Polybrominated diphenyl ethers (PBDEs) and polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) in fish from New York's Great Lakes and connecting channels

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NOTICE

ABSTRACT

A broad-based assessment of chemical residue concentrations in 1,277 fish from New York's Great Lakes and connecting channels was begun in 2010. Two previous reports (Li et al. 2014; Skinner et al. 2018) have described concentrations of mercury, polychlorinated biphenyls (PCBs), organochlorine pesticides and octachlorostyrene. Li et al. (2014) also included a partial assessment of polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs) and polybrominated diphenyl ethers (PBDEs). This report includes the chemical residue concentrations in 250 fish analyzed for over 40 PBDE congeners and 306 fish analyzed for 17 PCDD/F congeners and 8 PCDD/F homologs.

Forty-eight percent of PCDD/F concentrations, expressed as 2,3,7,8-TCDD toxic equivalents (TEQs), exceeded the recommended USEPA human consumption limit (1.2 pg/g). Some fish from nearly all waters sampled exceeded this USEPA criterion. The less restrictive New York State Department of Health criterion of 10 pg/g was exceeded by four percent of the samples, primarily fish from Cayuga Creek, a tributary of the Niagara River having a known historical source of TCDD. In contrast, none of the total PBDE concentrations in fish exceeded any known criteria for protection of human health.

For protection of fish consuming wildlife, PCDD/F concentrations, expressed as TEQs, exceeded protective criteria in 30 to 60 percent of the samples, depending on the criterion used. Further, total PBDE concentrations, particularly for penta-BDEs (including BDE-99 and BDE-100) exceeded several criteria for protection of fish or fish-consuming wildlife. An average of 52 percent of samples exceeded criteria for penta-BDEs; 6 differing criteria were used with 17 to 86 percent of samples exceeding a criterion. Further, 24 percent of samples exceeded the hexa-BDE criterion (4 ng/g) for protection of fish-consuming wildlife.

Concentrations of 2,3,7,8-TCDD in fish from Cayuga Creek have declined by an average of 73 percent between 1978-80 (only TCDD and TCDF were measured prior to the mid 1980s) and 2013-14 but concentrations were still above criteria for protection of human health. More dramatically, an average 95 percent decline in TCDD concentrations has occurred in fish from Lake Ontario during the same period. Trends for TCDD levels in Lake Erie fish could not be discerned due to elevated detection limits in the early time frame. TCDD TEQs in the St. Lawrence River and its tributaries have generally experienced declines similar to Lake Ontario between 1988 and 2013-14 although the range of declines is greater.

TCDD is still at problematic levels in the lower portion of Cayuga Creek despite remediation of upstream contributions. TCDD remaining in sediments from lower Cayuga Creek are likely the cause of elevated TCDD in fish from the creek and in waters downstream. Similarly, Cayuga Creek appears to be a significant source of PBDEs in fish. Examination and removal of TCDD and PBDE sources, if possible, is warranted.

Actions taken based on this study

The declines in TCDD and TEQ concentrations in salmonids from Lake Ontario contributed to the rationale for changes in health advisories for human consumers of fish. Health advisories for consumption of salmonids are now less stringent while health advice for common carp and channel catfish became more stringent due to PCDD/Fs.

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INTRODUCTION

Polybrominated diphenyl ethers (PBDEs) have been used as flame retardants in a variety of plastics (including for electronics), in carpeting and textiles, in polyurethane foam and some other lesser uses (Alaee et al. 2003; Birnbaum et al. 2004). PBDE residues in human blood, breast milk and other tissues (Hooper and She 2003; Mazdai et al. 2003; Schecter at al. 2003; Anderson et al. 2008) have their principal origin from household dust (Jones-Otazo et al. 2005; Lorber 2008), although exposures though food may be significant (Wu et al. 2007; Anderson et al. 2008). Fish and wildlife may contain significant levels of PBDEs (Shaw and Kannan 2009) which may have adverse impacts on neurobehavioral development, thyroid hormone levels, fetal survival, reduced pipping and hatching success of birds, and damage to liver and kidney morphology (Darnerud et al. 2001; Darnerud 2003; McKernan et al. 2009).

In the Great Lakes, PBDEs became a group of chemicals of concern in the 1990s. Lake trout from Lake Ontario had the greatest total PBDE concentrations of the Great Lakes while lake trout and walleye from Lake Erie had the lowest concentrations (Luross et al. 2002; Zhu and Hites 2004). Based on analysis of archived fish, concentrations of PBDEs in fish rapidly increased from the late 1970s and early 1980s until around 2000 (Zhu and Hites 2004; Carlson et al. 2010). Regulatory controls on PBDE usage is resulting in phase out PBDE use, causing initial declines in PBDE concentrations in fish beginning in the early portion of the millennium (Ismail et al. 2009, Crimmins et al. 2012; Gandhi et al. 2017b).

In contrast, polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) in Lake Ontario fish were first noted to be present in the early 1980s at concentrations of concern to human consumers (OMOE 1981, 1982; NYSDOH 1981a; O'Keefe et al. 1983; Stalling et al. 1983). PCDDs were produced as by-products of production of chlorophenols and certain pesticides, while PCDFs are by-products of incomplete combustion of PCBs and certain other chlorine containing compounds. PCDD/Fs also entered the environment through disposal, such as at Love Canal in Niagara Falls, NY (NYSDOH 1981a; Smith et al. 1983). In New York’s portion of Lake Ontario and the St. Lawrence River, recommendations to restrict human consumption of fish were already in place due to the presence of excessive concentrations of PCBs and mirex, but dioxins were added in 1981 as chemicals of concern (NYSDOH 1981b). PCDD/Fs have been examined only episodically due, in part, to the expense of analysis and the specialized facilities required for analysis of such toxic compounds. However, a background of information was developed in the 1980s for TCDD and/ or TCDF in Great Lakes fish, including Lake Erie and Lake Ontario (Ryan et al. 1983, 1984; Fehringer et al. 1985; DeVault et al. 1989; USEPA/NYSDEC/NYS/DOH/OCC 1990). Thereafter, the PCDD/F analyte list expanded to include all 17 congeners with 2,3,7,8-chlorine substitution. Most recently, monitoring of PCDD/Fs in fish has been most concentrated in Canadian waters (Bhavsar et al. 2008; Gandhi et al. 2017a). This study provides a comprehensive update of the database for PCDD/Fs in New York waters of the Great Lakes system and expands the scope of species examined.

This report presents the findings of the third phase of the study titled “Xenobiotics in Fish from New York’s Great Lakes International Waters,” which was funded by the U.S. Environmental Protection Agency’s Great Lakes Restoration Initiative. The report provides the complete data set for PBDEs and PCDD/Fs for the entire project in New York's Great Lakes basin. A portion of these data were applicable to Phase 1 of this project and were reported by Li et al. (2014). However, the availability of additional funding provided in more recent phases of the project permitted the analysis of additional samples for the areas addressed by Li et al. (2014) and includes samples for the St. Lawrence River and its connecting tributaries, and additional samples for PCDD/F analyses to address New York State Department of Health concerns.

The study objectives pertinent to this phase of the study include:

- Provide an assessment of polychlorinated dioxins and furans (PCDD/Fs) and brominated diphenyl ethers (PBDEs) in fish from each of New York's Great Lakes waters;

- Update polychlorinated dioxin and furan information in edible fish from Cayuga Creek, Niagara County, associated with industrial and closed hazardous waste sites, including Love Canal;

- Assess temporal changes, broad scale spatial patterns, and species differences in chemical residues in fish from each water where information permits; and

- Assess the potential to affect beneficial uses of these waters and, with the cooperation of the NYS Department of Health and the St. Regis Mohawk Tribe, obtain health advisory determinations based on the data generated by this project.

METHODS

Sampling

The methods of sample collection, species of fish sampled and handling procedures for the samples were described by Li et al. (2014) and Skinner et al. (2018). These original samples were collected from 2010 through 2014 (Table 1, Figures 1a and 1b). In addition, the New York State Department of Health (NYSDOH) requested other samples be collected to fill data gaps or to strengthen specific data sets for PCDD/Fs for health advisory determinations. These 49 samples were collected in 2014 through 2017 and are indicated as supplemental samples in Table 1. For this paper, migratory salmonids, when collected in tributary waters (Chautauqua Creek is a tributary of Lake Erie and Salmon River is a tributary of Lake Ontario) are treated as a separate location although the data could be combined with their receiving water. A summary of the combined lengths and weights of each species is provided in Table 2 with similar data for specific waterbodies in Appendix A.

Chemical analyses

An aliquot of thoroughly ground and homogenized tissue representing the standard fillet (a fillet with skin on and scales removed) of each fish was shipped frozen in a chemically clean jar to the contract laboratory, Pace Analytical Services, Inc., Minneapolis, Minnesota. Chain of custody forms, sample records and analytical requests accompanied the samples to the laboratory.

Lipid concentrations, expressed in percent, were determined by gravimetric methods. The lipid determinations are summarized in Table 3. Lipid concentrations are used for lipid normalization of contaminant concentrations.

PBDEs

PBDE analyses employed high resolution techniques in Method 1614A (USEPA 2010). A total of 250 samples were analyzed for PBDE congeners and resulted in a total of 11,151 concentration determinations. The frequency of detection of each PBDE analyte and the maximum concentrations determined are in Table 4. Some specific PBDEs were not determined for all samples. A total of 112 samples were analyzed for BDEs numbered -11, -12, -17, -25, -49, -71 and -138, while 138 samples were analyzed for coeluting BDEs numbered -12/13, -17/25, -49/71 and -138/166. The differing analyte lists reflect evolving analytical capability that occurred over the several years (2012 through 2016) during which PBDE analyses were conducted.

PCDD/Fs

All samples (n = 306; 257 original + 49 supplemental) were analyzed for PCDD/Fs by high resolution techniques in Method 1613B (USEPA 1994). The seventeen 2,3,7,8-substituted PCDD/Fs were quantified and reported along with total homolog concentrations for tetra- through hepta- PCDD/Fs. A total of 5202 determinations were made for 2,3,7,8-substituted PCDD/Fs and 2448 determinations for PCDD/F homologs. The frequency of detection for each analyte and the maximum concentrations determined are given in Table 5.

Reporting limits vs detection limits

The original data reports included reporting limits (RL) or practical reporting limits (PRL) for all samples and analytes. Detection limits (DL) were reported for 58.6% of PBDE determinations and 56.4% of PCDD/F determinations. The lack of consistency in reporting DLs increased difficulty of reporting the data, particularly when concentrations were near the reporting limits. At these low concentrations, there is increasing uncertainty in the concentrations being reported for each analyte. However, total PBDE concentrations and total 2,3,7,8-TCDD toxic equivalents are essentially unaffected by DL or RL reporting since concentrations near these limits rarely contributed meaningfully to totals.

Both the DL and RL were variable and were primarily dependent on the tissue mass used for analysis. Where DLs were available, concentration reporting gave DLs preference, particularly when handling certain data qualifiers (discussed later, page 7). In most cases, DLs for PBDEs were less than RLs (Table 4). For PCDD/Fs, the reporting limits and the DLs were similar

(Table 5). Tables 4 and 5 provide for each PBDE congener and each PCDD/F congener and homolog, respectively, the median DL and the median RL for samples where the DL are not given. Appendices B, C1 and C2 provide additional detail on DLs and RLs for PBDE congeners and PCDD/F congeners and homologs, respectively.

Quality control

Blanks

Blanks were run at a frequency of approximately one for every set of 20 samples, resulting in a total of 19 blanks for PBDE analyses and 21 for PCDD/F analyses. Blanks lacked detectable PBDE and PCDD/F congeners in most cases, as expected, but some detections and interferences were detected. Where interferences occurred, the true congener concentration in the blank cannot be determined. Therefore, the affected blank congener concentration was set at the appropriate detection or reporting limit. Where detectable congener concentrations, including from interference, were in the blank, the B qualifier was applied to sample data when the reported sample congener concentration was less than 10 times the corresponding blank congener concentration, and the associated blank concentration was subtracted from reported sample concentrations. If the resulting concentration was less than the detection or reporting limit, the appropriate detection or reporting limit was assigned to the sample.

A review of data handling for blank contamination for samples reported in 2012 and 2013 by Li et al. (2014) revealed blank contamination handling procedures were inconsistent with this standard NYSDEC practice. We therefore re-examined all PBDE and PCDD/F data used by Li et al. (2014) and applied consistent blank handling methods.

The blank management practices employed by Li et al. (2014) did not significantly affect their reported total PBDE or total 2,3,7,8-TCDD toxic equivalent concentrations. However, for specific PBDE and PCDD/F congeners, especially where concentrations were near detection or reporting limits, the impacts could be appreciable with both overestimates and underestimates of specific congener concentrations possible.

Lab control spikes

Lab control spikes and their duplicates were run at the same frequency as blanks, i.e., approximately one for every set of 20 samples. A total 19 lab control spikes and 19 lab control spike duplicates were run for PBDE analyses and, similarly, 21 lab control spikes and 21 lab control spike duplicates were run for PCDD/F analyses. Spikes of "clean" tissue samples for PBDE analyses were made with coeluting BDEs -28/33, and BDEs -47, -99, -100, -153, -154, -183 and -209. Similarly, spikes for PCDD/F analyses included 15 of the 17 congeners having 2,3,7,8-chlorine substitution. In general, recovery of the spikes was within the acceptance limits (see Appendix D for limits) of the analytical methods for over 99.5% of PBDE determinations (BDE-47 and BDE-99 each had one value outside the acceptance limits) and 98.9% of PCDD/F determinations (OCDD and OCDF were the primary exceptions). Repeatability of analysis, as measured by the absolute relative percent difference (|RPD|) of the lab control sample and its duplicate, was acceptable in 98.7% of PBDE comparisons (BDE-209 was the exception in two comparisons) and 99.4% of PCDD/F comparisons (one exception each for OCDD and OCDF).

A more robust discussion of the findings for these quality control samples is included in Appendix D.

Internal standards (isotope dilution)

Every sample, whether a fish sample or a quality control sample, had isotopically labeled internal standards analyzed at the same time. When a recovery of an internal standard was outside analytical method control limits, the recovery was "R" qualified. Recoveries of internal standards were used to adjust sample data to account for analytical variability with the intent of producing analytical results with greater quantitative accuracy.

Recoveries of 6 of the 8 BDEs used for internal standards were generally within the method acceptance range. However, recoveries for BDE-209 and BDE-183 were frequently lower than desired. In 27.3% of samples, labeled BDE-209 recovery was less than the lower limit of acceptability (i.e., 20% recovery) and for BDE-183, 20.0% of samples had recovery below the 30% recovery limit. Nonetheless, the laboratory generally considers reported results to be valid with isotope dilution with recoveries as low as 5%. Other BDEs only occasionally did not meet recovery limits. In one instance (sample number 13-0082-H) for BDE-209, an internal standard recovery of zero was given. Consequently, the practical reporting limit was highly elevated, causing the reported BDE-209 concentration to be non-detect. Due to the low recoveries of BDE-209, reported concentrations of BDE-209 should be treated with caution when analyzing or interpreting the resultant data.

Recoveries of internal standards for all PCDD/F congeners for all fish samples were within method acceptance limits. Only one blank sample had R qualifiers for low recovery of internal standards while all other quality control samples had acceptable recovery of internal standards.

Cleanup standards

Isotopically labeled BDE-139 was run with every sample analyzed for PBDEs. Recoveries of 13C-BDE-139 were acceptable in 97.5% of cases.

Two cleanup standards for PCDD/F analyses were injected in each PCDD/F sample but were not quantified.

Duplicate samples

No duplicate samples were analyzed for PBDEs in the 111 samples reported in 2012 and 2013. Six duplicate samples were analyzed for PBDEs in samples reported in 2015 and 2016 and resulted in 258 data pairs. In 148 pairs (53.7%) an |RPD| could not be calculated because both members of an analyte pair had concentrations that were less than detection or reporting limits, or, much less frequently, one member of the analyte pair was non-detect while the concentration of the other member was near the detection or reporting limit. Arguably, it could be stated that there was close agreement of analytical results and that these pairs met acceptance limits. Of the remaining 110 pairs (46.3% of the total pairs) for which |RPD| was calculated, 73.6% of the results were within acceptance limits. An |RPD| of 30% was exceeded by 29 pairs (26.4% of the quantifiable |RPD| pairs). Unacceptable |RPD| exceeding 50% was found three samples for BDE-209 and one sample each for BDEs -66, -99, -126, -206, -207 and -208. Similarly, the most extreme |RPD| values (exceeding 100%) occurred twice for BDE-209 and once for BDE-99. Half the unacceptable |RPD| results were associated with one duplicate sample (sample 13-0147-H). There was good repeatability of analyses for all PBDEs except BDE-209.

No duplicate samples were analyzed for PCDD/Fs in the 112 samples reported in 2012 and 2013. Seven duplicate samples were included in PCDD/F analyses reported in 2015 and 2018. All |RPD| results were within acceptance limits (i.e., less than or equal to 30%) and 94.8% were within an |RPD| of 20% or less. As with PBDEs, the |RPD| could not be calculated for some sample pairs because one or both samples in a duplicate pair had non-detectable concentrations, more specifically, 84.0% of PCDD/F congener pairs and 62.5% of homolog pairs. Where detectable concentrations were reported, they were near reporting limits in most cases, but 2,3,7,8-TCDF, when detected, was often an order of magnitude greater than the reporting limit.

Appendix D provides greater detail of the findings.

Standard reference materials (SRM)

No standard reference materials of any type were analyzed with samples reported in 2012 and 2013 (Phase 1 of the project). Subsequent analyses had limited inclusion of standard reference materials as described hereafter.

SRM1947 from the US National Institute of Standards and Technology was analyzed twice for PBDEs. Seven BDEs (i.e., -47, -49, -66, -99, -100, -153 and -154) have certified values and BDEs -28/33 and -155 have reference values. Most results (94%) were within the acceptance range; the one exception was a low BDE-66 concentration in one of the two samples.

CARP-2 from the Natural Resource Council of Canada was analyzed 5 times for PCDD/Fs. Nine compounds were evaluated, i.e., TCDF, 1,2,3,4,7,8-PeCDF, and the seven 2,3,7,8-substituted PCDDs. In the 10 measurements for the two furans, interferences occurred three times, one measurement was within acceptance limits and the remaining six measurements were higher than acceptance limits. For dioxins (n = 35 measurements), interferences occurred six times, 16 measurements were within acceptance limits, two were below acceptance limits and 11 were higher than acceptance limits.

One of the five CARP-2 samples was run in duplicate for PCDD/Fs. Most |RPD| results were within acceptance limits, i.e., less than or equal to 30%. An elevated |RPD| occurred for 1,2,3,6,7,8-HxCDF, 2,3,4,6,7,8-HxCDF, total HxCDF and OCDD.

Qualifiers

Several qualifiers were associated with the sample data. Three of the eight qualifiers caused an impact on the reported data for some samples. These three qualifiers, their meaning and the data handling due to the qualifiers are noted below.

Where blank contamination was noted ("B" qualifier), the analyte concentration in the sample was less than 10 times the associated method blank concentration. Blank qualifiers were assigned to 3.1% of PBDE concentrations, 7.1% of 2,3,7,8-substituted PCDD/F congener concentrations and 10.7% of PCDD/F homolog concentrations.

Two data qualifiers ("I" and "P") indicated probable interference with the reported analyte concentration, preventing the analyte concentration, if any, being reliably determined. The "I" qualifier was applied by the laboratory when an unspecified interference caused the recovery of the analyte to have a retention time marginally outside the acceptable retention time window for the analyte. The "P" qualifier was applied only to PCDD/Fs and indicates contamination with polychlorinated diphenyl ethers (PCDEs). Whenever these qualifiers were reported, the analyte concentration was reduced to less than the DL, or less than the RL when the DL was not given for both laboratory reporting and our statistical analysis. The laboratory also reported an estimated maximum possible concentration. A total of 9.3% of PBDE results, 9.2% of PCDD/F congener results and none of the PCDD/F homolog results were "I" qualified. A total of 4.5% of PCDD/F congener results and none of PCDD/F homolog concentrations were "P" qualified. It was noted that the rates of use of these two qualifiers declined over time indicating apparent improvements in the application of the analytical methods.

Statistical analyses

The PCDD/F data collected in the original sampling efforts from 2010−2014 are summarized separately from data collected from 2014−2017 in response to sampling requests by the NY State Department of Health. The possibility of temporal differences necessitated this reporting structure.

Analyte concentrations reported as less than detection limits or reporting limits were treated as zero for all computations. Where all values for a computation were less than the DL or the RL, the value is reported as non-detect (nd). Where fewer than 80% of samples for an analyte, fish and location were quantified, the mean and maximum concentration and the number of samples with quantified concentrations are given. In this case, the standard deviation is too unreliable for reporting due to the small sample numbers. However, where 80% or more of the samples for an analyte, species and location were quantified, the mean, standard deviation and maximum are given. The number of samples having quantifiable results, if less than all samples for the species and location, is given parenthetically.

2,3,7,8-TCDD toxic equivalents (TEQs) for humans and mammals were calculated for PCDD/Fs using the toxic equivalency factors (TEFs) in Van den Berg et al. (2006). Similarly, the TEFs of Van den Berg et al. (1998) were used to calculate TEQs for fish and birds.

Two nonparametric tests, the Kruskal-Wallis test or the Mann-Whitney test, were used for most comparisons among species and sites. These tests are valid with censored data and do not require normality of data distribution. For the Kruskal-Wallis test, when significant differences were found, post-hoc procedures in Conover (1980) were used to identify spatial differences.

RESULTS

PBDEs

Mean total PBDE concentrations (Table 6) ranged from 850 pg/g in white sucker from the St. Regis River to over 65,000 pg/g in common carp from Cayuga Creek with a maximum of 121,800 pg/g. Total PBDE concentrations exceeded 10,000 pg/g in at least one species from nearly all locations sampled; the one exception was the St. Regis River above the dam in Hogansburg, a reference station. Overall mean total PBDE concentrations by location are in Figure 2 and show the salmonines collected at the Salmon River Hatchery have the greatest total PBDE concentrations. However, it is important to note that Salmon River Hatchery chinook and coho salmon were generally larger/older fish than those sampled from Lake Ontario. Also, weights of chinook and coho salmon on their spawning migration up the Salmon River decline substantially contributing to PBDE reconcentration within their body.

Tetra-BDEs dominated homolog distributions, followed by penta- and hexa- homologs (Table 7 and Figure 3). These three homolog groups combined constitute almost 95% of total PBDE concentrations. As expected, the dominance of BDE-47 in the tetra- homolog group was apparent, as well as BDE-99 plus BDE-100 in the penta- homolog group; these three congeners alone accounted for close to three fourths of total PBDE concentrations (Table 8; Appendix E).

Eight individual congeners (BDEs -47, -49, -51, -99, -100, -153, -154, -155) and three coeluting pair of congeners (BDEs -17/25, -28/33, -49/71) were detected in 90% or more of the samples (Table 4). BDE-119/120 was detected in 89% of samples. Only BDEs -47, -99 and -100 had concentrations that exceeded 10,000 pg/g in some samples (Table 8). Six of the eight congeners above, three coeluters (BDE-28/33, BDE-49/71 and BDE-119/120), plus BDE-66, BDE-71 and BDE-209, had concentrations that equaled or exceeded 1000 pg/g in at least one sample. These congeners generally accounted for over 98 percent of the total PBDEs present (Tables 8 and 9). BDE-47 dominated all other PBDEs by contributing an average 45.9 percent of the total PBDEs and was present in 33.6 percent of samples at concentrations exceeding 10,000 pg/g. In contrast, BDE-99 and BDE-100 contributed an average 14.3 and 14.5 percent (Table 9), respectively, to total PBDE and were present in 5.6 and 4.0 percent, respectively, of samples at concentrations of 10,000 pg/g or more (Table 8). Both the greatest and lowest BDE-47 concentrations were reported from Cayuga Creek, i.e., a common carp with 89,547 pg/g and a brown bullhead with a non-detectable concentration (the only non-detect reported for BDE-47). Overall, common carp, channel catfish and the five salmonids (chinook and coho salmon, brown, lake and rainbow trout) contained the greatest BDE-47 concentrations. BDEs -1, -2, -10, -11, -30, -105 and -190 were not detected an any sample and BDEs -3, -7, -12, -12/13, -35, -116, -138, -166, -181, -203, -206, -207 and -208 were detected in fewer than 10% of samples (Table 4).

Typically, common carp contained the greatest concentrations of PBDE congeners (Table 6) at a site. However, exceptions occurred for specific congeners, notably BDE-99 and BDE-153 (Table 9). Forty-four of 47 common carp (93.6%) had BDE-99 concentrations that contributed less than 1.0 percent (usually less than 0.5%) to total PBDE; the maximum contribution was 3.97 percent. The BDE-99 contribution was at least an order of magnitude less than found in most other fish species. Similarly, BDE-153 in carp contributed less than 0.2 percent to total PBDE in 42 of 47 samples with a maximum contribution of 0.94%, again, at least an order of magnitude less than other species. In contrast, BDE-47 proportions were greater in carp than for most species except white perch and white sucker (Table 9). White sucker and white perch displayed congener relationships similar to common carp, but not quite as pronounced.

PCDD/Fs

An overall perspective by location of PCDD/F concentrations converted to 2,3,7,8-TCDD toxic equivalents (TEQ) for humans and mammals is given in Figure 4. Fish from Cayuga Creek contained the greatest TEQ concentrations (overall average of 7.35 pg/g), while the reference stations at the St. Regis River above the Hogansburg dam and the Grasse River above the dam in Massena had the lowest (0.048 and 0.073 pg/g, respectively). Common carp or channel catfish had the greatest TEQs (maximum of 29.49 pg/g in common carp from Cayuga Creek), while walleye frequently had the lowest TEQ concentrations (Table 10).

The principal congeners detected were 2,3,7,8-TCDD, 2,3,7,8-TCDF, 2,3,4,7,8-PeCDF and 1,2,3,7,8-PeCDD (Figure 5; Appendices F and G), and, as expected, they contributed the most to the TEQs. Also, OCDD was present in over 50% of the samples but contributed little to TEQs due to their low TEF. TCDD dominated (75%) TEQ values in Cayuga Creek and the lower Niagara River whereas fish in Lake Ontario and the Salmon River Hatchery had only about 38% of TCDD TEQs from TCDD. In Lake Erie and the St. Lawrence system TCDD was generally less than 30% of total TEQs. In these latter cases, 2,3,7,8-TCDF, 2,3,4,7,8-PeCDF and 1,2,3,7,8-PeCDD became primary contributors to total TEQ values.

Overall TEQs for samples collected in response to NYSDOH requests are shown in Figure 4b and the specific data are in Table 10 supplemental samples. TEQs in lake trout from the lower Niagara River exceeded 10 pg/g with an average TEQ of 12.7 pg/g. Three of five common carp from the lower Niagara River and four of five common carp from eastern Lake Ontario had TEQ values less than 10 pg/g. However, the remaining two common carp from the lower Niagara River had 15.8 and 16.8 pg/g TEQs and the fifth common carp from eastern Lake Ontario had the greatest TEQ (21.2 pg/g) reported for the supplemental samples. Most of the other fish samples had relatively low TEQs.

Age (length) – contaminant relationships

Age of lake trout was determined for 2010−2011 collections from eastern Lake Ontario to determine whether age-contaminant relationships were present. Total PBDEs increased with age

($r = 0.955$, $p < 0.01$, $n = 16$) for age three through eight-year old lake trout (Table 11). Two other larger lake trout were not aged because their size prevented reliable age determination based on aging scales, but it is probable that they were older than 8+ years. They both contained total PBDE concentrations which exceeded those of the younger lake trout.

In contrast, age was less correlated ($r = 0.579$, $p < 0.05$, $n = 15$) with increasing PCDD/F TEQs for lake trout of ages three through seven, and the correlation was lost ($r = 0.451$, $p > 0.05$, $n = 16$) when the single 8-year old fish was included. Inclusion of the two larger un-aged fish would not have improved the correlation if ages were known.

Since length is frequently used as a surrogate for age, correlation coefficients were determined for lake trout in the three data sets for which $n \geq 6$ fish. All length-concentration correlations were significant (Table 12) with the eastern Lake Ontario length-total PBDE correlation particularly strong ($p \ll 0.01$). Figure 6 provides individual data points for TEQs.

Supplemental lake trout samples from the lower Niagara River (3 fish) and western Lake Ontario (9 fish) had substantially different average total TEQ concentrations (12.7 ppt and 3.67 ppt, respectively; Table 10). The length distributions of the fish at the two locations were markedly different (i.e., 750 to 784 mm for the river and 357 to 740 mm in the lake); thus, the length-concentration relationship would be expected to have a significant impact on TEQ values. The three largest lake trout from Lake Ontario (721 to 740 mm) had 6.89 ppt average total TEQ, which accounts for a portion of the difference due to the length-concentration correlation. Possibly, the increased proximity of riverine lake trout to the primary PCDD/F sources may account for the remaining portion of the disparity.

Spatial distributions

PBDEs

Sample sizes were small for most species-location combinations, so the best general observation may be that PBDEs are widespread contaminants and the concentration ranges are often overlapping, with fish from disparate locations having similar PBDE levels (Table 13). Spatial differences, when present, occurred at the 0.05 significance level for most species. Walleye had spatial differences at the $p < 0.01$ significance level but only differences at the $p < 0.05$ significance level are included here for consistency of reporting.

Fish from Cayuga Creek generally had the greatest total PBDE levels for the species examined. Common carp exhibited no spatial differences in total PBDE concentrations over the entire Great Lakes basin. However, when common carp from the Niagara River-Cayuga Creek sub-basin were segregated, spatial differences were evident, i.e., Cayuga Creek caused increased PBDE concentrations in the lower Niagara River.

Salmonids from Lake Erie tended to have lower total PBDE concentrations than in Lake Ontario. In the Raquette River, the reference station above Route 420 had significantly greater total

PBDE concentrations than at the mouth of the river in two of three species (smallmouth bass and walleye).

PCDD/Fs

Total TEQ concentrations were distinctly greater in fish from Cayuga Creek than in other locations (see common carp and brown bullhead in Tables 10 and 14; see also Figure 4). Dioxins from Cayuga Creek, primarily TCDD (Figure 5), caused increased TEQ concentrations in fish from the lower Niagara River and affected Lake Ontario fish (Figure 4a). However, by the time Lake Ontario waters entered the St. Lawrence River, TEQ concentrations in fish had declined to about one-half Lake Ontario fish levels. The upper Niagara River and reference sites on St. Lawrence River tributaries had the lowest TEQ values.

Common carp and channel catfish generally contained the highest TEQ values from each location from which they were sampled. Conversely, walleye from all but one location (Cape Vincent) had among the lowest TEQ values (Table 10).

The overall Lake Erie TEQ value (Figure 4) was greater than expected. In Lake Erie, TEQs were driven by higher TEQ concentrations in common carp, channel catfish and lake trout (Table 10). TEQs in rainbow trout, smallmouth bass and walleye from Lake Erie were among the lowest 20% of TEQs in this study and resembled reference stations on tributaries of the St. Lawrence River. TEQs from Lake Erie were dominated by TCDF and 2,3,4,7,8-PeCDF contributions, whereas TEQs in Lake Ontario were dominated by TCDD and 1,2,3,7,8-PeCDD contributions (Figure 5).

DISCUSSION

Spatial distributions

PBDEs

Early investigations of PBDEs (e.g., Manchester-Neesvig et al. 2001; Luross et al. 2002; Zhu and Hites 2004) focused on the five most abundant BDE congeners (i.e., BDE-47, -99, -100, -153 and -154). In this study, with measurements for 50 BDE congeners (between 43 and 47 peaks due to changes in coeluting congeners at different analysis times), these five compounds remained the major BDE congeners and the total concentrations of the five compounds contributed an average of 88% of total BDEs (Table 9).

Historically, in lake trout of a single age class from each of the five Great Lakes, total PBDE concentrations were highest in Lake Ontario (95 ± 22 ng/g wet weight) and lowest in Lake Erie (27 ± 8.6 ng/g wet weight) (Luross et al. 2002).

Gandhi et al. (2017b, supplemental Table S1) reported analysis of an array of fish species from the Great Lakes taken between 2006 and 2013. In Lake Erie and Lake Ontario, total PBDE concentration ranges were similar for species common with this study. In lake trout from Lake

Ontario during 2008-2012, total PBDE concentrations reported by McGoldrick and Murphy (2016, supplemental Table S1) were nearly double (87.1 ng/g) those reported in this study (48.1 ng/g). In the St. Lawrence River near Montreal, mean total PBDEs on a lipid basis were 963 ng/g, 2876 ng/g and 3873 ng/g for yellow perch, northern pike and muskellunge, respectively (Houde et al. 2014), which is about an order of magnitude greater than concentrations in fish from the St. Lawrence River in this study when converted to a lipid basis.

Richman et al. (2013) examined potential sources of PBDEs along the Niagara River. In caged mussel studies along both shores of the river, Cayuga Creek was the greatest contributor of PBDEs to the Niagara River followed by Two Mile Creek and Gill Creek at less than half the concentrations. In our study, total PBDEs in Cayuga Creek also appear to be a primary contributor to total PBDEs in the lower Niagara River as evidenced by concentrations in common carp (Tables 6 and 13). All three streams are on the east side (US) of the river and have past or current industrial development and waste disposal that are potential sources of PBDEs. These sources of the PBDEs need to be identified and, where possible, control of the sources should be implemented. This could become a part of a more comprehensive program to identify PBDE sources with an ultimate goal of implementing further source controls where those actions are possible.

PCDD/Fs

The U.S. Environmental Protection Agency conducted a national probabilistic study of contaminants in fish that included 500 lakes and reservoirs in the contiguous states but excluded the Great Lakes. Median PCDD/F concentrations, expressed as TEQs, were 0.006 pg/g and 0.41 pg/g in predator and bottom-dwelling fish, respectively, while 90th percentile TEQ concentrations were 0.11 pg/g and 1.77 pg/g, respectively (Stahl et al. 2009). In New York's Great Lakes basin, these median TEQs were readily exceeded by many fish. For our study, 192 fish would be classified as predators, 111 as bottom-dwelling, and 3 yellow perch were not classified. The respective 90th percentile TEQ concentrations, a more rigorous measure of concentrations, were exceeded by 84.3% of predators and 48.6% of bottom-dwellers.

Cayuga Creek was the recipient of chemical wastes, including TCDD, disposed by a local industry (the former Hooker Chemical Corporation, renamed Hooker Chemical and Plastics Company, later owned by Occidental Chemical Corporation) at Love Canal in Niagara Falls, NY (NYSDOH 1981a; Smith et al. 1983). TCDD was the dominant PCDD/F analyte present.

Via Cayuga Creek, TCDD residues from Love Canal enter the lower Niagara River and Lake Ontario. Historically, elevated TCDD concentrations were noted in fish from Lake Ontario with a maximum value of 162 pg/g in a brown trout in 1978 (O'Keefe et al. 1983). USEPA/NYSDEC/NYSDOH/OCC (1990) conducted more intensive examination of TCDD levels in Lake Ontario fish collected in 1987. Spatial differences in 2,3,7,8-TCDD concentrations were absent for lake trout, brown trout and yellow perch but were present for white perch. Historically, white perch taken from the vicinity of the Niagara River contained higher levels of TCDD than white perch from the eastern end of the lake. For the current study, white perch from far western Lake Ontario were unavailable, but spatial differences in TEQs for white perch were absent between Irondequoit Bay or Sodus Bay in the center of the lake and more eastern fish (Table 14).

Whittle et al. (1992) and Bhavsar et al. (2008) used TCDD:TCDF ratios in lake trout to indicate Lake Ontario had a different composition of the two major PCDD/Fs than the other Great Lakes. TCDD was more dominant in Lake Ontario than in the upper Great Lakes with ratios in lake trout ranging from 0.56 to 0.88. In our study, lake trout had TCDD/TCDF ratios of 0.079 in Lake Erie, 0.59 in the lower Niagara River, 0.42 in western Lake Ontario, and 0.19 in eastern Lake Ontario (Table 15), showing an unambiguous signal of the Cayuga Creek discharge with down-gradient diminution. The current TCDD:TCDF ratio for Lake Ontario is about one-half that reported by the other authors.

TCDD:TCDF ratios in other species similarly demonstrate the major contribution of Cayuga Creek as a primary source of TCDD to the Great Lakes watershed (Table 15; see also Figures 4, 5 and 7). Ratios for fish upstream of Cayuga Creek were generally less than 0.3 whereas TCDD:TCDF ratios in Cayuga Creek ranged from about 4.0 to 8.0 in largemouth bass, rock bass and carp, and brown bullhead was 34:1. The ratios for carp declined to the range of 2.7 to 3.0 for the lower Niagara River and Lake Ontario, respectively, and declined to less than 0.5 (and generally less than 0.3) in the St. Lawrence River. The overall pattern of declining TCDD:TCDF ratios as distance from the primary source increases occurred for nearly all fish species.

The continuing prevalence of Cayuga Creek as a source of TCDD to fish in the Niagara River and Lake Ontario suggests sources within the drainage basin, including the sediments below the remediated area associated with Love Canal, continue to exist over twenty years after completion of remedial efforts at Love Canal. The identification of additional TCDD sources combined with greater removal of TCDD contaminated sediments and the TCDD sources identified require consideration and pursuit. Impairments of the fisheries resource due to TCDD contamination will not be removed without these actions.

The three sampled tributaries to the St. Lawrence River in the Massena vicinity all had a similar downstream to upstream pattern. Samples within a mile of the mouth of each of the Grasse, Raquette and St. Regis Rivers all had considerably higher concentrations than the upstream reference locations, which were all similarly low for species in common (Table 10). These reference locations were above fish passage barriers and therefore reflect the influence of the relatively unpolluted Adirondack watershed. The samples within a mile of the mouth show, in contrast, a combination of the continued influence from Lake Ontario and likely additional contributions from contaminated sites near Massena.

Temporal changes

PBDEs

This is the first examination of PBDEs in Great Lakes fish by New York. Assessments of year to year temporal changes based solely on New York State data cannot, therefore, be made. However, Zhu and Hites (2004) showed PBDE concentrations in archived fish (1980 to 2000) from the Great Lakes (including lake trout from Lake Ontario and walleye from Lake Erie) increased exponentially with time, doubling every 3 to 4 years. Further, the proportion of BDEs -47, -99 and -100 increased with respect to BDEs -153 and -154. Carlson et al. (2010) also showed the exponential increase in major PBDE congeners from 1980 to the mid-1990s but concentrations leveled off from 1997 through 1999. Crimmins et al. (2012) showed significant declines in the five major PBDE congeners (BDEs -47, -99, -100, -153 and -154) from 2000-2001 through 2009 for lake trout from Lake Ontario, whereas concentrations in Lake Erie walleye declined from levels observed in the early 1980s but became stable in the late 1990s.

Canadian investigators have conducted PBDE analyses of fish for several years. Retrospective analysis of lake trout collected between 1979 and 2004 from Lake Ontario found that through 1998 seven of eight BDE congeners increased at a doubling rate averaging 5 years, with BDE-209 an exception with 19 years to double (Ismail et al. 2009). After 1998, concentrations began to decline, except for BDE-209. Gandhi et al. (2017b) showed 46 to 74 percent declines in lower brominated PBDEs in several species of fish between 2006-07 and 2012. USEPA (2017) reported declines in specific PBDE homologs in Lake Ontario lake trout of 5.8%/year for tetra-BDEs, 6.4%/year for penta-BDEs and 3.4%/year for hexa-BDEs between 2000 and 2009. Similarly, E&CC Canada (2017) reported declines of 4.0%/year for penta-BDEs in Lake Ontario lake trout over a longer period from 1997 through 2012.

As supporting information, Norstrom et al. (2002) showed exponential increases of BDEs -47, -99 and -100 (doubling time averaging 2.8 years) between 1981 and 2000 for herring gull eggs from Lake Ontario but increases in BDEs -153, -154 and -183 were erratic and became a declining proportion of total PBDEs over time. Total PBDE concentrations in herring gull eggs stabilized from 2000 through 2006 (Gauthier et al. 2008). By 2012-2013, there was a 30% decline in the total concentration of seven principal BDEs; however, BDE-209 concentrations increased significantly (Su et al. 2015).

In fast growing fish seasonal changes in total PBDEs may be evident. In this study, age 2+ coho salmon from 2011 spring collections had significantly lower mean total PBDEs than age 2+ fall 2010 coho salmon collections (i.e., mean total PBDE of 10,400 pg/g and 45,700 pg/g, respectively). Similar seasonal variations in chemical residue concentrations in coho salmon were observed for PCBs (Horn at al. 1986) and mercury (Richter and Skinner 2020). For fast growing fish such as coho and chinook salmon, this emphasizes the need for making long term temporal comparisons based on fish collected in the same season (and age) for each year being compared.

Role of PBDE regulation

Most uses of PBDEs have been or are being phased out. Based on an agreement with USEPA, the sole United States manufacturer of penta- and octa-BDEs halted production by 2005. Significant imports of penta- and octa-BDEs were allowed to continue but those uses have been or are being phased out. Production and use of deca-BDE in the U.S. was largely eliminated by 2013, although full phase out is still occurring. Between 2006 and 2008, at least 11 states, including four of the eight Great Lakes states (including New York), imposed bans on use of penta- and octa-BDEs. Most of these states later adopted bans for deca-BDE. Similarly, Canada

(E&CC Canada 2018) and the European Union prohibited most PBDE uses in the early 2000s, and remaining uses are being phased out consistent with agreements per the Stockholm Convention for Persistent Organic Pollutants.

Based on timing alone, it appears that regulatory actions are playing a significant role in halting increasing PBDE concentrations in fish and wildlife. As time passes, reductions of PBDE concentrations in fish and wildlife are becoming apparent. The regulatory actions preceded the observed halt of increasing PBDE concentrations and the ensuing declines in PBDEs in Great Lakes fish and wildlife. However, efforts to reduce or eliminate sources of PBDEs must continue.

PCDD/Fs

This study reports the most extensive examination of TCDD levels in New York's Great Lakes fish since 1978-80 and 1987-88. Further, this study is the first post-remediation assessment of TCDD concentrations in adult (edible) fish within Cayuga Creek. Early assessments addressed only TCDD in adult fish since analytical capability had not been developed for other PCDD/F analytes. Later studies addressed all 17 of the 2,3,7,8-chlorine substituted PCDD/F congeners.

For Cayuga Creek, the limited evidence suggests a decline averaging 73% for common carp and rock bass since the period 1978-80 (Table 16). In both the 1978-80 and the current study, collections of adult fish occurred downstream of TCDD containment and removal action areas. Although the decline was substantial, concentrations remained elevated. Thus, TCDD remaining in sediments following these actions appears to be continuing to affect local fish populations and likely downstream fisheries in the lower Niagara River and Lake Ontario, as well.

Highly contaminated sediments having TCDD concentrations of 1000 pg/g or more were removed from tributaries of Cayuga Creek, Black and Bergholtz Creeks, below Love Canal in 1989 (USEPA 2019). As a result, young-of-year fish from these areas experienced an 84% or more decline in TCDD concentrations between 1982 and 1992 (Skinner 1993a, b). By 1997, TCDD in young-of-year fish became non-detectable in Bergholtz Creek, whereas, in non-remediated areas of Cayuga Creek and downstream Little River TCDD declined by an additional 56 to 78 percent (Preddice et al. 2002).

Temporal declines in TCDD levels in fish from Lake Ontario have averaged 95% between 1978-80 and 2010-2011 (Table 16), indicating a significant improvement in the quality of fish. The 1987 data (USEPA/NYSDEC/NYSDOH/OCC 1990) for TCDD in fish fillets were included in Table 16 to demonstrate the decline in TCDD concentrations for an interim period. This agrees with the 91% decline for fish in Lake Ontario lake trout for the period 1989 to 2013, and the 96% decline between 1979 and 2013 noted by Gandhi et al. (2019).

For US waters of Lake Ontario, DeVault et al. (1989) provided baseline (1984) concentrations of 18 PCDD/Fs in lake trout for future assessments of temporal trends. Declining temporal trends were subsequently noted by Huestis et al. (1997) for the period 1977 through 1993. Linear declines were extended to 2003 by Bhavsar et al. (2008), and Gewurtz et al. (2009) noted a fivefold decline on a lipid-basis (four-fold decline on a wet weight basis) in PCDD/Fs in lake trout between 1979 and 2004. For 600 mm lake trout from Lake Ontario, Bhavsar et al. (2008) estimated a TEQ decline rate of 1.5 pg/g/yr for the period 1989 to 1999; the estimated TEQs were about 15 pg/g in 1999. By projection, non-detection of TEQs in 600 mm lake trout would have been reached in about 10 years, i.e., 2009 to 2010. Gandhi et al. (2019) calculated a rate of decline of 1.05 pg/g/yr for 600 mm lake trout over the period 1978 to 2013 and reported a TEQ concentration of 2.3 pg/g in 2013. In this study, the estimated TEQs for 600 mm lake trout in 2010-2011 was 3.48 pg/g and in 2014 was 2.22 pg/g, i.e., very close to the Gandhi et al. (2019) estimate. It is apparent that the rate of decline for TEQs has slowed since 1999.

In three salmonids (rainbow trout, coho and chinook salmon) from Lake Ontario, O'Keefe et al. (2006) noted declining trends in TCDD and TCDF between 1978 and 1999. First-order declines (half-life of 11 years) in PCDD/F TEQs and four dioxin-like PCBs were noted in eggs from of chinook and coho salmon collected from the Salmon River, NY, between 2004 and 2014. The rate of decline closely approximates that for lake trout from Lake Ontario in the same period (Pagano et al. 2018).

In contrast to the above declines in Cayuga Creek and Lake Ontario, no significant declines were noted for common carp from the lower Niagara River between 2010 and 2014 (TEQs of 4.67 pg/g and 8.34 pg/g, respectively).

Based on New York data alone, temporal changes in fish from Lake Erie could not be quantified due to elevated detection limits in 1978-1980. However, a limited comparison for walleye in the DeVault et al. (1989) baseline data suggests a decline of 98 percent for TEQs. TCDD is now non-detectable while TCDF has declined by 90 percent.

In the St. Lawrence River, first measurements of PCDD/Fs in adult fish were made in 1988 for fish from the Massena area (Sloan and Jock 1990). They found TCDD concentrations were generally low, with penta- hexa- and hepta- dioxin congeners generally non-detectable. Contributions of dibenzofurans, primarily tetra- and penta- congeners were usually equivalent to or greater than TCDD. Therefore, for temporal comparisons, all concentrations were converted to TCDD toxic equivalents. In the Massena area below the Moses Saunders Dam, declines in TEQ concentrations of 80% or more were common, except in smallmouth bass (Table 17). Another exception occurred in the St. Regis River where changes in TEQs were variable; both significant declines and small increases were apparent. The latter increase may be an artifact of analytical variability or small sample size since analytical concentrations were approaching detection limits.

Evidence of PBDE differential debromination

Relative to most other fish species, common carp contained the lowest contributions of BDE-99 and BDE-153 to total PBDE concentrations, whereas BDE-47 contributions appear greater than for nearly all other species (Table 9). The exceptions include white perch and white sucker, which were approximately equivalent to common carp. In two other New York waters, the Hudson River (Xia et al. 2008) and Buffalo River (Loganthan et al. 1995; Skinner et al. 2009b), similar BDE relationships occurred for common carp, but also included striped bass, white perch, American eels and several species of minnows from the Hudson River.

In laboratory feeding experiments with common carp or goldfish, debromination of BDE-99 and BDE-153 reduced concentrations of these analytes while concurrently enhancing BDE-47 levels (Stapleton et al. 2004b; Zhang et al. 2014). Benedict et al. (2007) showed intestinal and liver microsomes were highly effective in converting BDE-99 to BDE-47, but the precise mechanism was not identified. Roberts et al. (2011) documented metabolic debromination of six different congeners (BDEs -99, -153, -183, -203, -208 and -209) by common carp, rainbow trout and chinook salmon with debromination dominated by loss of bromine from the *meta*-substituted position. Debromination by common carp occurred at a rate 10 to 100 times faster than for the two salmonids. Debromination of BDE-99 apparently led to increased concentrations of BDE-47 (Stapleton et al. 2004b; Stapleton et al. 2004c). In another study, debromination of PBDEs was observed in crucian carp (i.e., goldfish) but not in a species of catfish (Luo et al. 2017). Further, debromination of BDE-209 by common carp has been demonstrated by several studies (Stapleton at al. 2004a; Stapleton et al. 2006; La Guardia et al. 2007; Roberts et al. 2011), resulting in increased presence of several products, primarily hexa- through octa- BDEs. Structural examination of debromination with application of the findings above suggests the following:

BDE-	Structure	Position of Br^- removed
153	2,2’,4,4’,5,5’-hexa-BDE	
	⇓	meta
99	2,2’,4,4’,5-penta-BDE	
	⇓	meta
47	2,2’,4,4’-tetra-BDE	
	⇓	ortho
28	2,4,4’-tri-BDE	

None of the investigators have suggested that BDE-28 concentrations have increased as debromination progressed, perhaps due to the increased difficulty in removing bromine from the ortho position. Common carp in Table 9 contain BDE-28/33 concentrations (presumed to be primarily BDE-28) that are generally 3-fold greater than in other species, suggesting that at least some removal of bromine from the ortho- position may have occurred.

Comparison with environmental criteria

Criteria to protect human health

Total PBDEs and four BDE congeners did not exceed published criterion designed to protect human health (Table 18). PBDE concentrations were not sufficiently high in most Great Lakes fish to cause concern about human exposures via fish consumption by Canadian citizens, although concentrations (up to 390 ng/g total PBDE and up to 300 ng/g penta-BDE) in common carp from the Toronto waterfront were elevated sufficiently to cause restrictions on fish consumption (Gandhi et al. 2017b). The New York State Department of Health did not issue or propose a contrary opinion for fish consumers in New York when provided our results (Agnes Mukasa, NYSDOH, personal communication, December 6, 2018).

In early assessments of PBDE contributions to human exposures, it was believed that fish consumption was an important route of exposure as concentrations were increasing rapidly (Schecter et al. 2004; Zhu and Hites 2004; Ismail et al. 2009). Other routes of PBDE exposure, especially from house dust, have been found to be of significantly greater importance, and are followed by dietary ingestion of animal products and dairy products (Jones-Otazo et al. 2005; Wu et al. 2007; Lorber 2008; Frederiksen et al. 2009). The exposures via consumption of Great Lakes fish, and of fish in general, were relatively small and did not contribute strongly to total PBDE exposures (Anderson et al. 2008).

In contrast to PBDEs, nearly half the location-species combinations for TCDD TEQs (Table 18) exceeded the USEPA (2000) recommended limit for any consumption of 1.2 pg/g TCDD TEQs to protect adult fish consumers. Further, the less stringent recommendation (5.4 pg/g TEQ) of the Ontario Ministry of the Environment and Climate Change (Gandhi et al. 2017a) for protection of sensitive populations of people (i.e., children and women of child bearing age) was exceeded by 6.5 percent of the samples, primarily by fish from Cayuga Creek and lake trout from Lake Ontario.

For dioxin (2,3,7,8-TCDD), the New York State Department of Health uses a guideline of 10 pg/g for setting fish advisories for the general population of men over 15 and women over 50 that was first published in a NYSDOH news release issued in 1981 (NYSDOH 1981b). NYSDOH has stayed abreast of the available toxicological literature and continues to use the 10 pg/g fish advisory guideline for 2,3,7,8-TCDD for setting a specific advisory (NYSDOH 2019b). As the state of the science on PCDD/Fs has improved, NYSDOH currently applies the 2,3,7,8-TCDD fish advisory guideline to total TCDD toxic equivalents for chlorinated dioxin and furan mixtures (Agnes Mukasa, NYSDOH, personal communication, December 6, 2018).

The 10 pg/g criterion of the NY State Department of Health was exceeded almost exclusively by fish from Cayuga Creek; the maximum value was 29.5 pg/g TEQ in a common carp. Both Cayuga Creek and Lake Ontario have health advisories recommending restriction of consumption of fish due to the presence of PCDD/Fs, and in Lake Ontario due to the presence of PCBs and mirex as well. This is despite the remedial actions to control PCDD/Fs taken during the 1980s through the early 2000s at Love Canal, and subsequent removal of Love Canal from the U.S. Environmental Protection Agency's Superfund National Priorities List on September 30, 2004 (USEPA 2004).

Criteria to protect fish and wildlife

2,3,7,8-TCDD TEQs based on fish and piscivorous wildlife TEFs are summarized in Table 19.

Based on published criteria, fish and piscivorous wildlife lack adequate protection from the toxic effects of both PBDEs and PCDD/Fs (Table 20). Ninety-two percent of samples exceeded criteria for total penta-BDEs with exceedances appearing to be principally due to concentrations of BDE-99 and BDE-100 (E&CC Canada 2013). Similarly, 7.9% to 55% of the samples were not protective of fish consuming wildlife due to penta-BDEs. Further, 12% of the samples exceeded the wildlife diet criterion for hexa-BDEs.

New York's criterion (2.3 pg/g) for the protection of piscivorous wildlife from the toxic effects of PCDD/Fs (Newell et al. 1987) was exceeded by 28 to 66 percent of samples. Fish exceeding the criterion were principally from Cayuga Creek, the lower Niagara River and Lake Ontario, including the Salmon River Hatchery.

It has been characteristic to focus on the impacts or potential impacts of chemical residues on the health of humans. This study demonstrates that the health of fish and wildlife is at risk and that further actions to control sources of these compounds is warranted where they can be taken.

Other dioxin-like compounds

Currently, in New York the NYSDOH does not have plans to incorporate dioxin-like PCBs into the evaluation of PCDD/Fs (Agnes Mukasa, NYSDOH, personal communication, December 6, 2018). Certain PCB congeners produce dioxin-like toxicity and that toxicity has been quantified by several authors (for example, summaries in Hoffman et al. (1996)). Van den Berg et al. (1998 and 2006) recognized this phenomenon and developed standardized toxicity equivalency factors for PCDD/Fs and dioxin-like PCBs. In this study, the 12 dioxin-like PCBs were not quantified individually, so TEQ values reflect only toxicity of the 2,3,7,8- substituted PCDD/F congeners. If dioxin-like PCB congeners had been quantified, the resultant total TEQs would be greater, and could be dominated by the dioxin-like PCB contributions. Gandhi et al. (2019) noted dioxin-like PCBs, particularly PCB 126, contributed about 70 percent of the total TEQs in Great Lakes fish. Similarly, dioxin-like PCBs contributed 77% of total TEQs in striped bass from the tidal Hudson River and 93% of total TEQs in smallmouth bass from the river affected by PCB discharges (Skinner 2011). Further, the criteria for protection of wildlife consumers of aquatic biota due to dioxin-like PCB congeners can be as restrictive as for PCDD/F TEQs alone (CCME 2001b). Therefore, the relationship of total calculated TEQs to criteria to protect human health, or the health of fish and piscivorous wildlife could change significantly.

Health advisories

In New York State, the general health advice for consumers of fish is to eat up to four meals per month, spaced out to about a meal per week, when there is no significant accumulation of chemical residues in given species or waters. However, where significant accumulation of chemical residues has occurred, more restrictive health advice is issued to fish consumers. In the latter case, sensitive populations (women under the age of 50 years and children under age 15 years) will often receive more restrictive health advice than the general population of men over 15 years old and women over 50 years old.

All waters within New York's Great Lakes and connecting channels have at least one fish species with restrictive health advice. The primary basis for the advisories in all these waters is the presence of excessive concentrations of PCBs. Dioxins in Cayuga Creek, and mirex and dioxins in Lake Ontario also contribute to the health advisories (NYSDOH 2019a). The health advisories were changed based on findings in the first three phases of this study. Of the 63 specific health advisories for New York's Great Lakes, 25 (39%) became more lenient, 7 (11%) became more restrictive (primarily for common carp and channel catfish), and the remainder were unchanged. Based on concentrations of dioxins only, the NYSDOH determined that dioxin levels had not declined sufficiently to recommend a change to the "don't eat" advice for edible fish from Cayuga Creek. In contrast, Lake Ontario health advice was changed for some species of fish due to declines in PCBs, mirex and dioxins. The specific changes, if any, to health advisories in New York based on data from the first three phases of this study (Li et al. 2014; Skinner et al. 2018, and this study) are enumerated in Table 21.

In Canada, Gandhi et al. (2017a) examined a large historical record on contaminants in fish from the Great Lakes. They determined PBDE concentrations in fish were generally insufficient to warrant human health advisories at that time. However, PCDD/Fs continue to be a health advisory issue particularly in Lake Ontario as evidenced by continuing inclusion of dioxins as a contributing factor to health advisories in Lake Ontario and the lower Niagara River (Gandhi et al. 2017a; Gandhi et al. 2019; NYSDOH 2019a).

Beneficial use impairments

The continuing presence of health advisories to restrict consumption of fish in New York's Great Lakes waters represents continued impairment of a beneficial use of those fish as defined by the International Joint Commission (1988). Declining chemical residue concentrations and resultant partial relaxation of health advisory recommendations, while encouraging trends for continued long term recovery, were insufficient to remove the beneficial use impairment designation "Restrictions on fish and wildlife consumption" from New York's Lake Ontario waters. Continued surveillance of chemical residue concentrations in fish is warranted.

Since concentrations of PBDEs and PCDD/Fs exceeded criteria for protection of fish and wildlife (Table 20), there may be a basis for reconsidering their potential impact on other beneficial uses, most notably:

- Degradation of fish and wildlife populations, and
- Bird or animal deformities or reproduction problems.

For example, during the 1970s and early 1980s dioxins may have impaired lake trout reproduction in Lake Ontario through the presence of excessive residue concentrations (Mac and

Gilbertson 1990; Walker et al. 1991 and 1994; Guiney et al. 1996), and may have promoted blue sac disease (Symula et al. 1990; Walker et al. 1991 and 1994). Reproduction of herring gulls from colonies on Lake Ontario was affected and symptoms were consistent with those caused by excessive concentrations of TCDD (Gilbertson et al. 1991), and by other PCDD/F congeners contributing dioxin toxicity. Concentrations of TCDD and other PCDDs have declined dramatically since then to levels that laboratory studies indicate are not a direct cause of reproductive impairment of lake trout (Guiney et al. 1996). Nonetheless, lake trout reproduction continued to be impaired after PCDD/Fs declined due to low egg thiamine levels, likely the result of a diet rich in alewife, which contain the thiamine degrading enzyme thiaminase. Further, direct cause and effect are difficult to assign here as the onset of thiamine deficiency was partly coincident with or promptly succeeded PCDD/F concentrations no longer impairing reproduction. Thus, interactions affecting reproduction may have been possible for a short time, though this relationship has not been addressed by laboratory studies. More recently, lake trout egg thiamine levels have improved, presumably due to a dietary switch by lake trout to predation on invasive round goby (Steven R. LaPan, NYSDEC, personal communication, June 22, 2020). Finally, non-lethal impacts of PCDD/Fs may continue, for example, immune system depression (Spitzbergen et al. 1986 and 1988), which may impair or compromise the health of fish and wildlife.

For commercial PBDEs, primarily penta- homologs (commercial mixture DE-71), McKernan et al. (2009) noted changes in immune organs, altered reproductive behavior, and reduced embryo survival and hatching rates in American kestrel and chickens. The concentrations causing effects to kestrels and chickens are similar to penta-BDE concentrations found in the Great Lakes system. Marteinson et al. (2010) showed these effects are multi-generational and confirmed that existing environmental concentrations were sufficient to cause these effects. Similarly, Zhang et al. (2009) found ranch mink had adverse reproductive and developmental effects when experimentally exposed to penta-BDEs (DE-71). When compared to possible exposures for wild mink in the Great Lakes region, narrow safety margins were present and mink from Hamilton Harbor exceeded the no observed effect concentration.

RECOMMENDATIONS

The presence of elevated chemical residue concentrations in fish have led to continuing restrictions on human consumption of fish due to PCDD/Fs. Further, there is an increased risk to health of fish or the health of wildlife consumers of fish due to the presence of PBDEs and PCDD/Fs. The presence of these compounds in excess of multiple criteria to protect humans, fish and wildlife suggests additional actions to monitor and control these substances are warranted.

1. Continue surveillance of PCDD/F concentrations in Great Lakes fish consumed by humans to document changes in PCDD/F concentrations and provide a basis for further modification of human health recommendations regarding consumption of fish. The surveillance will be equally applicable for the assessment of potential impacts to fish and fish-consuming wildlife. It is recommended that surveillance of PCDD/Fs be conducted

at five-year intervals, provided funding is available. A ten-year frequency of surveillance must be considered the minimum.

2. Continue surveillance of PBDEs in fish due to their potential impacts on fish or fish-consuming wildlife, as well as for assessing temporal changes in concentrations. PBDE surveillance should be combined with PCDD/F surveillance.

3. Chemical analysis of fish in New York has focused on analysis of a standard fillet. The preference for this portion of the fish for analysis was introduced by the need for standardized methods which promote long term comparability of data and is a necessary benefit for monitoring programs to assess spatial and temporal differences. However, some people may consume other portions of the fish including the entire fish. Some populations will consume young or small fish, whole and without regard to species. Further, piscivorous fish and wildlife usually consume the entire fish and smaller fish than consumed by people. Chemical analyses of alternative fish portions, including whole fish and smaller fish, would provide a basis for better assessment of impacts of chemical exposures for alternative fish consuming populations.

4. The focus solely on potential human health impacts is too narrow. Fish and wildlife may sustain the greatest impact from the presence of PCDD/Fs and PBDEs as noted previously in this report. Some of the limited existing criteria for protection of fish or fish-consuming wildlife are over 20 years old, and advances in toxicological understanding have occurred since that time. Revisiting the rationale for existing criteria, especially older criteria, may be warranted to incorporate new information and to update the criteria, where necessary. Further, additional criteria for protection of fish and wildlife should be developed by agencies where those criteria are absent. Thereafter, regulatory actions incorporating the use of fish and wildlife criteria should be taken to further reduce exposures to PCDD/Fs and PBDEs where those actions are possible.

5. Potential impairment of at least two other beneficial uses, degradation of fish and wildlife populations and bird or animal deformities or reproduction problems, have been identified as being potentially impacted by PCDD/Fs and PBDEs. The International Joint Commission should conduct at least preliminary assessments of these potential impacts to determine whether impairment does or does not exist or has a reasonable possibility of existing within the Great Lakes.

6. The control of sources of PBDES and PCDD/Fs, and elimination of product uses that contribute PBDEs and PCDD/Fs to the environment, has resulted in substantial declines in concentrations of these compounds in fish. But the concentrations observed in fish are, in many cases, still too high. Therefore, further progress in these control and elimination efforts continue to be warranted. For example, investigation of the feasibility of further controls of PCDD/Fs associated with Cayuga Creek should be considered. Sources of PBDEs to the Great Lakes basin, including the Niagara River basin, should be investigated and controlled, where possible.

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Table 1: Sampling sites, species and numbers of fish selected for analysis for PBDEs and PCDD/Fs[1].

Waterbody	Sampling sites in waterbody	Species	No. Analyzed PBDEs	No. Analyzed PCDD/Fs	Year sampled
Lake Erie	Brockton Shoal	Lake trout	6	6	2010
		Walleye	1	1	2010
	Cattaraugus Creek	Common carp	3	3	2010
		Channel catfish	5	5	2010
	Dunkirk	Common carp	2	2	2010
	1 to 2 miles off Dunkirk	Smallmouth bass	3	3	2010
		Walleye	2	2	2010
Chautauqua Creek	Mouth upstream to Route 5 bridge	Rainbow trout	3	3	2010
Niagara River					
- upper	Grand Island	Common carp	5	5	2010
		Smallmouth bass	3	3	2010
	Strawberry Island	Largemouth bass	3	3	2010
- lower	Youngstown	Common carp	5	5	2010
		Smallmouth bass	3	3	2010
Cayuga Creek	Above mouth	Brown bullhead	6	6	5 in 2010, 1 in 2011
		Common carp	5	5	2010
		Largemouth bass	5	5	2010
		Rock bass	5	5	2 in 2010, 3 in 2011

Table 1 continued.

Waterbody	Sampling sites in waterbody	Species	No. Analyzed PBDEs	No. Analyzed PCDD/Fs	Year sampled
Lake Ontario	Charity Trench	Lake trout	3	3	2011
	Mexico Bay to Chaumont Bay	Lake trout	9	9	2010
	Stony Island to Stony Point	Lake trout	6	6	2011
	North and east of Galloo Island	Channel catfish	3	3	2010
		Smallmouth bass	3	3	2010
		White perch	3	3	2010
	Pultneyville	Smallmouth bass	3	3	2011
	Scriba	Brown trout	3	3	2011
	Sodus Bay	White perch	3	3	2011
	Western basin (in general)	Coho salmon	3	3	2011
Salmon River Hatchery	Hatchery	Chinook salmon	12	12	6 in 2010, 6 in 2011
		Coho salmon	6	6	2010
		Rainbow trout	6	6	2010
St. Lawrence River	Cape Vincent	Brown bullhead	1	2	2012
		Common carp	3	3	2012
		Smallmouth bass	3	3	2012
		Walleye	3	3	2012

Table 1 continued.

Waterbody	Sampling sites in waterbody	Species	No. Analyzed PBDEs	No. Analyzed PCDD/Fs	Year sampled
St. Lawrence River	Ogdensburg	Brown bullhead	3	3	2012
		Common carp	3	3	2012
		Channel catfish	2	2	2012
		Smallmouth bass	3	3	2013
		Walleye	3	3	2012
	Above Moses-Saunders Dam	Common carp	3	3	2013
		Channel catfish	3	3	2013
		Smallmouth bass	3	3	2013
		Walleye	3	3	2013
	Franklin County line	Brown bullhead	1	3	2014
		Common carp	3	3	1 in 2013, 2 in 2014
		Smallmouth bass	3	3	2013
		Walleye	3	3	2013
		Yellow perch	3	0	2013
	Raquette Point	Brown bullhead	1	3	2014
		Common carp	3	3	2013
		Channel catfish	3	3	2013
		Smallmouth bass	3	3	2013
		Walleye	3	3	2013

Table 1 continued.

Waterbody	Sampling sites in waterbody	Species	No. Analyzed PBDEs	No. Analyzed PCDD/Fs	Year sampled
Grasse River	Above dam in Massena	Smallmouth bass	3	3	2013
		Walleye	3	3	2013
		Yellow perch	0	3	2013
	Mouth upstream 1.0 mile	Common carp	3	3	2013
		Channel catfish	3	3	2013
		Smallmouth bass	3	3	2013
		Walleye	3	3	2013
Raquette River	Above Route 420 bridge	Common carp	3	3	2013
		Smallmouth bass	3	3	2013
		Walleye	3	3	2013
	Mouth upstream 1.0 mile	Common carp	3	3	2013
		Channel catfish	3	3	2013
		Smallmouth bass	3	3	2013
		Walleye	3	3	2013
St. Regis River	Above dam in Hogansburg	Brown bullhead	1	3	2013
		Smallmouth bass	3	3	2013
		Walleye	2	2	2013
		White sucker	3	3	2013

Table 1 continued.

Waterbody	Sampling sites in waterbody	Species	No. Analyzed PBDEs	PCDD/Fs	Year sampled
St. Regis River	Mouth upstream 1.0 mile	Common carp	3	3	2013
		Channel catfish	3	3	2013
		Smallmouth bass	3	3	2013
		Walleye	3	3	2013
		Supplemental samples for PCDD/Fs			
Niagara River - lower	Lower river	Common carp	0	5	2014
		Lake trout	0	3	2015
		White sucker	0	3	2014
Lake Ontario	Eighteenmile Creek	Brown trout	0	6	2015
	Keg Creek	White sucker	0	3	2017
	Eastern basin	Common carp	0	5	2014
		Channel catfish	0	3	2016
		Lake trout	0	3	2014
		White perch	0	3	2014
	Western basin	Lake trout	0	9	2014
Irondequoit Bay	Bay	Channel catfish	0	3	2015
		White perch	0	3	2015

[1] Total N = 250 samples analyzed for PBDEs and total N = 306 samples analyzed for PCDD/Fs.

Table 2: Overall summary of fish species lengths and weights for fish collected in 2010 through 2017.

Species	Species abbreviation	n	Length (mm) Mean ± SD	Length (mm) Min. – Max.	Weight (g) Mean ± SD	Weight (g) Min. – Max.
Brown bullhead	BB	20[1]	287 ± 37	210 - 348	341 ± 140	110 - 567
Brown trout	BT	3	489 ± 32	467 - 526	1875 ± 459	1588 - 2404
Common carp	CARP	47[2]	692 ± 101	445 - 885	5679 ± 2360	1262 - 11550
Channel catfish	CHC	25	637 ± 130	352 - 895	3641 ± 2334	375 - 8800
Chinook salmon	CHS	12	925 ± 51	815 - 1015	8358 ± 1111	5982 - 9752
Coho salmon	COS	9	679 ± 109	513 - 800	3187 ± 1413	1315 - 5557
Lake trout	LT	25[3]	669 ± 102	483 - 814	3507 ± 1665	1277 - 6586
Largemouth bass	LMB	8	376 ± 45	307 - 440	880 ± 299	453 - 1304
Rainbow trout	RT	9	616 ± 116	434 - 765	2380 ± 1148	890 - 3980
Rock bass	RB	5	203 ± 14	188 - 226	192 ± 46	156 - 269
Smallmouth bass	SMB	48	405 ± 46	320 - 499	1154 ± 544	450 - 3000
Walleye	WEYE	35	516 ± 68	370 - 684	1382 ± 624	400 - 3070
White perch	WP	6	255 ± 15	236 - 268	254 ± 49	191 - 308
White sucker	WS	3	350 ± 87	300 - 450	517 ± 419	250 - 1000
Yellow perch	YP	6	257 ± 17	230 - 280	232 ± 30	160 - 260
			Supplemental samples			
Brown trout	BT	6	534 ± 60	463 – 611	2172 ± 891	1040 - 3140
Common carp	CARP	10	676 ± 51	603 – 746	4619 ± 1359	2900 - 7030
Channel catfish	CHC	6	613 ± 53	551 – 677	2626 ± 1022	1454 - 4062
Lake trout	LT	15	648 ± 123	357 – 784	3059 ± 1331	370 - 5010
White perch	WP	6	293 ± 13	280 – 315	405 ± 84	322 - 547
White sucker	WS	6	460 ± 54	400 – 544	1048 ± 395	670 - 1540

[1] The recorded weight of one brown bullhead was unreliable and not included in weight summary.
[2] The weight of seven carp exceeded the capacity (2270 g) of the scale used, thus, were not included in weight summary.
[3] The recorded weight of one lake trout was unreliable and not included in weight summary.

Table 3: Lipid content (percent) of Great Lakes fish analyzed for PBDEs and PCDD/Fs[1].

Water	Species	Mean	SD[2]	Min.-Max.
Lake Erie	CARP	11.8/12.0[3]	6.53/6.84[3]	2.70 - 20.7/21.7[3]
	CHC	18.4	8.40	7.10 - 26.2
	LT	11.2	2.28	7.79 - 13.9
	SMB	3.77	0.51	3.36 - 4.35
	WEYE	3.20	1.36	2.22 - 4.76
Chautauqua Creek	RT	3.10	0.75	2.42 - 3.91
Niagara River				
- upper	CARP	10.4	9.02	2.48 - 24.7
	LMB	2.11	1.75	0.69 - 4.07
	SMB	2.37	0.78	1.73 - 3.24
- lower	CARP	10.3	9.06	1.87 - 23.2
	SMB	4.39	0.63	3.81 - 5.07
Cayuga Creek	BB	0.38	0.24	0.10 - 0.80
	CARP	2.12	0.59	1.50 - 2.80
	LMB	0.36	0.15	0.20 - 0.60
	RB	0.50	0.35	0.20 - 1.10
Lake Ontario	BT	15.1	2.23	13.03 - 17.5
	CHC	3.23	1.93	1.00 - 4.40
	COS	3.20	0.30	2.90 - 3.50
	LT	17.5	6.72	6.12 - 34.3
	SMB	3.05	2.86	0.50 - 7.90
	WP	3.05	1.68	1.50 - 6.01
Salmon River Hatchery	CHS	0.92	0.56	0.20 - 1.83
	COS	0.68	0.27	0.40 - 1.10
	RT	1.38	0.66	0.70 - 2.50
St. Lawrence River - Cape Vincent	BB	2.22		1.05 - 3.40
	CARP	6.21	2.53	3.44 - 8.40
	SMB	3.36	0.73	2.52 - 3.86
	WEYE	3.20	0.34	2.97 - 3.60

Table 3 continued.

Water	Species	Mean	SD[2]	Min.-Max.
St. Lawrence River - Ogdensburg	BB	1.35	0.43	0.92 - 1.79
	CARP	8.75	4.00	4.17 - 11.5
	CHC	7.81		1.83 - 13.8
	SMB	3.70	1.04	2.99 - 4.90
	WEYE	1.41	0.44	1.13 - 1.93
St. Lawrence River - Franklin County line	BB	0.87	0.53	0.56 - 1.49
	CARP	4.94	1.37	3.92 - 6.50
	SMB	2.53	0.030	2.50 - 2.56
	WEYE	2.22	0.84	1.28 - 2.92
	YP	0.74	0.14	0.61 - 0.89
St. Lawrence River - Raquette Point	BB	1.27	0.48	0.81 - 1.77
	CARP	6.66	6.75	1.96 - 14.4
	CHC	18.0	2.78	14.9 - 20.2
	SMB	4.45	0.92	3.78 - 5.50
	WEYE	1.78	0.84	0.82 - 2.41
Grasse River - above dam	SMB	2.38	0.60	1.75 - 2.94
	WEYE	0.59	0.29	0.36 - 0.92
	YP	0.73	0.12	0.60 - 0.84
Grasse River - mouth upstream 1.0 mile	CARP	6.48	3.05	4.55 - 10.0
	CHC	11.6	7.08	3.57 - 17.0
	SMB	4.63	0.85	3.69 - 5.36
	WEYE	2.54	0.53	1.98 - 3.05
Raquette River - above Route 420 bridge	CARP	4.06	0.36	3.65 - 4.31
	SMB	1.09	0.51	0.53 - 1.52
	WEYE	0.32	0.095	0.23 - 0.42
Raquette River - mouth upstream 1.0 mile	CARP	5.19	3.32	1.56 - 8.06
	CHC	9.83	3.76	5.49 - 12.2
	SMB	2.97	1.66	1.23 - 4.54
	WEYE	1.55	0.48	1.24 - 2.11

Table 3 continued.

Water	Species	Mean	SD[2]	Min.-Max.
St. Regis River	BB	1.73	0.38	1.49 - 2.16
- above dam	SMB	1.72	0.74	0.86 - 2.17
	WEYE	0.83		0.66 - 1.00
	WS	0.80	0.45	0.41 - 1.29
St. Regis River	CARP	4.79	3.77	2.57 - 9.15
- mouth upstream	CHC	19.5	2.82	17.5 - 22.7
1.0 mile	SMB	3.53	1.63	2.26 - 5.38
	WEYE	1.97	0.23	1.81 - 2.24
		Supplemental samples		
Niagara River				
- lower	CARP	12.8	8.18	5.66 – 21.8
	LT	14.1	4.30	11.5 – 19.1
	WS	1.58	1.05	0.73 – 2.76
Lake Ontario				
- Eighteenmile Cr.	BT	8.43	5.59	2.79 – 17.1
- Keg Creek	WS	2.53	1.37	1.40 – 4.05
- eastern basin	CARP	16.2	14.8	3.90 – 39.3
	CHC	14.2	5.90	9.75 – 20.9
	LT	9.26	4.33	4.47 − 12.9
	WP	3.14	0.49	2.58 – 3.48
- western basin	LT	12.1	5.26	3.81 – 19.8
Irondequoit Bay	CHC	7.97	6.35	4.25 – 15.3
	WP	5.24	2.55	2.97 – 8.00

[1] N = 250 samples for PBDEs and N = 257 samples for PCDD/Fs in original sampling. N = 49 samples in supplemental sampling for PCDD/F analysis.
[2] Standard deviation; calculated only for n > 2.
[3] Differing maximum values due to re-analysis of one sample.

Table 4: Frequency of detection and median detection or reporting limits (pg/g wet weight) of polybrominated diphenyl ether (PBDE) congeners.

BDE-	Homolog	% Detection[1]	Median concentration Detection limit	Reporting limit[2]	Maximum concentration determined
1	mono-BDE	0.0	50.5	19.9	nd[3]
2	mono-BDE	0.0	29	13.3	nd
3	mono-BDE	0.4	25	11.1	10.1
7	di-BDE	4.8	1.2	9.76	22
8/11[4]	di-BDE	8.8	1.0	19.5	21
10	di-BDE	0.0	1.15	9.76	nd
11[4, 5]	di-BDE	0.0	nr[6]	9.76	nd
12[5]	di-BDE	0.1	nr	9.76	11.2
12/13[7]	di-BDE	9.4	0.805	2.0	5.1
15	di-BDE	56.0	0.732	9.76	133
17[5]	tri-BDE	70.5	nr	9.76	425
17/25[7,8]	tri-BDE	93.5	1.55	2.0	460
25[5]	tri-BDE	80.4	nr	9.8	270
28/33	tri-BDE	98.4	1.4	19.5	7500
30	tri-BDE	0.0	1.55	9.8	nd
32	tri-BDE	20.8	1.13	9.76	18.2
35	tri-BDE	2.4	1.2	9.76	13
37	tri-BDE	28.0	1.225	9.8	24
47	tetra-BDE	99.6	3.665	9.8	89600
49[5]	tetra-BDE	100	nr	10.1	4170
49/71[7,8]	tetra-BDE	100	4.26	2.0	4500
51	tetra-BDE	90.0	2.845	9.9	402
66	tetra-BDE	73.6	5.725	10.3	1760
71[5]	tetra-BDE	64.3	nr	9.95	1890
75	tetra-BDE	52.4	3.62	9.95	135
77	tetra-BDE	21.2	3.8	9.8	84.1
79	tetra-BDE	36.0	3.65	9.95	406
85	penta-BDE	16.8	2.45	10.2	659
99	penta-BDE	91.2	1.8	9.9	14400
100	penta-BDE	100	1.4	9.8	16400
105	penta-BDE	0.0	3.29	13.8	nd
116	penta-BDE	0.8	5.8	18.9	171
118	penta-BDE	68.8	3.6	14.5	412
119/120	penta-BDE	89.6	1.8	19.6	1310
126	penta-BDE	70.8	1.6	9.8	246
128	hexa-BDE	18.4	14	14.75	143
138[5]	hexa-BDE	3.6	nr	10.7	82.6

Table 4 continued.

BDE-	Analyte	% Detection[1]	Median concentration Detection limit	Reporting limit[2]	Maximum concentration determined
138/166[7,8]	hexa-BDE	12.3	5.49	2.0	96.2
140	hexa-BDE	31.6	3.6	9.8	82.7
153	hexa-BDE	94.4	4.5	9.8	5380
154	hexa-BDE	100	2.3	9.76	8080
155	hexa-BDE	97.2	1.6	9.76	1730
166[5]	hexa-BDE	3.6	nr	9.8	32.9
181	hepta-BDE	0.8	17.5	15.9	19
183	octa-BDE	39.2	6.21	9.81	170
190	octa-BDE	0.0	25.5	19.4	nd
203	octa-BDE	1.6	84	38.8	41
206	nona-BDE	6.4	58	30	249
207	nona-BDE	8.0	41	20	249
208	non-BDE	6.4	35.6	19.8	133
209	deca-BDE	19.2	78.25	187	2900

[1] N = 250 samples except where indicated by a footnote attached to the first column.
[2] Reporting limits for samples without reported detection limits.
[3] nd = none detected.
[4] Samples analyzed for BDE-11 were also analyzed for the BDE-8/11 coelution. BDE-8 was not analyzed individually.
[5] N = 112 samples.
[6] nr = not reported.
[7] N = 138 samples. BDE-13 was not analyzed individually.
[8] Most coeluting BDE congeners were analyzed either as coeluting compounds or as individual compounds.

Table 5: Frequency of detection of 2,3,7,8-chlorine substituted PCDD/F congeners and tetra- through hepta- homologs of PCDD/Fs and their median detection or reporting limits (pg/g wet weight).

PCDD/F	% Detections[1]	Median concentration: Detection limit	Median concentration: Reporting limit[2]	Maximum concentration determined
2,3,7,8-TCDD	61.1	0.15	0.086	21
1,2,3,7,8-PeCDD	50.7	0.14	0.12	5.3
1,2,3,4,7,8-HxCDD	13.1	0.16	0.14	2.9
1,2,3,6,7,8-HxCDD	35.6	0.16	0.155	6.2
1,2,3,7,8,9-HxCDD	12.7	0.17	0.14	1.9
1,2,3,4,6,7,8-HpCDD	35.6	0.18	0.10	23
OCDD	38.9	0.43	0.26	240
2,3,7,8-TCDF	90.0	0.19	0.11	19
1,2,3,7,8-PeCDF	23.5	0.17	0.11	1.8
2,3,4,7,8-PeCDF	67.3	0.12	0.095	15
1,2,3,4,7,8-HxCDF	19.3	0.12	0.11	21
1,2,3,6,7,8-HxCDF	9.2	0.11	0.105	2.2
1,2,3,7,8,9-HxCDF	2.0	0.15	0.135	0.77
2,3,4,6,7,8-HxCDF	16.0	0.11	0.11	1.3
1,2,3,4,6,7,8-HpCDF	14.1	0.17	0.16	5.4
1,2,3,4,7,8,9-HpCDF	0.6	0.23	0.19	0.21
OCDF	9.8	0.37	0.20	1.2
∑TCDD	62.7	0.15	0.086	21
∑PeCDD	51.3	0.14	0.12	5.3
∑HxCDD	38.9	0.16	0.15	10
∑HpCDD	36.9	0.18	0.10	50
∑TCDF	92.2	0.19	0.11	57
∑PeCDF	79.7	0.15	0.105	17
∑HxCDF	60.8	0.13	0.11	23
∑HpCDF	16.0	0.20	0.17	5.4

[1] n = 306 samples.
[2] For samples without reported detection limits.

Table 6: Total polybrominated diphenyl ether concentrations (pg/g wet weight) in fish from New York's Great Lakes basin.

Water	Species	Mean	SD[1]	Min. − Max.
Lake Erie	CARP	37349	17703	17485 – 59009
	CHC	29006	17316	15798 – 57365
	LT	15352	6409	8261 – 25682
	SMB	4551	734	3886 – 5339
	WEYE	4603	2180	2145 – 6301
Chautauqua Creek	RT	7231	2242	4859 – 9317
Niagara River				
- upper	CARP	13146	25365	1088 – 58513
	LMB	7883	3096	5092 – 11214
	SMB	13579	5634	9593 – 20025
- lower	CARP	29440	22805	5714 – 63992
	SMB	34915	15038	23663 – 51995
Cayuga Creek	BB	11559	8042	4153 – 25810
	CARP	65068	36069	25660 – 121846
	LMB	18266	9859	8395 – 32089
	RB	6388	2545	3935 – 9909
Lake Ontario	BT	23094	3218	19846 − 26281
	CHC	32007	13668	16645 – 42824
	COS	10380	2253	8490 – 12873
	LT	48096	22738	13410 – 82248
	SMB	6984	5807	963 – 15002
	WP	4964	2411	2969 – 9427
Salmon River Hatchery	CHS	52364	11320	34873 – 75293
	COS	45707	4655	38184 – 51992
	RT	34043	9345	23014 – 50533
St. Lawrence River - Cape Vincent	BB	3169		3169
	CARP	11735	9333	2649 – 21298
	SMB	14089	4419	9071 – 17399
	WEYE	20264	22450	8493 – 46151

Table 6 continued.

Water	Species	Mean	SD[1]	Min. − Max.
St. Lawrence River - Ogdensburg	BB	11890	14533	1431 – 28485
	CARP	12798	1455	11166 – 13958
	CHC	14717		1644 – 27789
	SMB	5771	2001	3831 – 7828
	WEYE	3753	1879	1741 – 5462
St. Lawrence River - above Moses Saunders Dam	CARP	8391	6620	1195 – 14221
	CHC	35767	13497	21549 – 48404
	SMB	11850	2231	10355 – 14414
	WEYE	3881	2434	2402 – 6690
St. Lawrence River - Franklin County line	BB	2350		2350
	CARP	22876	30084	1252 – 57233
	SMB	10273	9818	2948 – 21429
	WEYE	5512	626	4865 – 6115
	YP	2223	1750	939 – 4216
St. Lawrence River - Raquette Point	BB	6890		6890
	CARP	9648	1631	7764 – 10596
	CHC	57687	25335	29730 – 79127
	SMB	6547	813	5684 – 7297
	WEYE	5402	3803	2851 – 9773
Grasse River - above dam	SMB	7357	6754	3394 – 15155
	WEYE	4711	1908	3436 – 6905
Grasse River - mouth upstream 1.0 mile	CARP	32942	23356	13930 – 59013
	CHC	29045	17581	9100 – 42297
	SMB	16921	1716	15065 − 18449
	WEYE	3194	885	2197 – 3886
Raquette River - above Route 420 bridge	CARP	20010	10235	9025 – 29277
	SMB	20867	9439	13218 – 31416
	WEYE	7301	2743	5161 – 10394
Raquette River - mouth upstream 1.0 mile	CARP	19763	7157	12762 – 27067
	CHC	51832	24820	34800 – 80310
	SMB	7456	5718	4044 – 14057
	WEYE	2071	1268	877 – 3401

Table 6 continued.

Water	Species	Mean	SD[1]	Min. − Max.
St. Regis River	BB	529		529
- above dam	SMB	4925	3322	1213 – 7618
	WEYE	1744		1349 − 2139
	WS	853	657	292 – 1575
St. Regis River	CARP	13930	11455	7245 – 27158
- mouth upstream	CHC	16697	6267	9477 – 20724
1.0 mile	SMB	7929	1173	6575 – 8636
	WEYE	11859	7900	7122 – 20979

[1] SD = standard deviation; calculated only for n > 2.

Table 7: Overall distribution of PBDE homologs (% of total PBDE).

Homolog	Mean	SD[1]	Min.	Max.	Median
Mono-	0.0001	0.0022	nd[2]	0.034	nd
Di-	0.045	0.10	nd	1.20	0.021
Tri-	2.62	2.90	nd	13.4	1.49
Tetra-	51.3	13.4	2.44	78.0	52.9
Penta-	30.4	10.4	10.5	85.5	31.3
Hexa-	14.2	7.32	4.47	41.4	12.0
Hepta-	0.0002	0.0025	nd	0.033	nd
Octa-	0.11	0.26	nd	2.11	nd
Nona-	0.088	0.43	nd	4.25	nd
Deca-	1.22	4.73	nd	48.7	nd

[1] Standard deviation.
[2] nd = none detected.

Table 8: Contributions of PBDE congeners to total PBDEs and frequency of exceeding a given congener concentration.

BDE congener/ coeluter	Frequency of exceeding: No.	%	Percent of total PBDEs Mean	SD[1]	Min.	Max.	Median
	≥ 10,000 pg/g						
47	84	33.6					
99	14	5.6					
100	10	4.0					
	≥ 1000 pg/g						
47	220	88.0	45.9	13.4	0	75.0	47.2
99	138	55.2	14.3	10.1	0	55.8	15.6
100	168	67.2	14.5	2.39	6.80	25.8	14.2
28/33	33	13.2	2.24	2.73	0	13.1	1.17
49	48	42.8	1.68	2.14	0	8.62	0
49/71	16	11.6	2.48	2.78	0	16.0	1.87
66	3	1.2	0.64	0.53	0	2.14	0.59
71	1	0.9	0.11	0.28	0	3.01	0
119/120	6	2.4	1.03	0.87	0	3.38	0.74
153	79	31.6	4.70	3.34	0	15.4	4.36
154	124	49.6	8.23	3.75	2.11	23.2	7.27
155	2	0.4	1.23	0.88	0	5.64	0.91
209	8	3.2	1.22	4.73	0	48.7	0
All others combined[1]	0	0.0	1.70	0.98	0	7.56	1.55

[1] A total of 38 individual or coeluting PBDE congeners.

Table 9: Proportions (%) of major PBDE congeners in total PBDEs by fish species (mean ± standard deviation).

Species	n	BDE-28/33	BDE-47	BDE-49+71[1]	BDE-99	BDE-100	BDE-119/120	BDE-153	BDE-154	BDE-155	BDE-209	All others
BB	13	0.40 ± 0.28	29.8 ± 12.1	1.49 ± 1.02	33.1 ± 11.4	12.3 ± 4.60	0.63 ± 0.88	6.13 ± 2.91	5.94 ± 5.33	0.66 ± 1.01	5.49 ± 13.9	3.55 ± 2.09
BT	3	1.87 ± 0.049	44.1 ± 1.91	5.64 ± 0.59	19.0 ± 1.65	13.2 ± 0.61	0.42 ± 0.033	4.37 ± 0.53	6.56 ± 0.59	0.70 ± 0.13	0.00	2.57 ± 0.11
CARP	47	7.41 ± 2.23	61.2 ± 7.91	4.76 ± 1.96	0.20 ± 0.66	15.0 ± 2.89	0.23 ± 0.17	0.13 ± 0.19	6.82 ± 2.52	1.09 ± 0.58	1.33 ± 3.83	1.80 ± 1.02
CHC	25	0.69 ± 0.43	39.9 ± 9.56	2.76 ± 1.36	18.5 ± 4.54	15.6 ± 2.34	1.54 ± 0.68	6.90 ± 2.74	9.79 ± 3.88	1.58 ± 0.97	0.27 ± 0.57	1.73 ± 0.54
CHS	12	1.54 ± 0.13	50.0 ± 1.25	4.16 ± 0.82	15.6 ± 0.86	13.5 ± 0.40	0.81 ± 0.79	4.06 ± 0.18	6.62 ± 0.60	0.65 ± 0.12	0.00	1.82 ± 0.16
COS	9	1.78 ± 0.11	48.5 ± 2.66	2.99 ± 0.87	16.3 ± 2.19	13.2 ± 0.42	1.66 ± 0.22	3.73 ± 0.26	6.70 ± 0.47	0.71 ± 0.09	0.74 ± 1.61	2.35 ± 0.82
LMB	8	1.07 ± 0.22	56.8 ± 5.10	3.69 ± 0.91	11.1 ± 3.99	15.3 ± 2.73	0.45 ± 0.40	3.53 ± 1.47	5.66 ± 1.88	0.87 ± 0.41	0.00	0.80 ± 0.29
LT	24	1.61 ± 0.23	48.9 ± 3.71	3.43 ± 0.50	13.6 ± 4.43	14.4 ± 1.74	0.85 ± 0.69	4.54 ± 0.73	8.22 ± 0.96	0.88 ± 0.22	0.04 ± 0.21	2.17 ± 0.48
RB	5	0.86 ± 0.18	56.2 ± 4.02	2.10 ± 0.84	19.9 ± 3.89	11.6 ± 0.26	0.48 ± 0.45	3.18 ± 0.50	4.10 ± 0.14	0.27 ±0.25	0.00	0.35 ± 0.22
RT	9	1.51 ± 0.22	49.5 ± 1.97	4.30 ± 0.76	13.1 ± 3.46	15.1 ± 1.24	0.97 ± 0.55	4.20 ± 0.27	7.42 ± 0.89	0.96 ± 0.14	0.00	1.86 ± 0.54
SMB	48	0.72 ± 0.57	34.3 ± 8.66	5.17 ± 1.40	20.3 ± 7.15	15.0 ± 1.99	1.48 ± 0.87	7.83 ± 2.70	10.5 ± 4.49	1.65 ± 1.11	0.92 ± 2.09	1.31 ± 0.60
WEYE	35	0.71 ± 0.43	38.1 ± 11.1	4.74 ± 1.47	18.4 ± 6.26	14.5 ± 1.64	1.64 ± 0.91	6.50 ± 2.78	9.50 ± 4.47	1.56 ± 1.00	2.65 ± 6.82	1.21 ± 0.46
WP	6	2.03 ± 0.36	60.0 ± 3.25	6.68 ± 0.96	0.19 ± 0.23	14.9 ± 1.72	0.39 ± 0.43	2.80 ± 0.69	8.44 ± 1.46	2.28 ± 0.46	0.00	1.82 ± 0.46
WS	3	3.13 ± 0.81	71.1 ± 2.27	3.07 ± 0.48	0.74 ± 1.06	12.8 ± 1.21	1.33 ± 0.20	1.17 ± 2.02	4.57 ± 0.55	0.86 ± 0.19	0.00	1.27 ± 0.10
YP	3	1.03 ± 0.29	42.1 ± 13.5	12.3 ± 4.93	10.0 ± 4.62	13.8 ± 2.49	1.73 ± 1.54	1.97 ± 2.32	7.56 ± 3.29	1.43 ± 0.91	6.42 ± 11.1	1.07 ± 0.28
Overall	250	2.24 ± 2.73	45.9 ± 13.4	4.27 ± 2.00	14.3 ± 10.1	14.5 ± 2.39	1.03 ± 0.87	4.70 ± 3.34	8.23 ± 3.75	1.23 ± 0.88	1.22 ± 4.73	1.70 ± 0.98

[1] Where concentrations of BDE-49 and BDE-71 were reported separately, BDE-49 contributed an average of 93% of the sum of two congeners. Indeed, 35% of the 111 samples had only BDE-49 and only one sample was less than 70% BDE-49.

Table 10: Mammalian and human health based 2,3,7,8-TCDD toxic equivalents (pg/g wet weight) for PCDD/Fs in fish from New York's Great Lakes basin.

Water	Species	Mean	SD[1]	Min.-Max.
Lake Erie	CARP	3.92	2.33	0.92 – 6.27
	CHC	2.46	0.92	1.10 – 3.44
	LT	2.52	1.36	1.39 – 4.91
	SMB	0.35	0.20	0.12 – 0.49
	WEYE	0.11	0.034	0.077 – 0.14
Chautauqua Creek	RT	0.57	0.24	0.34 – 0.82
Niagara River - upper	CARP	1.51	2.40	<0.001 – 5.71
	LMB	0.21	0.066	0.14 – 0.26
	SMB	0.91	0.17	0.71 – 1.02
-lower	CARP	4.67	4.04	0.35 – 10.9
	SMB	2.65	1.52	1.57 – 4.38
Cayuga Creek	BB	6.13	3.59	1.66 – 10.5
	CARP	16.7	7.80	9.74 – 29.5
	LMB	1.82	0.87	0.95 – 2.84
	RB	5.01	4.99	0.078 – 10.4
Lake Ontario	BT	2.03	0.47	1.55 – 2.48
	CHC	2.15	0.90	1.17 – 2.95
	COS	1.46	0.27	1.24 – 1.76
	LT	4.32	1.86	1.66 – 7.14
	SMB	0.43	0.44	0.059 – 1.60
	WP	0.52	0.44	0.097 – 1.35
Salmon River Hatchery	CHS	2.35	1.14	0.98 – 3.80
	COS	3.49	0.44	2.78 – 4.01
	RT	3.17	2.18	1.57 – 7.49
St. Lawrence River - Cape Vincent	BB	0.28		0.26 – 0.29
	CARP	1.71	1.39	0.12 – 2.72
	SMB	0.88	0.11	0.76 – 0.98
	WEYE	1.01	0.78	0.48 – 1.91

Table 10 continued.

Water	Species	Mean	SD[1]	Min.-Max.
St. Lawrence River - Ogdensburg	BB	0.14	0.066	0.073 – 0.20
	CARP	2.46	1.52	0.70 – 3.34
	CHC	2.08		0.19 – 3.98
	SMB	1.12	0.36	0.74 – 1.46
	WEYE	0.15	0.13	0.077 – 0.30
St. Lawrence River - above Moses Saunders Dam	CARP	1.93	2.06	0.10 – 4.16
	CHC	2.68	1.03	1.52 – 3.51
	SMB	1.39	0.96	0.65 – 2.47
	WEYE	0.24	0.12	0.11 – 0.34
St. Lawrence River - Franklin County line	BB	0.30	0.31	0.096 – 0.67
	CARP	1.30	0.90	0.30 – 1.60
	SMB	0.56	0.30	0.33 – 0.90
	WEYE	0.66	0.42	0.29 – 1.12
St. Lawrence River - Raquette Point	BB	0.12	0.11	nd[2] – 0.20
	CARP	0.47	0.46	0.13 – 0.99
	CHC	2.63	1.67	1.08 – 4.40
	SMB	0.85	0.42	0.40 – 1.23
	WEYE	0.035	0.061	nd – 0.11
Grasse River - above dam	SMB	0.12	0.097	0.062 – 0.23
	WEYE	0.046	0.014	0.031 – 0.059
	YP	0.053	0.019	0.033 – 0.071
Grasse River - mouth upstream 1.0 mile	CARP	2.48	1.76	0.94 – 4.40
	CHC	2.01	0.85	1.04 – 2.51
	SMB	1.35	0.29	1.07 – 1.65
	WEYE	0.32	0.26	0.065 – 0.58
Raquette River - above Route 420 bridge	CARP	0.72	0.20	0.49 – 0.84
	SMB	0.11	0.095	0.056 – 0.22
	WEYE	0.14	0.079	0.050 – 0.19
Raquette River - mouth upstream 1.0 mile	CARP	1.93	1.02	0.81 – 2.80
	CHC	3.64	2.91	1.83 – 7.05
	SMB	1.06	0.67	0.49 – 1.81
	WEYE	0.29	0.31	0.033 – 0.64

Table 10 continued.

Water	Species	Mean	SD[1]	Min.-Max.
St. Regis River -above dam	BB	0.11	0.12	nd – 0.24
	SMB	0.016	0.028	nd – 0.049
	WEYE	0.037		0.024 – 0.049
	WS	0.021	0.028	0.033 – 0.053
St. Regis River - mouth upstream 1.0 mile	CARP	0.76	0.66	0.18 – 1.48
	CHC	1.10	0.10	0.98 – 1.16
	SMB	0.36	0.21	0.12 – 0.53
	WEYE	0.22	0.16	0.058 – 0.38
		Supplemental samples		
Niagara River - lower	CARP	8.34	7.56	0.009 – 16.9
	LT	12.7	1.38	11.2 – 13.9
	WS	0.14	0.066	0.069 – 0.20
Lake Ontario - western	LT	3.67	2.87	0.63 – 8.51
- eastern	CARP	6.14	8.88	0.42 – 21.2
	CHC	1.03	0.75	0.31 – 1.81
	LT	3.06	0.98	2.00 – 3.94
	WP	0.71	0.054	0.67 – 0.77
Keg Creek	WS	1.02	0.78	0.13 – 1.58
Eighteenmile Creek	BT	1.36	0.68	0.57 – 2.40
Irondequoit Bay	CHC	3.16	4.86	0.34 – 8.78
	WP	0.30	0.41	nd[2] – 0.77

[1] Standard deviation; calculated only for n > 2.
[2] nd = none detected; all 2,3,7,8-substituted PCDD/F analytes were below detection limits.

Table 11: Total PBDEs and 2,3,7,8-TCDD toxic equivalents (TEQs) in aged lake trout from Lake Ontario, 2010-2011.

		Total PBDEs (pg/g)			2,3,7,8-TCDD TEQs (pg/g)		
Age	No.	Mean	SD[1]	Min. - Max.	Mean	SD	Min. - Max.
3	3	18177	4235	13410 - 21506	2.32	0.86	1.75 - 3.31
4	3	31333	7178	24561 - 38858	4.22	0.90	3.24 - 5.01
5	3	35937	8547	27601 - 44757	3.88	2.31	1.66 - 6.27
6	3	56177	7106	51900 - 64380	5.99	1.20	4.60 - 6.71
7	3	66033	4125	62846 - 70700	5.46	2.88	2.14 - 7.14
8	1	79195		79195	3.41		3.41
na[2]	2	81777		81307 - 82248	4.36		4.35 - 4.37

[1] Standard deviation; calculated only for $n > 2$.
[2] na = no age. These were large fish where age could not be reliably determined.

Table 12: Length-total concentration correlations for total TCDD TEQs and total PBDEs in lake trout.

			Correlation coefficient	
Water	Years	n	TCDD TEQ	∑PBDE
Lake Ontario - eastern	2010/11	18	0.5013*	0.9202**
L. Ontario – western	2014	9	0.6948*	no analyses
Lake Erie	2010	6	0.8290*	0.8476*

* $p < 0.05$; ** $p << 0.01$

Table 13: Spatial differences in total polybrominated diphenyl ether (PBDE) concentrations in fish from New York's Great Lakes basin[1].

Species	Spatial ranking (lowest to highest rank)[2]														
BB	Ogd	CC													
	—	—													
CARP[3]	UNR	>MSD	RP	CV	SRm	FCL	Ogd	>420	RRm	LNR	GR>d	Erie	CC		
	—	—	—	—	—	—	—	—	—	—	—	—	—		
	UNR	LNR	CC												
	—														
		—													
			—												
CHC	SRm	Erie	GRm	LOnt	>MSD	RRm	RP								
	—	—	—	—	—	—	—								
SMB	Erie	SR>d	Ogd	GR>d	RP	RRm	FCL	SRm	>MSD	UNR	LOnt	CV	GRm	>420	LNR
	—	—	—	—	—	—	—	—							
				—	—	—	—	—	—						
							—	—	—	—	—	—			
									—	—	—	—	—	—	
															—
WEYE	GRm	Ogd	>MSD	Erie	GR>d	RP	RRm	FCL	>420	CV	SRm				
	—	—	—	—	—										
		—	—	—	—	—	—								
			—	—	—	—	—	—							
							—	—	—						
									—	—	—				

COS	LOnt(spring)	SRH(fall)
LMB	UNR	CC
LT	Erie	LOnt
RT	ChC	SRH
WP	LOnt (west)	LOnt (east)

[1] Locations underlined by a common line are not statistically different.

[2] Location codes are: Erie = Lake Erie; ChC = Chautauqua Creek; UNR = upper Niagara River; LNR = lower Niagara River; CC = Cayuga Creek; LOnt = Lake Ontario; SRH = Salmon River Hatchery; CV = Cape Vincent; Ogd = Ogdensburg; >MSD = above Moses Saunders Dam; FCL = Franklin County Line; RP = Raquette Point; GR>d = Grasse River above dam; GRm = Grasse River mouth; >420 = Raquette River above Route 420 bridge; RRm = Raquette River mouth; SR>d = St. Regis River above dam; SRm = St. Regis River mouth.

[3] No significant spatial difference when all sites are compared. However, an exception occurred for a subset of common carp in the Niagara River basin as shown.

Table 14: Spatial differences in total 2,3,7,8-TCDD toxic equivalent concentrations in fish from New York's Great Lakes basin[1].

Species	Spatial ranking (lowest to highest rank)[2]														
BB	SR>d	Ogd	RP	FCL	CC										
CARP	RP	SRm	>420	UNR	FCL	>MSD	CV	RRm	Ogd	GRm	LNR	Erie	CC		
CHC	SRm	LOnt	GRm	RP	Erie	>MSD	RRm								
SMB	SR>d	>420	GR>d	SRm	Erie	FCL	LOnt	RP	CV	UNR	RRm	Ogd	>MSD	GRm	LNR
WEYE	RP	GR>d	>420	Erie	Ogd	RRm	SRm	>MSD	GRm	FCL	CV				

COS	LOnt (spring)	SRH (fall)
LMB	UNR	CC
LT	Erie	LOnt
RT	ChC	SRH
WP	LOnt (east)	LOnt (west)

[1] Locations underlined by a common line are not statistically different.

[2] Location codes are: Erie = Lake Erie; ChC = Chautauqua Creek; UNR = upper Niagara River; LNR = lower Niagara River; CC = Cayuga Creek; LOnt = Lake Ontario; SRH = Salmon River Hatchery; CV = Cape Vincent; Ogd = Ogdensburg; >MSD = above Moses Saunders Dam; FCL = Franklin County Line; RP = Raquette Point; GR>d = Grasse River above dam; GRm = Grasse River mouth; >420 = Raquette River above Route 420 bridge; RRm = Raquette River mouth; SR>d = St. Regis River above dam; SRm = St. Regis River mouth.

Table 15: TCDD:TCDF ratios in fish from New York's Great Lakes basin.

Species	Erie	UNR	CC	LNR	Ont-W	IB	Ont-E	CV	Ogd	>MSD	RP	FCL
BB			34.5					0.19	0.065		0.00	0.00
BT					0.19		0.19					
CARP	0.14	0.59	8.08	2.73			3.00	0.17	0.29	0.066	0.00	0.14
CHC	0.18					2.98	0.91		0.37	0.92	0.55	
LMB		0.083	4.29									
LT	0.079			0.59	0.42		0.19					
RB			6.98									
RT	0.00						2.22					
SMB	0.13	0.29		1.38			0.43	0.26	0.17	0.14	0.077	0.062
WEYE	0.057							0.20	0.084	0.17	0.00	0.070
WP						0.15	0.15					
WS				0.00	0.12					0.00		

Species	GR>d	GRm	RR420	RRm	SRR>d	SRRm
BB					0.00	
CARP		0.43		0.24		0.26
CHC		0.15		1.26		0.22
SMB	0.073	0.092	0.00	0.079	0.00	0.00
WEYE	0.00	0.095	0.041	0.084	0.00	0.17
WS					0.00	
YP	0.00					

Locations are: Erie = Lake Erie; UNR = upper Niagara River; CC = Cayuga Creek; LNR = lower Niagara River; Ont-W = western Lake Ontario; IB = Irondequoit Bay; Ont-E = eastern Lake Ontario; CV = St. Lawrence River at Cape Vincent; Ogd = St. Lawrence River at Ogdensburg; >MSD = St. Lawrence River above Moses Saunders Dam; RP = St. Lawrence River at Raquette Point; FCL = St. Lawrence River at the Franklin County line; GR>d = Grasse River above dam in Massena; GRm = Grasse River within 1.0 mile of the mouth; RR420 = Raquette River above the Route 420 bridge; RRm = Raquette River within 1.0 mile of mouth; SRR>d = St. Regis River above dam in Hogansburg; SRRm = St. Regis River within 1.0 mile of mouth.

Table 16: Temporal differences in 2,3,7,8-TCDD concentrations in fillets of fish from Lake Erie, Cayuga Creek and Lake Ontario.

		2,3,7,8-TCDD (pg/g wet weight)			%
Water	Species	1978-80[1]	1987[2]	2010-11[3]	Difference[5]
Lake Erie	CARP	<3.5[4]		0.88	nc[6]
	SMB	<2.4[4]		0.063	nc
	WEYE	<2.7[4]		nd[7]	nc
Cayuga Creek	CARP	87		11.56	-86.7
	RB	12		4.67	-61.1
Lake Ontario/ Salmon River Hatchery	BT	52	10.8	1.00	-98.0
	CHS	34		0.86	-97.5
	COS	22		1.64	-92.5
	LT	65[8]	27	1.77	nc[9]
	RT	20		2.08	-89.6
	SMB	5.9	4	0.33	-94.4
	WP	21	17-120[10]	0.17	-99.2

[1] Source and calculated from O'Keefe et al. 1983.
[2] Source and calculated from USEPA/NYSDEC/NYSDOH/OCC 1990.
[3] This study.
[4] Average was less than the detection limit given.
[5] Difference between 1978-80 and 2010-11.
[6] nc = no calculation possible.
[7] nd = none detected.
[8] Whole fish.
[9] nc = no calculation due to differing fish portions (whole fish versus standard fillet) analyzed.
[10] Range due spatial differences.

Table 17: Temporal differences in 2,3,7,8-TCDD toxic equivalents (pg/g wet weight) in fish from the Massena area of the St. Lawrence River.

Location	Species	2,3,7,8-TCDD TEQs 1988[1]	2013-14[2]	% Difference
St. Lawrence River				
- above Moses Saunders Dam	SMB	1.692	1.39	- 17.8
- Raquette Point	BB	2.896	0.12	- 95.8
	SMB	2.800	0.85	- 69.6
	WEYE	1.860	0.035	- 98.1
- Franklin Co. line	BB	17.03	0.30	- 98.2
Grasse River				
- mouth	CHC	15.57	2.01	- 87.1
	SMB	1.421	1.35	- 5.0
	WEYE	3.891	0.32	- 91.8
Raquette River				
- mouth	SMB	2.140	1.06	- 50.5
	WEYE	2.101	0.29	- 86.2
St. Regis River				
- above dam	SMB	1.261	0.016	- 98.7
	WEYE	0.00	0.037	nc[3]
- mouth	SMB	0.242	0.36	+ 48.7
	WEYE	1.762	0.22	- 87.5

[1] Calculated from data in Sloan and Jock (1990), Table 17, using toxicity equivalency factors from Van den Berg et al. (2006).
[2] This study.
[3] No calculation possible.

Table 18: Frequency that mean concentrations of location-species combinations exceed criteria to protect human health.

Analyte group	Population protected	Criterion	Means Exceeding Criterion Number	Means Exceeding Criterion %	Reference
∑PBDEs[1]	Total	> 630 ng/g	0	0	Klasing and Brodberg 2011
BDE-47	Sensitive populations	> 235	0	0	Gandhi et al. 2017a
	General population	> 939	0	0	
BDE-99	Sensitive populations	> 235	0	0	Gandhi et al. 2017a
	General population	> 939	0	0	
BDE-153	Sensitive populations	> 469	0	0	Gandhi et al. 2017a
	General population	> 1,877	0	0	
BDE-209	Sensitive populations	> 16,425	0	0	Gandhi et al. 2017a
	General population	> 65,701	0	0	
2,3,7,8-TCDD TEQs[2,3]	Adult population, 1 meal/wk[4]	0.15 pg/g	63	81.8	USEPA 2000
	Adult population, don't eat[4]	1.2	36	46.7	USEPA 2000
	General population	3.5	11	14.3	European Commission 2011
	Sensitive populations	5.4	5	6.5	Gandhi et al. 2017a
	Total population	10	2	2.6	NYSDOH 1981b, 2019b
	General population	21.6	0	0	Gandhi et al. 2017a

[1] N = 63 location-species combinations having 3 or more samples.
[2] N = 77 location-species combinations having 3 or more samples.
[3] Toxicity equivalency factors (TEFs) used were from Van den Berg et al. (2006).
[4] 10^{-5} cancer risk for adult population (70 kg) consuming 8 ounce meals.

Table 19: 2,3,7,8-TCDD toxic equivalents (pg/g wet weight) based on fish and bird toxicity equivalency factors[1] applied to fish from New York's Great Lakes basin.

		Fish			Birds		
Water	Species	Mean	SD[2]	Min.-Max.	Mean	SD[2]	Min.-Max.
Lake Erie	CARP	4.01	2.41	1.03 - 6.44	12.3	7.70	1.65 - 21.1
	CHC	2.92	1.05	1.63 - 4.33	5.53	1.90	3.18 - 8.44
	LT	2.46	1.27	1.42 - 4.67	9.86	5.52	4.70 - 19.4
	SMB	0.38	0.16	0.20 - 0.48	0.99	0.55	0.40 - 1.50
	WEYE	0.059	0.020	0.038 - 0.079	1.10	0.32	0.77 - 1.42
Chautauqua Creek	RT	0.47	0.17	0.32 - 0.65	4.06	2.34	1.66 - 6.34
Niagara River - upper	CARP	1.72	2.79	<0.001 - 6.59	2.82	3.70	<0.001 - 9.14
	LMB	0.19	0.063	0.12 - 0.23	0.73	0.23	0.47 - 0.91
	SMB	1.05	0.27	0.77 - 1.31	2.37	0.53	1.81 - 2.87
Niagara River - lower	CARP	4.70	4.17	0.32 - 11.2	7.55	5.86	0.85 - 17.0
	SMB	2.90	1.73	1.72 - 4.89	4.93	2.46	3.42 - 7.76
Cayuga Creek	BB	6.37	3.61	1.82 - 10.8	7.21	3.63	2.44 - 11.6
	CARP	17.9	8.47	10.2 - 31.8	22.7	10.2	13.5 - 39.3
	LMB	2.10	1.24	1.02 - 3.86	2.37	0.99	1.52 - 3.80
	RB	5.06	5.05	0.056 - 10.5	5.93	5.30	0.47 - 11.8

Table 19 continued.

Water	Species	Fish Mean	Fish SD[2]	Fish Min.-Max.	Birds Mean	Birds SD[2]	Birds Min.-Max.
Lake Ontario	BT	1.92	0.38	1.52 - 2.27	7.40	1.45	6.05 - 8.94
	CHC	2.33	0.89	1.36 - 3.10	4.45	1.92	2.49 - 6.32
	COS	1.26	0.29	1.01 - 1.58	5.09	0.25	4.90 - 5.38
	LT	4.10	1.84	1.40 - 6.93	16.2	5.41	7.05 - 23.6
	SMB	0.63	0.64	0.072 - 1.64	1.46	1.26	0.28 - 2.90
	WP	0.48	0.41	0.048 - 1.24	2.72	2.34	0.97 - 6.55
Salmon River Hatchery	CHS	2.25	1.17	0.93 - 3.73	8.07	1.69	5.25 - 10.9
	COS	3.09	0.39	2.46 - 3.51	10.4	1.48	8.54 - 12.5
	RT	3.28	2.32	1.05 - 7.90	6.07	3.94	2.75 - 14.0
St. Lawrence River - Cape Vincent	BB	0.30		0.28 - 0.33	0.93		0.47 - 1.38
	CARP	1.71	1.45	0.060 - 2.80	3.62	2.17	1.11 - 4.90
	SMB	0.76	0.11	0.64 - 0.85	3.04	0.24	2.87 - 3.32
	WEYE	0.99	0.79	0.50 - 1.90	3.18	1.66	2.18 - 5.10
St. Lawrence River - Ogdensburg	BB	0.11	0.064	0.036 - 0.15	0.80	0.11	0.73 - 0.93
	CARP	2.46	1.56	0.65 - 3.43	6.40	3.15	2.89 - 9.00
	CHC	2.31		0.16 - 4.47	4.16		0.82 - 7.49
	SMB	1.02	0.43	0.72 - 1.52	2.99	1.29	2.07 - 4.47
	WEYE	0.13	0.15	0.038 - 0.40	0.87	0.15	0.77 - 1.04

Table 19 continued.

Water	Species	Fish Mean	Fish SD[2]	Fish Min.-Max.	Birds Mean	Birds SD[2]	Birds Min.-Max.
St. Lawrence - above Moses Saunders Dam	CARP	1.87	2.01	0.053 - 4.02	7.30	7.14	0.96 - 15.0
	CHC	3.04	1.15	1.78 - 4.01	5.36	1.97	3.69 - 7.53
	SMB	1.42	1.04	0.62 - 2.60	4.68	2.69	2.91 - 7.78
	WEYE	0.22	0.12	0.092 - 0.32	0.82	0.45	0.41 - 1.29
St. Lawrence River - Franklin County line	BB	0.35	0.41	0.048 - 0.81	1.91	1.68	0.92 - 3.85
	CARP	1.75	1.33	0.28 - 2.89	4.42	2.22	1.86 - 5.81
	SMB	0.65	0.28	0.46 - 0.97	2.16	0.64	1.68 - 2.89
	WEYE	0.76	0.60	0.28 - 1.41	2.64	1.30	1.39 - 3.98
St. Lawrence River - Raquette Point	BB	0.16	0.14	nd - 0.25	0.67	0.58	nd - 1.09
	CARP	0.30	0.21	0.063 - 0.46	3.84	4.56	1.15 - 9.11
	CHC	2.77	1.93	1.16 - 4.90	5.80	3.18	3.38 - 9.40
	SMB	0.88	0.54	0.30 - 1.34	3.52	1.17	2.20 - 4.42
	WEYE	0.018	0.031	nd - 0.053	0.35	0.61	nd - 1.06
Grasse River - above dam	SMB	0.087	0.095	0.031 - 0.20	0.72	0.14	0.62 - 0.88
	WEYE	0.019	0.014	0.003 - 0.029	0.36	0.31	0.003 - 0.59
	YP	0.041	0.026	0.021 - 0.071	0.22	0.14	0.071 - 0.34
Grasse River - mouth upstream 1.0 mile	CARP	3.43	2.42	1.11 - 5.93	6.39	4.77	1.60 - 11.1
	CHC	2.43	1.00	1.27 - 3.10	4.98	2.45	2.17 - 6.66
	SMB	1.65	0.42	1.28 - 2.10	4.81	0.94	3.88 - 5.76
	WEYE	0.31	0.31	0.033 - 0.65	1.35	0.76	0.65 - 2.16

Table 19 continued.

Water	Species	Fish Mean	Fish SD[2]	Fish Min.-Max.	Birds Mean	Birds SD[2]	Birds Min.-Max.
Raquette River	CARP	0.77	0.22	0.51 - 0.92	1.47	0.35	1.09 - 1.79
- above Route 420	SMB	0.11	0.11	0.044 - 0.24	0.44	0.18	0.28 - 0.64
bridge	WEYE	0.12	0.075	0.031 - 0.16	0.41	0.12	0.27 - 0.51
Raquette River	CARP	2.01	0.94	0.93 - 2.70	5.75	5.07	1.55 - 11.4
- mouth upstream	CHC	4.93	4.44	2.10 - 10.1	8.87	7.57	4.13 - 17.6
1.0 mile	SMB	1.13	0.69	0.59 - 1.90	4.08	1.65	2.90 - 5.96
	WEYE	0.28	0.32	0.023 - 0.64	0.85	0.80	0.21 - 1.74
St. Regis River	BB	0.12	0.12	nd - 0.24	0.31	0.30	nd - 0.59
- above dam	SMB	0.009	0.016	nd - 0.028	0.16	0.27	nd - 0.47
	WEYE	0.036		0.012 - 0.059	0.26		0.24 - 0.29
	WS	0.010	0.014	0.016 - 0.026	0.21	0.28	nd - 0.53
St. Regis River	CARP	0.87	0.61	0.30 - 1.52	2.56	2.63	0.60 - 5.54
- mouth upstream	CHC	1.24	0.14	1.08 - 1.36	3.70	0.24	3.43 - 3.84
1.0 mile	SMB	0.38	0.28	0.060 - 0.60	2.41	1.13	1.20 - 3.45
	WEYE	0.19	0.16	0.029 - 0.34	0.82	0.30	0.58 - 1.15
Supplemental samples							
Niagara River							
- lower	CARP	8.62	7.79	0.001 - 17.3	12.6	12.5	0.001 - 28.9
	LT	12.83	1.39	11.2 - 13.8	27.7	2.19	26.2 - 30.2
	WS	0.087	0.049	0.034 - 0.13	1.01	0.40	0.69 - 1.46

Table 19 continued.

Water	Species	Fish Mean	Fish SD[2]	Fish Min.-Max.	Birds Mean	Birds SD[2]	Birds Min.-Max.
Lake Ontario							
- western	LT	3.77	3.07	0.60 - 8.50	9.57	6.48	4.20 - 24.6
- eastern	CARP	6.93	9.96	0.28 - 23.7	9.34	11.4	2.05 - 28.9
	CHC	1.05	0.85	0.33 - 1.99	2.87	2.63	0.056 - 5.27
	LT	2.82	1.05	1.74 - 3.84	9.40	2.88	6.30 - 12.0
	WP	0.74	0.054	0.68 - 0.79	2.14	0.98	1.01 - 2.82
- Keg Creek	WS	0.88	0.76	0.065- 1.57	4.92	6.02	1.30 - 11.9
- Eighteenmile Creek	BT	1.22	0.74	0.34 - 2.17	6.40	3.65	3.79 - 13.4
Irondequoit Bay	CHC	3.46	5.10	0.49 - 9.35	4.68	5.77	0.98 - 11.3
	WP	0.25	0.38	nd - 0.69	1.00	1.01	nd - 2.02

[1] Toxic equivalency factors from Van den Berg et al. (1998).
[2] Standard deviation; calculated only for n > 2.
[3] nd = none detected; all 2,3,7,8-substituted PCDD/F analytes were below detection limits.

Table 20: Frequency that mean concentrations of location-species combinations exceed criteria to protect fish and wildlife.

Analyte group[1]	Protected population	Criterion	Means Exceeding Criterion Number	Means Exceeding Criterion %	Reference
PBDE homolog/congener					E&CC Canada 2013
- ∑Tri-	Fish	120 ng/g	0	0	
- ∑Tetra-	Fish	88	0	0	
	In wildlife diet	44	0	0	
- ∑Penta-	Fish	1	58	92.0	
	In wildlife diet – mammals	3	35	55.5	
	In wildlife diet - birds	13	5[2]	7.9	
BDE-99	Fish	1	37	58.7	
	In wildlife diet	3	19	30.1	
BDE-100	Fish	1	46	73.0	
- ∑Hexa-	Fish	420	0	0	
	In wildlife diet	4	8	12.7	
- ∑Hepta-	In wildlife diet	64	0	0	
- ∑Octa-	In wildlife diet	63	0	0	
- ∑Nona-	In wildlife diet	78	0	0	
- Deca-	In wildlife diet	9	0	0	
2,3,7,8-TCDD TEQs	Fish-consuming wildlife	2.3 pg/g			Newell et al. 1987
	- based on mammal TEFs[3]		22	28.5	
	- based on fish TEFs[4]		29	37.6	
	- based on bird TEFs[4]		51	66.2	
	Fish-consuming wildlife				
	- mammals[3]	0.71	47	61.0	CCME 2001a
	- birds[4]	4.75	30	38.9	

[1] N = 63 location-species combinations for PBDEs and N = 77 location-species combinations for PCDD/F TEQs having 3 or more samples.
[2] A sixth location-species combination had a mean concentration of 12.99 ng/g total penta-BDEs.
[3] Toxicity equivalency factors (TEFs) were from Van den Berg et al. (2006).
[4] Toxicity equivalency factors (TEFs) were from Van den Berg et al. (1998).

Table 21: Pre- and post-study health advisories for consumption of fish from New York's Great Lakes basin[1]. Changes to less restrictive advice are in *italics*; changes to more restricted advice are underlined.

Water	Species	Old advice	New advice
	Men over age 15 years and women over age 50 years:		
Lake Erie	Common carp	One meal per week	One meal per month
	Channel catfish	One meal per week	One meal per month
	All other fish species	One meal per week	One meal per week
Niagara River			
- upper	Common carp	One meal per month	One meal per month
	Channel catfish	One meal per week	One meal per month
	All other fish species	One meal per week	One meal per week
- lower	Chinook salmon	One meal per month	*One meal per week*
	Coho salmon > 25"	One meal per month	*One meal per week*
	Coho salmon < 25"	One meal per week	One meal per week
	Rainbow trout	One meal per month	*One meal per week*
	Brown trout < 20"	One meal per month	*One meal per week*
	Brown trout > 20"	Do not eat	*One meal per week*
	Lake trout < 25"	One meal per month	*One meal per week*
	Lake trout > 25"	Do not eat	*One meal per week*
	Smallmouth bass	One meal per month	*One meal per week*
	Channel catfish	Do not eat	Do not eat
	White perch	Do not eat	Do not eat
	White sucker	One meal per month	One meal per month
	All other fish species	One meal per week	One meal per month
Lake Ontario	Chinook salmon	One meal per month	*One meal per week*
	Coho salmon > 25"	One meal per month	*One meal per week*
	Coho salmon < 25"	One meal per week	One meal per week
	Rainbow trout	One meal per month	*One meal per week*
	Brown trout < 20"	Do not eat	*One meal per week*
	Brown trout > 20"	One meal per month	Do not eat
	Lake trout < 25"	Do not eat	*One meal per week*
	Lake trout > 25"	Do not eat	Do not eat
	Smallmouth bass	One meal per week	One meal per week
	Channel catfish	Do not eat	Do not eat
	White perch		
	- western[2]	Do not eat	Do not eat
	- eastern[2]	One meal per month	One meal per month
	White sucker	One meal per month	One meal per month
	All other fish species	One meal per week	One meal per week

Table 21 continued.

Water	Species	Old advice	New advice
St. Lawrence River			
- whole river[3]	Common carp	Do not eat	Do not eat
	Channel catfish	Do not eat	Do not eat
	Brown trout > 20”	Do not eat	*One meal per month*
	Brown trout < 20”	One meal per month	*One meal per week*
	Lake trout > 25”	Do not eat	*One meal per month*
	Lake trout < 25”	One meal per month	*One meal per week*
	Chinook salmon	One meal per month	*One meal per week*
	Coho salmon > 25”	One meal per month	*One meal per week*
	Coho salmon < 25”	One meal per week	One meal per week
	Rainbow trout	One meal per month	*One meal per week*
	White sucker	One meal per month	One meal per month
	White perch	One meal per month	One meal per month
	All other fish species	One meal per week	One meal per week
- cove[4]	All fish species	Do not eat	Do not eat
	Women under age 50 years and children under age 15 years:		
Lake Erie	Common carp	Do not eat	*One meal per month*
	Channel catfish	One meal per week	Do not eat
	Burbot	One meal per week	One meal per week
	Rock bass	One meal per week	One meal per week
	Yellow perch	One meal per week	One meal per week
	All other fish species	One meal per week	One meal per month
Niagara River			
- upper	Common carp	Do not eat	Do not eat
	Channel catfish	Do not eat	Do not eat
	Burbot	Do not eat	*One meal per week*
	Rock bass	Do not eat	*One meal per week*
	Yellow perch	Do not eat	*One meal per week*
	All other fish species	Do not eat	*One meal per month*
- lower	All fish species	Do not eat	Do not eat
Lake Ontario	All fish species	Do not eat	Do not eat

Table 21 continued.

Water	Species	Old advice	New advice
St. Lawrence River			
- whole river[3]	All fish species	Do not eat	Do not eat
- cove[4]	All fish species	Do not eat	Do not eat

[1] Includes consideration of data reported by Li et al. (2014) and Skinner et al. (2018). New advice is based on news releases issued by the NY State Department of Health (NYSDOH 2013 and 2014). In some instances, no health advisory changes were made.
[2] West or east of Point Breeze as indicated.
[3] Includes tributaries to the first impassable barrier.
[4] Cove near Franklin County line.

Figure 1a: Sampling locations, western (upstream) locations.

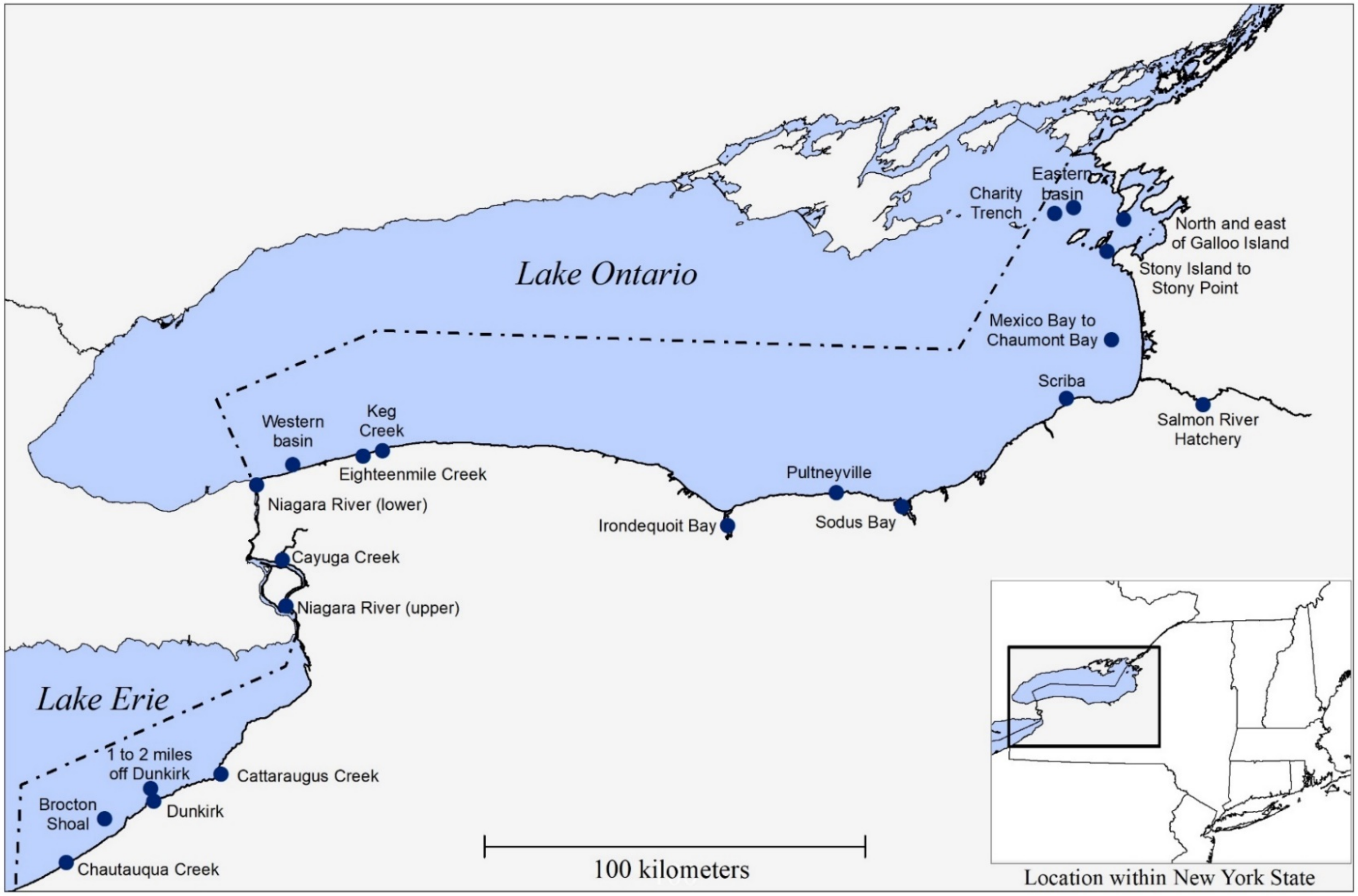


Figure 1b: Sampling locations, eastern (downstream) locations.

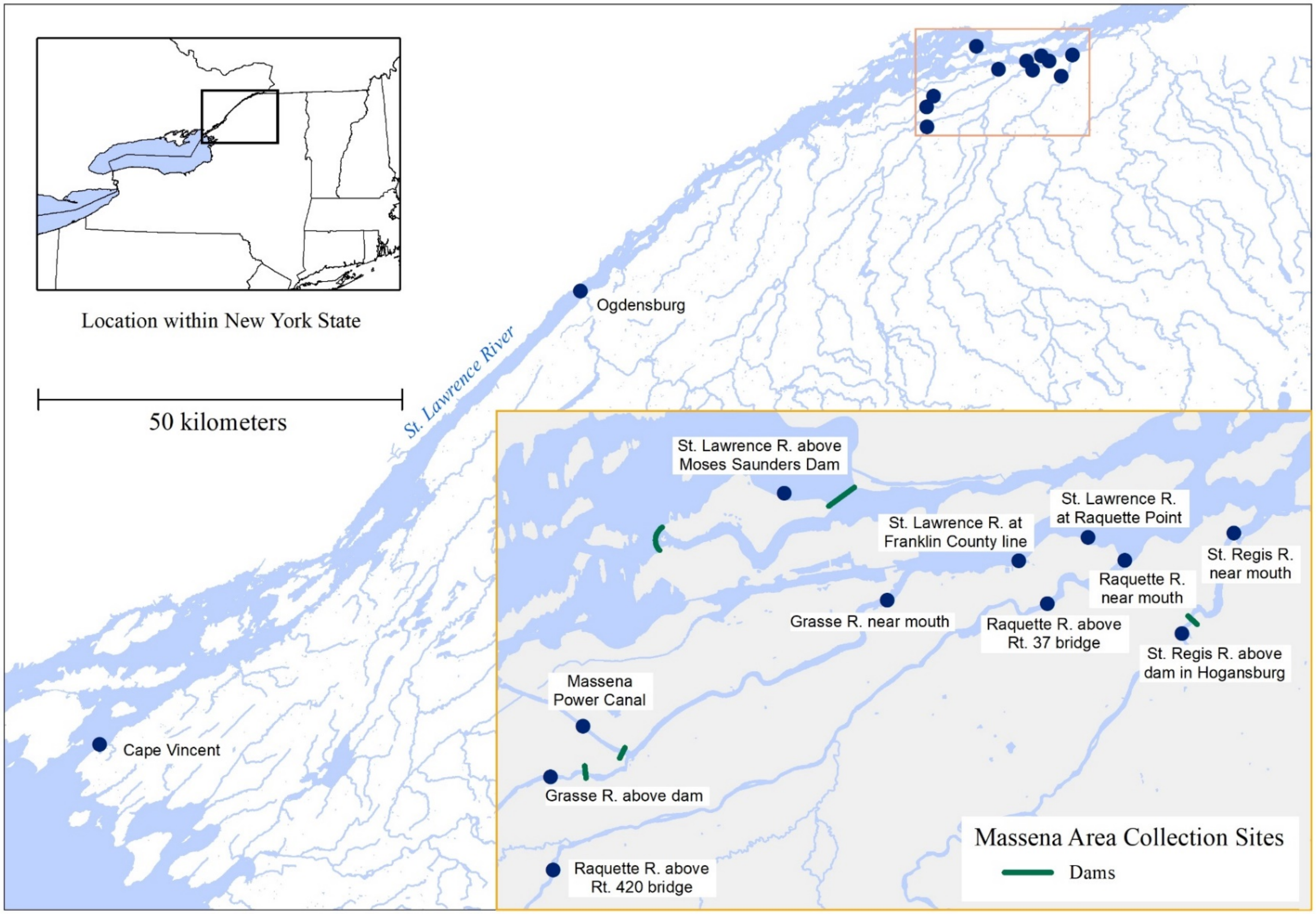


Figure 2: Overall mean total PBDE concentrations in fish by location from New York's Great Lakes basin.

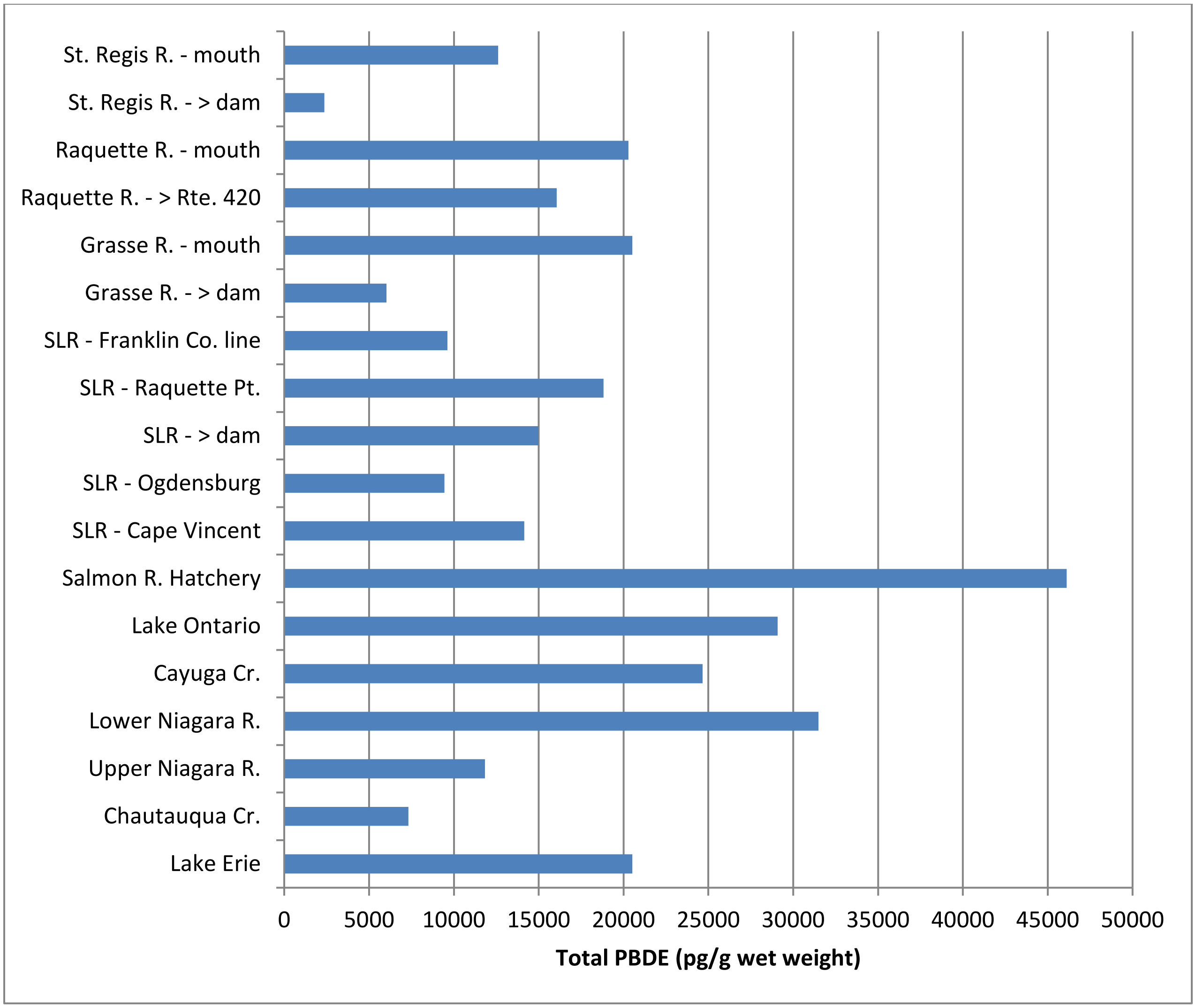


Figure 3: Distribution of PBDE homologs in fish from New York's Great Lakes basin.

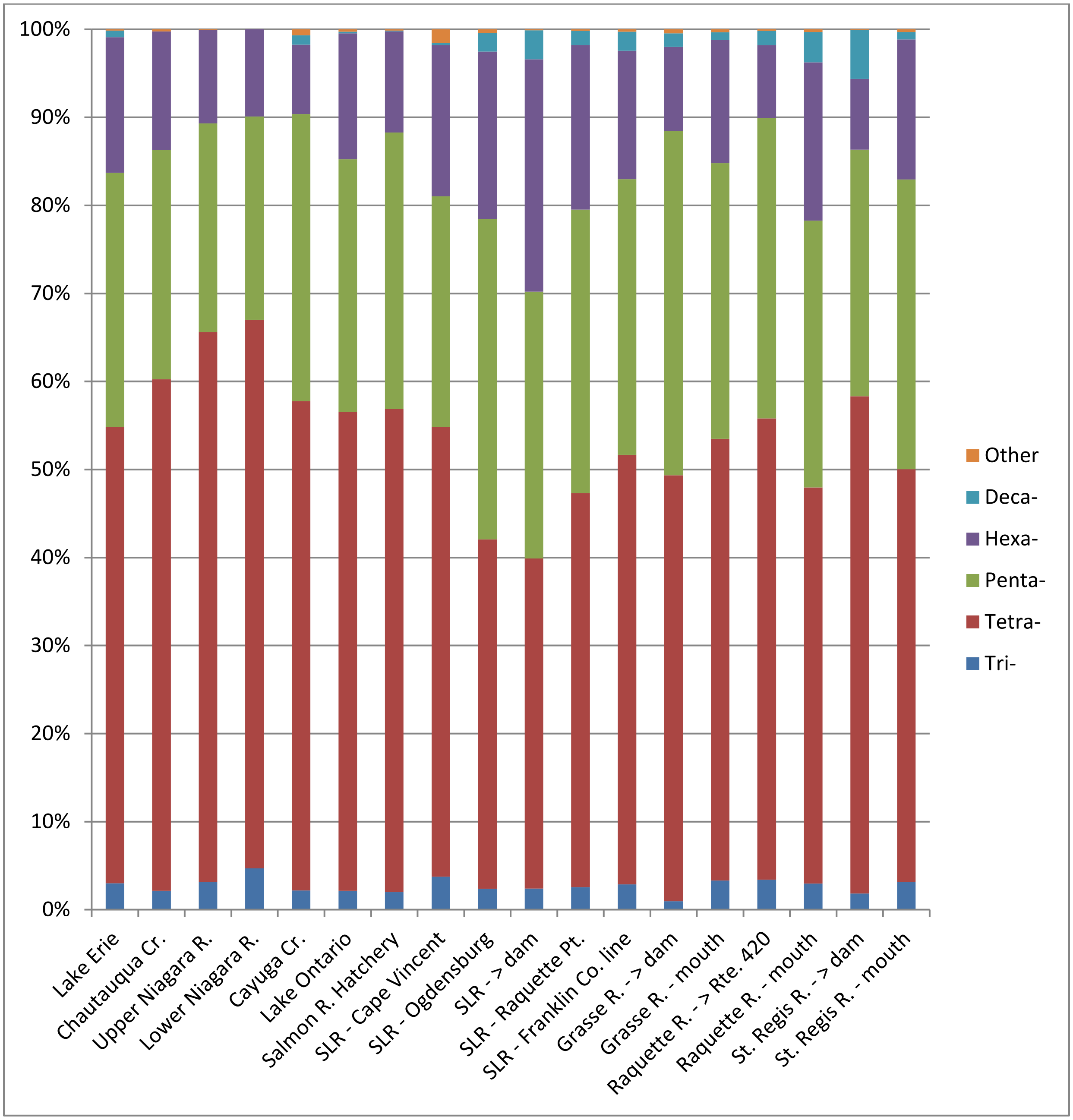
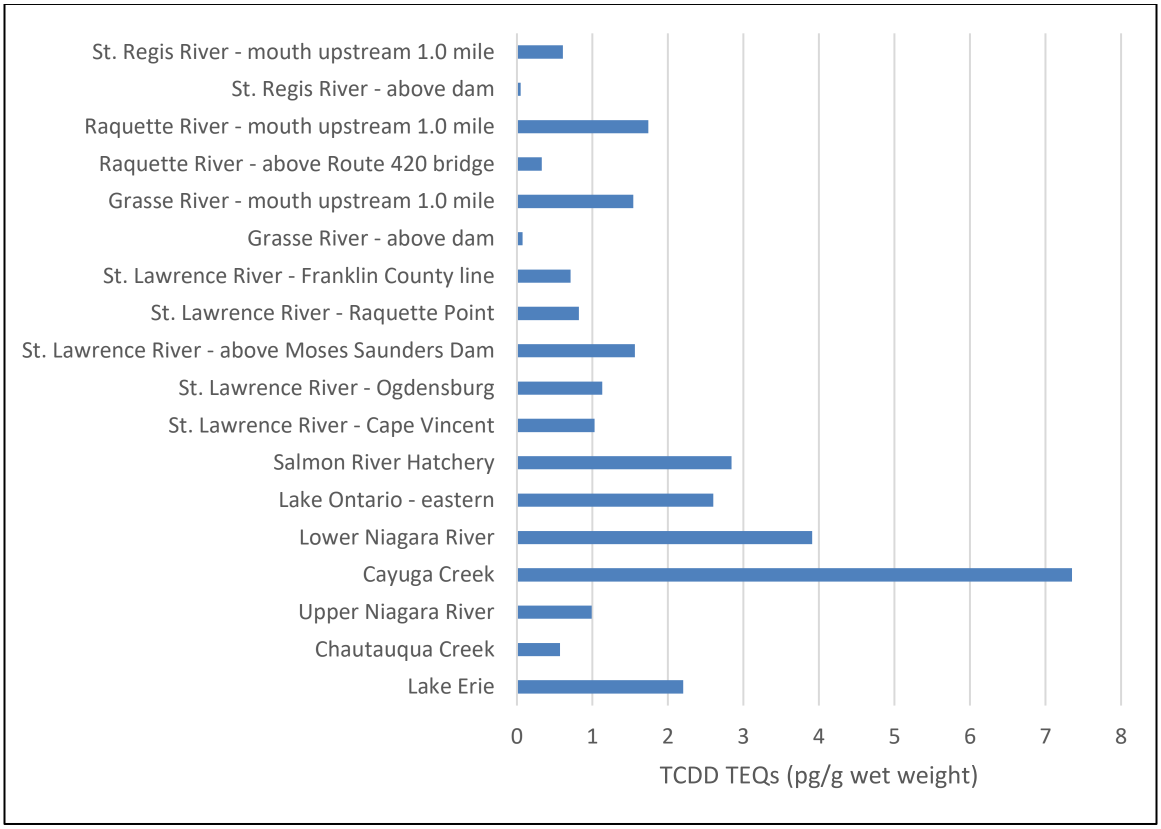


Figure 4: Mean overall human and mammalian 2,3,7,8-TCDD toxic equivalents in fish by location in New York's Great Lakes basin.

a) Original data



b) Supplemental data

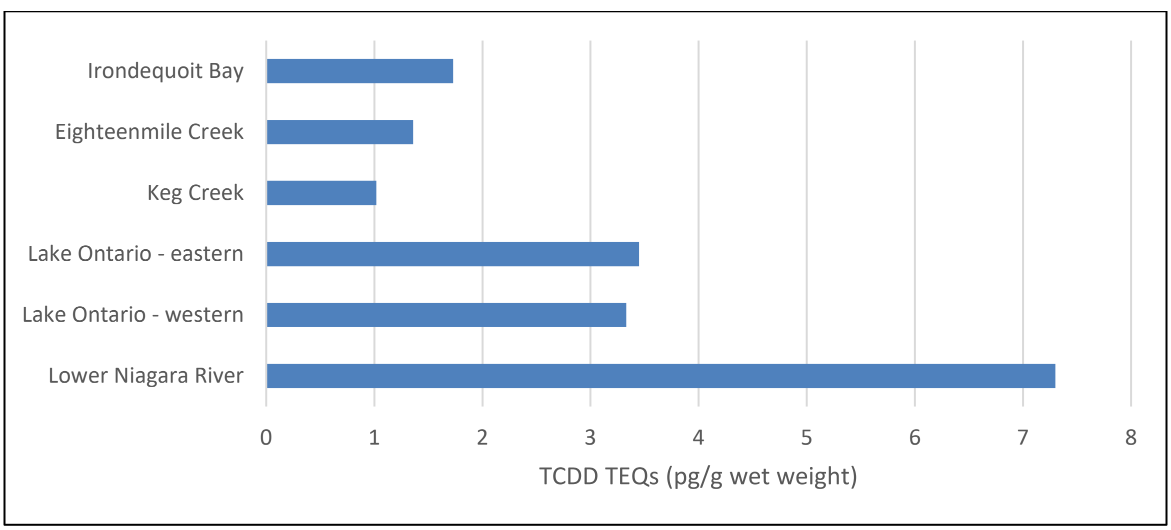


Figure 5: Distribution of PCDD/F congeners in fish from New York's Great Lakes basin.

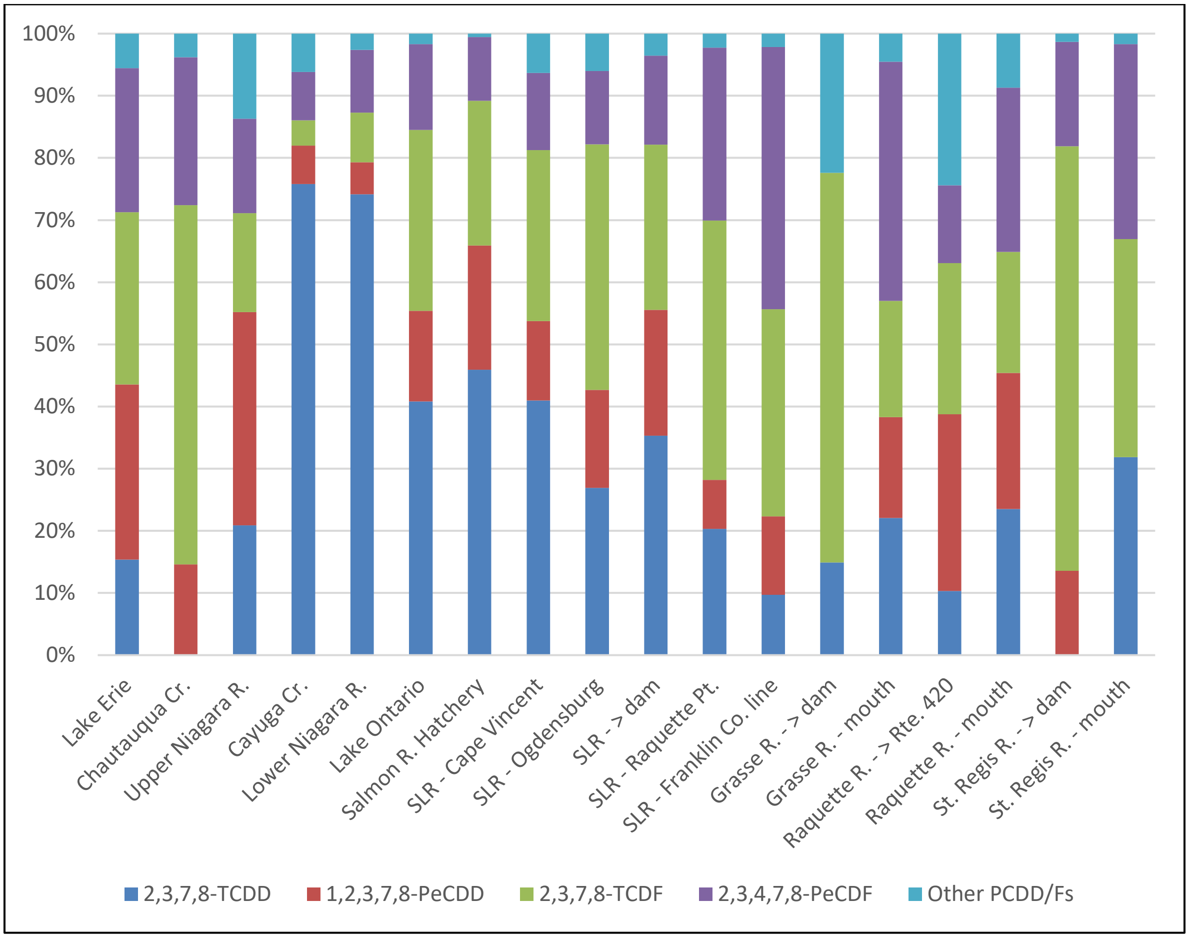


Figure 6: Length–TCDD TEQ relationships for lake trout taken from Lake Erie, the lower Niagara River, and Lake Ontario (2014 western and eastern basins and 2010–2011 eastern basin collections).

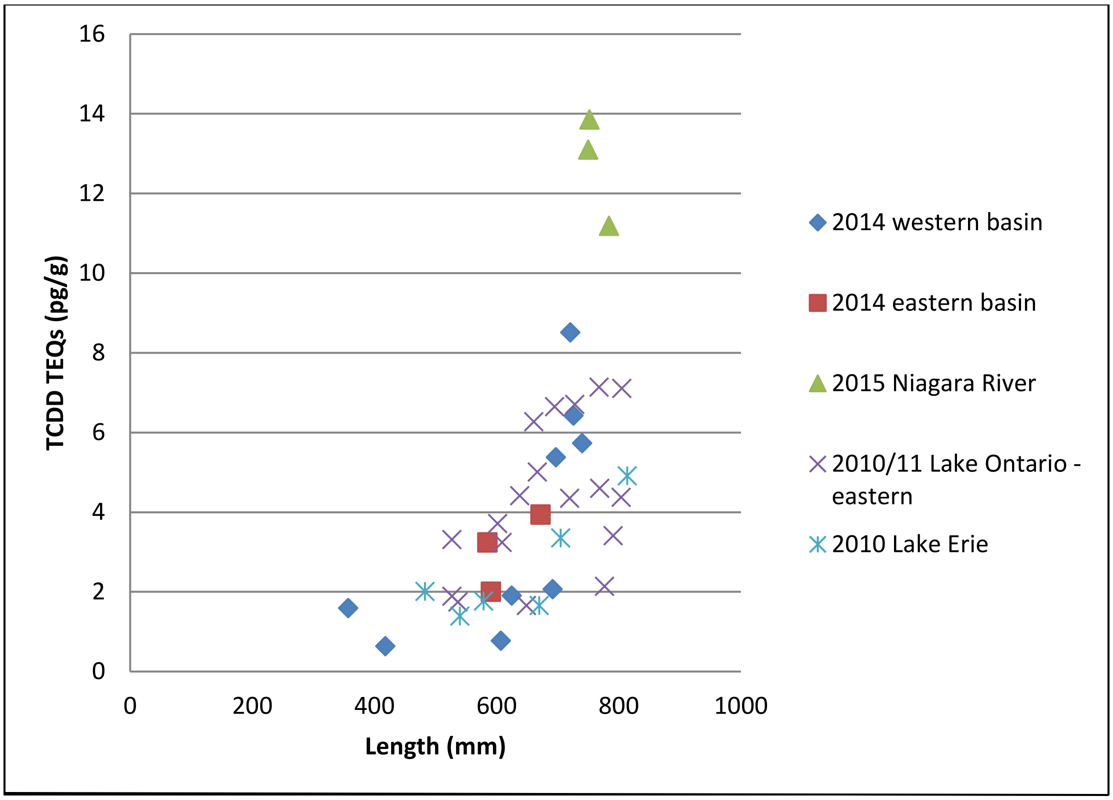
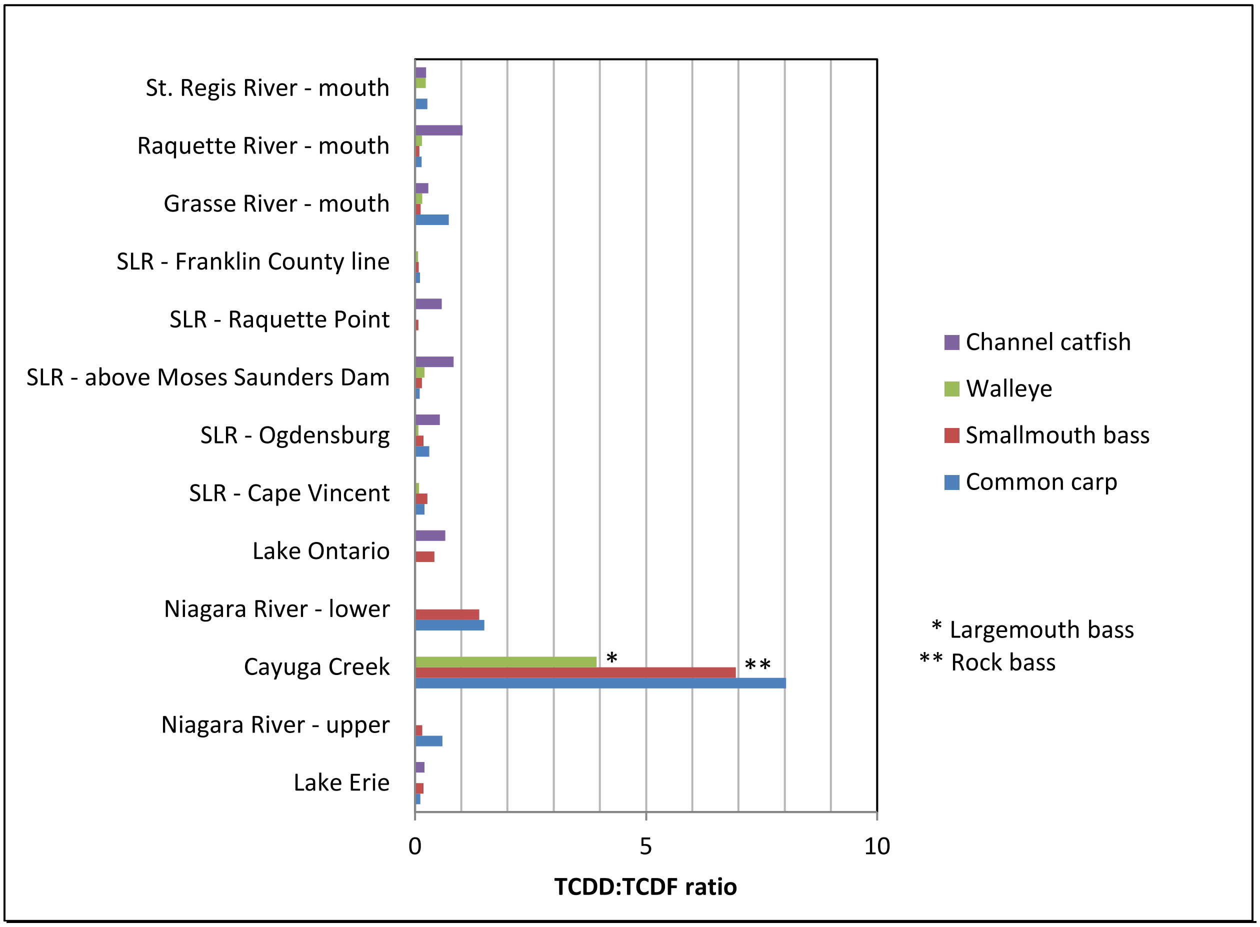


Figure 7: TCDD:TCDF concentration ratios in fish from New York's Great Lakes basin.



Polybrominated diphenyl ethers (PBDEs) and polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) in fish from New York's Great Lakes and connecting channels

APPENDICES

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A report in partial fulfilment of the grant
Xenobiotics in Fish from New York's Great Lakes International Waters
(GL-00E01310) Phase 3 awarded by the United States Environmental Protection Agency

Appendix A: Summary of lengths, weights and lipid content of fish samples by water.

Water	Species	n	Length (mm) Mean	SD	Min.-Max.	Weight (g) Mean	SD	Min.-Max.	Lipid (%) Mean	SD	Min.-Max
Lake Erie	CARP	5	734	93	651 - 853	6956	3486	4080 -11550	12.03	0.84	2.7 – 21.7
	CHC	5	818	63	748 - 895	7400	1540	5310 - 8800	18.38	8.40	7.1 – 26.2
	LT	6	632	121	483 - 814	3045	1587	1470 - 5555	11.23	2.28	7.79 – 13.9
	SMB	3	370	20	355 - 393	870	117	735 - 940	3.77	0.51	3.36 – 4.35
	WEYE	3	618	71	542 - 684	2490	752	1640 - 3070	3.20	1.36	2.22 – 4.76
Chautauqua Creek	RT	3	501	70	434 - 573	1377	438	890 – 1740	3.10	0.75	2.42 – 3.91
Niagara River - upper	CARP	5	522	56	445 - 600	[1]					
		3	492	42	445 - 527	1847	514	1262 – 2225	10.38	9.02	4.86 – 24.67
	LMB	3	385	28	367 - 417	949	184	836 – 1162	2.11	1.75	0.69 – 4.07
	SMB	3	403	21	384 - 425	1096	263	879 – 1389	2.37	0.78	1.73 – 3.24
Niagara River - lower	CARP	5	666	47	597 - 725	4224	1235	2495 – 5840	10.34	9.06	1.87 – 23.17
	SMB	3	368	5.8	365 - 375	794	62	751 - 865	4.39	0.63	3.81 – 5.07
Cayuga Creek	BB	6	303	29	266 - 348	[2]			0.38	0.24	0.10 – 0.80
		5	302	32	266 - 348	401	132	255 - 567			
	CARP	5	604	12	590 - 618	[1]			2.12	0.59	1.5 – 2.8
	LMB	5	371	55	307 - 440	839	366	453 – 1304	0.36	0.15	0.2 – 0.6
	RB	5	203	14	188 - 226	192	46	156 - 269	0.50	0.35	0.2 – 1.1
Lake Ontario	BT	3	489	32	467 - 526	1875	459	1588 – 2404	15.12	2.23	13.03 – 17.47
	CHC	3	490	43	461 - 539	1133	363	912 – 1552	3.23	1.93	1.0 – 4.4
	COS	3	540	28	513 - 568	1557	343	1315 – 1950	3.20	0.30	2.9 – 3.5
	LT	18	682	95	527 - 805	[3]			17.50	6.72	6.12 – 34.26
		17	685	97	527 - 805	3671	1707	1277 - 6586			
	SMB	6	373	20	341 - 398	805	183	620 – 1058	3.05	2.86	0.5 – 7.9
	WP	6	255	15	236 - 268	254	49	191 - 308	3.05	1.68	1.5 – 6.01

Appendix A continued.

			Length (mm)			Weight (g)			Lipid (%)		
Water	Species	n	Mean	SD	Min.-Max.	Mean	SD	Min.-Max.	Mean	SD	Min.-Max.
Salmon River	CHS	12	925	51	815 - 1015	8358	1111	5982 – 9752	0.92	0.56	0.2 – 1.83
Hatchery	COS	6	749	33	705 - 800	4002	868	3345 – 5557	0.68	0.27	0.4 – 1.1
	RT	6	674	87	566 - 765	2882	1061	1590 – 3980	1.38	0.66	0.7 – 2.5
St. Lawrence	BB	2	296		264 - 328	377		252 – 501	2.22		1.05 – 3.4
River	CARP	3	648	64	587 - 714	4333	1041	3500 – 5500	6.21	2.53	3.44 – 8.4
- Cape	SMB	3	467	11	460 - 480	1783	45	1748 – 1834	3.36	0.73	2.52 – 3.86
Vincent	WEYE	3	557	26	537 - 587	1934	268	1725 – 2236	3.20	0.34	2.97 – 3.6
St. Lawrence	BB	3	311	12	300 - 324	458	81	395 – 550	1.35	0.43	0.92 – 1.79
River	CARP	3	741	82	668 - 829	6233	5739	3800 – 9200	8.75	4.00	4.17 – 11.5
- Ogdensburg	CHC	2	507		352 - 662	2188		375 – 4000	15.63		1.83 – 13.8
	SMB	3	422	67	375 - 499	1900	985	1100 – 3000	3.70	1.04	2.99 – 4.9
	WEYE	3	492	90	405 - 585	1302	816	605 – 2200	1.41	0.44	1.13 – 1.93
St. Lawrence	CARP	3	750	80	670 - 830	5950	1702	4450 – 7800	10.59	9.35	3.52 – 21.2
River	CHC	3	647	57	600 - 710	3617	900	3000 – 4650	9.07	4.65	5.36 – 14.3
- above Moses	SMB	3	477	23	450 - 490	2050	265	1750 – 2250	4.15	0.88	3.53 – 5.17
Saunders Dam	WEYE	3	537	58	470 - 570	1500	427	1050 – 1900	1.92	0.77	1.07 – 2.58
St. Lawrence	BB	3	287	47	250 - 340	317	160	200 – 500	0.87	0.53	0.56 – 1.49
River	CARP	3	657	92	550 - 710	4183	1706	2400 – 5800	4.94	1.37	3.92 – 6.5
- Franklin	SMB	3	400	40	360 - 440	1017	275	700 – 1200	2.53	0.03	2.50 – 2.56
County line	WEYE	3	517	49	460 - 550	1450	458	950 – 1850	2.22	0.84	1.28 – 2.92
	YP	3	260	9.5	251 - 270	226	31	160 – 250	0.74	0.14	0.61 – 0.89

Appendix A continued.

			Length (mm)			Weight (g)			Lipid (%)		
Water	Species	n	Mean	SD	Min.-Max.	Mean	SD	Min.-Max.	Mean	SD	Min.-Max.
St. Lawrence River - Raquette Point	BB	3	285	22	270 - 310	298	85	230 – 393	1.27	0.48	0.81 – 1.77
	CARP	3	773	45	730 - 820	7250	529	6650 – 7650	6.66	6.75	1.96 – 14.4
	CHC	3	670	72	590 - 730	3900	1297	2450 – 4950	18.03	2.78	14.9 – 20.2
	SMB	3	420	36	390 - 460	1217	465	900 – 1750	4.45	0.92	3.78 – 5.5
	WEYE	3	517	57	470 - 580	1200	397	900 – 1650	1.78	0.84	0.82 – 2.41
Grasse River - mouth upstream one mile	CARP	3	760	78	710 - 850	6467	2162	5000 – 8950	6.48	3.05	4.55 – 10.0
	CHC	3	575	117	456 - 690	2283	1338	850 – 3500	9.25	5.35	3.57 – 14.2
	SMB	3	452	55	390 - 495	1667	729	900 – 2350	4.63	0.85	3.69 – 5.36
	WEYE	3	535	63	475 - 600	1467	503	1000 – 2000	2.54	0.53	1.98 – 3.05
Grasse River - above dam	SMB	3	417	31	390 - 450	1000	218	850 – 1250	2.37	0.60	1.75 – 2.94
	WEYE	3	478	23	455 - 500	983	225	750 – 1200	0.58	0.29	0.36 – 0.92
	YP	3	253	25	230 - 280	187	25	160 – 210	0.73	0.12	0.60 – 0.84
Raquette River - mouth upstream one mile	CARP	3	760	30	730 - 790	7157	1975	5200 – 9150	5.19	3.32	1.56 – 8.06
	CHC	3	643	40	600 - 680	3183	126	3050 – 3300	9.83	3.76	5.49 – 12.2
	SMB	3	410	46	360 - 450	1083	381	750 – 1500	2.97	1.66	1.23 – 4.54
	WEYE	3	426	5.8	420 - 430	717	76	650 – 800	1.55	0.48	1.24 – 2.11
Raquette River - above Route 420 bridge	CARP	3	773	76	720 - 860	6500	2029	4550 – 8600	4.06	0.36	3.65 – 4.31
	SMB	3	353	29	320 - 370	583	104	500 – 700	1.09	0.51	0.53 – 1.52
	WEYE	3	493	38	450 - 520	983	257	700 – 1200	0.32	0.095	0.23 – 0.42

Appendix A continued.

Water	Species	n	Length (mm)			Weight (g)			Lipid (%)		
			Mean	SD	Min.-Max.	Mean	SD	Min.-Max.	Mean	SD	Min.-Max.
St. Regis River	CARP	3	772	104	680 - 885	7167	1831	5650 – 9200	4.79	3.77	2.57 – 9.15
- mouth	CHC	3	585	63	525 - 650	2433	825	1750 – 3350	19.46	2.82	17.5 – 22.7
upstream	SMB	3	407	25	380 - 430	1083	275	800 – 1350	3.53	1.63	2.26 – 5.38
one mile	WEYE	3	552	53	500 - 605	1567	551	1200 – 2200	1.97	0.23	1.81 – 2.24
St. Regis River	BB	3	230	20	210 - 250	167	74	110 – 250	1.73	0.38	1.49 – 2.16[4]
- above dam	SMB	3	363	35	330 - 400	717	275	450 – 1000	1.72	0.74	0.86 – 2.17
	WEYE	2	440		370 - 510	800		400 – 1200	0.83		0.66 – 1.0
	WS	3	350	87	300 - 450	517	419	250 – 1000	0.80	0.45	0.41 – 1.29
Supplemental samples											
Niagara River - lower	CARP	5	689	56	603 – 746	5108	1662	2900 – 7030	12.78	8.18	5.66 – 21.8
	LT	3	762	19	750 – 784	4213	695	3730 – 5010	14.13	4.30	11.5 – 19.1
	WS	3	468	72	400 – 544	1077	438	670 – 1540	1.58	1.05	0.73 – 2.76
Lake Ontario - western	LT	9	620	140	357 – 740	2889	1504	370 – 4237	12.07	5.26	3.81 – 19.8
- eastern	CARP	5	663	47	612 – 738	4130	890	3088 – 5455	16.21	14.75	2.73 – 39.3
	CHC	3	658	30	623 – 677	3487	558	2947 – 4062	14.22	5.90	9.75 – 20.9
	LT	3	616	49	585 – 672	2414	327	2158 – 2783	9.26	4.33	4.47 – 12.9
	WP	3	289	7	283 – 296	383	60	345 – 452	3.14	0.49	2.58 – 3.48
Keg Creek	WS	3	451	43	425 – 501	1020	442	740 – 1530	2.53	1.37	1.40 – 4.05
Eighteenmile Creek	BT	6	534	60	463 – 611	2172	891	1040 – 3140	8.43	5.59	2.79 – 17.1

Appendix A continued.

Water	Species	n	Length (mm) Mean	SD	Min.-Max.	Weight (g) Mean	SD	Min.-Max.	Lipid (%) Mean	SD	Min.-Max.
Irondequoit	CHC	3	569	18	551 – 587	1766	274	1454 – 1970	7.97	6.35	4.25 – 15.3
Bay	WP	3	297	17	280 – 315	427	113	322 – 547	5.24	2.55	2.97 – 8.0

[1] Weight of carp exceeded the capacity (2270 g) of the scale used.
[2] Recorded weight of one brown bullhead was unreliable.
[3] Recorded weight of one lake trout was unreliable.
[4] One lipid concentration was unreliable. The lipid concentration reported by the NYSDEC laboratory was substituted.

Appendix B: Detection limits and reporting limits (pg/g wet weight) for polybrominated diphenyl ethers (BDEs) in fish from New York's Great Lakes basin.

	Detection limits			Reporting limits where: No detection limits (n = 111)		Reporting limits where: Detection limits given	
Analyte	n	Median	Min.-Max.	Median	Min. - Max.	Median	Min.-Max.
BDE-1	138	50.5	11.6 - 1050	19.9	9.35 - 100	2.0	1.7 - 17.5
BDE-2	137*	29	8.45 - 559	13.3	8.7 - 62.9	2.0	1.7 - 17.5
BDE-3	138	25	6.53 - 418	11.1	8.7 - 46.2	2.0	1.7 - 17.5
BDE-7	138	1.2	0.264 - 5.7	9.76	5.61 - 27	2.0	1.7 - 17.5
BDE-8/11	138	1.0	0.25 - 5.6	19.5	11.2 - 54.1	2.0	1.7 - 17.5
BDE-10	138	1.15	0.324 - 4.5	9.76	5.61 - 27	2.0	1.7 - 17.5
BDE-11	0			9.76	5.88 - 27		
BDE-12	0			9.76	5.61 - 27		
BDE-12/13	138	0.805	0.204 - 5.0			2.0	1.7 - 17.5
BDE-15	138	0.732	0.181 - 9.9	9.76	5.61 - 27	2.0	1.7 - 17.5
BDE-17	0			9.76	5.86 - 27		
BDE-17/25	138	1.55	0.437 - 18.9			2.0	1.7 - 17.5
BDE-25	0			9.8	5.61 - 27.9		
BDE-28/33	138	1.4	0.338 - 14.6	19.5	11.2 - 54.1	2.0	1.7 - 17.5
BDE-30	138	1.55	0.35 - 17	9.8	5.61 - 27	2.0	1.7 - 17.5
BDE-32	138	1.13	0.255 - 13.6	9.76	5.61 - 27	2.0	1.7 - 17.5
BDE-35	138	1.2	0.32 - 12.3	9.76	5.88 - 27	2.0	1.7 - 17.5
BDE-37	138	1.225	0.331 - 14	9.8	5.82 - 27	2.0	1.7 - 17.5
BDE-47	138	3.665	0.608 - 250	9.8	5.61 - 56.9	2.0	1.7 - 17.5
BDE-49	0			10.1	8.7 - 44.8		
BDE-49/71	138	4.26	0.548 - 480			2.0	1.7 - 17.5
BDE-51	138	2.845	0.42 - 280	9.9	8.7 - 59.1	2.0	1.7 - 17.5
BDE-66	138	5.725	0.734 - 480	10.3	8.7 - 51.5	2.0	1.7 - 17.5
BDE-71	0			9.95	8.7 - 51.6		
BDE-75	138	3.62	0.566 - 870	9.95	8.7 - 57.9	2.0	1.7 - 17.5
BDE-77	138	3.8	0.597 - 350	9.8	5.61 - 27.1	2.0	1.7 - 17.5
BDE-79	138	3.65	0.512 - 210	9.95	8.7 - 99.9	2.0	1.7 - 17.5
BDE-85	138	2.45	1.0 - 21.2	10.2	8.7 - 27	2.0	1.7 - 17.5
BDE-99	138	1.8	0.302 - 12	9.9	8.7 - 48	2.0	1.7 - 17.5

Appendix B continued.

Analyte	Detection limits n	Detection limits Median	Detection limits Min.-Max.	Reporting limits where: No detection limits (n = 111) Median	Reporting limits where: No detection limits (n = 111) Min. - Max.	Reporting limits where: Detection limits given Median	Reporting limits where: Detection limits given Min.-Max.
BDE-100	137*	1.4	0.37 - 32	9.8	1.9 - 29	2.0	1.7 - 17.5
BDE-105	138	3.29	1.5 - 25.1	13.8	8.7 - 46.7	2.0	1.7 - 17.5
BDE-116	138	5.8	1.4 - 71.4	18.9	8.7 - 170	2.0	1.7 - 17.5
BDE-118	138	3.6	0.96 - 83.5	14.5	8.7 - 79.9	2.0	1.7 - 17.5
BDE-119/120	138	1.8	0.33 - 26	19.6	14.1 - 70.8	2.0	1.7 - 17.5
BDE-126	138	1.6	0.70 - 13.5	9.8	8.7 - 27	2.0	1.7 - 17.5
BDE-128	137*	14	1.8 - 52.4	14.75	1.9 - 47.2	2.0	1.7 - 17.5
BDE-138	0			10.7	8.7 - 28.7		
BDE-138/166	137*	5.49	1.5 - 27.1			2.0	1.7 - 17.5
BDE-140	138	3.6	0.094 - 11.3	9.8	8.7 - 27	2.0	1.7 - 17.5
BDE-153	138	4.5	2.0 - 13	9.8	8.7 - 27	2.0	1.7 - 17.5
BDE-154	138	2.3	1.01 - 8.68	9.76	7.55 - 27	2.0	1.7 - 17.5
BDE-155	138	1.6	0.662 - 6.89	9.76	8.7 - 27	2.0	1.7 - 17.5
BDE-166	0			9.8	8.7 - 27		
BDE-181	138	17.5	1.6 - 400	15.9	8.7 - 56.9	2.0	1.7 - 17.5
BDE-183	138	6.21	0.76 - 110	9.81	8.7 - 56.9	2.0	1.7 - 17.5
BDE-190	138	25.5	2.5 - 580	19.4	9.62 - 64.6	2.0	1.7 - 17.5
BDE-203	138	84	10 - 1800	38.8	9.76 - 233	2.0	1.7 - 17.5
BDE-206	138	58	4.1 - 1000	30	9.76 - 166	2.0	1.7 - 17.5
BDE-207	138	41	3.0 - 810	20	9.71 - 82.2	2.0	1.7 - 17.5
BDE-208	138	35.6	2.5 - 760	19.8	9.71 - 76.7	2.0	1.7 - 17.5
BDE-209	138	78.25	16 - 3430	187	92.6 - 1030	20	17 - 175-

* For BDE-2, BDE-100, BDE-128 and BDE-138/166, detection limits were reported for 137 samples and each had another sample with a reported detection limit of zero.

Appendix C1: Detection limits and reporting limits (pg/g wet weight) for polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) for the original 257 fish samples in New York's Great Lakes basin.

			Reporting limits where:			
	Detection limits (n = 145)		No detection limits (n = 112)		Detection limits given	
Analyte	Median	Min.-Max.	Median	Min. - Max.	Median	Min.-Max.
2,3,7,8-TCDD	0.15	0.036 - 0.48	0.086	0.040 - 0.45	0.96	0.48 - 1.6
1,2,3,7,8-PeCDD	0.14	0.031 - 0.82	0.12	0.048 - 0.62	4.8	2.4 - 8.1
1,2,3,4,7,8-HxCDD	0.16	0.026 - 0.98	0.14	0.058 - 0.76	4.8	2.4 - 8.1
1,2,3,6,7,8-HxCDD	0.16	0.028 - 1.0	0.155	0.052 - 0.77	4.8	2.4 - 8.1
1,2,3,7,8,9-HxCDD	0.17	0.025 - 0.94	0.14	0.054 - 0.54	4.8	2.4 - 8.1
1,2,3,4,6,7,8-HxCDD	0.18	0.018 - 1.4	0.10	0.047 - 0.48	4.8	2.4 - 8.1
OCDD	0.43	0.048 - 5.3	0.26	0.079 - 1.7	9.6	4.8 - 16
2,3,7,8-TCDF	0.19	0.048 - 0.57	0.11	0.040 - 0.61	0.96	0.48 - 1.6
1,2,3,7,8-PeCDF	0.17	0.027 - 0.48	0.11	0.026 - 0.85	4.8	2.4 - 8.1
2,3,4,7,8-PeCDF	0.12	0.023 - 0.50	0.095	0.018 - 0.68	4.8	2.4 - 8.1
1,2,3,4,7,8-HxCDF	0.12	0.022 - 0.86	0.11	0.029 - 0.50	4.8	2.4 - 8.1
1,2,3,6,7,8-HxCDF	0.11	0.021 - 0.93	0.105	0.037 - 0.57	4.8	2.4 - 8.1
1,2,3,7,8,9-HxCDF	0.15	0.024 - 4.9	0.135	0.044 - 0.77	4.8	2.4 - 8.1
2,3,4,6,7,8-HxCDF	0.11	0.017 - 0.90	0.11	0.036 - 0.52	4.8	2.4 - 8.1
1,2,3,4,6,7,8-HpCDF	0.17	0.018 - 0.91	0.16	0.044 - 0.84	4.8	2.4 - 8.1
1,2,3,4,7,8,9-HpCDF	0.23	0.030 - 1.5	0.19	0.057 - 1.1	4.8	2.4 - 8.1
OCDF	0.37	0.026 - 4.3	0.20	0.075 - 0.85	9.6	4.8 - 16
∑TCDD	0.15	0.036 - 0.48	0.086	0.040 - 0.45	0.96	0.48 - 1.6
∑PeCDD	0.14	0.031 - 0.82	0.12	0.048 - 0.62	4.8	2.4 - 8.1
∑HxCDD	0.16	0.029 - 0.98	0.15	0.056 - 0.68	4.8	2.4 - 8.1
∑HpCDD	0.18	0.018 - 1.4	0.10	0.047 - 0.48	4.8	2.4 - 8.1
∑TCDF	0.19	0.043 - 0.57	0.11	0.040 - 0.61	0.96	0.48 - 1.6
∑PeCDF	0.15	0.025 - 4.3	0.105	0.028 - 0.75	4.8	2.4 - 8.1
∑HxCDF	0.13	0.021 - 1.1	0.11	0.044 - 0.50	4.8	2.4 - 8.1
∑HpCDF	0.20	0.024 - 1.2	0.17	0.051 - 0.95	4.8	2.4 - 8.1

Appendix C2: Detection limits (pg/g wet weight) for polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) for 49 supplemental fish samples from the Niagara River and Lake Ontario.

Analyte	Estimated detection limits Median	Min.-Max.
2,3,7,8-TCDD	0.32	0.11 – 0.66
1,2,3,7,8-PeCDD	0.51	0.20 – 0.84
1,2,3,4,7,8-HxCDD	0.26	0.095 – 0.50
1,2,3,6,7,8-HxCDD	0.26	0.092 – 0.61
1,2,3,7,8,9-HxCDD	0.24	0.098 – 0.41
1,2,3,4,6,7,8-HxCDD	0.20	0.056 – 0.49
OCDD	0.43	0.17 – 0.90
2,3,7,8-TCDF	0.31	0.094 – 0.75
1,2,3,7,8-PeCDF	0.39	0.17 − 1.2
2,3,4,7,8-PeCDF	0.37	0.15 − 0.89
1,2,3,4,7,8-HxCDF	0.23	0.078 – 0.77
1,2,3,6,7,8-HxCDF	0.20	0.092 – 0.42
1,2,3,7,8,9-HxCDF	0.17	0.088 – 0.52
2,3,4,6,7,8-HxCDF	0.21	0.078 – 0.46
1,2,3,4,6,7,8-HpCDF	0.33	0.13 − 0.97
1,2,3,4,7,8,9-HpCDF	0.40	0.11 − 1.1
OCDF	0.36	0.11 − 0.69
∑TCDD	0.32	0.11 − 0.66
∑PeCDD	0.51	0.20 − 0.84
∑HxCDD	0.26	0.11 − 0.42
∑HpCDD	0.20	0.056 – 0.49
∑TCDF	0.31	0.094 – 0.75
∑PeCDF	0.37	0.18 – 0.85
∑HxCDF	0.21	0.10 − 0.41
∑HpCDF	0.40	0.12 − 1.0

Appendix D: Summary of analytical quality control measures for PBDE and PCDD/F analyses of fish from New York's Great Lakes basin.

This appendix provides a characterization of the quality control measures taken to generate PBDE and PCDD/F data for fish and a listing of the qualifiers applied to the data generated for fish samples.

Quality control sample assessments

Blanks

- PBDEs

Seventeen blanks were run, although four blanks were associated with more than one sample report. Only unique samples are included in the summary below unless a blank was physically analyzed twice (two cases) based on analysis dates, therefore, total n = 19 samples. PBDE congeners with interferences, noted by an I qualifier, occurred a total of 29 times and are reported by congener in Table D1. Whenever an I qualifier was assigned, an estimated maximum possible concentration of the analyte was given. However, due to the interferences, the actual quantity, if any, of the PBDE congener cannot be reliably determined. Therefore, concentrations of all I qualified data were set to the detection or reporting limit, whichever was appropriate. Occasionally, both an I and a J qualifier (J qualifier means the concentration is estimated) was applied to an analytical result. In this latter case, the I qualifier controls and the analytical result was reset to the detection limit or reporting limit, whichever was applicable.

Twenty-eight of the 29 I qualified blank data occurred with J qualified detections that were less than the practical reporting limit (PRL); the exception was BDE-128 where no J qualifier occurred.

Some blank samples had PBDE congener concentrations approximating the practical reporting limit (PRL) and were given a J qualifier (Table D1). Of these samples, some were reported as being below the PRL and while others were above the PRL. The data reported as being below the PRL were included in analytical reports for analyses conducted in 2012 and 2013 only. For the 2012-2013 data set, all blank samples having the J qualifier less than the PRL were modified by substitution of the PRL and the qualifier was eliminated. This change was carried over to fish samples associated with the affected blank samples. J qualified data greater than the PRL were used without change and associated fish samples received a B qualifier if the fish sample PBDE congener concentration was less than 10 times the associated blank congener concentration. Also, blanks with concentrations above the PRL and having no qualifiers contained detectable PBDEs that must be reflected when addressing concentrations in fish samples, i.e., assigning a B qualifier to the fish samples associated with the blank, if the reported value was less than 10 times the blank concentration.

Table D1: Number of I and J qualifiers for PBDE congeners in blank samples.

PBDE congener	Total n	Number of blanks with I or J qualifiers I	J <PRL[#]	J>PRL	IJ	No. of blanks >PRL without I or J qualifier
1	19	0	0	0	0	0
2	19	0	0	0	0	0
3	19	1	2	0	1	0
7	19	0	0	0	0	0
8/11	19	1	2	0	1	0
10	19	0	0	0	0	0
12	9	0	0	0	0	0
13	19	0	1	0	0	0
12/13	10	0	0	0	0	0
15	19	2	6	1	2	2
17	9	1	5	0	1	0
17/25	10	0	0	0	0	0
25	9	0	1	0	0	0
28/33	19	6	9	11	6	0
30	19	0	0	0	0	0
32	19	0	0	0	0	0
35	19	1	1	0	1	0
37	19	1	1	0	1	0
47	19	0	0	9	0	12
49	9	2	3	0	2	0
49/71	10	0	0	0	0	0
51	19	0	1	0	0	0
66	19	1	1	0	1	0
71	9	0	0	0	0	0
75	19	0	0	0	0	0
79	19	0	0	0	0	0
85	19	1	1	0	1	0
99	19	0	1	9	0	10
100	19	3	8	4	3	1
105	19	0	0	0	0	0
116	19	0	1	0	0	0
118	19	0	0	0	0	0
119/120	19	0	0	0	0	0
126	19	0	0	0	0	0
128	19	1	0	0	0	0
138	9	0	0	0	0	0
138/166	10	0	0	0	0	0
140	19	0	0	0	0	0
153	19	4	4	1	4	0
154	19	3	4	2	3	0
155	19	0	0	0	0	0
166	9	0	0	0	0	0
181	19	0	0	0	0	0
183	19	1	1	1	1	0

190	19	0	0	0	0	0
203	19	0	0	0	0	0
206	19	0	0	1	0	2
207	19	0	0	3	0	2
208	19	0	0	3	0	2
209	19	0	3	7	0	3
Total	853	29	57	52	28	37

[#] PRL = practical reporting limit.

- PCDD/Fs

A total of 21 blank samples were analyzed, although two samples (numbers 47120 and 47047) were reported in multiple analytical reports; multiples were included only once in the total number of blank samples. This report includes data for 17 specific 2,3,7,8-chlorine substituted PCDD/Fs and eight PCDD/F homologs. The frequency of interferences (I qualifiers) with determination of PCDD/F congeners concentrations in blanks is noted in Table D2. Due to the inability to assign a specific concentration to a congener with an interference, the concentration assigned was the detection limit or the reporting limit, whichever was appropriate. No interferences were reported with homolog analyses of blanks. The two octa-chloro-congeners (OCDD and OCDF) represent their entire respective homolog group and data are included with the congener summary.

The total number of J qualified congener data within the blanks is provided in Table D2. J qualified data indicate a quantity of the analyte is present in the blank although usually at concentrations near but above the detection or reporting limit.

Several congeners within the blanks had both I and J qualifiers (Table D2). In this instance, the I qualifier controls the final concentration which was set at the detection limit or reporting limit, whichever was appropriate. This had the impact of reducing the number of J qualified data in the blanks and, consequently, the number of fish analytical results that may be blank qualified. Analytical results for corresponding fish samples were B qualified if they were less than 10 times the blank concentration.

Table D2: Summary of I and J qualifiers for PCDD/F congeners and homologs in blank samples.

	Number of blanks with I or J qualifiers		
Congener	I	J	IJ*
2,3,7,8-TCDD	0	0	0
1,2,3,7,8-PeCDD	0	2	0
1,2,3,4,7,8-HxCDD	0	0	0
1,2,3,6,7,8-HxCDD	0	2	0
1,2,3,7,8,9-HxCDD	0	1	0
1,2,3,4,6,7,8-HpCDD	3	9	2
1,2,3,4,6,7,8,9-OCDD	2	13	2
2,3,7,8-TCDF	0	8	0
1,2,3,7,8-PeCDF	4	2	1

2,3,4,7,8-PeCDF	3	5	2
1,2,3,4,7,8-HxCDF	2	3	2
1,2,3,6,7,8-HxCDF	2	2	2
2,3,4,6,7,8-HxCDF	2	2	2
1,2,3,7,8,9-HxCDF	0	1	0
1,2,3,4,6,7,8-HpCDF	2	5	2
1,2,3,4,7,8,9-HpCDF	0	0	0
1,2,3,4,6,7,8,9-OCDF	2	2	0
Homolog			
Tetra-CDD	0	0	0
Penta-CDD	0	2	0
Hexa-CDD	0	4	0
Hepta-CDD	0	8	0
Tetra-CDF	0	8	0
Penta-CDF	0	3	0
Hexa-CDF	0	3	0
Hepta-CDF	0	3	0

* Number of samples with both I and J qualifiers.

Lab control spikes and lab control spike duplicates

Lab control spikes are known quantity spikes of "clean" tissue or other material samples subjected to the analytical method to determine the effectiveness of recovery of the spiked material. Duplicates of lab control spikes help measure the repeatability of the analytical procedure.

The measure of repeatability is called the relative percent difference (RPD) and may be either positive or negative. Only the absolute value is used for evaluations, as represented by |RPD|. The normal acceptance range would be between zero and 30%, while unacceptable values are >30%.

- PBDEs

A total of 19 lab control spikes and 19 lab control spike duplicates, each containing eight BDE compounds, were analyzed. The laboratory's acceptable recovery limits for BDE compounds were 50 to 150 percent for the seven BDEs from -28/33 through -183, and 40 to 200 percent for BDE-209. All but two recoveries of lab control spikes and their duplicates were within the limits of the analytical method (Table D3); the two unacceptable recoveries were too high. In addition, the |RPD| values for the samples and analytes were generally within acceptance limits except in two instances, both for BDE-209 where the |RPD| values were 48.9 and 51.9 percent (Table D4).

Table D3: Summary of recoveries of lab control spikes and their duplicates for PBDE compounds (n = 38 samples/analyte).

	% Recovery					No. outside
BDE-	Mean	SD	Median	Min.	Max.	acceptance
28/33	110	9.0	109	91	138	0
47	126	20	122	104	199	1
99	118	14	114	100	160	1
100	107	8.3	106	88	133	0
153	109	9.6	108	93	149	0
154	104	6.7	103	89	119	0
183	97.5	9.9	97	81	118	0
209	116	21	113	90	196	0

Table D4: Repeatability (|RPD|) of PBDE analyses (n = 19 sample pairs/analyte).

	|RPD| (%)					No. outside
BDE-	Mean	SD	Median	Min.	Max.	acceptance
28/33	3.12	2.68	2.9	0	10.4	0
47	4.11	4.92	2.7	0	21.7	0
99	4.89	2.70	5.0	0.9	9.30	0
100	3.81	3.52	3.8	0	14.5	0
153	4.82	3.77	3.7	0.9	15.2	0
154	3.51	2.72	3.8	0	8.60	0
183	5.93	4.95	4.3	0	17.8	0
209	12.4	15.1	6.2	0.9	51.9	2

- PCDD/Fs

A total of 21 lab control spikes and 21 lab control spike duplicates, each containing 17 PCDD/F compounds, were analyzed. Most recoveries (98.8%) of lab control spikes and their duplicates were within the limits of the analytical method (Table D5). Only in one instance was the recovery below 70% and in 7 instances recoveries were above 130%; in all cases, the unacceptable recoveries were marginally outside acceptance limits. In addition, the |RPD| values for the samples and analytes are generally within acceptance limits except in two instances, one each for OCDD and OCDF where the |RPD| values were 30.6 and 42.8 percent, respectively, both in the same sample pair (samples LCS-63781 and LCSD-63782) (Table D6). Overall, only 0.56% of sample pairings exceeded the |RPD| acceptance value.

Table D5: Summary of recoveries of lab control spikes and their duplicates for PCDD/F compounds (n = 42 samples/analyte).

Congener	% Recovery Mean	SD	Median	Min.	Max.	No. outside acceptance
2,3,7,8-TCDD	95.9	9.1	94	79	121	0
1,2,3,7,8-PeCDD	99.9	5.4	99	89	113	0
1,2,3,4,7,8-HxCDD	112	6.7	111	99	132	1
1,2,3,6,7,8-HxCDD	116	6.0	116	105	128	0
1,2,3,7,8,9-HxCDD	111	7.5	111	97	130	0
1,2,3,4,6,7,8-HpCDD	103	6.1	103	90	118	0
1,2,3,4,6,7,8,9-OCDD	117	8.2	114	101	143	3
2,3,7,8-TCDF	113	7.1	113	96	132	1
1,2,3,7,8-PeCDF	113	5.9	112	97	127	0
2,3,4,7,8-PeCDF	110	6.5	109	96	125	0
1,2,3,4,7,8-HxCDF	112	5.2	112	98	124	0
1,2,3,6,7,8-HxCDF	110	6.9	109	93	127	0
2,3,4,6,7,8-HxCDF	106	6.8	105	92	124	0
1,2,3,7,8,9-HxCDF	109	7.4	108	91	127	0
1,2,3,4,6,7,8-HpCDF	111	6.6	112	97	123	0
1,2,3,4,7,8,9-HpCDF	105	6.3	104	90	119	0
1,2,3,4,6,7,8,9-OCDF	109	13.6	110	67	139	3

Table D6: Repeatability of PCDD/F analyses (n = 21 sample pairs/analyte).

Congener	|RPD| Mean	SD	Median	Min.	Max.	No. outside acceptance
2,3,7,8-TCDD	4.21	3.42	3.4	0	12.3	0
1,2,3,7,8-PeCDD	3.93	3.50	3.1	0	10.4	0
1,2,3,4,7,8-HxCDD	3.98	3.46	2.8	0	13.2	0
1,2,3,6,7,8-HxCDD	4.04	3.00	3.5	0	12.2	0
1,2,3,7,8,9-HxCDD	3.36	3.27	2.0	0	10.0	0
1,2,3,4,6,7,8-HpCDD	4.96	3.28	5.0	1.0	12.6	0
1,2,3,4,6,7,8,9-OCDD	5.54	7.09	2.7	0	30.6	1
2,3,7,8-TCDF	3.43	2.19	3.5	0	7.5	0
1,2,3,7,8-PeCDF	4.08	2.90	3.6	0	9.4	0
2,3,4,7,8-PeCDF	4.50	3.56	3.8	0	14.8	0
1,2,3,4,7,8-HxCDF	4.08	3.22	2.8	0.9	11.7	0
1,2,3,6,7,8-HxCDF	4.42	4.65	2.8	0	16.9	0
2,3,4,6,7,8-HxCDF	4.80	3.62	4.2	0	12.3	0
1,2,3,7,8,9-HxCDF	4.20	3.42	3.3	0	11.4	0
1,2,3,4,6,7,8-HpCDF	4.54	3.06	3.7	0	9.8	0
1,2,3,4,7,8,9-HpCDF	3.52	3.51	2.0	0	11.5	0
1,2,3,4,6,7,8,9-OCDF	8.96	10.3	6.2	0	42.8	1

Duplicates

Six fish samples were analyzed in duplicate for 43 PBDE congeners or coeluting congeners. Where a detectable concentration of a PBDE congener was reported for each member of a congener pair, an |RPD| was calculated. In 148 of the 258 congener pairs (53.7%), an |RPD| could not be calculated (calculation of the |RPD| is not applicable, or NA) because either: A) both members of the congener pair had concentrations that were less than detection or reporting limits, or, much less frequently, B) one member of the pair was non-detect while the other member of the pair had detectable concentrations near the detection or reporting limit. Table D7 provides the |RPD| values or NA indicators for each duplicate sample and PBDE congener pair.

Seven duplicate fish samples were analyzed for the 2,3,7,8-chlorine substituted PCDD/F congeners and for the tetra- through hepta- PCDD/F homologs. As with PBDEs, an |RPD| could not be calculated for 84.0% of the congener pairs and 62.5% of the homolog pairs since either one or both members of the duplicate pair had concentrations less than the reporting limit. Table D8 provides the |RPD| values or NA indicators for each duplicate sample and PCDD/F congener or homolog pair.

Table D7: |RPD| values for PBDE congeners in six duplicate fish samples.

	|RPD| values (%) in sample:					
BDE-	13-0609-P	13-0161-P	13-0095-P	13-0450-H	13-0147-H	13-0150-P
1	NA[#]	NA	NA	NA	NA	NA
2	NA	NA	NA	NA	NA	NA
3	NA	NA	NA	NA	NA	NA
7	NA	NA	NA	NA	NA	NA
8/11	NA	NA	NA	NA	NA	NA
10	NA	NA	NA	NA	NA	NA
12/13	NA	NA	NA	NA	NA	NA
15	15.5	8.7	8.8	19.9	30.6	11.9
17/25	15.7	6.7	3.1	31.2	32.7	NA
28/33	18.4	10.6	6.4	23.5	38.3	23.2
30	NA	NA	NA	NA	NA	NA
32	NA	19.4	NA	NA	NA	NA
35	NA	NA	NA	NA	NA	NA
37	NA	25.6	NA	NA	NA	18.0
47	9.4	5.4	8.5	24.8	31.4	20.7
49/71	11.8	0.2	9.7	4.2	26.9	22.4
51	13.2	48.6	4.4	29.8	9.2	21.1
66	NA	2.4	30.0	68.9	41.3	10.0
75	NA	NA	20.6	NA	27.0	3.8
77	NA	NA	NA	NA	NA	NA
79	NA	NA	NA	NA	NA	NA
85	NA	NA	8.4	5.8	41.8	NA
99	117.8	3.2	7.9	27.1	33.5	22.0
100	15.4	3.4	7.1	24.1	35.2	22.4
105	NA	NA	NA	NA	NA	NA
116	NA	NA	NA	NA	NA	NA
118	NA	1.0	32.5	33.0	NA	NA
119/120	NA	0.5	3.1	24.4	30.7	32.2
126	NA	6.9	59.6	16.8	37.3	13.1
128	NA	11.2	NA	NA	NA	NA
138/166	NA	NA	4.0	NA	NA	NA
140	NA	9.2	NA	NA	NA	NA
153	NA	1.6	11.9	25.3	40.8	17.8
154	16.3	5.2	6.1	28.6	39.7	20.0
155	17.4	10.8	8.1	26.5	32.6	16.9
181	NA	NA	NA	NA	NA	NA
183	NA	3.8	3.6	8.1	49.8	NA
190	NA	NA	NA	NA	NA	NA
203	NA	NA	22.7	NA	NA	NA
206	NA	77.5	NA	NA	NA	NA
207	NA	87.3	2.9	NA	NA	NA
208	NA	94.9	41.6	NA	NA	NA
209	72.2	123.4	15.2	NA	102.0	NA

[#] NA = |RPD| could not be calculated, therefore, is not applicable (see text for explanation).

Table D8: |RPD| values for PCDD/F congeners or homologs in seven duplicate fish samples.

Congener/homolog	|RPD| values (%) in sample:						
	13-0495-P	13-0503-P	14-0097-H	13-0178-H	179-70256204	0257313	1090961
2,3,7,8-TCDD	NA[#]	NA	NA	11.8	23.5	NA	10.3
1,2,3,7,8-PeCDD	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDD	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDD	NA	NA	NA	NA	6.2	16.5	23.0
1,2,3,7,8,9-HxCDD	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDD	NA	NA	NA	NA	NA	NA	NA
OCDD	NA	NA	NA	NA	NA	NA	NA
2,3,7,8-TCDF	8.5	13.0	21.6	3.4	NA	NA	8.1
1,2,3,7,8-PeCDF	NA	NA	NA	3.3	NA	NA	NA
2,3,4,7,8-PeCDF	NA	5.7	12.9	9.9	19.4	14.3	13.9
1,2,3,4,7,8-HxCDF	NA	NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDF	NA	NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-HxCDF	NA	NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDF	NA	NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDF	NA	NA	NA	NA	NA	5.7	NA
1,2,3,4,7,8,9-HpCDF	NA	NA	NA	NA	NA	NA	NA
OCDF	NA	NA	NA	NA	NA	NA	NA
Tetra-CDD	NA	NA	NA	11.8	23.5	NA	10.3
Penta-CDD	NA	NA	NA	NA	NA	NA	NA
Hexa-CDD	NA	NA	NA	NA	6.2	21.9	23.0
Hepta-CDD	NA	NA	NA	NA	NA	NA	NA
Tetra-CDF	21.1	13.0	21.6	30.0	0.7	9.1	2.2
Penta-CDF	NA	5.7	12.9	18.0	19.4	14.3	3.3
Hexa-CDF	NA	NA	NA	NA	NA	NA	11.0
Hepta-CDF	NA	NA	NA	NA	NA	5.7	NA

[#] NA = |RPD| could not be calculated, therefore, is not applicable (see text for explanation).

Internal standards (Isotope Dilution)

Every sample, whether a fish tissue or quality control sample, was injected with isotopically-labeled analytes as internal standards that provided the basis for adjusting sample data to obtain more accurate analytical results. The recovery of each analyte is assessed against general criteria within the analytical method. Where an analyte result exceeds criteria, an R qualifier is applied to the internal standard recovery. The qualifier does not change the application of the internal standard to computation of the reported analytical result but indicates there is some basis for concern for the reported result for that particular sample. As stated in the data package narratives from the laboratory and in follow up conversations with laboratory personnel, the laborory generally considers that isotope dilution provides valid results with labeled standard recovery as low as 5%.

The following assessment applies to the entire data set, i.e., the combination of fish samples plus quality control samples. The total number of internal standard samples was 315 and 381 for PBDEs and PCDD/Fs, respectively.

- PBDEs

The 13C-labeled compounds were BDEs -28, -47, -99, -100, -153, -154, -183 and -209. Low recovery (20 % or less) of 13C-BDE-209 occurred frequently (32.8 % of fish samples). Similarly, low recovery (30 % or less) of 13C-BDE-183 occurred in 24.4 % of fish samples. Other BDE internal controls seldom had an R qualifier.

In an anomaly, 13C-labeled BDE-209 was not detected in the internal standard for sample 13-0082-H. Consequently, the practical reporting limit was highly elevated causing the reported BDE-209 concentration to be non-detect.

- PCDD/Fs

For 2,3,7,8-substituted PCDD/Fs, 15 of the 17 compounds were injected with 13C isotopically-labeled internal standards in each sample; the two compounds excluded were 1,2,3,7,8,9-HxCDD and OCDF. In addition, 2,3,7,8-TCDD-37Cl4 was used as an internal standard.

Overall, recovery of internal standards was excellent. None of the internal standards for fish samples received an R qualifier. Only one quality control sample, a blank (number 46564), received R qualifiers. Recoveries of internal controls for all other quality control samples were within acceptance ranges for the analytical method. The R qualified blank had lower than desired recovery for most internal standard analytes, but only five were R qualified, i.e., 1,2,3,6,7,8-HxCDF, 2,3,4,6,7,8-HxCDF, 1,2,3,4,7,8-HxCDD, 1,2,3,6,7,8-HxCDD and 1,2,3,4,6,7,8-HpCDF. The concentrations reported for these analytes in the blank were all non-detect. There was, therefore, little if any apparent impact of low recovery on the blank.

Qualifiers in fish samples

B qualifiers

- PBDEs

A total of 347 analytical results out of 11,198 determinations (3.1 %) for PBDEs in fish samples were blank qualified. Of these, BDE-209 accounted for 41.2 % of the qualifiers while BDE-15 and BDE-99 contributed 19.6 and 16.4 % of the B qualifiers. The B qualifiers were assigned to the following numbers of samples and percentages of the fish samples (Table D9).

Table D9: Numbers of fish samples analyzed for PBDEs having a B qualifier[a].

PBDE congener	Number	% of fish samples
3	5	2.0
8/11	5	2.0
28/33	5	2.0
12	5	4.5[b]
15	68	27.2
17	3	2.7[b]
25	1	0.9[b]
99	57	22.8
154	2	0.8
183	3	1.2
206	8	3.2
207	23	9.2
208	19	7.6
209	143	57.2

[a] Total n = 250 fish samples unless otherwise footnoted.
[b] Only 112 fish samples were analyzed for BDE-12, BDE-17 and BDE-25.

- PCDD/Fs

A total of 368 analytical results (7.1 %) for PCDD/F congeners and 263 analytical results for PCDD/F homologs (10.7 %) in fish samples were blank qualified. Of these, OCDD accounted for 30.7 % of the qualifiers. The B qualifiers were assigned to the following numbers of samples and percentages of the fish samples (Table D10).

Table D10: Numbers of fish samples analyzed for PCDD/Fs having a B qualifier[a].

Congener	Number	% of fish samples
2,3,7,8-TCDD	0	0
1,2,3,7,8-PeCDD	19	6.2
1,2,3,4,7,8-HxCDD	0	0
1,2,3,6,7,8-HxCDD	9	2.9
1,2,3,7,8,9-HxCDD	2	0.6
1,2,3,4,6,7,8-HpCDD	75	24.5
1,2,3,4,6,7,8,9-OCDD	113	36.9
2,3,7,8-TCDF	72	23.5
1,2,3,7,8-PeCDF	17	5.5
2,3,4,7,8-PeCDF	26	8.5
1,2,3,4,7,8-HxCDF	15	4.9
1,2,3,6,7,8-HxCDF	0	0
2,3,4,6,7,8-HxCDF	0	0
1,2,3,7,8,9-HxCDF	0	0
1,2,3,4,6,7,8-HpCDF	19	6.2
1,2,3,4,7,8,9-HpCDF	1	0.3
1,2,3,4,6,7,8,9-OCDF	0	0
Homolog		
Tetra-CDD	10	3.3
Penta-CDD	23	7.5
Hexa-CDD	26	8.5
Hepta-CDD	119	38.9
Tetra-CDF	0	0
Penta-CDF	25	8.2
Hexa-CDF	37	12.1
Hepta-CDF	23	7.5

[a] Total n = 306 fish samples.

Qualifiers for interferences (I and P qualifiers)

- PBDEs

A total of 1044 of the 11,198 PBDE data points (9.3 %) for fish samples are I qualified. The distribution of I qualified BDEs is listed in Table D11. Over 50 % of the concentrations of BDE-11, -30 and -35 in fish samples contained unacceptable interferences and were I qualified. All I qualified concentrations were reset to less than the detection limit or reporting limit, whichever was applicable.

For PBDEs, there are no P qualifiers since the qualifier applies only to PCDD/Fs due to interference by polychlorinated diphenyl ethers (PCDEs).

Table D11: Numbers of fish samples with I qualified PBDE data[a].

PBDE congener	Number	% of fish samples
2	4	1.6
3	21	8.4
7	22	8.8
8/11	42	16.8
11	70	62.5[b]
12	32	28.5[b]
12/13	37	26.8[c]
15	33	13.2
17	8	7.1[b]
17/25	8	5.8[c]
25	11	9.8[b]
30	205	82.0
32	32	12.8
35	190	76.0
37	34	13.6
51	13	5.2
66	12	4.8
71	8	7.1[b]
75	31	12.4
77	14	5.6
79	26	10.4
85	6	2.4
99	4	1.6
116	17	6.8
118	16	6.4
119/120	9	3.6
126	43	17.2
128	20	8.0
138/166	5	3.6
140	26	10.4
153	12	4.8
155	3	1.2
166	1	0.9[b]
183	28	11.2
190	1	0.4

[a] Total n = 250 fish samples unless otherwise footnoted.
[b] n = 112 fish samples.
[c] n = 138 fish samples.

- PCDD/Fs

Only PCDD/F congener determinations contained I qualifiers and only PCDF congeners contained P qualifiers. Out of the 7650 PCDD/F congener or homolog determinations, a total of 721 analytical determinations (9.2 %) were I qualified and 354 analytical determinations (4.5 %) were P qualified. A listing of the numbers of samples with I or P qualifiers are found in Table D12.

Table D12: Number of fish samples analyzed for PCDD/Fs having an I or P qualifier[a].

	I qualifier		P qualifier	
Congener	Number	% of samples	Number	% of samples
2,3,7,8-TCDD	63	20.6	0	0
1,2,3,7,8-PeCDD	75	24.5	0	0
1,2,3,4,7,8-HxCDD	55	18.0	0	0
1,2,3,6,7,8-HxCDD	64	20.9	0	0
1,2,3,7,8,9-HxCDD	22	7.2	0	0
1,2,3,4,6,7,8-HpCDD	110	35.9	0	0
1,2,3,4,6,7,8,9-OCDD	71	23.2	0	0
2,3,7,8-TCDF	19	6.2	7	2.3
1,2,3,7,8-PeCDF	43	14.0	77	25.2
2,3,4,7,8-PeCDF	45	14.7	11	3.6
1,2,3,4,7,8-HxCDF	7	2.3	62	20.3
1,2,3,6,7,8-HxCDF	30	9.8	127	41.5
2,3,4,6,7,8-HxCDF	23	7.5	0	0
1,2,3,7,8,9-HxCDF	1	0.3	0	0
1,2,3,4,6,7,8-HpCDF	19	6.2	70	22.9
1,2,3,4,7,8,9-HpCDF	7	2.3	0	0
1,2,3,4,6,7,8,9-OCDF	19	6.2	0	0

[a] Total n = 306 fish samples.

Appendix E: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish[1].

[1] Total BDE concentrations are in Table 6 of the report.

The following rules were used in the presentation of data for polybrominated diphenyl ethers (PBDEs or BDEs) in fish in the eleven sub-appendices within Appendix E.

a. The parenthetic value for each species in column headings is the total number of samples analyzed.

b. "nd" indicates there were no detections of a specific BDE for the location and species. Similarly, "na" indicates no analyses were conducted for the specific BDE in the species and location.

c. In the body of each table, the mean concentration is the first value given for each BDE for each species and location. The mean only is given when fewer than 80% of samples within the species and location have detectable concentrations. Where samples lacked detection of the BDE congener, the non-detect was assigned a value of zero for computation of the mean.

d. The standard deviation is given when 80% or more of the sample values have detectable concentrations. Again, non-detects were assigned a value of zero for computations.

e. Parenthetic values within the sample data are the number of samples with detectable concentrations of the specific BDE congener. However, where a mean and standard deviation are given but are without a parenthetic value, all samples of the given species at the location contained the specified BDE at detectable concentrations.

f. The number on the second line following the mean concentration is the maximum BDE congener concentration determined for the species and location.

Appendix E1: Mean concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from Lake Erie and Chautauqua Creek.

	Lake Erie					Chautauqua Creek
Analyte	CARP (5)	CHC (5)	LT (6)	SMB (3)	WEYE (3)	RT (3)
BDE-1	nd	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd	nd
BDE-7	nd	nd	nd	nd	nd	nd
BDE-8/11	nd	nd	0.483 (1) 2.90	nd	nd	nd
BDE-10	nd	nd	nd	nd	nd	nd
BDE-11	na	na	na	nd	nd	nd
BDE-12	na	na	na	nd	nd	nd
BDE-12/13	1.02 (1) 5.10	0.26 (1) 1.30	0.30 (1) 1.80	na	na	na
BDE-15	27.6 ± 11.0 39.0	5.16 ± 3.67 (4) 9.50	6.57 (4) 15.0	nd	nd	3.80 (1) 11.4
BDE-17	na	na	na	nd	nd	4.17 (1) 12.5
BDE-17/25	186 ± 98.6 310	48.4 ± 26.9 84.0	36.3 (4) 79.0	na	na	na
BDE-25	na	na	na	3.67 (1) 11.0	14.4 ± 4.10 18.5	26.4 ± 9.72 34.1
BDE-28/33	2980 ± 1440 4500	188 ± 72.9 300	236 ± 147 490	29.6 ± 6.93 37.1	54.9 ± 18.4 75.6	128 ± 48.8 179
BDE-30	nd	nd	nd	nd	nd	nd
BDE-32	6.30 (3) 13.0	1.66 (2) 5.70	3.87 ± 2.25 6.00	nd	nd	nd
BDE-35	nd	nd	nd	nd	nd	nd
BDE-37	0.92 (1) 4.60	1.24 (1) 6.20	6.57 ± 2.38 9.10	nd	nd	nd
BDE-47	20800 ± 10400 35000	9240 ± 4900 17000	8420 ± 3580 14000	1310 ± 289 1640	2250 ± 997 3150	3760 ± 1200 4910
BDE-49	na	na	na	216 ± 12.1 229	264 ± 93.8 332	348 ± 127 437

BDE-49/71	2730 ± 1720	1180 ± 534	495 ± 164	na	na	na
	4500	2100	720			
BDE-51	202 ± 122	74.8 ± 38.3	65.5 ± 26.7	17.0 ± 3.52	19.0 ± 7.28	14.9 (2)
	340	140	110	21.1	26.7	32.7
BDE-66	nd	184 ± 109	68.0 ± 61.7(5)	50.1 ± 20.0	19.4 (2)	53.3 ± 23.7
		360	180	72.5	40.7	75.4
BDE-71	na	na	na	27.9 ± 13.1	24.8 ± 7.00	nd
				37.7	32.8	
BDE-75	17.8 (3)	21.8 ± 13.4	20.5 ± 8.48	nd	nd	5.00 (1)
	43.0	45.0	34.0			15.0
BDE-77	nd	2.40 (1)	2.50 (1)	nd	nd	nd
		12.0	15.0			
BDE-79	nd	14.8 (2)	28.3 (2)	9.33 (2)	11.5 (2)	31.7 ± 10.6
		63.0	120	15.9	20.2	40.2
BDE-85	nd	22.0 ± 19.8	nd	nd	nd	nd
		54.0				
BDE-99	6.94 ± 3.20	5160 ± 3480 (4)	950 ± 392	732 ± 107	394 ± 205	645 ± 242
	12.3	11000	1600	863	518	846
BDE-100	6940 ± 2810	5480 ± 3390	2630 ± 1040	867 ± 186	767 ± 372	1160 ± 317
	10000	11000	4300	1080	1010	1470
BDE-105	nd	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd	nd
BDE-118	nd	116 ± 71.2	29.5 ± 16.1	8.87 (1)	12.4 (2)	13.4 (2)
		230	58.0	26.6	20.7	24.5
BDE-119/120	115 ± 50.0	558 ± 287	303 ± 113	36.7 ± 5.38	20.1 (2)	44.1 ± 13.3
	160	1000	490	42.9	32.8	58.3
BDE-126	54.2 ± 30.4	64.6 ± 43.8	21.3 ± 7.92	19.6 (2)	9.77 (2)	13.1 ± 3.24
	92.0	140	35.0	35.7	15.9	16.7
BDE-128	3.20 (1)	31.8 ± 26.2 (4)	6.83(2)	nd	nd	nd
	16.0	72.0	24.0			
BDE-138	na	na	na	nd	nd	nd
BDE-138/166	nd	19.6 ± 15.1 (4)	nd	na	na	na
		42.0				
BDE-140	nd	15.0 ± 13.8 (4)	6.00 (3)	nd	nd	nd
		37.0	16.0			
BDE-153	28.6 ± 19.7	2400 ± 1630	563 ± 219	374 ± 66.4	214 ± 131	298 ± 69.9
	60.0	5000	920	444	312	352
BDE-154	2780 ± 1110	3440 ± 2270	1230 ± 427	552 ± 95.5	373 ± 220	585 ± 140
	4300	7100	1900	647	544	709

BDE-155	446 ± 215 750	582 ± 337 1100	152 ± 47.7 230	122 ± 16.2 140	61.1 ± 38.3 95.0	77.2 ± 20.2 97.8
BDE-166	na	na	na	nd	nd	nd
BDE-181	nd	3.80 (1) 19.0	nd	nd	nd	nd
BDE-183	nd	82.2 ± 51.6 170	13.1 ± 11.1 (5) 33.0	nd	nd	13.0 (2) 19.8
BDE-190	nd	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	nd	nd
BDE-206	nd	nd	nd	nd	nd	nd
BDE-207	nd	5.00 (1) 25.0	5.67 (1) 34.0	nd	nd	nd
BDE-208	nd	3.44 (1) 17.2	nd	nd	nd	nd
BDE-209	nd	52.0 (1) 260	43.3 (1) 260	161 (1) 483	90.0 (1) 270	nd

Appendix E2: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the upper Niagara River and Cayuga Creek.

	Upper Niagara River			Cayuga Creek			
Analyte	CARP (5)	LMB (3)	SMB (3)	BB (6)	CARP (5)	LMB (5)	RB (5)
BDE-1	nd	nd	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd	nd	nd
BDE-7	nd	nd	nd	nd	2.66 (1) 13.3	nd	nd
BDE-8/11	nd	nd	nd	nd	4.20 (1) 21.0	nd	nd
BDE-10	nd	nd	nd	nd	nd	nd	nd
BDE-11	nd	nd	nd	nd	nd	nd	nd
BDE-12	nd	nd	nd	nd	nd	nd	nd
BDE-12/13	na	na	na	na	na	na	na
BDE-15	nd	nd	nd	nd	19.8 ± 13.0 (4) 35.4	nd	nd
BDE-17	88.6 (2) 425	5.57 (1) 16.7	4.97 (1) 14.9	2.52 (1) 15.15	198 ± 97.8 329	25.3 ± 6.48 33.3	nd
BDE-17/25	na	na	na	na	na	na	na
BDE-25	42.7 (3) 194	11.4 (2) 22.2	20.0 ± 2.21 21.6	3.20 (1) 19.2	68.9 ± 34.8 101	14.9 ± 9.87 (4) 24.4	5.70 (2) 18.4
BDE-28/33	676 ± 1320 3040	95.8 ± 56.6 161	90.0 ± 31.6 126	42.1 (3) 204	3900 ± 1840 5480	174 ± 72.6 263	51.6 ± 10.1 60.1
BDE-30	nd	nd	nd	nd	nd	nd	nd
BDE-32	nd	nd	nd	nd	2.24 (1) 11.2	nd	nd
BDE-35	nd	nd	nd	nd	nd	nd	nd
BDE-37	nd	nd	nd	nd	nd	nd	nd
BDE-47	9780 ± 19100 43900	4150 ± 1850 6240	5580 ± 3280 9290	2280 ± 1550 (5) 4650	46400 ± 26700 89600	11100 ± 6390 20000	3610 ± 1530 5850
BDE-49	368 ± 638 1510	283 ± 84.2 351	481 ± 61.5 553	66.4 ± 69.8 204	1810 ± 1400 4170	516 ± 209 749	110 ± 43.7 165
BDE-49/71	na	na	na	na	na	na	na
BDE-51	46.0 (2) 217	19.1 ± 6.48 26.3	28.2 ± 7.47 36.7	21.3 (3) 97.9	244 ± 148 402	31.4 ± 8.07 38.9	nd
BDE-66	nd	49.3 ± 30.1 84.0	139 ± 53.6 199	62.4 ± 96.9 (5) 258	nd	108 ± 43.5 172	59.9 ± 23.0 100

BDE-71	7.04 (1) 35.2	39.6 ± 12.4 50.0	62.5 ± 4.77 66.5	9.03 (3) 30.6	199 ± 101 282	43.7 ± 30.2 (4) 82.0	20.8 (3) 41.2
BDE-75	nd	5.67 (1) 17.0	8.37 (2) 12.9	6.48 (1) 38.9	40.7 (3) 87.4	11.0 (3) 24.5	nd
BDE-77	nd	nd	nd	nd	nd	nd	nd
BDE-79	nd	9.63 (2) 16.5	15.3 (2) 29.9	nd	nd	nd	nd
BDE-85	nd	nd	nd	160 ± 245 659	nd	nd	nd
BDE-99	6.02 (1) 30.1	552 ± 39.1 583	3090 ± 1590 4830	4820 ± 4830 14400	nd	2280 ± 1040 3880	1250 ± 504 1860
BDE-100	1390 ± 2580 6000	1470 ± 662 2160	2010 ± 590 2690	1900 ± 2370 6670	8800 ± 4870 16400	2510 ± 1460 4540	740 ± 296 1150
BDE-105	nd	nd	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd	nd	nd
BDE-118	nd	13.1 (2) 27.2	52.4 ± 4.68 57.8	28.5 ± 22.2 (5) 63.9	nd	20.8 ± 6.33 27.7	5.88 (2) 17.2
BDE-119/120	13.5 (1) 67.3	33.2 ± 9.86 40.2	38.6 (2) 78.7	33.3 (3) 105	51.0 (2) 132	49.4 (3) 131	30.3 (3) 63.0
BDE-126	19.6 (1) 98.2	20.3 ± 8.19 27.5	27.7 ± 5.72 34.3	nd	21.6 (3) 43.6	1.92 (1) 9.60	nd
BDE-128	8.20 (1) 41.0	nd	nd	nd	nd	nd	nd
BDE-138	nd	nd	nd	20.6 (2) 82.6	nd	nd	nd
BDE-138/166	na	na	na	na	na	na	na
BDE-140	nd	nd	nd	21.1 (3) 82.7	nd	nd	nd
BDE-153	13.2 (2) 55.2	416 ± 205 603	843 ± 203 1030	648 ± 392 1240	46.2 (3) 170	464 ± 249 836	207 ± 98.7 315
BDE-154	589 ± 1110 2580	607 ± 204 789	941 ±222 1160	534 ± 465 1400	2780 ± 1550 5320	813 ± 469 1380	264 ± 112 424
BDE-155	78.6 ± 152 (4) 350	102 ± 42.1 127	139 ± 44.6 184	50.7 ± 39.3 119	412 ± 196 703	107 ± 43.1 155	20.3 (3) 47.9
BDE-166	nd	nd	nd	10.2 (3) 26.4	nd	nd	nd
BDE-181	nd	nd	nd	nd	nd	nd	nd
BDE-183	nd	nd	4.33 (1) 13.0	39.8 ± 24.4 (5) 64.9	nd	nd	nd
BDE-190	nd	nd	nd	nd	nd	nd	nd

BDE-203	nd	nd	nd	nd	nd	nd	nd
BDE-206	nd	nd	nd	70.7 (2) 249	nd	nd	8.02 (1) 40.1
BDE-207	nd	nd	nd	77.0 (3) 249	nd	nd	nd
BDE-208	nd	nd	nd	22.2 (1) 133	nd	nd	nd
BDE-209	nd	nd	nd	541 (3) 2620	nd	nd	nd

Appendix E3: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the lower Niagara River and Lake Ontario.

	Lower Niagara River		Lake Ontario					
Analyte	CARP (5)	SMB (3)	BT (3)	CHC (3)	COS (3)	LT (18)	SMB (6)	WP (6)
BDE-1	nd	nd	nd	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd	nd	nd	nd
BDE-3	nd	3.37 (1) 10.1	nd	nd	nd	nd	nd	nd
BDE-7	nd	nd	nd	nd	nd	nd	nd	nd
BDE-8/11	4.16 (1) 20.8	nd	nd	nd	nd	nd	nd	nd
BDE-10	nd	nd	nd	nd	nd	nd	nd	nd
BDE-11	nd	nd	nd	nd	nd	nd	nd	nd
BDE-12	2.24 (1) 11.2	nd	nd	nd	nd	nd	nd	nd
BDE-12/13	na	na	na	na	na	na	na	na
BDE-15	27.6 (3) 75.8	nd	20.3 ± 2.80 23.5	nd	nd	23.3 ± 10.7 (17) 46.2	nd	nd
BDE-17	162 ± 149 393	49.3 ± 11.1 61.2	38.6 ± 11.9 48.1	70.6 ± 51.1 129	37.1 ± 7.46 43.3	53.9 ± 30.0 (17) 107	4.27 (2) 13.5	28.3 (4) 75.8
BDE-17/25	na	na	na	na	na	na	na	na
BDE-25	110 ± 106 270	48.3 ± 21.2 72.8	114 ± 13.5 127	46.1 ± 22.0 69.1	20.0 (2) 37.8	159 ± 68.3 264	10.9 (3) 30.8	24.6 (4) 74.2
BDE-28/33	1750 ± 1340 3850	271 ± 113 401	433 ± 70.6 501	296 ± 170 457	195 ± 56.7 260	791 ± 365 1380	71.4 ± 55.3 (5) 144	98.3 ± 47.5 193
BDE-30	nd	nd	nd	nd	nd	nd	nd	nd
BDE-32	3.36 (1) 16.8	nd	7.35 (2) 12.7	nd	nd	7.90 (9) 18.2	nd	nd
BDE-35	nd	nd	nd	nd	nd	nd	nd	nd
BDE-37	nd	nd	3.53 (1) 10.6	nd	nd	10.6 (11) 24.0	nd	nd
BDE-47	19600 ± 15800 44100	14600 ± 6610 22200	10200 ± 1860 12100	15100 ± 7370 21100	5130 ± 1600 6960	22700 ± 10900 38800	2660 ± 2060 5020	3000 ± 1540 5840
BDE-49	1590 ± 1320 3300	1530 ± 706 2340	1290 ± 278 1610	957 ± 362 1270	319 ± 31.2 353	1520 ± 809 3550	364 ± 282 693	323 ± 180 666
BDE-49/71	na	na	na	na	na	na	na	na

BDE-51	192 ± 135 342	80.9 ± 13.0 95.8	66.7 ± 32.3 104	112 ± 69.9 192	46.3 ± 23.3 66.4	134 ± 73.3 360	22.1 (4) 50.3	30.6 ± 24.2 73.9
BDE-66	3.76 (1) 18.8	556 ± 206 787	368 ± 37.2 407	323 ± 134 465	125 ± 8.54 133	721 ± 375 1760	111 ± 107 (5) 269	21.9 ± 7.01 32.6
BDE-71	nd	78.7 ± 61.7 150	19.0 (2) 32.7	138 ± 83.1 226	40.6 ± 15.1 51.9	121 (11) 1890	21.9 (2) 86.8	19.1 (2) 65.2
BDE-75	32.7 ± 26.0 (4) 65.8	36.1 ± 12.3 50.0	42.3 ± 1.72 44.2	10.9 (1) 32.8	11.4 (2) 24.5	67.9 ± 38.4 (17) 124	6.20 (2) 19.9	1.95 (1) 11.7
BDE-77	nd	nd	16.1 ± 2.66 18.9	nd	nd	35.0 ± 16.0 84.1	nd	nd
BDE-79	nd	48.7 (2) 105	66.8 ± 8.50 75.2	nd	28.0 (2) 45.3	137 ± 82.2 (17) 328	17.2 (2) 61.7	4.20 (2) 14.7
BDE-85	nd	nd	nd	44.9 ± 26.3 75.1	nd	nd	nd	nd
BDE-99	7.48 (1) 37.4	7670 ± 3050 11000	4360 ± 542 4780	6480 ± 2500 8220	1400 ± 127 1540	7690 ± 3650 13400	1105 ± 1070 2740	12.6 (3) 36.6
BDE-100 289	3880 ± 2860 8390	5100 ± 2250 7650	3040 ± 327 3400	4050 ± 1640 5340	1380 ± 314 1730	6500 ± 3110 11500	1110 ± 940 2390	719 ± 1250
BDE-105	nd	nd	nd	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd	nd	nd	nd
BDE-118	nd	109 ± 40.7 155	111 ± 14.2 123	77.4 ± 31.8 113	40.7 ± 2.1 43.1	216 ±109 412	23.5 (4) 53.1	nd
BDE-119/120	47.9 (3) 91.2	110 ± 48.2 165	95.2 ± 5.92 100	219 ± 140 365	194 ± 29.4 228	209 ± 77.8 320	61.9 ± 45.8 (5) 122	25.0 (3) 63.0
BDE-126	52.9 ± 22.3 89.3	40.9 (2) 80.6	31.7 ± 6.68 37.3	15.7 (2) 33.7	nd	87.6 ± 58.0 (16) 240	14.4 (2) 51.8	6.58 (2) 24.5
BDE-128	nd	nd	21.7 (2) 35.6	nd	nd	67.8 ± 42.9 (16) 143	nd	nd
BDE-138	nd	nd	nd	11.2 (2) 20.4	nd	nd	nd	nd
BDE-138/166	na	na	na	na	na	na	na	na
BDE-140	nd	nd	17.6 ± 5.88 24.3	22.4 ± 10.7 34.8	7.07 (1) 21.2	31.1 ± 13.8 (17) 51.0	nd	nd
BDE-153 70.9	52.2 ± 42.9 (4) 106	1960 ± 807 2850	1000 ± 118 1130	1450 ± 487 1880	358 ± 65.9 432	2340 ± 1190 4670	512 ± 498 1360	140 ± 260
BDE-154 135	1730 ± 1160 3580	2340 ± 972 3420	1500 ± 80.8 1590	1820 ± 696 2370	721 ± 114 853	3950 ± 1960 8080	739 ± 648 1780	398 ± 639
BDE-155 35.2	221 ± 105 392	279 ± 110 397	160 ± 23.7 180	354 ± 145 490	86.3 ± 14.4 102	398 ± 220 918	118 ± 79.7 (5) 226	107 ± 158

BDE-166	nd	nd	nd	11.0 (1) 32.9	nd	nd	nd	nd
BDE-181	nd	nd	nd	nd	nd	nd	nd	nd
BDE-183	nd	4.77 (1) 14.3	36.9 ± 14.1 52.9	52.5 ± 18.0 72.3	12.4 (2) 24.0	74.7 ± 35.2 (17) 134	3.88 (2) 13.7	nd
BDE-190	nd	nd	nd	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	nd	nd	nd	nd
BDE-206	nd	nd	nd	nd	31.0 (1) 93.1	nd	nd	nd
BDE-207	nd	nd	nd	65.8 (2) 104	19.2 (1) 57.7	nd	nd	nd
BDE-208	nd	nd	nd	17.8 (1) 53.3	9.83 (1) 29.5	nd	nd	nd
BDE-209	nd	nd	nd	166 (2) 251	151 (1) 452	nd	nd	nd

Appendix E4: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the Salmon River Hatchery and the St. Lawrence River at Cape Vincent.

	Salmon River Hatchery			St. Lawrence River at Cape Vincent			
Analyte	CHS (12)	COS (6)	RT (6)	BB (1)	CARP (3)	SMB (3)	WEYE (3)
BDE-1	nd	nd	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd	nd	nd
BDE-7	nd	nd	1.75 (1) 10.5	nd	nd	nd	nd
BDE-8/11	nd	nd	nd	nd	9.77 ± 6.93 16.0	nd	0.784 (2) 1.65
BDE-10	nd	nd	nd	nd	nd	nd	nd
BDE-11	nd	nd	nd	na	na	na	na
BDE-12	nd	nd	nd	na	na	na	na
BDE-12/13	na	na	na	nd	1.43 (1) 4.30	nd	0.181(1) 0.544
BDE-15	3.20 (9) 13.2	nd	2.97 (1) 17.8	nd	21.4 ± 15.5 36.0	1.10 (1) 3.30	2.77 (2) 5.78
BDE-17	69.4 ± 54.7 (11) 138	107 ± 14.9 123	76.2 ± 33.5 133	na	na	na	na
BDE-17/25	na	na	na	1.44	137 ± 91.8 200	33.0 ± 6.24 38.0	31.8 ± 25.9 61.7
BDE-25	142 ± 28.5 173	112 ± 63.0 (5) 185	64.3 ± 37.0 (5) 111	na	na	na	na
BDE-28/33	804 ± 164 1020	790 ± 65.4 882	474 ± 156 770	14.5	1060 ± 866 1900	143 ± 35.1 180	155 ± 96.4 266
BDE-30	nd	nd	nd	nd	nd	nd	nd
BDE-32	2.74 (3) 11.9	nd	nd	nd	2.33 (1) 6.70	1.00 (1) 3.00	nd
BDE-35	nd	nd	nd	nd	nd	nd	nd
BDE-37	5.08 (5) 14.3	nd	1.63 (1) 9.81	nd	nd	3.17 ± 0.32 3.40	0.78 (1) 2.34
BDE-47	26200 ± 6050 39300	22000 ± 1720 24400	16400 ± 4570 24700	640	7470 ± 6230 14000	5130 ± 1650 6500	9180 ± 10400 21200
BDE-49	2070 ± 480 2710	1170 ± 435 1730	1260 ± 472 2080	na	na	na	na

BDE-49/71	na	na	na	70.4	777 ± 552 1300	850 ± 272 1100	1190 ± 1240 2620
BDE-51	159 ± 45.2 234	171 ± 56.5 247	152 ± 45.5 200	14.8	77.0 ± 51.4 120	50.0 ± 8.00 58.0	52.3 ± 47.1 106
BDE-66	607 ± 146 934	593 ± 58.7 708	417 ± 108 598	11.8	nd	91.0 ± 16.8 110	130 ± 128 276
BDE-71	62.2 (6) 194	96.2 ± 80.3 258	140 ± 37.1 181	na	na	na	na
BDE-75	77.2 ± 26.6 135	58.3 ± 34.2 (5) 101	63.5 ± 26.3 115	nd	8.33 (2) 14.0	10.3 (2) 19.0	19.0 (2) 47.8
BDE-77	21.8 ± 12.1 (10) 38.4	23.1 ± 12.2 (5) 32.2	4.02 (1) 24.1	2.91	nd	nd	7.70 (2) 18.4
BDE-79	50.2 (6) 148	54.7 (3) 143	141 (3) 406	11.8	nd	28.0 (2) 47.0	86.2 ± 94.6 195
BDE-85	nd	nd	nd	4.48	nd	nd	nd
BDE-99	8230 ± 1970 11900	8040 ± 903 9070	5140 ± 1240 7410	431	36.7 (1) 110	2170 ± 902 3100	2880 ± 3160 6530
BDE-100	7060 ± 1530 10200	6040 ± 614 6720	4930 ± 1310 6950	450	1400 ± 1100 2500	2000 ± 721 2600	2850 ± 3150 6480
BDE-105	nd	nd	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd	nd	nd
BDE-118	235 ± 70.7 346	212 ± 35.0 266	119 ± 34.2 180	26.0	nd	53.7 ± 18.0 72.0	102 ± 108 226
BDE-119/120	433 ± 442 1310	705 ± 99.9 786	405 ± 307 993	103	18.0 (2) 34.0	250 ± 72.1 310	450 ± 477 1000
BDE-126	50.3 ± 27.1 96.0	21.2 (4) 35.3	14.7 (4) 28.4	15.6	9.67 (2) 16.0	29.3 ± 6.66 35.0	28.8 (2) 71.0
BDE-128	61.6 (7) 139	69.6 ± 34.6 (5) 89.8	nd	nd	nd	8.67 (1) 26.0	nd
BDE-138	nd	nd	nd	na	na	na	na
BDE-138/166	na	na	na	nd	nd	nd	nd
BDE-140	35.5 ± 15.3 (11) 64.4	46.0 ± 4.63 51.6	17.7 (4) 34.7	nd	nd	8.33 ± 0.153 8.50	7.47 (1) 22.4
BDE-153	2110 ± 430 3030	1770 ± 222 2040	1440 ± 446 2190	452	16.0 ± 8.93 26.0	1080 ± 299 1300	1000 ± 1110 2290
BDE-154	3430 ± 632 4680	3000 ± 364 3420	2400 ± 724 3420	734	603 ± 421 1000	1700 ± 458 2100	1830 ± 2030 4170
BDE-155	333 ± 71.0 435	303 ± 27.4 333	307 ± 95.8 429	126	84.3 ± 54.5 130	250 ± 62.4 300	229 ± 246 512

BDE-166	nd	nd	nd	na	na	na	na
BDE-181	nd	nd	nd	nd	nd	nd	nd
BDE-183	38.3 (9) 79.7	53.8 ± 11.0 70.3	6.32 (1) 37.9	59.5	nd	8.67 (2) 13.0	20.5 (2) 51.4
BDE-190	nd	nd	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	nd	nd	nd
BDE-206	3.08 (1) 36.9	17.8 (1) 107	nd	nd	nd	nd	nd
BDE-207	nd	12.9 (1) 77.7	nd	nd	nd	27.7 (1) 83.0	nd
BDE-208	nd	8.32 (1) 49.9	nd	nd	nd	14.0 (1) 42.0	nd
BDE-209	nd	173 (1) 1040	nd	nd	10.0 (1) 30.0	120 (1) 320	nd

Appendix E5: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the St. Lawrence River at Ogdensburg.

	St. Lawrence River at Ogdensburg				
Analyte	BB (3)	CARP (3)	CHC (2)	SMB (3)	WEYE (3)
BDE-1	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd
BDE-7	nd	nd	0.645 (1) 1.29	nd	nd
BDE-8/11	nd	nd	0.52 (1) 1.04	nd	nd
BDE-10	nd	nd	nd	nd	nd
BDE-11	na	na	na	na	na
BDE-12	na	na	na	na	na
BDE-12/13	0.67 (2) 1.61	nd	nd	nd	nd
BDE-15	44.9 (2) 133	11.8 ± 4.30 16.0	2.14 3.30	0.80 (1) 2.40	0.68 (2) 1.04
BDE-17	na	na	na	na	na
BDE-17/25	18.1 ± 15.0 35.3	77.7 ± 45.4 130	17.2 30.0	8.03 (2) 15.0	6.49 ± 4.43 11.6
BDE-25	na	na	na	na	na
BDE-28/33	71.4 ± 93.7 179	1010 ± 80.8 1100	46.1 85.0	28.3 ± 8.73 38.0	14.3 ± 2.19 15.9
BDE-30	nd	nd	nd	nd	nd
BDE-32	nd	4.00 (2) 7.20	nd	nd	nd
BDE-35	nd	nd	nd	nd	nd
BDE-37	7.16 (2) 19.6	nd	nd	0.40 (1) 1.20	nd
BDE-47	3810 ± 4530 8980	6170 ± 153 6300	3870 7280	1570 ± 404 2000	1230 ± 898 2250
BDE-49	na	na	na	na	na
BDE-49/71	191 ± 174 387	583 ± 101 690	423 808	337 ± 97.1 420	187 ± 90.3 271
BDE-51	15.7 ± 8.07 22.4	82.3 ± 12.5 91.0	38.7 71.6	15.3 ± 2.31 18.0	8.22 (2) 15.9

BDE-66	52.1 ± 57.2	nd	133 ± 16	32.0 ± 13.2	26.2 ± 8.81
	117		249	42.0	32.5
BDE-71	na	na	na	na	na
BDE-75	10.3 (2)	9.33 (2)	4.67 (1)	1.67 (1)	nd
	26.0	18.0	9.34	5.00	
BDE-77	0.883 (1)	nd	5.30 (1)	nd	nd
	2.65		10.6		
BDE-79	56.6 (2)	6.00 (1)	32.8	nd	4.82 (2)
	153	18.0	60.4		8.06
BDE-85	140 ± 174	nd	18.2	nd	nd
	339		30.0		
BDE-99	5120 ± 6780	18.6 ± 7.57	2700	1070 ± 297	784 ± 552
	12900	27.3	4950	1400	1400
BDE-100	1010 ± 995	1930 ± 472	2280	880 ± 325	536 ± 224
	2110	2300	4310	1200	709
BDE-105	nd	nd	nd	nd	nd
BDE-116	57.0 (1)	nd	nd	nd	nd
	171				
BDE-118	34.3 ± 38.1	nd	83.2	25.7 ± 9.60	17.0 ± 4.85
	77.4		158	36.0	20.3
BDE-119/120	60.7 ± 54.2	39.3 ± 23.8	376	130 ± 50.5	73.2 ± 30.7
	119	65.0	721	180	108
BDE-126	4.59 (2)	29.3 ± 13.6	77.5	25.3 ± 12.7	14.1 ± 10.2
	9.34	45.0	151	39.0	25.7
BDE-128	nd	nd	nd	nd	nd
BDE-138	na	na	na	na	na
BDE-138/166	38.4 (2)	nd	8.50 (1)	nd	nd
	96.2		17.0		
BDE-140	nd	nd	3.81 (1)	nd	nd
			7.63		
BDE-153	646 ± 825	9.07 (2)	1660	547 ± 240	296 ± 201
	1590	19.0	3180	790	516
BDE-154	440 ± 442	1370 ± 635	2300	810 ± 380	467 ± 323
	931	2100	4420	1200	831
BDE-155	25.3 ± 19.2	207± 89.6	460	143 ± 41.4	85.9 ± 72.9
	44.8	310	893	180	169
BDE-166	na	na	na	na	na
BDE-181	nd	nd	nd	nd	nd

BDE-183	24.3 (2) 43.1	0.50 (1) 1.5	37.1 (1) 74.3	2.57 (1) 7.70	nd
BDE-190	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	nd
BDE-206	nd	66.7 (2) 180	nd	8.33 (1) 25.0	nd
BDE-207	nd	36.7 (1) 110	nd	6.53 (1) 19.6	nd
BDE-208	nd	30.1 (2) 83.0	nd	nd	nd
BDE-209	nd	1070 (2) 2900	134 (1) 269	123 (2) 200	nd

Appendix E6: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the St. Lawrence River above the Moses Saunders Dam.

Analyte	St. Lawrence River above the Moses Saunders Dam			
	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
BDE-1	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd
BDE-7	nd	nd	nd	nd
BDE-8/11	2.73 (1) 8.20	nd	nd	nd
BDE-10	nd	nd	nd	nd
BDE-11	na	na	na	na
BDE-12	na	na	na	na
BDE-12/13	2.30 (2) 4.90	0.171 (1) 0.512	nd	nd
BDE-15	11.4 ± 9.36 21.0	2.53 ± 0.931 3.60	1.00 (1) 3.00	0.549 (2) 1.17
BDE-17	na	na	na	na
BDE-17/25	71.1 ± 71.8 150	12.4 (2) 24.8	20.3 ± 4.51 25.0	1.41 (1) 4.22
BDE-25	na	na	na	na
BDE-28/33	628 ± 512 1100	95.5 ± 49.9 152	61.0 ± 18.1 78.0	12.5 ± 6.30 16.8
BDE-30	nd	nd	nd	nd
BDE-32	5.07 (2) 11.0	nd	0.367 (1) 1.10	nd
BDE-35	nd	nd	nd	nd
BDE-37	nd	nd	3.00 ± 1.15 4.20	nd
BDE-47	4570 ± 3710 7800	10900 ± 6770 18600	3070 ± 929 3700	714 ± 270 1010
BDE-49	na	na	na	na
BDE-49/71	622 ± 626 1300	659 ± 136 816	757 ± 147 870	166 ± 63.3 237
BDE-51	65.7 ± 60.5 130	79.3 ± 26.7 108	44.7 ± 9.45 52.0	9.25 (2) 22.0
BDE-66	nd	210 ± 132 289	86.7 (2) 150	9.63 (1) 28.9

BDE-71	na	na	na	na
BDE-75	10.0 (2) 17.0	3.19 (1) 9.57	10.2 ± 1.38 11.0	nd
BDE-77	nd	4.10 (1) 12.3	2.47 (1) 7.40	nd
BDE-79	10.0 (1) 30.0	56.6 ± 27.0 75.9	16.0 (1) 48.0	3.33 (1) 10.0
BDE-85	nd	17.9 ± 7.18 23.8	nd	nd
BDE-99	5.80 ± 4.26 10.4	5310 ± 2140 7200	1700 ± 360 2100	505 ± 144 658
BDE-100	1320 ± 930 2000	6090 ± 2160 8280	1930 ± 416 2400	551 ± 314 913
BDE-105	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd
BDE-118	nd	171 ± 59.2 206	51.7 ± 14.6 62.0	10.4 (1) 31.1
BDE-119/120	30.8 ± 24.2 52.0	875 ± 243 1020	333 ± 37.9 360	107 ± 66.5 183
BDE-126	13.4 (2) 33.0	159 ± 76.5 246	34.0 (2) 76.0	25.0 ± 21.9 50.2
BDE-128	nd	nd	8.67 (1) 26.0	nd
BDE-138	na	na	na	na
BDE-138/166	nd	12.8 (2) 24.7	nd	nd
BDE-140	nd	7.56 (2) 15.5	3.60 (2) 5.90	nd
BDE-153	9.0 (2) 15.0	4050 ± 1430 5380	1390 ± 540 1800	418 ± 345 816
BDE-154	860 ± 597 1300	5830 ± 1840 7170	1930 ± 666 2500	659 ± 512 1250
BDE-155	150 ± 105 250	1090 ± 564 1730	320 ± 125 440	135 ± 125 279
BDE-166	na	na	na	na
BDE-181	nd	nd	nd	nd
BDE-183	nd	28.2 (2) 43.4	7.43 (2) 14.0	nd

BDE-190	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd
BDE-206	nd	nd	2.33 (1) 7.00	nd
BDE-207	nd	nd	nd	nd
BDE-208	nd	nd	nd	nd
BDE-209	nd	139 (1) 416	60.0 (1) 180	555 (2) 1180

Appendix E7: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the St. Lawrence River at the Franklin County line.

	St. Lawrence River at the Franklin County line				
Analyte	BB (1)	CARP (3)	SMB (3)	WEYE (3)	YP (3)
BDE-1	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd
BDE-7	nd	nd	nd	nd	nd
BDE-8/11	nd	4.27 (2) 9.00	nd	nd	nd
BDE-10	nd	nd	nd	nd	nd
BDE-11	na	na	na	na	na
BDE-12	na	na	na	na	na
BDE-12/13	nd	0.533 (1) 1.60	nd	nd	nd
BDE-15	1.40	10.0 ± 2.77 13.0	1.53 (2) 2.50	1.42 ± 0.542 1.93	0.453(2) 0.694
BDE-17	na	na	na	na	na
BDE-17/25	2.46	68.3 ± 37.4 100	9.63 ± 4.79 15.0	6.71 ± 2.64 8.32	18.7 ± 20.4 42.2
BDE-25	na	na	na	na	na
BDE-28/33	15.5	2700 ± 4170 7500	50.7 ± 33.5 84.0	28.8 ± 2.73 31.9	23.9 ± 22.3 49.7
BDE-30	nd	nd	nd	nd	nd
BDE-32	nd	3.77 ± 3.09 7.30	nd	nd	nd
BDE-35	1.04	nd	nd	nd	nd
BDE-37	1.29	nd	4.03 ± 2.75 6.70	0.78 (1) 2.33	nd
BDE-47	742	13800 ± 17700 34000	3460 ± 3800 7800	1950 ± 405 2390	1020 ± 1040 2230
BDE-49	na	na	na	na	na
BDE-49/71	60.1	370 ± 233 560	513 ± 392 950	261 ± 80.5 343	302 ± 321 673
BDE-51	10.4	141 ± 190 360	22.3 ± 11.7 35.0	11.0 ± 2.86 13.0	3.57 (1) 10.7
BDE-66	6.92	nd	72.3 ± 59.2 140	9.40 (1) 28.2	8.39 ± 2.04 9.90

BDE-71	na	na	na	na	na
BDE-75	1.61	nd	7.50 (2) 17.0	nd	nd
BDE-77	nd	nd	2.10 (1) 6.30	nd	nd
BDE-79	nd	32.0 (1) 96.0	nd	nd	nd
BDE-85	23.2	nd	nd	nd	nd
BDE-99	756	5.10 (2) 11.0	2410 ± 2770 5600	1190 ± 241 1350	222 ± 158 385
BDE-100	311	4120 ± 5980 11000	1540 ± 1450 3200	878 ± 196 1080	301 ± 238 576
BDE-105	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd
BDE-118	12.4	nd	42.3 ± 28.7 73.0	17.8 (2) 32.5	1.94 (1) 5.81
BDE-119/120	29.1	59.0 ± 62.9 130	199 ± 116 310	94.7 ± 41.6 128	20.4 (2) 33.3
BDE-126	3.18	10.7 (1) 32.0	10.7 (2) 17.0	17.2 ± 6.18 21.6	2.40 (2) 5.41
BDE-128	nd	nd	nd	nd	nd
BDE-138	na	na	na	na	na
BDE-138/166	nd	nd	nd	nd	nd
BDE-140	nd	nd	1.47 (1) 4.40	nd	nd
BDE-153	166	8.67 (2) 17.0	760 ± 501 1300	387 ± 114 518	42.2 (2) 68.5
BDE-154	175	1210 ± 1570 3000	1020 ± 635 1700	469 ± 153 613	131 ± 39.6 159
BDE-155	14.7	176 ± 231 440	139 ± 63.1 180	83.4 ± 27.8 99.8	22.0 ± 9.22 32.6
BDE-166	na	na	na	na	na
BDE-181	nd	nd	nd	nd	nd
BDE-183	17.0	nd	nd	nd	nd
BDE-190	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	nd
BDE-206	nd	nd	nd	nd	nd

BDE-207	nd	11.7 (1) 35.0	nd	nd	nd
BDE-208	nd	7.33 (1) 22.0	nd	nd	nd
BDE-209	nd	81.3 (1) 244	nd	105.3 (1) 316	97.2 (1) 292

Appendix E8: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the St. Lawrence River at Raquette Point.

	St. Lawrence River at Raquette Point				
Analyte	BB (1)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
BDE-1	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd
BDE-7	nd	nd	nd	nd	nd
BDE-8/11	nd	1.80 (1) 5.40	nd	nd	nd
BDE-10	nd	nd	nd	nd	nd
BDE-11	na	na	na	na	na
BDE-12	na	na	na	na	na
BDE-12/13	nd	1.20 (1) 3.60	0.950 (1) 2.85	nd	nd
BDE-15	2.55	8.53 ± 5.77 15.0	9.00 (2) 14.2	2.20 ± 0.361 2.60	1.13 (2) 2.12
BDE-17	na	na	na	na	na
BDE-17/25	21.7	51.3 ± 32.6 89.0	103 ± 14.6 119	10.5 ± 5.82 16.0	8.50 ± 5.19 12.4
BDE-25	na	na	na	na	na
BDE-28/33	39.4	707 ± 120 830	506 ± 321 773	33.0 ± 2.65 35.0	38.9 ± 24.4 59.1
BDE-30	nd	nd	nd	nd	nd
BDE-32	nd	0.29 (1) 0.87	nd	0.267 (1) 0.80	nd
BDE-35	nd	nd	nd	nd	nd
BDE-37	6.04	nd	1.93 (1) 5.78	0.467 (1) 1.40	0.817 (1) 2.45
BDE-47	2660	5330 ± 1010 6500	29200 ± 14300 41100	1670 ± 57.7 1700	1700 ± 1440 3370
BDE-49	na	na	na	na	na
BDE-49/71	121	460 ± 161 610	1020 ± 464 1470	383 ± 58.6 450	236 ± 211 480
BDE-51	13.7	58.3 ± 9.29 66.0	72.2 ± 62.2 134	19.0 ± 3.61 23.0	15.4 ± 9.03 25.0
BDE-66	36.4	nd	305 ± 74.0 390	30.3 (2) 56.0	26.9 (2) 58.4

BDE-71	na	na	na	na	na
BDE-75	6.42	8.33 (2) 14.0	nd	5.50 ± 1.06 6.70	1.70 (1) 5.10
BDE-77	4.90	3.67 (1) 11.0	5.93 (1) 17.8	nd	nd
BDE-79	9.50	nd	97.5 ± 65.5 173	nd	3.80 (1) 11.4
BDE-85	82.1	nd	63.5 ± 39.4 109	nd	nd
BDE-99	2220	6.20 ± 3.53 10.2	7940 ± 1900 10100	1170 ± 153 1300	1140 ± 925 2190
BDE-100	859	1570 ± 305 1900	9030 ± 4170 12500	1020 ± 159 1200	815 ± 568 1470
BDE-105	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd
BDE-118	29.2	nd	177 ± 39.8 223	27.7 ± 7.51 35.0	19.4 (2) 46.0
BDE-119/120	30.1	35.3 ± 7.50 43.0	802 ± 416 1120	153 ± 35.1 190	113 ± 60.3 180
BDE-126	4.87	10.0 (2) 17.0	80.0 (2) 123	10.7 (2) 19.0	18.5 ± 7.27 26.9
BDE-128	nd	nd	13.3 (1) 40.0	nd	nd
BDE-138	na	na	na	na	na
BDE-138/166	19.9	nd	10.8 (1) 32.4	nd	nd
BDE-140	nd	nd	14.1 (2) 22.3	nd	nd
BDE-153	337	9.60 ± 3.81 14.0	2820 ± 1210 3630	697 ± 171 810	483 ± 219 733
BDE-154	325	787 ± 171 970	4820 ± 2370 6360	980 ± 231 1200	669 ± 260 967
BDE-155	23.8	140 ± 36.0 180	520 ± 292 693	143 ± 25.2 170	107 ± 47.0 159
BDE-166	na	na	na	na	na
BDE-181	nd	nd	nd	nd	nd
BDE-183	37.5	nd	36.6 (2) 58.9	nd	nd

BDE-190	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	nd
BDE-206	nd	20.3 (1) 61.0	nd	nd	nd
BDE-207	nd	12.3 (1) 37.0	nd	nd	nd
BDE-208	nd	nd	nd	nd	nd
BDE-209	nd	415 (2) 1100	nd	194 ± 115 314	nd

Appendix E9: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the Grasse River above the Massena Dam and from the mouth upstream 1.0 mile.

	Grasse River above Massena Dam		Grasse River from mouth upstream 1.0 mile			
Analyte	SMB (3)	WEYE (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
BDE-1	nd	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd	nd
BDE-7	nd	nd	5.83 (2)	15.2 ± 7.18	2.73 (1)	nd
			11.0	22.0	8.20	
BDE-8/11	nd	nd	9.00 ± 4.61	1.36 (1)	nd	nd
			14.0	4.10		
BDE-10	nd	nd	nd	nd	nd	nd
BDE-11	na	na	na	na	na	na
BDE-12	na	na	na	na	na	na
BDE-12/13	nd	nd	nd	nd	nd	nd
BDE-15	4.67 (2)	2.02 ± 0.401	7.30 (2)	7.33 (2)	12.4 ± 11.9	1.35 ± 0.60
	9.30	2.48	14.0	12.0	26.0	2.01
BDE-17	na	na	na	na	na	na
BDE-17/25	12.0 ± 4.64	8.28 (2)	276 ± 197	156 ± 114	53.3 ± 38.0	9.54 ± 3.77
	16.0	18.4	460	250	97.0	13.9
BDE-25	na	na	na	na	na	na
BDE-28/33	50.7 ± 42.8	26.9 ± 3.67	2570 ± 1500	212 ± 154	176 ± 160	21.6 ± 5.19
	100	31.0	4300	350	360	25.8
BDE-30	nd	nd	nd	nd	nd	nd
BDE-32	0.467 (1)	nd	12.2 ± 6.82	6.67 (2)	0.63 (1)	nd
	1.40		18.0	10.0	1.90	
BDE-35	nd	nd	4.33 (1)	nd	nd	nd
			13.0			
BDE-37	5.00 (2)	1.78 ± 0.831	nd	2.10 (1)	3.53 (2)	0.653 (2)
	11.0	2.71		6.30	7.60	1.29
BDE-47	2630 ± 2400	2400 ± 898	21400 ± 17000	13500 ± 7920	5930 ± 2270	1190 ± 327
	5400	3410	41000	19000	8500	1530
BDE-49	na	na	na	na	na	na
BDE-49/71	343 ± 335	201 ± 130	813 ± 374	603 ± 417	800 ± 361	201 ± 63.3
	730	349	1100	950	1100	256
BDE-51	10.4 (2)	13.5 ± 8.40	183 ± 60.3	101 ± 41.9	38.7 ± 12.7	13.5 ± 6.27
	23.0	22.8	240	130	47.0	20.5

BDE-66	15.1 (2) 41.0	15.7 (2) 24.6		nd	137 ± 94.5 230	81.7 ± 27.1 110	26.2 ± 11.0 36.3
BDE-71	na	na		na	na	na	na
BDE-75	2.27 (2) 4.10	1.63 (2) 3.55		13.3 (1) 40.0	5.30 (1) 16.0	9.00 (2) 14.0	0.700 (1) 2.10
BDE-77	nd	nd		nd	nd	nd	nd
BDE-79	6.67 (1) 20.0	nd		nd	21.0 (1) 63.0	nd	3.31 (1) 9.95
BDE-85	1.57 (1) 4.70	nd		nd	86.7 ± 64.1 160	4.67 (1) 14.0	nd
BDE-99	2230 ± 1880 4400	949 ± 639 1680		5.90 ± 2.60 7.40	6570 ± 4260 11000	3530 ± 1200 4800	590 ± 217 821
BDE-100	800 ± 692 1600	634 ± 205 866		4500 ± 3310 8300	3840 ± 2530 5500	2400 ± 400 2800	481 ± 113 553
BDE-105	nd	nd		nd	nd	nd	nd
BDE-116	nd	nd		nd	nd	7.67 (1) 23.0	nd
BDE-118	24.3 ± 17.9 45.0	11.2 (2) 23.5		nd	75.7 ± 46.3 110	62.3 ± 16.8 77.0	14.2 ± 5.54 18.4
BDE-119/120	67.3 ± 54.3 130	24.3 (2) 46.3		84.3 ± 92.2 190	264 ± 174 370	293 ± 124 370	67.1 ± 31.7 100
BDE-126	1.60 (2) 2.80	2.61 (2) 4.28		29.0 ± 9.64 36.0	20.3 ± 13.5 30.0	18.3 (2) 30.0	4.77 (1) 14.3
BDE-128	5.00 (1) 15.0	nd		nd	12.0 (1) 36.0	5.00 (1) 15.0	nd
BDE-138	na	na		na	na	na	na
BDE-138/166	nd	nd		nd	30.0 ± 16.4 48.0	nd	nd
BDE-140	6.23 (2) 13.0	nd		nd	15.0 ± 9.00 24.0	nd	nd
BDE-153	350 ± 278 670	165 ± 39.3 207		30.7 ± 28.6 61.0	1360 ± 844 1900	1380 ± 548 1700	213 ± 74.6 275
BDE-154	293 ± 231 560	224 ± 35.7 262		1680 ± 1000 2800	1750 ± 1240 2700	1830 ± 737 2400	293 ± 104 393
BDE-155	15.0 (2) 33.0	30.0 ± 1.85 31.9		297 ± 155 450	198 ± 144 330	257 ± 111 340	61.6 ± 22.5 85.2
BDE-166	na	na		na	na	na	na
BDE-181	nd	nd		nd	3.17 (1) 9.50	nd	nd

BDE-183	19.0 ± 7.00 24.0	nd	nd	53.7 ± 28.5 82.0	12.1± 6.99 20.0	nd
BDE-190	nd	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	23.0 (2) 41.0	nd	nd
BDE-206	27.0 (1) 81.0	nd	32.7 (1) 98.0	nd	nd	nd
BDE-207	nd	nd	20.3 (1) 61.0	12.0 (1) 36.0	nd	nd
BDE-208	13.0 (1) 39.0	nd	13.7 (1) 41.2	6.73 (1) 20.2	nd	nd
BDE-209	417 (2) 1200	nd	900 (1) 2700	nd	nd	nd

Appendix E10: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the Raquette River above the Route 402 bridge and from the mouth upstream 1.0 mile.

	Raquette River above the Route 420 bridge			Raquette River from mouth upstream 1.0 mile			
Analyte	CARP (3)	SMB (3)	WEYE (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
BDE-1	nd	nd	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd	nd	nd
BDE-7	nd	nd	nd	4.30 (2)	0.433 (1)	nd	nd
				8.30	1.30		
BDE-8/11	1.00 (1)	nd	nd	3.97 ± 0.750	nd	nd	nd
	3.00			4.40			
BDE-10	nd	nd	nd	nd	nd	nd	nd
BDE-11	na	na	na	na	na	na	na
BDE-12	na	na	na	na	na	na	na
BDE-12/13	nd	nd	nd	nd	nd	nd	nd
BDE-15	18.7 ± 9.07	2.17 (2)	2.01 (2)	15.3 ± 5.86	6.27 ± 3.09	2.30 ± 1.31	0.559 (2)
	29.0	3.50	3.66	22.0	8.20	3.80	1.11
BDE-17	na	na	na	na	na	na	na
BDE-17/25	127 ± 20.8	15.0 ± 2.00	12.0 ± 7.07	77.0 ± 13.4	40.0 (2)	15.7 ± 10.9	4.98 (2)
	150	17.0	17.0	92.0	62.0	28.0	8.93
BDE-25	na	na	na	na	na	na	na
BDE-28/33	1770 ± 1290	56.0 ± 12.3	51.8 ± 15.6	1810 ± 854	406 ± 444	38.6 ± 27.6	9.48 ± 3.11
	3100	70.0	65.9	2400	900	70.0	12.1
BDE-30	nd	nd	nd	nd	nd	nd	nd
BDE-32	1.27 (1)	0.367 (1)	nd	5.50 ± 4.06	1.56 (1)	nd	nd
	3.80	1.10		9.40	4.70		
BDE-35	4.00 (1)	nd	nd	nd	2.23 (1)	nd	0.35 (1)
	12.0				6.70		1.05
BDE-37	nd	6.20 ± 0.818	2.92 ± 1.21	nd	nd	1.63 (2)	nd
		7.10	3.98			3.50	
BDE-47	12300 ± 5970	7100 ± 2450	3380 ± 920	11600 ± 5170	26300 ± 15900	2140 ± 1790	539 ± 332
	18000	9800	4420	17000	44000	4200	908
BDE-49	na	na	na	na	na	na	na
BDE-49/71	733 ± 233	633 ± 223	172 ± 41.9	803 ± 265	543 ± 316	500 ± 418	92.2 ± 54.3
	1000	880	203	1100	760	980	153
BDE-51	96.7 (2)	16.3 ± 3.21	12.8 ± 4.36	127 ± 50.2	91.7 ± 33.8	20.3 ± 6.66	4.30 (2)
	170	20.0	17.2	170	130	28.0	9.88

BDE-66	nd	142 ± 62.4 200	46.9 ± 32.6 83.2	nd	173 ± 45.1 220	56.3 ± 25.1 85.0	3.26 (1) 9.79
BDE-71	na	na	na	na	na	na	na
BDE-75	nd	6.63 (2) 12.0	nd	9.00 (1) 27.0	8.33 (2) 13.0	6.50 (2) 14.0	nd
BDE-77	nd	nd	1.31 (1) 3.92	nd	nd	nd	nd
BDE-79	nd	nd	9.57 (1) 28.7	nd	30.0 (1) 90.0	4.00 (1) 12.0	nd
BDE-85	nd	nd	8.51 (2) 15.6	nd	99.7 ± 61.6 170	nd	nd
BDE-99	10.3 (2) 28.0	7430 ± 4120 12000	1830 ± 1180 3190	8.23 ± 3.43 12.2	9130 ± 3750 13000	1400 ± 1130 2700	364 ± 309 714
BDE-100	3200 ± 1870 4900	2770 ± 1170 4100	920 ± 340 1310	3200 ± 1300 4000	7770 ± 3670 12000	1180 ± 884 2200	278 ± 199 505
BDE-105	nd	nd	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd	nd	nd
BDE-118	nd	73.7 ± 31.8 110	24.1 ± 15.9 42.5	nd	106 ± 53.0 150	36.3 ± 27.8 68.0	10.4 ± 8.47 20.1
BDE-119/120	48.0 ± 22.7 64.0	187 ± 108 310	48.0 ± 21.3 72.6	50.3 ± 6.03 56.0	453 ± 128 600	155 ± 109 280	46.3 ± 34.1 85.5
BDE-126	13.7 (1) 41.0	8.07 ± 2.05 9.80	2.49 (1) 7.47	25.7 ± 5.51 31.0	29.7 ± 23.1 54.0	17.7 (2) 27.0	7.71(2) 18.3
BDE-128	nd	nd	nd	nd	17.0 (2) 26.0	nd	nd
BDE-138	na	na	na	na	na	nd	na
BDE-138/166	nd	nd	nd	nd	41.0 ± 21.7 66.0	nd	nd
BDE-140	nd	6.20 (2) 9.50	0.983 (1) 2.95	nd	12.3 (2) 24.0	nd	nd
BDE-153	15.7 ± 6.66 23.0	1230 ± 759 2100	260 ± 151 435	15.9 ± 11.9 29.0	2430 ± 1000 3400	717 ± 511 1300	186 ± 149 358
BDE-154	1070 ± 605 1600	1020 ± 597 1700	313 ± 114 444	1400 ± 436 1900	3630 ± 1190 5000	993 ± 706 1800	270 ± 206 507
BDE-155	171 ± 109 270	55.7 ± 12.0 68.0	34.2 ± 12.5 48.4	213 ± 40.4 250	390 ± 81.8 480	157 ± 98.3 270	49.1 ± 38.2 93.2
BDE-166	na	na	na	na	na	na	na
BDE-181	nd	nd	nd	nd	nd	nd	nd

BDE-183	1.83 (1) 5.50	2.13 (1) 6.40	nd	nd	61.0 ± 16.1 78.0	1.30 (1) 3.90	nd
BDE-190	nd	nd	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	17.3 (2) 32.0	nd	nd
BDE-206	10.3 (1) 30.8	nd	nd	17.0 (1) 51.0	nd	nd	nd
BDE-207	6.93 (1) 20.8	nd	nd	17.7 (1) 53.0	6.27 (1) 18.8	nd	nd
BDE-208	nd	nd	nd	8.00 (1) 24.0	6.67 (2) 15.7	nd	nd
BDE-209	333 ± 577 1000	107 ± 105 210	166 (1) 497	367 ± 635 1100	nd	13.3 (1) 40	205 (1) 616

Appendix E11: Concentrations (pg/g wet weight) of individual polybrominated diphenyl ether (BDE) congeners in fish from the St. Regis River above the Hogansburg Dam and from the mouth upstream 1.0 mile.

	St. Regis River above Hogansburg Dam				St. Regis River from mouth upstream 1.0 mile			
Analyte	BB (1)	SMB (3)	WEYE (2)	WS (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
BDE-1	nd	nd	nd	nd	nd	nd	nd	nd
BDE-2	nd	nd	nd	nd	nd	nd	nd	nd
BDE-3	nd	nd	nd	nd	nd	nd	nd	nd
BDE-7	nd	nd	nd	nd	nd	nd	nd	nd
BDE-8/11	nd	nd	nd	nd	1.57 (1) 4.70	nd	nd	nd
BDE-10	nd	nd	nd	nd	nd	nd	nd	nd
BDE-11	na	na	na	na	na	na	na	na
BDE-12	na	na	na	na	na	na	na	na
BDE-12/13	nd	nd	nd	nd	nd	nd	nd	nd
BDE-15	nd	1.80 (2) 3.90	0.86 (1) 1.72	1.79 ± 1.12 3.08	9.40 ± 11.8 23.0	5.28 ± 2.42 7.37	1.17 (1) 3.50	1.79 (2) 3.61
BDE-17	na	na	na	na	na	na	na	na
BDE-17/25	2.23	5.13 (2) 8.40	4.45 5.05	4.99 ± 3.36 8.84	73.3 ± 75.4 160	70.4 ± 30.7 101	15.7 ± 4.72 21.0	24.1 ± 9.65 35.2
BDE-25	na	na	na	na	na	na	na	na
BDE-28/33	2.80	29.2 ± 30.9 64.0	12.6 13.1	23.2 ± 12.0 34.9	1390 ± 1300 2900	132 ± 72.6 181	45.7 ± 9.07 56.0	42.7 ± 5.85 48.1
BDE-30	nd	nd	nd	nd	nd	nd	nd	nd
BDE-32	nd	nd	nd	nd	3.27 (1) 9.80	nd	nd	nd
BDE-35	nd	nd	nd	nd	2.67 (1) 8.00	nd	nd	nd
BDE-37	nd	2.37 (2) 3.90	0.29 (1) 0.59	0.51 (1) 1.53	nd	nd	0.90 (1) 2.70	1.61 (2) 2.63
BDE-47	121	2490 ± 2070 4600	868 907	597 ± 442 1080	8270 ± 6700 16000	6790 ± 2970 8620	2430 ± 208 2600	4240 ± 2770 7430
BDE-49	na	na	na	na	na	na	na	na
BDE-49/71	9.49	125 ± 70.0 170	51.3 58.2	24.6 ± 17.3 43.9	607 ± 602 1300	559 ± 187 681	450 ± 88.9 520	488 ±257 780
BDE-51	0.996	4.70 (2) 9.40	1.31 (1) 2.62	2.31 (2) 4.95	93.7 ± 67.5 170	41.3 ± 12.2 54.8	23.3 ± 5.68 28.0	24.2 ± 15.2 41.8
BDE-66	nd	17.0 ± 8.23 26.0	8.40 (1) 16.8	nd	nd	129 ± 74.2 205	56.3 ± 20.6 80.0	59.4 ± 33.8 90.8

BDE-71	na	na	na	na	na	na	na	na
BDE-75	nd	0.967 (1) 2.90	nd	nd	2.53 (1) 7.60	5.93 (2) 12.9	nd	4.11(2) 8.79
BDE-77	nd	nd	nd	nd	nd	2.43 (1) 7.28	nd	0.94(1) 2.81
BDE-79	nd	nd	nd	nd	18.7 (1) 56.0	25.5 (2) 51.4	nd	6.40 (1) 19.2
BDE-85	3.36	nd	nd	0.91 (1) 2.74	nd	21.4 ± 8.01 29.9	nd	nd
BDE-99	68.3	1210 ± 880 2100	376 657	5.87 (2) 13.5	9.50 ± 5.57 14.1	2820 ± 965 3590	1600 ±100 1700	3150 ± 2310 5810
BDE-100	36.0	573 ± 355 870	229 260	114 ± 97.5 223	2070 ± 1670 4000	2670 ± 1020 3320	1260 ± 242 1400	1720 ± 1250 3160
BDE-105	nd	nd	nd	nd	nd	nd	nd	nd
BDE-116	nd	nd	nd	nd	nd	nd	nd	nd
BDE-118	nd	12.5 ± 7.42 19.0	5.10 (1) 10.2	nd	nd	26.0 (1) 78.0	33.3 ± 9.29 41.0	51.1 ± 33.7 89.9
BDE-119/120	nd	35.0 ± 18.0 50.0	10.7 14.1	11.8 ± 10.4 23.7	41.3 ± 32.6 79.0	294 ± 114 397	153 ± 37.9 180	169 ± 107 293
BDE-126	nd	0.80 (1) 2.40	nd	nd	23.0 ± 18.2 44.0	48.1 ± 17.1 64.5	22.0 ± 7.00 27.0	18.1 ± 12.0 31.6
BDE-128	nd	nd	nd	nd	nd	nd	nd	nd
BDE-138	na	na	na	na	na	na	na	na
BDE-138/166	nd	nd	nd	nd	nd	nd	nd	nd
BDE-140	nd	nd	nd	nd	nd	2.30 (1) 6.89	nd	2.07 (1) 6.20
BDE-153	16.0	187 ± 104 270	85.8 105	18.4 (1) 55.2	1.73 (1) 5.20	1080 ± 310 1310	720 ± 182 830	697 ± 524 1300
BDE-154	11.2	190 ± 108 280	82.7 88.8	41.3 ± 35.1 80.1	1070 ± 898 2100	1630 ± 537 1940	920 ± 231 1100	919 ± 682 1700
BDE-155	nd	6.87 17.0	7.88 8.65	6.77 ± 4.79 12.2	172 ± 112 300	257 ± 68.2 310	170 ± 52.9 210	99.8 ± 71.5 182
BDE-166	na	na	na	na	na	na	na	na
BDE-181	nd	nd	nd	nd	nd	nd	nd	nd
BDE-183	nd	2.50 (1) 7.50	nd	nd	nd	13.9 (2) 26.1	nd	nd
BDE-190	nd	nd	nd	nd	nd	nd	nd	nd
BDE-203	nd	nd	nd	nd	nd	nd	nd	nd

BDE-206	nd	nd	nd	nd	12.3 (1) 37.0	nd	nd	nd
BDE-207	nd	nd	nd	nd	10.7 (1) 32.0	nd	nd	nd
BDE-208	nd	nd	nd	nd	6.67 (1) 20.0	nd	nd	nd
BDE-209	258	27.7 (1) 83	nd	nd	37.7 (1) 113	67.2 (1) 202	24.3 (1) 73.0	142 ± 156 310

Appendix F: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish.

The following rules were used in the presentation of data for polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDDs or PCDF, respectively, or PCDD/F) in fish in the eleven sub-appendices within Appendix F.

a. The parenthetic value for each species in column headings is the total number of samples analyzed.

b. "nd" indicates there were no detections of a specific PCDD/F for the location and species. Similarly, "na" indicates no analyses were conducted for the specific PCDD/F in the species and location.

c. In the body of each table, the mean concentration is the first value given for each PCDD/F for each species and location. The mean only is given when fewer than 80% of samples within the species and location have detectable concentrations. Where samples lacked detection of the PCDD/F, the non-detect was assigned a value of zero for computation of the mean.

d. The standard deviation is given when 80% or more of the sample values have detectable concentrations. Again, non-detects were assigned a value of zero for computations.

e. Parenthetic values within the sample data are the number of samples with detectable concentrations of the specific PCDD/F. However, where a mean and standard deviation are given but are without a parenthetic value, all samples of the given species at the location contained the specified PCDD/F at detectable concentrations.

f. The number on the second line following the mean concentration is the maximum PCDD/F congener or homolog concentration determined for the species and location.

Appendix F1: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from Lake Erie and Chautauqua Creek[1].

Analyte	Lake Erie					Chautauqua Creek
	CARP (5)	CHC (5)	LT (6)	SMB (3)	WEYE (3)	RT (3)
2,3,7,8-TCDD	0.88 ± 0.67 1.90	0.34 (3) 0.72	0.52 ± 0.25 0.96	0.063 (1) 0.19	nd	nd
1,2,3,7,8-PeCDD	1.15 ± 0.69 2.00	1.05 ± 0.72 (4) 1.90	0.80 ± 0.55 (5) 1.60	0.16 (2) 0.24	nd	0.050 (1) 0.15
1,2,3,4,7,8-HxCDD	0.66 ± 0.48 (4) 1.20	0.36 (3) 0.79	nd	nd	nd	nd
1,2,3,6,7,8-HxCDD	1.94 ± 1.11 2.90	0.78 (3) 1.50	0.26 (2) 1.10	nd	nd	0.22 (2) 0.33
1,2,3,7,8,9-HxCDD	0.29 (3) 0.70	0.42 ± 0.12 0.58	nd	nd	nd	0.033 (1) 0.098
1,2,3,4,6,7,8-HpCDD	4.32 ± 4.12 (4) 11.0	0.47 (3) 0.89	0.040 (1) 0.24	nd	nd	0.040 (1) 0.12
OCDD	8.87 ± 9.42 (4) 24.0	0.62 ± 0.43 (4) 0.95	0.28 (2) 1.20	0.097 (1) 0.29	0.29 (2) 0.58	0.27 (2) 0.43
2,3,7,8-TCDF	7.83 ± 5.33 14.0	1.56 ± 0.89 2.65	6.95 ± 4.15 14.0	0.50 (2) 0.86	1.09 ± 0.32 1.40	3.53 ± 2.15 5.60
1,2,3,7,8-PeCDF	0.36 (1) 1.80	0.16 (1) 0.78	0.48 ± 0.26 (5) 0.78	0.073 (1) 0.22	0.10 (2) 0.18	nd
2,3,4,7,8-PeCDF	2.26 ± 1.25 3.60	2.50 ± 0.77 3.80	1.54 ± 0.72 2.80	0.26 (2) 0.40	nd	0.47 ± 0.26 0.73
1,2,3,4,7,8-HxCDF	0.24 (1) 1.20	nd	nd	nd	nd	nd
1,2,3,6,7,8-HxCDF	0.30 (2) 0.99	0.026 (1) 0.13	0.018 (1) 0.11	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	0.14 (2) 0.36	nd	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDF	0.36 (3) 0.80	nd	nd	nd	nd	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd
OCDF	nd	nd	nd	nd	nd	nd

	Lake Erie					Chautauqua Creek
Analyte	CARP (5)	CHC (5)	LT (6)	SMB (3)	WEYE (3)	RT (3)
Homologs						
Tetra-CDD	0.88 ± 0.67	0.34 (3)	0.51 ± 0.25	0.073 (1)	nd	0.040 (1)
	1.9	0.72	0.96	0.22		0.12
Penta-CDD	1.15 ± 0.69	1.05 ± 0.72 (4)	0.80 ± 0.55 (5)	0.16 (2)	0.050 (1)	0.050 (1)
	2.0	1.9	1.6	0.24	0.15	0.15
Hexa-CDD	2.90 ± 1.71	1.59 ± 0.95	0.26 (2)	nd	nd	0.19 (2)
	4.3	2.7	1.1			0.34
Hepta-CDD	5.42 ± 4.35 (4)	0.51 (3)	0.24 (2)	nd	nd	0.03 (1)
	11.0	0.97	1.2			0.09
Tetra-CDF	9.49 ± 6.81	1.89 ± 0.50	7.47 ± 4.39	0.37 (2)	1.56 ± 0.86	4.20 ± 2.92
	17.0	2.45	15.0	0.67	2.2	6.9
Penta-CDF	4.60 ± 2.44	3.44 ± 1.21	2.47 ± 1.14	0.34 (2)	0.14 (2)	1.30 ± 0.50
	7.7	5.2	4.2	0.61	0.25	1.8
Hexa-CDF	1.01 ± 0.53	1.84 ± 1.08	0.082 (2)	3.33 ± 0.40	2.41 ± 1.48	3.30 ± 2.26
	1.6	3.0	0.38	3.7	3.5	5.8
Hepta-CDF	0.36 (3)	nd	nd	nd	nd	nd
	0.80					

[1] Mean only is given when less than 80% of samples have detectable concentrations. Mean and standard deviation are given when 80% or more of samples have detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F2: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the upper Niagara River and Cayuga Creek[1].

	Upper Niagara River			Cayuga Creek			
Analyte	CARP (5)	LMB (3)	SMB (3)	BB (6)	CARP (5)	LMB (5)	RB (5)
2,3,7,8-TCDD	0.38 (3) 1.70	0.047 (1) 0.14	0.14 (2) 0.21	5.23 ± 3.57 10.0	11.56 ± 5.85 21.0	1.43 ± 0.63 2.20	4.68 ± 4.85 (4) 10.0
1,2,3,7,8-PeCDD	0.53 (3) 2.10	0.097 (2) 0.19	0.38 ± 0.20 0.61	0.32 (4) 0.67	1.66 ± 0.59 2.50	0.15 (3) 0.30	0.11 (2) 0.31
1,2,3,4,7,8-HxCDD	0.20 (1) 1.00	nd	nd	nd	nd	0.58 (1) 2.9	nd
1,2,3,6,7,8-HxCDD	0.52 (1) 2.60	nd	0.14 (2) 0.27	0.32 (2) 1.20	nd	nd	nd
1,2,3,7,8,9-HxCDD	0.10 (1) 0.51	nd	nd	0.078 (2) 0.25	0.30 (3) 0.59	nd	nd
1,2,3,4,6,7,8-HpCDD	1.28 (3) 6.0	nd	nd	0.63 (2) 1.99	2.63 ± 1.48 (4) 4.09	0.054 (1) 0.27	0.048 (1) 0.24
OCDD	2.42 (3) 11.0	0.43 (2) 0.85	0.15 (1) 0.45	10.4 ± 11.6 (5) 26.9	3.28 ± 1.79 5.9	nd	0.14 (1) 0.7
2,3,7,8-TCDF	0.65 ± 0.38 (4) 0.98	0.55 ± 0.18 0.72	0.88 ± 0.58 1.50	0.15 (4) 0.25	1.44 ± 0.36 1.80	0.36 ± 0.15 0.54	0.67 ± 0.22 1.00
1,2,3,7,8-PeCDF	nd	nd	0.16 (1) 0.47	nd	nd	nd	nd
2,3,4,7,8-PeCDF	1.13 (3) 4.30	0.040 (1) 0.12	0.95 ± 0.57 1.60	1.38 ± 0.48 2.1	6.76 ± 3.41 12.0	0.36 ± 0.20 0.67	0.46 (3) 0.83
1,2,3,4,7,8-HxCDF	0.42 (1) 2.10	nd	nd	1.01 (4) 2.40	11.74 ± 6.03 21.0	0.37 ± 0.32 (4) 0.89	0.15 (2) 0.41
1,2,3,6,7,8-HxCDF	0.44 (1) 2.20	nd	nd	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	0.13 (1) 0.63	nd	nd	0.037 (1) 0.22	0.71 ± 0.48 (4) 1.30	nd	nd
1,2,3,4,6,7,8-HpCDF	0.20 (1) 1.0	nd	0.037 (1) 0.11	nd	nd	nd	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd	nd
OCDF	nd	nd	nd	nd	0.28 (2) 0.75	nd	nd

Analyte	Upper Niagara River CARP (5)	Upper Niagara River LMB (3)	Upper Niagara River SMB (3)	Cayuga Creek BB (6)	Cayuga Creek CARP (5)	Cayuga Creek LMB (5)	Cayuga Creek RB (5)
Homologs							
Tetra-CDD	0.63 (2) 1.7	0.053 (1) 0.16	0.15 (2) 0.25	5.23 ± 3.57 10.0	11.56 ± 5.85 21.0	1.43 ± 0.63 2.20	4.68 ± 4.85 (4) 10.0
Penta-CDD	0.54 (3) 2.1	0.097 (2) 0.19	0.38 ± 0.20 0.61	0.40 (4) 0.98	1.66 ± 0.59 2.5	0.15 (3) 0.30	0.11 (2) 0.31
Hexa-CDD	0.82 (1) 4.1	nd	0.12 (2) 0.19	0.33 (2) 1.21	0.25 (3) 0.49	0.58 (1) 2.9	nd
Hepta-CDD	1.26 (2) 6.0	nd	nd	1.3 (3) 4.0	2.24 ± 1.45 (4) 3.6	nd	0.17 (3) 0.36
Tetra-CDF	2.57 ± 3.82 (4) 9.3	0.36 ± 0.18 0.53	0.69 ± 0.58 1.31	0.72 ± 0.57 (5) 1.6	3.40 ± 1.71 5.9	1.16 ± 1.01 2.9	1.93 ± 1.32 4.0
Penta-CDF	1.19 (3) 4.3	0.63 ± 0.33 0.95	1.29 ± 0.46 1.6	1.68 ± 0.64 2.7	9.40 ± 4.81 17.0	0.77 ± 0.37 1.3	0.64 ± 0.49 (4) 1.3
Hexa-CDF	1.06 (3) 4.3	2.10 ± 1.10 3.2	2.87 ± 2.14 5.3	2.48 ± 1.45 4.9	12.7 ± 6.71 23.0	1.53 ± 1.28 3.7	1.46 ± 0.67 2.2
Hepta-CDF	0.20 (1) 1.0	nd	nd	nd	nd	nd	nd

[1] Mean only is given when less than 80% of samples have detectable concentrations. Mean and standard deviation are given when 80% or more of samples have detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F3: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the lower Niagara River and Lake Ontario[1].

	Lower Niagara River		Lake Ontario					
Analyte	CARP (5)	SMB (3)	BT (3)	CHC (3)	COS (3)	LT (18)	SMB (6)	WP (6)
2,3,7,8-TCDD	3.72 ± 3.34	1.80 ± 0.96	1.00 ± 0.26	1.04 ± 0.46	0.93 ± 0.13	1.79 (13)	0.33 (4)	0.16 (3)
	8.30	2.90	1.30	1.40	1.00	3.70	0.87	0.41
1,2,3,7,8-PeCDD	0.29 (2)	0.090 (1)	0.24 (2)	0.45 ± 0.16	0.13 (1)	0.72 (12)	0.20 (4)	0.032 (1)
	0.98	0.27	0.39	0.61	0.40	1.50	0.48	0.19
1,2,3,4,7,8-HxCDD	nd	nd	nd	0.14 (2)	nd	nd	nd	nd
				0.21				
1,2,3,6,7,8-HxCDD	0.27 (2)	nd	nd	0.49 (2)	nd	0.34 (10)	nd	0.032 (1)
	0.73			0.89		0.81		0.19
1,2,3,7,8,9-HxCDD	nd	nd	nd	0.081 (2)	nd	nd	nd	nd
				0.15				
1,2,3,4,6,7,8-HpCDD	1.12 ± 0.91	0.064 (1)	nd	0.50 (2)	nd	0.051 (4)	0.033 (1)	0.066 (3)
	2.2	0.19		0.87		0.35	0.20	0.29
OCDD	1.47 (3)	nd	0.36 ± 0.040	0.40 (2)	nd	0.25 (3)	0.67 (3)	0.27 (3)
	3.60		0.38	0.80		3.6	2.60	0.55
2,3,7,8-TCDF	2.48 ± 2.12	1.30 ± 0.27	5.33 ± 1.23	1.59 ± 0.77	4.03 ± 0.51	11.7 ± 4.06	0.78 ± 0.76 (5)	2.18 ± 1.94 (5)
	4.80	1.50	6.70	2.4	4.60	19.0	1.9	5.2
1,2,3,7,8-PeCDF	nd	nd	0.053 (1)	0.34 ± 0.18	nd	0.11 (3)	0.083 (3)	0.083 (2)
			0.16	0.53		0.81	0.18	0.28
2,3,4,7,8-PeCDF	0.97 (3)	1.59 ± 1.15	0.81 ± 0.18	1.29 ± 0.52	nd	1.97 ± 0.85 (15)	0.17 (3)	0.33 (4)
	2.80	2.90	0.95	1.80		3.30	0.49	0.75
1,2,3,4,7,8-HxCDF	0.84 (2)	1.53 (1)	0.073 (1)	0.12 (2)	nd	0.048 (3)	nd	0.030 (2)
	3.00	4.60	0.22	0.20		0.36		0.096
1,2,3,6,7,8-HxCDF	nd	nd	nd	nd	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	nd	nd	0.10 (2)	nd	0.067 (5)	nd	0.028 (2)
				0.16		0.34		0.10
1,2,3,4,6,7,8-HpCDF	nd	nd	0.060 (1)	nd	nd	0.088 (4)	0.23 (1)	nd
			0.18			0.78	1.40	
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd	nd	nd
OCDF	nd	nd	nd	nd	nd	0.016 (1)	0.20 (1)	nd
						0.29	1.20	

	Lower Niagara River		Lake Ontario					
Analyte	CARP (5)	SMB (3)	BT (3)	CHC (3)	COS (3)	LT (18)	SMB (6)	WP (6)
Homologs								
Tetra-CDD	3.72 ± 3.34	1.80 ± 0.96	1.10 ± 0.43	1.04 ± 0.46	0.93 ± 0.13	1.75 (13)	0.35 (4)	0.20 (4)
	8.3	2.9	1.6	1.4	1.0	3.7	0.87	0.41
Penta-CDD	0.29 (2)	0.090 (1)	0.30 (2)	0.45 ± 0.16	0.11 (1)	0.72 (12)	0.18 (4)	0.032 (1)
	0.98	0.27	0.52	0.61	0.33	1.5	0.48	0.19
Hexa-CDD	0.27 (2)	nd	nd	0.44 (2)	nd	0.34 (10)	nd	nd
	0.73			0.78		0.81		
Hepta-CDD	1.06 ± 0.78	nd	nd	0.55 (2)	0.080 (1)	0.28 (2)	0.18 (4)	0.048 (1)
	1.97			0.92	0.24	0.35	0.40	0.29
Tetra-CDF	4.42 ± 3.58	3.17 ± 2.38	5.53 ± 1.37	1.66 ± 0.88	7.83 ± 0.12	14.9 ± 5.43	0.79 (4)	2.83 ± 2.82 (5)
	8.3	5.9	7.0	2.6	7.9	24.0	2.2	7.7
Penta-CDF	1.39 ± 1.74 (4)	1.59 ± 1.15	1.13 ± 0.15	1.65 ± 0.73	0.94 ± 0.30	2.71 ± 1.75 (17)	0.30 ± 0.32 (5)	0.60 ± 0.57 (5)
	4.3	2.9	1.3	2.4	1.2	7.7	0.86	1.5
Hexa-CDF	0.88 (3)	4.83 ± 3.67	0.19 (1)	0.22 (2)	2.90 ± 0.26	3.47 ± 2.93 (16)	0.46 (3)	0.40 ± 0.17
	3.0	8.7	0.56	0.41	3.2	9.3	2.6	0.63
Hepta-CDF	0.060 (1)	nd	0.060 (1)	nd	nd	0.28 (5)	0.27 (1)	nd
	0.30		0.18			3.4	1.4	

[1] Mean only is given when less than 80% of samples have detectable concentrations. Mean and standard deviation are given when 80% or more of samples have detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F4: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the Salmon River Hatchery and the St. Lawrence River at Cape Vincent[1].

	Salmon River Hatchery			St. Lawrence River at Cape Vincent			
Analyte	CHS (12)	COS (6)	RT (6)	BB (2)	CARP (3)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	1.00 (6) 2.40	2.00 ± 0.26 2.30	2.08 ± 1.36 4.80	0.090 (1) 0.18	0.41 (2) 0.62	0.63 ± 0.10 0.71	0.49 (2) 1.00
1,2,3,7,8-PeCDD	0.50 (9) 0.99	0.69 ± 0.11 0.84	0.37 (4) 1.1	nd	0.69 (2) 1.20	nd	0.19 (2) 0.40
1,2,3,4,7,8-HxCDD	nd	nd	nd	nd	0.48 (2) 0.81	nd	nd
1,2,3,6,7,8-HxCDD	0.073 (4) 0.32	0.11 (2) 0.37	0.10 (3) 0.35	0.29 0.31	1.57 (2) 2.50	nd	nd
1,2,3,7,8,9-HxCDD	nd	nd	nd	nd	0.15 (1) 0.44	nd	nd
1,2,3,4,6,7,8-HpCDD	0.076 (2) 0.76	0.018 (1) 0.11	0.11 (3) 0.26	0.11 (1) 0.22	4.36 ± 3.21 6.60	nd	nd
OCDD	1.42 (2) 16.2	0.37 (1) 2.2	0.52 (4) 0.90	0.50 (1) 1.00	5.00 ± 3.87 9.10	nd	nd
2,3,7,8-TCDF	5.62 ± 0.88 6.9	7.70 ± 1.18 9.50	2.90 ± 1.37 4.7	0.46 (1) 0.92	1.97 ± 0.81 2.70	2.40 ± 0.20 2.60	2.10 ± 0.79 3.00
1,2,3,7,8-PeCDF	0.10 (4) 0.34	nd	0.19 (3) 0.77	nd	0.23 (1) 0.68	nd	0.36 (2) 0.56
2,3,4,7,8-PeCDF	0.93 (9) 1.60	nd	1.29 ± 1.01 3.30	0.37 0.46	0.45 (2) 0.80	nd	0.36 (2) 0.65
1,2,3,4,7,8-HxCDF	0.016 (2) 0.10	0.16 (1) 0.94	0.13 (3) 0.54	nd	nd	nd	nd
1,2,3,6,7,8-HxCDF	nd	nd	nd	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	nd	0.032 (1) 0.19	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDF	nd	nd	nd	nd	1.44 ± 0.95 2.30	0.44 ± 0.31 0.80	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd	nd
OCDF	0.10 (1) 1.20	0.11 (3) 0.32	nd	nd	nd	0.14 (1) 0.41	nd

Analyte	Salmon River Hatchery CHS (12)	COS (6)	RT (6)	St. Lawrence River at Cape Vincent BB (2)	CARP (3)	SMB (3)	WEYE (3)
Homologs							
Tetra-CDD	1.00 (6)	2.00 ± 0.26	2.08 ± 1.36	0.17 (1)	0.41 (2)	0.63 ± 0.10	0.49 (2)
	2.4	2.3	4.8	0.34	0.62	0.71	1.0
Penta-CDD	0.50 (9)	0.65 ± 0.39	0.37 (4)	nd	0.69 (2)	nd	0.19 (2)
	0.99	0.84	1.1		1.2		0.40
Hexa-CDD	0.027 (1)	0.11 (2)	0.018 (1)	0.29	2.03 (2)	nd	nd
	0.32	0.37	0.11	0.31	3.8		
Hepta-CDD	0.17 (2)	0.13(4)	0.11 (2)	0.11 (1)	4.36 ± 3.21	nd	nd
	1.82	0.38	0.42	0.22	6.6		
Tetra-CDF	8.25 ± 3.67	13.00 ± 1.67	2.90 ± 1.37	0.33 (1)	2.00 ± 1.23	2.23 ± 0.33	1.93 ± 0.94
	16.0	15.0	4.7	0.67	3.3	2.6	3.0
Penta-CDF	2.21 ± 1.50	2.80 ± 1.38	1.62 ± 1.29	0.59	1.33 (2)	nd	0.73 (2)
	5.7	4.6	4.1	0.73	2.1		1.2
Hexa-CDF	2.34 (9)	6.60 ± 1.41	0.16 (2)	nd	0.67 (2)	nd	0.087 (1)
	6.5	8.5	0.88		1.3		0.26
Hepta-CDF	nd	nd	nd	nd	1.44 ± 0.95	0.44 ± 0.31	nd
					2.3	0.80	

[1] Mean only is given when less than 80% of samples have detectable concentrations. Mean and standard deviation are given when 80% or more of samples have detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F5: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the St. Lawrence River at Ogdensburg[1].

	St. Lawrence River at Ogdensburg				
Analyte	BB (3)	CARP (3)	CHC (2)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	0.040 (1) 0.12	1.10 ± 0.70 1.60	0.70 (1) 1.40	0.35 ± 0.16 0.53	0.056 (1) 0.17
1,2,3,7,8-PeCDD	nd	0.53 (2) 0.82	0.71 1.30	0.28 ± 0.089 0.38	nd
1,2,3,4,7,8-HxCDD	nd	0.12 (1) 0.37	0.23 (1) 0.47	0.11 (1) 0.34	nd
1,2,3,6,7,8-HxCDD	0.080 (1) 0.24	0.76 ± 0.36 1.00	0.65 (1) 1.30	0.25 (2) 0.60	nd
1,2,3,7,8,9-HxCDD	nd	0.11 (1) 0.33	0.17 (1) 0.35	0.21 (1) 0.63	nd
1,2,3,4,6,7,8-HpCDD	nd	1.76 ± 1.02 2.40	0.82 1.40	7.78 ± 13.2 23.0	nd
OCDD	nd	2.50 ± 1.21 3.60	0.60 (1) 1.20	80.2 ± 138 240	nd
2,3,7,8-TCDF	0.69 ± 0.067 0.73	3.60 ± 1.55 5.20	1.30 1.90	1.88 ± 0.67 2.60	0.38 (2) 0.65
1,2,3,7,8-PeCDF	nd	nd	nd	0.25 (2) 0.55	nd
2,3,4,7,8-PeCDF	0.070 (1) 0.21	1.13 ± 0.57 1.60	1.40 (1) 2.80	0.40 (2) 0.90	0.067 (1) 0.20
1,2,3,4,7,8-HxCDF	nd	nd	nd	0.029 (1) 0.088	nd
1,2,3,6,7,8-HxCDF	nd	0.050 (1) 0.15	nd	0.027 (1) 0.80	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	0.040 (1) 0.12	0.10 (1) 0.21	0.073 (2) 0.15	nd
1,2,3,4,6,7,8-HpCDF	nd	nd	nd	0.16 (1) 0.48	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd
OCDF	nd	nd	nd	nd	nd

Analyte	St. Lawrence River at Ogdensburg BB (3)	CARP (3)	CHC (2)	SMB (3)	WEYE (3)
Homologs					
Tetra-CDD	0.040(1) 0.12	1.10 ± 0.70 1.6	0.70 (1) 1.4	0.38 ± 0.15 0.53	0.057 (1) 0.17
Penta-CDD	nd	0.53 (2) 0.82	0.71 1.3	0.32 ± 0.065 0.38	nd
Hexa-CDD	0.080 (1) 0.24	1.11 ± 0.70 1.7	1.05 (1) 2.1	2.42 (2) 7.0	nd
Hepta-CDD	nd	4.10 ± 4.23 8.8	1.12 2.0	16.9 ± 28.7 50.0	nd
Tetra-CDF	0.92 ± 0.25 1.2	4.47 ± 1.68 6.3	1.45 1.9	2.36 ± 0.60 2.8	0.75 ± 0.072 0.81
Penta-CDF	0.07 (1) 0.21	4.85 ± 3.81 8.1	1.4 (1) 2.8	0.61 ± 0.68 1.4	0.12 (1) 0.36
Hexa-CDF	nd	2.36 ± 3.00 5.8	1.30 (1) 2.6	0.45 (2) 1.1	nd
Hepta-CDF	nd	nd	nd	0.37 (1) 0.75	nd

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F6: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the St. Lawrence River above the Moses Saunders Dam[1].

	St. Lawrence River above the Moses Saunders Dam			
Analyte	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	0.53 (2) 1.20	1.13 (2) 2.20	0.43 ± 0.23 0.69	0.12 ± 0.040 0.15
1,2,3,7,8-PeCDD	0.47 (2) 1.0	0.63 (2) 1.10	0.34 (2) 0.68	0.047 (1) 0.14
1,2,3,4,7,8-HxCDD	0.31 (2) 0.73	0.19 (2) 0.36	nd	nd
1,2,3,6,7,8-HxCDD	0.60 (1) 1.80	0.71 (2) 1.40	0.26 (2) 0.60	nd
1,2,3,7,8,9-HxCDD	0.13 (1) 0.39	0.16 (2) 0.29	nd	nd
1,2,3,4,6,7,8-HpCDD	1.46 ± 1.36 2.8	0.45 ± 0.15 0.55	0.03 (1) 0.09	0.043 (1) 0.13
OCDD	1.11 (2) 2.17	0.12 (1) 0.37	0.16 (1) 0.47	0.64 (2) 1.47
2,3,7,8-TCDF	5.42 ± 5.12 11.0	1.35 ± 0.90 2.30	2.90 ± 1.30 4.40	0.61 ± 0.39 1.05
1,2,3,7,8-PeCDF	0.20 (2) 0.50	nd	0.13 (1) 0.38	0.11 (2) 0.19
2,3,4,7,8-PeCDF	0.81 (2) 1.70	2.20 ± 0.72 3.00	0.99 ± 0.88 2.00	0.029 (1) 0.088
1,2,3,4,7,8-HxCDF	nd	nd	nd	nd
1,2,3,6,7,8-HxCDF	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	0.13 (2) 0.26	0.11 (2) 0.18	nd	nd
1,2,3,4,6,7,8-HpCDF	0.36 (2) 0.79	0.053 (1) 0.16	0.037 (1) 0.11	0.037 (1) 0.11
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd
OCDF	0.037 (1) 0.11	0.043 (1) 0.13	0.037 (1) 0.11	0.043 (1) 0.13

Analyte	St. Lawrence River above the Moses Saunders Dam			
	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
Homologs				
Tetra-CDD	0.59 (2)	1.13 (2)	0.43 ± 0.23	0.12 ± 0.040
	1.4	2.2	0.69	0.15
Penta-CDD	0.47 (2)	0.63 (2)	0.34 (2)	0.12 (2)
	1.0	1.1	0.68	0.23
Hexa-CDD	1.04 (2)	1.06 ± 0.76	0.26 (2)	nd
	2.9	1.8	0.60	
Hepta-CDD	1.30 (2)	0.32 ± 0.046	0.027 (1)	nd
	2.7	0.36	0.08	
Tetra-CDF	7.70 ± 6.11	1.78 ± 0.68	3.10 ± 1.13	0.75 ± 0.43
	14.0	2.5	4.4	1.25
Penta-CDF	1.78 ± 1.42	2.5 ± 0.62	1.52 ± 0.62	0.16 (2)
	2.7	3.2	2.1	0.36
Hexa-CDF	0.41 (2)	0.20 (2)	0.047 (1)	0.13 (2)
	0.63	0.45	0.14	0.30
Hepta-CDF	0.36 (2)	0.053 (1)	0.037 (1)	0.093 (2)
	0.79	0.16	0.11	0.17

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F7: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the St. Lawrence River at the Franklin County line[1].

	St. Lawrence River at the Franklin County line			
Analyte	BB (3)	CARP (3)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	nd	0.16 (2) 0.25	0.10 (1) 0.30	0.10 (2) 0.20
1,2,3,7,8-PeCDD	nd	0.16 ± 0.11 0.27	0.12 (2) 0.20	0.13 (2) 0.21
1,2,3,4,7,8-HxCDD	nd	0.11 (2) 0.18	nd	nd
1,2,3,6,7,8-HxCDD	nd	0.20 (2) 0.31	nd	0.050 (1) 0.15
1,2,3,7,8,9-HxCDD	nd	0.082 (2) 0.17	nd	nd
1,2,3,4,6,7,8-HpCDD	nd	0.37 ± 0.22 0.61	nd	0.023 (1) 0.07
OCDD	0.20 (2) 0.48	0.18 (2) 0.30	nd	nd
2,3,7,8-TCDF	1.36 ± 1.00 2.50	1.53 ± 0.96 2.50	1.20 ± 0.38 1.60	1.52 ± 0.41 1.80
1,2,3,7,8-PeCDF	0.11 (1) 0.32	0.35 ± 0.19 0.55	nd	0.15 (2) 0.29
2,3,4,7,8-PeCDF	0.53 (2) 1.30	2.50 ± 2.07 4.40	0.74 ± 0.13 0.83	0.88 ± 0.90 1.90
1,2,3,4,7,8-HxCDF	0.033 (1) 0.099	0.17 (2) 0.28	nd	nd
1,2,3,6,7,8-HxCDF	0.019 (1) 0.057	0.026 (1) 0.077	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	0.040 (1) 0.12	nd	nd
1,2,3,4,6,7,8-HpCDF	0.053 (1) 0.16	0.13 (2) 0.21	nd	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd
OCDF	nd	nd	nd	nd

Analyte	St. Lawrence River at the Franklin County line BB (3)	CARP (3)	SMB (3)	WEYE (3)
Homologs				
Tetra-CDD	nd	0.16 (2) 0.25	0.10 (1) 0.30	0.10 (2) 0.20
Penta-CDD	nd	0.16 ± 0.11 0.27	0.12 (2) 0.20	0.13 (2) 0.21
Hexa-CDD	nd	0.41 (2) 0.7	nd	0.050 (1) 0.15
Hepta-CDD	nd	0.25 ± 0.16 0.43	nd	nd
Tetra-CDF	2.67 ± 2.41 5.4	2.58 ± 1.47 3.8	1.40 ± 0.49 1.8	1.75 ± 0.64 2.3
Penta-CDF	0.70 (2) 1.8	3.13 ± 2.02 4.8	0.77 ± 0.068 0.83	1.08 ± 0.77 1.9
Hexa-CDF	0.040 (1) 0.12	0.26 (2) 0.46	0.024 (1) 0.073	nd
Hepta-CDF	0.053 (1) 0.16	0.13 (2) 0.21	nd	nd

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F8: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the St. Lawrence River at Raquette Point[1].

	St. Lawrence River at Raquette Point				
Analyte	BB (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	nd	nd	1.39 ± 0.84 2.10	0.18 (2) 0.33	nd
1,2,3,7,8-PeCDD	nd	nd	0.50 (1) 1.50	0.21 (2) 0.37	nd
1,2,3,4,7,8-HxCDD	nd	nd	nd	nd	nd
1,2,3,6,7,8-HxCDD	nd	0.27 (1) 0.82	0.44 (2) 0.67	nd	nd
1,2,3,7,8,9-HxCDD	nd	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDD	nd	0.67 (1) 2.00	0.86 (2) 1.50	nd	nd
OCDD	nd	1.09 (1) 3.28	nd	nd	nd
2,3,7,8-TCDF	0.38 (2) 0.65	3.60 ± 4.78 9.1	2.40 ± 0.66 3.00	2.37 ± 0.32 2.60	0.35 (1) 1.06
1,2,3,7,8-PeCDF	nd	nd	nd	0.13 (1) 0.38	nd
2,3,4,7,8-PeCDF	0.28 (2) 0.44	0.24 (1) 0.71	1.50 (2) 3.30	0.75 (2) 1.30	nd
1,2,3,4,7,8-HxCDF	nd	nd	nd	nd	nd
1,2,3,6,7,8-HxCDF	nd	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDF	nd	nd	nd	nd	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd
OCDF	nd	nd	nd	nd	nd

Analyte	St. Lawrence River at Raquette Point				
	BB (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
Homologs					
Tetra-CDD	nd	nd	1.39 ± 0.84 2.1	0.18 (2) 0.33	nd
Penta-CDD	nd	nd	0.50 (1) 1.5	0.21 (2) 0.37	nd
Hexa-CDD	nd	0.27 (1) 0.82	0.44 (2) 0.67	nd	nd
Hepta-CDD	nd	0.57 (1) 1.7	0.70 (2) 1.2	nd	nd
Tetra-CDF	0.29 (2) 0.54	4.88(2) 13.0	2.32 ± 0.79 3.0	2.35 ± 0.52 2.7	0.32 (1) 0.95
Penta-CDF	0.28 (2) 0.44	0.87 (2) 1.9	1.50 (2) 3.3	0.89 (2) 1.7	nd
Hexa-CDF	nd	nd	nd	0.14 (1) 0.42	0.10 (1) 0.31
Hepta-CDF	nd	nd	nd	nd	nd

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F9: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the Grasse River above the Massena Dam and from the mouth upstream 1.0 mile[1].

	Grasse River above Massena Dam			Grasse River from mouth upstream 1.0 mile			
Analyte	SMB (3)	WEYE (3)	YP (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	0.053 (1) 0.16	nd	0.015 (1) 0.046	0.39 ± 0.17 0.58	0.34 (2) 0.52	0.27 (2) 0.52	0.15 (2) 0.26
1,2,3,7,8-PeCDD	nd	nd	nd	0.37 (2) 0.86	0.57 ± 0.18 0.74	0.23 (2) 0.43	nd
1,2,3,4,7,8-HxCDD	nd	nd	nd	0.14 (1) 0.42	nd	0.040 (1) 0.12	nd
1,2,3,6,7,8-HxCDD	nd	0.10 (1) 0.31	0.030 (1) 0.089	0.41 (2) 0.96	0.89 ± 0.20 1.10	0.13 (1) 0.39	0.060 (1) 0.18
1,2,3,7,8,9-HxCDD	nd	nd	nd	0.090 (1) 0.27	0.12 (1) 0.35	nd	nd
1,2,3,4,6,7,8-HpCDD	nd	nd	0.097 (2) 0.16	0.37 (1) 1.10	1.23 ± 0.15 1.40	0.10 (2) 0.17	0.060 (1) 0.18
OCDD	nd	nd	nd	0.37 ± 0.16 0.55	0.53 (2) 0.85	nd	nd
2,3,7,8-TCDF	0.67 ± 0.050 0.72	0.36 (2) 0.59	0.19 (2) 0.32	0.61 (2) 1.55	1.17 (2) 1.75	2.28 ± 0.31 2.55	0.98 ± 0.31 1.25
1,2,3,7,8-PeCDF	nd	nd	0.066 (2) 0.12	0.53 (2) 1.10	0.063 (1) 0.19	0.16 (1) 0.49	nd
2,3,4,7,8-PeCDF	nd	nd	nd	4.81 ± 3.49 7.70	2.87 ± 1.07 3.80	2.00 ± 0.70 2.80	0.22 (1) 0.65
1,2,3,4,7,8-HxCDF	nd	nd	0.044 (2) 0.089	0.76 (2) 1.80	nd	nd	nd
1,2,3,6,7,8-HxCDF	nd	nd	0.056 (2) 0.085	0.33 (2) 0.72	0.043 (1) 0.13	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	nd	0.025 (1) 0.076	0.12 (1) 0.37	0.10 (1) 0.30	nd	nd
1,2,3,4,6,7,8-HpCDF	nd	nd	0.043 (1) 0.13	nd	nd	nd	0.093 (1) 0.28
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd	nd
OCDF	nd	nd	0.053 (1) 0.16	nd	nd	nd	nd

Analyte	Grasse River above Massena Dam SMB (3)	WEYE (3)	YP (3)	Grasse River from mouth upstream 1.0 mile CARP (3)	CHC (3)	SMB (3)	WEYE (3)
Homologs							
Tetra-CDD	0.053 (1)	nd	0.028 (1)	0.39 ± 0.17	0.41 (2)	0.84 (2)	0.15 (2)
	0.16		0.084	0.58	0.71	2.0	0.26
Penta-CDD	nd	nd	nd	0.37 (2)	0.57 ± 0.18	0.23 (2)	nd
				0.86	0.74	0.43	
Hexa-CDD	0.087 (1)	0.10 (1)	0.030 (1)	0.62 (2)	1.02 ± 0.14	0.17 (1)	0.14 (1)
	0.26	0.31	0.089	1.6	1.1	0.51	0.42
Hepta-CDD	0.067 (1)	nd	0.16 (2)	0.37 (1)	1.23 ± 0.15	0.10 (2)	0.06 (1)
	0.20		0.26	1.1	1.4	0.17	0.18
Tetra-CDF	0.42 ± 0.050	0.36 (2)	0.31 (2)	3.28 (2)	2.27 (2)	2.65 ± 0.52	0.98 ± 0.32
	0.47	0.85	0.55	9.1	3.75	3.25	1.35
Penta-CDF	nd	nd	0.28 ± 0.11	6.07 ± 4.81	3.27 ± 1.46	2.43 ± 1.02	0.33 (2)
			0.36	11.0	4.8	3.6	0.65
Hexa-CDF	nd	nd	0.23 ± 0.16	1.22 (2)	0.32 (2)	0.073 (1)	0.17 (2)
			0.34	2.9	0.68	0.22	0.27
Hepta-CDF	nd	nd	0.043 (1)	nd	nd	nd	0.093 (1)
			0.13				0.28

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F10: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the Raquette River above the Route 420 bridge and from the mouth upstream 1.0 mile[1].

	Raquette River above the Route 420 bridge			Raquette River from mouth upstream 1.0 mile			
Analyte	CARP (3)	SMB (3)	WEYE (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	0.16 (2)	nd	0.021 (1)	0.49 ± 0.23	0.81 ± 0.26	0.24 (2)	0.053 (1)
	0.27		0.064	0.70	0.98	0.48	0.16
1,2,3,7,8-PeCDD	0.25 ± 0.10	0.029 (1)	0.066 (2)	0.51 ± 0.20	0.62 (2)	0.26 (2)	0.10 (2)
	0.26	0.088	0.12	0.70	1.30	0.52	0.24
1,2,3,4,7,8-HxCDD	0.11 (2)	nd	nd	0.26 (2)	0.22 (2)	0.025 (1)	nd
	0.19			0.61	0.45	0.074	
1,2,3,6,7,8-HxCDD	0.44 ± 0.051	nd	0.095 ± 0.023	0.80 (2)	1.02 ± 0.31	0.070 (1)	0.050 (1)
	0.48		0.12	1.70	1.20	0.21	0.15
1,2,3,7,8,9-HxCDD	0.087 (2)	nd	nd	0.21 (2)	0.23 (2)	nd	nd
	0.13			0.47	0.39		
1,2,3,4,6,7,8-HpCDD	0.88 ± 0.21	nd	0.032 (1)	2.28 ± 1.93	1.21 ± 1.04	0.015 (1)	0.086 (2)
	1.00		0.095	4.50	2.40	0.045	0.22
OCDD	1.20 ± 1.13	0.48 (2)	0.057 (1)	1.81 ± 1.59	1.71 ± 2.21	nd	nd
	2.50	1.37	0.17	3.60	4.27		
2,3,7,8-TCDF	0.57 ± 0.068	0.30 ± 0.045	0.30 ± 0.061	3.38 ± 4.12	0.79 ± 0.57	2.60 ± 0.89	0.52 ± 0.40
	0.62	0.34	0.37	8.10	1.37	3.60	0.97
1,2,3,7,8-PeCDF	0.16 ± 0.091	0.022 (1)	nd	0.37 ± 0.17	0.17 (2)	0.11 (1)	nd
	0.26	0.054		0.55	0.25	0.34	
2,3,4,7,8-PeCDF	0.40 ± 0.22	0.082 (2)	0.10 ± 0.015	1.22 ± 0.72	6.53 ± 7.37	0.96 ± 0.36	0.14 (2)
	0.62	0.15	0.11	1.90	15.0	1.30	0.36
1,2,3,4,7,8-HxCDF	0.16 (2)	0.10 (2)	0.020 (1)	0.10 (1)	0.037 (1)	nd	0.017 (1)
	0.28	0.18	0.060	0.31	0.11		0.051
1,2,3,6,7,8-HxCDF	0.22 ± 0.11	0.022 (1)	0.033 (2)	0.30 ± 0.12	0.30 ± 0.14	0.028 (1)	0.015 (1)
	0.35	0.065	0.092	0.41	0.46	0.085	0.045
1,2,3,7,8,9-HxCDF	nd	0.061 (2)	0.011 (1)	nd	nd	nd	0.010 (1)
		0.14	0.034				0.029
2,3,4,6,7,8-HxCDF	0.15 (2)	0.082 (2)	0.052 ± 0.005	0.24 ± 0.095	0.24 ± 0.056	0.033 (1)	0.037 (1)
	0.32	0.18	0.057	0.33	0.29	0.098	0.11
1,2,3,4,6,7,8-HpCDF	0.052 (1)	0.26 (2)	0.012 (1)	0.27 (2)	0.21	nd	0.026 (1)
	0.16	0.57	0.037	0.56	0.62		0.077
1,2,3,4,7,8,9-HpCDF	0.014 (1)	0.070 (1)	nd	nd	nd	nd	nd
	0.043	0.21					
OCDF	0.087 (2)	0.12 (2)	0.027 (1)	0.20 (2)	0.21 ± 0.095	0.031 (1)	0.046 (2)
	0.15	0.26	0.081	0.32	0.32	0.094	0.076

Analyte	Raquette River above the Route 420 bridge CARP (3)	SMB (3)	WEYE (3)	Raquette River from mouth upstream 1.0 mile CARP (3)	CHC (3)	SMB (3)	WEYE (3)
Homologs							
Tetra-CDD	0.19 (2)	0.023 (1)	0.021 (1)	0.49 ± 0.23	0.81 ± 0.26	0.24 (2)	0.078 (2)
	0.34	0.069	0.064	0.70	0.98	0.48	0.16
Penta-CDD	0.25 ± 0.010	0.029 (1)	0.066 (2)	0.51 ± 0.20	0.58 (2)	0.26 (2)	0.10 (2)
	0.26	0.088	0.12	0.70	1.3	0.52	0.24
Hexa-CDD	0.78 ± 0.18	0.083 (2)	0.14 ± 0.057	1.28 ± 1.37	1.52 ± 0.59	0.97 (1)	0.050 (1)
	0.90	0.13	0.20	2.8	2.0	0.29	0.15
Hepta-CDD	0.81 ± 0.20	0.053 (1)	0.04 (1)	2.31 ± 2.00	1.17 ± 1.10	0.017 (1)	0.03 (1)
	1.01	0.16	0.12	4.6	2.4	0.05	0.09
Tetra-CDF	0.76 ± 0.36	0.55 ± 0.31	0.50 ± 0.13	5.23 ± 5.98	0.96 ± 0.48	2.80 ± 1.15	0.68 ± 0.28
	1.17	0.87	0.62	12.0	1.37	4.1	0.97
Penta-CDF	1.21 ± 0.57	0.27 (2)	0.19 ± 0.096	2.98 ± 2.08	7.08 ± 6.93	1.23 ± 0.64	0.22 (1)
	1.85	0.49	0.30	5.1	15.0	1.95	0.65
Hexa-CDF	0.94 ± 0.66	0.41 ± 0.57	0.29 ± 0.012	1.15 ± 0.69	0.93 ± 0.39	0.11 (1)	0.10 ± 0.075
	1.7	1.0	0.21	1.6	1.2	0.33	0.18
Hepta-CDF	0.20 (1)	0.46 (2)	0.11 ± 0.025	0.37 ± 0.38	0.24 (2)	nd	0.026 (1)
	0.59	0.74	0.14	0.79	0.62		0.077

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix F11: Concentrations (pg/g wet weight) of individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish from the St. Regis River above the Hogansburg Dam and from the mouth upstream 1.0 mile[1].

Analyte	St. Regis River above Hogansburg Dam				St. Regis River from mouth upstream 1.0 mile			
	BB (3)	SMB (3)	WEYE (2)	WS (3)	CARP (3)	CHC (3)	SMB (3)	WEYE (3)
2,3,7,8-TCDD	nd	nd	nd	nd	0.35 (2) 0.74	0.48 ± 0.049 0.51	nd	0.15 (2) 0.30
1,2,3,7,8-PeCDD	0.077 (1) 0.23	nd	nd	nd	nd	nd	nd	nd
1,2,3,4,7,8-HxCDD	nd	nd	nd	nd	nd	0.077 (1) 0.23	nd	nd
1,2,3,6,7,8-HxCDD	nd	nd	nd	nd	nd	0.42 ± 0.091 0.49	nd	nd
1,2,3,7,8,9-HxCDD	nd	nd	nd	nd	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDD	0.12 (1) 0.36	nd	nd	nd	0.97 (2) 2.20	0.29 (2) 0.45	nd	nd
OCDD	nd	nd	nd	nd	nd	nd	nd	nd
2,3,7,8-TCDF	0.17 (2) 0.40	0.15 (1) 0.46	0.21 (2) 0.24	0.21 (2) 0.53	1.30 (2) 3.60	1.97 ± 0.10 2.07	1.83 ± 0.65 2.50	0.66 ± 0.16 0.85
1,2,3,7,8-PeCDF	nd	0.030 (1) 0.091	nd	nd	nd	0.44 ± 0.093 0.52	nd	nd
2,3,4,7,8-PeCDF	0.063 (1) 0.19	nd	0.050 (1) 0.10	nd	0.91 ± 0.30 1.20	1.20 ± 0.10 1.30	0.58 (2) 0.95	nd
1,2,3,4,7,8-HxCDF	nd	nd	nd	nd	nd	nd	nd	nd
1,2,3,6,7,8-HxCDF	nd	nd	nd	nd	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	nd	nd	nd	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDF	nd	nd	nd	nd	nd	nd	nd	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd	nd	nd
OCDF	nd	nd	nd	nd	nd	nd	nd	nd

Analyte	St. Regis River above Hogansburg Dam BB (3)	SMB (3)	WEYE (2)	WS (3)	St. Regis River from mouth upstream 1.0 mile CARP (3)	CHC (3)	SMB (3)	WEYE (3)
Homologs								
Tetra-CDD	nd	nd	nd	nd	0.35 (2) 0.74	0.48 ± 0.049 0.51	nd	0. 15 (2) 0.30
Penta-CDD	0.077 (1) 0.23	nd	nd	nd	nd	nd	nd	nd
Hexa-CDD	nd	nd	nd	0.23 (1) 0.68	nd	0.50 ± 0.20 0.71	nd	nd
Hepta-CDD	0.24 (1) 0.71	nd	nd	nd	0.97 (2) 2.2	0.38 (2) 0.68	nd	nd
Tetra-CDF	0.28 (2) 0.61	0.17 (1) 0.51	0.15 (1) 0.30	0.23 (2) 0.37	1.71 (2) 4.7	1.84 ± 0.12 1.91	1.83 ± 0.65 2.5	0.61 ± 0.23 0.85
Penta-CDF	0.063 (1) 0.19	0.030 (1) 0.091	0.050 (1) 0.10	nd	1.17 ± 0.31 1.5	1.67 ± 0.15 1.8	0.58 (2) 0.95	nd
Hexa-CDF	0.050 (1) 0.15	nd	nd	nd	0.60 (1) 1.8	0.17 (1) 0.52	nd	0.24 (1) 0.71
Hepta-CDF	nd	nd	nd	nd	nd	nd	nd	nd

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix G: Supplemental analysis for individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners or homologs in fish.

The following rules were used in the presentation of data for polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDDs or PCDF, respectively, or PCDD/F) in fish in the two sub-appendices within Appendix G.

a. The parenthetic value for each species in column headings is the total number of samples analyzed.

b. "nd" indicates there were no detections of a specific PCDD/F for the location and species. Similarly, "na" indicates no analyses were conducted for the specific PCDD/F in the species and location.

c. In the body of each table, the mean concentration is the first value given for each PCDD/F for each species and location. The mean only is given when fewer than 80% of samples within the species and location have detectable concentrations. Where samples lacked detection of the PCDD/F, the non-detect was assigned a value of zero for computation of the mean.

d. The standard deviation is given when 80% or more of the sample values have detectable concentrations. Again, non-detects were assigned a value of zero for computations.

e. Parenthetic values within the sample data are the number of samples with detectable concentrations of the specific PCDD/F. However, where a mean and standard deviation are given but are without a parenthetic value, all samples of the given species at the location contained the specified PCDD/F at detectable concentrations.

f. The number on the second line following the mean concentration is the maximum PCDD/F congener or homolog concentration determined for the species and location.

Appendix G1: Supplemental analyses for individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish collected from the lower Niagara River, western Lake Ontario and Irondequoit Bay[1].

	Lower Niagara River			Western Lake Ontario	Irondequoit Bay	
Analyte	CARP (5)	LT (3)	WS (3)	LT (9)	CHC (3)	WP (3)
2,3,7,8-TCDD	6.58 ± 6.05 (4) 13.0	7.73 ± 1.07 8.4	nd[3]	2.16 (6) 4.8	1.97 (1) 5.9	0.21 (1) 0.62
1,2,3,7,8-PeCDD	0.22 (2) 0.65	2.13 ± 0.31 2.4	nd	0.43 (4) 1.2	0.57 (1) 1.7	nd
1,2,3,4,7,8-HxCDD	0.52 (3) 1.2	nd	nd	nd	0.13 (1) 0.4	nd
1,2,3,6,7,8-HxCDD	1.87 ± 2.01 (4) 4.1	1.03 ± 0.24 1.3	nd	0.15 (3) 0.57	0.64 (2) 1.4	0.097 (1) 0.29
1,2,3,7,8,9-HxCDD	0.43 (3) 1.0	nd	nd	nd	0.10 (1) 0.31	nd
1,2,3,4,6,7,8-HpCDD	3.43 ± 3.92 (4) 7.8	nd	nd	0.060 (1) 0.54	nd	0.25 (1) 0.74
OCDD	7.04 ± 5.71 15.0	0.33 (1) 1.0	nd	0.078 (1) 0.70	0.34 (1) 1.01	0.15 (1) 0.45
2,3,7,8-TCDF	3.22 (3) 10.0	13.3 ± 2.08 15.0	0.97 ± 0.38 1.4	5.13 (7) 15.0	0.47 (2) 0.74	0.79 (2) 1.4
1,2,3,7,8-PeCDF	0.41 (2) 1.1	0.58 (2) 1.1	nd	nd	nd	nd
2,3,4,7,8-PeCDF	2.30 ± 2.25 (4) 5.0	4.30 ± 0.35 4.7	nd	1.85 (7) 4.2	1.65 ± 1.17 3.0	nd
1,2,3,4,7,8-HxCDF	1.41 (3) 4.5	nd	0.39 (2) 0.60	nd	nd	nd
1,2,3,6,7,8-HxCDF	nd	nd	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	0.50 (2) 0.77	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	0.44 (2) 1.2	0.51 (2) 0.92	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDF	1.92 ± 2.22 (4) 5.4	0.18 (1) 0.54	nd	nd	nd	nd
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd
OCDF	0.27 (2) 0.74	nd	nd	0.04 (1) 0.36	nd	nd

Analyte	Lower Niagara River CARP (5)	LT (3)	WS (3)	Western Lake Ontario LT (9)	Irondequoit Bay CHC (3)	WP (3)
Homologs						
Tetra-CDD	6.58 ± 6.05 (4) 13.0	8.07 ± 0.49 8.4	nd	2.16 (6) 4.8	1.97 (1) 5.9	0.21 (1) 0.62
Penta-CDD	0.21 (2) 0.65	2.13 ± 0.31 2.4	nd	0.43 (4) 1.2	0.57 (1) 1.7	nd
Hexa-CDD	2.84 ± 3.09 (4) 6.3	1.03 ± 0.24 1.3	nd	0.27 (4) 1.1	0.88 (2) 2.1	0.097 (1) 0.29
Hepta-CDD	3.43 ± 3.92 (4) 7.8	nd	nd	0.060 (2) 0.54	nd	0.25 (1) 0.74
Tetra-CDF	15.2 ± 16.7 (4) 43.0	45.0 ± 11.8 55.0	1.23 ± 0.48 1.6	16.0 ± 7.97 33.0	28.7 ± 17.6 49.0	3.93 ± 1.59 5.7
Penta-CDF	4.36 ± 4.89 (4) 11.0	8.47 ± 4.81 14.0	nd	2.29 (7) 5.6	3.29 ± 4.00 7.9	0.26 (1) 0.79
Hexa-CDF	4.88 (3) 13.0	9.20 ± 3.12 11.0	0.39 (2) 0.60	0.72 (3) 3.2	7.77 ± 8.89 18.0	nd
Hepta-CDF	1.92 ± 2.22 (4) 5.4	0.18 (1) 0.54	nd	nd	nd	nd

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.

Appendix G2: Supplemental analyses for individual polychlorinated dibenzo-*p*-dioxin and dibenzofuran congeners and homologs in fish collected from Lake Ontario at Keg Creek and Eighteen Mile Creek, and eastern Lake Ontario[1].

	Keg Creek	Eighteen Mile Cr.	Eastern Lake Ontario			
Analyte	WS (3)	BT (6)	CARP (5)	CHC (3)	LT (3)	WP (3)
2,3,7,8-TCDD	0.50 (1)	0.40 (2)	2.88 (2)	nd	2.23 ± 0.64	nd
	1.5	1.2	11.0		2.7	
1,2,3,7,8-PeCDD	nd	0.24 (2)	1.7 (3)	0.52 (2)	nd	0.40 ± 0.031
		0.82	5.3	0.86		0.43
1,2,3,4,7,8-HxCDD	nd	nd	0.83 (3)	0.20 (1)	nd	nd
			2.4	0.61		
1,2,3,6,7,8-HxCDD	nd	0.035 (1)	1.40 (2)	1.13 (2)	0.070 (1)	0.19 (2)
		0.21	6.2	2.3	0.21	0.30
1,2,3,7,8,9-HxCDD	nd	nd	0.38 (1)	nd	nd	nd
			1.9			
1,2,3,4,6,7,8-HpCDD	nd	nd	6.20 ± 5.89	1.08 (2)	0.12 (1)	0.047 (1)
			16.0	2.4	0.37	0.14
OCDD	0.73 ± 0.036	0.27 (2)	10.2 ± 6.80	0.73 (2)	0.26 (1)	0.41 (2)
	0.77	1.1	21.0	1.1	0.79	0.89
2,3,7,8-TCDF	4.1 (2)	5.13 ± 3.39	0.96 (2)	1.67 (2)	6.67 ± 1.63	1.2 (2)
	11.0	11.0	2.9	2.6	7.8	1.8
1,2,3,7,8-PeCDF	nd	nd	0.28 (1)	nd	nd	nd
			1.4			
2,3,4,7,8-PeCDF	0.29 (1)	0.60 (4)	3.64 ± 4.95 (4)	0.67 (1)	0.50 (1)	0.52 ± 0.12
	0.87	1.6	12.0	2.0	1.5	0.64
1,2,3,4,7,8-HxCDF	0.25 (1)	0.28 (1)	0.26 (1)	nd	nd	0.20 (1)
	0.76	1.7	1.3			0.59
1,2,3,6,7,8-HxCDF	nd	nd	nd	nd	nd	nd
1,2,3,7,8,9-HxCDF	nd	nd	nd	nd	nd	nd
2,3,4,6,7,8-HxCDF	nd	nd	nd	nd	nd	nd
1,2,3,4,6,7,8-HpCDF	nd	nd	0.60 (1)	nd	nd	0.073 (1)
			3.0			0.22
1,2,3,4,7,8,9-HpCDF	nd	nd	nd	nd	nd	nd
OCDF	nd	nd	nd	nd	nd	nd

Analyte	Keg Creek WS (3)	Eighteenmile Cr. BT (6)	Eastern Lake Ontario CARP (5)	CHC (3)	LT (3)	WP (3)
Homologs						
Tetra-CDD	0.50 (1)	0.40 (2)	2.96 (3)	0.19 (1)	2.23 ± 0.64	0.067 (1)
	1.5	1.2	11.0	0.56	2.7	0.20
Penta-CDD	nd	0.24 (2)	1.70 (3)	0.52 (2)	nd	0.40 ± 0.031
		0.82	5.3	0.86		0.43
Hexa-CDD	nd	0.035 (1)	2.58 (3)	1.33 (2)	0.070 (1)	0.19 (2)
		0.21	10.0	2.9	0.21	0.30
Hepta-CDD	nd	nd	6.60 ± 6.73	1.18 (2)	0.12 (1)	0.15 (2)
			18.0	2.7	0.37	0.31
Tetra-CDF	7.77 ± 9.73	13.8 ± 10.05	26.5 ± 26.6	7.13 ± 2.76	13.7 ± 1.53	1.33 (2)
	19.0	29.0	57.0	10.0	15.0	2.2
Penta-CDF	0.92 (2)	0.60 (4)	5.10 ± 6.60 (4)	1.73 (2)	1.73 ± 0.68	0.52 ± 0.12
	1.9	1.6	16.0	3.7	2.5	0.64
Hexa-CDF	1.22 ± 0.47	1.04 (4)	2.66 (2)	0.63 (1)	0.67 (1)	0.53 (1)
	1.7	2.3	12.0	1.9	2.0	1.6
Hepta-CDF	nd	nd	0.60 (1)	nd	nd	0.073 (1)
			3.0			0.22

[1] Mean only when less than 80% of samples with detectable concentration. Mean and standard deviation when 80% or more of samples with detectable concentrations. Where an analyte is detected, the maximum values are on the second line for the analyte.
[2] nd = none detected.