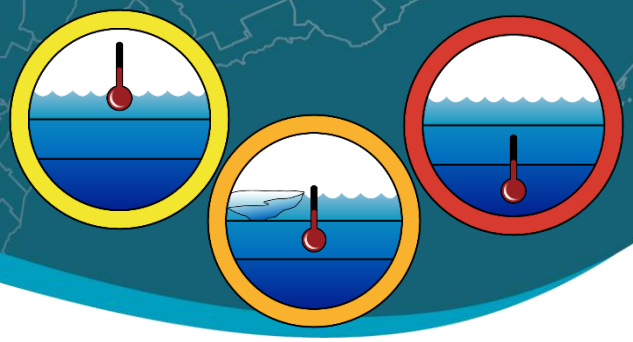
Monitoring the State of the
ST. LAWRENCE RIVER



Oceanographic Processes: Temperatures and Sea Ice

Indicator name: Surface layer temperatures
Status: Moderate in 2018–2024
Trend: Deterioration

Indicator name: Cold intermediate layer temperatures and sea ice:
Status: Moderate-Poor in 2018-2024
Trend: Deterioration

Indicator name: Deep water temperatures:
Status: Poor in 2018-2024
Trend: Deterioration since 2008-2012

Highlights

The index of surface water temperatures in the Gulf of St. Lawrence was Moderate on average for the period 2018–2024. The index of cold intermediate layer temperatures and winter sea ice conditions was Moderate-Poor. The deep water temperature index was Poor in each year of the period 2018–2024, associated with 100-year temperature records at 250 and 300 m broken in 2015 and 2016, which were broken again almost every year until 2022.

Problem

The Atlantic Zone Monitoring Program (AZMP) aims to detect, track and understand changes in the productivity and state of the marine environment in order to ensure sound management of the St. Lawrence ecosystem. Measurements of oceanographic variables are taken during major surveys conducted four times a year.

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 deep water layer. Surface water temperatures typically reach maximum values in early to mid-August, with gradual cooling occurring thereafter. Wind-induced mixing during the fall leads to a progressively deeper and cooler mixed layer, eventually encompassing the CIL. In winter, the surface

layer deepens and extends to an average depth of 75 m but may exceed 150 m in some locations. During spring, surface warming, sea ice melt waters, and continental runoff lead to a lower-salinity and higher-temperature surface layer. Beneath this surface layer, cold waters from the previous winter are partly isolated from the atmosphere and form the summer CIL. This layer will persist until the following winter, gradually warming and deepening over the summer and more rapidly during the fall as vertical mixing intensifies. Underneath these two layers lie the deep layer unaffected from winter cooling. This layer comes into the Gulf from the ocean at the continental slope. We describe here the temperatures associated with the three layers of the water column throughout the Gulf of St. Lawrence, as well as the state of the maximum seasonal sea ice cover.

Study area

During AZMP surveys, a probe is lowered through the water column in order to measure temperature and salinity as a function of depth during four surveys, done each year, covering the Gulf of St. Lawrence (Figure 1). In addition, sea surface temperatures and ice cover throughout the Gulf of St. Lawrence are obtained from remote sensing measurements.

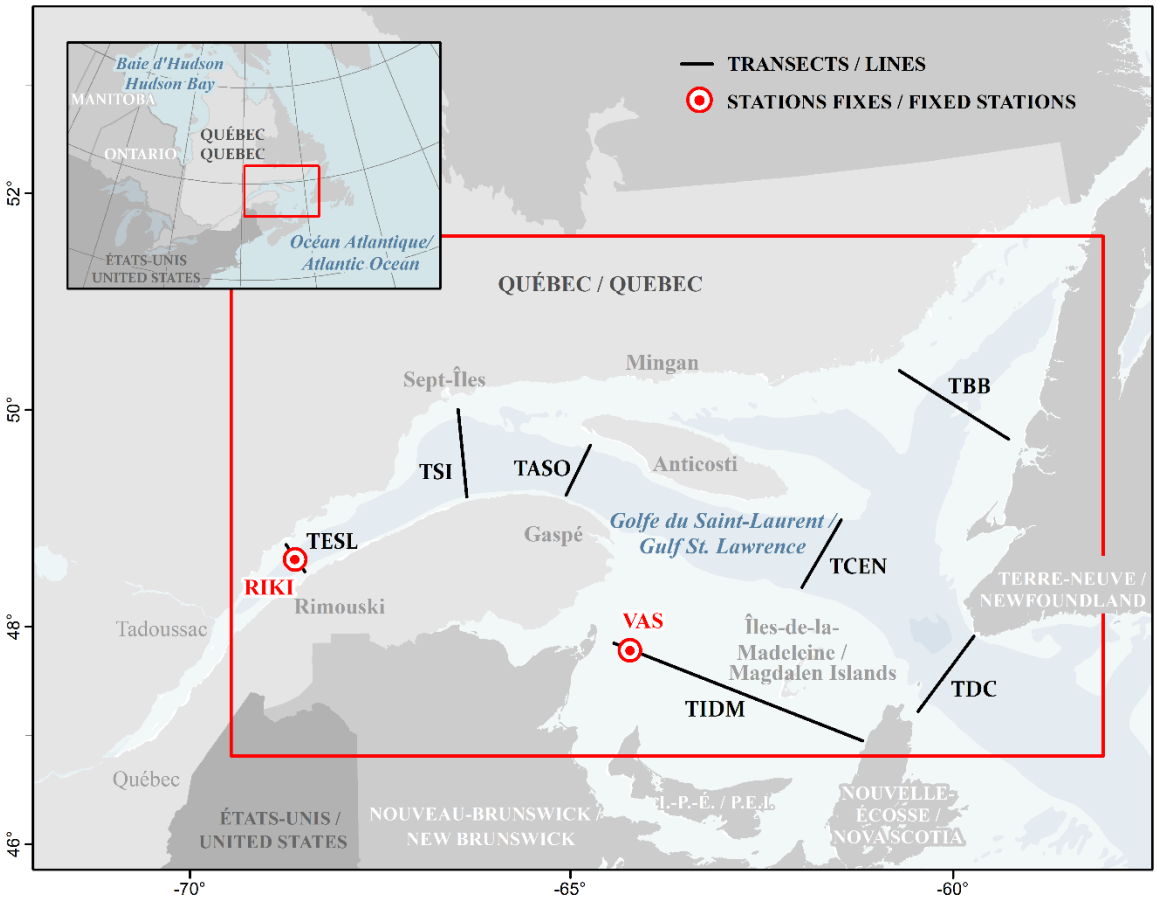


Figure 1: Map of the Gulf of St. Lawrence showing the lines (black lines) covered by the Atlantic Zone Monitoring Program and the positions of the two fixed stations (red dots).

Key measures

Surface layer temperatures

- Surface temperature anomalies in August and mean temperature anomalies from May to November relative to historical values, based on satellite data.
- Seasonal phenology anomalies characterized by the date on which the surface temperature averaged across the Gulf of St. Lawrence rises above the threshold of 12°C in springtime and decreases below it in the fall.

Cold intermediate layer temperatures and sea ice

- Maximum seasonal sea ice volume in the Gulf of St. Lawrence, derived from ice charts produced by Environment and Climate Change Canada's Canadian Ice Service by assigning a thickness value to each stage of ice development.
- Area of the bottom on the Magdalen Shallows occupied by waters colder than 1°C in September.
- Mean bottom temperature on the Magdalen Shallows in September.
- Average minimum temperature of the cold intermediate layer in the Gulf of St. Lawrence in August (northern Gulf) and September (Magdalen Shallows).

Deep water temperatures

- Mean temperature at depths of 150 m, 200 m, 250 m and 300 m.

To monitor the status of oceanographic indicators of the St. Lawrence, various key measurements identified in the previous section were compared with the values obtained during the 1981–2010 reference period and indices reflecting a deviation from normal conditions have been developed.

First, an annual anomaly value is calculated for each index. It corresponds to the difference between the value of the measurement for the year in question and the mean calculated for the reference period. This difference is then divided by the standard deviation for this parameter for the reference period. A negative (or positive) anomaly signifies that the value of the measurement for the year in question is less (or greater) than the average for the reference period. For temperature and ice conditions, the direction of change (positive or negative) cannot be interpreted as being intrinsically "Good" or "Poor". However, assuming that the aim is to preserve the ecosystem as it existed according to the historical data, any significant change (positive or negative) relative to its historical state can be considered "Poor" and, conversely, the absence of significant change can be considered "Good". Thus, the absolute value of the sum of the normalized anomalies of the indices was used to describe the state of each key measurement.

Status and trends

Surface layer temperatures

The surface temperature index was Moderate on average during the 2018–2024 period (Figure 2). The index was Poor in 2021 and 2024 during this period. For those two years, none of the key measures were classified as Good. May to November sea surface temperature was at a record high in 2024.

This index is variable through the years, but the long term trend is to deterioration because of global warming.

Cold intermediate layer temperatures and sea ice

The index of CIL temperatures and winter sea ice conditions was Moderate-Poor on average during the 2018–2024 period. The index was at a record Poor level in 2021.

This index is also variable through the years, but the long term trend is to deterioration because of global warming.

Deep water temperatures

The deep waters of the Gulf are a mixture of warm water from the Gulf Stream and cold water from the Labrador Current that enter the Gulf through the Laurentian Chanel at the continental slope, located south of Cabot Strait. A change in the proportions of this mix is the main cause of the observed changes in deep water temperatures. Temperatures of the deep waters have on average increased between 2009 and 2022, with inward advection of warm waters from Cabot Strait.

The index of deep water temperatures was Poor on average during the 2018–2024 period, caused by the 100-year high temperature records at depths of 300 and 250 m broken in 2015 and 2016, and broken again nearly every year until 2022. Average temperatures at all depths from 150 to 300 m reached record highs in 2022.

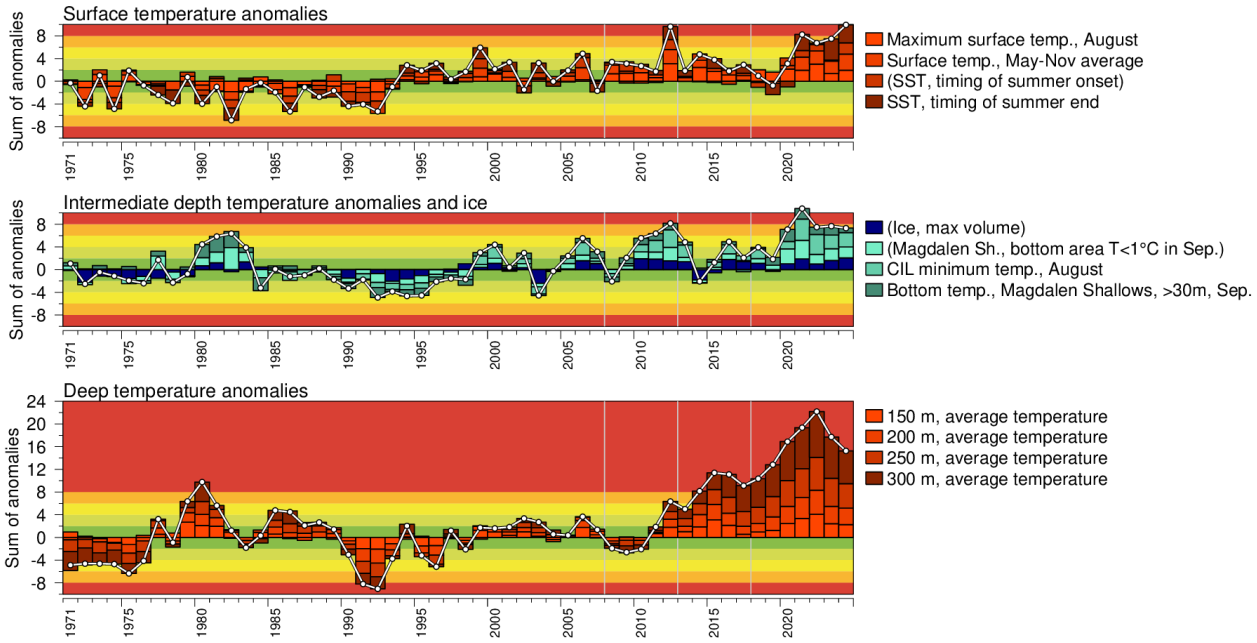


Figure 2. Indicators for the tree key measurements: surface temperatures, cold intermediate layer temperatures and winter sea ice, deep water temperatures. The variables shown in parentheses are inverted so that a positive anomaly corresponds to a warm anomaly (early warming, less sea ice, less area on the Magdalen Shallows occupied by cold waters).

Outlook

Surface water temperatures are correlated with air temperatures. The average April-November air temperature over the Gulf of St. Lawrence has increased at an average rate of 1.3°C per 100 years over the past 150 years. Summertime intermediate layer temperatures and the maximum quantity of winter sea ice are correlated with winter air temperatures, which has increased nearly twice as quickly as the April-November temperature. Although both indicators vary from year to year, their trends will be towards deterioration due to global warming.

The variability in deep water temperatures is attributed to the change in the proportion of warm Gulf Stream waters and cold Labrador Current waters entering the Laurentian Channel at the continental slope. However, the water temperature at 300 m in this area was below normal in 2024 for the first time since 2008. This indicator should therefore be subject to a respite in the next five years.

For more information

GALBRAITH, P.S., CHASSÉ, J., SHAW, J.-L., LEFAIVRE, D. and BOURASSA, M.-N. 2025. Physical Oceanographic Conditions in the Gulf of St. Lawrence during 2024. Can. Tech. Rep. Hydrogr. Ocean Sci. 397: v + 95 p. https://doi.org/10.60825/eznq-0815.

State of the St. Lawrence Monitoring Program

Five government partners—Environment and Climate Change Canada; Fisheries and Oceans Canada; Parks Canada; the Ministère de l'Environnement et de la Lutte contre les changements climatiques du Québec; and the Ministère des Forêts, de la Faune et des Parcs du Québec—and Stratégies Saint-Laurent, a non-governmental organization that works actively with riverside communities, are pooling their expertise and efforts to provide Canadians with information on the state of the St. Lawrence and the long-term trends affecting it.

For more information about the State of the St. Lawrence Monitoring Program, please consult our website: https://www.planstlaurent.qc.ca/en/developing-knowledge/state-st-lawrence-monitoring-program.

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