Toxic Contamination in Sediments

Lake Saint-Louis: Where Two Rivers Meet

Photo: Nathalie Gratton, Environment Canada

Shipek corer

Background

Lake Saint-Louis, formed by the confluence of the Ottawa and St. Lawrence rivers, is one of Quebec's most popular lakes with pleasure boaters. With an average depth of three metres (m) over more than half its area, the lake forms an immense 148-km^2 triangle stretching for more than 25 km. The water mass of the Great Lakes extends throughout almost the entire lake, while that of the Ottawa River flows alongside Montreal Island before reaching the Lachine Rapids.

Photo: Martin Jean, Environment Canada

Aerial view of Lake Saint-Louis Islands

The St. Lawrence ship channel cuts through Lake Saint-Louis, allowing commercial ship traffic to move on through the Beauharnois Canal into Lake Saint-François and up the St. Lawrence to the Great Lakes. With the opening of the St. Lawrence Seaway in the late 1950s and the construction of hydroelectric dams, the area upstream of Lake Saint-Louis became heavily industrialized, especially along the Saint-Louis River. This industrialization has inevitably had repercussions on the aquatic environment, because of discharges of numerous contaminants of varying degrees of toxicity.

Canada

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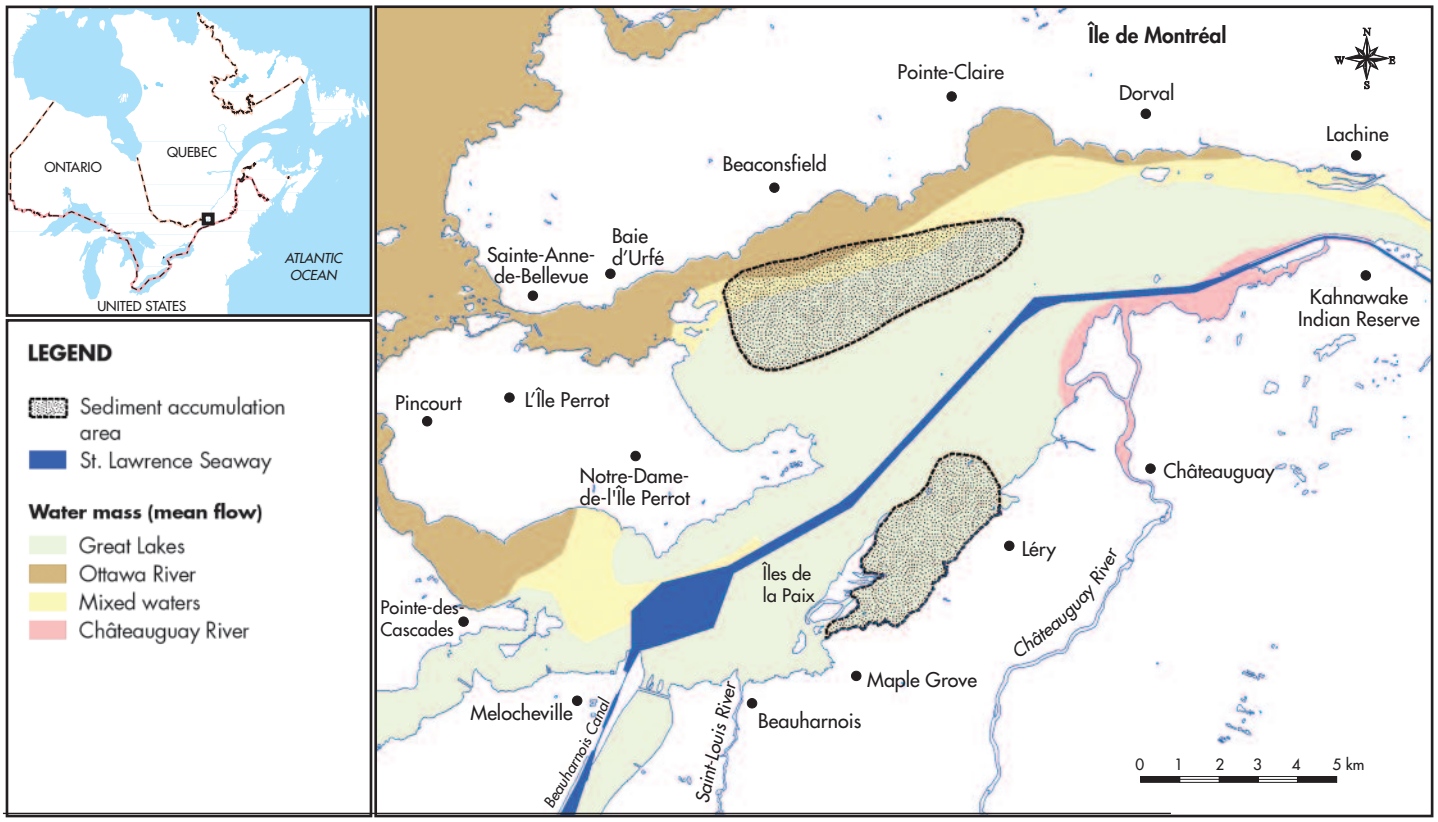
Figure 1. Location map of Lake Saint-Louis



Source: Modified from Fortin et al., 1994.

The waters and sediments of Lake Saint-Louis became increasingly contaminated with toxic substances such as mercury and polychlorinated biphenyls (PCBs). Because of the differing sources of the inflows of water and sediment particles, the northern part of Lake Saint-Louis presents a different sedimentary and geochemical picture than the southern part.

A high proportion of the suspended particles from the Ottawa River settle on the bottom of the lake off Beaconsfield, thus forming muddy sediment beds several kilometres wide. On the south side of the lake, between the Îles de la Paix island group and the shore, there is another sedimentary basin containing particles from the St. Lawrence River, the erosion of the Îles de la Paix, and the Saint-Louis River.

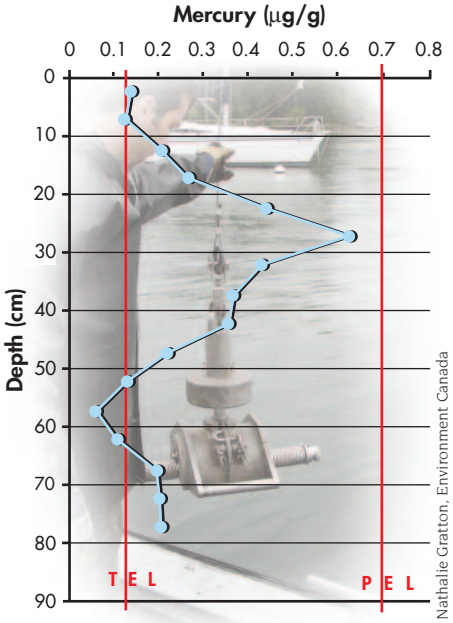
Overview of the Situation

As Quebec's population grew and its industry developed during the mid-20th century. Subsequently, the loadings of toxic substances were reduced considerably through steps taken to reduce emissions of hazardous wastes under the St. Lawrence Action Plan and the Quebec government's *Programme de réduction des rejets industriels* (program to reduce industrial wastes). Hence, the concentrations of the various organic substances in the sediments have gradually diminished, and the concentrations of metals are now close to the values observed in the early 1970s. Though these concentrations still slightly exceed the levels considered likely to have effects on benthic organisms, improved wastewater treatment must be seen as having done much to improve the quality of the aquatic environment.

Northern Part of the Lake

In the northern part of Lake Saint-Louis, the sediment loadings from the Ottawa River cause accumulations of about 1 cm of muddy sediment per year over an area of more than 20 km^2. At some locations, the sediment is at least 2 m deep, reflecting the great stability of this part of the lake. Ancient sediments sampled in this sedimentary basin show a relatively rapid increase in mercury (Hg) concentrations in the environment.

Figure 2. Distribution of mercury (Hg) concentrations in sediment in the nothern part of Lake Saint-Louis



TEL: Threshold Effect Level.
PEL: Probable Effect Level.

Photo: Nathalie Gratton, Environment Canada

Table 1. Average concentration of different toxic substances in surficial sediment in Lake Saint-Louis

	Average concentration (µg/g)								
	As	Cd	Cr	Cu	Ni	Pb	Zn	Hg	PCB
SAMPLING YEAR									
1976									
Entire lake	–	–	68	33	43	28	169	3.68	–
Northern part	–	–	61	27	47	32	194	0.42	–
Southern part	–	–	74	39	40	25	148	6.38	–
1986									
Entire lake	5.9	–	95	33	33	33	211	1.11	0.132*
Northern part	5.9	–	101	36	35	42	258	0.27	0.138*
Southern part	6.0	–	89	31	30	33	151	2.09	0.121*
2003									
Entire lake	7.8	0.83	68	26	38	29	153	0.30	0.020**
Northern part	9.6	0.93	73	27	40	33	180	0.11	0.017**
Southern part	4.8	0.66	59	26	33	23	110	0.60	0.023**
PERCENT CHANGE									
From 1976 to 2003									
Entire lake	–	–	0	21	13	-4	10	92	–
Northern part	–	–	-20	2	15	-4	7	74	–
Southern part	–	–	20	33	7	7	26	91	–
From 1986 to 2003									
Entire lake	-31	–	29	21	-14	23	27	73	85
Northern part	-64	–	28	24	-16	22	30	60	87
Southern part	20	–	34	17	-9	28	28	71	81
SEDIMENT QUALITY CRITERIA									
TEL	5.9	0.6	37	36	–	35	120	0.17	0.034
PEL	17	3.5	90	200	–	91	310	0.49	0.280

* The average PCB concentration in 1986 is the sum of Aroclors 1242, 1254 and 1260.

** Congeners were used to calculate the approximate value of the average concentration of Aroclors 1242, 1254 and 1260.

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Photo: Nathalie Gratton, Environment Canada

This increase, which is also observed for metals (copper [Cu], zinc [Zn], lead [Pb], and nickel [Ni]) and PCBs, is caused by the use of these substances in various industrial processes. In the more recent sediments, the concentrations are lower, with values close to the Threshold Effect Level (TEL) for benthic organisms.

For the northern part of the lake as a whole, mercury concentrations fell by 75% from 1976 to 2003, while those for PCBs fell by 85% from 1985 to 2003, except for the sediments confined within the Dorval marina, which still show high concentrations of PCBs, possibly associated with older sediments. The majority of the metals (chromium [Cr], Cu, Pb and Zn) show an approximately 30% decrease in concentration from 1985 to 2003. This decrease must be regarded as relatively small and insignificant compared with those measured in the other lakes along the St. Lawrence, especially because the concentrations of arsenic (As) and Ni have increased while nearly 50% of the current average concentrations of the various metals still exceed the TEL for benthic organisms.

Figure 3. Spatial distribution of mercury (Hg) in sediment in Lake Saint-Louis in 1985 and 2003

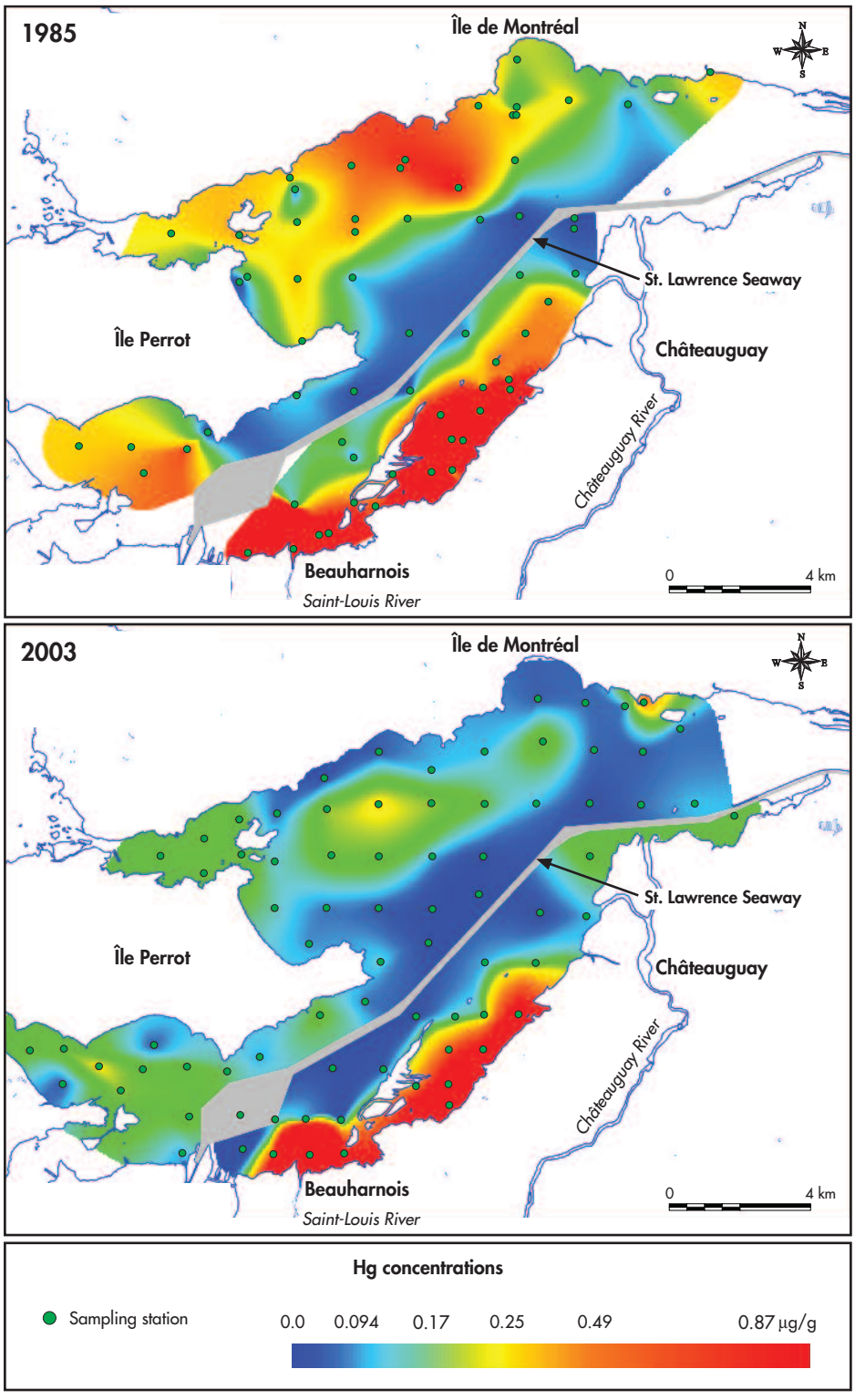
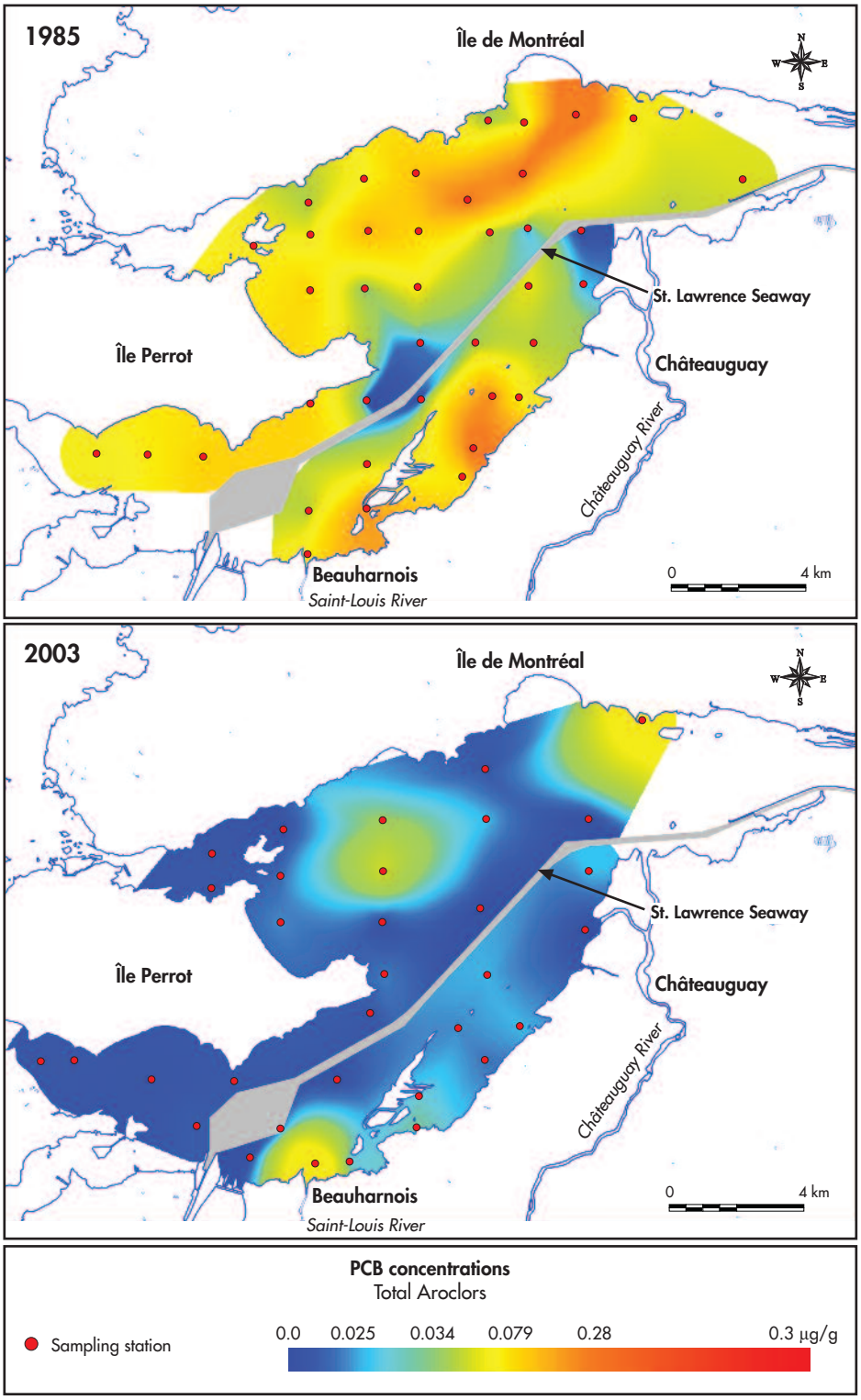


Figure 4. Spatial distribution of polychlorinated biphenyls (PCBs) in sediment in Lake Saint-Louis in 1986 and 2003



Southern Part of the Lake

On the south side of the lake, the sediment particles from the Saint-Louis River settle almost exclusively in a small basin between an island group called the Îles de la Paix and the lake's south shore. Sediment accumulation here is fairly substantial, but more unstable. High water levels in the St. Lawrence in spring and fall cause heavy erosion of the muddy bottoms and the contours of the islands, thus causing large amounts of material to move downstream.

Geochemical data on sediment samples gathered in 1976, 1985 and 2003 show that the mercury concentrations measured in the southern part of Lake Saint-Louis have decreased by about 90% over nearly 30 years. But even so, the concentrations of contaminants in the sediment around the Îles de la Paix remain above the Probable Effect Level (PEL) for benthic organisms.

The concentrations of PCBs have decreased by about 85% since 1985, as the result of improved wastewater treatment in the region and a general decrease in PCBs in the St. Lawrence over the past 20 years. However, the highest concentrations of PCBs are still found at the mouth of the Saint-Louis River, upstream from the Îles de la Paix.

Outlook

Over the past few decades, environmental clean-up efforts by various levels of government, by industry, and by environmental organizations have considerably improved the quality of life of the aquatic organisms in the St. Lawrence River ecosystem. The results show major reductions in the concentrations of toxic substances in sediment in practically the entire river, and for conventional substances, this trend should continue. Despite these encouraging results, however, there are still many other substances that are present in the ecosystem and about which little information is yet available. Examples of these substances include tributyltin (TBT), contained in marine paint; dioxins and furans, discharged by various industrial plants; and a number of new emerging substances, such as polybrominated diphenyl ethers (PBDEs), which are used as flame retardants in household products, and perfluorooctanes (PFOs) and perfluorinated alkyls (PFAs), which are used as water and oil repellents in textiles and food packaging. All of these substances can have harmful effects on benthic organisms. Evaluation of the status of these emerging substances is becoming not only a new priority in sediment-quality monitoring efforts, but also a new challenge, because these substances are more widespread in the environment and harder to control at the source.

Photo: Nathalie Gratton, Environment Canada

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KEY MEASURES

Sediment Quality Criteria and Contamination Thresholds

Two types of tools are used to monitor sediment quality: sediment quality criteria and the Threshold of Significant Contamination (TSC).

The sediment quality criteria define two levels of contamination: the Threshold Effect Level (TEL) and the Probable Effect Level (PEL). Below the TEL level, organisms are not regarded as being affected by the various chemicals, because concentrations are very low. Above the TEL level, the most sensitive organisms are possibly affected by toxic substances; above the PEL level, chemical concentrations are high enough to produce deleterious effects in organisms.

The threshold of significant contamination (TSC) applies only to metals and is defined by the Anthropogenic Enrichment Factor (AEF). The AEF is the rate by which a contaminant exceeds its preindustrial concentration and to which a factor of 2.5 is applied to take natural variations into account. When the preindustrial level is not known, the AEF can be calculated using the TEL. It is believed that levels of contamination above the TSC cannot be the result of variations in sediment texture or geology alone, but that a relatively substantial anthropogenic input must be involved.

Photo: Martin Jean, Environment Canada

To Know More

CHAMPOUX, L. and H. SLOTERDJK. 1988. *Étude de la qualité des sédiments du Lac Saint-Louis 1984-1985*, Environment Canada, Conservation and Protection, Inland Waters Directorate, Quebec Region.

ENVIRONMENT CANADA and MINISTÈRE DU DÉVELOPPEMENT DURABLE, DE L'ENVIRONNEMENT ET DES PARCS. 2007. *Critères pour l'évaluation de la qualité des sédiments au Québec et cadres d'application : prévention, dragage et restauration*. 45 pages.

PELLETIER, M. (in preparation). *Répartition spatiale et temporelle de la qualité des sédiments du Lac Saint-Louis*. Environment Canada, Science and Technology Branch, Quebec Region.

SÉRODES, J.-B. 1978. *Qualité des sédiments de fond du fleuve Saint-Laurent entre Cornwall et Montmagny*. Technical Report No. 15. Regional Inland Waters Directorate. 139 pp. + maps.

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State of the St. Lawrence Monitoring Program

Under the current Canada–Québec agreement, the St. Lawrence Plan for a Sustainable Development, six government partners—Environment Canada, the Ministère du Développement durable, de l'Environnement et des Parcs du Québec, Fisheries and Oceans Canada, the Ministère des Ressources naturelles et de la Faune du Québec, the Canadian Space Agency, and the Parks Canada Agency—together with Stratégies Saint-Laurent, a non-governmental organization that works actively with riverside communities, are pooling their expertise to provide Canadians with information on the state of the St. Lawrence River at regular intervals.

To obtain the fact sheets and additional information about the State of the St. Lawrence Monitoring Program, please visit our Web site at:

www.planstlaurent.qc.ca

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