Sub-Indicator: Contaminants in Fish Fillets

Overall Assessment

Status: Fair

Trends:

10-Year Trend (2013-2022): Improving

Long-term Trend (1975-2023): Improving

Rationale: Fish consumption advisories for all of the Great Lakes have typically been driven by polychlorinated biphenyls (PCBs). Levels of PCBs in the edible portion of five indicator Great Lakes fish have declined substantially (65-94%) since the 1970s following regulatory and remedial actions (Figure 1). Mercury has been a secondary driver of the fish consumption advisories. Mercury levels in the edible portion of five indicator Great Lakes fish have also on average declined by 8-56% during the last 40-50 years (Figure 2). Overall, long-term trends have shown improvements in the levels of both contaminants for all of the five Great Lakes.

Looking at short-term trends for the past 10 years, PCB levels in the edible portion of fish tissue have either improved or remained unchanged for all of the Great Lakes (Figure 1), while mercury levels have largely remained stable or slightly improved (Figure 2).

Status and trend assessments were based on data for five indicator fish, namely Chinook Salmon, Coho Salmon, Lake Trout, Walleye and Lake Whitefish. Data generated by the Province of Ontario were used for Lake Superior, Lake Huron, Lake Erie and Lake Ontario, while data provided by the United States Environmental Protection Agency (U.S. EPA) and States of Michigan, Wisconsin, Illinois, and Indiana were used for Lake Michigan status and trend assessments. Reliance upon a single data source for the four Great Lakes allowed for more consistent comparison between reporting cycles but may not reflect the status and/or trends at the State level.

Lake-by-Lake Assessment

Lake Superior

Status: Good

10-Year Trend (2013-2022): Improving

Long-term Trend (1975-2023): Improving

Rationale: Lake Superior fish consumption advisories for the Canadian waters are primarily driven by mercury (53%) and PCBs (35%), while the remaining advisories are due to elevated levels of per- and polyfluoroalkyl substances (PFAS), dioxins/furans and toxaphene. Substantial improvements have been observed in the levels of mercury (average 39%) and PCBs (average 84%) during the last 45+ years; however, the levels appear to be improving at slower rates in recent years (e.g., Figures 1 and 2). As a result of the improved contaminant levels in edible fish tissue, fish consumption advisories for the Canadian waters of Lake Superior have improved. For example, during the last 10 years, the *Do Not Eat* advisories have declined from 16.9% to 11.4% and partial restrictions (1 to 4 meals per month) from 31.4% to 23.8%, and subsequent increases in unrestricted (8+ meals per month) advisories from 51.7% to 64.8%.

During this reporting cycle, average levels of both mercury (0.20 µg/g; range of averages for multiple fish species 0.10-0.38 µg/g) and PCBs (68 ng/g; 41-145 ng/g) remained in the Good category, although individual values varied between Good and Fair (Figures 1 and 2, Table 2).

Lake Michigan

Status: Fair

10-Year Trend (2013-2022): Improving

Long-term Trend (1975-2022): Improving

Rationale: Lake Michigan fish consumption advisories issued by the surrounding Great Lakes states are largely driven by PCBs, while the remaining advisories are mostly due to elevated levels of mercury and in some cases PFAS. PCB levels in Lake Michigan fish were historically among the worst, along with Lake Ontario, in the Great Lakes, but substantial improvements (average 94%) during the last 45+ years have now resulted in fewer differences when compared with the other Great Lakes. Mercury levels have been relatively low and improved (average 8%) between the mid-1980s and 2022. Further, the PCB and mercury levels continued to improve during the last decade as well (e.g., Figures 1 and 2). As a result, fish consumption advisories have either improved (e.g., Walley and Lake Whitefish) or remained the same (e.g., Chinook Salmon, Coho Salmon, and Lake Trout) since 2014.

During this reporting cycle, average level of mercury (0.08 µg/g; 0.04-0.11 µg/g) remained in the Good category, while average level of PCBs (168 ng/g; 90-205 ng/g) remained in the Fair category (Figures 1 and 2, Table 2).

Lake Huron

Status: Good

10-Year Trend (2013-2022): Unchanging to Improving

Long-term Trend (1976-2023): Improving

Rationale: Lake Huron fish consumption advisories for the Canadian waters are largely driven by mercury (41%) and PCBs (36%), while the remaining advisories are mostly due to elevated levels of PFAS and dioxins/furans. Substantial improvements have been observed in the levels of mercury (average 31%) and PCBs (average 85%) during the last 45 years+; however, the levels appear to be improving at slower rates in the recent years (e.g., Figures 1 and 2). As a result of the improved/stable contaminant levels in edible fish tissue, fish consumption advisories for the Canadian waters of Lake Huron have improved during the last 10 years as evident from the declines in the *Do Not Eat* advisories from 17.7% to 8.7% and partial restrictions (1 to 4 meals per month) from 29.7% to 23.9%, and subsequent increases in unrestricted (8+ meals per month) advisories from 52.6% to 67.5%.

During this reporting cycle, average levels of both mercury (0.13 µg/g; 0.06-0.22 µg/g) and PCBs (76 ng/g; 33-140 ng/g) remained in the Good category, although some PCB values were in the Fair category (Figures 1 and 2, Table 2).

Lake Erie

Status: Good

10-Year Trend (2013-2022): Improving

Long-term Trend (1976-2021): Improving

Rationale: Lake Erie fish consumption advisories for the Canadian waters are driven primarily by PCBs (57%) and secondarily by mercury (34%), while the remaining advisories are mostly due to elevated levels of PFAS. PCB and mercury levels in Lake Erie fish were historically among the lowest and improved further during the 1970s and 1980s (Figure 2). Substantial improvements have been observed in the levels of PCBs (average 65%) and mercury (average 56%) during the last 45+ years (e.g., Figures 1 and 2). However, as reported in the State of the Great Lakes (SOGL) 2019 report, these levels then stabilized and, in some cases, slightly increased (Figure 2). The increase in mercury and PCB levels were attributed to possible alterations of the food web from invasive species such as mussels and round goby (Hogan et al. 2007, Bhavsar et al. 2010). The recent measurements included in the SOGL 2022 report and collected during this reporting cycle have been generally lower and indicate improved trends over both the long- and short-term (Figures 1 and 2). As a result of the improved contaminant levels in edible fish tissue, fish consumption advisories for the Canadian waters of Lake Erie have improved during the last 10 years as evident from the declines in the *Do Not Eat* advisories from 24.2% to 11.9% and partial restrictions (1 to 4 meals per month) from 39.9% to 28.8%, and subsequent increases in unrestricted (8+ meals per month) advisories from 36.0% to 59.3%.

Average levels of both PCBs (97 ng/g; 64-133 ng/g) and mercury (0.10 µg/g; 0.03-0.15 µg/g) remained in the Good category during this reporting cycle, although some PCB values were in the Fair category (Figures 1 and 2, Table 2).

Lake Ontario

Status: Fair

10-Year Trend (2013-2022): Unchanging to Improving

Long-term Trend (1975-2022): Improving

Rationale: Lake Ontario fish consumption advisories for the Canadian waters are driven predominantly by PCBs (67%) and secondarily by mercury (25%), while the remaining advisories are mostly due to elevated levels of dioxins/furans and PFAS. PCB levels in edible portions of Lake Ontario fish were among the worst, along with Lake Michigan, in the Great Lakes but substantial (average 93%) improvements have been observed since the 1970s. Levels of mercury have also improved (by average 43%) during the last 45+ years. However, the PCB and mercury levels appear to be improving at slower rates in recent years (e.g., Figures 1 and 2). As a result of the improved/stable contaminant levels in edible fish tissue, fish consumption advisories for the Canadian waters of Lake Ontario have improved during the last 10 years as evident from the declines in the *Do Not Eat* advisories from 32.1% to 18.0% and partial restrictions (1 to 4 meals per month) from 34.7% to 31.7%, and subsequent increases in unrestricted (8+ meals per month) advisories from 33.1% to 50.3%.

During this reporting cycle, average level of mercury (0.16 µg/g) remained in the Good category although some values were in the Fair category (range 0.11-0.27 µg/g), while average level of PCBs (158 ng/g) remained in the Fair category although some values were in the Good category (range 41-369 ng/g) (Figures 1 and 2, Table 2).

Status Assessment Definitions

Good: Recent average mercury concentration <0.25 parts per million (ppm or µg/g) and PCB concentration <0.1 ppm (<100 ng/g or parts per billion - ppb) in edible fish tissue typically resulting in 8 or more meals per month advisories.

Fair: Recent average mercury concentration between 0.25 and 1 ppm or PCB concentration between 0.1 and 1 ppm (100 – 1000 ng/g) in edible fish tissue typically resulting in 1 to 4 meals per month advisories.

Poor: Recent average mercury or PCB concentration >1 ppm (>1000 ng/g) in edible fish tissue typically resulting in <1 meal per month or “do not eat” advisories.

Undetermined: Contaminant data have not been available or have been insufficient to assess condition of the ecosystem components.

Trend Assessment Definitions

Improving: Concentrations of PCBs and mercury are on average declining.

Unchanging: Concentrations of PCBs and mercury are not declining or increasing.

No Trend: Data are available for a ten-year or longer time period but the contaminant concentrations in edible fish tissue are not significantly Improving or Deteriorating due to high variability in the data. No Trend is distinct from Unchanging, which is used when variability is relatively low.

Deteriorating: Concentrations of PCBs and mercury are on average increasing.

Undetermined: Insufficient information to derive trends with confidence.

Endpoints and/or Targets

An assessment of contaminants of interest in edible fish tissue can help track progress towards meeting the Ecosystem Objective of “Fish in the Great Lakes ecosystem should be safe to eat. Consumption should not be limited by contaminants originated from human activities”. Assessments include long- and short-term trend evaluations of levels of contaminants of concern in edible fish tissue. A declining trend for these contaminants represents an improvement in the environment and the potential for reduced exposure to contaminants from consumption of Great Lakes fish. The elimination of fish consumption advisories that are restricting consumption of Great Lakes fish due to contaminants from human activities may be considered to be an appropriate endpoint (See Tables 1 and 2).

Sub-Indicator Purpose

The purpose of this sub-indicator is to assess levels of contaminants that pose a risk to human health and infer the potential harm through the consumption of Great Lakes fish. Special emphasis has been paid to contaminants that have triggered fish consumption advisories such as persistent, bioaccumulative, and toxic (PBT) contaminants, including mercury and PCBs in edible fish tissue of Great Lakes fish. Mercury and PCBs are designated as chemicals of mutual concern under the Great Lakes Water Quality Agreement between the U.S. and Canada.

This Contaminants in Fish Fillets report includes contaminant information for the fillet of the fish that is typically consumed by people. The Toxic Chemicals in Whole Fish sub-indicator report includes contaminant information for the bones, organs, scales, blood, etc. of the fish. Other differences exist in the species of fish reported and the chemicals assessed in each report.

Ecosystem Objective

Fish in the Great Lakes ecosystem should be safe to eat. Consumption should not be limited by contaminants originating from human activities.

This sub-indicator best supports work towards General Objective #3 of the 2012 Great Lakes Water Quality Agreement (GLWQA) which states that the waters of the Great Lakes should "allow for human consumption of fish and wildlife unrestricted by concerns due to harmful pollutants."

Both U.S. and Canadian agencies monitor contaminants in edible portions of Great Lakes fish to provide advice on safe consumption. This sub-indicator assesses the status of the ecosystem by comparing contaminant concentrations in fish to risk-based contaminant levels established by fish advisory programs that result in consumption advice (Tables 1 and 2). The outcome of this comparison is then used to relate the ecosystem status to General Objective #3 of the GLWQA.

Methods

Concentrations of contaminants (e.g., PCBs, mercury) from the edible fish tissue of species most consumed by Great Lakes basin citizens are used as an indicator of exposure to these contaminants. Temporal trends of contaminants and assessment of the risk-based advisory levels associated with these contaminants are used to track progress toward meeting the Ecosystem Objective. Levels of contaminants in fish are measured in individual or composited samples noting that they vary by type and size of fish and by location. Choosing appropriate indicator species is crucial and should be based on fish consumption patterns and availability of data, both of which can change over time. Therefore, there may not be complete consistency between reporting years.

For the Province of Ontario, fish are collected annually, in accordance with the Fish Contaminant Monitoring Program of the Ontario Ministry of the Environment, Conservation and Parks (OMECP). U.S. samples are collected according to the Great Lakes state programs. For the status assessment, levels and trends of PBT chemicals in the most edible portion of fish (i.e., fillets) are assessed and compared against the concentration cut-off criteria derived from the advice categories used by the Province of Ontario and U.S. Great Lakes states identified in the Guide to Eating Ontario Fish and the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory from the Great Lakes Consortium for Fish Consumption Advisories (Tables 1 and 2).

Since the 1970s, there have been improvements in the levels of many PBT contaminants in the Great Lakes basin due to bans on their use and/or production and restrictions on emissions. However, because of their ability to persist in the environment and bioaccumulate, some PBT contaminants continue to be of concern. Historically, elevated levels of a variety of contaminants including PCB, mercury, dioxins/furans, mirex and toxaphene have restricted consumption of Great Lakes fish. However, concentrations of many PBTs (e.g., mirex, chlordane) have declined to levels such that they can be eliminated from regular monitoring to prioritize resources for other purposes such as monitoring contaminants of emerging concern (CECs) (Gandhi et. al 2014, 2015). Dioxins/furans do result in some advisories; however, because PCB and mercury are currently the most limiting contaminants in eating Great Lakes fish, the assessment is largely evaluated based on findings of PCB and mercury.

Monitoring of CECs continues to be a priority for Provincial, State, and Tribal programs as concentrations and toxicity of these contaminants continue to be assessed for inclusion into advice. PFAS related fish consumption advisories have been recently issued by the Great Lakes States and Province of Ontario for certain fish from some Great Lakes locations. PFAS were noted in this report but were not assessed as part of the formal sub-indicator report for 2025. Polybrominated diphenyl ethers (PBDEs) and polychlorinated naphthalenes (PCNs) were omitted

because fish consumption is not considered the primary route of exposure at present (Gandhi et al. 2017a, Gewurtz et al. 2018, Lorber 2008). Levels of PBDEs in edible fish tissue declined by 46–74% between 2006/07 and 2012, and although they might have remained in use in existing consumer items, their accumulation in fish was not expected to be substantial (Gandhi et al. 2017a). Similarly, the levels of PCNs have been relatively low in Great Lakes fish, and important PCN contaminants (PCN-66/67) declined between 2006 and 2012 (Gewurtz et al. 2018). These trends were complemented by previously reported decrease in PCNs in Lake Ontario Lake Trout between 1979 and 2004 (Gewurtz et al. 2009).

Discussion

Fish contaminant monitoring data included in this assessment include those produced annually by Ontario's Fish Contaminant Monitoring Program, individual state monitoring programs, and results of the 2010 and 2015 Great Lakes Human Health Fish Tissue Study. In 2009, U.S. EPA's Great Lakes National Program Office's Great Lakes Fish Monitoring and Surveillance Program eliminated the edible fish analysis portion of its program, refocused its efforts on identifying emerging contaminants in whole fish, and therefore could not contribute new data to this sub-indicator. The analysis for this sub-indicator was limited to fish species that are of interest for human consumption as well as are good indicators of contaminants of concern (i.e., PCBs and mercury). Five selected fish species were Lake Trout, Walleye, Lake Whitefish, Coho Salmon, and Chinook Salmon. Fish contaminant levels can be influenced by age, and thereby size, of fish. To prepare spatial and temporal trends, narrow size ranges of 55-65 cm for Lake Trout, Coho Salmon and Chinook Salmon, and 45-55 cm for Walleye and Lake Whitefish were considered.

Ontario's Fish Contaminant Monitoring Program

Ontario started monitoring contaminants in fish in the late 1960s. Ontario's Fish Contaminant Monitoring Program was formally established in 1976, and the first fish consumption advisories were issued in 1977. Staff from the Ontario Ministry of Natural Resources and OMECP collect the fish, which are then analyzed by OMECP for a variety of substances, including mercury, PCBs, mirex, dichlorodiphenyltrichloroethane (DDT), dioxins, and contaminants of emerging concern (e.g., PFASs, PBDEs). The results are used to develop the Guide to Eating Ontario Fish, which gives size-specific consumption advice for each species and location tested. The Guide to Eating Ontario Fish gives advice to anglers, subsistence fishers and their families, and First Nations and Métis communities in determining which fish species and what size caught from Ontario water bodies can be consumed to minimize exposure to toxicants. The Guide compiles information for more than 2,700 locations around the Province of Ontario, including regions covering the Canadian waters of the Great Lakes.

Great Lakes Human Health Fish Tissue Study

U.S. EPA's Office of Water, Great Lakes National Program Office, and Office of Research and Development collaborated to conduct the Great Lakes Human Health Fish Tissue Study. The Great Lakes Human Health Fish Tissue Study was initiated in 2010 under the Agency's National Coastal Condition Assessment (NCCA), and it is the first statistically based study of fish contamination in the Great Lakes. Fish samples were collected from 157 randomly selected sites in 2010 and 152 randomly selected sites in 2015 throughout the five U.S. Great Lakes. Fillet samples were analyzed for mercury, PCBs, PBDE, PFAS, and omega 3 fatty acids in 2010. Fillet samples were analyzed for mercury, PCBs, PFAS, dioxins and furans, emerging chemicals, and omega 3 & 6 fatty acids in 2015.

Great Lakes Consortium for Fish Consumption Advisories

The Great Lakes Consortium for Fish Consumption Advisories (Consortium) is a collaboration of fish advisory program managers from government health, water quality, and fisheries agencies in the eight U.S. states bordering the Great Lakes and Province of Ontario. The purpose of the Consortium is to share information about contaminants found in fish of the Great Lakes region, evaluate human health effects of those contaminants, and develop protocols and methods for determining fish consumption advice and communications. The Consortium has its roots in a taskforce formed in the early 1980s. Consortium membership is fluid but typically includes representatives from the eight U.S. states bordering the Great Lakes—Indiana, Illinois, Michigan, Minnesota, New York, Ohio, Pennsylvania and Wisconsin—and Province of Ontario. Staff from the Great Lakes Indian Fish and Wildlife Commission also participate. The following goals for fish consumption advisories guide the continuing work of the Consortium: 1) develop common methods for determination of consumption advice and implement consistent advice for shared waters, 2) use, share, and advance credible data and science, 3) evaluate the risks and benefits of consuming Great Lakes fish to develop a shared understanding among Consortium members and incorporate these messages into fish consumption advice, and 4) establish and utilize best practices for communicating risks and benefits and influencing the behavior of fish consumers. Members provided contaminant concentration data for this sub-indicator.

PCBs

Levels of total PCBs in fish ranged from a few hundred to thousands of nanograms per gram (ng/g) or parts per billion (ppb) during the 1970s (Figure 1). In many cases, these historical levels were higher than the PCB advisory benchmark of about 2000 ng/g at that time (Table 1). PCBs were banned during the late 1970s, which spurred declines in their environmental levels. PCB concentrations have declined substantially over the past four decades in all of the Great Lakes (Figure 1). The declines varied by fish type and lake, but were as much as >90% in many cases. Recent PCB levels in selected sizes of fish from the five Great Lakes are generally below 300 ng/g. Scientific studies conducted between the 1980s and 2000s highlighted greater toxicity of PCBs, which resulted in lower advisory benchmarks over time. At present, the advisory benchmarks for severe restriction on fish consumption (i.e., not more than 1-2 meals per month) are about an order of magnitude lower than the pre-1990s. As such, despite substantial declines in the fish PCB levels, PCBs continue to be of concern for health of humans consuming Great Lakes fish.

PCBs levels appear to be improving in most cases albeit at a slower rate compared to the historical declines during the 1970s and 1980s. A greater variability and slower declines at lower levels are typical and other stressors (e.g., invasive species) may be contributing to the slower improvements. These factors can affect food web dynamics and contaminant pathways to fish higher in the food chain (see Linkages section).

Mercury

Mercury concentrations in fish historically exceeded fish consumption advisory benchmarks more frequently than in recent years (Figure 2). The levels have generally declined by about half over the last four decades, and the concentrations in the selected sizes of fish from the five Great Lakes are now below 0.25 µg/g (Figure 2).

PFAS

Emerging contaminants, such as PFAS, in edible portion of Great Lakes fish continue to be a priority for monitoring and surveillance for the Great Lakes states and the Province of Ontario. The Province of Ontario and the Great Lakes states have been examining levels of PFAS in fish and have issued site-specific advice where fish have been tested for elevated levels of perfluorooctane sulfonic acid (PFOS), a chemical of the PFAS family. Concentrations of

PFOS in three popular Great Lakes fish for consumption, namely Chinook Salmon, Lake Trout and Walleye, observed between 2019 and 2023 are shown in Figure 3. The measured PFOS levels were typically below the 20 ng/g (Figure 3) and can be considered low (Gandhi et al. 2017b). These low levels are reflected in the fish consumption advisories where only about 10% of the advisories issued for the Canadian waters of the Great Lakes are due to PFAS. The PFOS levels were the lowest in Lake Superior and appear to be the highest in Lake Michigan. PFAS compounds, however, are currently not factored into the determination of current status or long- and short-term trend assessments for the Great Lakes. A more comprehensive reporting on PFAS shall be considered for the 2028 State of the Great Lakes (SOGL) reporting cycle.

Actions are being taken locally, nationally, and internationally regarding the manufacturing and use of PFAS. The science on the adverse health effects of PFAS and other contaminants continues to evolve. The relevant agencies are tracking these scientific developments so that the advice on safe eating of Great Lakes fish is updated based on the latest and most reliable science. With that in mind, it is recommended to consult fish consumption advisories issued by local state, Tribal, or provincial agencies before eating Great Lakes fish, as the advice will be based on the most up-to-date information available on levels of PFAS and other contaminants in fish from that waterbody.

Dioxins/furans, Toxaphene, and Mirex

Previous reporting cycles identified that dioxins/furans, toxaphene and mirex are less of a concern than the dominant contaminants that drive consumption advice, such as PCBs and mercury, from the perspective of health risk to humans through fish consumption. Levels of these contaminants have declined over the last 30-40 years and continue to decline in recent years (Gandhi et al. 2014, 2015, 2019). The recent levels have resulted in relatively minor restrictions on eating Great Lakes fish. For this reason, dioxins/furans, toxaphene, and mirex are no longer reported in this sub-indicator.

Linkages

Sources of chemical contaminants, and their cycling through the ecosystem, vary among the lakes. Therefore, it is important to have an understanding of how contaminants arrive to the Great Lakes and ultimately into fish species through diet, in addition to the presence of contaminants and their potential harm. This sub-indicator can easily be linked to most of the sub-indicators in the Toxic Chemicals indicator:

- Toxic Chemicals in Whole Fish
    - Levels of toxic chemicals found in the edible portions of fish can be related to their corresponding whole body levels. As such, the trends presented for whole body Lake Trout and Walleye can be compared to the trends presented in this indicator for the edible portion of those species.
- Toxic Chemicals in Herring Gull Eggs
    - Toxic chemicals found in fish eating and colonial nesting waterbirds can be closely linked with the levels of those chemicals in whole fish and edible portion of fish that may be consumed by the waterbirds.
- Toxic Chemicals in Water
    - Fish are exposed to toxic chemicals via diet and gill uptake. The levels of toxics in water can therefore be an indicator of a partial exposure to fish and can be linked with the levels found in the edible portion of fish.

- Toxic Chemicals in Sediment
    - The levels of toxic chemicals in fish can be linked with the corresponding levels in sediment as fish can acquire toxic chemicals from lower trophic level species such as benthos that are in contact with sediment through food web processes. This can be especially true for legacy contaminants such as PCBs that were emitted decades ago and created a repository in the sediments, which are now acting as a source of PCBs in the overlying waters and the aquatic food webs.

It should be noted that other external factors such as invasive species can affect fish contaminant trends regardless of overall declines in active pools of contaminants in the system. For example, invasions of dreissenid mussels and Round Goby in Lake Erie appear to have increased transfer of contaminants historically deposited in the sediments to higher trophic level fish (e.g., Bhavsar et al. 2010, Hogan et al. 2007).

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	Yes	https://www.health.state.mn.us/communities/environment/fish/index.html https://data-wi-dnr.opendata.arcgis.com/datasets/017063456bcc4569894bf8a0c0400335_10/explore https://dph.illinois.gov/topics-services/environmental-health-protection/toxicology/fish-advisories/map.html https://www.in.gov/health/eph/fish-consumption-advisory/ https://gis-michigan.opendata.arcgis.com/maps/7303c25d46c5468bacd157ea828c4760/about https://data.ontario.ca/dataset/guide-to-eating-ontario-fish-advisory-database/resource/bbc157b9-309c-4d5c-9403-a6f71d503451 https://odh.ohio.gov/wps/wcm/connect/gov/cd619fce-6bcb-4e15-9bf4-8d4d50e4155f/2024_Sportfish+FCA+Booklet.pdf.pdf?MOD=AJPERES&CONVERT_TO=url&CACHEID=ROOTWORKSPACE.Z18_M1HGGIK0N0JO00QO9DDDDM3000-cd619fce-6bcb-4e15-9bf4-8d4d50e4155f-p08zKE3 https://www.dep.pa.gov/About/Regional/NorthwestRegion/Community-Information/Pages/Fish_Advisory.aspx https://www.health.ny.gov/environmental/outdoors/fish/health_advisories/ https://www.epa.gov/choose-fish-and-shellfish-wisely/national-coastal-

		condition-assessment-great-lakes-human-health

Data Limitations

Data for use in developing indicators exist; however, there are differences in extent, frequency and methods of sample collection as well as analytical techniques for contaminant measurements, especially for PCBs, within and among jurisdictions. Status and trend assessments were based on data generated by the Province of Ontario for Lake Superior, Lake Huron, Lake Erie and Lake Ontario. Lake Michigan status and trend assessments were generated based on data provided by the U.S. EPA and States of Michigan, Wisconsin, Illinois, and Indiana. Reliance upon a single data source, such as the province, allowed for more consistent comparison between reporting cycles but may not reflect the status and/or trends at the State level.

Additional Information

There are differences in the way fish samples are analyzed for contaminants and fish consumption advisories are developed in the U.S. and Canada. This means that the data and fish consumption advisories cannot be directly compared between the two countries. For this sub-indicator, more consistent data generated by the Province of Ontario for fish from the Canadian waters of the Great Lakes were mostly utilized for Lakes Ontario, Erie, Huron and Superior, while data generated by the U.S. agencies were utilized for Lake Michigan. Since large-bodied fish considered in this assessment have large home ranges and likely move across the border, utilization of only Ontario data for Lakes Superior, Huron, Erie and Ontario should not be a major concern. A comparison of the recent contaminant levels to the corresponding advisory benchmarks has been provided by considering similarities in the benchmarks used by the agencies on both sides of the border.

An increased focus on emerging contaminants is occurring in monitoring programs in the U.S. and Canada. While the U.S. EPA's Great Lakes National Program Office no longer collects or analyzes edible fish tissue samples, the Office has instituted an Emerging Contaminants Surveillance Program in whole fish that looks to identify the presence or absence of emerging contaminants of interest and will inform state monitoring and advisory programs.

The Ontario Ministry of the Environment, Conservation and Parks continues to monitor contaminants of long term concern such as PCBs, dioxins/furans, mercury and organochlorine pesticides. During the last couple of decades, the Province has analyzed certain contaminants of emerging concern for the Great Lakes environment such as PBDEs, PFASs and PCNs in selected fish samples. Depending on the monitoring requirements, community-based science also facilitates the collection of fish for the Fish Contaminant Monitoring Program.

It should be noted that the analysis presented in this sub-indicator report is cursory and a more in-depth data analysis of the monitoring data is recommended to draw a firm conclusion on contaminant trends. Monitoring data for the connecting channels of the Great Lakes were not considered as fish captured from the channels could be migratory and the data may not reflect the local conditions.

Report Authors

Satyendra P. Bhavsar, Fish Contaminant Monitoring Program, Ontario Ministry of the Environment, Conservation and Parks

Brian Lenell, Great Lakes National Program Office, U.S. Environmental Protection Agency

Report Contributors

Contacts for State Data included in this sub-indicator

Ali Meils, Indiana Department of Environmental Management

Justin Irlam, Illinois Environmental Protection Agency

Sean Strom, Wisconsin Department of Natural Resources

Brandon Armstrong, Michigan Department of Environment, Great Lakes and Energy

References

Bhavsar, S.P., Gewurtz, S.B., McGoldrick, D.J., Keir, M.J., Backus, S.M. 2010. Changes in Mercury Levels in Great Lakes fish between 1970s and 2007. Environmental Science and Technology 44:3273–3279, 2010.

Gandhi, N., Bhavsar, S.P., R.W.K., Tang, A. Drouillard, K.G., Arhonditsis, G.B. 2014. Significance of toxaphene in Great Lakes fish consumption advisories. Journal of Great Lakes Research 40, 71-79.

Gandhi, N., R.W.K., Tang, Bhavsar, S.P., Reiner, E.J., Morse, D., Arhonditsis, G.B., Drouillard, K.G., Chen, T. 2015. Is mirex still a contaminant of concern for the North American Great Lakes?, Journal of Great Lakes Research 41 (2015) 1114–1122.

Gandhi, N., Gewurtz, S.B., Drouillard, K.G., Kolic, T., MacPherson, K., Reiner, E.J., Bhavsar, S.P. 2017a. Polybrominated diphenyl ethers (PBDEs) in Great Lakes fish: Levels, patterns, trends and implications for human exposure. Science of the Total Environment 576 (2017) 907–916.

Gandhi, N., Drouillard, K. G., Arhonditsis, G. B., Gewurtz, S. B., & Bhavsar, S. P. 2017b. Are fish consumption advisories for the Great Lakes adequately protective against chemical mixtures?. Environmental health perspectives 125(2017) 586-593.

Gandhi, N., Gewurtz, S.B., Drouillard, K.G., Kolic, T., MacPherson, K., Reiner, E.J., Bhavsar, S.P. 2019. Dioxins in Great Lakes fish: Past, present and implications for future monitoring. Chemosphere 222 (2019) 479-488.

Gewurtz, S.B., Lega, R., Crozier, P.W., Whittle, D.M., Fayez, L., Reiner, E.J., et al., 2009. Factors influencing trends of polychlorinated naphthalenes and other dioxin-like compounds in lake trout (*Salvelinus namaycush*) from Lake Ontario, North America (1979–2004). Environ. Toxicol. Chem. 28, 921–930.

Gewurtz, S.B., Gandhi, N., Drouillard, K., Kolic, T., MacPherson, K., Reiner, E.J., Bhavsar, S.P. 2018. Levels, patterns, trends and significance of polychlorinated naphthalenes (PCNs) in Great Lakes fish. Science of the Total Environment. 624:499-508.

Hogan, L.S., Marschall, E., Folt, C., Stein, R.A., 2007. How non-native species in Lake Erie influence trophic transfer of mercury and lead to top predators. J. Great Lakes Res. 33:46–61.

Lorber, M. 2008. Exposure of Americans to polybrominated diphenyl ethers. Journal of Exposure Science and Environmental Epidemiology, 18, 2-19.

List of Tables

Table 1. Contaminant Concentrations and Fish Consumption Guidelines set by the Guide to Eating Ontario Fish (based on Health Canada TDIs) and the Sport Fish Advisory Taskforce. Sensitive population includes people who are or may become pregnant and children under 15. The green category represents 8+ meals per month advisories that can be considered “unrestrictive”, yellow represents 1 to 4 meals per month or “partial restriction”, and red represents 0 to half meal per month or “severe restriction”. Source: Ontario Ministry of the Environment, Conservation and Parks and Great Lakes Sport Fish Advisory Task Force (PCB Protocol 1993, Mercury Protocol 2007). Consumption advice is based on an average fish meal of 227 grams (8 ounces) for an average-size adult weighing 70 kilograms (154 pounds), linearly scaled by weight for others.

Table 2. Contaminant Concentration criteria used for the status assessments. The criteria were based on the PCB and mercury consumption limits presented in Table 1. These criteria were used to determine the status assessments of Good, Fair and Poor. The concentrations are in either µg/g (parts per million, ppm), or ng/g (parts per billion, ppb).

List of Figures

Figure 1. Total PCB concentrations (ng/g) in five fish species from the Great Lakes observed between 1975 and 2023 with focus on 2000 onwards. Lake Michigan measurements were for skin-on fillets, while skin-removed fillets for the other lakes. Conversion factor: 1000 ng/g = 1 µg/g or parts per million (ppm). Dashed red and green lines represent the cut-off criteria above/below which the levels would be considered Poor and Good, respectively, as per Table 2. Source: Ontario Ministry of the Environment, Conservation and Parks, U.S. Environmental Protection Agency, Indiana Department of Environmental Management, Illinois Environmental Protection Agency, Wisconsin Department of Natural Resources, Michigan Department of Environment, Great Lakes and Energy

Figure 2. Total mercury concentrations (µg/g) in five fish species from the Great Lakes observed between 1975 and 2023. Lake Michigan measurements were for skin-on fillets, while skin-removed fillets for the other lakes. Dashed green lines represent the cut-off criteria below which the levels would be considered Good as per Table 2. Source: Ontario Ministry of the Environment, Conservation and Parks, U.S. Environmental Protection Agency, Indiana Department of Environmental Management, Illinois Environmental Protection Agency, Wisconsin Department of Natural Resources, Michigan Department of Environment, Great Lakes and Energy

Figure 3. Concentrations of perfluorooctane sulfonic acid (PFOS) (ng/g) in three fish species from the Great Lakes observed between 2019 and 2023. Lake Michigan measurements were for skin-on and skin-off fillets, while skin-removed fillets for the other lakes. Source: Ontario Ministry of the Environment, Conservation and Parks, U.S. Environmental Protection Agency, Indiana Department of Environmental Management, Illinois Environmental Protection Agency, Wisconsin Department of Natural Resources, Michigan Department of Environment, Great Lakes and Energy.

Last Updated

State of the Great Lakes 2025 Report

Table 1. Contaminant Concentrations and Fish Consumption Guidelines set by the Guide to Eating Ontario Fish (based on Health Canada TDIs) and the Sport Fish Advisory Taskforce. Sensitive population includes people who are or may become pregnant and children under 15. The green category represents 8+ meals per month advisories that can be considered "unrestrictive", yellow represents 1 to 4 meals per month or "partial restriction", and red represents 0 to half meal per month or "severe restriction". Source: Ontario Ministry of the Environment, Conservation and Parks and Great Lakes Sport Fish Advisory Task Force (PCB Protocol 1993, Mercury Protocol 2007). Consumption advice is based on an average fish meal of 227 grams (8 ounces) for an average-size adult weighing 70 kilograms (154 pounds), linearly scaled by weight for others.

Meals per month	PCB (ug/g)			Hg (ug/g)		
	Sensitive*	Sensitive**	General**	Sensitive*	Sensitive**	General**
32	0 - .05	<.026	<.026	0 <=.05	<0.06	<0.15
16		.026-.053	.026-.053		0.06-0.12	0.15-0.3
12		.053-.070	.053-.070		0.12-0.16	0.3-0.4
8		.070-.105	.070-.105	>0.05 <= .11	0.16-0.25	0.4-0.6
4	.06 - .2	.105-.211	.105-.211	.0.11 <= .22	0.25-0.5	0.6-1.2
2			.211-.422			1.2-1.8
1	.21 - 1.0		.422-.844	>.22 <= 0.95		
0.5	1.1 - 1.9					
0 (do not eat)	>1.9	>.211	>.844	>0.95	>0.5	>1.8

* Sport Fish Advisory Consortium Protocol
** Ontario Ministry of the Environment, Conservation and Parks

Table 2. Contaminant Concentration criteria used for the status assessments. The criteria were based on the PCB and mercury consumption limits presented in Table 1. These criteria were used to determine the status assessments of Good, Fair and Poor. The concentrations are in either µg/g (parts per million, ppm), or ng/g (parts per billion, ppb).

Status	PCB		Hg
	µg/g	ng/g	µg/g
Good	<0.1	<100	<0.25
Fair	0.1 - 1	100 - 1000	0.25 - 1
Poor	>1	>1000	>1

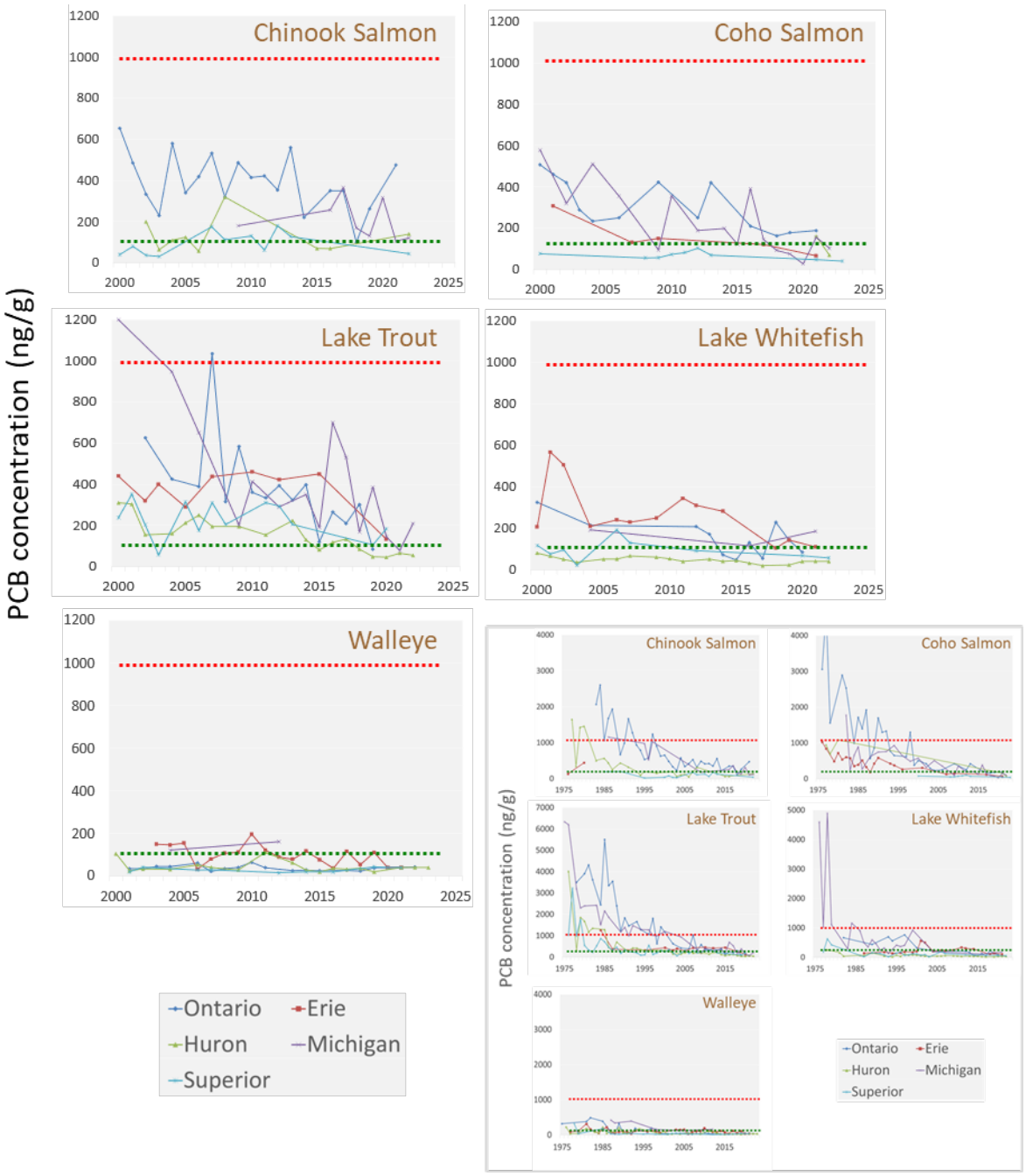

Figure 1. Total PCB concentrations (ng/g) in five fish species from the Great Lakes observed between 1975 and 2023 (inset in lower right) with focus on 2000 onwards. Lake Michigan measurements were for skin-on fillets, while skin-removed fillets for the other lakes. Conversion factor: 1000 ng/g = 1 µg/g or parts per million (ppm). Dashed red and green lines represent the cut-off criteria above/below which the levels would be considered Poor" and Good, respectively, as per Table 2. Source: Ontario Ministry of the Environment, Conservation and Parks, U.S. Environmental Protection Agency, Indiana Department of Environmental Management, Illinois Environmental Protection Agency, Wisconsin Department of Natural Resources, Michigan Department of Environment, Great Lakes and Energy

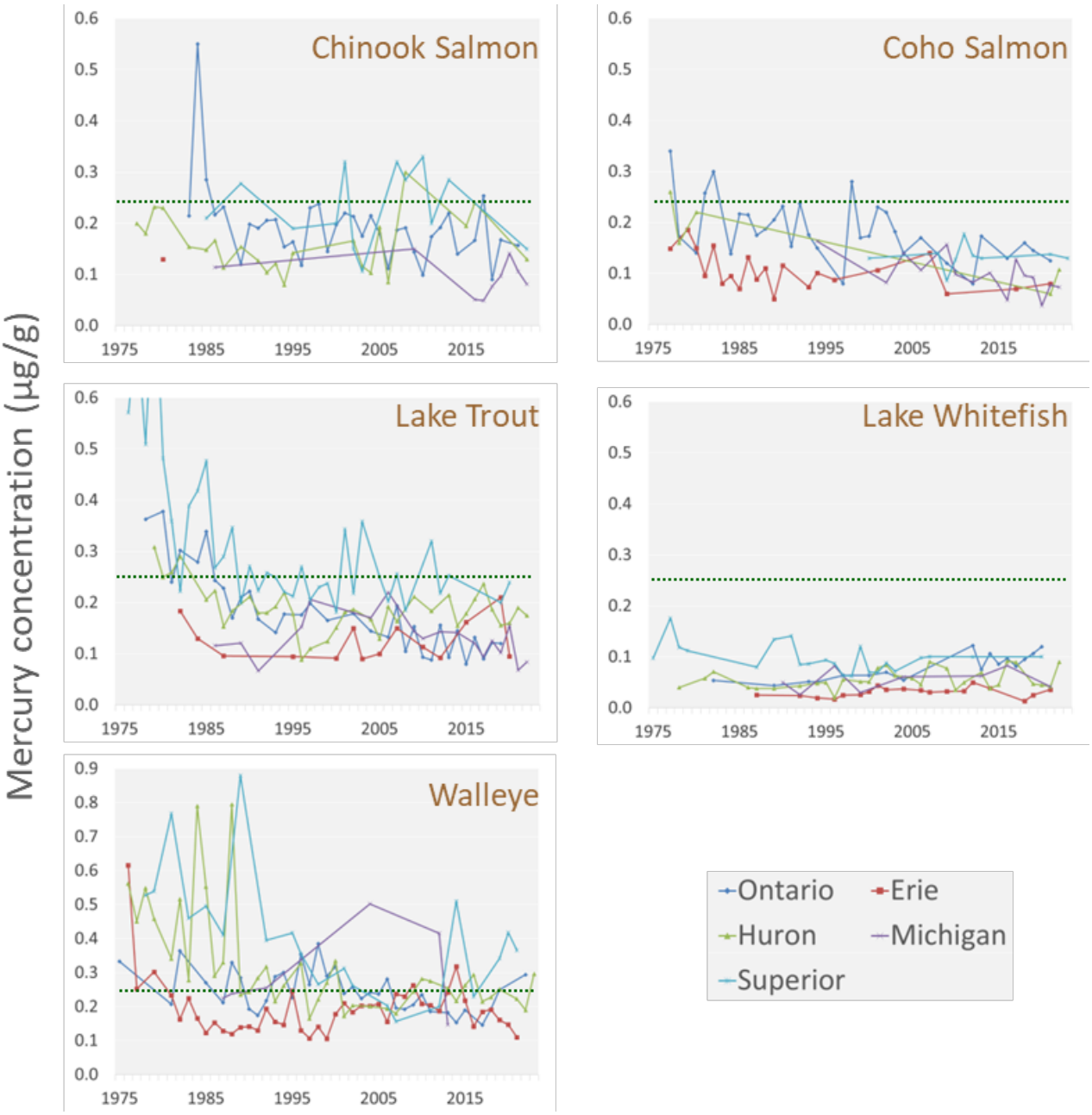

Figure 2. Total mercury concentrations (µg/g) in five fish species from the Great Lakes observed between 1975 and 2023. Lake Michigan measurements were for skin-on fillets, while skin-removed fillets for the other lakes. Dashed green lines represent the cut-off criteria below which the levels would be considered Good as per Table 2. Source: Ontario Ministry of the Environment, Conservation and Parks, U.S. Environmental Protection Agency, Indiana Department of Environmental Management, Illinois Environmental Protection Agency, Wisconsin Department of Natural Resources, Michigan Department of Environment, Great Lakes and Energy.

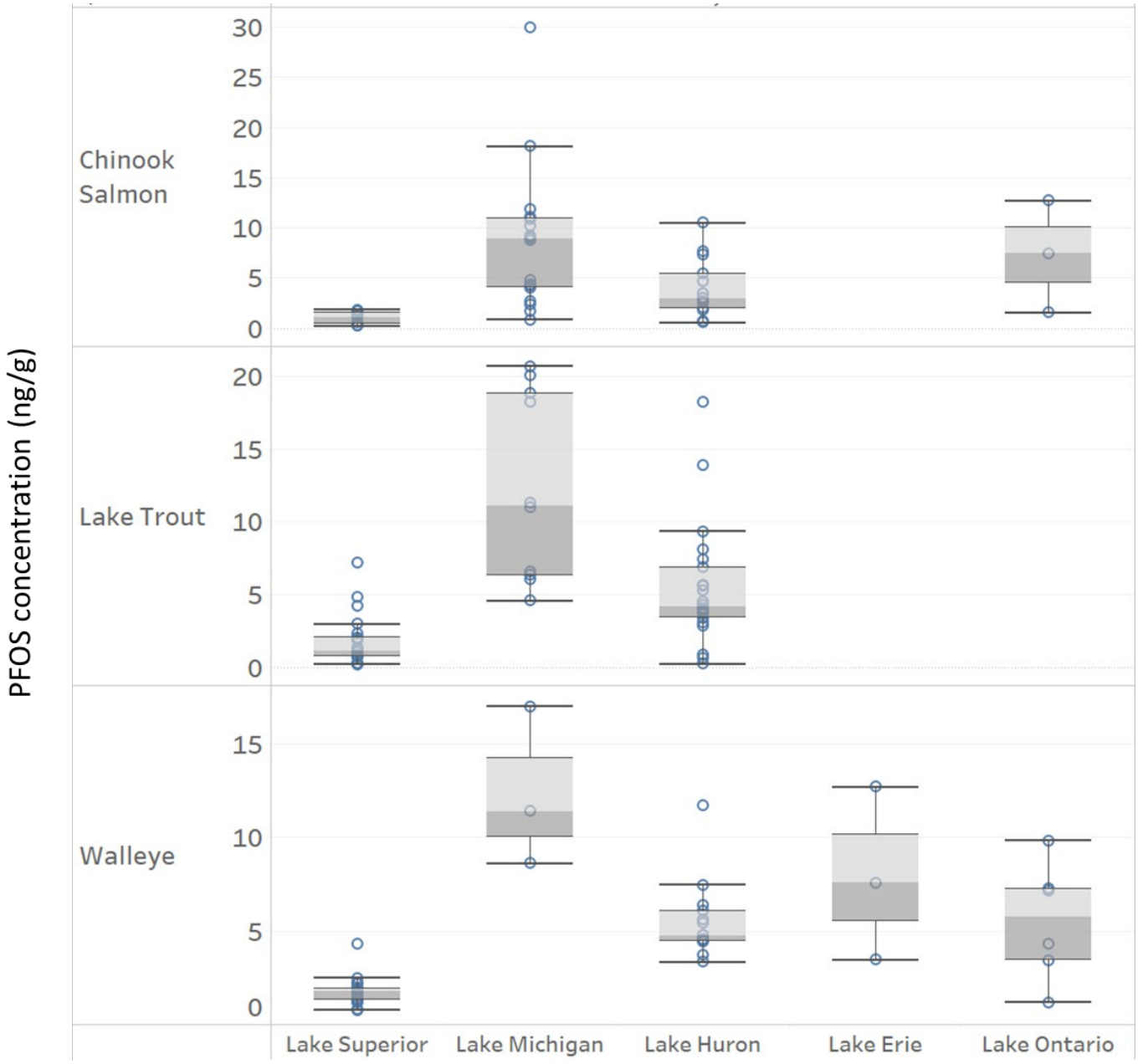

Figure 3. Concentrations of perfluorooctane sulfonic acid (PFOS) (ng/g) in three fish species from the Great Lakes observed between 2019 and 2023. Lake Michigan measurements were for skin-on and skin-off fillets, while skin-removed fillets for the other lakes. Source: Ontario Ministry of the Environment, Conservation and Parks, U.S. Environmental Protection Agency, Indiana Department of Environmental Management, Illinois Environmental Protection Agency, Wisconsin Department of Natural Resources, Michigan Department of Environment, Great Lakes and Energy.