Monitoring the State of the
ST. LAWRENCE RIVER

Bacteriological water quality along the St. Lawrence River shoreline – 4th edition

Indicator: Potential Freshwater Swimming Sites
Status: Moderate–poor in 2022–2024
Trend: Deteriorating since 2017–2019

Highlights

The overall bacteriological water quality along the St. Lawrence River shoreline for 2022–2024 is considered moderate–poor, with only 5 of the 16 sites (32%) showing good potential for recreational use. Water quality varies across sites but deteriorates significantly downstream of the Greater Montreal area.

This represents a decline compared with the 2017–2019 period, which was rated as moderate, and may be explained by a higher proportion of samples collected following heavy rainfall events. Analyses of the full dataset since 2003 have also made it possible to better understand the effects of rainfall and tides on exceedances of the direct contact criterion.

Issue

The shores of the St. Lawrence River offer many sites suitable for a variety of recreational activities, such as swimming, paddleboarding and kayaking. Direct contact with the water associated with these activities poses a health risk, primarily caused by the potential presence of pathogenic microorganisms of fecal origin. Fecal coliforms and *Escherichia coli* (*E. coli*) are used as indicators of fecal contamination (Health Canada, 2024). The higher their concentration, the greater the health risk.

Sources of fecal contamination in surface waters are largely associated with human activities. In urban areas, the discharge of untreated wastewater, the presence of cross-connections in sewer systems and sewer overflows during rainfall events represent significant sources of fecal contamination in watercourses. In agricultural settings, fecal

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contamination of surface waters is mainly linked to improper storage of animal waste or to land application practices that promote its transport by runoff into aquatic environments. The presence of domestic animals and wildlife species, such as bird colonies and aquatic mammals, also contributes to contamination through their droppings.

Since 2003, a monitoring program for sentinel sites along the freshwater section of the St. Lawrence River has made it possible to establish an overview of bacteriological quality along the shoreline and to monitor changes over time.

Photo: The Anse Tibbits area in Lévis is one of the sites monitored by the Ministère de l'Environnement, de la Lutte contre les changements climatiques, de la Faune et des Parcs (MELCCFP). Source: Dominic Vachon.

Study area

Between 1999 and 2002, a study on bacteriological water quality was conducted at 48 sites located along the shores of the St. Lawrence River between Montreal and Île d'Orléans (MELCCFP, 2025a). 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, public access, aesthetic qualities and overall site potential. In 2003, 16 of these sites were selected as sentinel sites (Figure 1) based on their representativeness of the 48 sites. They were monitored weekly from late June to late August (10 visits per year) from 2003 to 2009, as well as from 2017 to 2024.

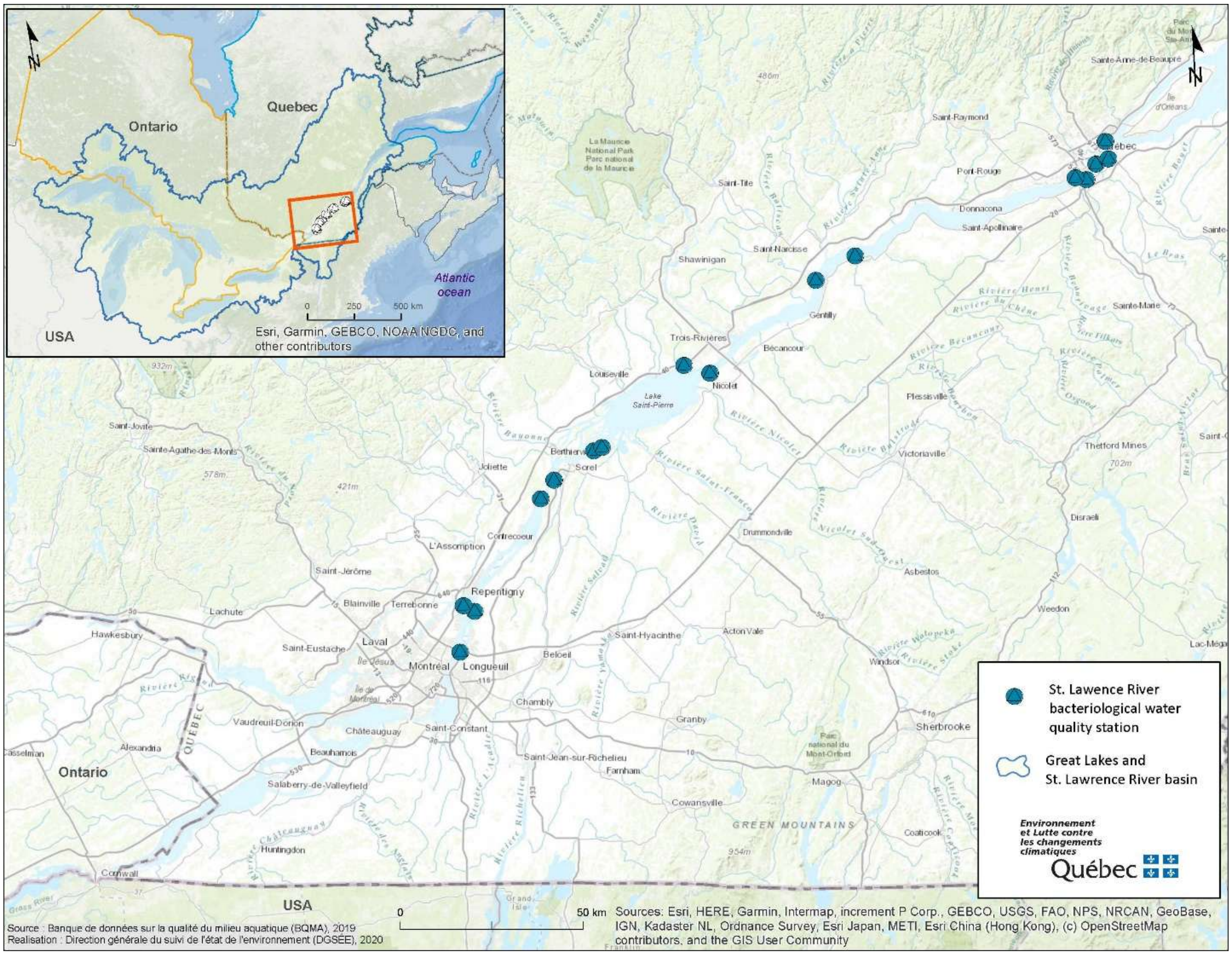

Figure 1. Location of the 16 sites selected for monitoring.

Key measurements

Bacteriological quality measurements by site

Bacteriological quality is assessed by measuring *E. coli* concentrations (colony-forming units per 100 mL; CFU/100 mL) in the water. For each site visit, an *E. coli* concentration is obtained as the arithmetic mean of measurements taken at two depths (30 cm and 1.2 m). From 2003 to 2009, these two measurements consisted of the arithmetic mean of two or three samples per depth. From 2017 to 2024, the two measurements taken during each visit consisted of composite samples made up of three subsamples each (three subsamples at 30 cm and three at a depth of 1.2 m). An annual or three-year rating for each site is derived from the median of the *E. coli* concentrations obtained across all site visits.

Bacteriological quality ratings are assigned on the basis of the median value obtained:

- 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): 201 CFU/100 mL or more

In addition, the site's bacteriological quality is also evaluated on the basis of the frequency of exceedances. This measure corresponds to the percentage of sampled days on which the site's *E. coli* concentration exceeds the direct contact criterion of 200 CFU/100 mL.

Overall condition of sites along the shoreline

The overall status of the indicator is determined by the percentage of sites with good recreational potential, as follows:

- 80% and above: good
- 67% to 79%: moderate–good
- 50% to 66%: moderate
- 20% to 49%: moderate–poor
- Below 20%: poor

The percentage of sites with good recreational potential is calculated as the percentage of 16 sites with a bacteriological quality rating of at least "fair" and a frequency of exceedances of no more than 30% (i.e., at least 70% of samples without exceedance). Note that a change in terminology has been introduced since the 2017–2019 assessment. However, the calculation of the index remains equivalent, allowing for comparisons with previous years.

Status and trends

Water quality along the shoreline varies by location

The bacteriological water quality along the St. Lawrence River shoreline for 2021–2024 is rated moderate–poor, with only 5 of the 16 sites (32%) exhibiting good potential for recreational use. These sites are characterized by a three-year bacteriological quality rating of at least “fair” (median *E. coli* concentrations below 200 CFU/100 mL), and by at least 70% of site visits with no exceedance of the *E. coli* direct contact recreational criterion (200 CFU/100 mL) (MELCCFP, 2025c). This criterion is based on epidemiological studies that establish *E. coli* concentration thresholds. Below these thresholds, the risk is considered acceptable for recreational activities involving direct contact with water, including those that may result in full-body immersion or submersion of the head (Health Canada, 2012, 2023). For the 2022–2024 period, no site received an “excellent” quality rating, and only one quarter of sites were rated “good.” Across all sites sampled between 2022 and 2024, the average *E. coli* concentration exceeded the direct contact criterion of 200 CFU/100 mL in 46% of visits.

However, bacteriological water quality is not uniformly distributed along the St. Lawrence; the shores in certain areas are more affected by poor bacteriological conditions. Figure 2 shows the distribution of *E. coli* concentrations and the frequency of exceedances of the direct contact criterion at various sites for the 2022–2024 period. When the sites are ordered from upstream to downstream, *E. coli* concentrations at sites located between Montreal and Lake Saint-Pierre (Figure 2a) show considerable variability, with ratings ranging from “good” to “poor.” This stretch of the St. Lawrence is characterized by distinct water masses that mix very little, creating a physical barrier between sites along the north and south shores. Some sites are fed by water masses with good bacteriological quality, while others lie within the plume of major discharges of untreated wastewater. This is particularly clear at two sites near Sorel-Tracy (Lanoraie and Île à la Pierre), where *E. coli* concentrations are consistently very high and exceed the direct contact criterion at every visit. Sites located between Lake Saint-Pierre and Quebec City show less variability in *E. coli* concentrations, with most sites having a three-year quality rating in the range between “fair” and “poor.” Nevertheless, the *E. coli* direct contact criterion is frequently exceeded (Figure 2b).

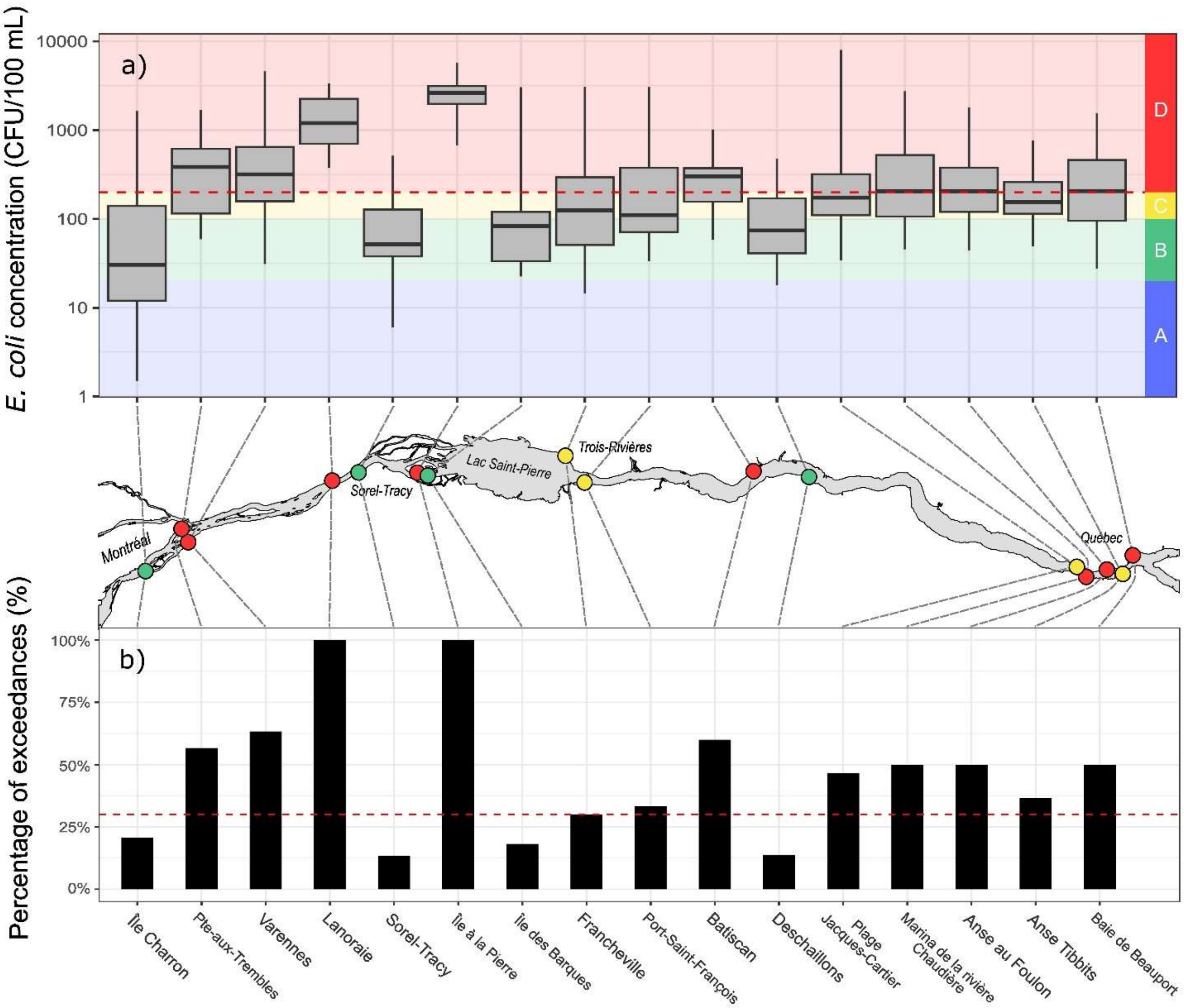

Figure 2. The bacteriological water quality at the 16 sites along the St. Lawrence River shoreline for the 2022–2024 period. **a)** Distribution of *E. coli* concentrations by site, presented as box-and-whisker plots on a logarithmic scale. For each box, the horizontal line indicates the median, and the box limits correspond to the 25th and 75th percentiles. The vertical lines extending from the box represent the range of extreme values. The red dotted line indicates the direct contact criterion of 200 CFU/100 mL. The colours correspond to the bacteriological quality ratings: A (excellent), B (good), C (fair) and D (poor). The median rating for each site is shown on the map. **b)** Percentage of visits between 2022 and 2024, during which the average *E. coli* concentration exceeded the direct contact criterion for each site. The red dotted line indicates the 30% exceedance threshold used to identify sites with good recreational potential.

General trend toward deterioration

The most recent assessment for the 2017–2019 period indicated a moderate status. The bacteriological water quality along the St. Lawrence River shoreline has deteriorated in recent years relative to both recent conditions and those observed at the beginning of the monitoring program. However, the status varies considerably from one year to another, with the percentage of sites with good recreational potential ranging between 20% and 60% (Figure 3). Part of this interannual variability in bacteriological water quality can be explained by the average accumulation of rainfall over a three-day period (the sampling day and the two preceding days) (Anderson, 2021; MELCCFP, 2025d). Years with high three-day rainfall accumulations (such as 2023) have fewer sites with good recreational potential. Conversely, years with better bacteriological water quality coincide with lower average three-day rainfall accumulations, as was the case between 2017 and 2019.

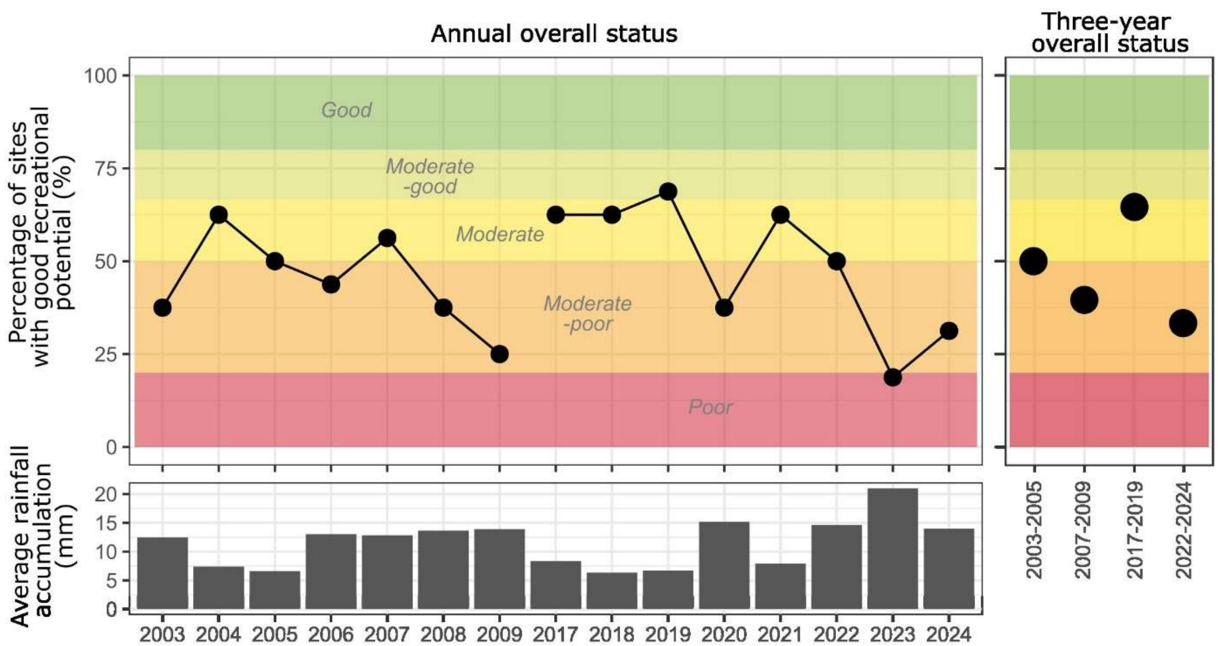

Figure 3. Changes in bacteriological water quality along the St. Lawrence River shoreline between 2003 and 2024. In the upper part of the figure, the overall annual status for the 2003–2009 and 2017–2024 periods, as well as the three-year overall status (three-year block), is determined by the percentage of sites with good recreational potential (%) involving direct contact. The grey bars show the average rainfall accumulation (on the sampling day and the two preceding days) on an annual basis.

Rainfall and tidal effect

Analyses of the full dataset since 2003 have made it possible to better understand the effect of rainfall on exceedances of the direct contact criterion, and therefore on the recreational potential of sites along the St. Lawrence River shoreline. A logistic regression (logit model) was performed on all monitoring stations, using binary data indicating whether the criterion was exceeded (0 = no exceedance observed; 1 = exceedance observed). This type of model makes it possible to estimate the probability that the direct contact criterion will be exceeded as a function of three-day rainfall accumulation, including the sampling day and the two preceding days.

The model results suggest a significant rainfall effect across the St. Lawrence as a whole (Figure 4) and are supported by the agreement between observed exceedance frequencies and model predictions (not shown). As rainfall accumulation increases, the likelihood of exceeding the criterion also increases. For example, when no rainfall accumulation is recorded, the model predicts a 0.39 probability of exceeding the direct contact criterion. In other words, between 2003 and 2024, across all stations, there was approximately a 40% chance of exceeding the criterion under dry conditions (i.e., 0 mm of rainfall accumulation over three days). In addition, the probability threshold of 0.5, above which exceedance becomes more likely than not, is reached with as little as 13 mm of rainfall accumulation over three days. For more intense rainfall events, such as 80 mm of rain, the probability of exceeding the direct contact criterion increases to 0.91. However, the model shows considerable variability, as illustrated by the extent of the grey area around the regression curve, which represents the 95% confidence interval (Figure 4). This variability is mainly caused by differences among sampling sites. The curve therefore reflects the overall behaviour of bacteriological water quality in the St. Lawrence River in response to rainfall events, rather than conditions at any specific site.

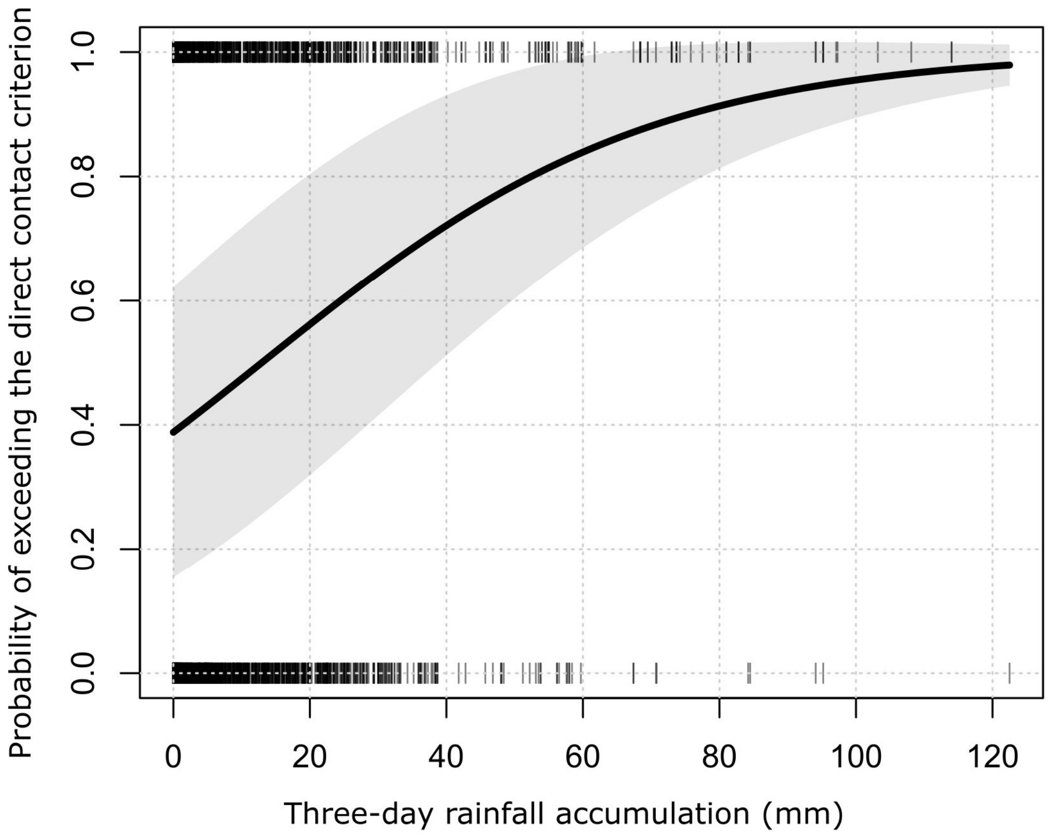

Figure 4. Logistic regression showing the effect of rainfall accumulation on the probability of exceeding the direct contact criterion for all sites combined (n = 2,339). The curve shows a logistic regression (logit) performed using a mixed-effects model with "rainfall accumulation" as the fixed variable and "station" treated as a random effect (glmer function in R; R Core Team, 2023). The fixed variable "rainfall accumulation" is statistically significant according to the Wald test (p < 0.001). The shaded area represents the 95% confidence interval (bootMer function in R; R Core Team, 2023). The thin black lines represent the observed criterion exceedance data (0 = no exceedance observed, 1 = exceedance observed) used to build the model.

A similar analysis evaluating the effect of rainfall events on criterion exceedances is presented by incorporating the additional tidal effect at the seven fluvial estuary stations (Figure 5). The model results were validated through the agreement between observed exceedance frequencies and predictions (not shown). For this model, the "rainfall accumulation" and "tide" variables are significant, whereas the interaction between tide and rainfall is not significant (based on the Wald test). These results indicate that the probabilities of exceeding the direct contact criterion differ between the two tidal conditions, but respond similarly to rainfall accumulation. The probability of exceedance is higher during ebb tides and lower during flood tides. For example, for a three-day rainfall accumulation of 20 mm, the probability of exceeding the criterion is 0.51 during an ebb tide, compared with 0.32 during a flood tide. Improved bacteriological water quality during flood tides has previously been reported for the Quebec City area (Anderson, 2021). This may be explained by the influx of water masses from the St. Lawrence Estuary during flood tides, which are more diluted and therefore contain lower concentrations of *E. coli*.

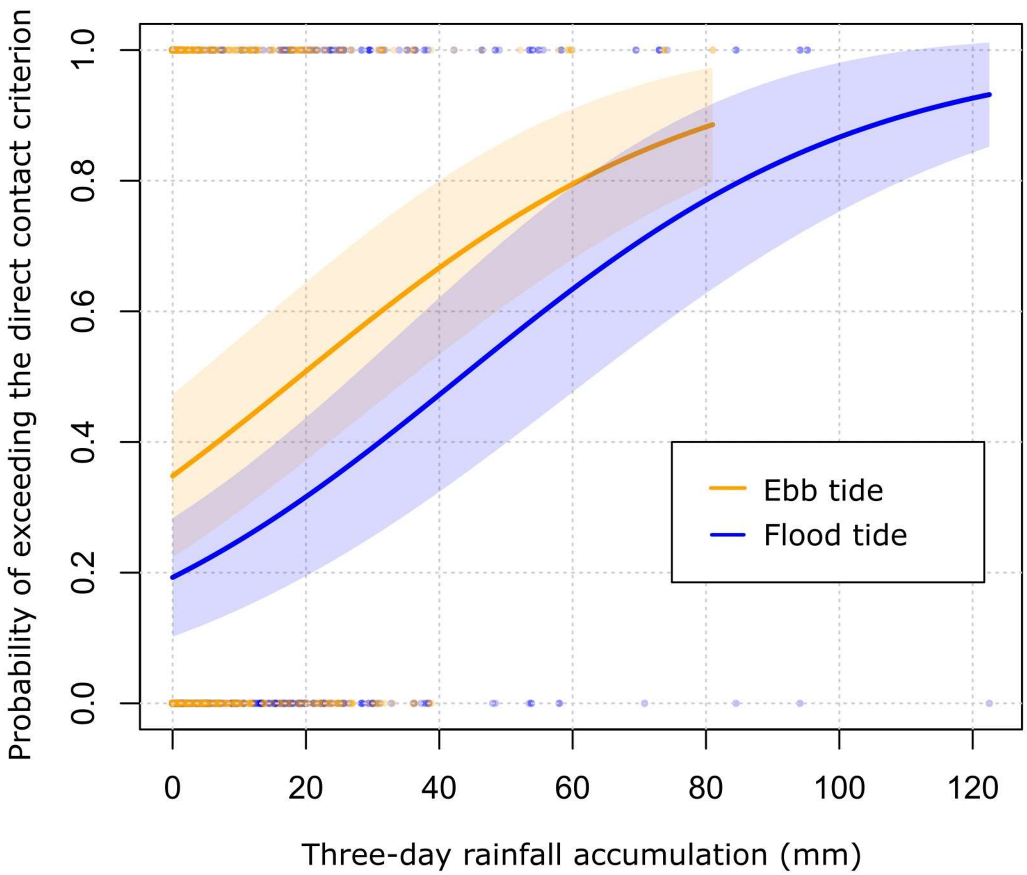

Figure 5. Effect of rainfall accumulation on the probability of exceeding the direct contact criterion during ebb tide (orange) and flood tide (blue) for the seven fluvial estuary stations (n = 1,018). This logistic regression (logit) was performed using a mixed-effects model with "rainfall accumulation" and "tide" as fixed variables (glmer function in R; R Core Team, 2023). The "station" variable was treated as a random effect. All fixed variables in the model are statistically significant ($p < 0.05$) according to the Wald test. The interaction between rainfall and tides was not significant ($p = 0.18$) and was therefore excluded from the model. The shaded areas represent the 95% confidence intervals (bootMer function in R; R Core Team, 2023). The binary data (0 = no exceedance, 1 = criterion exceedance) used to build the model are shown as orange points (ebb tide) and blue points (flood tide).

Outlook

It is well known that heavy rainfall can generate wastewater overflows (Mailhot and Talbot, 2014) and contribute to the deterioration of bacteriological water quality in aquatic environments (Rechenburg et al., 2006; Shah et al., 2007). In addition, other sources of fecal contamination, including those of agricultural origin (Patoine and d'Auteuil-Potvin, 2020), may also be transported to the St. Lawrence by runoff following rainfall events. Therefore, any measures that reduce the frequency of untreated wastewater overflows and limit the transport of microorganisms into aquatic environments should lead to improvements in bacteriological water quality.

Even in the absence of rainfall, concentrations of *E. coli* may still exceed the direct contact criterion, suggesting point sources, such as discharges of untreated wastewater, or indicating the persistence of microorganisms following rainfall events. Once in the environment, fecal coliforms can persist for several days, particularly at low temperatures and with limited exposure to UV radiation (Blaustein et al., 2013; Maraccini et al., 2016). Therefore, the installation of disinfection systems at wastewater treatment plants remains a key measure to restore recreational use at sites located downstream of these types of discharges.

The impact of climate change on bacteriological quality in the St. Lawrence must also be considered. A study on climate change effects in Quebec predicts an increase in the frequency and duration of wastewater overflows in May and October, and a decrease in July and August (Fortier, 2013). An analysis incorporating precipitation projections for Quebec suggests that while the annual number of overflows may remain stable, their volume is expected to increase as a result of extreme rainfall events (MELCCFP, 2023). It is also projected that the risk of drought will increase in summer (MDDLCC, 2018). A recent meta-analysis suggests that, overall, heatwaves and drought events tend to reduce fecal coliform concentrations in watercourses, primarily as a result of decreased non-point source pollution and accelerated die-off caused by higher temperatures (Graham et al., 2024).

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