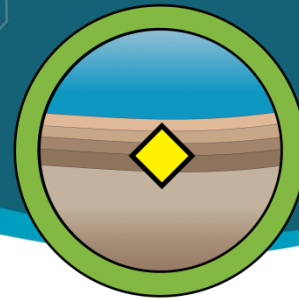


# Monitoring the State of the ST. LAWRENCE RIVER

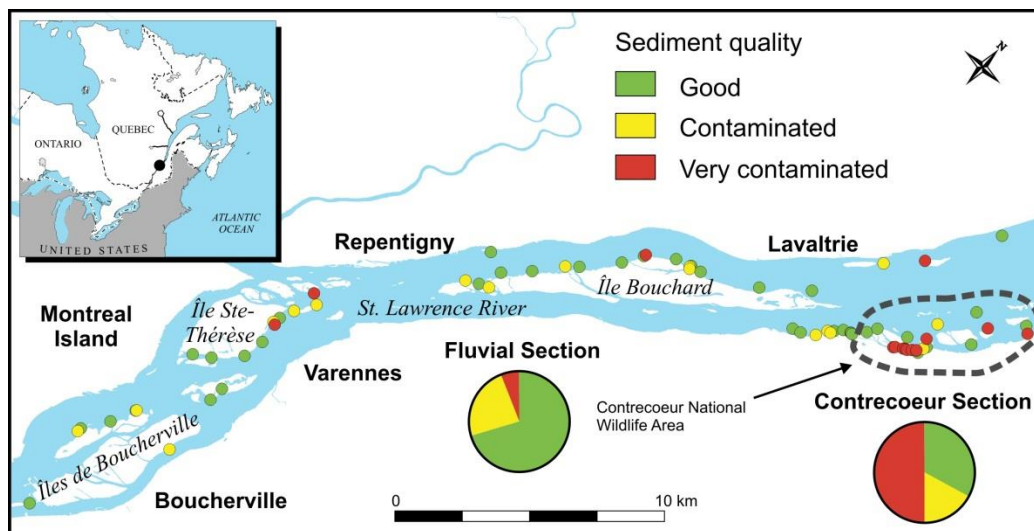


## Sediment quality in the fluvial section of the St. Lawrence

### Highlights

**Status:** Overall, sediment quality in the upstream portion of the fluvial section between 2004 and 2014 was good, but in the Contrecoeur area it was considered poor (figure 1).

**Temporal changes:** The concentrations measured for the major substances associated with 20th-century industrial activity remained high in 2014 and exceeded the concentration thresholds, primarily in the Contrecoeur area.



Pie charts represent the proportion of sites classified according to sediment quality.

Figure 1. Sampling locations and sediment quality index in the sectors being monitored, 2004–2014

## Problem

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The fluvial section of the St. Lawrence is located between the cities of Montreal and Sorel and is dotted with numerous islands. The upstream portion of the fluvial section includes the confluence with the waters of the Ottawa River, which flow into the St. Lawrence via rivière des Milles Îles and rivière des Prairies.

The environmental issue of sediment quality is associated with discharges of wastewater from the City of Montreal and the municipalities in its northern and southern suburbs. In addition, the industrialized areas in the east end of Montreal and the Port of Montreal, just upstream, are sources of contamination

from metals, polychlorinated biphenyls (PCBs), hydrocarbons and butyltins.

Îles de Contrecoeur National Wildlife Area, located across from the municipality of Contrecoeur, is made up of 22 islands surrounded by wetlands. This protected area is home to many species of birds, reptiles and mammals. However, it is vulnerable to contamination from industrial activities being carried out along the shores in this part of the St. Lawrence.

Only the portion between Montreal and Contrecoeur was covered in this study; samples could not be taken between Contrecoeur and Sorel because the currents were too strong.

## Key measures

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### Sediment quality criteria and indices

The sediment quality criteria used in this document (TEL: threshold effect level) are taken from EC and MDDEP (2007). They are defined on the basis of observed biological effects on benthic and pelagic organisms and contaminant concentrations measured in sediment.

The quality indices are calculated by dividing the measured concentration of each substance (mercury, metals, PCBs and PAHs) in each sample by the TEL quality criterion for the substance in question. An index higher than 1 indicates that the concentration exceeds the criterion and biological effects may be observed, whereas an index lower than 1 indicates that sediment quality is good. Mean quality indices were calculated for metals (except mercury) and PAHs.

The overall indicator status is based on the proportion of uncontaminated sites and contaminated sites relative to the total number of sites characterized. This proportion defines an overall status that ranges from good to poor.

## Hydrology and sedimentology

The velocity of currents is relatively high, exceeding 1 m/sec in some places. The water in the St. Lawrence flows directly over postglacial clay deposits left by the Champlain Sea more than 8,000 years ago. However, fine sediments representative of the particles circulating in those waters have been deposited

along the north and south shores of the St. Lawrence and the shores of various islands. Sediments are deposited only in certain places: small bays, areas covered with aquatic plants, or areas within navigation infrastructure that are sheltered from currents (figure 2).

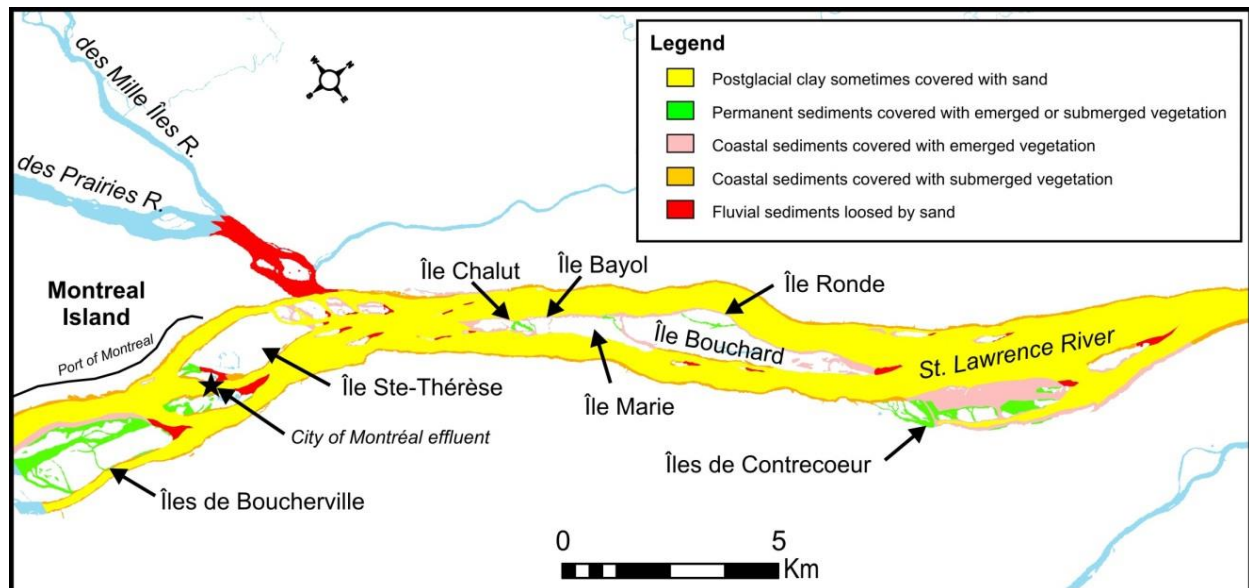


Figure 2. Sediment substrate in the fluvial section

## Sediment quality status

Sediments in the fluvial section are composed mostly of sand, with a bit of silt and clay. That composition, which is low in fine particulates, does not tend to accumulate contaminants. For that reason, sediment quality in the fluvial section was considered good when the samples from the Contrecoeur area were excluded from the calculations (table 1).

Concentrations of metals, mercury and PAHs were below the TEL quality criterion. However, concentrations of chrome, copper and zinc exceeded the

TEL by more than 30%, reaching maximum values of 165 µg/g, 118 µg/g and 913 µg/g, respectively. The highest concentrations of metals and mercury were found along the northwest shores of île Bayol, île Chalut and île Bouchard and in the channels of the îles de Contrecoeur (figures 3 and 4).

Among the 13 PAHs measured in this study, between 20% and 40% of the concentrations exceeded the TEL. Anthracene, benz(a)anthracene, benzo(a)pyrene and phenanthrene

showed the highest concentrations. PAHs were found downstream from the City of Montreal effluent outfall on the south shore of île Sainte-Thérèse, and around the îles de Boucherville and the îles de Contrecoeur (figure 5).

A little over half of the samples (53%) exceeded the TEL for PCBs. The

highest concentrations were distributed throughout the fluvial section (figure 6).

Lastly, PBDEs were mainly located downstream from the City of Montreal effluent outfall (figure 7) – a predictable result, since they are present in municipal wastewater.

**Table 1. Median and maximum concentrations of substances analyzed in sediments for Lake Saint-Louis, the fluvial section, Lake Saint-Pierre and the Contrecoeur area**

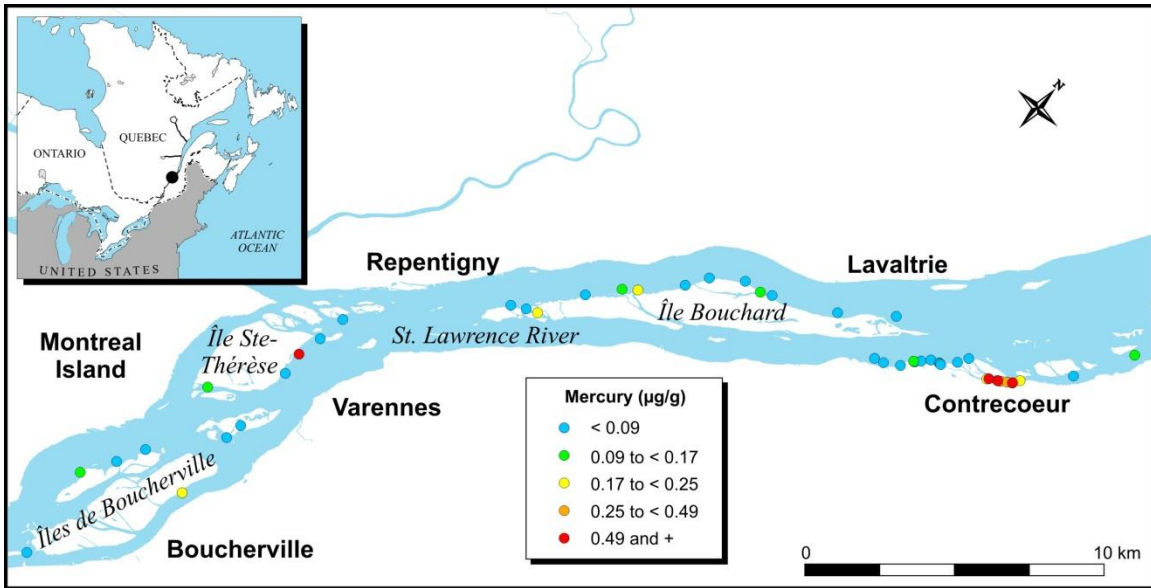
Substance	Unit	TEL quality criterion	Fluvial sector, excluding Contrecoeur		Contrecoeur area		Lake Saint-Louis*		Lake Saint-Pierre*	
			Median	Maximum	Median	Maximum	Median	Maximum	Median	Maximum
Arsenic	µg/g	5.9	2.7	7.4	5.0	8.2	4.7	71.6	1.7	6.4
Cadmium	µg/g	0.6	0.3	1.4	<b>1.2</b>	3.4	<b>0.7</b>	4.1	0.2	2.2
Chrome	µg/g	37	32	165	<b>118</b>	226	<b>46</b>	93	17	81
Copper	µg/g	36	22	118	<b>79</b>	242	22	57	11	67
Nickel	µg/g	47	21	56	<b>52</b>	77	33	59	13	50
Lead	µg/g	35	12	91	<b>61</b>	215	18	58	6	47
Zinc	µg/g	120	82	913	<b>481</b>	2180	<b>185</b>	396	47	294
Mercury	µg/g	0.17	0.04	0.21	<b>0.31</b>	0.68	0.09	0.28	0.03	0.23
Metals index	--	1	0.6		<b>2.0</b>	6.2	0.9		0.3	
PCBs	µg/g	0.034	<b>0.040</b>	0.725	<b>0.128</b>	0.195	0.021	0.231	0.018	0.129
Benzo(a)pyrene	µg/g	0.032	0.012	0.350	<b>0.120</b>	0.160	<b>0.041</b>	0.092	0.021	0.270
PAH index	--	1	0.3		<b>2.0</b>	3.6	0.7		0.5	
BDE #99	ng/g	0.4	0.22	1.3	<b>2.5</b>	3.8	0.38	1.3	0.36	1.8
Total PBDEs	ng/g	--	4.3	132.5	30.0	78.1	7.4	39.6	7.9	61.1
Butyltins	ng Sn/g	5	--	--	<b>10.1</b>	2093	--	--	--	--

\* The analysis results from Lake Saint-Louis and Lake Saint-Pierre will be published at a later date.

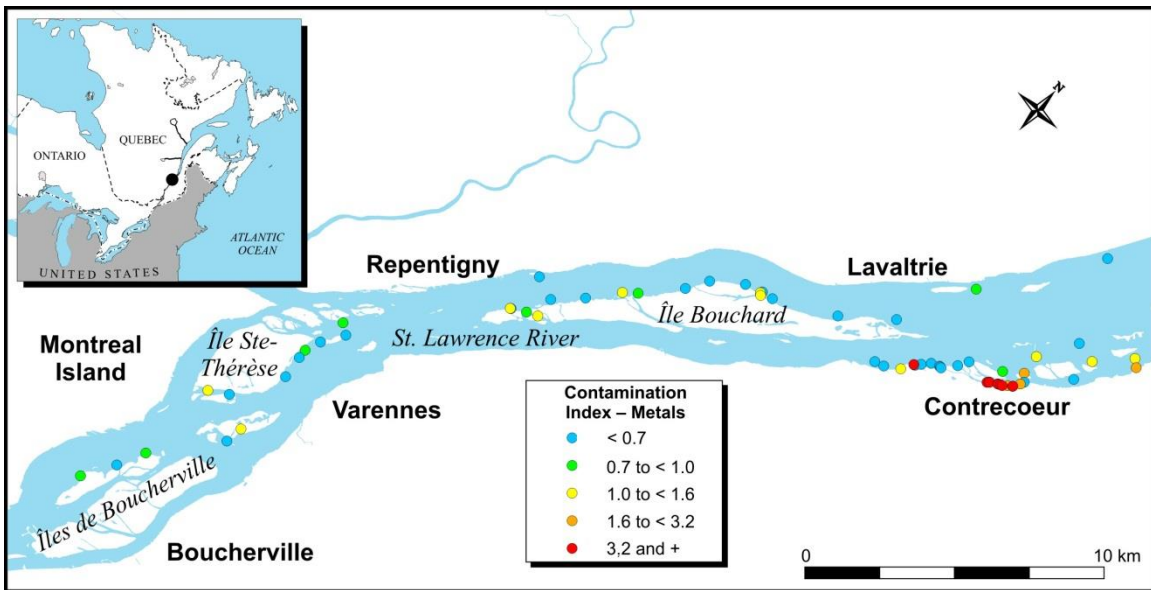
## Spatial analysis of contamination

Freshets in the spring and high water levels in the fall cause sediment resuspension, consequently, it is not possible to draw a reliable picture of the evolution of the contamination because there is too little permanent accumulation. However, it is possible to compare the median and maximum

concentrations in the fluvial section with those of sediment samples taken upstream in the northern part of Lake Saint-Louis and downstream in Lake Saint-Pierre. Those comparisons can be used to assess the impact of the sources of contamination in the fluvial section.



**Figure 3. Mercury concentrations in sediments in the fluvial section of the St. Lawrence, 2004–2014**



**Figure 4. Metals index for sediments in the fluvial section of the St. Lawrence, 2004–2014**

Sediments in the fluvial section, other than those in the Contrecoeur area, are depleted of organic matter and fine particulates. That limits adsorption of contaminants by particles, despite significant inputs from upstream sources

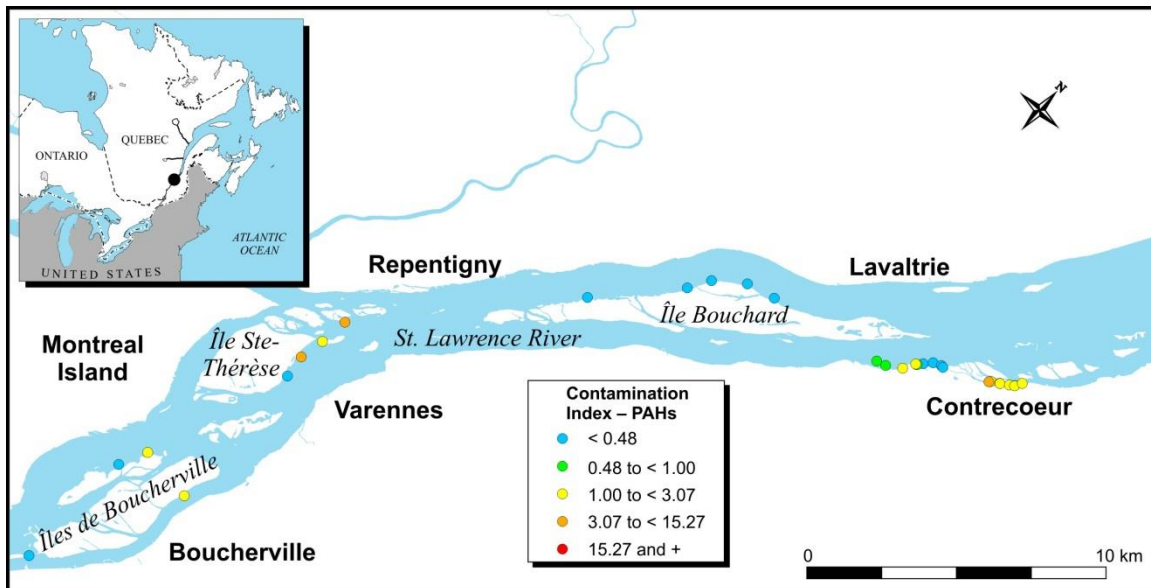
such as the City of Montreal effluent outfall and the Port of Montreal.

Contamination from metals, which is primarily associated with mineral matter, tended to decrease from upstream (Lake

Saint-Louis) to downstream (Lake Saint-Pierre). However, it was not possible to identify any such trend for contaminants associated with organic matter, such as mercury, PCBs, PAHs and PBDEs (table 1).

The maximum concentrations were higher in the fluvial section than in the lakes for copper, lead, zinc, PCBs, total

PBDEs and the majority of PAHs, including benzo(a)pyrene. Those concentrations, which were sometimes extreme, are evidence of the high inputs of contaminants (table 1). The higher concentrations of chrome may be due to the fact that the postglacial clay covering the riverbed in the fluvial section is enriched in this metal.



**Figure 5. PAH index for sediments in the fluvial section of the St. Lawrence, 2004–2014**

## Contrecœur area

The contamination in the Contrecœur area was located in a channel between the south shore and the îles de Contrecœur. The sediment there was contaminated by mercury and heavy metals such as chrome, lead and zinc. Mercury levels were 3 to 4 times higher than the threshold concentration that has effects on aquatic organisms (TEL criterion). The highest concentrations of chrome and lead were 6 times higher than their TEL, while concentrations of zinc were as high as 2,180 µg/g, more

than 18 times higher than its criterion (table 1).

In addition, very high concentrations of butyltins exceeding 2,000 ng Sn/g were found at the outlet of the île au Dragon channel. As yet, no source has been identified for these contaminants, which have historically been used as biocides in paint for boat and ship hulls (Pelletier et al., 2014). Further studies have been conducted and will be published at a later date.

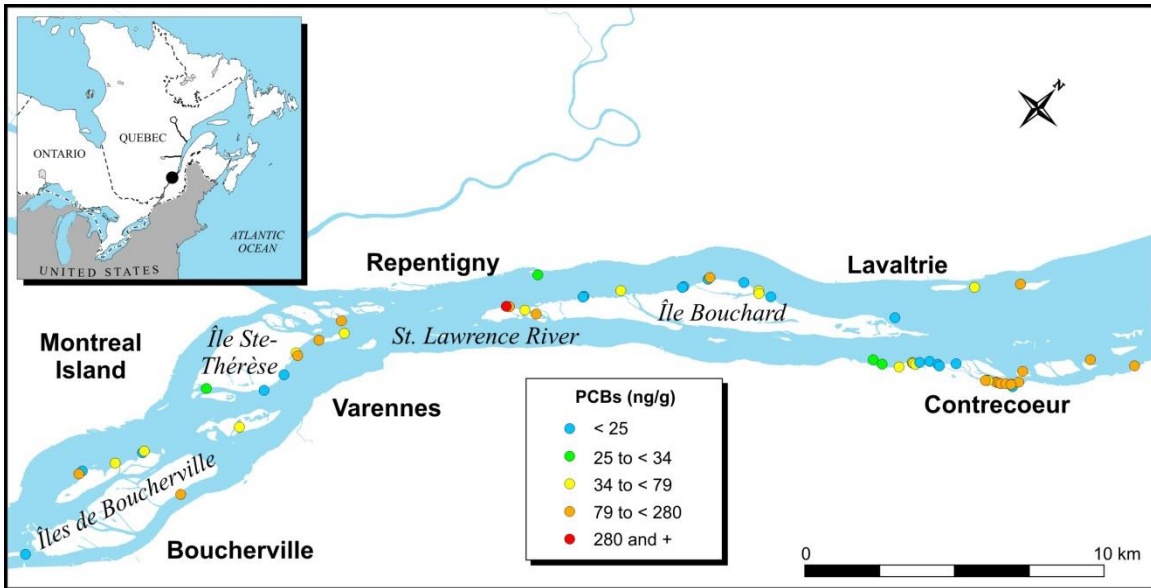


Figure 6. PCB concentrations in sediments in the fluvial section of the St. Lawrence, 2004–2014

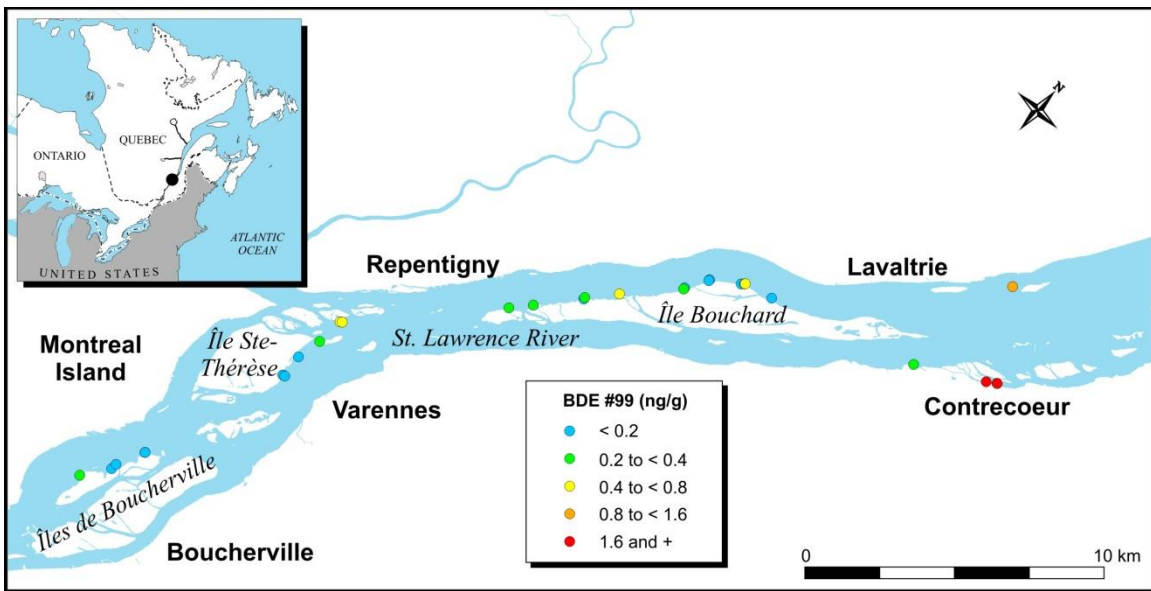


Figure 7. BDE 99 concentrations in sediments in the fluvial section of the St. Lawrence, 2004–2014

## Outlook

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Currently, sediment quality is monitored by sampling surface sediments and using the samples to characterize annual inputs of contaminant-bearing particles. The results of this monitoring are used to produce an up-to-date picture of contaminant concentrations in the aquatic environment that could affect the habitats of many benthic organisms. However, there are not many locations in the fluvial section where sediments are deposited over time. For the past few years, particles have been captured by sediment traps placed on the riverbed, and this method has proven effective for studying emerging substances of interest such as PBDEs, siloxanes and a number of others directly associated with municipal wastewater (Armellin et al., 2018; Isabel et al., in writing). Therefore, it is important to continue monitoring and surveillance of these substances using appropriate techniques to measure their impacts on the aquatic environment.

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## ***State of the St. Lawrence Monitoring Program***

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

For more information about the State of the St. Lawrence Monitoring Program, please consult our website:

[http://planstlaurent.qc.ca/en/state\\_monitoring.html](http://planstlaurent.qc.ca/en/state_monitoring.html).

## Prepared by

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