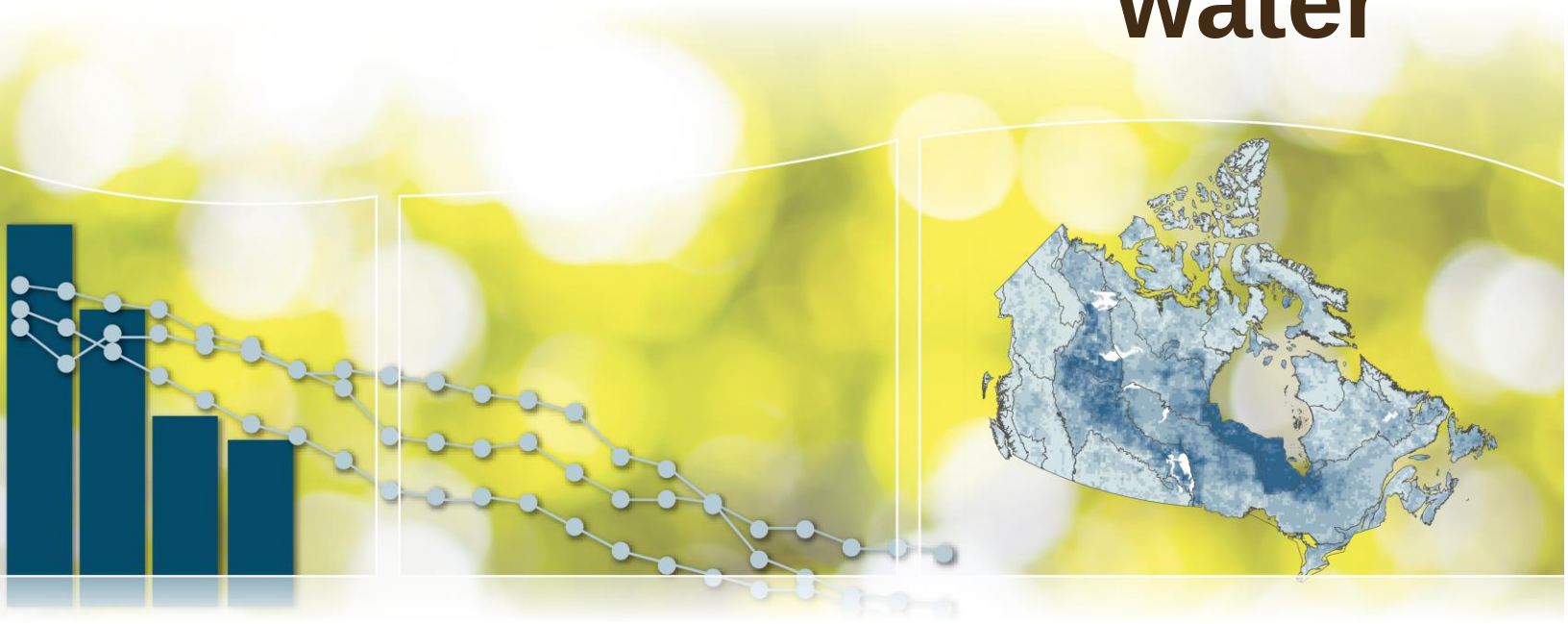
Environment and Climate Change Canada
Environnement et Changement climatique Canada

Canadian Environmental Sustainability Indicators

Perfluorooctane sulfonate in fish and water



Canada

Suggested citation for this document: Environment and Climate Change Canada (2019) Canadian Environmental Sustainability Indicators: Perfluorooctane sulfonate in Fish and Water. Consulted on *Month day, year*.
Available at: www.canada.ca/en/environment-climate-change/services/environmental-indicators/perfluorooctane-sulfonate-fish-water.html

Cat. No.: En4-144/56-2018E-PDF
ISBN: 978-0-660-28870-3

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January 2019

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Perfluorooctane sulfonate in fish and water

Perfluorooctane sulfonate (PFOS) has been used in stain repellents, fire-fighting foams and metal plating. It is of ecological concern, given its widespread occurrence and its bioaccumulation, persistence, and toxicity in animals. These indicators assess PFOS concentrations in fish tissue and water against the Federal Environmental Quality Guidelines.[1]

Perfluorooctane sulfonate in fish tissue

Key results

From 2015 to 2017, fish sampling was conducted in 9 drainage regions in Canada.

- The analysis found that the concentration of PFOS was below the guidelines for fish health in all fish from all sampled drainage regions
- Four (4) out of the 9 sampled drainage regions had samples showing concentrations of PFOS that exceeded the wildlife diet guidelines

Table 1. Perfluorooctane sulfonate concentrations in fish relative to guidelines by drainage region, Canada, 2015 to 2017

Sampled drainage region	Guidance exceedance for fish health	Guidance exceedance for fish as diet for wildlife predators
Yukon	No	No[A]
Peace–Athabasca	No	No
Lower Mackenzie	No	No
Assiniboine–Red	No	**Yes**
Lower Saskatchewan–Nelson	No	**Yes**
Churchill	No	No
Great Lakes	No	**Yes**
St. Lawrence	No	**Yes**
Maritime Coastal	No	No[A]

Additional data for Table 1

Note: [A] Represents a change between the results from the 2011 to 2014 sampling campaign and the 2015 to 2017 sampling campaign.
Source: Environment and Climate Change Canada (2018) Chemical Management Plan Monitoring and Surveillance.

In some instances, PFOS concentrations in fish exceeded the guidelines for the protection of mammals and birds that eat fish, suggesting that PFOS could threaten predators higher in the food chain. In the Great Lakes region, the majority of the samples showed concentrations of PFOS that exceeded the wildlife diet guidelines.

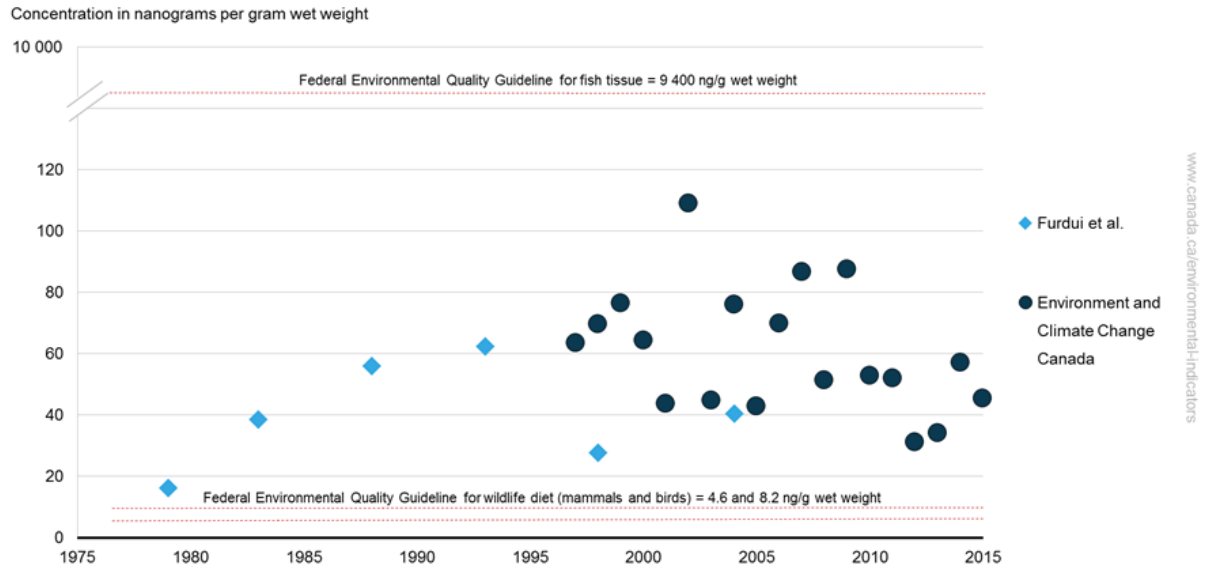
[1] The Federal Environmental Quality Guidelines are numerical limits established under the Chemicals Management Plan to protect aquatic life. Concentrations below the guidelines are not of concern, while concentrations above guidelines indicate that further evaluation may be required.

Perfluorooctane sulfonate trend in fish in Lake Ontario

Key results

- PFOS concentrations in lake trout showed an overall increase between 1979 and 2000
- After 2000, the concentration stabilized for a few years[2] and then appear to decrease

Figure 1. Perfluorooctane sulfonate concentrations in lake trout from Lake Ontario, 1979 to 2015



Data for Figure 1

Note: The concentration of perfluorooctane sulfonate in fish is expressed as an annual average (geometric mean). Two (2) datasets are represented in this chart (see the

[2] Gewurtz SB et al. (2012) Perfluoroalkyl contaminants in Lake Ontario Lake Trout: Detailed examination of current status and long-term trends. *Environmental Science & Technology* 46: 5842-5850.

Data sources and **methods** section for details). The top dotted line represents the Federal Environmental Quality Guideline for fish tissue. The lower two dotted lines represent the Federal Environmental Quality Guidelines for wildlife diet (mammals and birds).
Source: Environment and Climate Change Canada (2018) Chemicals Management Plan Environmental Monitoring and Surveillance.

To provide context on changes through time, additional data showing PFOS concentrations in Lake Ontario fish are presented for the period 1979 to 2015. Levels of PFOS in lake trout were well below the guideline for fish tissue in all collection years. This suggests a low probability of adverse effects to fish related to PFOS exposure. These results suggest that, although PFOS concentrations in lake trout from Lake Ontario have stopped increasing in response to the voluntary and regulatory actions (2006 and 2012), corresponding concentration in trout from the most recent years may be declining, although more data is required to confirm a decline is underway.

In contrast, PFOS levels were all above the guidelines for wildlife diet and could represent a risk to wildlife that feed on fish.

Perfluorooctane sulfonate in water

Key results

From 2016 to 2017, 163 water samplings were conducted in 8 drainage regions in Canada.

- The analysis found that all water samples had PFOS concentrations at least 200-fold lower than the guideline for water
- Perfluorooctane sulfonate was detected in 49% of samples and concentrations ranged from less than 2 nanograms per liter (ng/L) up to 26.1 ng/L

Table 2. Perfluorooctane sulfonate concentrations in water relative to guidelines by drainage region, Canada, 2016 to 2017

Sampled drainage region	Guidance exceedance for concentration in water
Pacific Coastal	No
Okanagan–Similkameen	No
Assiniboine–Red	No
Great Lakes	No
St. Lawrence	No
St. John–St. Croix	No
Maritime Coastal	No
Newfoundland–Labrador	No

Additional data for Table 2

Source: Environment and Climate Change Canada (2018) Chemicals Management Plan Environmental Monitoring and Surveillance.

About the indicators

What the indicators measure

These indicators identify the drainage regions where concentrations are below or above the Federal Environmental Quality Guidelines (the guidelines) for perfluorooctane sulfonate (PFOS) in fish and

water. The guidelines were developed under the Chemicals Management Plan and are used in this report to evaluate whether, and the degree to which, concentrations in the environment exceed the guidelines.

Why these indicators are important

These indicators provide information on the presence of PFOS in the environment and indications of the progress of strategies and policies to reduce or control their occurrence in the environment.

Perfluorooctane sulfonate is a synthetic substance belonging to a larger class of organic fluorochemicals that are partially or completely saturated with fluorine. Because of its chemical properties and use patterns, PFOS is typically found at higher concentrations in water than in air and can spread far from its point of release through oceanic currents. In addition, PFOS precursor compounds can travel through air and often end up in the Arctic, where they degrade to PFOS. Perfluorooctane sulfonate is a highly persistent substance. It bioaccumulates, potentially harming many species including top predatory fish, birds and mammals.

Perfluorooctane sulfonate is considered a high-priority chemical under the Chemicals Management Plan. The Government of Canada declared PFOS to be toxic as defined under the *Canadian Environmental Protection Act, 1999*. Perfluorooctane sulfonate was never manufactured in Canada and was voluntarily phased out of production by its primary supplier in the United States in 2002. In 2006, the Government of Canada developed a Risk management strategy for perfluorooctane sulfonate and its salts and precursors with the objective of minimizing its release into the Canadian environment. PFOS is listed on the *Prohibition of Certain Toxic Substances Regulations, 2012*, which prohibits the manufacture, use, sale and import of PFOS and products containing PFOS with a limited number of exemptions.

Because PFOS and its precursors can be transported over long distances through water and air, PFOS found in the Canadian environment may originate from both domestic and foreign sources. Consequently, Canada is engaged in two international agreements that severely restrict production and the use of PFOS. These agreements are the *Stockholm Convention on Persistent Organic Pollutants* and the *Protocol on Persistent Organic Pollutants of the United Nations Convention on Long-range Transboundary Air Pollution*. The objective of these international agreements is to protect human health and the environment from persistent organic pollutants.

Despite restrictions, PFOS remains in the Canadian environment because of a combination of long-range transport of both PFOS and compounds that break down to PFOS, its widespread use in the past, and its persistence in the environment.

The Perfluorooctane sulfonate in fish and water indicators contribute to the measurement of progress towards the 2016–2019 Federal Sustainable Development Strategy.

Related indicators

The Polybrominated diphenyl ethers in fish and sediment indicators identify the drainage regions where concentrations of polybrominated diphenyl ethers in fish and sediment are above the Federal Environmental Quality Guidelines.

Safe and healthy communities

These indicators support the measurement of progress towards the following 2016–2019 Federal Sustainable Development Strategy long-term goal: All Canadians live in clean, sustainable communities that contribute to their health and well-being.

Data sources and methods

Data sources

Perfluorooctane sulfonate (PFOS) environmental concentration data were obtained from Environment and Climate Change Canada's Chemicals Management Plan Monitoring and Surveillance Program.

More information

The sampling locations for fish and water varied throughout the reporting years. Data for fish and water were gathered in as many drainage regions as permitted by program capacity in any year. To provide a better representation of each drainage region, all the samples for all the recent available years, namely 2015 to 2017 for fish and 2016 to 2017 for water, were used to calculate the indicators.

There is a time lag of 2 to 3 years between the sampling date and publication of the indicators. This time lag is due to the time required to perform the monitoring, to compile the data, to validate (that is, perform quality assurance and control), analyze, review and report on the indicators, and to ensure enough recent data is available for comparison with past data or previous editions of the indicators.

Perfluorooctane sulfonate in fish from Lake Ontario

For the analysis of PFOS in fish from Lake Ontario, data were obtained from 4 distinct datasets. The first comes from a study led by Furdui from the Ontario's Ministry of the Environment in collaboration with Fisheries and Oceans Canada and Environment and Climate Change Canada. It covers 7 sample years spread over a period from 1979 to 2004. The other 3 datasets come from Environment and Climate Change Canada's Freshwater Quality Monitoring and Surveillance program:

- a retrospective analysis conducted using specimens from the National Aquatic Biological Specimen Bank covering each year from 1997 to 2008
- an analysis undertaken by AXYS Analytical for Environment and Climate Change Canada covering 2009 to 2011
- an analysis conducted by Environment and Climate Change Canada's National Laboratory for Environmental Testing covering 2012 to 2015

Federal Environmental Quality Guidelines

The Federal Environmental Quality Guidelines (the guidelines) provide benchmarks for the quality of the ambient environment. Where the guideline is met there is low likelihood of adverse effects on species that are exposed. The guidelines can serve 3 functions:

- they can aid in preventing pollution by providing targets for acceptable environmental quality
- they can assist in evaluating the significance of concentrations of chemical substances currently found in the environment (monitoring of water, sediment, and biological tissue)
- they can serve as performance measures of the success of risk management activities

The guidelines were developed under the Chemical Management Plan. Measured concentrations exceeding the guideline levels indicate the potential for aquatic organisms or their wildlife's predators to be affected by PFOS.

Four (4) different guidelines were used in the development of the indicators. Two (2) Guidelines for PFOS in fish tissue and in water are for the protection of aquatic life. Two (2) additional guidelines for PFOS are used to compare measured concentrations in fish tissue and are designed for the protection of wildlife (for example, mammals and birds) that prey on aquatic life.

Table 3. Federal Environmental Quality Guidelines for perfluorooctane sulfonate

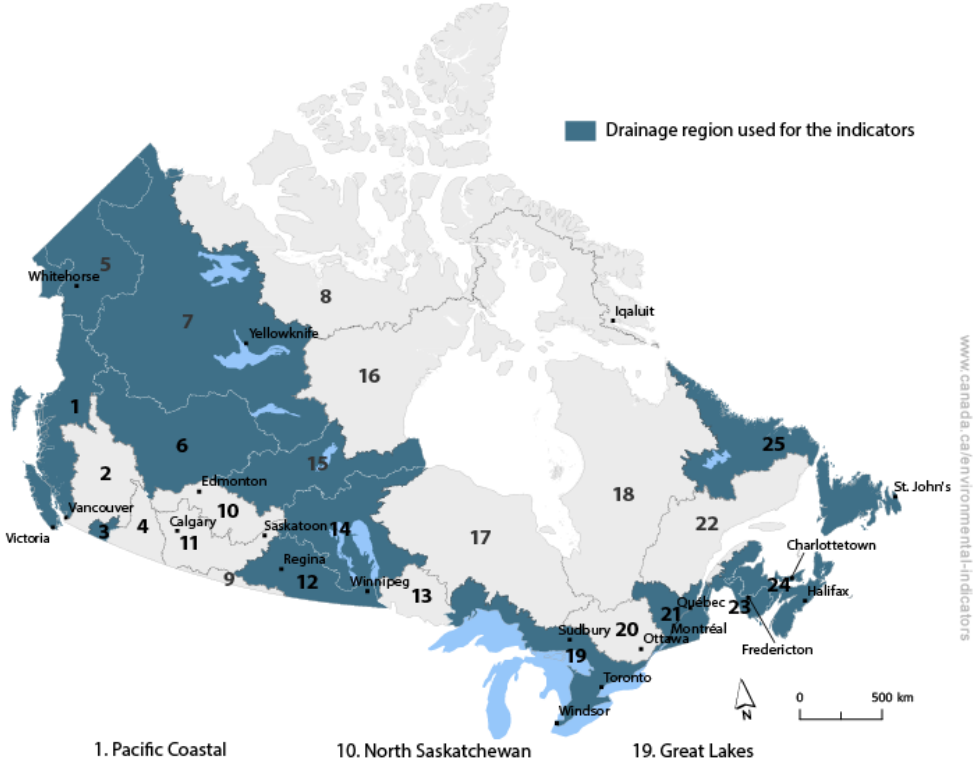
Guideline	Guideline value for perfluorooctane sulfonate
Fish tissue	9 400 nanograms per gram (ng/g) wet weight
Water	6 800 nanograms per litre (ng/L)
Wildlife diet for mammals	4.6 ng/g wet weight
Wildlife diet for birds	8.2 ng/g wet weight

Source: Environment and Climate Change Canada (2018) *Canadian Environmental Protection Act, 1999* Federal Environmental Quality Guidelines Perfluorooctane Sulfonate (PFOS).

Spatial coverage

The indicators use water drainage regions as the geographical unit for the calculation of the national indicators. These drainage regions correspond to those defined in Statistics Canada's Standard Drainage Area Classification.

Figure 2. Geographic extent of the drainage regions used for the indicators



Source: Statistics Canada (2009) Standard Drainage Area Classification (SDAC) 2003.

Methods

The Perfluorooctane sulfonate in fish and water indicators determine whether the Federal Environmental Quality Guidelines (the guidelines) for PFOS in fish and water have been exceeded in each drainage region.

More information

Perfluorooctane sulfonate in fish tissue and in water

Monitoring for PFOS in fish was conducted in 9 drainage regions between 2015 and 2017 and in 8 drainage regions between 2016 and 2017 for PFOS in water. Samples with PFOS concentrations above the guidelines are defined as an exceedance.

Table 4. Species of fish per drainage region for perfluorooctane sulfonate in fish, 2015 to 2017

Drainage region	Waterbody	Species name
Yukon	Kusawa Lake	Lake Trout

Drainage region	Waterbody	Species name
Peace–Athabasca	Lake Athabasca	Lake Trout
Lower Mackenzie	Great Bear Lake	Lake Trout
Assiniboine–Red	Lake Diefenbaker	Walleye
Lower Saskatchewan–Nelson	Lake Winnipeg	Walleye
Churchill	Cold Lake	Lake Trout
Churchill	Reindeer Lake	Lake Trout
Great Lakes	Lake Huron	Lake Trout
Great Lakes	Lake Ontario	Lake Trout
Great Lakes	Lake Superior	Lake Trout
St. Lawrence	Lac Memphrémagog	Lake Trout
St. Lawrence	St. Lawrence River	Walleye
Maritime Coastal	Kejimkujik Lake	Brook Trout

Source: Environment and Climate Change Canada (2018) Chemicals Management Plan Environmental Monitoring and Surveillance.

Perfluorooctane sulfonate trend in fish from Lake Ontario

A retrospective analysis of PFOS concentrations in lake trout from Lake Ontario was completed by Environment and Climate Change Canada using samples preserved in the National Aquatic Biological Specimen Bank in order to extend the monitoring timeline back to 1979. These measurements were combined with PFOS concentrations from studies done by Furdui VI et al. (2007 and 2008) covering the years 1979 to 2004.[3] Furdui VI et al. also obtained Lake Ontario Lake trout from the National Aquatic Biological Specimen Bank and analyzed the samples at Ontario's Ministry of the Environment. These concentrations were added to more recent samplings done by Environment and Climate Change Canada.

Caveats and limitations

Monitoring and surveillance of PFOS in lakes and rivers under the Chemicals Management Plan began in 2007 (except for Lake Ontario, which was initiated in the 1990s).

Monitoring is not necessarily performed at the same location each year because of challenges in obtaining fish or water samples. These challenges include remoteness, shipping logistics and resource constraints. Given this, a year-to-year comparison at the national level is not yet possible. To address this limitation, the Perfluorooctane sulfonate in fish and water indicators are estimated by grouping the samples in the drainage area for multiple years: 2015 to 2017 for fish and 2016 to 2017 for water.

[3] Furdui VI et al. (2008) Temporal trends of perfluoroalkyl compounds with isomer analysis in lake trout from Lake Ontario (1979-2004). *Environmental Science & Technology* 42: 4739-4744.

Resources

References

Environment and Climate Change Canada (2006) Risk management strategy for perfluorooctane sulfonate and its salts and precursors . Retrieved on October 10, 2018.

Environment and Climate Change Canada (2011) Environmental Monitoring and Surveillance in Support of the Chemicals Management Plan. Retrieved on October 10, 2018.

Environment and Climate Change Canada (2012) Canada's National Aquatic Biological Specimen Bank and Database. Retrieved on October 10, 2018.

Environment and Climate Change Canada (2013) Perfluorooctane Sulfonate in the Canadian Environment. Retrieved on October 10, 2018.

Environment and Climate Change Canada (2018) *Canadian Environmental Protection Act, 1999* Federal Environmental Quality Guidelines Perfluorooctane Sulfonate (PFOS). Retrieved on October 10, 2018.

Furdui VI, Stock NL, Ellis DA, Butt CM, Whittle DM, Crozier PW, Reiner EJ, Muir DC and Mabury SA (2007) Spatial distribution of perfluoroalkyl contaminants in lake trout from the Great Lakes. *Environmental Science & Technology* 41: 1554-1559.

Furdui VI, Helm PA, Crozier PW, Lucanciu C, Reiner EJ, Marvin CH, Whittle DM, Mabury SA and Tomy GT (2008) Temporal trends of perfluoroalkyl compounds with isomer analysis in lake trout from Lake Ontario (1979-2004). *Environmental Science & Technology* 42(13): 4739-4744. Retrieved on October 10, 2018.

Gewurtz SB, De Silva AO, Backus SM, McGoldrick DJ, Keir MJ, Small J, Melymuk L and Muir DCG (2012) Perfluoroalkyl contaminants in Lake Ontario Lake Trout: Detailed examination of current status and long-term trends. *Environmental Science & Technology* 46: 5842-5850.

McGoldrick DJ, Clark MG, Keir MJ, Backus SM and Malecki MM (2010) Canada's national aquatic biological specimen bank and database. *Journal of Great Lakes Research* 36(2): 393-398. Retrieved on October 10, 2018.

Annex

Annex A. Data tables for the figures presented in this document

Table A.1Table 1. Perfluorooctane sulfonate concentrations in fish relative to guidelines by drainage region, Canada, 2015 to 2017 and 2011 to 2014

Sampling period	Sampled drainage region	Sample size (number of fish)	Guidance exceedance for fish health (number of exceedances)	Guidance exceedance for mammalian diet (number of exceedances)	Guidance exceedance for avian diet (number of exceedances)
2015 to 2017	Yukon	10	0	0	0
2015 to 2017	Peace–Athabasca	10	0	0	0
2015 to 2017	Lower Mackenzie	10	0	0	0
2015 to 2017	Assiniboine–Red	10	0	7	3
2015 to 2017	Lower Saskatchewan–Nelson	10	0	6	1
2015 to 2017	Churchill	20	0	0	0
2015 to 2017	Great Lakes	60	0	56	52
2015 to 2017	St. Lawrence	16	0	7	6
2015 to 2017	Maritime Coastal	10	0	0	0
2011 to 2014	Columbia	20	0	1	1
2011 to 2014	Yukon	29	0	1	0
2011 to 2014	Peace–Athabasca	30	0	0	0
2011 to 2014	Lower Mackenzie	20	0	0	0
2011 to 2014	Assiniboine–Red	23	0	22	17
2011 to 2014	Winnipeg	50	0	43	13
2011 to 2014	Churchill	50	0	0	0
2011 to 2014	Great Lakes	231	0	208	180
2011 to 2014	St. Lawrence	37	0	37	36
2011 to 2014	Saint John–St. Croix	9	0	0	0
2011 to 2014	Maritime Coastal	24	0	1	0

Source: Environment and Climate Change Canada (2018) Chemicals Management Plan Environmental Monitoring and Surveillance.

Table A.2. Data for Figure 1. Perfluorooctane sulfonate concentrations in lake trout from Lake Ontario, 1979 to 2015

Year	Sample size (number of fish)	Geometric mean concentration (nanograms/gram wet weight)	Data source
1979	4	16.2	Furdui VI et al.
1983	5	38.5	Furdui VI et al.
1988	5	56.0	Furdui VI et al.
1993	5	62.4	Furdui VI et al.
1998	5	27.6	Furdui VI et al.
2001	5	43.8	Furdui VI et al.
2004	5	40.5	Furdui VI et al.
1997	7	63.5	Environment and Climate Change Canada, Retrospective analysis
1998	8	69.5	Environment and Climate Change Canada, Retrospective analysis
1999	6	76.4	Environment and Climate Change Canada, Retrospective analysis
2000	8	64.2	Environment and Climate Change Canada, Retrospective analysis
2001	3	43.7	Environment and Climate Change Canada, Retrospective analysis
2002	9	109.0	Environment and Climate Change Canada, Retrospective analysis
2003	7	44.7	Environment and Climate Change Canada, Retrospective analysis
2004	6	76.0	Environment and Climate Change Canada, Retrospective analysis
2005	6	42.7	Environment and Climate Change Canada, Retrospective analysis
2006	12	69.7	Environment and Climate Change Canada, Retrospective analysis
2007	5	86.5	Environment and Climate Change Canada, Retrospective analysis
2008	10	51.3	Environment and Climate Change Canada, Retrospective analysis
2009	10	87.4	Environment and Climate Change Canada, AXYS Analytical study
2010	10	52.8	Environment and Climate Change Canada, AXYS Analytical study

Year	Sample size (number of fish)	Geometric mean concentration (nanograms/gram wet weight)	Data source
2011	10	52.0	Environment and Climate Change Canada, AXYS Analytical study
2012	10	31.1	Environment and Climate Change Canada, National Laboratory for Environmental Testing
2013	10	34.1	Environment and Climate Change Canada, National Laboratory for Environmental Testing
2014	20	57.1	Environment and Climate Change Canada, National Laboratory for Environmental Testing
2015	10	45.4	Environment and Climate Change Canada, National Laboratory for Environmental Testing

Note: The concentration of perfluorooctane sulfonate in fish is expressed as an annual average (geometric mean).
Source: Environment and Climate Change Canada (2018) Chemicals Management Plan Environmental Monitoring and Surveillance.

Table A.3. Data for Table 2. Perfluorooctane sulfonate concentrations in water relative to guidelines by drainage region, Canada, 2016 to 2017

Sampled drainage region	Total sample size (number of water samples)	Detectable sample (number of water samples)	Detection percentage	Guidance exceedance for concentration in water	Minimum concentration (nanograms per litre)	Maximum concentration (nanograms per litre)
Pacific Coastal	10	9	90	No	2.1	11.9
Okanagan–Similkameen	10	6	60	No	2.8	9.3
Assiniboine–Red	52	22	42	No	1.9	22.8
Great Lakes	37	31	84	No	2.2	26.1
St. Lawrence	26	3	12	No	2.5	3.8
St. John–St. Croix	4	1	25	No	3.2	3.2
Maritime Coastal	17	4	24	No	2.2	3.4
Newfoundland–Labrador	7	3	43	No	2.0	3.8
Total	**163**	**79**	**48**	**No**	**1.9**	**26.1**

Source: Environment and Climate Change Canada (2018) Chemicals Management Plan Environmental Monitoring and Surveillance.

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