2008 Cuyahoga River and Nearshore Lake Erie Fish Tissue Study

January 6, 2010

The City of Akron
Cleveland Metroparks
Cuyahoga Valley National Park
Northeast Ohio Regional Sewer District
Ohio Division of Wildlife
Ohio Environmental Protection Agency

Seth Hothem
Northeast Ohio Regional Sewer District
Project Leader

EXECUTIVE SUMMARY

In 2008, a study was conducted to determine current concentrations of PCBs, pesticides, and mercury in fish tissue samples from the Cuyahoga River and nearshore Lake Erie. These contaminants were chosen due to their historical significance and their ability to bioaccumulate in fish, and to compare results to current water quality criteria.

Fish were collected from sites on the Cuyahoga River (one reference, six AOC), Lake Erie (two reference, three AOC), and the Chagrin River (one reference) using electrofishing methods. Composite samples were collected to represent potential health impacts to humans who consume contaminated fish. Whole-body samples were collected to represent potential impacts to piscivorous wildlife and to apply certain standards that are applicable to whole-body samples. The results were compared to previous studies conducted in 1989-1992 and in 2005 to determine if any changes in fish contaminant levels have occurred since those times. The results were also compared to applicable federal and state standards to evaluate potential ecological or human health risks.

Generally, it was found that total and lipid-normalized PCB fish tissue concentrations were greater in the AOC than at the reference sites. The concentrations in the AOC were generally greater than in the 2005 study, while the reference site concentrations were about the same as in 2005. Risk assessments utilizing both the noncancer hazard index and the cancer potency factor indicate the potential for adverse health effects from eating fish contaminated with PCBs from the AOC sites. With a sufficient data set, the concentrations measured would result in fish consumption advisories that, for some species, could be more restrictive than those currently in place.

Organochlorine pesticides were also detected in many of the composite fillet samples. However, when assessed using available reference doses and cancer potency factors for chlordane and DDT and its metabolites, lifetime exposure at the measured concentrations falls within accepted risk guidelines.

The mercury results obtained from the study indicate that contamination is not just associated with the AOC. Composite fillet and whole-body fish tissue concentrations of mercury in samples collected from reference sites were generally equal to or greater than those found in the AOC. The mercury results from 2008 were about the same as in the 1989-1992 study, but lower than in 2005. Comparing upstream to downstream at Akron WWTP and Southerly WWTC showed no adverse impact from their discharges.

Continued monitoring of fish from these areas is needed to further track changes in these contaminants. This will help to determine the effectiveness of pollutant reduction efforts, assess the fate of pollutants already in the environment, and provide necessary information for updating the Ohio Sport Fish Consumption Advisory Program.

INTRODUCTION

The lower Cuyahoga River and part of the Lake Erie shoreline near the Cuyahoga River have been designated as one of 42 Great Lakes Areas of Concern (AOC) by the International Joint Commission (IJC). AOCs are defined by the U.S.-Canada Great Lakes Water Quality Agreement (Annex 2 of the 1987 Protocol) as "geographic areas that fail to meet the general or specific objectives of the agreement where such failure has caused or is likely to cause impairment of beneficial use..." One of the beneficial use impairments for the Cuyahoga River is restrictions on fish consumption. The Cuyahoga River receives effluent from industrial and municipal discharges in addition to overflows from storm and combined sewers. Two of the largest municipal dischargers are the Northeast Ohio Regional Sewer District's (NEORSD) Southerly Wastewater Treatment Center (WWTC) and the City of Akron Wastewater Treatment Plant (WWTP). The river also receives pollutants from nonpoint sources such as agricultural, suburban and urban runoff, sediments, and atmospheric deposition. Fish and other organisms that are living in the river and nearshore Lake Erie can be exposed to contaminants found in discharges, overflows, runoff, and sediments and accumulate them in their bodies. This can potentially cause health-related problems for humans and wildlife that eat the fish and are thus exposed to these contaminants.

In support of Cuyahoga River Remedial Action Plan, two previous studies were completed by NEORSD, the City of Akron, the Cuyahoga County Board of Health, the Cuyahoga Valley National Park, the Ohio Department of Health, the Ohio Department of Natural Resources (ODNR), the Ohio Environmental Protection Agency (EPA), and the United States Fish and Wildlife Service. In these studies, as in the current study, fish tissue samples from within the Cuyahoga River AOC and at reference locations were collected to determine the types and concentrations of compounds that had accumulated in the edible portions of those fish. The previous collections were made from 1989 to 1992 and in 2005 at six Cuyahoga River sites from river mile (RM) 63.3 to RM 10.0 and at one Chagrin River site at RM 5.1. Collections were also made at five Lake Erie nearshore sites between Lakewood and Eastlake. In 2005, a site was added in the Cuyahoga River shipping channel at RM 1.2.

Results from the 1989-1992 study indicated the presence of 3 polychlorinated biphenyl (PCB) mixtures, 11 pesticide compounds, 7 volatile organic compounds, and 6 heavy metals (Cuyahoga River Community Planning Organization, 1994). In 2005, PCBs, mercury, and selenium were detected at measurable quantities. Pesticides were not detected, most likely due to higher detection limits than in the 1989-1992 study. Of the chemicals that were detected, only total PCB concentrations exceeded or approached the applicable U.S. Food & Drug Administration (FDA) Action Levels in any of the samples from both studies. While a risk assessment of mercury and pesticide concentrations did not exceed their respective action levels, in some cases they were high enough that they would result in fish consumption advisories based on categories currently used by the State of Ohio.

The purpose of the current study was to conduct sampling and analysis to determine concentrations of mercury, PCBs, and pesticides in the tissues of fish living in the Cuyahoga River and nearshore Lake Erie AOC. These contaminants were chosen due to their historical significance and their ability to bioaccumulate in fish, and to compare the results to current water quality criteria. Two types of fish samples were collected during the study. Fillet samples were collected to represent potential impacts to humans who consume contaminated fish. Whole-body samples were collected to represent potential impacts to piscivorous wildlife and to apply certain standards that are applicable to whole-body samples. The results were compared to those from the 1989-1992 and 2005 studies to determine if any changes in fish contaminant levels have occurred since those times. The results were also compared to applicable federal and state standards to evaluate potential ecological or human health risks.

METHODS

During late summer and early autumn of 2008, fish were collected from thirteen sites in the Cuyahoga River, the Chagrin River and nearshore Lake Erie. These sites were selected because they included heavily fished areas, areas of known pollution sources, and reference locations. For the most part, sampling locations duplicated the sites used in the previous two studies. These locations are shown in Figure 1 and detailed in Table 1. The Cuyahoga River sites from RM 54.1 to RM 1.2 and the Lake Erie sites within the Cleveland Harbor and off Wildwood Park are located within the AOC. The Cuyahoga River site at RM 63.3, the Lake Erie sites off Lakewood and Eastlake, and the Chagrin River site are located outside the AOC and were used as reference locations.

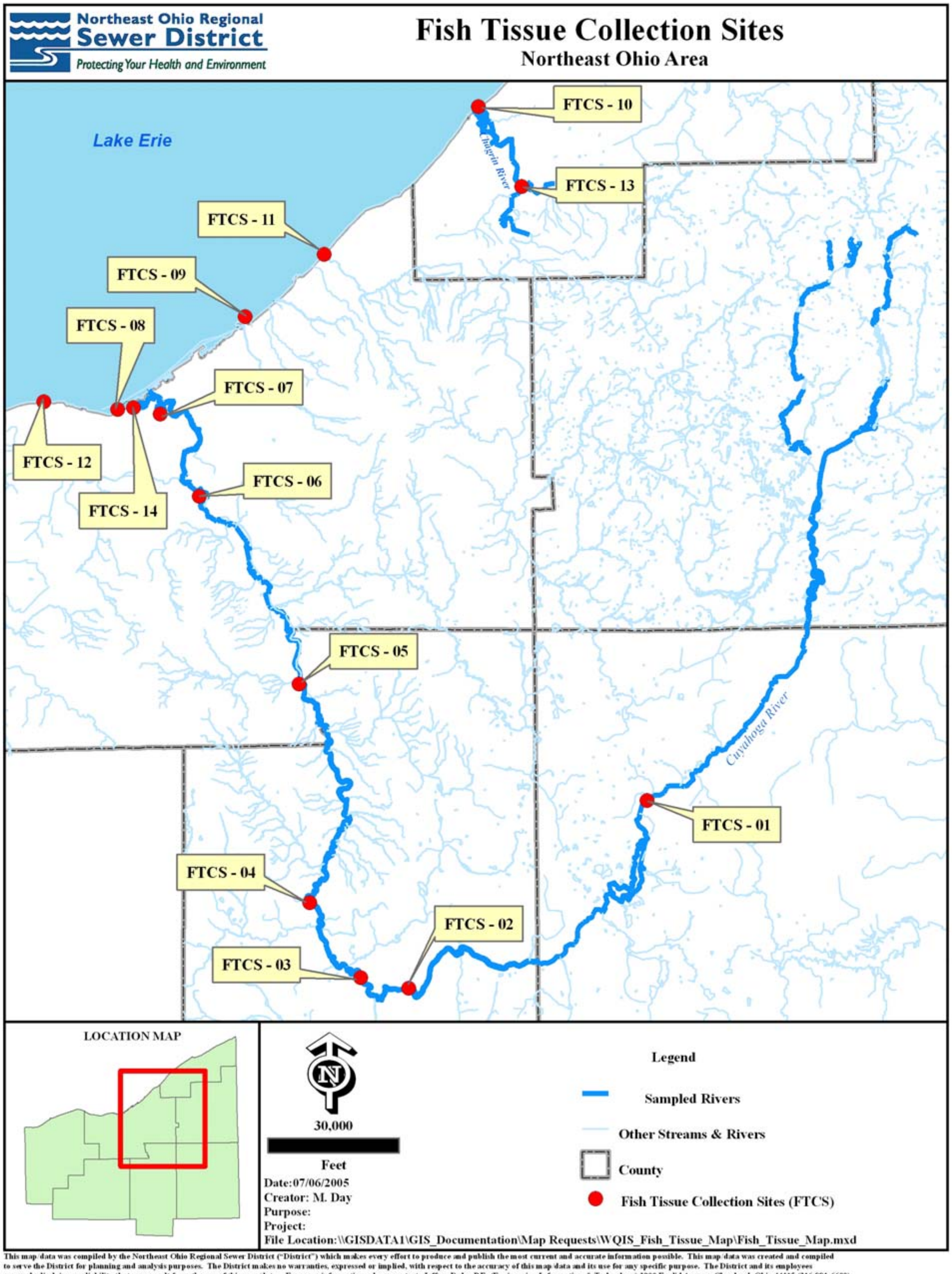


Figure 1. Study Map

Table 1. Sampling Locations			
Site Name	**Site Location**	**River Mile**	**Purpose**
Cuyahoga River at Shalersville (FTCS-01)	Upstream from State Route 303	63.3	Reference
Cuyahoga River Upstream of Akron (FTCS-02)	Ohio Edison Dam Pool	45.1	AOC
Cuyahoga River Upstream of Akron WWTP (FTCS-03)	Upstream of Portage Path and Downstream of the Little Cuyahoga River	41.0	AOC
Cuyahoga River Downstream of Akron WWTP (FTCS-04)	Near Bolanz Road	33.2*	Impact of Akron WWTP/AOC
Cuyahoga River Near Route 82 (FTCS-05)	Upstream of canal diversion dam	21.0	AOC
Cuyahoga River at Southwest Interceptor (FTCS-06)	Downstream of Southerly WWTC	10.0	Impact of SWWTC/AOC
Cuyahoga River Navigation Channel (FTCS-07)	Irishtown Bend	1.2	AOC
Lake Erie West Harbor (FTCS-08)	Between Edgewater Marina and Cuyahoga River		AOC
Lake Erie East Harbor (FTCS-09)	Between East 72nd Marina and East 55th Street		AOC
Lake Erie off Eastlake (FTCS-10)			Reference
Lake Erie off Wildwood (FTCS-11)	Between Wildwood Park Marina and Villa Angela Beach		AOC
Lake Erie off Lakewood (FTCS-12)	Between Rocky River and Lakewood Park		Reference
Chagrin River at Daniels Park (FTCS-13)	Upstream of the confluence with the East Branch	5.1	Reference

*River mile 37.0 was sampled in the 1989-1992 and 2005 studies. Site location was changed in 2008 to allow for easier access.

Two types of samples were collected during this study: composite and whole-body. The majority of the fillet samples were composites of three to six fish fillets of the same species and size class. Fish were considered to be of the same size class if the minimum and the maximum lengths of individual fish did not vary by more than 10%. Whenever possible, two bottom-feeding species and two sport species were collected at each site. Bottom-feeding species included carp, catfish species, and sucker species. Sport fish were defined as those fish that are commonly sought by anglers and included smallmouth and largemouth bass, members of the sunfish family, white and black crappie, walleye, sauger, northern pike, yellow perch, white bass, white perch, and freshwater drum. The bottom-dwellers represented worst-case risk through human consumption for certain pollutants because they are generally in closer proximity to contaminants, and the sport fish represented most likely human consumption. The largest size classes from each species found at a site were used to also represent worst-case risk because of the tendency of pollutants to increase in fish over time and as the fish get larger. The whole-body samples consisted of up to 12 individuals of a sport species belonging to the same size class. These samples were collected at all sites.

All fish collections were made from August 20 through October 15, 2008. Collections were made by NEORSD, ODNR, and Ohio EPA personnel. The primary method of collection was with either a boat-mounted electrofishing unit or longline electrofishing equipment (Figure 2) based upon standardized Ohio EPA methods (Ohio EPA, 1988). All fish shocked at a site were collected and placed in a live well for processing. Precautions were taken to keep all of the fish alive and to release, unharmed, fish not used as a sample. All fish were kept in a live well until the fish to be prepared as samples were selected, to prevent them from being shocked more than once. Care was taken to prevent the fish from coming into contact with oil, plastic, sediment, etc. that could contaminate the tissue samples. The fish were weighed to the nearest gram, and a measurement to the nearest millimeter of the total length was taken (Figure 3).

Figure 2. Longline Electrofishing

Figure 3. Fish Measurement

A sample information form, including the type of collection device, names of samplers, notes concerning any unusual event or discharges, and a brief description of the weather, along with individual records of each fish retained for analysis with information on species, weight, length, and notations of physical deformities, was completed for each site. Completed forms for each site are located in Appendix B.

The selected fish were sacrificed, then wrapped in aluminum foil and put into a plastic bag. Whole-body samples were put into a cooler filled with dry ice. The coolers were washed with hot water and 10% nitric acid and rinsed with de-ionized water prior to use. Samples to be filleted were put into a cooler filled with regular ice. All samples were then transported to the NEORSD Environmental & Maintenance Services Center (EMSC) in Cuyahoga Heights for processing.

In order to determine the age of the fish, scales or dorsal and pectoral spines (for catfish) were collected from each fish used as a sample. Scales were collected from the left side of the fish between the lateral line and the dorsal insertion. Catfish dorsal and pectoral spines were rotated and removed from their joints. The scales and/or spines were placed in paper envelopes with date, sample code and species information. They were then sent to the ODNR Division of Wildlife office in Akron for aging.

The fish for the composite samples were scaled and filleted at the NEORSD EMSC in order to reduce possible contamination in the field. The fish were placed upon an aluminum foil-lined cutting board with the dull side towards the fish. The aluminum foil was changed between each species prepared for each site. The skin was removed for channel catfish, bullheads, carp, and suckers and left on for all other species. This was done to mimic anglers' worst-case likely preparation of their catch prior to consumption. The fillets for each species were combined into one composite sample. Fish collected as whole-body samples were kept as individuals instead of making a composite sample.

Composite and whole-body samples were cut into chunks using a meat cleaver. The chunked samples were then processed in a commercial-grade stainless steel blender. Enough dry ice was added to the blender to ensure that the entire sample was frozen and no moisture was visible. The resulting powder was thoroughly mixed by hand and divided between one or two 125mL glass jars with Teflon lids and labeled with date, sample code and species. The remaining sample was discarded. The blender and all tools used during blending were washed with soap and water and rinsed with acetone between each sample. All processed samples were placed in a freezer at -37°C for storage prior to analysis.

NEORSD Analytical Services analyzed fish fillet and whole-body samples for mercury using EPA Method 245.2. TestAmerica (Burlington, Vermont) analyzed the fish fillet samples for percent lipids (method SW846 8290), PCBs (method SW846 8082), and pesticides (method SW846 8081A). Some split samples were also analyzed by TestAmerica for mercury concentrations using EPA SW846 method 7471A.

RESULTS & DISCUSSION

Overall results for each of the parameters analyzed are discussed below. Individual results for each sample are available upon request. The number of samples for some of the species analyzed was very limited. The results in these instances are presented here to provide a general overview of suspected conditions at a site. Because of this, it is possible that a more robust data set may result in a different set of conclusions.

When numbers of samples were sufficient, a statistical analysis was conducted to determine the significance of differences between results. Generally, an analysis of variance (ANOVA) was conducted for groups of data. When the results from the

ANOVA indicated that at least one of the means was significantly different at the $\alpha=0.05$ level, individual pairs of means were then compared using Fisher's Least Significant Difference. Tables showing the results from these analyses are presented in Appendix C.

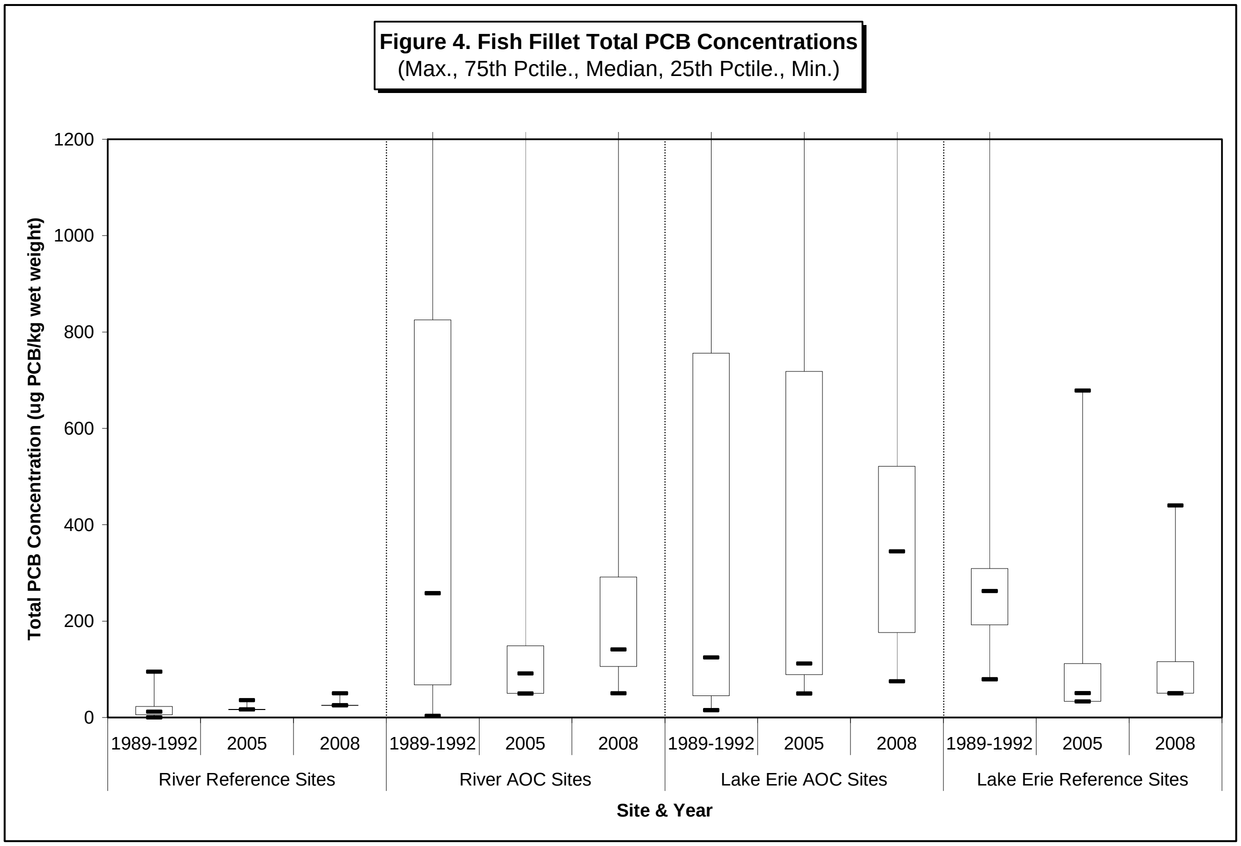
PCBs

A total of 54 composite fillet samples were analyzed for PCB concentrations by TestAmerica. Twenty-eight percent of the samples analyzed had PCB concentrations below the reporting limit of 50 µg/Kg. Commercial mixtures of PCBs, known as Aroclors, that were detected in the samples included Aroclor 1242, Aroclor 1254, and Aroclor 1260.

For all comparisons made using the PCB results, concentrations below the detection limit were assumed to be one-half the detection limit if that particular Aroclor was detected in another sample from that site or from a site of a similar type. All sites in the river portion of the AOC were considered to be similar, as were those in the lake portion of the AOC. The reference sites were all considered individually. Additionally, for the purpose of determining which Aroclors were present, the results from the 2005 and 2008 studies were considered to be from a single study, while the 1989-1992 study results were considered to be separate from the later studies.

Total PCBs

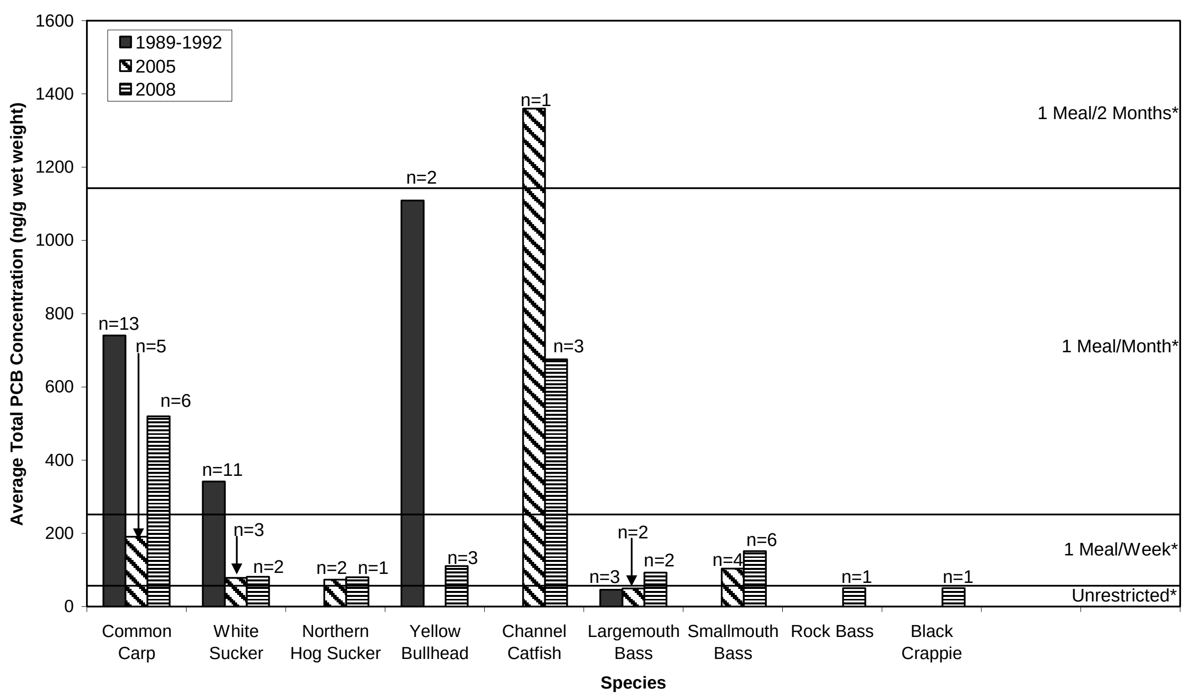
In 2008, the highest total PCB concentrations occurred in the Lake Erie portion of the AOC, while the lowest ones were at the river reference sites (Figure 4). A statistically significant difference was found between the results from the Lake AOC and the results from both the lake and river reference sites (Appendix C, Table 9). When compared to the previous studies, it can be seen that the median concentrations at river reference sites were at about the same levels. The lake reference sites' levels were about the same as in 2005, but lower than in the 1989-1992 study. The difference between the results from the 2008 study and the results from the 1989-1992 study, however, was not found to be statistically significant. For the river AOC sites, the median concentration was slightly higher than in 2005. Overall concentrations were significantly less than in the 1989-1992 study (Appendix C, Table 2). The median concentration for the Lake Erie AOC sites was greater than in either of the previous two studies, but overall concentrations were not significantly higher statistically. The higher concentrations of PCBs in fish collected from the AOC sites may be due to the higher amount of urbanization in the lower reaches of the Cuyahoga River and the persistence of these compounds in the environment. Although the production-based discharge of PCBs was banned in 1977 and their manufacturing, processing, and distribution in commerce were banned in 1979, their tendency to remain in sediments and resistance to degradation allows them to still accumulate in fish tissue today.



In September 1993, the Great Lakes Sport Fish Advisory Task Force released the *Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory* (Anderson et al., 1993). This document proposed categories based upon a health protection value of 5E-5 mg/kg/day PCB residue in sport fish. The health protection value takes into account available toxicological and epidemiological data, with an emphasis on adverse reproductive and neuro-developmental effects. A modified version of this protocol was used as the basis for the State of Ohio Fish Consumption Advisory Program (State of Ohio, 2008).

Using the categories developed by the Great Lakes Sport Fish Advisory Task Force and used by the State of Ohio in its Fish Consumption Advisory Program, two of the species collected in the Cuyahoga River AOC, rock bass and black crappie, had total PCB concentrations that were below fish consumption advisory levels (Figure 5). Neither of these species was analyzed in the previous two studies, so no historical comparison could be made. The other species collected had concentrations that would result in an advisory. White suckers, northern hog sucker, yellow bullhead, largemouth bass, and smallmouth bass would fall into the “one meal per week” category, while common carp and channel catfish would be in the “one meal per month” category. The concentrations measured for yellow bullhead and channel catfish were less than in the 1989-1992 and the 2005 studies, respectively. The category into which the yellow bullhead falls is also less restrictive than in the 2009 State of Ohio advisory. Except for white suckers, the concentrations that were measured in the other species resulted in more restrictive categories than when they were sampled previously and are also higher than in the 2009 State of Ohio advisory for PCBs. Although the white sucker concentration was slightly higher than in 2005, it falls into a category that is less restrictive than the 2009 advisory level. These comparisons should not be interpreted as an update to the State of Ohio advisory, since a more extensive data set may be needed before advisory changes can be made.

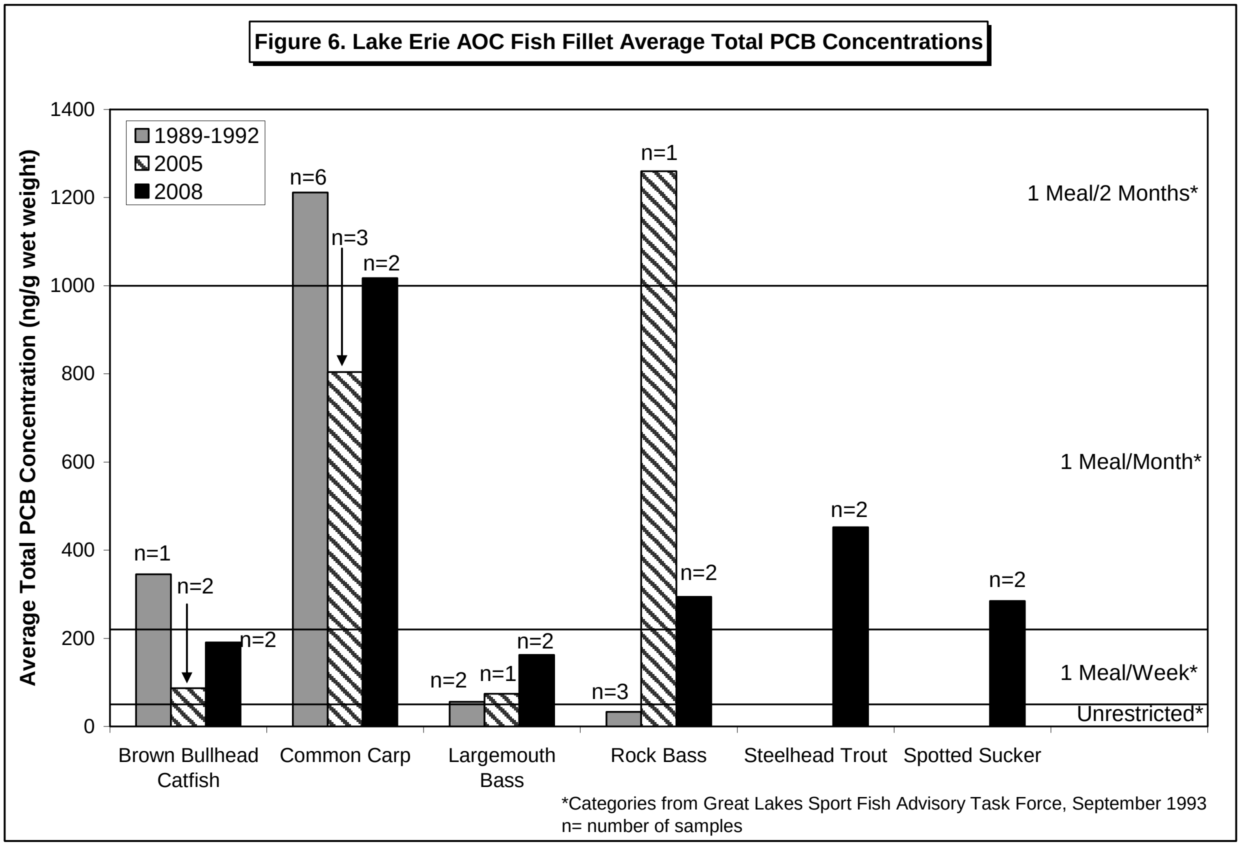
Figure 5. Cuyahoga River AOC Fish Fillet Average Total PCB Concentrations



*Categories from Great Lakes Sport Fish Advisory Task Force, September 1993
n= number of samples

For the Lake Erie portion of the AOC, two of the species had total PCB concentrations that would result in a "one meal per week" consumption advisory (Figure 6). For brown bullhead and largemouth bass, the concentrations measured were slightly greater than in the previous study, but were in the same category. The rock bass sample, however, had a much lower concentration than in 2005. For steelhead trout and spotted sucker samples, the measured concentration would result in a "one meal per month" advisory. These species were not analyzed in either of the earlier studies. Common carp had the highest total PCB concentrations and would fall into the "one meal per two months" category. This is a more restrictive category than what would have resulted in

2005 and is also more restrictive than what is currently in place. Once again, these comparisons should not be interpreted as an update to the State of Ohio advisory, since a more extensive data set may be needed before advisory changes can be made.



A risk assessment was conducted to determine whether the PCB concentrations were at high enough concentrations to cause impacts to human health. Two values were compared to the results to determine potential noncancer human health effects. The first of these was the Great Lakes Sport Fish Advisory Task Force Health Protection Value of 5.0E-5 mg/kg-d, which applies to total PCB concentrations (1993). The second value that was used was the oral reference dose listed in the United States EPA Integrated Risk Information System (IRIS) for Aroclor 1254. This value was used because there is currently no reference dose established for total PCBs. While there is also a reference dose for Aroclor 1016, that PCB mixture was not detected in any of the samples. For this analysis, a weighted exposure dose was calculated using geometric mean concentrations for each trophic level and assumptions used by the Great Lakes Water Quality Initiative (U.S. EPA, 1995b). Using both the Health Protection Value and the Aroclor 1254 reference dose, it was determined that the average fillet concentrations in the samples from the lake AOC sites were high enough that there is the potential for causing adverse noncancer human health effects (Tables 2 and 3). These results were similar to risk assessments conducted using data from the 1989-1992 and 2005 studies. The most significant difference found was a reduction in risk associated with exposure to total PCBs at the lake reference sites when comparing the results from the 1989-1992 study to the 2005 and 2008 studies.

The cancer potency factor given in IRIS for total PCBs was used to also determine lifetime cancer risks associated with consumption of fish fillets with the geometric mean concentrations found in the study (Table 2). In doing so, it was found that the calculated cancer risks were greater than the risk goal of 1E-5 (one case per 100,000 population) used by the Ohio EPA (2004). These results were also similar to the previous two studies, except for an increase in the risk at the river reference sites. This increased risk was mostly likely due to higher detection limits for the analyses completed in the 2008 study.

Table 2. Total PCB Noncancer Hazard Index and Lifetime Cancer Risk

Location	Geometric Mean Fillet Concentration* (mg/kg)	Calculated 15.0 g/d Exposure Dose** (mg/kg-d)	Health Protection Value*** (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index	IRIS Slope Factor $(mg/kg\text{-}d)^{-1}$	Calculated 15.0 g/d Lifetime Cancer Risk
2008						
Lake AOC		6.65E-05	5.00E-05	1.33	2.0	1.33E-04
Trophic Level 3	0.319					
Trophic Level 4	0.307					
Lake Reference		1.83E-05	5.00E-05	0.37	2.0	3.66E-05
Trophic Level 3	0.074					
Trophic Level 4	0.089					
River AOC		3.56E-05	5.00E-05	0.71	2.0	7.12E-05
Trophic Level 3	0.181					
Trophic Level 4	0.161					
River Reference		5.60E-06	5.00E-05	0.11	2.0	1.12E-05
Trophic Level 3	0.030					
Trophic Level 4	0.025					
2005						
Lake AOC		5.58E-05	5.00E-05	1.12	2.0	1.12E-04
Trophic Level 3	0.184					
Trophic Level 4	0.285					
Lake Reference		1.67E-05	5.00E-05	0.33	2.0	3.34E-05
Trophic Level 3	0.150					
Trophic Level 4	0.055					
River AOC		2.23E-05	5.00E-05	0.45	2.0	4.46E-05
Trophic Level 3	0.112					
Trophic Level 4	0.101					

Table 2. Total PCB Noncancer Hazard Index and Lifetime Cancer Risk						
	Geometric Mean Fillet Concentration*	Calculated 15.0 g/d Exposure Dose**	Health Protection Value***	Calculated 15.0 g/d Noncancer Hazard	IRIS Slope Factor	Calculated 15.0 g/d Lifetime Cancer Risk
Location	(mg/kg)	(mg/kg-d)	(mg/kg-d)	Index	$(mg/kg\text{-}d)^{-1}$	
River Reference		3.68E-06	5.00E-05	0.07	2.0	7.36E-06
Trophic Level 3	0.019					
Trophic Level 4	0.017					
1989-1992						
Lake AOC		3.34E-05	5.00E-05	0.67	2.0	6.68E-05
Trophic Level 3	0.515					
Trophic Level 4	0.042					
Lake Reference		5.41E-05	5.00E-05	1.08	2.0	1.08E-04
Trophic Level 3	0.579					
Trophic Level 4	0.149					
River AOC		1.85E-05	5.00E-05	0.37	2.0	3.70E-05
Trophic Level 3	0.224					
Trophic Level 4	0.043					
River Reference		1.86E-06	5.00E-05	0.04	2.0	3.71E-06
Trophic Level 3	0.008					
Trophic Level 4	0.009					

*Concentrations below the detection limit assumed to be 1/2 detection limit if that Aroclor measured elsewhere in any similar site.

**Human body weight of 70kg and lifetime exposure are assumed. Weighted dose based on assumption of consuming 3.6 g/day of trophic level 3 fish and 11.4 g/day of trophic level 4 fish.

***Great Lakes Sport Fish Advisory Task Force Health Protection Value, 1993

Table 3. Aroclor 1254 Noncancer Hazard Index				
	Geometric Mean Fillet Concentration*	Calculated 15.0 g/d Exposure Dose**	IRIS Reference Dose	Calculated 15.0 g/d Noncancer Hazard
Location	(mg/kg)	(mg/kg-d)	(mg/kg-d)	Index
2008				
Lake AOC		2.50E-05	2.00E-05	1.25
Trophic Level 3	0.125			
Trophic Level 4	0.114			
Lake Reference		8.08E-06	2.00E-05	0.40
Trophic Level 3	0.038			
Trophic Level 4	0.038			
River AOC		1.40E-05	2.00E-05	0.70
Trophic Level 3	0.086			
Trophic Level 4	0.073			

Table 3. Aroclor 1254 Noncancer Hazard Index

Location	Geometric Mean Fillet Concentration* (mg/kg)	Calculated 15.0 g/d Exposure Dose** (mg/kg-d)	IRIS Reference Dose (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index
River Reference		5.36E-06	2.00E-05	0.27
Trophic Level 3	0.025			
Trophic Level 4	0.025			
2005				
Lake AOC		3.83E-05	2.00E-05	1.92
Trophic Level 3	0.131			
Trophic Level 4	0.194			
Lake Reference		1.10E-05	2.00E-05	0.55
Trophic Level 3	0.103			
Trophic Level 4	0.035			
River AOC		9.84E-06	2.00E-05	0.49
Trophic Level 3	0.045			
Trophic Level 4	0.046			
River Reference		3.79E-06	2.00E-05	0.19
Trophic Level 3	0.021			
Trophic Level 4	0.017			
1989-1992				
Lake AOC		3.69E-06	2.00E-05	0.18
Trophic Level 3	0.028			
Trophic Level 4	0.014			
Lake Reference		6.14E-06	2.00E-05	0.31
Trophic Level 3	0.082			
Trophic Level 4	0.012			
River AOC		7.12E-07	2.00E-05	0.04
Trophic Level 3	0.005			
Trophic Level 4	0.003			
River Reference		---	2.00E-05	---
Trophic Level 3	ND			
Trophic Level 4	ND			

*Concentrations below the detection limit assumed to be 1/2 detection limit if measured elsewhere in any similar site.

**Human body weight of 70kg and lifetime exposure are assumed. Weighted dose based on assumption of consuming 3.6 g/day of trophic level 3 fish and 11.4 g/day of trophic level 4 fish.

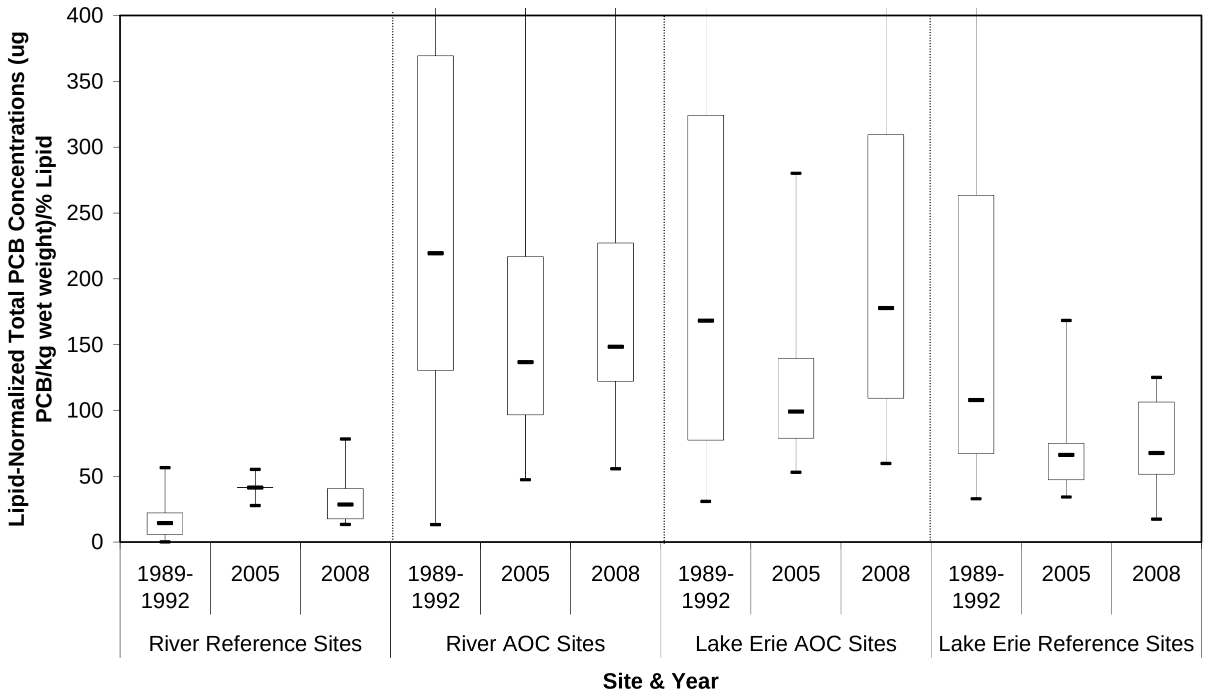
ND= Aroclor 1254 not detected at either river reference site

Lipid-Normalized PCBs

In addition to total PCBs, lipid-normalized PCB concentrations were also examined in the fish tissue samples collected in 2008. Lipid-normalized concentrations can provide a better measure of contamination than total PCBs because they take into account differences in fatty tissue that can accumulate PCBs (Rasmussen et al., 1990). These concentrations were calculated by dividing the total PCB concentration in each sample by the percent lipids.

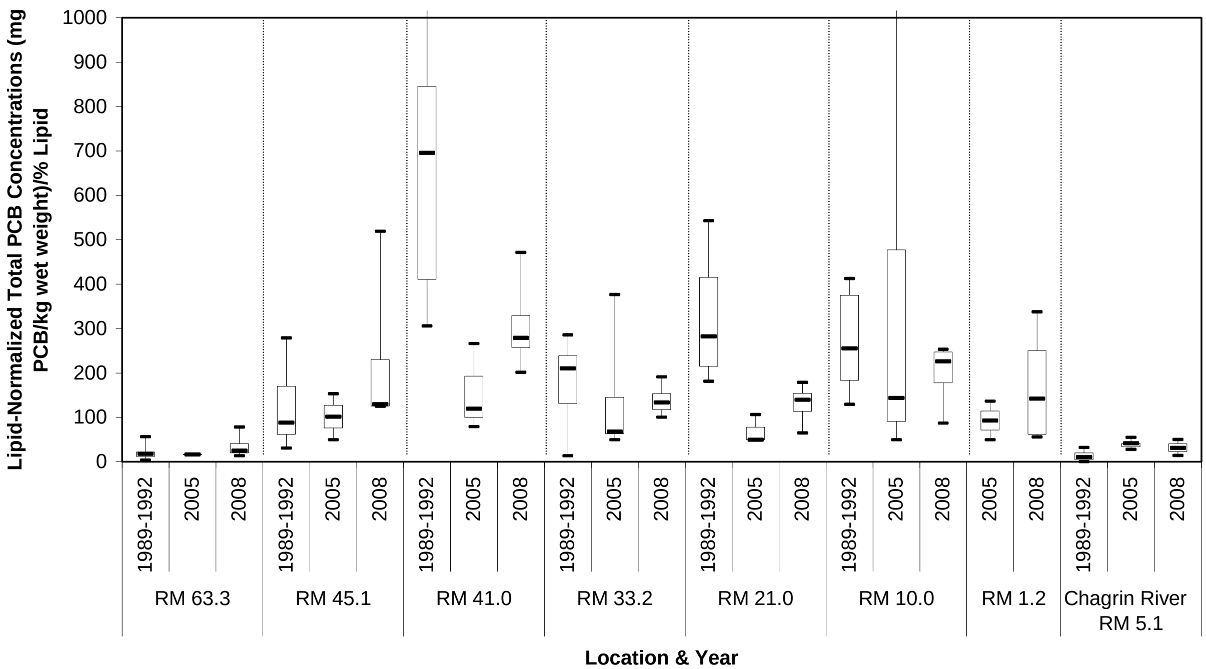
When the AOC and reference sites are compared to each other, it can be seen that the lipid-normalized PCB concentrations at the AOC sites were generally higher than the reference sites (Figure 7), with the difference being statistically significant (Appendix C, Table 21). The median concentration for the Lake Erie AOC sites was similar to the 1989-1992 study results, but was higher than in the 2005 study. The Cuyahoga River AOC sites had levels that were lower than in the 1989-1992 study and about the same as in the 2005 study. The difference between the 1989-1992 and 2008 studies, however, was not statistically significant. For the reference sites, the median concentrations were approximately the same as in the 2005 study. Compared to the 1989-1992 study, however, the median concentration at the lake reference sites was lower and the median concentration at the river reference sites was higher in 2008. The difference between the overall results from the 1989-1992 and 2008 studies at the river reference sites was found to be statistically significant (Appendix C, Table 13). However, this difference was mostly likely due to lower detection limits in the 1989-1992 study rather than an actual increase in PCB concentrations in the 2008 study.

Figure 7. Fish Fillet Lipid-Normalized Total PCB Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)



A site-to-site comparison of the river sites shows that both of the reference sites had median lipid-normalized PCB concentrations approximately the same as in both of the previous studies (Figure 8). For the AOC sites, the highest median concentration occurred at the site immediately upstream of Akron WWTP, while the lowest was at the Ohio Edison Dam Pool. The median concentrations at these sites in 2008 were generally higher than in the 2005 study, but lower than in the 1989-1992 study.

Figure 8. Cuyahoga River and Chagrin River Fish Fillet Lipid-Normalized Total PCB Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)



The results for the individual species collected in the Cuyahoga River AOC generally display a different trend than those for the sites as a whole. For most of the species collected in the 2008 study, the average lipid-normalized PCB concentrations were lower than in either of the previous studies (Figure 9). The exceptions to this were smallmouth bass, which was higher in 2008 than 2005, and rock bass and black crappie, which were not collected during any of the previous studies.

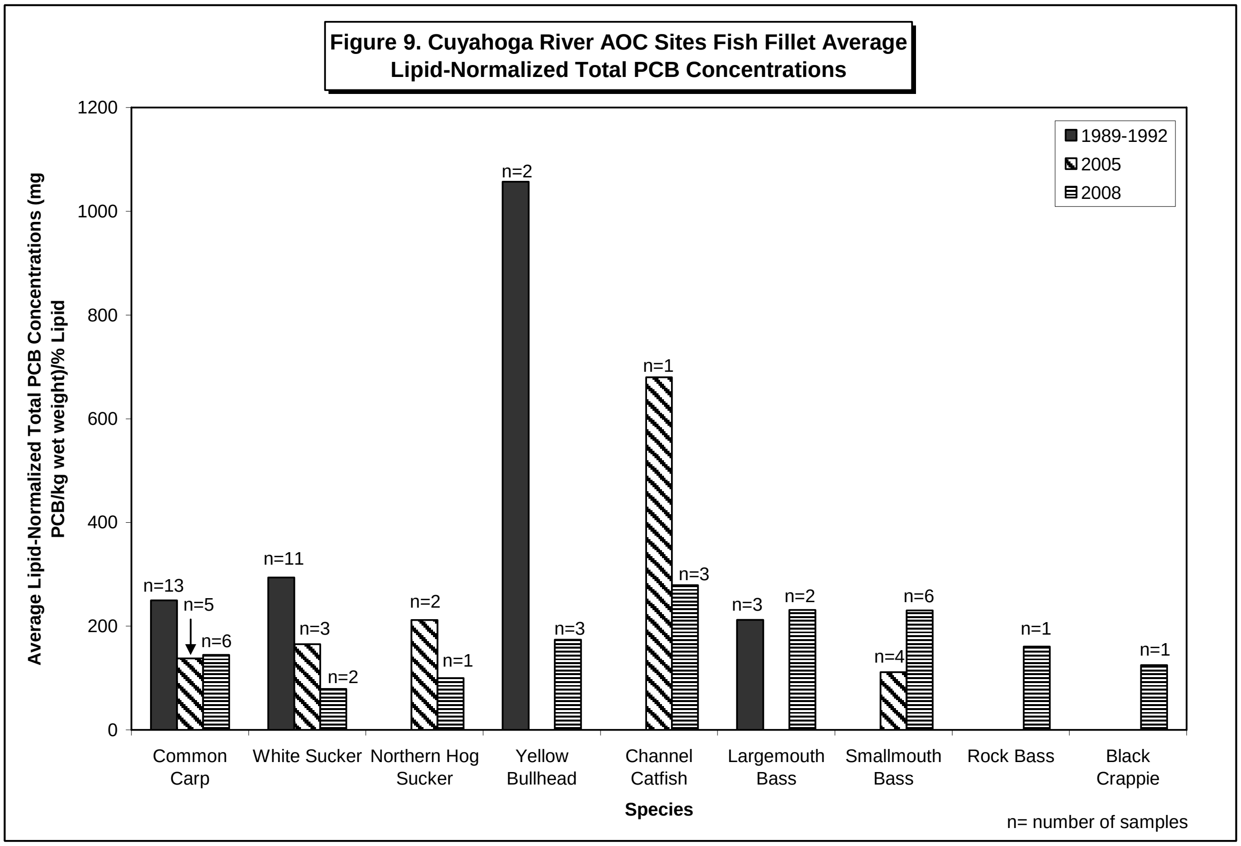


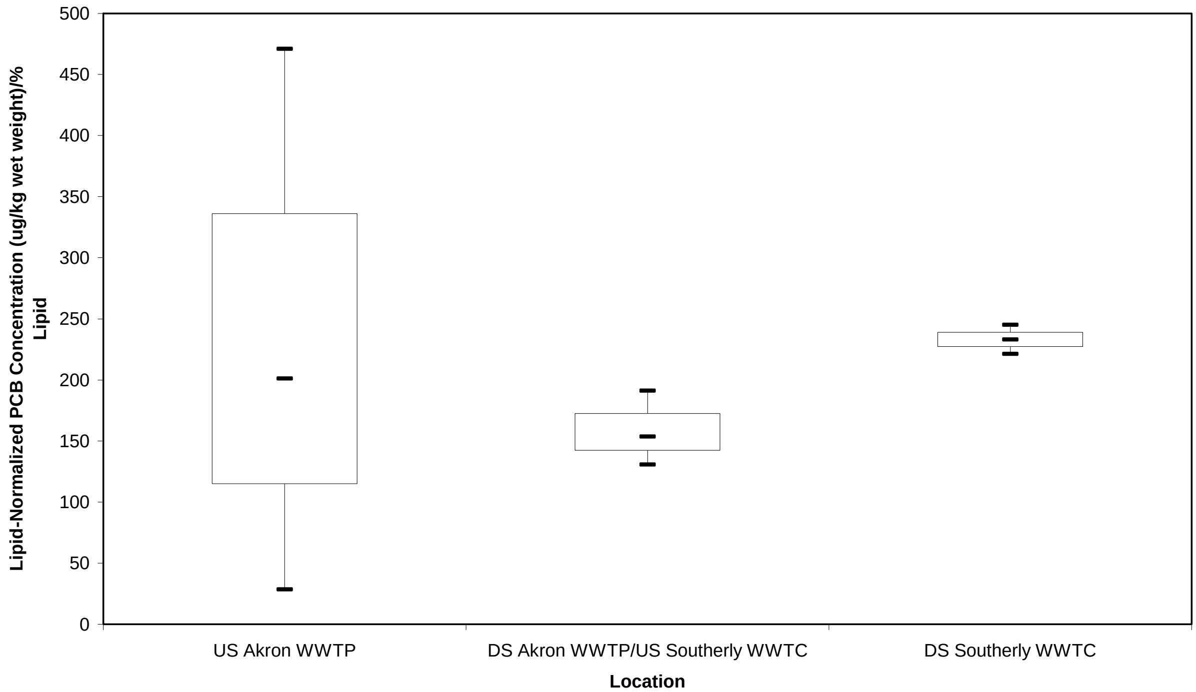
Figure 9. Cuyahoga River AOC Sites Fish Fillet Average Lipid-Normalized Total PCB Concentrations

In addition to examining the species from the AOC as a whole, a comparison was also completed using data collected from the sites upstream and downstream of the Akron WWTP and Southerly WWTC. This was done to evaluate whether effluent from the treatment plants could be having an impact on PCB concentrations. One issue associated with this type of analysis is that, due to fish mobility, the specific location at which fish are exposed to the contaminant remains uncertain. For the purposes of this assessment, the concentrations measured are nevertheless assumed to be the result of exposure at the location in which the fish were collected, and the uncertainty associated with this assumption should be kept in mind throughout interpretation of the data.

The comparison completed for smallmouth bass shows that the highest median lipid-normalized PCB concentrations occurred downstream of both treatment plants, while the lowest occurred between Akron WWTP and Southerly WWTC (Figure 10). However, the differences among the median concentrations for all three locations did not appear to be significantly different. For common carp, not enough samples were collected to evaluate potential impacts from Akron WWTP; therefore, only the potential for impacts from Southerly WWTC was examined. In doing so, it can be seen that the median concentration was much lower downstream of Southerly WWTC than upstream in 2008 (Figure 11). This differs from previous results, in which the median concentration downstream was equal to or greater than the concentration upstream of Southerly

WWTC.

Figure 10. 2008 Cuyahoga River Smallmouth Bass Fillet Lipid-Normalized PCB Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)



The lowest lipid-normalized PCB median concentration for the Lake Erie sites in 2008 occurred at the Lakewood reference site, while the highest occurred at the Cleveland Harbor West site in the AOC (Figure 12). Compared to the 2005 study, the median concentrations increased at the AOC sites and stayed about the same at the reference sites. The concentrations at the AOC sites were also generally within the same range as in the 1989-1992 study. The continued presence of PCBs at the AOC sites may be due to the prevalence and persistence of these compounds in the environment and impediments to their removal from some areas.

Figure 11. Cuyahoga River Common Carp Fillet Lipid-Normalized PCB Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)

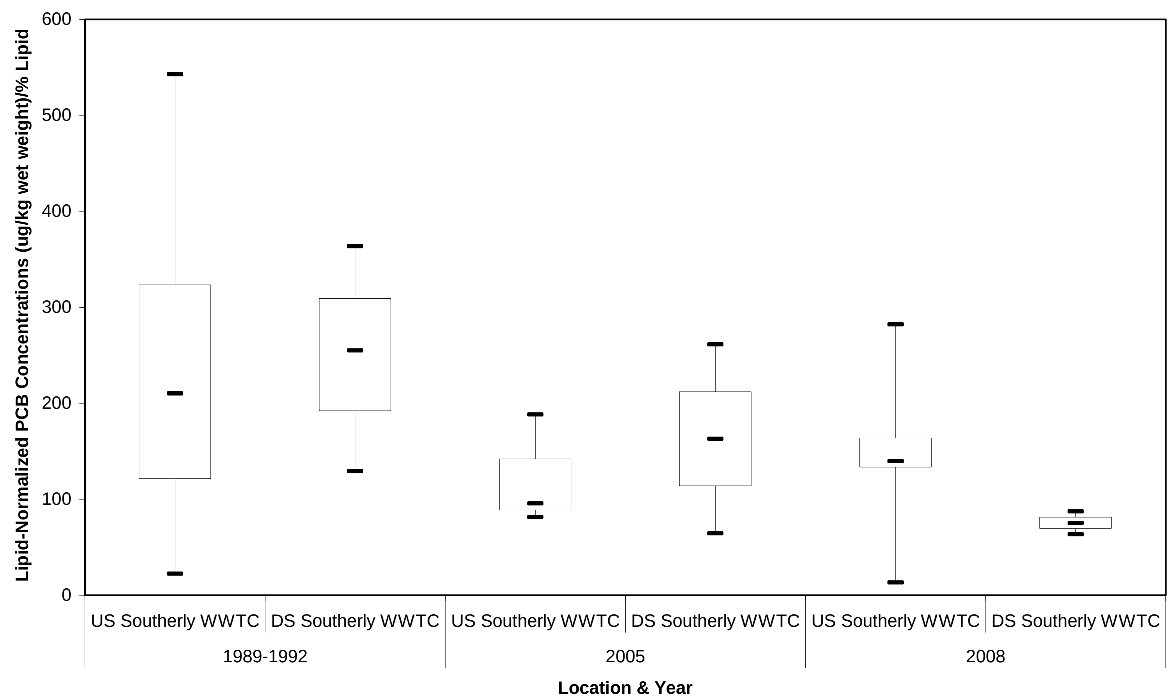
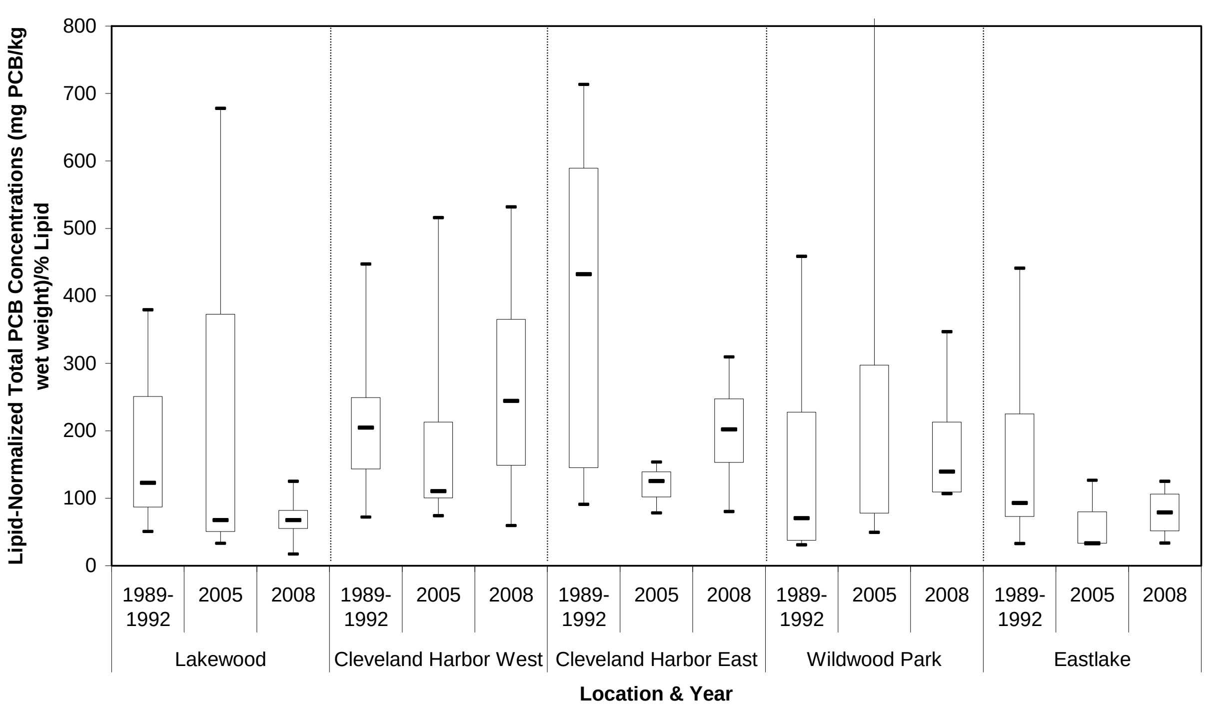
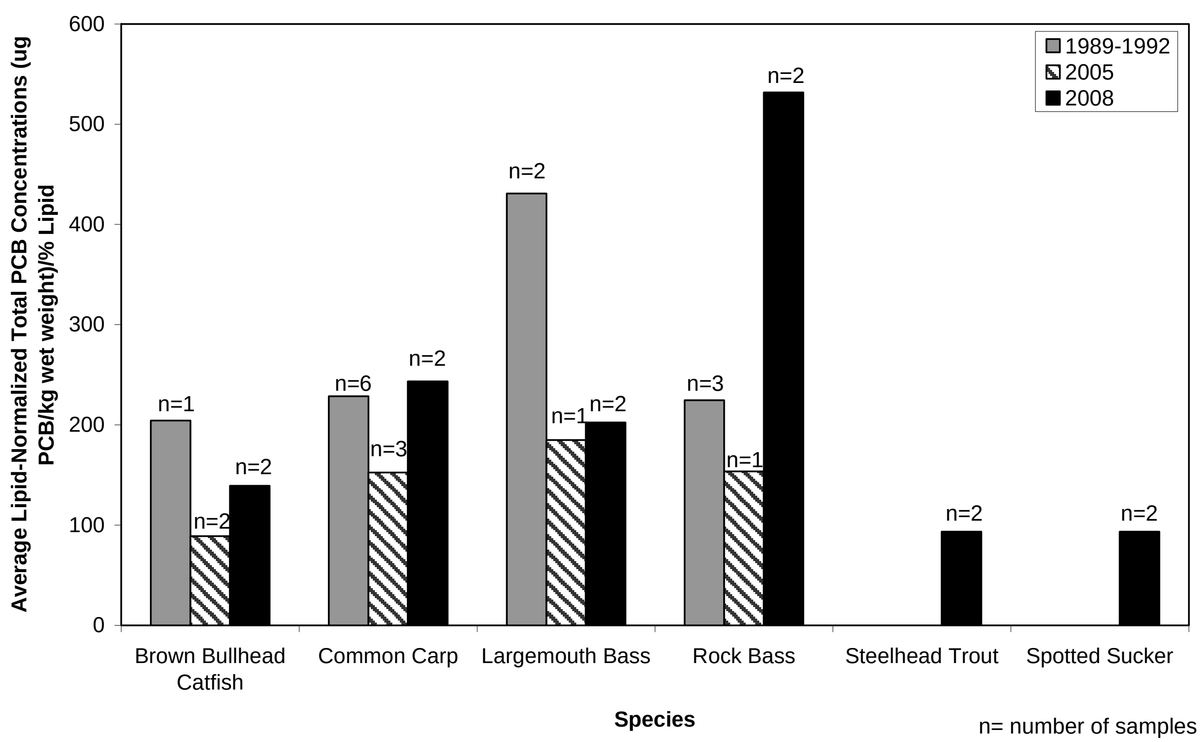


Figure 12. Lake Erie Fish Fillet Lipid-Normalized Total PCB Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)



In contrast to the river samples, the lipid-normalized PCB concentrations for all of the species in the Lake Erie portion of the AOC were higher than in the previous study (Figure 13). Two of the species, common carp and rock bass, were also higher than in the 1989-1992 study. The latter was notably higher than either of the previous studies. It is uncertain why this occurred, but may be due to localized “hot spots” of PCBs still present in some areas. This was the first study in which steelhead trout and spotted suckers were analyzed, so no historical comparison could be made for them.

Figure 13. Lake Erie AOC Fish Fillet Average Lipid-Normalized Total PCB Concentrations



PESTICIDES

Thirty-eight of the composite fillet samples were analyzed by TestAmerica for a total of 22 pesticides and pesticide breakdown products (Table 4). The seventeen samples analyzed by Ohio EPA’s Division of Environmental Services were tested for all of these pesticides except for endrin aldehyde and chlordane and its breakdown products. These compounds are no longer monitored by Ohio EPA because, in recent years, they have not detected them in high enough concentrations to be of concern. In the 2005 study, no pesticides were detected. This was most likely the result of higher detection limits than in the 1989-1992 or 2008 studies. In 2008, nine different pesticides or breakdown products were detected. These pesticides were found in the river and lake AOC and reference sites. The pesticides that were detected included:

1. Heptachlor epoxide in 2 samples;
2. Endrin in 2 samples;
3. Dieldrin in 3 samples;
4. 4,4-DDT in 4 samples;
5. 4,4-DDD in 10 samples;
6. 4,4-DDE in 22 samples;
7. Chlordane in 10 samples;
8. Alpha-chlordane in 11 samples; and
9. Gamma-chlordane in 5 samples.

Table 4. Pesticides Analyzed	
Aldrin	alpha- BHC
beta-BHC	delta-BHC
gamma-BHC	Chlordane
alpha-chlordane	Gamma-chlordane
4,4'-DDD	4,4'-DDE
4,4'-DDT	Dieldrin
Endrin	Endrin aldehyde
Endrin ketone	Endosulfan I
Endosulfan II	Endosulfan sulfate
Heptachlor	Hepachlor epoxide
Methoxychlor	Toxaphene

These chemicals are of concern due to their persistence in the environment and the harmful effects that they can cause to humans and wildlife. For these reasons, use of these pesticides was banned in the U.S. in the 1970s and 80s. Although it has been at least twenty years since they were used, the pesticides and their breakdown products listed above can still be found in the environment because of their high half-lives.

When comparing the pesticide concentrations that were measured to the concentrations used to set advisory consumption rates used by the State of Ohio (Table 5), only two of the fish sampled had concentrations that would be high enough to warrant a fish consumption advisory. A common carp sample from Lake Erie West Harbor had a heptachlor epoxide concentration that would result in a consumption advisory of "one meal per week". There was also a channel catfish sample from the site immediately downstream of Southerly WWTC that had heptachlor epoxide and chlordane concentrations that would result in "one meal per week" consumption advisory for both. There are currently no advisories issued by the State of Ohio for either one of these chemicals. Since fish advisories are not based on single samples at the extremes of concentration ranges, these comparisons should not be interpreted as warranting an update to the State of Ohio advisory. A more extensive data set showing generally higher concentrations would be needed before advisory changes could be made.

Table 5. Ohio Fish Consumption Advisory Chemicals: Fillet Chemical Upper Bound Limit Concentrations (mg/kg) and Advisory Meal Consumption Rate Using the Great Lakes' Governors Procedure*

Chemical	Unrestricted	1/Week	1/Month	6/Year	Do Not Eat
Aldrin	<0.030	0.131	0.568	1.135	>1.135
Total Chlordane	<0.500	2.188	9.459	18.919	>18.919
Total DDT	<0.500	2.188	9.459	18.919	>18.919
Dieldrin	<0.050	0.220	1.000	1.999	>1.999
Endosulfan	<6.000	26.25	131.514	227.027	>227.027
Endrin	<0.300	1.313	5.676	11.351	>11.351
Heptachlor	<0.500	2.188	9.459	18.919	>18.919
Heptachlor Epoxide	<0.013	0.057	0.246	0.492	>0.492
Methoxychlor	<5.000	21.875	94.545	189.189	>189.189
Toxaphene	<0.250	1.094	4.73	9.459	>9.459

*Adapted from State of Ohio Cooperative Fish Tissue Monitoring Program (2008)

An analysis of the noncancer hazard index and the lifetime cancer risk associated with chlordane and DDT and its metabolites indicates that the concentrations of these compounds detected in the fish samples were not high enough to be of concern in either the AOC or at the reference sites (Tables 6-9). The noncancer hazard index for both chlordane and DDT was well below one in all instances. In addition, the calculated cancer risks for both of those compounds, as well as for DDD and DDE, was lower than the risk goal of 1E-5 used by the Ohio EPA. These results are similar to what was found in the 1989-1992 study.

Table 6. Chlordane Noncancer Hazard Index and Lifetime Cancer Risk

Location	Average Fillet Concentration* (mg/kg)	Calculated 15.0 g/d Exposure Dose** (mg/kg-d)	IRIS Reference Dose (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index	IRIS Slope Factor $(mg/kg\text{-}d)^{-1}$	Calculated 15.0 g/d Lifetime Cancer Risk
			2008			
Lake AOC	5.27E-02	1.13E-05	5.00E-04	0.02	3.50E-01	3.95E-06
Lake Reference	1.96E-02	4.20E-06	5.00E-04	0.01	3.50E-01	1.47E-06
River AOC	6.92E-02	1.48E-05	5.00E-04	0.03	3.50E-01	5.19E-06
River Reference	0.00E+00	0.00E+00	5.00E-04	0.00	3.50E-01	0.00E+00

*Concentrations below the detection limit assumed to be zero.
**Human body weight of 70kg and lifetime exposure are assumed.

Table 7. DDT Noncancer Hazard Index and Lifetime Cancer Risk

Location	Average Fillet Concentration* (mg/kg)	Calculated 15.0 g/d Exposure Dose** (mg/kg-d)	IRIS Reference Dose (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index	IRIS Slope Factor $(mg/kg\text{-}d)^{-1}$	Calculated 15.0 g/d Lifetime Cancer Risk
			2008			
Lake AOC	7.92E-03	1.70E-06	5.00E-04	3.39E-03	3.40E-01	5.77E-07
Lake Reference	0.00	0.00	5.00E-04	0.00	3.40E-01	0.00
River AOC	4.75E-03	1.02E-06	5.00E-04	2.04E-03	3.40E-01	3.46E-07
River Reference	0.00	0.00	5.00E-04	0.00	3.40E-01	0.00
			1989-1992			
Lake AOC	3.30E-03	7.07E-07	5.00E-04	1.41E-03	3.40E-01	2.40E-07
Lake Reference	2.53E-03	5.43E-07	5.00E-04	1.09E-03	3.40E-01	1.85E-07
River AOC	4.21E-03	9.02E-07	5.00E-04	1.80E-03	3.40E-01	3.07E-07
River Reference	1.05E-03	2.25E-07	5.00E-04	4.50E-04	3.40E-01	7.65E-08

*Concentrations below the detection limit assumed to be zero.
**Human body weight of 70kg and lifetime exposure are assumed.

Table 8. DDE Noncancer Hazard Index and Lifetime Cancer Risk

Location	Average Fillet Concentration* (mg/kg)	Calculated 15.0 g/d Exposure Dose** (mg/kg-d)	IRIS Reference Dose (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index	IRIS Slope Factor $(mg/kg\text{-}d)^{-1}$	Calculated 15.0 g/d Lifetime Cancer Risk
2008						
Lake AOC	1.70E-02	3.64E-06	NA	NA	3.40E-01	1.24E-06
Lake Reference	6.00E-03	1.29E-06	NA	NA	3.40E-01	4.37E-07
River AOC	1.93E-02	4.14E-06	NA	NA	3.40E-01	1.41E-06
River Reference	1.04E-02	2.23E-06	NA	NA	3.40E-01	7.58E-07
1989-1992						
Lake AOC	3.22E-02	6.91E-06	NA	NA	3.40E-01	2.35E-06
Lake Reference	4.12E-02	8.83E-06	NA	NA	3.40E-01	3.00E-06
River AOC	2.34E-02	5.02E-06	NA	NA	3.40E-01	1.71E-06
River Reference	1.58E-02	3.39E-06	NA	NA	3.40E-01	1.15E-06

*Concentrations below the detection limit assumed to be zero.
**Human body weight of 70kg and lifetime exposure are assumed.
NA= Not available

Table 9. DDD Noncancer Hazard Index and Lifetime Cancer Risk

Location	Average Fillet Concentration* (mg/kg)	Calculated 15.0 g/d Exposure Dose** (mg/kg-d)	IRIS Reference Dose (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index	IRIS Slope Factor $(mg/kg\text{-}d)^{-1}$	Calculated 15.0 g/d Lifetime Cancer Risk
2008						
Lake AOC	7.21E-03	1.55E-06	NA	NA	2.41E-01	3.72E-07
Lake Reference	1.26E-03	2.70E-07	NA	NA	2.41E-01	6.51E-08
River AOC	5.52E-03	1.18E-06	NA	NA	2.41E-01	2.85E-07
River Reference	0.00E+00	0.00E+00	NA	NA	2.41E-01	0.00E+00
1989-1992						
Lake AOC	2.03E-02	4.35E-06	NA	NA	2.41E-01	1.05E-06
Lake Reference	1.92E-02	4.12E-06	NA	NA	2.41E-01	9.92E-07
River AOC	1.37E-02	2.93E-06	NA	NA	2.41E-01	7.07E-07
River Reference	6.36E-03	1.36E-06	NA	NA	2.41E-01	3.29E-07

*Concentrations below the detection limit assumed to be zero.
**Human body weight of 70kg and lifetime exposure are assumed.
NA= Not available

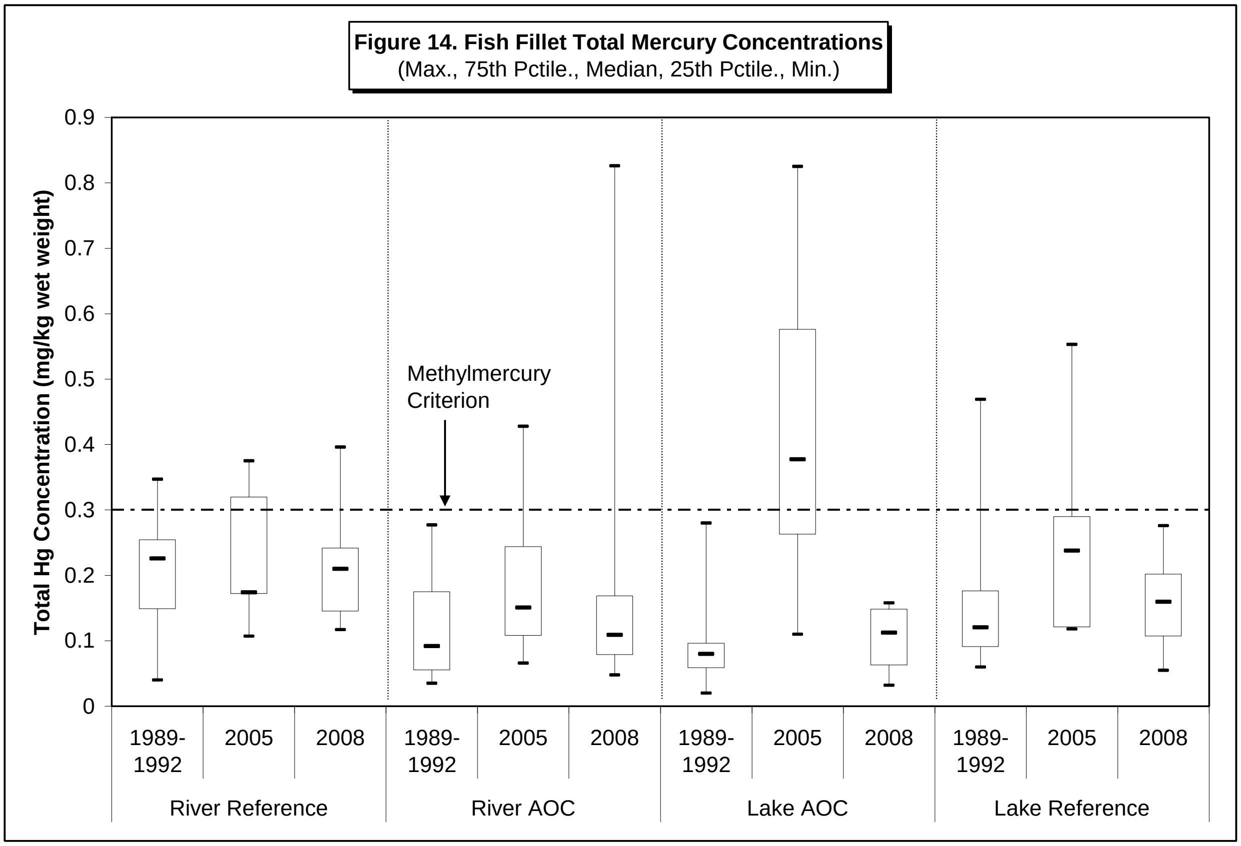
Mercury

Fifty-four composite fillet and 142 whole-body fish were analyzed for total mercury concentrations. Analysis was completed by NEORSD Analytical Services and the Ohio EPA Division of Environmental Services. Some split samples were also sent to TestAmerica for further inter-laboratory comparison. A discussion of the split sample results are presented in Appendix B. Mercury was detected in measurable quantities in every sample analyzed from all three laboratories.

Composite Fillets

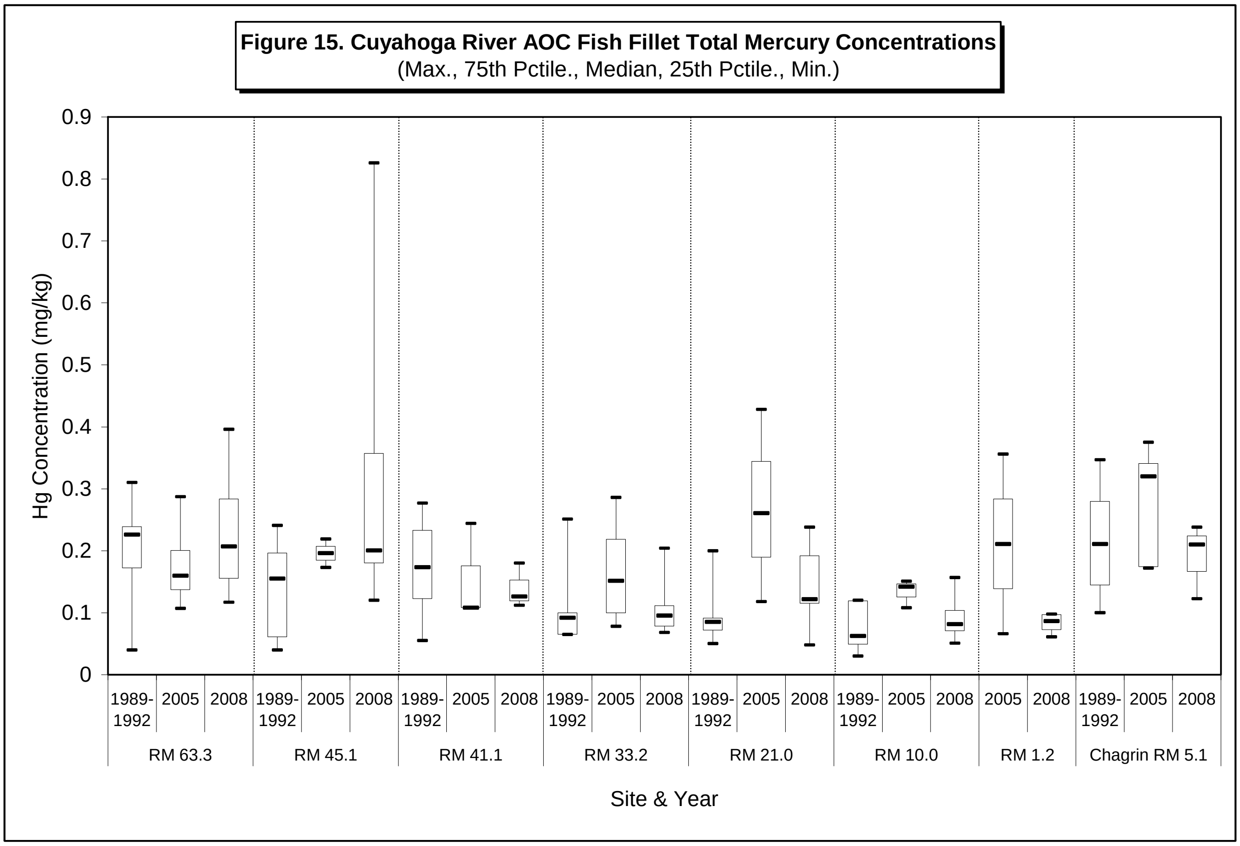
Analysis of mercury concentrations in composite fillet samples was performed to evaluate the potential for impacts if consumed by humans. Results were evaluated in terms of changes over time and differences among locations. They were compared to the U.S. EPA human health water quality criterion for methylmercury, which is 0.3 mg methylmercury/kg fish tissue wet weight. The methylmercury criterion was adopted in 2001 and is intended to protect consumers of fish and shellfish. It is assumed that virtually all mercury in fish tissue is in the form of methylmerucry, and therefore, analysis of mercury serves as a substitute for measuring methylmercury (U.S. EPA, 2006). The concentrations in the fillets were also compared to those used by the State of Ohio to set meal consumption advisories (State of Ohio, 2008). The advisory is currently based upon a health protection value of 0.1 μg mercury/kg/day for those people consuming sport fish (Great Lakes Fish Advisory Workgroup, 2007).

When comparing the AOC sites in the river and lake to their respective reference sites, it was found that the median mercury concentrations for both types of AOC sites were lower than the reference ones, but not significantly so. All of the median concentrations were well below the methylmercury criterion (Figure 14). Compared to the previous two studies, the median concentrations in 2008 were about the same as in the 1989-1992 study, but less than in the 2005 study. Only the concentrations at the lake AOC sites, though, were found to be significantly lower in 2008 compared to 2005 (Appendix C, Table 25).

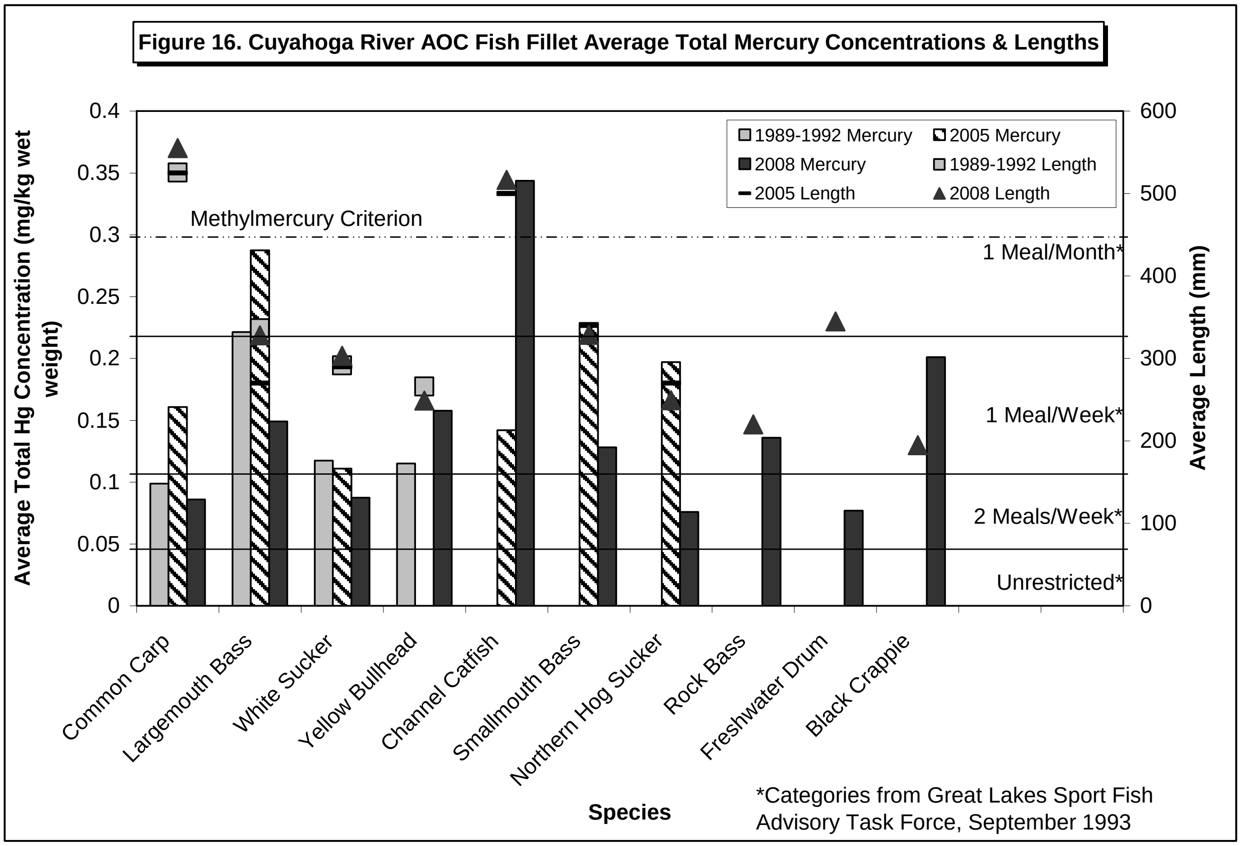


In the Cuyahoga River, the highest median mercury concentrations occurred at the two reference sites and at the Ohio Edison Dam Pool (Figure 15). The lowest median concentrations occurred at the two sites downstream of Southerly WWTC. All of the median concentrations were below the human health water quality criterion, with only two samples above that value. These samples were collected from the sites near Shalersville and at the Ohio Edison Dam Pool.

The State of Ohio currently has a statewide fish consumption advisory in place for mercury that recommends not eating more than one meal per week of most fish (Ohio EPA, 2009). When compared to these recommendations, mercury levels in all of the samples except one were within the "one or two meals per week" categories (Figure 16). The exception to this was a channel catfish sample from the Ohio Edison Dam Pool that would fall into the "one meal per month" category, which is more restrictive than the current advisory in place. This was also the only species that exhibited a mercury level above the methylmercury criterion.

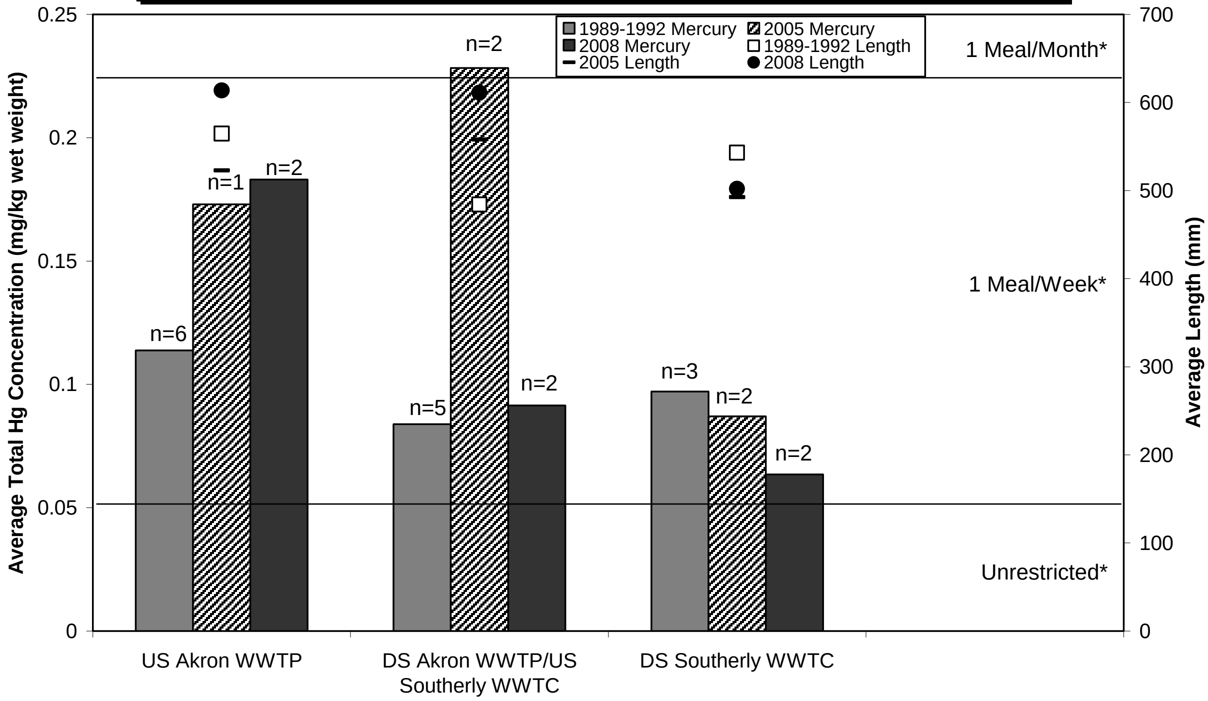


All of the species except yellow bullhead and channel catfish had lower concentrations than in either of the previous two studies. Yellow bullhead had a higher concentration than in the 1989-1992 study, and channel catfish concentrations were higher than in 2005. Generally, mercury concentrations increase as fish become larger due to bioaccumulation in muscle tissue (Great Lakes Fish Advisory Workgroup, 2007). The increases in mercury in 2008 for the yellow bullhead and channel catfish cannot be attributed to differences in the size of the fish, though, because they were about the same length as in those studies. Smallmouth bass mercury levels were lower than the criterion for the "one meal per month" advisory currently in place from the Ohio Edison Dam Pool to the mouth of the river.



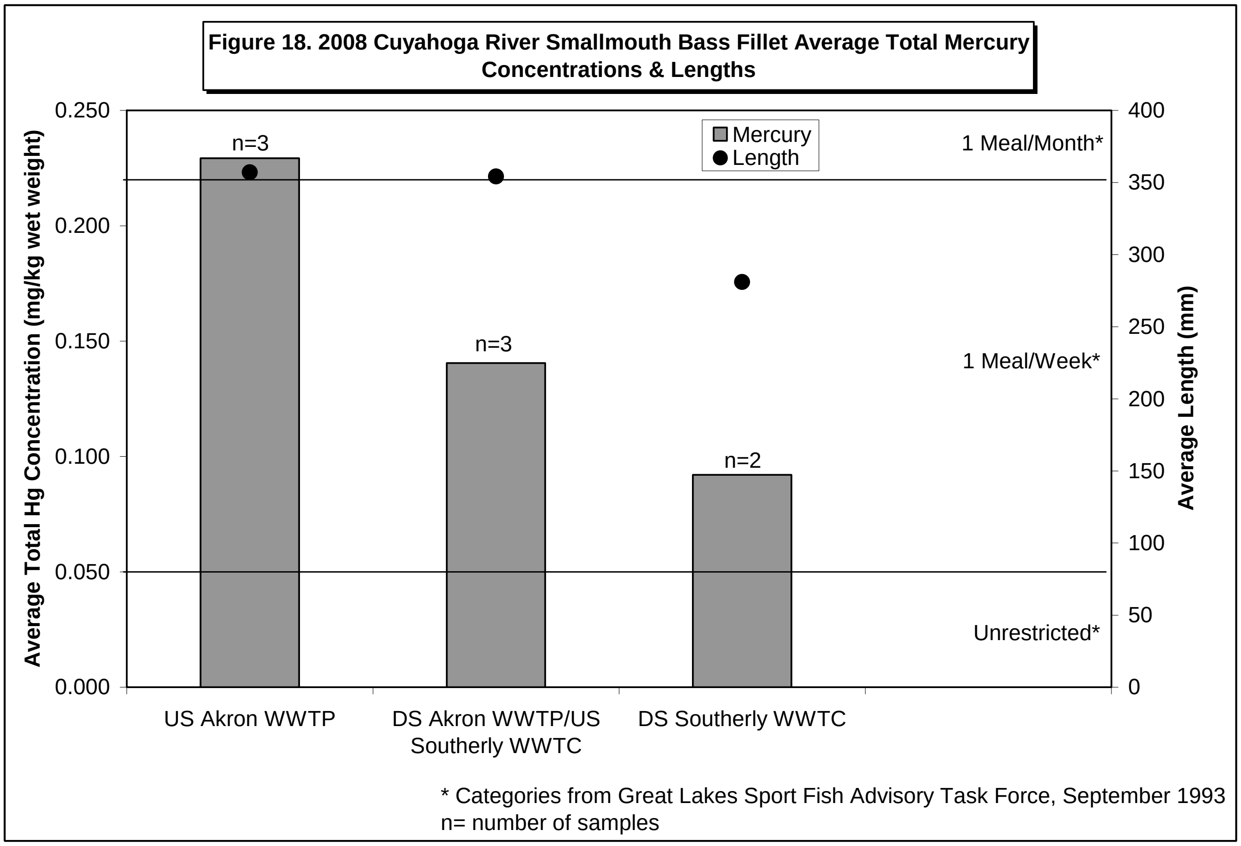
Trace concentrations of mercury are present in effluent that is discharged from wastewater treatment plants. The significance of these discharges in terms of bioaccumulation in fish tissue is still not completely understood. Because of this, common carp and smallmouth bass collected upstream and downstream of Akron WWTP and Southerly WWTC were compared to evaluate any possible effects. When this comparison is done for common carp, it can be seen that lower mercury concentrations were found in the sections of the river downstream from the treatment plants (Figure 17). For the sites downstream of Southerly WWTC, part of this difference may be explained by the smaller fish that were collected at those locations. The fish in the section of the river downstream of Akron WWTP, but upstream of Southerly WWTC, had fish that were about the same size as those upstream of the Akron treatment plant. These results were similar to those found in the previous two studies. Although higher mercury concentrations were found downstream of Akron WWTP in 2005, the fish collected in that section were larger than in the other sections sampled.

Figure 17. Cuyahoga River Common Carp Fillet Average Total Mercury Concentrations & Lengths

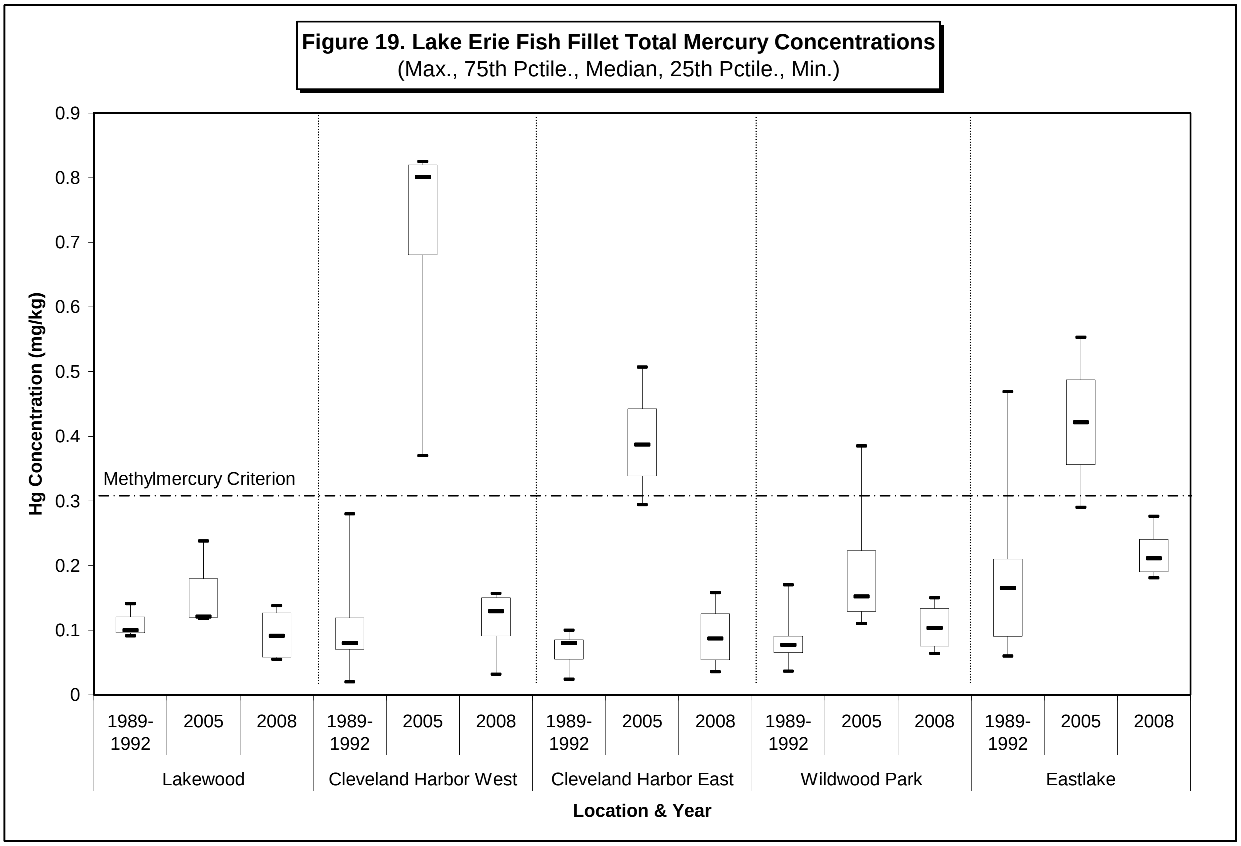


*Categories from Great Lakes Sport Fish Advisory Task Force, September 1993
n = number of samples

The results for the smallmouth bass collected in 2008 show a similar trend (Figure 18). The lowest average mercury concentration occurred at the sites downstream of Southerly WWTC. It is possible that this may be related to fish size, as the fish collected there were smaller than those collected upstream. However, the concentrations appear to be consistent with an absence of increased mercury bioaccumulation attributable to the plant effluent. The fish collected between Akron WWTP and Southerly WWTC were the same size as those collected upstream of Akron WWTP and the mercury concentrations were still lower, indicating that the differences in concentration were due to some other factor. Therefore, based on these results and the ones for common carp, the results do not indicate that either treatment plant is increasing fish tissue mercury levels in the river.

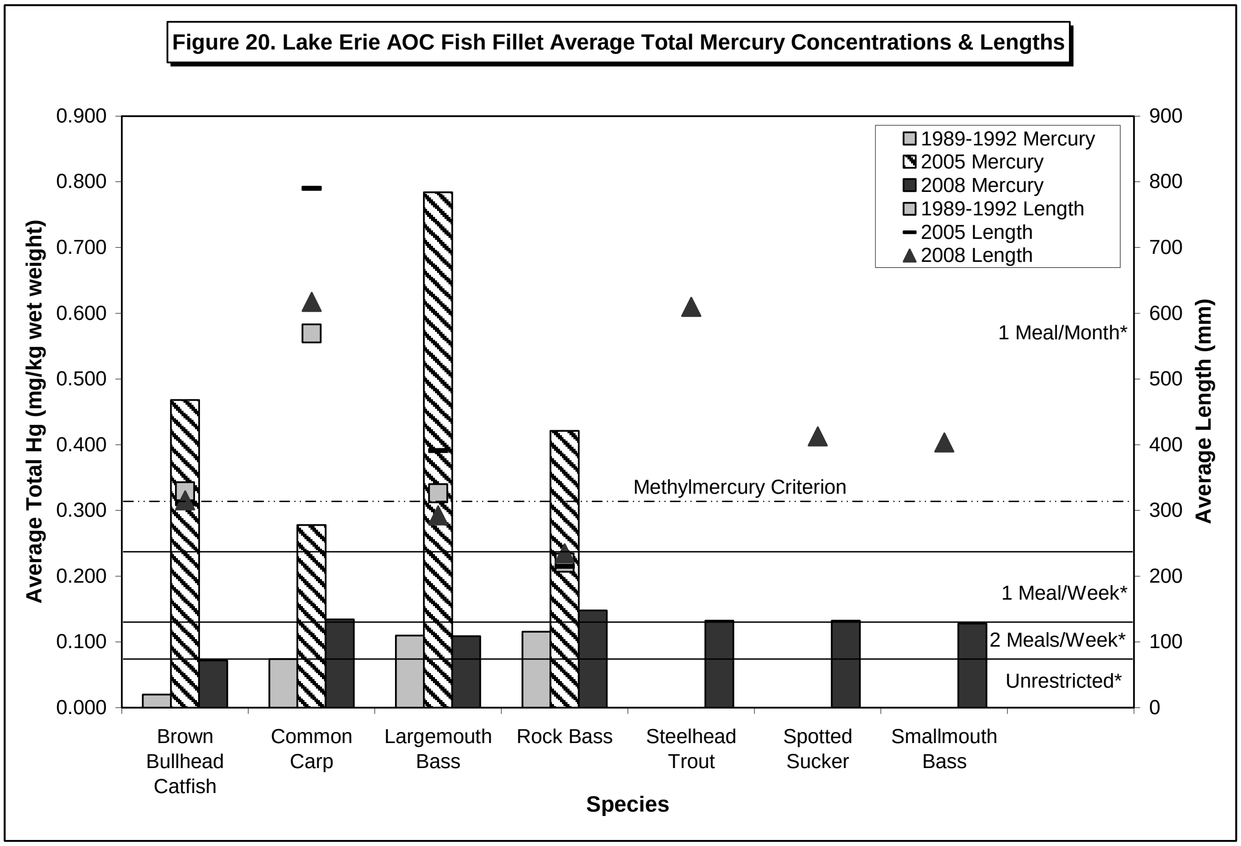


The results for the individual sites in Lake Erie indicate that mercury concentrations were highest at the Eastlake site, with the mercury levels at the other sites being similar to each other (Figure 19). All of the fillet samples were lower than the 0.3 mg/kg criterion. The median concentrations in 2008 were lower and, at some sites, much lower than in 2005, but they were similar to the 1989-1992 levels. The reason for the much higher levels in 2005 remains unknown. The 2008 median values at Cleveland Harbor West, Wildwood, and Eastlake were only slightly higher than those from the 1989-1992 study, while the Cleveland Harbor East and Lakewood sites had mercury levels that were about the same as in 1989-1992.



When examining the results for individual species in the Lake Erie portion of the AOC, brown bullhead and largemouth bass had mercury concentrations that would place it into the "two meals per week" category (Figure 20). The other species were at concentrations in the "one meal per week" category, which is the same as the statewide advisory regarding mercury.

Four of the species that were collected in 2008 were also collected in the previous two studies. All of the average concentrations measured in 2008 were lower than in 2005. Three of the species exhibited levels slightly higher than in 1989-1992, while largemouth bass levels were about the same. The common carp and largemouth bass were larger in 2005 than those from 2008, which may account for some of the differences in mercury concentration, but the sizes of fish for the other two species were about the same. The lengths of fish collected in the 1989-1992 and 2008 studies were generally similar, so any differences in mercury concentrations should not be due to size.



As with the pesticide and PCB results, a risk assessment was completed for mercury for the AOC and reference sites to evaluate the potential for harm to humans consuming fish caught within those areas. Based on the current reference dose for methylmercury, the calculated noncancer hazard index, assuming a consumption of 15.0 g/day, a body weight of 70 kg, and lifetime exposure, does not approach one for any of the site types (Table 10). These results are similar to those in both the 1989-1992 study and the 2005 study.

Table 10. Methylmercury Noncancer Hazard Index

Location	Geometric Mean Fillet Concentration (mg/kg)	Calculated 15.0 g/d Exposure Dose* (mg/kg-d)	IRIS Reference Dose (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index
2008				
Lake AOC		2.31E-05	1.00E-04	0.23
Trophic Level 3	0.07			
Trophic Level 4	0.12			
Lake Reference		2.90E-05	1.00E-04	0.29
Trophic Level 3	0.14			
Trophic Level 4	0.13			

Table 10. Methylmercury Noncancer Hazard Index

Location	Geometric Mean Fillet Concentration (mg/kg)	Calculated 15.0 g/d Exposure Dose* (mg/kg-d)	IRIS Reference Dose (mg/kg-d)	Calculated 15.0 g/d Noncancer Hazard Index
River AOC		2.60E-05	1.00E-04	0.26
Trophic Level 3	0.10			
Trophic Level 4	0.13			
River Reference		4.55E-05	1.00E-04	0.46
Trophic Level 3	0.18			
Trophic Level 4	0.22			

2005				
Lake AOC		8.31E-05	1.00E-04	0.83
Trophic Level 3	0.31			
Trophic Level 4	0.41			
Lake Reference		5.03E-05	1.00E-04	0.50
Trophic Level 3	0.19			
Trophic Level 4	0.25			
River AOC		4.00E-05	1.00E-04	0.40
Trophic Level 3	0.14			
Trophic Level 4	0.20			
River Reference		4.56E-05	1.00E-04	0.46
Trophic Level 3	0.22			
Trophic Level 4	0.21			

1989-1992				
Lake AOC		1.99E-05	1.00E-04	0.20
Trophic Level 3	0.05			
Trophic Level 4	0.11			
Lake Reference		3.99E-05	1.00E-04	0.40
Trophic Level 3	0.08			
Trophic Level 4	0.22			
River AOC		4.10E-05	1.00E-04	0.41
Trophic Level 3	0.10			
Trophic Level 4	0.22			
River Reference		3.72E-05	1.00E-04	0.37
	0.20			
	0.17			

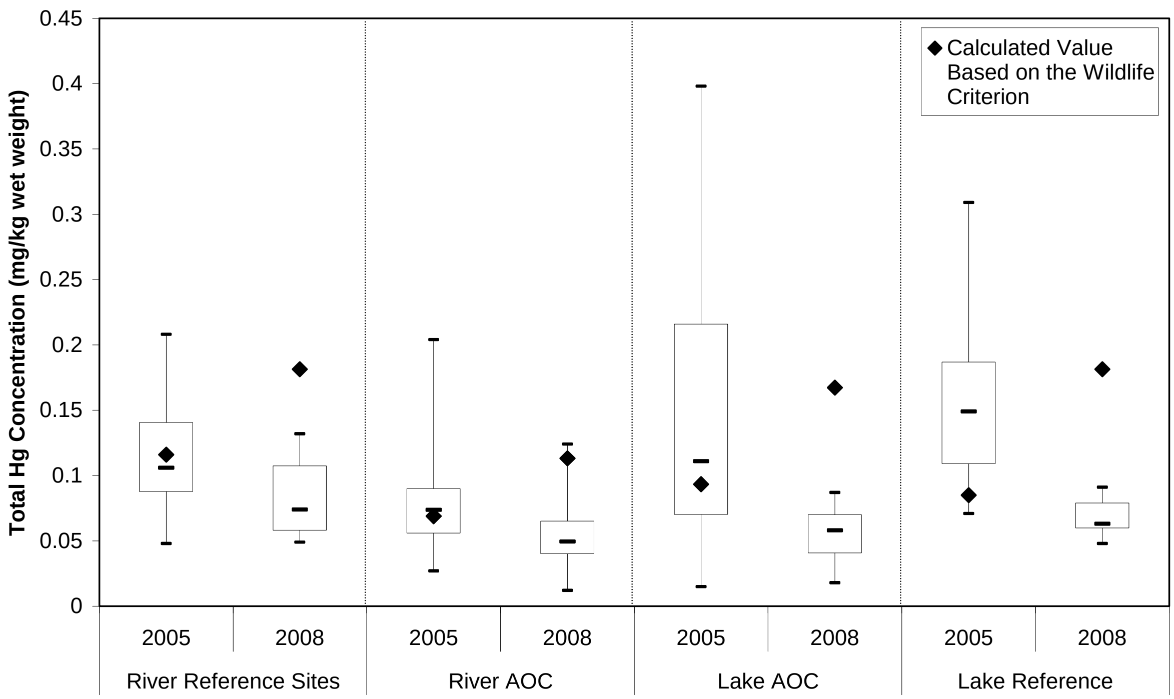
*Human body weight of 70kg and lifetime exposure are assumed. Weighted dose based on assumption of consuming 3.6 g/day of trophic level 3 fish and 11.4 g/day of trophic level 4 fish.

Whole-Body Samples

In addition to composite fillet samples, whole-body samples were also analyzed for total mercury concentrations. These samples were collected to evaluate the potential for impacts to piscivorous wildlife. The wildlife criterion for mercury according to the Great Lakes Water Quality Initiative (U.S. EPA, 1995a) is 1.3 ng/L. This criterion for ambient water quality can be converted to a fish-tissue basis and adjusted based on trophic level-specific bioaccumulation factors (BAFs). For trophic level 3 species, the BAF is 27,906 L/kg, while the BAF for trophic level 4 species is 139,532 L/kg (U.S. EPA, 1995a).

An analysis of the four types of sites indicates that, similar to the 2005 study, there is not much difference among the median concentrations for each site (Figure 21). The median concentrations were all below the trophic level adjusted fish-tissue basis wildlife criterion, whereas in 2005, only the river reference sites had median concentrations below this value. When including all the concentrations, however, those from the river and lake AOC sites were found to be significantly lower than the reference sites in 2008 (Appendix C, Table 41). A comparison of the 2005 and 2008 concentrations using t-tests indicates that the concentrations measured in 2008 were significantly lower than those from 2005 (Appendix C, Tables 31-38).

Figure 21. Whole Body Fish Total Mercury Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)



For the river sites, the highest median concentrations occurred at the two reference sites. There did not appear to be a significant difference among the median concentrations for the sites in the Cuyahoga River (Figure 22), but an analysis of all the concentrations measured at the site immediately downstream of Akron WWTP found these concentrations to be significantly lower than the concentrations at the site immediately downstream of Southerly WWTC and at the reference site near Shalersville (Appendix C, Table 44). The concentrations from the site on the Chagrin River were found to be significantly higher than any of the other river sites (Appendix C, Table 44). All of the sites except for the one at the Ohio Edison Dam Pool were below the calculated value based on the wildlife criterion. In addition, the median concentrations for the sites were generally lower than in 2005.

Smallmouth bass collected upstream and downstream of Akron WWTP and Southerly WWTC were compared to evaluate whether the treatment plants could be having an impact on mercury concentrations in fish. It was found that the fish downstream of both plants had lower median concentrations than those that were collected upstream (Figure 23). Some of this may be due to the slightly smaller fish that were collected in those locations. However, the differences in mercury concentrations seem to be greater than the differences in the size of fish that were collected. Therefore, it does not appear that either treatment plant is causing increased mercury levels to be accumulated in fish downstream of their effluent discharges.

Figure 22. 2008 Cuyahoga River Whole Body Fish Total Mercury Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)

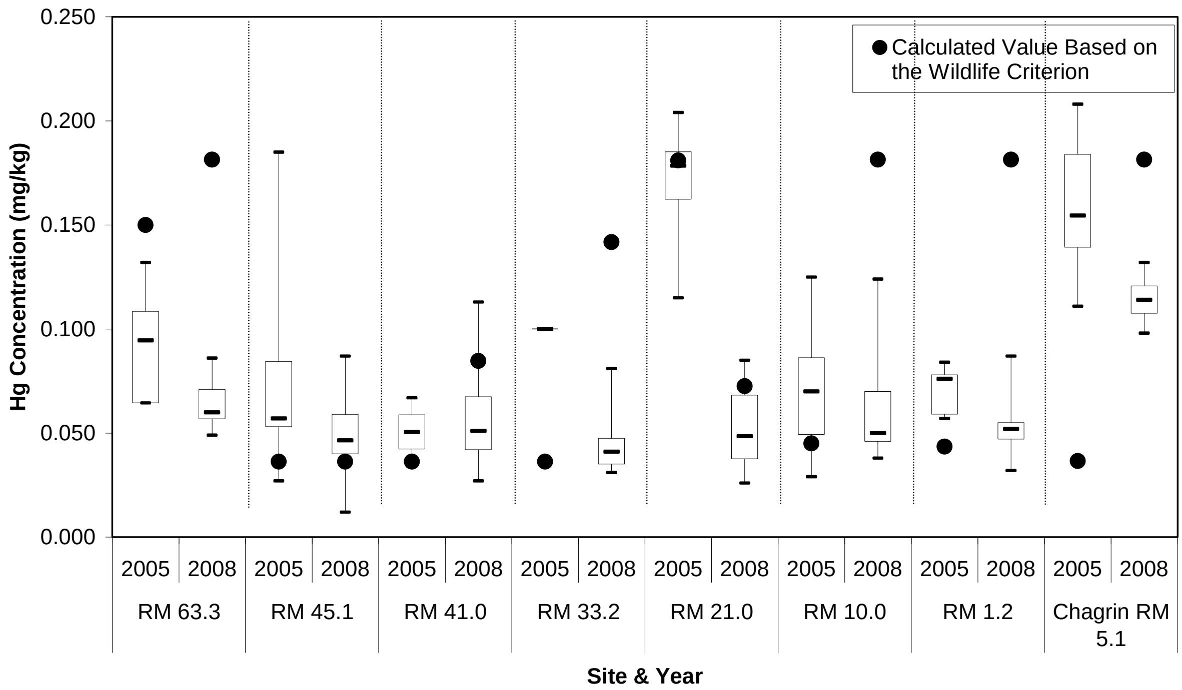
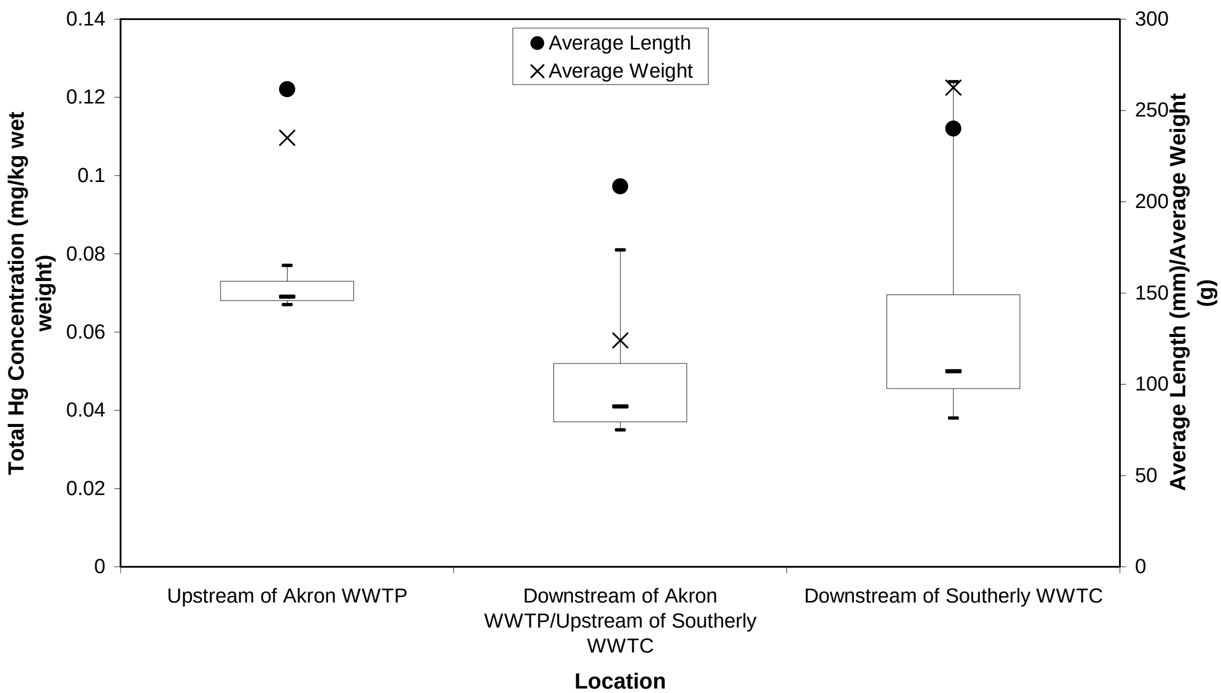
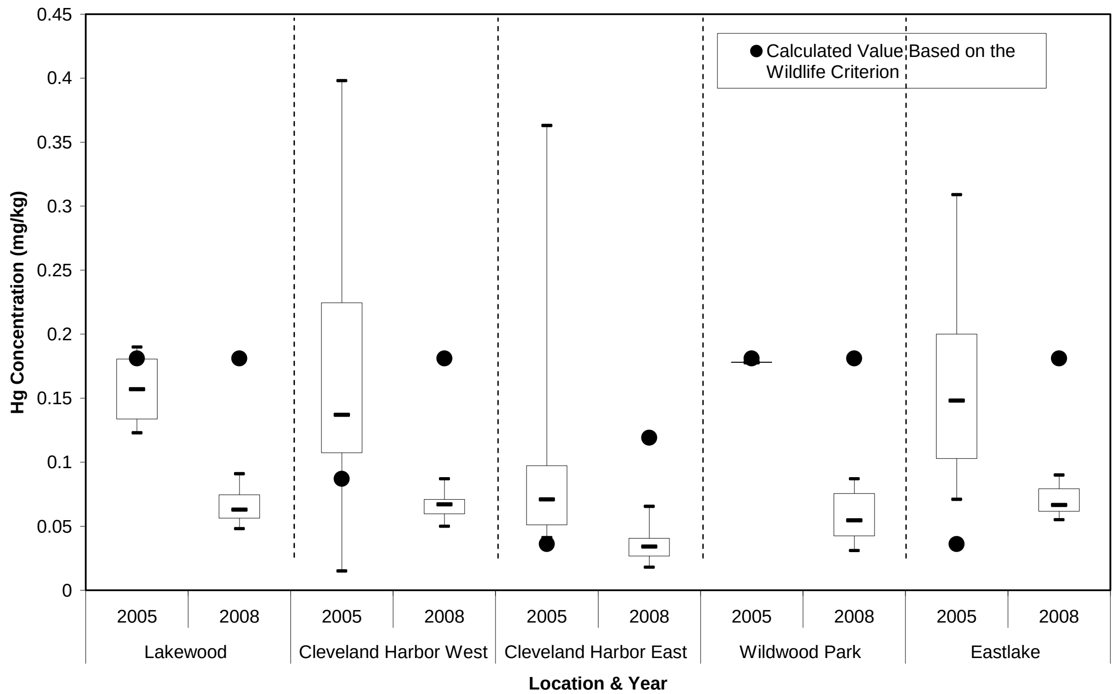


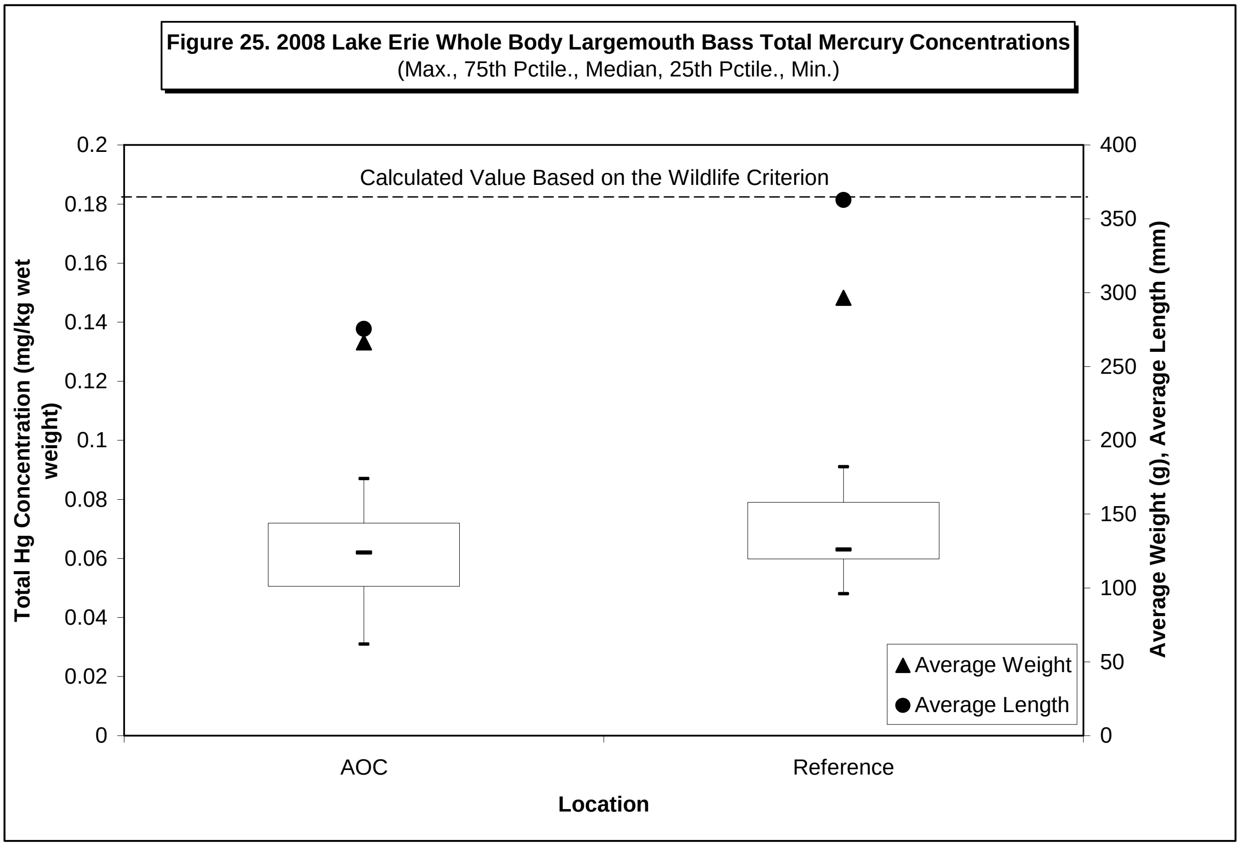
Figure 23. Cuyahoga River Whole Body Smallmouth Bass Total Mercury Concentrations, Weights & Lengths (2008)
(Max., 75th Pctile., Median, 25th Pctile., Min.)



For Lake Erie, the median concentrations were all below the calculated value based on the wildlife criterion (Figure 24). The lowest concentration occurred at the Cleveland Harbor East location. This statistically significant difference was most likely due to the collection of a few sunfish at this site, which are at a lower trophic level (Appendix C, Table 46). The fish collected at the other sites were all largemouth bass, a trophic level 4 species. There was no significant difference between the AOC and reference sites (Figure 25). This was true even though the fish for the reference sites were slightly longer.

Figure 24. Lake Erie Whole Body Fish Total Mercury Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)





CONCLUSIONS

In 2008, fish tissue samples from Lake Erie, the Cuyahoga River and the Chagrin River were analyzed for PCB, pesticide, and mercury concentrations and compared to studies completed in 1989-1992 and 2005. The concentrations of these contaminants were found to vary both among sites and when compared to historical results.

Generally, total and lipid-normalized PCB fish tissue concentrations were greater in the AOC than either the river or lake reference sites. The concentrations in the AOC were generally greater than in the 2005 study, while the reference site concentrations were about the same. Individual species varied as to whether they had PCB levels higher or lower than in previous studies. However, many of the concentrations measured in individual species were at levels high enough that they would result in fish consumption advisories, sometimes more restrictive than those currently in place. A risk assessment utilizing both the noncancer hazard index and cancer potency factor indicated the potential for causing adverse health effects from eating fish contaminated with PCBs at both the lake and river AOC sites. These results demonstrate that, although the manufacturing and distribution of PCBs were banned in the 1970s, they are still present in the environment due to their resistance to degradation and that, apparently, consumption advisories continue to be warranted.

While organochlorine pesticides were also detected in many of the composite fillet samples, assessments using available reference doses and cancer potency factors for chlordane and DDT and its metabolites indicate acceptable risk associated with lifetime exposure to measured concentrations. Similar to PCBs, the presence of these compounds within fish tissue indicates their persistence in the environment many years after their production was stopped.

The mercury results obtained from the study indicate that contamination is not just associated with the AOC. Composite fillet and whole-body fish tissue concentrations of mercury in samples collected from reference sites outside the AOC generally were equal to or greater than those found in the AOC. The results also indicate that although some of the concentrations measured were high enough to warrant a fish consumption advisory, they were mostly below the U.S. EPA human health criterion for methylmercury. The noncancer hazard index for both the AOC and reference sites also did not indicate a high enough risk to be of concern. When compared to past studies, the results from 2008 were generally about the same as in the 1989-1992 study, but lower than in 2005. A comparison upstream and downstream of Akron WWTP and Southerly WWTC did not show an increase in bioaccumulation attributable to their discharges.

Overall, the results from this study suggest there are still some problems associated with contamination of fish tissue in the locations that were sampled. These problems are not just limited to the AOC, as samples collected outside of the AOC were also found, in some instances, to have contaminant concentrations greater than those inside the AOC. It also does not appear that either of the major municipal wastewater treatment plant discharges to the Cuyahoga River is increasing the levels of these contaminants. Continued monitoring of fish from these areas is needed to further track changes in contaminants over time. This will help to determine the effectiveness of pollutant reduction efforts, measure the degradation of pollutants already present in the environment, and provide necessary information for updating the Ohio Sport Fish Consumption Advisory Program.

REFERENCES

Anderson, H.A., J.F. Amrhein, P. Shubat, J. Hess. 1993. Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory. Great Lakes Fish Advisory Task Force.

Cuyahoga River Community Planning Organization. 1994. 1989-1992 Fish Tissue Collection and Analysis.

Great Lakes Fish Advisory Workgroup. 2007. A Protocol for Mercury-based Fish Consumption Advice. An addendum to the 1993 "Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory."

Ohio EPA. 1988. Biological Criteria for the Protection of Aquatic Life: Volume II: Users Manual for Biological Assessment of Ohio Surface Waters.

Ohio EPA. 2004. Human Health Cumulative Carcinogenic Risk and Non-carcinogenic Hazard Goals for DERR Remedial Response and Office of Federal Facility Oversight Technical Decision Compendium. Division of Emergency and Remedial Response.

Ohio EPA. 2009. Ohio Sport Fish Consumption Advisory. Division of Surface Water.

Rasmussen, J.B., D.J. Rowan, D.R.S. Lean, and J.H. Carey. 1990 Food Chain Structure in Ontario Lakes Determines PCB levels in Lake Trout (*Salvelinus namaycush*) and Other Pelagic Fish. Canadian Journal of Fisheries and Aquatic Sciences. 47:2030-2038.

State of Ohio. 2008. Cooperative Fish Tissue Monitoring Program. Sport Fish Tissue Consumption Advisory Program.

U.S. EPA. 1995a. Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors. EPA-820-B-95-005. U.S. Environmental Protection Agency, Office of Water.

U.S. EPA. 1995b. Great Lakes Water Quality Initiative Criteria documents for the Protection of Human Health. EPA-820-B-95-006. U.S. Environmental Protection Agency, Office of Water.

U.S. EPA. 2006. Draft Guidance for Implementing the January 2001 Methylmercury Water Quality Criterion. EPA 823-B-04-001. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.

2008 Cuyahoga River and Nearshore Lake Erie Fish Tissue Study Appendices

Appendix A. Completed Collection Forms

2008 Fish Tissue Study Sample Form						
Date:	8/20/08, 9/8/2008					
Location:	Cuyahoga River at Shalersville (FTCS-01)					
Collection Method:	Longline Electrofishing					
Names of Samplers:	Smith/Hothem, Maichle, Toot-Levy, Aman, Wagner					
Weather:						
Comments:	Composite samples collected Ohio EPA, whole body by NEORSD & ODNR					
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
R-0902310009-01	Rock Bass	187	135		N/A	N/A
R-0902310009-02		203	160		N/A	N/A
R-0902310009-03		165	95		N/A	N/A
R-0902310009-04		165	90		N/A	N/A
R-0902310009-05		165	80		N/A	N/A
R-0902310009-06		160	80		N/A	N/A

Sport Fish Species 2						
R-0902130010-01	Smallmouth Bass	395	900		N/A	N/A
Bottom Feeder Species 1						
R-0902130011-01	Common Carp	720	4900		N/A	N/A
R-0902130011-02		637	3500		N/A	N/A
Bottom Feeder Species 2						
R-0902130012-01	Yellow Bullhead Catfish	250	240		N/A	N/A
R-0902130012-02		222	190		N/A	N/A
R-0902130012-03		220	180		N/A	N/A

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
R-0808270037	Rock Bass	169	79		9/16/2008	3
R-0808270038	Rock Bass	180	110		9/16/2008	3
R-0808270039	Rock Bass	159	73		9/16/2008	3
R-0808270040	Rock Bass	173	102		9/16/2008	3
R-0808270041	Rock Bass	165	81		9/16/2008	3
R-0808270042	Rock Bass	164	81		9/16/2008	3
R-0808270043	Rock Bass	170	102		9/16/2008	3
R-0808270044	Rock Bass	175	105		9/16/2008	3
R-0808270045	Rock Bass	165	82		9/16/2008	3
R-0808270046	Rock Bass	157	83		9/16/2008	3
R-0808270047	Rock Bass	184	122		9/16/2008	3
R-0808270048	Rock Bass	181	104	Lesion	9/16/2008	3

2008 Fish Tissue Study Sample Form						
Date:	9/5/2008					
Location:	Cuyahoga River Upstream of Akron- Ohio Edison Dam Pool (FTCS-02)					
Collection Method:	Boat Electrofishing					
Names of Samplers:	Carbonaro, Hothem, Maichle, Roff, Zablotny, Aman, Fry, Hillman					
Weather:	Partly Cloudy 75°					
Comments:						
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
R-0808280002-01	Largemouth Bass	325	442		10/30/2008	4
R-0808280002-02		285	292			3
R-0808280002-03		285	314			3
R-0808280002-04		315	420			4
R-0808280002-05		280	272			3

Sport Fish Species 2						
R-0808280003-01	Black Crappie	215	126		10/30/2008	2
R-0808280003-02		190	90			3
R-0808280003-03		180	77			2

Bottom Feeder Species 1						
R-0808280004-01	Common Carp	510	1470		10/31/2008	7
R-0808280004-02		550	1750			8
R-0808280004-03		560	2020			8
R-0808280004-04		570	1920			10
R-0808280004-05		555	1980			8

Bottom Feeder Species 2						
R-0808280005-01	Channel Catfish	610	1550		10/30/2008	N/A

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
R-0808280006	Northern Bluegill Sunfish	175	95			3
R-0808280007	Northern Bluegill Sunfish	170	89		9/30/2008	2
R-0808280008	Northern Bluegill Sunfish	170	84			6
R-0808280009	Northern Bluegill Sunfish	170	84			4
R-0808280010	Northern Bluegill Sunfish	170	85			4
R-0808280011	Northern Bluegill Sunfish	150	61			3
R-0808280012	Northern Bluegill Sunfish	160	72		9/30/2008	3
R-0808280013	Northern Bluegill Sunfish	160	59			3
R-0808280014	Northern Bluegill Sunfish	160	70			3
R-0808280015	Northern Bluegill Sunfish	155	56			2
R-0808280016	Northern Bluegill Sunfish	150	64		9/30/2008	4
R-0808280017	Northern Bluegill Sunfish	150	58			3

2008 Fish Tissue Study Sample Form						
Date:	8/26/2008					
Location:	Cuyahoga River Upstream of Akron WWTP (FTCS-03)					
Collection Method:	Boat Electrofishing					
Names of Samplers:	Smith					
Weather:						
Comments:	Sampling conducted by Ohio EPA					
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Species 1						
R-0902130001	Smallmouth Bass	352	600			
		360	650			
		395	700			
Sport Fish Species 2						
R-0902130003	Smallmouth Bass	307	400			
Bottom Feeder Species 1						
R-0902130002	Yellow Bullhead Catfish	255	250			
		270	295			
		230	185			

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
R-0808250039	Smallmouth Bass	270	260		9/15/2008	N/A
R-0808250040	Smallmouth Bass	260	220		9/15/2008	N/A
R-0808250041	Smallmouth Bass	255	225		9/15/2008	N/A
R-0808250042	Northern Rock Bass	202	280		9/15/2008	N/A
R-0808250043	Green Sunfish	122	40		9/15/2008	N/A
R-0808250044	Green Sunfish	120	40		9/15/2008	N/A
R-0808250045	Green Sunfish	125	40		9/12/2008	N/A
R-0808250046	Pumpkinseed Sunfish	100	15		9/12/2008	N/A
R-0808250047	Northern Bluegill Sunfish	125	40		9/12/2008	N/A
R-0808250048	Northern Bluegill Sunfish	115	20		9/12/2008	N/A
R-0808250049	Northern Bluegill Sunfish	112	20		9/12/2008	N/A
R-0808250050	Northern Bluegill Sunfish	105	25		9/12/2008	N/A

2008 Fish Tissue Study Sample Form						
Date:	8/20/08, 9/5/2008					
Location:	Cuyahoga River @ Bolanz Road (FTCS-04)					
Collection Method:	Boat Electrofishing					
Names of Samplers:	Smith/Carbonaro, Hothem, Maichle, Roff, Zablotny, Aman, Fry, Hillman					
Weather:	Cloudy					
Comments:	Composites collected by NEORSD & Ohio EPA					
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
R-0808290004-01	Smallmouth Bass	300	320		10/31/2008	3
R-0808290004-02		315	392			4
R-0808290004-03		295	334			5
R-0808290004-04		276	280			3
Sport Fish Species 2 (Ohio EPA)						
R-0902130015-01	Rock Bass	218	218		N/A	N/A
R-0902130015-02		205	185		N/A	N/A
R-0902130015-03		210	200		N/A	N/A
Sport Fish Species 3 (Ohio EPA)						
R-0902130016	Smallmouth Bass	410	900		N/A	N/A

Bottom Feeder Species 1						
R-0808290006-01	Common White Sucker	297	277		10/31/2008	1
R-0808290006-02		305	296			2
R-0808290006-03		338	374			2
R-0808290006-04		305	298			2
R-0808290006-05		307	317			2

Bottom Feeder Species 2						
R-0808290007-01	Northern Hog Sucker	250	185		10/31/2008	2
R-0808290007-02		239	174			2
R-0808290007-03		250	178			2
R-0808290007-04		236	157			2
R-0808290007-05		272	226			2

Bottom Feeder Species 3 (Ohio EPA)						
R-0902130017-01	Yellow Bullhead Catfish	247	250		N/A	N/A
R-0902130017-02		210	125		N/A	N/A
R-0902130017-03		185	105		N/A	N/A
R-0902130017-04		200	120		N/A	N/A

Bottom Feeder Species 4 (Ohio EPA)						
R-0902130018-01	Common Carp	605	3400		N/A	N/A
R-0902130018-02		605	3650		N/A	N/A
R-0902130018-03		612	3400		N/A	N/A

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
R-0808290008	Smallmouth Bass	256	208		9/17/2008	3
R-0808290009	Smallmouth Bass	255	218		9/17/2008	4
R-0808290010	Smallmouth Bass	195	96		9/16/2008	2
R-0808290011	Smallmouth Bass	166	45		9/16/2008	1
R-0808290012	Smallmouth Bass	170	57		Sample lost	
R-0808290013	Smallmouth Bass	170	53		9/17/2008	1
R-0808290014	White Perch	170	72		9/17/2008	2
R-0808290015	White Perch	188	100		9/17/2008	2
R-0808290016	Northern Rock Bass	180	125		9/16/2008	3
R-0808290017	Northern Bluegill Sunfish	130	46		9/16/2008	2
R-0808290018	Green Sunfish	140	61		9/16/2008	2
R-0808290019	Pumpkinseed Sunfish	137	55		9/16/2008	2

2008 Fish Tissue Study Sample Form						
Date:	8/25/2008					
Location:	Cuyahoga River Near Route 82 (FTCS-05)					
Collection Method:	Boat Electrofishing					
Names of Samplers:	Smith					
Weather:						
Comments:	Sampling conducted by Ohio EPA					
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
R-0902130006-01	Smallmouth Bass	386	900		N/A	N/A
		326	480		N/A	N/A
Sport Fish Species 2						
R-0902130008-01	Rock Bass	238	300		N/A	N/A
		220	240		N/A	N/A
Bottom Feeder Species 1						
R-090213004-01	Yellow Bullhead Catfish	284	400		N/A	N/A
		300	500		N/A	N/A
		270	350		N/A	N/A
Bottom Feeder Species 2						
R-0902130005-01	Channel Catfish	380	500		N/A	N/A
Bottom Feeder Species 3						
R-0902130007-01	Common Carp	620	3550		N/A	N/A
		625	3350		N/A	N/A
		600	3350		N/A	N/A

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
R-0808250027	Smallmouth Bass	292	330		9/15/2008	N/A
R-0808250028	Smallmouth Bass	280	295		9/15/2008	N/A
R-0808250029	Northern Rock Bass	125	182		9/15/2008	N/A
R-0808250030	Northern Bluegill Sunfish	120	40		9/15/2008	N/A
R-0808250031	Northern Bluegill Sunfish	112	40		9/15/2008	N/A
R-0808250032	Northern Bluegill Sunfish	100	30		9/15/2008	N/A
R-0808250033	Northern Bluegill Sunfish	105	25		9/15/2008	N/A
R-0808250034	Green Sunfish	151	80		9/15/2008	N/A
R-0808250035	Green Sunfish	121	40		9/15/2008	N/A
R-0808250036	Green Sunfish	112	35		9/15/2008	N/A
R-0808250037	Green Sunfish	110	35		9/15/2008	N/A
R-0808250038	Green Sunfish	104	30		9/15/2008	N/A

2008 Fish Tissue Study Sample Form	
Date:	10/7/2008
Location:	Cuyahoga River at Southwest Interceptor (FTCS-06)
Collection Method:	Boat Electrofishing
Names of Samplers:	Carbonaro, Hothem, Maichle, Rhoades, Zablotny
Weather:	Sunny, 65°
Comments:	

Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
R-0809020026-01	Smallmouth Bass	280	300		10/23/2008	3
R-0809020026-02		281	332			5
R-0809020026-03		270	274			3
Sport Fish Species 2						
R-0809020027-01	Freshwater Drum	360	470		10/23/2008	7
R-0809020027-02		330	500			3
Bottom Feeder Species 1						
R-0809020028-01	Common Carp	440	1800	Deformity	10/23/2008	7
R-0809020028-02		530	2550			7
Bottom Feeder Species 2						
R-0809020029-01	Channel Catfish	560	2600	Erosion	10/23/2008	N/A
R-0809020029-02		560	2100			N/A

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
R-0809020030	Smallmouth Bass	350	620		10/21/2008	5
R-0809020031	Smallmouth Bass	332	562		10/29/2008	4
R-0809020032	Smallmouth Bass	300	422		10/23/2008	N/A
R-0809020033	Smallmouth Bass	270	282		10/29/2008	3
R-0809020034	Smallmouth Bass	200	120		10/21/2008	3
R-0809020035	Smallmouth Bass	182	100		10/21/2008	2
R-0809020036	Smallmouth Bass	184	92		10/21/2008	1
R-0809020037	Smallmouth Bass	190	100		10/23/2008	2
R-0809020038	Smallmouth Bass	182	84		10/21/2008	2
R-0809020039	Northern Rock Bass	200	180		10/21/2008	5

2008 Fish Tissue Study Sample Form

Date:	10/14/2008
Location:	Cuyahoga River Navigation Channel (FTCS-07)
Collection Method:	Boat Electrofishing
Names of Samplers:	Hothem, Maichle, Zablotny
Weather:	Cloudy, 70°
Comments:	

Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
R-0809020042-01	Largemouth Bass	365	672		10/20/2008	4
R-0809020042-02		352	641			4
Sport Fish Species 1						
R-0809020043-01	Smallmouth Bass	285	323		10/20/2008	3
Bottom Feeder Species 1						
R-0809020044-01	Common Carp	509	2430		10/20/2008	7
R-0809020044-02		527	2200			6
R-0809020044-03		521	2320			5
Bottom Feeder Species 2						
R-0809020045-01	Common White Sucker	307	314		10/20/2008	2
R-0809020045-02		285	254			1

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
R-0809020046	Largemouth Bass	241	194		10/20/2008	2
R-0809020047	Largemouth Bass	296	328		10/20/2008	5
R-0809020048	Largemouth Bass	258	248		10/20/2008	3
R-0809020049	Largemouth Bass	228	181		10/23/2008	3
R-0809020050	Largemouth Bass	206	132		10/17/2008	2
R-0809020051	Largemouth Bass	243	217		10/20/2008	2
R-0809020052	Largemouth Bass	220	155		10/20/2008	3
R-0809020053	Largemouth Bass	219	144		10/20/2008	2
R-0809020054	Largemouth Bass	209	127		10/20/2008	2
R-0809020055	Smallmouth Bass	212	120		10/20/2008	1
R-0809020056	Smallmouth Bass	198	98		10/20/2008	1
R-0809020057	Northern Rock Bass	229	256		10/20/2008	4

2008 Fish Tissue Study Sample Form						
Date:	9/26/2008					
Location:	Lake Erie West Harbor (FTCS-08)					
Collection Method:	Boat Electrofishing					
Names of Samplers:	Hothem, Rhoades, Zablotny					
Weather:	Partly Cloudy					
Comments:						
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
L-0809020001-01	Largemouth Bass	350	650		10/28/2008	4
L-0809020001-02		344	720			5
L-0809020001-04		362	710			4
L-0809020001-05		375	1000			4
Sport Fish Species 2						
L-0809020002-01	North Rock Bass	240	312		10/27/2008	5
L-0809020002-02		231	351			6
L-0809020002-03		230	281			4
Bottom Feeder Species 1						
L-0809020003-01	Common Carp	612	3520		10/28/2008	10
L-0809020003-02		650	3810			7
L-0809020003-03		600	3170			6
Bottom Feeder Species 2						
L-0809020004-01	Spotted Sucker	384	782		10/28/2008	3
L-0809020004-02		404	854			3
L-0809020004-03		412	1000			3
L-0809020004-04		410	872			3
L-0809020004-05		390	850			3

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
L-0809020005	Largemouth Bass	310	540		10/28/2008	4
L-0809020006	Largemouth Bass	314	550		10/28/2008	2
L-0809020007	Largemouth Bass	300	454		10/28/2008	3
L-0809020008	Largemouth Bass	310	510		10/27/2008	2
L-0809020009	Largemouth Bass	272	348		10/29/2008	3
L-0809020010	Largemouth Bass	262	338		10/28/2008	2
L-0809020011	Largemouth Bass	282	462		10/28/2008	4
L-0809020012	Largemouth Bass	264	300		10/28/2008	3
L-0809020013	Largemouth Bass	260	310		10/28/2008	4
L-0809020014	Largemouth Bass	270	350		10/28/2008	5
L-0809020015	Largemouth Bass	258	272		10/27/2008	3
L-0809020016	Largemouth Bass	310	472		10/28/2008	3

2008 Fish Tissue Study Sample Form						
Date:	9/26/2008					
Location:	Lake Erie East Harbor (FTCS-09)					
Collection Method:	Boat Electrofishing					
Names of Samplers:	Hothem, Rhoades, Zablotny					
Weather:	Sunny, 75°					
Comments:						
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
L-0809020017-01	Steelhead Trout	590	2200		10/27/2008	4
L-0809020017-02		630	3150			3
Sport Fish Species 2						
L-0809020018-01	Largemouth Bass	242	212		10/27/2008	4
L-0809020018-02		222	162			4
L-0809020018-03		218	162	Deformed tail		3
Bottom Feeder Species 1						
L-0809020019-01	Common Carp	600	3420		10/24/2008	9
L-0809020019-02		622	3200			8
L-0809020019-03		620	3340			8
Bottom Feeder Species 2						
L-0809020020-01	Spotted Sucker	418	1000		10/24/2008	3
L-0809020020-02		440	1080			2
L-0809020020-03		426	1100			6
L-0809020020-04		418	1000			3

Whole Body Samples						
Sample #	Species	Length (mm)	Weight (g)	DELTs	Processed	Age
Sport Fish Species						
L-0909020021	Largemouth Bass	268	262		10/27/2008	5
L-0909020022	Largemouth Bass	270	310		10/27/2008	5
L-0909020023	Largemouth Bass	250	250		10/27/2008	4
L-0909020024	Northern Bluegill Sunfish	111	20		10/27/2008	2
L-0909020025	Pumpkinseed Sunfish	98	12		10/27/2008	2
L-0909020026	Bluegill x Pumpkinseed Sunfish	98	10		10/27/2008	2
L-0909020027	Northern Rock Bass	120	20		10/27/2008	1

2008 Fish Tissue Study Sample Form

Date:	10/13/2008
Location:	Lake Erie Eastlake (FTCS-10)
Collection Method:	Boat Electrofishing
Names of Samplers:	Carbonaro, Hothem, Rhoades, Rivera
Weather:	Sunny, 70°
Comments:	

Composite Fillet Samples						
Sample #	Species	Length (mm)	Weight (g)	DELTs	Processed	Age
Sport Fish Species 1						
L-0809020033-01	Largemouth Bass	376	816		10/17/2008	5
L-0809020033-02		375	810			7
L-0809020033-03		396	1080			6
Sport Fish Species 2						
L-0809020034-01	Northern Rock Bass	205	190		10/17/2008	4
L-0809020034-02		198	170			7
L-0809020034-03		198	192			6
L-0809020034-04		195	158			7
Bottom Feeder Species 1						
L-0809020035-01	Common Carp	560	2240		10/17/2008	10
L-0809020035-02		525	1940			7
L-0809020035-03		547	2200			9
Bottom Feeder Species 2						
L-0809020036-01	Golden Redhorse	418	828		10/17/2008	6
L-0809020036-02		394	872			7
L-0809020036-03		390	646			6

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
L-0809020037	Largemouth Bass	272	310		10/16/2008	5
L-0809020038	Largemouth Bass	284	342	Lesion	10/16/2008	6
L-0809020039	Largemouth Bass	275	296		10/16/2008	4
L-0809020040	Largemouth Bass	273	322		10/16/2008	3
L-0809020041	Largemouth Bass	321	580		10/16/2008	7
L-0809020042	Largemouth Bass	280	304		10/16/2008	4
L-0809020043	Largemouth Bass	265	272		10/16/2008	6
L-0809020044	Largemouth Bass	275	320		10/16/2008	4
L-0809020045	Largemouth Bass	250	220		10/31/2008	5
L-0809020046	Largemouth Bass	247	230		10/17/2008	7
L-0809020047	Largemouth Bass	240	178		10/16/2008	5
L-0809020048	Largemouth Bass	235	188		10/31/2008	3

2008 Fish Tissue Study Sample Form						
Date:	10/8/2008					
Location:	Lake Erie off Wildwood (FTCS-11)					
Collection Method:	Boat Electrofishing					
Names of Samplers:	Hothem, Rhoades, Zablotny					
Weather:	Rain					
Comments:						
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
L-0809250016-01	Steelhead Trout	585	2200		10/30/2008	2
L-0809250016-02		635	2450			4
Sport Fish Species 2						
L-0809250017-01	Smallmouth Bass	392	1175		10/29/2008	8
L-0809250017-02		415	1250			4
Bottom Feeder Species 1						
L-0809250018-02	Brown Bullhead	300	430			4
L-0809250018-03		300	420			4
L-0809250018-04		322	518			4
L-0809250018-05		320	590			4

Bottom Feeder Species 2						
L-0809250019-01	Brown Bullhead	315	450		10/29/2008	4
L-0809250019-02		310	390			4
L-0809250019-03		311	410			4
L-0809250019-05		345	530			4

Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
L-0809250020	Largemouth Bass	375	850		10/30/2008	6
L-0809250021	Largemouth Bass	290	380		10/29/2008	4
L-0809250022	Largemouth Bass	305	430		10/30/2008	8
L-0809250023	Largemouth Bass	285	390		10/30/2008	5
L-0809250024	Largemouth Bass	285	410		10/30/2008	5
L-0809250025	Largemouth Bass	285	380		10/29/2008	3
L-0809250026	Largemouth Bass	270	300		10/30/2008	4
L-0809250027	Largemouth Bass	255	278		10/29/2008	3
L-0809250028	Largemouth Bass	238	200		10/29/2008	4
L-0809250029	Largemouth Bass	235	170		10/29/2008	6
L-0809250030	Largemouth Bass	220	180		10/29/2008	4
L-0809250031	Largemouth Bass	195	100		10/30/2008	4

2008 Fish Tissue Study Sample Form

Date:	10/13/2008
Location:	Lake Erie off Lakewood (FTCS-12)
Collection Method:	Boat Electrofishing
Names of Samplers:	Carbonaro, Hothem, Rhoades, Rivera
Weather:	Sunny, 80°
Comments:	

Composite Fillet Samples

Sample #	Species	Length (mm)	Weight (g)	DELTs	Processed	Age
Sport Fish Species 1						
L-0809250001-01	Smallmouth Bass	382	1260		10/24/2008	5
L-0809250001-02		400	1120			4
L-0809250001-03		395	1080			5
Sport Fish Species 2						
L-0809250002-01	Largemouth Bass	355	710		10/24/2008	7
L-0809250002-02		370	802			6
L-0809250002-03		350	678			7
Bottom Feeder Species 1						
L-0809250003-01	Freshwater Drum	405	528	Lesion		6
L-0809250003-02		435	780			10
Bottom Feeder Species 2						
L-0809250004-01	Common Carp	475	1580		10/29/2008	7
L-0809250004-02		465	1360			4
L-0809250004-03		488	1620			5

Whole Body Samples

Sample #	Species	Length (mm)	Weight (g)	DELTs	Processed	Age
Sport Fish Species						
L-0809250005	Largemouth Bass	258	246	Lesion	10/29/2008	6
L-0809250006	Largemouth Bass	257	296		10/23/2008	4
L-0809250007	Largemouth Bass	280	360		10/24/2008	4
L-0809250008	Largemouth Bass	254	242		10/24/2008	5
L-0809250009	Largemouth Bass	263	320		10/29/2008	6
L-0809250010	Largemouth Bass	250	238		10/23/2008	6
L-0809250011	Largemouth Bass	266	268		10/24/2008	6
L-0809250012	Largemouth Bass	243	206		10/24/2008	4
L-0809250013	Largemouth Bass	284	372		10/24/2008	5
L-0809250014	Largemouth Bass	278	380		10/23/2008	6
L-0809250015	Largemouth Bass	277	326		10/24/2008	5
L-0809250032	Largemouth Bass	265	300		10/29/2008	5

2008 Fish Tissue Study Sample Form						
Date:	9/11/2008					
Location:	Chagrin River at Daniels Park (FTCS-13)					
Collection Method:	Longline Electrofishing					
Names of Samplers:	Hothem, Maichle, Rhoades, Zablotny					
Weather:	Sunny, 65°					
Comments:						
Composite Fillet Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species 1						
R-0809100025-01	Smallmouth Bass	275	240		10/31/2008	5
R-0809100025-02		301	328			6
Bottom Feeder 1						
R-0809100027-01	Golden Redhorse	371	540		10/31/2008	4
R-0809100027-02		364	481			5
R-0809100027-03		375	522			4
R-0809100027-04		350	441			3
R-0809100027-05		365	461			5
Bottom Feeder 2						
R-0809100028-01	Northern Hog Sucker	251	166		10/31/2008	3
R-0809100028-02		242	164			3
R-0809100028-03		252	187			3
R-0809100028-04		253	173			3
R-0809100028-05		236	158			2
Whole Body Samples						
Sample #	**Species**	**Length (mm)**	**Weight (g)**	**DELTs**	**Processed**	**Age**
Sport Fish Species						
R-0809100029	Smallmouth Bass	222	125		10/2/2008	4
R-0809100030	Smallmouth Bass	184	67		10/2/2008	1
R-0809100031	Smallmouth Bass	178	68		10/2/2008	2
R-0809100032	Northern Rock Bass	199	154		9/30/2008	8
R-0809100033	Smallmouth Bass	200	194		10/2/2008	2
R-0809100034	Smallmouth Bass	202	101		9/30/2008	4
R-0809100035	Smallmouth Bass	227	143		10/2/2008	4

Appendix B. Comparison of mercury duplicate and split samples

In order to evaluate the precision of the mercury analysis, split samples were analyzed by each of the laboratories. Approximately 10% of the composite fillet and whole-body samples were submitted to NEORSD's Analytical Services Department as blind duplicates. The duplicate samples were made by splitting the homogenized powder that was prepared by blending of the fish tissue samples. The precision of the analysis was measured using relative percent difference (RPD). For this type of analysis, a RPD of 20% is considered statistically acceptable. Any result over this value is investigated to determine the reason for the disparity. The exception to this is when the results are less than ten times the practical quantitation limits (PQL). In these instances, larger relative difference percentages are considered acceptable due to the relatively small quantities that are being measured.

As shown in Table 1, the RPD between each pair of duplicate samples analyzed by NEORSD except for one was below the acceptance limit of 20%. The one instance in which the RPD was greater occurred in a smallmouth bass sample from the site in Lake Erie off of Lakewood. The most likely reason for the higher difference between this set of duplicate samples is that the result for one of the samples was approximately ten times the PQL of 0.010 mg/Kg.

Table 1. NEORSD Mercury Duplicate Sample Comparison

NEORSD Sample ID	Sample Point	Fish Species	Mercury Result (mg/Kg)	Duplicate Mercury Result (mg/kg)	Relative Percent Difference
L-0809020003	Lake Erie West Harbor	Common Carp	0.105	0.116	10.0
L-0809020008		Largemouth Bass	0.056	0.050	11.3
L-0809020009		Largemouth Bass	0.083	0.084	1.2
L-0809020017	Lake Erie East Harbor	Steelhead Trout	0.122	0.107	13.1
L-0809020023		Largemouth Bass	0.038	0.040	5.1
L-0809250001	Lake Erie off Lakewood	Smallmouth Bass	0.145	0.101	**35.8**
L-0809250009		Largemouth Bass	0.081	0.077	5.1
L-0809020041	Lake Erie off Eastlake	Largemouth Bass	0.062	0.062	0.0
L-0809020046		Largemouth Bass	0.095	0.080	17.1
L-0809250026	Lake Erie off Wildwood Park	Largemouth Bass	0.056	0.050	11.3
R-0808290004	Cuyahoga River DS of Akron WWTP	Smallmouth Bass	0.101	0.090	11.5
R-0809100028	Chagrin River at Daniels Park	Northern Hog Sucker	0.119	0.126	5.7

As another means of measuring precision, split samples were sent to TestAmerica and received by NEORSD's Analytical Services Department from Ohio EPA's Division of Environmental Services. The samples that were submitted to TestAmerica were from the Lake Erie East and West Harbor sites. These samples were chosen because the results from the 2005 study indicated much higher mercury levels at those locations compared to the other sites that were sampled. The split samples received by NEORSD's Analytical Services Department from Ohio EPA were from the Cuyahoga River and were being monitored as part of the Ohio Sport Fish Consumption Advisory Program. There were five instances in which the RPD between samples analyzed by NEORSD and TestAmerica were greater than 20% (Table 2) and two instances in which the same occurred between NEORSD and Ohio EPA results (Table 3). For all of these samples, the results obtained were less than ten times the PQL and, therefore, do not warrant further investigation. Based on all of the results, it appears that a high level of precision was achieved by each of the laboratories involved in analysis of the samples for this study.

Table 2. Comparison between NEORSD and TestAmerica mercury results

NEORSD Sample ID	Sample Point	Fish Species	NEORSD Mercury (mg/Kg)	TestAmerica Mercury (mg/Kg)	Relative Percent Difference
L-0809020001	Lake Erie West Harbor	Largemouth Bass	0.157	0.16	1.9
L-0809020002		Rock Bass	0.148	0.13	12.9
L-0809020003		Common Carp	0.111	0.11	0.5
L-0809020004		Spotted Sucker	0.032	0.026	**20.7**
L-0809020005		Largemouth Bass	0.074	0.079	6.5
L-0809020006		Largemouth Bass	0.070	0.056	**22.2**
L-0809020007		Largemouth Bass	0.062	0.065	4.7
L-0809020008		Largemouth Bass	0.053	0.057	7.3
L-0809020009		Largemouth Bass	0.084	0.083	0.6
L-0809020010		Largemouth Bass	0.087	0.081	7.1
L-0809020011		Largemouth Bass	0.064	0.06	6.5
L-0809020012		Largemouth Bass	0.050	0.057	13.1
L-0809020013		Largemouth Bass	0.060	0.062	3.3
L-0809020014		Largemouth Bass	0.070	0.066	5.9
L-0809020015		Largemouth Bass	0.058	0.058	0.0
L-0809020016		Largemouth Bass	0.070	0.083	17.0
L-0809020017	Lake Erie East Harbor	Steelhead Trout	0.115	0.10	13.5
L-0809020018		Largemouth Bass	0.060	0.041	**37.6**
L-0809020019		Common Carp	0.158	0.15	5.2
L-0809020020		Spotted Sucker	0.036	0.023	**42.7**
L-0809020021		Largemouth Bass	0.066	0.039	**50.7**
L-0809020022		Largemouth Bass	0.034	0.028	19.4
L-0809020023		Largemouth Bass	0.039	0.038	2.6
L-0809020024		Bluegill	0.018	0.019	5.4

Table 3. Comparison between NEORSD and Ohio EPA mercury results

NEORSD Sample ID	Sample Point	Fish Species	NEORSD Mercury mg/kg	Ohio EPA Mercury mg/kg	Relative Percent Difference
R-0902130009	Cuyahoga River at Shalersville	Rock Bass	0.117	0.127	8.2
R-0902130010		Smallmouth Bass	0.396	0.447	12.1
R-0902130011		Common Carp	0.246	0.23	6.7
R-0902130012		Yellow Bullhead	0.168	0.175	4.1
R-0902130001	Cuyahoga River US of Akron WWTP	Smallmouth Bass	0.180	0.188	4.3
R-0902130002		Yellow Bullhead	0.126	0.128	1.6
R-0902130003		Smallmouth Bass	0.112	0.134	17.9
R-0902130015	Cuyahoga River DS of Akron WWTP	Rock Bass	0.080	0.094	16.1
R-0902130016		Smallmouth Bass	0.204	0.203	0.5
R-0902130017		Yellow Bullhead	0.109	0.1	8.6
R-0902130018		Common Carp	0.068	0.055	**21.1**
R-0902130004	Cuyahoga River Upstream of Canal Diversion Dam	Yellow Bullhead	0.238	0.198	18.3
R-0902130005		Channel Catfish	0.048	0.036	**28.6**
R-0902130006		Smallmouth Bass	0.122	0.121	0.8
R-0902130007		Common Carp	0.115	0.095	19.0
R-0902130008		Rock Bass	0.192	0.181	5.9

Appendix C. Statistical Analysis Results

Total PCBs

Table 1. ANOVA for River AOC Total PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1295404.013	2	647702.006	3.968	0.023
Within Groups	1.306E7	80	163210.924		
Total	1.435E7	82			

Table 2. Multiple Comparisons- Fisher's Least Significant Difference for River AOC Total PCB Results

(I) River_AOC	(J) River_AOC	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1989-1992	2005	**293.21955***	116.09642	**0.014***	62.1803	524.2588
	2008	**213.03264***	101.19322	**0.038***	11.6517	414.4136
2005	1989-1992	**-293.21955***	116.09642	**0.014***	-524.2588	-62.1803
	2008	-80.18690	122.05013	0.513	-323.0744	162.7006
2008	1989-1992	**-213.03264***	101.19322	**0.038***	-414.4136	-11.6517
	2005	80.18690	122.05013	0.513	-162.7006	323.0744

*** The mean difference is significant at the 0.05 level.**

Table 3. ANOVA for River Reference Total PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	458.757	2	229.379	0.719	0.495
Within Groups	10210.811	32	319.088		
Total	10669.568	34			

Table 4. ANOVA for Lake AOC Total PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50054.274	2	25027.137	0.065	0.937
Within Groups	1.620E7	42	385654.853		
Total	1.625E7	44			

Table 5. ANOVA for Lake Reference Total PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1489021.932	2	744510.966	1.216	0.319
Within Groups	1.163E7	19	612334.318		
Total	1.312E7	21			

Table 6. ANOVA for 1989-1992 Study Total PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3677803.056	3	1225934.352	3.326	0.024
Within Groups	3.023E7	82	368612.354		
Total	3.390E7	85			

Table 7. Multiple Comparisons- Fisher's Least Significant Difference for 1989-1992 Study Total PCB Results

(I) Study_1989_1992	(J) Study_1989_1992	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	**457.24622***	171.35678	**0.009***	116.3630	798.1294
	Lake AOC	8.27053	163.45520	0.960	-316.8939	333.4350
	Lake Reference	-199.64753	236.72566	0.401	-670.5703	271.2752
River Reference	River AOC	**-457.24622***	171.35678	**0.009***	-798.1294	-116.3630
	Lake AOC	**-448.97568***	190.14667	**0.021***	-827.2380	-70.7134
	Lake Reference	**-656.89375***	255.88512	**0.012***	-1165.9308	-147.8567
Lake AOC	River AOC	-8.27053	163.45520	0.960	-333.4350	316.8939
	River Reference	**448.97568***	190.14667	**0.021***	70.7134	827.2380
	Lake Reference	-207.91807	250.66242	0.409	-706.5655	290.7293
Lake Reference	River AOC	199.64753	236.72566	0.401	-271.2752	670.5703
	River Reference	**656.89375***	255.88512	**0.012***	147.8567	1165.9308
	Lake AOC	207.91807	250.66242	0.409	-290.7293	706.5655

*** The mean difference is significant at the 0.05 level.**

Table 8. ANOVA for 2005 Study Total PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1364260.956	3	454753.652	2.720	0.057
Within Groups	6688367.333	40	167209.183		
Total	8052628.290	43			

Table 9. ANOVA for 2008 Study Total PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	841615.762	3	280538.587	3.591	0.020
Within Groups	3984360.265	51	78124.711		
Total	4825976.027	54			

Table 10. Multiple Comparisons- Fisher's Least Significant Difference for 2008 Study Total PCB Results

(I) Study_2008	(J) Study_2008	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	235.76786	118.11368	0.051	-1.3552	472.8910
	Lake AOC	-157.81310	96.43942	0.108	-351.4233	35.7971
	Lake Reference	145.35357	112.05247	0.200	-79.6012	370.3083
River Reference	River AOC	-235.76786	118.11368	0.051	-472.8910	1.3552
	Lake AOC	**-393.58095***	132.93256	**0.005***	-660.4542	-126.7077
	Lake Reference	-90.41429	144.65912	0.535	-380.8296	200.0010
Lake AOC	River AOC	157.81310	96.43942	0.108	-35.7971	351.4233
	River Reference	**393.58095***	132.93256	**0.005***	126.7077	660.4542
	Lake Reference	**303.16667***	127.57735	**0.021***	47.0444	559.2889
Lake Reference	River AOC	-145.35357	112.05247	0.200	-370.3083	79.6012
	River Reference	90.41429	144.65912	0.535	-200.0010	380.8296
	Lake AOC	**-303.16667***	127.57735	**0.021***	-559.2889	-47.0444

*** The mean difference is significant at the 0.05 level.**

Lipid-Normalized PCBs

Table 11. ANOVA for River AOC Lipid-Normalized PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	305855.925	2	152927.963	2.859	0.064
Within Groups	4012047.329	75	53493.964		
Total	4317903.254	77			

Table 12. ANOVA for River Reference Lipid-Normalized PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4007.620	2	2003.810	8.906	0.001
Within Groups	7200.172	32	225.005		
Total	11207.792	34			

Table 13. Multiple Comparisons- Fisher's Least Significant Difference for River Reference Lipid-Normalized PCB Results

(I) River_Reference	(J) River_Reference	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
1989-1992	2005	**-23.91628***	6.06984	**0.000**	-36.2801	-11.5524
	2008	**-17.27165***	6.63220	**0.014**	-30.7810	-3.7623
2005	1989-1992	**23.91628***	6.06984	**0.000**	11.5524	36.2801
	2008	6.64463	7.55938	0.386	-8.7533	22.0426
2008	1989-1992	**17.27165***	6.63220	**0.014**	3.7623	30.7810
	2005	-6.64463	7.55938	0.386	-22.0426	8.7533

*** The mean difference is significant at the 0.05 level.**

Table 14. ANOVA for Lake AOC Lipid-Normalized PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	92577.014	2	46288.507	1.922	0.159
Within Groups	1011413.084	42	24081.264		
Total	1103990.098	44			

Table 15. ANOVA for Lake Reference Lipid-Normalized PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	50976.034	2	25488.017	2.380	0.121
Within Groups	192751.791	18	10708.433		
Total	243727.825	20			

Table 16. ANOVA for 1989-1992 Study Lipid-Normalized PCB Results

Study_1989_1992_Lipid-Normalized PCBs

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1094825.020	3	364941.673	6.895	0.000
Within Groups	4287246.195	81	52928.965		
Total	5382071.215	84			

Table 17. Multiple Comparisons- Fisher's Least Significant Difference for 1989-1992 Study Lipid-Normalized PCB Results

(I) Study_1989_1992	(J) Study_1989_1992	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	**294.33192***	65.23790	**0.000**	164.5290	424.1349
	Lake AOC	80.62519	62.25842	0.199	-43.2495	204.4999
	Lake Reference	133.69408	89.92424	0.141	-45.2270	312.6151
River Reference	River AOC	**-294.33192***	65.23790	**0.000**	-424.1349	-164.5290
	Lake AOC	**-213.70674***	72.05274	**0.004**	-357.0691	-70.3444
	Lake Reference	-160.63784	96.96317	0.101	-353.5641	32.2884
Lake AOC	River AOC	-80.62519	62.25842	0.199	-204.4999	43.2495
	River Reference	**213.70674***	72.05274	**0.004**	70.3444	357.0691
	Lake Reference	53.06890	94.98412	0.578	-135.9197	242.0575
Lake Reference	River AOC	-133.69408	89.92424	0.141	-312.6151	45.2270
	River Reference	160.63784	96.96317	0.101	-32.2884	353.5641
	Lake AOC	-53.06890	94.98412	0.578	-242.0575	135.9197

*** The mean difference is significant at the 0.05 level.**

Table 18. ANOVA for 2005 Study Lipid-Normalized PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	121365.348	3	40455.116	3.764	0.019
Within Groups	376211.410	35	10748.897		
Total	497576.758	38			

Table 19. Multiple Comparisons- Fisher's Least Significant Difference for 2005 Study Lipid-Normalized PCB Results

(I) Study_2005	(J) Study_2005	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	**142.62655***	44.29560	**0.003**	52.7017	232.5514
	Lake AOC	62.23603	41.77261	0.145	-22.5669	147.0389
	Lake Reference	104.86129	54.01442	0.060	-4.7938	214.5164
River Reference	River AOC	**-142.62655***	44.29560	**0.003**	-232.5514	-52.7017
	Lake AOC	-80.39051	46.59930	0.093	-174.9921	14.2111
	Lake Reference	-37.76526	57.82821	0.518	-155.1628	79.6322
Lake AOC	River AOC	-62.23603	41.77261	0.145	-147.0389	22.5669
	River Reference	80.39051	46.59930	0.093	-14.2111	174.9921
	Lake Reference	42.62526	55.91916	0.451	-70.8967	156.1472
Lake Reference	River AOC	-104.86129	54.01442	0.060	-214.5164	4.7938
	River Reference	37.76526	57.82821	0.518	-79.6322	155.1628
	Lake AOC	-42.62526	55.91916	0.451	-156.1472	70.8967

*** The mean difference is significant at the 0.05 level.**

Table 20. ANOVA for 2008 Study Lipid-Normalized PCB Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	228611.493	3	76203.831	6.941	0.001
Within Groups	559954.771	51	10979.505		
Total	788566.263	54			

Table 21. Multiple Comparisons- Fisher's Least Significant Difference for 2008 Study Lipid-Normalized PCB Results

(I) Study_2008	(J) Study_2008	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	**152.56864***	44.27896	**0.001***	63.6749	241.4624
	Lake AOC	-30.77695	36.15362	0.399	-103.3584	41.8045
	Lake Reference	**112.14117***	42.00671	**0.010***	27.8092	196.4732
River Reference	River AOC	**-152.56864***	44.27896	**0.001***	-241.4624	-63.6749
	Lake AOC	**-183.34559***	49.83432	**0.001***	-283.3922	-83.2990
	Lake Reference	-40.42747	54.23042	0.459	-149.2996	68.4446
Lake AOC	River AOC	30.77695	36.15362	0.399	-41.8045	103.3584
	River Reference	**183.34559***	49.83432	**0.001***	83.2990	283.3922
	Lake Reference	**142.91812***	47.82674	**0.004***	46.9019	238.9343
Lake Reference	River AOC	**-112.14117***	42.00671	**0.010***	-196.4732	-27.8092
	River Reference	40.42747	54.23042	0.459	-68.4446	149.2996
	Lake AOC	**-142.91812***	47.82674	**0.004***	-238.9343	-46.9019

*** The mean difference is significant at the 0.05 level.**

Composite Fillet Mercury

Table 22. ANOVA for River AOC Composite-Fillet Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.045	2	0.023	1.955	0.148
Within Groups	0.901	78	0.012		
Total	0.946	80			

Table 23. ANOVA for River Reference Composite-Fillet Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.005	2	0.002	0.291	0.749
Within Groups	0.259	32	0.008		
Total	0.263	34			

Table 24. ANOVA for Lake AOC Composite-Fillet Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.013	2	0.506	26.663	0.000
Within Groups	0.817	43	0.019		
Total	1.830	45			

Table 25. Multiple Comparisons- Fisher's Least Significant Difference for Lake AOC Composite-Fillet Mercury Results

(I) Lake_AOC	(J) Lake_AOC	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
1989-1992	2005	**-0.34301***	0.04946	**0.000***	-0.4427	-0.2433
	2008	-0.01526	0.04946	0.759	-0.1150	0.0845
2005	1989-1992	**0.34301***	0.04946	**0.000***	0.2433	0.4427
	2008	**0.32775***	0.05626	**0.000***	0.2143	0.4412
2008	1989-1992	0.01526	0.04946	0.759	-0.0845	0.1150
	2005	**-0.32775***	0.05626	**0.000***	-0.4412	-0.2143

*** The mean difference is significant at the 0.05 level.**

Table 26. ANOVA for Lake Reference Composite-Fillet Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.041	2	0.020	1.255	0.309
Within Groups	0.291	18	0.016		
Total	0.331	20			

Table 27. ANOVA for 1989-1992 Study Composite-Fillet Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.155	3	0.052	8.470	0.000
Within Groups	0.499	82	0.006		
Total	0.654	85			

Table 28. Multiple Comparisons- Fisher's Least Significant Difference for 1989-1992 Study Composite-Fillet Mercury Results

(I) Study_1989_1992	(J) Study_1989_1992	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	**-0.08196***	0.02202	**0.000***	-0.1258	-0.0382
	Lake AOC	0.03513	0.02101	0.098	-0.0067	0.0769
	Lake Reference	-0.04278	0.03042	0.163	-0.1033	0.0177
River Reference	River AOC	**0.08196***	0.02202	**0.000***	0.0382	0.1258
	Lake AOC	**0.11710***	0.02444	**0.000***	0.0685	0.1657
	Lake Reference	0.03918	0.03288	0.237	-0.0262	0.1046
Lake AOC	River AOC	-0.03513	0.02101	0.098	-0.0769	0.0067
	River Reference	**-0.11710***	0.02444	**0.000***	-0.1657	-0.0685
	Lake Reference	-0.07792*	0.03221	0.018	-0.1420	-0.0138
Lake Reference	River AOC	0.04278	0.03042	0.163	-0.0177	0.1033
	River Reference	-0.03918	0.03288	0.237	-0.1046	0.0262
	Lake AOC	**0.07792***	0.03221	**0.018***	0.0138	0.1420

*** The mean difference is significant at the 0.05 level.**

Table 29. ANOVA for 2005 Study Composite-Fillet Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.445	3	0.148	5.288	0.004
Within Groups	1.095	39	0.028		
Total	1.540	42			

Table 29. Multiple Comparisons- Fisher's Least Significant Difference for 2005 Study Composite-Fillet Mercury Results

(I) Study_2005	(J) Study_2005	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	-0.04757	0.06906	0.495	-0.1873	0.0921
	Lake AOC	**-0.24571***	0.06317	**0.000***	-0.3735	-0.1179
	Lake Reference	-0.07879	0.08523	0.361	-0.2512	0.0936
River Reference	River AOC	0.04757	0.06906	0.495	-0.0921	0.1873
	Lake AOC	**-0.19814***	0.07388	**0.011***	-0.3476	-0.0487
	Lake Reference	-0.03122	0.09345	0.740	-0.2202	0.1578
Lake AOC	River AOC	**0.24571***	0.06317	**0.000***	0.1179	0.3735
	River Reference	**0.19814***	0.07388	**0.011***	0.0487	0.3476
	Lake Reference	0.16692	0.08918	0.069	-0.0135	0.3473
Lake Reference	River AOC	0.07879	0.08523	0.361	-0.0936	0.2512
	River Reference	0.03122	0.09345	0.740	-0.1578	0.2202
	Lake AOC	-0.16692	0.08918	0.069	-0.3473	0.0135

*** The mean difference is significant at the 0.05 level.**

Table 30. ANOVA for 2008 Study Composite-Fillet Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.055	3	0.018	1.367	0.264
Within Groups	0.673	50	0.013		
Total	0.728	53			

Whole Body Mercury

Table 31. Group Statistics for River AOC Whole-Body Mercury Results

	River_AOC	N	Mean	Std. Deviation	Std. Error Mean
River_AOC_Whole_Body_Mercury	2005	40	0.0801	0.04335	0.00685
	2008	68	0.0532	0.02012	0.00244

Table 32. Independent Samples Test for River AOC Whole-Body Mercury Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
River_AOC_Whole_Body_Mercury	Equal variances assumed	13.580	0.000	4.386	106	0.000	0.02690	0.00613	0.01474	0.03906
	Equal variances not assumed			3.698	49.055	0.001	0.02690	0.00728	0.01228	0.04153

Table 33. Group Statistics for River Reference Whole-Body Mercury Results

	River_Reference	N	Mean	Std. Deviation	Std. Error Mean
River_Reference_Whole_Body_Mercury	2005	20	0.1164	0.05035	0.01126
	2008	19	0.0823	0.02742	0.00629

Table 34. Independent Samples Test for River Reference Whole-Body Mercury Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
River_Reference_Whole_Body_Mercury	Equal variances assumed	5.059	0.031	2.603	37	**0.013**	0.03406	0.01308	0.00755	0.06057
	Equal variances not assumed			2.641	29.664	**0.013**	0.03406	0.01290	0.00771	0.06041

Table 35. Group Statistics for Lake AOC Whole-Body Mercury Results

	Lake_AOC	N	Mean	Std. Deviation	Std. Error Mean
Lake_AOC_Whole_Body_Mercury	2005	33	0.1419	0.09644	0.01679
	2008	31	0.0563	0.01969	0.00354

Table 36. Independent Samples Test for Lake AOC Whole-Body Mercury Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Lake_AOC_Whole_Body_Mercury	Equal variances assumed	35.989	0.000	4.846	62	0.000	0.08561	0.01766	0.05029	0.12092
	Equal variances not assumed			4.990	34.829	0.000	0.08561	0.01716	0.05077	0.12044

Table 37. Group Statistics for Lake Reference Whole-Body Mercury Results

	Lake_Reference	N	Mean	Std. Deviation	Std. Error Mean
Lake_Reference_Whole_Body_Mercury	2005	19	0.1565	0.06594	0.01513
	2008	24	0.0679	0.01280	0.00261

Table 38. Independent Samples Test for Lake Reference Whole-Body Mercury Results

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Lake_Reference_Whole_Body_Mercury	Equal variances assumed	19.290	0.000	6.455	41	0.000	0.08867	0.01374	0.06093	0.11641
	Equal variances not assumed			5.776	19.077	0.000	0.08867	0.01535	0.05655	0.12080

Table 39. ANOVA for 2005 Study Whole-Body Mercury Results

Study_2005_Whole_Body_Mercury

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.105	3	0.035	7.567	0.000
Within Groups	0.497	108	0.005		
Total	0.602	111			

Table 40. Multiple Comparisons- Fisher's Least Significant Difference for 2005 Study Whole-Body Mercury Results

(I) Study_2005	(J) Study_2005	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	-0.03629	0.01858	0.053	-0.0731	0.0005
	Lake AOC	**-0.06178***	0.01596	**0.000***	-0.0934	-0.0301
	Lake Reference	**-0.07644***	0.01891	**0.000***	-0.1139	-0.0390
River Reference	River AOC	0.03629	0.01858	0.053	-0.0005	0.0731
	Lake AOC	-0.02549	0.01923	0.188	-0.0636	0.0126
	Lake Reference	-0.04015	0.02174	0.068	-0.0832	0.0029
Lake AOC	River AOC	**0.06178***	0.01596	**0.000***	0.0301	0.0934
	River Reference	0.02549	0.01923	0.188	-0.0126	0.0636
	Lake Reference	-0.01466	0.01954	0.455	-0.0534	0.0241
Lake Reference	River AOC	**.07644***	0.01891	**0.000***	0.0390	0.1139
	River Reference	.04015	0.02174	0.068	-0.0029	0.0832
	Lake AOC	.01466	0.01954	0.455	-0.0241	0.0534

*** The mean difference is significant at the 0.05 level.**

Table 41. ANOVA for 2008 Study Whole-Body Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.015	3	0.005	11.920	0.000
Within Groups	0.056	138	0.000		
Total	0.071	141			

Table 42. Multiple Comparisons- Fisher's Least Significant Difference for 2008 Study Whole-Body Mercury Results

(I) Study_2008	(J) Study_2008	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
River AOC	River Reference	**-0.02913***	0.00523	**0.000***	-0.0395	-0.0188
	Lake AOC	-0.00307	0.00437	0.483	-0.0117	0.0056
	Lake Reference	**-0.01467***	0.00479	**0.003***	-0.0241	-0.0052
River Reference	River AOC	**0.02913***	0.00523	**0.000***	0.0188	0.0395
	Lake AOC	**0.02606***	0.00587	**0.000***	0.0144	0.0377
	Lake Reference	**0.01446***	0.00619	**0.021***	0.0022	0.0267
Lake AOC	River AOC	0.00307	0.00437	0.483	-0.0056	0.0117
	River Reference	**-0.02606***	0.00587	**0.000***	-0.0377	-0.0144
	Lake Reference	**-0.01160***	0.00548	**0.036***	-0.0224	-0.0008
Lake Reference	River AOC	**0.01467***	0.00479	**0.003***	0.0052	0.0241
	River Reference	**-0.01446***	0.00619	**0.021***	-0.0267	-0.0022
	Lake AOC	**0.01160***	0.00548	**0.036***	0.0008	0.0224

*** The mean difference is significant at the 0.05 level.**

Table 43. ANOVA for 2008 Cuyahoga River Whole-Body Mercury Results

Cuyahoga_Site_2008_Whole_Body_Mercury

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.026	7	0.004	10.584	0.000
Within Groups	0.027	79	0.000		
Total	0.053	86			

Table 44. Multiple Comparisons- Fisher's Least Significant Difference for 2008 Cuyahoga River Whole-Body Mercury Results

(I) Cuyahoga_Site_2008	(J) Cuyahoga_Site_2008	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
FTCS-01 Shalersville	FTCS-02 Ohio Edison Dam Pool	0.01475	0.00762	0.056	-0.0004	0.0299
	FTCS-03 Upstream of Akron WWTP	0.00725	0.00762	0.344	-0.0079	0.0224
	FTCS-04 Downstream of Akron WWTP	**0.01749***	0.00779	**0.027**	0.0020	0.0330
	FTCS-05 SR82	0.01038	0.00762	0.177	-0.0048	0.0255
	FTCS-06 Downstream of Southerly WWTC	0.00069	0.00823	0.933	-0.0157	0.0171
	FTCS-07 Irishtown Bend	0.01000	0.00762	0.193	-0.0052	0.0252
	FTCS-13 Chagrin River @ Daniels Park	**-0.05085***	0.00887	**0.000**	-0.0685	-0.0332
FTCS-02 Ohio Edison Dam Pool	FTCS-01 Shalersville	-0.01475	0.00762	0.056	-0.0299	0.0004
	FTCS-03 Upstream of Akron WWTP	-0.00750	0.00762	0.328	-0.0227	0.0077
	FTCS-04 Downstream of Akron WWTP	0.00274	0.00779	0.726	-0.0128	0.0182
	FTCS-05 SR82	-0.00437	0.00762	0.567	-0.0195	0.0108
	FTCS-06 Downstream of Southerly WWTC	-0.01406	0.00823	0.091	-0.0304	0.0023
	FTCS-07 Irishtown Bend	-0.00475	0.00762	0.535	-0.0199	0.0104
	FTCS-13 Chagrin River @ Daniels Park	**-0.06560***	0.00887	**0.000**	-0.0833	-0.0479
FTCS-03 Upstream of Akron WWTP	FTCS-01 Shalersville	-0.00725	0.00762	0.344	-0.0224	0.0079
	FTCS-02 Ohio Edison Dam Pool	0.00750	0.00762	0.328	-0.0077	0.0227
	FTCS-04 Downstream of Akron WWTP	0.01024	0.00779	0.192	-0.0053	0.0257
	FTCS-05 SR82	0.00313	0.00762	0.683	-0.0120	0.0183

	FTCS-06 Downstream of Southerly WWTC	-0.00656	0.00823	0.428	-0.0229	0.0098
	FTCS-07 Irishtown Bend	0.00275	0.00762	0.719	-0.0124	0.0179
	FTCS-13 Chagrin River @ Daniels Park	**-0.05810***	0.00887	**0.000**	-0.0758	-0.0404
FTCS-04 Downstream of Akron WWTP	FTCS-01 Shalersville	**-0.01749***	0.00779	**0.027**	-0.0330	-0.0020
	FTCS-02 Ohio Edison Dam Pool	-0.00274	0.00779	0.726	-0.0182	0.0128
	FTCS-03 Upstream of Akron WWTP	-0.01024	0.00779	0.192	-0.0257	0.0053
	FTCS-05 SR82	-0.00712	0.00779	0.363	-0.0226	0.0084
	FTCS-06 Downstream of Southerly WWTC	**-0.01680***	0.00838	**0.049**	-0.0335	-0.0001
	FTCS-07 Irishtown Bend	-0.00749	0.00779	0.339	-0.0230	0.0080
	FTCS-13 Chagrin River @ Daniels Park	**-0.06834***	0.00902	**0.000**	-0.0863	-0.0504
FTCS-05 SR82	FTCS-01 Shalersville	-0.01038	0.00762	0.177	-0.0255	0.0048
	FTCS-02 Ohio Edison Dam Pool	0.00437	0.00762	0.567	-0.0108	0.0195
	FTCS-03 Upstream of Akron WWTP	-0.00313	0.00762	0.683	-0.0183	0.0120
	FTCS-04 Downstream of Akron WWTP	0.00712	0.00779	0.363	-0.0084	0.0226
	FTCS-06 Downstream of Southerly WWTC	-0.00968	0.00823	0.243	-0.0261	0.0067
	FTCS-07 Irishtown Bend	-0.00038	0.00762	0.961	-0.0155	0.0148
	FTCS-13 Chagrin River @ Daniels Park	**-0.06122***	0.00887	**0.000**	-0.0789	-0.0436
FTCS-06 Downstream of Southerly WWTC	FTCS-01 Shalersville	-0.00069	0.00823	0.933	-0.0171	0.0157
	FTCS-02 Ohio Edison Dam Pool	0.01406	0.00823	0.091	-0.0023	0.0304
	FTCS-03 Upstream of Akron WWTP	0.00656	0.00823	0.428	-0.0098	0.0229
	FTCS-04 Downstream of Akron WWTP	**0.01680***	0.00838	**0.049**	0.0001	0.0335

	FTCS-05 SR82	0.00968	0.00823	0.243	-0.0067	0.0261
	FTCS-07 Irishtown Bend	0.00931	0.00823	0.261	-0.0071	0.0257
	FTCS-13 Chagrin River @ Daniels Park	**-0.05154***	0.00940	**0.000***	-0.0703	-0.0328
FTCS-07 Irishtown Bend	FTCS-01 Shalersville	-0.01000	0.00762	0.193	-0.0252	0.0052
	FTCS-02 Ohio Edison Dam Pool	0.00475	0.00762	0.535	-0.0104	0.0199
	FTCS-03 Upstream of Akron WWTP	-0.00275	0.00762	0.719	-0.0179	0.0124
	FTCS-04 Downstream of Akron WWTP	0.00749	0.00779	0.339	-0.0080	0.0230
	FTCS-05 SR82	0.00038	0.00762	0.961	-0.0148	0.0155
	FTCS-06 Downstream of Southerly WWTC	-0.00931	0.00823	0.261	-0.0257	0.0071
	FTCS-13 Chagrin River @ Daniels Park	**-0.06085***	0.00887	**0.000***	-0.0785	-0.0432
FTCS-13 Chagrin River @ Daniels Park	FTCS-01 Shalersville	**0.05085***	0.00887	**0.000***	0.0332	0.0685
	FTCS-02 Ohio Edison Dam Pool	**0.06560***	0.00887	**0.000***	0.0479	0.0833
	FTCS-03 Upstream of Akron WWTP	**0.05810***	0.00887	**0.000***	0.0404	0.0758
	FTCS-04 Downstream of Akron WWTP	**0.06834***	0.00902	**0.000***	0.0504	0.0863
	FTCS-05 SR82	**0.06122***	0.00887	**0.000***	0.0436	0.0789
	FTCS-06 Downstream of Southerly WWTC	**0.05154***	0.00940	**0.000***	0.0328	0.0703
	FTCS-07 Irishtown Bend	**0.06085***	0.00887	**0.000***	0.0432	0.0785

*** The mean difference is significant at the 0.05 level.**

Table 45. ANOVA for 2008 Lake Erie Whole-Body Mercury Results

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	0.006	4	0.002	7.015	0.000
Within Groups	0.011	50	0.000		
Total	0.017	54			

Table 46. Multiple Comparisons- Fisher's Least Significant Difference for 2008 Lake Erie Whole-Body Mercury Results

(I) Lake_Site_2008	(J) Lake_Site_2008	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
FTCS-08 Cleveland Harbor West	FTCS-09 Cleveland Harbor East	**0.03086***	0.00706	**0.000***	0.0167	0.0450
	FTCS-10 off Eastlake	-0.00333	0.00606	0.585	-0.0155	0.0088
	FTCS-11 off Wildwood	0.00921	0.00606	0.135	-0.0030	0.0214
	FTCS-12 off Lakewood	0.00121	0.00606	0.843	-0.0110	0.0134
FTCS-09 Cleveland Harbor East	FTCS-08 Cleveland Harbor West	**-0.03086***	0.00706	**0.000***	-0.0450	-0.0167
	FTCS-10 off Eastlake	**-0.03420***	0.00706	**0.000***	-0.0484	-0.0200
	FTCS-11 off Wildwood	**-0.02165***	0.00706	**0.003***	-0.0358	-0.0075
	FTCS-12 off Lakewood	**-0.02965***	0.00706	**0.000***	-0.0438	-0.0155
FTCS-10 off Eastlake	FTCS-08 Cleveland Harbor West	0.00333	0.00606	0.585	-0.0088	0.0155
	FTCS-09 Cleveland Harbor East	**0.03420***	0.00706	**0.000***	0.0200	0.0484
	FTCS-11 off Wildwood	**0.01254***	0.00606	**0.044***	0.0004	0.0247
	FTCS-12 off Lakewood	0.00454	0.00606	0.457	-0.0076	0.0167
FTCS-11 off Wildwood	FTCS-08 Cleveland Harbor West	-0.00921	0.00606	0.135	-0.0214	0.0030
	FTCS-09 Cleveland Harbor East	**0.02165***	0.00706	**0.003***	0.0075	0.0358
	FTCS-10 off Eastlake	**-0.01254***	0.00606	**0.044***	-0.0247	-0.0004
	FTCS-12 off Lakewood	-0.00800	0.00606	0.193	-0.0202	0.0042
FTCS-12 off Lakewood	FTCS-08 Cleveland Harbor West	-0.00121	0.00606	0.843	-0.0134	0.0110
	FTCS-09 Cleveland Harbor East	**0.02965***	0.00706	**0.000***	0.0155	0.0438
	FTCS-10 off Eastlake	-0.00454	0.00606	0.457	-0.0167	0.0076
	FTCS-11 off Wildwood	0.00800	0.00606	0.193	-0.0042	0.0202

*** The mean difference is significant at the 0.05 level.**