Xenobiotics in Fish from Lake Erie, the Niagara River, Cayuga Creek and Lake Ontario, New York

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ABSTRACT

Xenobiotics in fish represent an important environmental and human health risk. Up-to-date environmental monitoring of xenobiotics is essential to safeguard public health. We provide data on xenobiotics in fish collected from 2010 through 2012 in New York State waters of Lake Erie, the upper Niagara River, Cayuga Creek, the lower Niagara River, Lake Ontario and the Salmon River at Altmar. Samples from 664 individual fish were analyzed for mercury, polychlorinated biphenyls (PCBs) and a selected group of organochlorine pesticides (OCPs), including dichlorodiphenyltrichloro-ethane (DDT) and its metabolites, chlordane and its metabolites, dieldrin, aldrin, mirex, photomirex, heptachlor, heptachlor epoxide, hexachlorocyclohexane (HCH) isomers, hexachlorobenzene (HCB) and octachlorostyrene. We further analyzed a subset of 113 samples for polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) and polybrominated diphenyl ethers (PBDEs).

Concentrations of PCBs, OCPs and PCDD/Fs in fish decreased compared to historical values, and contaminant levels differed by species and location. All but one fish had a mercury concentration below 1 ppm, the U.S. Food and Drug Administration (FDA) action level. Freshwater drum from the Niagara River had the highest levels of mercury. In addition, mercury levels were significantly influenced by fish length. Most fish (99%) had PCB levels below the 2 ppm FDA tolerance level and 80% had PCB levels below 0.5 ppm. Carp from Lake Erie had the highest level of PCBs, with 20% exceeding the FDA tolerance level. OCPs were most often undetected or slightly above the detection limits with the exception of DDT and its metabolites, whose levels were also generally low. PCB and DDT concentrations were highly correlated, but both were only occasionally correlated with mercury.

Most fish had relatively low PCDD/F toxic equivalents (TEQ), with 93% below the New York State Department of Health fish advisory guideline. However, 33% of fish from Cayuga Creek had TEQs above the guideline. Many PBDE congeners were detected in appreciable levels in fish but a risk assessment indicated that PBDEs do not appear to be a major concern for the Lake Ontario and lower Niagara River fish advisories.

These results have led to positive outcomes for fish consumption advisories and progress towards potentially removing the fish consumption beneficial use impairment in the Great Lakes Niagara River Area of Concern. Using these data, on May 22, 2014, the New York State Department of Health relaxed some fish consumption advisories for Lake Ontario and the Niagara River downstream of Niagara Falls for men over 15 and women over 50.

INTRODUCTION

The Great Lakes are the world's largest surface freshwater system, containing one-fifth of the world's surface freshwater (Herdendorf 1990). They provide excellent fishing opportunities for anglers around the country. Unfortunately, despite the enormous size of the Great Lakes, they are not immune to environmental pollution. Many pollutants have found their way into fish in the Great Lakes and bioaccumulated to levels that are potentially harmful for human consumers.

To cope with this threat, many states including New York have issued fish consumption advisories to help the public avoid consuming contaminated fish. While these fish advisories have the desired effect of protecting the public from toxic contaminants, they can also have the undesired effect of discouraging the public from fish consumption (Shimshack and Ward 2010). Fish are an excellent source of protein and omega-3 fatty acids, and fish consumption has been linked to beneficial health effects on the cardiovascular system and neurodevelopment (Mozaffarian 2006). If a fish advisory is unnecessarily restrictive, it denies the public the chance to obtain the nutritional benefits of fish, and also has a detrimental effect on the commercial and recreational fishing industries. Thus, fish consumption advisories must balance competing needs of encouraging fish consumption and protecting the public from fish contaminants. To achieve the best balance, up-to-date fish contaminant data must be available to enable the fish advisories to accurately reflect the current contaminant situation.

Mercury is a widespread contaminant in aquatic environments (Wiener et al. 2012). Fish consumption is the major route of mercury exposure for the general population (Shimshack and Ward 2010) and mercury is the most frequent cause for fish consumption advisories in the United States (USEPA 2011). Mercury is released into the environment through natural process such as volcanic eruptions, but human activities, especially mining and coal burning, contribute significantly to the global mercury pool (Driscoll et al. 2013). Since the industrial revolution, mercury levels in biota have increased rapidly due to increased anthropogenic mercury emissions (Dietz et al. 2009). Currently, most mercury input to aquatic systems comes from atmospheric mercury deposition (Fitzgerald et al. 1998). While mercury emissions in the United States and Europe have decreased in recent decades, the reduction has been offset by increasing emissions from Asia (Selin 2009), creating ongoing concerns about mercury concentrations in fish.

Organochlorine pesticides (OCPs) are a group of structurally diverse chlorinated organic compounds that were once widely used as pesticides. Use of OCPs was banned in the United States due to environmental and human health concerns but legacy contamination persists in the environment (USEPA 2003) and can be found in fish in Great Lakes waters (Bhavsar et al. 2007, Salamova et al. 2013).

Polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) are the byproducts of industrial processes, such as incineration of municipal or medicinal waste, chlorine bleaching of paper pulp, and pesticide manufacturing. They can also be produced by natural processes such as forest fires (Srogi 2008). The environmental release of PCDD/Fs in the United State has decreased, with a 90% drop in the release of dioxin-like compounds between 1987 and 2000 (USEPA 2006). Despite this reduction, PCDD/Fs continue to be found in fish from the Great Lakes (Bhavsar et al. 2008, Gewurtz et al. 2009), and sometimes at levels that warrant fish advisories (NYSDOH 2014).

Polybrominated diphenyl ethers (PBDEs) are a group of brominated flame retardants mainly used in a wide variety of consumer products such as upholstery in furniture and plastics in electronic devices. Because PBDEs are used as an additive and are not chemically bonded to the material matrix, they can easily leach into the environment. As a result, they have become ubiquitous environmental pollutants that have been widely detected in global ecosystems (Luross et al. 2002). Compared to legacy contaminants such as PCBs and OCPs, PBDEs only gained attention recently as hazardous environmental contaminants. PBDE levels in humans, fish and wildlife steadily increased from the 1970s to the early 2000s (Hites 2004), but the trend appears to have reversed in the last decade (Crimmins et al. 2012). Commercial PBDE products are mainly marketed as three different formulations: penta-BDE, octa-BDE and deca-BDE (Schecter et al. 2010). Penta-BDE, octa-BDE and deca-BDE have been banned in the European Union and phased out in the United States (USEPA 2009, Möller et al. 2011, USEPA 2014). With this cessation of usage, PBDEs are expected to be eventually eliminated from the environment. However, at present, many PBDE-containing products are still in use and continue releasing PBDEs into the environment.

For decades, the New York State Department of Environmental Conservation (NYSDEC) has monitored concentrations of environmental contaminants in fish, and the New York State Department of Health (NYSDOH) has used NYSDEC's data to update the state's fish consumption advisories (Horn and Skinner 1985, NYSDOH 2014). With the potential for fish contaminant levels to drop as pollution is curtailed and hazardous sites are cleaned up, a comprehensive reassessment of environmental contaminants in New York's Great Lakes waters is long overdue to provide a timely re-evaluation of fish contaminant levels and fish advisories.

To address this need, the United States Environmental Protection Agency (USEPA), as part of the Great Lakes Restoration Initiative, provided funding for NYSDEC to analyze a variety of legacy and emerging contaminants in fish collected from 2010 through 2012. As legacy contaminants, mercury, PCBs, OCPs and PCDD/Fs have been the cause of fish consumption advisories issued by the New York State Department of Health (NYSDOH 2014). PBDEs are contaminants of emerging concern that have been previously found in fish from New York waters (Skinner et al. 2009, Skinner 2011, 2012) as well as in fish from other waters (Ross et al. 2009, Chen et al. 2011), but the health risks they pose to fish consumers have not previously been addressed in New York State.

We report on contaminant analyses of fish collected from Lake Erie, the Niagara River, Cayuga Creek, Lake Ontario and the Salmon River within New York State. Mercury, PCBs and selected OCPs were analyzed for all samples. PCDD/Fs and PBDEs were analyzed for a subset of the samples. These data provide the scientific basis for re-evaluating the health risk of consuming fish from these Great Lakes waters, with the potential to relax advisories on fish consumption, and for identifying potential threats posed by new toxic chemicals. We additionally seek to further the GLRI priority for "Toxic Substances and Areas of Concern" and advance USEPA's desire to show progress towards delisting International Joint Commission areas of concern (AOC) by removing beneficial use impairments (BUIs).

MATERIALS AND METHODS

1. Fish collection and preparation

From 2010 to 2012, regional staff of NYSDEC collected fish from New York State waters of Lake Erie, the Niagara River, Lake Ontario, Cayuga Creek and the Salmon River at the Salmon River Hatchery at Altmar (Figure 1). Niagara Falls separates the Niagara River into two sections with little opportunity for fish interchange. We collected fish from both the upper Niagara River, which is contiguous with Lake Erie, and the lower Niagara River, which is contiguous with Lake Ontario, with free interchange of fish possible between the lakes and their adjacent river sections. Cayuga Creek is a tributary of the Niagara River that enters just above Niagara Falls, and that received drainage laden with toxic chemicals from the Love Canal hazardous waste site (Skinner 1993). Due to Lake Ontario's size, we distinguished between fish collected from its eastern and western basins. Collections at the Salmon River Hatchery, which drains into eastern Lake Ontario, were of spawning salmonids from the lake.

Target fish species were collected by electrofishing or gill netting, and only fish of legal or edible size were kept as samples. Standard information of location, date, collection personnel, fish species, fish length, fish weight and tag number was recorded on collection record forms in the field. Samples were held alive or on ice during transportation to NYSDEC facilities. Upon arrival, samples were frozen at -18ºC for storage. Standardized chain of custody procedures were followed. The collected fish species are listed in Table 1 with numbers by location and species in Table 2.

Fish samples were prepared at NYSDEC's Hale Creek Field Station according to the laboratory's standard operating procedures. Of the 664 fish analyzed, 620 were prepared as an NYSDEC standard fillet (skin off, left side fillet for brown bullhead and channel catfish; scales off, skin on, left side fillet for other species) and 44 fish too small to provide sufficient analytical mass from a standard fillet were prepared as whole body with head and viscera removed. In general, whole body with head and viscera removed is a method that closely approximates the standard fillet, so we combined fish prepared with these methods in statistical analyses. Samples were thoroughly ground and homogenized, placed in appropriate glass bottles, labeled externally and stored in freezers at -18º C until removed for chemical analysis.

We measured length for all individuals (Table 3) and wet weights for most (Table 4). Plots of weight versus length showed no substantial outliers, providing a check on the measurements (Figure 2). We determined ages when possible for the five salmonid species (Figure 3). Ages of marked (fin clipped) hatchery raised fish were directly determined from the marks; however, with only four sets of marks, ages of older lake trout could not be distinguished. Ages were otherwise determined by counting annuli on scales.

2. Mercury, PCBs and OCPs

All fish samples were analyzed for percent lipid, total mercury, PCBs and OCPs by the Analytical Services Unit at NYSDEC's Hale Creek Field Station (HCFS). Percent lipid was determined gravimetrically. Total mercury was analyzed using the protocol HCFS SOP *HG.1998.FISH.1*

(Mercury in Fish Tissues), which is based on EPA Method 245.6 - Determination of Mercury in Tissues by Cold Vapor Atomic Absorption Spectrometry, Revision 2.3 (April 1991). Briefly, fish samples were homogenized, freeze-dried, and digested in concentrated nitric acid and sulfuric acid. The digested samples were oxidized with potassium permanganate and potassium persulfate, and then reduced with stannous chloride. Mercury vapor was carried by argon gas to an optical cell with a mercury lamp (254 nm), using a Leeman Labs AP/PS200II Mercury Analysis System. Mercury concentration was determined by cold vapor atomic absorption spectrometry.

We analyzed PCBs and OCPs by a capillary GC-ECD method [HCFS SOP *OC1.107 (Organochlorine Residues)*] based on FDA Pesticide Analytical Manual Vol.1, 3rd Edition, Sections 202, 203 and 304. We also analyzed octachlorostyrene with the OCPs due to its structural similarity, although it is mainly a byproduct of industrial processes involving chlorinated compounds and has never been manufactured as a pesticide (Chu et al. 2003, Yanagiba et al. 2009). At least ten percent of the samples were qualitatively confirmed by capillary GC-MS. Fish samples were homogenized, freeze-dried and soxhlet-extracted with hexane/acetone (1:1). The extract was cleaned up by Florisil, evaporated to dryness on a rotovap, and dissolved with isooctane. For gas chromatography, hydrogen was used as the carrier gas and a DB-1 capillary column (60 m x 0.25 mm, 0.25 μm film) was used for GC-ECD and GC-MS. PCBs were analyzed as Aroclor 1242 and combined Aroclors 1254 and 1260 using 26 peaks for quantitation. We analyzed a total of 22 organochlorine pesticides and their metabolites: p,p'-DDE, p,p'-DDD, p,p'-DDT, o,p'-DDE, o,p'-DDD, o,p'-DDT, heptachlor, heptachlor epoxide, trans-chlordane, cis-chlordane, trans-nonachlor cis-nonachlor, oxychlordane, aldrin, dieldrin, photomirex, mirex, HCB, alpha HCH, beta HCH, gamma HCH, octachlorostyrene.

As a quality control measure, one reference material sample, one laboratory duplicate, and one method blank were analyzed for every 20 samples. The reference material for mercury was DORM-2 Dogfish Muscle from NRC (National Research Council), Canada. We used several types of reference materials for PCBs and OCPs, including NIST SRM 1947, Hudson Reference Material developed by NYSDEC (Sloan et al. 2007), and coho salmon collected on 10/18/2000 from the Salmon River.

All results were within control limits for accuracy, precision and potential contamination, based on recommended control limits in Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1, 3rd edition (USEPA 2000).

3. PCDD/Fs and PBDEs

A subset of fish samples, sent as ground homogenate from HCFS, was analyzed by Pace Analytical Services, Minneapolis, Minnesota, for PCDD/Fs with USEPA Method 1613B, and for PBDEs with USEPA Method 1614. We analyzed 110 fish for both PCDD/Fs and PBDEs, 2 fish for PCDD/Fs only, and 1 fish and 1 reference material sample for PBDEs only. With rare exceptions for 2,3,7,8-TCDF, all PCDD/F results met the required quality requirements in USEPA Method 1613B (USEPA 1994). All blanks for PCDD/Fs were below the contract required quantitation limits. In some cases, blank values above the detection limits were reported but were not considered to affect the validity of the analytical results. PBDEs more frequently failed to meet required reporting limits specified in USEPA Method 1614 (USEPA 2010a). One source of the higher reporting limits for

PBDEs was the sample dilution, which was necessary to counteract the effects of interference chemicals in the samples. With few exceptions, most percent recoveries of analyte internal standards for laboratory spike samples were within the target ranges of the analytical methods. For the reference material sample, all the relative percent differences between standard values and analytical results were below 25%, indicating acceptable accuracy.

Although quality assurance parameters were outside of the EPA method specifications in some cases, we concluded that the limited extent of these excursions did not adversely affect data quality. Any result with blank value above zero had the corresponding blank value deducted. If a zero or negative value was produced after blank deduction, the result was treated as a value below the detection limit. For results reported as estimated because they were between the detection and quantitation limits, we used the reported value in statistical analysis. Following Pace's reporting process, we treated PCDD/F results qualified for polychlorinated diphenyl ether (PCDE) or other interferences as undetected. Pace informed us that PCDE interference, which is common in tissue samples, masks the presence of furans and can produce a false positive signal. In practice, high levels of interference usually occurred in PCDD/Fs with low toxicities so the effect on overall toxicity should be relatively small. We treated PBDE results qualified for interference similarly.

Nine of the samples analyzed by Pace were also analyzed by Clarkson University as a quality control measure. Clarkson University is a recipient of an EPA grant for the Great Lakes Fish Monitoring and Surveillance Program. The research team has strong experience and expertise in fish contaminant monitoring, including advanced capacities with both legacy and emerging chemicals (Clarkson University, 2011). Given the small sample size of the Clarkson analyses, we report statistics only on the Pace results.

4. Database

The analytical results were compiled into a database in Microsoft Access 2007 format. The database contains fish collection information such as collection date, location and coordinates, biometric data including species, weight and length, and analytical results. The database schema and the database file are in Appendix B, available digitally.

5. Statistical analysis

We performed all statistical analysis with R 2.13.2 (R Development Core Team 2011), using the beeswarm package (Eklund 2011) for some scatter plots. Whiskers on box plots show 1.5 times the interquartile range.

A substantial proportion of analytical results for some contaminants was below detection limits. While substituting with half the detection limit or some other value is often used to handle nondetects, substitution introduces artifacts into the mean and has adverse effects on calculated standard deviations and statistical tests (Helsel 2012). We investigated several alternative methods recommended by Helsel (2012), including maximum likelihood estimation, the Kaplan-Meier method and regression on order statistics, but obtained inconsistent results, probably due to insufficient sample size. We consequently substituted one-half the detection limit for nondetects

when calculating means and standard deviations, but calculated these statistics only when at least half of the results were over the detection limit. We also substituted half the detection limit when creating summed totals such as total PCBs. A total was treated as a nondetect only if all its components were not detected. We further summarized data using quantiles, which are not sensitive to the presence of censored data. A number preceded by a less than sign (<) in the data summaries is the detection limit and indicates that results were nondetects.

We used nonparametric Mann-Whitney U or Kruskal-Wallis tests in most comparisons among species or sites, as these techniques are valid with censored data and do not require normality of the data. When we found a significant difference among multiple groups, we used the multiple comparison method of Siegel and Cattellan (1988), as implemented in the R package pgirmess (Giraudoux 2011), to identify statistically significant pairs. Least squares regression and other parametric techniques were restricted to analyses where only a small proportion of results were nondetect or missing.

Mercury levels usually increase with fish size (Sonesten 2003, Simonin et al. 2009, Chumchal et al. 2010, Dang and Wang 2012). We used linear regression to test this relationship for each species and location combination. Where the relationship was significant, we used the regression parameters to standardize the mercury concentration of each fish to the median length for its species across all sites using the method described in Appendix A.

We present both wet weight and lipid normalized results for PCBs. Wet weight results are relevant to ecological and human health risk, as they reflect the actual contaminant load of the fish being consumed. However, wet weight values for lipophilic contaminants are influenced by the lipid content of the fish, complicating comparisons among sites and species. Lipid normalizing, dividing the wet weight concentration by the percent lipid of the fish, accounts for the differences in lipid content of the fish to provide values that better reflect environmental exposure to the contaminant, enabling more valid comparisons among sites or species (Braune et al. 1999, Sloan et al. 2002, Gewurtz et al. 2011).

RESULTS

1. Analytes

1.1. Percent lipid

Percent lipid varied considerably by species and location (Table 5). Species with high percent lipid content, with a median greater than 5% at all locations, were brown trout, common carp, channel catfish, freshwater drum and lake trout. Percent lipid was generally not related to fish length (Figure 4).

In some cases, the same species from different locations had statistically different (Mann-Whitney U, $P < 0.05$) lipid levels. For example, channel catfish from Lake Erie had higher percent lipid than those from the eastern basin of Lake Ontario, and coho salmon from the western basin of Lake Ontario had higher percent lipid than those from the Salmon River Hatchery.

Hale Creek and Pace Analytical Services reported appreciable differences in percent lipid for the 113 fish analyzed at both laboratories. Relative percent differences between the two laboratories ranged from 1% to 140%, with many exceeding 100%. Investigation failed to produce a reliable basis for the difference although 94% of results from Pace's first batch were lower than Hale Creek's results while 73% of Pace's second batch results were higher than Hale Creek's.

1.2. Mercury

Mercury was detected in all fish. Concentrations ranged from 0.029 ppm to 1.090 ppm, with a median of 0.129 ppm and a mean of 0.158 ppm (Table 6). Only one fish, a freshwater drum from the Niagara River, had mercury above the FDA action level of 1 ppm (USFDA 2011). Most species and location combinations had a statistically significant ($P < 0.05$) positive relationship between fish length and mercury level (Table 7, Figure 5). For these collections, we adjusted the mercury level to remove the effect of fish length (Table 8). Subsequent results reported for length adjusted mercury use these length adjusted concentrations when the regression was significant and use unadjusted concentrations otherwise. Non-significant relationships, 13 of 38, were mainly in carp (3 of 4), bullheads and catfish (2 of 3), and the four introduced salmonid species (6 of 7) (Table 7).

Fish species differed in length adjusted mercury concentration at all seven collection locations (Kruskal Wallis test, $P < 0.05$, Figure 6). Nonparametric multiple comparisons identified one or more statistically significant pairwise differences at every location (Table 9). Summarizing these comparisons (Table 10) showed which species tended to have higher or lower mercury levels than others. For example, brown trout was significantly lower in 4 of 5 comparisons and significantly higher in 0 of 5. Brown trout, coho salmon and yellow perch had low mercury levels relative to other species at the same location, while channel catfish, freshwater drum, largemouth bass and walleye had relatively high mercury levels compared to other species at the same location (Table 10). Chinook salmon was also statistically higher than the other species at its single collection site but it is difficult to generalize from only two comparisons.

Within a species, length adjusted mercury levels showed species differences among locations in fewer than half the possible comparison pairs (Table 11, Kruskal Wallis test $P < 0.05$, Figure 7). Table 12 summarizes the comparisons in Table 11, showing that Lake Erie and the western basin of Lake Ontario tended to have lower mercury levels relative to other locations for the same species, and the lower Niagara River often had higher mercury levels relative to other locations for the same species. Freshwater drum from the upper and lower Niagara River had the highest mercury levels, with mean length adjusted concentration of 0.454 ppm and 0.521 ppm, respectively (Table 8).

1.3. PCBs

PCB concentrations ranged from nondetect to 7.1 ppm for Aroclor 1242 and to 6.2 ppm for Aroclors 1254/1260 (Table 6). Concentrations of less chlorinated PCBs measured as Aroclor 1242 (Table 13) were usually lower than those of more chlorinated PCBs measured as Aroclors 1254 and 1260 (Table 14). All mean total PCB concentrations were below the FDA tolerance level of 2 ppm (USFDA 2011) (Table 15). Only 1% of individual fish had a total PCB concentration above the FDA tolerance level (Table 16) and 80% were below 0.5 ppm.

Plots of total PCB versus length provide little evidence of a consistent relationship (Figure 8), precluding useful length adjustment for PCBs. Total PCB levels differed among species (Figure 9). Table 17 lists the statistically significant comparison pairs ($P < 0.05$) among species for each location. Table 18 summarizes the comparison results: Common carp, channel catfish and coho salmon had high total PCB relative to other species at the same location, while rock bass, white sucker and yellow perch had lower total PCB. Among species with a small number of comparisons, brown bullhead was statistically lower than other species at 2 collection locations, and chinook salmon was statistically higher than other species at 1 collection location.

With lipid normalized PCB (Table 19, Figure 10), brown trout and white sucker had relatively low levels compared to other species at the same location, while largemouth bass and smallmouth bass had relatively high levels (Table 20 and Table 21). Plots of total PCB concentration versus percent lipid suggest a potentially positive relationship for some species (Figure 11), although differences among sites complicate conclusions.

Total PCB levels varied by collection location for each species (Figure 12). Statistically significant comparison pairs among locations are listed in Table 22 and summarized in Table 23. The upper Niagara River and Lake Ontario had lower total PCB levels than other locations for the same species, and Cayuga Creek had higher total PCB levels. With lipid normalized PCBs (Figure 13, Table 24 and Table 25), the upper Niagara River and western basin of Lake Ontario had lower levels, while the lower Niagara River and Cayuga Creek had higher levels.

1.4. DDTs

Among the six analyzed DDTs and metabolites, p,p’-DDT (Table 26) and p,p’-DDE (Table 27) were detected in most fish, though at low levels, while the detection frequency of p,p’-DDD (Table 28) varied among sites. In contrast, o,p’-DDT (Table 29), o,p’-DDE (Table 30) and o,p’-DDD (Table 31) were rarely detected. The maximum total DDT was 0.73 ppm (Table 32), well below the

5 ppm FDA action level for DDTs in fish edible tissues (USFDA 2011). DDT concentration generally did not appear to be influenced by fish length (Figure 14). The most prevalent form of DDT was p,p'-DDE (Figure 15), a degradation product of p,p'-DDT.

Total DDT differed among species at each location (Figure 16), with rock bass, white sucker, and yellow perch relatively low in total DDT compared to other species at the same location, and common carp and lake trout relatively high (Kruskal Wallis tests and subsequent nonparametric multiple comparisons, $P < 0.05$; Table 33, Table 34). Fish also differed in total DDT among locations (Figure 17). Kruskal Wallis tests and subsequent nonparametric multiple comparisons identified statistically significant pairwise differences among locations (Table 35). Lake Erie, the upper Niagara River and the eastern basin of Lake Ontario had relatively low total DDT for the same species, while the lower Niagara River and western basin of Lake Ontario had relatively high total DDT (Table 36).

1.5. Chlordane

Detections of cis-chlordane (Table 37), oxychlordane (Table 38), cis-nonachlor (Table 39) and trans-nonachlor (Table 40) were generally at low frequencies, and all trans-chlordane results were below the detection limit of 0.005 ppm. The maximum total chlordane level, the sum of these five constituents (Table 41), was 0.13 ppm and the maximum location mean was 0.036 ppm, well under the 0.3 ppm FDA action level (USFDA 2011) for chlordane in fish edible tissues.

1.6. Mirex and photomirex

Mirex was most frequently detected in salmonids and in fish from the lower Niagara River (Table 42). With the exception of one lake trout from the eastern basin of Lake Ontario with a concentration of 0.182 ppm, all fish had mirex concentration below the FDA action level of 0.1 ppm (USFDA 2011).

Photomirex, the photodegradation product of mirex, was detected less commonly (Table 43) than mirex. The maximum level of photomirex was 0.072 ppm, and came from the lake trout with the highest mirex level. When both contaminants were detected in a fish, photomirex and mirex concentrations had a pronounced positive relationship ($P < 0.05$; chinook salmon $R^2 = 0.90$, coho salmon $R^2 = 0.82$, freshwater drum $R^2 = 0.57$, lake trout $R^2 = 0.98$, rainbow trout $R^2 = 0.72$; Figure 18).

1.7. Other OCPs

The other organochlorine pesticides were detected only infrequently. Alpha HCH and beta HCH were detected only at Cayuga Creek (Table 44) and gamma HCH was not detected in any samples above the detection limit of 0.005 ppm.

Aldrin was not detected in any sample at or above the detection limit of 0.005 ppm and dieldrin was detected only in two lake trout from the eastern basin of Lake Ontario at levels just above the

detection limit of 0.025 ppm (Table 45). Aldrin and dieldrin levels were well below 0.3 ppm, the FDA action levels for aldrin and dieldrin (USFDA 2011).

HCB levels were in general very low, with most results either below the detection limit (0.002 ppm) or barely above it (Table 46). The few fish with relatively high, though still quite low, concentration were two carp from Cayuga Creek (0.113 ppm and 0.015 ppm), one brown bullhead from Cayuga Creek (0.037 ppm) and one carp from the lower Niagara River (0.021 ppm).

Octachlorostyrene was detected in only five fish (Table 47) at a maximum concentration of 0.025 ppm, only five times the detection limit. No fish had detectable levels of heptachlor (detection limit 0.005 ppm) or its metabolite heptachlor epoxide (detection limit 0.010 ppm).

1.8. PCDD/Fs

Most PCDD/Fs were detected in fewer than half of the fish (Table 48). PCDD/F congeners share a common mechanism of toxicity, mediated by the AHR (aryl hydrocarbon receptor) signal pathway. Therefore, the toxicity of PCDD/Fs is largely additive, and the overall toxicity of PCDD/F mixtures to humans and mammals can be expressed as the toxic equivalency (TEQ) by summing up the individual compound concentrations multiplied by toxic equivalency factors (TEFs) (Van den Berg et al. 2006). TEF is the relative toxicity of individual congeners compared to the toxicity of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (TCDD), the most toxic form of PCDD/Fs. The calculated TEQs, broken down by species and locations, are summarized in Table 49. The mean TEQ for all samples was 3.35 ± 4.09 ppt (mean ± standard deviation). Most fish had relatively low TEQs with 93% below the NYSDOH advisory guideline. Carp from Cayuga Creek had the highest TEQs, ranging from 9.75 to 29.55 ppt with a median of 13.30 ppt. Four carp, one brown bullhead and two rock bass from Cayuga Creek, and one carp from the lower Niagara River had TEQs exceeding the NYSDOH advisory guideline. TEQ did not show a consistent relationship with fish length (Figure 19). Among the PCDD/F congeners, 2,3,7,8-TCDD, 2,3,7,8-TCDF, 2,3,4,7,8-PeCDF and 1,2,3,7,8-PeCDD contributed most towards the total TEQ (Figure 20).

Statistical power for comparisons among species or locations was limited by small sample sizes of three to six individuals. Within this constraint, TEQs seldom differed among fish species from the same location (Figure 21). Exceptions (Kruskal Wallis test and subsequent nonparametric multiple comparisons, $P < 0.05$) were that carp had higher TEQ than largemouth bass in Cayuga Creek, lake trout was higher than smallmouth bass or white perch in the eastern basin of Lake Ontario, and coho salmon was higher than chinook salmon from the Salmon River Hatchery (Table 50).

TEQs differed somewhat among fish collection locations (Figure 22). Statistically significant ($P < 0.05$) differences were that carp and largemouth bass in Cayuga Creek had higher TEQ levels than those in the upper Niagara River, coho salmon from the Salmon River Hatchery had higher TEQ levels than those in the western basin of Lake Ontario, rainbow trout from the Salmon River Hatchery had higher TEQ levels than those in Lake Erie and smallmouth bass in the lower Niagara River had higher TEQ levels than those in eastern basin of Lake Ontario (Table 51).

The relative percent differences of the nine samples analyzed in duplicate by Pace and Clarkson ranged from 0.2% to 192%. These differences are generally in line with the relatively wide limits allowed in the EPA method for PCDD/Fs (USEPA 1994) for intra-laboratory precision and indicate the general usability of the Pace results.

1.9. PBDEs

About two-thirds of 47 analyzed PBDE congeners were detected (Table 52). The average total PBDE level was 29,044 ± 24,300 ppt. The predominant PBDE congeners were BDE-47, BDE-49, BDE-99, BDE-100, BDE-153 and BDE-154 (Figure 23). Carp from Cayuga Creek had the highest PBDE levels, ranging from 26,045 ppt to 122,557 ppt with a median of 64,178 ppt (Table 53). With a few exceptions, total PBDE was not related to fish length (Figure 24). PBDE levels had few significant differences among species within a location (Figure 25, Table 54). Similarly, few species differed significantly among locations (Figure 26, Table 55).

The relative percent differences of the nine samples analyzed in duplicate by Pace and Clarkson ranged from 0% to 191%. Some PBDEs, such as deca-BDE, may be degraded by light and heat, making accurate measurements difficult (de Boer and Wells 2006) and possibly contributing to the difference. As with dioxins and furans, the differences are generally in line with the relatively wide limits allowed in the EPA method for PBDEs (USEPA 2010a) and indicate the general usability of the Pace results.

2. Relationship among mercury, PCBs and DDT

Among the organochlorine pesticides, only DDT had a sufficient proportion of detections to permit analysis of correlations with mercury and PCBs. For most species, DDT and PCB levels exhibited high and statistically significant ($P < 0.05$) correlations whereas correlations between mercury and total PCBs or total DDT were either low or not significant (Figures 27 through 30; Table 56). For some species, the relationship between PCB and DDT depended on location. For example, rainbow trout from the Salmon River Hatchery had higher DDT levels than those from Lake Erie at the same level of PCB (Figure 29).

DISCUSSION

Relative to human consumption concerns, we found generally low concentrations of PCBs, organochlorine pesticides and PCDD/Fs. Many of the pesticides were detected at low frequency or not at all, while DDT, PCBs and PCDD/Fs remained nearly ubiquitous. With the exception of carp and channel catfish from Lake Erie, mean contaminant concentrations were below the FDA tolerance or action levels (US FDA 2011) and below the New York State Department of Health fish advisory guidelines. The Lake Erie carp and channel catfish, both very lipid rich fish, had mean PCB concentrations above and just below, respectively, 1 ppm. Most individual fish were also below the FDA levels and NYSDOH guidelines.

Levels of these contaminants have dropped considerably since initial monitoring began in the 1970s and since subsequent major monitoring events. Mean smallmouth bass PCB concentrations in the upper Niagara River, Lake Erie and Lake Ontario dropped from 3.23 ppm, 1.32 ppm and 15.79 ppm, respectively, in 1978 and 1979 (NYSDEC 1978, 1979) to 0.189 ppm in the upper Niagara River, 0.360 ppm in Lake Erie, 0.202 ppm in the western basin of Lake Ontario and 0.077 ppm in the eastern basin of Lake Ontario (Table 15). Over the same time period, mean DDT and mirex in smallmouth bass from the upper Niagara River declined from 0.12 ppm and 0.01 ppm, respectively (NYSDEC 1979) to 0.017 ppm and below 0.002 ppm, and in smallmouth bass from Lake Ontario declined from 1.41 ppm and 0.41 ppm (NYSDEC 1978) to 0.025 ppm and below 0.005 ppm. A general declining trend for PCBs and OCPs in Great Lakes fish has been reported elsewhere as well (Hickey et al. 2006, Ekram Azim et al. 2011, Mahmood et al. 2013, Salamova et al. 2013).

PCDD/F TEQs also decreased. Mean TCDD concentrations were 51 ppt in Lake Ontario lake trout in 1980, 5.9 ppt in Lake Ontario smallmouth bass in 1979 and 87 ppt in carp from Cayuga Creek in 1980 (O'Keefe et al. 1983). In a 1980s study, TCDD ranges in Lake Ontario were 29–41 ppt for lake trout, 10–17 ppt for brown trout, and 30–93 ppt for white perch (USEPA and NYSDEC 1994). Current mean TEQs, of which TCDD is only a component, were 4.4 ppt for lake trout in the eastern basin of Lake Ontario, 1.04 ppt for smallmouth bass in the western basin of Lake Ontario, 0.35 ppt for smallmouth bass in the eastern basin of Lake Ontario, and 16.71 ppt for carp in Cayuga Creek (Table 49).

These contaminant levels dropped sufficiently to enable the New York State Department of Health to relax some fish consumption advisories. NYSDOH relaxed the advisories for men over 15 and women over 50 for several salmonids in Lake Ontario and the lower Niagara River, as well as for smallmouth bass from the lower Niagara River (NYSDOH 2014). This is a substantial step towards potentially removing the restrictions on fish and wildlife consumption beneficial use impairment from the Niagara River Area of Concern established by the Great Lakes Water Quality Agreement of 1978, as amended in 1987 (International Joint Commission 1988). On the other hand, the 2010 fish collections led NYSDOH to recommend more restrictive advice for certain species from Lake Erie and the upper Niagara River due to slight increases in PCB concentrations, providing better protection for the public.

In contrast to PCBs, OCPs and PCDD/Fs, where diminishing fish concentrations are driven by curtailment of release followed by decreasing availability due to sequestration or loss from the environment, mercury availability and dynamics depend in a complex manner on changes in local,

regional and global patterns of release (Simonin et al. 2009, Hutcheson et al. 2014) and deposition (Pirrone et al. 1998, Yu et al. 2014), as well as local biogeochemistry (Grieb et al. 1990, Simonin et al. 2008, Dittman and Driscoll 2009, Chasar et al. 2009, Chumchal et al. 2010, Yu et al. 2011). Altered food webs due to introduced species that affect feeding patterns and trophic relations (Turschak et al. 2014) may also change mercury accumulation in fish.

With the exception of one freshwater drum from the Niagara River, none of the fish had a mercury level exceeding the FDA action level of 1 ppm. On the other hand, mercury was detected in all individuals even though average levels have dropped substantially since the early 1970s. In a 1972 study, mean fish mercury levels in Lake Ontario were 0.66 ppm for smallmouth bass, 0.88 ppm for white perch and 0.29 ppm for channel catfish, and means in Lake Erie were 0.47 ppm for walleye, 0.45 ppm for smallmouth bass, 0.42 ppm for rock bass and 0.35 ppm for yellow perch (Boulton and Hetling 1972). Since then, means dropped by half or more to 0.152 ppm for smallmouth bass, 0.203 ppm for white perch and 0.155 ppm for channel catfish in Lake Ontario, and to 0.266 ppm for walleye, 0.202 ppm for smallmouth bass, 0.137 ppm for rock bass and 0.072 ppm for yellow perch in Lake Erie. However, fish mercury levels have changed little or even possibly increased in the last 15 years. For example, in 1999, mean mercury concentrations were 0.123 ppm in Lake Ontario lake trout and 0.124 ppm in Lake Erie walleye (Carlson and Swackhamer 2006), while we found concentrations of 0.141 ppm and 0.266 ppm, respectively. Others have similarly found a decline in Great Lakes fish mercury concentrations since the 1970s, but that in recent years the decline may have stopped or reversed in some cases (Weis 2004, Monson 2009, Bhavsar et al. 2010, Zananski et al. 2011). Yu et al.'s (2014) reconstruction of mercury deposition in five forested areas in New York and New England showed a decline of about 25% from a recent peak in the 1970s. This regional pattern may explain the initial drop seen in fish from that period, but the more recent stability is less readily understood.

Although we found detectable concentrations of PBDEs in all fish, an assessment conducted by NYSDOH determined that PBDE exposure from eating up to four meals per month of any of the analyzed fish species does not appear to be a major concern for Lake Ontario and lower Niagara River fish advisories (NYSDOH, personal communication).

As in most environmental samples (Luross et al. 2002, Roberts et al. 2011), only a few of the 209 possible congeners constituted nearly all of the PBDEs. BDE-47 was the predominant congener, with BDE-99 and BDE-100 also important in many cases (Figure 23). BDE-99 (35−50%), BDE-47 (25−37%) and BDE-100 (6−10%) are the major congeners in the penta-BDE formulation product (USEPA 2010b). The high proportion of BDE-99 and BDE-47 probably reflects the fact that penta-BDE was the major PBDE product used in North America (Hites 2004). Although BDE-99 is more abundant than BDE-47 in the penta-BDE formulation, we found BDE-47 to be the more abundant of the two. Similar congener patterns have been reported by others (Hites 2004, Crimmins et al. 2012). A possible reason is the degradation of BDE-99 in fish. BDE-99 can undergo debromination in fish, causing its levels to decrease. The rate of debromination differs among fish species, with carp debrominating BDE-99 much faster than rainbow trout or chinook salmon (Roberts et al. 2011). While rainbow trout and chinook salmon, as well as other species, had substantial proportions of BDE-99, carp had virtually none (Figure 23), supporting this debromination hypothesis. Skinner et al. (2009) similarly found that BDE-47 alone was the dominant congener in

carp and bluntnose minnows whereas both BDE-47 and BDE-99 were dominant in brown bullhead and pumpkinseed.

Reflecting the phase out in their use (USEPA 2009, Möller et al. 2011, USEPA 2014), PBDE levels in fish from the Great Lake appear to have dropped in recent years. For example, yearly PBDE means as determined by the sum of congeners BDE-47, BDE-99, BDE-100, BDE-153 and BDE-154 for fish collected during 2004–2009 were 50–107 ppb for lake trout in Lake Ontario and 11–22 ppb for walleye in Lake Erie (Crimmins et al. 2012). In comparison, our sums of these 5 congeners were 11.9−24.2 ppb for lake trout in Lake Ontario and 1.8−5.3 ppb for walleye in Lake Erie. Luross et al. (2002) reported a mean of 95 ppb PBDEs in 1997 Lake Ontario lake trout while we found a mean of 48 ppb.

Several findings reflect site specific legacies or characteristics of the contaminants. Cayuga Creek is noteworthy for high PCDD/F TEQs, especially for carp (Figure 21), as well as for high PCB concentrations. As a receiving water from the former Hooker Chemical Corporation Love Canal hazardous waste site, large quantities of these and other hazardous materials were discharged into the creek (Skinner 1993, Irvine et al. 2005). Persistently high concentrations in the fish suggest the local environmental persistence of these chemicals. With the exception of three fish from Lake Erie with barely detectable concentrations, all mirex detections came from Cayuga Creek and downstream waters of the lower Niagara River and Lake Ontario. The main source of mirex to the system was the former Hooker Chemical Corp. in Niagara Falls, NY, with a secondary source from New York's Oswego River (Hetling and Collin 1978, Van Hove Holdrinet et al. 1978, Makarewicz et al. 2003). Although, as also found by others, mirex concentrations in fish have dropped (Makarewicz et al. 2003, Carlson et al. 2010), the signal from its environmental release persists 35 years after processing at Hooker ended.

PCB and DDT concentrations were strongly correlated, whereas neither was consistently correlated with mercury (Figures 27-30, Table 56). This finding likely reflects similar environmental and biological pathways for PCB and DDT that differ from those of mercury. Both PCB and DDT are persistent, lipophilic chemicals that bioaccumulate in fatty tissues through similar mechanisms (Verhaert et al. 2013) while inorganic mercury requires microbial transformation to methylmercury to effectively bioaccumulate (Harris et al. 2007). Because of its high affinity for thiol groups, methylmercury tends to accumulate in tissues containing proteins with high cysteine contents, such as muscle tissues (Amlund et al. 2007). The most prevalent DDT compound was p,p'-DDE (Figure 15) whereas the predominant component in commercial technical DDT is p,p'-DDT (ATSDR, 2002). Because p,p'-DDE is the degradation product of p,p'- DDT, a high proportion of p,p'-DDT is a sign that the DDT mixture has been environmentally weathered (Ssebugere et al. 2009).

It is more difficult to relate some findings to site history. One carp from the upper Niagara River had PCB and OCP concentrations far in excess of the other carp from this location. This fish was also considerably more contaminated than carp from Lake Erie, even though Lake Erie carp otherwise had higher concentrations than those from the upper Niagara River. Although this fish had the highest lipid content of all carp, percent lipid is insufficient to explain the difference with the other fish. While we cannot determine the cause of this fish's high contaminant levels, the concentrations suggest that the potential for considerable accumulation, at least in isolated cases, remains. In another example, freshwater drum from both sections of the Niagara River had

considerably higher levels of mercury than other species, including freshwater drum in Lake Erie and other species in the river (Table 10, Figure 6). A possible explanation is the dietary habit of freshwater drum. Because they have fused lower pharyngeal bones, freshwater drum can crush harder food items such as zebra mussels. They may be able to consume some contaminated food sources unavailable to many other species, thus accumulating more mercury.

The most salient difference among collection locations for a species was between the coho salmon collected from the Salmon River Hatchery in October 2010 and those collected in western Lake Ontario in June 2011. All fish, except a single three year old from the western basin of Lake Ontario which was the largest from both sites, were two years post hatching. The fall fish, however, had an extra season of growth, and were considerably larger (e.g., Figure 5). These larger fish had considerably greater contaminant concentrations (Figures 5, 8, 14, 19, 24), though lower percent lipid (Figure 4). The higher fall contaminant levels, a pattern also found by Horn et al. (1986), might be due to cohort differences or accumulation of contaminants as the fish grew over the summer, perhaps mediated by diet changes, while the percent lipid decrease might also be associated with the energetic demands of migration and spawning.

RECOMMENDATIONS

1. Conduct a second round of sampling and analysis of mercury, PCBs, OCPs and PCDD/Fs in Lake Ontario and the lower Niagara River. These data are needed so that the New York State Department of Health can consider further relaxation of the fish consumption advisories for these waters.

2. Fund the remainder of the study as envisioned in the original grant application to US EPA to enable a screening assessment of Great Lakes fish of hexabromocyclododecane (HCBD), perfluoro-compounds (PFCs), polychlorinated naphthalenes (PCNs) and tetrabromobisphenol A (TBBPA). These contaminants of emerging concern have been found in fish from New York State and from other Great Lakes, but we have only limited information on their distribution in New York's Great Lakes waters.

3. Repeat this comprehensive fish collection and analysis beginning in 2020. Monitoring approximately every ten years is needed both to assure continued protection of the sport fish consuming public and to track progress in the remediation and clean up of persistent toxic chemicals. DEC will continue its more limited monitoring, every two to three years, of Lake Ontario salmonids.

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Table 1. Collected fish species.

Species	Species Code	Scientific Name
brown bullhead	**BB**	*Ameiurus nebulosus*
brown trout	**BT**	*Salmo trutta*
common carp	**CARP**	*Cyprinus carpio*
channel catfish	**CHC**	*Ictalurus punctatus*
chinook salmon	**CHS**	*Oncorhynchus tshawytscha*
coho salmon	**COS**	*Oncorhynchus kisutch*
freshwater drum	**DRUM**	*Aplodinotus grunniens*
largemouth bass	**LMB**	*Micropterus salmoides*
lake trout	**LT**	*Salvelinus namaycush*
rock bass	**RB**	*Ambloplites rupestris*
rainbow trout	**RT**	*Oncorhynchus mykiss (Salmo gairdneri)*
smallmouth bass	**SMB**	*Micropterus dolomieu*
walleye	**WEYE**	*Sander vitreus*
white perch	**WP**	*Morone americana*
white sucker	**WS**	*Catostomus commersoni*
yellow perch	**YP**	*Perca flavescens*

Table 2. Collected fish by collection site and species.

	Lake Erie	Upper Niagara River	Lower Niagara River	Cayuga Creek	Lake Ontario, West	Lake Ontario, East	Salmon River Hatchery	TOTAL
brown bullhead				10				10
brown trout						10		10
common carp	15	15	15	10				55
channel catfish	15					11		26
chinook salmon							30	30
coho salmon					28		20	48
freshwater drum	15	13	17					45
largemouth bass		15		11				26
lake trout	15					98		113
rock bass	18	15	7	9				49
rainbow trout	15						30	45
smallmouth bass	16	15	15		15	10		71
walleye	15							15
white perch	15				10	25		50
white sucker					5	10		15
yellow perch	15	23	18					56
TOTAL	154	96	72	40	58	164	80	664

Table 3. Fish length (mm). SD = standard deviation.

Species	*Min*	*Median*	*Max*	*N*	*Mean*	*SD*
brown bullhead	250	288	348	10	290	33
brown trout	467	493	531	10	495	23
common carp	359	609	870	55	613	103
channel catfish	254	620	895	26	633	167
chinook salmon	815	936	1015	30	925	44
coho salmon	513	609	845	48	646	103
freshwater drum	262	521	643	45	519	87
largemouth bass	270	348	440	26	354	36
lake trout	317	661	870	113	640	125
rock bass	150	208	262	49	205	28
rainbow trout	360	605	765	45	602	101
smallmouth bass	284	363	508	71	368	49
walleye	380	577	684	15	559	83
white perch	163	239	313	50	241	35
white sucker	333	424	520	15	415	59
yellow perch	140	187	295	56	193	40

Table 4. Fish weight (g). Samples with missing weight values were excluded. SD = standard deviation.

Species	*Min*	*Median*	*Max*	*N*	*Mean*	*SD*
brown bullhead	170	332	567	9	300	167
brown trout	1451	1905	2404	10	1919	353
common carp	652	3845	12190	42	3029	2828
channel catfish	127	2702	8800	26	3811	2877
chinook salmon	5982	8165	11226	30	8413	1212
coho salmon	1315	2381	5698	48	2928	1405
freshwater drum	190	2110	3946	45	2131	1039
largemouth bass	453	673	1304	26	736	216
lake trout	259	3066	7567	112	3171	1675
rock bass	75	200	440	49	205	88
rainbow trout	440	2090	3980	45	2200	935
smallmouth bass	369	765	2400	71	862	428
walleye	490	2092	3070	14	1805	822
white perch	60	213	520	48	228	114
white sucker	389	774	1342	15	780	301
yellow perch	43	75	340	56	101	68

Table 5. Percent lipid.

Species	Location	N	Mean	Standard Deviation	Median	Range
brown bullhead	Cayuga Creek	10	0.76	0.43	0.62	0.30 - 1.48
brown trout	Lake Ontario East	10	15.13	2.95	15.02	10.46 - 19.15
carp	Lake Erie	15	9.18	5.34	7.97	2.71 - 21.24
	Upper Niagara River	15	8.00	5.34	6.96	1.81 - 21.65
	Lower Niagara River	15	8.42	4.23	8.80	1.53 - 15.32
	Cayuga Creek	10	4.26	1.70	4.65	0.78 - 6.40
channel catfish	Lake Erie	15	14.93	4.41	13.96	5.06 - 23.61
	Lake Ontario East	11	5.83	3.91	5.09	0.93 - 12.65
chinook salmon	Salmon River Hatchery	30	1.34	0.74	1.25	0.26 - 3.56
coho salmon	Lake Ontario West	28	6.60	2.06	6.50	3.15 - 10.57
	Salmon River Hatchery	20	2.49	1.11	2.40	0.82 - 4.43
freshwater drum	Lake Erie	15	5.07	3.04	3.83	0.76 - 10.07
	Upper Niagara River	13	8.65	4.48	9.55	0.75 - 15.57
	Lower Niagara River	17	6.19	2.64	5.25	1.76 - 10.54
largemouth bass	Upper Niagara River	15	2.04	1.01	1.90	0.80 - 4.08
	Cayuga Creek	11	1.01	0.42	1.01	0.61 - 2.05
lake trout	Lake Erie	15	12.62	4.28	11.98	7.67 - 25.09
	Lake Ontario East	98	13.89	4.89	14.76	2.04 - 24.42
rock bass	Lake Erie	18	1.15	0.35	1.12	0.63 - 1.94
	Upper Niagara River	15	0.88	0.26	0.85	0.54 - 1.49
	Lower Niagara River	7	1.17	0.34	1.35	0.66 - 1.52
	Cayuga Creek	9	1.03	0.40	0.92	0.72 - 2.05
rainbow trout	Lake Erie	15	3.69	2.61	3.32	0.64 - 12.13
	Salmon River Hatchery	30	3.39	1.26	3.27	1.05 - 6.13
smallmouth bass	Lake Erie	16	5.12	1.96	4.76	2.85 - 10.38
	Upper Niagara River	15	1.81	0.99	1.76	0.35 - 4.66
	Lower Niagara River	15	2.04	0.64	1.93	0.82 - 3.30
	Lake Ontario West	15	4.42	1.72	4.31	1.51 - 7.65
	Lake Ontario East	10	1.74	0.71	1.66	0.91 - 2.78
walleye	Lake Erie	15	2.93	1.08	2.92	0.81 - 4.36
white perch	Lake Erie	15	6.49	1.73	5.96	4.21 - 9.68
	Lake Ontario West	10	3.77	1.27	3.50	2.03 - 6.08
	Lake Ontario East	25	3.50	1.38	2.88	1.15 - 6.53
white sucker	Lake Ontario West	5	1.93	0.61	1.57	1.46 - 2.87
	Lake Ontario East	10	1.22	0.67	1.00	0.54 - 2.66
yellow perch	Lake Erie	15	0.79	0.23	0.78	0.32 - 1.20
	Upper Niagara River	23	1.47	0.65	1.38	0.57 - 3.06
	Lower Niagara River	18	0.97	0.25	1.00	0.51 - 1.51

Table 6. Mercury, PCB and OCP summary results (ppm).

Analyte	Min	10%	25%	Median	75%	90%	Max
mercury	0.029	0.053	0.078	0.129	0.184	0.270	1.090
Aroclor 1242	<0.010	<0.01	0.017	0.037	0.076	0.140	7.074
Aroclor 1254/Aroclor 1260	<0.030	0.035	0.082	0.194	0.348	0.548	6.206
p,p'-DDD	<0.002	<0.002	<0.002	0.005	0.012	0.019	0.088
p,p'-DDE	<0.002	0.004	0.008	0.025	0.076	0.119	0.620
p,p'-DDT	<0.002	<0.002	<0.002	0.005	0.011	0.018	0.080
o,p-DDD	<0.015	<0.015	<0.015	<0.015	<0.015	<0.015	0.017
o,p-DDE	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.012
o,p-DDT	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009
heptachlor	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
heptachlor epoxide	<0.010	<0.010	<0.010	<0.010	<0.01	<0.010	<0.010
cis-chlordane	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	0.017
cis-nonachlor	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	0.033
trans-chlordane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
trans-nonachlor	<0.005	<0.005	<0.005	<0.005	0.008	0.014	0.057
oxychlordane	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	0.020
aldrin	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
dieldrin	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	0.030
mirex	<0.002	<0.002	<0.002	<0.002	0.013	0.023	0.182
photomirex	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	0.072
alpha-hexachlorocyclohexane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.038
beta-hexachlorocyclohexane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.024
gamma-hexachlorocyclohexane	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.004
hexachlorobenzene	<0.002	<0.002	<0.002	<0.002	<0.002	0.004	0.113
octachlorostyrene	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.017

Table 7. Mercury (ppm). The "–" indicates that the linear relationship between mercury and length was not statistically significant ($P < 0.05$).

Location	Species	N	Mean	Standard Deviation	Median	Range	R^2 Hg vs. Length
Lake Erie	carp	15	0.143	0.062	0.142	0.035 - 0.275	-
	channel catfish	15	0.166	0.073	0.142	0.074 - 0.299	-
	freshwater drum	15	0.123	0.059	0.126	0.034 - 0.221	0.33
	lake trout	15	0.118	0.032	0.111	0.087 - 0.189	0.57
	rock bass	18	0.137	0.054	0.124	0.068 - 0.250	-
	rainbow trout	15	0.098	0.022	0.092	0.067 - 0.146	-
	smallmouth bass	16	0.202	0.121	0.207	0.037 - 0.461	0.73
	walleye	15	0.266	0.131	0.262	0.077 - 0.542	0.53
	white perch	15	0.067	0.037	0.058	0.029 - 0.177	0.76
	yellow perch	15	0.072	0.025	0.070	0.038 - 0.126	0.26
Upper Niagara River	carp	15	0.085	0.068	0.056	0.030 - 0.284	-
	freshwater drum	13	0.650	0.241	0.661	0.173 - 1.090	0.66
	largemouth bass	15	0.146	0.061	0.142	0.070 - 0.340	0.38
	rock bass	15	0.088	0.029	0.081	0.062 - 0.171	0.43
	smallmouth bass	15	0.172	0.060	0.162	0.101 - 0.328	0.53
	yellow perch	23	0.054	0.017	0.053	0.029 - 0.117	0.56
Lower Niagara River	carp	15	0.144	0.061	0.135	0.044 - 0.293	0.26
	freshwater drum	17	0.589	0.214	0.650	0.101 - 0.904	0.37
	rock bass	7	0.214	0.101	0.213	0.090 - 0.411	0.81
	smallmouth bass	15	0.200	0.048	0.191	0.131 - 0.286	0.41
	yellow perch	18	0.066	0.023	0.060	0.037 - 0.132	0.46
Cayuga Creek	brown bullhead	10	0.093	0.032	0.078	0.061 - 0.158	-
	carp	10	0.181	0.153	0.137	0.035 - 0.572	-
	largemouth bass	11	0.189	0.087	0.172	0.117 - 0.436	0.68
	rock bass	9	0.097	0.035	0.094	0.051 - 0.150	0.57
Lake Ontario West	coho salmon	28	0.056	0.008	0.056	0.045 - 0.083	-
	smallmouth bass	15	0.155	0.038	0.151	0.065 - 0.217	-
	white perch	10	0.104	0.023	0.099	0.073 - 0.139	0.43
	white sucker	5	0.066	0.032	0.055	0.035 - 0.120	0.79
Lake Ontario East	brown trout	10	0.066	0.015	0.067	0.038 - 0.094	-
	channel catfish	11	0.155	0.052	0.164	0.043 - 0.211	0.42
	lake trout	98	0.141	0.063	0.136	0.038 - 0.330	0.56
	smallmouth bass	10	0.149	0.053	0.136	0.084 - 0.255	0.74
	white perch	25	0.244	0.112	0.209	0.086 - 0.474	0.46
	white sucker	10	0.120	0.069	0.110	0.043 - 0.244	-
Salmon River Hatchery	chinook salmon	30	0.216	0.046	0.221	0.116 - 0.352	-
	coho salmon	20	0.105	0.014	0.101	0.076 - 0.132	-
	rainbow trout	30	0.147	0.036	0.141	0.088 - 0.260	0.49

Table 8. Length adjusted mercury (ppm).

Location	Species	N	Mean	Standard Deviation	Median	Range
Lake Erie	carp [a]	15	0.143	0.062	0.142	0.035 - 0.275
	channel catfish [a]	15	0.166	0.073	0.142	0.074 - 0.299
	freshwater drum	15	0.159	0.048	0.143	0.104 - 0.251
	lake trout	15	0.135	0.021	0.133	0.109 - 0.186
	rock bass [a]	18	0.137	0.054	0.124	0.068 - 0.250
	rainbow trout [a]	15	0.098	0.022	0.092	0.067 - 0.146
	smallmouth bass	16	0.133	0.063	0.124	0.037 - 0.294
	walleye	15	0.287	0.090	0.276	0.143 - 0.481
	white perch	15	0.082	0.018	0.078	0.058 - 0.118
	yellow perch	15	0.045	0.022	0.039	0.011 - 0.090
Upper Niagara River	carp [a]	15	0.085	0.068	0.056	0.030 - 0.284
	freshwater drum	13	0.454	0.141	0.429	0.165 - 0.779
	largemouth bass	15	0.145	0.048	0.127	0.090 - 0.270
	rock bass	15	0.113	0.022	0.113	0.075 - 0.158
	smallmouth bass	15	0.169	0.041	0.179	0.108 - 0.270
	yellow perch	23	0.054	0.011	0.057	0.024 - 0.074
Lower Niagara River	carp	15	0.119	0.052	0.108	0.043 - 0.252
	freshwater drum	17	0.521	0.170	0.536	0.168 - 0.802
	rock bass	7	0.083	0.044	0.089	0.025 - 0.145
	smallmouth bass	15	0.232	0.037	0.230	0.179 - 0.304
	yellow perch	18	0.071	0.017	0.069	0.038 - 0.124
Cayuga Creek	brown bullhead [a]	10	0.093	0.032	0.078	0.061 - 0.158
	carp [a]	10	0.181	0.153	0.137	0.035 - 0.572
	largemouth bass	11	0.179	0.050	0.165	0.105 - 0.270
	rock bass	9	0.122	0.023	0.119	0.091 - 0.176
Lake Ontario West	coho salmon [a]	28	0.056	0.008	0.056	0.045 - 0.083
	smallmouth bass [a]	15	0.155	0.038	0.151	0.065 - 0.217
	white perch	10	0.099	0.017	0.102	0.069 - 0.124
	white sucker	5	0.109	0.015	0.110	0.095 - 0.131
Lake Ontario East	brown trout [a]	10	0.066	0.015	0.067	0.038 - 0.094
	channel catfish	11	0.199	0.040	0.207	0.126 - 0.247
	lake trout	98	0.147	0.042	0.141	0.053 - 0.290
	smallmouth bass	10	0.145	0.027	0.140	0.104 - 0.207
	white perch	25	0.209	0.082	0.195	0.075 - 0.440
	white sucker [a]	10	0.120	0.069	0.110	0.043 - 0.244
Salmon River Hatchery	chinook salmon [a]	30	0.216	0.046	0.221	0.116 - 0.352
	coho salmon [a]	20	0.105	0.014	0.101	0.076 - 0.132
	rainbow trout	30	0.133	0.026	0.126	0.104 - 0.210

[a] Unadjusted results repeated from Table 7 because the regression of mercury concentration on length was not significant.

Table 9. Statistically significant ($P < 0.05$) comparisons of length adjusted mercury among different species at each location. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch.

Location	Comparison			Location	Comparison			Location	Comparison		
Lake Erie	CARP	>	YP	Upper Niagara River	CARP	<	DRUM	Lake Ontario West	COS	<	SMB
	CHC	>	WP		CARP	<	LMB		COS	<	WP
	CHC	>	YP		CARP	<	SMB		COS	<	WS
	DRUM	>	WP		DRUM	>	RB	Lake Ontario East	BT	<	CHC
	DRUM	>	YP		DRUM	>	YP		BT	<	LT
	LT	>	YP		LMB	>	YP		BT	<	SMB
	RB	<	WEYE		RB	>	YP		BT	<	WP
	RB	>	YP		SMB	>	YP		CHC	>	LT
	RT	<	WEYE	Lower Niagara River	CARP	<	DRUM		CHC	>	WS
	SMB	<	WEYE		DRUM	>	RB		LT	<	WP
	SMB	>	YP		DRUM	>	YP		WP	>	WS
	WEYE	>	WP		RB	<	SMB	Salmon River Hatchery	CHS	>	COS
	WEYE	>	YP		SMB	>	YP		CHS	>	RT
				Cayuga Creek	BB	<	LMB		COS	>	RT

Table 10. Comparison summary for length adjusted mercury among different species. Low Count and High Count are the number of times a species had a statistically lower or higher mercury level, respectively, than other species at the same location.

Species	*Species Code*	*Number of Comparisons*	*Low Count*	*Low Percent*	*High Count*	*High Percent*
brown bullhead	BB	3	1	33%	0	0%
brown trout	BT	5	4	80%	0	0%
common carp	CARP	21	4	19%	1	5%
channel catfish	CHC	14	0	0%	5	36%
chinook salmon	CHS	2	0	0%	2	100%
coho salmon	COS	5	5	100%	0	0%
freshwater drum	DRUM	18	0	0%	8	44%
largemouth bass	LMB	8	0	0%	3	38%
lake trout	LT	14	2	14%	2	14%
rock bass	RB	21	4	19%	2	10%
rainbow trout	RT	11	2	18%	1	9%
smallmouth bass	SMB	26	1	4%	7	27%
walleye	WEYE	9	0	0%	5	56%
white perch	WP	17	3	18%	4	24%
white sucker	WS	8	2	25%	1	13%
yellow perch	YP	18	13	72%	0	0%

Table 11. Statistically significant ($P < 0.05$) comparisons of length adjusted mercury among different locations for each species. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery.

Species	**Comparison Pairs**		
carp	LE	>	UN
coho salmon	LOW	<	SRH
freshwater drum	LE	<	UN
	LE	<	LN
largemouth bass	UN	<	CY
rainbow trout	LE	<	SRH
smallmouth bass	LE	<	LN
	UN	<	LN
	LN	>	LOW
	LN	>	LOE
white perch	LE	<	LOE
	LOW	<	LOE
yellow perch	LE	<	LN
	UN	<	LN

Table 12. Comparison summary for length adjusted mercury among different locations. Low Count and High Count are the number of times a location had a statistically lower or higher mercury level, respectively, than other locations for the same species.

Location	***Location Code***	***Number of Comparisons***	***Low Count***	***Low Percent***	***High Count***	***High Percent***
Lake Erie	LE	19	6	32%	1	5%
Upper Niagara River	UN	15	4	27%	1	7%
Lower Niagara River	LN	14	0	0%	7	50%
Cayuga Creek	CY	7	0	0%	1	14%
Lake Ontario West	LOW	8	3	38%	0	0%
Lake Ontario East	LOE	9	1	11%	2	22%
Salmon River Hatchery	SRH	2	0	0%	2	100%

Table 13. Aroclor 1242 (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	carp	15	0	0%	0.116	0.177	0.072	0.023 - 0.744
	channel catfish	15	0	0%	0.053	0.017	0.050	0.028 - 0.084
	freshwater drum	15	2	13%	0.021	0.014	0.018	< 0.010 - 0.06
	lake trout	15	0	0%	0.036	0.016	0.031	0.019 - 0.078
	rock bass	18	18	100%	N/A	N/A	<0.010	<0.010
	rainbow trout	15	2	13%	0.020	0.009	0.021	<0.010 - 0.034
	smallmouth bass	16	5	31%	0.017	0.011	0.017	<0.010 - 0.036
	walleye	15	4	27%	0.014	0.008	0.013	<0.010 - 0.033
	white perch	15	0	0%	0.027	0.011	0.024	0.014 - 0.061
	yellow perch	15	15	100%	N/A	N/A	<0.010	<0.010
Upper Niagara River	carp	15	1	7%	0.546	1.809	0.043	<0.010 - 7.074
	freshwater drum	13	0	0%	0.024	0.016	0.022	0.010 - 0.076
	largemouth bass	15	2	13%	0.022	0.015	0.017	<0.010 - 0.062
	rock bass	15	14	93%	N/A	N/A	<0.010	<0.010 - 0.013
	smallmouth bass	15	1	7%	0.037	0.042	0.029	<0.010 - 0.177
	yellow perch	23	12	52%	N/A	N/A	<0.010	<0.010 - 0.107
Lower Niagara River	carp	15	0	0%	0.210	0.297	0.114	0.014 - 1.211
	freshwater drum	17	0	0%	0.071	0.041	0.069	0.020 - 0.168
	rock bass	7	0	0%	0.090	0.089	0.079	0.016 - 0.279
	smallmouth bass	15	0	0%	0.040	0.015	0.034	0.014 - 0.075
	yellow perch	18	5	28%	0.050	0.138	0.013	<0.010 - 0.589
Cayuga Creek	brown bullhead	10	4	40%	0.020	0.022	0.012	<0.010 - 0.072
	carp	10	0	0%	0.304	0.146	0.297	0.031 - 0.611
	largemouth bass	11	0	0%	0.088	0.049	0.080	0.038 - 0.193
	rock bass	9	0	0%	0.040	0.018	0.035	0.024 - 0.083
Lake Ontario West	coho salmon	28	0	0%	0.048	0.017	0.046	0.022 - 0.085
	smallmouth bass	15	0	0%	0.037	0.016	0.036	0.010 - 0.070
	white perch	10	0	0%	0.023	0.006	0.024	0.014 - 0.035
	white sucker	5	0	0%	0.014	0.004	0.012	0.011 - 0.020
Lake Ontario East	brown trout	10	0	0%	0.098	0.024	0.094	0.070 - 0.139
	channel catfish	11	0	0%	0.141	0.102	0.137	0.016 - 0.333
	lake trout	98	0	0%	0.103	0.052	0.108	0.013 - 0.241
	smallmouth bass	10	4	40%	0.013	0.008	0.012	<0.010 - 0.029
	white perch	25	0	0%	0.150	0.095	0.130	0.023 - 0.359
	white sucker	10	6	60%	N/A	N/A	<0.010	<0.010 - 0.159
Salmon River Hatchery	chinook salmon	30	0	0%	0.053	0.025	0.048	0.018 - 0.148
	coho salmon	20	0	0%	0.061	0.014	0.058	0.032 - 0.085
	rainbow trout	30	0	0%	0.040	0.014	0.041	0.016 - 0.063

Table 14. Aroclor 1254/1260 (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	carp	15	0	0%	1.416	1.425	0.979	0.170 - 6.206
	channel catfish	15	0	0%	0.923	0.490	0.863	0.348 - 1.938
	freshwater drum	15	0	0%	0.326	0.271	0.263	0.096 - 1.230
	lake trout	15	0	0%	0.346	0.141	0.320	0.188 - 0.732
	rock bass	18	4	22%	0.048	0.027	0.044	<0.030 - 0.118
	rainbow trout	15	0	0%	0.223	0.074	0.218	0.102 - 0.363
	smallmouth bass	16	1	6%	0.343	0.242	0.330	<0.030 - 0.726
	walleye	15	1	7%	0.143	0.090	0.136	<0.030 - 0.322
	white perch	15	0	0%	0.172	0.077	0.155	0.076 - 0.355
	yellow perch	15	9	60%	N/A	N/A	<0.030	<0.030 - 0.066
Upper Niagara River	carp	15	5	33%	0.348	0.991	0.051	<0.030 - 3.907
	freshwater drum	13	0	0%	0.192	0.161	0.145	0.058 - 0.669
	largemouth bass	15	0	0%	0.120	0.067	0.103	0.054 - 0.326
	rock bass	15	7	47%	0.029	0.015	0.031	<0.030 - 0.056
	smallmouth bass	15	0	0%	0.151	0.095	0.134	0.049 - 0.427
	yellow perch	23	8	35%	0.051	0.038	0.047	<0.030 - 0.138
Lower Niagara River	carp	15	0	0%	0.361	0.391	0.197	0.059 - 1.419
	freshwater drum	17	0	0%	0.384	0.288	0.277	0.094 - 1.199
	rock bass	7	1	14%	0.069	0.036	0.061	<0.030 - 0.128
	smallmouth bass	15	0	0%	0.251	0.112	0.199	0.139 - 0.536
	yellow perch	18	4	22%	0.073	0.068	0.048	<0.030 - 0.282
Cayuga Creek	brown bullhead	10	3	30%	0.053	0.032	0.055	<0.030 - 0.106
	carp	10	0	0%	0.322	0.160	0.290	0.047 - 0.658
	largemouth bass	11	0	0%	0.216	0.205	0.139	0.058 - 0.795
	rock bass	9	0	0%	0.087	0.043	0.074	0.038 - 0.180
Lake Ontario West	coho salmon	28	0	0%	0.170	0.058	0.173	0.086 - 0.316
	smallmouth bass	15	1	7%	0.166	0.069	0.173	<0.030 - 0.283
	white perch	10	0	0%	0.074	0.029	0.070	0.032 - 0.131
	white sucker	5	2	40%	0.026	0.014	0.022	<0.030 - 0.049
Lake Ontario East	brown trout	10	0	0%	0.196	0.037	0.199	0.152 - 0.254
	channel catfish	11	0	0%	0.273	0.155	0.286	0.042 - 0.525
	lake trout	98	0	0%	0.422	0.256	0.392	0.055 - 2.030
	smallmouth bass	10	2	20%	0.064	0.035	0.067	<0.030 - 0.131
	white perch	25	0	0%	0.198	0.108	0.182	0.050 - 0.449
	white sucker	10	6	60%	N/A	N/A	<0.030	<0.030 - 0.222
Salmon River Hatchery	chinook salmon	30	0	0%	0.371	0.112	0.364	0.154 - 0.704
	coho salmon	20	0	0%	0.345	0.072	0.333	0.194 - 0.510
	rainbow trout	30	0	0%	0.277	0.103	0.258	0.117 - 0.549

Table 15. Total PCBs (ppm).

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean[a]	Standard Deviation[a]	Median	Range[b]
Lake Erie	carp	15	0	0%	1.532	1.477	1.071	0.203 - 6.345
	channel catfish	15	0	0%	0.976	0.503	0.909	0.376 - 2.019
	freshwater drum	15	0	0%	0.347	0.283	0.285	0.107 - 1.290
	lake trout	15	0	0%	0.383	0.156	0.353	0.212 - 0.810
	rock bass	18	4	22%	0.053	0.027	0.049	ND - 0.123
	rainbow trout	15	0	0%	0.243	0.081	0.242	0.107 - 0.390
	smallmouth bass	16	1	6%	0.360	0.253	0.347	ND - 0.760
	walleye	15	1	7%	0.157	0.096	0.147	ND - 0.355
	white perch	15	0	0%	0.199	0.088	0.179	0.090 - 0.416
	yellow perch	15	9	60%	N/A	N/A	0.020	ND - 0.071
Upper Niagara River	carp	15	1	7%	0.894	2.798	0.089	ND - 10.981
	freshwater drum	13	0	0%	0.215	0.176	0.168	0.074 - 0.745
	largemouth bass	15	0	0%	0.142	0.079	0.121	0.059 - 0.388
	rock bass	15	6	40%	0.034	0.014	0.036	ND - 0.062
	smallmouth bass	15	0	0%	0.189	0.130	0.170	0.054 - 0.604
	yellow perch	23	8	35%	0.070	0.057	0.053	ND - 0.221
Lower Niagara River	carp	15	0	0%	0.571	0.638	0.311	0.073 - 2.310
	freshwater drum	17	0	0%	0.455	0.321	0.359	0.114 - 1.329
	rock bass	7	0	0%	0.159	0.106	0.143	0.071 - 0.373
	smallmouth bass	15	0	0%	0.291	0.125	0.248	0.159 - 0.611
	yellow perch	18	3	17%	0.122	0.198	0.062	ND - 0.871
Cayuga Creek	brown bullhead	10	3	30%	0.073	0.051	0.067	ND - 0.178
	carp	10	0	0%	0.626	0.268	0.626	0.078 - 1.041
	largemouth bass	11	0	0%	0.304	0.210	0.225	0.096 - 0.842
	rock bass	9	0	0%	0.127	0.057	0.106	0.062 - 0.236
Lake Ontario West	coho salmon	28	0	0%	0.218	0.072	0.220	0.108 - 0.378
	smallmouth bass	15	0	0%	0.202	0.084	0.210	0.025 - 0.353
	white perch	10	0	0%	0.097	0.034	0.098	0.046 - 0.166
	white sucker	5	0	0%	0.039	0.018	0.034	0.026 - 0.069
Lake Ontario East	brown trout	10	0	0%	0.295	0.060	0.293	0.227 - 0.393
	channel catfish	11	0	0%	0.413	0.252	0.381	0.058 - 0.824
	lake trout	98	0	0%	0.525	0.298	0.500	0.068 - 2.221
	smallmouth bass	10	2	20%	0.077	0.041	0.075	ND - 0.152
	white perch	25	0	0%	0.348	0.191	0.336	0.073 - 0.717
	white sucker	10	5	50%	0.073	0.111	0.026	ND - 0.381
Salmon River Hatchery	chinook salmon	30	0	0%	0.423	0.134	0.410	0.183 - 0.852
	coho salmon	20	0	0%	0.406	0.084	0.392	0.226 - 0.585
	rainbow trout	30	0	0%	0.317	0.115	0.298	0.133 - 0.607

[a] N/A is used when more than 50% of samples are non-detect.
[b] ND = nondetect.

Table 16. Fish with total PCB exceeding the FDA tolerance level (2 ppm).

Location	Species	Length (mm)	Lipid (%)	Total PCB (ppm)
Lake Erie	channel catfish	851	12.11	2.0193
	common carp	815	10.95	2.215
	common carp	650	5.52	6.345
	common carp	651	8.68	2.674
Upper Niagara River	common carp	535	21.65	10.981
Lower Niagara River	common carp	669	12.27	2.310
Lake Ontario East	lake trout	824	14.55	2.221

Table 17. Statistically significant ($P < 0.05$) comparisons of total PCB among different species at each location. BB = brown bullhead, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch.

Location	Comparison		
Lake Erie	CARP	>	RB
	CARP	>	RT
	CARP	>	WEYE
	CARP	>	WP
	CARP	>	YP
	CHC	>	RB
	CHC	>	RT
	CHC	>	WEYE
	CHC	>	WP
	CHC	>	YP
	DRUM	>	RB
	DRUM	>	YP
	LT	>	RB
	LT	>	YP
	RB	<	RT
	RB	<	SMB
	RT	>	YP
	SMB	>	YP
Upper Niagara River	CARP	>	RB
	DRUM	>	RB
	DRUM	>	YP
	LMB	>	RB
	LMB	>	YP
	RB	<	SMB
	SMB	>	YP
Lower Niagara River	CARP	>	YP
	DRUM	>	YP
	SMB	>	YP
Cayuga Creek	BB	<	CARP
	BB	<	LMB
	CARP	>	RB
Lake Ontario West	COS	>	WP
	COS	>	WS
	SMB	>	WP
	SMB	>	WS
Lake Ontario East	CHC	>	SMB
	CHC	>	WS
	LT	>	SMB
	LT	>	WS
	SMB	<	WP
	WP	>	WS
Salmon River Hatchery	CHS	>	RT
	COS	>	RT

Table 18. Comparison summary of total PCB among different species. Low Count and High Count are the number of times a species had a statistically lower or higher total PCB level, respectively, than other species at the same location.

Species	*Species Code*	*Number of Comparisons*	*Low Count*	*Low percent*	*High Count*	*High percent*
brown bullhead	BB	3	2	67%	0	0%
common carp	CARP	21	0	0%	9	43%
channel catfish	CHC	14	0	0%	7	50%
chinook salmon	CHS	2	0	0%	1	50%
coho salmon	COS	5	0	0%	3	60%
freshwater drum	DRUM	18	0	0%	5	28%
largemouth bass	LMB	8	0	0%	3	38%
lake trout	LT	14	0	0%	4	29%
rock bass	RB	21	11	52%	0	0%
rainbow trout	RT	11	4	36%	2	18%
smallmouth bass	SMB	26	3	12%	7	27%
walleye	WEYE	9	2	22%	0	0%
white perch	WP	17	4	24%	2	12%
white sucker	WS	8	5	63%	0	0%
yellow perch	YP	18	12	67%	0	0%

Table 19. Lipid normalized PCBs (ppm).

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean[a]	Standard Deviation[a]	Median	Range[b]
Lake Erie	common carp	15	0	0%	22.0	27.3	13.3	3.25 - 115
	channel catfish	15	0	0%	7.52	5.17	6.10	2.03 - 19.5
	freshwater drum	15	0	0%	9.10	8.64	6.14	1.89 - 37.5
	lake trout	15	0	0%	3.08	1.03	2.84	2.15 - 6.32
	rock bass	18	4	22%	4.8	2.64	4.19	ND - 12.5
	rainbow trout	15	0	0%	9.02	5.69	6.90	1.72 - 20.8
	smallmouth bass	16	1	6%	6.79	4.20	5.60	ND - 14.9
	walleye	15	1	7%	5.98	6.00	4.51	ND - 26.3
	white perch	15	0	0%	3.21	1.60	2.80	1.40 - 7.59
	yellow perch	15	9	60%	N/A	N/A	3.28	ND - 16.1
Upper Niagara River	common carp	15	1	7%	6.08	12.9	1.27	ND - 50.7
	freshwater drum	13	0	0%	3.3	2.97	2.02	1.04 - 11.1
	largemouth bass	15	0	0%	7.79	4.60	6.33	4.33 - 22.2
	rock bass	15	6	40%	3.96	1.48	3.63	ND - 8.11
	smallmouth bass	15	0	0%	11.5	6.97	10.1	6.85 - 34.3
	yellow perch	23	8	35%	4.59	3.25	3.91	ND - 16.6
Lower Niagara River	common carp	15	0	0%	6.65	5.75	4.82	2.17 - 21.1
	freshwater drum	17	0	0%	8.53	6.62	5.63	1.89 - 26.0
	rock bass	7	0	0%	13.1	6.44	10.8	7.59 - 26.1
	smallmouth bass	15	0	0%	14.6	4.42	14.3	8.49 - 21.4
	yellow perch	18	3	17%	12.2	17.9	5.64	ND - 79.2
Cayuga Creek	brown bullhead	10	3	30%	9.34	3.86	9.60	ND - 15.8
	common carp	10	0	0%	15.3	6.14	13.5	8.43 - 27.3
	largemouth bass	11	0	0%	33.6	30.6	21.4	15.4 - 120
	rock bass	9	0	0%	13.1	6.40	11.4	6.41 - 28.1
Lake Ontario West	coho salmon	28	0	0%	3.42	0.899	3.34	2.04 - 5.12
	smallmouth bass	15	0	0%	4.59	1.54	4.70	1.66 - 7.40
	white perch	10	0	0%	2.63	0.664	2.52	1.88 - 3.89
	white sucker	5	0	0%	2.02	0.465	1.78	1.52 - 2.61
Lake Ontario East	brown trout	10	0	0%	1.98	0.401	1.93	1.46 - 2.71
	channel catfish	11	0	0%	8.11	3.85	7.49	2.50 - 16.0
	lake trout	98	0	0%	3.75	1.79	3.38	1.89 - 15.3
	smallmouth bass	10	2	20%	4.43	2.07	4.36	ND - 7.59
	white perch	25	0	0%	10.4	6.06	9.03	2.94 - 30.4
	white sucker	10	5	50%	5.11	5.89	3.37	ND - 21.6
Salmon River Hatchery	chinook salmon	30	0	0%	38.8	17.9	37.3	17.0 - 83.2
	coho salmon	20	0	0%	19.2	8.29	17.3	9.25 - 41.2
	rainbow trout	30	0	0%	9.92	3.13	9.32	4.61 - 16.4

[a] N/A is used when more than 50% of samples are non-detect.
[b] ND = nondetect.

Table 20. Statistically significant ($P < 0.05$) comparisons of lipid normalized PCB among different species at each location. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch.

Location	Comparison			Location	Comparison			Location	Comparison		
Lake Erie	CARP	>	LT	Upper Niagara River	CARP	<	LMB	Lake Ontario West	COS	>	WS
	CARP	>	RB		CARP	<	SMB		SMB	>	WP
	CARP	>	WEYE		DRUM	<	LMB		SMB	>	WS
	CARP	>	WP		DRUM	<	SMB	Lake Ontario East	BT	<	CHC
	CARP	>	YP		RB	<	SMB		BT	<	LT
	DRUM	>	LT		SMB	>	YP		BT	<	SMB
	DRUM	>	WP	Lower Niagara River	CARP	<	SMB		BT	<	WP
	LT	<	RT		DRUM	<	SMB		CHC	>	LT
	RT	>	WP		SMB	>	YP		LT	<	WP
Cayuga Creek	BB	<	LMB	Salmon River Hatchery	CHS	>	COS		SMB	<	WP
	LMB	>	RB		CHS	>	RT		WP	>	WS
					COS	>	RT				

Table 21. Comparison summary for lipid normalized PCB among different species. Low Count and High Count are the number of times a species had a statistically lower or higher lipid normalized PCB level, respectively, than other species at the same location.

Species	Species code	Number of Comparisons	Low Count	Low Percent	High Count	High Percent
brown bullhead	BB	3	1	33%	0	0%
brown trout	BT	5	4	80%	0	0%
common carp	CARP	21	3	14%	5	24%
channel catfish	CHC	14	0	0%	2	14%
chinook salmon	CHS	2	0	0%	2	100%
coho salmon	COS	5	1	20%	2	40%
freshwater drum	DRUM	18	3	17%	2	11%
largemouth bass	LMB	8	0	0%	4	50%
lake trout	LT	14	5	36%	1	7%
rock bass	RB	21	3	14%	0	0%
rainbow trout	RT	11	2	18%	2	18%
smallmouth bass	SMB	26	1	4%	10	38%
walleye	WEYE	9	1	11%	0	0%
white perch	WP	17	4	24%	4	24%
white sucker	WS	8	3	38%	0	0%
yellow perch	YP	18	3	17%	0	0%

Table 22. Statistically significant ($P < 0.05$) comparisons of total PCB among different locations for each species. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery.

Species	**Comparison Pairs**		
common carp	LE	>	UN
	LE	>	LN
channel catfish	LE	>	LOE
coho salmon	LOW	<	SRH
freshwater drum	UN	<	LN
largemouth bass	UN	<	CY
lake trout	LE	<	LOE
rock bass	LE	<	LN
	LE	<	CY
	UN	<	LN
	UN	<	CY
smallmouth bass	LE	>	LOE
	LN	>	LOE
	LOW	>	LOE
white perch	LE	>	LOW
	LOW	<	LOE
yellow perch	LE	<	LN

Table 23. Comparison summary for total PCB among different locations. Low Count and High Count are the number of times a location had a statistically lower or higher total PCB level, respectively, than other locations for the same species.

Location	***Location Code***	***Number of Comparisons***	***Low***	***Low Percent***	***High***	***High Percent***
Lake Erie	LE	19	4	21%	5	26%
Upper Niagara	UN	15	5	33%	0	0%
Lower Niagara	LN	14	1	7%	5	36%
Cayuga Creek	CY	7	0	0%	3	43%
Lake Ontario West	LOW	8	3	38%	1	13%
Lake Ontario East	LOE	9	4	44%	2	22%
Salmon River Hatchery	SRH	2	0	0%	1	50%

Table 24. Statistically significant ($P < 0.05$) comparisons of lipid normalized PCB among different locations for each species. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery.

Species	Comparison Pairs		
common carp	LE	>	UN
	LE	>	LN
	UN	<	CY
coho salmon	LOW	<	SRH
freshwater drum	LE	>	UN
	UN	<	LN
largemouth bass	UN	<	CY
lake trout	LE	<	LOE
rock bass	LE	<	LN
	LE	<	CY
	UN	<	LN
	UN	<	CY
smallmouth bass	LE	<	LN
	UN	>	LOW
	UN	>	LOE
	LN	>	LOW
	LN	>	LOE
white perch	LE	<	LOE
	LOW	<	LOE
white sucker	LOW	<	LOE
yellow perch	LE	<	LN

Table 25. Comparison summary for lipid normalized PCB among different locations. Low Count and High Count are the number of times a location had a statistically lower or higher lipid normalized PCB level, respectively, than other locations for the same species.

Location	*Location Code*	*Number of Comparisons*	*Low*	*Low Percent*	*High*	*High Percent*
Lake Erie	LE	19	6	32%	3	16%
Upper Niagara River	UN	15	7	47%	2	13%
Lower Niagara River	LN	14	1	7%	7	50%
Cayuga Creek	CY	7	0	0%	4	57%
Lake Ontario West	LOW	8	5	63%	0	0%
Lake Ontario East	LOE	9	2	22%	4	44%
Salmon River Hatchery	SRH	2	0	0%	1	50%

Table 26. p,p'-DDT (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	1	7%	0.015	0.011	0.014	<0.002 - 0.034
	channel catfish	15	0	0%	0.012	0.005	0.011	0.005 - 0.024
	freshwater drum	15	2	13%	0.007	0.006	0.005	<0.002 - 0.026
	lake trout	15	0	0%	0.008	0.004	0.007	0.003 - 0.020
	rock bass	18	18	100%	N/A	N/A	<0.002	<0.002
	rainbow trout	15	1	7%	0.003	0.001	0.003	<0.002 - 0.007
	smallmouth bass	16	1	6%	0.012	0.007	0.011	<0.002 - 0.027
	walleye	15	3	20%	0.004	0.002	0.004	<0.002 - 0.009
	white perch	15	7	47%	0.002	0.001	0.002	<0.002 - 0.003
	yellow perch	15	14	93%	N/A	N/A	<0.002	<0.002 - 0.002
Upper Niagara River	common carp	15	13	87%	N/A	N/A	<0.002	<0.002 - 0.013
	freshwater drum	13	9	69%	N/A	N/A	<0.002	<0.002 - 0.004
	largemouth bass	15	14	93%	N/A	N/A	<0.002	<0.002 - 0.003
	rock bass	15	15	100%	N/A	N/A	<0.002	<0.002
	smallmouth bass	15	8	53%	N/A	N/A	<0.002	<0.002 - 0.005
	yellow perch	23	23	100%	N/A	N/A	<0.002	<0.002
Lower Niagara River	common carp	15	6	40%	0.003	0.002	0.003	<0.002 - 0.006
	freshwater drum	17	1	6%	0.008	0.005	0.007	<0.002 - 0.022
	rock bass	7	3	43%	0.002	0.001	0.002	<0.002 - 0.005
	smallmouth bass	15	0	0%	0.009	0.020	0.004	0.002 - 0.080
	yellow perch	18	13	72%	N/A	N/A	<0.002	<0.002 - 0.004
Cayuga Creek	brown bullhead	10	9	90%	N/A	N/A	<0.002	<0.002 - 0.003
	common carp	10	1	10%	0.003	0.001	0.003	<0.002 - 0.005
	largemouth bass	11	9	82%	N/A	N/A	<0.002	<0.002 - 0.002
	rock bass	9	8	89%	N/A	N/A	<0.002	<0.002 - 0.034
Lake Ontario West	coho salmon	28	0	0%	0.007	0.003	0.006	0.002 - 0.014
	smallmouth bass	15	0	0%	0.015	0.006	0.015	0.007 - 0.031
	white perch	10	1	10%	0.006	0.003	0.005	<0.002 - 0.012
	white sucker	5	0	0%	0.007	0.005	0.004	0.003 - 0.015
Lake Ontario East	brown trout	10	0	0%	0.009	0.002	0.009	0.007 - 0.011
	channel catfish	11	1	9%	0.007	0.004	0.007	<0.002 - 0.013
	lake trout	98	1	1%	0.018	0.008	0.017	<0.002 - 0.057
	smallmouth bass	10	4	40%	0.002	0.001	0.002	<0.002 - 0.004
	white perch	25	9	36%	0.003	0.002	0.002	<0.002 - 0.008
	white sucker	10	7	70%	N/A	N/A	<0.002	<0.002 - 0.005
Salmon River Hatchery	chinook salmon	30	0	0%	0.014	0.006	0.013	0.005 - 0.033
	coho salmon	20	0	0%	0.011	0.003	0.011	0.006 - 0.017
	rainbow trout	30	0	0%	0.010	0.004	0.010	0.004 - 0.017

Table 27. p,p'-DDE (ppm).

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	0	0%	0.094	0.065	0.075	0.013 - 0.257
	channel catfish	15	0	0%	0.061	0.033	0.053	0.025 - 0.129
	freshwater drum	15	0	0%	0.012	0.012	0.008	0.003 - 0.050
	lake trout	15	0	0%	0.029	0.013	0.023	0.016 - 0.067
	rock bass	18	2	11%	0.004	0.003	0.004	<0.002 - 0.012
	rainbow trout	15	0	0%	0.019	0.005	0.018	0.010 - 0.029
	smallmouth bass	16	0	0%	0.020	0.012	0.020	0.003 - 0.040
	walleye	15	0	0%	0.012	0.007	0.011	0.003 - 0.023
	white perch	15	0	0%	0.010	0.004	0.009	0.006 - 0.017
	yellow perch	15	6	40%	0.002	0.001	0.002	<0.002 - 0.005
Upper Niagara River	common carp	15	1	7%	0.043	0.132	0.007	<0.002 - 0.521
	freshwater drum	13	1	8%	0.007	0.006	0.006	<0.002 - 0.024
	largemouth bass	15	0	0%	0.010	0.005	0.009	0.004 - 0.025
	rock bass	15	4	27%	0.002	0.001	0.002	<0.002 - 0.005
	smallmouth bass	15	0	0%	0.009	0.005	0.008	0.003 - 0.023
	yellow perch	23	2	9%	0.004	0.002	0.004	<0.002 - 0.010
Lower Niagara River	common carp	15	0	0%	0.232	0.198	0.163	0.023 - 0.620
	freshwater drum	17	0	0%	0.055	0.039	0.039	0.020 - 0.138
	rock bass	7	0	0%	0.024	0.025	0.013	0.006 - 0.076
	smallmouth bass	15	0	0%	0.033	0.016	0.027	0.016 - 0.069
	yellow perch	18	0	0%	0.019	0.013	0.019	0.004 - 0.050
Cayuga Creek	brown bullhead	10	1	10%	0.006	0.005	0.004	<0.002 - 0.016
	common carp	10	0	0%	0.021	0.012	0.017	0.005 - 0.050
	largemouth bass	11	0	0%	0.010	0.005	0.009	0.005 - 0.016
	rock bass	9	0	0%	0.019	0.035	0.008	0.004 - 0.113
Lake Ontario West	coho salmon	28	0	0%	0.055	0.023	0.058	0.021 - 0.125
	smallmouth bass	15	0	0%	0.070	0.029	0.070	0.029 - 0.146
	white perch	10	0	0%	0.080	0.051	0.074	0.022 - 0.184
	white sucker	5	0	0%	0.034	0.018	0.030	0.019 - 0.066
Lake Ontario East	brown trout	10	0	0%	0.047	0.010	0.046	0.034 - 0.060
	channel catfish	11	0	0%	0.028	0.015	0.027	0.002 - 0.046
	lake trout	98	0	0%	0.104	0.064	0.096	0.014 - 0.481
	smallmouth bass	10	1	10%	0.009	0.008	0.006	<0.002 - 0.025
	white perch	25	0	0%	0.010	0.008	0.008	0.003 - 0.040
	white sucker	10	4	40%	0.003	0.002	0.003	<0.002 - 0.007
Salmon River Hatchery	chinook salmon	30	0	0%	0.115	0.039	0.116	0.056 - 0.250
	coho salmon	20	0	0%	0.107	0.021	0.107	0.065 - 0.151
	rainbow trout	30	0	0%	0.073	0.023	0.073	0.035 - 0.118

Table 28. p,p'-DDD (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	0	0%	0.014	0.009	0.014	0.004 - 0.035
	channel catfish	15	0	0%	0.020	0.009	0.016	0.009 - 0.041
	freshwater drum	15	3	20%	0.005	0.003	0.004	<0.002 - 0.013
	lake trout	15	0	0%	0.010	0.005	0.009	0.005 - 0.024
	rock bass	18	18	100%	N/A	N/A	<0.002	<0.002
	rainbow trout	15	1	7%	0.006	0.003	0.006	<0.002 - 0.011
	smallmouth bass	16	4	25%	0.004	0.003	0.004	<0.002 - 0.010
	walleye	15	3	20%	0.003	0.002	0.003	<0.002 - 0.006
	white perch	15	0	0%	0.006	0.002	0.006	0.004 - 0.009
	yellow perch	15	15	100%	N/A	N/A	<0.002	<0.002
Upper Niagara River	common carp	15	5	33%	0.008	0.02	0.003	<0.002 - 0.080
	freshwater drum	13	7	54%	N/A	N/A	<0.002	<0.002 - 0.003
	largemouth bass	15	11	73%	N/A	N/A	<0.002	<0.002 - 0.004
	rock bass	15	15	100%	N/A	N/A	<0.002	<0.002
	smallmouth bass	15	10	67%	N/A	N/A	<0.002	<0.002 - 0.004
	yellow perch	23	20	87%	N/A	N/A	<0.002	<0.002 - 0.003
Lower Niagara River	common carp	15	0	0%	0.031	0.025	0.024	0.003 - 0.088
	freshwater drum	17	0	0%	0.007	0.006	0.004	0.002 - 0.021
	rock bass	7	4	57%	N/A	N/A	<0.002	<0.002 - 0.005
	smallmouth bass	15	3	20%	0.003	0.002	0.002	<0.002 - 0.010
	yellow perch	18	15	83%	N/A	N/A	<0.002	<0.002 - 0.004
Cayuga Creek	brown bullhead	10	6	60%	N/A	N/A	<0.002	<0.002 - 0.007
	common carp	10	0	0%	0.010	0.005	0.009	0.003 - 0.022
	largemouth bass	11	3	27%	0.003	0.002	0.002	<0.002 - 0.007
	rock bass	9	5	56%	N/A	N/A	<0.002	<0.002 - 0.026
Lake Ontario West	coho salmon	28	0	0%	0.007	0.002	0.007	0.002 - 0.013
	smallmouth bass	15	0	0%	0.008	0.003	0.008	0.004 - 0.015
	white perch	10	0	0%	0.014	0.010	0.013	0.003 - 0.038
	white sucker	5	0	0%	0.006	0.003	0.006	0.004 - 0.011
Lake Ontario East	brown trout	10	0	0%	0.010	0.002	0.010	0.008 - 0.015
	channel catfish	11	3	27%	0.004	0.002	0.004	<0.002 - 0.009
	lake trout	98	0	0%	0.017	0.008	0.017	0.003 - 0.039
	smallmouth bass	10	8	80%	N/A	N/A	<0.002	<0.002 - 0.004
	white perch	25	12	48%	0.002	0.001	0.002	<0.002 - 0.004
	white sucker	10	10	100%	N/A	N/A	<0.002	<0.002
Salmon River Hatchery	chinook salmon	30	0	0%	0.014	0.006	0.014	0.005 - 0.033
	coho salmon	20	0	0%	0.014	0.003	0.015	0.008 - 0.020
	rainbow trout	30	0	0%	0.008	0.003	0.008	0.003 - 0.012

Table 29. o,p'-DDT (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	15	100%	N/A	N/A	<0.005	<0.005
	channel catfish	15	15	100%	N/A	N/A	<0.005	<0.005
	freshwater drum	15	15	100%	N/A	N/A	<0.005	<0.005
	lake trout	15	15	100%	N/A	N/A	<0.005	<0.005
	rock bass	18	18	100%	N/A	N/A	<0.005	<0.005
	rainbow trout	15	15	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	16	16	100%	N/A	N/A	<0.005	<0.005
	walleye	15	15	100%	N/A	N/A	<0.005	<0.005
	white perch	15	15	100%	N/A	N/A	<0.005	<0.005
	yellow perch	15	15	100%	N/A	N/A	<0.005	<0.005
Upper Niagara River	common carp	15	15	100%	N/A	N/A	<0.005	<0.005
	freshwater drum	13	13	100%	N/A	N/A	<0.005	<0.005
	largemouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	rock bass	15	15	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	yellow perch	23	23	100%	N/A	N/A	<0.005	<0.005
Lower Niagara River	common carp	15	15	100%	N/A	N/A	<0.005	<0.005
	freshwater drum	17	16	94%	N/A	N/A	<0.005	<0.005 - 0.006
	rock bass	7	7	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	yellow perch	18	18	100%	N/A	N/A	<0.005	<0.005
Cayuga Creek	brown bullhead	10	10	100%	N/A	N/A	<0.005	<0.005
	common carp	10	10	100%	N/A	N/A	<0.005	<0.005
	largemouth bass	11	11	100%	N/A	N/A	<0.005	<0.005
	rock bass	9	9	100%	N/A	N/A	<0.005	<0.005
Lake Ontario West	coho salmon	28	28	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	white perch	10	10	100%	N/A	N/A	<0.005	<0.005
	white sucker	5	5	100%	N/A	N/A	<0.005	<0.005
Lake Ontario East	brown trout	10	10	100%	N/A	N/A	<0.005	<0.005
	channel catfish	11	11	100%	N/A	N/A	<0.005	<0.005
	lake trout	98	73	74%	N/A	N/A	<0.005	<0.005 - 0.009
	smallmouth bass	10	10	100%	N/A	N/A	<0.005	<0.005
	white perch	25	25	100%	N/A	N/A	<0.005	<0.005
	white sucker	10	10	100%	N/A	N/A	<0.005	<0.005
Salmon River Hatchery	chinook salmon	30	28	93%	N/A	N/A	<0.005	<0.005 - 0.006
	coho salmon	20	20	100%	N/A	N/A	<0.005	<0.005
	rainbow trout	30	30	100%	N/A	N/A	<0.005	<0.005

Table 30. o,p'-DDE (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
L. Erie	common carp	15	13	87%	N/A	N/A	<0.005	<0.005 - 0.01
	channel catfish	15	15	100%	N/A	N/A	<0.005	<0.005
	freshwater drum	15	15	100%	N/A	N/A	<0.005	<0.005
	lake trout	15	15	100%	N/A	N/A	<0.005	<0.005
	rock bass	18	18	100%	N/A	N/A	<0.005	<0.005
	rainbow trout	15	15	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	16	16	100%	N/A	N/A	<0.005	<0.005
	walleye	15	15	100%	N/A	N/A	<0.005	<0.005
	white perch	15	15	100%	N/A	N/A	<0.005	<0.005
	yellow perch	15	15	100%	N/A	N/A	<0.005	<0.005
Upper Niagara River	common carp	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.005
	freshwater drum	13	13	100%	N/A	N/A	<0.005	<0.005
	largemouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	rock bass	15	15	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	yellow perch	23	23	100%	N/A	N/A	<0.005	<0.005
Lower Niagara River	common carp	15	15	100%	N/A	N/A	<0.005	<0.005
	freshwater drum	17	17	100%	N/A	N/A	<0.005	<0.005
	rock bass	7	7	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	yellow perch	18	18	100%	N/A	N/A	<0.005	<0.005
Cayuga Creek	brown bullhead	10	10	100%	N/A	N/A	<0.005	<0.005
	common carp	10	10	100%	N/A	N/A	<0.005	<0.005
	largemouth bass	11	11	100%	N/A	N/A	<0.005	<0.005
	rock bass	9	9	100%	N/A	N/A	<0.005	<0.005
Lake Ontario West	coho salmon	28	28	100%	N/A	N/A	<0.005	<0.005
	smallmouth bass	15	15	100%	N/A	N/A	<0.005	<0.005
	white perch	10	10	100%	N/A	N/A	<0.005	<0.005
	white sucker	5	5	100%	N/A	N/A	<0.005	<0.005
Lake Ontario East	brown trout	10	9	90%	N/A	N/A	<0.005	<0.005 - 0.005
	channel catfish	11	11	100%	N/A	N/A	<0.005	<0.005
	lake trout	98	67	68%	N/A	N/A	<0.005	<0.005 - 0.012
	smallmouth bass	10	10	100%	N/A	N/A	<0.005	<0.005
	white perch	25	25	100%	N/A	N/A	<0.005	<0.005
	white sucker	10	10	100%	N/A	N/A	<0.005	<0.005
Salmon River Hatchery	chinook salmon	30	30	100%	N/A	N/A	<0.005	<0.005
	coho salmon	20	20	100%	N/A	N/A	<0.005	<0.005
	rainbow trout	30	30	100%	N/A	N/A	<0.005	<0.005

Table 31. o,p'-DDD (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	15	100%	N/A	N/A	<0.015	<0.015
	channel catfish	15	15	100%	N/A	N/A	<0.015	<0.015
	freshwater drum	15	15	100%	N/A	N/A	<0.015	<0.015
	lake trout	15	15	100%	N/A	N/A	<0.015	<0.015
	rock bass	18	18	100%	N/A	N/A	<0.015	<0.015
	rainbow trout	15	15	100%	N/A	N/A	<0.015	<0.015
	smallmouth bass	16	16	100%	N/A	N/A	<0.015	<0.015
	walleye	15	15	100%	N/A	N/A	<0.015	<0.015
	white perch	15	15	100%	N/A	N/A	<0.015	<0.015
	yellow perch	15	15	100%	N/A	N/A	<0.015	<0.015
Upper Niagara River	common carp	15	14	93%	N/A	N/A	<0.015	<0.015 - 0.017
	freshwater drum	13	13	100%	N/A	N/A	<0.015	<0.015
	largemouth bass	15	15	100%	N/A	N/A	<0.015	<0.015
	rock bass	15	15	100%	N/A	N/A	<0.015	<0.015
	smallmouth bass	15	15	100%	N/A	N/A	<0.015	<0.015
	yellow perch	23	23	100%	N/A	N/A	<0.015	<0.015
Lower Niagara River	common carp	15	14	93%	N/A	N/A	<0.015	<0.015 - 0.008
	freshwater drum	17	17	100%	N/A	N/A	<0.015	<0.015
	rock bass	7	7	100%	N/A	N/A	<0.015	<0.015
	smallmouth bass	15	15	100%	N/A	N/A	<0.015	<0.015
	yellow perch	18	18	100%	N/A	N/A	<0.015	<0.015
Cayuga Creek	brown bullhead	10	10	100%	N/A	N/A	<0.015	<0.015
	common carp	10	10	100%	N/A	N/A	<0.015	<0.015
	largemouth bass	11	11	100%	N/A	N/A	<0.015	<0.015
	rock bass	9	9	100%	N/A	N/A	<0.015	<0.015
Lake Ontario West	coho salmon	28	28	100%	N/A	N/A	<0.015	<0.015
	smallmouth bass	15	15	100%	N/A	N/A	<0.015	<0.015
	white perch	10	10	100%	N/A	N/A	<0.015	<0.015
	white sucker	5	5	100%	N/A	N/A	<0.015	<0.015
Lake Ontario East	brown trout	10	10	100%	N/A	N/A	<0.015	<0.015
	channel catfish	11	11	100%	N/A	N/A	<0.015	<0.015
	lake trout	98	98	100%	N/A	N/A	<0.015	<0.015
	smallmouth bass	10	10	100%	N/A	N/A	<0.015	<0.015
	white perch	25	25	100%	N/A	N/A	<0.015	<0.015
	white sucker	10	10	100%	N/A	N/A	<0.015	<0.015
Salmon River Hatchery	chinook salmon	30	30	100%	N/A	N/A	<0.015	<0.015
	coho salmon	20	20	100%	N/A	N/A	<0.015	<0.015
	rainbow trout	30	30	100%	N/A	N/A	<0.015	<0.015

Table 32. Total DDT (ppm).

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range[a]
Lake Erie	common carp	15	0	0%	0.137	0.076	0.126	0.030 - 0.310
	channel catfish	15	0	0%	0.105	0.045	0.092	0.051 - 0.202
	freshwater drum	15	0	0%	0.036	0.021	0.031	0.018 - 0.101
	lake trout	15	0	0%	0.060	0.021	0.054	0.040 - 0.123
	rock bass	18	2	11%	0.019	0.003	0.018	ND - 0.027
	rainbow trout	15	0	0%	0.041	0.008	0.041	0.025 - 0.053
	smallmouth bass	16	0	0%	0.048	0.022	0.049	0.017 - 0.087
	walleye	15	0	0%	0.032	0.010	0.030	0.017 - 0.049
	white perch	15	0	0%	0.031	0.005	0.030	0.024 - 0.041
	yellow perch	15	6	40%	0.017	0.001	0.017	ND - 0.021
Upper Niagara River	common carp	15	1	7%	0.066	0.159	0.023	ND - 0.639
	freshwater drum	13	1	8%	0.023	0.007	0.020	ND - 0.041
	largemouth bass	15	0	0%	0.025	0.006	0.024	0.019 - 0.045
	rock bass	15	4	27%	0.017	0.001	0.017	ND - 0.020
	smallmouth bass	15	0	0%	0.025	0.007	0.023	0.017 - 0.044
	yellow perch	23	2	9%	0.019	0.003	0.018	ND - 0.026
Lower Niagara River	common carp	15	0	0%	0.279	0.223	0.210	0.039 - 0.727
	freshwater drum	17	0	0%	0.082	0.048	0.066	0.038 - 0.197
	rock bass	7	0	0%	0.040	0.027	0.030	0.021 - 0.096
	smallmouth bass	15	0	0%	0.057	0.034	0.046	0.032 - 0.166
	yellow perch	18	0	0%	0.035	0.014	0.034	0.018 - 0.071
Cayuga Creek	brown bullhead	10	1	10%	0.023	0.006	0.021	ND - 0.031
	common carp	10	0	0%	0.046	0.017	0.040	0.022 - 0.079
	largemouth bass	11	0	0%	0.027	0.006	0.025	0.019 - 0.037
	rock bass	9	0	0%	0.042	0.054	0.023	0.018 - 0.185
Lake Ontario West	coho salmon	28	0	0%	0.081	0.028	0.085	0.040 - 0.165
	smallmouth bass	15	0	0%	0.106	0.038	0.105	0.054 - 0.203
	white perch	10	0	0%	0.113	0.062	0.111	0.040 - 0.242
	white sucker	5	0	0%	0.060	0.026	0.053	0.038 - 0.104
Lake Ontario East	brown trout	10	0	0%	0.079	0.014	0.078	0.063 - 0.102
	channel catfish	11	0	0%	0.051	0.021	0.050	0.017 - 0.076
	lake trout	98	0	0%	0.154	0.080	0.148	0.034 - 0.596
	smallmouth bass	10	1	10%	0.025	0.010	0.021	ND - 0.046
	white perch	25	0	0%	0.027	0.010	0.025	0.017 - 0.059
	white sucker	10	4	40%	0.018	0.003	0.017	ND - 0.024
Salmon River Hatchery	chinook salmon	30	0	0%	0.155	0.050	0.156	0.079 - 0.332
	coho salmon	20	0	0%	0.144	0.027	0.144	0.092 - 0.194
	rainbow trout	30	0	0%	0.103	0.030	0.101	0.054 - 0.155

[a] ND = nondetect

Table 33. Statistically significant ($P < 0.05$) comparisons of total DDT among different species at each location. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch.

Location	Comparison		
Lake Erie	CARP	>	DRUM
	CARP	>	RB
	CARP	>	WEYE
	CARP	>	WP
	CARP	>	YP
	CHC	>	DRUM
	CHC	>	RB
	CHC	>	WEYE
	CHC	>	WP
	CHC	>	YP
	DRUM	>	YP
	LT	>	RB
	LT	>	YP
	RB	<	RT
	RB	<	SMB
	RT	>	YP
	SMB	>	YP
Upper Niagara River	CARP	>	RB
	DRUM	>	RB
	LMB	>	RB
	LMB	>	YP
	RB	<	SMB
	SMB	>	YP
Lower Niagara River	CARP	>	RB
	CARP	>	SMB
	CARP	>	YP
	DRUM	>	YP
Cayuga Creek	BB	<	CARP
	CARP	>	RB
Lake Ontario West	SMB	>	WS
Lake Ontario East	BT	>	WS
	CHC	<	LT
	LT	>	SMB
	LT	>	WP
	LT	>	WS
Salmon River Hatchery	CHS	>	RT
	COS	>	RT

Table 34. Comparison summary for total DDT among different species. Low Count and High Count are the number of times a species had a statistically lower or higher total DDT, respectively, than other species at the same location.

Species	***Species Code***	***Number of Comparisons***	***Low Count***	***Low Percent***	***High Count***	***High Percent***
brown bullhead	BB	3	1	33%	0	0%
brown trout	BT	5	0	0%	1	20%
common carp	CARP	21	0	0%	11	52%
channel catfish	CHC	14	1	7%	5	36%
chinook salmon	CHS	2	0	0%	1	50%
coho salmon	COS	5	0	0%	1	20%
freshwater drum	DRUM	18	2	11%	3	17%
largemouth bass	LMB	8	0	0%	2	25%
lake trout	LT	14	0	0%	6	43%
rock bass	RB	21	11	52%	0	0%
rainbow trout	RT	11	2	18%	2	18%
smallmouth bass	SMB	26	2	8%	5	19%
walleye	WEYE	9	2	22%	0	0%
white perch	WP	17	3	18%	0	0%
white sucker	WS	8	3	38%	0	0%
yellow perch	YP	18	10	56%	0	0%

Table 35. Statistically significant ($P < 0.05$) comparisons of total DDT among different locations for each species. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery.

Species	***comparison pairs***		
common carp	LE	>	UN
	UN	<	LN
	LN	>	CY
channel catfish	LE	>	LOE
coho salmon	LOW	<	SRH
freshwater drum	LE	<	LN
	UN	<	LN
lake trout	LE	<	LOE
rock bass	LE	<	LN
	UN	<	LN
	UN	<	CY
rainbow trout	LE	<	SRH
smallmouth bass	LE	<	LOW
	UN	<	LN
	UN	<	LOW
	LN	>	LOE
	LOW	>	LOE
white perch	LE	<	LOW
	LOW	>	LOE
white sucker	LOW	>	LOE
yellow perch	LE	<	UN
	LE	<	LN
	UN	<	LN

Table 36. Comparison summary for total DDT among different locations. Low Count and High Count are the number of times a location had a statistically lower or higher total DDT, respectively, than other locations for the same species.

Location	***Location Code***	***Number of Comparisons***	***Low Count***	***Low Percent***	***High Count***	***High Percent***
Lake Erie	LE	19	8	42%	2	11%
Upper Niagara River	UN	15	8	53%	1	7%
Lower Niagara River	LN	14	0	0%	10	71%
Cayuga Creek	CY	7	1	14%	1	14%
Lake Ontario West	LOW	8	1	13%	6	75%
Lake Ontario East	LOE	9	5	56%	1	11%
Salmon River Hatchery	SRH	2	0	0%	2	100%

Table 37. cis-Chlordane (ppm). N/A is used for mean and standard deviation when nondetects exceed 50%. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	6	40%	0.005	0.003	0.005	<0.005 - 0.011
	channel catfish	15	3	20%	0.007	0.003	0.006	<0.005 - 0.012
	freshwater drum	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.005
	lake trout	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.007
Upper Niagara River	common carp	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.017
Lower Niagara River	common carp	15	11	73%	N/A	N/A	<0.005	<0.005 - 0.008
	freshwater drum	17	15	88%	N/A	N/A	<0.005	<0.005 - 0.008
Cayuga Creek	brown bullhead	10	9	90%	N/A	N/A	<0.005	<0.005 - 0.006
	common carp	10	7	70%	N/A	N/A	<0.005	<0.005 - 0.010
Lake Ontario West	coho salmon	28	25	89%	N/A	N/A	<0.005	<0.005 - 0.005
Lake Ontario East	brown trout	10	9	90%	N/A	N/A	<0.005	<0.005 - 0.005
	lake trout	98	31	32%	0.006	0.003	0.006	<0.005 - 0.014
Salmon River Hatchery	chinook salmon	30	26	87%	N/A	N/A	<0.005	<0.005 - 0.009
	coho salmon	20	12	60%	N/A	N/A	<0.005	<0.005 - 0.007
	rainbow trout	30	28	93%	N/A	N/A	<0.005	<0.005 - 0.006

Table 38. Oxychlordane (ppm). N/A is used for mean and standard deviation when nondetects exceed 50%. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lower Niagara River	freshwater drum	17	13	76%	N/A	N/A	<0.005	<0.005 - 0.009
Cayuga Creek	largemouth bass	11	9	82%	N/A	N/A	<0.005	<0.005 - 0.007
Lake Ontario East	brown trout	10	6	60%	N/A	N/A	<0.005	<0.005 - 0.006
	channel catfish	11	8	73%	N/A	N/A	<0.005	<0.005 - 0.013
	lake trout	98	33	34%	0.007	0.004	0.007	<0.005 - 0.020
	white perch	25	24	96%	N/A	N/A	<0.005	<0.005 - 0.008
Salmon River Hatchery	chinook salmon	30	17	57%	N/A	N/A	<0.005	<0.005 - 0.012
	coho salmon	20	13	65%	N/A	N/A	<0.005	<0.005 - 0.007
	rainbow trout	30	24	80%	N/A	N/A	<0.005	<0.005 - 0.006

Table 39. cis-Nonachlor (ppm). N/A is used for mean and standard deviation when nondetects exceed 50%. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	6	40%	0.006	0.004	0.007	<0.005 - 0.014
	channel catfish	15	2	13%	0.007	0.004	0.006	<0.005 - 0.015
	freshwater drum	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.009
	lake trout	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.008
	smallmouth bass	16	15	94%	N/A	N/A	<0.005	<0.005 - 0.005
Upper Niagara River	common carp	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.010
Lower Niagara River	common carp	15	11	73%	N/A	N/A	<0.005	<0.005 - 0.010
	freshwater drum	17	15	88%	N/A	N/A	<0.005	<0.005 - 0.010
Lake Ontario West	coho salmon	28	27	96%	N/A	N/A	<0.005	<0.005 - 0.006
Lake Ontario East	lake trout	98	27	28%	0.007	0.005	0.007	<0.005 - 0.033
Salmon River Hatchery	chinook salmon	30	13	43%	0.005	0.003	0.006	<0.005 - 0.013
	coho salmon	20	11	55%	N/A	N/A	<0.005	<0.005 - 0.007
	rainbow trout	30	23	77%	N/A	N/A	<0.005	<0.005 - 0.006

Table 40. trans-Nonachlor (ppm). N/A is used for mean and standard deviation when nondetects exceed 50%. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	4	27%	0.009	0.005	0.010	<0.005 - 0.017
	channel catfish	15	0	0%	0.013	0.007	0.012	0.005 - 0.029
	freshwater drum	15	12	80%	N/A	N/A	<0.005	<0.005 - 0.017
	lake trout	15	9	60%	N/A	N/A	<0.005	<0.005 - 0.012
	smallmouth bass	16	11	69%	N/A	N/A	<0.005	<0.005 - 0.008
Upper Niagara River	common carp	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.015
Lower Niagara River	common carp	15	8	53%	N/A	N/A	<0.005	<0.005 - 0.017
	freshwater drum	17	9	53%	N/A	N/A	<0.005	<0.005 - 0.019
	smallmouth bass	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.005
Cayuga Creek	brown bullhead	10	9	90%	N/A	N/A	<0.005	<0.005 - 0.005
	common carp	10	8	80%	N/A	N/A	<0.005	<0.005 - 0.009
Lake Ontario West	coho salmon	28	13	46%	0.005	0.003	0.006	<0.005 - 0.012
	smallmouth bass	15	12	80%	N/A	N/A	<0.005	<0.005 - 0.007
Lake Ontario East	brown trout	10	3	30%	0.005	0.002	0.006	<0.005 - 0.008
	lake trout	98	10	10%	0.014	0.008	0.013	<0.005 - 0.057
Salmon River Hatchery	chinook salmon	30	1	3%	0.011	0.004	0.011	<0.005 - 0.025
	coho salmon	20	0	0%	0.011	0.003	0.010	0.006 - 0.015
	rainbow trout	30	9	30%	0.007	0.003	0.007	<0.005 - 0.012

Table 41. Total chlordane (ppm).[a]

Location	Species	N	Nondetect (number)	Nondetect (percent)	Mean[b]	Standard Deviation[b]	Median[c]	Range[c]
Lake Erie	common carp	15	3	20%	0.025	0.010	0.028	ND - 0.046
	channel catfish	15	0	0%	0.032	0.013	0.028	0.015 - 0.060
	freshwater drum	15	12	80%	N/A	N/A	ND	ND - 0.036
	lake trout	15	9	60%	N/A	N/A	ND	ND - 0.032
	smallmouth bass	16	11	69%	N/A	N/A	ND	ND - 0.020
Upper Niagara River	common carp	15	14	93%	N/A	N/A	ND	ND - 0.048
Lower Niagara River	common carp	15	8	53%	N/A	N/A	ND	ND - 0.040
	freshwater drum	17	9	53%	N/A	N/A	ND	ND - 0.046
	smallmouth bass	15	14	93%	N/A	N/A	ND	ND - 0.015
Cayuga Creek	brown bullhead	10	9	90%	N/A	N/A	ND	ND - 0.018
	common carp	10	7	70%	N/A	N/A	ND	ND - 0.026
	largemouth bass	11	9	82%	N/A	N/A	ND	ND - 0.017
Lake Ontario West	coho salmon	28	13	46%	0.015	0.004	0.016	ND - 0.028
	smallmouth bass	15	12	80%	N/A	N/A	ND	ND - 0.017
Lake Ontario East	brown trout	10	3	30%	0.017	0.004	0.016	ND - 0.024
	channel catfish	11	8	73%	N/A	N/A	ND	ND - 0.023
	lake trout	98	10	10%	0.036	0.018	0.036	ND - 0.126
	white perch	25	24	96%	N/A	N/A	ND	ND - 0.018
Salmon River Hatchery	chinook salmon	30	1	3%	0.025	0.01	0.025	ND - 0.061
	coho salmon	20	0	0%	0.025	0.007	0.022	0.016 - 0.036
	rainbow trout	30	9	30%	0.018	0.006	0.017	ND - 0.031

[a] Collections with all nondetects not shown: Lake Erie: rock bass, rainbow trout, walleye, white perch, yellow perch; Upper Niagara River: freshwater drum, largemouth bass, rock bass, smallmouth bass, yellow perch; Lower Niagara River: rock bass, yellow perch; Cayuga Creek: rock bass; Lake Ontario western basin: white perch, white sucker; Lake Ontario eastern basin: smallmouth bass, white sucker.
[b] N/A is used when more than 50% of samples were nondetects.
[c] ND = nondetect.

Table 42. Mirex (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	12	80%	N/A	N/A	<0.002	<0.002 - 0.003
	channel catfish	15	14	93%	N/A	N/A	<0.002	<0.002 - 0.002
Upper Niagara River	common carp	15	14	93%	N/A	N/A	<0.002	<0.002 - 0.005
Lower Niagara River	common carp	15	3	20%	0.016	0.026	0.006	<0.002 - 0.088
	freshwater drum	17	2	12%	0.017	0.015	0.012	<0.002 - 0.051
	smallmouth bass	15	1	7%	0.005	0.003	0.004	<0.002 - 0.014
	yellow perch	18	17	94%	N/A	N/A	<0.002	<0.002 - 0.003
Cayuga Creek	brown bullhead	10	5	50%	0.002	N/A	N/A	<0.002 - 0.004
	common carp	10	1	10%	0.012	0.007	0.01	<0.002 - 0.025
	largemouth bass	11	8	73%	N/A	N/A	<0.002	<0.002 - 0.004
	rock bass	9	5	56%	N/A	N/A	<0.002	<0.002 - 0.004
Lake Ontario West	coho salmon	28	0	0%	0.01	0.005	0.009	0.004 - 0.019
	smallmouth bass	15	1	7%	0.007	0.003	0.007	<0.002 - 0.012
	white perch	10	9	90%	N/A	N/A	<0.002	<0.002 - 0.002
Lake Ontario East	brown trout	10	0	0%	0.008	0.002	0.007	0.006 - 0.011
	channel catfish	11	2	18%	0.005	0.003	0.005	<0.002 - 0.008
	lake trout	98	0	0%	0.026	0.021	0.023	0.003 - 0.182
	smallmouth bass	10	8	80%	N/A	N/A	<0.002	<0.002 - 0.005
	white perch	25	14	56%	N/A	N/A	<0.002	<0.002 - 0.009
Salmon River Hatchery	chinook salmon	30	0	0%	0.019	0.006	0.018	0.009 - 0.035
	coho salmon	20	0	0%	0.018	0.004	0.017	0.011 - 0.026
	rainbow trout	30	0	0%	0.017	0.008	0.015	0.007 - 0.035

Table 43. Photomirex (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lower Niagara River	common carp	15	13	87%	N/A	N/A	<0.005	<0.005 - 0.016
	freshwater drum	17	11	65%	N/A	N/A	<0.005	<0.005 - 0.013
Lake Ontario West	coho salmon	28	26	93%	N/A	N/A	<0.005	<0.005 - 0.007
	smallmouth bass	15	14	93%	N/A	N/A	<0.005	<0.005 - 0.005
	lake trout	98	21	21%	0.010	0.008	0.009	<0.005 - 0.072
Salmon River Hatchery	chinook salmon	30	2	7%	0.008	0.002	0.007	<0.005 - 0.014
	coho salmon	20	3	15%	0.006	0.002	0.006	<0.005 - 0.009
	rainbow trout	30	10	33%	0.006	0.003	0.007	<0.005 - 0.013

Table 44. HCH isomers (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%. Results with 100% nondetects are not shown.

HCH isomers	Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
alpha HCH	Cayuga Creek	brown bullhead	10	7	70%	N/A	N/A	<0.005	<0.005 - 0.015
		common carp	10	0	0%	0.021	0.012	0.022	0.006 - 0.038
		largemouth bass	11	8	73%	N/A	N/A	<0.005	<0.005 - 0.011
		rock bass	9	8	89%	N/A	N/A	<0.005	<0.005 - 0.011
beta HCH	Cayuga Creek	brown bullhead	10	7	70%	N/A	N/A	<0.005	<0.005 - 0.015
		common carp	10	1	10%	0.015	0.008	0.017	<0.005 - 0.024
		largemouth bass	11	8	73%	N/A	N/A	<0.005	<0.005 - 0.008
		rock bass	9	7	78%	N/A	N/A	<0.005	<0.005 - 0.012

Table 45. Dieldrin (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%. ND indicates nondetects. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Ontario East	lake trout	98	96	98%	N/A	N/A	<0.025	<0.025 - 0.03

Table 46. HCB (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%. ND indicates nondetects. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lake Erie	common carp	15	12	80%	N/A	N/A	<0.002	<0.002 - 0.003
	lake trout	15	14	93%	N/A	N/A	<0.002	<0.002 - 0.002
	rainbow trout	15	14	93%	N/A	N/A	<0.002	<0.002 - 0.002
Upper Niagara River	common carp	15	14	93%	N/A	N/A	<0.002	<0.002 - 0.004
Lower Niagara River	common carp	15	5	33%	0.004	0.005	0.003	<0.002 - 0.021
	freshwater drum	17	13	76%	N/A	N/A	<0.002	<0.002 - 0.004
Cayuga Creek	brown bullhead	10	8	80%	N/A	N/A	<0.002	<0.002 - 0.037
	common carp	10	2	20%	0.016	0.034	0.004	<0.002 - 0.113
	largemouth bass	11	10	91%	N/A	N/A	<0.002	<0.002 - 0.004
Lake Ontario West	coho salmon	28	11	39%	0.002	0.001	0.003	<0.002 - 0.005
Lake Ontario East	brown trout	10	1	10%	0.003	0.001	0.003	<0.002 - 0.005
	lake trout	98	20	20%	0.004	0.002	0.004	<0.002 - 0.009
Salmon River Hatchery	chinook salmon	30	28	93%	N/A	N/A	<0.002	<0.002 - 0.003
	coho salmon	20	12	60%	N/A	N/A	<0.002	<0.002 - 0.003
	rainbow trout	30	29	97%	N/A	N/A	<0.002	<0.002 - 0.002

Table 47. Octachlorostyrene (ppm). N/A is used for mean and standard deviation when nondetects exceeded 50%. ND indicates nondetects. Results with 100% nondetects are not shown.

Location	Species	N	Number of Nondetect	Nondetect (percent)	Mean	Standard Deviation	Median	Range
Lower Niagara River	common carp	15	13	87%	N/A	N/A	<0.005	<0.005 - 0.017
Lake Ontario East	lake trout	98	96	98%	N/A	N/A	<0.005	<0.005 - 0.013
Salmon River Hatchery	coho salmon	20	19	95%	N/A	N/A	<0.005	<0.005 - 0.006

Table 48. PCDD/F (ppt).

Analyte	Min	10%	25%	Median	75%	90%	Max
2,3,7,8-TCDD	<0.45	<0.45	<0.45	1.15	2.2	5.7	21
1,2,3,7,8-PeCDD	<0.56	<0.56	<0.56	<0.56	0.625	1.1	2.5
1,2,3,4,7,8-HxCDD	<0.76	<0.76	<0.76	<0.76	<0.76	<0.76	2.9
1,2,3,4,6,7,8-HpCDD	<0.48	<0.48	<0.48	<0.48	<0.48	0.51	5.86
1,2,3,6,7,8-HxCDD	<0.77	<0.77	<0.77	<0.77	<0.77	<0.77	2.6
1,2,3,7,8,9-HxCDD	<0.54	<0.54	<0.54	<0.54	<0.54	<0.54	0.59
OCDD	<0.67	<0.67	<0.67	1.4	2.8	4.1	11
2,3,7,8-TCDF	<0.39	<0.39	0.71	1.9	5.78	10.7	18.8
1,2,3,7,8-PeCDF	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85
2,3,4,7,8-PeCDF	<0.65	<0.65	<0.65	0.76	1.509	2.7	11.9
1,2,3,4,7,8-HxCDF	<0.5	<0.5	<0.5	<0.5	<0.5	0.94	21
1,2,3,6,7,8-HxCDF	<0.57	<0.57	<0.57	<0.57	<0.57	<0.57	2.2
1,2,3,7,8,9-HxCDF	<0.77	<0.77	<0.77	<0.77	<0.77	<0.77	<0.77
2,3,4,6,7,8-HxCDF	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	1.3
1,2,3,4,6,7,8-HpCDF	<0.84	<0.84	<0.84	<0.84	<0.84	<0.84	1.4
1,2,3,4,7,8,9-HpCDF	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
OCDF	<0.85	<0.85	<0.85	<0.85	<0.85	<0.85	1.2

Table 49. TEQs (ppt).

Location	Species	N	Mean	Standard Deviation	Median	Range
Lake Erie	rainbow trout	3	0.68	0.25	0.68	0.43 - 0.94
	smallmouth bass	3	0.47	0.13	0.53	0.32 - 0.56
	walleye	3	0.28	0.04	0.29	0.24 - 0.31
Upper Niagara River	common carp	5	1.58	2.38	0.40	0.11 - 5.74
	largemouth bass	3	0.31	0.08	0.32	0.22 - 0.38
	smallmouth bass	3	0.96	0.19	1.05	0.74 - 1.10
Lower Niagara River	common carp	5	4.79	4.03	3.80	0.52 - 10.99
	smallmouth bass	3	2.79	1.62	2.04	1.69 - 4.64
Cayuga Creek	brown bullhead	5	6.20	3.60	6.64	1.76 - 10.68
	common carp	5	16.71	7.83	13.30	9.75 - 29.55
	largemouth bass	5	1.83	0.89	1.45	0.93 - 2.89
	rock bass	5	5.09	4.98	3.12	0.20 - 10.44
Lake Ontario West	coho salmon	3	1.57	0.23	1.53	1.36 - 1.82
	smallmouth bass	3	1.04	0.74	1.23	0.22 - 1.67
	white perch	3	0.43	0.17	0.35	0.32 - 0.62
Lake Ontario East	brown trout	3	2.09	0.43	2.09	1.67 - 2.53
	channel catfish	3	1.72	0.76	1.88	0.89 - 2.39
	lake trout	18	4.42	1.84	4.46	1.81 - 7.21
	smallmouth bass	3	0.35	0.20	0.36	0.15 - 0.54
	white perch	3	0.80	0.40	0.61	0.53 - 1.26
Salmon River Hatchery	chinook salmon	12	2.41	0.83	2.16	1.34 - 3.62
	coho salmon	6	3.56	0.45	3.63	2.86 - 4.11
	rainbow trout	6	3.01	2.17	2.34	1.57 - 7.35

Table 50. Statistically significant ($P < 0.05$) comparisons of TEQ levels among different species at each location. CARP = common carp, LMB = largemouth bass, LT = lake trout, SMB = smallmouth bass, WP = white perch, CHS = chinook salmon, COS = coho salmon.

Location	Comparison		
Cayuga Creek	CARP	>	LMB
Lake Ontario East	LT	>	SMB
	LT	>	WP
Salmon River Hatchery	CHS	<	COS

Table 51. Statistically significant ($P < 0.05$) comparisons of TEQ levels among different locations for each species.

Species	Comparison		
common carp	upper Niagara River	<	Cayuga Creek
coho salmon	Lake Ontario West	<	Salmon River Hatchery
largemouth bass	upper Niagara River	<	Cayuga Creek
rainbow trout	Lake Erie	<	Salmon River Hatchery
smallmouth bass	lower Niagara River	>	Lake Ontario East

Table 52. PBDE congeners (ppt).

Analyte	Min	10%	25%	Median	75%	90%	Max
BDE-1	<100	<100	<100	<100	<100	<100	<100
BDE-2	<62.9	<62.9	<62.9	<62.9	<62.9	<62.9	<62.9
BDE-3	<46.2	<46.2	<46.2	<46.2	<46.2	<46.2	<46.2
BDE-7	<27	<27	<27	<27	<27	<27	<27
BDE-10	<27	<27	<27	<27	<27	<27	<27
BDE-11	<27	<27	<27	<27	<27	<27	<27
BDE-12	<27	<27	<27	<27	<27	<27	<27
BDE-15	<19.8	<19.8	<19.8	<19.8	<19.8	25.8	73.3
BDE-17	<13.5	<13.5	<13.5	33.9	75.7	129	424.7
BDE-25	<27	<27	<27	38.8	112.5	178	270
BDE-30	<27	<27	<27	<27	<27	<27	<27
BDE-32	<27	<27	<27	<27	<27	<27	<27
BDE-35	<27	<27	<27	<27	<27	<27	<27
BDE-37	<27	<27	<27	<27	<27	<27	<27
BDE-47	<19.5	1678.1	3409.8	10182.7	22467.4	31468.1	89567.5
BDE-49	28.8	110.6	297.2	730	1524.3	2250	4170
BDE-51	<27	<27	<27	70	160	200	402
BDE-66	<51.5	<51.5	<51.5	172	537	710.2	1759.2
BDE-71	<33.9	<33.9	<33.9	<33.9	62.2	154	1890
BDE-75	<47.3	<47.3	<47.3	<47.3	60	86.6	135
BDE-77	<27.1	<27.1	<27.1	<27.1	<27.1	33	84.1
BDE-79	<99.9	<99.9	<99.9	<99.9	<99.9	131	406
BDE-85	<27	<27	<27	<27	<27	<27	659
BDE-99	<9.9	26	506.7	3014	7260.4	9472	14373.5
BDE-100	140.2	492	1102.2	3334	6167.2	8384	16394
BDE-105	<46.7	<46.7	<46.7	<46.7	<46.7	<46.7	<46.7
BDE-116	<170	<170	<170	<170	<170	<170	<170
BDE-118	<27	<27	<27	49.6	175.5	254	412
BDE-126	<27	<27	<27	<27	44.5	88.5	240
BDE-128	<47.2	<47.2	<47.2	<47.2	<47.2	91.4	143
BDE-138	<28.7	<28.7	<28.7	<28.7	<28.7	<28.7	82.6
BDE-140	<27	<27	<27	<27	31.9	44.9	82.7
BDE-153	<11.2	47.3	203.6	836	1725	2394.2	4670
BDE-154	48.7	300	545.5	1490	3019	4120	8080
BDE-155	<27	36.8	89.4	182	332	429	918
BDE-166	<27	<27	<27	<27	<27	<27	32.9
BDE-181	<56.9	<56.9	<56.9	<56.9	<56.9	<56.9	<56.9
BDE-183	<56.9	<56.9	<56.9	<56.9	<56.9	72.3	134
BDE-190	<64.6	<64.6	<64.6	<64.6	<64.6	<64.6	<64.6
BDE-203	<233	<233	<233	<233	<233	<233	<233
BDE-206	<151	<151	<151	<151	<151	<151	249
BDE-207	<82.2	<82.2	<82.2	<82.2	<82.2	<82.2	249
BDE-208	<76.7	<76.7	<76.7	<76.7	<76.7	<76.7	133
BDE-209	<1030	<1030	<1030	<1030	<1030	<1030	2620
BDE-(8/11)	<54.1	<54.1	<54.1	<54.1	<54.1	<54.1	<54.1
BDE-(28/33)	<19.9	39.3	80.7	314.4	829.7	1148.5	5480
BDE-(119/120)	<40.2	<40.2	<40.2	91.2	200	414	1310

Table 53. Total PBDEs (ppt).

Location	Species	N	Mean	Standard Deviation	Median	Range
Lake Erie	rainbow trout	3	7489	2237	7795	5115 - 9558
	smallmouth bass	3	4661	800	4237	4162 - 5584
	walleye	3	4779	2078	5618	2412 - 6305
Upper Niagara River	common carp	5	13506	25410	2378	1409 - 58954
	largemouth bass	3	8135	3098	7603	5338 - 11465
	smallmouth bass	3	13832	5629	11383	9843 - 20272
Lower Niagara River	common carp	5	29917	22822	25142	6208 - 64508
	smallmouth bass	3	35346	15020	29551	24088 - 52400
Cayuga Creek	brown bullhead	5	13204	8091	11023	4545 - 26087
	common carp	5	65612	36199	64178	26045 - 122557
	largemouth bass	5	18619	9898	13675	8713 - 32499
	rock bass	4	6955	2423	6589	4201 - 10279
Lake Ontario West	coho salmon	3	10513	2401	9604	8699 - 13236
	smallmouth bass	3	9744	7437	12628	1297 - 15308
	white perch	3	3734	448	3818	3250 - 4135
Lake Ontario East	brown trout	3	23383	3197	23483	20138 - 26529
	channel catfish	3	32239	13748	36857	16777 - 43082
	lake trout	18	48438	22734	48555	13662 - 82470
	smallmouth bass	3	4862	3348	4289	1836 - 8459
	white perch	3	7095	2385	5987	5467 - 9832
Salmon River Hatchery	chinook salmon	12	52696	11317	54017	35215 - 75586
	coho salmon	6	45991	4571	46142	38505 - 51991
	rainbow trout	6	34530	9363	33039	23370 - 50974

Table 54. Statistically significant ($P < 0.05$) comparisons of PBDE levels among different species at each location. CARP = common carp, RB = rock bass, LT = lake trout, SMB = smallmouth bass, WP = white perch, CHS = chinook salmon, RT = rainbow trout.

Location	Comparison		
Cayuga Creek	CARP	>	RB
Lake Ontario East	LT	>	SMB
	LT	>	WP
Salmon River Hatchery	CHS	>	RT

Table 55. Statistically significant ($P < 0.05$) comparisons of PBDE levels among different locations for each species.

Species	Comparison		
common carp	upper Niagara River	<	Cayuga Creek
coho salmon	Lake Ontario West	<	Salmon River Hatchery
rainbow trout	Lake Erie	<	Salmon River Hatchery
white perch	Lake Ontario West	<	Lake Ontario East

Table 56. Pearson product-moment correlation (r) for Hg *vs.* PCB, Hg *vs.* DDT and DDT *vs.* PCB. The "–" indicates that the correlation was not significant ($P < 0.05$).

Species	Location	r		
		Hg *vs.* PCB	Hg *vs.* DDT	DDT *vs.* PCB
brown bullhead	Cayuga Creek	-	-	0.67
brown trout	Lake Ontario East	-	-	0.91
common carp	Lake Erie	-	-	-
	Upper Niagara River	0.83	0.82	0.74[a]
	Lower Niagara River	-	0.61	-
	Cayuga Creek	-	-	-
channel catfish	Lake Erie	0.80	0.74	0.98
	Lake Ontario East	0.76	-	0.86
chinook salmon	Salmon River Hatchery	-0.43	-0.43	0.97
coho salmon	Lake Ontario West	0.45	0.57	0.95
	Salmon River Hatchery	-	-	0.96
freshwater drum	Lake Erie	-	-	0.94
	Upper Niagara River	-	-	-
	Lower Niagara River	-	-	0.51
largemouth bass	Upper Niagara River	-	-	0.98
	Cayuga Creek	-	-	-
lake trout	Lake Erie	0.64	0.72	0.94
	Lake Ontario East	0.81	0.81	0.98
rock bass	Lake Erie	-	0.53	0.85
	Upper Niagara River	-	-	0.77
	Lower Niagara River	-	-	-
	Cayuga Creek	-	-	-
rainbow trout	Lake Erie	-	0.58	0.74
	Salmon River Hatchery	0.60	0.50	0.97
smallmouth bass	Lake Erie	0.87	0.87	0.99
	Upper Niagara River	-	-	0.52
	Lower Niagara River	-	-	0.82
	Lake Ontario West	0.55	-	0.76
	Lake Ontario East	-	0.66	0.78
walleye	Lake Erie	0.78	0.73	0.95
white perch	Lake Erie	-	0.68	0.84
	Lake Ontario West	-	-	0.96
	Lake Ontario East	-	-	0.70
white sucker	Lake Ontario West	0.98	-	0.93
	Lake Ontario East	0.72	0.88	0.78
yellow perch	Lake Erie	0.59	-	0.65
	Upper Niagara River	-	-	0.83
	Lower Niagara River	-	-	0.79

[a] Excludes one outlier (see Figure 27).

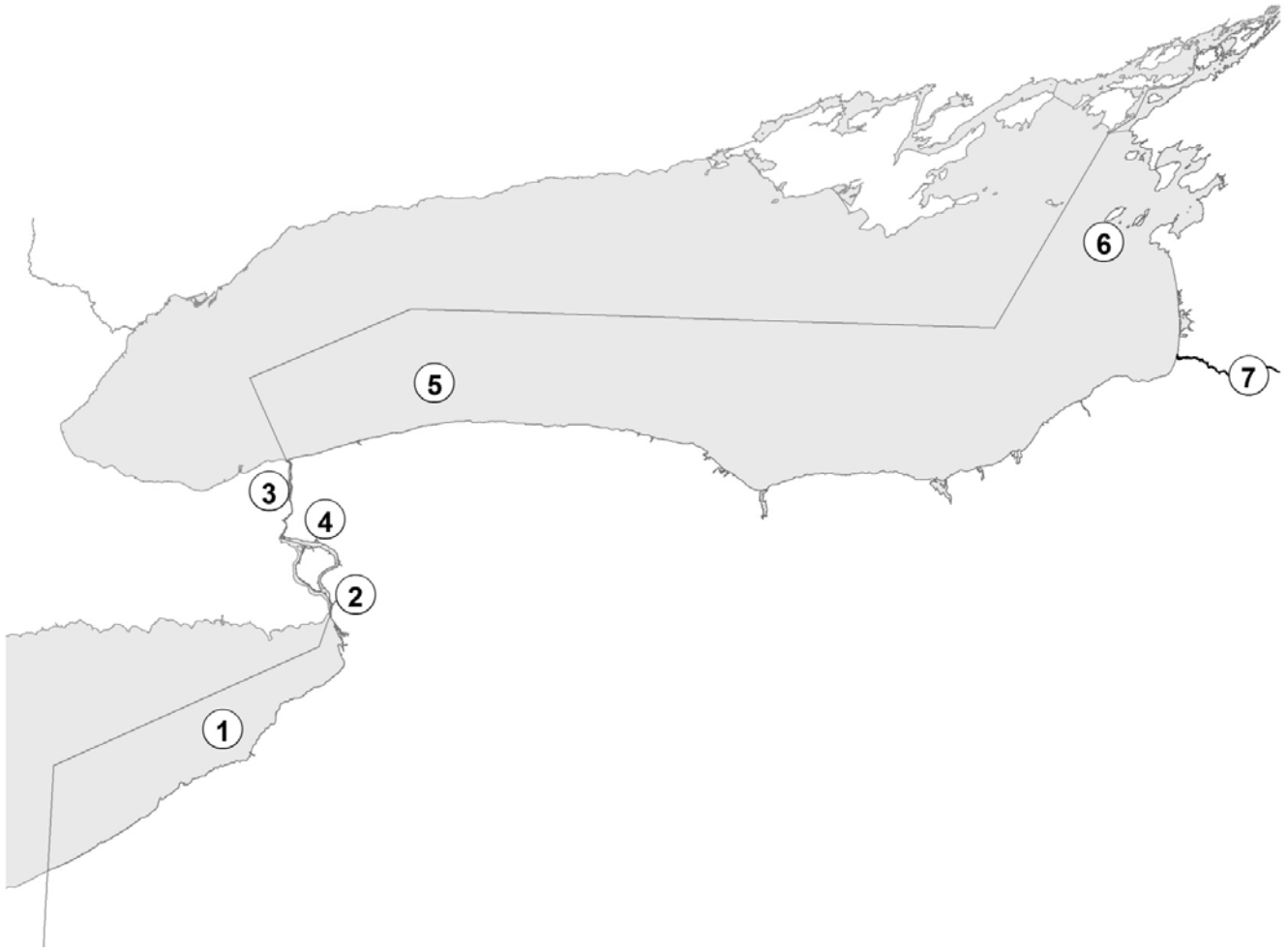


Figure 1. Fish collection sites. 1 = Lake Erie, 2 = upper Niagara River, 3 = lower Niagara River, 4 = Cayuga Creek, 5 = Lake Ontario western basin, 6 = Lake Ontario eastern basin, 7 = Salmon River Hatchery at Altmar.

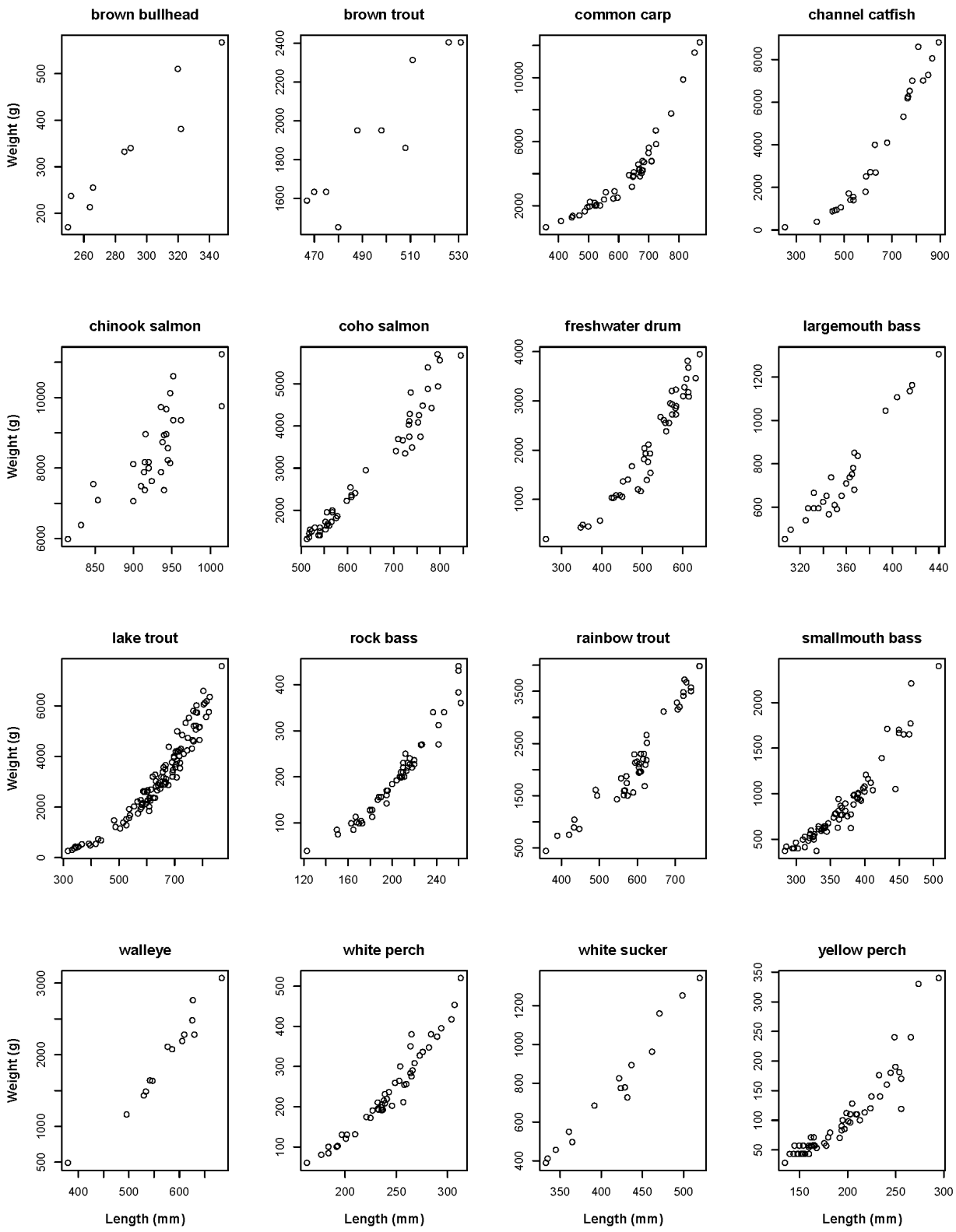


Figure 2. Fish length (mm) versus weight (g). Axis scales and origins differ among panels.

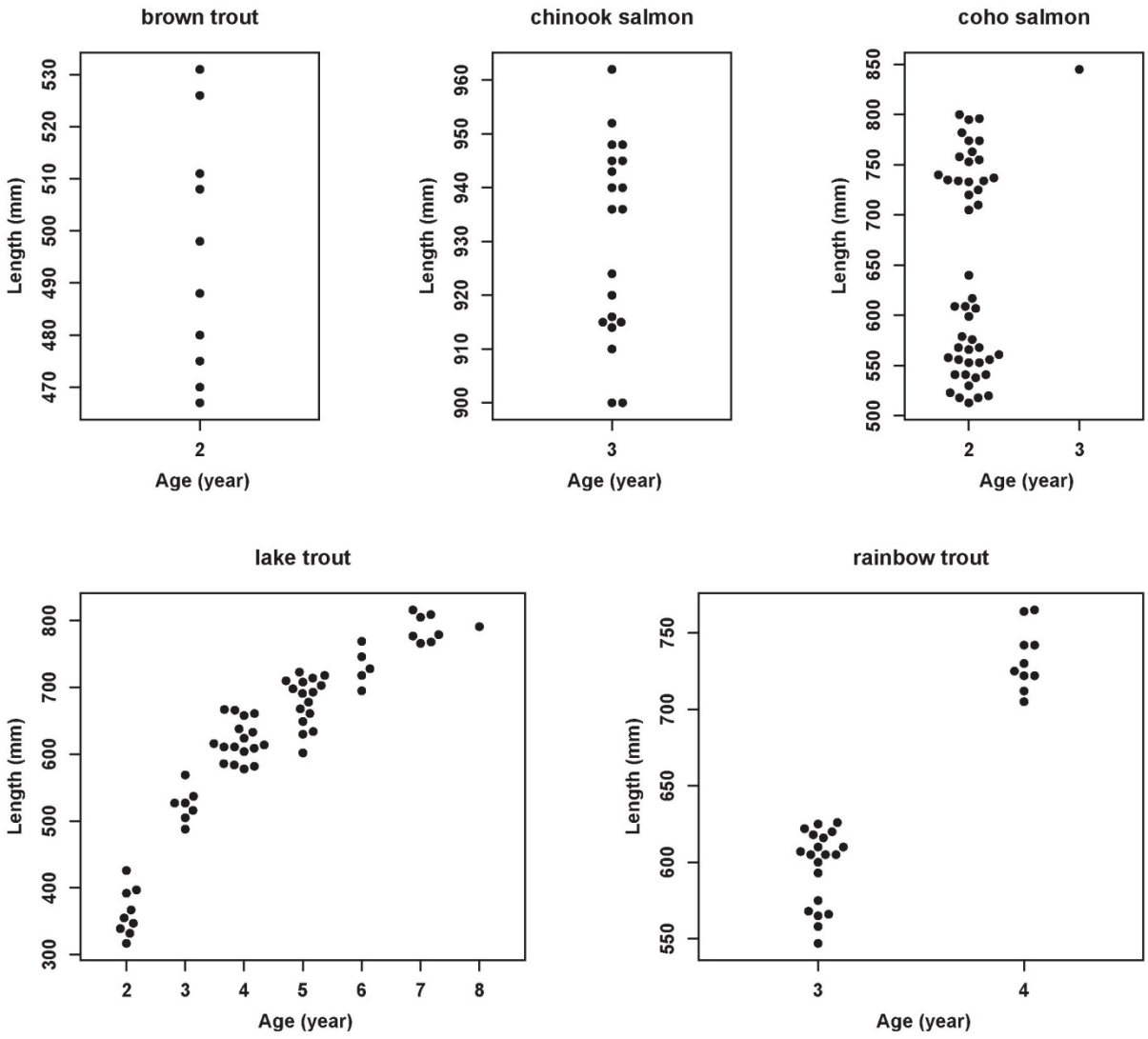


Figure 3. Length versus age. Axis scales and origins differ among panels.

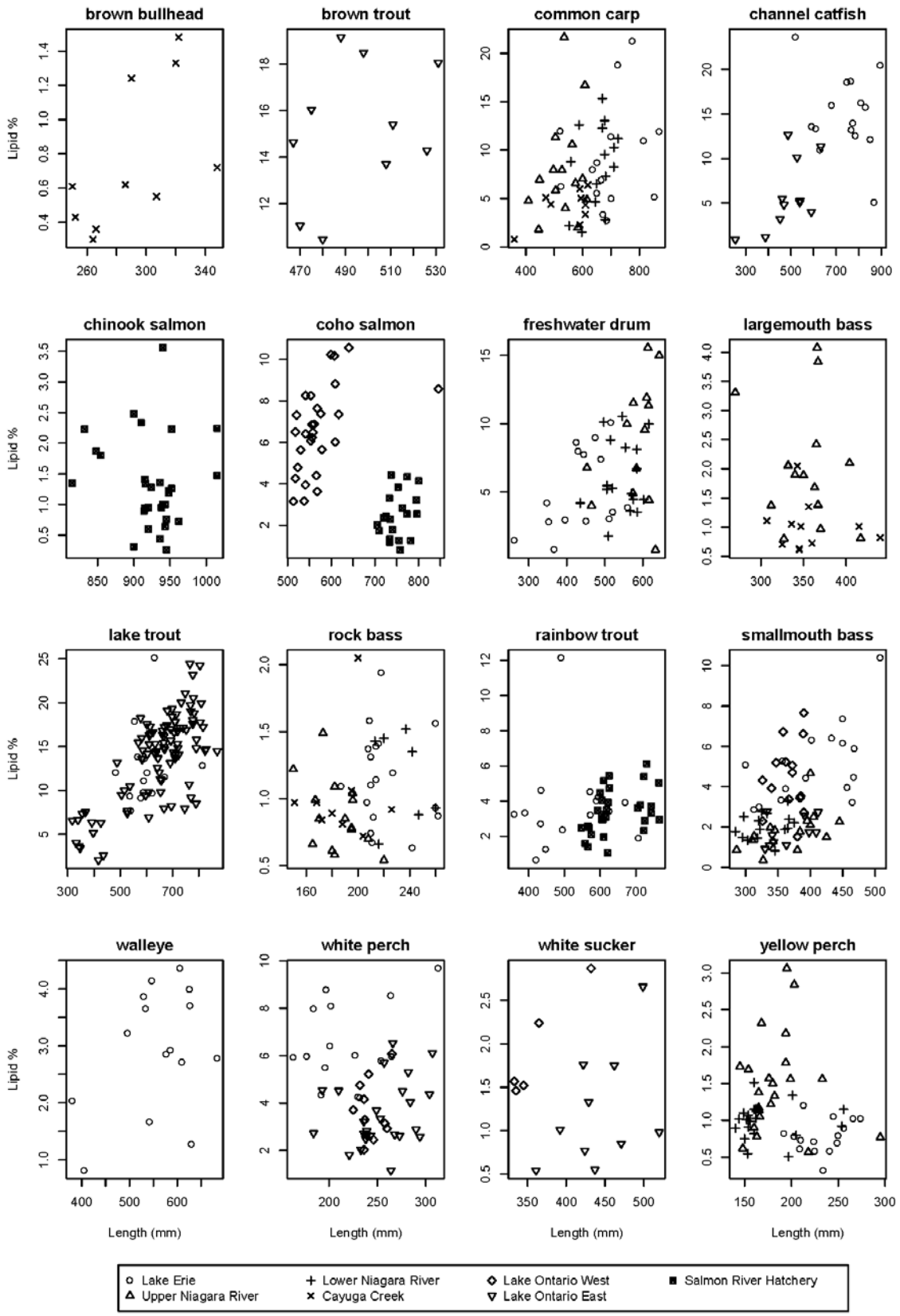


Figure 4. Percent lipid versus fish length. Axis scales and origins differ among panels.

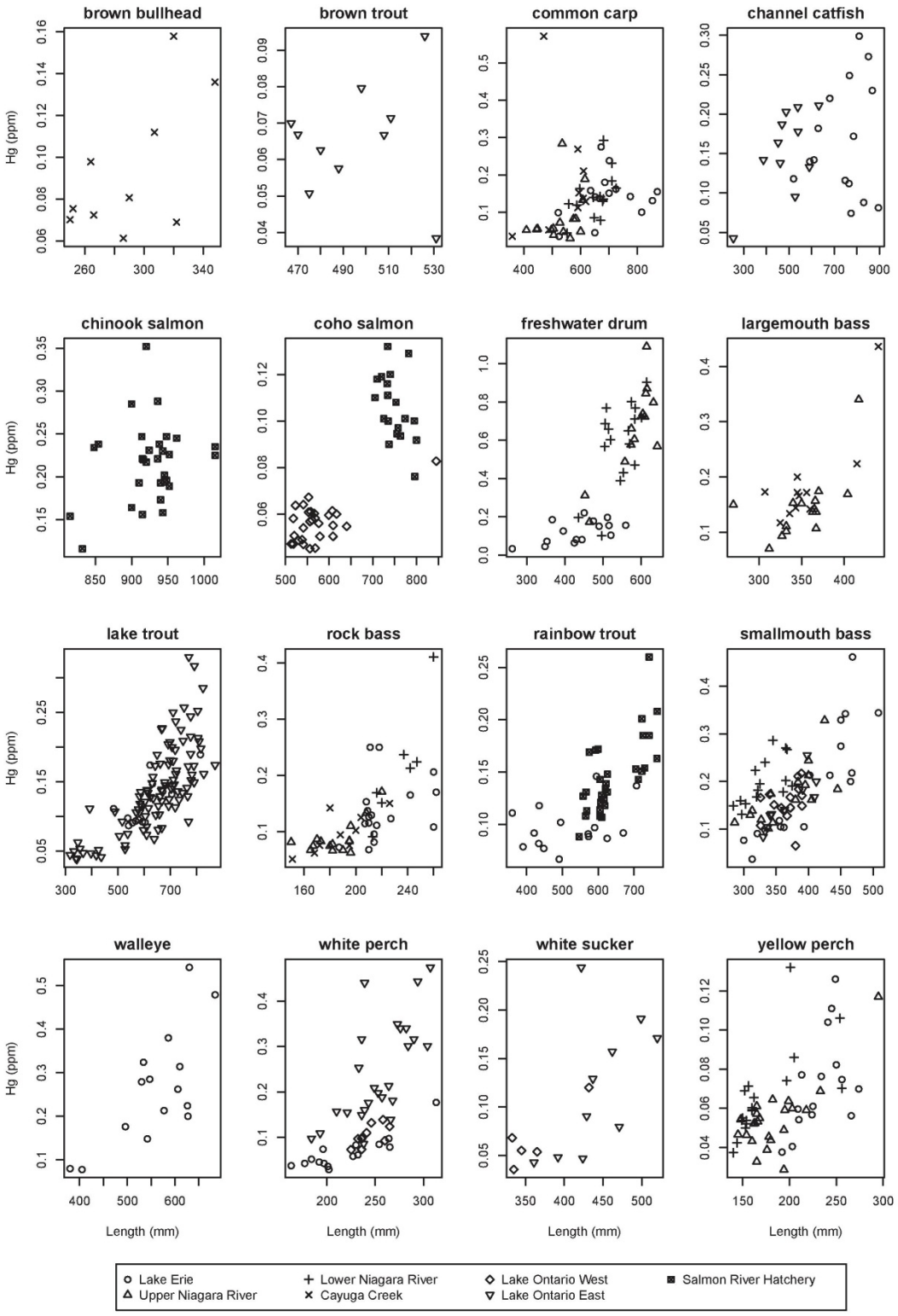


Figure 5. Mercury level versus fish length. Axis scales and origins differ among panels.

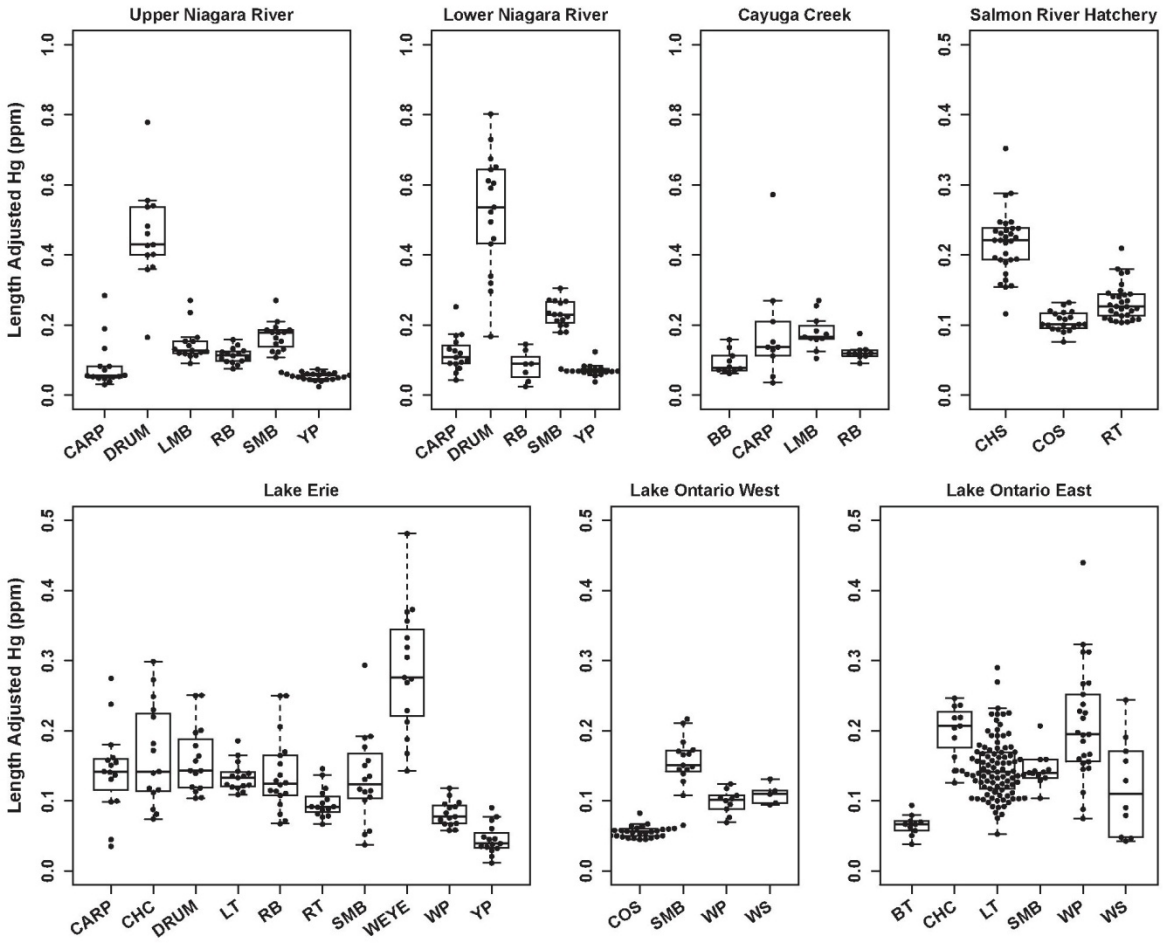


Figure 6. Length adjusted mercury levels grouped by location. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch. Vertical scale differs among panels.

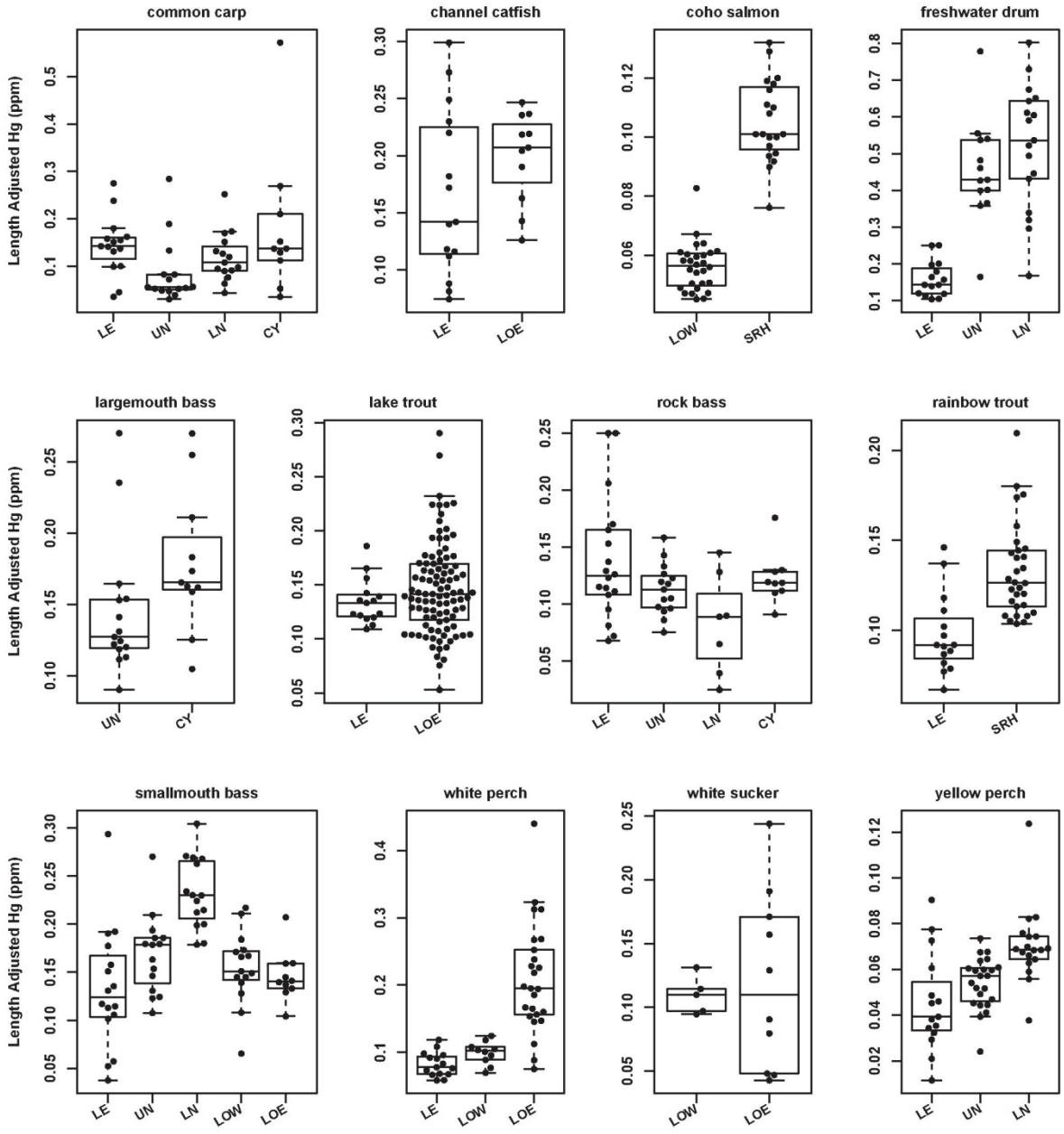


Figure 7. Length adjusted mercury levels grouped by species. Only species with multiple locations are shown. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery. Vertical scale and Y axis origin differ among panels.

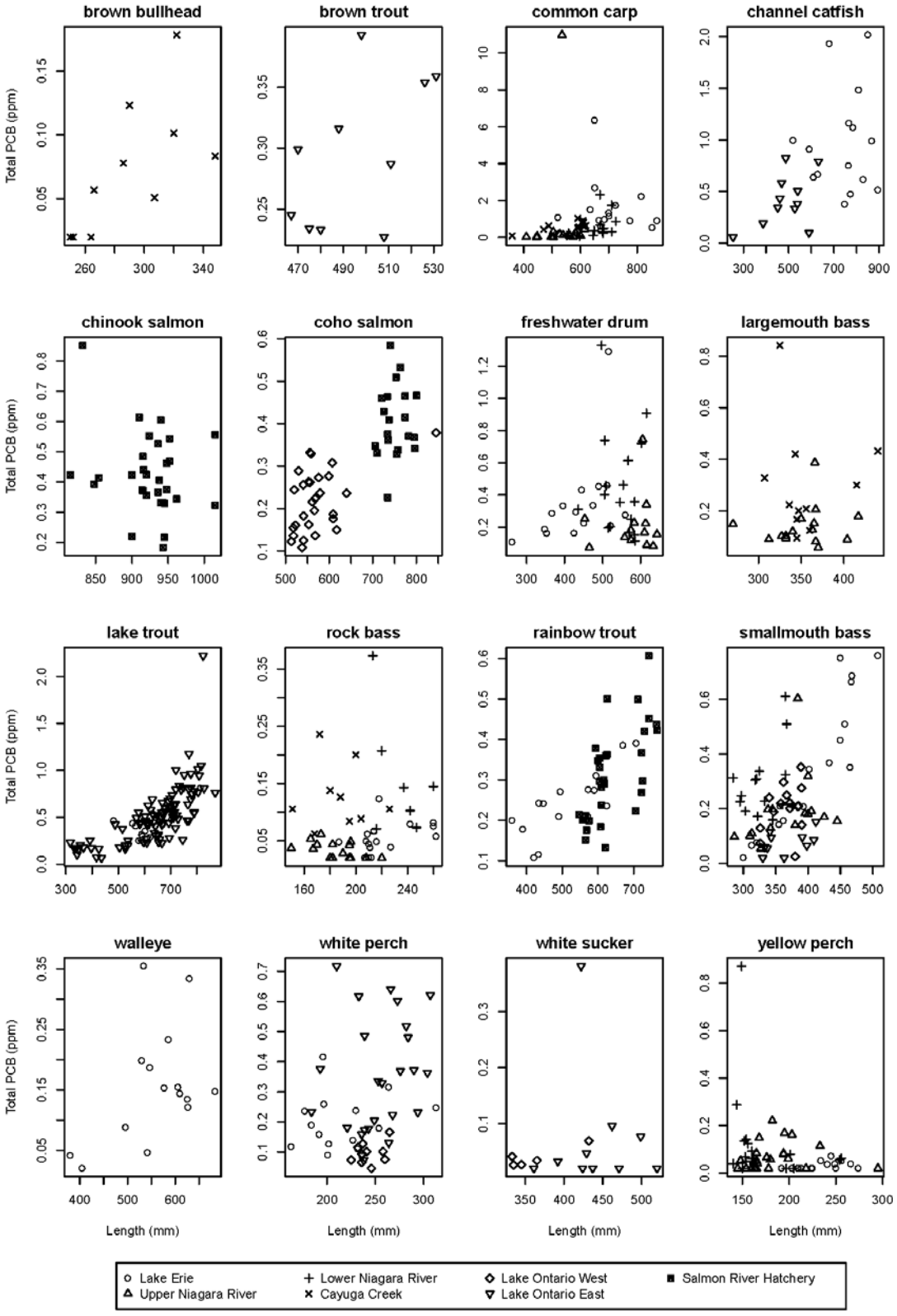


Figure 8. Total PCB versus fish length. Axis scales and origins differ among panels.

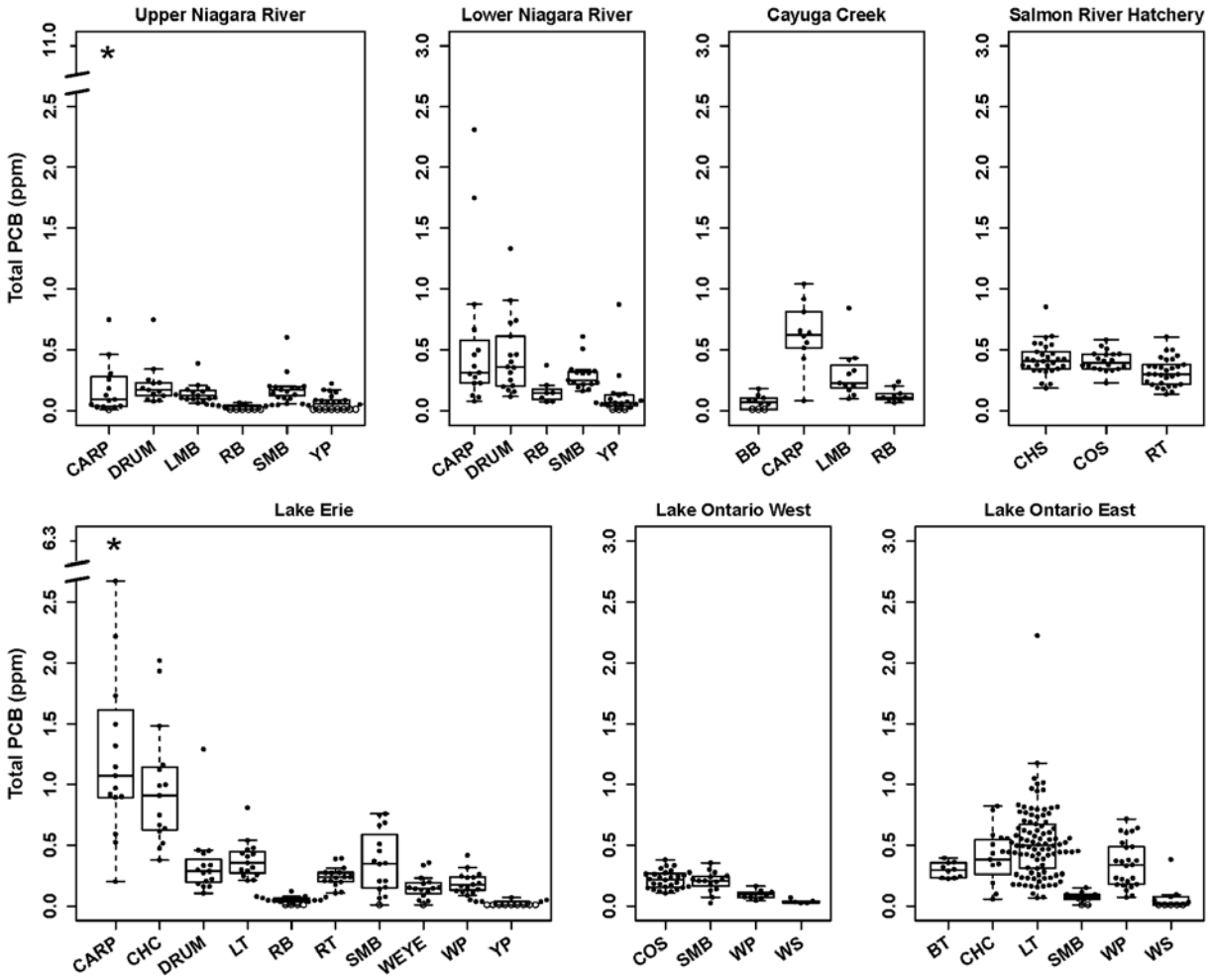


Figure 9. Total PCB levels grouped by location. Open circles indicate nondetect, and asterisks indicate outliners. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch.

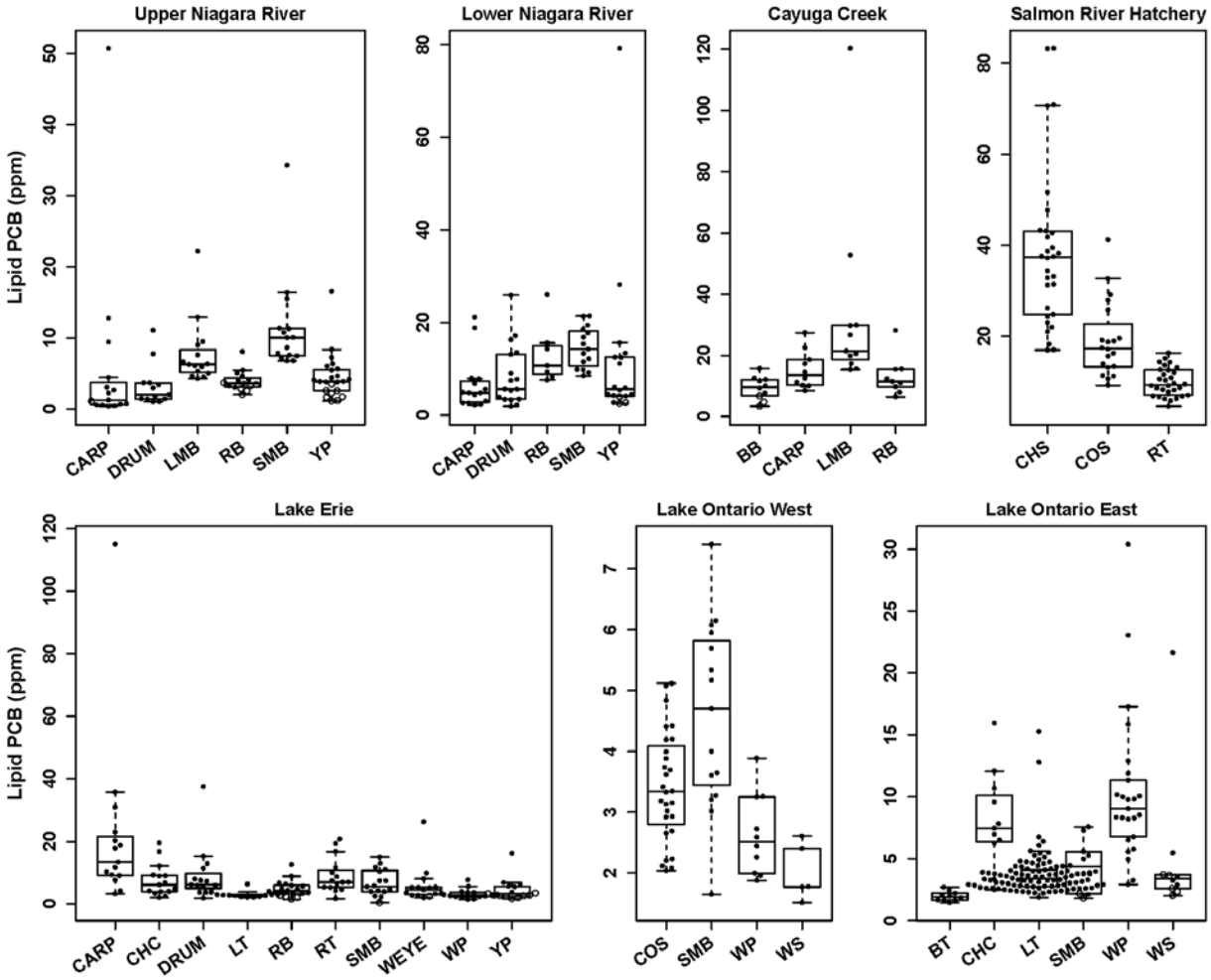


Figure 10. Lipid normalized PCB levels grouped by location. Open circles indicate nondetect. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch. Vertical scale and Y axis origin differ among panels.

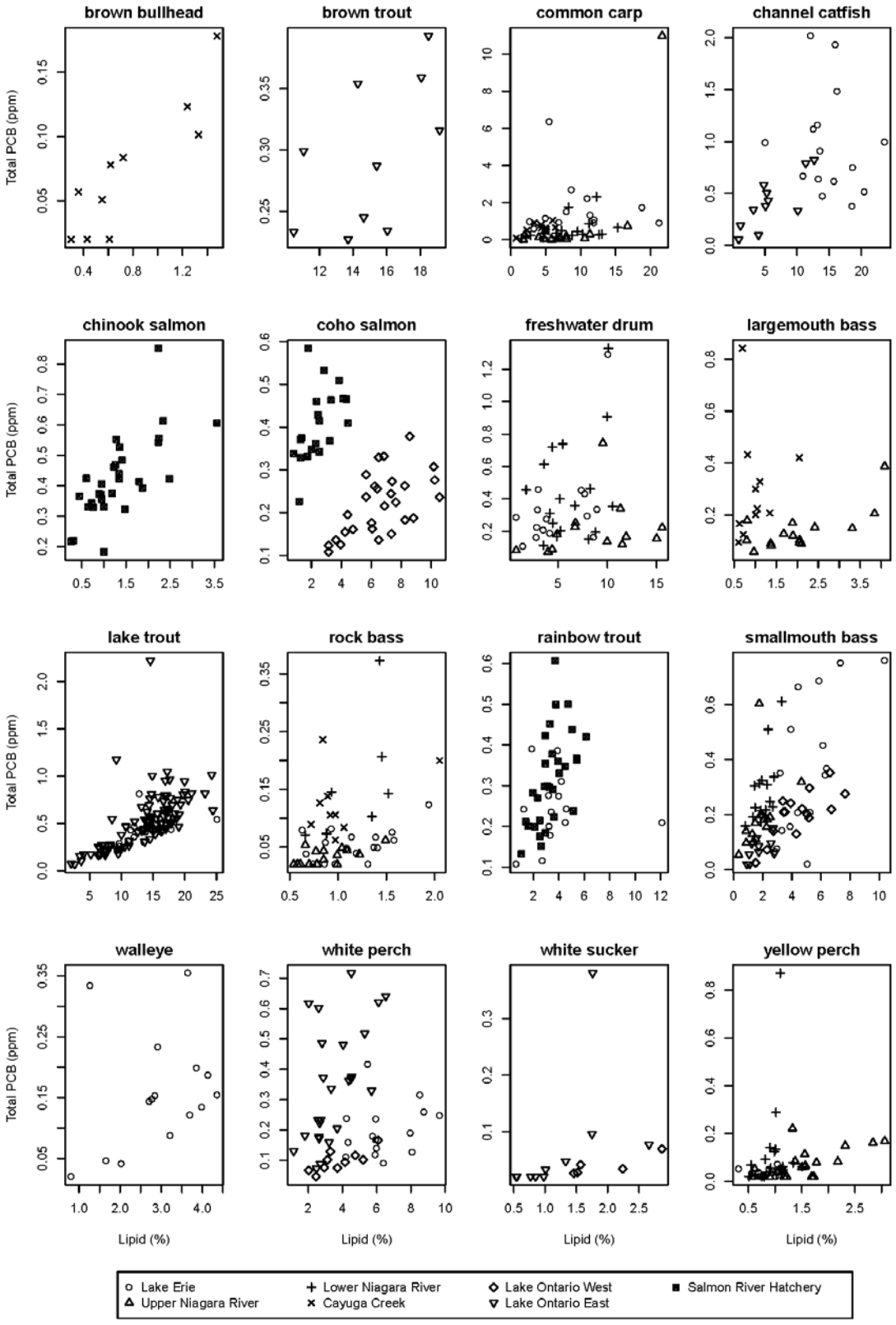


Figure 11. Total PCB versus percent lipid. Axis scales and origins differ among panels.

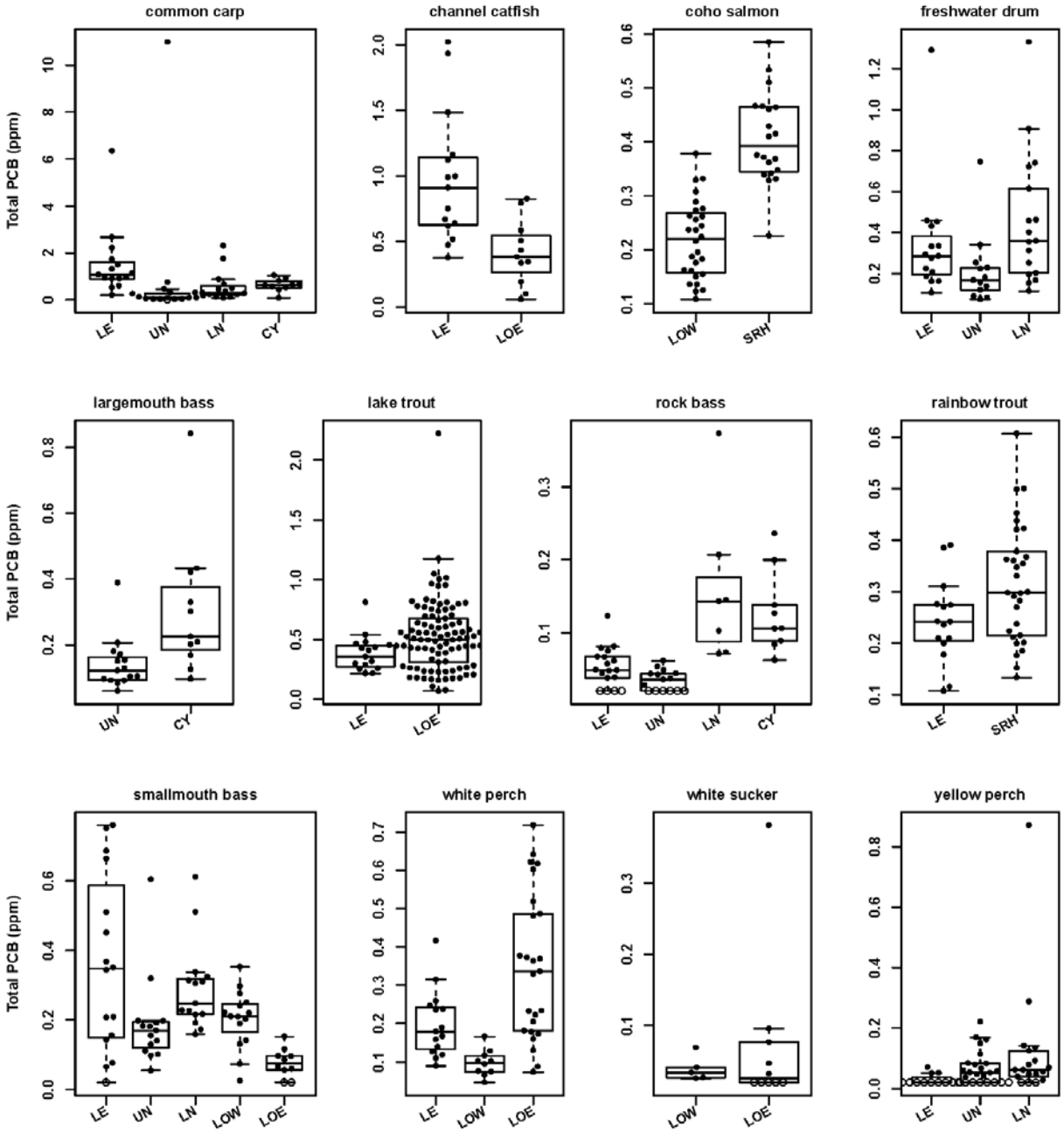


Figure 12. Total PCB levels grouped by species. Only species with multiple locations are shown. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery. Vertical scale and Y axis origin differ among panels.

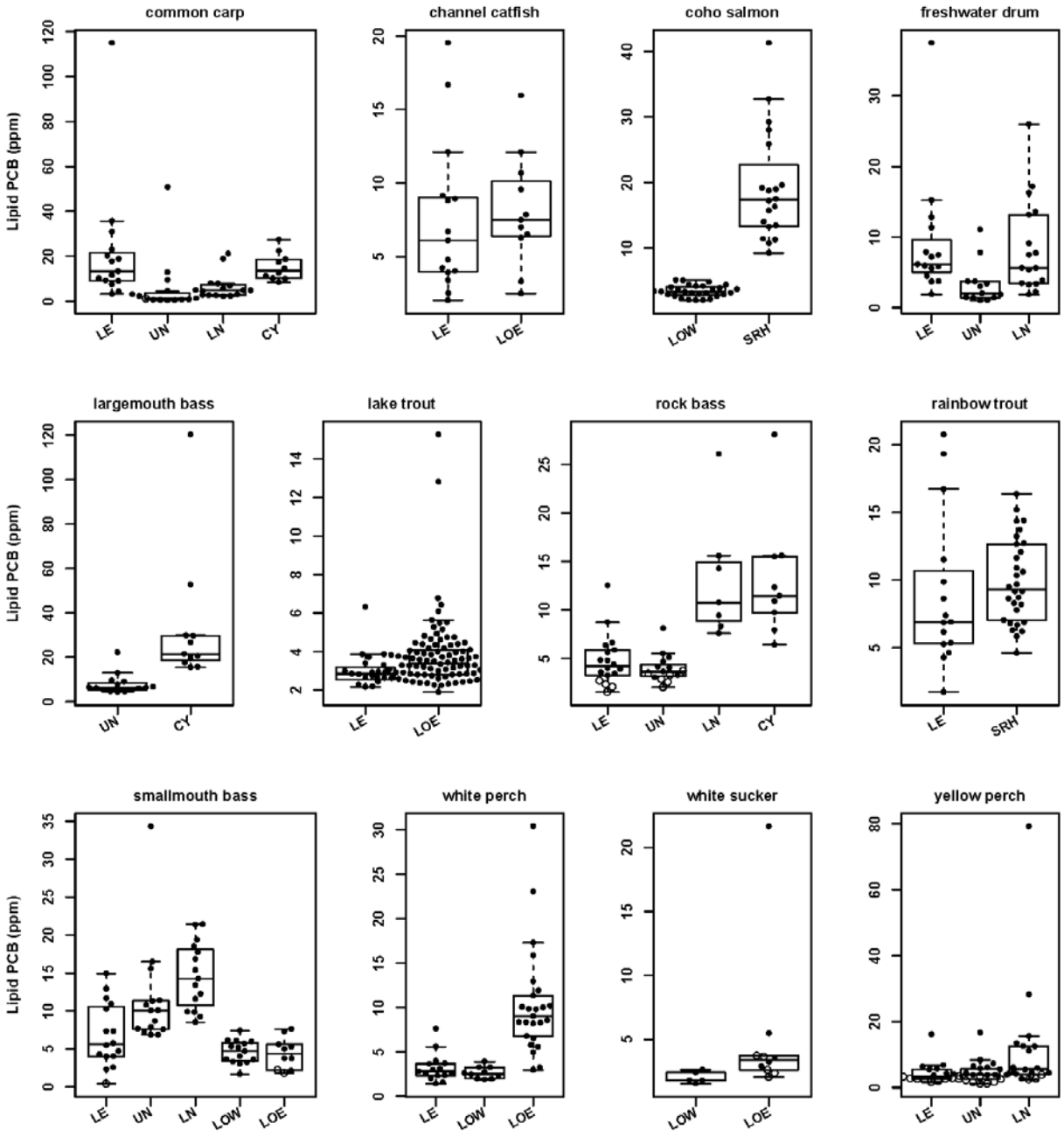


Figure 13. Lipid normalized PCB levels grouped by species. Only species with multiple locations are shown. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery. Vertical scale and Y axis origin differ among panels.

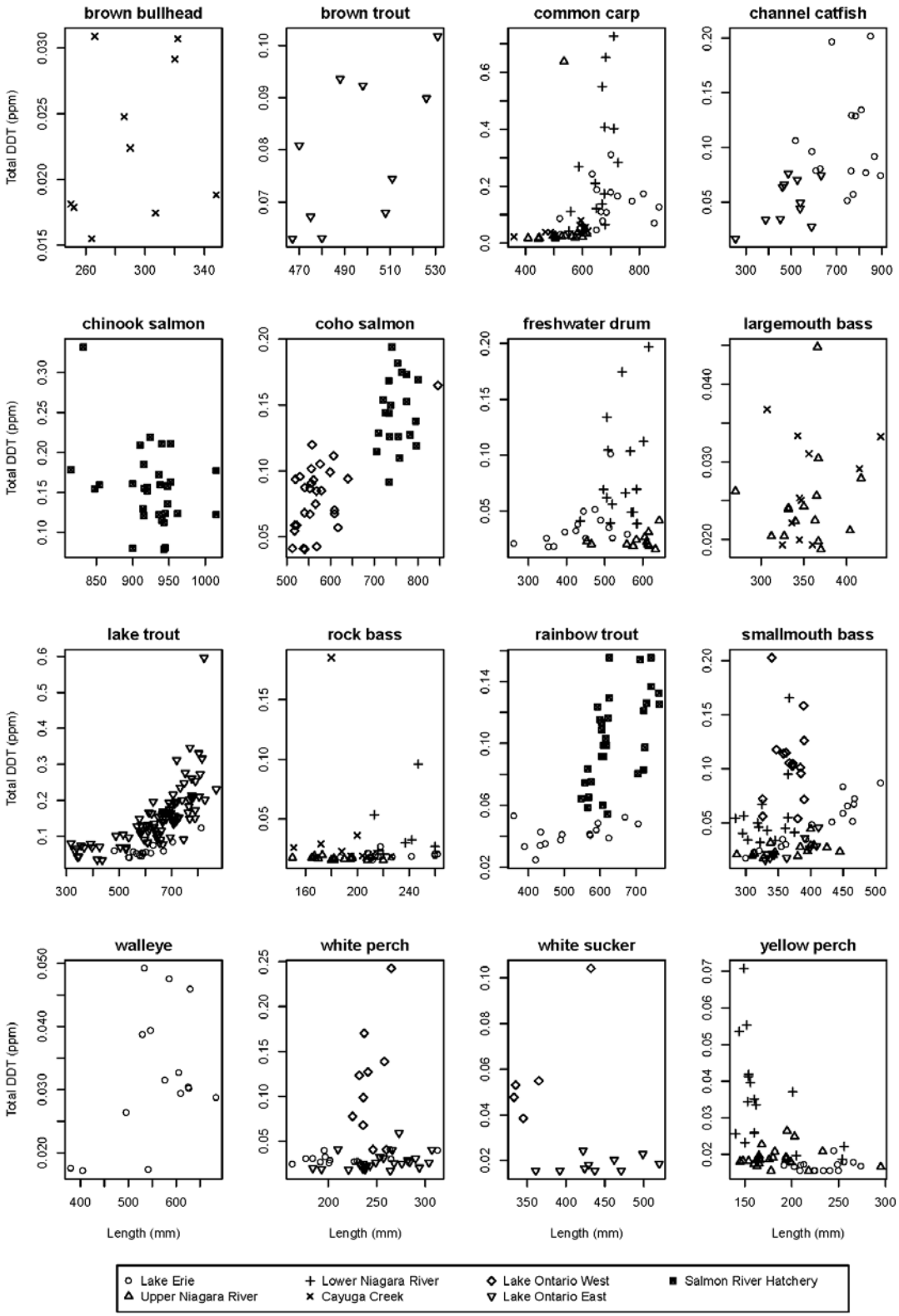


Figure 14. Total DDT versus length. Axis scales and origins differ among panels.

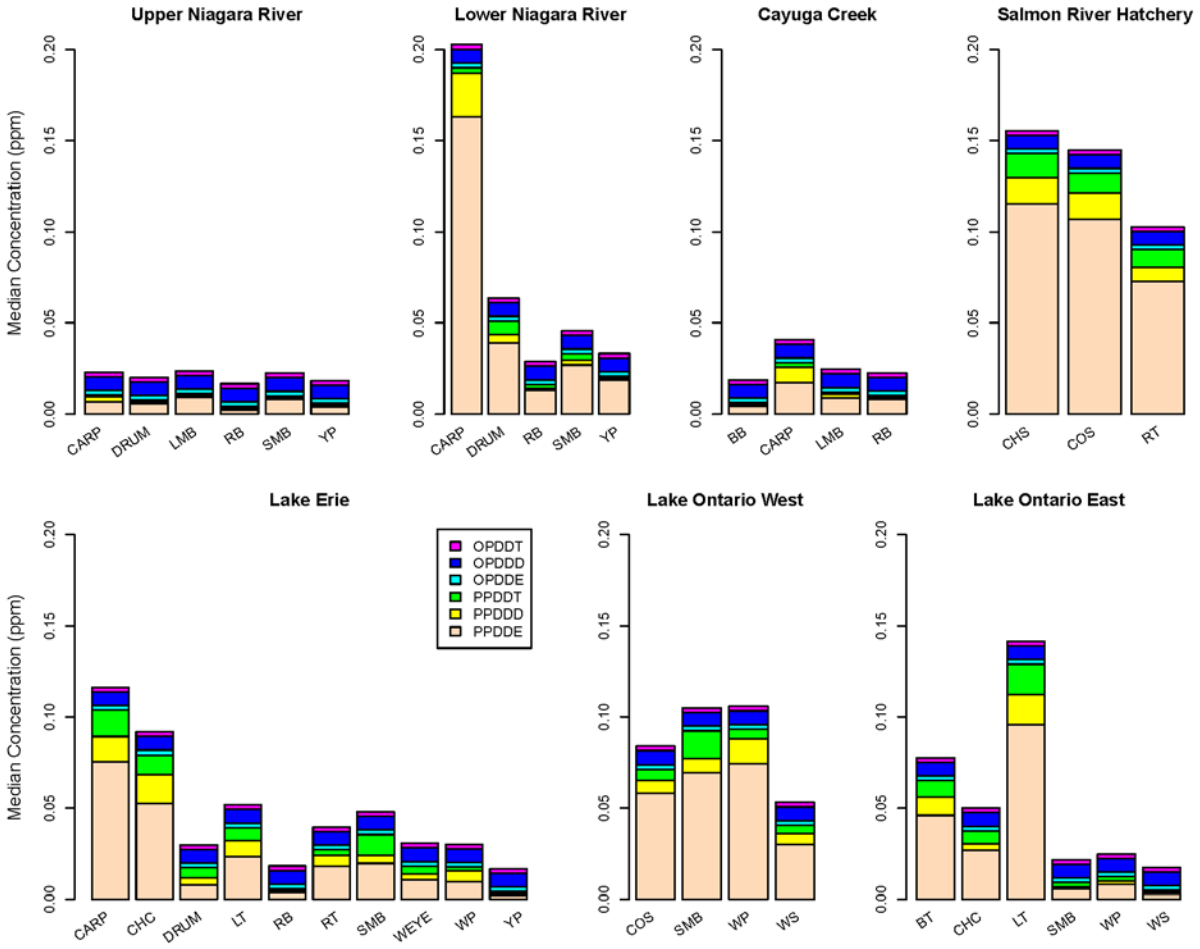


Figure 15. Median concentrations of DDTs by species at each location. CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, YP = yellow perch.

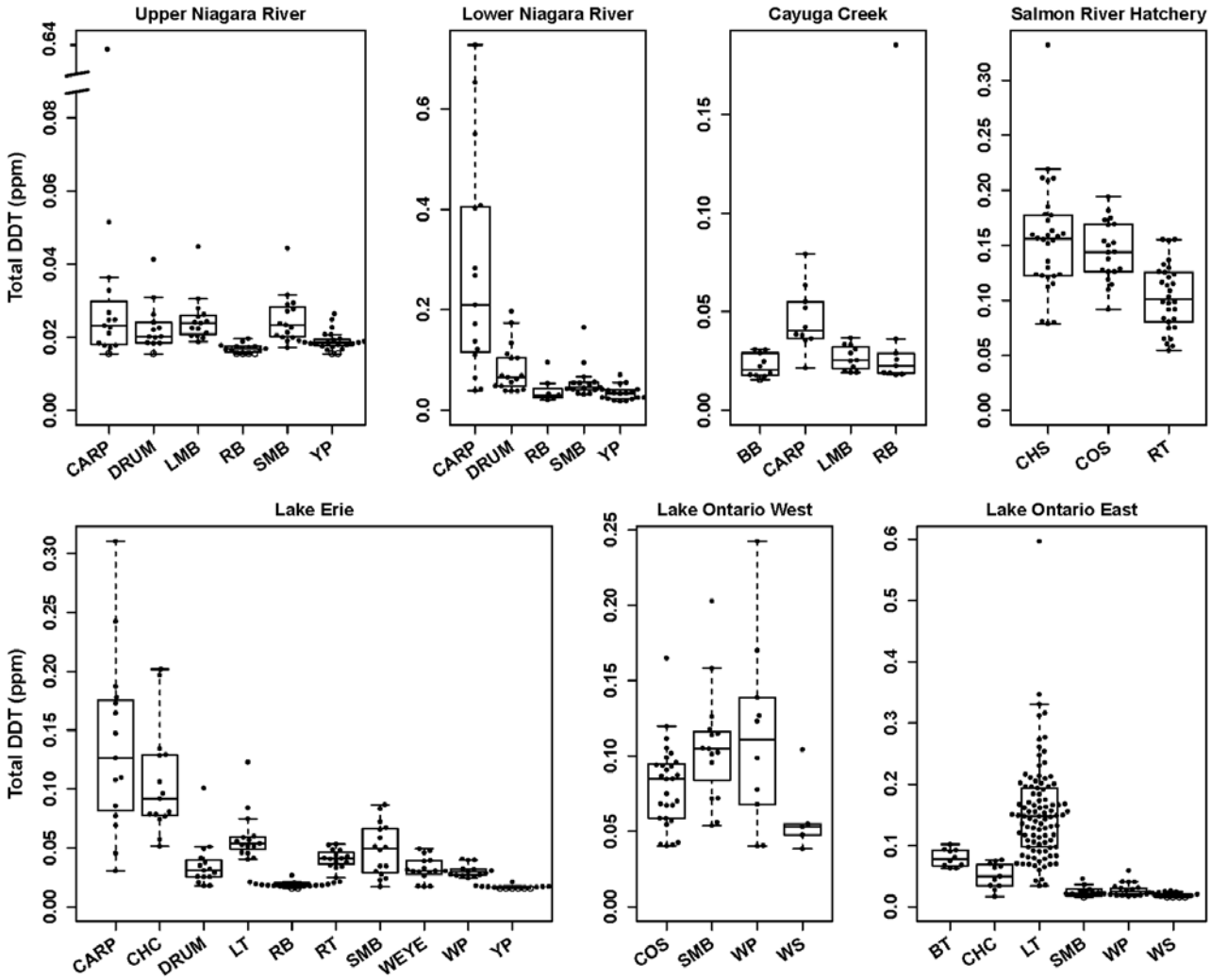


Figure 16. Total DDT levels grouped by location. Open circles indicate nondetect. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, WS = white sucker, YP = yellow perch. Vertical scale differs among panels.

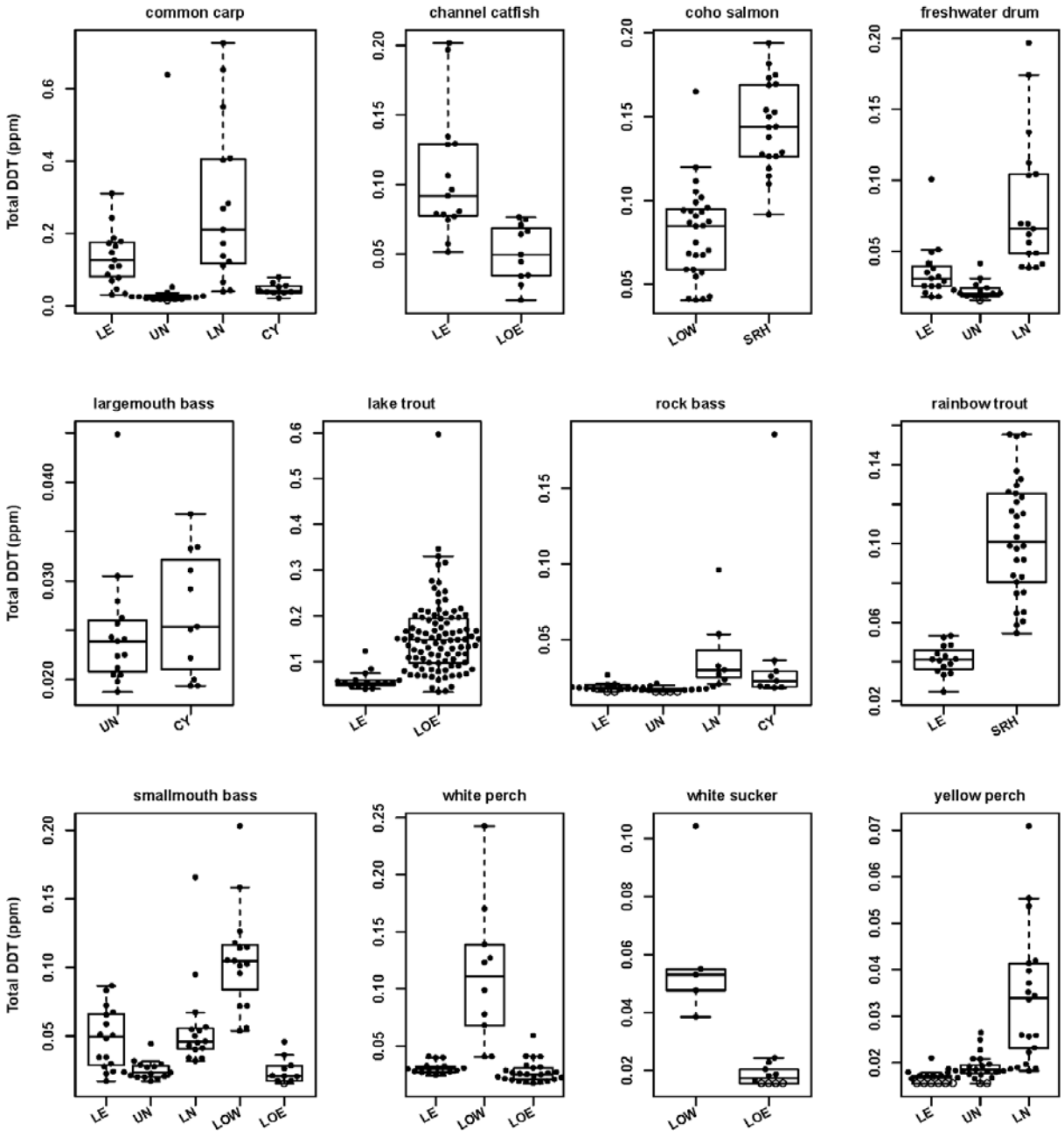


Figure 17. Total DDT levels grouped by species. Open circles indicate nondetect. Only species with multiple locations are shown. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery. Vertical scale and Y axis origin differ among panels.

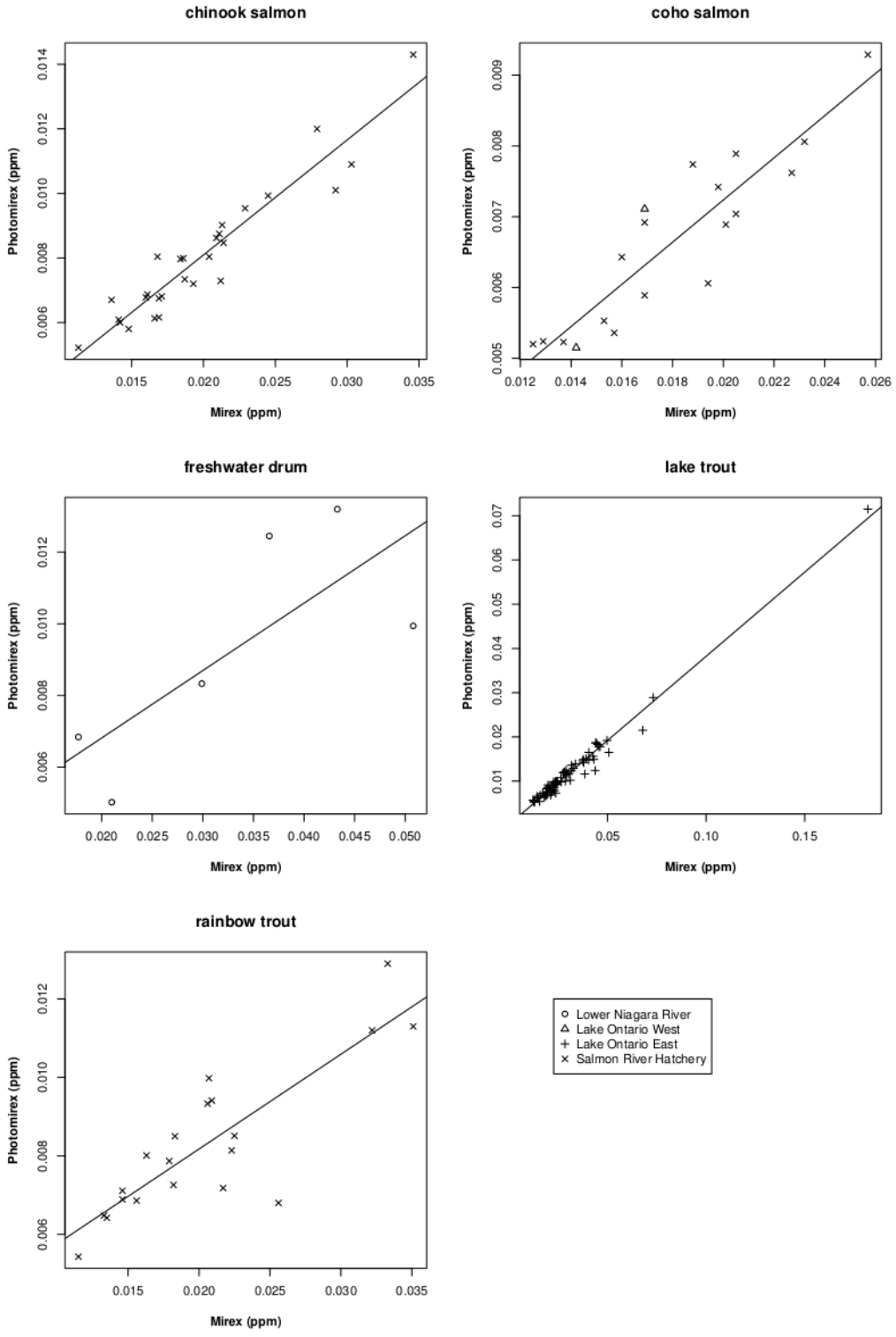


Figure 18. Photomirex versus mirex. Only data with both mirex and photomirex above detection limits are shown. Axis scales and origins differ among panels.

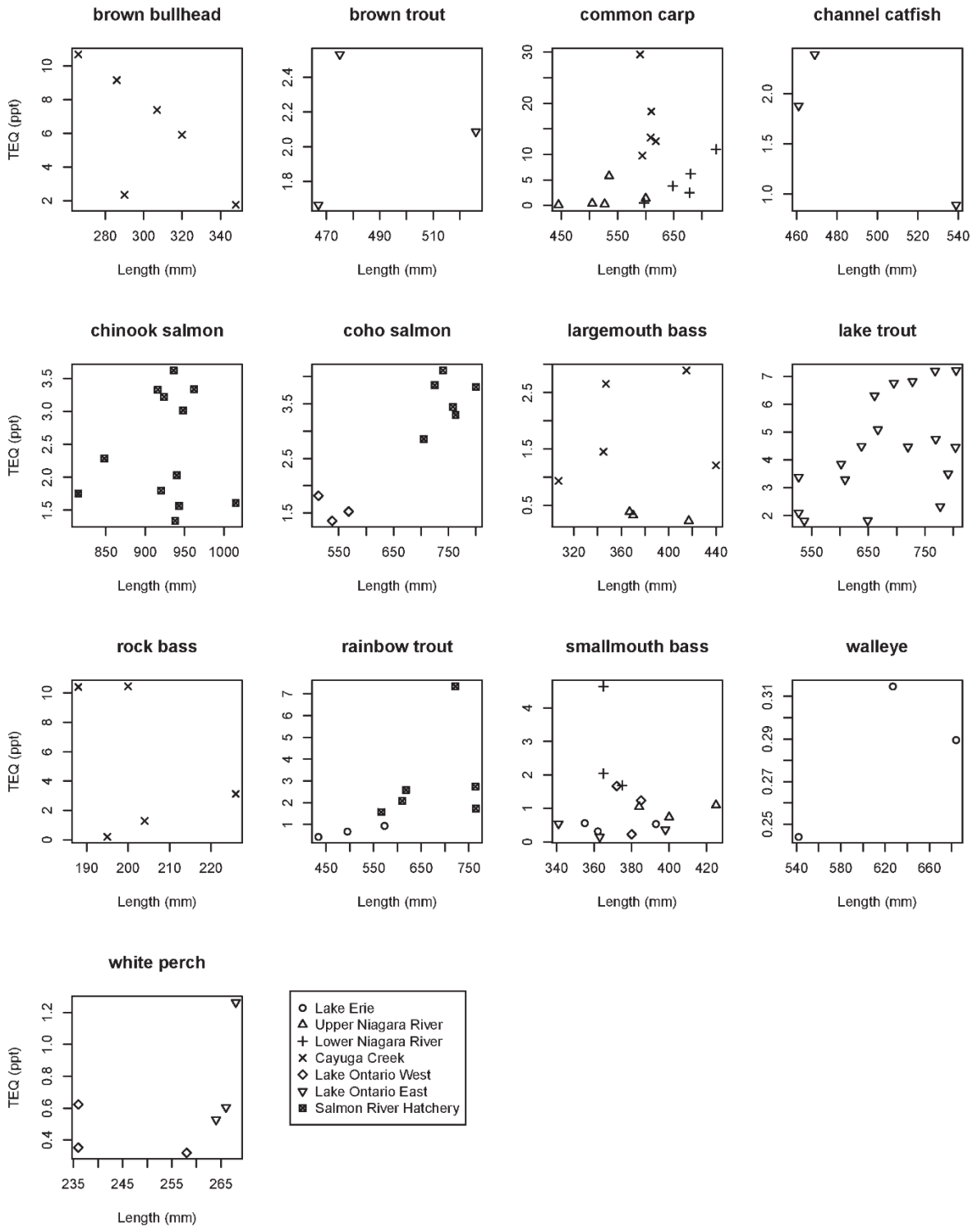


Figure 19. TEQ versus fish length. Axis scales and origins differ among panels.

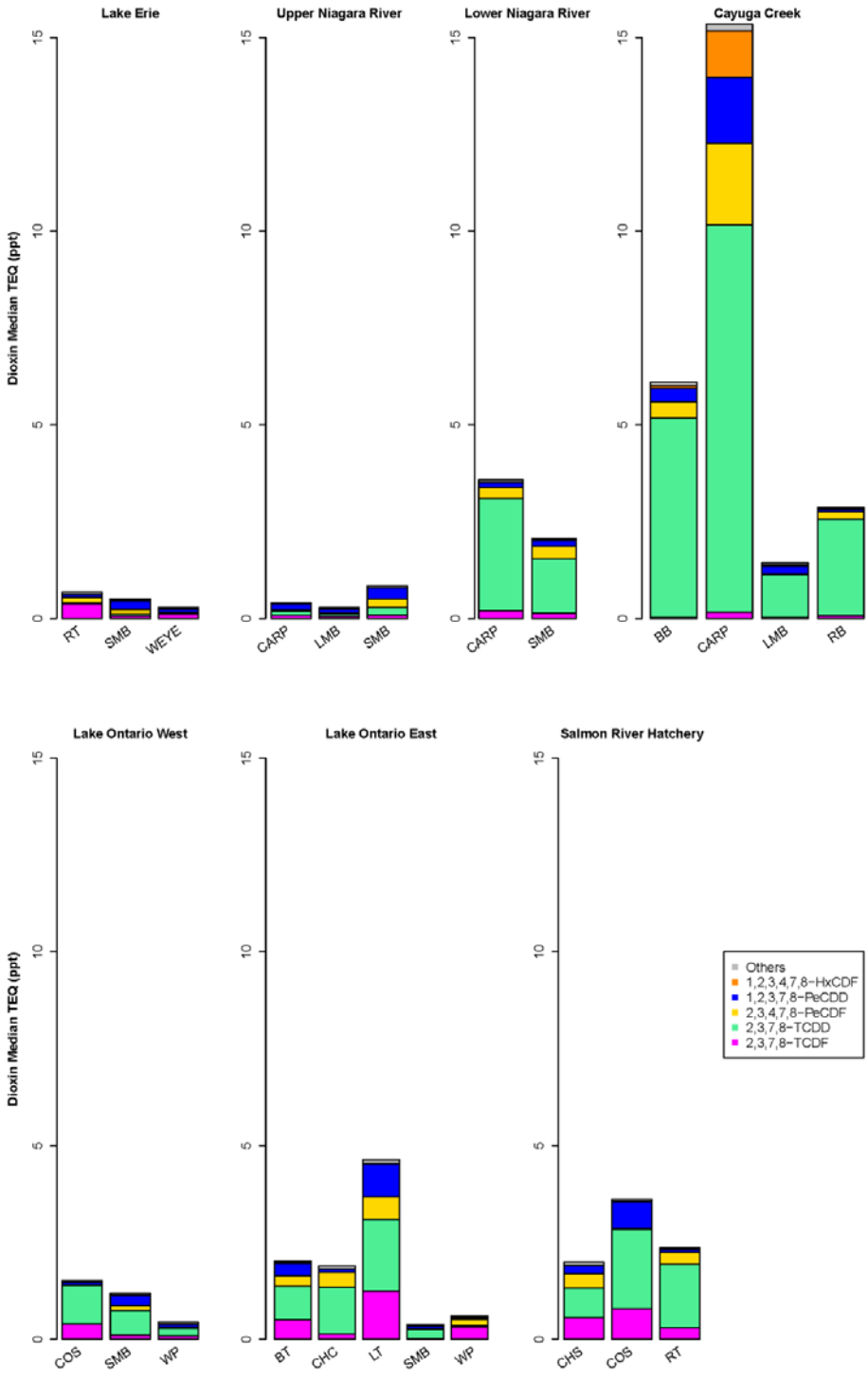


Figure 20. Median TEQs of dioxin/furan congeners. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, YP = yellow perch.

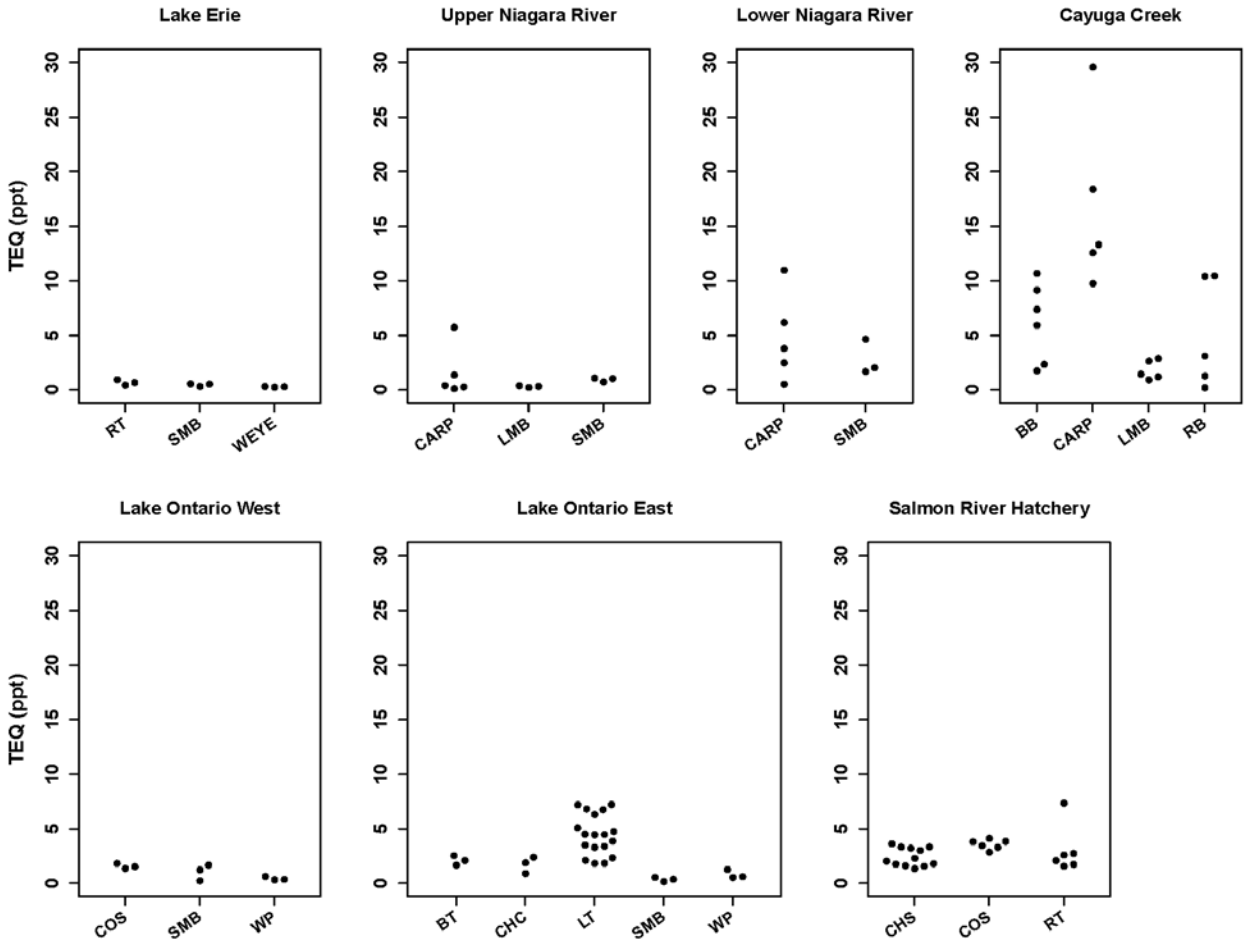


Figure 21. TEQ levels grouped by location. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, YP = yellow perch.

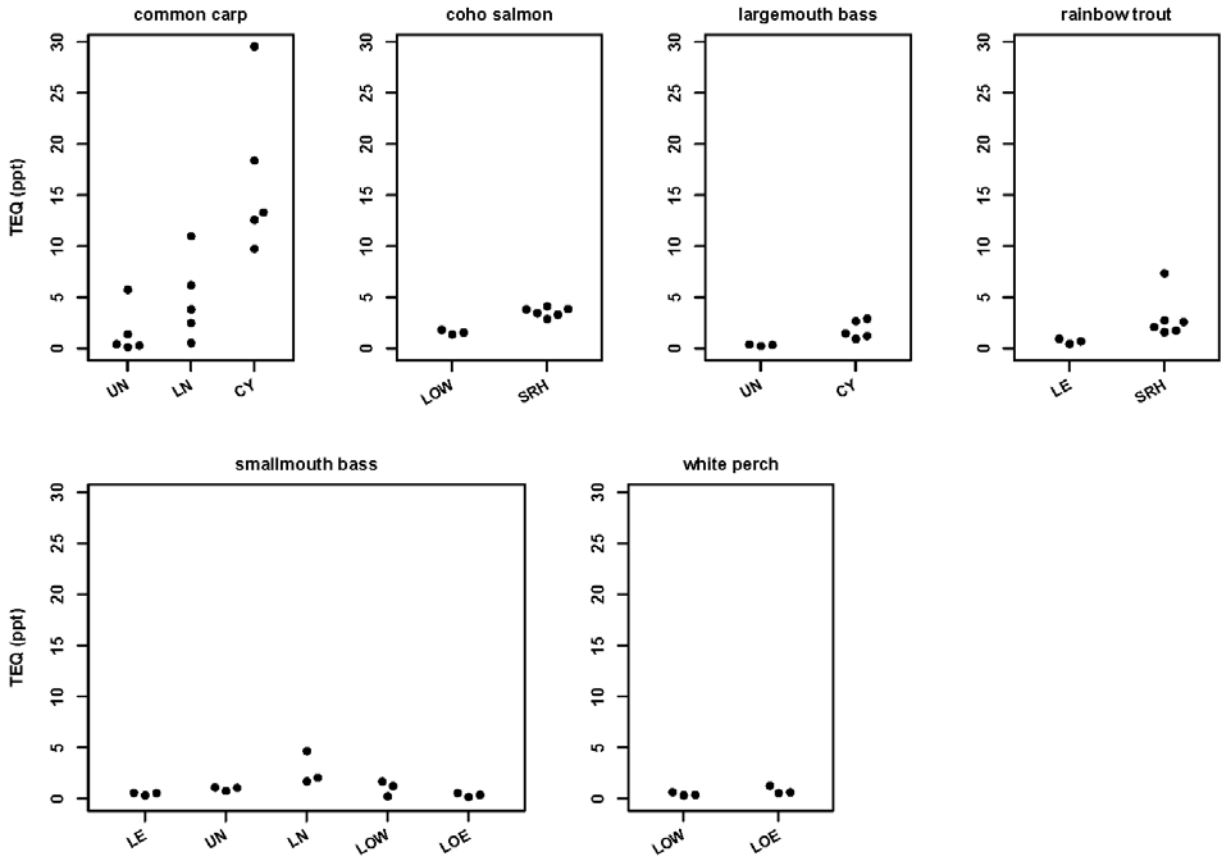


Figure 22. TEQ levels grouped by species. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery.

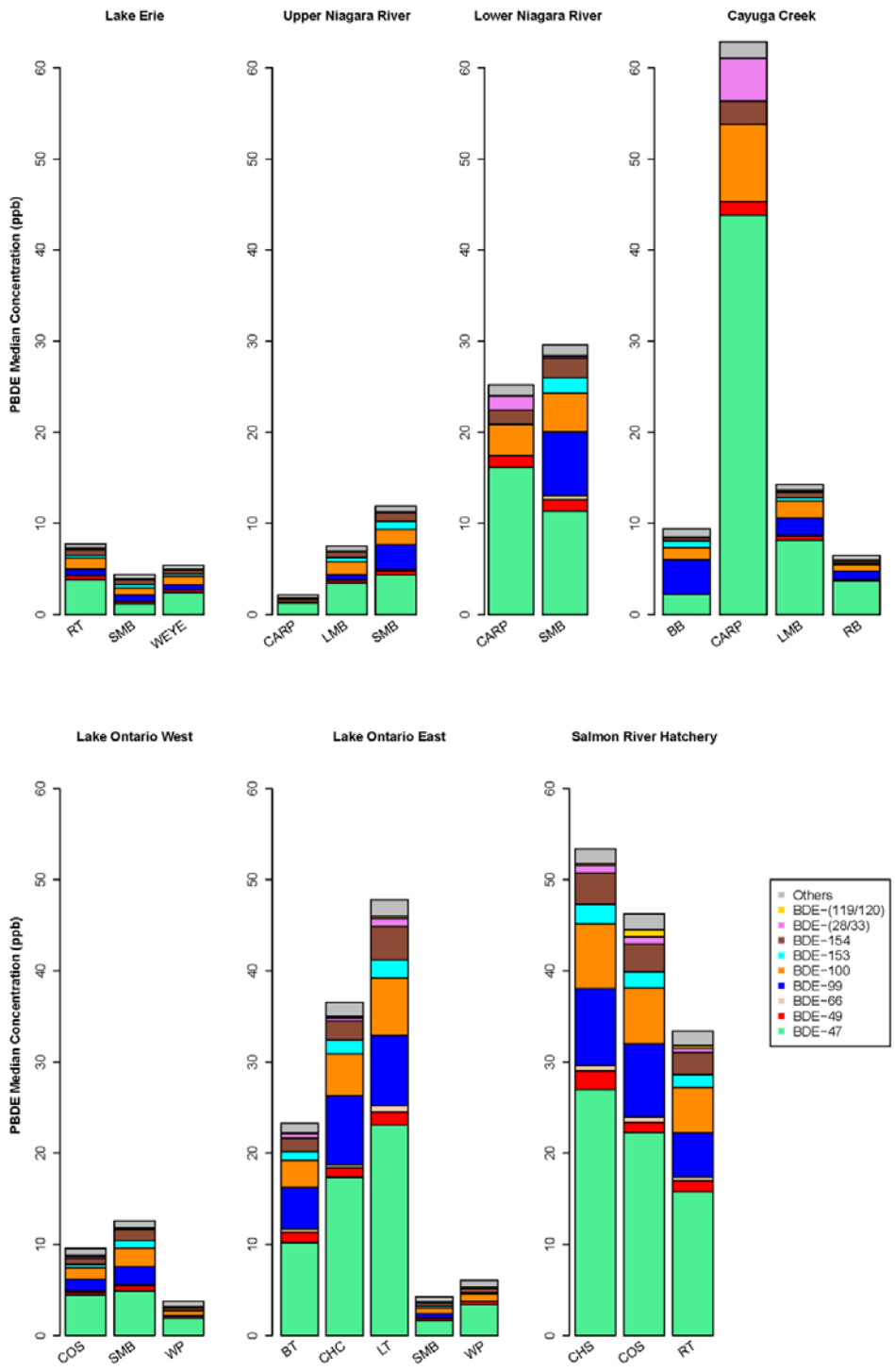


Figure 23. Median levels of PBDE congeners. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, YP = yellow perch.

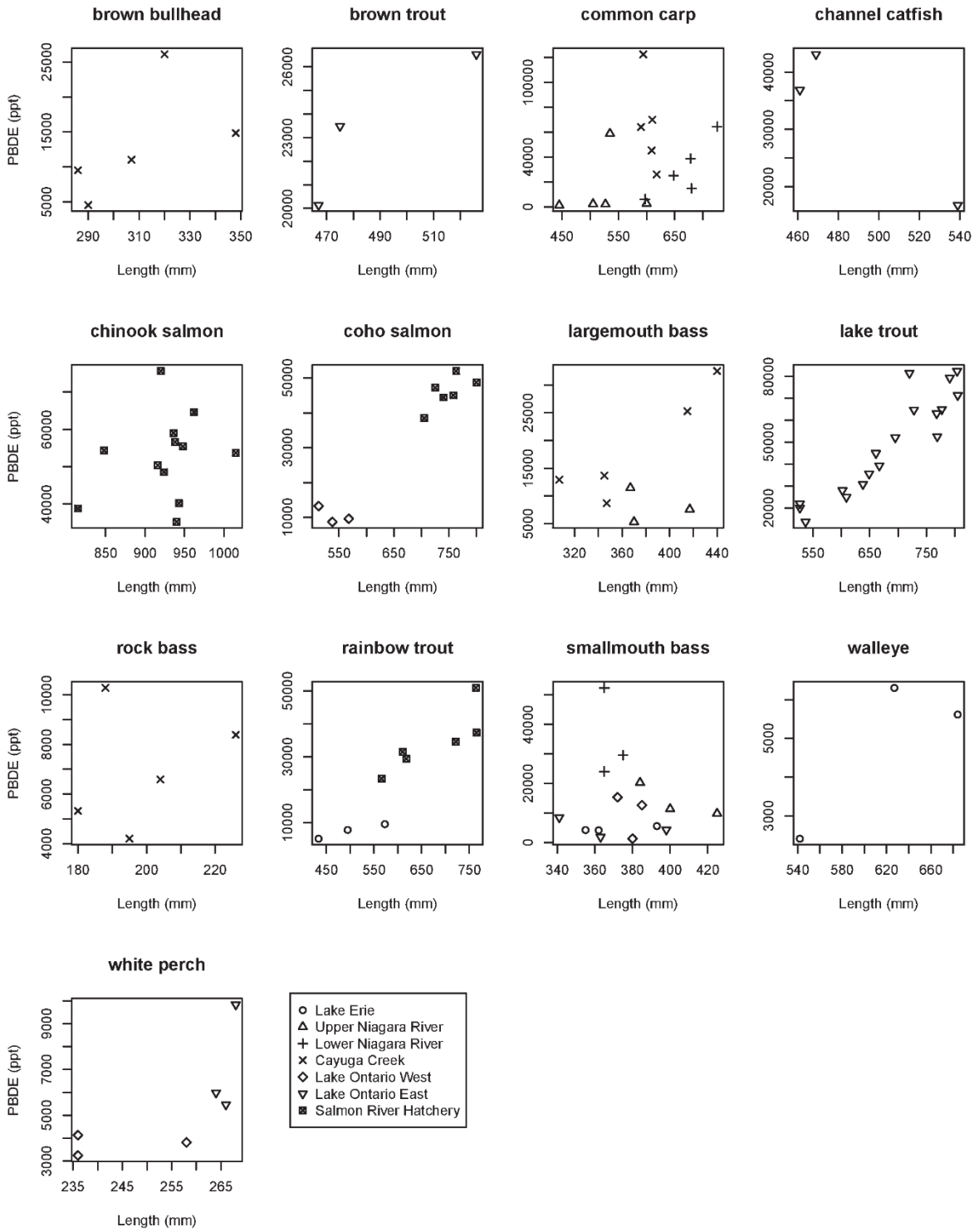


Figure 24. PBDE versus fish length. Axis scales and origins differ among panels.

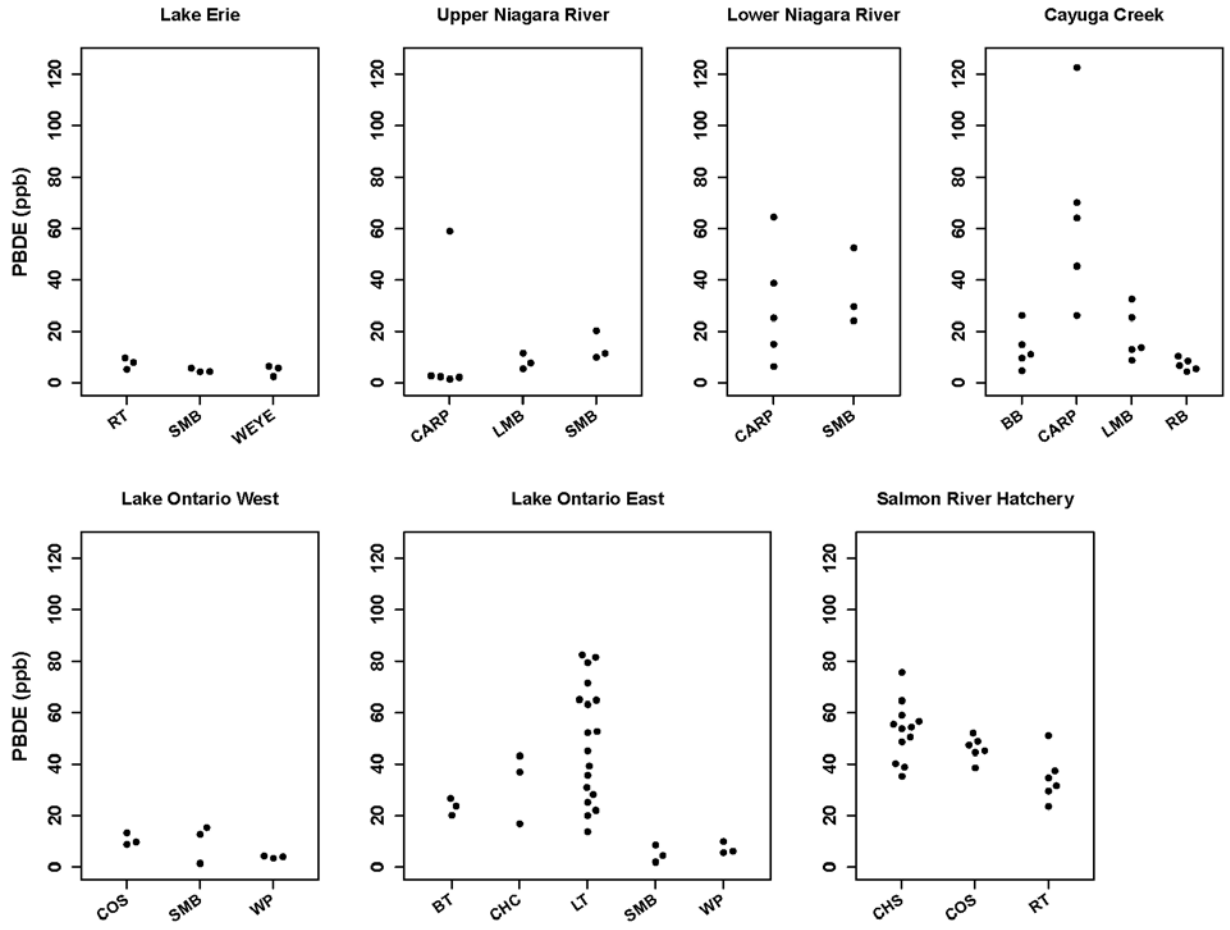


Figure 25. PBDE levels grouped by location. BB = brown bullhead, BT = brown trout, CARP = common carp, CHC = channel catfish, CHS = chinook salmon, COS = coho salmon, DRUM = freshwater drum, LMB = largemouth bass, LT = lake trout, RB = rock bass, RT = rainbow trout, SMB = smallmouth bass, WEYE = walleye, WP = white perch, YP = yellow perch.

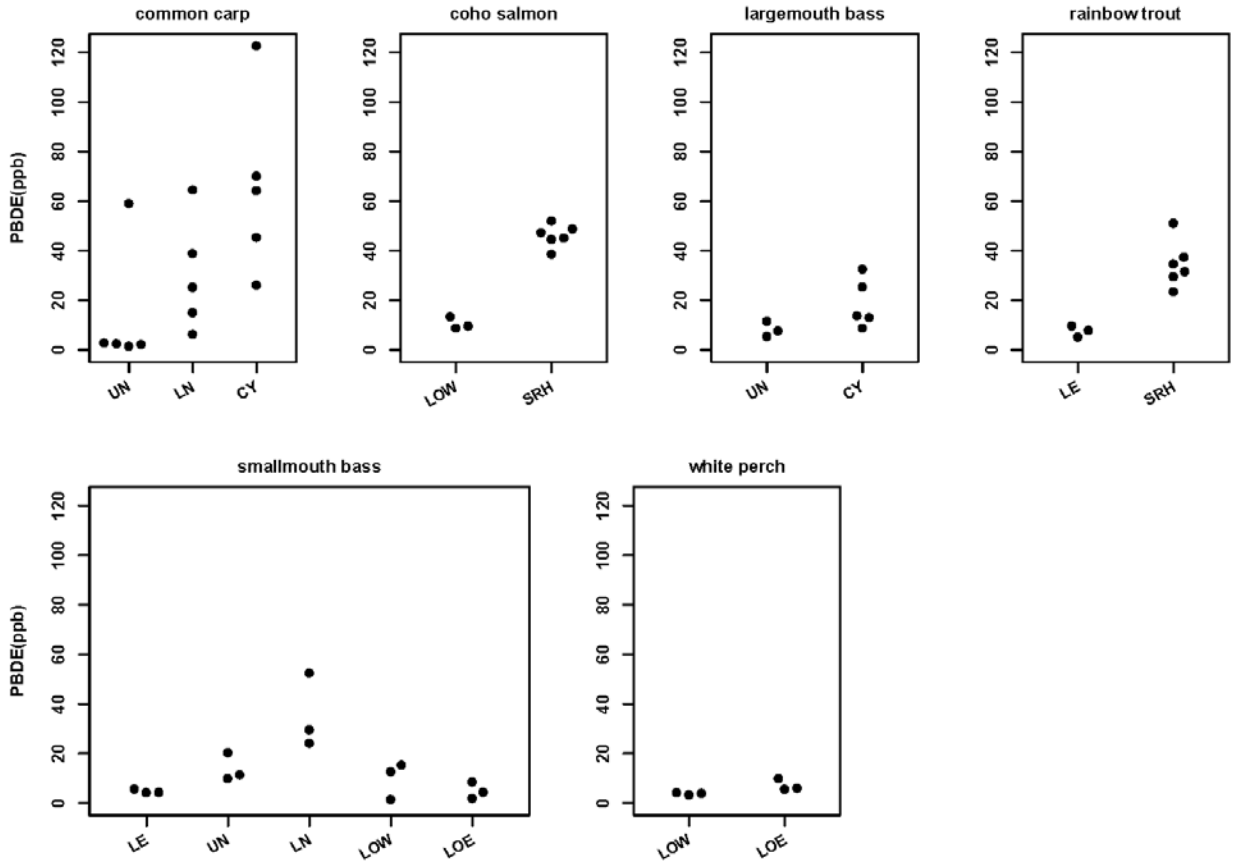


Figure 26. PBDE levels grouped by species. LE = Lake Erie, UN = Upper Niagara River, LN = Lower Niagara River, CY = Cayuga Creek, LOW = Lake Ontario West, LOE = Lake Ontario East, SRH = Salmon River Hatchery.

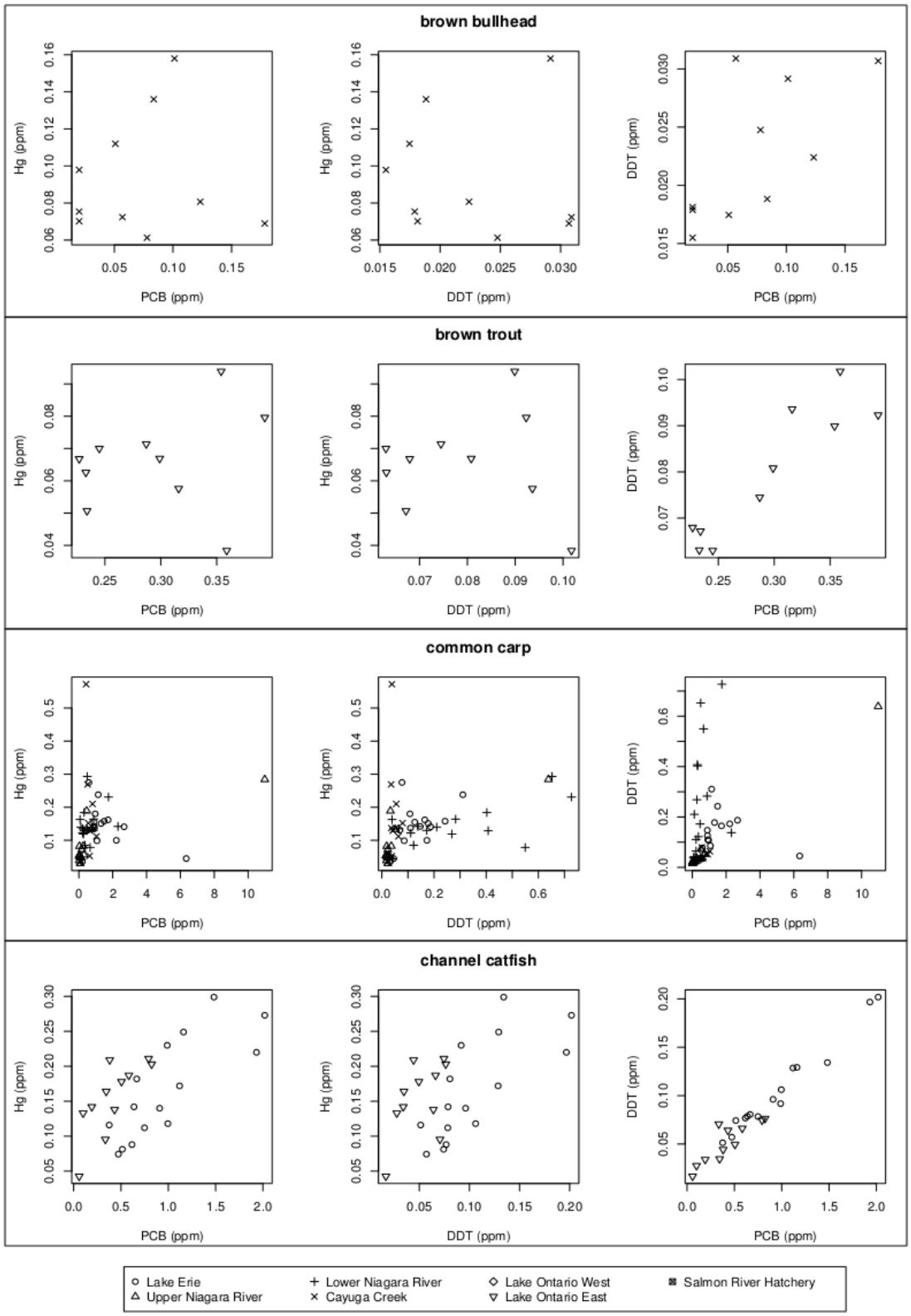


Figure 27. Relationship among mercury, total PCB and total DDT, part 1. Axis scales and origins differ among panels.

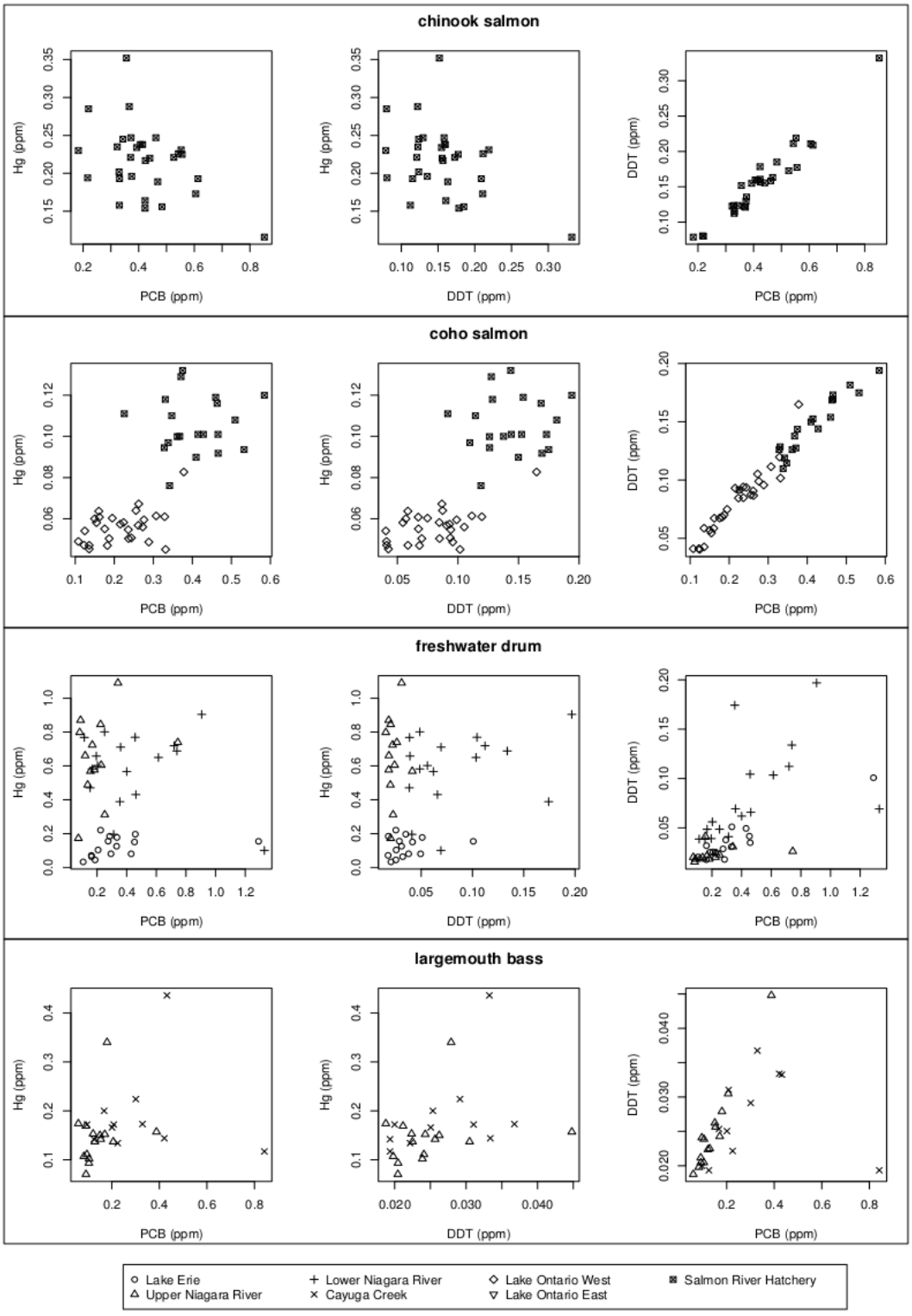


Figure 28. Relationship among mercury, total PCB and total DDT, part 2. Axis scales and origins differ among panels.

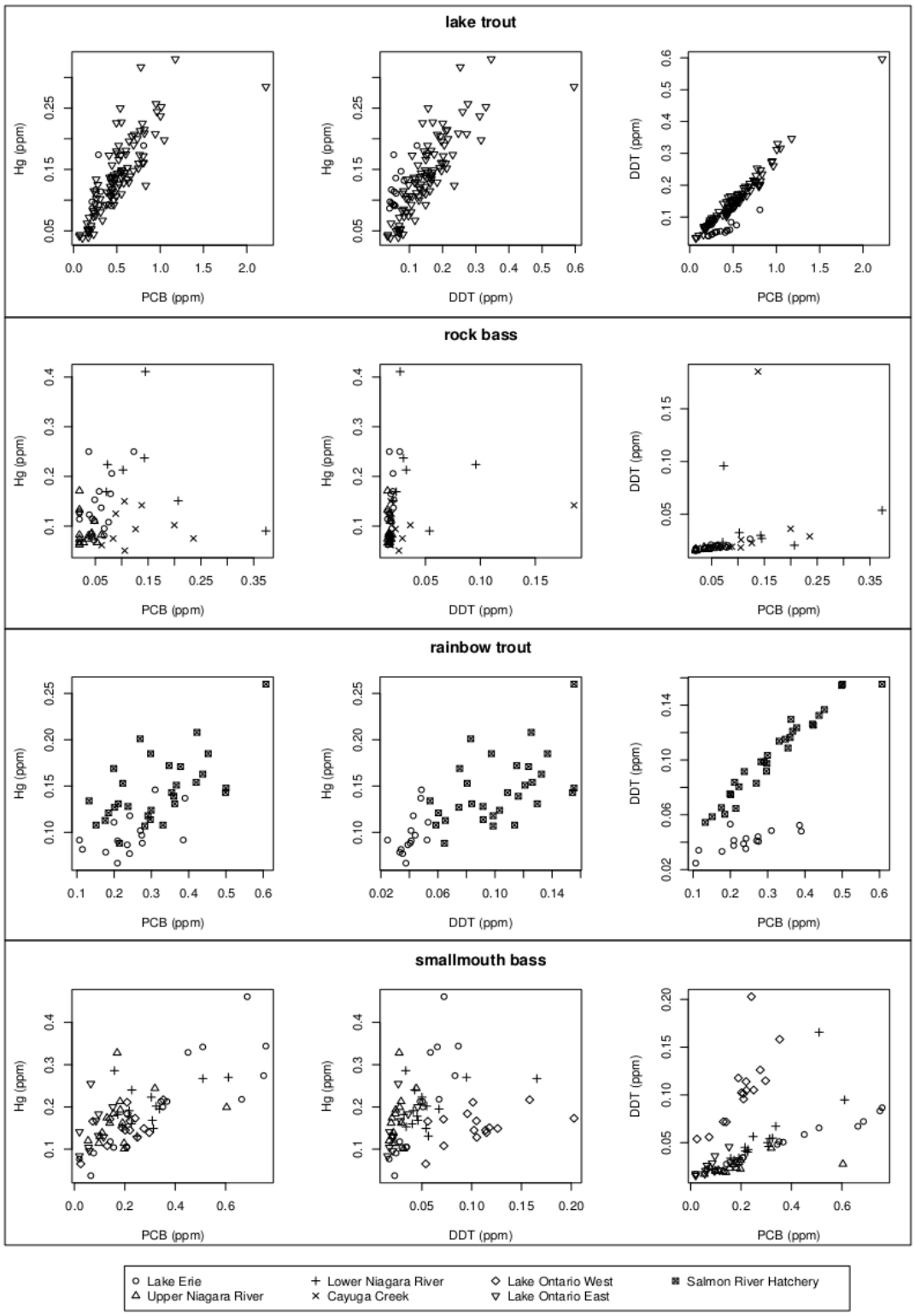


Figure 29. Relationship among mercury, total PCB and total DDT, part 3. Axis scales and origins differ among panels.

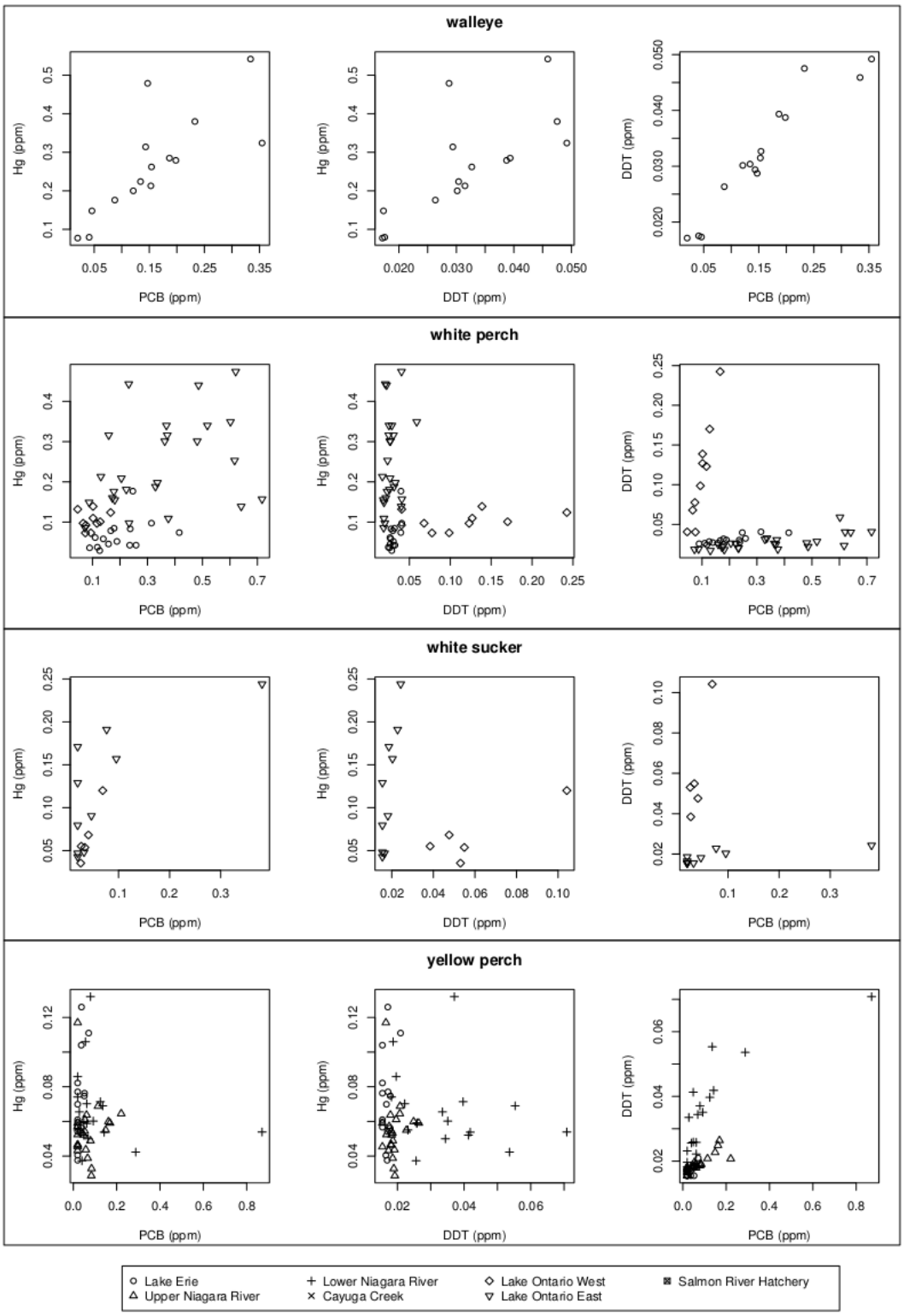
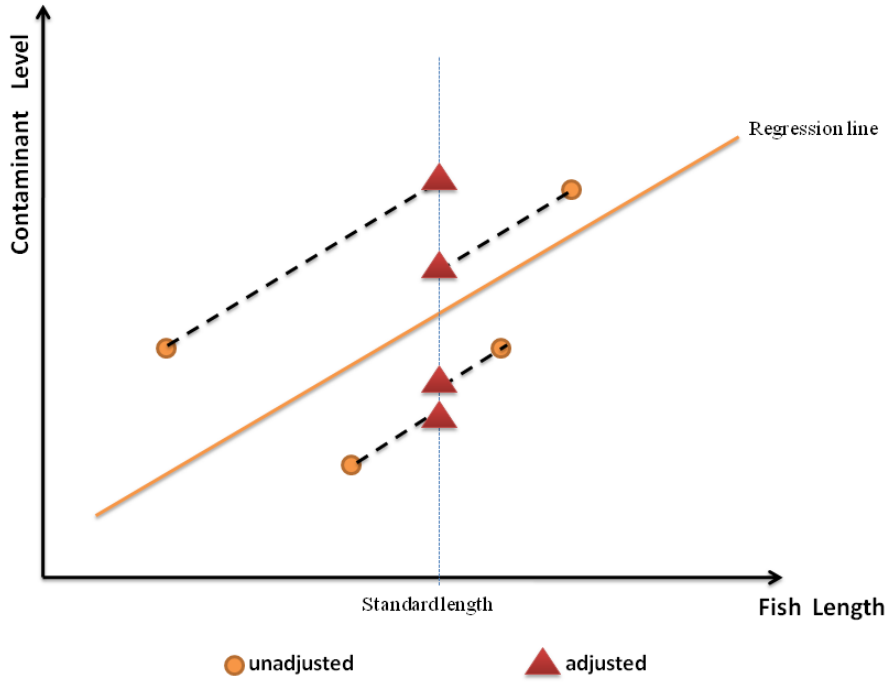


Figure 30. Relationship among mercury, total PCB and total DDT, part 4. Axis scales and origins differ among panels.

Appendix A

Method for Adjusting Contaminant Levels for Fish Length



1. For each species and location, make a scatterplot of contaminant level against fish length (shown as the gold circles in the schematic figure above).

2. Perform linear regression. If linear regression indicates a statistically significant relationship between contaminant level and fish length ($P < 0.05$), length adjustment will be performed; otherwise, there is no need for length adjustment.

3. For data needing length adjustment, the standard length for a species is defined as the median length of all analyzed fish.

4. The length adjusted value (red triangles) is the level predicted by the regression at the standard length plus the residual of the regression.