Government of Canada Gouvernement du Canada

Canada

ENVIRONMENTAL MONITORING AND SURVEILLANCE IN SUPPORT OF

THE CHEMICALS MANAGEMENT PLAN

Bisphenol A in the Canadian Environment

Environment and Climate Change Canada

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1 Introduction

The Chemicals Management Plan (CMP) is a joint initiative by Environment and Climate Change Canada (ECCC) and Health Canada (HC) with the objective to protect the health and environment of Canadians from harmful substances. Bisphenol A, commonly known as BPA, is a man-made chemical compound used in the plastics industry to make polycarbonate plastics and epoxy resins (Environment Canada and Health Canada, 2008b). Under the CMP, Canada was the first country to take action on BPA (Environment Canada and Health Canada, 2008a). Through risk assessment activities conducted under the *Canadian Environmental Protection Act, 1999* (CEPA 1999), the Government of Canada concluded in a 2008 Screening Assessment Report that BPA posed a risk to the environment and human health (Environment Canada and Health Canada, 2008b). Based on this conclusion, BPA was added to the List of Toxic Substances in Schedule 1 of CEPA 1999 (Canada, 2010). The Government of Canada subsequently developed and implemented measures to reduce the risk from BPA to the environment and human health (Canada, 2018b). In addition, BPA is a substance reportable to the National Pollutants Release Inventory.

The Government of Canada has been monitoring BPA in the environment and in wastewater and landfill leachate across Canada for various time periods starting in 2004. Results from these monitoring activities have supported the risk management actions taken for this chemical, including the evaluation of their effectiveness to reduce the concentrations of BPA in the environment (ECCC, 2020). This report summarizes data collected as part of these monitoring activities.

2 Context

2.1 Monitoring and Surveillance under the Chemicals Management Plan

Monitoring (a system of long-term standardized measurements) and surveillance (focused short-term standardized measurements) are key elements of the Government of Canada's Chemicals Management Plan and are important for identifying exposures to substances and associated environmental or human health implications. For simplicity, the term "monitoring" will be used throughout this report to refer to both "monitoring and surveillance". Monitoring information feeds into science-based decision-making processes, such as assessing whether a substance is harmful to the environment or human health and evaluating the effectiveness of measures put in place to manage the risk posed by the substance.

Under the CMP Environmental Monitoring and Surveillance Program, ECCC scientists collect data on the concentrations of specific chemical substances in air, surface water, sediment, and wildlife (fish, birds) across Canada. Recognizing that many chemicals of concern ultimately end up in wastewater and waste, monitoring at wastewater treatment plants (WWTPs) and landfill sites is also conducted. Monitoring for BPA was conducted in surface water (2008 to 2018), sediment (2011 to 2018), fish (2004 to 2009), bird egg and plasma (2009 to 2015), wastewater (2008 to 2013), and in landfill leachate (2008 to 2013) collected from selected sampling sites across Canada.

Health Canada conducts human biomonitoring and monitoring in media of concern to human health including house dust, indoor air, and drinking water. With regards to BPA, biomonitoring analysis was conducted, as well as liquid and powdered infant formula surveys (Health Canada, 2018). These activities fall outside the scope of this report.

The goal of this report is to summarize monitoring data generated by ECCC in order to provide information on the spatial distribution of BPA in Canada and on temporal trends of this substance in certain environmental media from 2004 to 2018. The information presented in this report is used as part of the Evaluation of the Effectiveness of Risk Management Measures for Bisphenol A (BPA) – Ecological Component (ECCC, 2020), which aims to evaluate the effectiveness of measures that have been put in place since 2012 to manage the risk posed by BPA to the environment.

2.2 Background on BPA

BPA is a synthetic substance used to make polycarbonate plastics and epoxy resins (Cheminfo Services Inc., 2012; Crain et al., 2007; Environment Canada and Health Canada, 2008b). Polycarbonate plastic is a clear, thick, and resilient material found in reusable water bottles, CDs, DVDs, eyewear such as goggles and sun glasses, microwaveable food containers, bicycle helmets, and many other common household and consumer items (Beronius and Hanberg, 2011). Epoxy resins are used in a wide variety of products; in Canada they are used in paints/coatings and as plating agents, as intermediates in the manufacture of other products, in adhesives and sealants in grout, flooring, plastics and concrete, lubricants, and additives, and in the petroleum production process to prevent corrosion and build-up (ECCC and HC, 2019). BPA is also present in thermal paper used, for example, in receipts from retail stores and in airplane and lottery tickets (Bernier and Vandenberg, 2017).

BPA is produced in high volumes worldwide; in 2015, global BPA usage was approximately 7.7 million metric tonnes and was predicted to reach 10.6 million tonnes by 2022 (Research and Markets, 2016). The quantity of BPA reported to be used by Canadian facilities subject to a pollution prevention notice for BPA was about 1,000 kg in 2016 (Canada, 2018a).

Releases of BPA to the environment may occur during the production, processing, use, or disposal of the substance or products containing it, especially if products are exposed to high heat (Cooper et al., 2011; Environment Canada and Health Canada, 2008a; Environment Canada and Health Canada, 2008b). Though the quantities released from each product are small, the quantity of products in use makes this source non-negligible. BPA may also enter the environment through the application of biosolids from wastewater treatment on agricultural fields (Environment Canada and Health Canada, 2008b; Lee and Peart, 2000). Degradation of the flame retardant tetrabromobisphenol A (TBBPA) is also a source of BPA to the environment under oxygen-poor conditions, such as those found in buried sediment (Arbeli et al., 2006; Environment Canada and Health Canada, 2013; Voordeckers et al., 2002). There are no known natural sources of BPA.

BPA is not persistent under aerobic conditions and has a half-life of approximately 4 hours in air and 1 week in water and soil (Cousins et al., 2002; Environment Canada and Health Canada, 2008b; Staples et al., 1998). However, under oxygen-poor conditions, BPA does not degrade or degrades slowly (Environment Canada and Health Canada, 2008b; Voordeckers et al., 2002; Ying and Kookana, 2003). Despite its relatively short aerobic half-life, BPA is frequently detected in the environment because continuous anthropogenic releases replenish BPA that is lost through degradation (Flint et al., 2012). BPA is an endocrine disruptor and can adversely affect reproduction, growth, and development of both aquatic and terrestrial organisms (ECCC, 2018). BPA has a low to moderate potential to bioaccumulate in organisms in part due to their metabolism; many animals are able to degrade and excrete this chemical and its metabolites (Belfroid et al., 2002; Environment Canada and Health Canada, 2008b; Flint et al., 2012).

ECCC has developed Federal Environmental Quality Guidelines (FEQGs) to assess the ecological significance of levels of BPA in the environment (ECCC, 2018). The report Evaluation of the Effectiveness of Risk Management Measures for Bisphenol A (BPA) – Ecological Component (ECCC, 2020) compares the FEQGs to the environmental levels of BPA presented in this report in order to evaluate the effectiveness of risk management actions taken for this chemical.

3 Monitoring Results

Results and analysis for BPA concentrations measured by ECCC between 2004 and 2018, in surface water, sediment, fish, and birds across Canada are presented below, with a focus on spatial distribution. As much as possible, the monitoring sites for surface water, sediment, and fish were selected to represent major drainage regions across Canada (Appendix A). In addition, BPA monitoring sites for all media aimed to incorporate existing locations of long-term monitoring. Temporal trends of BPA are presented for surface water as well as in three dated sediment cores collected from Lake Ontario in 2013 and the St. Lawrence River (Lake St. Pierre and Boucherville Islands) in 2012. Monitoring results for Canadian wastewater (2009 to 2013) and landfill leachate (2008 to 2013) are also described below. When more than one data point for a given medium and location were available, the median (that is, the 50th percentile) and maximum values are reported.

3.1 Surface water

The data presented for surface water originates from samples collected at 51 sites (10 drainage regions) within streams, rivers, and lakes across the country between 2008 and 2018 (Figures 1 and 2). The frequency of surface water collection varied, with samples typically

obtained on a monthly, quarterly, or annual basis, depending on the site and year. The BPA concentrations in surface water collected between 2012 and 2018 are also presented in Lalonde and Garron (2020).

A portion of surface water samples were collected upstream and downstream of a municipal WWTP in three water bodies, namely the Grand River, Ontario, Thames River, Ontario, and Wascana Creek, Saskatchewan. For each of these systems, BPA concentrations were higher downstream (median = 14 ng/L for Grand River, 13 ng/L for Thames River, and 75 ng/L for Wascana Creek) than upstream (median = less than the detection limit of 3.7 to 14.4 ng/L for Grand River, Thames River, and Wascana Creek). It is important to note that BPA is not produced by the WWTPs, but quantities may persist in wastewater after treatment (see wastewater section).

BPA levels were higher in urban water bodies compared to rural or mixed-use water bodies. For example, BPA was consistently detected in Toronto, Ontario, streams such as Mimico Creek (median = 44 ng/L), Highland Creek (median = 17 ng/L), and Taylor Creek (median = 34 ng/L). Historical industrial sources also appeared to influence early BPA surface water measurements. For example, between 2008 and 2012, prior to the implementation of risk management measures, BPA concentrations in Beaverdams Creek, in Thorold, Ontario, were the highest in the surface water monitoring record (median = 338 ng/L, maximum = 6,370 ng/L). The monitoring site in Beaverdams Creek is downstream of two paper-recycling mills (one was later idled indefinitely). The BPA concentrations in Beaverdams Creek upstream of the two mills were substantially lower (median = 13 ng/L), indicating that the mills may have been major contributors of BPA at the time. More recent BPA concentrations in surface water collected

from Beaverdams Creek between 2013 and 2018 were considerably lower than previously measured (median = below the detection limit (3.7 to 14.4 ng/L), maximum = 1,889 ng/L).

BPA was only occasionally detected in surface water collected from rural areas. For example, sampling sites in smaller communities such as Emerson, Manitoba on the Red River, and Napan, New Brunswick on the Napan River, had medians below the detection level (3.7 to 14.4 ng/L). In addition, BPA concentrations were generally low in surface water collected from large waterbodies such as the St. Lawrence River (median = below the detection limit (3.7 to 14.4 ng/L)) and the Niagara River (median = below the detection limit (3.7 to 14.4 ng/L)), where the large volumes of water can dilute potentially high BPA concentrations to low levels. Major exceptions to this include enclosed harbours with WWTP discharges. This is shown in a site on the south side of Hamilton Harbour (Site 914, median = 47 ng/L), which is located adjacent to the diffuser of one of three WWTPs discharging to the harbour.

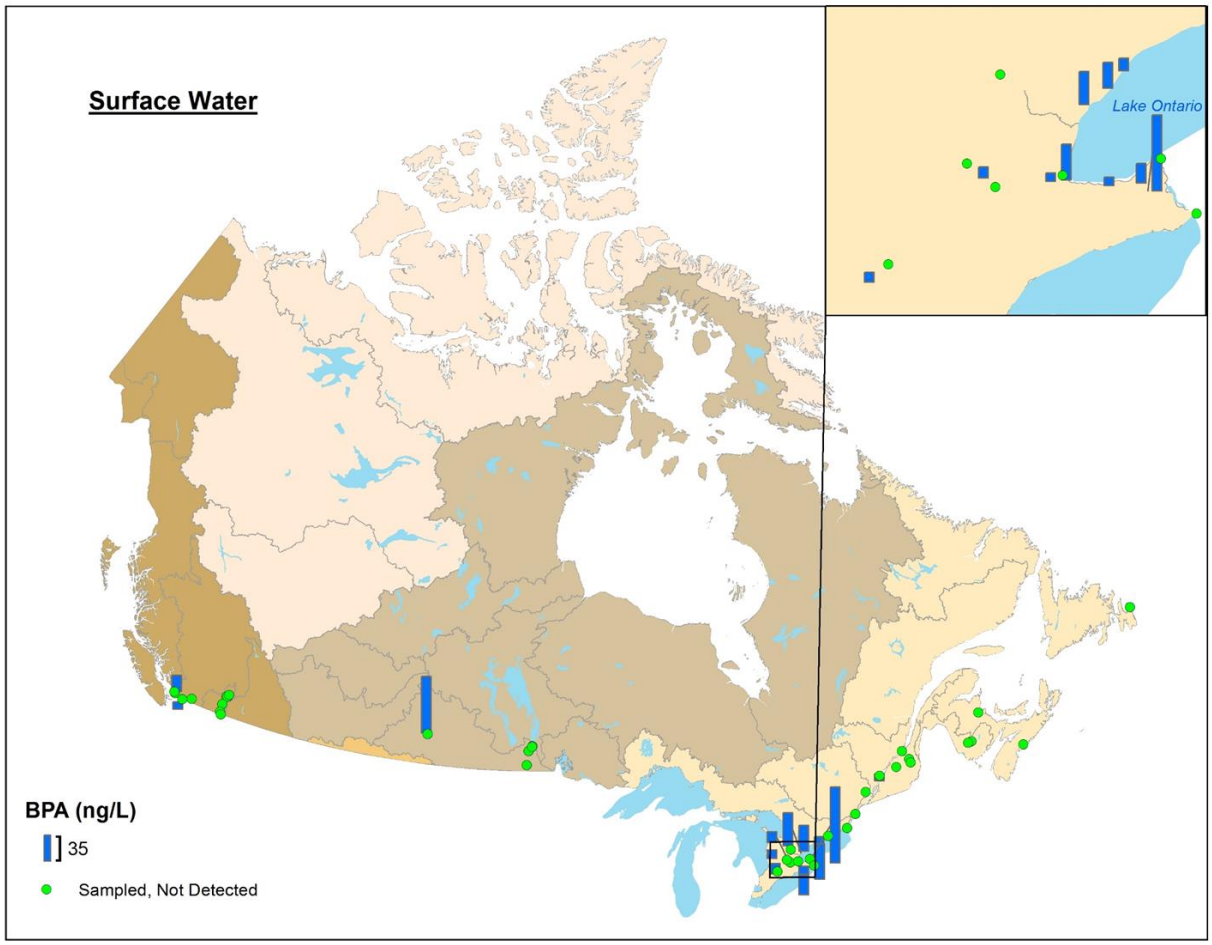

Figure 1: BPA concentrations in surface water (2008 to 2018) samples collected across Canada. Where more than one data point was available for a given location, the median value was plotted, and is represented by a blue bar proportional to the one in the legend. The green circles represent sites where either BPA was not detected, or, if there were multiple samples, the median was below the detection level. The divisions on the map represent Canada's drainage regions, which are identified in Appendix A, comprising 25 of Canada's major rivers.

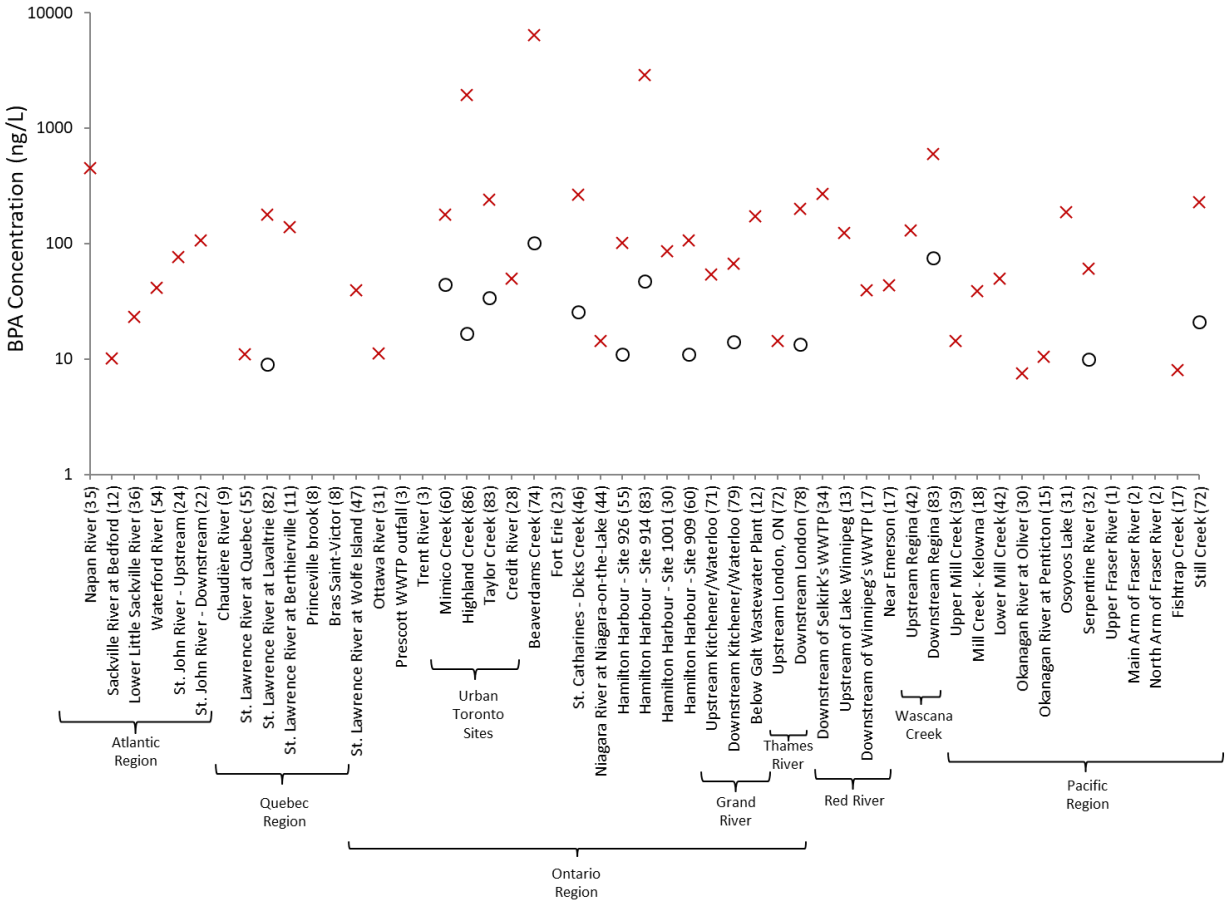

Figure 2: BPA concentrations in surface water bodies across Canada between 2008 and 2018. For each location, the median (that is, the 50th percentile) concentration is shown as a black circle and the maximum concentration is shown as a red "×". The median and maximum concentrations are not shown if they are under the detection limit for the methodology used in their analysis, that is, if they contained too little BPA for it to be detected. The detection limits vary between samples (with a range of 1 to 14.4 ng/L) as there were different methodologies used in quantifying their BPA content. The numbers in parentheses indicate the number of water samples collected and analyzed for BPA at each location.

Time trends of BPA were evaluated in surface water at 12 sites where samples were collected consistently over a 10-year period. These sites include St. Lawrence River at Quebec, St. Lawrence River at Lavaltrie (Quebec), Highland Creek (Ontario), Taylor Creek (Ontario),

Hamilton Harbour (Sites 909, 914, and 926; Ontario), Beaverdams Creek (Ontario), Grand River (Ontario) downstream of Kitchener/Waterloo, Thames River (Ontario) downstream of London, Wascana Creek (Saskatchewan) downstream of Regina, and Still Creek (British Columbia). The time trends of BPA in surface water were statistically analyzed using the Seasonal Kendall trend test (Gewurtz et al., 2019; Helsel and Hirsch, 2002; Millard, 2018) and the trend line was calculated using Akritas-Theil-Sen nonparametric regression (Helsel, 2012).[1] Significant declining trends ($p<0.05$) between 2008 and 2018 were found at 9 of 12 of these long-term monitoring sites. For instance, the time trend results for three sites, Hamilton Harbour Site 909, Beaverdams Creek, and Still Creek are shown in Figure 3. St. Lawrence River at Lavaltrie, Hamilton Harbour (Site 914), and Wascana Creek, downstream of Regina, were the only locations where BPA concentrations in surface water did not significantly ($p>0.05$) decrease between 2008 and 2018. It should be noted that the BPA concentrations in surface water were analyzed in three different analytical laboratories. Between 2008 and 2011, the samples were analyzed at ECCC's National Water Research Institute in Burlington, Ontario, between 2012 and March 2014, the samples were analyzed by AXYS Analytical Services Ltd. in Sidney, British Columbia, and between April 2014 and 2018, the samples were analyzed by ECCC's National Laboratory for Environmental Testing in Burlington, Ontario. A detailed description of the time trends of BPA in surface water is presented in Gewurtz et al. (2020).

[1] The statistical tests that were used to assess the time trends of BPA in surface water were selected due to their applicability to datasets that contain concentrations that are below the detection limit. For further reading on these tests, please see Helsel and Hirsch (2002) and Helsel (2012).

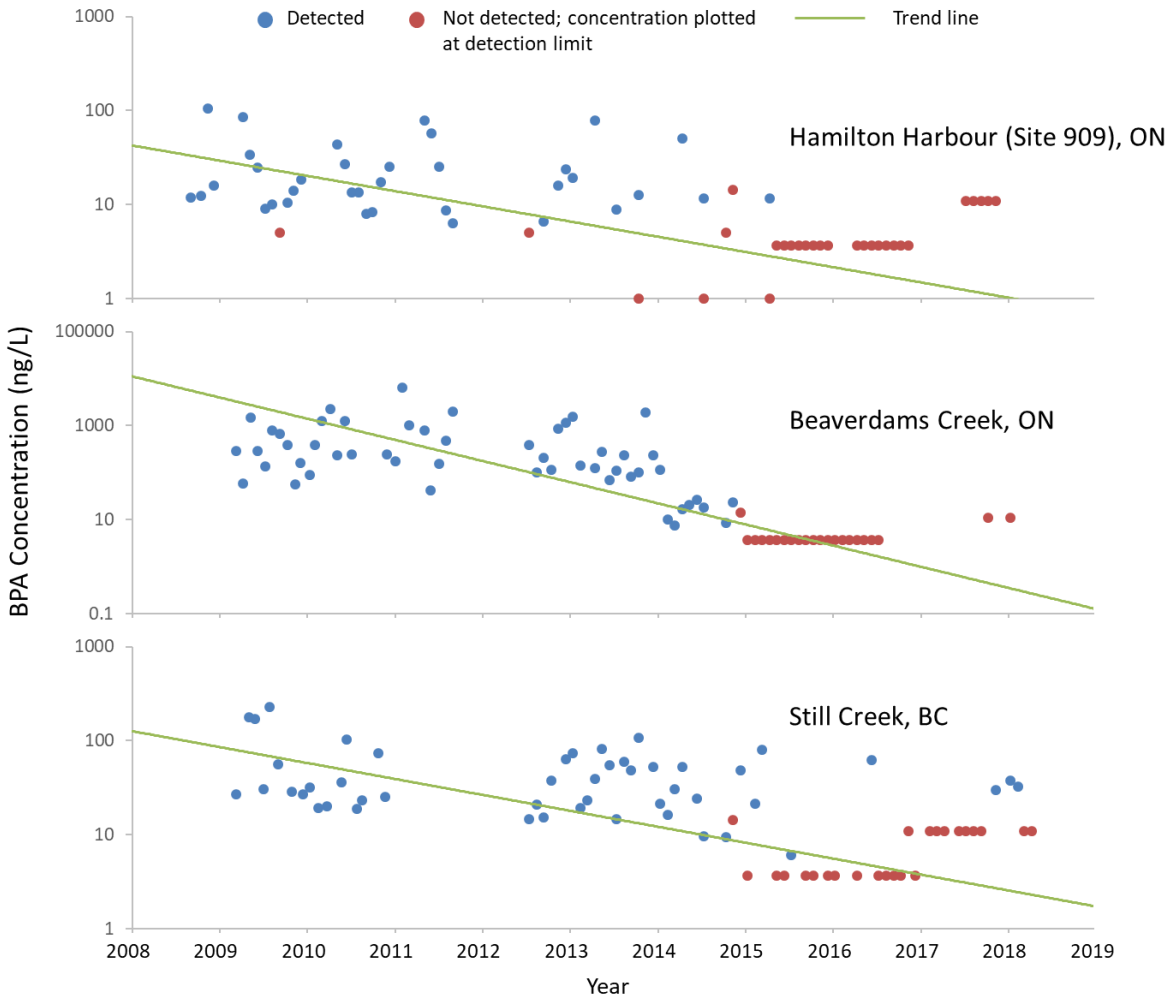

Figure 3: Time trends of BPA concentrations in three surface water bodies in Canada between 2008 and 2018. The detection limits vary between samples as there were different methodologies used in quantifying their BPA content.

3.2 Sediment

BPA was measured in 272 surface sediment samples collected from 31 sites (nine drainage regions) across Canada between 2011 and 2018 (Figures 4 and 5). Sediment samples were collected every year, although specific sampling locations varied in each year and in some locations, sediment was only collected once. The surface sediment samples were collected in the

top layer with a total depth ranging between 1 and 3 cm. Different sites were targeted during each year of sample collection. BPA concentrations were below the detection limit (<2 µg/kg dry weight) in 68% of sediment samples. Similar to surface water, urbanized and industrialized sites generally contained higher BPA concentrations than more remote locations. For example, in the Pacific region, Still Creek station near Vancouver had median and maximum concentrations of 37 and 51 µg/kg dry weight, respectively. In the Great Lakes basin, the majority of concentrations measured were below the detection limit, except in the Detroit River (32 µg/kg dry weight) and in the Hamilton Harbour (130 µg/kg dry weight) and Toronto Harbour (57 µg/kg dry weight) regions of Lake Ontario. Relatively elevated concentrations were also observed in the St. Lawrence River downstream of Montreal (32 µg/kg dry weight) and in Lake Saint-Pierre (33 µg/kg dry weight). In the Atlantic region, three samples with relatively elevated concentrations were observed in Banook Lake near Dartmouth, Nova Scotia (27 µg/kg dry weight), the St. John River near Fredericton, New Brunswick (40 µg/kg dry weight) and the Waterford River near St. John's, Newfoundland (36 µg/kg dry weight). As discussed in the report Evaluation of the Effectiveness of Risk Management Measures for Bisphenol A (BPA) – Ecological Component (ECCC, 2020), the surface sediment layer can be representative of multiple years of data, depending on the sedimentation rate in a given water body. Therefore, even the most recent samples may contain BPA deposited prior to the implementation of risk management activities. In addition, sediment is an area with little to no oxygen and the rate of BPA degradation is slower than in water. It is important to note that BPA has been observed to migrate downward within sediment (Peng et al., 2007), which could influence concentrations observed in surface sediment.

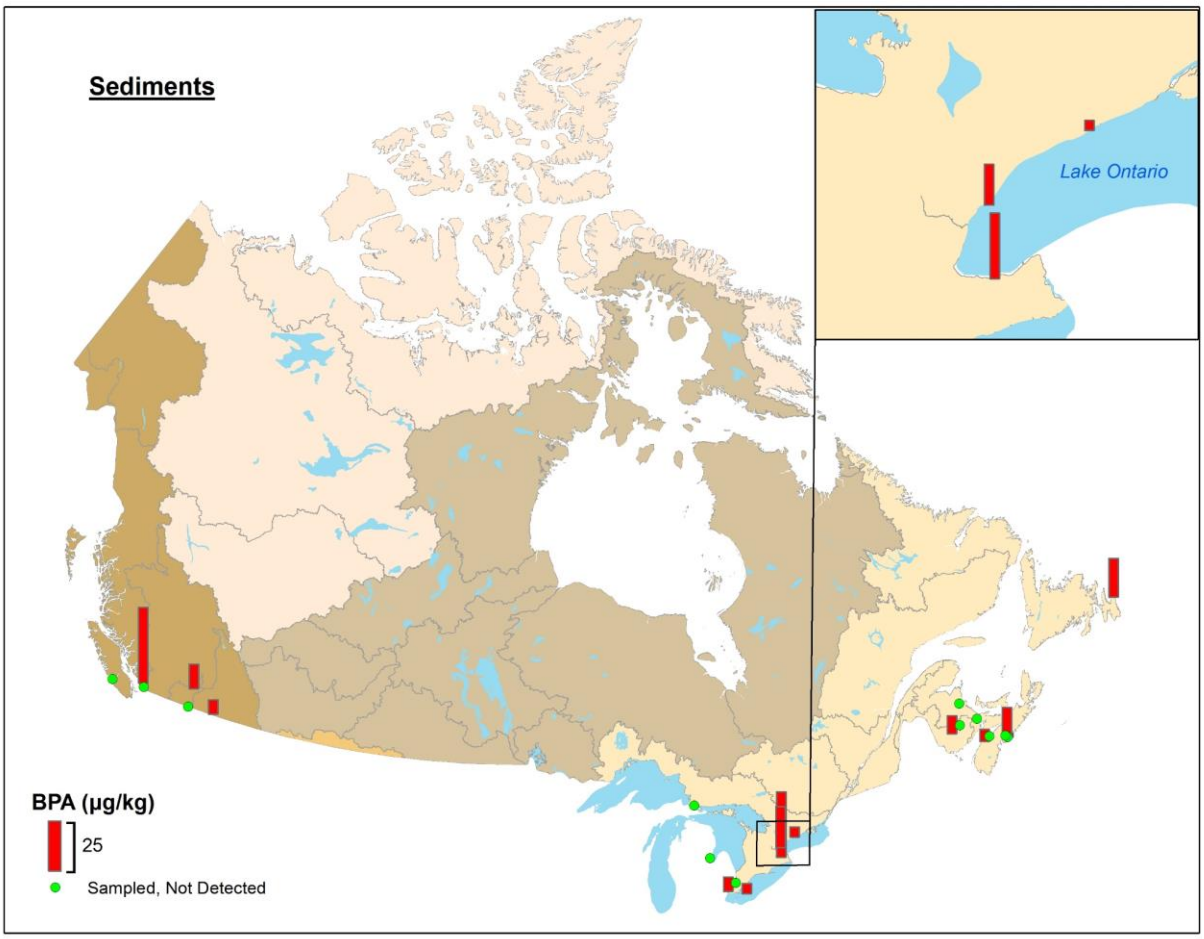

Figure 4: BPA concentrations in surface sediment samples collected across Canada between 2011 and 2018. The surface sediment were collected in the top layer with a total depth ranging between 1 and 3 cm. Where more than one data point was available for a given location, the median value was plotted, which is represented by a red bar proportional to the one in the legend. The green circles represent sites where either BPA was not detected, or, if there were multiple samples, the median was below the detection level. The divisions on the map represent Canada's drainage regions, which are identified in Appendix A, comprising 25 of Canada's major rivers.

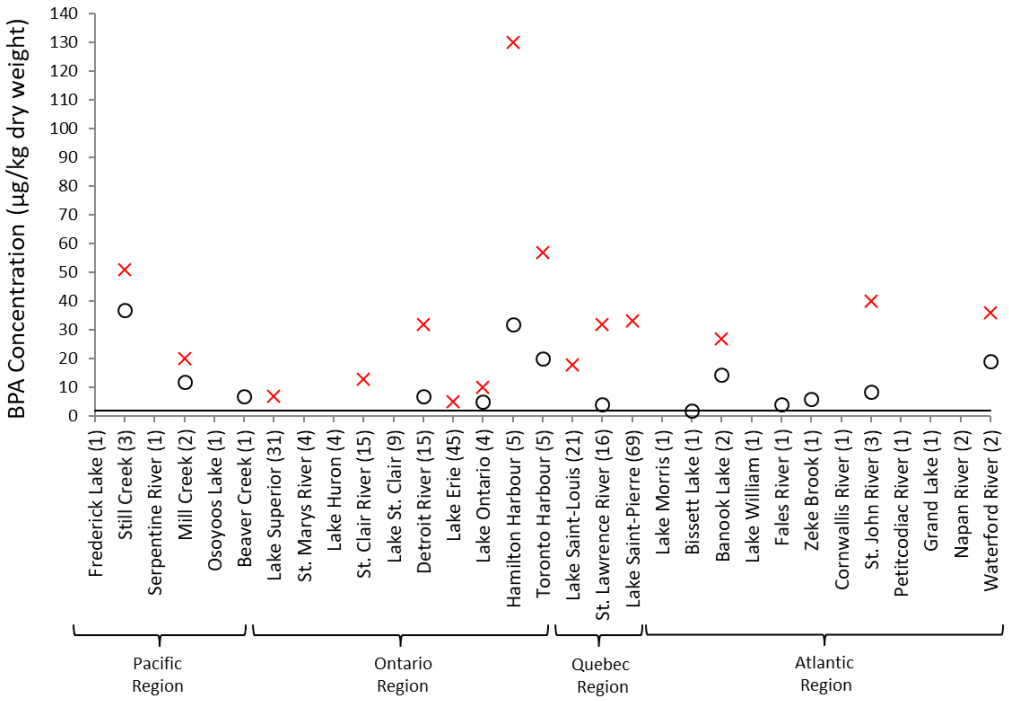

Figure 5: BPA concentrations in surface sediment collected from water bodies across Canada between 2011 and 2018. The surface sediment were collected in the top layer with a total depth ranging between 1 and 3 cm. For each location, the median (that is, the 50th percentile) concentration or value (if only one measurement) is shown as a black circle. The maximum concentration (red "×") is also shown where there was more than one data point for a given location. The detection limit of 2 µg/kg dry weight (black line) is shown for comparison. The median and maximum BPA concentrations are not shown if they were below the limit of detection. The numbers in parentheses indicate the number of sediment samples collected and analyzed for BPA at each location.

BPA was measured in suspended sediment in the St. Lawrence River downstream of the Montreal WWTP from June to November 2012 (Figure 6). Suspended sediment samples were collected 1 metre above the river bottom over five-week time periods. The integrated samples were collected in June, July, August, October, and November.

Upstream of the effluent outfall, average concentrations of BPA were 11.8 μg/kg dry weight. BPA concentrations increased four-fold 4 km downstream of the outfall to an average of 41.2 μg/kg dry weight. At 20 km downstream, suspended sediment samples taken from the middle of the river, where the effluent plume is expected to travel (Marcogliese et al., 2015), showed a decrease in BPA levels to an average of 18.4 μg/kg dry weight. Samples taken at 20 km downstream on the south shore, where the main flow of the river runs, had average BPA concentrations of 11.8 μg/kg dry weight, which is a slight decrease from the 13.8 μg/kg dry weight average at 13 km from the outfall. The water on the north shore of this section of the St. Lawrence River stems primarily from the Prairies River, Quebec, where several wastewater effluent discharge locations contribute to the water mass. The BPA average concentration at 20 km downstream on the north shore was 21.6 μg/kg dry weight, slightly below the average of 25.2 μg/kg dry weight on the north shore, 12 km from the outfall.

In this section of the St. Lawrence River corridor, the water velocity is high (30 cm/s) and there is not a defined sedimentation basin. The decrease in BPA concentration in suspended sediments in the effluent plume and on the south shore is due to the dilution of the suspended sediment load near the WWTP. However, the data suggest that the effects of this dilution in the water on the north shore are limited by inflow mainly from the Prairies River, where several wastewater effluent discharge locations can contribute to increasing the BPA load. Concentrations measured 20 km from the outfall on the south shore were similar to those measured upstream.

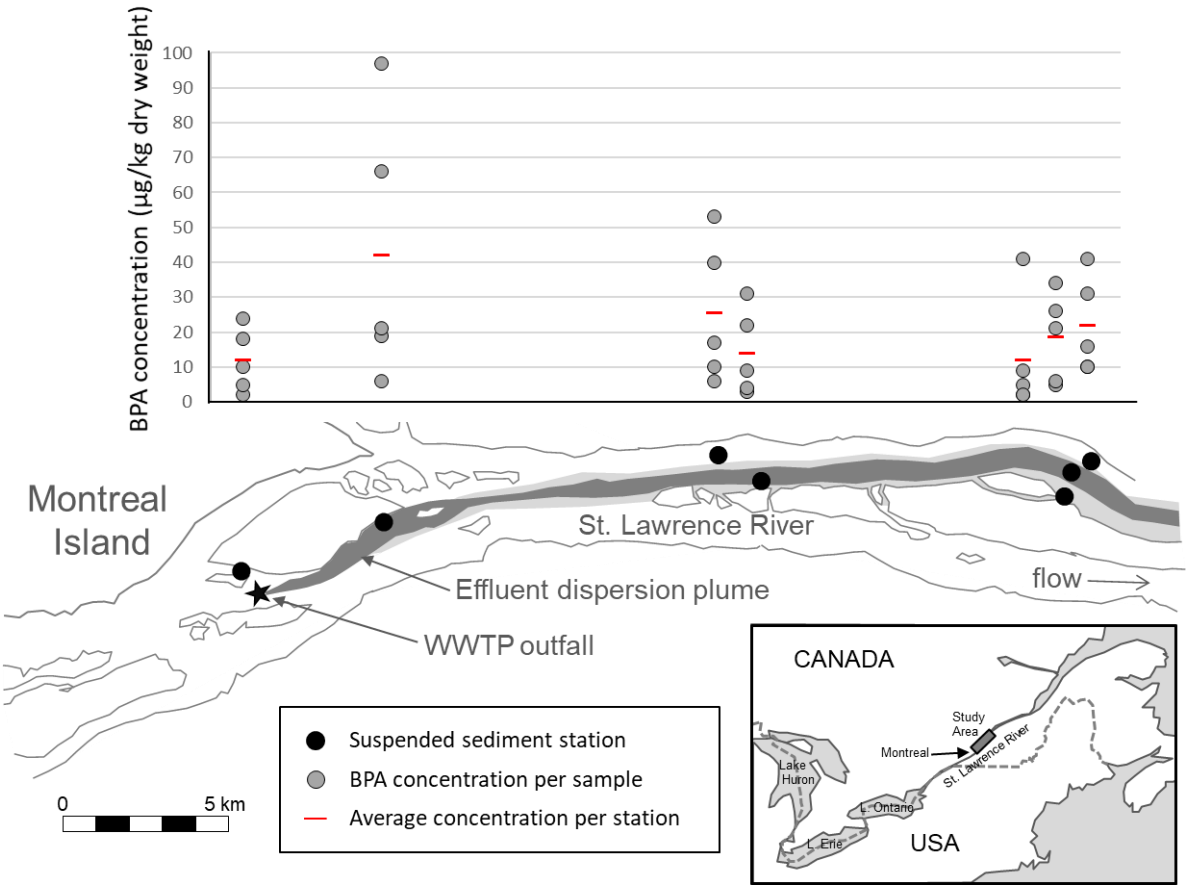

Figure 6: BPA concentrations in suspended sediment of the St. Lawrence River collected along the effluent plume from the Montreal WWTP, upstream and various distances downstream from the WWTP outfall in 2012. The north shore receives its water in large part from the Prairies River, and the south shore receives its water mainly from the St. Lawrence River.

Inferences on temporal trends of BPA were obtained from three dated sediment cores collected from Lake Ontario in 2013, Lake St. Pierre in 2012, and a channel on the Boucherville Islands near Montreal in 2012 (Figure 7). The temporal profile of BPA concentrations in Lake Ontario sediments is consistent with the widespread use of BPA in the plastics industry since the early 1960s. Concentrations were relatively stable, ranging from 18 to 36 µg/kg dry weight between the 1960s and the 1990s. In the mid-1990s, BPA concentrations in the temporal profile

of Lake Ontario sediments doubled to 70 μg/kg dry weight. The temporal profile of sediments on the Boucherville Islands also shows a peak BPA concentration of 10 μg/kg dry weight during this same period. The temporal profile of Lake Ontario sediments shows a gradual decrease in BPA concentrations between 1995 and 2006. This decrease could be related to water treatment in the various industries and municipalities located in the lake's watershed. This decrease is also apparent in the sediment profile of the Boucherville Islands and appears to correspond to the commissioning of the WWTP to service the municipalities on the south shore of Montreal in 1992. BPA was not detected in Lake St. Pierre until 2008, and thus time trends could not be evaluated in this core until the mid-2000s. Starting in the mid-2000s, the temporal profiles show an increase in BPA concentrations in Lake Ontario, the Boucherville Islands, and Lake St. Pierre, which differs from the time trends in surface water during this period, where BPA concentrations decreased. This increase of BPA concentrations in sediment cores could be the result of several factors including degradation of the flame retardant tetrabromobisphenol A (TBBPA) to BPA in sediment (Environment Canada and Health Canada, 2013). Concentrations of TBBPA may have increased in the mid-2000s through its use as a replacement for regulated flame retardants (e.g., polybrominated diphenyl ethers) in consumer products (Environment Canada and Health Canada, 2013). Similar to surface sediment samples discussed above, concentrations of BPA in sediment cores could be influenced by downward migration of BPA within the core (Peng et al., 2007).

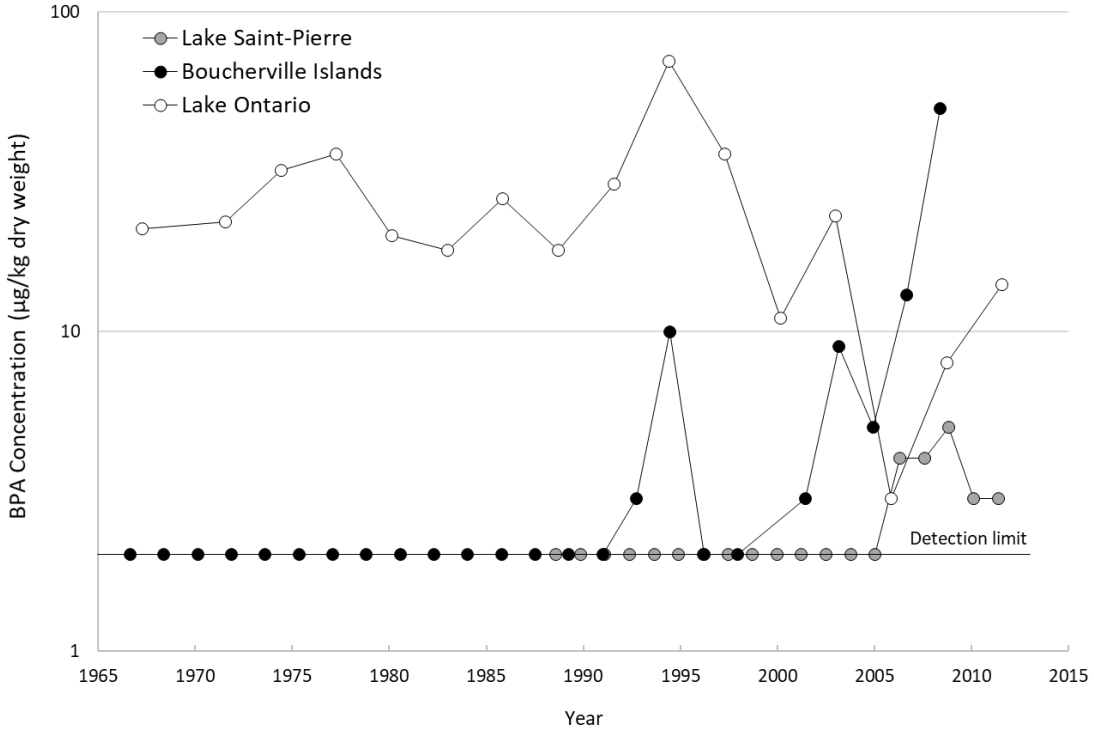

Figure 7: Concentrations of BPA (µg/kg dry weight) in three sediment cores, collected from Lake Ontario in 2013, Lake Saint-Pierre in 2012, and the Boucherville Islands in 2012. The detection limit of 2 µg/kg (solid black line) is shown for comparison.

3.3 Biota

BPA was measured in whole fish of various species collected from Hamilton Harbour (2004), lake trout (*Salvelinus namaycush*) from Lakes Ontario (2007) and Superior (2009) and walleye (*Sander vitreus*) from Lake Huron by the French River in 1995. The highest BPA levels were found in gizzard shad (*Dorosoma cepedianum*) (median = 13.5 pg/g wet weight, maximum = 22.2 pg/g) and common carp (*Cyprinus carpio*) (median = 5.5 pg/g wet weight, maximum = 36.3 pg/g) from Hamilton Harbour in 2004 (Figure 8). Three WWTPs discharge into the Hamilton Harbour (one of which receives landfill leachate) and there are several landfill sites located in the Hamilton Harbour watershed. The surface water in the Hamilton Harbour also

contains relatively elevated BPA concentrations. BPA was not detected in lake trout from Lake Ontario or Lake Superior and had a low detection frequency in Lake Huron. This is not surprising as the large water volume of these lakes likely dilute BPA to low concentrations, as found for surface water.

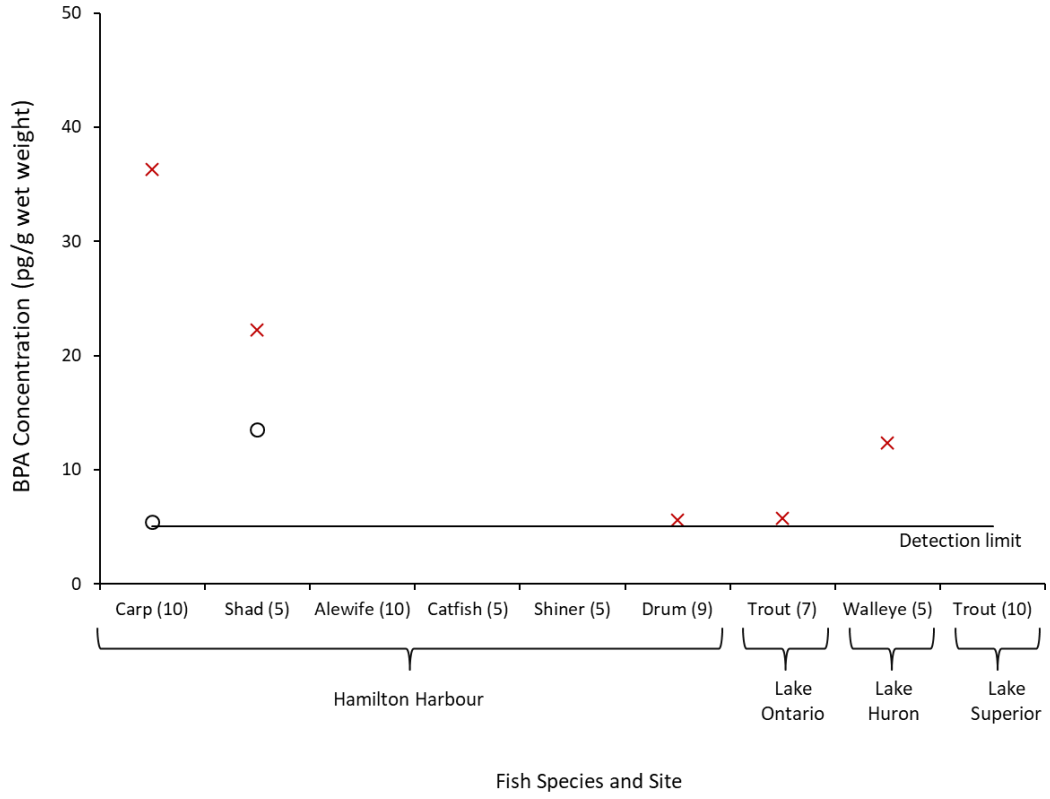

Figure 8: BPA concentrations in fish (whole samples) collected from Ontario surface water bodies between 1995 and 2009. For each location, the median (that is, the 50th percentile) concentration is shown as a black circle and the maximum concentration is shown as a red "×". The detection limit of 5 pg/g wet weight is indicated as a black line. The median and maximum BPA concentrations are not shown if they were below the limit of detection. The numbers in parentheses indicate the number of fish samples collected and analyzed for BPA at each location.

BPA was also measured in two types of bird tissue: eggs and plasma. Eggs were collected for three species, the glaucous-winged gull (*Larus glaucescens*), herring gull (*Larus argentatus*), and tree swallow (*Tachycineta bicolor*), at seven sites in Quebec, Ontario, and three Pacific regions in 2009. Collection locations included remote areas as well as sites receiving direct inputs of treated wastewater at Hamilton Harbour and a sewage lagoon where increased BPA exposure might be expected. BPA was not detected in any bird eggs from these sites.

BPA in plasma was measured in chicks of the European starling (*Sturnus vulgaris*), tree swallow (*Tachycineta bicolor*), and double-crested cormorant (*Phalacrocorax auritus*) between 2009 and 2012. The goal of this monitoring was to determine birds' exposure to BPA in different locations. Ten collection sites included three landfills and three WWTPs, where exposure to BPA might be expected, as well as three sites within an industrial area (Hamilton Harbour) and a reference site at a conservation area in Milton, Ontario (Figure 9). Median BPA concentrations were highest in starling plasma collected from one of the landfill sites. BPA was also detected in plasma of tree swallows feeding immediately downstream of the outflow of the three WWTPs. BPA was detected in plasma of cormorants from sites within the Hamilton Harbour industrial site but not in starlings or swallows from this area, or in swallows from the reference site in Milton.

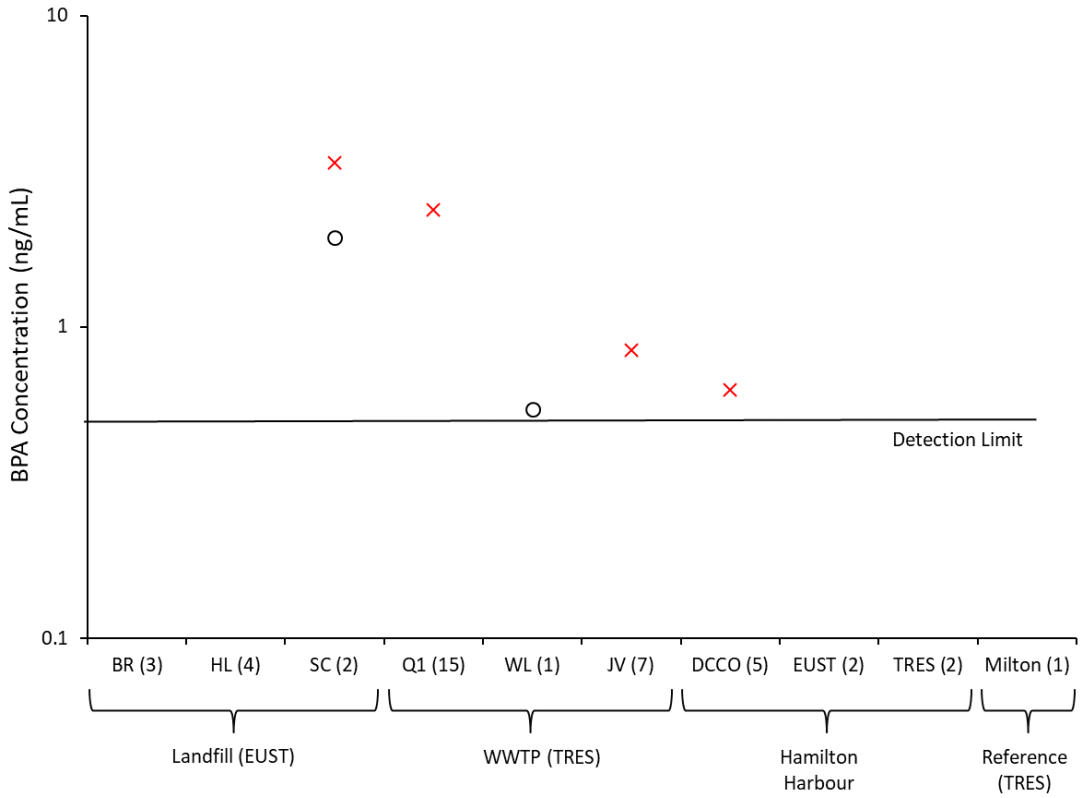

Figure 9: BPA concentrations in plasma of chicks of European starlings (EUST), tree swallows (TRES), and double-crested cormorants (DCCO) from landfill and WWTP sites, Hamilton Harbour (an industrial area), and a conservation area (reference site) in Ontario collected between 2009 and 2012. Codes are used for the landfills and WWTPs to protect the anonymity of the participating sites. For each site, the median (that is, the 50th percentile) concentration or value (if only one measurement) is shown as a black circle. The maximum concentration (red "×") is also shown where there was more than one data point for a given location. The detection limit (0.5 ng/mL) is shown for comparison. The median and maximum BPA concentrations are not shown if they were below the limit of detection. The numbers in parentheses indicate the number of plasma samples collected and analyzed for BPA at each location.

In 2014 and 2015, plasma of European starling chicks was collected at nest boxes adjacent to three fields treated with biosolids (applied one year prior) and at two field sites where no biosolids were applied (reference fields). Chicks near fields amended with biosolids one year

post-application had a median BPA concentration of 0.06 ng/mL (max of 4.57 ng/mL) while the median concentration at reference fields was below the limit of detection (max of 17.51 ng/mL; Figure 10). In 2015, monitoring was also conducted at a biosolid-treated field two years post-application and at this site, chicks had a median BPA concentration of 6.19 ng/mL (max of 54.3 ng/mL). A higher median BPA concentration in plasma of European starlings near biosolids-treated fields suggests that BPA exposure may be higher in birds nesting in the vicinity of such soils.

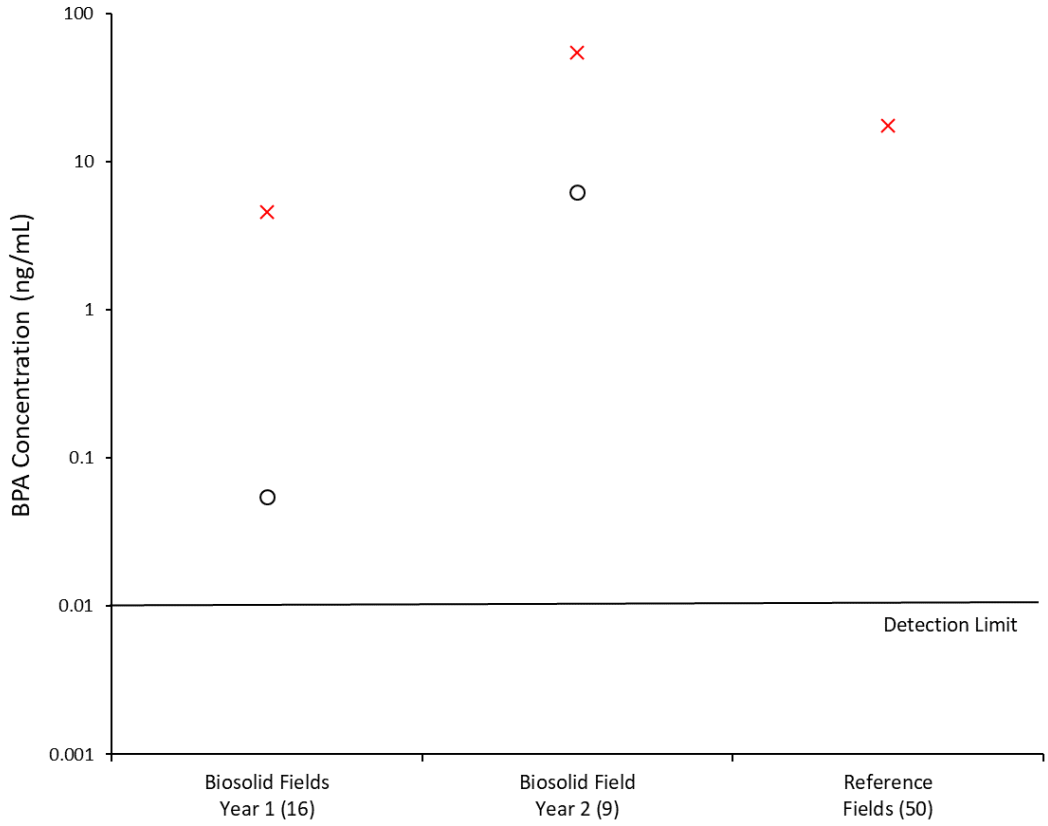

Figure 10: BPA concentrations in plasma of European starling chicks at nests near biosolid-treated fields 1 year post-application (3 fields) and 2 years post-application (1 field) in 2014 and 2015. Median (that is, the 50th percentile) concentrations (black circle) and maximum concentrations (red ×) are shown for each site. The detection limit (0.01 ng/mL) is shown for comparison. The median concentration at reference fields was

below the limit of detection. The numbers in parentheses indicate the number of plasma samples collected and analyzed for BPA at each location.

3.4 Wastewater and Landfills

The wastewater treatment component of the CMP Environmental Monitoring and Surveillance program provides information on the significance of wastewater effluent discharges and land application of treated biosolids as sources of BPA to the environment. Between 2009 and 2012, 25 WWTPs representing typical wastewater treatment processes in Canada were sampled in summer and winter. Some of the WWTPs monitored receive landfill leachate. Municipal systems as well as systems located on federal or aboriginal lands were included in the program. Influent BPA concentrations across all WWTPs ranged from 34 ng/L to 8,000 ng/L, with a median value of 400 ng/L. Effluent BPA concentrations ranged from 5 ng/L to 7,400 ng/L, with a median value of 150 ng/L. Removal rates of BPA during wastewater treatment ranged from 1% to 77% as medians, depending on the treatment type used. Results from wastewater solids analysis showed median BPA concentrations of 230 ng/g in primary sludge (range = 59 ng/g to 870 ng/g), 290 ng/g in waste biological sludge (range = 27 ng/g to 4,600 ng/g), and 460 ng/g in treated biosolids (range = 38 ng/g to 12,000 ng/g). These results indicate that BPA is consistently present in wastewater solids and effluents (Guerra et al., 2015). The median BPA concentration in WWTP effluent of 150 ng/L is greater than in surface water collected at sites downstream of WWTPs such as the Grand River (14 ng/L at 5 km downstream), Thames River (13 ng/L at 6 km downstream), Wascana Creek (75 ng/L at 8.5 km downstream), and Hamilton Harbour (47 ng/L within 5 km from all WWTPs).

In order to monitor the potential release of BPA from a segment of the solid waste sector, landfill leachate was collected from a total of 13 Canadian municipal solid waste landfill sites between 2008 and 2013 (Conestoga Rovers & Associates, 2013; Conestoga Rovers & Associates, 2015). The landfills all receive municipal solid waste and some also receive other types of waste such as industrial, commercial and institutional waste, construction waste, and sewage sludge. Samples were collected prior to treatment at all landfill sites. Treated leachate samples were additionally obtained from four landfills that have an on-site leachate treatment system. In samples of raw leachate, BPA concentrations ranged from below the method reporting limit (10 to 20,000 ng/L) to 1,940,000 ng/L, with a median of 56,050 ng/L. BPA was detected in 93% of these samples. In samples of treated leachate, BPA concentrations ranged from below the method reporting limit (1 to 20,000 ng/L) to 299,000 ng/L, with a median of 588 ng/L. BPA was detected in 65% of these samples. The large method reporting limit range was caused by dilution of some of the samples during the analytical procedure to bring concentrations within a range that could be detected by the instruments. On-site treatment of landfill leachate resulted in an average and median BPA removal rate of 93% and 100%, respectively. For most of the monitored landfills, untreated leachate is discharged to WWTPs. Approximately 87% of the leachate generated by large landfills in Canada (greater than 40,000 tonnes of municipal solid waste per year) is treated by municipal WWTPs (Conestoga Rovers & Associates, 2015). The remainder is either treated onsite prior to release (7.1%) or is released directly into the environment without treatment (5.5%) (Conestoga Rovers & Associates, 2015). Additionally, leachate generated at some, particularly smaller, landfills may be released to the environment via surface water runoff or groundwater discharge. Ultimately, these data indicate that some landfill leachate could represent a source of BPA to the environment.

4 Conclusions

BPA levels measured in surface water, sediment, fish, and birds across Canada were generally higher near sources such as wastewater discharged from WWTPs (some of which receive landfill leachate), landfill sites and paper-recycling mills, and in large cities compared to other sampling sites. High concentrations of BPA were also detected in WWTP effluent and in landfill leachate. These results suggest that human activities, such as industry and consumer use of polycarbonate plastic, contribute to BPA found in the environment.

5 References

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6 For More Information

The Chemicals Management Plan and Monitoring Program

- The Chemicals Management Plan: http://www.chemicalsubstanceschimiques.gc.ca/plan/index-eng.php
- Monitoring and Research under the Chemicals Management Plan: http://www.chemicalsubstanceschimiques.gc.ca/fact-fait/monitor-surveill-eng.php
- Environmental Monitoring and Surveillance: Chemicals Management: https://www.canada.ca/en/environment-climate-change/services/science-technology/programs/monitoring-surveillance-chemicals-management.html

Risk Assessment and Management of BPA

- Bisphenol A in Batch 2 of the Challenge: https://www.canada.ca/en/health-canada/services/chemical-substances/challenge/batch-2/bisphenol-a.html
- Screening Assessment for the Challenge Phenol, 4,4' -(1-methylethylidene)bis- (Bisphenol A): http://www.ec.gc.ca/ese-ees/3C756383-BEB3-45D5-B8D3-E8C800F35243/batch2_80-05-7_en.pdf
- CEPA 1999 Schedule 1 – List of Toxic Substances: http://www.ec.gc.ca/lcpe-cepa/default.asp?lang=En&n=0DA2924D-1&wsdoc=4ABEFFC8-5BEC-B57A-F4BF-11069545E434
- Risk Management Action Milestones for BPA:

http://www.chemicalsubstanceschimiques.gc.ca/challenge-defi/batch-lot-2/bisphenol-a/bpa-risk_hazard-eng.php

Health Canada's Activities

- Maternal-Infant Research on Environmental Chemicals: http://www.hc-sc.gc.ca/ewh-semt/contaminants/human-humaine/mirec-eng.php
- The Canadian Health Measures Survey: http://www.hc-sc.gc.ca/ewh-semt/contaminants/human-humaine/chms-ecms-eng.php
- Canadian Total Diet Study: http://www.hc-sc.gc.ca/fn-an/surveill/total-diet/index-eng.php
- Prohibiting the use of BPA in baby bottles http://gazette.gc.ca/rp-pr/p2/2010/2010-10-13/pdf/g2-14421.pdf
- Bisphenol A (BPA) Health Information for Canadians https://www.canada.ca/en/health-canada/services/home-garden-safety/bisphenol-bpa.html

Federal Environmental Quality Guidelines

- *Canadian Environmental Protection Act, 1999*: Federal Environmental Quality Guidelines Bisphenol A. https://www.canada.ca/en/environment-climate-change/services/evaluating-existing-substances/federal-environmental-quality-guidelines-bisphenol-a.html

7 Appendix A. Canadian drainage regions

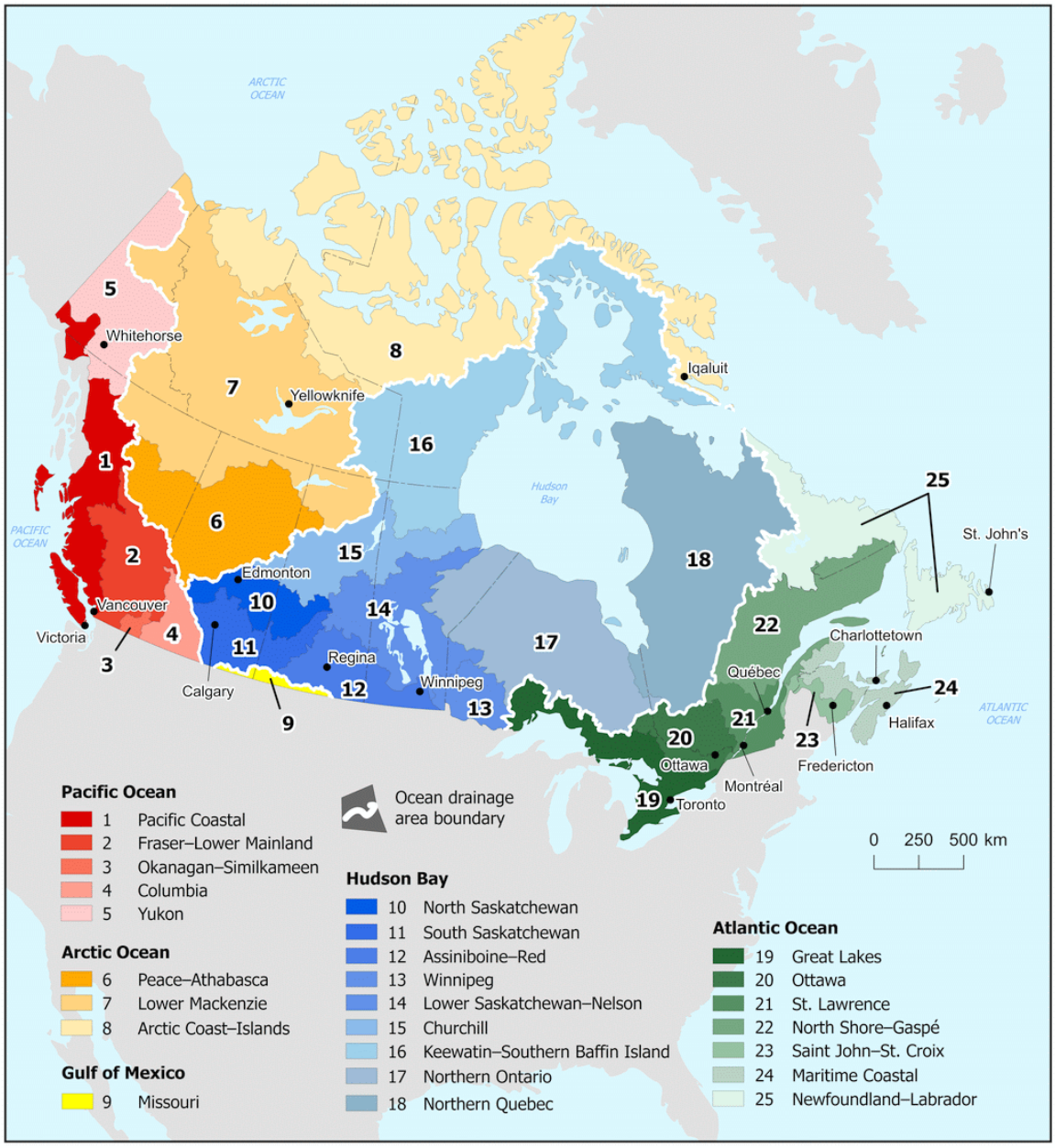

Figure A-1: Map of Canada with the drainage regions labeled (Statistics Canada, 2017). This map was originally generated by Statistics Canada, Environment, Energy and Transportation Statistics Division in 2009, with special tabulation from Pearse et al. (1985).