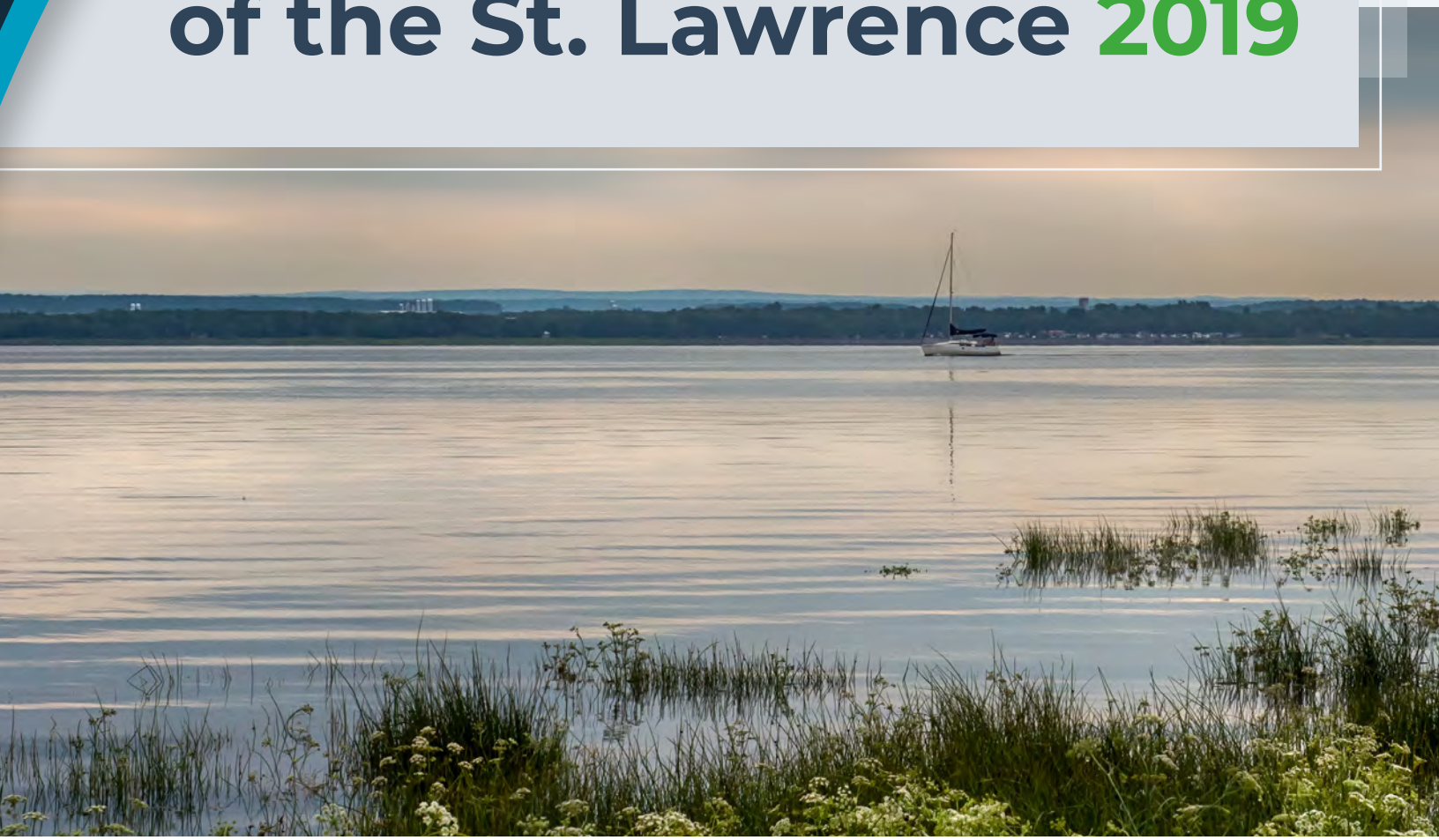
ST. LAWRENCE
Action Plan 2011-2026

Overview of the State of the St. Lawrence 2019



Canada

www.planstlaurent.qc.ca

Québec

Foreword

As co-chairs of the State of the St. Lawrence Monitoring Program, we are very pleased to present you with the Overview of the State of the St. Lawrence 2019. We have prepared this Overview within the context of the St. Lawrence Action Plan 2011-2026 framework, thanks to the joint efforts of two Quebec departments (Department of Environment and the Fight Against Climate Change and Department of Forests, Wildlife and Parks) and three federal departments and agencies (Environment and Climate Change Canada, Fisheries and Oceans Canada and the Parks Canada Agency). We have drawn a picture of the health status of the St. Lawrence's freshwater and saltwater ecosystems using environmental indicators chosen by the Program and pertaining to water, sediments, biological resources, shorelines and uses. These indicators are based on proven methods and are supported by evidence-based data, and most of them have been reported on in previous Overviews. In this edition, we've also included analyses of three major challenges the St. Lawrence River is facing: the excessive nutrient loads in Lake Saint-Pierre, the acidification of the waters of the Gulf, and the impact of climate change on the River's tributaries.

As with previous editions, the Overview of the State of the St. Lawrence 2019 is intended to serve as an information tool for St. Lawrence decision-makers and stakeholders. We certainly don't claim to have taken into account all studies pertaining to the state of the St. Lawrence in order to produce this Overview but rather we have published results stemming directly from the Program under the St. Lawrence Action Plan 2011-2026.

Currently, the general public can access most of the monitoring data on the state of the St. Lawrence through various government and non-government data portals.[1] The added-value proposition of this Overview is its integration of data in the form of indicators and the science-based interpretations offered by experts from the participating provincial and federal departments. As a result, we provide information which allows for a nuanced understanding of the River's state of health and its evolution over time.

As we once again take stock of the state of the St. Lawrence River, encouraging signs of improvements are more and more apparent. Indeed, the ratings for most of the indicators range from moderate to good. We must however be concerned with the Beluga and its decline which doesn't seem to be stopping, as well as with the introduction of invasive alien animal species throughout the St. Lawrence.

The State of the St. Lawrence Monitoring Program continues due to concerted efforts made over the past 30 years. The Program partners work together enthusiastically and are committted to ensuring the Program's continous improvement for the years to come.

As co-chairs of the State of the St. Lawrence Monitoring Program, we are immensely proud of this Overview of the State of the St. Lawrence 2019, the product of numerous individuals' sustained work, to whom we extend our warmest thanks and without whom this report would not have been possible.

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1. http://www.environnement.gouv.qc.ca/eau/portail/index.htm

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Table of Contents

Figure List

Table List

Acronym List

%Crust&Moll	Relative Dominance of Crustaceans and Molluscs
AIS	Aquatic Invasive Species
BDEs	Bromodiphenylethers
CFU	Colony-Forming Unit
DAP	Direct Anthropogenic Pressure
DFO	Fisheries and Oceans Canada
ECCC	Environment and Climate Change Canada
ETPA	Ephemeroptera, Trichoptera, Pisidiidae and Anisoptera
IAAS	Invasive Aquatic Animal Species
IAPS	Invasive Alien Plant Species
II	Invasion Index
INA	Interconnection of Natural Areas
$IQBP_5$	Index of Bacteriological and Physicochemical Water Quality
MELCC	Ministère de l'Environnement et de la Lutte contre les changements climatiques
MFFP	Ministère des Forêts, de la Faune et des Parcs
OA	Ocean Acidification
PAH	Polycyclic Aromatic Hydrocarbons
PBDES	Polybrominated Diphenyl Ethers
PCA	Parks Canada Agency
PCBs	Polychlorinated Biphenyls
RCP	Representative Concentration Pathway
Rich.	Community Richness
SABL	Société d'aménagement de la baie de Lavallière
SLAP	St. Lawrence Action Plan 2011-2026
SS	Suspended Solids
SSL	Stratégies Saint Laurent
SWCP	Shellfish Water Classification Program
TCDD-TEQ	Tetrachlorodibenzo-p-Dioxin - Toxic Equivalency Factor
TEL	Threshold Effect Level
UNESCO	United Nations Educational, Scientific and Cultural Organization
WCP	Watercourse Protection
ZIP	Priority Intervention Zone

Introduction

The St. Lawrence is a fundamental hub of culture and economic development for Quebecers as well as all Canadians. It benefits from a prime location which makes it a major transportation corridor and an almost indispensable route for transit between Canada's provinces and between Canada and the rest of the world. The St. Lawrence has been exploited, modified and also polluted by human activities. Its vast natural terrestrial and aquatic spaces have been impacted, particularly during the 20th century, by modifications to the river's flow regime, deteriorating water quality, shoreline alteration and erosion, and declining plant and animal communities. Despite efforts over the past several decades to reduce such impacts, this great watercourse remains vulnerable to intensive agriculture, encroachments in its floodplain, dredging of navigation channels, and flow regulation. In addition, there are now unavoidable environmental issues such as climate change, invasive species and new pollutants commonly referred to as pollutants of emerging interest whose effects are still barely known.

With water quality and biodiversity health having always been core concerns of both the federal and provincial levels of government, the State of the St. Lawrence Monitoring Program was launched in 2003 under a Canada-Quebec Agreement known as the St. Lawrence Action Plan 2011-2026 (SLAP). Five government partners work together under this Program, namely Environment and Climate Change Canada (ECCC), the Quebec Department of Environment and the Fight Against Climate Change (MELCC), the Quebec Department of Forests, Wildlife and Parks (MFFP), Fisheries and Oceans Canada (DFO) and the Parks Canada Agency (PCA), as well as Stratégies Saint-Laurent (SSL), a non-governmental organization working with shoreline communities. This monitoring Program is a key component towards integrated management of the St. Lawrence River.

The mandate of the State of the St. Lawrence Monitoring Program Working Group is to arrive at a diagnosis, provide an overview of the state of the various components of the river ecosystem and associated issues, and to update it every five years.

After publication of the first Overview in 2003, followed by updates in 2008 and 2014, the Overview of the State of the St. Lawrence 2019 is intended to be a continuation of ongoing efforts to monitor the state of the river and publish updated overviews. It is based on an evolving process which transforms and gradually enhances the Program in light not only of the knowledge acquired but also of the needs expressed by many stakeholders to have information on the state of the St. Lawrence that is as up-to-date as possible.

At regular intervals, the partners analyze a series of environmental indicators based on the most recent scientifically sound results. These indicators help us to have a better understanding of the state of the St. Lawrence and how it has changed. They also make it possible to assess the condition of the ecosystem and guide decision-making, which in turn ensures the protection and sustainability of the St. Lawrence according to the three priorities of the St. Lawrence Action Plan 2011-2026, which are: biodiversity conservation, sustainable uses and improved water quality.

The 2019 Overview consists of three sections. The first section describes the landscape of the St. Lawrence River and highlights its socio-economic importance. The second section presents the monitoring Program and the changes in the state of the St. Lawrence over time through its monitoring indicators. The last section addresses the main issues facing the St. Lawrence over the medium and long term.

1 State of the St. Lawrence Monitoring Program

1.1 Landscapes of the St. Lawrence

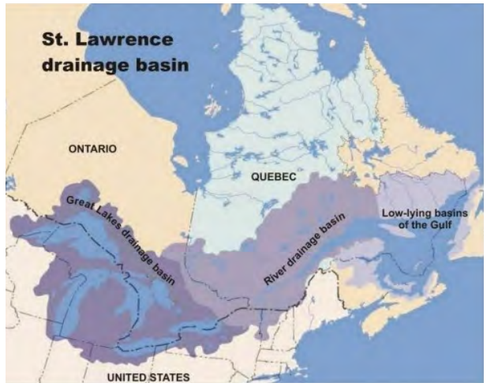


Figure 1.1: St. Lawrence drainage basin

Linking the Great Lakes to the Atlantic Ocean, the St. Lawrence River borders southern Ontario and flows through Quebec from west to east over a distance of 1,600 km, making it the third longest river in North America, after the Mississippi and Mackenzie rivers [1]. It extends over a drainage area of 1.6 million km^2, which includes the Great Lakes and covers a large portion of the Atlantic Ocean watershed (figure 1.1). The river's hydrographic network has over 244 tributaries in Quebec, encompassing 25% of the world's freshwater reserves [2]. It drains into the Atlantic Ocean through the world's largest estuary, 370 km long and 48 km wide at its mouth, with a mean annual discharge of 13,000 m^3/s.

In terms of landscape, the St. Lawrence is dotted with 600 islands along its entire length, the largest being Île d'Orléans, Anticosti Island and Montreal Island. Along the fluvial section, the landscape is characterized by three fluvial lakes: Lake Saint-François, Lake Saint-Louis and Lake Saint-Pierre. Lake Saint-Pierre is recognized as a wetland of international importance according to the Ramsar Convention and has been designated a World Biosphere Reserve by UNESCO, thanks to its exceptional migratory bird sanctuary and its hundred islands. Similarly, Lake Saint-François and 500 other sites along the shores of the St. Lawrence constitute unique ecosystems with great biological richness and a wide variety of freshwater, estuarine and marine habitats. These ecosystems are also recognized worldwide as wetlands of international importance (Ramsar). The St. Lawrence contains 20% of Quebec's protected areas [2]. Many species of birds, fish and plants live here, some of which are emblematic of the St. Lawrence, such as the Beluga, the Great Blue Heron and the Atlantic Puffin.

Photo: C. Lepire. ECCC

1.2 Economic importance of the St. Lawrence

The St. Lawrence is fed by the Great Lakes, which form the world's greatest freshwater expanse and are home to the largest concentration of population and industrial centres in North America. In addition, several densely populated cities and industrial areas are built along the shores of the St. Lawrence. In total, more than 30 million Americans and 15 million Canadians [2] live in this immense watershed, which supplies most of them with drinking water. The St. Lawrence also constitutes an important link for the hydro-electric sector and, with its clean energy, contributes to reducing Canada's greenhouse gas emissions.

The Seaway facilities along the shores of the St. Lawrence as well as the network of 20 ports [3] are equally important and make this one of the world's busiest shipping corridor [1]. They contribute to the prosperity of several economic sectors (import-export, cargo and passenger transportation, and recreational boating), as well as constituting an invaluable source of income for fishing and aquaculture. Approximately 110 million tonnes of cargo of all kinds pass through the Seaway annually [4].

The St. Lawrence is also an excellent tourism destination and a popular resort and cottage area. Several hundred thousand tourists come from all over the world to visit the shores of the estuary and the Gulf of St. Lawrence every year, notably to observe the 13 whale species and other marine mammals of the region. The numerous uses of the St. Lawrence River constitute an excellent opportunity to create high-quality jobs for the people living in its watershed and therefore a source of social well-being and economic prosperity for both Canada and Quebec.

1.3 Monitoring activities

Thanks to the collaboration and expertise of the partners from the Working Group, it was possible to prepare, through the 2019 Overview, a summary of the aquatic ecosystem health of the St. Lawrence on the basis of the most recent results obtained between 2013 and 2017 (and over a wider time interval for some indicators) for some 20 environmental monitoring activities concerning water, sediments, biological resources, shorelines and uses. The 2019 Overview also briefly outlines the most significant issues affecting the socio-ecological components of the river, which affect their state in the short, medium and long term.

Several indicators have been developed based on a site's ecological characteristics and socio economic context. Some of these indicators have been continuously monitoried since 2003, while others have been added to the Program according to their representativeness and relevance (Table 1.1). These additions aim to improve spatial and temporal coverage of the St. Lawrence Action Plan 2011-2026 monitoring Program activities.

For this Overview, the quality of aquatic ecosystems was monitored for three hydrographic sectors (Figure 1.2), whose physical properties vary from upstream to downstream:

- The fluvial corridor (fluvial section and fluvial estuary);
- The upper estuary;
- The lower estuary and the Gulf.

There is a battery of indicators for each sector in relation to its hydrological and ecosystem characteristics. A diagnosis of the state of the indicators is based on the results compiled by the partners in the context of their mandates.

The visual description of the state of the indicators and their trends is facilitated by the use of pictograms (Table 1.1) and pastilles (Table 1.2). In both illustrations, the color (green, light green, yellow, orange and red) corresponds to the indicator's state. As for the trend, it is represented by a sign in the middle of the pastilles indicating a comparison (improving, stable, deteriorating) between the state of the indicator in the 2014 Overview and in the 2019 Overview[2].

Most of the indicators are presented with geolocated monitoring sites in order to provide readers with additional information which highlights the upstream-downstream gradient of the state of the aquatic ecosystem and also favors an understanding of issues affecting regions of interest.

Table 1.1: State of the St. Lawrence monitoring indicators in the 2019 Overview

PICTOGRAM	NAME OF THE INDICATOR	OVERVIEWS IN WHICH INDICATOR IS PRESENT	LEAD DEPARTMENT
	Monitoring of land use	2019	ECCC
	Physical, chemical and bacteriological parameters of river water	2003-2008-2014-2019	MELCC
	Contamination of river water by toxic substances	2003-2008-2014-2019	ECCC
	Contamination of sediments by toxic substances	2003-2008-2014-2019	ECCC
	Contamination of freshwater fish by toxic substances	2003-2008-2014-2019	MELCC
	Status of the Great Blue Heron population	2003-2008-2014-2019	ECCC
	Community of riparian benthic macroinvertebrates	2008-2014-2019	ECCC
	Monitoring of invasive aquatic animal species in the St. Lawrence	2019	MFFP
	Monitoring of fish communities in fresh and brackish water	2003-2008-2014-2019	MFFP
	Study of the Striped Bass population	2003-2008-2014-2019	MFFP
	Monitoring of invasive alien plant species in the St. Lawrence	2003-2008-2014-2019	MELCC
	Status of the Beluga population	2003-2008-2014-2019	DFO
	Monitoring of marine aquatic invasive species in the St. Lawrence	2019	DFO
	Phytoplankton community in the estuary and Gulf	2003-2008-2014-2019	DFO
	Zooplankton community in the estuary and Gulf	2003-2008-2014-2019	DFO
	Monitoring of toxic algae in the estuary and Gulf	2003-2008-2014-2019	DFO
	Status of the Northern Gannet population	2003-2008-2014-2019	ECCC
	Status of seabird populations	2003-2008-2014-2019	ECCC
	Shellfish water quality in the estuary and Gulf	2003-2008-2014-2019	ECCC
	Oceanographic processes	2003-2008-2014-2019	DFO

2. Exceptions to this comparison will be explained within each indicator's section.

Table 1.2: State/Trend Pastilles

ÉTAT	TENDANCE	PASTILLE
Good	Improving	
	Stable	
	Deteriorating	
Moderate-good	Improving	
	Stable	
	Deteriorating	
Moderate	Improving	
	Stable	
	Deteriorating	
Moderate-poor	Improving	
	Stable	
	Deteriorating	
Poor	Improving	
	Stable	
	Deteriorating	

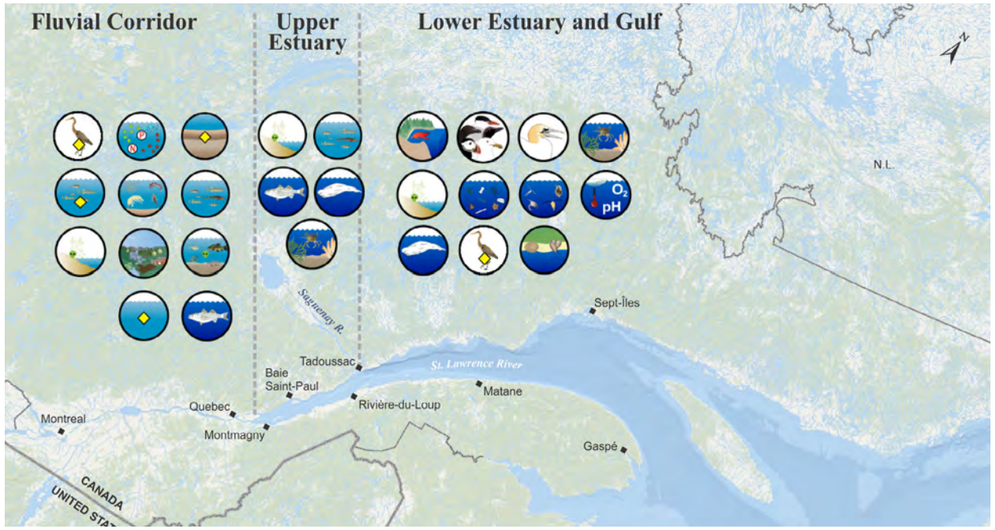


Figure 1.2: Distribution of the indicators by monitoring sector in the St. Lawrence

2. Overall status of the St. Lawrence and trends over time

2 Overall status of the St. Lawrence and trends over time

The St. Lawrence is doing well and its quality shows a positive trend, with improvement over time. In fact, a summary of the results of the monitoring indicators for the 2013-2017 period (2019 Overview) provides an overall assessment of "moderate-good," which represents a clear improvement compared with the previous Overviews.

A comparative analysis of the state of the 14 indicators present in both the 2014 and 2019 Overviews reveals that 5 indicators have improved and changed classification category, increasing from "moderate" to "good" (one indicator), from "moderate" to "moderate-good" (two indicators), from "moderate-poor" to "moderate" (one indicator) and from "moderate-poor" to "moderate-good" (one indicator), while 9 remained stable and none regressed to a lower category.

For the six indicators not present in both the 2014 and 2019 Overviews (change in key measurements or in spatial and temporal coverage), analysis revealed four indicators with a status of stable, one improving and one deteriorating during the monitoring time interval for each respective indicator (figure 2.1).

A detailed analysis of the State of the St. Lawrence Monitoring Program indicators, by ecosystem component, revealed the following results:

- Findings concerning water and sediment quality in the St. Lawrence differ from one sector to another. A significant decrease in heavy metals and a slight decrease in nutrients characterized the freshwater portion of the river, which was assigned a "moderate-good" state. The saltwater portion of the river experienced however less satisfactory episodes during the 2013-2017 period since the oceanographic processes were ranked as moderate with a tendency to worsen. With respect to shellfish waters, 52% of the sites assessed do not meet the criteria of an approved or conditionally approved area and thus do not allow shellfish harvesting.
- Significant improvements were observed for several indicators of biological resources being monitored. Highlights of this improvement indicate that phytoplankton species are in a better situation and that the status of zooplankton species has improved slightly. Fish communities show encouraging recovery signs for some species, notably Striped Bass and Lake Sturgeon. Seabirds are maintaining a stable state on the whole, although the Common Murre population showed an estimated 77% increase, the Razorbill population reached a record number of 26,000 breeding pairs and the status of the Atlantic Puffin is no longer worrisome. The Northern Gannet population level is considered good, with reproductive success having increased from 8% to 50%. The Great Blue Heron showed a significant decrease in contaminant levels, with the exception of mean concentrations of polybrominated diphenyl ethers (PBDEs) on Manowin Island, which increased by 3.6% relative to historical values.
- Finally, despite several indicators improving, the state of the Beluga's population remains a concern as it continues to decline. The situation is unchanged for the indicators related to invasive plant and animal species; it therefore remains a concern, for all of the St. Lawrence.

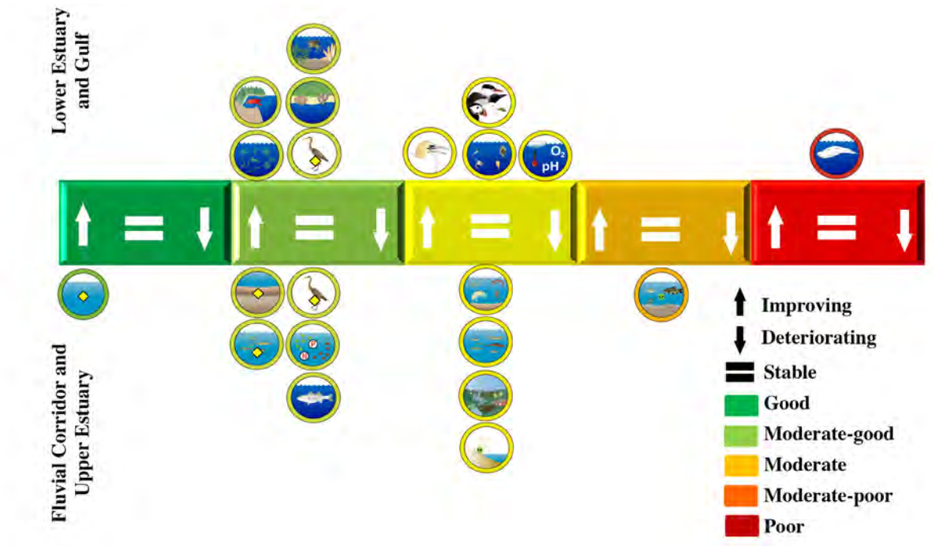


Figure 2.1: Distribution of the indicators assessed in 2019 based on their state and their trend

2.1 State of the fluvial corridor and upper estuary

The freshwater fluvial corridor is composed of the fluvial section and the fluvial estuary. It extends from Cornwall to Île d'Orléans and includes the three fluvial lakes – Saint François, Saint Louis and Saint Pierre – in addition to the fluvial portions such as the sections between Montreal and Sorel and between Trois-Rivières and Quebec City. This corridor is characterized by heavy urbanization, shoreline alteration by humans, the presence of major tributaries that drain agricultural lands, and vast areas of wetlands.

The upper estuary is the point where fresh water first mixes with salt water from the Gulf, resulting in brackish water. This sector extends from Montmagny to the Laurentian Channel at Tadoussac, where the Saguenay River empties. This section is less vulnerable to anthropogenic pressures.

The base flow of the fluvial corridor originates in the Great Lakes, to which are added the flows of major tributaries such as the Ottawa River, the Saint-Maurice River and the Richelieu River. Between 2013 and 2017, the levels of the Great Lakes were slightly below historical averages. In addition, the tributaries' contributions varied considerably, their inflows being more pronounced in the spring. Consequently, the mean annual flow of the fluvial corridor and of the upper estuary during this period was generally low. This causes numerous impacts, the severity of which is proportional to the magnitude of the decline in these flows. In such conditions, basic functioning of the river and its bed is likely to be considerably compromised; water pollution levels could increase, which would adversely affect aquatic life [5], restrict recreational uses and cause significant disruptions in the drinking water supply.

The monitoring of this section of the St. Lawrence was carried out with a set of indicators representing the following ecosystem components: water, sediments, biological resources and shorelines. Each indicator is briefly described, and emphasis is placed on highlights of its state and changes over time. The details for each of these indicators are presented in fact sheets available on the St. Lawrence Action Plan's website.

INDICATOR: Monitoring of land use

Overall state: "moderate" with stable trend[3]

The health of the St. Lawrence depends on the inputs and effluents that it receives from its watershed, whether these are from natural or anthropogenic sources. Studying this indicator makes it possible to assess the relationship between the condition of the shorelines, the type of land use within the specific watersheds, and the state of the water quality and ecosystems of the St. Lawrence River. This study dealt with a large portion of the St. Lawrence watershed, spread over seven subwatersheds of its fluvial section, as shown in Figure 2.2.

Three indices representing complementary aspects of the state of land use were used to determine the magnitude of the pressure exerted by the various existing activities on water quality, namely:

- **Direct anthropogenic pressure (DAP):** represents the percentage of the subwatershed covered by agricultural and urban activities (SOLEC, 2016);
- **Watercourse protection (WCP):** defined by the percentage of natural areas (wetlands, grasslands, forests) found within a 100-m riparian buffer strip (Alberti et al., 2007 and Tiner, 2004);
- **Interconnection of natural areas (INA):** estimated based on road density, i.e. the sum of the length of the roads as a proportion of the total area of the watershed (km/km^2); the higher the index, the greater the degree of natural environment fragmentation (Alberti et al., 2007 and Tiner, 2004).

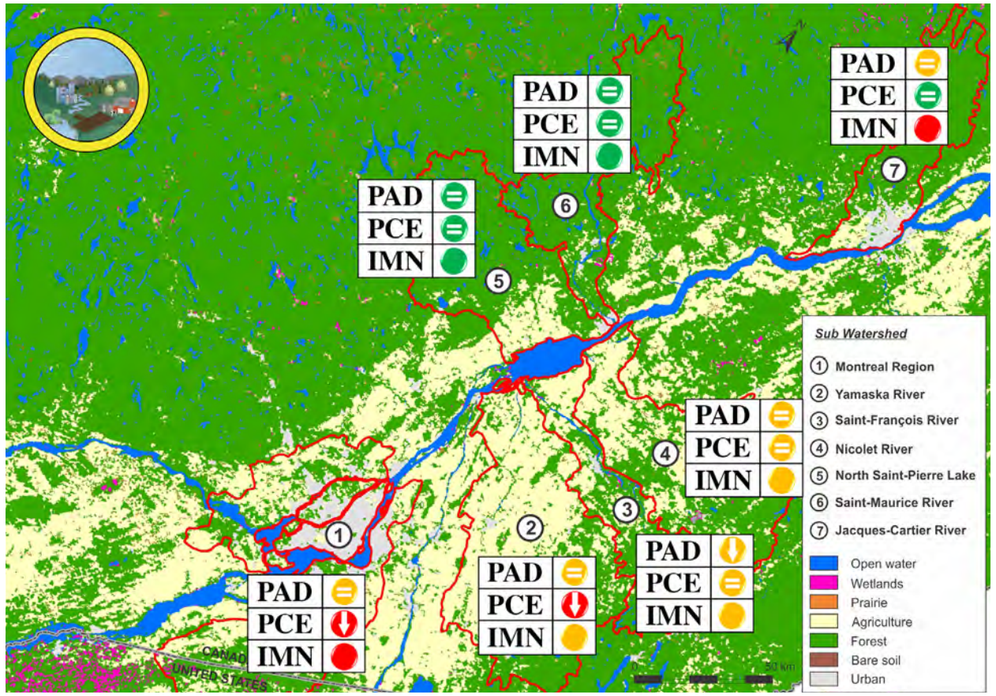


Figure 2.2: State and trend of the three land use indices (DAP, WCP, INA), by study sector

3. This indicator was not monitored in the 2014 Overview

The overall state of land use along the St. Lawrence in 2015 was assessed as "moderate" with a stable general trend. The ranking assigned to the three indices was approximately identical for all of the subwatersheds studied.

- **Non-threatening anthropogenic pressure: state of the DAP index**

The two subwatersheds north of Lake Saint-Pierre, and the Saint-Maurice River are assessed as "not of concern" according to the DAP index, A maximum of 14% of their lands is occupied by agricultural or urban activities. However, the subwatersheds of the Yamaska, Saint-François, Jacques-Cartier and Nicolet rivers, in addition to Montreal, were ranked as "to be monitored."

The Montreal and Yamaska subwatersheds are the most problematic, since a little more than a third of their area consists of agricultural land.

- **Watercourse protection south of the St. Lawrence River assessed as "of concern": state of the WCP index**

According to this index, the two subwatersheds known for their high level of human activities (Montreal and Yamaska River) are assessed as "of concern" owing to the expansion of agricultural activities to the detriment of natural areas. Only 47% and 41% of their respective shorelines have conserved their natural character. In addition, the two agricultural subwatersheds of Saint-François and Nicolet are ranked as "to be monitored," since their shorelines consist of between 50% and 75% natural areas. However, the north of Lake Saint-Pierre, as well as the Saint-Maurice and Jacques-Cartier rivers, were rated as "not of concern" for this index.

- **Fragmented natural areas to the south and interconnected natural areas to the north: state of the INA index**

The road network density is high in the most urbanized subwatersheds: approximately 3.87 km/km^2 in the Montreal subwatershed and 1.95 km/km^2 in the Jacques-Cartier River subwatershed, far exceeding the upper limit of natural environment connectivity, which is set at 1.6 km/km^2. These two regions are therefore rated as "of concern." The agricultural subwatersheds of the Nicolet, Saint-François and Yamaska rivers were assigned a "to be monitored" state, since the density of their road network is between 0.9 and 1.6 km/km^2. In addition, the two subwatersheds on the north shore of the St. Lawrence (the north of Lake Saint-Pierre and the Saint-Maurice) have an index of less than 0.9 km/km^2. Their state is therefore "not of concern."

- **The trend of changes in land use between 1975, 2000 and 2015 in the Montreal and Quebec City regions**

The analysis of the changes highlights the expansion (gain) and the reduction (loss) of the land use classes (open water, wetland, prairie, agriculture, forest, bare soil, urban) and demonstrates how the landscape has changed between the years 1975, 2000 and 2015. Only two regions were analyzed owing to very dynamic changes in land use: the **Greater Montreal area**, where urban expansion took place to the detriment of forest and agriculture, with a total gain estimated at 240 km^2 between 2000 and 2015; and the **Greater Quebec City area**, where urban expansion occurred to the detriment of agriculture in the St. Lawrence Valley, particularly on the Canadian Shield. Furthermore, for both major regions, urban and agricultural expansion follows a north-south axis, moving away from the St. Lawrence River.

INDICATOR: Physicochemical and bacteriological parameters of the St. Lawrence River water

Overall state: "moderate-good" with stable trend between the 2014 and 2019 Overviews

The St. Lawrence River water quality monitoring network, which has been in place since 1990, includes 27 sampling stations located between Lake Saint-François and Île d'Orléans. Thirteen parameters are monitored at each of these stations (Figure 2.3), five of which are used for the calculation of the Index of Bacteriological and Physicochemical Water Quality ($IQBP_5$):

- Total phosphorus;
- Ammonia nitrogen;
- Nitrites and nitrates;
- Fecal coliforms;
- Chlorophyll *a*.

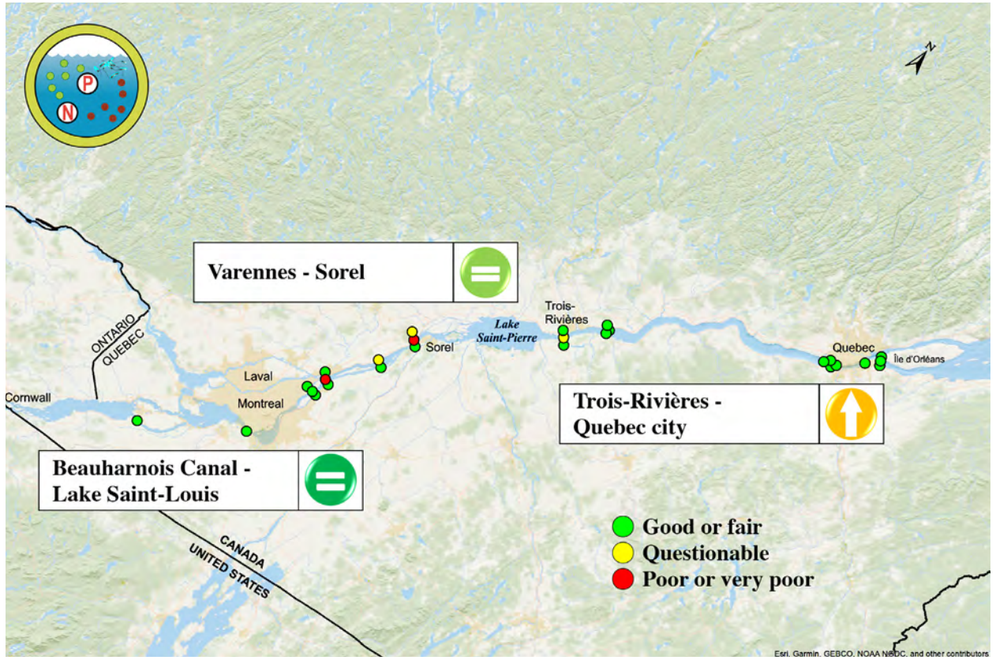


Figure 2.3: State and trend of $IQBP_5$ by sector since the 2014 Overview

Since 2015, the IQBP of the St. Lawrence River has been calculated based on five parameters. In the 2014 Overview, the water quality in the St. Lawrence was evaluated using $IQBP_6$, which included suspended solids. This parameter was subsequently removed from the index calculation, since an in-depth review revealed that the presence of suspended solids was mainly attributable to the erosion of the river bed and banks. Consequently, the values published in this report, both for 2015-2017 and for the previous years, are based on $IQBP_5$.

Owing to a change in the location of one of the stations, the trend analyzes were carried out on 26 of the 27 stations monitored in 2015-2017. In addition, owing to a change in the phosphorus analysis methods that occurred at the end of 2011, the trends for this parameter had to be measured in two phases: from 1995 to 2011, then from 2012 to 2018.

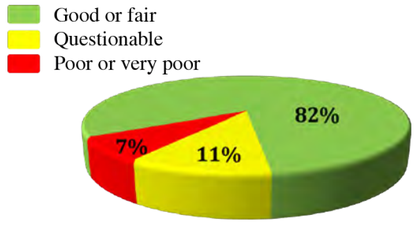


Figure 2.4: State of $IQBP_5$ of the St. Lawrence between 2015 and 2017

Overall water quality in the St. Lawrence is relatively stable

Based on $IQBP_5$, water quality of the main water masses in the river is classified as "moderate-good," with 48% of the 27 monitoring sites having good water quality in 2015-2017. More specifically, 82% of the sites had good or fair water quality, while two sites (7%) had poor or very poor water quality (Figure 2.4).

The annual percentage of stations with good or fair water quality according to $IQBP_5$ fluctuated between 74% and 89% between 1995 and 2017. In 2015 and 2016, it was 85%. In 2017, it had decreased to 78%.

Water quality varies between the upstream and downstream reaches

Water quality in the section extending from the Beauharnois Canal to the outlet of Lake Saint-Louis is assessed as "good." However, water quality deteriorates downstream of Montreal, with the section located between Varennes and Sorel having a "moderate-good" state, while the section between Trois-Rivières and Quebec City has a "moderate" state.

Despite this finding, overall water quality improves downstream of Lake Saint-Pierre, with more sites having a "fair" rating and no site rated as having poor or very poor water quality.

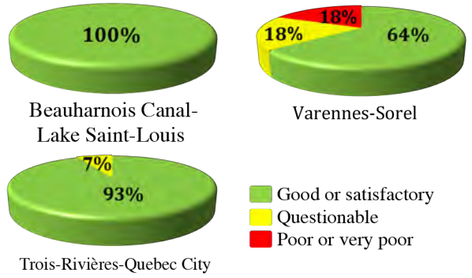


Figure 2.5: Classification of the water quality at the monitoring sites, by sector

Water quality is largely determined by wastewater discharges

The decline in water quality is largely due to fecal coliforms. In 2015-2017, 41% of the monitoring sites exceeded the 200 CFU/100 mL criterion established for swimming at least half of the time. This state does not appear to have improved, since the majority of sites (78%) showed no significant change in fecal coliform levels between 1995 and 2017.

The high concentrations observed are mainly attributable to discharges from the Montreal, Longueuil and Repentigny wastewater treatment plants, which treat, but do not disinfect, their wastewater before discharging it into the St. Lawrence. The heavy precipitation recorded in the spring of 2017 in the southern part of the province may also have contributed to a larger number of municipal sewer system overflows, which constitute another source of contamination by fecal coliforms.

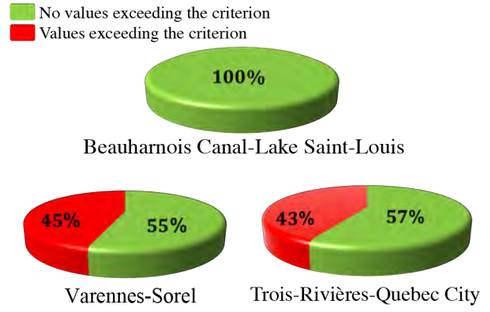


Figure 2.6: Median fecal coliform values exceeding the 200 CFU/100 mL criterion at the monitoring sites, by sector

Contradictory trends?

In total, 46% of the sites exhibited a significant decrease in phosphorus concentrations between 1995 and 2011, while no trend was evident for the other sites. This downward trend continued in 2012 and 2018 at only 8% of the sites, while others remained stable. Although chlorophyll *a* increased significantly at 92% of the monitoring sites, the median values indicate good water quality most of the time.

Policies introduced and work carried out at the St. Lawrence River watershed level to reduce the use and discharges into the environment of phosphorus had a positive effect on the concentrations measured between 1995 and 2011. Between 2002 and 2011, similar improvements were observed in 33% of the St. Lawrence tributaries. (MELCC, 2014). However, the reduction in phosphorus does not appear to have led to a reduction in chlorophyll *a*. This could be caused by enhanced photosynthesis resulting from warmer water temperature and an earlier start to the growing season. This trend should be monitored in the coming years.

Photo: MELCC

INDICATOR: Contamination of river water by toxic substances

Overall state: “good” with improving trend between the 2014 and 2019 Overviews

Water contamination by toxic substances receive particular attention in the St. Lawrence monitoring Program owing to the fact that toxic substances persist in water and can enter the food web through bioaccumulation and biomagnification in wildlife and plants, thereby disrupting ecosystem functioning and equilibrium.

Toxic substances selected to assess the state of this indicator are heavy metals for which a water quality criterion for the protection of aquatic life exists (arsenic, cadmium, copper, iron, mercury, nickel, lead and zinc). These heavy metals currently exceed their criteria, or have exceeded them in the past. This diagnosis is supported by analysis results of other toxic substances, such as pesticides (atrazine, metolachlor, simazine at the Quebec City station) and polybrominated diphenyl ethers (PBDEs, particularly BDE 28, 47, 99, 100, 153 and 209 at the Lavaltrie station and at the Quebec City station).

Heavy metal monitoring is carried out at the stations shown in Figure 2.7, namely:

- Carillon;
- Bécancour;
- Lavaltrie;
- Quebec City.

For the 2012-2017 period, overall state of water quality in the fluvial section of the St. Lawrence was rated as “good.” In general, no values exceeding the water quality guidelines were recorded for the heavy metals analyzed (Figure 2.7). This is a fairly significant improvement compared to the 2007-2012 state (2014 Overview), which was rated as “moderate.”

Figure 2.7: State of water contamination by heavy metals, PBDEs and pesticides, by monitoring site

Upstream to downstream concentration gradient observed

In the fluvial section of the St. Lawrence, an upstream to downstream concentration gradient was observed for arsenic and nickel. Levels recorded showed an upward trend. Values were lower at the Carillon and Lavaltrie stations than at the Bécancour and Quebec City stations. For the other heavy metals however, a downward trend was observed from Carillon to Quebec City.

Some values exceeded the criteria, but the overall situation was rated “not of concern”

While arsenic and nickel levels showed an upward trend between 2012 and 2017, the values remained below the water quality guidelines. Although iron and cadmium concentrations exceeded the guideline values, the frequency of these exceedances over time was very low (<3%) and had no impact on the overall assessment, indicating that the water quality in terms of heavy metal levels is good.

Photo: Caroline Robert. ECCC

Pesticides and PBDEs: other indicators of improvement

Quebec City station pesticide concentrations remained below the water quality guidelines, as observed in 2014 therefore maintaining a “good” and stable state.

For PBDEs, not only was a reduction in median concentrations observed from the Lavaltrie station towards the Quebec City station, there was also a general downward trend compared with the situation described in 2014. The values measured were all below the water quality guidelines.

A general trend towards improvement

Fairly significant reduction, between the 2014 and 2019 Overviews of the median concentrations for the great majority of contaminants, reflects an improvement in water quality in the fluvial corridor. Iron does not follow this trend which suggests that there were probably more iron inputs in the water during the 2012-2017 period, particularly in the Ottawa River and the Montreal area, since the Carillon and Lavaltrie stations have the highest median values.

Photo: Martin Jean. ECCC

INDICATOR: Contamination of sediments by toxic substances

Overall state: "moderate-good" with improving trend[4]

Sediment quality monitoring is carried out every 10 years in the St. Lawrence fluvial section and the fluvial lakes. Unlike water, changes in sediment contaminant concentrations occur very slowly and are measured in decades.,

The sites where surface sediment quality was monitored between 2013 and 2017 are located in Lake Saint-Louis and Lake Saint-Pierre as well as throughout the fluvial section between the Boucherville Islands and Lavaltrie on the north shore. On the south shore, only the Contrecoeur Islands sector was sampled (Figure 2.8). The sediment quality criteria cited in this document (TEL: threshold effect level) are taken from ECCC and MDDEP (2007) report and were determined based on the biological effects observed in benthic and pelagic organisms as well as on the contaminant levels measured in sediments.

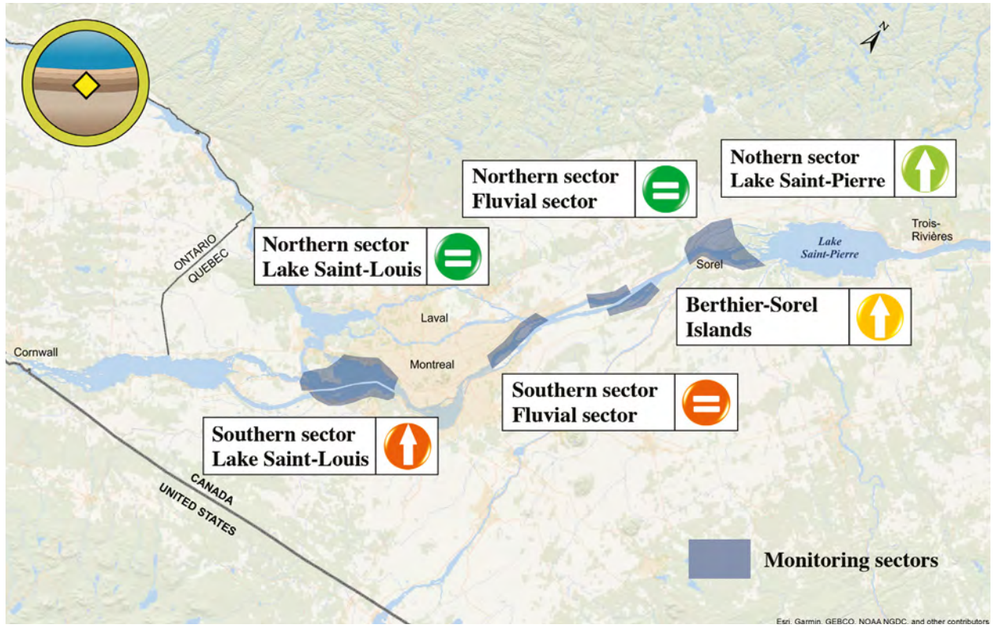


Figure 2.8: State and trend of surface sediment quality, by monitoring sector

4. Change in indicator's spatial coverage beween 2014 and 2019 Overviews

Lake Saint-Louis

The historical contamination persists in surface sediments

Surface sediment quality in the lake is heterogeneous, between the northern and southern sectors. In 2015, the state of sediments was rated as "good" in the northern sector and "moderate-poor" in the southern sector. The southern sector is heavily contaminated owing mainly to high concentrations of polycyclic aromatic hydrocarbons (PAHs), mercury, polychlorinated biphenyls (PCBs) and furans which exceed the TEL (Figure 2.9). In the northern sector, only arsenic remains of concern along the shores of Montreal Island.

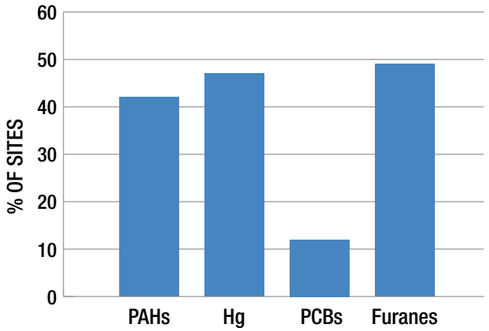


Figure 2.9: Percentage of sites in the southern sector that exceed the TEL for each contaminant monitored

An improving trend, for the most part

The mitigation measures aimed at sources of contamination as well as the industrial and urban wastewater treatment programs specific to Lake Saint-Louis implemented since the 1980s have had a positive impact, which explains the downward trend for the majority of contaminants between 2003 and 2015. In the southern sector, despite the exceedances recorded, a 12% to 53% reduction in mean concentrations was observed for all contaminants except mercury, which remains problematic. Mercury levels continue to be significantly higher than the quality guidelines and are declining slowly.

Fluvial section

Contrecoeur sector sediments are an exception compared with those of the fluvial section

Generally, despite the continual discharges of wastewater from the City of Montreal as well as the effluents from the industrialized east end of Montreal and from the Port of Montreal, the surface sediment quality of the fluvial section remains "good." This finding is largely attributable to the nature of these sediments as they are mainly composed of sand with a fine silt and clay portion, which makes them less likely to accumulate contaminants.

Sediment sampling - Photo: Magella Pelletier, ECCC

In addition, exceedances are sometimes recorded locally, mainly east of Sainte-Thérèse Island and west of Ronde Island, as well as in Île du Dragon channel between the islands and the south shore of the St. Lawrence, where several industries are active.

A stable trend for the fluvial section, but of concern for the Contrecoeur sector

There was no improvement in sediment contamination in the Contrecoeur sector from 2004 to 2014, and it is difficult to anticipate any improvement given the industrial and municipal operations that take place along the shores of this sector. This situation is cause for concern since there is a National Wildlife Area in the sector consisting of 22 islands surrounded by aquatic grass beds and distributed over a 10 km section along the St. Lawrence. The presence of contaminated sediments could jeopardize its biodiversity.

Lake Saint-Pierre

A state of concern since the emergence of new contaminants

The overall quality of surface sediments in Lake Saint-Pierre was “good” in 2013, with the exception of the Berthier-Sorel Islands sector, which is contaminated by PCBs, PAHs, dioxins and furans. Furthermore, the presence of new contaminants such as PBDEs leads to new concerns about this aquatic environment. These very persistent substances adhere to the fine particulate matter of the sediments. In 2013, 42% of the monitoring sites exceeded the guideline value (0.4 ng/g) for BDE-99 established by the federal government for the protection of aquatic animal life. These sites are mainly located in the northern sector of the lake.

Up to 59% reduction in contaminants in 10 years

Lake Saint-Pierre surface sediment quality shows an improving trend despite new contaminants findings. Between 2003 and 2013, levels of PBDEs, including BDE-99, decreased by 59%. An even greater reduction (75%) is observed in the Berthier-Sorel Islands sector during the same period. The trends for the other toxic contaminants show that the mean concentrations of metals and PCBs fell by approximately 75% and 82%, respectively, between 1986 and 2013.

INDICATOR: Contamination of freshwater fish by toxic substances

Overall state: “moderate-good” with improving trend between the 2014 and 2019 Overviews

The fish contamination indicator includes three species (Walleye, Northern Pike and White Sucker) captured in three fluvial lakes of the St. Lawrence (Figure 2.10). Yellow Perch, also monitored for PCBs and PBDEs, is not included in the indicator.

Walleyes and Northern Pikes are analyzed individually for mercury and as a homogenate of several large fish for PCBs and PBDEs. Yellow Perch are analyzed as a homogenate of several fish for PCBs and PBDEs. In all these cases, only the flesh is used. When it comes to White Suckers, whole fish are used and are analyzed individually for mercury, PCBs and PBDEs.

For this indicator, fish sampling is conducted every three or five years. In addition, depending on the species and the contaminants assessed, the sampling years may differ.

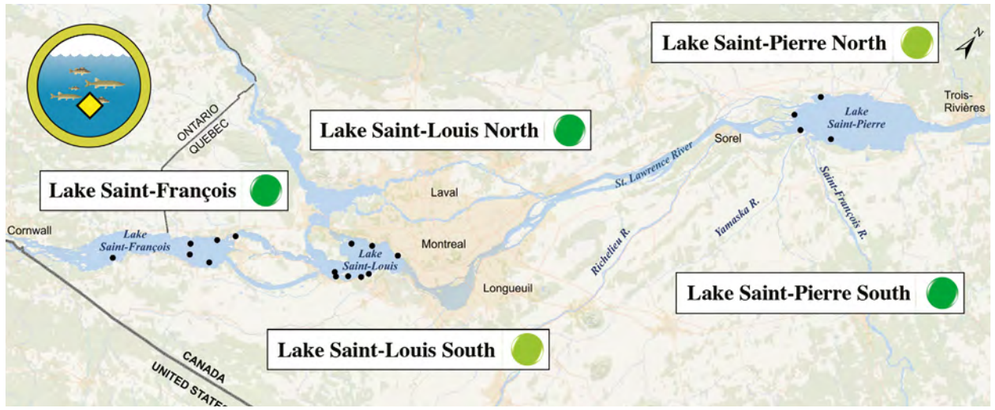


Figure 2.10: Monitoring sites and state of fish contamination by PBDEs, PCBs and Hg

Low levels of contamination in fish

At the sites visited in 2014 or 2016, average mercury levels were generally below the Health Canada guideline (0.5 mg/kg) for Walleye and Northern Pike. This standard was exceeded only in Northern Pike found in the southern Lake Saint-Louis sector (1.6 times higher).

Average PCB levels in fish captured between 2013 and 2016 were below the European Union standard of 125 µg/kg, with the exception of a single value (130 µg/kg) measured in Walleyes from northern Lake Saint-Pierre in 2013. Similarly, with the exception of northern Lake Saint-Pierre in 2013 (190 µg/kg), all the average PCB levels in whole White Suckers were below the MELCC criterion for the protection of piscivorous terrestrial wildlife (160 µg/kg).

Between 2013 and 2016, average penta-BDE levels were below the federal environmental quality guideline value of 3 µg/kg, except in 2013 for Walleye in southern Lake Saint-Pierre (4.8 µg/kg) as well as for Walleye (13.9 µg/kg) and whole White Sucker (6.2 µg/kg) in northern Lake Saint-Pierre.

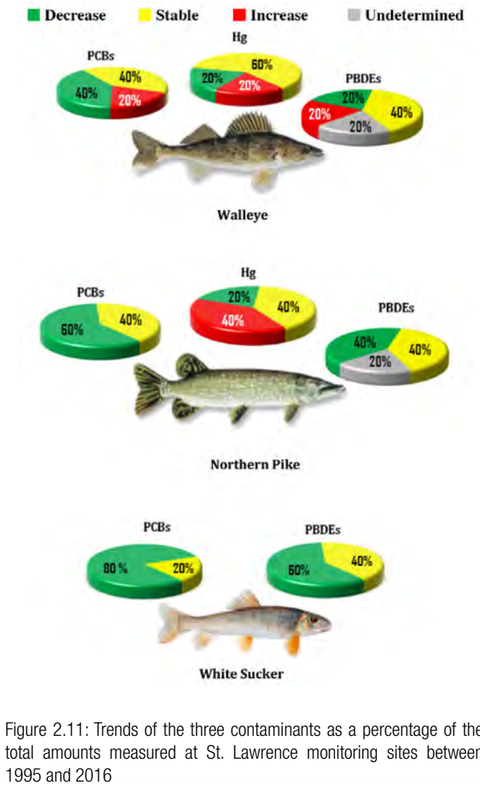


Figure 2.11: Trends of the three contaminants as a percentage of the total amounts measured at St. Lawrence monitoring sites between 1995 and 2016

Spatial distribution varies depending on the contaminant

Between 2014 and 2016, the state reported for Lake Saint-François, northern Lake Saint-Louis and southern Lake Saint-Pierre was “good,” while the results for southern Lake Saint-Louis and northern Lake Saint-Pierre showed a “moderate-good” state.

- **Mercury:** In southern Lake Saint-Louis, 425 mm Walleyes and 600 mm Northern Pikes exhibited significantly higher average mercury levels (0.49 mg/kg and 0.80 mg/kg, respectively) than at the other sites.
- **PCBs:** For the 2013-2016 period, there were few differences in average PCB levels in fish muscle tissues between the sectors studied. However, levels appeared to be a little higher in Walleye than in Northern Pike. For the 2013-2016 period, the average PCB levels in whole White Suckers in northern Lake Saint-Pierre (175 µg/kg) and in Lake Saint-François (141 µg/kg) were similar. However, these are significantly higher than in southern Lake Saint-Louis (90 µg / kg) and southern Lake Saint-Pierre Sud (110 µg / kg), both having similar PCB levels.
- **PBDEs:** For the 2013-2016 period, average PBDE levels in whole White Suckers in northern Lake Saint-Pierre (39 µg/kg) were significantly higher than in southern Lake Saint-Pierre (27 µg/kg) which are significally higher than in Lake Saint-François (3.5 µg/kg) and in southern Lake Saint-Louis (4.9 µg/kg). Saint-François and southern Saint-Louis lakes have similar PBDE levels. In northern Lake Saint-Louis, the data were insufficient to conduct a statistical study.

A relatively stable or slightly declining trend

In general, mercury levels did not vary significantly or exhibited only small differences between measurements from 2014-2016 and measurements from samples taken in the past, since 1995. Significant decreases were observed in Lake Saint-François for Walleye and in the southern Lake Saint-Louis for Northern Pikes. However, a significant increase was noted for Northern Pike in the southern Lake Saint-Pierre and northern Lake Saint-Pierre sectors, as well as for Walleye in the southern Lake Saint-Pierre sector.

Compared with 1996-2002, average PCB levels measured in fish muscle tissues during the 2013-2016 period remained relatively comparable to or possibly lower than in previous sampling efforts, apart from the Walleyes captured in 2013 in northern Lake Saint-Pierre, which exhibited possibly higher values (sample insufficient for statistical analysis; 130 µg/kg in 2013 versus 43 µg/kg in 2002). On the other hand, whole White Suckers in the three lakes have significantly lower average PCB levels during the 2013-2016 period than during the 1996-2002 period.

Average PBDE levels measured in fish muscle tissues during the 2013-2016 period remained comparable to or possibly a little lower than those measured during the previous years, with the exception of the levels in Walleyes captured in 2013 in northern Lake Saint-Pierre, which show a slight increase (41.4 µg/kg) compared with those captured in 2007 (22.8 µg/kg) and 2002 (19.8 µg/kg). However, for whole White Suckers, average PBDE levels in northern and southern Lake Saint-Pierre as well as in Lake Saint-François are significantly lower in 2013-2016 than in 2002-2004. In Lake Saint-Louis, although levels are currently low, data prior to 2013 are insufficient for comparison.

INDICATOR: Status of the Great Blue Heron population

Overall state: “moderate-good” with stable trend between the 2014 and 2019 Overviews

The largest wader in Quebec, the Great Blue Heron is a piscivorous bird that sits at the top of the food chain. During its breeding season, it travels to its nesting ground, which is near its foraging area. This proximity makes the Great Blue Heron an ideal indicator for the assessment of pollution levels in the local aquatic environment over time and space.

This indicator was studied by monitoring the five most abundant or most worrisome groups of contaminants found in Great Blue Heron eggs (mercury, total PCBs, DDE, total PBDEs, TCDD-TEQ). The colonies in the fluvial corridor for which this monitoring was carried out were located at:

- Île aux Hérons;
- Grande Île.

To assess the state of this indicator, the concentrations of contaminants recorded during the 2011-2016 period (with the exception of TCDD-TEQ, the levels of which were not monitored during this period) were compared to historical data, and to toxicity criteria or thresholds taken from the scientific literature.

Results showed that the overall state of contamination of Great Blue Herons in the fluvial corridor was “moderate-good.” Contaminant levels decreased compared to historical data, while 75% of the 2016 values were below toxicity criteria. This finding was similar for both monitoring sites, although with a slight difference between contaminant groups (Figure 2.12).

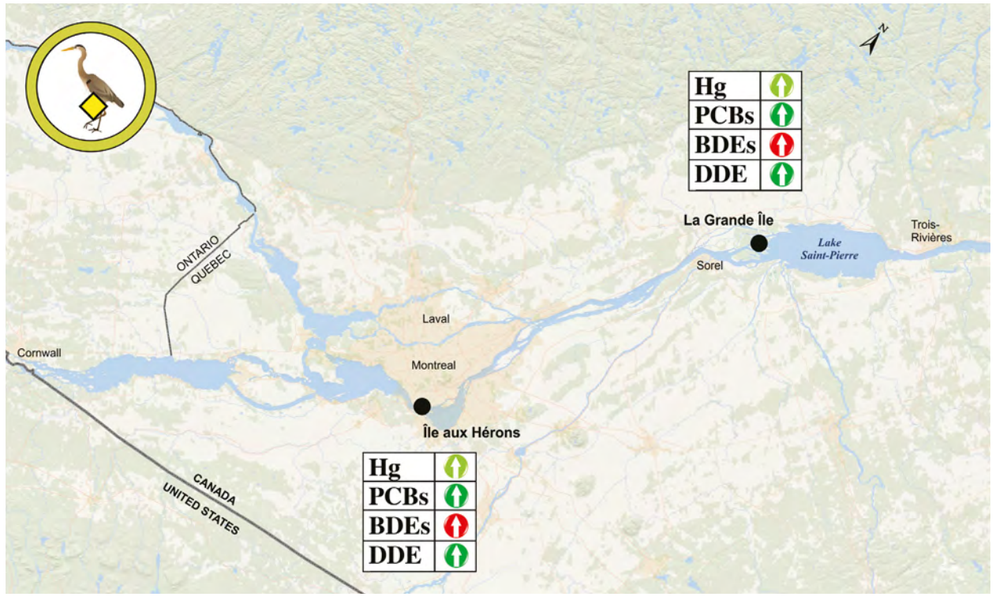
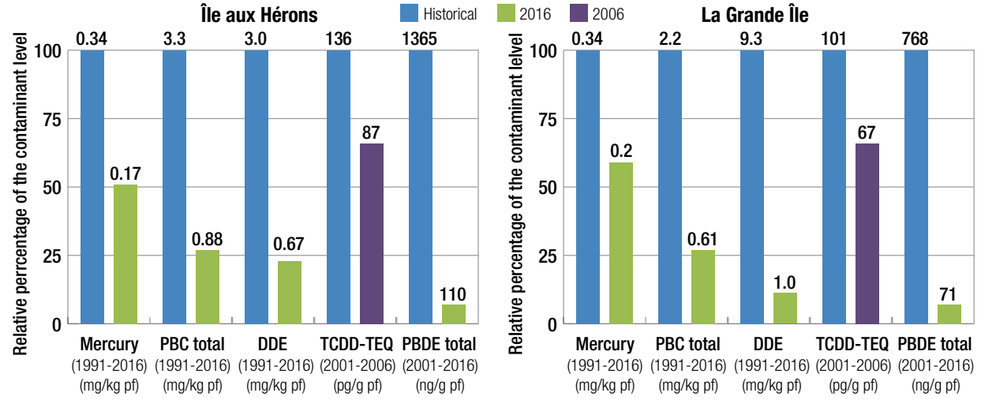


Figure 2.12: State and trend of contaminant levels in Great Blue Heron eggs, by monitoring site

A fairly significant decrease in contaminant levels

The largest decreases in contaminant levels were recorded for DDE and PBDE at the Île aux Hérons and Grande Île monitoring sites. Relative to historical values, reductions of more than 75% were observed. A 41% to 73% reduction of mercury and PCB levels were observed for both sites, as shown in Figure 2.13.

The two monitoring sites in the fluvial corridor recorded an average decrease of more than 73% for all contaminants.



NB: The values above each bar represent the pollutant levels

Figure 2.13: Comparison between historical values and recent values for contaminant levels in Great Blue Heron eggs

■ **Contaminant levels were generally only marginally above the criteria**

PBDEs were the only contaminant whose levels exceeded the toxicity criterion. At Île aux Hérons, BDE levels in eggs were almost twice as high as the criterion (191%), and at Grande Île, the figure was 116%. However, this criterion is based on few studies and the fact that the criterion was exceeded does not necessarily mean that adverse effects are to be expected.

■ **Contaminant levels showed an overall declining trend, with a few exceptions**

On the whole, the trends derived from a comparison of historical data and 2016 data showed a decrease for both sites. There was an encouraging reduction in PCB, DDE and PBDE levels. The decrease in mercury levels, on the other hand, was minor. This finding is fairly similar to the 2014 Overview. However, a few disparities were: at Île aux Hérons, PCB levels decreased relative to the 2014 Overview, while mercury levels increased slightly, and levels at Grande Île remained unchanged.

Collection of benthic macroinvertebrates - Photo: Alain Armellin, ECCC

INDICATOR: Communities of riparian benthic macroinvertebrates

Overall state: “moderate” with stable trend between the 2014 and 2019 Overviews

Benthic macroinvertebrate communities are composed of several species of insects, worms, crustaceans and molluscs living on the bottom of lakes and rivers or in their substrate. They exhibit a wide range of stress responses to disturbances and are a useful complement to water and sediment physicochemical monitoring to describe the state of a watercourse. In addition, they constitute an important link in the food web of aquatic environments (Wallace and Webster, 1996) and bioaccumulate and biomagnify several contaminants.

Monitoring of St. Lawrence River benthic communities was carried out from 2013 to 2018. Three indices are used to assess this indicator:

- Community richness (Rich.): expressed as the number of genera per sample;
- Relative dominance of crustaceans and molluscs in benthic communities (%Crust&Moll);
- Number of families sensitive to organic pollution (ETPA: Ephemeroptera, Trichoptera, Pisidiidae and Anisoptera).

The overall state of the benthic communities of the St. Lawrence during the 2013-2018 period was rated as “moderate.” However, the results were not the same for the four regions monitored for this indicator (Figure 2.14).

■ **An improving trend for Lake Saint-François**

This indicator was assessed as “moderate-good” for Lake Saint-François, mainly owing to the presence of a large number of ETPA. The number of genera found at these stations was also satisfactory. There is an increasing trend, given that during the 2010-2014 period, the benthic community along the north shore of the lake was among the most degraded in the St. Lawrence after the fluvial section.

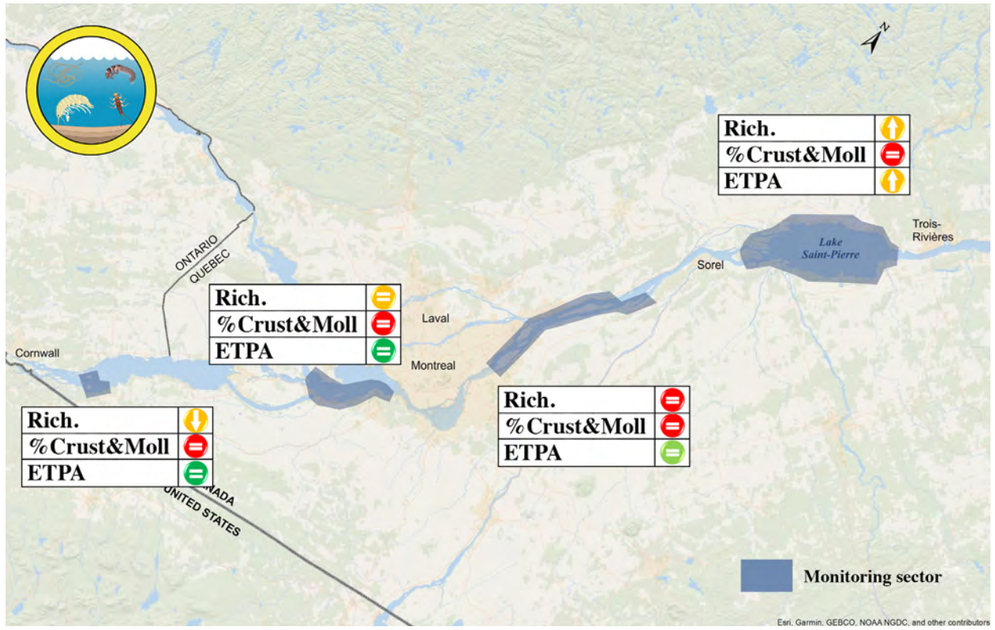


Figure 2.14: State and trend of the three indices, by monitoring sector

■ **Conditions are not improving for Lake Saint-Louis and the fluvial section**

The state recorded for the stations associated with these two regions was “moderate-poor.” Their benthic communities exhibited an impoverished number of genera and a relatively low abundance of crustaceans and molluscs. Compared with the 2004-2010 period, conditions at the stations in Lake Saint-Louis have deteriorated. The main cause is believed to be changes in the benthic habitat in the Saint-Bernard Island sector, i.e. a reduction in the surface area of aquatic grass beds. The conditions at the stations associated with the fluvial section are not improving owing to the influence of the dispersion plume from the wastewater outfall of the City of Montreal, which continues to have a major impact on ecosystem quality.

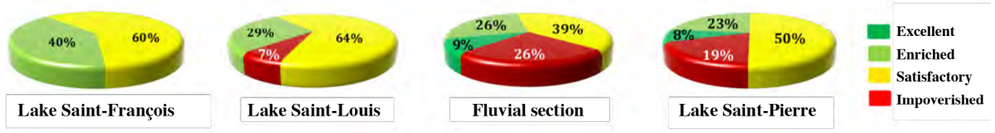


Figure 2.15: State of community richness as a percentage of monitoring sites

■ **Significant interannual fluctuations in the Lake Saint-Pierre community**

Despite the fact that water quality downstream of Montreal remains problematic, the state of the benthic communities of Lake Saint-Pierre was estimated as “moderate.” The number of genera as and ETPA families were satisfactory. However, the relative abundance of crustaceans and molluscs increased considerably at all the stations in the lake, particularly between 2012 and 2014, which caused the impoverishment of its benthic community during this period.

The values of these various indicators fluctuate significantly from year to year. This is particularly the case for the metric %Crust&Moll, while the metric associated with sensitive species showes smaller interannual variations. There are several possible causes for this phenomenon, including natural causes such as interannual fluctuations in the hydrological cycle. The riparian habitat where these organisms are found is strongly influenced by the range of the water level.

In spite of the interannual fluctuations recorded since 2004, the overall trend of the lake's benthic communities remains stable.

Photos: Alain Armellin, ECCC

INDICATOR: Monitoring of invasive aquatic animal species in the St. Lawrence

Overall state: "moderate-poor" with stable trend since the 2014 Overview[5]

The Round Goby Index is the main parameter used to assess the state of the St. Lawrence in terms of invasive aquatic animal species (IAAS). This index is calculated based on the frequency of occurrence of the Round Goby in the stations sampled as part of the *Réseau de suivi ichtyologique* (RSI). The RSI is an annual fish survey program carried out by the Ministère des Forêts, de la Faune et des Parcs (MFFP) which covers the seven sectors of the St. Lawrence River in succession.

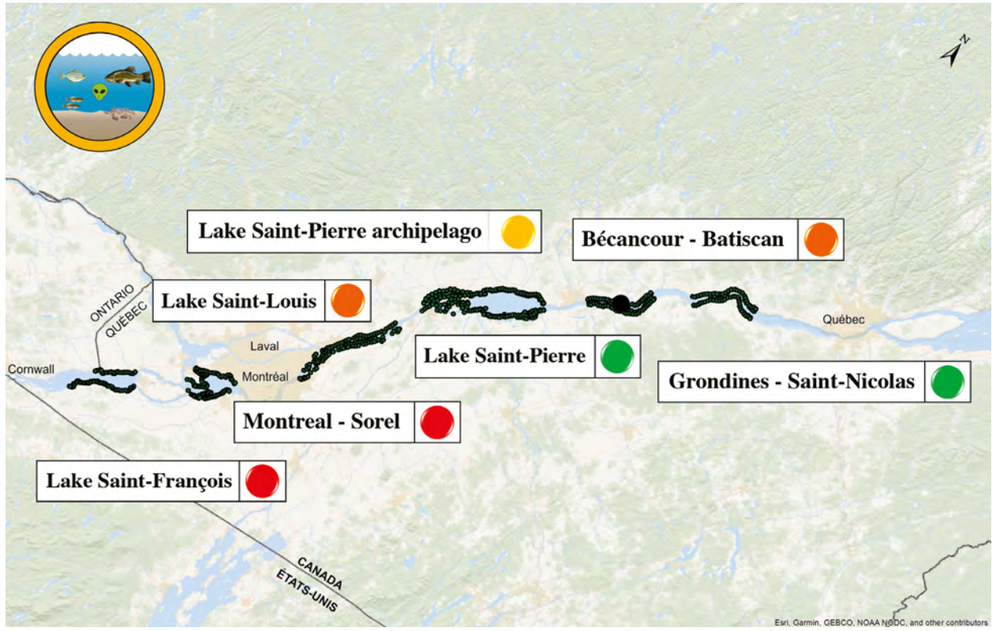


Figure 2.16: Distribution of capture sites and state of the Round Goby Index, by monitoring sector

5. This indicator was not presented in the 2014 Overview but its trend for the 2019 Overview was calculated as if it had been assessed in the 2014 Overview, the data being available.

In addition to the RSI, invasive aquatic species are detected and monitored by a monitoring network to which MFFP field teams as well as some 50 volunteer commercial fishers contribute.

The Round Goby, an invasive species that is spreading quickly

Round Goby - Photo credit: @Wikipedia Creative Commons

The state of the freshwater portion of the St. Lawrence in terms of invasive aquatic animal species (IAAS) was rated as "moderate-poor." Four complete sampling periods of the St. Lawrence have been carried out since data collection began under the RSI in 1995. The index has shown an upward trend since the first report of the Round Goby in the Quebec waters of the St. Lawrence in 1997: 0% (1995-1997, pre invasion), 0.2% (2001-2006), 58% (2007-2011, establishment) and 56% (2012-2016). The rapid colonization and establishment of the Round Goby throughout the fluvial corridor has resulted in disturbances to other species in the St. Lawrence and to the ecosystems. A recent decline has been observed in the abundance of the Tessellated Darter and the Banded Killifish, two species in direct competition with the Round Goby (Morissette et al., 2019).

The upstream sections of the St. Lawrence are more affected

Although the Round Goby has become established throughout the fluvial section, the upstream sectors of the St. Lawrence River report the highest abundances of this species. In particular, the average number of gobies captured by station in Lake Saint-François increased from 34 in 2009 to 41 in 2014, which makes it the water body that supports the highest densities of all the sectors sampled.

No improvement anticipated

Since 1995, the trend in terms of IAAS in the St. Lawrence River has been deteriorating. The other parameters monitored (total number, frequency or biomass of invasive species) do not point to an improvement. This finding is consistent with the global trend, where the impacts and threats posed by invasive aquatic species are steadily increasing (Havel et al., 2015).

Since the 2014 Overview, the Round Goby Index has nonetheless remained stable, although the detection of two new invasive species of concern (the Spiny Water Flea and the Grass Carp) are raising concerns about a further deterioration in the state of this index in the near future. It is currently impossible to determine with certainty the level of abundance or establishment of these species in the St. Lawrence. This situation reinforces the conclusion that once an invasive aquatic species becomes established in an environment, it is difficult, if not impossible, to eradicate it. Preventing their introduction and spread remains the most effective way to combat invasive aquatic species.

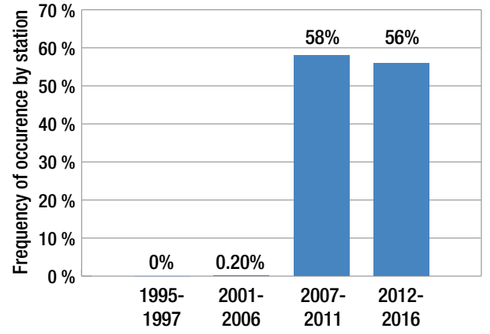


Figure 2.17: Changes in the Round Goby Index over time

INDICATOR: Monitoring of fish communities in fresh and brackish waters

Overall state: "moderate" with stable trend[6] between the 2014 and 2019 Overviews

Data from multiple sources are necessary to assess the state of the freshwater fish communities of the St. Lawrence River owing to its great spatial heterogeneity and the varied habitat preferences and vital needs of the some 80 species that it supports. Different indicators have therefore been compiled in order to provide an overview of the state of the fish communities and aquatic habitats of the St. Lawrence River and assess the changes in these components over the last 25 years. These indicators include an index of biotic integrity, an assessment of the state of the stocks of certain recreational and commercial fish species, an assessment of the status of species at risk and an index of the state of submerged aquatic grass beds.

Figure 2.18: Main sectors of the St. Lawrence sampled by the Réseau de suivi ichtyologique (RSI) [fish monitoring network] and the Réseau d'inventaire des poissons de l'estuaire (RIPE) [estuary fish inventory network]

State and trends vary depending on species and sector

The indices used suggest that the overall state of health of the fish communities in the fluvial section of the St. Lawrence is "moderate." A detailed analysis of these indicators reveals that the results sometimes differ greatly between different species and sectors.

Over the past two decades, there have been a number of rapid changes in the characteristics of aquatic habitats and in the structure of fish communities which reflect an evolving ecosystem with a deteriorating trend in certain sectors. Several stocks of recreational or commercial fish species have experienced episodes of overfishing over the years. Fortunately, appropriate management measures have made it possible, in certain cases, to restore the populations to a sustainable harvesting level (e.g. Walleye). However, some stocks of interest for recreational and commercial fishing have been slow to recover and still show signs of collapse or low abundance despite the numerous initiatives aimed at promoting their recovery (e.g. American Eel and Yellow Perch in Lake Saint-Pierre). This demonstrates that factors other than fishing must be considered (e.g. habitat quality and size, water quality, connectivity between habitats, presence of invasive species).

Certain fish species such as Striped Bass and Lake Sturgeon are showing encouraging signs of recovery. Conversely, despite significant recovery efforts, the abundance of certain species such as the Copper Redhorse remains at a critical level. Significant variability is sometimes observed within the same species between different sectors. For example, stocks of Yellow Perch in lakes Saint-François and Saint-Louis are abundant and support a sustainable recreational fishery, while those of Lake Saint-Pierre and in the section between the Laviolette Bridge and Saint-Pierre-les-Becquets have experienced a significant decline during the last two decades.

Possible cause: habitat fragmentation and decline of aquatic plant beds

Several pressures, mainly anthropogenic, may explain some declines. These pressures include the deterioration of habitat quality, as well as habitat fragmentation, which contributes to the loss of spawning sites.

A new index intended to assess changes over time in the aquatic habitats of the St. Lawrence River has been developed for exploratory purposes based on data collected for the RSI over the last 20 years. The most significant changes are observed in Lake Saint-Pierre, where the percentage of surveys reporting the presence of aquatic plants has fallen dramatically since 2002.

The importance of the tributaries of the St. Lawrence

Beginning in the 2000s, intensification of initiatives to expand knowledge about threatened and vulnerable fish species has made it possible to significantly increase the number of occurrences surveyed. For a number of species, most of these new occurrences have been recorded in the tributaries of the St. Lawrence River. This underlines the fact that these tributaries offer a unique mosaic of habitats for aquatic wildlife and represent important areas for biodiversity.

Photo: MFFP

Photo: MFFP

INDICATOR: Status of the Striped Bass population

Overall state: "moderate-good" with stable trend between the 2014 and 2019 Overviews

The sustained efforts begun in 2002 to reintroduce the Striped Bass in the St. Lawrence River have yielded positive results. Since 2013, the MFFP has conducted beach seine monitoring in mid September at a total of 100 stations along the St. Lawrence River in order to quantify the annual variations in the recruitment of Striped Bass (abundance of young-of-the-year). This monitoring takes place from Trois-Rivières to La Malbaie on the north shore, and from Bécancour to L'Isle-Verte on the south shore (Figure 2.19).

6. It is important to note that these findings vary by species and sector.

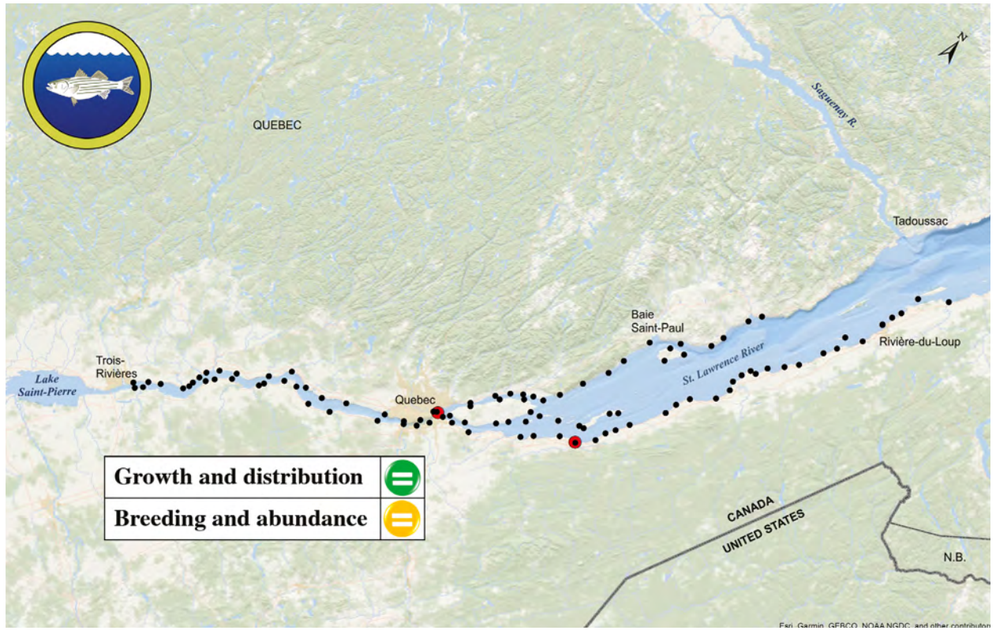


Figure 2.19: Locations of the spawning grounds (in red) and of the monitoring sites of young-of-the-year (in black) for the Striped Bass population of the St. Lawrence River

The MFFP also conducts monitoring of the abundance of adults at the spawning sites in Beauport Bay (since 2015) and in the Rivière du Sud watershed in Montmagny (since 2017) in order to calculate a standardized catch per unit effort index.

The information obtained through these two demographic monitoring programs, combined with other research data, makes it possible to assess the progress of Striped Bass recovery over time.

The reintroduced Striped Bass population is doing well

The overall assessment of the recovery of the Striped Bass population of the St. Lawrence River is “moderate-good.” In 2014, this population’s growth and spatial distribution were already considered good, while reproduction and abundance were rated as moderate. The situation remained unchanged in 2019. All the evidence points to a slightly increasing trend in recruitment, but no conclusions can be drawn concerning the abundance of adults.

On the whole, the annual stocking program using Striped Bass fry produced at the MFFP’s fish hatchery in Baldwin-Coaticook, combined with the availability of suitable habitats for spawning and juvenile feeding, has enabled the reintroduced population to become established and maintain itself in the St. Lawrence River.

Early days yet for this monitoring program

Knowledge acquired through monitoring and the research activities conducted to date, along with reports provided by the public, indicate that, from a demographic standpoint, the population is at least stable or most likely increasing. However, the standardized demographic monitoring of this population is still relatively recent, being in place for only three to six years. This is a limitation that must be taken into account in interpreting the data and when issuing opinions. In fact, the high interannual variability generally observed in this species, especially in terms of recruitment, may mask the demographic trends in the short term. Caution is therefore advised in drawing any conclusions. Maintaining the monitoring effort over the medium and long term will make it possible to assess the level of recovery of this population with greater certainty.

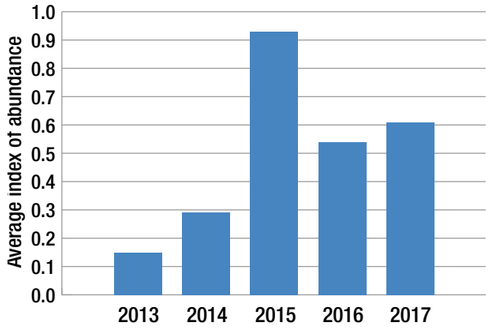


Figure 2.20: Annual variation in the abundance of young-of-the-year Striped Bass

Photo: MFFP

Photo: Jim Levison

Photo: MFFP

INDICATOR: Monitoring of invasive alien plant species in the St. Lawrence

Overall state: "moderate" with stable trend since the 2014 Overview[7]

The purpose of the monitoring network for invasive alien plant species (IAPS) in the St. Lawrence wetlands is to provide an overview of the distribution and abundance of the main IAPS and to assess their evolution over time. The species monitored are Reed Phalaris, Flowering-Rush, Water Chestnut, European Frog-Bit, Eurasian Water-Milfoil, Japanese Knotweed, Common Reed and Purple Loosestrife.

The sampling plan calls for a visit to the sites every three years. Between 2008 and 2014, the Haut Saint-Laurent, Jacques-Cartier, Des Seigneuries (since 2012), Lac Saint-Pierre, Deux-Rives and Sud-de-l'Estuaire (since 2014) ZIP [priority intervention zone] committees, as well as the Société d'aménagement de la baie de Lavallière (SABL), carried out a monitoring program at more than 380 sites distributed in shallow water, in high and low marshes, as well as in shrub and treed swamps. During this period, two sampling cycles were carried out. The majority of the sites (209) were sampled twice, with the first visit between 2008 and 2010 and the second visit between 2012 and 2014, while 177 sites were sampled only once. In all cases, the most recent samples were used for the analyses.

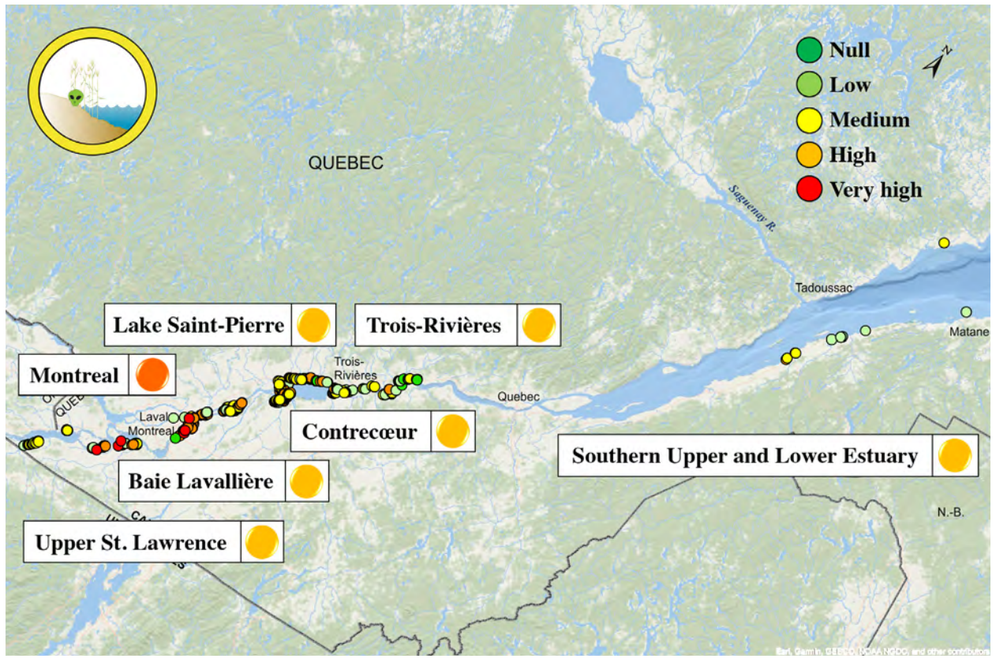


Figure 2.21: Degree of invasion by invasive alien plant species observed at monitoring stations, and state by sector

7. There have been changes in this indicator's key measurements beween the 2014 and 2019 Overviews

It is important to note that the key measurements used to determine the state of IAPS have been changed since the 2014 Overview. Consequently, the temporal trends presented below are based on the calculations performed according to the key measurements currently used:

- Coverage by species (proportion of the area of the station occupied by a species);
- Index of abundance by species by sector (mean coverage of a species for all the stations in a sector);
- Degree of invasion (coverage occupied by all the IAPS, at the scale of an individual station, of a sector and of the entire territory covered by the monitoring network).

Widely distributed invasive alien plant species

The seven sectors where stations were visited between 2008 and 2014 exhibited a medium ("moderate") degree of invasion, apart from the Montreal sector, where a high degree of invasion ("moderate-poor") was observed.

The most recent data collected between 2008 and 2014 indicate that 93% of the stations visited are affected by at least one of the IAPS monitored. Approximately 3% of the stations were found to have a very high degree of invasion, 33% a high degree, 35% a medium degree and 22% a low degree (Figure 2.22).

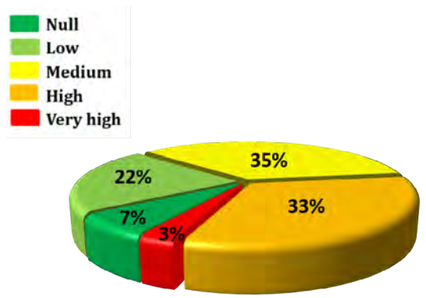


Figure 2.22: Degree of invasion at the stations, all sectors combined

The stations where a high or very high degree of invasion was reported are more common in the upstream sectors of the St. Lawrence than in the downstream sectors (Figure 2.23). This may be linked to the greater presence in the upstream sectors of human activities such as horticulture as well as commercial shipping and recreational boating. In addition, any disturbance of the vegetation or soil can create an environment conducive to the establishment and spread of IAPS.

Three species that stand out

Reed Phalaris, Common Reed and Purple Loosestrife are the IAPS that are contributing the most to the invasion of the St. Lawrence wetlands studied.

Reed Phalaris is the species with the highest index of abundance. It is present in all the sectors studied, where its index of abundance is generally medium or high. Purple Loosestrife is the species observed at the largest number of stations. However, its index of abundance remains low or medium depending on the sector. Finally, the Common Reed was surveyed at nearly a third of the stations of the monitoring network. Its index of abundance varies, but is high in the sectors furthest upstream.

A stable trend, except for the Common Reed

The trend was assessed by comparing data collected at the stations visited in 2008-2010 with data from those visited in 2012-2014.

Although the degree of invasion varied slightly in the various sectors between these two monitoring cycles, the trend indicating a medium degree of invasion is stable. The Trois-Rivières sector experienced the greatest decrease in the degree of invasion, while the Upper St. Lawrence sector recorded the largest increase. However, this increase was not sufficient either to change the rating of the sector or to consider this an upward trend.

The Common Reed is the only species with an overall index of abundance considered to exhibit an upward trend. The number of sites where it has been observed practically doubled between the two survey periods. This upward trend was observed in several sectors, with the exception of the Trois-Rivières and Lake Saint-Pierre sectors, where the species continues to be uncommon at the sites sampled.

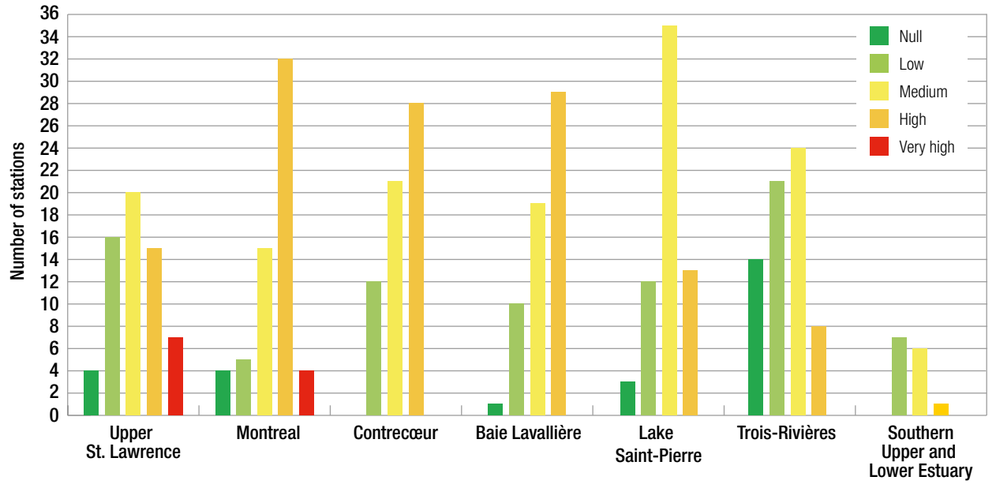


Figure 2.23: Degree of invasion by invasive alien plant species, by monitoring sector

2.2 State of the lower estuary and Gulf

The lower estuary of the St. Lawrence is one of the largest and deepest estuaries in the world: it extends over a distance of nearly 250 km from the mouth of the Saguenay River to Pointe-des-Monts. Its water is saline; however inflows of warmer freshwater from the fluvial section and its tributaries create a temporary stratification in summer and produce significant upwellings of deep water that mix with the surface water [6].

The Gulf of St. Lawrence, a veritable inland sea half-enclosed by the island of Newfoundland, extends from Pointe-des-Monts to the Atlantic Ocean. It is connected to the Atlantic by the Cabot Strait and the Strait of Belle Isle. The Gulf includes a greater variety of habitats and is home to a greater diversity of species than the estuary [7]. For example, large populations of breeding seabirds and migratory whales converge in the Gulf every breeding season [7]. However, it is acknowledged that the presence of ice, which persists for four or five months, has a substantial impact on the life of the biological species of the estuary and Gulf [7].

Monitoring of the lower estuary and the Gulf of St. Lawrence has been carried out through a set of indicators that focus mainly on the biological resources, given their great diversity and their vulnerability to climate change in this part of the St. Lawrence. Each indicator is described briefly and emphasis is placed on the highlights that best express its state and its trend. Details for each of these indicators are presented in fact sheets that are available on the St. Lawrence Action Plan website.

INDICATOR: Status of the Beluga population

Overall state: “poor” with stable trend between the 2014 and 2019 Overviews

The St. Lawrence Beluga population is isolated from the other Beluga populations of the Arctic or of the circumpolar regions. Owing to their permanent presence in the estuary, Beluga whales are exposed to the growing pressures exerted by human activities on marine mammals in general. Collision risks and disturbances from pleasure crafts, chronic noise generated by marine traffic, and chemical and bacteriological contaminants are a few examples of these pressures. Since the last century, these pressures have increasingly threatened its presence in the St. Lawrence. The overall assessment of the indicator for the 2013-2017 period is “poor.”

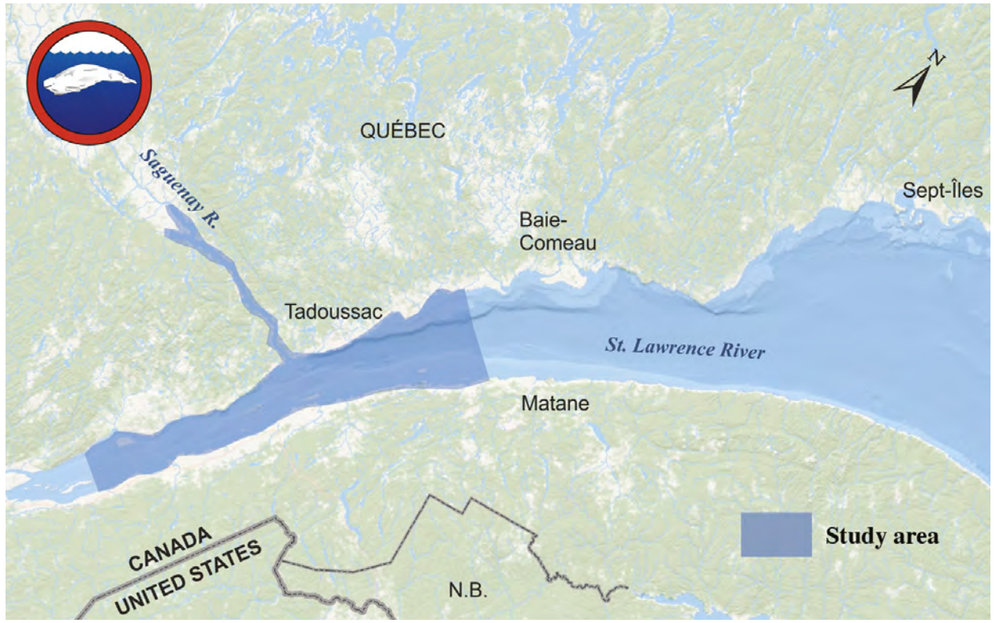


Figure 2.24: Study area of the Beluga population

Worrisome trends

Population decline has been happening for several years. The population does not appear to be recovering and is currently estimated at 889 individuals. Both the indicator of the abundance of the proportion of individuals aged 0–1 year indicator and the mortality indicator raise concerns about the status of the St. Lawrence Beluga population, as was the case in the 2014 Overview. The decline of this species is explained partly by an increase in newborn mortality since 2008 (Gosselin et al., 2017). Between 2010 and 2017, the number of newborn carcasses reported was 4 to 17 times higher than the median number observed between 1983 and 2007. These increases remain unexplained, but could reflect an increase in births, and probably also a real genuine difficulty for newborns (or their mothers) to survive.

Scientists have noted calving problems which may have also resulted in the death of several adult females. Since none of the calves examined showed any pathological signs that could explain their death, it is highly probable that a rupture of the mother-calf bond is the main cause of calf mortality.

Many other factors may also contribute to this mortality, and they vary depending on the season and the distribution of the Beluga whales. The most probable factors are:

- Warmer water and atmospheric temperatures, and ice conditions (cover and duration) that are weaker than in the 1990s and extreme since 2010;
- High contamination by some toxic compounds;
- Chronic exposure to underwater noise associated with marine traffic;
- Disturbance by small boats and commercial vessels;
- Lack of food caused by climate variability and fishing.

A declining population

The St. Lawrence Beluga population was estimated at nearly 10,000 individuals at the beginning of the 20th century. It then fell to approximately 1,000 individuals at the end of the 1970s, due to commercial and sport hunting of Beluga. After a period of relative stability or slow growth, the population began another period of decline in the early 2000s at a rate of around 1% per year (Fisheries and Oceans Canada, 2018). The most recent estimate for this species is approximately 889 individuals in 2012. The population likely continues to decrease given the high newborn mortality (Gosselin and al., 2017) and the increasing number of females dying during the calving period (Lair and al., 2016).

During the 1990s, the proportion of young Beluga whales, from 0 to 1 year was estimated to be between 15% and 18% of the population. Since 2000, this proportion has been two to three times lower, varying between 3% and 8% (Gosselin, and al., 2014). This indicator is considered poor. Young should make up roughly 20% of the total population for this indicator to be considered good. A low recruitment level can have impacts on population recovery capacity when these cohorts reach sexual maturity.

The St. Lawrence Beluga continues to be one of the most contaminated marine mammals

While the levels of pollutants such as PCBs and DDT in the Beluga have declined during the past decade, new pollutants, particularly PBDEs, have taken their place with concentrations that increased exponentially during the 1990s. However, this growth has slowed in adult males since the early 2000s and appears to be stabilizing according to the most recent observations in 2013 (Simond et al., 2017).

St. Lawrence Beluga whales - Photo: Ficheries and Oceans Canada

INDICATOR: Monitoring of aquatic invasive species in the St. Lawrence

Overall state: "moderate-good" with stable trend[8]

The purpose of the aquatic invasive species (AIS) monitoring program, led by Fisheries and Oceans Canada, is to provide an overview of the distribution and abundance of AIS throughout the estuary and Gulf of St. Lawrence in order to detect the emergence of new invasions as quickly as possible and try to minimize the risks of their introduction and spread.

This program initially focused on three sectors, which have been monitored since 2003, namely:

- Îles-de-la-Madeleine;
- Gaspésie;
- North shore of the Gulf of St. Lawrence.

In 2016, spatial coverage of the program was extended to a fourth sector, namely the Lower estuary / upper estuary.

The AIS indicator is expressed by the invasion index (II). It is established by comparing the state of the situation of marine AIS in Quebec to that of the Canadian east coast, and is therefore a relative invasion index. It is calculated for each marine sector by adding the proportions of the sites o ccupied by each AIS for each monitoring year. The overall invasion index is then determined for the entire St. Lawrence by combining the results obtained for the four marine sectors. The II score increases with the increase in the number of AIS present, up to a limit of 11.

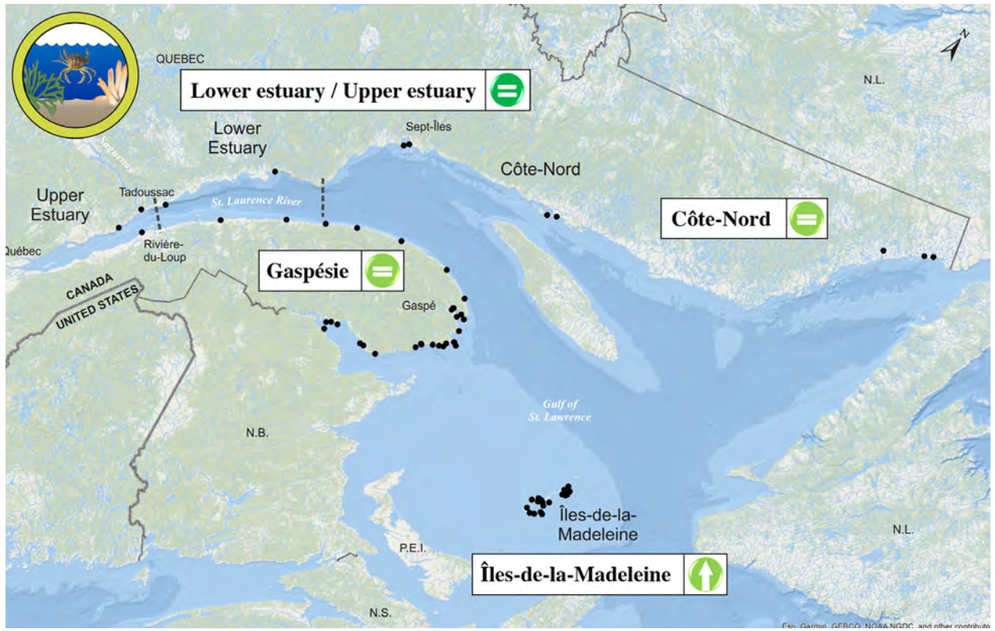


Figure 2.25: State and trend of the presence of aquatic invasive species, by monitoring sector

8. This indicator was not assessed in the 2014 Overview

The overall assessment of the state of the indicator was “moderate-good” for the marine portion of the St. Lawrence during the 2016-2017 period, with a slight difference noted between the sectors (Figure 2.25). The Gaspésie and North Shore of the Gulf of St. Lawrence sectors remained stable with the same assessment (“moderate-good”) as in the 2013 2015 period. The rating for the Magdalen Islands improved from “moderate” to “moderate-good” between the same periods. The lower estuary / upper estuary sectors, recently added to the monitoring program, were assigned a “good” rating in 2016-2017, since no AIS were detected.

- **Several alien marine animal species are already present in the Îles-de-la-Madeleine**

Following the detection and spread of several invasive species in the Îles-de-la-Madeleine, such as European Green Crab and Japanese Skeleton Shrimp in 2004, Golden Star Tunicate and Sea Squirt in 2006, Membranipora Bryozan in 2007 and Violet Tunicate in 2010, the II steadily increased between 2003 and 2011. However, an improvement in the state of the indicator was recorded during the 2013-2015 period, mainly owing to the decline of the European Green Crab population in 2014 and its virtual disappearance between 2016 and 2017.

- **A worrisome situation despite a fairly low invasion index**

The II is lower in the Gaspésie region and on the North Shore of the Gulf of St. Lawrence than in the Magdalen Islands. The indicator has remained in the “moderate-good” category since the beginning of monitoring in these two sectors. However, the detection of Japanese Skeleton Shrimp on the North Shore of the Gulf in 2016 shows that the situation can evolve and hence become of concern.

- **Climate change could further complicate the situation**

Although the II categories are stable, the overall results of the monitoring program show that the number and abundance of IMAS present in the marine portion of the St. Lawrence are increasing and that the invasions are continuing. In a context of climate change, these trends are likely to worsen since environmental conditions could become favourable to the survival of new species.

European Green Crab - Photo: Ficheries and Oceans Canada

Golden Star Tunicate - Photo: Ficheries and Oceans Canada

Sea Squirt - Photo: Ficheries and Oceans Canada

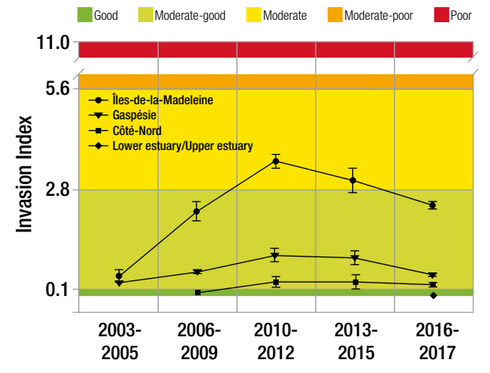


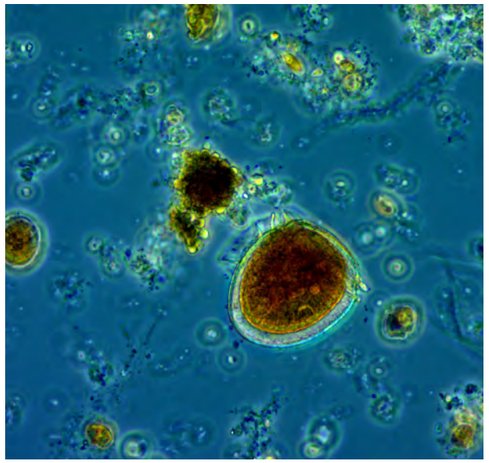
Figure 2.26: Temporal variation in the state of the invasion index, by monitoring sector

INDICATOR: Phytoplankton community in the estuary and Gulf

Overall state: “moderate-good” with improving trend between the 2014 and 2019 Overviews

Phytoplankton are at the base of the food chain in the marine environment. Like plants in the terrestrial environment, phytoplankton have the ability to convert inorganic carbon (CO2) into organic carbon by photosynthesis . Organic carbon can then be used as an energy source by the higher trophic levels.

An overall state of “moderate-good” was assigned to this indicator during the 2013-2017 period, although with disparities between the monitoring sectors.



Dinoflagellate - *Dinophysis rotundata*

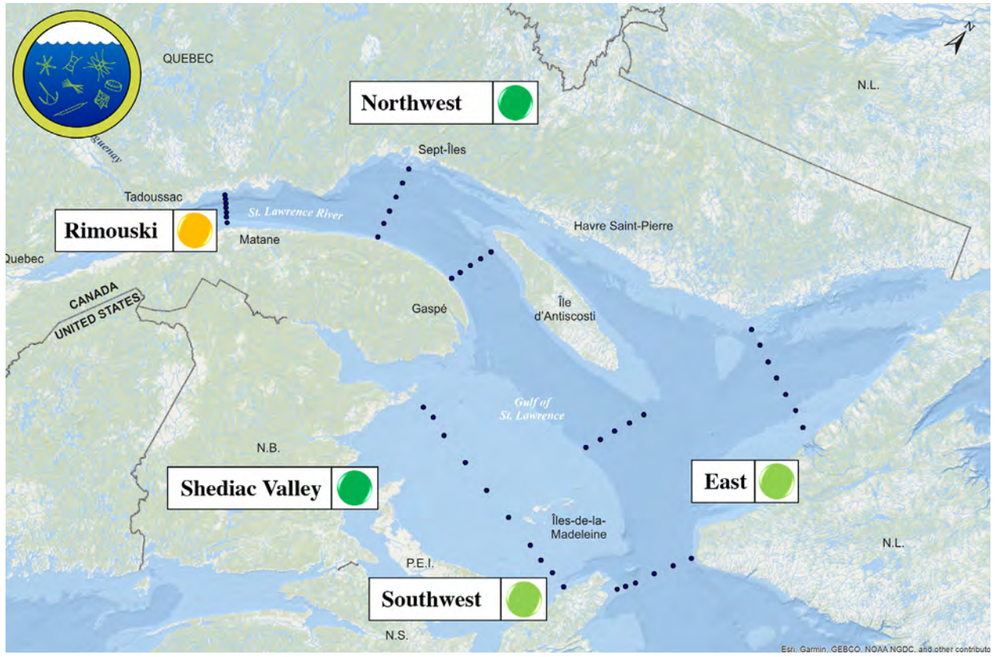


Figure 2.27: State of the phytoplankton community of the lower estuary and Gulf, by monitoring sector

A highly variable spring bloom and lower phytoplankton biomass

Satellite observations generally show lower phytoplankton biomass throughout the season in the entire Gulf of St. Lawrence between 2013 and 2017, compared with the levels seen in the 1999-2010 reference period. The difference is small, however, and this index is generally rated as "moderate-good" (Figure 2.27).

- In Rimouski, the state of phytoplankton was classified as "moderate" owing mainly to the diatom/dinoflagellate ratio. During the 2013-2017 period, this ratio was much higher than the 1999-2010 historical average, mainly owing to the low abundances of dinoflagellates observed since 2013.
- In the southwestern and eastern Gulf of St. Lawrence, the state of phytoplankton was classified as "moderate-good." It was noted that the beginning of the spring bloom in this sector was quite variable, occurring either earlier or later compared with the 1990-2010 reference period.
- For the northwestern sector and the Shediac Valley sector, the state of phytoplankton was classified as "good" during the 2013-2017 period.

Environmental variability may explain the variations in phytoplankton biomass

The warming of the water and the inflows of freshwater influence the stratification of the water column and the nutrient content in the surface layer, where phytoplankton are found. It has been demonstrated that these two factors have significant impacts on phytoplankton biomass and its composition in terms of large taxonomic groups during the production season.

An improving trend between the 2014 and 2019 Overviews

The overall state of phytoplankton in the estuary and Gulf of St. Lawrence was rated as "moderate-good" during the 2013-2017 period, despite the reduction in satellite-derived phytoplankton biomass values. A slight improvement has been observed, and its overall state was classified as "moderate" in 2008-2012 (2014 Overview). The 2014 report noted an increase in dinoflagellates, while the current assessment shows a decrease in the abundance of this taxon at the Rimouski station. In the northwestern Gulf of St. Lawrence region, all the indicators are near the long-term average, a result that has helped improve the overall rating.

INDICATOR: Zooplankton community in the estuary and Gulf

Overall state: "moderate" with stable trend between the 2014 and 2019 Overviews

Zooplankton are microscopic animals living suspended in the water and moving mainly with marine currents. This is the second link in the pelagic marine food web responsible for the transfer of energy between phytoplankton and higher trophic levels (e.g. fish, whales). The different taxonomic groups of zooplankton reflect the diversity of the wildlife found in aquatic environments.

This indicator was assigned an overall state of "moderate" during the 2013-2017 period, with a few differences between the monitoring sectors (Figure 2.28).

More warm-water zooplankton species and fewer cold-water species

The index of abundance of warm-water species largely explains the "moderate" rating assigned to zooplankton; it greatly increased over the 2013-2017 period, in comparison with the 1999-2010 reference period. This increase particularly affected the Rimouski station and the northwestern Gulf of St. Lawrence station owing to the presence of *Metridia lucens* and copepods in the genus *Centropages* (small crustaceans). Concurrently, the abundance of copepods associated with cold water, in this case *Calanus glacialis*, has declined significantly in several regions of the estuary and Gulf.

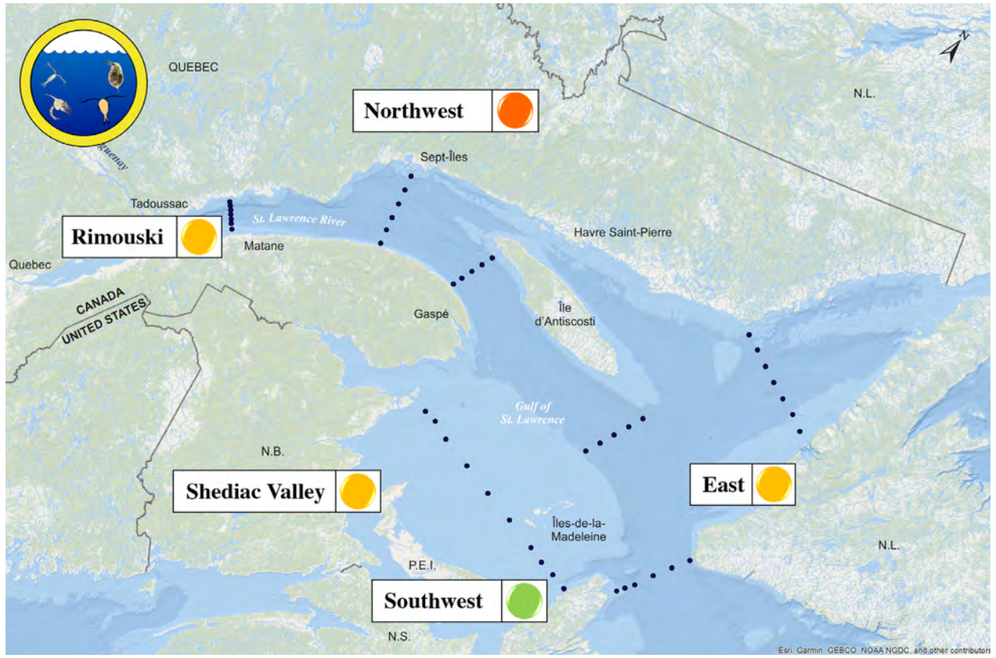


Figure 2.28: State of the zooplankton community of the lower estuary and Gulf, by monitoring sector

Lower zooplankton biomass

Copepod with egg sac - Photo: Ficheries and Oceans Canada

From 2013 to 2017, although an increase in the abundance of copepods was noted, the zooplankton biomass showed a significant decrease in all sectors. These observations, which at first seem contradictory, are explained by a change in the structure of the zooplankton community with more small species of copepods and fewer large copepods observed. Since small species have lower biomass values than the large species, this results in a reduction of zooplankton biomass and, consequently, a reduction in the availability of this resource for the species that feed on it.

Environmental variability may explain the zooplankton community assemblage

Environmental factors influence the zooplankton community assemblage. These factors vary from year to year and can include:

- Temperature of the cold intermediate layer;
- Effect of seasonal climatic variations on the phytoplankton bloom;
- Quantity and type of food available (phytoplankton);
- Freshwater discharge of the St. Lawrence in the spring and the relative contribution of its masses to the ecosystem.

Consequences for species of commercial value

Zooplankton play an important role in the marine food web and in the carbon cycle. They constitute an essential resource for many pelagic animals. Any alteration in their production level can have consequences for recruitment

processes and for higher trophic level productivity, including species of commercial value. Those variations in the dynamics of plankton production are added to the other environmental stress factors, including hypoxia and the acidification of marine water.

INDICATOR: Monitoring of toxic algae in the estuary and Gulf

Overall state: "moderate-good" with improving trend between the 2014 and 2019 Overviews

Toxic algae are naturally present in saltwater and are part of the St. Lawrence ecosystem. However, their mass proliferation leads to high concentrations of the associated neurotoxins in the water. These neurotoxins accumulate throughout the food chain through the phenomena of bioaccumulation and biomagnification and cause the mortality of many marine and aquatic species. The purpose of the toxic algae monitoring program is to track the appearance and spread of these algae in the St. Lawrence by counting all the species recognized as toxic, harmful or invasive between May and October of each year. The sites monitored by this program are located in the following six regions:

- Tadoussac;
- Rimouski;
- Sept-Îles;
- Gascons;
- Penouille (Gaspésie);
- Havre-aux-Maisons (Magdalen Islands).

Figure 2.29: Toxic algae monitoring sites

Two indices are used to assess the state and trend of toxic algae at each station, namely the frequency of blooms and the maximum cell density compared to historical data (1994-2007) for the two most problematic groups of species in the waters of the estuary and Gulf of St. Lawrence, namely:

- The *Alexandrium* species complex (*A. catenella*, formerly *A. tamarense*, *A. pseudogonyaulax*, *A. ostenfeldii)*, producers of PSP (paralytic shellfish poisoning) toxins;
- The *Pseudo-nitzschia* species complex (*P. pseudodelicatissima, P. pungens, P. seriata*), recognized as producers of domoic acid (neurotoxin).

A marked improvement in the indices for both species complexes

The overall state of the indicator during the 2013-2017 period was "moderate-good" along the lower estuary and Gulf of St. Lawrence as compared to "moderate" between 2008-2012 (2014 Overview). The assessment was virtually the same for the four indices. With respect to the cell density index, both species complexes recorded a near-normal maximum density, and their state was rated as "moderate-good." The frequency of blooms was significantly reduced compared with the historical average, and was assigned a state of "good" for the *Alexandrium* species complex and a state of "moderate-good" for the *Pseudo-nitzschia* species complex.

Red tide in 2008 - Photo: M. Starr, Fisheries and Oceans Canada

A genuine improving trend or only a temporary phenomenon?

Heavy precipitation followed by an increase in river flows contribute to an increase in blooms within both species complexes. In 1998, 2002, 2006, 2008 and 2013, similar conditions resulted in unusual levels and a definite upward trend in the abundance of *Pseudo nitzschia* and in blooms of *Alexandrium catenella* in the lower estuary and Gulf of St. Lawrence. The relatively dry summers that characterized the 2013 to 2017 period could be one of the reasons for the overall improvement in the index. The improvement in the indices during this period could be a temporary anomaly rather than a long-term improving trend, since several other factors, such as river inputs of dissolved organic matter, nutrients and other materials such as humic substances, can stimulate growth or increase the stability of the water column, promoting cell proliferation and retention. The monitoring of toxic algae over the next few years will allow us to answer this question.

INDICATOR: Status of the Northern Gannet population

Overall state: "moderate" with improving trend between the 2014 and 2019 Overviews

There are only six Northern Gannet colonies in North America: three on the coast of Newfoundland and three in Quebec. The Quebec colonies are distributed among three sites: Bonaventure Island in the Gaspésie region, Falaise aux Goélands on Anticosti Island and Bird Rocks in the Magdalen Islands (Figure 2.30). However, during the nesting period, the species' foraging area includes much of the Gulf and extends as far as the lower estuary. The characterization of the overall status of the Northern Gannet population is based on the level and trend of its abundance, reproductive success and contamination of its eggs.

Figure 2.30: Monitoring sites of Northern Gannet populations in the Gulf of the St. Lawrence

A low level of reproduction despite the population's good size

An overall rating of "moderate" was assigned to this indicator between 2013 and 2017, reflecting a slightly improving trend in the short term compared with the 2014 Overview. The number of breeding pairs fluctuated between 75,000 and 82,000 during the 2013-2017 period, when the population reached a level considered "good" without showing a clear trend. Several annual fluctuations were recorded during this period both at Bonaventure Island and at Bird Rocks. Ultimately, the population trend has remained relatively stable, although a decline was anticipated following the last assessment. An improvement was noted on Bonaventure Island, where reproductive success increased from 8% in 2012 to 35%–50% between 2013 and 2017. Although this result is still poor, it indicates an encouraging trend in the short term.

The size of the colonies could decrease over the long term

Since 2009, the year when the Northern Gannet population reached a maximum level, signs of its decline have begun to appear. Reproductive success remains low, with less than 60% of pairs successfully reproducing (Figure 2.31).

Such a low level of reproduction can only result in a decline of the breeding population over the long term. Studies have shown that the birds must travel a considerable distance from their colony to forage for food, which could adversely affect reproductive success. The worrisome situation of mackerel and herring stocks in the Gulf could have an impact on the Northern Gannet's status. However, in the past few years, the population of this species has shown a lot of resilience, with its numbers remaining stable with a gradual improvement recorded in reproductive success. This finding stands in contrast to the assessment "of concern" issued in 2012.

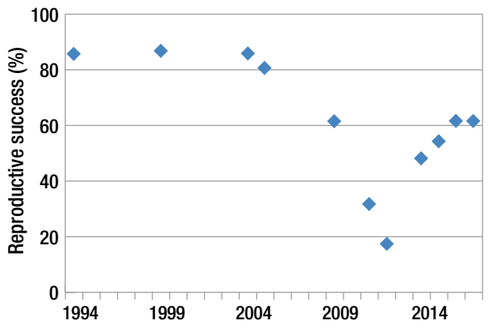


Figure 2.31: Reproductive success of Northern Gannets on Bonaventure Island between 1994 and 2017

INDICATOR: Status of the Great Blue Heron population

Overall state: "moderate-good" with stable trend between the 2014 and 2019 Overviews

The contamination of Great Blue Heron eggs is monitored in the estuary and the Gulf of St. Lawrence, as is the case in the fluvial corridor, for the same groups of contaminants. In addition, the same method for assessing the indicator was used at the two colonies which are located on:

- Île aux Basques;
- Manowin Island.

The overall rating of the indicator in the estuary and Gulf is the same as for the fluvial corridor, i.e. "moderate-good" (Figure 2.32).

The Great Blue Heron - Photo: Parks Canada

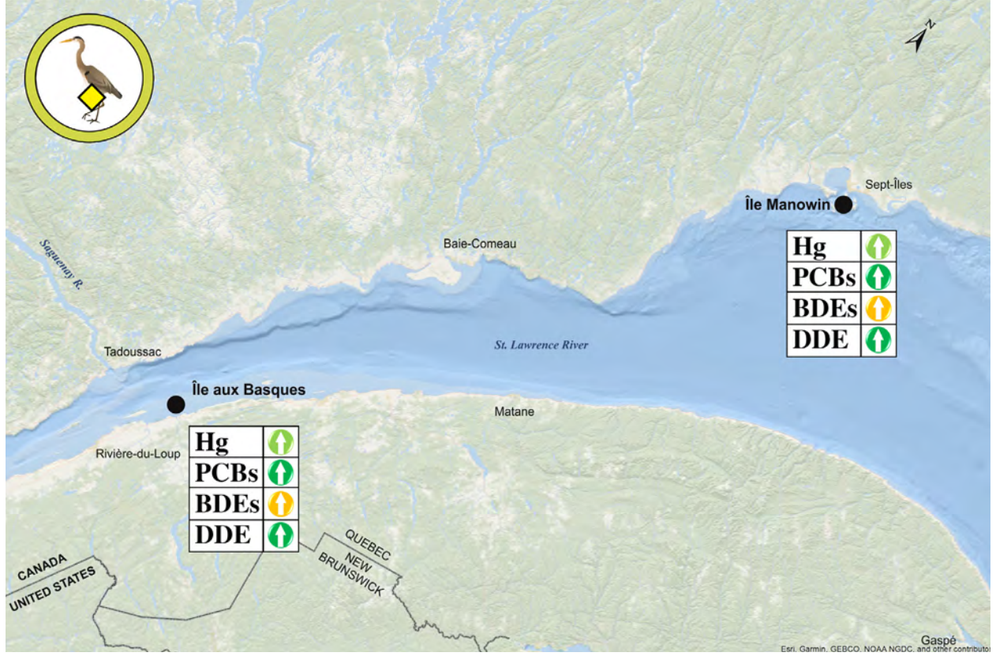
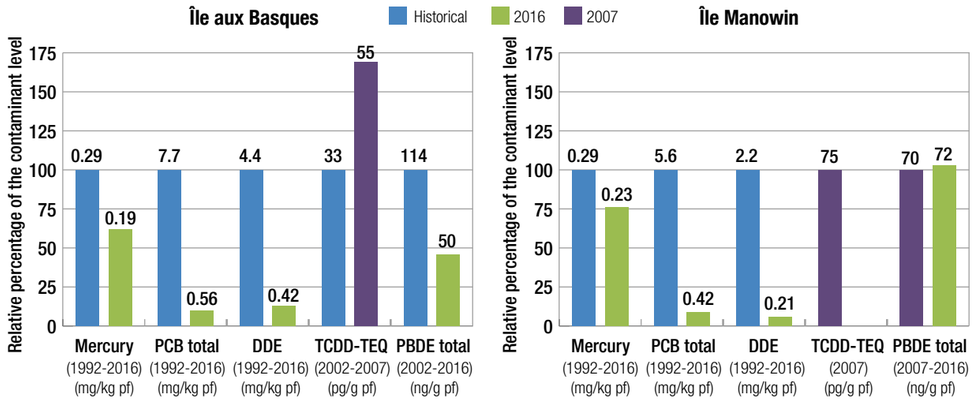


Figure 2.32: State and trend of contaminant levels in Great Blue Heron eggs, by monitoring site



NB: The values above each bar represent the contaminant levels.

Figure 2.33: Comparison of contaminant levels in Great Blue Heron eggs between historical values and recent values

Mean contaminant levels have fallen, but the decrease is very uneven

At Île aux Basques, the reduction in the mean concentrations of all contaminants compared with the historical values is fairly encouraging. PCB and DDE levels have dropped by between 90% and 93%, while a smaller decrease was observed for mercury (34.4%) and PBDEs (55.8%). However, on Manowin Island, mercury levels decreased by only 20.7%, while PBDEs levels, conversely, recorded a slight increase of 3.6% compared with historical values, as Figure 2.33 shows.

On the whole, the two monitoring sites in the estuary and Gulf exhibited an average decrease of more than 59% for all contaminants.

Contaminant levels generally exceeded the toxicity criteria only marginally

A comparison of contaminant levels with the toxicity criteria reveals that only PBDE had values exceeding the criteria, by 81% at Île aux Basques and 115% at Manowin Island.

However, this criterion is based on a small number of studies, and the fact that this criterion was exceeded does not necessarily mean that harmful effects are to be anticipated.

Trends were fairly similar to those of the 2014 Overview

The results of the 2019 Overview indicate that mean contaminant levels at Île aux Basques decreased compared with the 2014 Overview. At Manowin Island, several changes were observed: PCB and DDE levels decreased, while mercury levels increased compared with the 2014 Overview. PBDE levels not only more than doubled, but also exceeded the toxicity criteria in 2019. In the 2014 Overview, the PBDE levels of this colony were below the toxicity criteria.

INDICATOR: Status of seabird populations

Overall state: “moderate” with stable trend between the 2014 and 2019 Overviwes

The population trend of various bird species is indicative of the health of the ecosystem and, in particular, of environmental conditions (e.g. abundance of forage fish, availability of nesting habitat, predation, human disturbance).

The general state of this indicator, “moderate,” is based on the breeding pair counts in the North Shore migratory bird sanctuaries in 2015 for five characteristic species of the Gulf of St. Lawrence. This finding is similar to that in the 2014 Overview based on the 2010 surveys; it shows divergent, but relatively stable, trends in the seabirds of the North Shore of the St. Lawrence .

The Herring Gull: a downward trend giving rise to concern

Photo: ECCC

The state of the Herring Gull at present is rated as “moderate-poor.” A decline of 24% was observed from 2010 to the 2015 survey, when 2,304 breeding pairs were counted. In the early 1990s, the population experienced a significant decline, falling by 70%, from more than 20,000 breeding individuals to less than 5,000. The short-term trend is fairly stable, but with a gradual downward trend over the long term, since there are no signs of recovery. Scientists have observed that the period of decline in Herring Gull populations on the North Shore coincided with the decline of cod in the Gulf of St. Lawrence. Gulls are omnipresent in ports, where they feed on discarded fish waste, particularly cod, from the fisheries. The decline in the cod fishery has had an impact on the gull population.

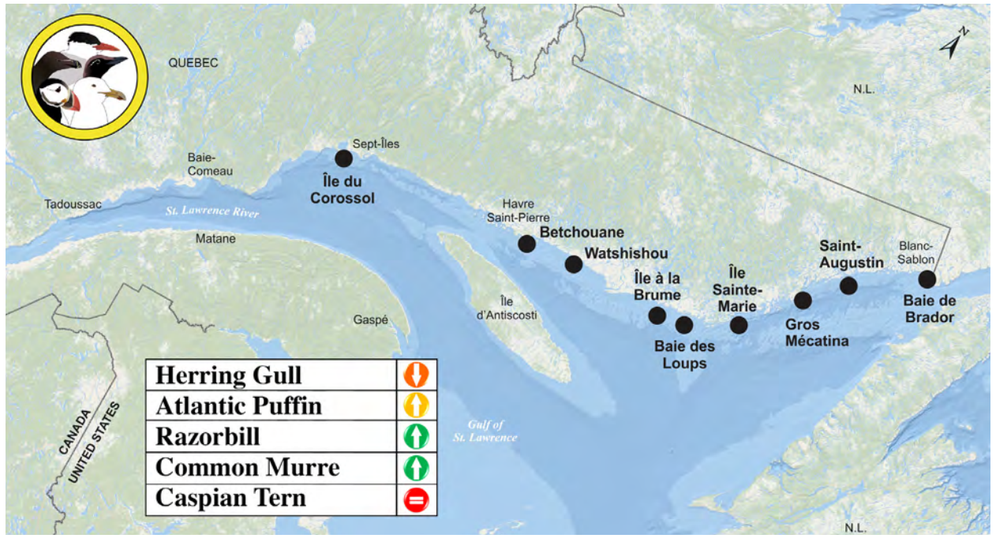


Figure 2.34: Monitoring sites of the seabird populations of the North Shore, and the state and trend for each species

The Atlantic Puffin: a slight increase, but the status of the population should be monitored

Photo: ECCC

The emblematic Atlantic Puffin is a tourist attraction on the North Shore, despite the fact that it is not easy to observe since its nesting sites are few in number and relatively inaccessible. In the migratory bird sanctuaries of the North Shore, a slight increase in the number of breeding pairs was recorded in 2015, reaching 12,273 nesting pairs. The recent stabilization of the Atlantic Puffin population, dating from 2015, should be monitored, particularly since 80% of the population is concentrated at one site, the Baie de Brador Migratory Bird Sanctuary, near Blanc-Sablon.

The Razorbill: a record number of individuals in 2015

Photo: J-F. Rail, ECCC

Favourable conditions in their environment, particularly the abundance of food, place Razorbill populations in a comfortable position in the Gulf of St. Lawrence. An upward trend has been observed for the short and long term. Razorbill populations experienced an increase of 61% in the number of breeding pairs between 2005 and 2010, and the 2015 survey indicates a further 43% increase in its population compared with 2010. This represents a record number of individuals observed in 2015 in the migratory bird sanctuaries of the North Shore since their establishment in 1925, reaching nearly 26,000 breeding pairs, an estimate of nearly 15 times the 1982 figures.

The Common Murre: an improving trend

Photo: J-F. Rail, ECCC

The Common Murre, a species that can be found alongside the Razorbill, is also a piscivorous bird. It spends most of its life at sea and returns to land only during the breeding season. It nests in very dense colonies, which makes it very vulnerable to disturbance.

The Common Murre population in the migratory bird sanctuaries of the North Shore of the St. Lawrence is doing quite well. According to the 2015 survey, 16,969 breeding pairs were counted, and a 29% increase in the number of individuals compared with 2010 was observed.

Although the population experienced a 51% decline between 1999 and 2005, the number of individuals increased considerably between 2005 and 2010, an increase estimated at 77%. Hence, an upward trend is evident over both the long term and the short term.

The Caspian Tern: a very timid reappearance

The Caspian Tern has only one regular nesting site in Quebec, which is located in the Île à la Brume Migratory Bird Sanctuary [8]. The population found at this site in 2015 is still present, but it is at its lowest level, represented by a single breeding pair. This points to a continuing downward trend. After the 1988 survey, when 15 birds were counted, no individuals were observed during the 1993 and 1999 surveys. This species had completely disappeared from the site. This significant decline could be explained, among other factors, by the fact that these birds are greatly affected by frequent disturbance in their rare nesting sites on the North Shore [8]. It was only in 2005 and 2010 that three individuals were observed in the migratory bird sanctuary. Although this reappearance is encouraging, the state of the indicator continued to be "of concern" in 2015.

Photo: ECCC

INDICATOR: Shellfish water quality in the estuary and Gulf

Overall state: "moderate-good" with stable trend between the 2014 and 2019 Overviews

Coastal waters are very vulnerable to the impacts of human activities, which still cause the loss of uses such as clam and mussel harvesting. Fecal coliforms present in waste water accumulate in the flesh of shellfish and can make them unfit for consumption. The Shellfish Water Classification Program (SWCP) has established three ratings to assign to assessed areas to indicate whether their water quality is acceptable for shellfish harvesting:

- A: Meets the criteria of an approved area;
- B: Meets the criteria of a conditionally approved area;
- C: Does not meet the criteria of an approved area (restricted or prohibited).

Of the 257 sectors assessed, an average of 130 were sampled annually between 2014 and 2018.

Shellfish water quality varies depending on the region

The overall state of access to shellfish harvest areas based on St. Lawrence water quality was rated as "moderate-good" between 2014 and 2018. Of the 257 sectors identified, 52% were rated C and shellfish harvesting was therefore not possible, 40% met the criteria of an approved sector (A) and 8% received a B rating. It is important to note that water quality and the proportion of sectors identified as A or B vary greatly between different regions.

Figure 2.35: Assessed sectors of shellfish waters

Water sampling on the North Shore - Photo: Y. Lamontagne, ECCC

Îles-de-la-Madeleine

The bacteriological quality of the shellfish waters in the Magdalen Islands is rated as "excellent." The total number of areas assessed was 45 and most (80%) met the criteria of an approved area and were rated A, while shellfish harvesting was not possible in only 16% of the sectors. In comparison with the results of the previous 2010-2014 period, the state of access for use of the islands' assessed sectors remains stable.

Lower North Shore

This region includes a large proportion of coastal zones that have not been subdivided into shellfish harvest sectors. However, the quality of their water is expected to be excellent since there are no nearby sources of contamination. Of the 18 sectors assessed, nearly 56% are rated A, and their trend is stable over the short term.

Middle North Shore

The quality of shellfish waters in this regions is divided between A and C. The same finding was made during the 2010-2014 period, thus showing a stable trend.

Upper North Shore / Charlevoix

Over half of the sectors assessed in the Upper North shore and Charlevoix regions (52%) were rated as either A or B. As for the previous regions, the trend of access for use of these assessed sectors is stable between 2014 and 2018.

Gaspésie

The Gaspésie region contains the largest number of shellfish harvest sectors assessed under the program. Only 32% of the 70 sectors met the criteria of an approved area or of a conditionally approved area (A or B rating), while 68% were rated C. No improvement has been observed since 2010-2014 as the same percentage of areas rated C was recorded during this period.

Lower St. Lawrence

Of the 27 shellfish harvest sectors assessed, 81% were rated C. Although the total number of shellfish harvest sectors is not very high, this is the region that has the highest percentage of sites rated C. It also exhibits a stable trend over the short term (2014-2018) of access for use of these assessed sectors.

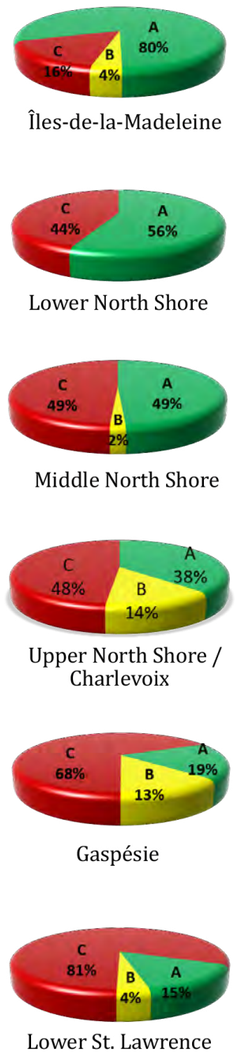


Figure 2.36: Classification of shellfish waters as a percentage of the sites, by assessed sector

An improvement in water quality is predicted over the long term

The overall trend for access to shellfish harvest sectors based on the bacteriological quality of the water in 2018 was stable compared with the state in 2014. Whether in the Gaspésie region, in the Lower St. Lawrence, in the Magdalen Islands or along the North Shore, wastewater from municipalities or from isolated homes as well as agricultural activities were the main sources of bacteriological contamination. Over the long term, an improvement in water quality may be observed following the implementation of the *Wastewater Systems Effluent Regulations* under the *Fisheries Act*, which would promote construction and upgrade of wastewater treatment plants. A few municipalities in the Charlevoix and Upper North Shore regions have begun the process of improving their wastewater treatment systems.

Anse à Mercier, Lower St. Lawrence - Photo: Y. Lamontagne, ECCC

Public signage prohibiting harvesting, Gaspésie - Photo: Y. Lamontagne, ECCC

INDICATOR: Oceanographic processes

Overall state: "moderate" with deteriorating trend[9]

The parameters measured to determine temporal changes in and the state of oceanographic processes are water temperature at different depths, dissolved oxygen and acidity. The state of the lower estuary and the Gulf of St. Lawrence was rated as "moderate" for this period based on the data for the 2013-2017 period. A comparison of these results with those for the period preceding 2013 shows a deterioration in the overall state of the sites studied.

A "moderate-good" state of water temperatures

The summer waters of the estuary and Gulf of St. Lawrence consist of three layers: surface water, which undergoes a fairly significant seasonal cycle through its interaction with the atmosphere; the cold intermediate layer, which forms when water from the mixed winter surface layer becomes trapped; and deep water below 150 m, which undergoes few interactions with the atmosphere.

- During the 2013-2017 period, the state of surface water temperatures was rated as "moderate-good." During the period from May to November, for example, average surface temperatures, were slightly above normal. The trend remains stable in comparison with the temperature series for the 2008 2012 period.
- An index combining the average temperature of the cold intermediate layer, the area it covers on the bottom of the Magdalen Shallows and the state of the ice cover is representative of winter conditions in the Gulf. This index was rated as "good" on average for the 2013-2017 period, although it received a "moderate-good" rating in 2013 and 2016.
- The temperatures of the deep waters of the Gulf have shown a significant increase over the past several years, which resulted in a "moderate-poor" rating for this sector for the 2013-2017 period. These temperatures have reached record levels since the beginning of data collection in 1915. The area of sea bottom where temperatures higher than 6°C are measured increased in the Anticosti

9 There were changes in key measurements of this indicator between the 2014 and 2019 Overviews.

Channel, the Esquiman Channel and the Central Gulf during the same period. This temperature threshold was also reached in the northwestern Gulf in 2016. The deep water is composed of a mix of warm water from the Gulf Stream and cold water from East Labrador current, a change in the proportion of this mix being the main cause of the changes in deep water temperatures.

- **Decrease in dissolved oxygen in the deep waters in the Gulf of St. Lawrence**

The index for dissolved oxygen in the deep waters of the St. Lawrence Estuary averaged moderate-poor during the 2013-2017 period. It had deteriorated since the previous period, reaching a record at 17% of the saturation level in 2017. The enrichment of the Gulf Stream waters can only worsen the hypoxic situation since these waters are less rich in dissolved oxygen than the waters of the Labrador current.

- **An increase in acidity**

Concurrently with the reduction in oxygen, the pH of deep water below 300 m has decreased by 0.2 to 0.3 unit, i.e. an increase in acidity of approximately 100%. This acidification results in a decreased availability of calcium carbonate, which is necessary to form the shells and skeletons of many organisms. The accumulation of CO2 from the atmosphere, the origin of the water masses and the decomposition of organic matter in deep water are believed to be responsible for the acidification of the St. Lawrence.

- **An ominous deteriorating trend attributed to global warming**

A worrisome deteriorating trend in the overall state of this indicator has been recorded since the 2008-2012 period, mainly owing to the elevated deep water temperatures, attributed to the change in the proportion of warm water from the Gulf Stream and cold water from the Labrador that comprise the deep waters of the Gulf of St. Lawrence. This situation is expected to deteriorate further for at least the next few years. The overall trend is also due to a reduction in dissolved oxygen and to the acidity of the deep waters of the St. Lawrence estuary, which have reached record levels. However, the water temperatures in the cold intermediate layer have improved since the last assessment (2008-2012), even though large interannual variability is still observed. Surface water temperatures remain stable compared with the same period.

3. Issues and perspectives

3 Issues and perspectives

3.1 Is Lake Saint-Pierre protected against excessive nutrient inputs?

Lake Saint-Pierre is the largest wetland (350 km2) and the largest of the three fluvial lakes located along the St. Lawrence River. Owing to its ecological significance (as a wetland, for example), as well as the richness of its biodiversity, it was designated a Ramsar site in 1998 and a UNESCO World Biosphere Reserve in 2001. This lake is fed by 11 main tributaries, of which 7 are located on the north shore of the St. Lawrence and 4 on the south shore. Unlike the tributaries on the north shore, which have watersheds consisting essentially of forested land, the tributaries on the south shore have watersheds consisting mainly of agricultural land devoted to intensive cropping. In addition to the ecological importance of this ecosystem, the impact that the functioning of this lake can have on neighbouring ecosystems is also a reason to ensure it receives greater attention. Owing to the intensive agricultural activity in the watersheds of the south shore, as well as its geographic position (this is the fluvial lake closest to the marine environment), this lake is likely to have a significant impact on the water quality and functioning of the St. Lawrence estuary.

The water quality in the St. Lawrence River (including Lake Saint-Pierre) reached a critical level in the 1970s due to anthropogenic changes in the watersheds and an increase in phosphorus (P) inputs. Measures aimed at reducing these inputs were implemented in Lake Ontario. The responsible government authorities also initiated and implemented measures targeting municipal, industrial and agricultural sources of P. As a result of these actions, the nutrient situation has improved. For example, the level of dissolved P in water has decreased significantly compared with the levels in the 1970s and 2008 (Hudon et al., 2018). However, despite these restoration efforts, data from a recent report on water quality in Quebec rivers show that the situation of the tributaries of Lake Saint-Pierre still leaves much to be desired. Figure 3.1, developed using the data from that report (Patoine, 2017), shows that levels of nitrogen (Figure 3.1.a), suspended solids (SS) (Figure 3.1.b) and phosphorus (Figure 3.1.c) measured in the tributaries of the lake during the 2009-2012 period exceeded the water quality guidelines, virtually without exception.

This finding is also confirmed by more recent data (2015-2017) collected in the tributaries of the south shore (Environment and Climate Change Canada, 2018). In addition, the annual loads of these elements and particles are still very high, and in 10 of the 11 tributaries, phosphorus from non-point sources of anthropogenic origin is by far the main source of this element.

Another noteworthy fact is that the relative proportion of anthropogenic non-point sources of phosphorus is generally higher in the tributaries on the north shore (figure 3.2), which have comparatively lower nutrient and SS loads, and little agricutural activities in their watersheds. These results show that, despite the improvement and protection measures implemented, the quantities of nutrients and SS discharged into the lake by tributaries exceed the water quality guidelines. Furthermore, the mean levels of nitrates-nitrites in the lake in 2008 increased significantly compared with the 1970-1979 levels (Hudon et al., 2018).

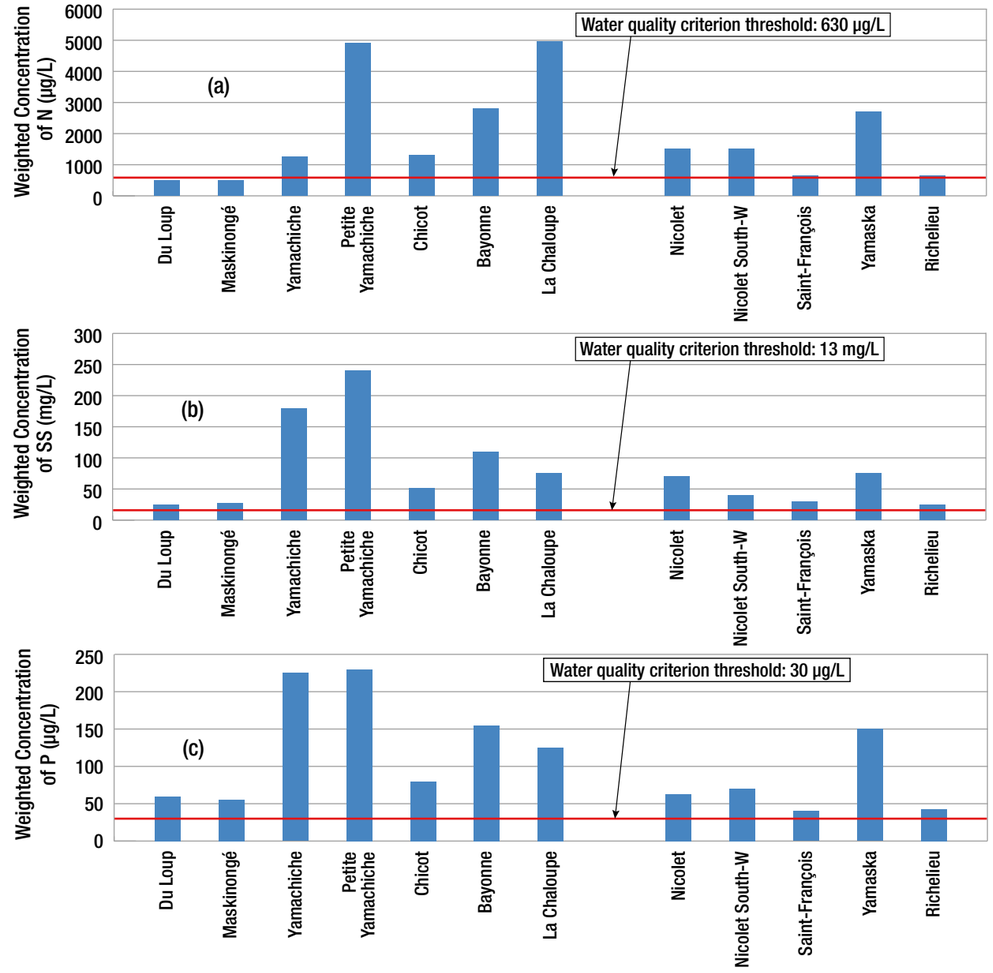


Figure 3.1: Weighted levels of nitrogen (a), suspended solids (b) and phosphorus (c) in Lake Saint-Pierre during the 2009-2012 period (data from Patoine, 2017)

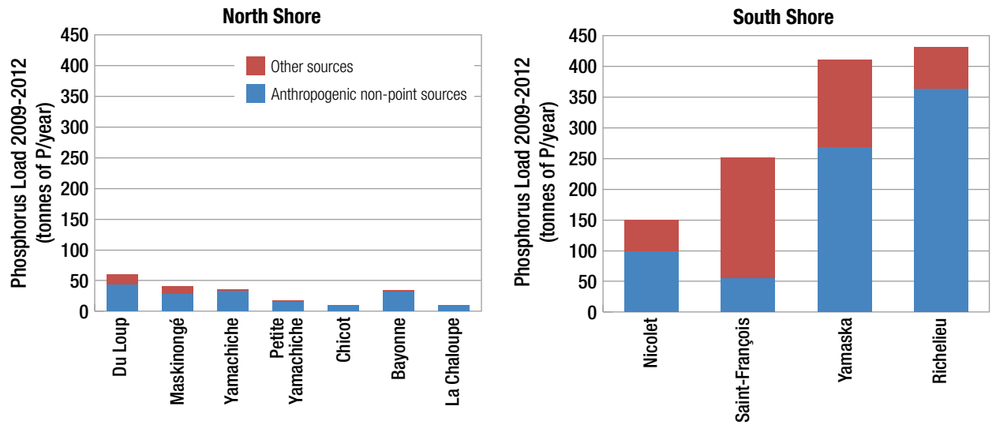


Figure 3.2: Weighted phosphorus loads in the tributaries of Lake Saint-Pierre during the 2009-2012 period (data from Patoine, 2017)

It is true that some indices indicate an improving trend for some aspects of the lake. For example, metrics (richness, diversity, abundance) concerning riparian benthic macroinvertebrates show improvement. However, the lack of buffer strips between the lake's wetlands and agricultural environments leaves this ecosystem exposed and increases its vulnerability to external stress factors of agricultural origin, such as pesticides (Giroux, 2018) and nutrients.

Since acquiring better knowledge of non-point source pollution in order to improve the water quality in the St. Lawrence (and therefore of Lake Saint-Pierre) is one of the objectives of the St. Lawrence Action Plan 2011-2026, it is essential that further actions be taken to reduce the nutrient and SS levels in this lake and its tributaries to levels in accordance with the applicable water quality guidelines.

Various measures have been implemented by the competent authorities with the goal of controlling nutrient levels, particularly phosphorus, including regulatory changes that increase powers at the municipal level, upgrading of wastewater treatment systems and incentives for changes in agricultural practices aimed at reducing excessive nutrient discharges. In terms of the advancement of knowledge, it would be advisable to reassess the nutrient mass balance of the lake (in light of its spatial heterogeneity and the changes that have occurred over the past few years), and to reapply similar measures as well as prioritize those that various action plans have recommended be applied on a continuous basis. If nothing is done to address this issue, it is to be feared that 1) this lake will continue to accumulate nutrients and SS, which will accelerate the deterioration of water and habitat quality; and that 2) a significant fraction of these inputs, including organic matter, will end up in the lower estuary of the St. Lawrence, where they will contribute to the acidification of deep water that has been observed there and permanently disrupt its functioning.

3.2 Ocean acidification: What are the impacts of atmospheric carbon dioxide and fluvial inputs on the ecosystem of the estuary and the Gulf of St. Lawrence?

Every year, the surface of the world's oceans absorbs approximately a third of the total carbon dioxide (CO_2) emissions. Although the oceans help reduce the levels of atmospheric CO_2, this ecological service comes at a price. When CO_2 mixes with and dissolves in seawater, chemical reactions occur that cause an increase in hydrogen ions (H^+), thereby lowering the water's pH and making it more acidic. This phenomenon is accompanied by a reduction in the availability of carbonate ions, an important building block of the skeletons and shells of many marine organisms. Since the beginning of the industrial revolution, the quantities of CO_2 absorbed by the oceans have cause the acidity of the water to increase by nearly 30%. At the current rate of CO_2 emissions worldwide, the acidity of the world's oceans could increase by more than 100% by the year 2100. This is a level of acidity that the oceans have not experienced over the past 20 million years, at least. Obviously, these projections raise serious questions about the capacity of marine ecosystems (and the species that live in them) to adapt to the changing conditions.

The estuary and the Gulf of St. Lawrence are particularly vulnerable to the effects of ocean acidification, since CO_2 is more easily absorbed in cold water. The freshwater inflows from the St. Lawrence and other rivers also increase the process of acidification in the region. Freshwater has a lower pH than seawater and reduces the alkalinity of the marine environment, reducing its buffering capacity in the context of acidification. Fluvial inputs of organic matter and nutrients can also have an impact on the extent of acidification and the rate at which the estuary and the Gulf of St. Lawrence are acidifying. The decomposition or breakdown of organic matter causes an increase in the quantity of CO_2 and a reduction in pH, especially in deep water isolated from the atmosphere. It is therefore not surprising that the most acidic waters of the St. Lawrence are located in the deeper layers of the estuary. These oxygen-poor and CO_2-rich (acidic) waters remain isolated from the atmosphere for many years, during their movement toward the head of the Laurentian Channel.

The pH of the bottom waters of the St. Lawrence estuary is decreasing much more quickly than the pH of surface waters and the pH at a global scale. Since 1934, the pH of bottom waters has decreased by 0.3–0.4 unit (increase in acidity of more than 100%), leading today to record pH levels of 7.5 to 7.6. This reduction in the pH of bottom waters is similar to the change in pH that is expected to occur in the high seas by the end of the century. During the last decade alone, ocean acidification increased by almost 30% (equivalent to 0.1 unit of pH). This means that the increase in acidification is occurring more quickly, which is cause for concern. In addition to the higher atmospheric levels of CO_2, the recent changes in the properties of the water masses entering the Gulf and the possible increase in levels of oxygen use in the water column and at the surface of sediments could be factors contributing to this amplification.

In addition to the changes identified in the St. Lawrence estuary, Fisheries and Oceans Canada surveys have shown that persistent zones of acidified bottom waters exist at the head of the Esquiman and Anticosti channels. Acidified water has also been found in the shallow waters of the southern Gulf of St. Lawrence. Inputs of organic matter and nutrients from the St. Lawrence River and from the estuary may provide part of the explanation for the presence of these CO_2-rich conditions in these shallow water zones.

One of the major consequences of the acidification of the estuary and the Gulf of St. Lawrence is the significant reduction in the availability of carbonate ions (calcite and aragonite) which are necessary for calcifying organisms, including molluscs, crustaceans, gastropods, echinoderms and corals. To date, few studies have been published on the impact of acidification in the estuary and Gulf of St. Lawrence, but studies conducted elsewhere suggest that the calcium carbonate concentrations currently observed in the bottom waters of the region could already be having an impact on calcifying organisms, such as a reduction in their growth and survival. The pH reduction in the estuary and the Gulf could also have impacts on non-calcifying organisms as well as on several key ecosystem processes and services. A better understanding of the processes amplifying the acidification of the St. Lawrence and the effects on the ecosystem is essential so that effective mitigation measures can be taken.

3.3 Impact of climate change on the Quebec tributaries of the St. Lawrence

Climate change will modify the hydrologic regime of the St. Lawrence owing to the expected effects on precipitation, snow cover and evapotranspiration (Ouranos, 2010 and 2015). Given the size of the river and its many tributaries, the impacts are complex and vary according to the different regions of the watershed.

Looking at the expected impacts of climate change on the various tributaries of the St. Lawrence River, the main trends predicted for the 2041-2070 period (according to the RCP4.5 greenhouse gas emission and concentration scenario) consist of earlier spring floods, with a reduction in flood volumes and peaks for the southernmost part of southern Quebec (DEH, 2015 and 2018). In particular, the projections for this time frame indicate that it is very probable that the day on which the peak spring flood occurs (JQ1maxP) on all the tributaries of the St. Lawrence will be moved ahead by 15 (RCP4.5 scenario presented in Figure 3.3) to 20 (RCP8.5 scenario) days. For example, the peak spring flood on the Chaudière River would occur in late March instead of mid-April.

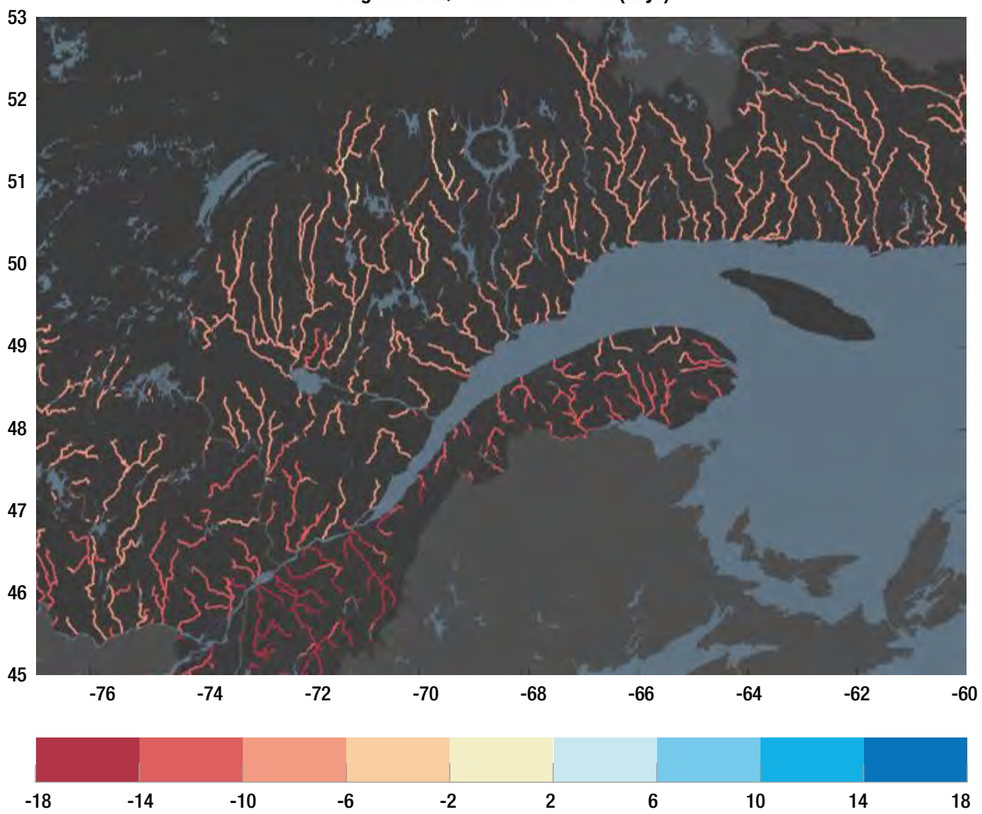


Figure 3.3: Magnitude of the change (days) for the timing of the peak of spring flood (JQ1maxP indicator)

In addition, summer low flows will be more severe and last longer, while winter low flows will be less severe. For the 2041-2070 period, the projections for the tributaries of the St. Lawrence describe a very probable reduction of 10% to 40% in the summer low flow with a two-year return period estimated over a time frame of seven consecutive days (Q7min2E, RCP4.5 scenario; Figure 3.4).

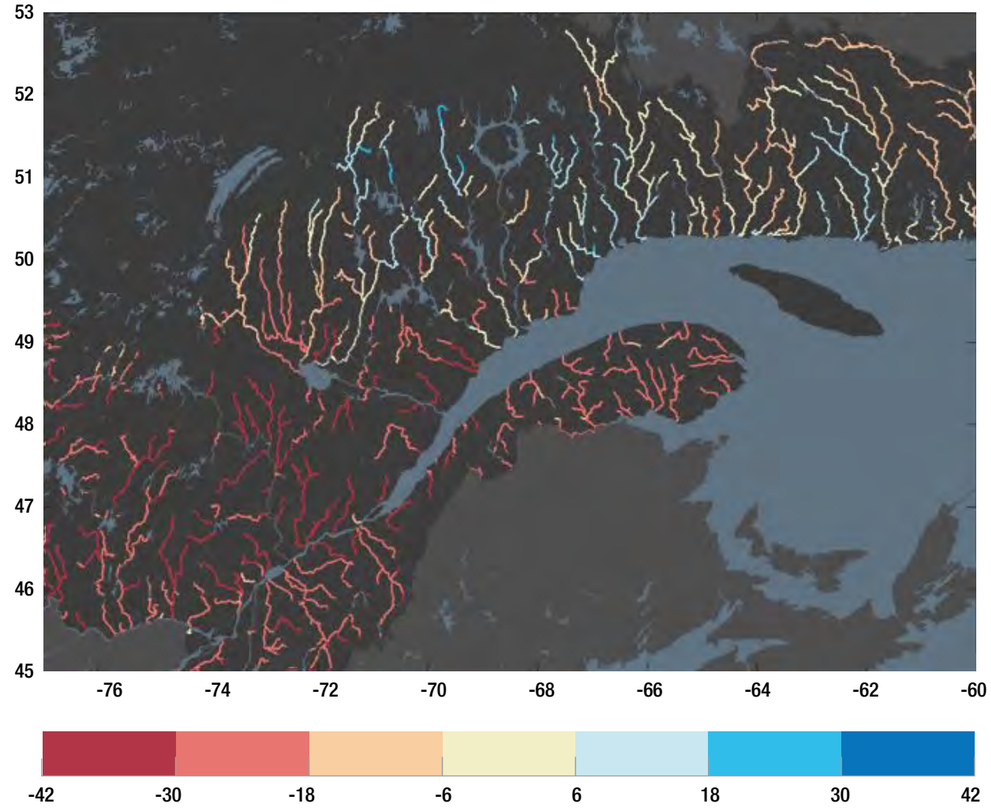


Figure 3.4: Magnitude of the change (%) for the summer low flow with a two-year return period estimated over a time frame of seven consecutive days (Q7min2E indicator)

All these changes will have significant consequences for water uses and ecosystems (Ouranos, 2010). For example, the anticipated decrease in spring flows and water levels will have a negative impact on shipping, will require changes in the management of dams and will result in a reduction of flood risks for certain tributaries. The expected consequences of more severe summer low flows could include a reduction in the capacity of the receiving environment to handle pollutants of various types (domestic and industrial wastewater, for example), greater drinking water supply problems or the drying out of wetlands, leading to impacts on fish and migratory bird populations.

In the wake of the extreme hydrological events experienced over the past few years, particularly the floods in the spring of 2011, 2017 and 2019, several studies and collaborative efforts initiated at the provincial and federal levels have achieved some progress in terms of developing measures for adapting water management in a climate change context.

In addition, given the many and often conflicting uses of water, climate change adaptation measures related to water management must include the participation of the users concerned.

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