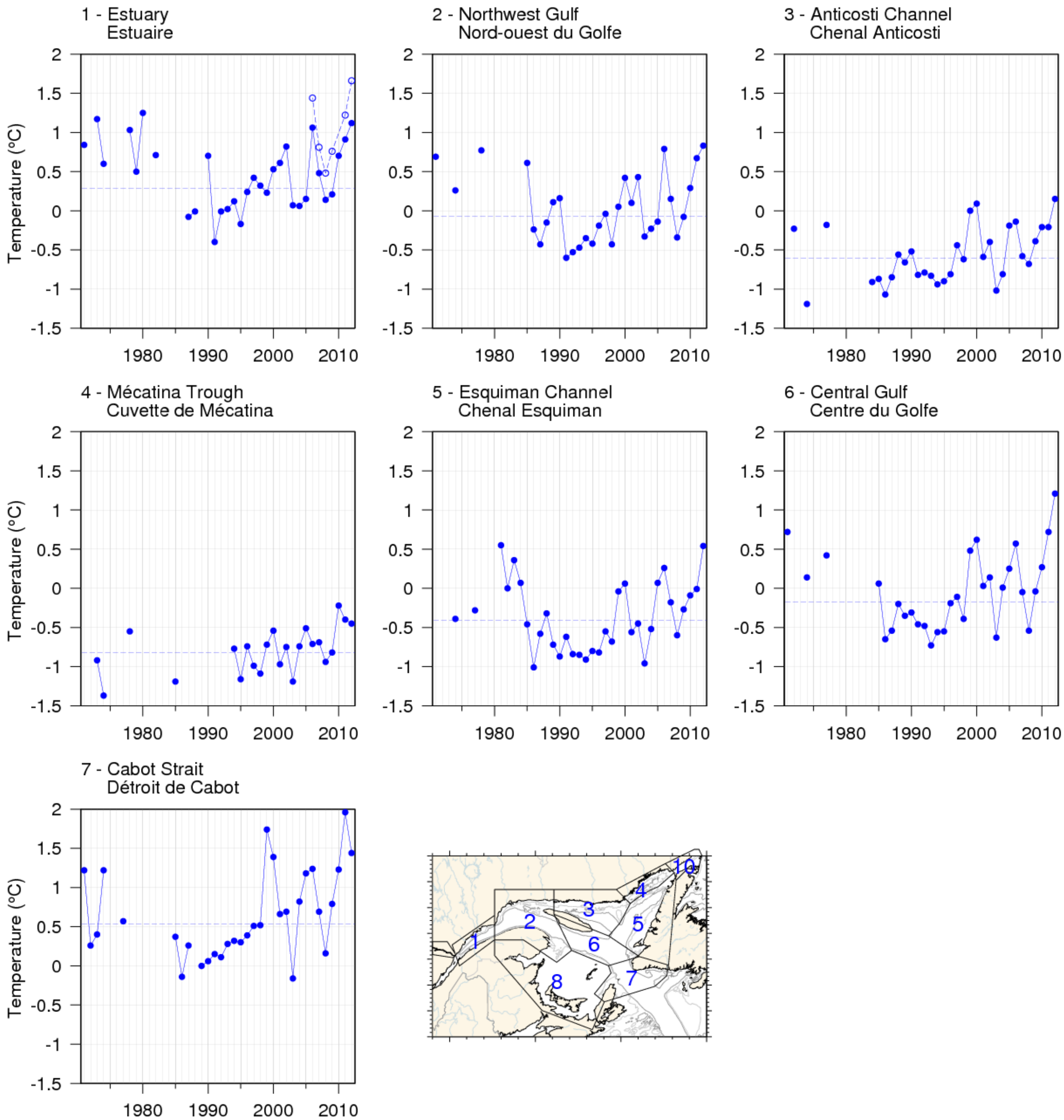


Figure 31. Temperature minimum of the CIL spatially averaged for the seven areas where the CIL minimum temperature can be clearly identified. The spatial average of the CIL temperature minimum in November 2006-2009 and 2011-2012 is also shown for the St. Lawrence estuary (dashed line).

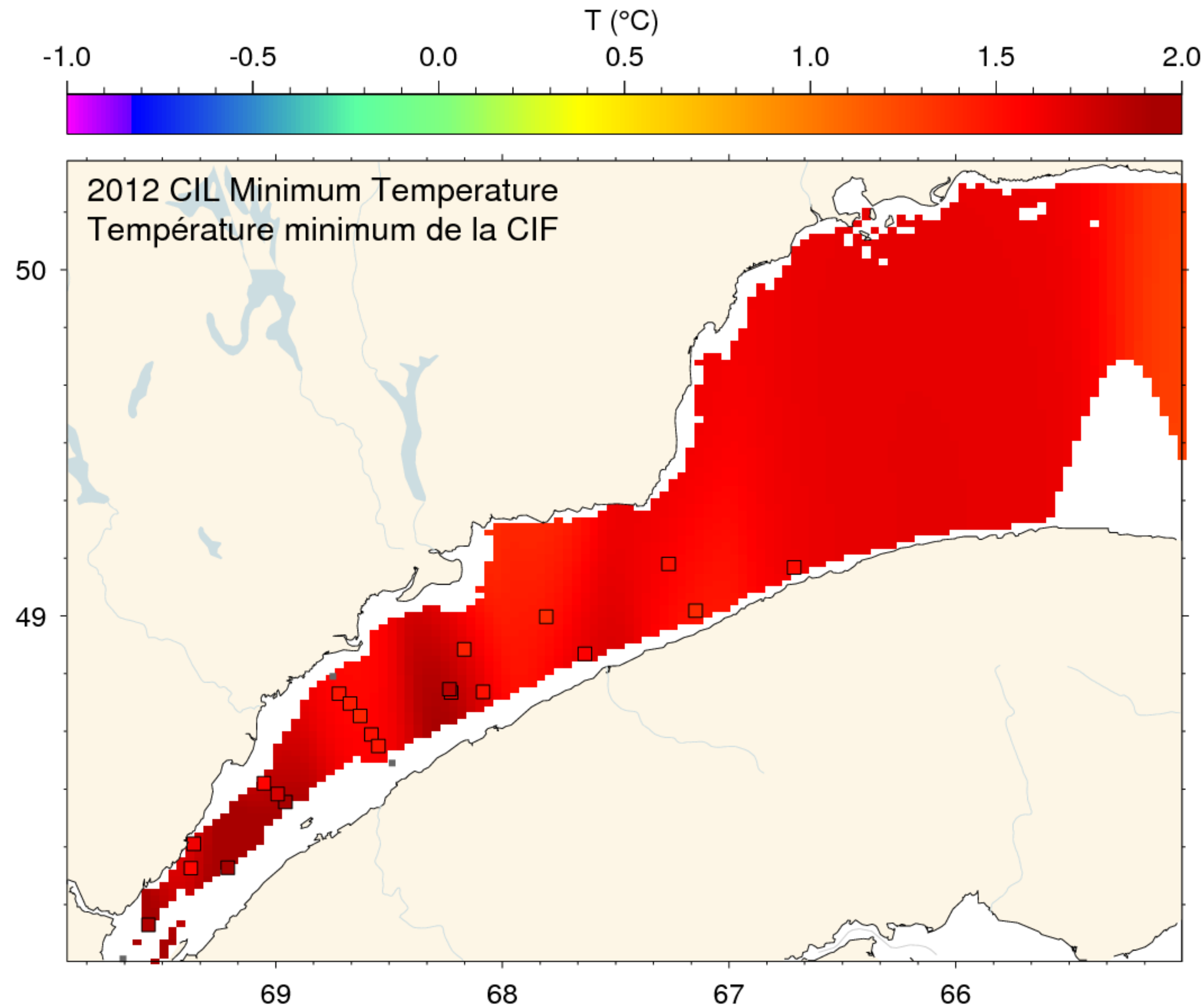


Figure 32. Cold intermediate layer minimum temperature in November 2012 in the St. Lawrence Estuary.

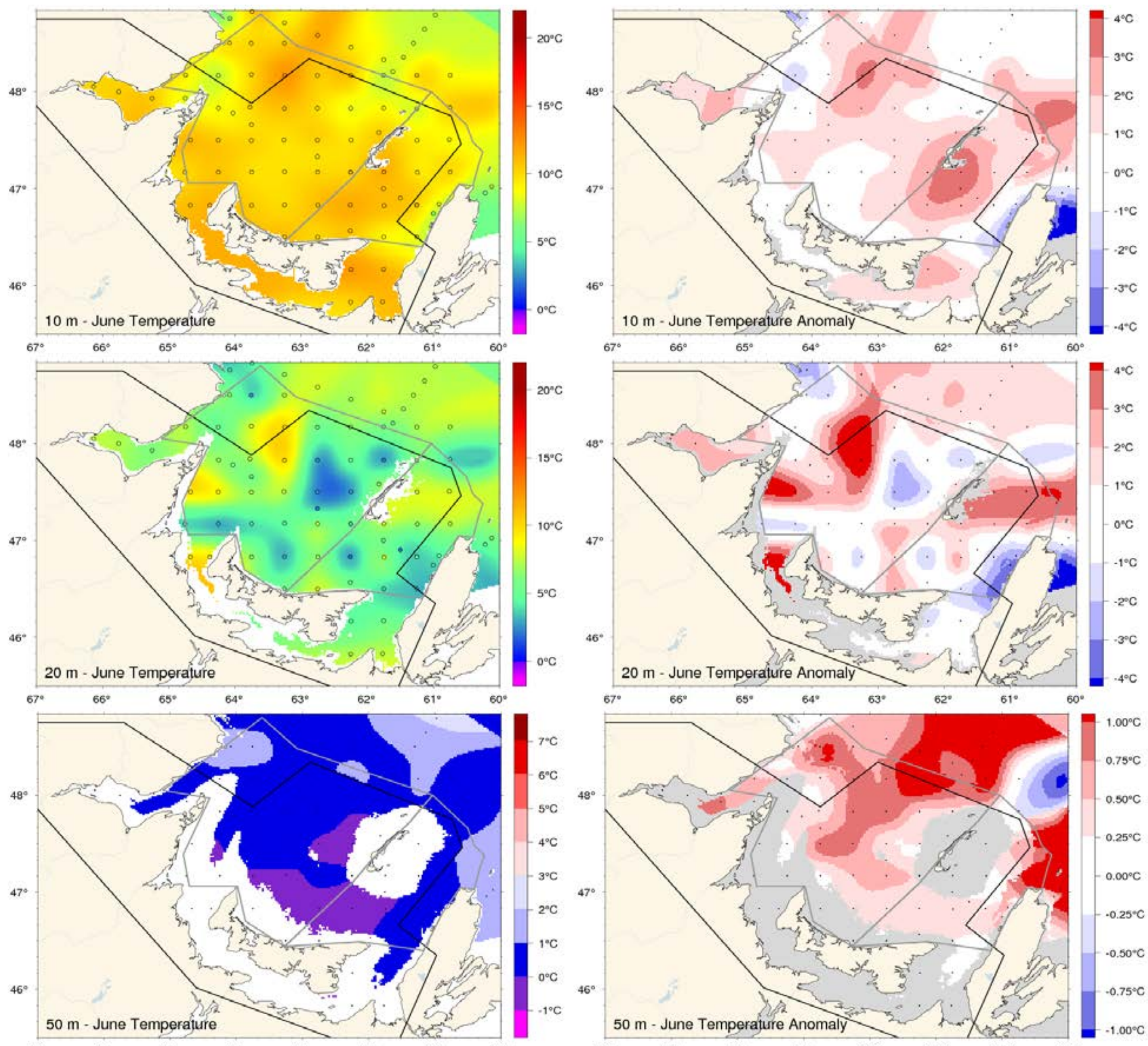


Figure 33. June depth-layer temperature and anomaly fields on the Magdalen Shallows at 10, 20 and 50 m. Anomalies are based on 1971-2010 climatologies for all available years (appearing on Table 15) The black outline delimites Region 8 (Figure 2) and the gray outlines delimit western and eastern regions of the Magdalen Shallows (Figure 15).

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 8. The SST colour-coding is based on the 1985-2010 climatology and the numbers are mean temperatures in ºC. The colour-coding of the 10 to 75 m lines are according to normalized anomalies based on the 1981-2010 climatologies, but the numbers are mean temperatures in ºC.

Shelf	Variable	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Western Shelf	SST June																									
Western Shelf	10 m temp.	9.1			7.2		6.4	7.8	5.3	8.6	8.1		7.4	7.7			7.4	8.9	7.1			9.6		9.5	9.6	8.0
Western Shelf	20 m temp.	4.5			4.9		4.8	4.0	3.3	5.7	4.7		4.2	1.7			5.2	4.3	4.1			6.6		5.5	4.2	6.1
Western Shelf	30 m temp.	2.4			2.9		2.7	2.2	2.0	2.1	2.4		2.2	-0.2			2.1	1.3	2.6			3.7		2.4	1.2	2.4
Western Shelf	50 m temp.	0.7			0.9		0.6	0.5	0.3	0.1	0.8		-0.2	-0.6			-0.1	-0.8	0.7			1.4		0.8	-0.7	-0.5
Western Shelf	75 m temp.	0.5			0.7		0.1	0.1	0.1	0.5	0.9		0.5	1.1			-0.2	-0.2	0.2			0.8		0.2	-0.6	-0.5
Eastern Shelf	SST June																									
Eastern Shelf	10 m temp.	10.6			6.8		7.8	6.8	4.8	7.6	8.4		7.4	6.4			6.7	8.6	7.5			8.7		8.2	10.3	7.2
Eastern Shelf	20 m temp.	6.1			4.6		6.1	3.8	2.0	5.0	5.4		3.6	2.3			5.2	5.2	4.6			6.9		5.7	5.0	6.2
Eastern Shelf	30 m temp.	3.2			2.4		3.3	2.5	0.7	2.4	3.8		1.6	0.3			1.5	2.0	2.1			4.2		2.2	1.4	3.3
Eastern Shelf	50 m temp.	1.1			1.5		1.1	1.5	0.4	1.4	1.3		-0.3	-0.3			0.1	-0.5	0.5			1.6		0.3	-0.1	0.3
Eastern Shelf	75 m temp.	1.7			2.4		0.6	1.2	0.4	3.9	1.5		0.2	1.2			-0.0	0.0	1.2			0.9		0.8	1.1	0.9

Shelf	Variable	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	2012	Climatology
Western Shelf	SST June	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	10.8	9.92°C ± 1.06
Western Shelf	10 m temp.	8.7	8.2	10.2	7.9	8.6	8.2	7.5	8.4	7.4	8.2		9.7	7.6	9.5	9.9	9.3	8.5	8.3	7.9	8.0	8.5	11.6	8.6	8.0	9.3	8.6	8.7	10.0	8.44°C ± 1.11
Western Shelf	20 m temp.	5.0	6.1	4.4	4.2	4.3	4.4	5.4	4.3	5.8	3.8		3.9	4.3	3.5	4.9	5.8	3.9	4.9	3.8	5.5	3.2	3.7	5.1	3.5	5.0	6.4	4.7	5.7	4.63°C ± 0.96
Western Shelf	30 m temp.	1.7	2.9	1.2	2.1	1.0	2.8	3.0	1.5	1.6	1.4		1.6	2.7	0.2	1.9	3.0	1.5	2.0	1.6	3.1	1.6	1.3	2.0	0.7	1.9	3.6	2.1	2.3	2.03°C ± 0.82
Western Shelf	50 m temp.	-0.2	-0.5	-0.9	-0.3	-0.1	-0.0	-0.2	-0.3	-1.1	-0.6		-0.6	0.0	-0.6	0.2	0.0	0.1	0.1	-0.5	0.1	0.2	0.2	0.1	-0.7	-0.1	0.9	0.2	0.5	-0.01°C ± 0.56
Western Shelf	75 m temp.	0.7	-0.6	-0.4	-0.2	0.1	-0.2	-0.5	-0.3	-0.9	-0.5		-0.4	-0.7	-1.0	-0.2	-0.1	-0.5	0.1	-0.6	-0.5	0.0	0.7	0.1	-0.7	-0.1	0.4	0.3	0.8	-0.02°C ± 0.53
Eastern Shelf	SST June	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	10.7	9.17°C ± 1.13
Eastern Shelf	10 m temp.	8.2	8.3	9.4	8.0	8.4	8.0	7.5	7.1	6.8	7.7		9.1	7.1	9.1	10.5	8.8	8.5	7.7	7.3	7.4	7.1	11.4	7.9	8.2	8.7	8.5	8.1	9.9	8.10°C ± 1.24
Eastern Shelf	20 m temp.	4.6	7.6	3.5	4.9	2.9	4.5	5.3	2.8	4.3	4.7		4.5	4.4	3.7	7.0	6.0	4.1	5.1	4.0	5.4	4.3	3.6	3.2	4.2	5.5	7.0	5.9	5.8	4.80°C ± 1.26
Eastern Shelf	30 m temp.	1.4	3.8	0.7	2.2	0.2	2.6	2.0	0.4	0.4	1.7		1.0	2.5	0.8	3.4	3.4	1.5	2.7	1.2	3.4	2.0	1.1	1.0	0.2	2.2	4.5	2.2	1.9	2.03°C ± 1.13
Eastern Shelf	50 m temp.	-0.1	-0.7	-0.5	0.0	-0.3	-0.2	-0.6	-0.8	-1.0	-0.7		-0.1	0.4	-0.6	0.9	0.5	0.1	0.6	-0.6	0.3	0.9	0.7	0.2	-0.9	0.0	1.8	0.7	0.4	0.24°C ± 0.74
Eastern Shelf	75 m temp.	0.7	-0.8	-0.0	0.9	-0.6	-0.3		0.0	-0.4	0.5		0.0	-0.1	-0.3	0.8	1.1	0.3	0.8	-0.1	0.6	1.1	1.1	0.6	0.1	0.5	1.1	1.8	1.4	0.68°C ± 0.86

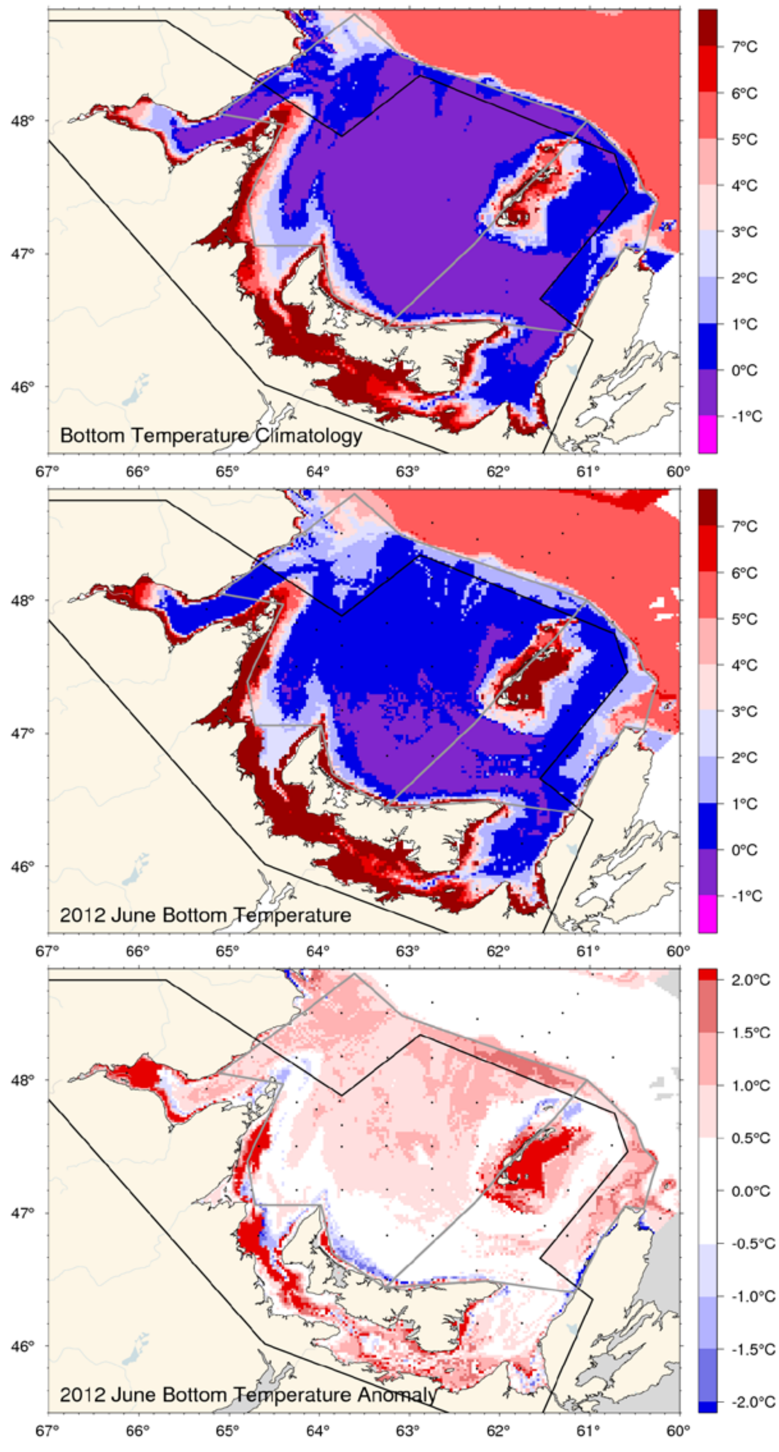


Figure 34. June bottom temperature climatology (top), 2012 observations (middle) and anomaly (bottom).

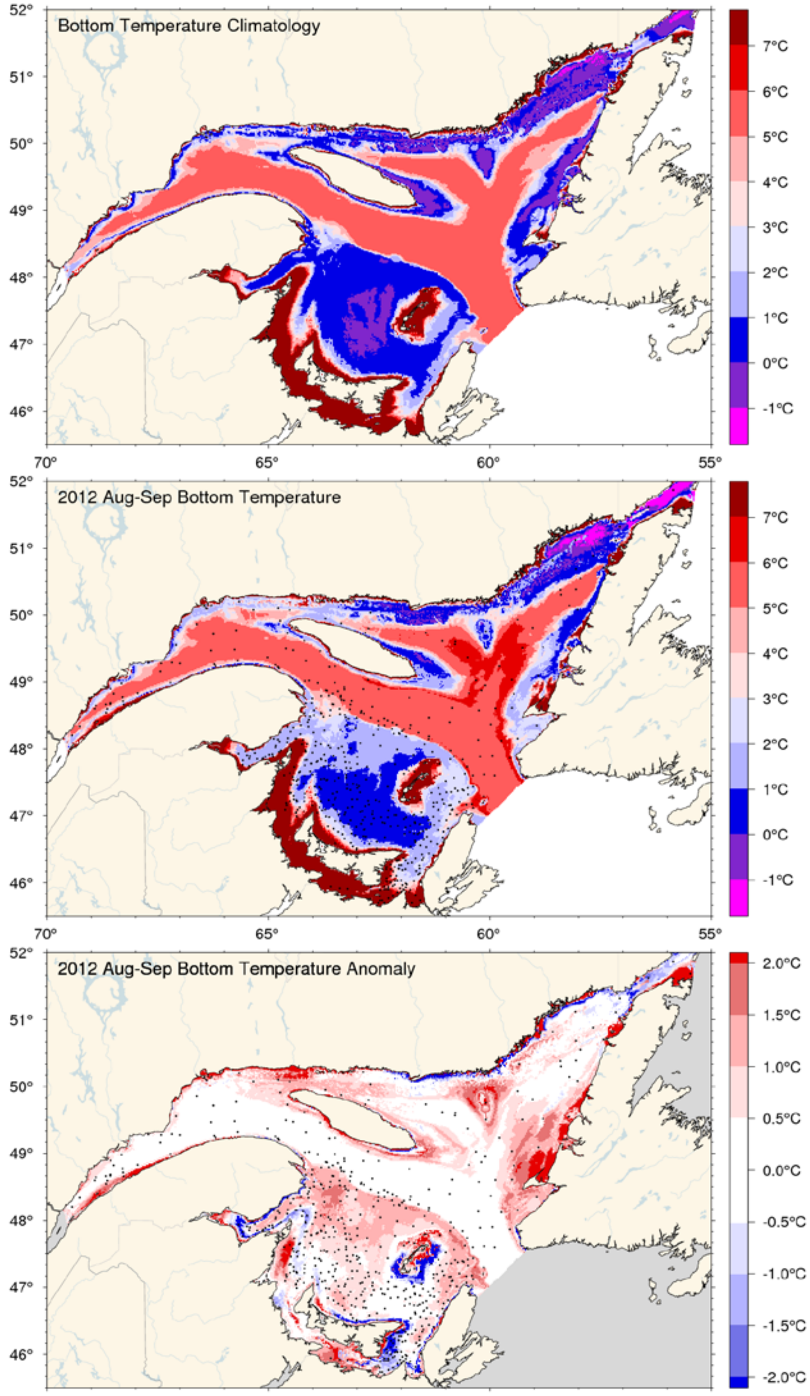


Figure 35. August-September bottom temperature climatology (top), 2012 observations (middle) and anomaly (bottom).

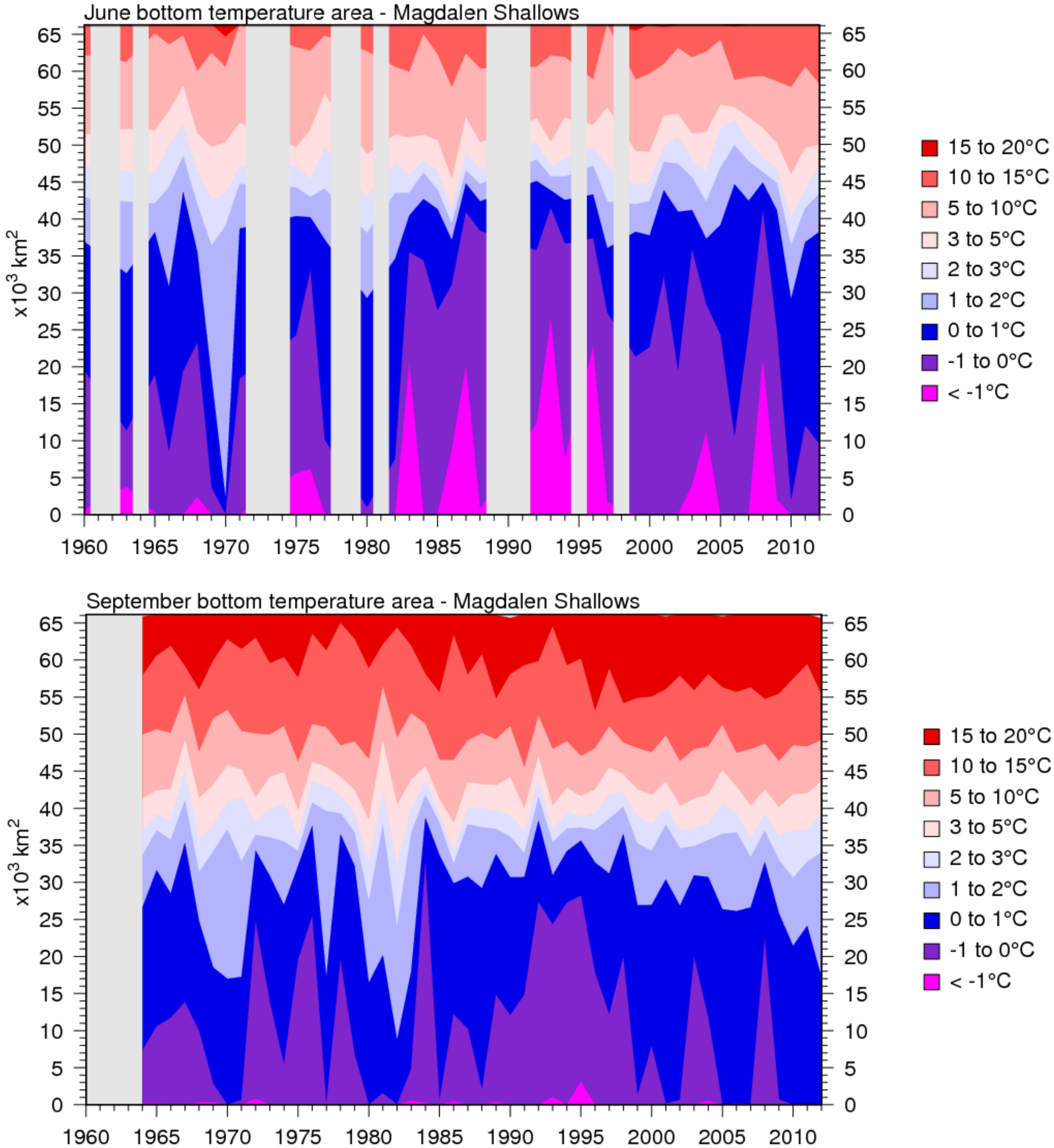


Figure 36. Time series of the bottom areas covered by different temperature bins in June (top) and August-September (bottom) for the Magdalen Shallows (region 8) for the bottom panel. Data are majoritarily from September for the bottom panel.

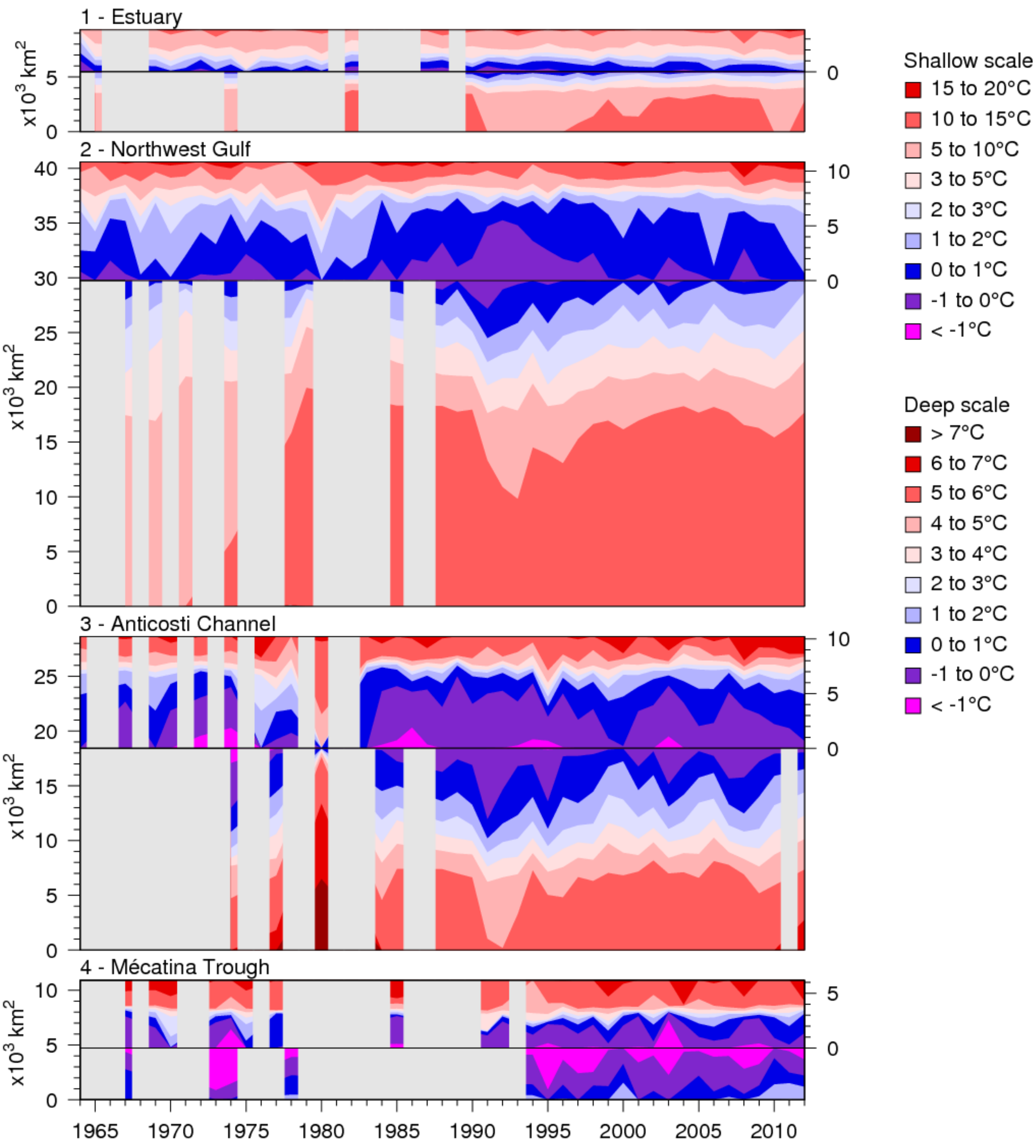


Figure 37. Time series of the bottom areas covered by different temperature bins in August and September for regions 1 to 4. The panels are separated by a black horizontal line into shallow (<100m) and deep (>100 m) areas to distinguish between warmer waters above and below the CIL. The shallow areas 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.

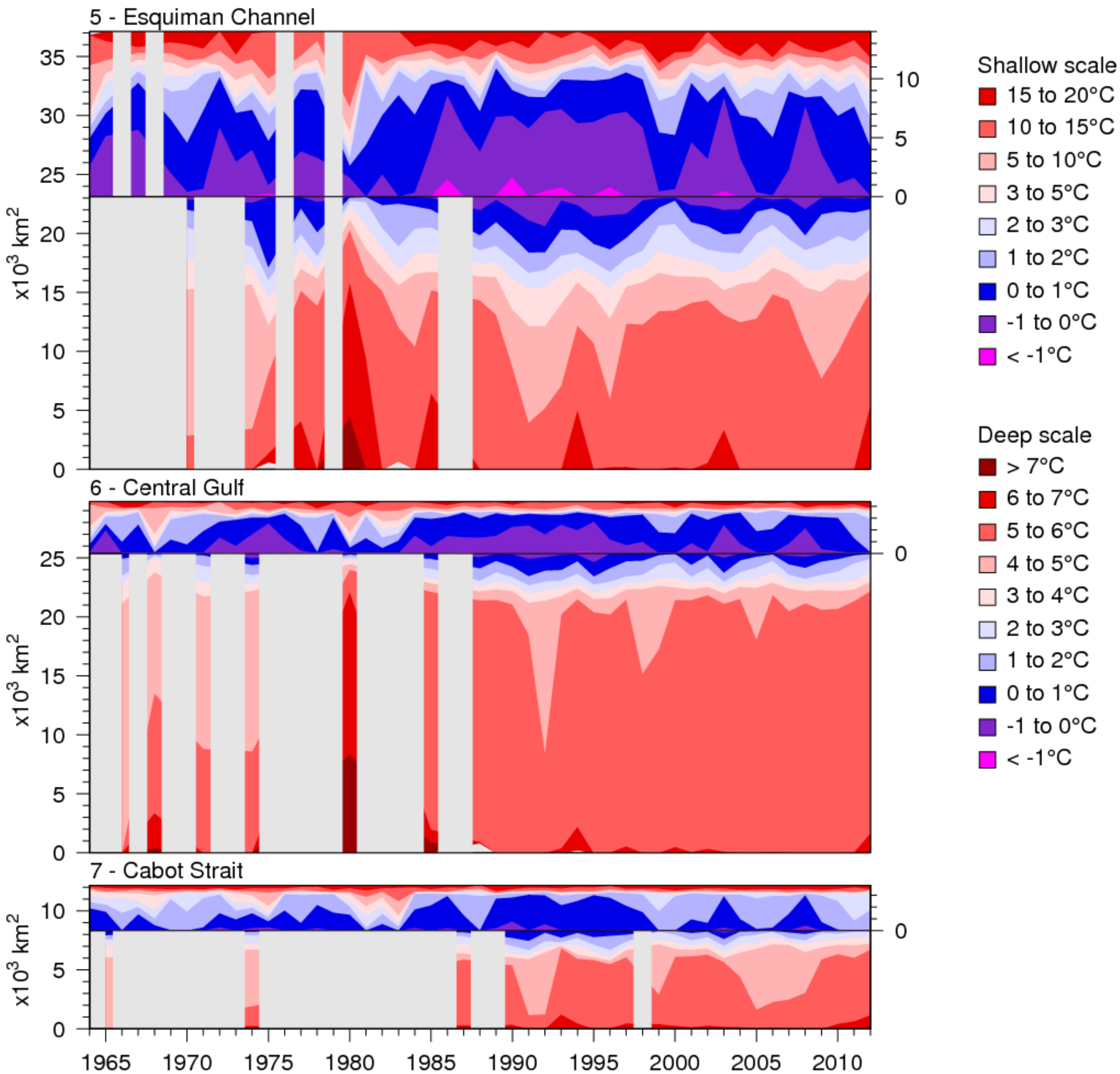


Figure 38. Time series of the bottom areas covered by different temperature bins in August and September for regions 5 to 7. The panels are separated into shallow (<100 m) and deep (>100 m) areas to distinguish between warmer waters above and below the CIL See Figure 37 caption.

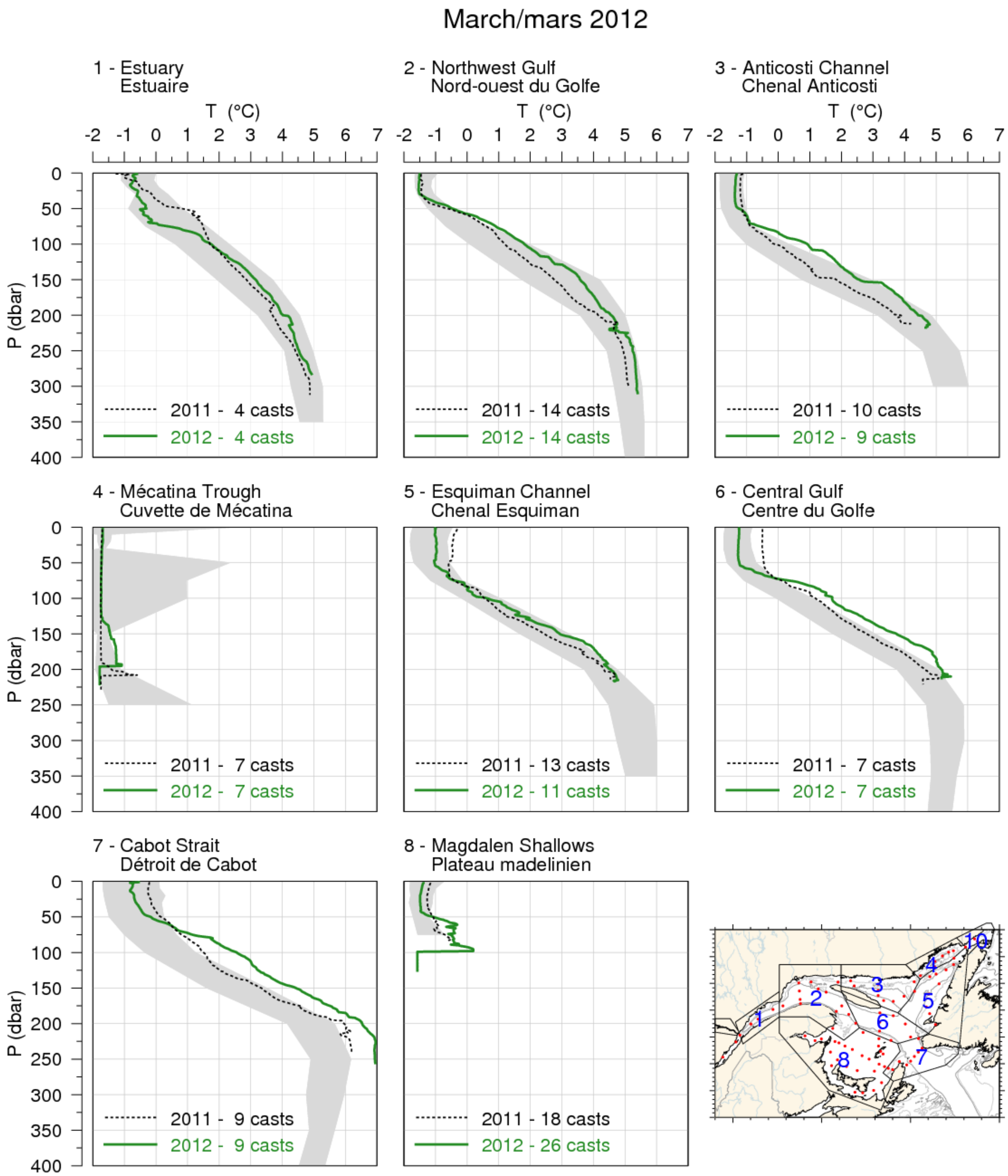


Figure 39. Mean temperature profiles observed in each region of the Gulf during the March helicopter survey. The shaded area represents the 1981–2010 (but mostly 1996–2010) climatological monthly mean ± 1 SD. Mean profiles for 2011 are also shown for comparison.

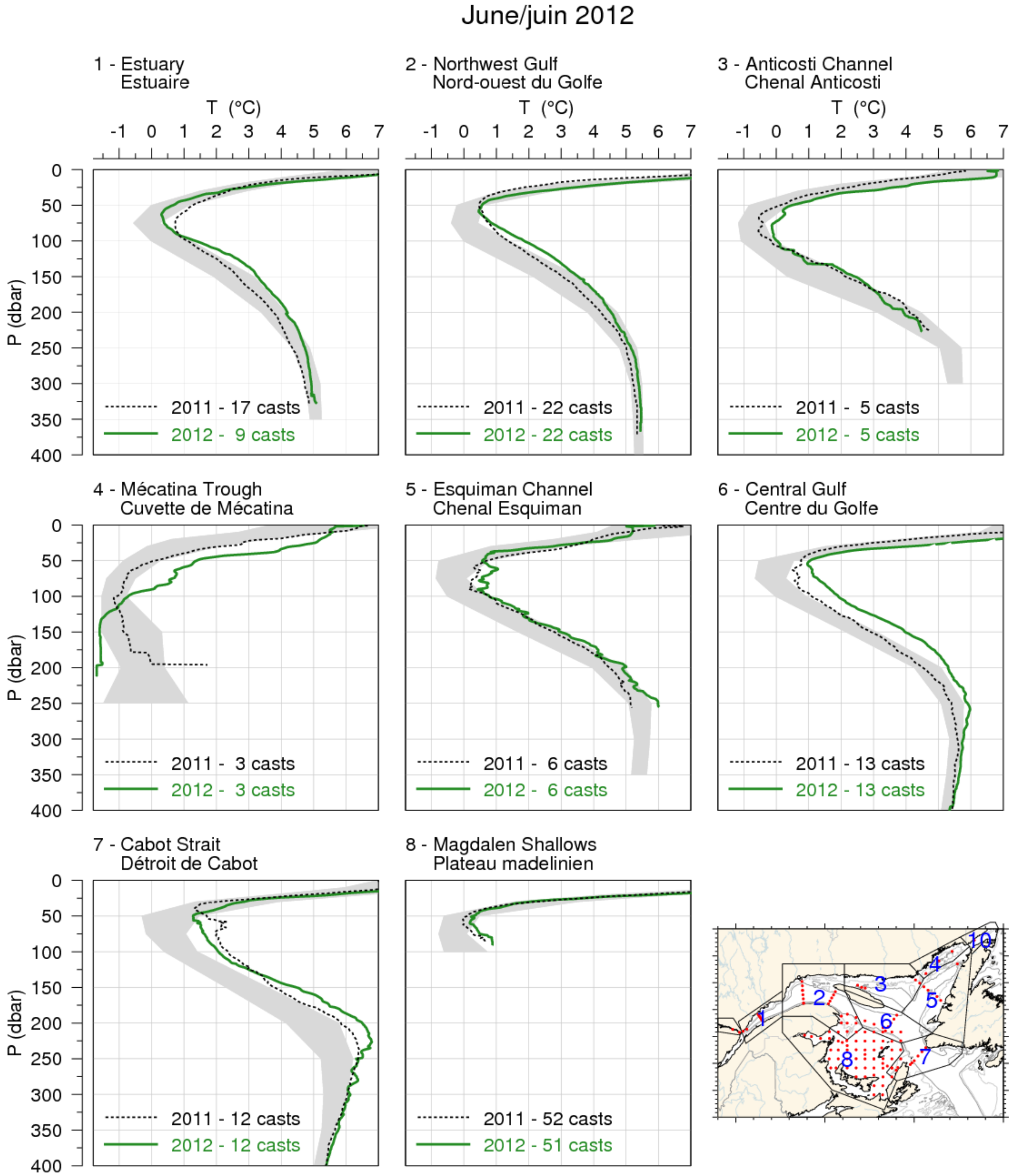


Figure 40. Mean temperature profiles observed in each region of the Gulf during June. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD. Mean profiles for 2011 are also shown for comparison.

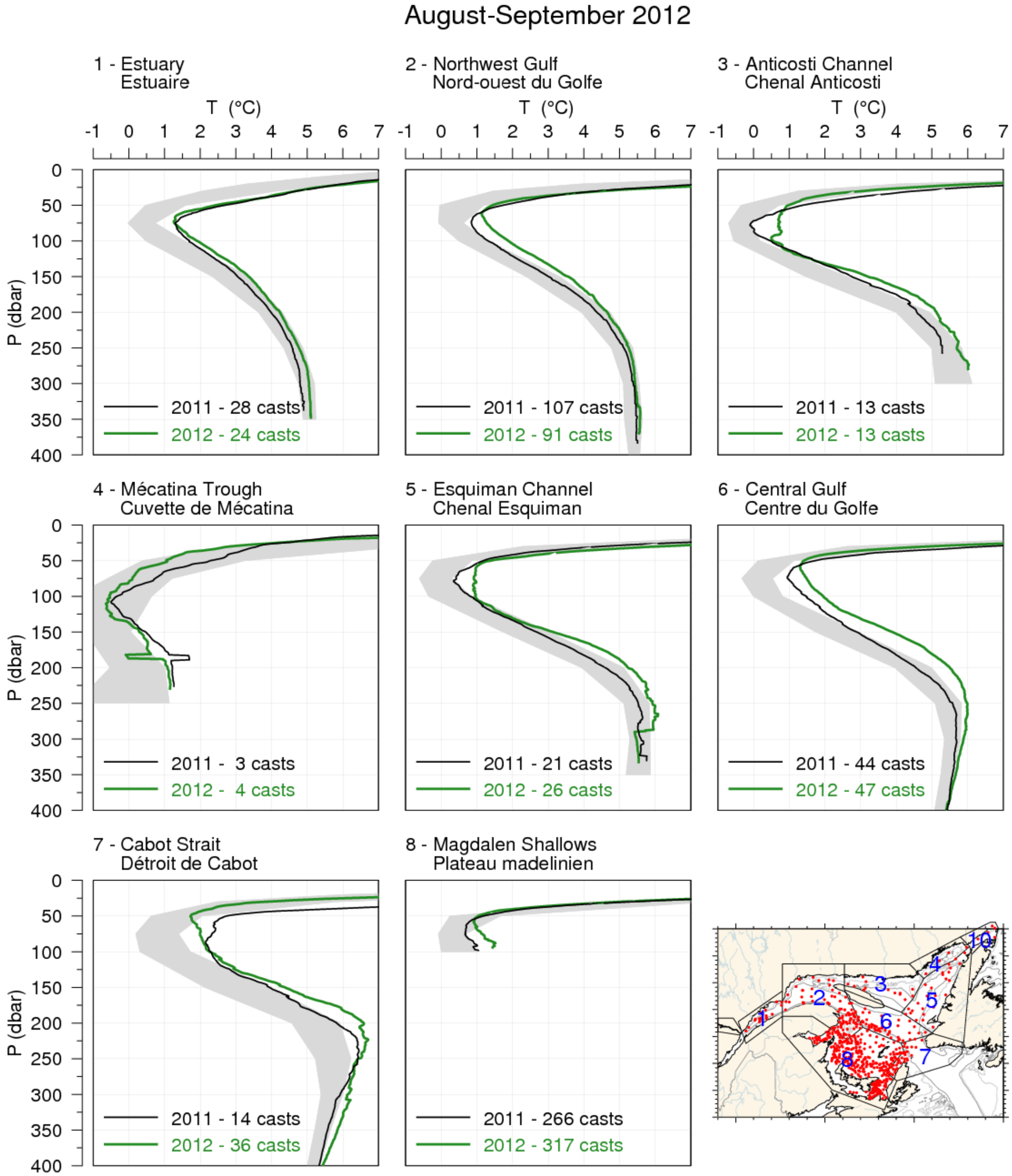


Figure 41. Mean temperature profiles observed in each region of the Gulf during August and September. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD for August for regions 1 through 7 and for September for region 8. Mean profiles for 2011 are also shown for comparison.

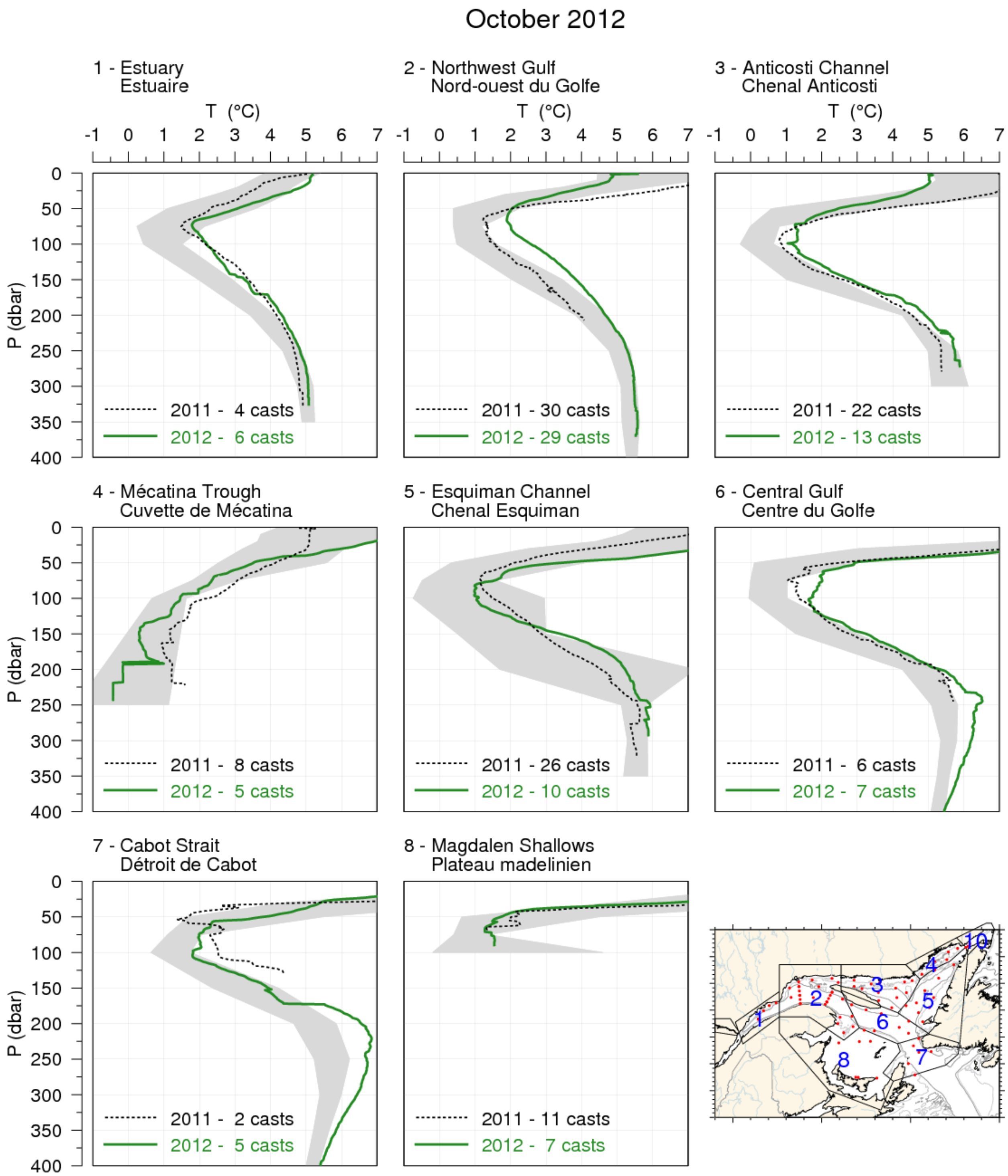


Figure 42. Mean temperature profiles observed in each region of the Gulf during the October AZMP survey. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD. Mean profiles for 2011 are also shown for comparison.

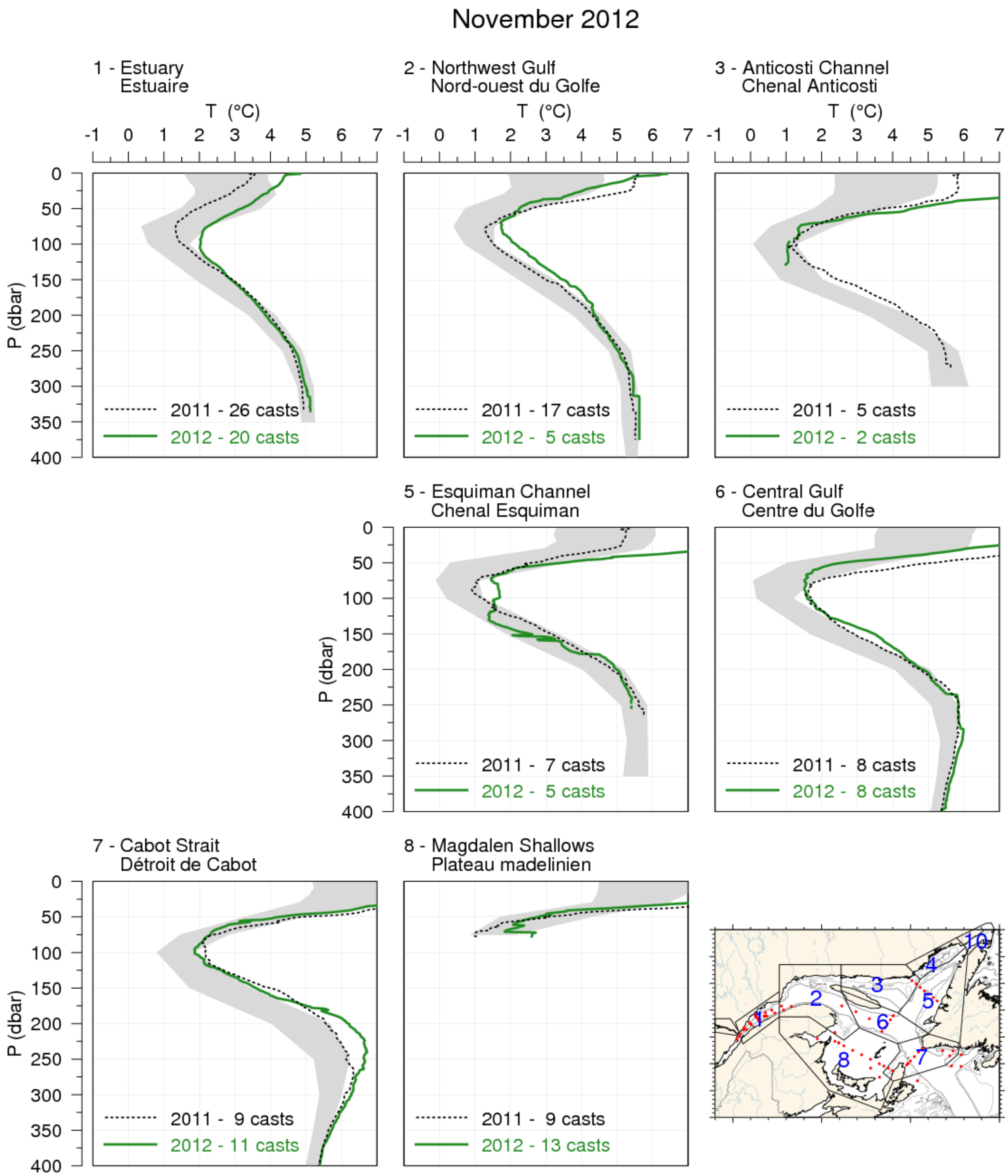


Figure 43. Mean temperature profiles observed in each region of the Gulf during the November AZMP survey. The shaded area represents the 1981–2010 climatological monthly mean ± 1 SD. Mean profiles for 2011 are also shown for comparison.

Table 16. Depth-layer monthly average temperature summary for months during which the eight Gulf-wide oceanographic surveys took place in 2011 and 2012. The colour-coding is according to the temperature anomaly relative to the monthly 1981–2010 climatology of each region.

1 - Estuary / Estuaire

	2011 Mar	2011 June	2011 Aug	2011 Oct	2012 Mar	2012 June	2012 Aug	2012 Nov
0 m	-0.95	8.8	11.4	5.0	-0.64	8.0	10.6	4.4
10 m	-0.79	5.4	9.4	4.1	-0.69	6.5	8.6	4.3
20 m	-0.47	3.2	7.0	3.6	-0.77	4.0	6.3	4.1
30 m	-0.13	2.4	5.5	3.3	-0.59	2.6	4.8	3.8
50 m	0.8	1.3	3.1	2.3	-0.30	0.8	2.5	3.2
75 m	1.5	0.7	1.3	1.5	0.3	0.5	1.3	2.2
100 m	1.7	1.1	1.5	2.2	1.7	1.3	1.8	2.0
150 m	2.9	2.7	2.9	3.4	3.1	3.3	3.3	2.9
200 m	3.7	3.8	3.9	4.2	4.0	4.2	4.2	3.9
250 m	4.4	4.3	4.5	4.7	4.5	4.8	4.7	4.7
300 m	4.9	4.7	4.8	4.8	4.9	5.0	5.1	5.0
350 m		4.9	4.9	4.9		5.1	5.1	5.1

2 - Northwest Gulf / Nord-ouest du Golfe

	2011 Mar	2011 June	2011 Aug	2011 Nov	2012 Mar	2012 June	2012 Aug	2012 Nov
0 m	-1.45	8.2	15.1	5.5	-1.51	10.2	16.2	5.5
10 m	-1.45	5.9	12.9	5.5	-1.51	7.7	13.6	5.2
20 m	-1.46	2.7	6.7	5.4	-1.53	4.5	8.1	4.4
30 m	-1.45	1.3	3.8	4.8	-1.49	2.4	4.3	3.7
50 m	-0.64	0.5	1.6	2.6	-0.48	0.6	1.4	2.2
75 m	0.6	0.8	0.9	1.3	0.9	0.9	1.3	1.7
100 m	1.2	1.3	1.3	1.5	1.8	1.8	1.8	2.1
150 m	2.8	3.0	2.9	3.0	3.6	3.5	3.5	3.5
200 m	3.9	4.2	4.4	4.3	4.4	4.5	4.6	4.4
250 m	5.0	5.0	5.1	5.1	5.2	5.1	5.2	5.0
300 m	5.1	5.2	5.4	5.4	5.4	5.4	5.4	5.5
350 m		5.3	5.4	5.5		5.4	5.5	5.6
400 m			5.5					

3 - Anticosti Channel / Chenal Anticosti

	2011 Mar	2011 June	2011 Aug	2011 Nov	2012 Mar	2012 June	2012 Aug	2012 Oct
0 m	-1.17	5.6	15.8	5.8	-1.32	6.8	17.5	5.0
10 m	-1.19	4.5	13.8	5.8	-1.35	6.7	14.6	5.0
20 m	-1.20	2.8	8.2	5.8	-1.36	4.3	6.3	4.9
30 m	-1.19	1.6	4.5	5.7	-1.37	2.7	3.0	4.4
50 m	-1.13	0.1	1.4	3.7	-1.25	0.5	1.0	2.5
75 m	-0.89	-0.4	0.0	1.7	-0.70	-0.1	0.7	1.5
100 m	-0.11	-0.1	0.5	1.3	0.9	0.0	0.7	1.2
150 m	1.3	2.1	2.8	2.5	2.6	2.4	3.1	2.8
200 m	3.7	4.1	4.6	4.5	4.4	3.6	5.1	4.9
250 m			5.2	5.5			5.7	5.7

4 - Mécatina Trough / Cuvette de Mécatina

	2011 Mar	2011 June	2011 Aug	2011 Nov	2012 Mar	2012 June	2012 Aug	2012 Oct
0 m	-1.70	6.4	14.0		-1.68	5.7	16.4	7.6
10 m	-1.71	5.5	9.1		-1.69	5.6	12.4	7.5
20 m	-1.72	3.6	5.2		-1.69	5.2	5.7	6.9
30 m	-1.73	2.1	3.6		-1.71	4.3	2.8	6.0
50 m	-1.73	0.1	2.3		-1.73	1.4	1.1	3.5
75 m	-1.74	-0.8	0.7		-1.73	0.6	0.1	2.3
100 m	-1.74	-1.1	-0.3		-1.73	-0.7	-0.5	1.9
150 m	-1.75	-0.9	0.5		-1.45	-1.6	0.3	0.3
200 m	-1.50	0.0	1.2		-1.26	-1.6	1.1	1.0

5 - Esquiman Channel / Chenal Esquiman

	2011 Mar	2011 June	2011 Aug	2011 Nov	2012 Mar	2012 June	2012 Aug	2012 Oct
0 m	-0.31	6.4	15.4	5.2	-0.82	5.2	18.5	9.2
10 m	-0.41	5.0	14.2	5.2	-0.94	5.2	17.7	9.2
20 m	-0.45	4.0	9.5	5.2	-0.91	4.6	11.8	8.6
30 m	-0.46	3.2	4.5	4.8	-0.98	2.7	6.1	7.4
50 m	-0.51	0.7	1.2	2.6	-0.98	0.6	1.4	3.4
75 m	-0.41	0.3	0.4	1.0	-0.41	0.6	0.9	1.6
100 m	0.5	0.8	0.8	1.2	0.4	0.8	0.9	1.0
150 m	2.4	2.8	2.7	3.1	2.9	3.0	3.1	3.4
200 m	4.3	4.5	4.6	4.8	4.6	4.9	5.2	5.2
250 m		5.1	5.5	5.6		6.0	5.8	5.7
300 m			5.7				6.0	5.9

6 - Central Gulf / Centre du Golfe

	2011 Mar	2011 June	2011 Aug	2011 Nov	2012 Mar	2012 June	2012 Aug	2012 Nov
0 m	-0.50	8.7	15.8	8.1	-1.08	9.7	19.0	7.8
10 m	-0.50	7.1	13.9	8.1	-1.07	8.9	17.3	7.8
20 m	-0.51	4.1	8.7	8.1	-1.08	6.7	9.8	7.5
30 m	-0.51	2.0	5.1	8.1	-1.20	4.1	4.8	6.1
50 m	-0.46	0.8	1.6	5.1	-1.22	1.0	1.4	2.6
75 m	0.1	0.7	0.9	2.0	0.4	1.3	1.5	1.5
100 m	1.2	1.1	1.4	1.7	1.8	1.9	2.0	1.6
150 m	2.8	2.9	2.7	2.9	3.8	4.0	4.0	3.5
200 m	4.6	4.5	4.4	4.8	5.1	5.3	5.5	4.8
250 m		5.4	5.5	5.9		5.9	6.1	5.9
300 m		5.6	5.7	5.7		5.8	5.9	5.9
350 m		5.5	5.6	5.6		5.6	5.7	5.7
400 m		5.4	5.5	5.4		5.5	5.4	5.5
450 m			5.3	5.3		5.3	5.3	

7 - Cabot Strait / Détroit de Cabot

	2011 Mar	2011 June	2011 Aug	2011 Nov	2012 Mar	2012 June	2012 Aug	2012 Nov
0 m	-0.22	7.4	15.1	8.4	-0.73	9.1	19.4	9.9
10 m	-0.24	7.2	14.7	8.4	-0.77	8.3	14.9	9.9
20 m	-0.23	4.7	13.0	8.1	-0.70	5.6	6.2	9.7
30 m	-0.14	2.0	9.8	7.8	-0.63	2.8	3.3	7.7
50 m	0.2	1.7	3.4	4.9	-0.19	1.3	2.2	4.2
75 m	0.8	2.0	2.4	2.5	1.1	1.6	1.6	2.3
100 m	1.5	2.4	2.1	2.1	2.5	2.1	1.9	1.9
150 m	3.3	3.8	3.5	4.0	4.4	4.5	4.3	3.6
200 m	5.6	5.8	5.8	5.6	6.3	6.5	6.5	6.2
250 m		6.4	6.5	6.1	6.9	6.5	6.7	6.6
300 m		6.0	5.9	6.1		6.1	6.3	6.3
350 m		5.7	5.6	5.7		5.8	5.8	5.7
400 m		5.4	5.3	5.4		5.4	5.5	5.4
450 m		5.1	5.2	5.1		5.2	5.3	5.3
500 m			5.1	5.1			5.2	

8 - Magdalen Shallows / Plateau madelinien

	2011 Mar	2011 June	2011 Sep	2011 Nov	2012 Mar	2012 June	2012 Sep	2012 Nov
0 m	-1.15	9.7	14.8	8.4	-1.35	11.2	16.5	9.2
10 m	-1.21	8.9	14.6	8.4	-1.43	10.1	16.3	9.1
20 m	-1.25	5.6	12.1	8.2	-1.48	5.9	12.0	8.5
30 m	-1.26	2.6	6.5	7.5	-1.49	2.4	5.5	7.1
50 m	-1.12	0.2	1.4	3.2	-1.14	0.4	1.3	2.6
75 m	-0.72	0.2	0.7	1.3	-0.29	0.5	1.0	1.8
100 m					0.2	0.9	1.4	

Table 17. Depth-layer monthly average stratification and salinity summary for months during whichthe eight Gulf-wide oceanographic surveys took place in 2011 and 2012. 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

	2011				2012			
	Mar	June	Aug	Oct	Mar	June	Aug	Nov
Strat.	2.12	8.0	4.7	3.6	3.66	4.8	3.5	1.9
0 m	28.2	21.7	26.1	27.4	27.0	26.0	28.2	28.7
10 m	28.5	24.3	26.9	29.4	28.4	26.9	28.7	28.8
20 m	29.0	27.4	27.9	30.2	29.5	28.3	29.5	29.3
30 m	29.6	29.1	29.0	30.6	30.4	29.7	30.2	29.9
50 m	30.9	30.9	30.8	31.6	31.6	31.2	31.4	31.0
75 m	32.2	31.8	32.0	32.4	32.2	32.1	32.3	32.0
100 m	32.8	32.4	32.7	33.1	32.8	32.6	32.8	32.6
150 m	33.5	33.3	33.5	33.7	33.5	33.6	33.6	33.4
200 m	33.9	33.9	34.0	34.1	34.0	34.1	34.0	33.9
250 m	34.2	34.2	34.3	34.3	34.2	34.3	34.3	34.3
300 m	34.4	34.4	34.4	34.4	34.4	34.5	34.5	34.4
350 m		34.4	34.4	34.4		34.5	34.5	34.5

2 - Northwest Gulf / Nord-ouest du Golfe

	2011				2012			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
Strat.	0.70	4.3	4.9	1.7	0.57	4.1	4.8	2.0
0 m	30.7	27.3	27.7	29.6	31.3	27.9	28.4	29.9
10 m	30.8	28.6	28.4	29.6	31.3	28.7	29.0	30.1
20 m	31.2	30.2	29.9	30.0	31.6	30.2	30.2	30.8
30 m	31.3	31.0	30.7	30.5	31.6	31.0	31.0	31.2
50 m	31.6	31.8	31.5	31.4	32.1	31.8	31.8	32.0
75 m	32.1	32.3	32.1	32.2	32.5	32.4	32.3	32.5
100 m	32.5	32.7	32.6	32.6	32.9	32.8	32.8	32.9
150 m	33.5	33.6	33.5	33.5	33.7	33.6	33.6	33.6
200 m	34.0	34.1	34.2	34.1	34.1	34.1	34.1	34.1
250 m	34.5	34.4	34.5	34.5	34.6	34.5	34.5	34.4
300 m	34.5	34.6	34.7	34.7	34.7	34.7	34.7	34.7
350 m		34.7	34.8	34.8		34.7	34.7	34.8
400 m			34.8					

3 - Anticosti Channel / Chenal Anticosti

	2011				2012			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
Strat.	0.09	1.7	3.6	0.6	0.08	1.5	3.9	0.9
0 m	31.8	30.3	29.8	31.1	31.7	30.6	30.2	31.1
10 m	31.8	30.6	30.1	31.1	31.7	30.6	30.5	31.2
20 m	31.8	31.4	30.9	31.1	31.8	31.0	31.3	31.4
30 m	31.9	31.6	31.4	31.2	31.8	31.4	31.6	31.5
50 m	31.9	31.9	31.8	31.6	31.8	31.7	31.9	31.9
75 m	32.0	32.1	32.1	32.0	32.0	32.1	32.4	32.3
100 m	32.2	32.3	32.5	32.4	32.5	32.4	32.7	32.7
150 m	32.8	33.1	33.4	33.3	33.3	33.2	33.4	33.4
200 m	33.8	34.0	34.2	34.1	34.0	33.7	34.2	34.1
250 m			34.5	34.5			34.5	34.6

4 - Mécatina Trough / Cuvette de Mécatina

	2011				2012			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
Strat.	0.09	1.7	2.7		0.23	1.0	3.7	1.0
0 m	32.0	30.4	30.5		32.0	30.7	30.1	31.1
10 m	32.1	30.6	30.9		32.0	30.7	30.6	31.1
20 m	32.1	31.1	31.4		32.1	30.8	31.4	31.2
30 m	32.1	31.5	31.6		32.2	30.9	31.7	31.4
50 m	32.1	31.9	31.8		32.3	31.5	32.0	31.8
75 m	32.1	32.1	32.0		32.4	31.9	32.3	32.1
100 m	32.2	32.2	32.2		32.6	32.4	32.6	32.2
150 m	32.2	32.5	32.6		32.8	32.7	32.9	32.7
200 m	32.2	32.7	32.8		32.9	32.8	33.1	33.0

5 - Esquiman Channel / Chenal Esquiman

	2011				2012			
	Mar	June	Aug	Nov	Mar	June	Aug	Oct
Strat.	0.25	1.1	3.2	0.7	0.19	0.9	3.7	1.4
0 m	31.5	31.1	30.4	31.2	31.5	31.3	30.6	30.9
10 m	31.7	31.3	30.5	31.2	31.6	31.3	30.7	30.9
20 m	31.8	31.4	31.0	31.3	31.7	31.4	31.1	31.0
30 m	31.8	31.5	31.4	31.3	31.7	31.6	31.4	31.2
50 m	31.8	31.8	31.8	31.8	31.8	31.9	31.8	31.8
75 m	31.9	32.0	32.1	32.2	32.0	32.4	32.3	32.3
100 m	32.4	32.4	32.4	32.6	32.4	32.7	32.6	32.6
150 m	33.2	33.4	33.3	33.5	33.3	33.4	33.4	33.5
200 m	34.0	34.1	34.1	34.2	34.0	34.1	34.2	34.2
250 m		34.4	34.5	34.6		34.6	34.5	34.5
300 m			34.6				34.7	34.6

6 - Central Gulf / Centre du Golfe

	2011				2012			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
Strat.	0.06	2.0	4.6	1.0	0.08	1.9	4.4	1.5
0 m	31.6	30.4	28.5	30.8	31.5	30.7	29.9	30.7
10 m	31.6	30.6	29.3	30.8	31.5	30.8	30.1	30.7
20 m	31.6	31.1	30.7	30.8	31.5	31.1	30.8	30.8
30 m	31.7	31.5	31.3	30.8	31.5	31.4	31.4	31.2
50 m	31.7	31.9	31.8	31.6	31.6	31.9	31.9	31.9
75 m	31.9	32.2	32.2	32.2	32.0	32.3	32.4	32.4
100 m	32.5	32.6	32.6	32.5	32.6	32.8	32.8	32.7
150 m	33.4	33.4	33.3	33.3	33.6	33.7	33.7	33.5
200 m	34.1	34.1	34.0	34.1	34.3	34.2	34.3	34.1
250 m		34.5	34.5	34.6		34.6	34.6	34.6
300 m		34.7	34.7	34.8		34.7	34.8	34.7
350 m		34.8	34.8	34.9		34.8	34.8	34.8
400 m		34.9	34.9	34.9		34.9	34.9	34.9
450 m			34.9	34.9		34.9	34.9	

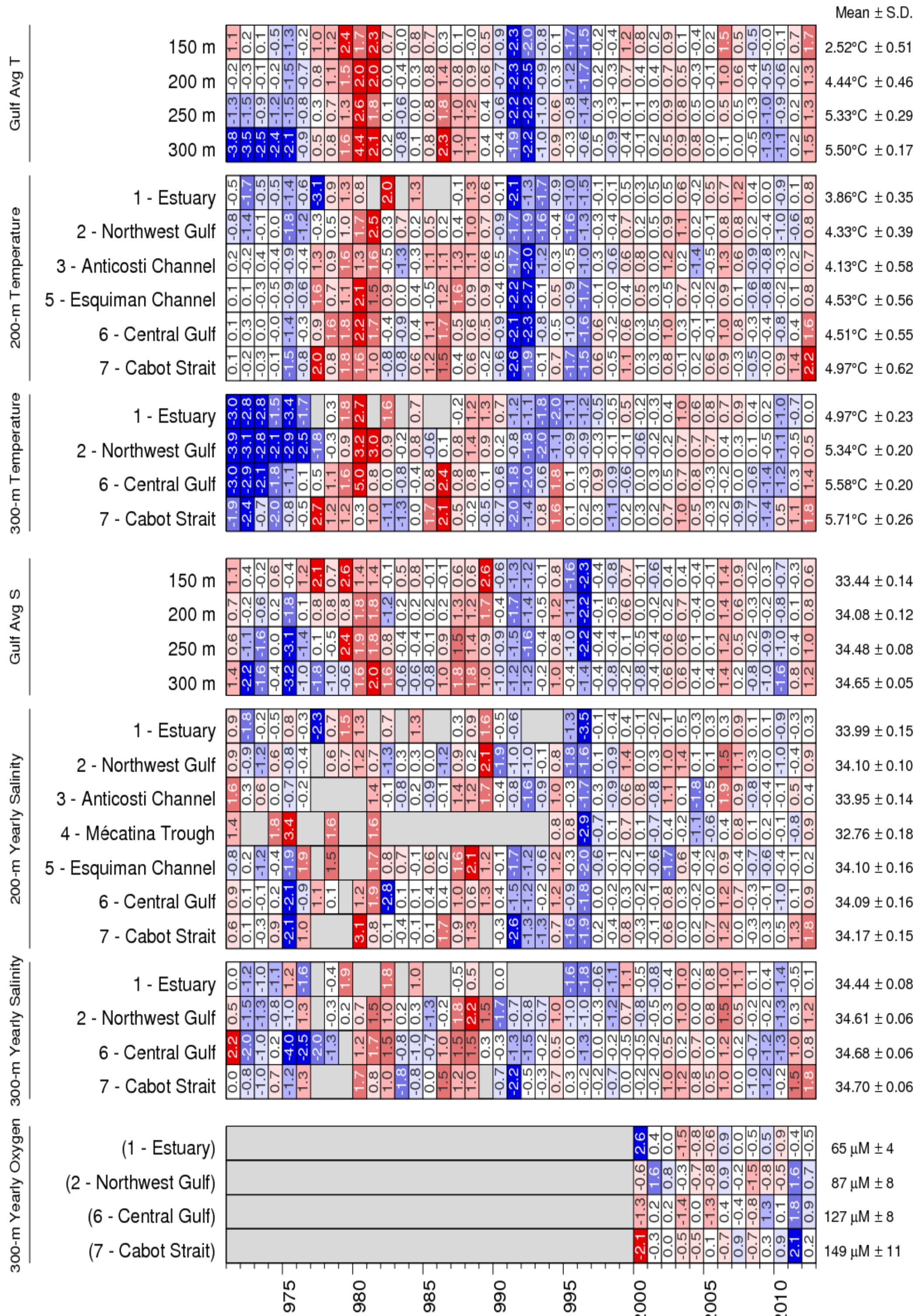
7 - Cabot Strait / Détroit de Cabot

	2011				2012			
	Mar	June	Aug	Nov	Mar	June	Aug	Nov
Strat.	0.62	1.9	3.2	1.4	0.82	1.8	4.0	1.9
0 m	30.7	30.0	30.3	30.4	30.2	30.5	30.7	30.6
10 m	30.8	30.0	30.7	30.5	30.4	30.6	31.0	30.6
20 m	31.0	30.5	31.2	30.7	30.7	30.9	31.4	30.8
30 m	31.2	30.9	31.5	30.9	30.9	31.2	31.7	31.3
50 m	31.5	31.6	32.1	31.6	31.3	31.6	32.1	32.1
75 m	31.9	32.5	32.4	32.4	32.0	32.3	32.4	32.6
100 m	32.4	32.9	32.6	32.8	32.7	32.8	32.8	32.7
150 m	33.4	33.6	33.4	33.6	33.8	33.7	33.6	33.4
200 m	34.3	34.3	34.3	34.2	34.4	34.4	34.4	34.3
250 m		34.7	34.7	34.6	34.8	34.6	34.7	34.7
300 m		34.8	34.8	34.8		34.8	34.8	34.8
350 m		34.9	34.9	34.8		34.8	34.9	34.9
400 m		34.9	34.9	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	

8 - Magdalen Shallows / Plateau madelinien

	2011				2012			
	Mar	June	Sep	Nov	Mar	June	Sep	Nov
Strat.	0.29	3.3	4.4	2.4	0.57	2.8	4.3	2.2
0 m	30.4	28.2	27.9	28.8	30.1	29.3	28.9	29.5
10 m	30.5	28.7	28.1	28.8	30.1	29.6	29.0	29.6
20 m	30.5	29.5	28.7	29.1	30.2	30.1	29.5	29.9
30 m	30.5	30.2	29.8	29.7	30.3	30.6	30.4	30.3
50 m	30.8	31.1	31.2	31.1	30.8	31.3	31.5	31.4
75 m	31.2	31.9	31.9	31.9	31.5	32.0	32.0	32.0
100 m					31.9	32.2	32.5	

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 300m. 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 all data are included). The numbers in the boxes are normalized anomalies.



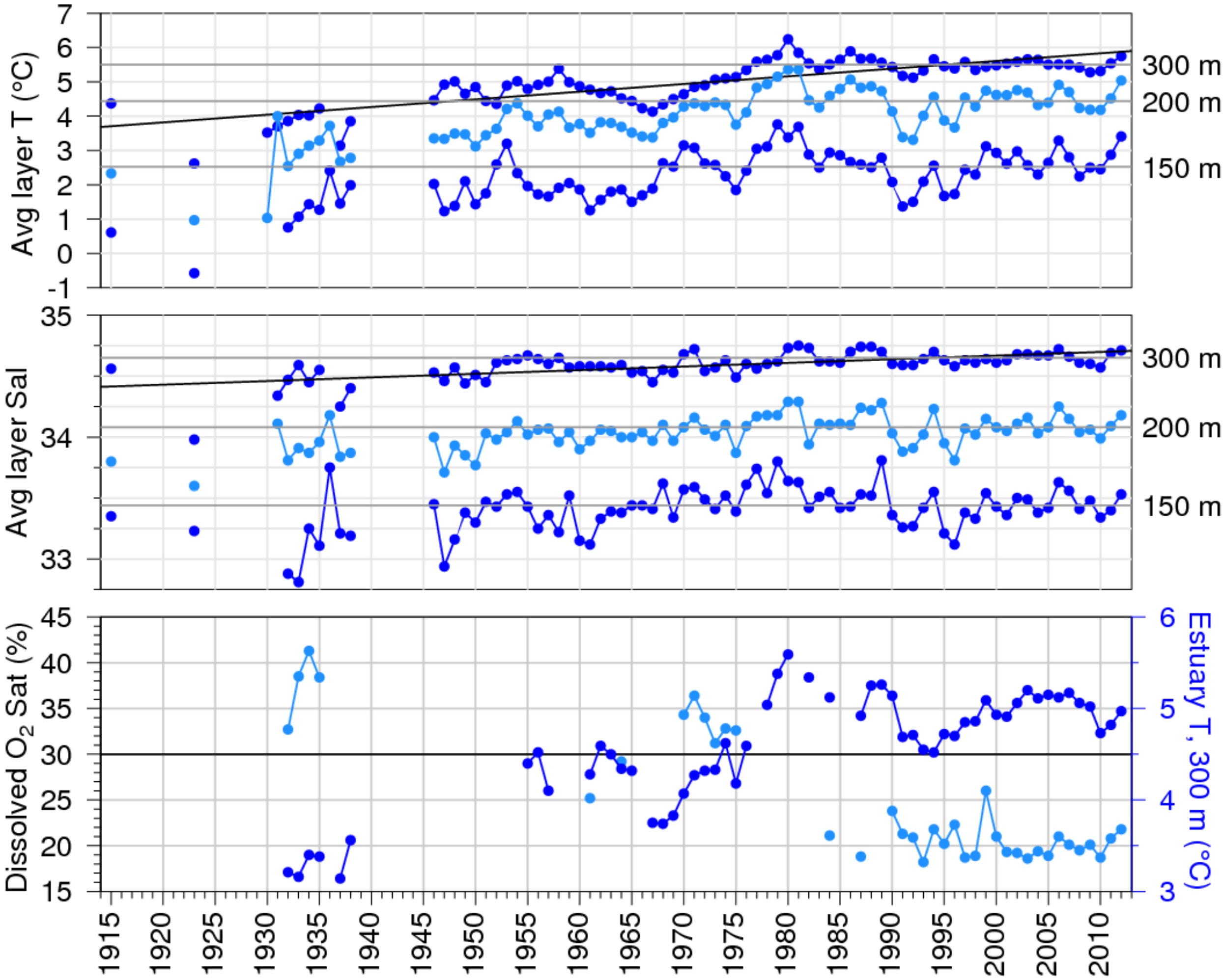


Figure 44. Layer-averaged temperature and salinity time series for the Gulf of St. Lawrence and dissolved oxygen saturation between 295 m and the bottom in the deep central basin of the St. Lawrence Estuary. The temperature and salinity panels show the 150 m, 200 m, and 300 m annual averages and the horizontal lines are 1981–2010 means. Sloped lines show linear regressions for temperature and salinity at 300 m of respectively 2.2°C and 0.3 per century 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.

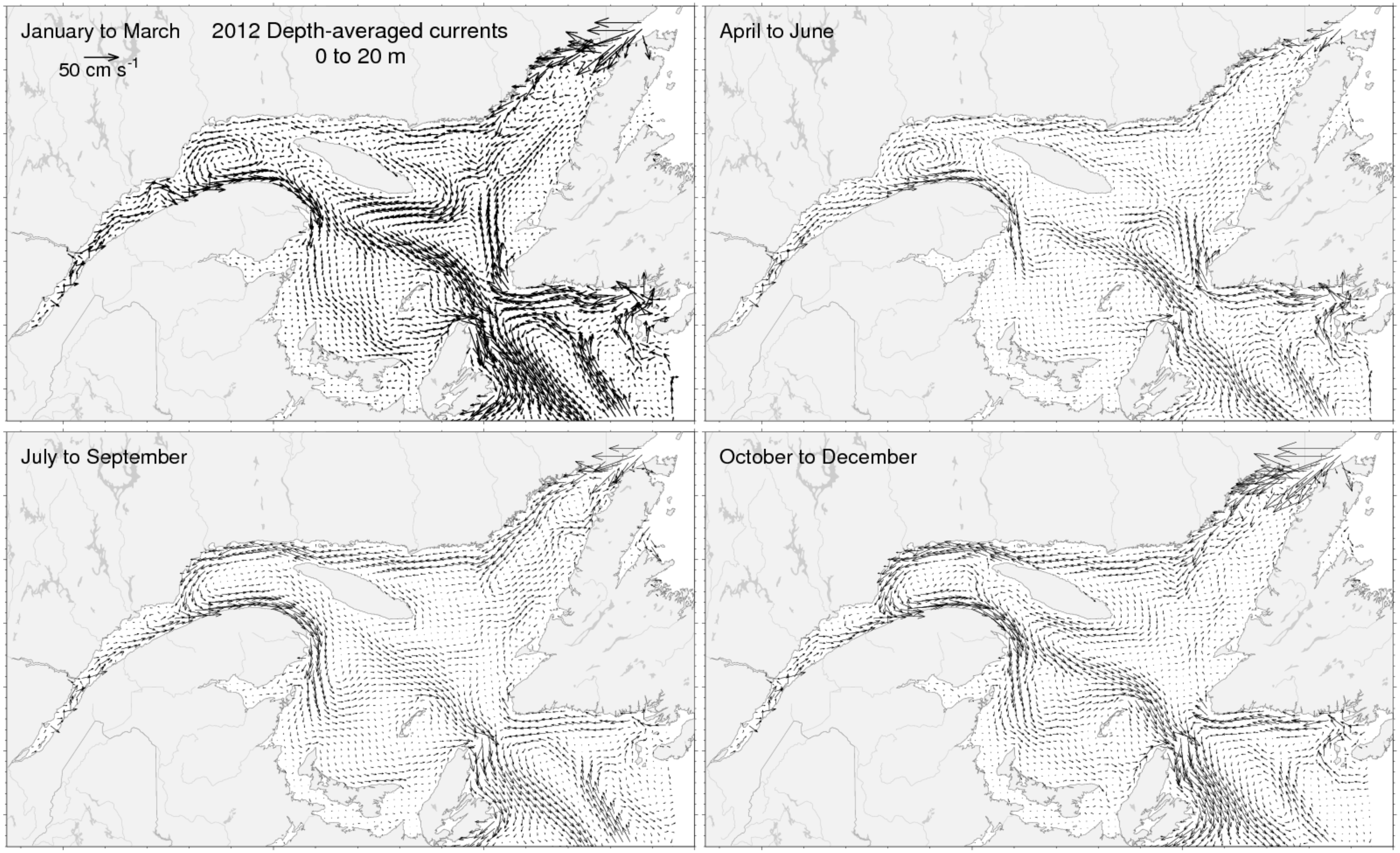


Figure 45. Depth-averaged currents from 0 to 20 m for each three-month period of 2012.

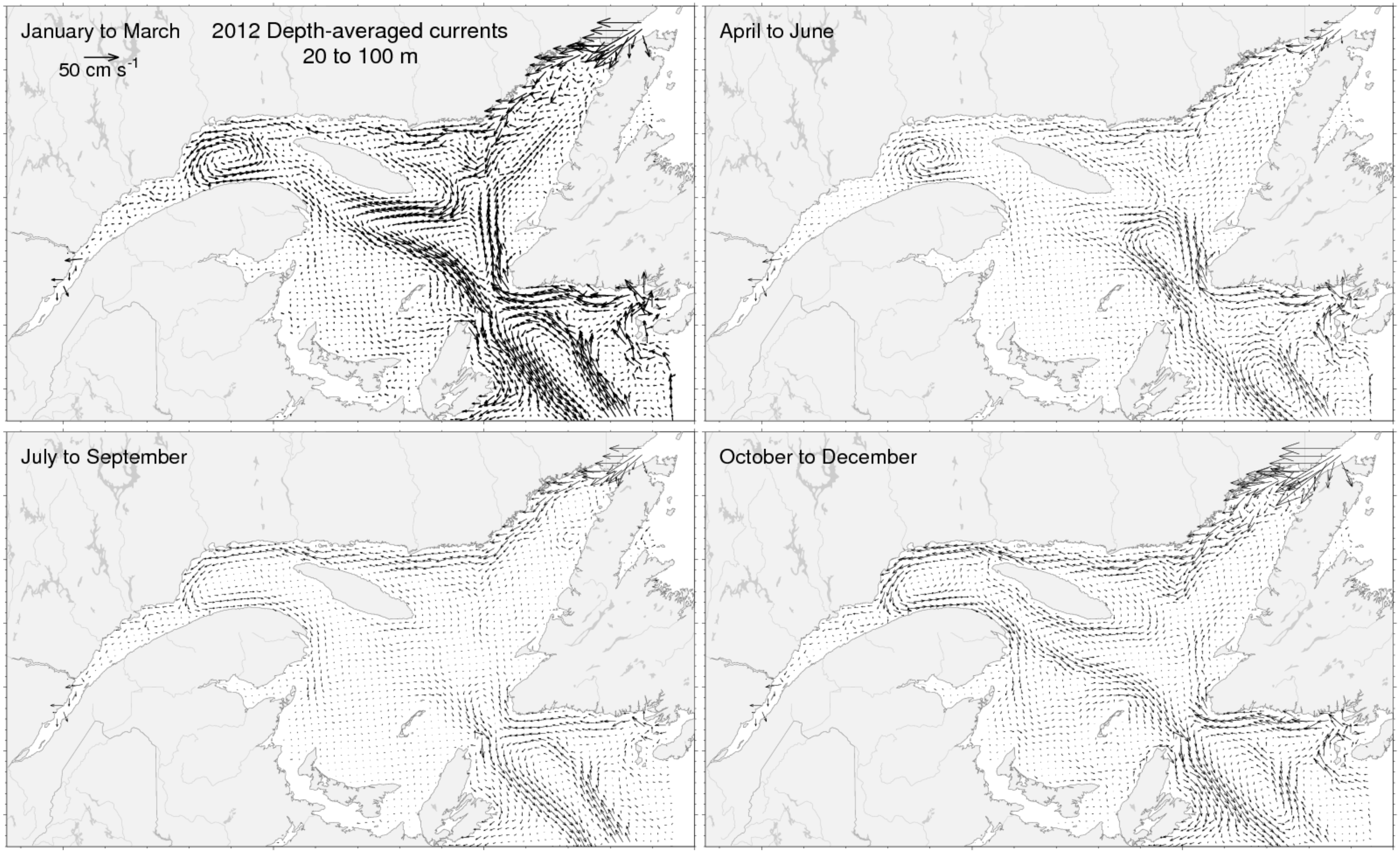


Figure 46. Depth-averaged currents from 20 to 100 m for each three-month period of 2012.

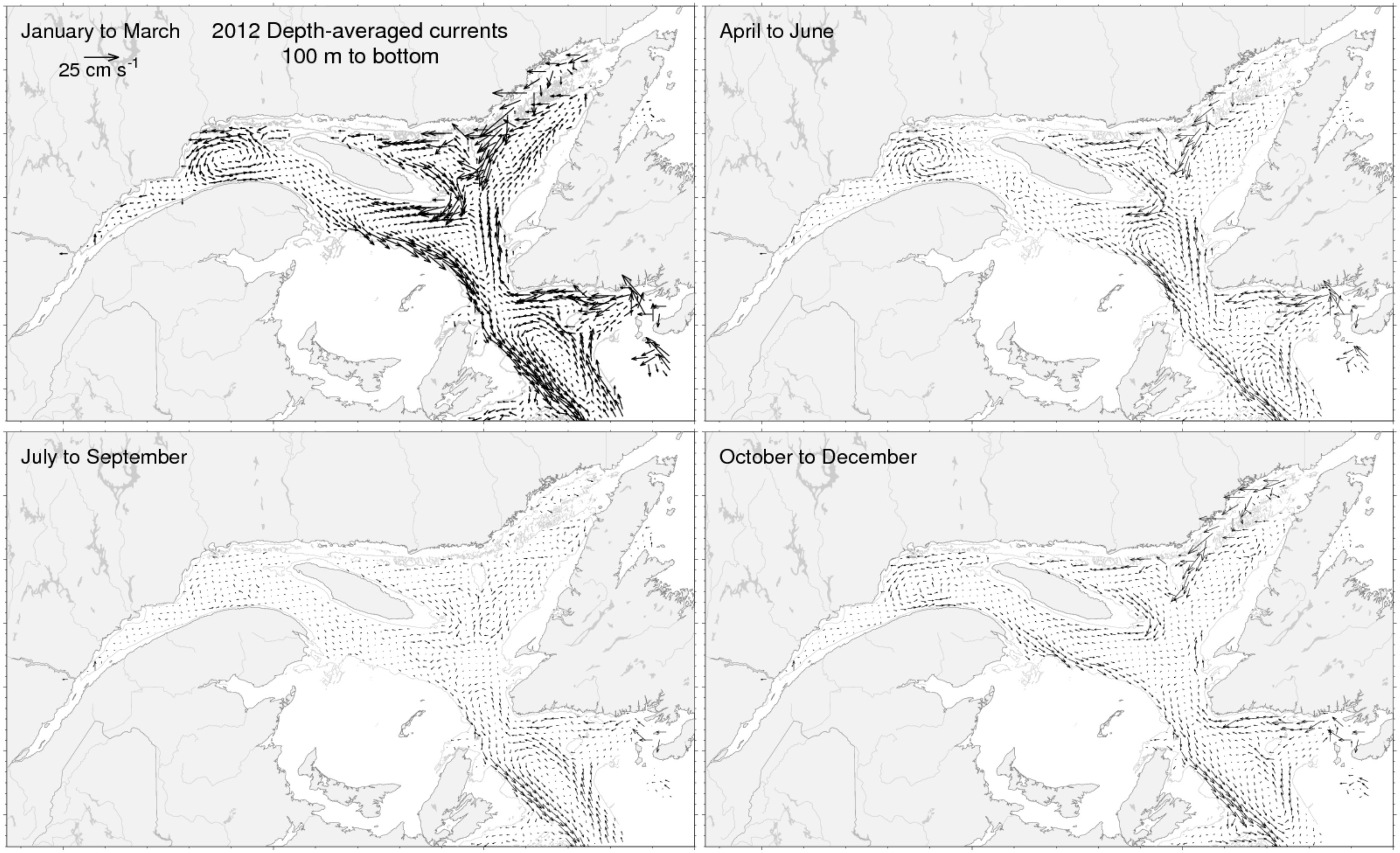


Figure 47. Depth-averaged currents from 100 m to the bottom for each three-month period of 2012.

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 2006–2012 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	2012	Mean ± SD
Pointe-des-Monts	J	-0.7	0.4	0.1	-1.6	-0.1	1.7	0.1	$16.84 \times 10^3\ m^3\ s^{-1} \pm 1.3$
	F	1.2	-1.0	-0.7	0.8	0.8	-1.3	0.2	$15.73 \times 10^3\ m^3\ s^{-1} \pm 2.0$
	M	-1.6	0.6	-0.7	-0.2	-0.2	0.4	1.6	$18.72 \times 10^3\ m^3\ s^{-1} \pm 1.4$
	A	-0.3	-0.9	0.6	1.2	-1.6	0.7	0.3	$22.99 \times 10^3\ m^3\ s^{-1} \pm 1.5$
	M	-0.2	-0.7	0.7	-0.0	-1.4	1.7	0.0	$23.98 \times 10^3\ m^3\ s^{-1} \pm 3.8$
	J	-0.3	-0.6	1.1	0.4	-1.6	1.2	-0.2	$21.03 \times 10^3\ m^3\ s^{-1} \pm 3.3$
	J	-0.4	-0.8	0.9	1.1	-1.4	1.0	-0.4	$18.11 \times 10^3\ m^3\ s^{-1} \pm 3.3$
	A	-0.3	-1.2	1.2	0.6	-1.1	1.1	-0.3	$16.72 \times 10^3\ m^3\ s^{-1} \pm 2.8$
	S	0.7	-1.3	0.4	-0.3	0.2	1.4	-1.2	$16.11 \times 10^3\ m^3\ s^{-1} \pm 1.4$
	O	1.7	-1.4	-0.5	0.2	0.6	-0.5	-0.1	$16.42 \times 10^3\ m^3\ s^{-1} \pm 2.0$
	N	2.0	-0.9	-0.4	-0.5	0.7	-0.4	-0.4	$17.25 \times 10^3\ m^3\ s^{-1} \pm 2.1$
	D	1.2	-1.5	-0.6	0.0	1.4	-0.2	-0.3	$16.10 \times 10^3\ m^3\ s^{-1} \pm 2.7$
Honguedo	J	0.2	-0.1	0.0	0.0	0.4	-2.0	1.4	0.200 Sv ± 0.051
	F	0.1	-0.6	0.0	0.8	1.0	-1.9	0.5	$95.99 \times 10^3\ m^3\ s^{-1} \pm 75.7$
	M	0.7	1.3	-1.8	-0.6	0.3	0.2	-0.2	0.116 Sv ± 0.035
	A	-1.0	0.3	-1.3	1.6	0.1	-0.4	0.7	0.167 Sv ± 0.052
	M	-0.9	-1.1	1.2	-0.5	0.5	1.3	-0.6	0.111 Sv ± 0.054
	J	-1.2	-0.8	1.2	0.3	-0.7	1.3	-0.2	0.204 Sv ± 0.071
	J	-0.2	-1.3	-0.4	1.6	1.1	-0.3	-0.5	0.335 Sv ± 0.049
	A	0.9	-1.4	1.1	-1.3	0.4	0.2	0.1	0.372 Sv ± 0.051
	S	1.1	-0.6	0.6	-1.0	1.3	-1.0	-0.4	0.361 Sv ± 0.024
	O	0.4	-0.9	-0.0	0.5	1.8	-1.2	-0.4	0.409 Sv ± 0.060
	N	-0.9	1.3	1.4	-0.9	-0.1	-0.8	-0.0	0.423 Sv ± 0.107
	D	-2.0	-0.4	0.2	1.0	0.6	-0.1	0.7	0.391 Sv ± 0.085
Cabot	J	-0.2	-0.8	-0.1	-0.3	0.2	2.1	-0.8	0.496 Sv ± 0.066
	F	1.5	-0.8	-0.6	0.7	-0.0	0.5	-1.3	0.355 Sv ± 0.041
	M	-0.3	-0.9	2.0	-0.8	0.5	-0.4	-0.2	0.303 Sv ± 0.026
	A	0.5	0.4	1.4	-1.4	0.7	-1.1	-0.5	0.242 Sv ± 0.052
	M	1.1	0.5	1.1	-0.9	0.2	-0.5	-1.4	0.143 Sv ± 0.053
	J	1.0	-1.9	-0.2	0.8	-0.6	0.5	0.2	0.125 Sv ± 0.073
	J	0.3	-0.1	-0.1	1.8	-1.6	-0.3	-0.1	0.130 Sv ± 0.042
	A	0.1	0.7	1.6	-0.8	-0.5	0.3	-1.4	0.266 Sv ± 0.027
	S	0.2	0.6	-0.7	0.5	-0.9	1.6	-1.2	0.400 Sv ± 0.043
	O	1.0	-0.5	0.8	0.9	-1.4	-1.1	0.2	0.551 Sv ± 0.056
	N	-0.2	-2.1	0.1	0.8	0.6	0.3	0.5	0.539 Sv ± 0.032
	D	-0.7	-1.1	-0.6	0.7	1.2	-0.7	1.2	0.516 Sv ± 0.062

Outward Transport

Section	Month	2006	2007	2008	2009	2010	2011	2012	Mean ± SD
Pointe-des-Monts	J	-0.0	1.0	-0.6	-0.4	1.6	-0.1	-1.4	0.291 Sv ± 0.040
	F	-2.0	0.5	-0.2	1.2	0.2	0.0	0.3	0.259 Sv ± 0.030
	M	-1.0	1.4	-1.0	0.5	0.9	0.1	-1.0	0.231 Sv ± 0.028
	A	-1.0	0.8	-0.2	1.7	-1.0	-0.6	0.3	0.275 Sv ± 0.047
	M	-1.0	-1.1	-0.4	0.3	-0.1	1.8	0.5	0.244 Sv ± 0.054
	J	-0.5	-1.5	-1.0	1.1	0.4	0.7	0.8	0.177 Sv ± 0.023
	J	-0.8	-0.7	0.2	2.0	0.3	-1.0	-0.0	0.198 Sv ± 0.040
	A	-1.3	-0.3	1.5	-0.7	-0.2	-0.2	1.2	0.206 Sv ± 0.043
	S	-0.5	-0.4	0.3	-0.6	2.1	0.0	-0.9	0.212 Sv ± 0.047
	O	0.8	-0.4	-0.1	1.8	-1.3	-0.5	-0.3	0.268 Sv ± 0.016
	N	-0.4	1.3	1.4	-0.6	-0.1	-1.2	-0.3	0.267 Sv ± 0.046
	D	-0.6	-0.5	-0.5	0.4	2.1	-0.6	-0.3	0.325 Sv ± 0.106
Honguedo	J	-0.0	-1.1	-0.1	1.0	1.7	-0.8	-0.6	0.678 Sv ± 0.127
	F	-0.5	-0.4	-0.4	1.8	0.3	-1.3	0.6	0.492 Sv ± 0.085
	M	-1.5	0.8	-0.9	0.2	0.8	-0.5	1.2	0.534 Sv ± 0.083
	A	-0.9	0.5	0.0	1.9	-1.1	-0.1	-0.3	0.607 Sv ± 0.118
	M	-1.1	1.7	-0.4	-0.5	0.2	0.9	-0.6	0.495 Sv ± 0.086
	J	-0.9	1.1	0.2	-0.7	-0.3	1.6	-1.0	0.460 Sv ± 0.086
	J	-0.2	-0.2	-0.7	2.2	0.1	-0.6	-0.7	0.499 Sv ± 0.057
	A	-0.2	-1.0	1.6	-0.8	-0.5	1.1	-0.2	0.573 Sv ± 0.073
	S	-0.9	-0.9	0.7	-1.0	1.6	0.5	-0.1	0.607 Sv ± 0.056
	O	0.1	-0.5	-0.5	0.7	1.4	-1.6	0.5	0.721 Sv ± 0.043
	N	-0.5	1.0	1.2	-1.4	0.5	-1.1	0.2	0.770 Sv ± 0.148
	D	-1.4	-0.6	0.6	0.0	1.7	-0.4	0.1	0.937 Sv ± 0.233
Cabot	J	-0.0	1.1	0.4	1.3	-0.9	-0.7	-1.3	2.063 Sv ± 0.222
	F	-1.6	1.4	0.7	0.0	0.6	-0.4	-0.7	1.933 Sv ± 0.179
	M	-1.8	0.9	-0.3	-0.7	0.8	0.8	0.3	1.699 Sv ± 0.226
	A	-1.0	0.2	-0.0	-1.0	-0.8	1.4	1.2	1.586 Sv ± 0.177
	M	0.1	-0.7	-0.9	-0.9	0.1	2.0	0.3	1.164 Sv ± 0.163
	J	-0.2	0.0	-0.6	-1.1	1.0	1.7	-0.8	0.909 Sv ± 0.173
	J	-0.0	-0.5	-0.5	-0.8	2.2	0.1	-0.4	0.872 Sv ± 0.179
	A	0.2	0.2	-1.2	-1.3	1.6	0.4	0.2	1.038 Sv ± 0.237
	S	-0.7	1.3	-1.2	-1.1	1.1	0.2	0.4	0.978 Sv ± 0.268
	O	-0.9	1.0	-1.1	-0.6	1.2	1.0	-0.5	1.119 Sv ± 0.263
	N	-0.5	1.9	-0.8	-1.1	-0.0	0.6	-0.0	1.411 Sv ± 0.163
	D	-0.8	1.5	0.9	0.2	0.2	-1.0	-1.0	2.092 Sv ± 0.188

Estuarine ratio

Section	Month	2006	2007	2008	2009	2010	2011	2012	Mean ± SD
Pointe-des-Monts	J	0.3	0.7	-0.7	0.4	1.5	-0.9	-1.4	17.36 ± 2.55
	F	-1.9	1.1	0.3	0.1	-0.5	1.0	-0.0	16.76 ± 3.10
	M	0.0	1.0	-0.6	0.7	1.0	-0.2	-1.8	12.35 ± 1.51
	A	-1.0	1.4	-0.4	1.3	-0.5	-1.0	0.2	11.96 ± 1.83
	M	-1.2	-0.9	-1.0	0.4	1.5	0.6	0.6	10.21 ± 1.77
	J	-0.2	-0.7	-1.3	0.2	1.8	-0.5	0.6	8.60 ± 1.81
	J	-0.5	-0.0	-0.6	0.6	1.7	-1.4	0.2	11.17 ± 2.60
	A	-1.1	0.7	0.3	-1.1	0.7	-0.9	1.4	12.50 ± 2.80
	S	-0.8	0.1	0.1	-0.5	2.1	-0.5	-0.6	13.19 ± 2.65
	O	-1.2	1.4	0.4	0.6	-1.3	0.2	-0.1	16.50 ± 1.92
	N	-1.1	1.5	1.2	-0.3	-0.5	-0.8	-0.1	15.73 ± 3.74
	D	-1.4	0.5	-0.3	0.6	1.6	-0.7	-0.2	20.16 ± 4.69
Honguedo	J	-0.3	-0.8	-0.3	0.3	0.3	1.9	-1.2	3.62 ± 1.18
	F	0.2	1.2	0.3	0.2	-0.0	-2.1	0.2	3.01 ± 5.20
	M	-1.1	-0.7	1.9	0.3	-0.2	-0.6	0.3	5.10 ± 1.96
	A	0.4	-0.2	1.9	-0.5	-1.0	0.2	-0.9	3.86 ± 1.14
	M	0.3	2.0	-0.9	-0.1	-0.6	-0.8	-0.0	5.51 ± 3.20
	J	0.9	1.5	-1.0	-0.8	0.5	-0.6	-0.6	2.46 ± 0.82
	J	0.1	2.0	-0.2	0.0	-1.3	-0.3	-0.1	1.50 ± 0.15
	A	-1.3	0.7	0.4	0.9	-1.1	1.0	-0.5	1.55 ± 0.16
	S	-1.8	-0.6	0.3	-0.3	0.7	1.5	0.3	1.68 ± 0.14
	O	-0.6	1.2	-0.4	-0.3	-1.6	0.9	1.0	1.78 ± 0.17
	N	1.4	-1.1	-1.0	-0.4	1.2	-0.3	0.4	1.84 ± 0.19
	D	0.7	-0.5	0.6	-1.2	1.6	-0.6	-0.8	2.42 ± 0.37
Cabot	J	0.0	1.3	0.2	1.0	-0.7	-1.6	-0.3	4.23 ± 0.75
	F	-1.7	1.3	0.7	-0.5	0.2	-0.6	0.5	5.53 ± 0.96
	M	-1.4	1.3	-1.2	-0.3	0.3	0.9	0.3	5.64 ± 0.91
	A	-0.9	-0.4	-0.9	0.7	-0.9	1.5	0.8	6.89 ± 1.92
	M	-0.8	-0.7	-0.9	0.3	-0.4	0.7	1.8	9.58 ± 4.79
	J	0.3	-2.3	0.4	0.3	0.6	0.4	0.3	-4.68 ± 30.58
	J	-0.4	-0.3	-0.3	-0.8	2.2	-0.1	-0.3	7.95 ± 5.34
	A	0.1	-0.2	-1.4	-0.9	1.6	0.2	0.8	3.95 ± 1.05
	S	-0.7	0.8	-0.9	-1.1	1.4	-0.3	0.8	2.47 ± 0.75
	O	-0.9	0.8	-1.0	-0.7	1.3	1.0	-0.5	2.09 ± 0.70
	N	-0.3	2.1	-0.6	-0.9	-0.3	0.2	-0.2	2.64 ± 0.48
	D	0.0	1.7	0.9	-0.4	-0.7	-0.2	-1.3	4.11 ± 0.70

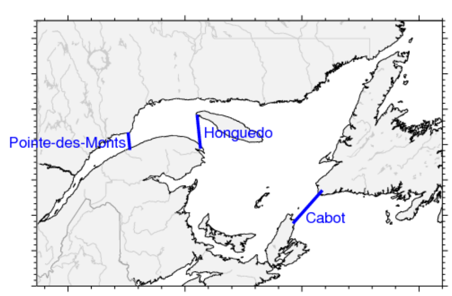


Table 20. Monthly averaged modelled transports across sections of the Gulf of St. Lawrence since 2006. The numbers on the right are the 2006–2012 means and standard deviations, with positive values toward east and north. The numbers in the boxes are normalized anomalies. Colours indicate the magnitude of the anomaly (e.g., negative anomalies are still shown in red when the mean transport is negative across the section).

Jacques-Cartier

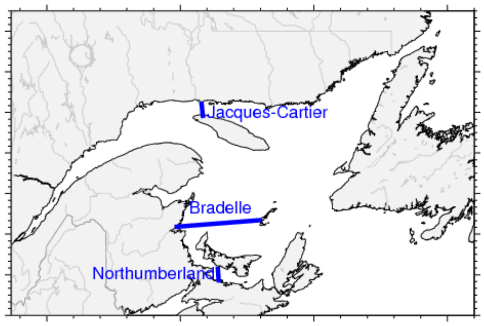
Month	2006	2007	2008	2009	2010	2011	2012	Mean ± SD
J	-0.2	0.1	-0.0	-0.2	-0.4	2.0	-1.3	-0.181 Sv ± 0.053
F	-0.1	0.6	-0.0	-0.8	-1.1	1.9	-0.5	$-79.94 \times 10^{3}\ m^{3}\ s^{-1} \pm 72.8$
M	-0.8	-1.2	1.8	0.5	-0.3	-0.2	0.2	$-93.72 \times 10^{3}\ m^{3}\ s^{-1} \pm 33.3$
A	1.0	-0.4	1.3	-1.6	-0.1	0.5	-0.7	-0.140 Sv ± 0.052
M	0.9	1.1	-1.2	0.4	-0.6	-1.2	0.6	$-82.03 \times 10^{3}\ m^{3}\ s^{-1} \pm 51.3$
J	1.2	0.8	-1.2	-0.3	0.7	-1.3	0.2	-0.177 Sv ± 0.067
J	0.1	1.2	0.5	-1.5	-1.2	0.4	0.5	-0.312 Sv ± 0.050
A	-1.0	1.3	-1.0	1.4	-0.5	-0.1	-0.1	-0.352 Sv ± 0.050
S	-1.1	0.5	-0.5	1.0	-1.3	1.1	0.3	-0.343 Sv ± 0.024
O	-0.4	0.9	0.1	-0.4	-1.8	1.2	0.5	-0.392 Sv ± 0.059
N	0.9	-1.3	-1.4	0.9	0.2	0.7	0.0	-0.404 Sv ± 0.108
D	2.0	0.3	-0.2	-1.0	-0.6	0.1	-0.7	-0.375 Sv ± 0.085

Bradelle

Month	2006	2007	2008	2009	2010	2011	2012	Mean ± SD
J	0.5	-0.4	0.7	-1.6	0.9	-1.0	0.8	-0.372 Sv ± 0.106
F	2.1	0.2	-0.3	-0.1	-0.3	-0.9	-0.6	-0.273 Sv ± 0.036
M	0.4	-1.4	0.5	0.5	0.5	-1.5	0.9	-0.192 Sv ± 0.086
A	-0.3	-0.5	1.5	-0.8	1.1	-1.2	0.2	-0.190 Sv ± 0.055
M	0.7	-0.9	-0.8	0.5	-1.3	0.3	1.5	-0.128 Sv ± 0.070
J	0.6	-0.8	-1.0	1.6	-0.3	-0.9	0.8	$-53.97 \times 10^{3}\ m^{3}\ s^{-1} \pm 95.3$
J	1.3	-1.6	0.0	0.8	0.7	-0.8	-0.5	$-88.69 \times 10^{3}\ m^{3}\ s^{-1} \pm 48.8$
A	-0.3	-1.6	-0.0	0.3	0.8	1.4	-0.7	$-60.20 \times 10^{3}\ m^{3}\ s^{-1} \pm 57.5$
S	-0.4	-0.8	-0.3	0.3	-1.3	1.6	0.8	$-67.56 \times 10^{3}\ m^{3}\ s^{-1} \pm 75.3$
O	-0.6	0.4	0.0	0.6	-2.0	0.4	1.0	$-90.95 \times 10^{3}\ m^{3}\ s^{-1} \pm 130.2$
N	-0.2	0.3	-1.9	1.4	-0.4	0.5	0.4	-0.187 Sv ± 0.071
D	-0.8	-0.0	-1.3	-0.8	1.3	1.1	0.4	-0.364 Sv ± 0.113

Northumberland

Month	2006	2007	2008	2009	2010	2011	2012	Mean ± SD
J	0.1	0.2	-0.3	-0.9	0.5	1.7	-1.3	$4.11 \times 10^{3}\ m^{3}\ s^{-1} \pm 5.7$
F	0.4	-0.5	0.7	0.9	0.9	-0.7	-1.7	$-2.21 \times 10^{3}\ m^{3}\ s^{-1} \pm 2.5$
M	0.6	0.0	-1.6	-0.6	1.5	0.5	-0.5	$0.85 \times 10^{3}\ m^{3}\ s^{-1} \pm 2.0$
A	0.6	-0.5	-1.9	0.8	1.0	0.2	-0.2	$4.43 \times 10^{3}\ m^{3}\ s^{-1} \pm 4.6$
M	-1.5	0.2	0.6	0.6	1.2	0.3	-1.3	$2.97 \times 10^{3}\ m^{3}\ s^{-1} \pm 5.0$
J	-1.4	0.1	1.6	-1.0	0.1	0.7	-0.2	$2.16 \times 10^{3}\ m^{3}\ s^{-1} \pm 3.4$
J	-0.7	0.5	-0.7	1.1	-1.6	0.7	0.8	$4.73 \times 10^{3}\ m^{3}\ s^{-1} \pm 3.2$
A	-0.3	0.3	1.8	0.5	-1.3	-0.5	-0.5	$2.29 \times 10^{3}\ m^{3}\ s^{-1} \pm 5.9$
S	-0.5	0.1	1.3	-0.5	0.8	0.5	-1.7	$-2.06 \times 10^{3}\ m^{3}\ s^{-1} \pm 3.8$
O	1.0	-0.6	-0.8	-0.3	0.5	1.5	-1.2	$-1.52 \times 10^{3}\ m^{3}\ s^{-1} \pm 5.1$
N	-0.2	-0.7	0.7	-1.1	1.9	-0.5	-0.3	$-0.05 \times 10^{3}\ m^{3}\ s^{-1} \pm 3.7$
D	0.7	-0.1	-0.2	0.3	1.4	-1.8	-0.3	$9.79 \times 10^{3}\ m^{3}\ s^{-1} \pm 7.1$



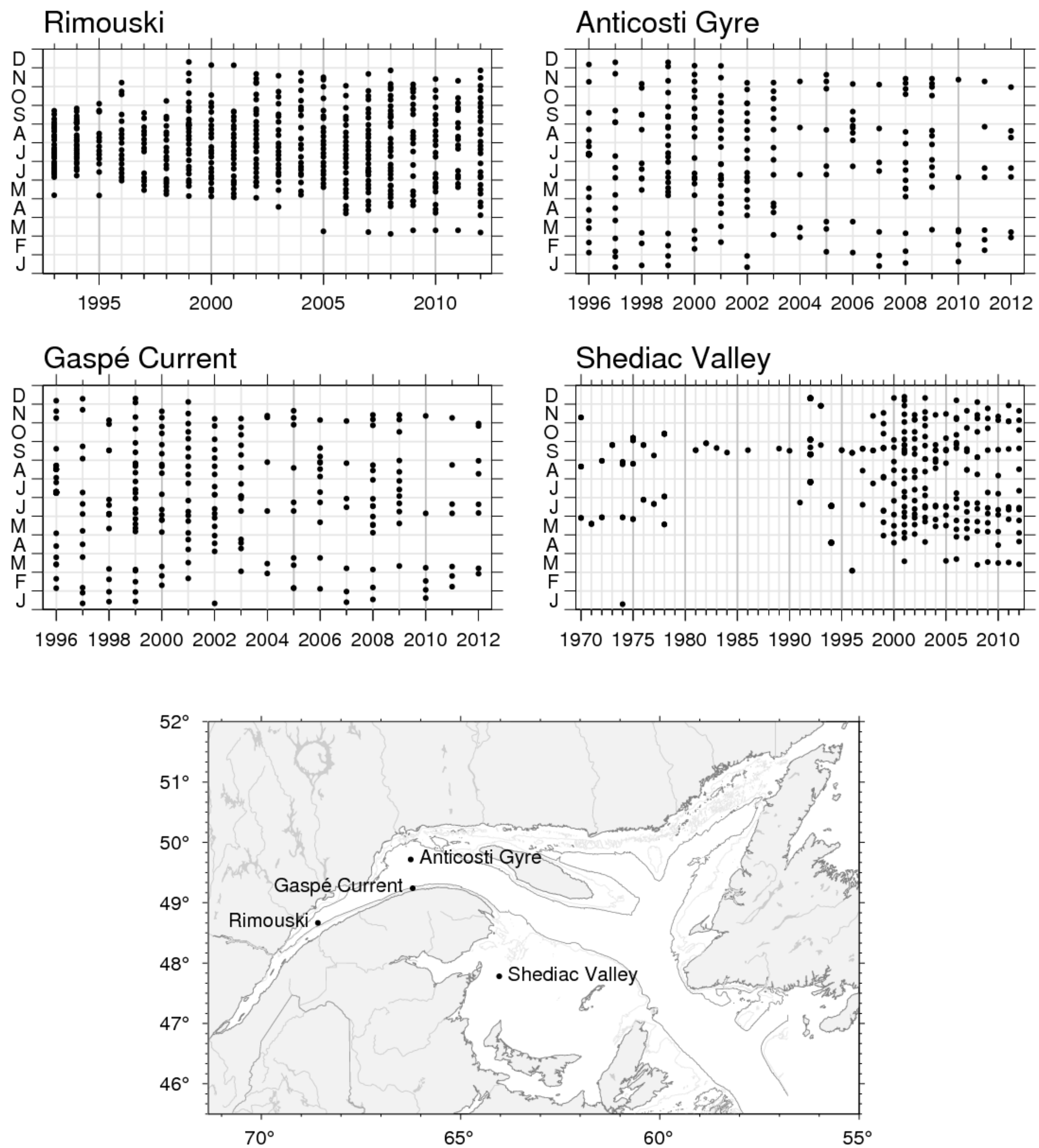


Figure 48. Sampling frequency and positions of the AZMP stations (Rimouski, Anticosti Gyre, GaspéCurrent, and Shediac Valley).

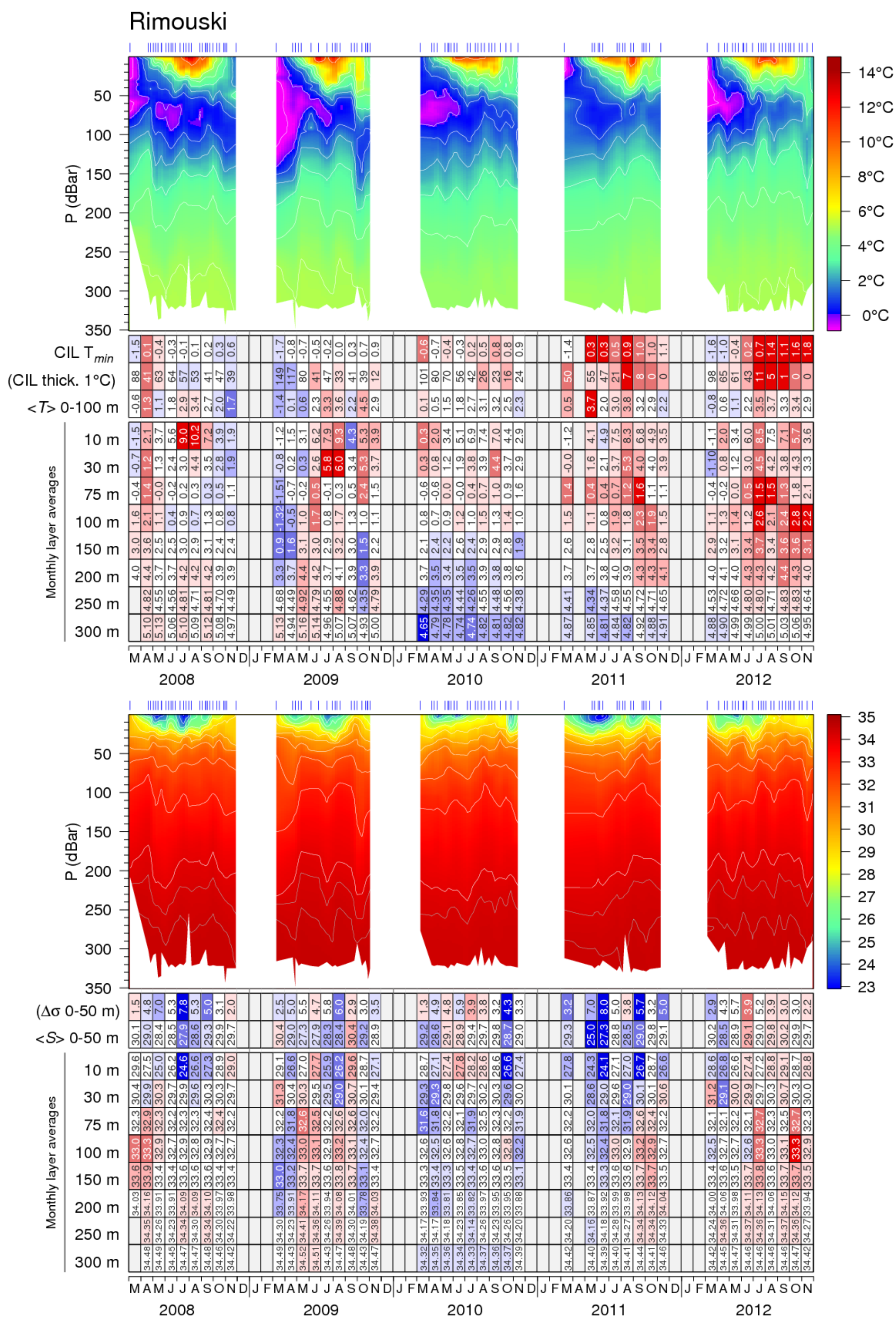


Figure 49. Isotherm (top) and isohaline (bottom) time series at the Rimouski station; tick marks above indicate sample dates. The scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1993–2010 monthly climatology for the station (yearly climatology for 250 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).

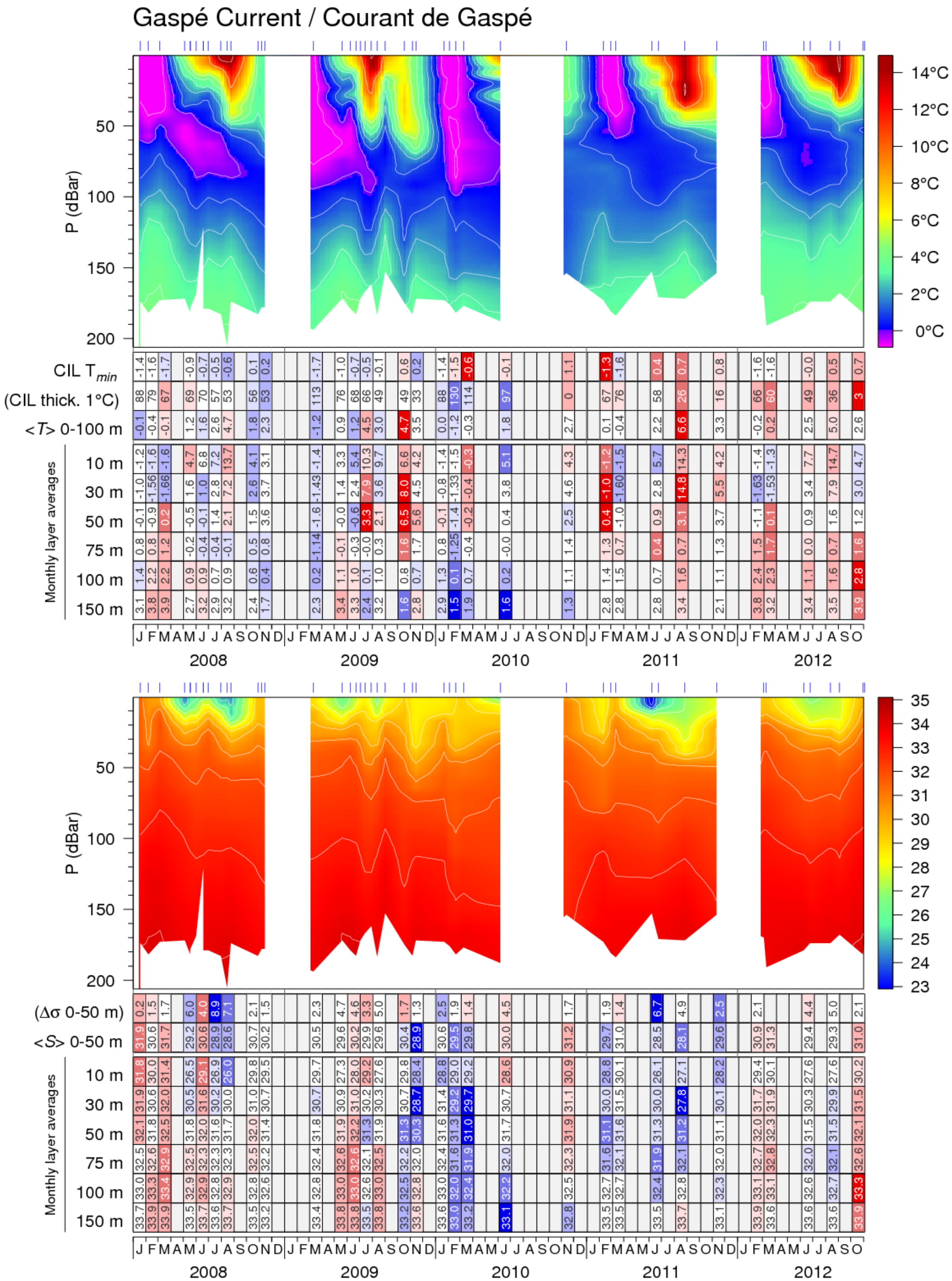


Figure 50. Isotherm (top) and isohaline (bottom) time series at the Gaspé Current station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1996–2012 monthly climatology for the station.

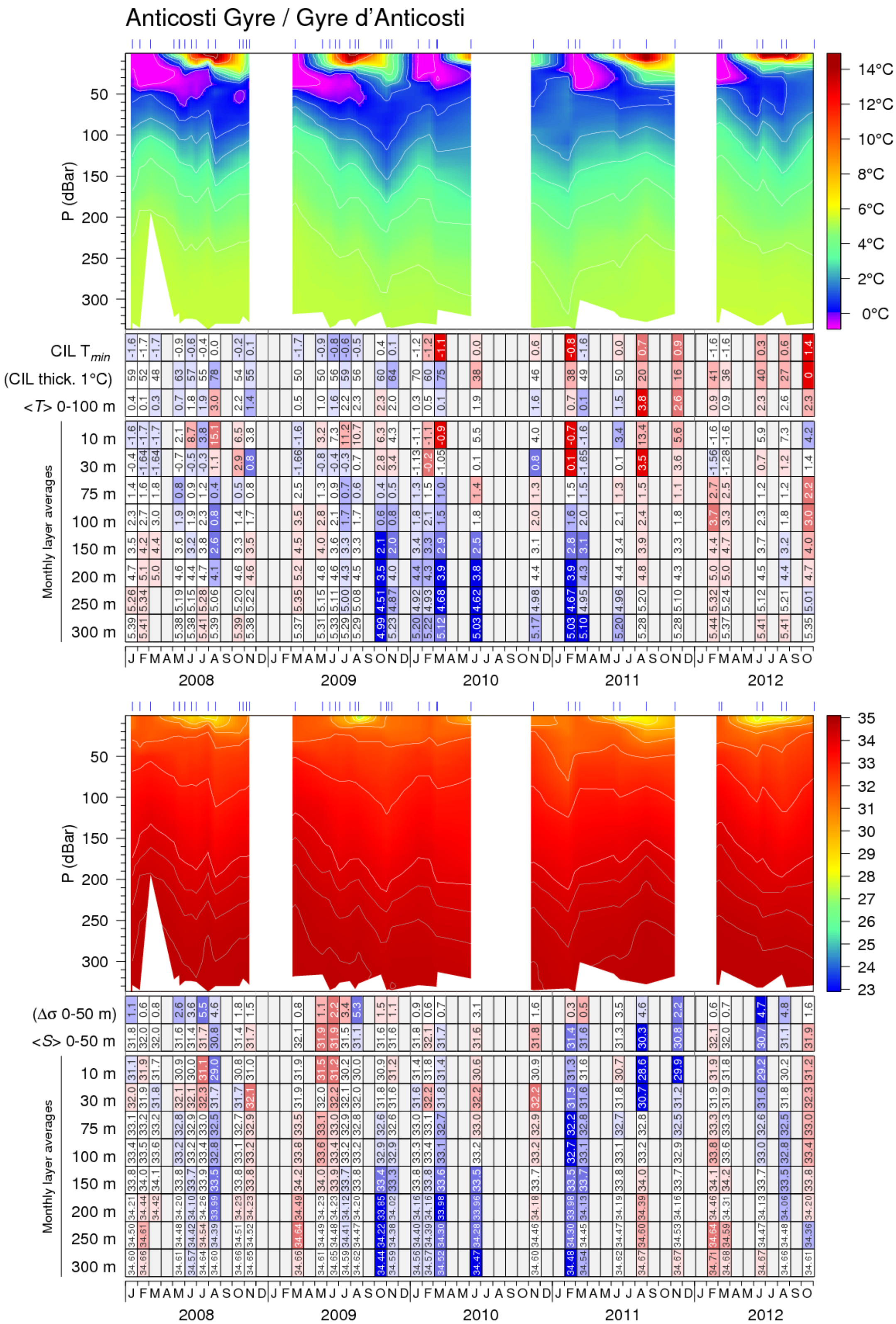


Figure 51. Isotherm (top) and isohaline (bottom) time series at the Anticosti Gyre station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1996–2012 monthly climatology for the station (yearly climatology for 250 m and deeper).

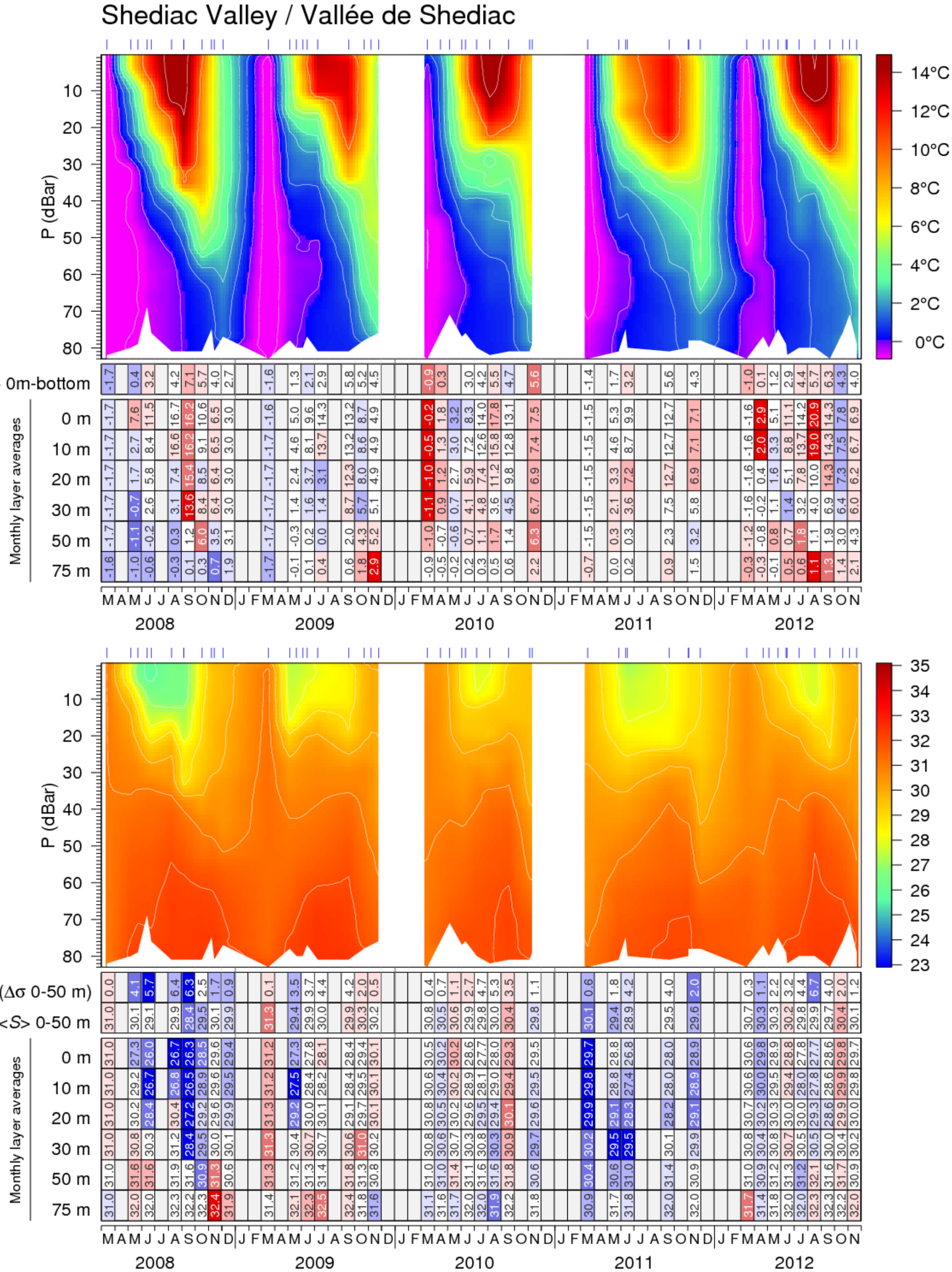


Figure 52. Isotherm (top) and isohaline (bottom) time series at the Shediac Valley station; tick marks above indicate sample dates. Scorecard tables are monthly layer averages colour-coded according to the anomaly relative to the 1981–2012 monthly climatology for the station (input to climatology is sparse prior to 1999).

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	2012	Mean ± SD
T [0-100 m]	Rimouski	2.2	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	2.9	2.38°C ± 0.58
T [0-100 m]	Gaspé Current						2.6	2.1	2.9	2.4	2.3	2.6	3.1	2.3		2.6	3.2		2.5	2.9			3.0	2.65°C ± 0.35
T [0-100 m]	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			2.3	1.86°C ± 0.34
T [0-100 m]	Shediac Valley		3.0					2.4		3.2	3.8	3.8	3.5	3.0	2.5	2.7	3.5	4.2	4.1	3.5	4.1	4.1	4.2	3.54°C ± 0.66
S [0-50 m]	Rimouski	0.8	-0.6	-1.0	-0.0	0.6	-1.5	-0.8	-0.4	0.9	0.8	0.8	1.4	1.5	-0.1	-0.4	0.3	1.1	-0.8	-1.2	0.2	-2.2	0.7	29.16 ± 0.49
S [0-50 m]	Gaspé Current						0.4	-1.6	-2.0	1.3	-0.0	0.2	0.3	1.6		-0.3	-0.4		-0.5	0.6			0.6	29.80 ± 0.30
S [0-50 m]	Anticosti Gyre						-1.5	-1.1	-1.2	0.9	0.3	0.3	1.5	1.4		-1.1	0.0		-0.3	0.9			-0.5	31.46 ± 0.18
S [0-50 m]	Shediac Valley		0.1							0.0	0.1	0.3	1.1	2.1	-0.8	-0.6	-0.1	1.1	-1.6	-0.1	0.7	-1.6	0.4	29.94 ± 0.30
$\Delta\sigma_t$ [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	4.1	4.51 kg m^{-3} ± 0.63
$\Delta\sigma_t$ [0,50 m]	Gaspé Current						3.7	4.8	4.1	3.9	4.5	4.1	5.0	4.4			3.8		5.3	3.7			3.9	4.27 kg m^{-3} ± 0.54
$\Delta\sigma_t$ [0,50 m]	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			3.7	3.05 kg m^{-3} ± 0.35
$\Delta\sigma_t$ [0,50 m]	Shediac Valley		3.6							3.5	3.8	3.3	3.5	3.7	3.7	3.9	3.9	3.3	5.0	3.9	3.3	3.8	3.7	3.71 kg m^{-3} ± 0.41
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	0.77	-0.09°C ± 0.43
T [CIL min]	Gaspé Current						-0.37	-0.26	-0.68	-0.34	0.03	-0.20	0.13	-0.45		-0.33	0.55		-0.45	-0.26			0.30	-0.18°C ± 0.34
T [CIL min]	Anticosti Gyre						-0.30	-0.47	-0.67	-0.46	0.07	-0.10	0.03	-0.60		-0.45	0.54		-0.38	-0.47			0.53	-0.21°C ± 0.40
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	20	51 m ± 18
CIL thick. < 1°C	Gaspé Current						72	61	64	65	52	57	48	75		68	27		58	59			34	57 m ± 14
CIL thick. < 1°C	Anticosti Gyre						60	70	70	54	40	42	36	53		70	33		61	56			26	52 m ± 15

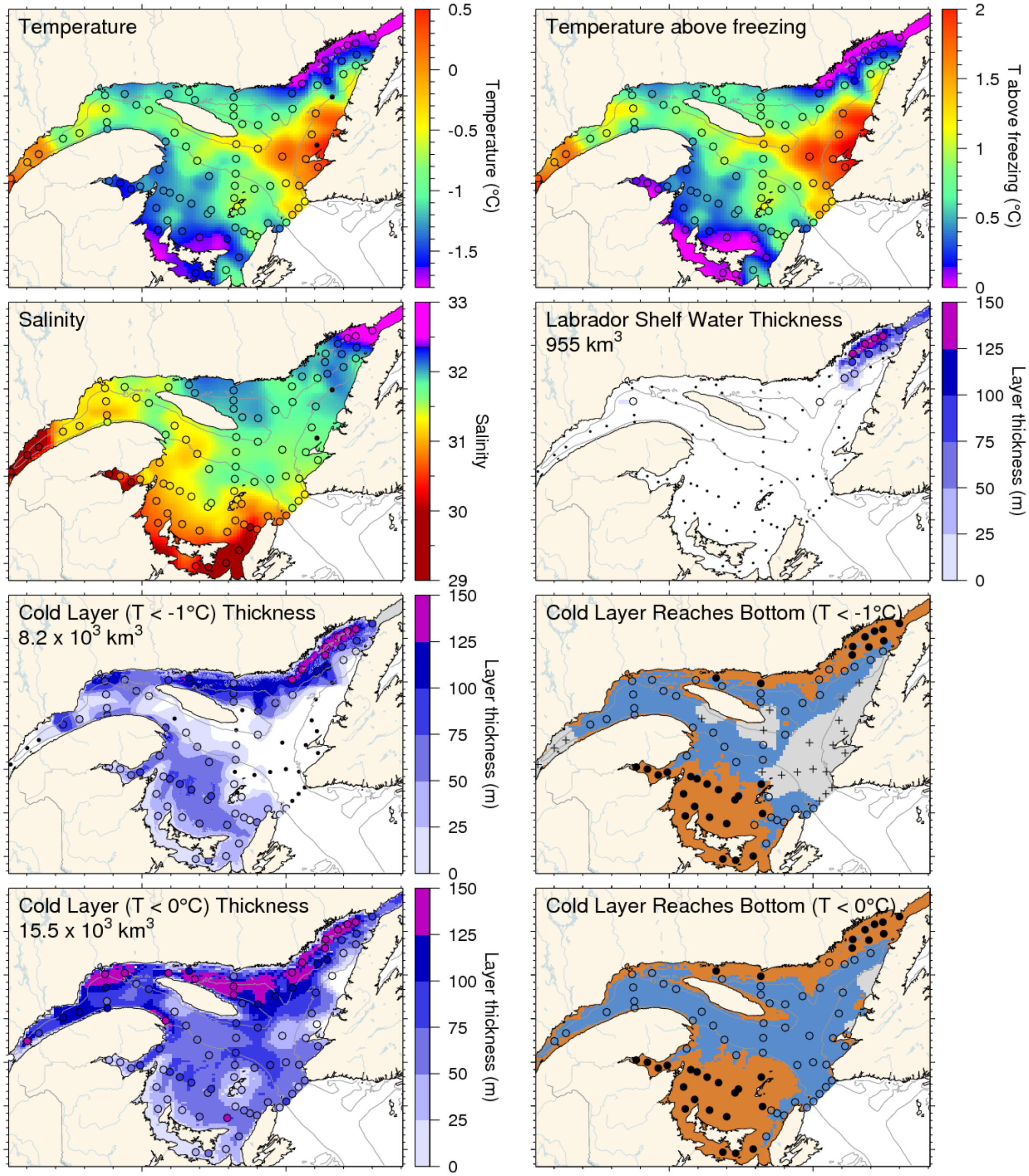


Figure 53. March 2013 surface cold layer characteristics: surface water temperature (upper left), temperature difference with the freezing point (upper right), salinity (second row left), estimate of the thickness of the Labrador Shelf water intrusion (second row right), and cold layer (T<-1°C and <0°C) thicknesses and where they reach bottom. 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.

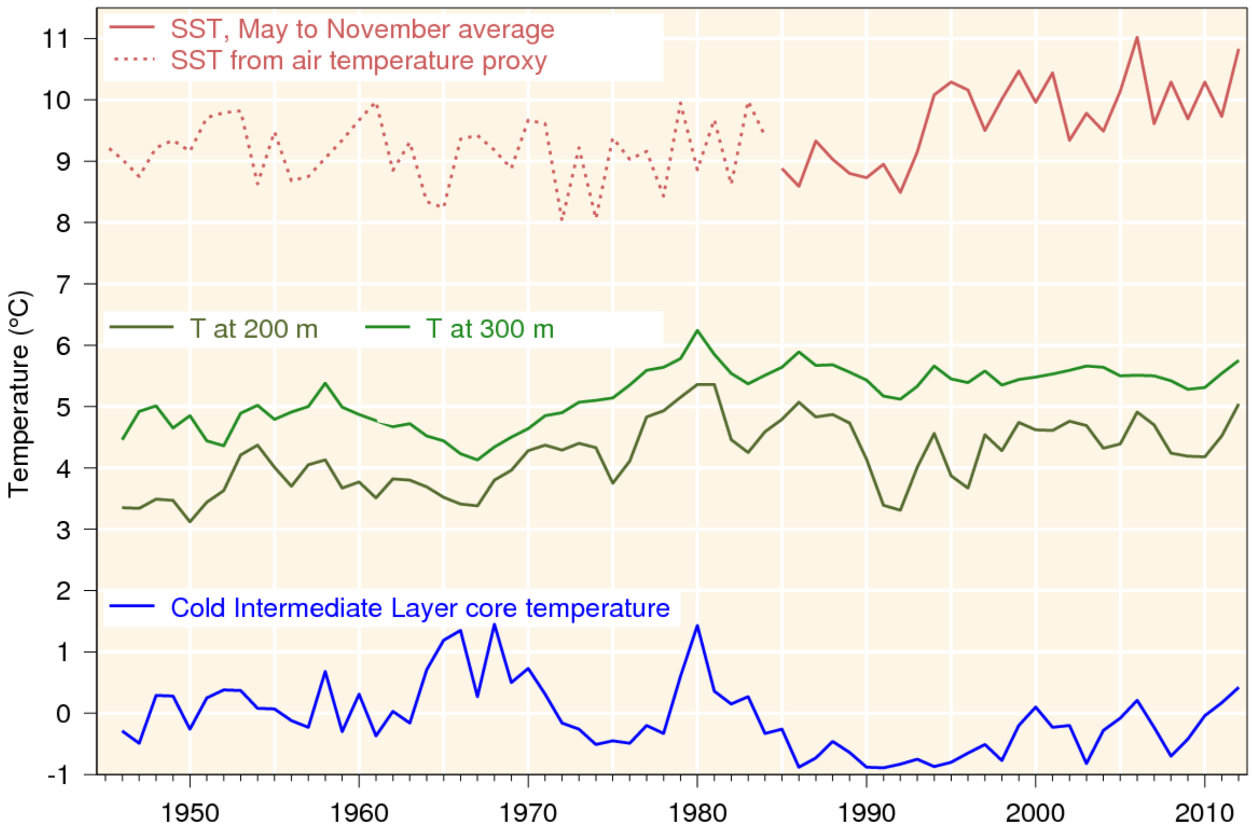


Figure 54. Water temperatures in the Gulf of St. Lawrence. May–November SST averaged over the Gulf (1985–2010, red line), completed by a proxy based on April–November air temperature (1945–1984, red dashed line). Layer-averaged temperature for the Gulf of St. Lawrence at 200 and 300 m (green lines). Cold intermediate layer minimum temperature index in the Gulf of St. Lawrence (blueline). SST and its air temperature proxy from Galbraith et al. (2012).

Table 22. Surface and deep indicators used in the composite climate index (Figure 55).

	Indicator	1971				1975					1980				
Surface indicators	SST, GSL May-Nov average	0.0	-2.4	-0.6	-2.3	-0.3	-0.9	-0.7	-1.8	0.5	-1.1	0.1	-1.5	0.6	-0.3
	(Ice, max volume)	-0.2	0.9	0.4	0.4	0.5	0.4	0.6	-0.2	0.4	-0.8	-1.0	-0.0	-1.0	-0.3
	GSL, summer CIL Index	1.8	0.6	0.4	-0.3	-0.1	-0.2	0.5	0.2	2.6	4.7	2.0	1.4	1.7	0.2
	(sGSL, Sep. T<1°C Btm Area)	-1.9	0.8	0.3	-0.4	0.5	1.4	-1.9	1.2	0.5	-2.1	-1.5	-3.3	-1.8	1.5
	Bottom temp., Magdalen Shallows, Sep.	-0.4	-1.0	-0.7	-0.6	0.6	-2.5	-0.6	-1.6	-0.5	1.9	-2.0	1.1	-0.9	-1.9
Deep indicators	150 m GSL avg temp.	1.1	0.2	0.1	-0.5	-1.3	-0.2	1.0	1.2	2.4	1.7	2.3	0.7	-0.0	0.8
	200 m GSL avg temp.	-0.2	-0.3	-0.1	-0.2	-1.5	-0.7	0.8	1.1	1.5	2.0	2.0	0.0	-0.4	0.3
	250 m GSL avg temp.	-1.3	-1.5	-0.9	-1.2	-1.5	-0.8	0.3	0.7	1.3	2.6	1.8	0.1	-0.6	0.0
	300 m GSL avg temp.	-3.8	-3.5	-2.5	-2.4	-2.1	-0.9	0.5	0.8	1.6	4.4	2.1	0.2	-0.8	0.1

	Indicator	1985					1990					1995			
Surface indicators	SST, GSL May-Nov average	-1.1	-1.5	-0.4	-0.9	-1.2	-1.3	-1.0	-1.7	-0.7	0.7	1.0	0.8	-0.2	0.6
	(Ice, max volume)	0.1	0.2	-0.0	0.0	0.1	1.5	-0.0	0.8	2.1	1.6	1.2	0.0	0.5	-1.0
	GSL, summer CIL Index	0.4	-1.2	-0.8	-0.1	-0.6	-1.2	-1.2	-1.1	-0.9	-1.2	-1.0	-0.6	-0.3	-0.9
	(sGSL, Sep. T<1°C Btm Area)	0.7	0.1	0.3	0.0	0.7	0.2	0.2	1.5	0.3	0.8	1.0	0.6	0.3	1.2
	Bottom temp., Magdalen Shallows, Sep.	0.9	0.7	-0.2	-0.5	0.0	-0.6	0.6	-2.3	-0.5	-0.8	-0.7	0.2	-1.1	-0.7
Deep indicators	150 m GSL avg temp.	0.7	0.3	0.1	-0.0	0.5	-0.9	-2.3	-2.0	-0.8	0.1	-1.7	-1.5	-0.2	-0.4
	200 m GSL avg temp.	0.8	1.4	0.8	0.9	0.6	-0.7	-2.3	-2.5	-0.9	0.3	-1.2	-1.7	0.2	-0.3
	250 m GSL avg temp.	0.8	1.8	1.0	1.2	0.4	-0.6	-2.2	-2.2	-1.0	0.6	-0.8	-1.4	0.3	-0.3
	300 m GSL avg temp.	0.8	2.3	1.0	1.1	0.4	-0.4	-1.9	-2.2	-1.0	0.9	-0.3	-0.6	0.5	-0.9

	Indicator		2000					2005					2010		2012	Mean ± S.D.
Surface indicators	SST, GSL May-Nov average	1.3	0.5	1.3	-0.4	0.3	-0.2	0.8	2.1	0.0	1.0	0.1	1.0	0.2	1.8	9.61°C ± 0.66
	(Ice, max volume)	-0.5	-1.1	-0.4	-0.3	2.2	-0.3	-0.1	-1.5	-1.1	0.2	-0.2	-2.0	-1.9	-1.6	70.8 km^3 ± 30.2
	GSL, summer CIL Index	0.5	1.3	0.5	0.5	-1.1	0.3	0.8	1.6	0.5	-0.7	-0.0	0.9	1.5	2.1	-0.41°C ± 0.39
	(sGSL, Sep. T<1°C Btm Area)	-0.4	-0.4	0.2	-0.4	0.3	0.2	-0.5	-0.5	-0.4	0.6	-0.5	-1.3	-0.8	-1.9	29.2 ± 6.2 (x10^3 km^2)
	Bottom temp., Magdalen Shallows, Sep.	0.9	0.7	0.2	1.3	0.4	0.2	0.1	0.9	1.1	-0.1	1.5	1.2	0.8	1.0	5.06°C ± 0.51
Deep indicators	150 m GSL avg temp.	1.2	0.8	0.2	0.9	0.1	-0.4	0.2	1.5	0.5	-0.5	-0.0	-0.1	0.7	1.7	2.52°C ± 0.51
	200 m GSL avg temp.	0.7	0.4	0.4	0.7	0.5	-0.3	-0.1	1.0	0.6	-0.4	-0.5	-0.6	0.2	1.3	4.44°C ± 0.46
	250 m GSL avg temp.	0.1	0.1	0.3	0.9	0.8	0.5	0.0	0.5	0.5	-0.3	-1.0	-0.9	0.2	1.3	5.33°C ± 0.29
	300 m GSL avg temp.	-0.4	-0.1	0.2	0.5	0.9	0.8	0.0	0.1	0.0	-0.5	-1.3	-1.1	0.2	1.5	5.50°C ± 0.17

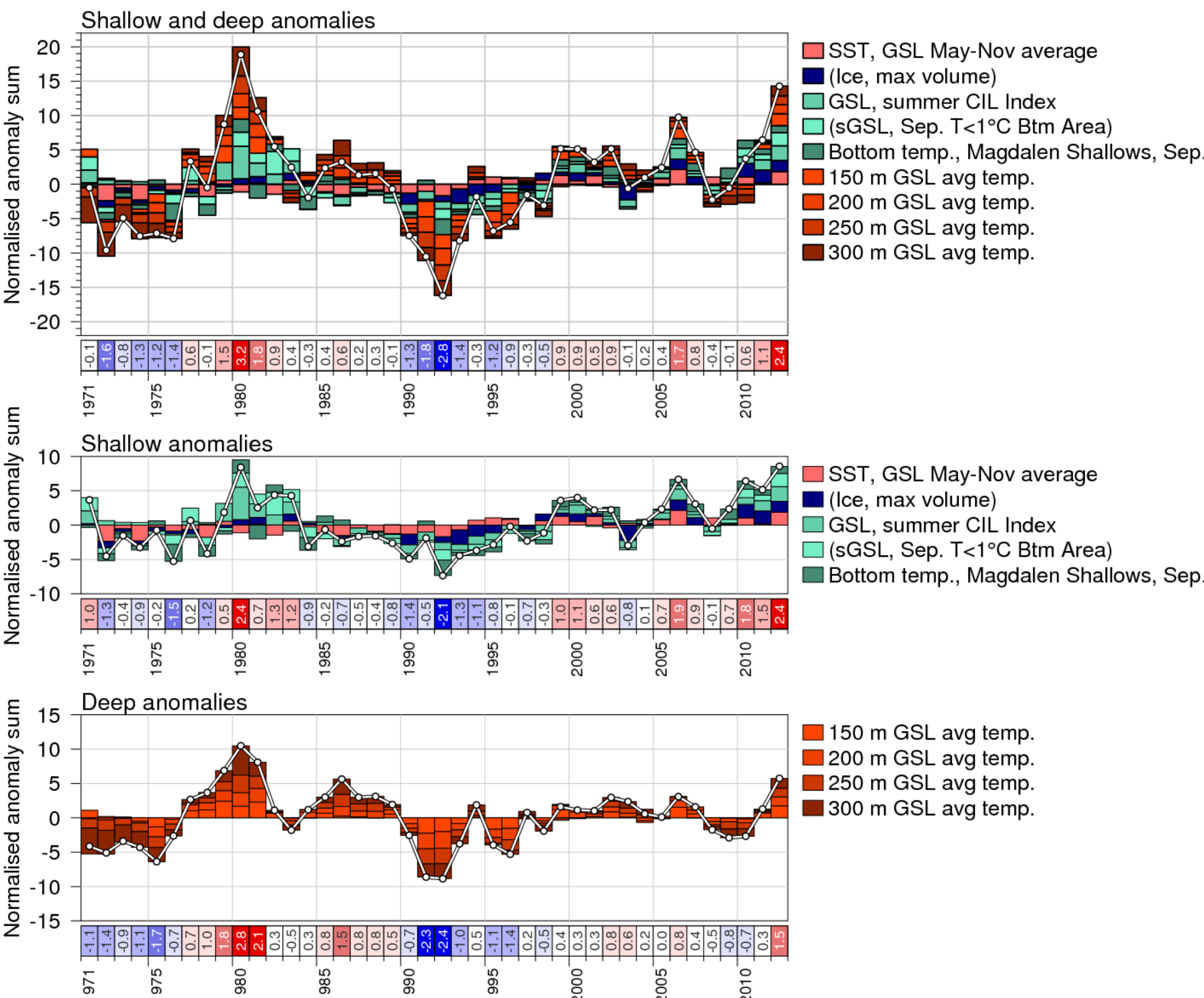


Figure 55. Composite climate indices (white lines and dots) derived by summing various standardized anomalies from different parts of the environment (colored boxes stacked above the abscissa are positive anomalies, and below are negative). Top panel sums anomalies representing the entire water column, middle panel sums shallow anomalies and bottom panel sums deep anomalies.