

Lake Fish Tissue

Lakes and reservoirs provide important sport fisheries and other recreational opportunities, and lake ecosystems provide critical habitat for aquatic species and support wildlife populations that depend on aquatic species for food. Lakes and reservoirs occur in a variety of landscapes and can receive contaminants from several sources, including direct discharges into the water, atmospheric deposition, and agricultural or urban runoff. A group of contaminants of particular concern are the persistent, bioaccumulative, and toxic (PBT) chemicals. These contaminants are highly toxic, long-lasting chemicals that can accumulate in fish, reaching levels that can affect the health of people and wildlife that eat them.

PBT contaminants can originate from a variety of sources. A primary source of one of the most important PBTs, mercury, is combustion at coal-fired power plants and other industrial operations (see the [Mercury Emissions indicator](#)); mercury emitted to the air can then be transported and deposited in lakes and reservoirs. Among other important PBTs, most uses of DDT became illegal in the U.S. in 1972; production and use of PCBs in the U.S. were phased out by 1979; chlordane was banned in 1988; and dioxin levels in the environment have been declining since the early 1970s (U.S. EPA, 2009).

This indicator is based on tissue samples of predator and bottom-dwelling fish species collected and analyzed for EPA's National Study of Chemical Residues in Lake Fish Tissue (U.S. EPA, 2009). The data generated from this probabilistic survey (Olsen et al., 2009; Stahl et al., 2009) are designed to estimate the national distribution of the mean levels of PBT chemicals in fish tissue from lakes (not including the Great Lakes) and reservoirs of the contiguous 48 states. The indicator consists of statistical distributions of the concentrations of 14 PBT chemicals or chemical groups in predator and bottom-dwelling fish tissue, including mercury, arsenic (total inorganic), dioxins/furans, total PCBs, and 10 organochlorine pesticides.

Fish samples were collected from 500 lakes and reservoirs over a 4-year period (2000-2003). Sampling locations were selected from the estimated 147,000 target lakes and reservoirs in the contiguous 48 states based on an unequal probability survey design. The lakes and reservoirs were divided into six size categories, and varying probabilities were assigned to each category to achieve a similar number of lakes in each size category. The lakes and reservoirs ranged from 1 hectare (about 2.5 acres) to 365,000 hectares (about 900,000 acres), were at least 1 meter (3 feet) deep, and had permanent fish populations.

Because no predator or bottom-dwelling species occurs in all 500 lakes and reservoirs, the study focused on 12 target predator species and six target bottom-dwelling species to minimize the effect of sampling different species. These species were chosen because they are commonly consumed in the study area, have a wide geographic distribution, and potentially accumulate high concentrations of PBT chemicals. Sampling teams applied consistent materials and methods nationwide. From each lake or reservoir, teams collected composite samples of five adult fish of similar size for one predator species (e.g., bass or trout) and one bottom-dwelling species (e.g., carp or catfish) where one or both were available (U.S. EPA, 2002). Sampling the 500 lakes and reservoirs yielded 486 composite samples for predator species and 395 composite samples for bottom-dwelling species. Fillets were analyzed for predators, and whole bodies were analyzed for bottom-dwelling fish. Fillet data represent the edible part of the fish most relevant to human health, while whole-body data are more relevant to wildlife consumption. A single laboratory prepared fish tissue samples for analysis in a strictly controlled environment, and tissue samples were sent to four analytical laboratories. The same laboratory analyzed tissue samples for each chemical group (e.g., PCBs or organochlorine pesticides), using the same standard analytical method, for the duration of the study. Concentrations of dioxins and furans were reported on a toxic equivalency quotient (TEQ) basis, which adjusts for the different toxicities of the various dioxin and furan compounds.

Concentrations of mercury, PCBs, dioxins and furans, DDT, and chlordane in predator fillets were compared with human health screening values. The mercury screening value is EPA's tissue-based water quality criterion (U.S. EPA, 2016). The other screening values are risk-based consumption limits from EPA's *Guidance for Assessing Chemical Contaminant Data for Use in Fish Consumption Limits: Volume 2* (U.S. EPA, 2000).

What the Data Show

Mercury, PCBs, dioxins and furans, and DDT are widely distributed in lakes and reservoirs in the contiguous 48 states (Exhibits 1 and 2). Mercury and PCBs were detected in 100 percent of both predator and bottom-dweller composite samples. Dioxins and furans were detected in 81 percent of the predator composite samples and 99 percent of the bottom-dweller composite samples, and DDT was detected in 78 percent of the predator composites and 98 percent of the bottom-dweller composites.

Median concentrations in predator fillets (i.e., half of the lakes and reservoirs had fish with higher values) were as follows: mercury, 0.285 ppm; total PCBs, 2.161 ppb; dioxins and furans, 0.006 ppt [TEQ]; and total DDT, 1.47 ppb (Exhibit 1). Median concentrations in whole, bottom-dwelling fish were lower for mercury (0.069 ppm), but higher for total PCBs (13.88 ppb), dioxins and furans (0.406 ppt [TEQ]), and total DDT (12.68 ppb) (Exhibit 2).

Exhibit 3 shows the proportion of lakes that exceeded human health screening values for five commonly detected chemicals. Mercury was detected above human health screening values in almost 50 percent of the lakes sampled. The percentage of lakes above screening values was much lower for the other chemicals. DDT and chlordane were detected above human health screening values in less than 2 percent and 1 percent of the lakes sampled, respectively.

Limitations

- Survey data are not available for Alaska, Hawaii, or Puerto Rico.
- The Great Lakes and the Great Salt Lake are not included in the target population.
- Because the distribution of sampling sites was based on the frequency of occurrence of lakes and reservoirs, contaminants in lakes and reservoirs in arid states (e.g., Arizona, New Mexico, and Nevada) are not well represented.
- Due to the inaccessibility of some target lakes (e.g., landowner denial of access), the results are representative of the sampled population of

lakes (approximately 80,000) rather than the original target population of 147,000 lakes.

- Trend data are not yet available, as this is the first time that a national lake fish tissue survey has been conducted using a probabilistic sampling design. These data can serve as a baseline for future surveys.

Data Sources

The data for this indicator were obtained from EPA's National Study of Chemical Residues in Lake Fish Tissue (U.S. EPA, 2009). Information about this study is available at <https://www.epa.gov/fish-tech/national-lake-fish-tissue-study>.

References

Olsen, A.R., B.D. Snyder, L.L. Stahl, and J.L. Pitt. 2009. Survey design for lakes and reservoirs in the United States to assess contaminants in fish tissue. *Environ. Monit. Assess.* 150:91-100.

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U.S. EPA (United States Environmental Protection Agency). 2016. Human Health Criteria - Methylmercury. <https://nepis.epa.gov/Exe/ZyPDF.cgi/20003UU4.PDF?Dockey=20003UU4.pdf> (PDF) (308pp, 16.5M).

U.S. EPA. 2009. The National Study of Chemical Residues in Lake Fish Tissue. EPA-823-R-09-006. <https://www.epa.gov/sites/default/files/2018-11/documents/national-study-chemical-residues-lake-fish-tissue.pdf> (PDF) (242pp, 7.62M).

U.S. EPA. 2002. Field sampling plan for the National Study of Chemical Residues in Lake Fish Tissue. EPA-823-R-02-004. <https://www.epa.gov/sites/default/files/2018-11/documents/field-sampling-plan-lake-fish-tissue.pdf> (PDF) (40 pp, 558K).

U.S. EPA. 2000. Guidance for assessing chemical contaminant data for use in fish advisories: Volume 2: Risk assessment and fish consumption limits. Third edition. EPA-823-B-00-008. <https://www.epa.gov/sites/production/files/2015-06/documents/volume2.pdf> (PDF) (383 pp, 1.53M).

| Contaminant | Number of samples | Number of samples above MDL | Percentiles for fillet tissue concentrations (ppm) | | | | | | |
|-------------------------|-------------------|-----------------------------|--|----------|----------|----------------------|-----------------------|------------------------|------------------------|
| | | | 5th | 10th | 25th | 50th (median) | 75th | 90th | 95th |
| Mercury | 486 | 486 | 0.059 | 0.089 | 0.177 | 0.285 | 0.432 | 0.562 | 0.833 |
| Total PCBs | 486 | 486 | 0.000351 | 0.000494 | 0.001000 | 0.002161 | 0.008129 | 0.018159 | 0.033161 |
| TEQ dioxins/furans only | 486 | 395 | * | * | * | 6 x 10 ⁻⁹ | 46 x 10 ⁻⁹ | 109 x 10 ⁻⁹ | 318 x 10 ⁻⁹ |
| Total inorganic arsenic | 486 | 2 | * | * | * | * | * | * | * |
| Total chlordane | 486 | 96 | * | * | * | * | * | 0.003617 | 0.008266 |
| Total DDT | 486 | 378 | * | * | * | 0.00147 | 0.00694 | 0.01966 | 0.03057 |
| Dicofol | 486 | 15 | * | * | * | * | * | * | * |
| Dieldrin | 486 | 24 | * | * | * | * | * | * | 0.001193 |
| Total endosulfan | 486 | 18 | * | * | * | * | * | * | * |

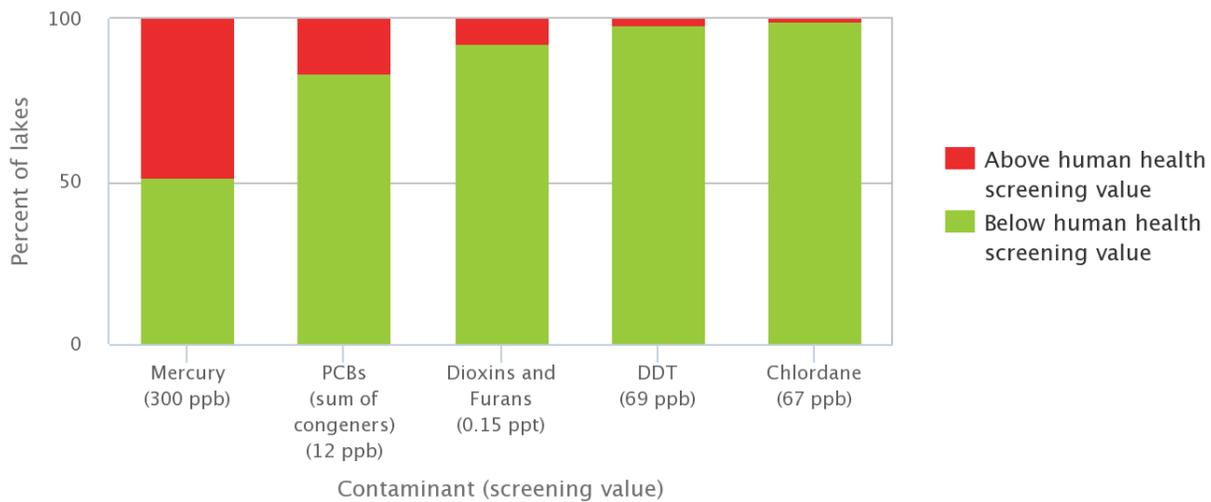
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Exhibit 2. Lake fish tissue PBT contaminant concentration estimates for bottom-dwellers (whole fish) in the contiguous U.S., 2000–2003

| Contaminant | Number of samples | Number of samples above MDL | Percentiles for whole-body tissue concentrations (ppm) | | | | | | |
|-------------------------|-------------------|-----------------------------|--|-----------------------|------------------------|------------------------|-------------------------|-------------------------|-------------------------|
| | | | 5th | 10th | 25th | 50th (median) | 75th | 90th | 95th |
| Mercury | 395 | 395 | 0.019 | 0.020 | 0.039 | 0.069 | 0.124 | 0.220 | 0.247 |
| Total PCBs | 395 | 395 | 0.001579 | 0.002308 | 0.005146 | 0.013876 | 0.070050 | 0.130787 | 0.198324 |
| TEQ dioxins/furans only | 395 | 393 | 19 x 10 ⁻⁹ | 59 x 10 ⁻⁹ | 165 x 10 ⁻⁹ | 406 x 10 ⁻⁹ | 1067 x 10 ⁻⁹ | 1770 x 10 ⁻⁹ | 2006 x 10 ⁻⁹ |
| Total inorganic arsenic | 395 | 36 | * | * | * | * | * | * | 0.037 |
| Total chlordane | 395 | 197 | * | * | * | 0.001653 | 0.009313 | 0.025964 | 0.030931 |
| Total DDT | 395 | 388 | 0.00108 | 0.00182 | 0.00423 | 0.01268 | 0.0353 | 0.15392 | 0.21863 |
| Dicofol | 395 | 8 | * | * | * | * | * | * | * |
| Dieldrin | 395 | 73 | * | * | * | * | * | 0.003436 | 0.024613 |
| Total endosulfan | 395 | 23 | * | * | * | * | * | * | * |

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Exhibit 3. Percent of lakes above or below human health screening values for predators (fillets) in the contiguous U.S., 2000–2003



Coverage: Lakes and reservoirs of the contiguous 48 states.

Based on eating one 8-ounce meal of fish per week.

ppb = parts per billion ppt = parts per trillion

Trend analysis has not been conducted because these data represent a single snapshot in time. For more information about uncertainty, variability, and statistical analysis, view the technical documentation for this indicator.

Data source: U.S. EPA, 2009