

Monitoring the State of the ST. LAWRENCE RIVER



BIOLOGICAL RESOURCES

WATER

SEDIMENTS

SHORELINES

USES

Benthic Macroinvertebrate Communities

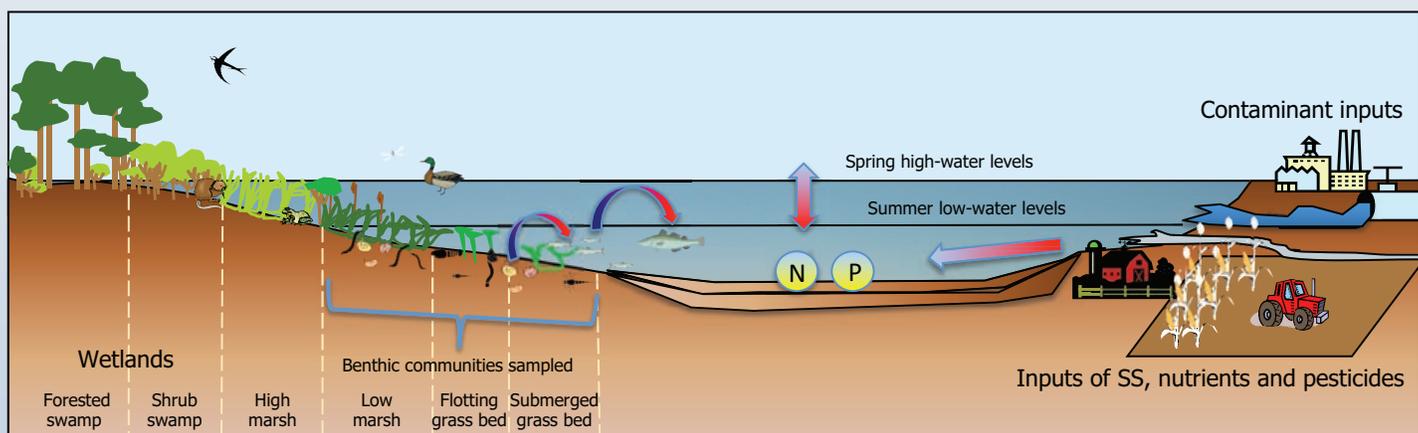
An indicator of water quality and aquatic ecosystem health in the St. Lawrence River

2nd Edition

Issue

This document provides an overview of the health of aquatic ecosystems through the analysis of changes in the composition of benthic invertebrate communities. Given

their diversity and abundance, invertebrates exhibit a wide range of sensitivity responses to disturbances and, as a result, effectively complement physicochemical monitoring of water and sediment. Evaluation of water or sediment quality does not generally take into account the combined effects of chemicals, short-term contamination spikes caused by phenomena such as leaching by rain of products spread over agricultural land or accumulated in streets, nontoxic ecological disturbances such as eutrophication or hydrological changes, or the presence of alien species. Benthic macroinvertebrates also constitute a significant link in aquatic ecosystems insofar as they are a food source for numerous animal species and may consequently serve as vectors for the bioaccumulation of certain contaminants (Figure 1).



N = nitrogen; P = phosphorous; SS = suspended solids.

Figure 1 Natural and anthropogenic factors acting on macroinvertebrates

Overview of the situation

Distribution of communities

Monitoring of freshwater benthic communities has been carried out in Lake Saint-Pierre since 2004 (Armellin 2010), in Lake Saint-Louis and the fluvial section between Montréal and Sorel since 2007 and in Lake Saint-François since 2009 (Figure 2). The sampling sites are all located in low marshes and aquatic grass beds, taking into account the

landscape context, nature of the local sediment and nearby water bodies (mixed waters of Ottawa River/Great Lakes, Great Lakes and tributaries). A number of control sites were designated based on the criteria set out in Table 1 with a view to evaluating the biological condition of the grass beds and marshes. One objective of the monitoring is to identify metrics that might assist in effectively characterizing the state of benthic communities through comparison of values measured at the control sites.

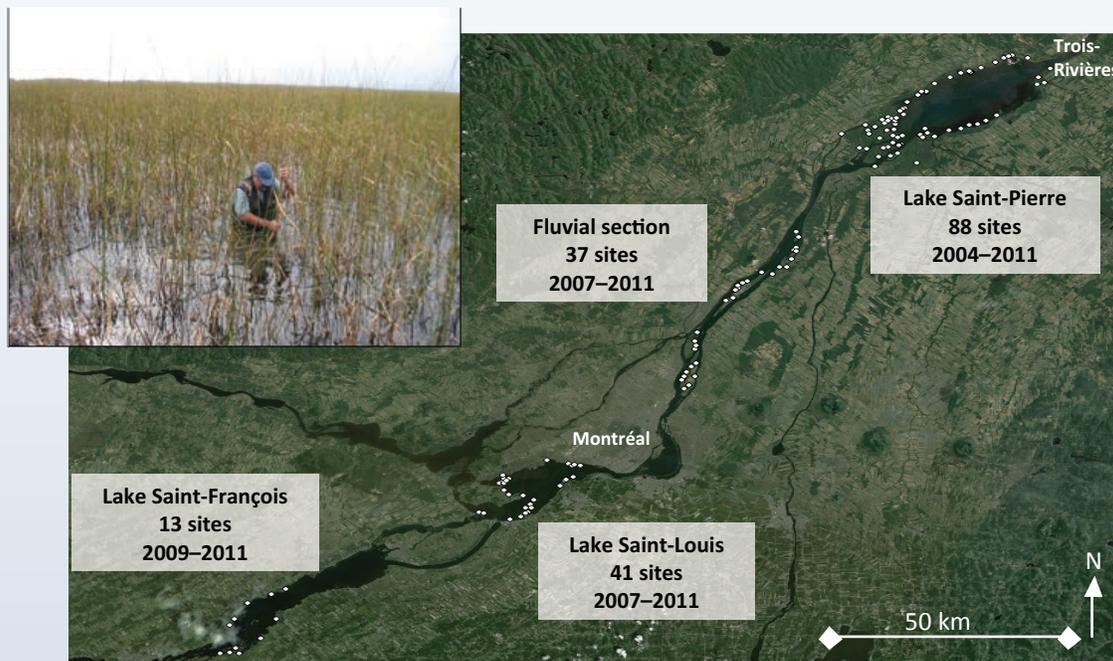


Figure 2 Locations of stations sampled between 2004 and 2011

Table 1 Selection criteria for control stations for monitoring benthic communities in the St. Lawrence River

LANDSCAPE		
% urban area	Percentage of urban area within a 1-km radius of site	≤ 5%
% agricultural land	Percentage of agricultural land within a 1-km radius of site	≤ 25%
SEDIMENT		
Occasional effect level (OEL)	Level above which multiple benthic species are exposed to harmful effects (criteria for the protection of aquatic life)*	Copper ≤ 63 mg/kg Mercury ≤ 0,25 mg/kg Lead ≤ 52 mg/kg Zinc ≤ 170 mg/kg
Probable effect level (PEL)	Requires further sediment characterization	Chromium ≤ 90 mg/kg
HYDRODYNAMICS		
Distance from tributaries	The station must be located away from pollution sources to minimize the influence of pollution on macroinvertebrate composition	1000 m from agricultural tributaries 5000 m from treatment plant outfalls

* Environment Canada and Ministère du Développement durable, de l'Environnement et des Parcs du Québec. 2007.

The low marshes and aquatic grass beds of Lake Saint-Pierre are home to a fairly diversified community of benthic invertebrates with more than 60 families. However, 5 groups alone account for 76.5% of the total abundance of the organisms sampled. By order of importance, these groups

are amphipod crustaceans (Gammaridea) (39.9%), aquatic worms (Oligochaeta) (16.0%), midge larvae (Chironomidae) (8.9%), isopod crustaceans (Asellidae) (6.7%) and mayfly larvae (Caenidae) (5.0%).

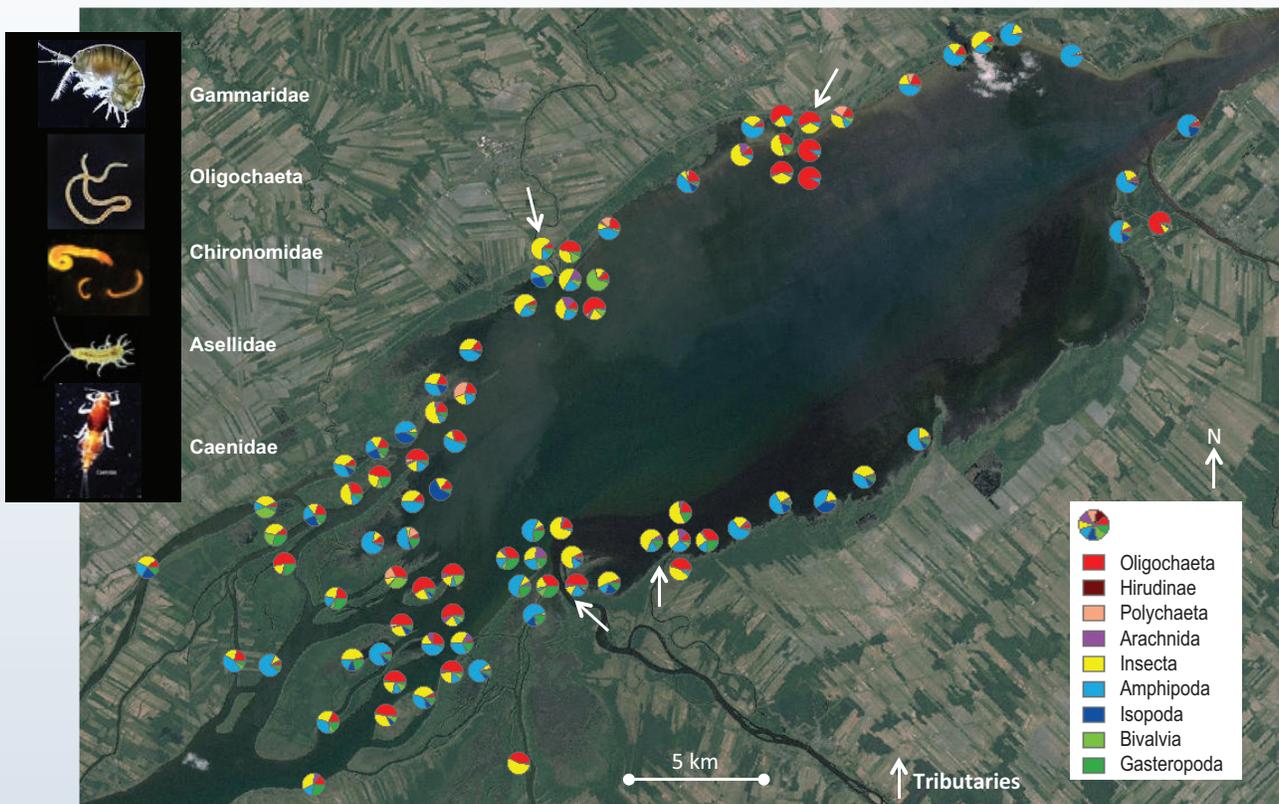


Figure 3 Distribution of the dominant macroinvertebrates in Lake Saint-Pierre

The influence of tributary inflow plumes in the St. Lawrence is evident in changes in the composition of macroinvertebrate communities. A greater proportion of oligochaetes and insects is observed downstream from these tributaries. The communities located around islands in the Berthier-Sorel archipelago also exhibit greater diversification in terms of their composition, whereas communities located on the lake's north and south shores away from tributaries are dominated by amphipods, insects and isopods in that order.

In the fluvial section between Montréal and Sorel, the low marshes are fairly similar to sites further downstream in Lake Saint-Pierre in terms of their macroinvertebrate composition. By order of importance, the dominant groups

are amphipod crustaceans (Gammaridea) (36.1%), aquatic worms (Oligochaeta) (21.6%), midge larvae (Chironomidae) (8.1%), dragonfly larvae (Coenagrionidae) (5.0%) and water mites (4.6%). The influence of the plume from the municipal wastewater treatment plant in Montréal appears evident through changes in the macroinvertebrate community, with very strong dominance by Oligochaeta noted at the Île Sainte-Thérèse and Île Contrecoeur stations exposed to this inflow.

Lake Saint-Louis, meanwhile, presents a more sharply contrasting distribution compared with distributions in other areas of the river. The lake's strong dominance of amphipod crustaceans (Gammaridea) is noted here, with that group

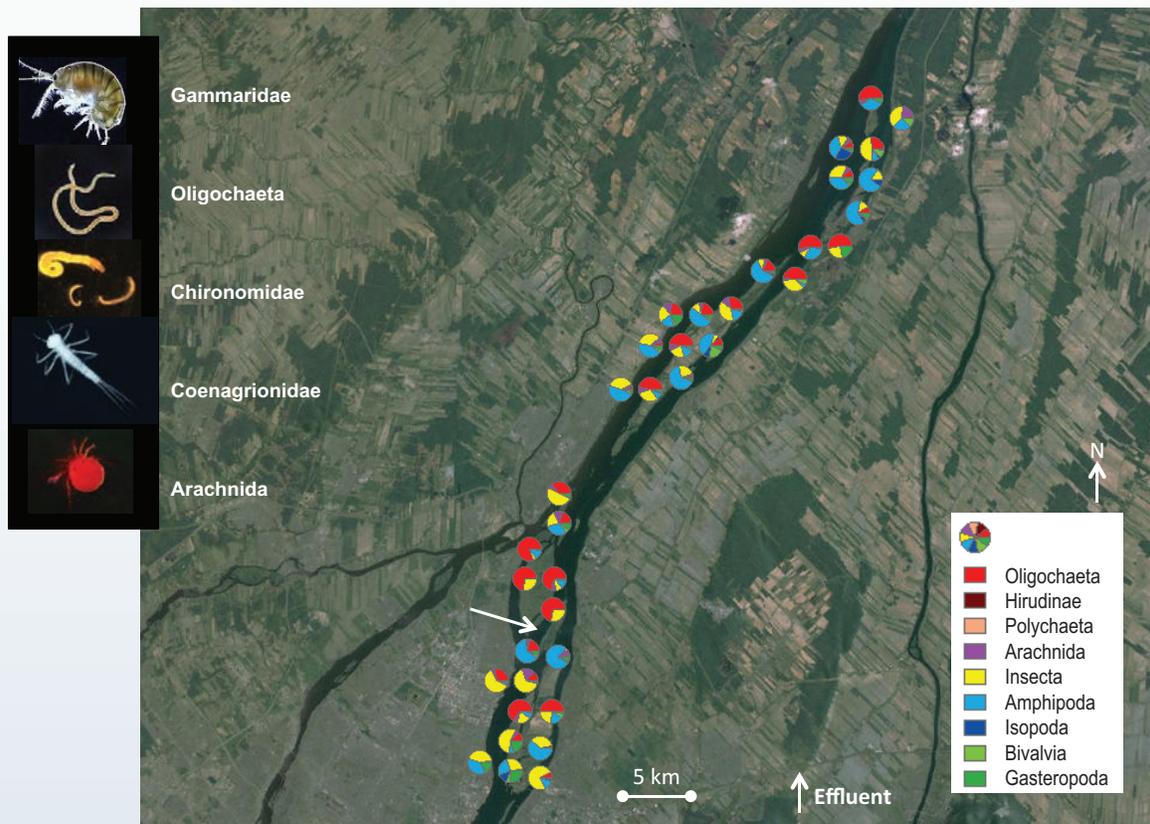


Figure 4 Distribution of the dominant macroinvertebrates in the fluvial section between Montréal and Sorel

accounting for 65.0% of all macroinvertebrates sampled. This lake also contains mayfly larvae (Caenidae) (6.6%), aquatic worms (Oligochaeta) (4.7%), water mites (4.4%) and midge fly larvae (Chironomidea) (4.0%). Lake Saint-Louis is also notable in that it is home to numerous families of pollution-sensitive macroinvertebrates—9 families in all—compared with 2 in the fluvial section downstream from Montréal. All sites with the exception of 4 sites around the Îles de la Paix have pollution-sensitive macroinvertebrates in proportions of as high as 38%, giving an indication of

the diversity of the lake’s habitats and a lesser influence of sources of disturbances.

Lake Saint-François was sampled only more recently (2009–2011), which explains the lesser number of sampling sites. The dominant families are aquatic worms (Oligochaeta) (19.6%), midge larvae (Chironomidea) (19.0%), amphipod crustaceans (Gammaridea) (14.3%), water mites (8.9%) and amphipod crustaceans from the Hyalellidae subfamily (7.1%).



Figure 5 Distribution of the dominant macroinvertebrates in Lake Saint-Louis

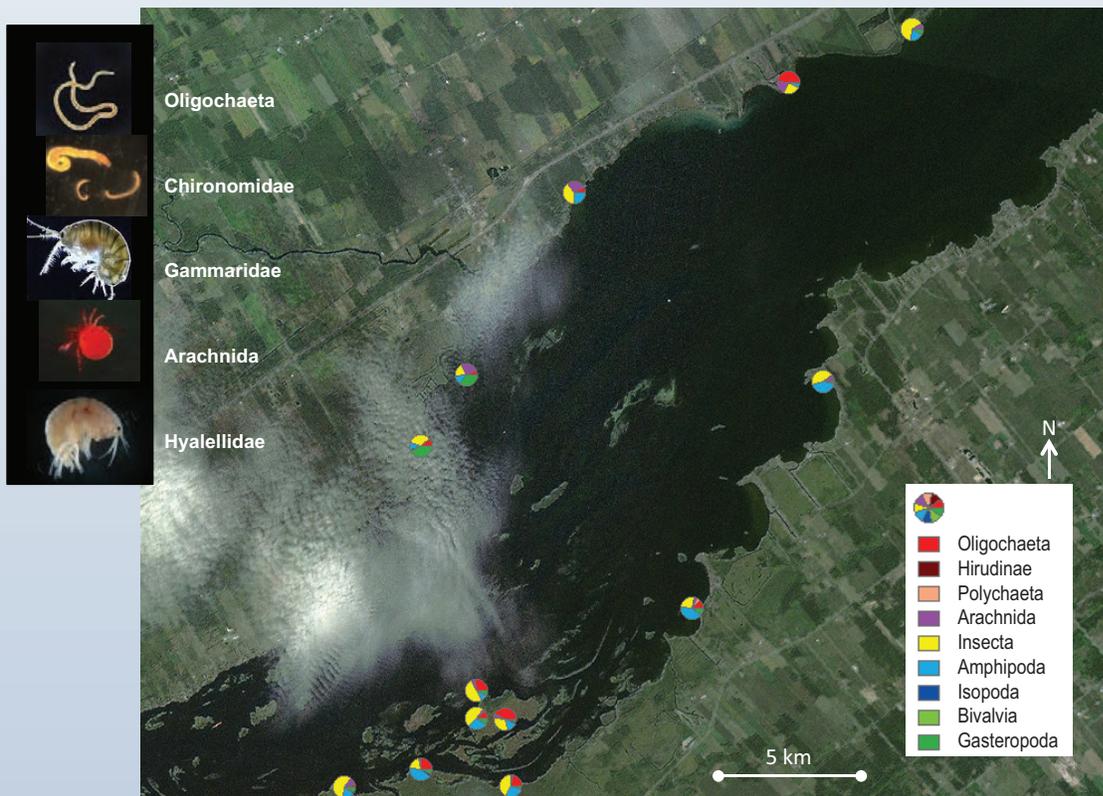


Figure 6 Distribution of the dominant macroinvertebrates in Lake Saint-François

Results of metrics

Laboratory analysis of macroinvertebrate communities was conducted for each sampling site. The results were compiled in spreadsheet format indicating the counts of the various species identified in each sample. Based on these results, the researchers established a series of metrics, or measurements to show each community's composition, richness, diversity and pollution tolerance. A total of 40 metrics were calculated among all 181 river sites located between Lake Saint-François and Lake Saint-Pierre. More detailed analysis of the relationship between these metrics and the degree of disturbance at the sites enabled identification of a number of key metrics that increase or decrease significantly in the presence of disturbances. The metrics identified for use in determining the state of benthic communities were the number of families, the percentage of Ephemeroptera, Plecoptera and Trichoptera, and the percentage of Oligochaetes.

The control sites were used to establish criteria for the metrics through classification of the sites in terms of the various percentiles of the values observed at these sites. The various categories are illustrated using colours (Figure 7) to represent the direction and magnitude of changes in the metric in response to disturbances.

The first metric presented (Figure 8) is that for the number of families (number of taxa) of macroinvertebrates sampled at each site. This metric indicating the richness of communities is known to decrease as disturbances increase. For example, as water quality decreases, the number of macroinvertebrate families also decreases, with only the most tolerant families surviving. The chart depicts the scope of the values observed in each river section; a slight decrease in richness is observed as one travels downstream. The map following the chart illustrates the results of classification at each site based on the criteria defined using the control sites. The fluvial

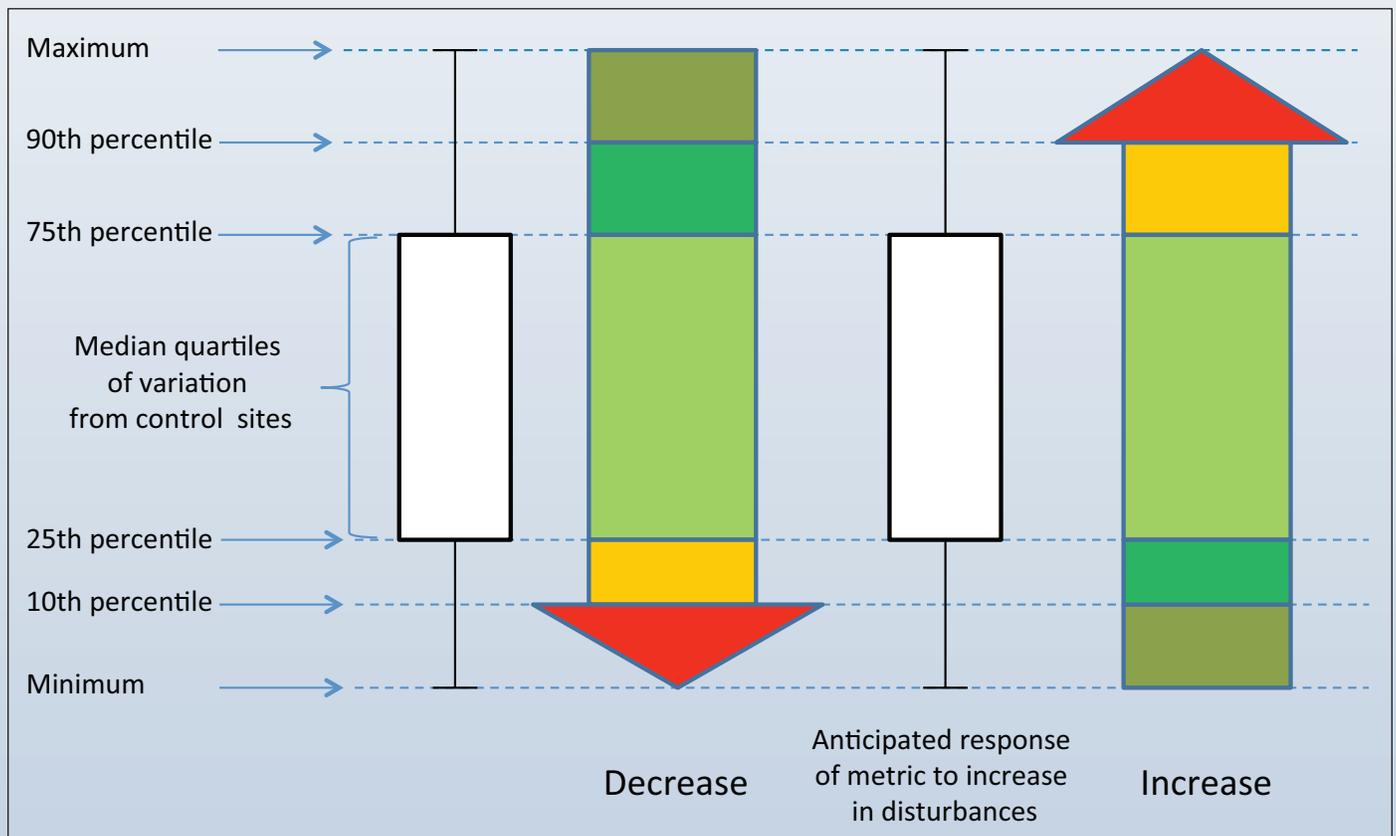
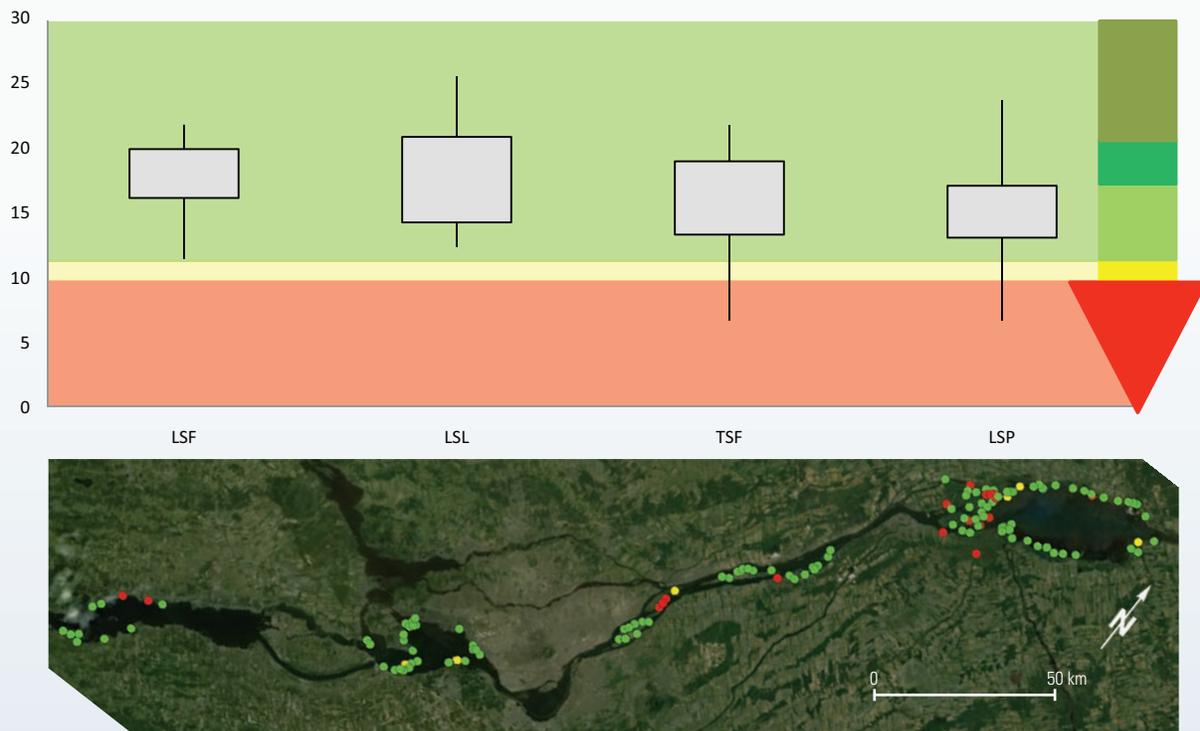


Figure 7 Distribution of metric criteria in percentile form



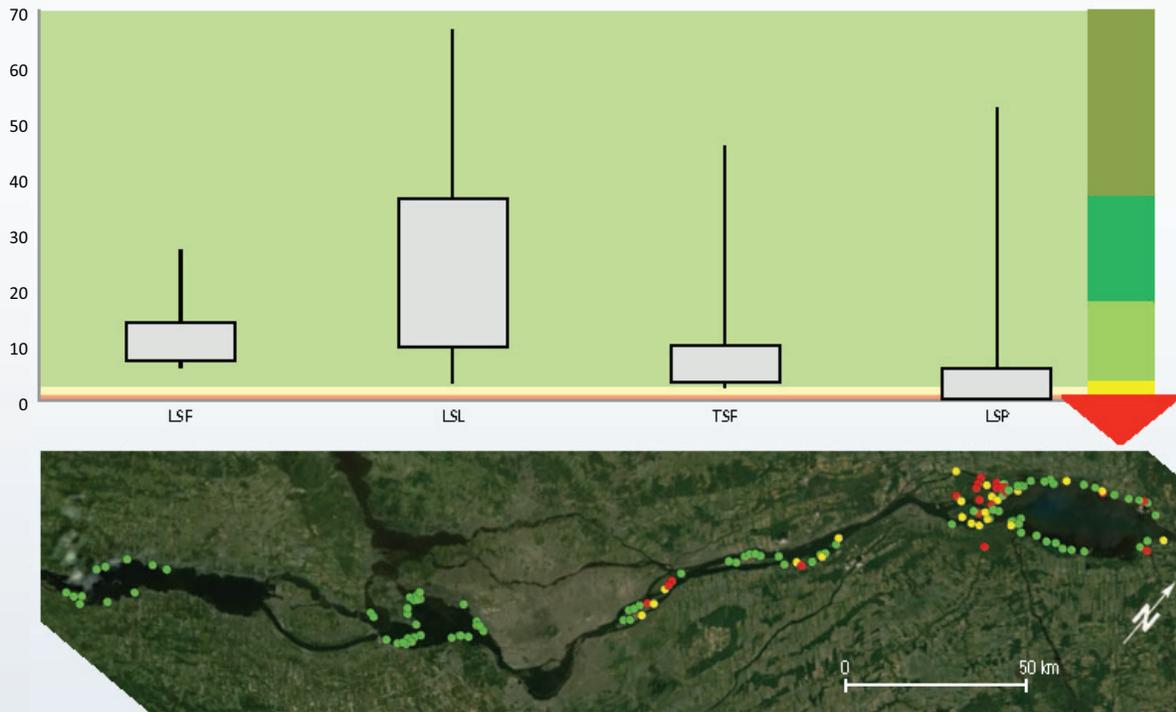
Note: The criteria used were as follows: sites with fewer than 10 families were classified as being in poor condition (red); sites with 11 families in fair condition; and sites with 12 or more families as equivalent or superior to the control sites and consequently in good condition (LSF: Lake Saint-François; LSL: Lake Saint-Louis; FS: Fluvial section; LSP: Lake Saint-Pierre).

Figure 8 Distribution of numbers of taxa (families) of macroinvertebrates at all sites grouped by river section

section and the Berthier-Sorel archipelago are not as rich in macroinvertebrate families as the other areas.

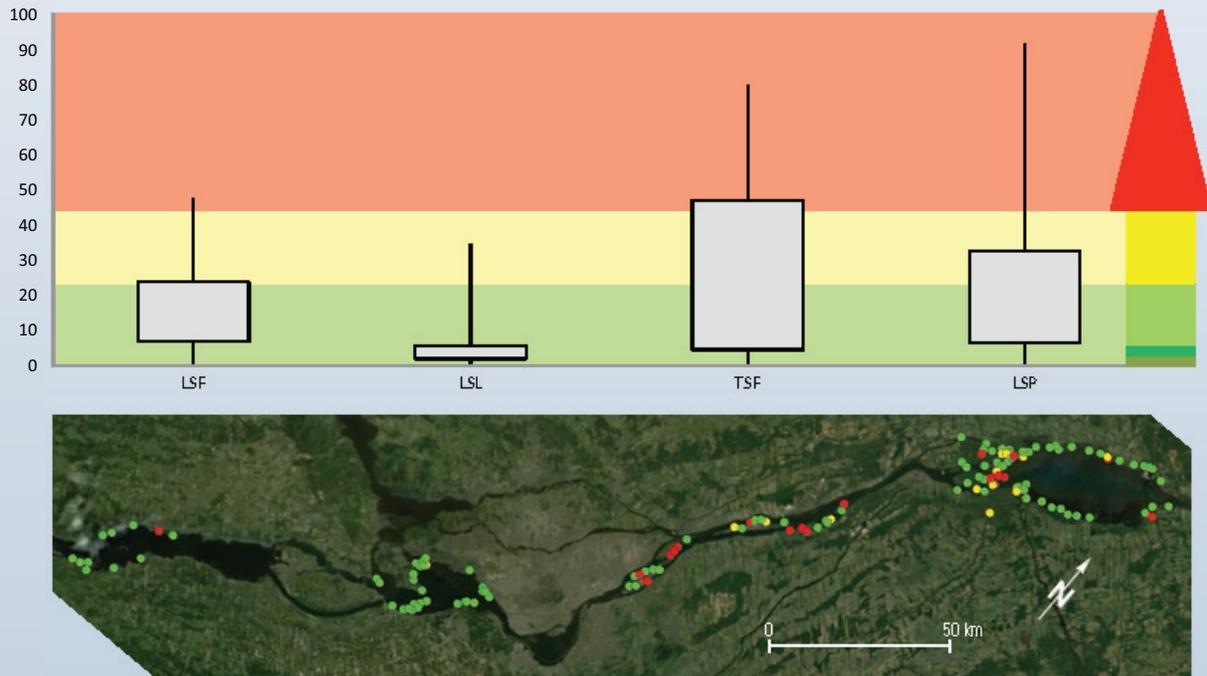
The second metric subject to study was the percentage of Ephemeroptera, Plecoptera and Trichoptera (%EPT) (Figure 9). This metric decreases as disturbances increase, the Ephemeroptera, Plecoptera and Trichoptera families generally being more sensitive to pollution. These families occur abundantly in water bodies of good to excellent quality. The percentage of EPT is significantly higher in Lake Saint-Louis than in other reaches of the river. This is very likely due to the diversity of the substrates in that lake (which are also coarser in the northern part of the lake) and to the presence of brown water from the Ottawa River.

The third metric presented is the percentage of Oligochaetes (Figure 10). Oligochaetes are aquatic worms known to be highly pollution-tolerant. Their proportion consequently increases as local disturbances increase. A notable increase in Oligochaetes is observed beginning at the fluvial section, which is also where the municipal wastewater plume from Montréal enters the river. Sites with a high proportion of Oligochaetes are also found around the Berthier-Sorel archipelago, and there is one such site as well in Lake Saint-François.



Note: The criteria used were as follows: sites where the percentage was between 0% and 0.44% were classified as highly different from the control sites and consequently in poorer condition; sites with a percentage of between 0.45% and 1.70% in fair condition; and sites with a percentage of 1.71% or higher as equivalent or superior to the control sites and consequently in good condition (LSF: Lake Saint-François; LSL: Lake Saint-Louis; FS: Fluvial section; LSP: Lake Saint-Pierre).

Figure 9 Distribution of percentages of Ephemeroptera, Plecoptera and Trichoptera (EPT) at all sites grouped by river section



Note: The criteria used were as follows: sites with a percentage of 47.8% or higher were classified as being in poor condition; between 25.2% and 47.8% in fair condition; and below 25.2% as equivalent or superior to the control sites (LSF: Lake Saint-François; LSL: Lake Saint-Louis; FS: Fluvial section; LSP: Lake Saint-Pierre).

Figure 10 Distribution of percentages of Oligochaetes at all sites grouped by river section

KEY MEASURES

Metrics and reference conditions

Metrics are counts conducted within the macroinvertebrate communities that can serve as intermediate means of assessing biological quality. Metrics may be established for specific composition, richness, diversity or pollution tolerance. The reference condition approach (RCA) is relatively complex but also powerful. It involves developing a statistical model to compare composition in terms of invertebrates found at a site with the average predicted composition values at control sites with similar characteristics with regard to natural habitat. The control sites are selected in areas that have undergone little or no degradation due to human activity. However, these sites can be difficult to find in some areas. If such is the case, control sites are selected in areas exhibiting the most optimal environmental conditions (Table 1).

Besides contributing to the St. Lawrence Action Plan, these studies support the efforts of the Canadian Aquatic Biomonitoring Network (CABIN) (www.ec.gc.ca/rcba-cabin/Default.asp?lang=En&n=72AD8D96-1), a national program targeting the establishment of a network of sites for assessing the health of aquatic ecosystems across Canada.

Perspectives

Although the preceding metrics serve to evaluate different properties of the benthic communities, their responses are all similar. The most highly degraded benthic communities are those in the fluvial section and around the Berthier-Sorel archipelago and, to a lesser extent, on the north shore of Lake Saint-François. These sites were significantly less rich in macroinvertebrates and had a higher proportion of the highly pollution-tolerant worms (Oligochaeta). A reference model highlighting the relationships between community condition, water quality and ecosystem integrity is currently under development. Prior studies have also demonstrated the importance of water levels and the input of organic matter and nutrients as the main stresses for benthic communities in the St. Lawrence (Tall et al. 2008).

For additional information

Armellin, A. 2010. Benthic Macroinvertebrate Communities: An Indicator of Ecosystem Health and Water Quality in Lake Saint-Pierre. A report under the Monitoring the State of the St. Lawrence River Program. http://planstlaurent.qc.ca/fileadmin/site_documents/documents/SESL/communautes_benthiques_2010_e.pdf

Tall, L., G. Méthot, A. Armellin and B. Pinel-Alloul. 2008. Bioassessment of Benthic Macroinvertebrates in Wetland Habitats of Lake Saint-Pierre (St. Lawrence River). *Journal of Great Lakes Research*, 34:599–614.

Environment Canada and Ministère du Développement durable, de l'Environnement et des Parcs du Québec. 2007. Criteria for the Assessment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation. 39 pages.



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State of the St. Lawrence Monitoring Program

Four government partners—Environment Canada, Fisheries and Oceans Canada, Parks Canada Agency, and Ministère du Développement durable, de l'Environnement, 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 its long-term evolution. To this end, environmental indicators have been developed on the basis of data collected as part of each organization's ongoing environmental monitoring activities.

These activities cover the main components of the environment, namely water, sediments, biological resources, uses and shorelines.

For more information on the State of the St. Lawrence Monitoring Program, please visit the program website at www.planstlaurent.qc.ca/en/.

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