

Monitoring the State of the ST. LAWRENCE RIVER



What is the status of benthic communities in the St. Lawrence River?

Indicator name: Benthic communities
Status: Moderate to poor
Trend: No change

Highlights

Benthic macroinvertebrates—insects, worms and molluscs that live on the bottom of lakes and rivers—can be used to determine whether environmental conditions are good or show signs of disturbance. According to the results of monitoring studies conducted by Environment and Climate Change Canada scientists, the status of benthic macroinvertebrate communities in the St. Lawrence River ranges from moderate to poor depending on the sector concerned. An upstream-downstream gradient of degradation has been observed between Lake Saint-François and Lake Saint-Pierre. In Lake Saint-Pierre, all the coastal benthic communities have been exposed to pesticide contamination.

Issue

In natural aquatic ecosystems, benthic organisms are distributed according to their biological needs. Some benthic organisms require oxygen rich water or the presence of calcium, while others live in or on soft or rocky substrates. The set of environmental conditions that a species needs in order to complete its life cycle and maintain a stable population is referred to as its “ecological niche.” Since benthic organisms respond to changes in their environmental conditions, they are useful indicators for aquatic biomonitoring aimed at assessing water quality (presence of nutrients, heavy metals and pesticides).

Certain species are more sensitive than others to various stressors and may exhibit a decrease in their growth or reproduction (chronic effect) or even mortality (acute effect), which may ultimately result in changes in abundance and benthic community composition. Over time, changes in environmental conditions lead to changes within species assemblage living in a biotope. Natural factors that cause change include climatic variations (precipitation, temperature), wetland type (aquatic grass beds vs. low marsh), site elevation or the presence of a competing species.

In addition, there are anthropogenic factors such as urban and agricultural runoff (including, in particular, the pesticides mentioned in this study) whose impacts have been observed on benthic communities downstream from the Island of Montreal. These impacts partly explain the decrease that has been observed in the number of benthic species. Monitoring results for the period prior to 2013 already showed a worrisome situation for benthic communities in the Varennes-Contrecoeur section of the St. Lawrence, around the Contrecoeur Islands and the Berthier-Sorel Islands in Lake Saint-Pierre; however, this was not the case for communities located farther upstream in Lake Saint-François and Lake Saint-Louis (Savage et al., 2013).

Study area

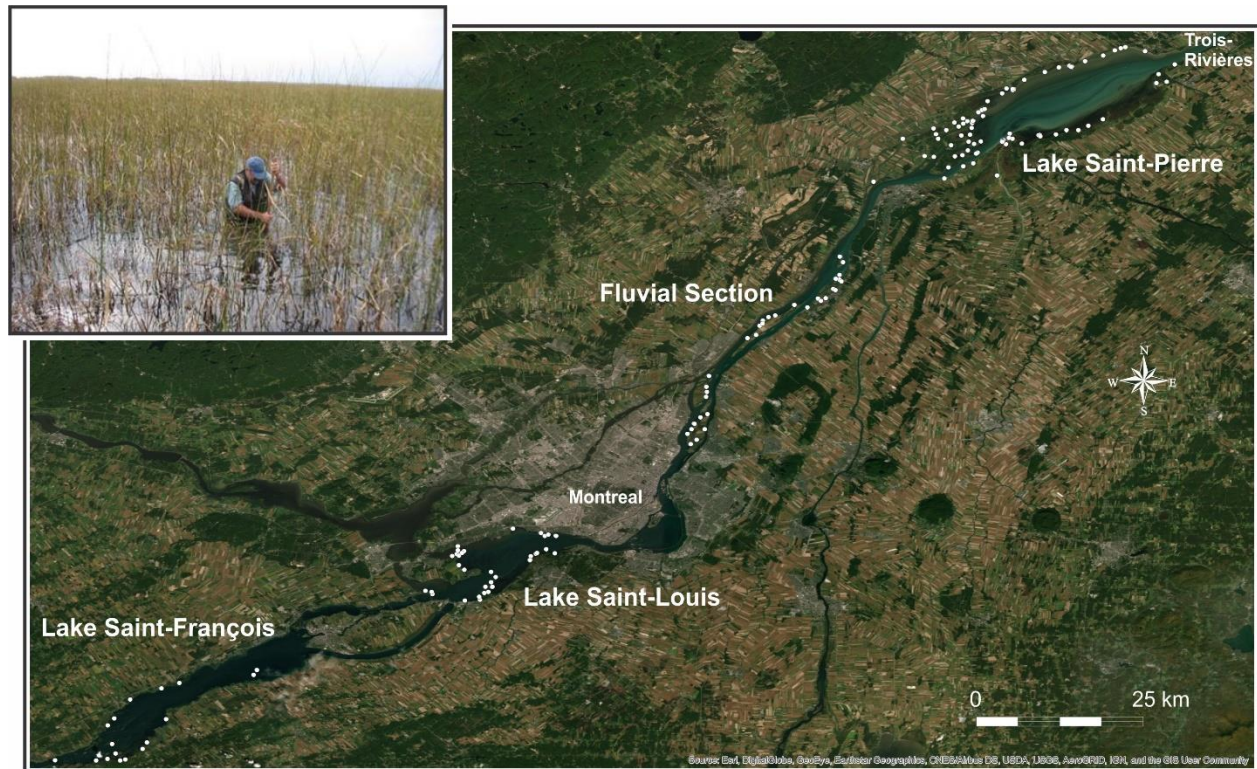


Figure 1: Distribution of benthic macroinvertebrate sampling stations – wetland sampling

The benthic communities were monitored from 2004 to 2018 at sampling stations located in four sectors. From upstream to downstream, they are Lake Saint-François, Lake Saint-Louis, the Varennes-Contrecoeur fluvial section and Lake Saint-Pierre. Samples of benthic macroinvertebrates were collected in aquatic grass beds and coastal low marshes in accordance with the Canadian Aquatic Biomonitoring Network (CABIN) wetland protocol¹.

¹ (<https://www.canada.ca/en/environment-climate-change/services/canadian-aquatic-biomonitoring-network/resources.html>).

Key measures

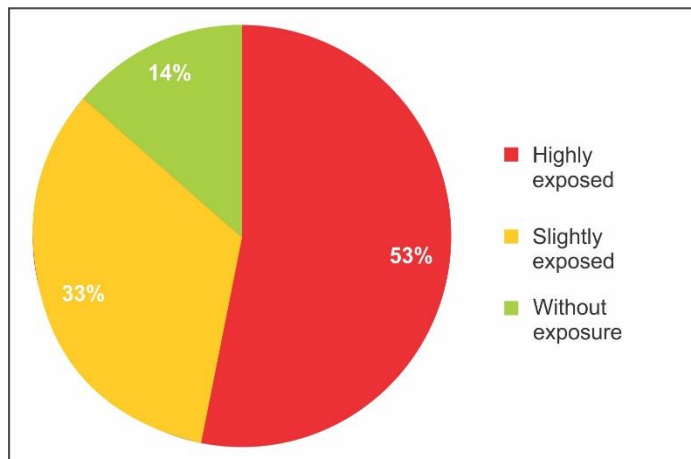
The biological traits of a species are biological, behavioural (growth, foraging, etc.) and ecological (thermal preferences, dissolved oxygen, etc.) descriptors. These traits can be used to assess the diversity of ecological niches and, therefore, the quality of an ecosystem. The SPEAR (SPECies At Risk) bioindicator was used to assess the status of benthic communities because it measures the response of benthic organisms to pesticides (Beketov et al., 2009).

The SPEAR index is based on generation time, migration ability and the presence of sensitive stages (eggs, larvae) during the period of maximum pesticide exposure. This index is advantageous in that it does not consider the particular composition of a benthic community, making it relatively independent of confounding factors related to geography, geomorphology and natural factors that affect benthic communities (von der Ohe and Goedkoop, 2013).

Since no data are available on the sensitivity of most macroinvertebrates to toxic substances, *Daphnia magna* was used as a reference species to estimate relative sensitivity to toxic substances (von der Ohe and Liess, 2004). The SPEAR index ranges in value from 0 to 2, depending on the level of exposure to pesticides. Benthic communities can be classified into three categories: highly exposed ($0 < \text{SPEAR} \leq 0.55$), slightly exposed ($0.55 < \text{SPEAR} < 1.14$) or unexposed ($\text{SPEAR} \geq 1.14$) to pesticides.

Current Status

Taking into account all of the benthic macroinvertebrate communities in the wetlands of the St. Lawrence, the communities at over 50% of the monitoring stations were found to be highly exposed to pesticides, communities at 33% of the stations were slightly exposed



and communities at 14% of the stations were unexposed. The large percentage of highly exposed stations (shown in figure 2) is attributable to the fact that most of the sites sampled were at Lake Saint-Pierre, a sector with a worrisome status in terms of pesticide pollution.

Figure 2: Pesticide exposure at St. Lawrence River stations from 2004 to 2018

In fact, SPEAR index values were found to differ depending on the fluvial section concerned. The median values exhibited a decrease from upstream to downstream, declining from 0.65 in Lake Saint-François to 0.37 in Lake Saint-Pierre. The spatial distribution of the SPEAR index values for the fluvial lakes provides a more nuanced view of areas that are exposed or unexposed to pesticides in the St. Lawrence River study areas.

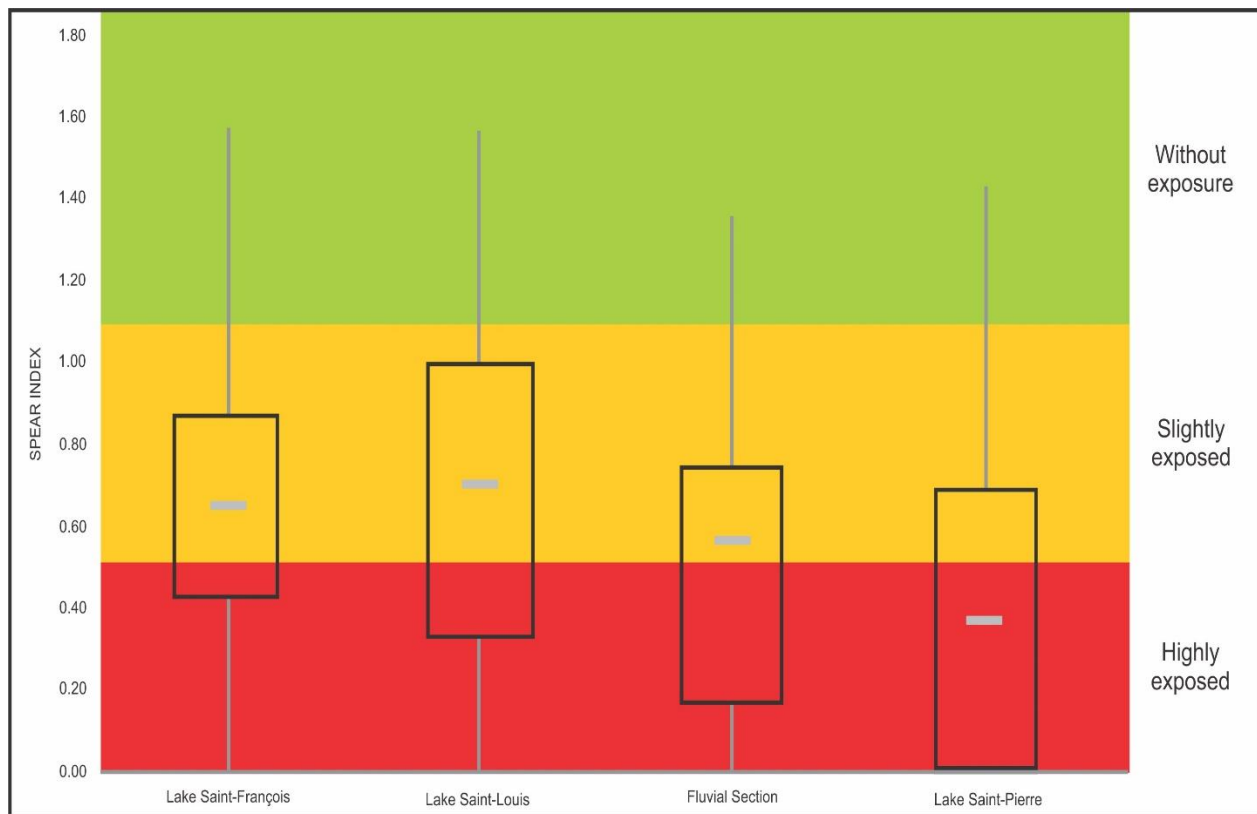


Figure 3: Median SPEAR index values in the four sectors of the St. Lawrence River

In Lake Saint-François, the majority of benthic communities are either slightly exposed or completely unexposed to pesticides. The dispersion plumes of tributaries that drain farmlands have been found to have a slight influence on stations near the Salmon River (south shore) and the Raisin River (north shore).

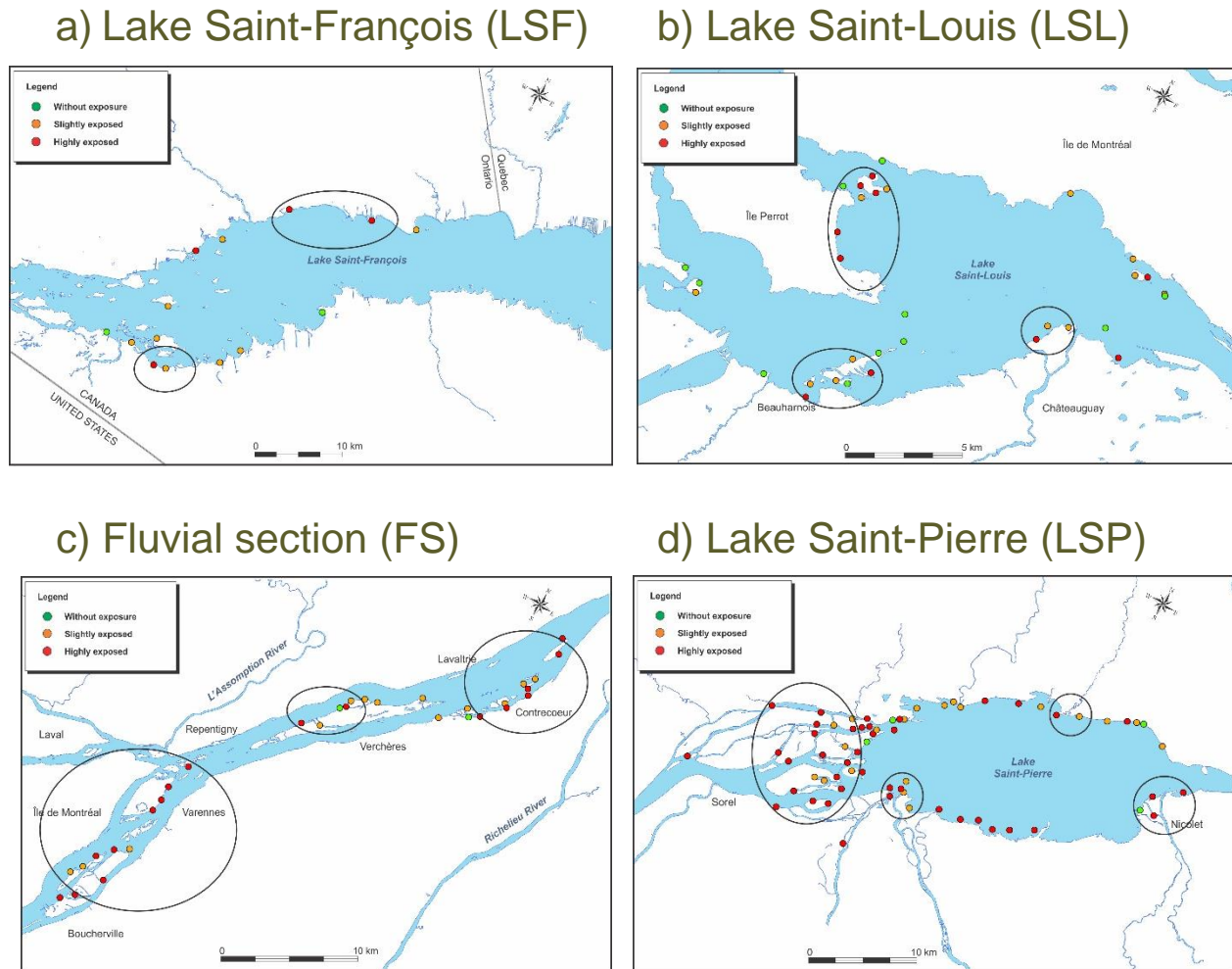


Figure 4: Spatial variation of the SPEAR index in the St. Lawrence River, between Cornwall and Trois-Rivières.

In Lake Saint-Louis, the impact of pesticides is particularly noticeable in three sectors which fall into the highly exposed category: Anse à Perrot on Île Perrot, Îles-de-la-Paix and Île Saint-Bernard. These three sectors are located near potential sources of pesticides, such as landscaping operations in the municipality of Île-Perrot, dispersion plumes from the Saint-Louis River affecting Îles-de-la-Paix and dispersion plumes from the Châteauguay River affecting Île Saint-Bernard. It should be noted that 59% of the Châteauguay River provincial watershed (ministère de l'Environnement et la lutte contre les changements climatiques, 2019a) and 90% of the Saint-Louis River watershed (ministère de l'Environnement et la lutte contre les changements climatiques, 2019b) have an agricultural vocation.

In the fluvial section downstream from Montreal, current land use within the boundaries of Îles-de-Boucherville Park includes corn fields and a golf course. The Varennes and Verchères archipelagos have an agricultural vocation and their shores are exposed to the dispersion plumes from the city of Montreal, which enter the River near Île aux Vaches. The Contrecoeur Islands on the north shore of the municipality of Contrecoeur are highly exposed to pesticides.

The benthic communities in Lake Saint-Pierre, which is located in the core of the St. Lawrence Plain, are heavily affected by pesticides; few sites can be considered to be free from the effects of those substances. The benthic communities in the Baie de la Batture-aux-Carpes and the Baie de l'Île-de-Grâce are the only ones that are not exposed to pesticides. The sectors with the highest exposure levels are the Berthier-Sorel Islands, the south shore (due to the influence of plumes from the Yamaska and Nicolet Rivers) and the mouth of the Yamachiche River on the north shore.

Outlook

It has been known for years that pesticides (fungicides, herbicides and insecticides) are present in the St. Lawrence and that it receives inputs of these substances from its tributaries (Giroux et al., 2016; Trudeau et al., 2010). Pesticide use is closely associated with the production of field crops such as corn and soybean which mostly use herbicides, but also neonicotinoid insecticides. The concentrations of those in Canadian surface waters are likely to have adverse effects on aquatic invertebrates (Anderson et al., 2015). In 2018, corn crops in the Montérégie and Centre-du-Quebec regions accounted for 75% of the grain corn and 38% of the fodder corn produced in Quebec (Institut de la statistique du Québec, 2018). The presence of about 20 different pesticides was detected in the rivers of these two regions. The concentrations of some of these substances, particularly in the Châteauguay and Yamaska Rivers, exceeded the criteria for the protection of aquatic life, producing a chronic effect on benthic communities (Giroux et al., 2016).

Pesticides are applied primarily in the spring. In Lake Saint-Pierre and the Yamaska River, peak concentrations in the water occur between the middle and the end of June (Giroux

et al., 2016; Trudeau et al., 2010). However, these substances have persistent effects on benthic wildlife, given that the SPEAR index values are from samples collected in September, four months after pesticide applications in the spring. In 2018, an ECCC pilot project undertaken in the St. Lawrence River brought to light the presence of several pesticides in the water between May and September, at concentrations of up to 45 ng/L. This was for acetamiprid, chlorantraniliprole, clothianidin-d3 and thiacloprid-13C6 (ECCC, unpublished data). Despite lethal toxicity values not being reached, contaminants have chronic effects on feeding behaviours, predator-prey interactions, life history characteristics, fecundity and other physiological functions of macroinvertebrates. These changes eventually result in a decline in species abundance and diversity in benthic communities; these reductions benefit tolerant species (Beketov et al., 2009; Beketov et al., 2013).

This initial analysis, conducted at the taxonomic level of the family, has made it possible to observe the impact of pesticides in the fluvial section of the St. Lawrence River. However, further calibration will be required to use the SPEAR index as a management tool because, although the majority of families are the same in Europe and North America, there are significant differences at the genus and species levels. Note that the SPEAR index was developed in Europe.

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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.

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