Sub-Indicator: Beach Advisories

Overall Assessment

Status: Good

Trends:

10-Year Trend (2014-2023): Unchanging

Long-term Trend (Canada – 2010-2023; US – 2008-2023): Unchanging to Improving

Rationale: From 2020 to 2023, monitored Great Lakes beaches were assessed as Good. Monitored U.S. Great Lakes beaches were open and safe for swimming 94% of the swimming season and monitored Canadian Great Lakes beaches were safe for swimming 89% of the swimming season based on the respective acceptable *Escherichia coli (E. coli)* concentrations. The Canadian 10-year trend is assessed as Unchanging as determined by linear regression analysis, which indicated no statistically significant change over time in the Canadian data. The Canadian long-term trend is considered Improving because regression analysis indicated an improvement over the 14-year period. The U.S. trend 10-year and long-term trends are assessed as Unchanging due to linear regression analysis indicating no statistically significant change.

Lake-by-Lake Assessment

Lake Superior

Status: Good

10-Year Trend (2014-2023): Unchanging to Improving

Long-term Trend (Canada – 2010-2023; US – 2008-2023): Unchanging to Improving

Rationale: From 2020 to 2023, monitored Lake Superior beaches were assessed as Good. U.S. Lake Superior beaches were open and safe for swimming for an average of 98% of the swimming season and monitored Canadian Lake Superior beaches were safe for swimming an average of 99% of the swimming season based on the respective acceptable *E. coli* concentrations. The 10-year and long-term trends based on Canadian Lake Superior beach data are both assessed as Improving, as linear regression analysis indicated that the trends are statistically significant, and Improving for both time periods. The 10-year and long-term trends for U.S. Lake Superior beaches are assessed as Unchanging due to a lack of statistical significance.

Lake Michigan

Status: Good

10-Year Trend (2014-2023): Improving

Long-term Trend (2008-2023): Improving

Rationale: All Lake Michigan beaches are in the United States, so there is no binational assessment for this lake. From 2020 to 2023, monitored Lake Michigan beaches were assessed as Good because beaches were open and safe for swimming for an average of 97% of the swimming season based on U.S. acceptable *Escherichia coli (E. coli)* concentrations. The 10-year and long-term trends are both considered Improving because regression analysis of the U.S. data available indicated an Improving trend in the percent of beach days open and safe for swimming.

Lake Huron (including St. Marys River)

Status: Good

10-Year Trend (2014-2023): Unchanging to Improving

Long-term Trend (Canada – 2010-2023; US – 2008-2023): Unchanging to Improving

Rationale: From 2020 to 2023, monitored Lake Huron beaches were assessed as Good. Monitored U.S. Lake Huron beaches were open and safe for swimming for an average of 97% percent of the swimming season, and monitored Canadian Lake Huron beaches were safe for swimming for an average of 94% of the swimming season based on the respective acceptable *E. coli* concentrations. The 10-year and long-term trends based on Canadian Lake Huron beach data are both assessed as Improving, as linear regression analysis indicated that the trends are statistically significant, and Improving for both time periods. The 10-year and long-term trends in the U.S. data are considered Unchanging.

Lake Erie (including St. Clair-Detroit River Ecosystem)

Status: Fair to Good

10-Year Trend (2014-2023): Unchanging

Long-term Trend (Canada – 2010-2023; US – 2008-2023): Unchanging

Rationale: From 2020 to 2023, monitored Lake Erie beaches were assessed as Fair to Good. Monitored U.S. Lake Erie beaches were open and safe for swimming for 80% of the swimming season (falling under the U.S. criteria of Fair), and monitored Canadian Lake Erie beaches were safe for swimming an average of 83% of the swimming season (falling under the Canadian criteria of Good) based on the respective acceptable *E. coli* concentrations. The 10-year and long-term trends based on U.S. and Canadian Lake Erie beach data are both assessed as Unchanging, as linear regression analysis indicated that the trends are not statistically Improving or Deteriorating.

Lake Ontario (including Niagara River and International section of the St. Lawrence River)

Status: Good

10-Year Trend (2014-2023): Unchanging

Long-term Trend (Canada – 2010-2023; US – 2008-2023): Unchanging

Rationale: From 2020 to 2023, monitored Lake Ontario beaches were assessed as Good. Monitored U.S. Lake Ontario beaches were open and safe for swimming for 93% of the swimming season, and monitored Canadian Lake Ontario beaches were safe for swimming an average of 86% of the swimming season based on the respective acceptable *E. coli* concentrations. The 10-year and long-term trends based on U.S. and Canadian Lake Ontario beach data are both assessed as Unchanging, as linear regression analysis indicated that the trends are not statistically Improving or Deteriorating.

Status Assessment Definitions

Good: Greater than 90% of available beach days in the U.S., or greater than 80% of beach days in Canada, meet bacterial standards.

Fair: 80% to 89.99% of available beach days in the U.S., or 70% to 79.9% of beach days in Canada, meet bacterial standards.

Poor: Less than 79.9% of available beach days in the U.S., or less than 69.9% of beach days in Canada, meet bacterial standards.

Undetermined: Data are not available or are insufficient to assess condition of the ecosystem components.

Trend Assessment Definitions

Improving: The percentage of beach days that meet bacterial standards shows a statistically significant (p-value ≤ 0.05) trend towards more acceptable conditions based on linear regression analysis.

Unchanging: The percentage of beach days that meet bacterial standards shows no Improving or Deteriorating trends based on linear regression analysis, and there is no significant interannual variability (i.e. conditions are relatively stable), based on a visual inspection of the data.

No Trend: The trend is not statistically Improving, Deteriorating, or stable (Unchanging) due to high interannual variability in the data, based upon visual inspection of the data.

Deteriorating: The percentage of beach days that meet bacterial standards shows a statistically significant (p-value ≤ 0.05) trend away from acceptable conditions based on linear regression analysis.

Undetermined: A sufficient amount of data are not available to report on a trend.

Endpoint and/or Targets

All monitored Great Lakes beaches should achieve a status of Good and a trend of Improving or Unchanging. US Great Lakes beaches should be open and safe for swimming for 90% or more of the swimming season. Canadian Great Lakes beaches should be open and safe for swimming for 80% or more of the swimming season.

Sub-Indicator Purpose

- To assess the percentage of days that Great Lakes beaches are open and safe for swimming by assessing health-related (*E. coli*) monitoring data and/or closings at recreational beaches.
- To infer potential harm from pathogens to human health through body contact with nearshore recreational waters.

Ecosystem Objective

Waters should be safe for recreational use. Waters used for recreational activities involving bodily contact should be free from pathogens, such as bacteria, parasites, and viruses that may harm human health.

This sub-indicator supports work towards General Objective #2 of the 2012 Great Lakes Water Quality Agreement which states that the Waters of the Great Lakes should “allow for swimming and other recreational use, unrestricted by environmental quality concerns”.

Methods

This sub-indicator measures the percentage of days during the swimming season that Great Lakes beaches monitored by beach safety programs have acceptable *Escherichia coli* (*E. coli*) concentrations, and are open and safe for swimming.

The swimming season for Great Lakes beaches is generally from the Memorial Day/Victoria Day weekend to Labor Day weekend; however, this may vary depending on the municipality, tribe, health unit, or county. Therefore, all swimming season days from Great Lakes beaches that are reported by beach managers are used in this report. The number of days that each beach was open and/or safe for swimming was calculated based on this standard to be consistent with the past State of the Great Lakes reports. The trends in the percentage of beach days open for both Canadian and U.S. beaches were determined using linear modeling in R, using an F-test to determine any trends in the percentage of beach days open over time. A p-value ≤ 0.05 was considered significant (R Core Team, 2020).

United States

In the US, the frequency of beach monitoring varies between states and tribes - from once a month to daily sampling - depending on available funding and staffing making it difficult to compare beach water quality among states and tribal lands. Non-monitored beaches are not included in this sub-indicator. Non-monitored beaches are entered into US databases as open and safe for swimming for 100% of the beach season because the lack of monitoring resulted in no postings. The assumption that non-monitored beaches were always safe for swimming would result in an overstatement of the safety of Great Lakes beaches, and therefore non-monitored beaches are removed from the analysis.

Canada

The Canadian data assessed in this report are exclusively from beaches monitored by Public Health Units (PHUs) located on the waters of the Great Lakes and connecting channels. Beaches not located directly on the waters of the Great Lakes and their connecting channels are not included in this assessment, such as beaches on in-land lakes. The frequency of beach monitoring conducted by PHUs typically ranges from daily to once per month.

This report assesses 14 years of Canadian seasonal beach water quality data (2010-2023). All Canadian data used in this assessment were either obtained directly from the PHUs, or from the Public Health Ontario laboratory's LabWare laboratory information management system (LIMS). Specifically, all data from 2010-2019 were provided directly by PHUs, and 2020-2023 data were from the LIMS. The LIMS identified additional monitored Canadian Great Lakes beaches that were not included in prior reports, therefore this report assesses a greater number of Canadian beaches in the 2020-2023 swimming seasons. Additionally, this report includes data from Canadian beaches on the international section of the St. Lawrence River from 2020-2023, whereas past reports did not include these beaches.

Raw monitoring data from 2010-2023 were re-analyzed against the *E. coli* guidelines as outlined in the Ontario Guidelines for Recreational Water Quality, which were implemented in 2018 (Ontario Ministry of Health and Long-term Care, 2018), to determine the percentage of days that beaches met the *E. coli* standards outlined in the 2018 guidelines, and therefore *would have* been considered safe to swim. Therefore, it is important to note that the Canadian data in this report are not reflective of the actual number of days that Great Lakes beaches were closed and/or swimming advisories were posted, but rather the number of days that beaches would have been considered as unsafe for swimming, if the 2018 Ontario *E. coli* standards were followed at all beaches.

Discussion

Recreational activities such as swimming, boating, and beach activities can involve direct contact with water. In some situations, water can be contaminated with pathogens (parasites, bacteria, viruses), which can lead to gastrointestinal illness (including diarrhea, nausea, and vomiting), as well as skin, ear, eye, respiratory and wound infections. *E. coli* in fresh water, and Enterococci in salt water, are the two most commonly monitored bacteria used for indicating water safety for human health. Great Lakes beach monitoring is conducted to primarily detect *E. coli*, which is a type of bacteria which normally lives in intestines in humans and animals. *E. coli* can indicate the presence of harmful pathogens from fecal contamination. Recreational waters may become contaminated with *E. coli*, and other organisms from animal and human feces due to failing septic systems, combined sewer overflows, storm water runoff, waterfowl, boat wastes, and other pollution sources. When monitoring results reveal elevated levels of *E. coli*, the state or local government/health units issue a beach advisory or closure notice until further sampling shows that the water quality is meeting the applicable water quality standards.

In the U.S., the U.S. Environmental Protection Agency (U.S. EPA) suggests the use of a Beach Action Value (BAV) to make beach advisory or closure decisions. Any single sample above the BAV could trigger a beach notification until another sample below the BAV is collected. U.S. EPA's recommended BAVs are outlined in U.S. EPA's Recreational Water Quality Criteria (RWQC) which were revised in December 2012, in accordance with the Beaches Environmental Assessment and Coastal Health (BEACH) Act. The revised criteria reflect the latest scientific knowledge and are designed to protect the public from exposure to harmful levels of pathogens while participating in water-contact activities.

U.S. EPA's revised RWQC correspond to two different illness rates that states and tribes must select and apply at their inland and coastal recreation waters. U.S. EPA suggests that a state or tribe's chosen criterion illness rate be used to determine the corresponding BAV. Based on an estimated illness rate of 36 per 1,000 primary contact recreators, EPA recommends a BAV of 235 *E. coli* coliform forming units (cfu) per 100 mL or 70 Enterococci cfu per 100 mL. Based on an estimated illness rate of 32 per 1,000 primary contact recreators, EPA recommends a BAV of 190 *E. coli* cfu per 100 mL or 60 Enterococci cfu per 100 mL (U.S. EPA Recreational Water Quality Criteria 2012). The State of Michigan uses 130 *E. coli* cfu per 100 mL as a 30-day geometric mean, and a maximum of 300 *E. coli* cfu per 100 mL based on the geometric mean of three or more samples taken during the same sampling event at representative locations within a defined sampling area, to make beach notification decisions. Some U.S. states and municipalities have started to use qPCR analyses for same day beach sample results. The qPCR BAV is the equivalent of the state standard used for culture of E. coli or Enterococci, as determined by comparison studies.

U.S. EPA is authorized by the BEACH Act to award grants to coastal and Great Lakes states, territories and eligible tribes to help local authorities monitor their coastal and Great Lakes beaches and notify the public of water quality conditions that may be unsafe for swimming. Great Lakes beach managers are able to regularly monitor beach water quality and advise bathers of potential risks to human health when water quality standards for bacteria are exceeded. When levels of fecal indicator bacteria exceed a state or tribe's BAV, swimming at beaches is prohibited or advisories are issued to inform beachgoers that swimming may be unsafe. The swimming season typically starts Memorial Day weekend and ends on Labor Day. The U.S. EPA provides publicly-accessible data about beach closings and advisories for U.S. coastal beaches at its Beach Advisory and Closing On-line Notification (BEACON) system at:. http://www.epa.gov/waterdata/beacon-20-beach-advisory-and-closing-online-notification (U.S. EPA BEACON). This data is typically available six months after the beach season ends. States and tribes each have publicly-accessible websites or mobile applications with data available about beach advisories and closings on a daily basis throughout the beach season.

In Ontario, recreational public beaches are monitored for *E. coli* concentrations by the responsible PHU. The PHUs observe and analyze the *E. coli* monitoring data to determine whether it is safe to swim in the waters of the beach. Up until 2017, the Ontario standard for acceptable *E. coli* concentrations was a geometric mean of 100 *E. coli* cfu per 100 mL (Ontario Ministry of Health and Long-term Care, 2014). The Beach Advisories sub-indicator report based the assessment on this standard in the SOGL 2019 and prior cycles, however, starting with the SOGL 2022 report, this sub-indicator has been assessed using the *E. coli* standards as outlined in the Ontario Operational Approaches for Recreational Water Quality, which were implemented in 2018 (Ontario Ministry of Long-term Health and Care, 2018). These standards are consistent with those from Health Canada's Guidelines for Canadian Recreational Water Quality (2012). In accordance with these standards, *E. coli* concentrations in water should not exceed the following:

- 200 *E. coli* cfu per 100 mL (geometric mean concentration, minimum of 5 samples); or,
- 400 *E. coli* per 100 mL, maximum limit for a single water quality sample.

Following these standards, recreational beach waters are posted as unsafe for swimming when *E. coli* levels exceed these thresholds, and the waters remain posted until further sampling indicates that *E. coli* levels have dropped below the thresholds. It is important to note however that not all PHUs follow these standards. It is up to the discretion of the PHU to make the final decision as to whether or not the beach shall be closed based on the *E. coli* monitoring results. For example, some PHUs may not close a beach if there is a single sample exceedance over the 400 *E. coli* per 100 mL and will instead only close the beach if the geometric mean exceeded the 200 *E. coli* cfu per 100 mL limit. Also, some PHUs may choose to follow the previous standard of a geometric mean of 100 *E. coli* cfu per 100 mL. Regardless, to ensure consistency, this report assesses Canadian Great Lakes beach data from 2010-2023 that has been re-analyzed against the 2018 Ontario *E. coli* standards. This was completed by analyzing the raw *E. coli* beach data from PHU monitoring events and re-calculating the number of days during the swimming season that beaches *would have* been safe or unsafe for swimming, had the *E. coli* standards identified in the 2018 Ontario Operational Approaches been used. Therefore, it is important to note that the Canadian data in this report is not reflective of the percentage of days that beaches actually remained open during the 2010-2023 swimming seasons.

In the Beach Advisories sub-indicator reports from the SOGL 2019 cycle and earlier, the assessments for Canadian beaches were based on data as far back as 1999. Starting with the SOGL 2022 report however, only data as far back as 2010 were reanalyzed against the 2018 Ontario *E. coli* standards. Therefore, determining a trend based on data farther back then 2010 would be inconsistent and inaccurate. Reanalyzing beach data is a very intensive and time-consuming process, therefore it is unlikely that future SOGL reports will reanalyze and assess data earlier than 2010.

The PHU monitoring frequency during the 2020-2023 swimming seasons also varied between beaches. Beaches in the lower Great Lakes were typically monitored more frequently compared to beaches in the upper Great Lakes. In Lake Superior, 0% of beaches were monitored daily, 44% were monitored weekly or more frequently (but not daily), and 56% were monitored monthly. In Lake Huron, 0% of beaches were monitored daily, 82% were monitored weekly or more frequently (but not daily), 4% were monitored once every 2-3 weeks, and 14% were monitored monthly. In Lake Erie, 7% of beaches were monitored daily, 83% were monitored weekly or more frequently (but not daily), and 10% were monitored monthly. In Lake Ontario, 14% of beaches were monitored daily, 84% were monitored weekly or more frequently (but not daily), and 2% were monitored between once every 2-3 weeks to monthly.

Assessment of Great Lakes Beaches

US Great Lakes Beaches-Overall Assessment

Since 2008, U.S. Great Lakes beaches have been assessed as Good, and both the long-term and 10-year trends in the percentage of monitored U.S. Great Lakes beaches open and safe for swimming is described as Unchanging (Figure 1). Overall, the U.S. Great Lakes monitored beaches were open and safe for 94% of the swimming season from 2020 thru 2023. During this period, on average 412 (83%) of monitored U.S. Great Lakes beaches were safe for swimming greater than 90% of the season, 39 (8%) of beaches were safe for swimming greater than 80% but less than 90% of the season, and 45 (9%) of beaches were safe for swimming less than 80% of the beach season based on *E. coli* standards (Figure 2).

US Lake Superior Beaches

U.S. Lake Superior beaches are assessed as Good, with monitored beaches considered safe for swimming 98% of the swimming seasons for 2020 thru 2023. There has been little change in the status of monitored U.S. Lake Superior beaches since 2008, and both the 10-year and long-term trends are considered Unchanging (Figure 1). During the 2020 thru 2023 swim seasons, on average 108 monitored U.S. Lake Superior beaches (94%) were safe for swimming greater than 90% of the season, 5 monitored U.S. Lake Superior beaches (4%) were safe for swimming greater than 80% but less than 90% of the season, and 3 monitored U.S. Lake Superior beaches (2%) were safe for less than 80% of the swimming season in Lake Superior based on *E. coli* standards (Figure 2).

US Lake Michigan Beaches

U.S. Lake Michigan beaches were assessed as Good, with monitored beaches considered safe for swimming 97% of the seasons for 2020 thru 2023. Since 2008, there is a slight increasing trend in the percentage of days beaches were open and safe for swimming during the swimming season, and both the 10-year and long-term trends are considered Improving (Figure 1). During the 2020 thru 2023 swim seasons, on average 197 monitored U.S. Lake Michigan beaches (91%) were safe for swimming greater than 90% of the season, 13 monitored U.S. Lake Michigan beaches (6%) were safe for swimming greater than 80% but less than 90% of the season, and 7 monitored U.S. Lake Michigan beaches (3%) were safe for less than 80% of the swimming season in Lake Michigan based on *E. coli* standards (Figure 2).

US Lake Huron Beaches

U.S. Lake Huron beaches were assessed as Good, with monitored beaches considered safe for swimming 97% of the seasons for 2020 thru 2023. Since 2008, there has been relatively little change in the status of U.S. Lake Huron beaches. Based on regression analysis, both the long-term and 10-year trends are considered Unchanging (Figure 1). During the 2020 thru 2023 swim seasons, on average 57 monitored U.S. Lake Huron beaches (95%) were safe for swimming greater than 90% of the season, 1 monitored U.S. Lake Huron beach (2%) was safe for swimming greater than 80% but less than 90% of the season, and 2 monitored U.S. Lake Huron beaches (3%) were safe for less than 80% of the swimming season in Lake Huron based on *E. coli* standards (Figure 2).

US Lake Erie Beaches

U.S. Lake Erie beaches were assessed as Fair, with monitored beaches considered safe for swimming 80% of the seasons for 2020 thru 2023. Since 2008, there has been relatively little change in the status of U.S. Lake Erie beaches. Based on regression analysis, both the long-term and 10-year trends are considered Unchanging (Figure 1). During the 2020 thru 2023 swim seasons, on average 35 monitored U.S. Lake Erie beaches (42%) were safe for swimming greater than 90% of the season, 17 monitored U.S. Lake Erie beaches (20%) were safe for swimming greater than 80% but less than 90% of the season, and 31 monitored U.S. Lake Erie beaches (37%) were safe for less than 80% of the swimming season in Lake Erie based on *E. coli* standards (Figure 2).

US Lake Ontario Beaches

U.S. Lake Ontario beaches were assessed as Good, with monitored beaches considered safe for swimming 93% of the seasons for 2020 thru 2023. Since 2008, there has been relatively little change in the status of U.S. Lake Ontario beaches. Based on regression analysis, both the long-term and 10-year trends are considered Unchanging (Figure 1). During the 2020 thru 2023 swim seasons, on average 15 monitored U.S. Lake Ontario beaches (75%) were safe for swimming greater than 90% of the season, 3 monitored U.S. Lake Ontario beaches (15%) were safe for swimming greater than 80% but less than 90% of the season, and 2 monitored U.S. Lake Ontario beaches (10%) were safe for less than 80% of the swimming season in Lake Ontario based on *E. coli* standards (Figure 2).

Canadian Great Lakes Beaches – Overall Assessment

From 2020 to 2023, monitored Canadian beaches on the Great Lakes were assessed as Good because beaches met Ontario bacterial standards and were safe for swimming an average of 89% of the swimming season (Figure 3). Results of the linear modeling for the 10-year trend indicate the trend is not statistically Improving or Deteriorating, and upon visual observation of the data, the interannual variability is not high. Therefore the 10-year trend is assessed as Unchanging. The results of linear modeling indicate a long-term trend of Improving.

Over the most recent 10-years of data available (2014-2023), monitored Canadian beaches on the Great Lakes met Ontario bacterial standards were safe for swimming 88% of the swimming season. Over the entire 14 years of data available (2010-2023), monitored Canadian beaches on the Great Lakes met Ontario bacterial standards and were safe for swimming 87% of the swimming season.

During the 2020-2023 swimming seasons, 41% of Canadian beaches on the Great Lakes did not exceed the Ontario bacterial standards once and were safe for swimming the entire swimming season. Note this calculation (as well as similar calculations noted in the individual lake sections below) is considering each beach within each year as one independent value. Specifically, the dataset for the 2020 swimming season consists of 217 beaches, of which 98 were safe for swimming during the entire 2020 season. The dataset for the 2021 swimming season consists of 209 beaches, of which 78 were safe for swimming the entire 2021 season. The dataset for the 2022 swimming season consists of 209 beaches, of which 80 were safe for swimming the entire 2022 season. The dataset for the 2023 swimming season consists of 231 beaches, of which 97 were safe for swimming the entire 2023 season. So therefore over the four years, 353 out of 866 beaches (41%) were open and safe for swimming during the 2020-2023 swimming seasons. Also, over this same four-year period of 2020-2023, 78% of beaches were assessed as Good (safe for swimming 80% or more of the swimming season), 8% were assessed as Fair (safe for swimming 70-79.9% of the swimming season), and 12% were assessed as Poor (safe for swimming less than 70% of the swimming season) (Figure 4).

During the 2010-2023 swimming seasons, 35% of Canadian beaches on the Great Lakes did not exceed the Ontario bacterial thresholds once. Also, during this same 14-year period, 76% of Canadian beaches on the Great Lakes were assessed as Good, 11% were assessed as Fair, and 13% were assessed as Poor (Figure 4).

Canadian Lake Superior Beaches

From 2020 to 2023, monitored Canadian Lake Superior beaches were assessed as Good because beaches met Ontario bacterial standards and were safe for swimming an average of 99% of the swimming seasons (Figure 3). Results of the linear modeling for the 10-year and long-term trends indicate a statistically significant Improving trend for both time periods. For the most recent 10 years of data available (2014-2023), monitored Canadian Lake Superior beaches met Ontario bacterial standards and were safe for swimming 97% of the swimming season. For the entire 14 years of data available (2010-2023), monitored Canadian Lake Superior beaches met Ontario bacterial standards and were safe for swimming 96% of the swimming season.

During the 2020-2023 swimming seasons, 88% of Canadian Lake Superior beaches did not exceed the Ontario bacterial standards once and were safe for swimming the entire swimming season. Also over this same four-year

period, 99% of Canadian Lake Superior beaches achieved a status of Good, and 1% achieved a status of Fair. There were no beaches that were assessed as Poor (Figure 4).

During the entire 2010-2023 swimming seasons, 75% of Canadian Lake Superior beaches did not exceed the Ontario bacterial standards once and were safe for swimming the entire swimming season. Also during this same 14-year period, 95% of Canadian Lake Superior beaches were assessed as Good, 2% were assessed as Fair, and 3% were assessed as Poor (Figure 4).

Canadian Lake Huron Beaches (including St. Marys River)

From 2020 to 2023, monitored Canadian Lake Huron beaches were assessed as Good because beaches met Ontario bacterial standards and were safe for swimming an average of 94% of the swimming seasons (Figure 3). Results of the linear modeling for the 10-year and long-term trends indicate a statistically significant Improving trend for both time periods. For the most recent 10 years of data available (2014-2023), monitored Canadian Lake Huron beaches met Ontario Bacterial standards and were safe for swimming 92% of the swimming season. For the entire 14 years of data available (2010-2023), monitored Canadian Lake Huron beaches met Ontario Bacterial standards and were safe for swimming 91% of the swimming season.

During the 2020-2023 swimming seasons, 57% of Canadian Lake Huron beaches did not exceed the Ontario bacterial thresholds once and were safe for swimming the entire swimming seasons. Also over this same four-year period, 90% of Canadian Lake Huron Beaches were assessed as Good, 3% were assessed as Fair, and 7% were assessed as Poor (Figure 4).

During the 2010-2023 swimming seasons, 46% of Canadian Lake Huron beaches did not exceed the Ontario bacterial standards once and were safe for swimming the entire swimming seasons. Also during this same 14-year period, 84% of Canadian Lake Huron beaches were assessed as Good, 8% were assessed as Fair, and 8% were assessed as Poor (Figure 4).

Canadian Lake Erie Beaches (including St. Clair-Detroit River Ecosystem)

From 2020 to 2023, monitored Canadian Lake Erie beaches were assessed as Good because beaches met Ontario bacterial standards and were safe for swimming an average of 83% of the swimming seasons (Figure 3). The results of the linear modeling for both the 10-year and long-term trends indicate the trends are not statistically Improving or Deteriorating, and there is not a high level of interannual variability based on a visual observation of the data. Therefore the trends for both time periods are assessed as Unchanging. For the most recent 10 years of data available (2014-2023), monitored Canadian Lake Erie beaches met Ontario bacterial standards and were safe for swimming 82% of the swimming season. For the entire 14 years of data available (2010-2023), monitored Canadian Lake Erie beaches met Ontario bacterial standards and were safe for swimming 81% of the swimming season.

During the 2020-2023 swimming seasons, 34% of Canadian Lake Erie beaches did not exceed the Ontario bacterial standards once and were safe for swimming the entire swimming seasons. Also over this same four-year period, 67% of Canadian Lake Erie beaches were assessed as Good, 11% were assessed as Fair, and 22% were assessed as Poor (Figure 4).

During the entire 2010-2023 swimming seasons, 21% of Canadian Lake Erie beaches did not exceed the Ontario bacterial standards once and were safe for swimming the entire swimming seasons. Also during this same 14-year period, 62% of Canadian Lake Erie beaches were assessed as Good, 16% were assessed as Fair, and 22% were assessed as Poor (Figure 4).

Canadian Lake Ontario Beaches (including Niagara River and the international section of the St. Lawrence River)

From 2020 to 2023, monitored Canadian Lake Ontario beaches were assessed as Good because beaches met Ontario bacterial standards and were safe for swimming an average of 86% of the swimming seasons (Figure 3). The results of the linear modeling for both the 10-year and long-term trends indicate the trends are not statistically Improving or Deteriorating, and there is not a high level of interannual variability based on a visual observation of the data. Therefore the trends for both time periods are assessed as Unchanging. For the most recent 10 years of data available (2014-2023), monitored Canadian Lake Ontario beaches met Ontario bacterial standards and were safe for swimming 87% of the swimming seasons. For the entire 14 years of data available (2010-2023), monitored Canadian Lake Ontario beaches were safe for swimming 86% of the swimming season.

During the 2020-2023 swimming seasons, 17% of Canadian Lake Ontario beaches did not exceed the Ontario bacterial standards once and were safe for swimming the entire swimming seasons. Also over this same four-year period, 72% of Canadian Lake Ontario beaches were assessed as Good, 14% were assessed as Fair, and 14% were assessed as Poor (Figure 4).

During the entire 2010-2023 swimming seasons, 21% of Canadian Lake Ontario beaches did not exceed the Ontario bacterial thresholds once and were safe for swimming the entire swimming seasons. Also during this same 14-year period, 72% of Canadian Lake Ontario beaches were assessed as Good, 14% were assessed as Fair, and 14% were assessed as Poor (Figure 4).

Linkages

Water Levels

- High water levels may lead to flooding, high erosion rates, unsafe swimming conditions due to currents and waves, and loss of beach area (U.S. Army Corps of Engineers, 2003; Michigan Department of Natural Resources, 2021). In 2019, all the Great Lakes were well above average water levels. Lakes Erie and Ontario both had record high peak water levels in 2019 compared to each Lake's overall monthly record high since 1918. During this year, many Great Lakes beaches retreated, losing recreational areas, and others were flooded (Frauhammer, 2019; Holland, 2019; Moore, 2019).
- The Great Lakes were in a period of high water levels starting in 2015. Lakes Superior, Michigan, Huron, and Erie were above monthly water level averages from 2015 through 2019. Lake Ontario water levels were above the monthly water level average from 2017 through 2019 except for three months within the time frame (U.S. Army Corps of Engineers, 2020).

Precipitation Amounts

- Heavy precipitation and storm water runoff can increase pathogens in recreational waters by flushing pathogens directly into nearby surface water. Storm water runoff can collect pathogens from soil, sand, streets, or agricultural land. Heavy precipitation can overwhelm combined sewer systems or municipalities with aging infrastructure resulting in the discharge of untreated wastewater or storm water into streams, rivers, drains, or lakes. Heavy precipitation and storm water runoff can also disturb and re-suspend pathogens in sediments and beach sand (Patz, Uejio, & McLellan, 2008; Staley et al. 2018a)
- Beach postings may be the result of bacterial loadings from tributaries and extreme precipitation events. Improved wastewater treatment in response to these pressures may reduce the number of beach postings. Implementation of best management practices and green infrastructure to reduce the volume of storm water runoff may also decrease the number of beach advisories (Podolsky and MacDonald, 2008).

Cladophora/Algal Bloom Extent

- Algal Blooms may produce toxins, which can have adverse health effects. Thereby, a beach may be considered unsafe for swimming due to an algal bloom event, and a beach advisory may be posted due to algal blooms (Centers for Disease Control and Prevention, 2018). The U.S. BEACON database does not contain information on advisories due to an algal bloom event alone. This report (for both Canadian and U.S. portions) solely focuses on beach advisories due to the exceedance of *E. coli*.
- *E. coli* also has a unique, strong association with *Cladophora. Cladophora* provides a suitable habitat for indicator bacteria and potential pathogens to persist and potentially grow, which may, in turn, impact recreational beach water quality (Englebert et al., 2008; USGS, 2009).

Invasive Species – Dreissenid Mussels

- Filtration by dreissenid mussels produces clearer waters, which allows for UV rays to penetrate the surface. Sunlight can cause cellular damage in bacteria, which may be linked decreases in *E. coli* levels across Lake Michigan (Weiskerger and Whitman, 2018). However, cellular damage can also impact beneficial bacteria, which are responsible for sustaining the health of the ecosystem by recycling carbon and nutrients.

Assessing Data Quality

Data Characteristics	Agree	Neutral or Unknown	Disagree	Not Applicable
Data are documented, validated, or quality-assured by a recognized agency or organization	X			
Data are from a known, reliable and respected generator of data and are traceable to original sources	X			
Geographic coverage and scale of data are appropriate to the Great Lakes Basin			X	
Data obtained from sources within the U.S. are comparable to those from Canada	X			
Uncertainty and variability in the data are documented and within acceptable limits for this sub-indicator report	X			
Data used in assessment are openly available and accessible	U.S.: Yes Canada: Upon request	U.S.: https://watersgeo.epa.gov/beacon2/reports.html Canada: Data may be accessed from Public Health Units upon request.		

Notes on Accessing Data

Efforts are underway to ensure the data used for the Canadian assessment is publicly available. Contact Beach Advisories sub-indicator report Canadian lead author Jacob Orlandi for more information (Jacob.orlandi@cwa-aec.gc.ca).

Data Limitations

- Variability in the data from year-to-year may result from the variations in monitoring and reporting and may not be solely attributable to actual increases or decreases in levels of microbial contaminants. In addition, variability of weather from year to year may affect the variability in bacterial counts.
- Viruses and parasites, although a concern in recreational waters, are difficult to isolate and quantify at present, and widely available measurement techniques have yet to be developed.
- Although considered reliable indicators of potential harm to human health, the presence of *E. coli* and/or *Enterococcus* may not necessarily be related to fecal contamination.
- Although data obtained from the U.S. and Canada are comparable in terms of quality of data from the source, the data are not comparable in terms of actual beach postings since each country uses different posting criteria and frequency of monitoring. The U.S. posts a beach as unsafe if *E. coli* levels are above 235 *E. coli* per 100 mL (State of Michigan uses 130 *E. coli* cfu per 100 mL as a 30-day geometric mean, and a maximum of 300 *E. coli* cfu per 100 mL), whereas Ontario (based on the 2018 guidelines) considers a beach as unsafe if *E. coli* levels exceed the threshold of 200 *E. coli* cfu per 100 mL (based on a geometric mean of at least 5 samples), or a single-sample maximum concentration of at least 400 *E. coli* cfu per 100 mL. However, PHUs may use alternative thresholds.
- The U.S. long-term trend assesses the entire data set available for U.S Great Lakes beaches using the data available in the BEACON database, which is updated annually, and basin wide data entries started in 2008.
- Currently, it is difficult to report on beach advisories as they relate to Harmful Algal Blooms (HABs). Typically, PHUs do note if an algal bloom is present while testing for *E. coli*. Still, specialized and expensive tests are needed to determine if the algae are toxic. Beach advisories/closures as a result of HABs/algal blooms may be a future component of this report, however this sub-indicator currently only assesses the percentage of days that beaches are open and safe for swimming during the beach season based on *E. coli* levels.
- There is variability in state and tribal beach monitoring frequencies. Information about developing beach monitoring programs is included in EPA's National Beach Guidance and Performance Criteria for Grants, http://www.epa.gov/beach-tech/national-beach-guidance-and-required-performance-criteria-grants. As a BEACH Act grant entity, states and tribes are required to develop a tiered monitoring plan which must adequately address the frequency and location of monitoring and the assessment of coastal recreation waters based on a review of existing monitoring data, periods of recreational use of the waters, the nature and extent of use of the waters, the proximity to known point and nonpoint sources of pollution, and the effect of stormwater runoff on the waters. The goal of a tiered monitoring plan is to define combinations of monitoring activities that align with identified priorities (tiers), are appropriate for the level of risk and use of a given beach, effectively allocate available monitoring resources and address site-specific circumstances. A BEACH Act grant-funded program must prioritize the use of grant funds

for monitoring on the basis of the use of the waters and risk to human health. For example, Michigan which has hundreds of coastal beaches monitors its Tier 1 beaches once per week whereas Illinois monitors many of its beaches 7 days per week. Michigan's annual beach open status averages at being open at approximately 97% of the time; whereas, Illinois averages more in the 89% range. Tier 1 or "high priority" beaches are monitored more frequently than Tier 3 beaches, some of which may not be monitored at all. The monitoring frequencies for each entity can be found at EPA's Beach Advisory and Closing Online Notification (BEACON) system (under Report Selection) at: http://watersgeo.epa.gov/beacon2/reports.html.

- This report includes information on the percentage of Canadian beaches that are open the entire swimming seasons, however it is important to consider that a relatively small portion of beaches are monitored daily. Most beaches are monitored weekly or less frequently, including many beaches that are monitored monthly. Therefore, it is possible that there may have been *E. coli* exceedances in between monitoring events, however they would not have been acknowledged as the beach was not monitored when those exceedances occurred.
- The percentage of days that U.S. Great Lakes beaches were open and safe for swimming for 2008-2023 calculated in this report vary slightly from the calculations in the past report due to data management within the BEACON database. If errors in data are found, then the data are removed from the database. As a result, data accessed in 2020 may be different from data accessed in 2024. Data in this report were accessed from BEACON in September and October 2024.
- Not all PHUs provide single sample data for Canadian Great Lakes beaches, some only provide geometric mean data. Therefore, it is possible that there may have been additional cases where the beaches would have exceeded the 2018 Ontario bacterial thresholds, which includes a max single sample count of 400 *E. coli* cfu/100 ml, but these exceedances were missed due to a lack of single sample *E. coli* data.
- In Ontario, some PHUs may use predictive modelling to assist with decision to post beaches as unsafe for swimming, however this report only analyzed the raw *E. coli* PHU sampling results, and not modelling results.

Additional Information

Additional point and non-point source pollution in coastal areas may result in additional beach postings, particularly during wet weather conditions, unless contaminant sources are reduced or removed (or new controls introduced). Great Lakes beach sample results generally contain similar bacteria levels after events with similar meteorological conditions (primarily wind direction and the volume and duration of rainfall). If episodes of poor recreational water quality can be associated with specific events such as meteorological events of a certain threshold, then forecasting for episodes of elevated bacterial counts may become more accurate.

Research on Emerging Technologies

There may be new indicators and new detection methods available through current research efforts occurring binationally in both public and private sectors and academia. Although currently a concern in recreational waters, viruses and parasites are difficult to isolate and quantify, and widely available measurement techniques have yet to be implemented. Although considered reliable indicators of potential harm to human health, the presence of *E. coli* and/or Enterococcus may not necessarily be related to fecal contamination.

New rapid detection methods are beginning to be used at several U.S. Great Lakes locations to provide the public with same day beach water quality results and advisory information. The Chicago Park District and the City of Racine Health Department use rapid quantitative Polymerase Chain Reaction (qPCR) methods for Enterococci and *E. coli* respectively to determine beach advisories and closures. Michigan has set up a large laboratory network across the state to use the rapid qPCR method for *E. coli* along with Colilert. EPA's Office of Research and Development in Cincinnati, Ohio assisted Michigan Department of Environmental Quality (MDEQ) by providing training to multiple health departments in the state and continues to provide technical assistance on PCR methods to grantee partners throughout the Great Lakes. Recently, the Milwaukee, Wisconsin Health Department has done culture/qPCR comparative testing for *E. coli* at some of their beaches, and will begin using qPCR analyses for beach monitoring and notification in 2025.

Emerging Technologies at Toronto Beaches

In recent years, beaches located in Toronto and the surrounding area have served as a prime location for research, development and application of innovative technologies to identify sources of microbial contamination. In 2018, water samples from Toronto Harbour and the Don River watershed were analyzed for *E. coli*, wastewater chemicals and microbial source tracking using a digital PCR (dPCR) technique (Edge et al., 2020). Microbial DNA markers were found to be useful for interpreting the sources of elevated *E. coli* concentrations and were used to identify bacteria found in the gut of seagulls to distinguish seagull fecal contamination from that of other birds, including Canada Geese. While wet weather events were correlated to increases in *E. coli* and human DNA markers, human DNA markers were also widely detected on dry sampling days, suggesting widespread sewage-cross connections into stormwater and dry weather combined sewer overflow systems (Edge et al., 2020). These results identified that the cumulative impact of urban cross-connections is likely greater than initially thought, and that human sewer contamination is not just a wet weather combined sewer overflow concern.

At Marie Curtis Beach, Staley et al. (2018a) applied environmental DNA (eDNA) sequencing to analyze DNA extracted from water samples to improve the understanding of sources of fecal pollution. Water samples were analyzed for DNA sequences from humans, as well as other mammals or bird species. The results of this study indicated not only that extreme rain events can significantly elevate *E. coli* concentration in beach waters, but also that they can result in increased diversity of mammal and bird eDNA sequences (Staley et al., 2018a).

At Rouge Beach, located in the Toronto and Region Area of Concern, Staley et al. (2018b) assessed *E. coli,* as well as human-specific and gull-specific quantitative Polymerase Chain Reaction (qPCR) microbial source tracking markers. A preliminary comparison using dPCR methodologies for both human- and gull-specific microbial source tracking markers was conducted to assess sensitivity and specificity. The study found that the occurrence of human fecal contamination along Rouge beach was associated with rain events, and that during dry weather, the predominant source of fecal contamination was sourced from gull droppings. Additionally, this study determined that while dPCR and qPCR methodologies identified matching levels of human and gull markers in stormwater and beach locations respectively, the dPCR multiplex assay was more sensitive, detecting fecal contamination that was not detected by qPCR assays. These results indicate that dPCR assays could potentially be a valuable tool used by beach managers to identify of low levels of fecal contamination.

Studies have been conducted at recreational beaches in Toronto to explore the application and benefits of the USEPA's 1609.1 qPCR-based method. In 2020 and 2021, a total of 405 samples were taken from Marie Curtis East Beach and Sunnyside Beach to be analyzed using both the traditional culture-based filtration method and qPCR-based testing (Saleem et al., 2022). The study found that qPCR is reliable, with the results matching culture-based methods 80-90% of the time (Saleem et al., 2022). Additionally, the qPCR method can provide results 3.5 hours after being delivered to a laboratory. It was also identified that use of the USEPA 1609.1 method resulted in multiple false positives and negatives at the same two beaches over a 38-day testing period (Saleem et al., 2023).

These results indicate that the use of the qPCR method could enhance public health protection and optimize beach use.

Beach Management Success Stories

Bluffer's Park Beach

Bluffer's Park Beach, located within the Toronto and Region Area of Concern, has historically been impacted by bacterial contamination. Since the 1980's, beach postings would often exceed 80% of the swim season, including one year (2005) where the beach was unsafe for swimming for 93% of the swimming season (City of Toronto, 2009; Lake Ontario Waterkeeper, 2006). From 2005 to 2007, expanded *E. coli* surveillance and microbial source tracking techniques were applied to identify the sources of fecal pollution. Significant *E. coli* hotspots were identified in the beach sand pore water, as well, following rain events, overflow from nearby streams and a parking lot were found to contaminate beach waters. Microbial source tracking results indicated that the predominant source of contamination was animal fecal pollution, rather than human sewage. These findings were consistent with the observations of waterfowl (mainly gulls and Canada geese) and wildlife in the beach area, including observations of fecal droppings, which are direct sources of *E. coli* (Edge et al., 2018). As a remedial effort, the City of Toronto implemented a bird management program which included using trained dogs to deter waterfowl, as well as public education to deter feeding of waterfowl. Additionally, the wetland and dune system behind the beach was reengineered, increasing the water retention capacity of the marsh, as well as creating a barrier to prevent runoff onto the beach and direct stormwater overflows into infiltration basins. Community engagement was also a key player in this restoration process, as members of the public assisted with planting dune and wetland areas (Edge et al., 2018). Through these remedial efforts, water quality improved significantly at Bluffer's Park Beach, and in 2011 it was officially designated as a Blue Flag beach, thereby passing water quality tests over 80% of the time, and fulfilling environmental management, and safety standards (Toronto and Region Conservation Authority, 2017). As of 2023, Bluffer's Park Beach is still officially a Blue Flag Beach (Lake Ontario Waterkeeper, n.d.).

Thunder Bay Area of Concern

In March 2023, the Beach Closings Beneficial Use Impairment (BUI) for the Thunder Bay Area of Concern was assessed and found to be not impaired because the established BUI delisting criteria were met following several remedial actions taken by the City of Thunder Bay and community partners. Remedial actions included managing stormwater inputs, upgrading septic systems, and improving water circulation through the partial removal of a breakwall at one of the three public beaches in the Thunder Bay Area of Concern. Implementing bird and animal management programs was also necessary, because bacterial contamination (*E. coli*); was primarily due to animal and bird droppings. Water quality testing has shown improvements in water quality at the three beaches, and that provincial and federal human health guidelines for recreational water quality have been met for several consecutive years.

Niagara River Area of Concern

In March 2023, the Beach Closings BUI for the Canadian side of the Niagara River Area of Concern was assessed and found to be restored. This achievement was made possible through targeted remedial actions around the Town of Niagara-on-the-Lake which improved conditions such that the established BUI delisting criteria were met. Through extensive water quality monitoring and microbial source-tracking studies from 2010-2018, the sources of bacterial contamination (*Escherichia coli* - *E. coli*) that had been impacting the Niagara River Area of Concern's single public beach were identified. Remedial actions taken to reduce the amount of *E. coli* included installation of raccoon gates, improvements in sewer infrastructure, implementation of best management practices (e.g., regular maintenance of catch basins), and constructing an engineered bioswale to intercept and reduce *E. coli* levels before

it could reach the beach. Since then, water quality testing has confirmed improved water quality that has met provincial and federal human health guidelines for recreational water quality for several consecutive years.

St. Lawrence River Area of Concern

In December 2023, the Beach Closings BUI for the St. Lawrence River Area of Concern at Cornwall/Akwesasne was assessed and found to be not impaired. Water quality monitoring at 28 Akwesasne beaches, Charlottenburgh Park Beach and Glengarry Park Beach between 2012 and 2021 showed that less than 20% of weekly tests at each beach exceeded the *E. coli* threshold during the annual swimming season. Additional studies between 2002 and 2019 showed that *E. coli* levels in recreational areas other than regularly monitored public beaches were also consistently below the *E. coli* threshold for recreational water quality. Continued annual monitoring for *E. coli* is conducted by the Eastern Ontario Health Unit at Charlottenburgh Park and Glengarry Park beaches and by the Mohawk Council of Akwesasne Health Department at the Akwesasne beaches.

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List of Figures

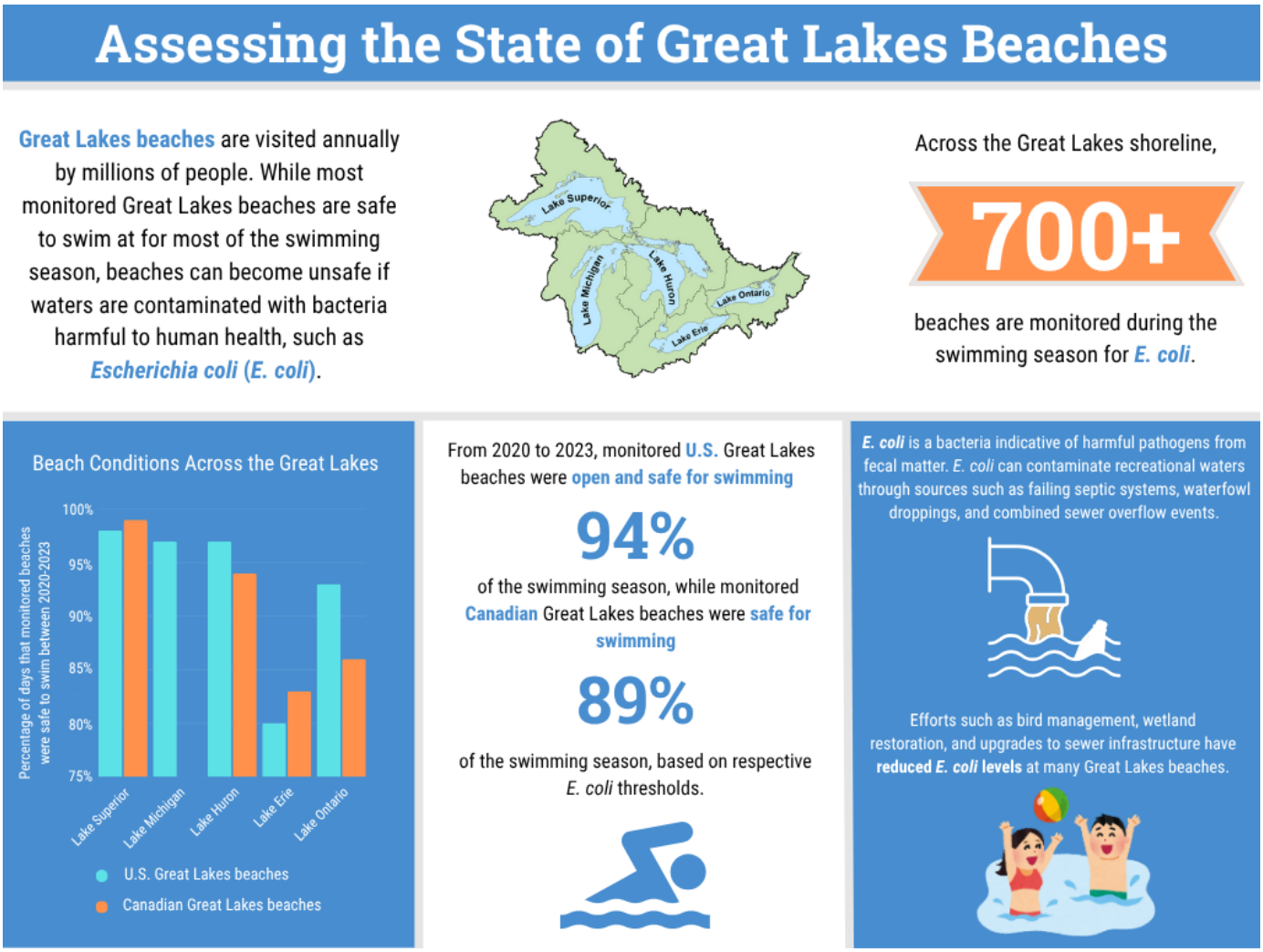
Figure 1. Percentage of days during the swimming season that U.S. Great Lakes beaches were open and safe for swimming from 2008-2023. A black dashed line is present if there was a significant (p-value ≤ 0.05) long-term trend in the data, and a solid black line is present if there was a significant (p-value ≤ 0.05) 10-year trend in the data. The value in the ( ) represents the number of beaches monitored each year. The dashed green line represents the US threshold for Good of 90% of beach days open, and the red dashed line represents the US threshold for Fair of 80% of beach days open.

Figure 2. The number of US Great Lakes beaches that fell into the categories of Good (beach met US state and tribal bacterial standards and was safe for swimming ≥ 90% of the swimming season), Fair (beach met US state and tribal bacterial standards and was safe for swimming between 80%-89.9% of the swimming season), and Poor (beach met US state and tribal bacterial standards and was safe for swimming ≤ 79.9% of the swimming season) for the 10-year period of 2014-2023. The value above the bars indicates the total number of beaches that fell into that category.

Figure 3. Percentage of days during the swimming season that Canadian Great Lakes beaches met Ontario bacterial standards and were safe for swimming from 2010-2023. A black dashed line is present if there is a significant (p-value ≤ 0.05) long-term (2010-2023) trend in the data, and a solid black line is present if there is a significant (p-value ≤ 0.05) 10-year (2014-2023) trend in the data. The number within the parenthesis represents the number of beaches monitored each year. The dashed green line represents the Canadian threshold for Good of (80% of beach days safe to swim), and the red dashed line represents the Canadian threshold for Poor: (69.9% of beach days safe to swim). All bars that extend to above the green dashed line are considered Good, all bars that extend to between the green and red dashed lines are considered Fair, and all bars that extend to below the red dashed line are considered Poor.

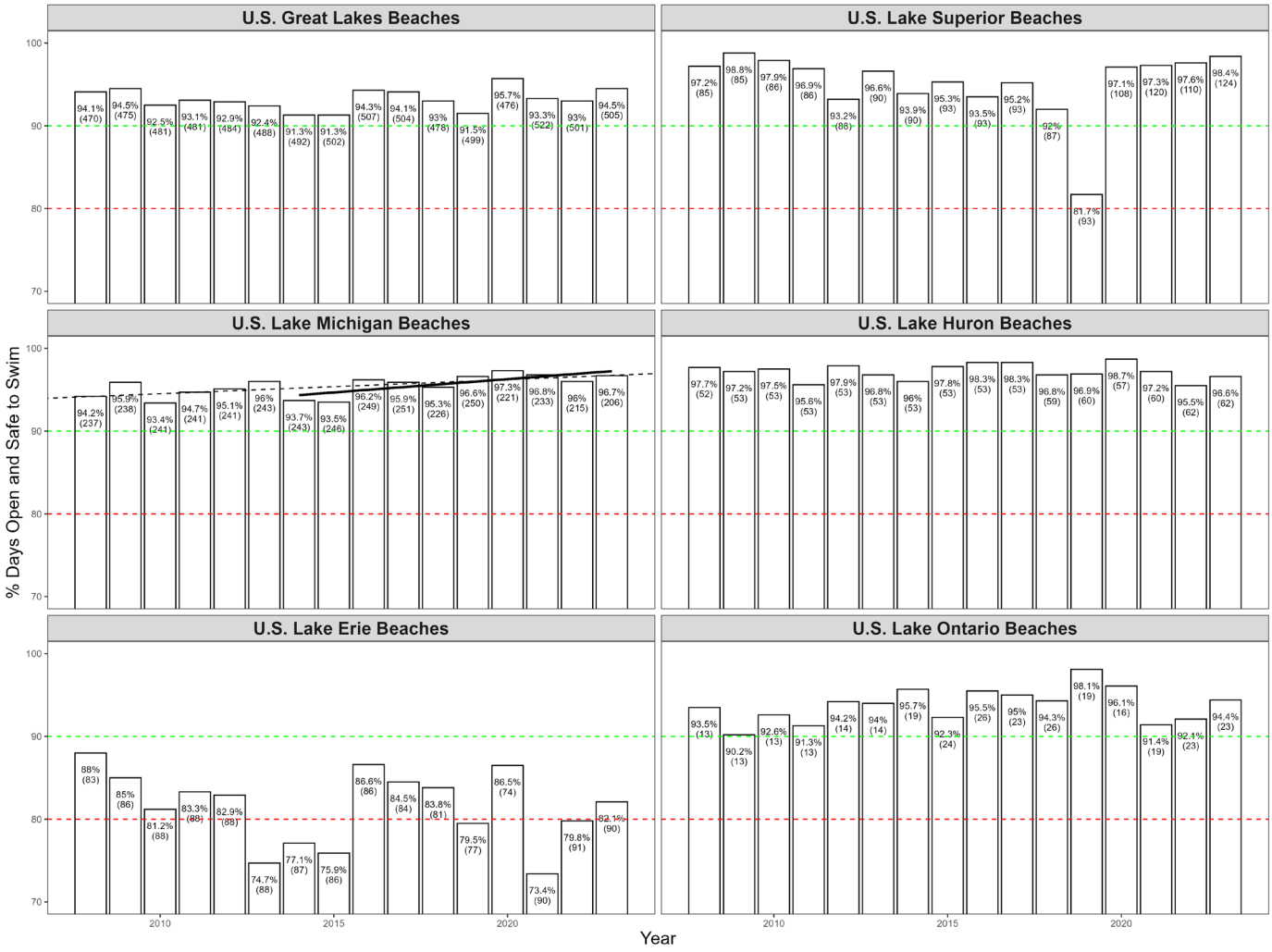
Figure 4. The number of Canadian Great Lakes beaches that fell into the categories of Good (beach met Ontario bacterial standards and was safe for swimming ≥ 80% of the swimming season), Fair (beach met Ontario bacterial standards and was safe for swimming between 70%-79.9% of the swimming season), and Poor (beach met Ontario bacterial standards and was safe for swimming less ≤ 69.9% of the swimming season) for the 10-year period of 2014-2023. The value above the bars indicates the total number of beaches that fell into that category.

Graphical Abstract



Last Updated

State of the Great Lakes 2025 Report



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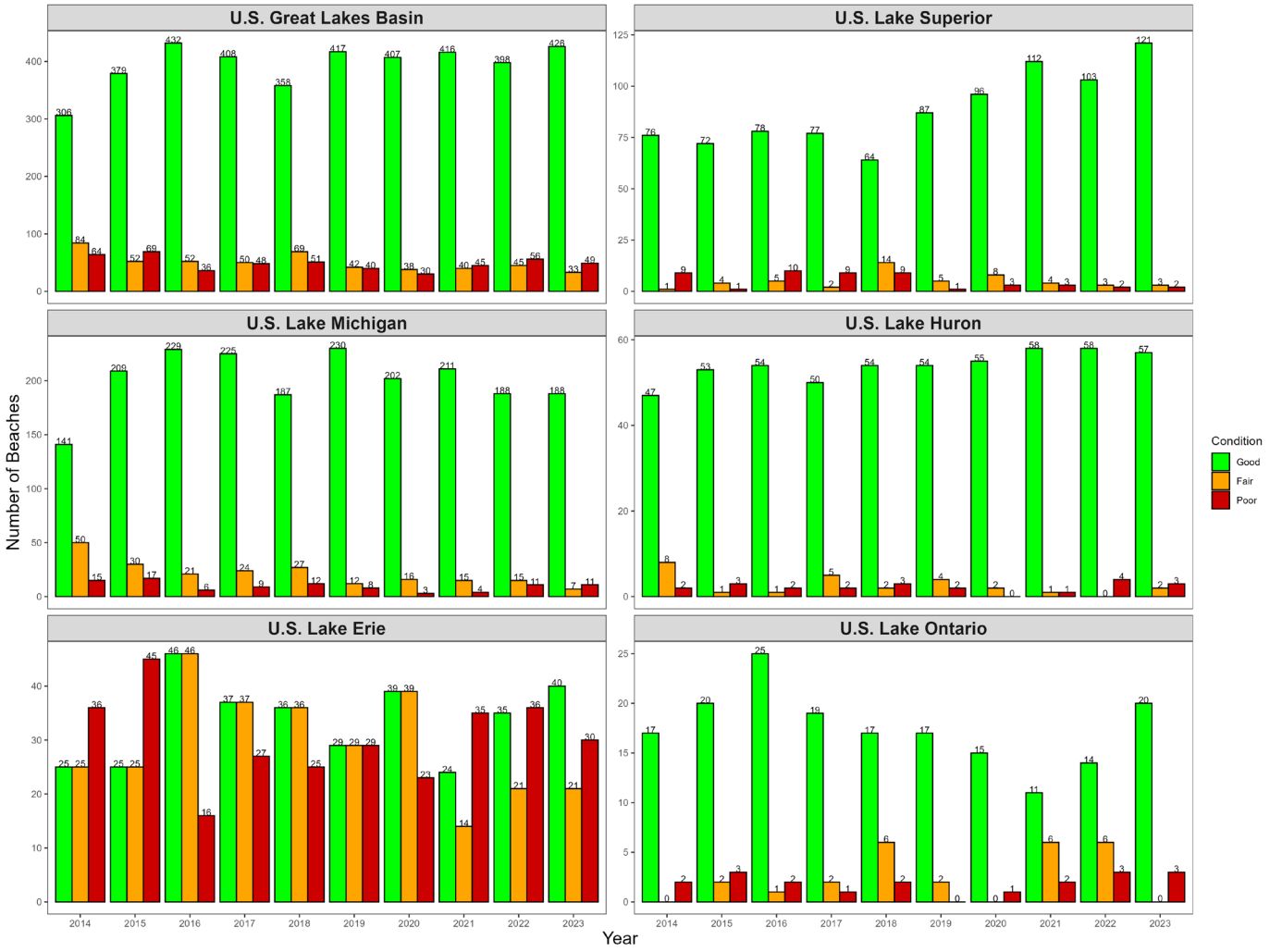

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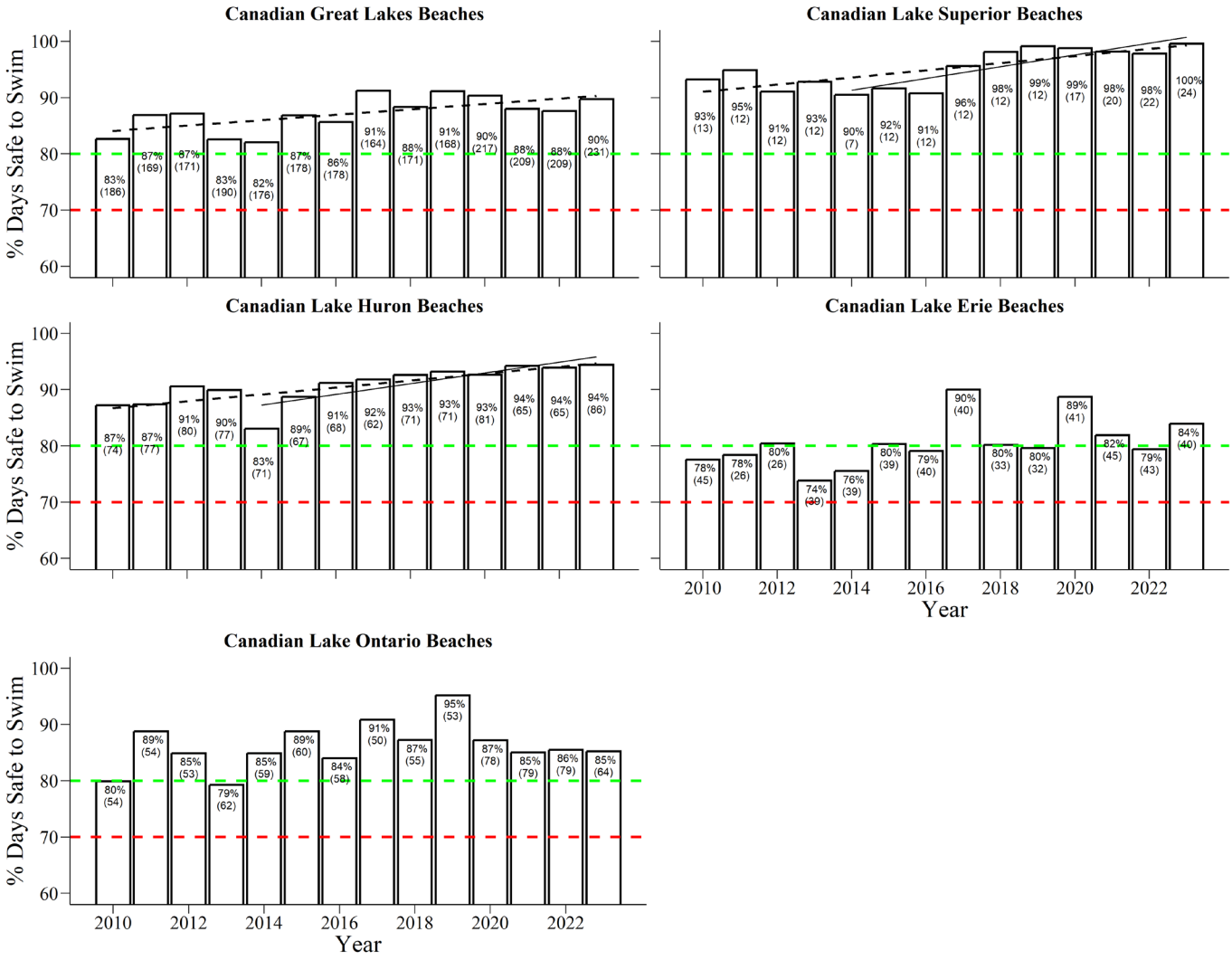

Figure 3. Percentage of days during the swimming season that Canadian Great Lakes beaches met Ontario bacterial standards and were safe for swimming from 2010-2023. A black dashed line is present if there is a significant (p-value ≤ 0.05) long-term (2010-2023) trend in the data, and a solid black line is present if there is a significant (p-value ≤ 0.05) 10-year (2014-2023) trend in the data. The number within the parenthesis represents the number of beaches monitored each year. The dashed green line represents the Canadian threshold for Good of (80% of beach days safe to swim), and the red dashed line represents the Canadian threshold for Poor: (69.9% of beach days safe to swim). All bars that extend to above the green dashed line are considered Good, all bars that extend to between the green and red dashed lines are considered Fair, and all bars that extend to below the red dashed line are considered Poor.

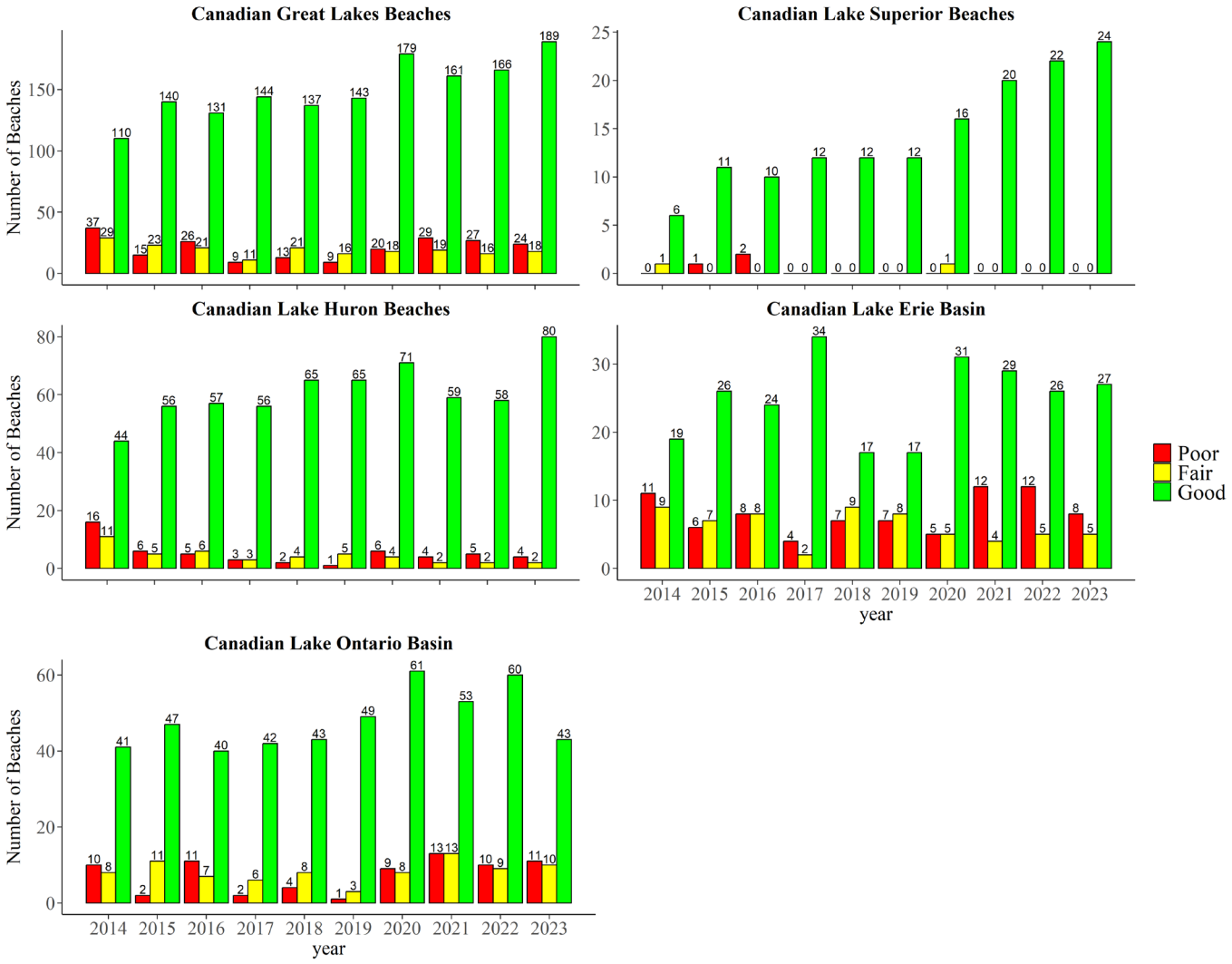

Figure 4. The number of Canadian Great Lakes beaches that fell into the categories of Good (beach met Ontario bacterial standards and was safe for swimming ≥ 80% of the swimming season), Fair (beach met Ontario bacterial standards and was safe for swimming between 70%-79.9% of the swimming season), and Poor (beach met Ontario bacterial standards and was safe for swimming less ≤ 69.9% of the swimming season) for the 10-year period of 2014-2023. The value above the bars indicates the total number of beaches that fell into that category.