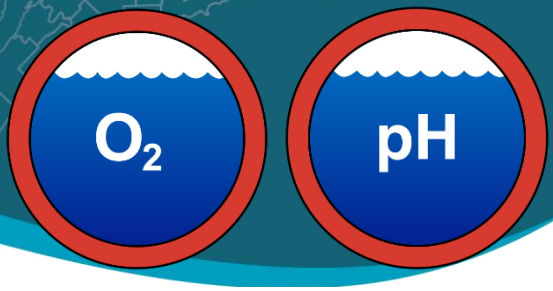
Monitoring the State of the
ST. LAWRENCE RIVER



Deoxygenation and Acidification in the St. Lawrence Estuary

Indicator name: Deoxygenation
Status: Poor in 2020-2024
Trend: Deteriorating since 2015-2019

Indicator name: Acidification
Status: Poor in 2020-2024
Trend: Deteriorating since 2015-2019

Highlights

Oxygen levels in the deep waters of the St. Lawrence estuary have been monitored since the early 1970s. In 2022, they reached their lowest values ever recorded and remained close to these record lows in 2023 and 2024. Annual pH measurements carried out since 2014 reveal a trend towards acidification of the estuary's deep waters, characterized by a drop in pH, which reached a record low in 2023.

Problem

In order to better understand and monitor changing oceanographic conditions, and to support the sustainable management of marine activities and resources, Fisheries and Oceans Canada implemented the Atlantic Zone Monitoring Program (AZMP) in 1998. The purpose of the program is to detect, monitor and predict changes in productivity and state in the Canadian Atlantic zone. Sampling campaigns carried out in the estuary and Gulf of St. Lawrence collect essential data for the preservation of this marine ecosystem and the study of climate issues. Among these issues, deoxygenation and acidification threaten the fragile balance of marine life in the deep waters of the St. Lawrence estuary.

Deoxygenation is linked to reduced oxygen content and generally occurs in the deep layers of the water column, where exchanges with the atmosphere are rare. Waters are considered hypoxic when their oxygen saturation level is below 30%.

Acidification, a complex phenomenon that lowers the pH of salt water, is caused by the increase in anthropogenic CO_2 and its dissolution at the ocean surface. Acidification can affect marine organisms, leading to many energy compromises and changes in calcification rates.

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In the deep layers of the water column, deoxygenation and acidification are modulated by the remineralization of organic matter, which consumes oxygen and releases CO_2. The warming of deep waters can accelerate this process by favouring the respiration of microorganisms, which remineralize organic matter.

Study area

Under the AZMP, deoxygenation and acidification in the lower St. Lawrence estuary are monitored during three annual oceanographic surveys carried out in June, August–September and October, as well as weekly sampling done at the Rimouski station between May and November.

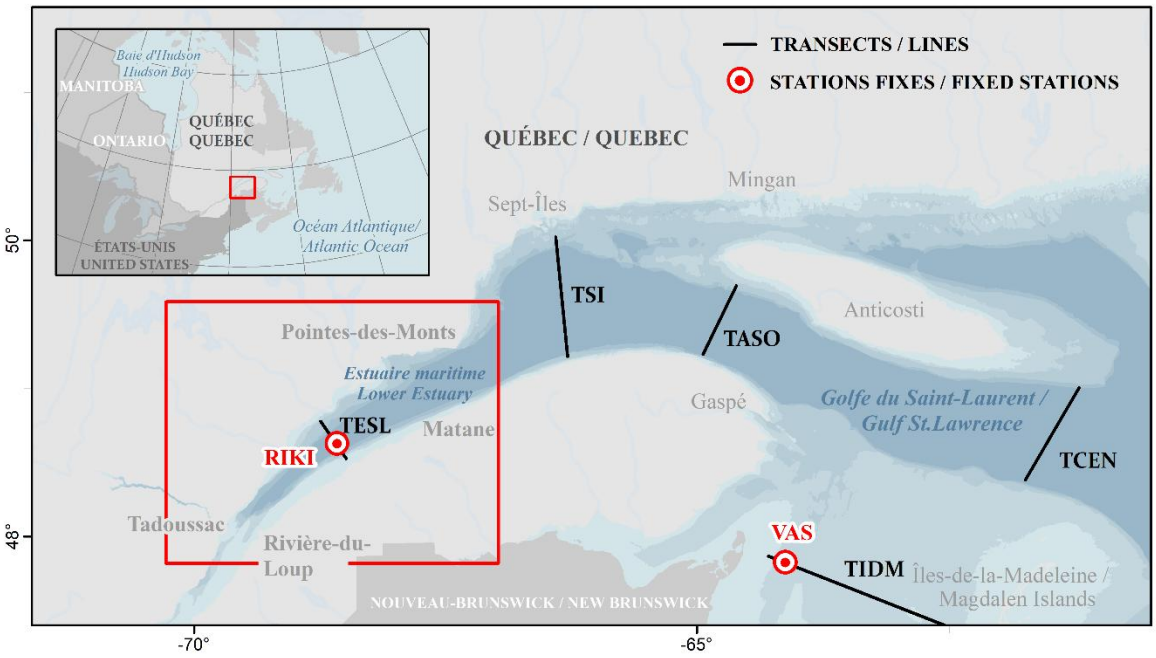

Figure 1. Map of the estuary and Gulf of St. Lawrence. The study area appears in the red box. This shows the position of the TESL line (black line) and the RIKI fixed station (red dot) covered by the Atlantic Zone Monitoring Program in the St. Lawrence estuary.

Key measures

- Mean annual **oxygen saturation levels (%)** in the deep waters (> 295 m) of the lower estuary obtained from titration data and oxygen probe data.
- Mean annual **pH values (full scale)** in deep waters (> 295 m) in the lower estuary obtained from spectrophotometric measurements (2014–2024 period) and through modelled reconstruction (1961–2007 period, Mucci et al. 2011).

Status and trends

Deoxygenation of the deep waters of the lower St. Lawrence estuary

The saturation index of dissolved oxygen in the deep waters of the St. Lawrence estuary was Poor in each year of the 2020–2024 period, with mean annual saturation levels below 15% (Figure 2). During the previous period (2015–2019), the index was Moderate–Poor, with saturation levels between 15% and 20%. There is therefore a deterioration in the current period compared with the previous period.

Since the beginning of the time series in 1971, the oxygen content of the estuary's deep waters has decreased by more than half. At that time, oxygen saturation levels were slightly above the hypoxia threshold (30%). However, since the mid-1980s, these waters are in a nearly permanent state of severe hypoxia (< 20%). Deoxygenation seems to have increased between 2021 and 2022, with the mean annual saturation level falling from 15% to 10.8%. Since then, it has remained stable at around 11%. This marked decrease coincided with an increase in the proportion of warm, oxygen-poor waters in the depths of the estuary, largely characterized by the signature of the Gulf Stream.

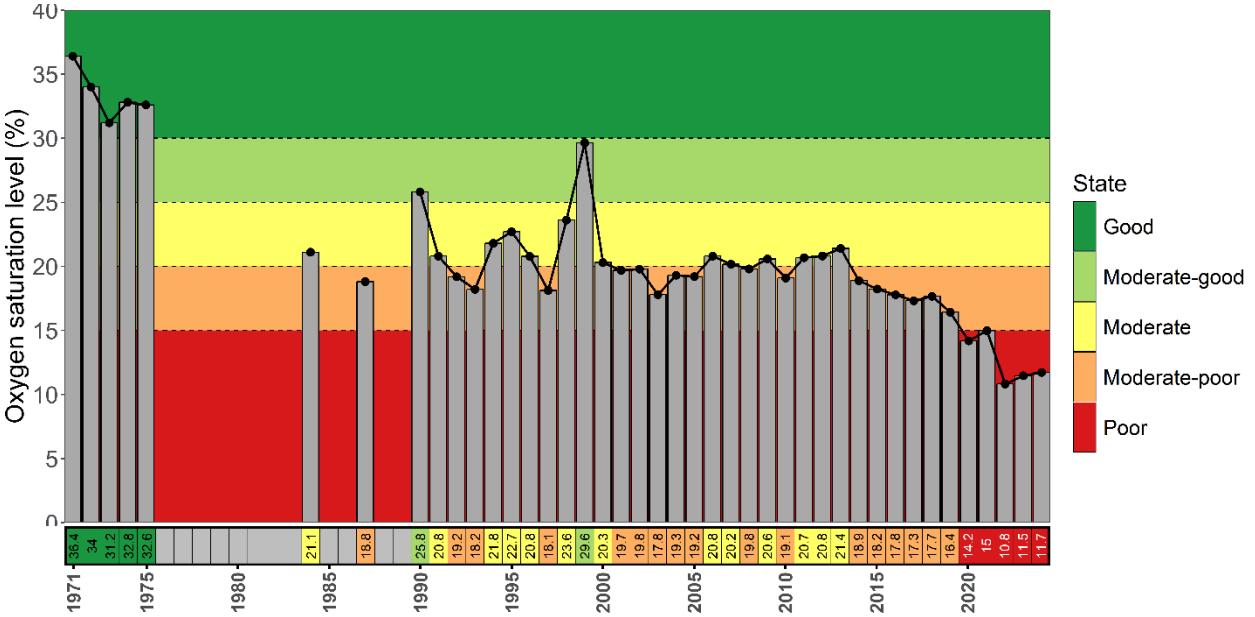

Figure 2. Mean annual oxygen saturation levels (%) in the deep waters of the lower St. Lawrence estuary.

Acidification of the deep waters of the lower St. Lawrence Estuary

The pH index of the deep waters of the lower St. Lawrence estuary was Poor over the 2020–2024 period, with mean annual values below 7.55 units (Figure 3). In 2023, the index fell to a minimum of 7.50. During the previous period (2015–2019), the pH index was Moderate–Poor (between 7.55 and 7.65 units). There has thus been a decline in the current period compared with the previous period.

In the early 1930s, the pH of the estuary's deep waters was around 7.8 or 7.9, values considered normal in the estuarine environment (status: Good). Today, the pH is around

7.5, representing a decrease of 0.3–0.4 pH units. This decrease corresponds to a 100% to 150% increase in acidity in less than 100 years. The decrease in pH is associated with a number of changes in the hydrogeographic and biogeochemical processes in the deep waters of the St. Lawrence estuary.

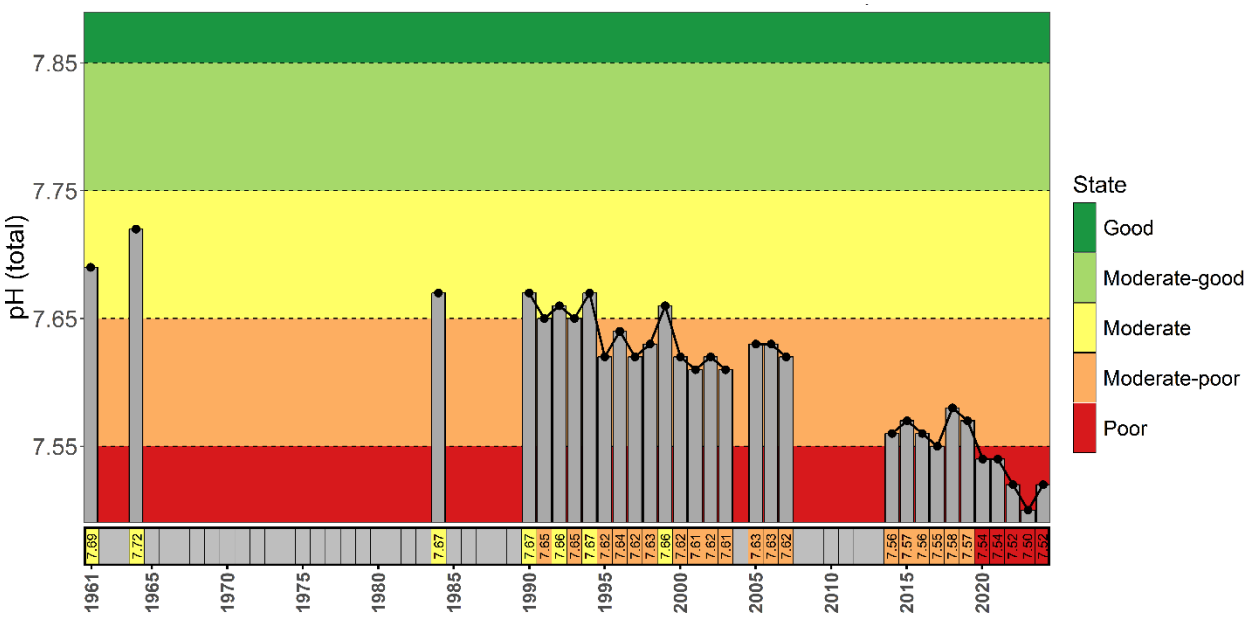

Figure 3. Mean annual pH values (full scale) in the deep waters of the lower St. Lawrence estuary.

Outlook

The trends observed indicate a continuing deterioration in the state of the deep waters of the lower St. Lawrence estuary linked to persistent deoxygenation and acidification. Dissolved oxygen saturation and pH reached record lows in 2022 and 2023, respectively, and have remained near these minimum values since. Although the variability of ocean currents can modify the composition of deep water masses reaching the estuary and mitigate deoxygenation and acidification, other factors such as rising temperatures, increased anthropogenic CO_2 and eutrophication could exacerbate these issues.

For more information

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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, de la Faune et des Parcs du Québec; and the Ministère des Ressources naturelles et des Forêts 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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Acknowledgments

The monitoring of deoxygenation and acidification is made possible through the dedication of the employees participating in Fisheries and Oceans Canada's Atlantic Zone Monitoring Program and the Aquatic Climate Change Adaptation Services Program.

Cat. No.: En78-4/2025E-PDF
ISBN: 978-0-660-79907-0

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