Monitoring the State of the
ST. LAWRENCE RIVER

Safety of potential freshwater St. Lawrence River swimming sites – 3rd edition

Indicator: Potential Freshwater Swimming Sites
Status: Moderate in 2017–2019
Trend: Stable since 2003–2005

Highlights

The bacteriological quality of sixteen sentinel freshwater swimming sites in the St. Lawrence River is considered moderate for 2017–2019. Quality varies among the sites studied, deteriorating immediately downstream of the Montreal urban area.

This state has been stable since 2003–2005 and is mainly due to the absence of major changes in bacterial contamination associated with wastewater overflow during rainy weather and discharge of non-disinfected wastewater from the Montreal area.

Problem

The shores of the St. Lawrence River offer many sites that can be used for recreational activities, including those such as bathing that involve direct contact with water.

Some bathing sites that were abandoned years ago due to poor water quality have reopened, while others remain unsuitable for bathing and, in some cases, for all recreational uses that involve direct or indirect contact with water.

Since 2003, the monitoring program for potential freshwater swimming sites in the St. Lawrence River has resulted in a portrait of the riverbank bacteriological quality at sixteen sentinel sites, including any observed temporal changes. The program was suspended between 2010 and 2016 while awaiting major sanitation operations to be completed, including disinfection of Montreal wastewater and construction of retention basins in Quebec City. Monitoring resumed in 2017 in order to provide an updated status report prior to the completion of the operations in Montreal.

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Photo. While sites along the St. Lawrence attract people, not all are suitable for bathing. The anse Tibbits area is one of the sites monitored by the MELCC. Source: Caroline Anderson.

Study area

Between 1999 and 2002, the Ministère de l'Environnement et de la Lutte contre les changements climatiques studied the bacteriological quality of water at 48 sites between Montreal and Île d'Orléans. The sites were selected on the basis of the following criteria: historic beaches, beaches formerly supervised under the Environnement-Plage program, sites currently in use, existing public access, aesthetic qualities and overall potential for bathing. Since 2003, 16 of these sites have been used as sentinel sites (Figure 1). They have been monitored weekly between late June and late August from 2003 to 2009, and from 2017 to 2019 (10 visits per year).

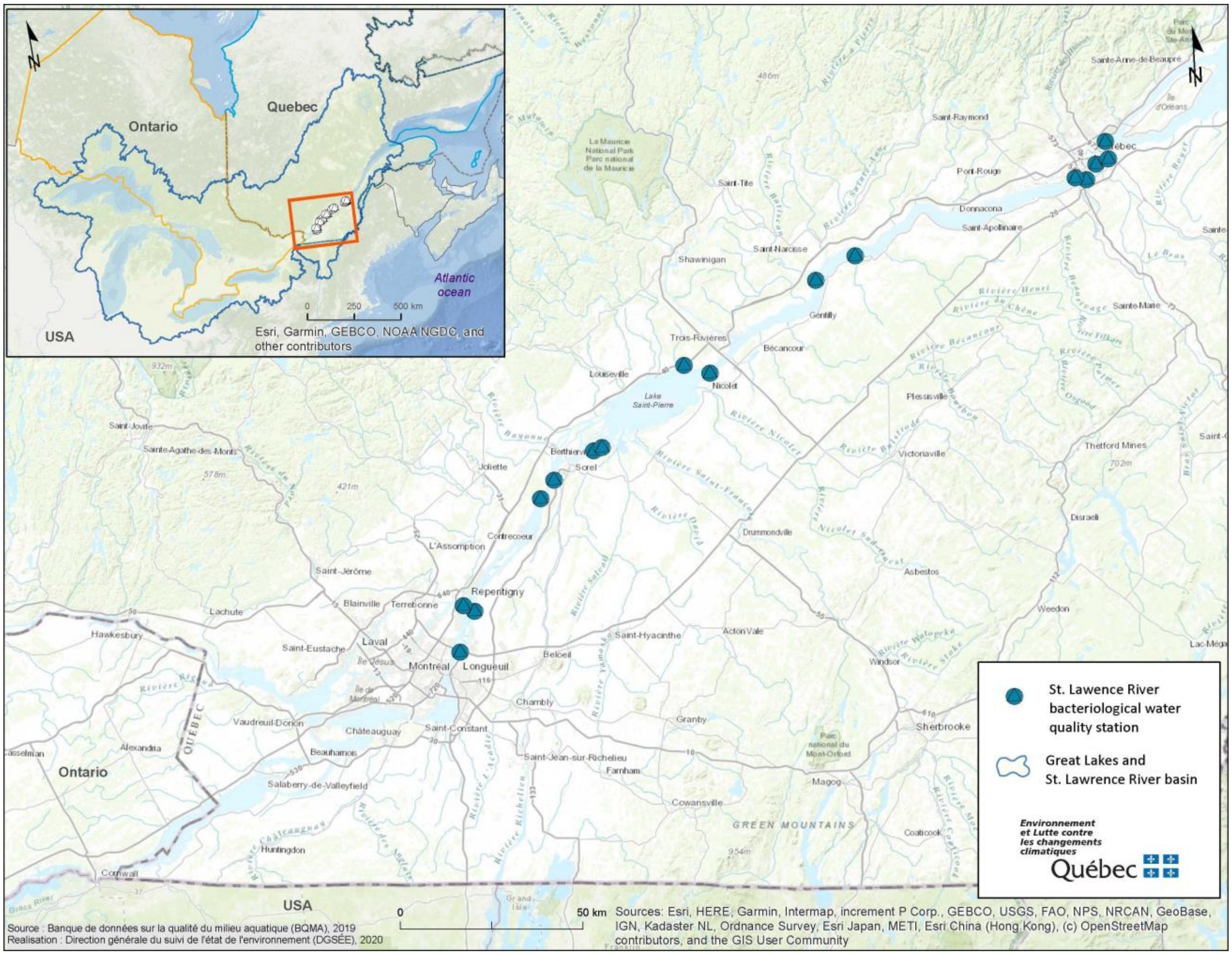

Figure 1. Location of the 16 potential freshwater river swimming sites selected for monitoring.

Key measures

Quality Ratings

Bacteriological quality is assessed using *E. coli* concentrations (CFU/100 ml) in water. The sampling method used prior to 2010 is different from the one used as of 2017, which led to a different method of determining quality ratings (Hebert, 2010; MELCC, 2021a). In the current study, the method used for determining pre-2010 ratings was aligned with the one used in 2017, which may explain some differences in findings from previous publications.

- 2017 to 2019: Two composite samples of three samples each (3 at a depth of 30 cm and 3 at a depth of 1.2 m) were taken per visit. For each site, the rating per visit was obtained by an arithmetic mean of the composite samples. The annual score is the median of the arithmetic means.
- 2003 to 2009: 4 to 6 samples were taken per visit (2 or 3 at each of the two depths). For each site, an arithmetic mean is applied to samples of the same depth to generate two composite samples that are comparable to 2017–2019 data. The rest of the calculations are the same as described for 2017–2019.

The following ratings were assigned on the basis of the calculated value:

- A (excellent quality): 0 to 20 CFU/100 ml;
- B (good quality): 21 to 100 CFU/100 ml;
- C (fair quality): 101 to 200 CFU/100 ml;
- D (poor quality): more than 200 CFU/100 ml. This value corresponds to the established bathing water quality criterion (direct contact).

Bacteriological quality indicators

Four indicators were used to further interpret water quality:

- Percentage of Quality Sites (PQS) refers to the percentage of sites, out of 16 in all, that have excellent or good seasonal bacteriological quality (A or B rating).
- Percentage of Swimmable Days (PSD) is the percentage of days for which the bathing quality criterion of 200 CFU/100 ml is met. It is equivalent to a maximum of 160 days (16 sites × 10 visits) per year.
- The percentage of sites with good potential (SGP) is the percentage of sites with excellent or good potential. This means that bathing is possible at each of these sites at least 70% of the time and that the site has a seasonal rating of A, B, or C (Hebert, 2010).
- Percentage dry weather (PDW) represents the percentage of visits made when the sum of precipitation on the day of sampling and the previous two days was less than 5 mm.

<u>Multi-year values</u>
For multi-year (3-year) results, median *E. coli* concentrations were first calculated by year, to meet the annual basis on which the mechanics for determining the ratings were established (Health Canada, 2012; MELCC, 2021a). For the multi-year quality rating, an average of the three annual medians was then calculated. For the PQS and SGP indicators, annual results by site (3 years × 16 sites) were used.

<u>Overall status of potential swimming sites in the river</u>
The overall status of the indicator is determined by the percentage of sites with good or very good bathing potential (SGP), which are:

- 80 % and above: good;
- 67 % to 79 %: moderate-good;
- 50 % to 66 %: moderate;
- 20 % to 49 %: moderate-poor;
- below 20 %: poor.

Status and trends

Water quality for bathing varies by site

The overall status of the sixteen potential swimming sites for 2017–2019 was moderate. Nearly 65 % of the sites on average had good or very good potential (SGP). This means that about two out of three sites were swimmable at least 70 % of the time and that their annual ratings for 2017-2019 were A through C. As well, on average, just under half (44 %) of the sites achieved a Quality Site Rating (PQS), ranking excellent or good (A or B) for the 2017-2019 interval. For all sites combined, 64 % of the days monitored were swimmable (PSD).

Water quality varied among the sites surveyed (Figure 2). The difference in measured *E. coli* concentrations among them was statistically significant (analysis of variance; $p < 0.05$). This suggests that the sources of contamination or their effects vary among the study sites.

In particular, the site with excellent quality (Figures 2 and 3, site *a*) had significantly lower *E. coli* concentrations than all other sites (t-test with Bonferroni corrections; $p < 0.01$). Located upstream of non-disinfected sewage discharges from Montreal, Longueuil and Repentigny, it might also be less affected by sewage overflow in wet weather than sites *b* and *c* (Hébert, 2010) and is now opened for bathing. By contrast, the two sites with significantly ($p < 0.0001$) higher concentrations than all other stations (Figures 2 and 3, sites *d* and *f*) are located downstream of the non-disinfected sewage discharges from the Montreal area and may also be influenced by raw sewage overflow directly into the river, as well as into the L'Assomption, des Prairies and Mille-Îles rivers (Hébert, 2010; City of Montreal, 2019; MELCC, 2020a). Median water quality at these sites was deteriorated to the point where it approached or exceeded the surface water quality criterion for indirect contact (e.g., canoeing, fishing) of 1000 CFU/100 ml.

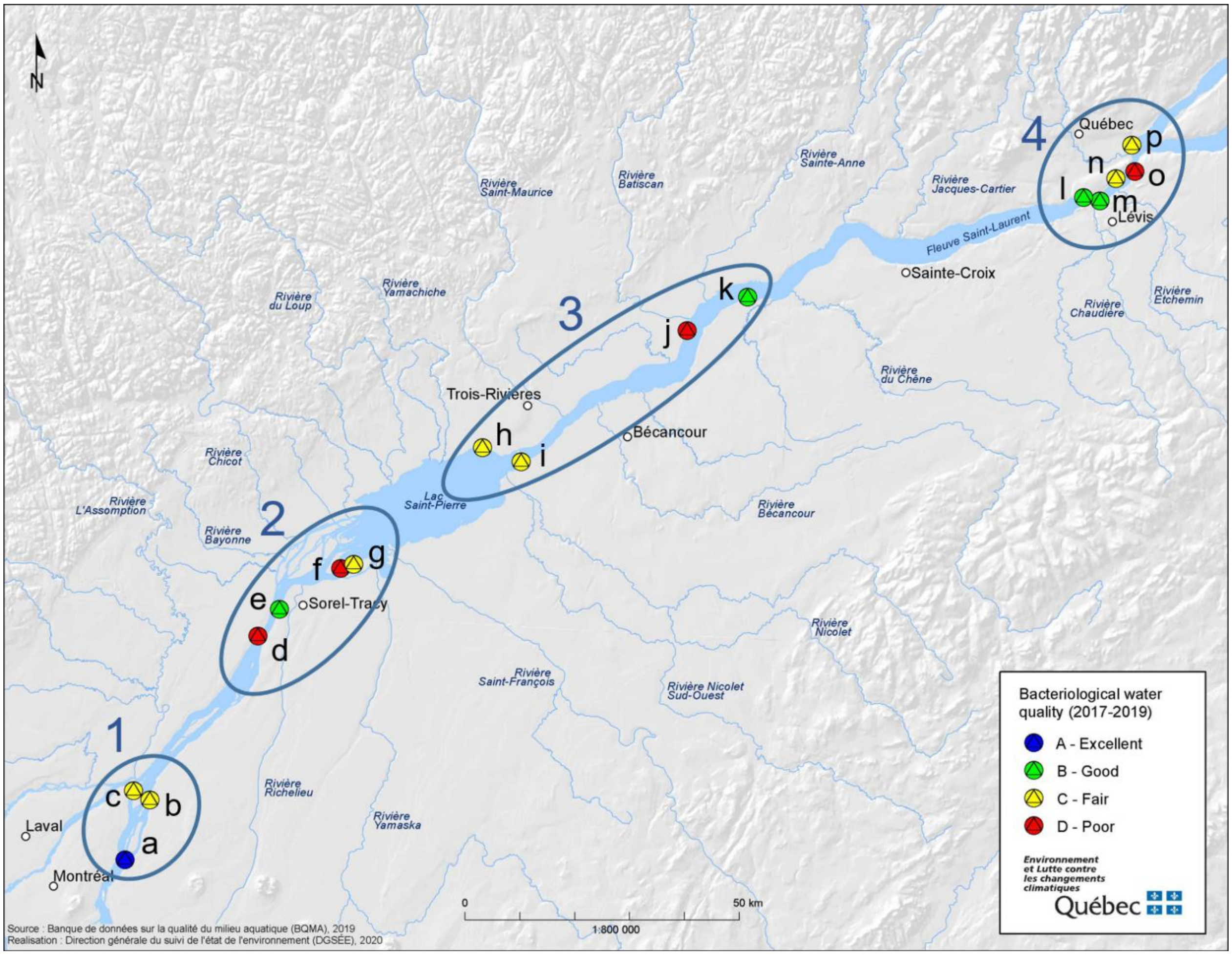

Figure 2. 2017–2019 bacteriological quality at potential freshwater bathing sites in the St. Lawrence River. Four stretches are identified by circles and numbered from 1 to 4: 1) Longueuil to Varennes; 2) Lanoraie to the islands of Sorel; 3) Francheville to Deschaillons; 4) Quebec-Lévis. Sites are identified by letters *a* to *p*. *a*: Parc de l'Île-Charron, Longueuil; *b*: Parc de la Commune, Varennes; *c*: Parc Pierre-Payet, Pointe-aux-Trembles; *d*: Quai de Lanoraie, Lanoraie; *e*: Parc Maisouna, Sorel-Tracy; *f*: Île à la Pierre, Sainte-Anne-de-Sorel; *g*: Île des Barques, Sainte-Anne-de-Sorel; *h*: Club Multivoile 4 Saisons Centre nautique de Francheville, (Trois-Rivières); *i*: Parc Port-Saint-François, Nicolet; *j*: Plage Batiscan, Batiscan; *k*: Club nautique D'Eschaillons, Deschaillons-sur-Saint-Laurent; *l*: Parc de la Plage-Jacques-Cartier, Quebec City; *m*: Parc de la Marina-de-la-Chaudière, Saint-Romuald; *n*: Anse-au-Foulon, Quebec City; *o*: Parc de l'Anse-Tibbits, Lévis; *p*: Plage de la Baie de Beauport, Quebec City.

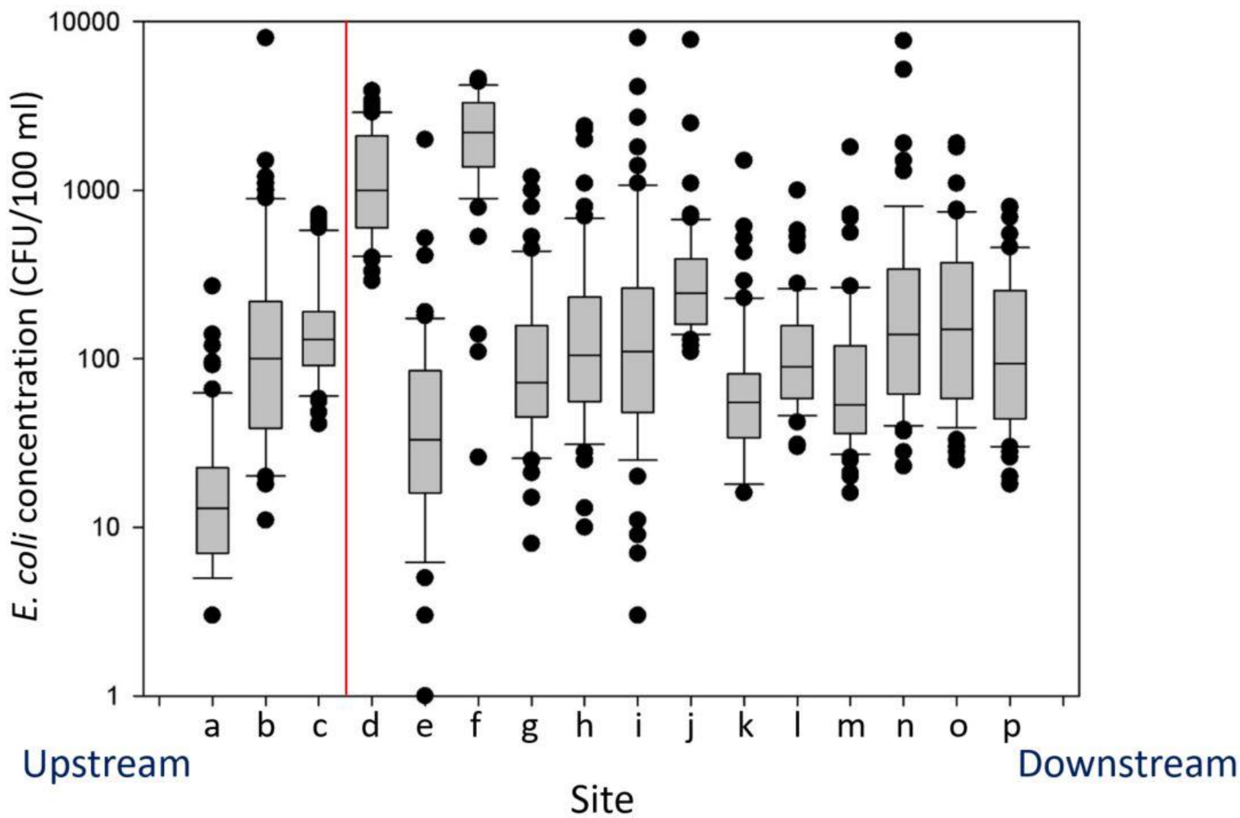

Figure 3. Box plot representing variability in measured *E. coli* concentrations by site for 2017–2019. Site identification (*a* through *p*) corresponds to Figure 2. The red vertical line indicates the separation between the upstream and downstream location from Montreal's non-disinfected wastewater discharge.

Figure 4 presents the distribution of quality ratings based on the four river stretches shown in Figure 2:

1. Longueuil to Varennes (upstream of Montreal wastewater effluent; potential local influences);
2. Lanoraie to Sorel Islands (potentially influenced by Montreal wastewater effluent and other local sources);
3. Francheville to Deschaillons (potential local influences);
4. Québec-Lévis (potential local influences).

Bacteriological quality deteriorates immediately downstream of the Montreal area, with the distribution of poor quality (D rating) increasing from 19% to 58% between the stretch upstream of the non-disinfected Montreal discharge and the one located downstream.

Quality remained variable between Francheville and Deschaillons, depending on the site. Local sources of contamination must be considered, but it is not excluded that the bacterial plume from the Montreal urban area also affects some of these sites on occasion. In fact, the monitoring of the main water masses of the river by the MELCC (Groupe de travail

Suivi de l’état du Saint-Laurent, 2019) shows that this plume is still perceptible at the outlet of Lac Saint-Pierre, in Trois-Rivières.

However, water quality tends to improve in the Quebec City-Lévis sector, with a decrease in D ratings to 29%. Yet the percentage of dry weather was higher at the time of sampling for this section, which may explain some of the improvement noted.

Overall, non-disinfected discharge from the Montreal, Longueuil and Repentigny wastewater treatment plants compromise recreational use (direct and indirect contact) on a portion of the river. However, there remain some enclaves where bacteriological quality measured in 2017–2019 was good (4 sites) or excellent (1 site).

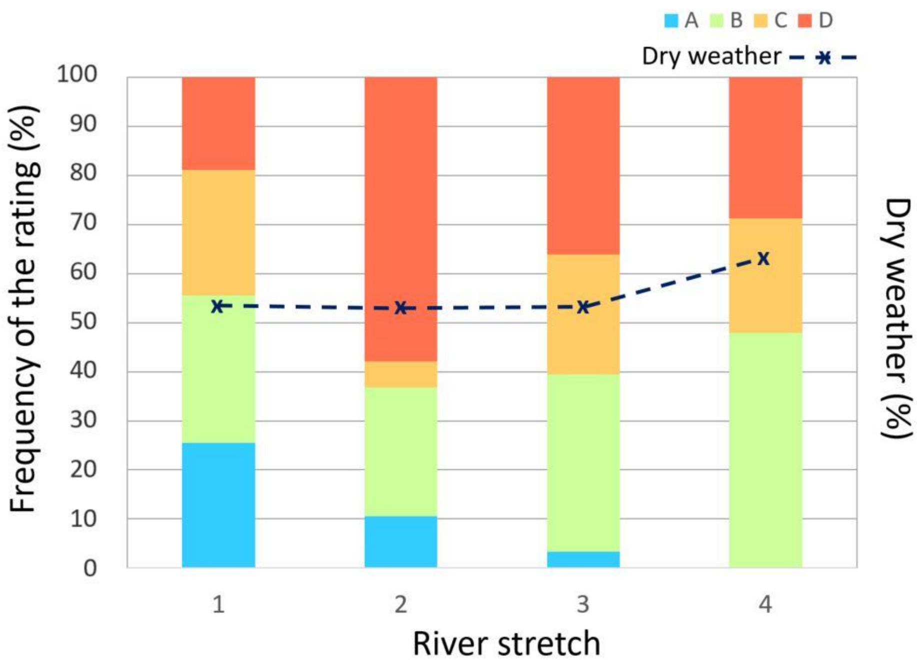

Figure 4. Distribution of quality ratings and dry weather by river stretch for 2017–2019. The percentages of ratings and dry weather were compiled with data obtained by visit date for each site in one given stretch.

A trend that doesn’t improve much

The state of potential swimming sites in the river varies from moderate-poor to moderate-good depending on the monitoring year (Figure 5). The quality indicators also show significant variability among monitoring years (Figure 6).

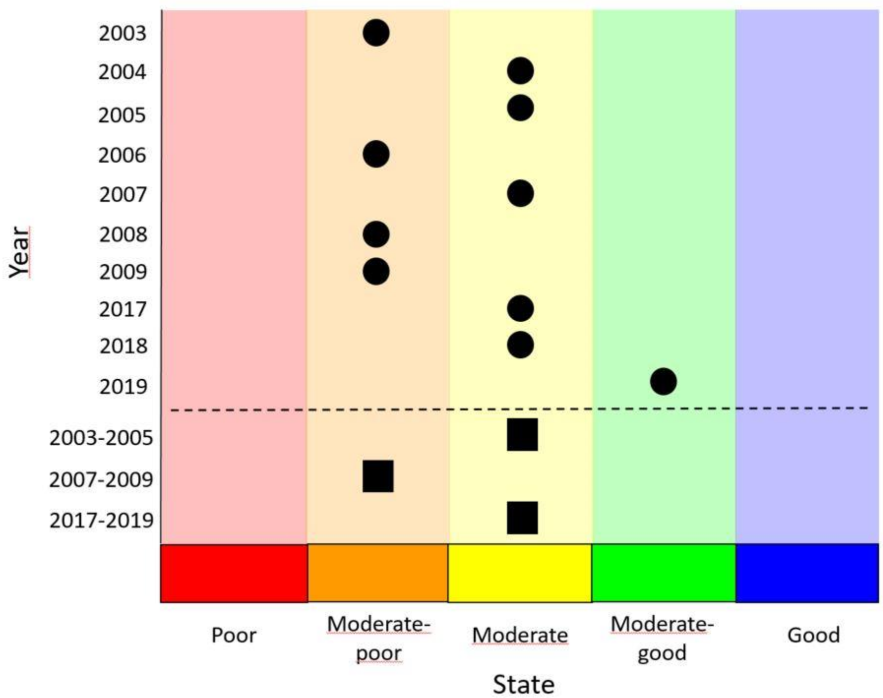

Figure 5. Changes in the overall status of potential freshwater swimming sites in the river between 2003 and 2019.

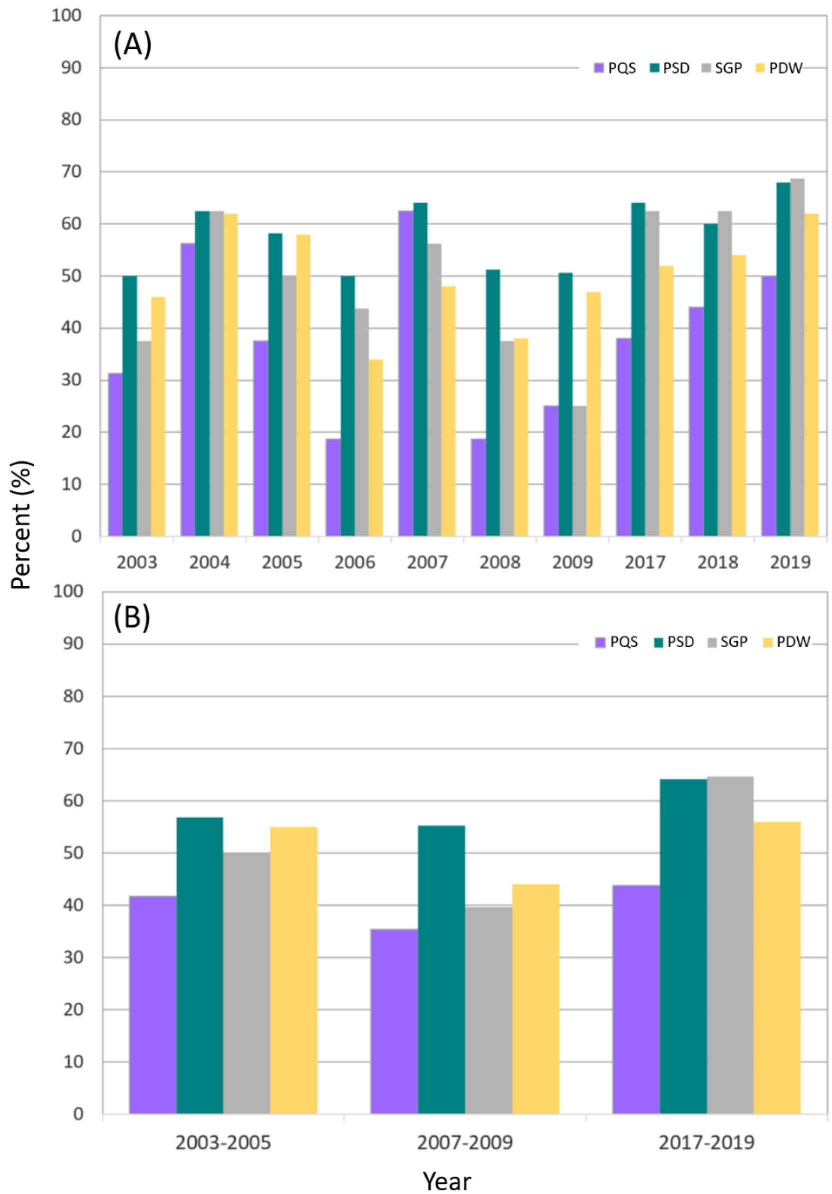

Figure 6. Changes in quality indicators for potential swimming sites (A) between 2003 and 2019 and (B) for 2003–2005, 2007 to 2009 and 2017–2019.

In order to assess temporal trends and reduce the effect of inter-annual variability, the trend was assessed by grouping years 2003 to 2005 and 2017 to 2019. The overall trend for these two groups is maintenance of moderate status. The years 2007 to 2009 (prior to the suspension of monitoring) were also examined (Figure 6). The 2007–2009 period had a lower percentage of quality sites, swimmable days, and good potential sites than the other two groups, resulting in a moderate-poor status.

The inter-annual variability in bacteriological water quality can be explained in part by the percentages of dry and wet weather. Years characterized by a greater percentage of sampling during dry weather had a significantly ($p < 0.05$) greater percentage of quality sites ($rs = 0.76$), swimmable days ($r^2 = 0.59$) and good potential sites ($r^2 = 0.45$).

This observation is consistent with studies conducted in Quebec and elsewhere in the world demonstrating the effect of precipitation on increasing wastewater overflow and subsequent deterioration of the bacteriological quality of aquatic environments (Fortier, 2013; Hébert, 2010; MELCC, 2020a; Rechenburg et al., 2006; Shah et al., 2007; Shehane et al., 2005). In agricultural settings, surface runoff may also add microorganisms associated with animal droppings to streams (Garcia-Arminsen & Servais, 2007; Patoine, 2011; Patoine & D'Auteuil-Potvin, 2015; Sullivan et al., 2007). Hence, increased runoff from heavy precipitation could contribute to the further deterioration of bacteriological water quality. For the St. Lawrence River itself, however, sources of agricultural origin have a lesser impact than those of urban origin (Roy, 2002; Hébert, 2010). They could nevertheless explain some of the variation in water quality at sites subject to the influence of agricultural tributaries.

In terms of temporal trends, the percentage of dry weather was higher in 2017–2019 and 2003–2005 compared to 2007–2009. This could help explain the slight deterioration noted for the latter group of years, given that the situation changed little among the periods studied with respect to non-disinfected water from the Montreal sector.

The water depth and tidal effect

Sites were sampled at two depths: 0.3 m and 1.2 m. These correspond approximately to the depth at which children wade and the depth at which an average adult would swim and submerge. Analysis of the paired data reveals that median *E. coli* concentrations measured between 2017 and 2019 at 0.3 m were higher ($p < 0.0001$; sign test) than those observed at 1.2 m. The median difference in concentrations between the two depths is 62 CFU/100 ml for all cases where differences were positive. However, this value varied widely by site (from 1% to 98% of the value measured at 0.3 m).

The higher contamination at 0.3 m could be explained by wave resuspension of *E. coli* that would have settled in shoreline sediments (Health Canada, 2012). Contamination from leaching of bird droppings, which has been observed along the river's edges at some sites, is another possible source (Health Canada, 2012; Wither et al., 2005).

A tidal effect was also noted between 2017 and 2019 at the seven stations located in tidal areas. The median *E. coli* concentration was significantly higher ($p < 0.001$; ANOVA with interaction) at ebb tide than at flood tide, while variability in concentrations was greater at flood tide ($p < 0.05$; Ansari Bradley test). The tidal effect, however, varied among stations ($p < 0.05$; ANOVA with interaction), suggesting that the quality of some sites is influenced by this factor to a greater extent than others.

Outlook

A significant portion of inter-annual variability in the overall bacteriological quality at the sixteen sampled sites can be explained by the proportion of dry or wet weather days. This suggests that anthropogenic activities that exacerbate the transport of potentially pathogenic microorganisms (e.g. bacteria, viruses) to the aquatic environment during rainy weather have an impact on bathing in the St. Lawrence River.

As such, any action that reduces the frequency of raw wastewater overflow and runoff of microorganisms into an aquatic environment should result in an improvement in the bacteriological quality of the water at the local level.

In addition, the installation of disinfection equipment at wastewater treatment plants remains a preferred choice for recovering recreational practices in the river stretch immediately downstream of the Montreal urban area.

In the context of climate change, where a greater number of extreme rainfall events is predicted, combined with higher temperatures that will undoubtedly lead to Quebecers wanting to cool off by bathing (Rousseau et al., 2004; Fortier, 2013; Ouranos, 2015), such action will prove essential.

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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: https://www.planstlaurent.qc.ca/en/developing-knowledge/state-st-lawrence-monitoring-program.

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