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.

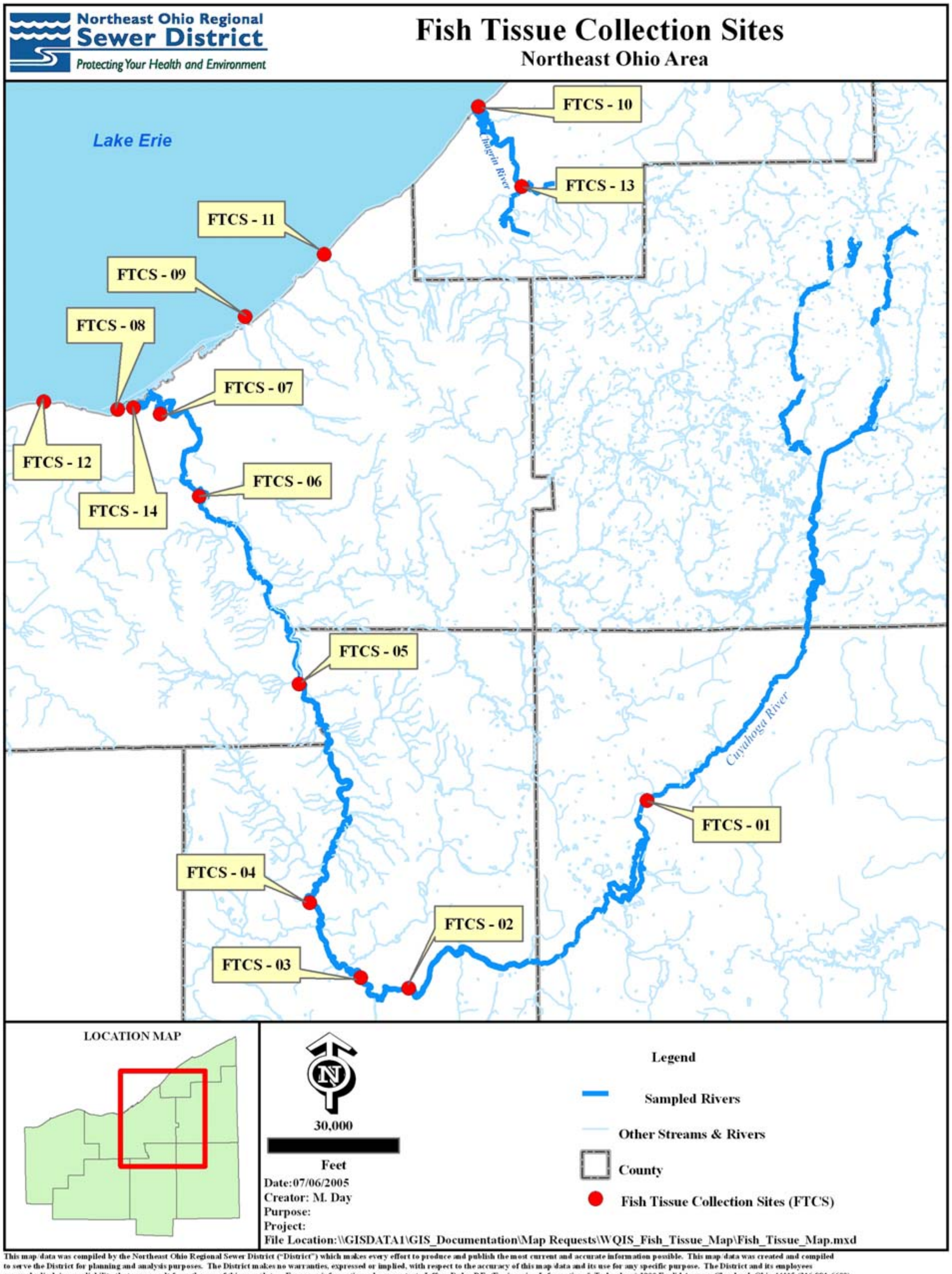


Figure 1. Study Map

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.

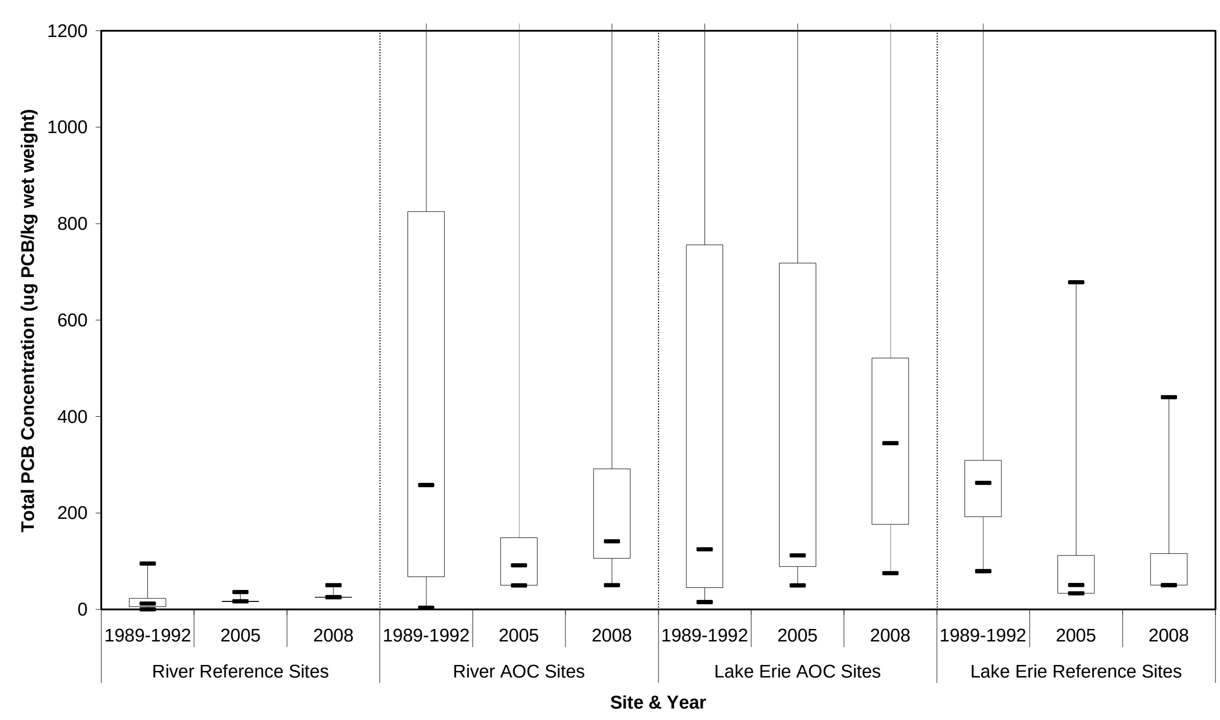
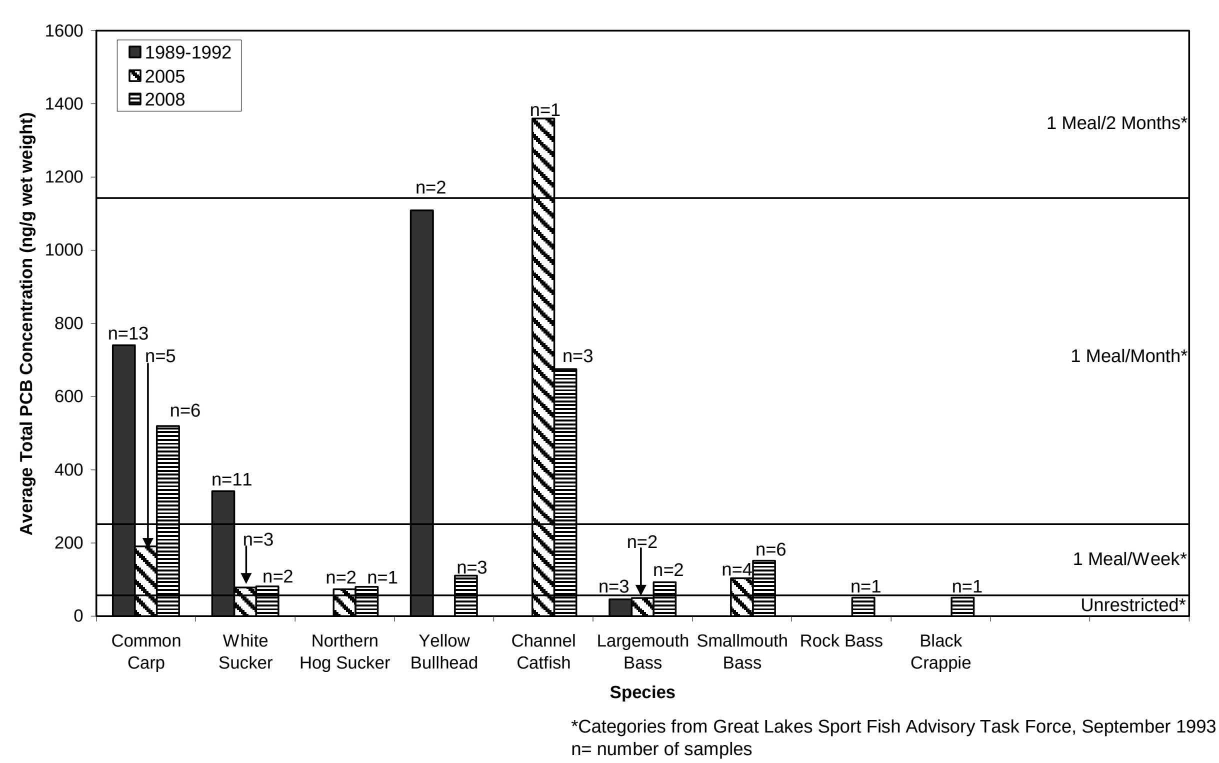


Figure 4. Fish Fillet Total PCB Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)

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.

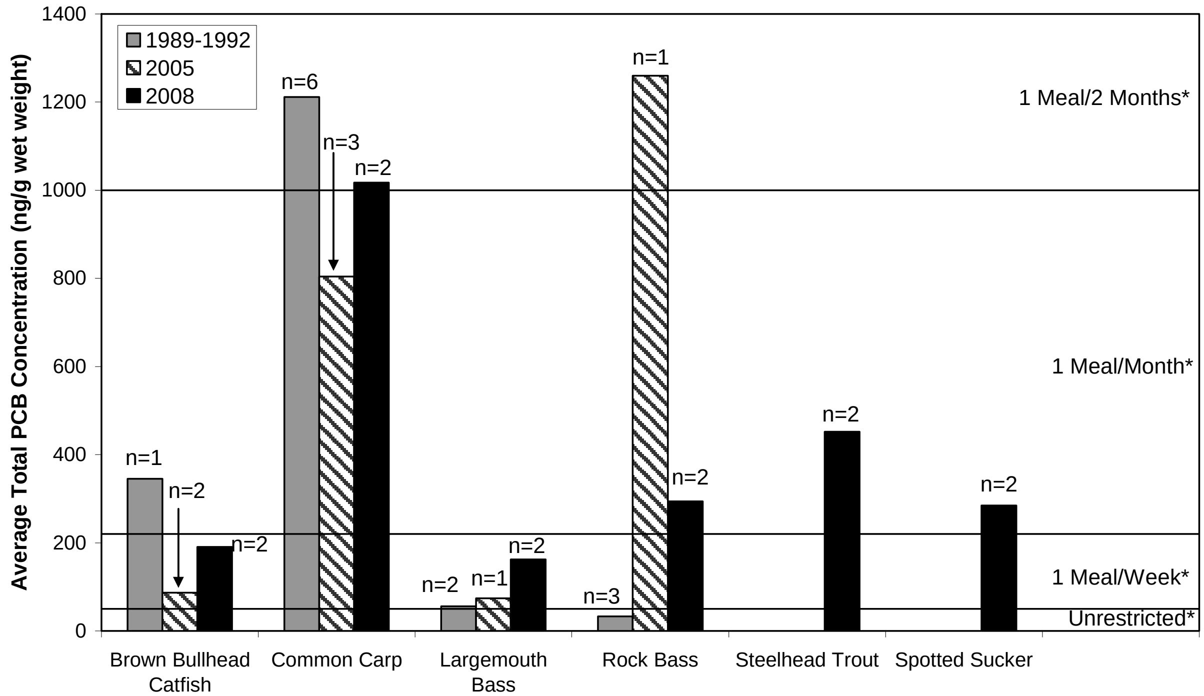
Figure 5. Cuyahoga River AOC Fish Fillet Average Total PCB Concentrations



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.

Figure 6. Lake Erie AOC Fish Fillet Average Total PCB Concentrations



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

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

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
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

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		2.50E-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.

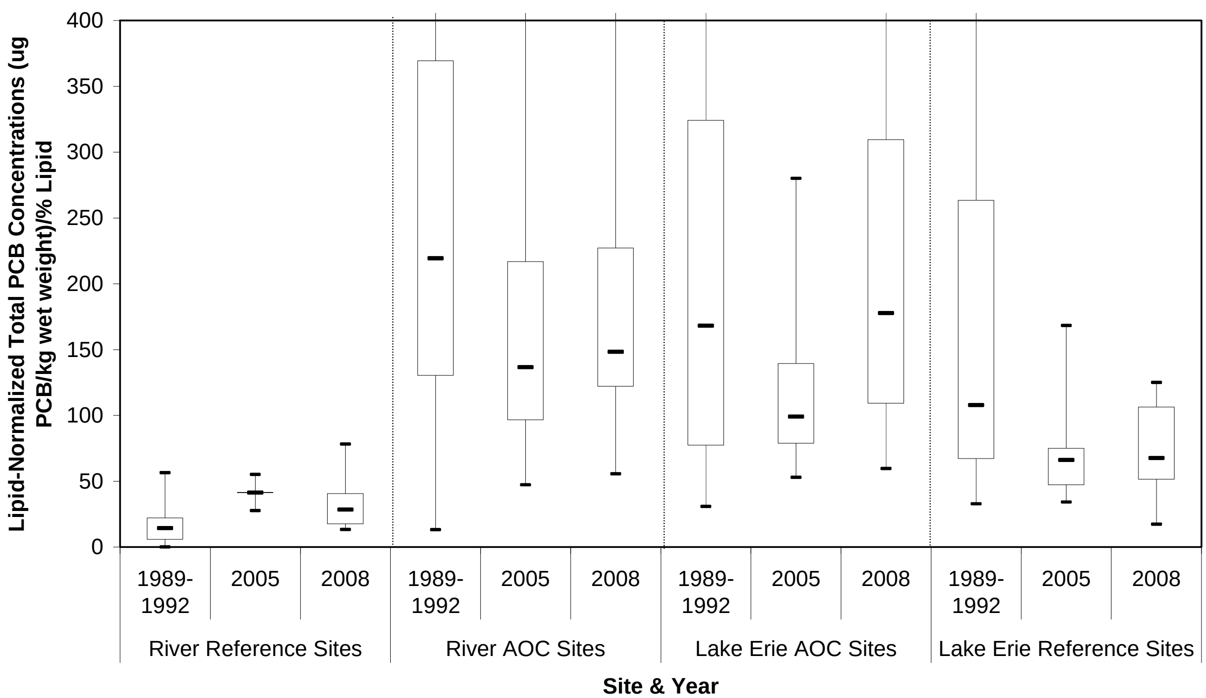
ND= Aroclor 1254 not detected at either river reference site

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.

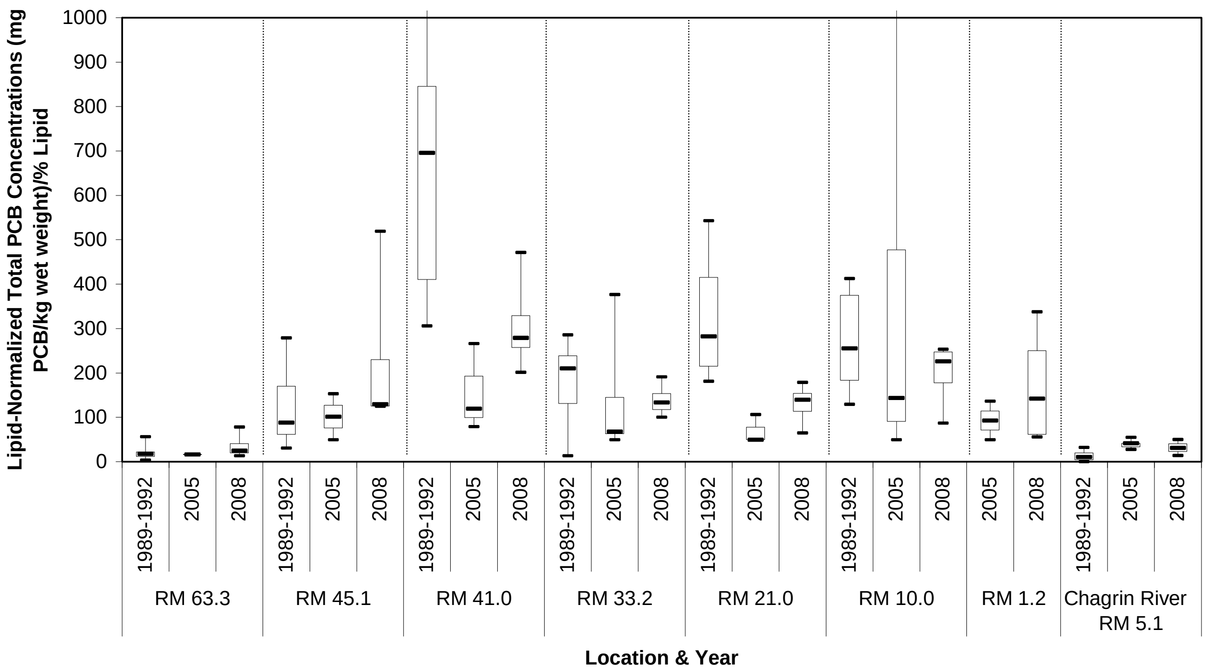
When the AOC and reference sites are compared to each other, it can be seen that the lipid-normalized PCB concentrations at the AOC sites were generally higher than the reference sites (Figure 7), with the difference being statistically significant (Appendix C, Table 21). The median concentration for 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.)

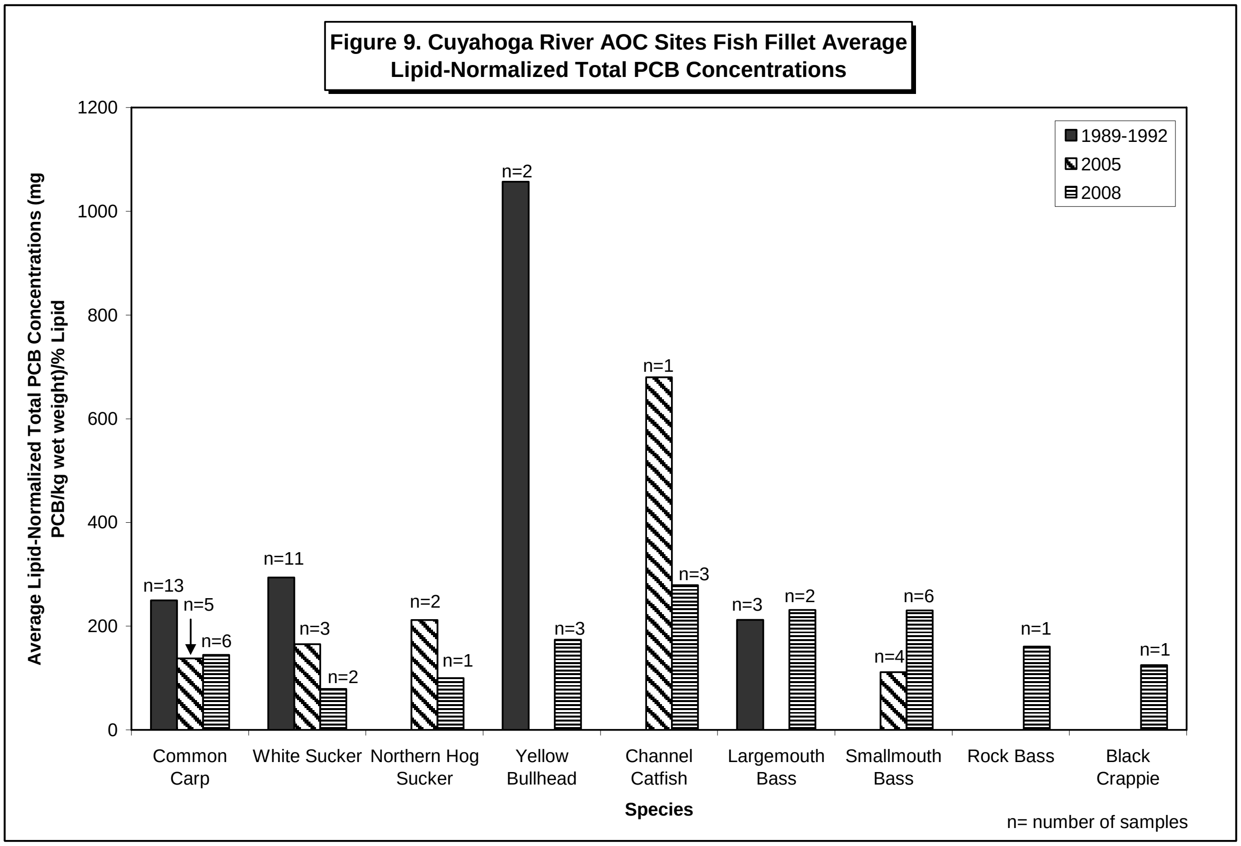


A site-to-site comparison of the river sites shows that both of the reference sites had median lipid-normalized PCB concentrations approximately the same as in both of the previous studies (Figure 8). For the AOC sites, the highest median concentration occurred at the site immediately upstream of Akron 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.

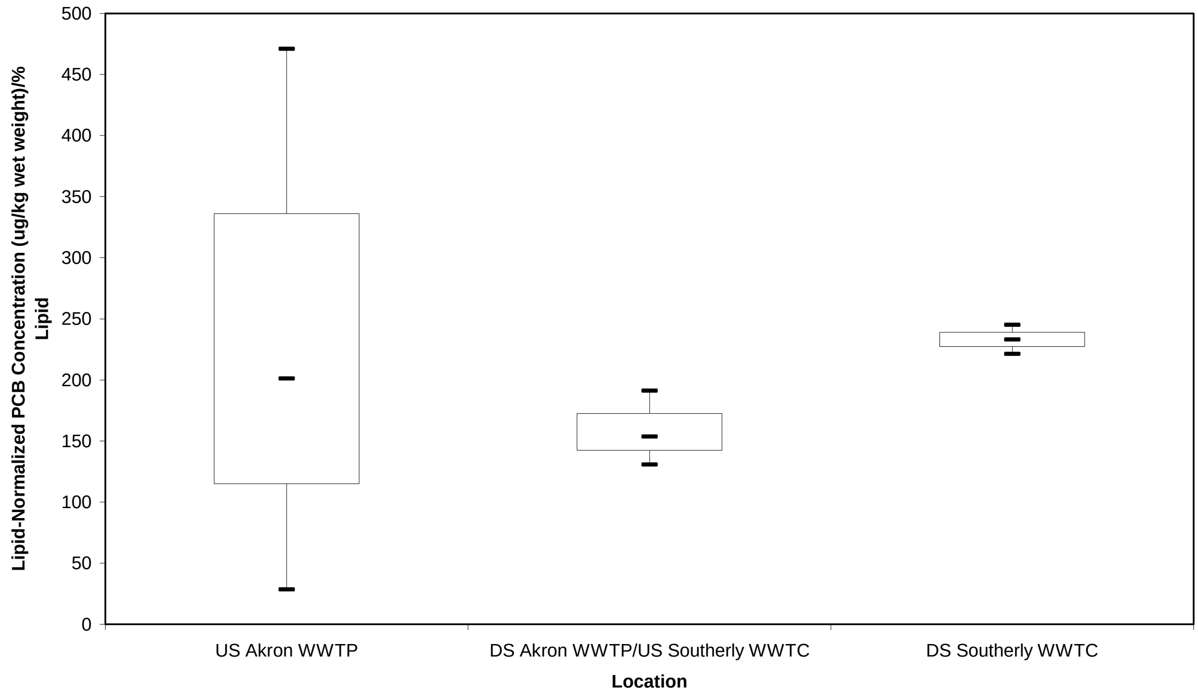


In addition to examining the species from the AOC as a whole, a comparison was also completed using data collected from the sites upstream and downstream of the Akron WWTP and Southerly WWTC. This was done to evaluate whether effluent from the treatment plants could be having an impact on PCB concentrations. 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.)

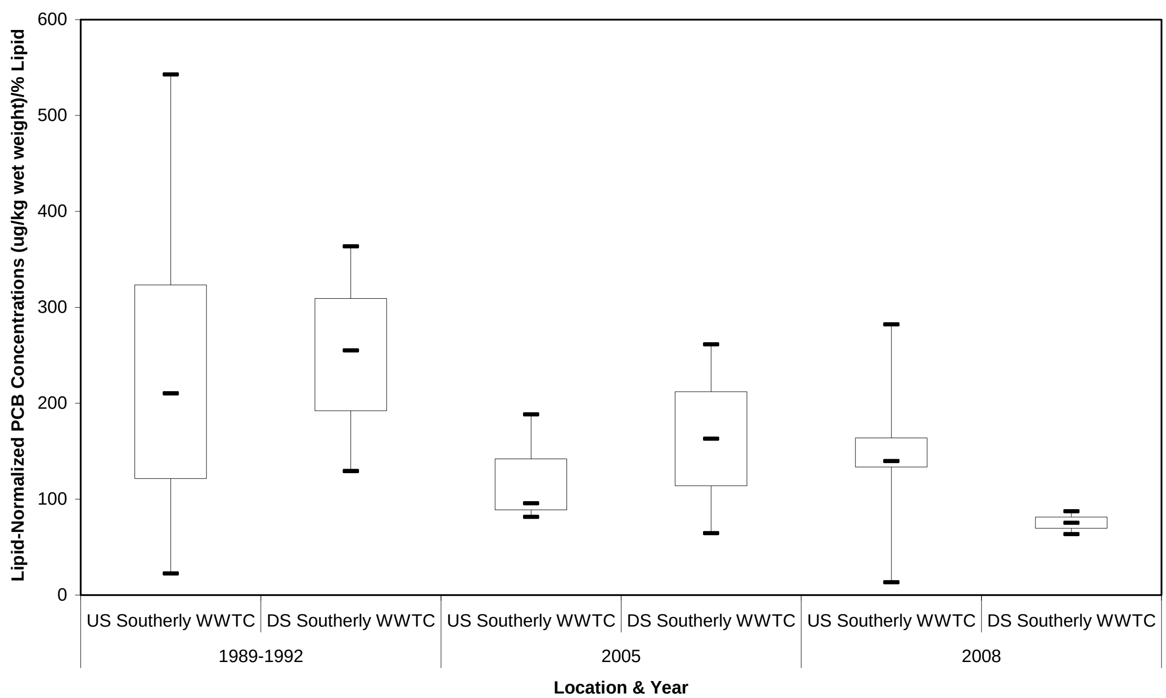
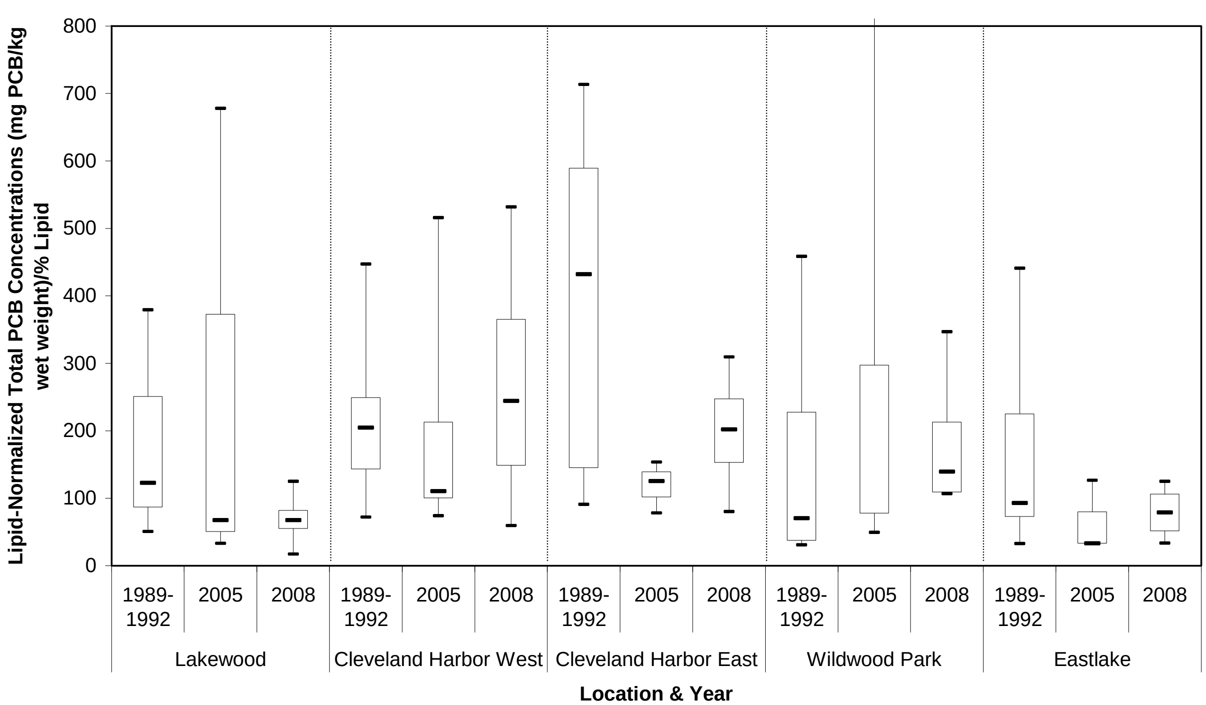
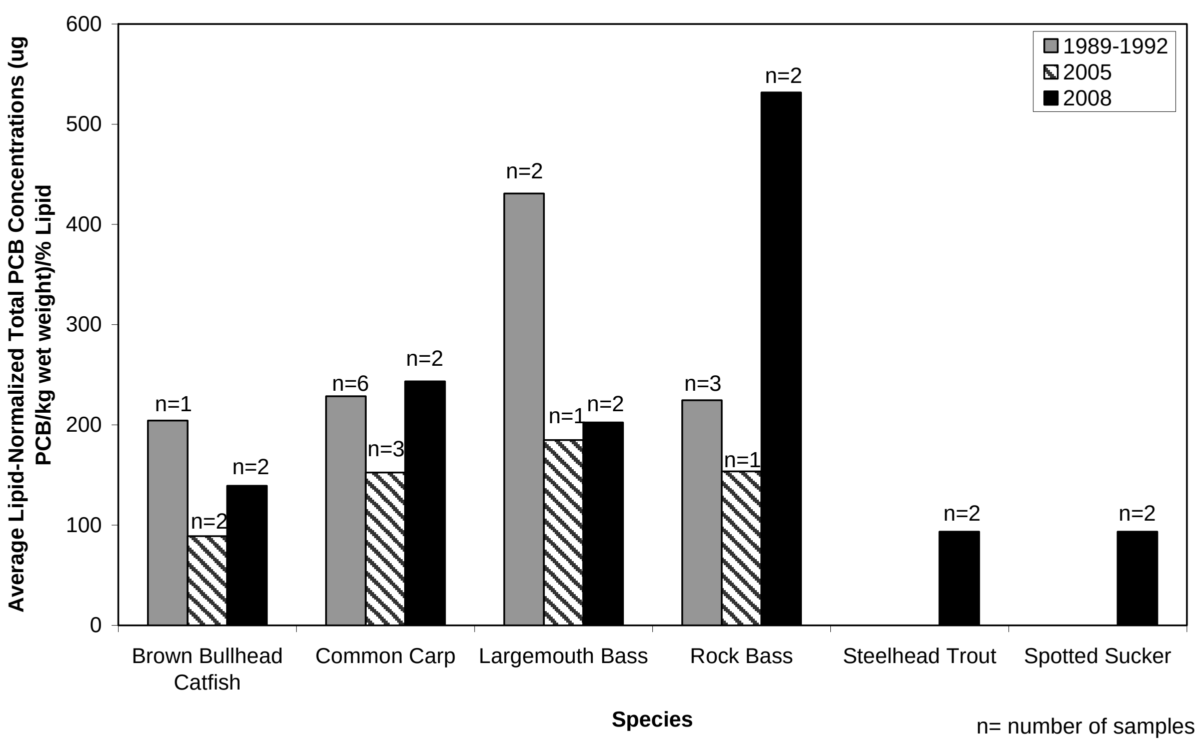


Figure 12. Lake Erie Fish Fillet Lipid-Normalized Total PCB Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)



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						
	Average Fillet Concentration*	Calculated 15.0 g/d Exposure Dose**	IRIS Reference Dose	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	$(mg/kg\text{-}d)^{-1}$	
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						
	Average Fillet Concentration*	Calculated 15.0 g/d Exposure Dose**	IRIS Reference Dose	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	$(mg/kg\text{-}d)^{-1}$	
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

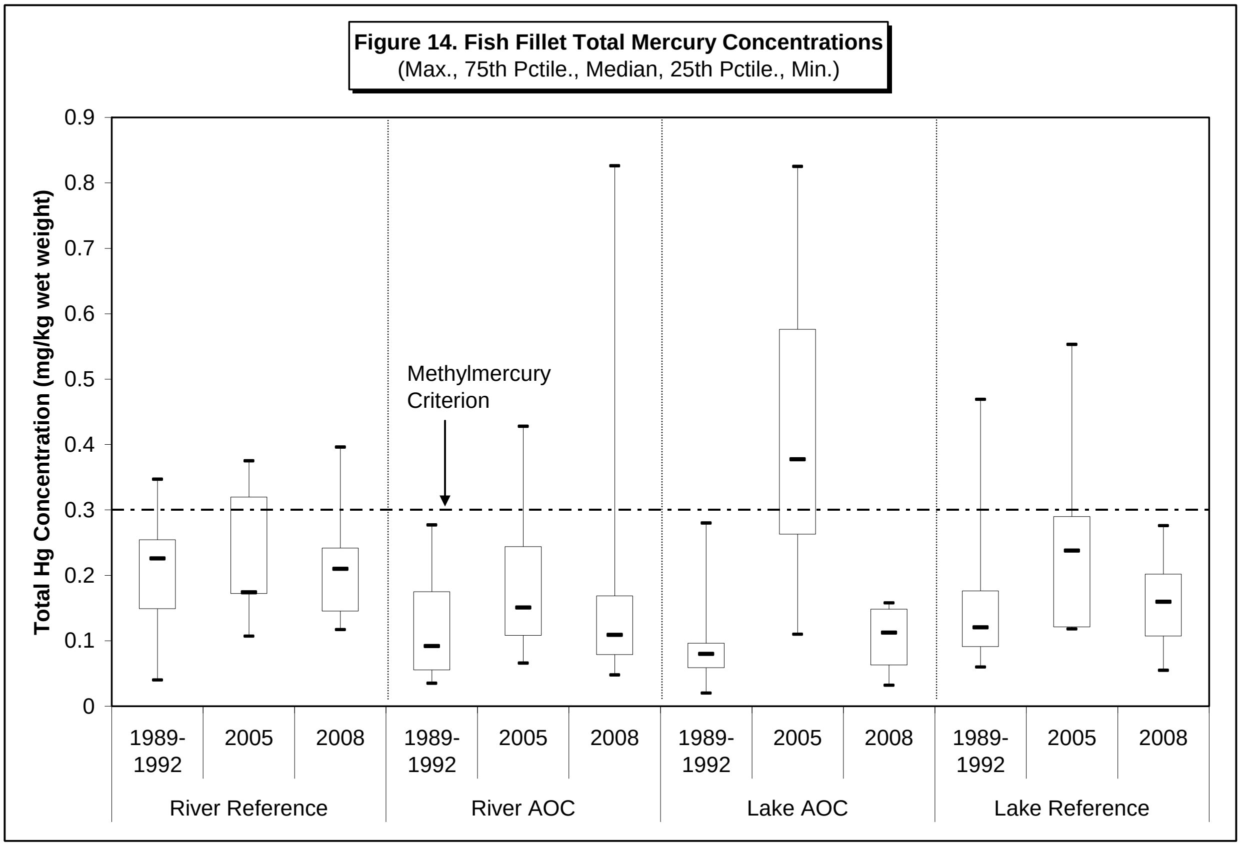
Mercury

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).

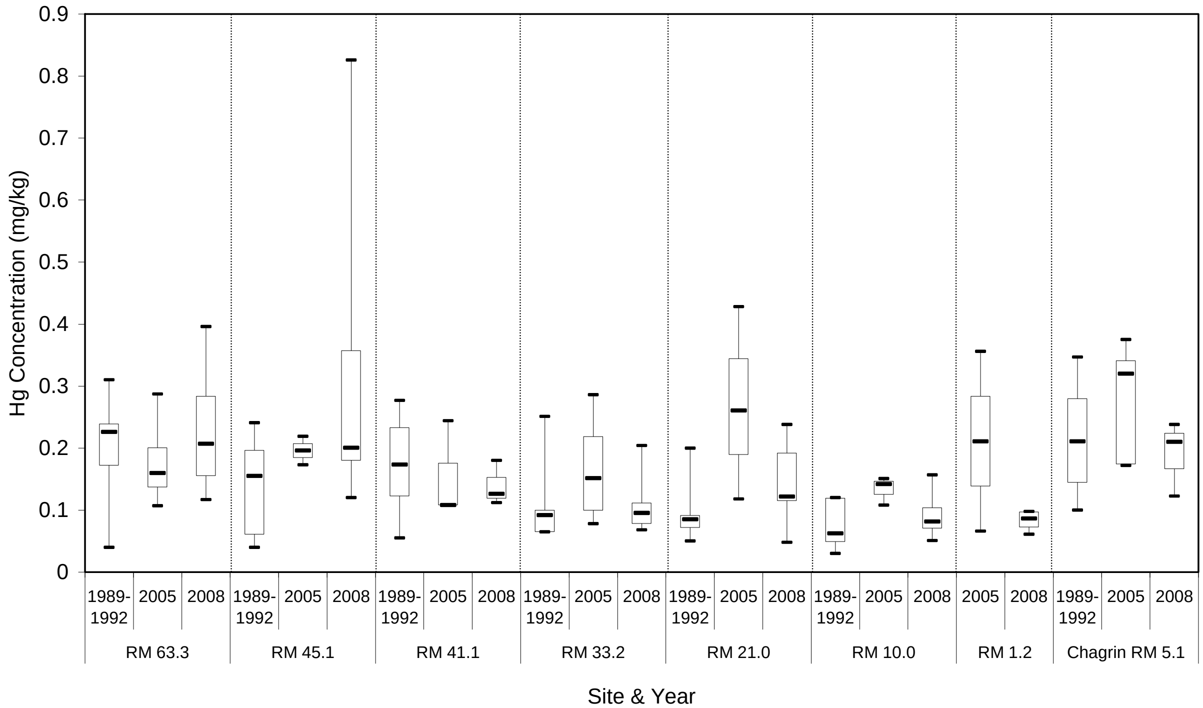
When comparing the AOC sites in the river and lake to their respective reference sites, it was found that the median mercury concentrations for both types of AOC sites were lower than the reference ones, but not significantly so. All of the median concentrations were well below the methylmercury criterion (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.

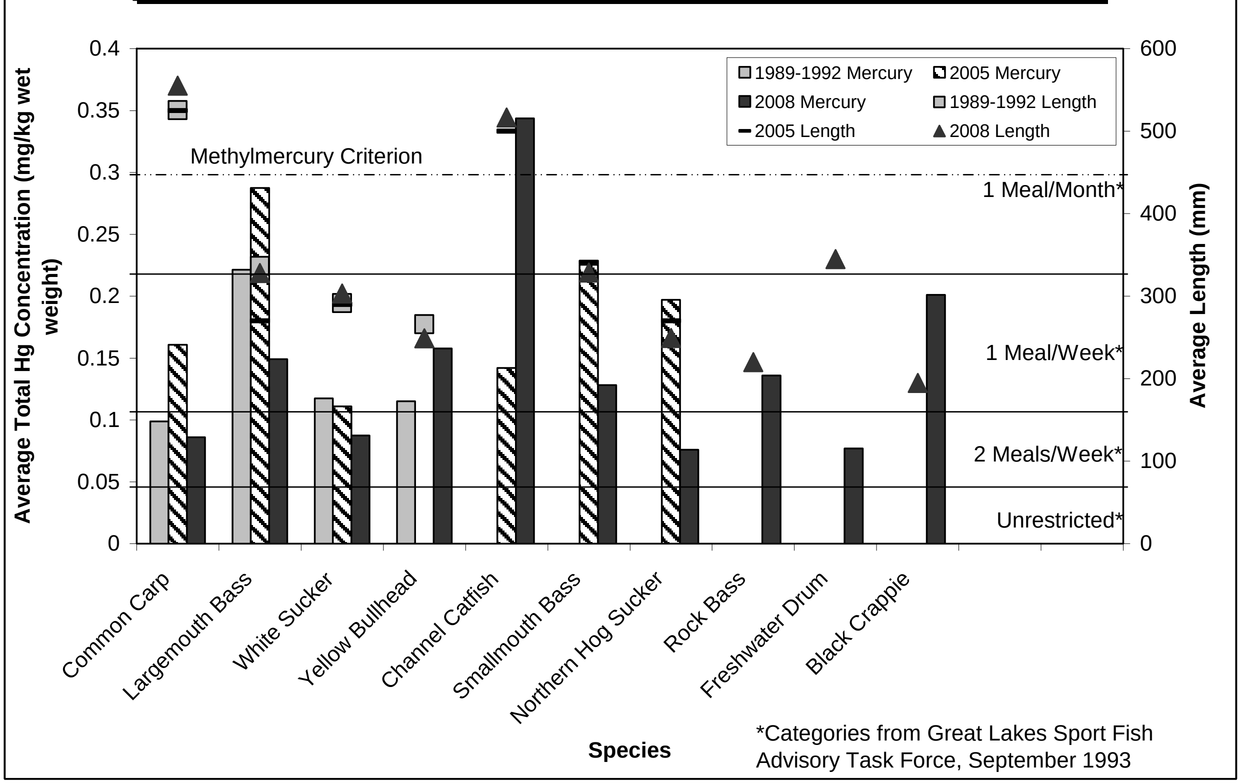
The State of Ohio currently has a statewide fish consumption advisory in place for mercury that recommends not eating more than one meal per week of most fish (Ohio EPA, 2009). When compared to these recommendations, mercury levels in all of the samples except one were within the “one or two meals per 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.

Figure 15. Cuyahoga River AOC Fish Fillet Total Mercury Concentrations
(Max., 75th Pctile., Median, 25th Pctile., Min.)



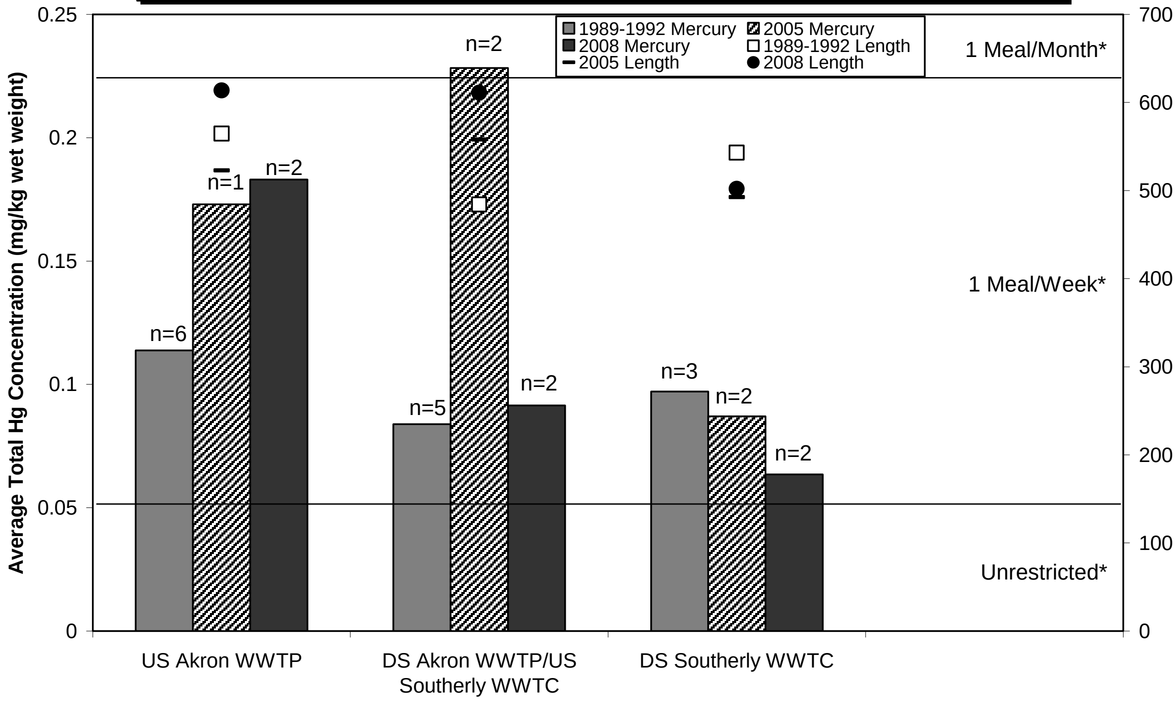
All of the species except yellow bullhead and channel catfish had lower concentrations than in either of the previous two studies. Yellow bullhead had a higher concentration than in the 1989-1992 study, and channel catfish concentrations were higher than in 2005. Generally, mercury concentrations increase 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.

Figure 16. Cuyahoga River AOC Fish Fillet Average Total Mercury Concentrations & Lengths



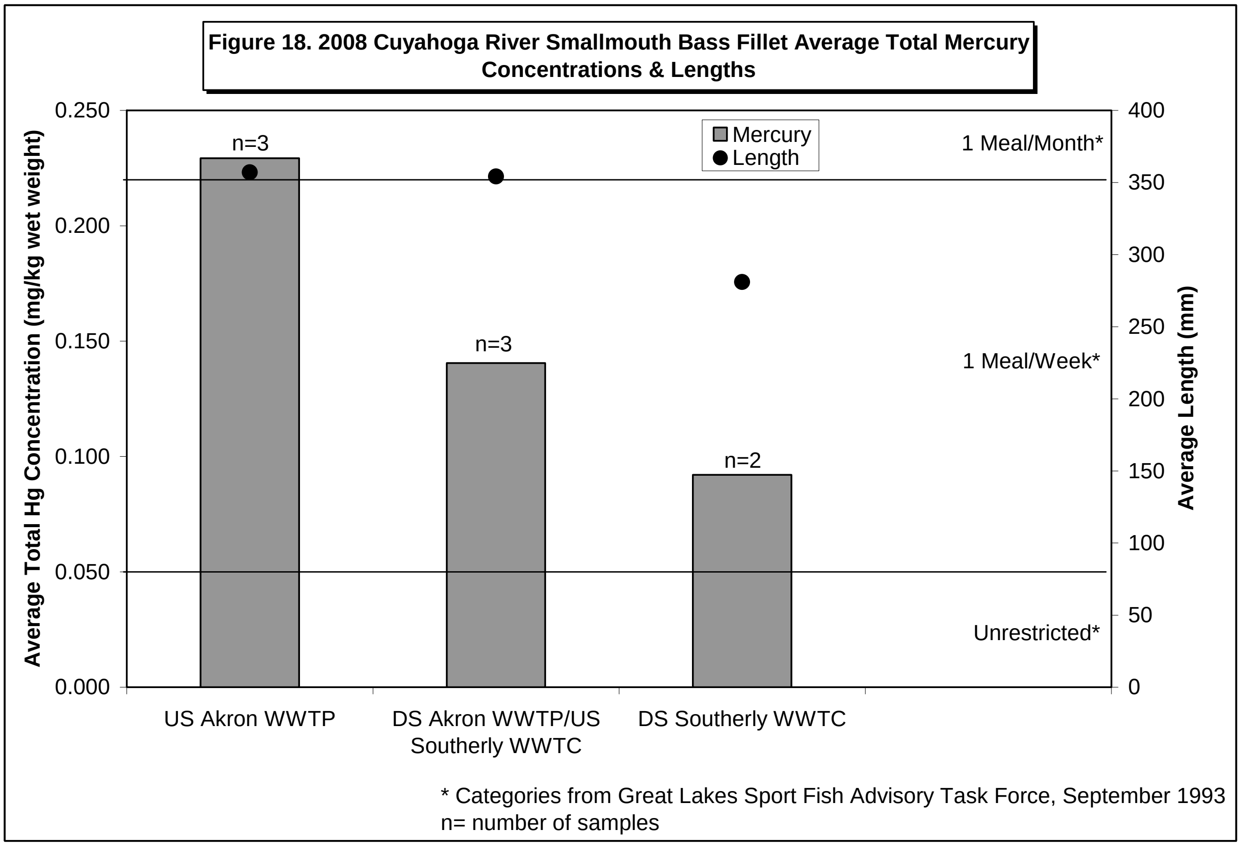
Trace concentrations of mercury are present in effluent that is discharged from wastewater treatment plants. The significance of these discharges in terms of bioaccumulation in fish tissue is still not completely understood. Because of this, common carp and smallmouth bass collected upstream and downstream 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

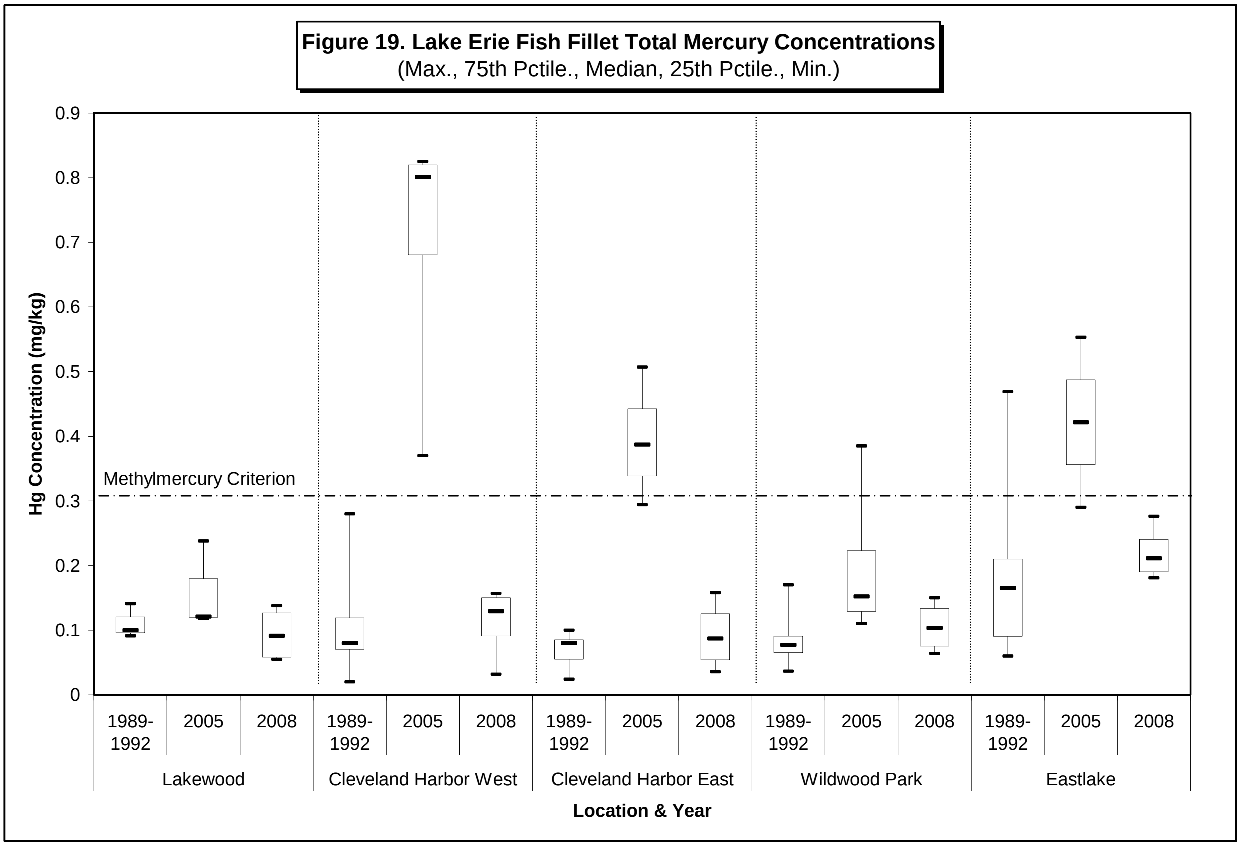


*Categories from Great Lakes Sport Fish Advisory Task Force, September 1993
n = number of samples

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.

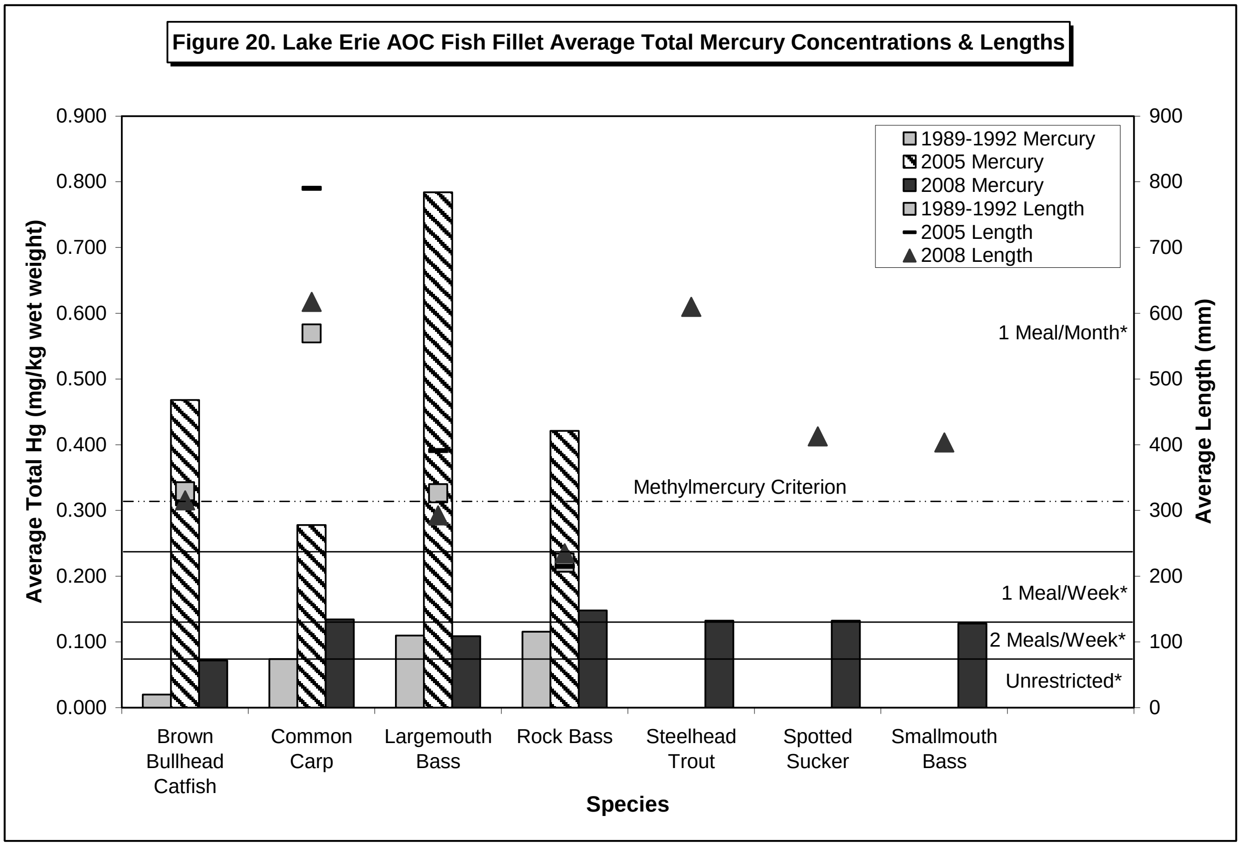


The results for the individual sites in Lake Erie indicate that mercury concentrations were highest at the Eastlake site, with the mercury levels at the other sites being similar to each other (Figure 19). All of the fillet samples were lower than the 0.3 mg/kg criterion. The median concentrations in 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			

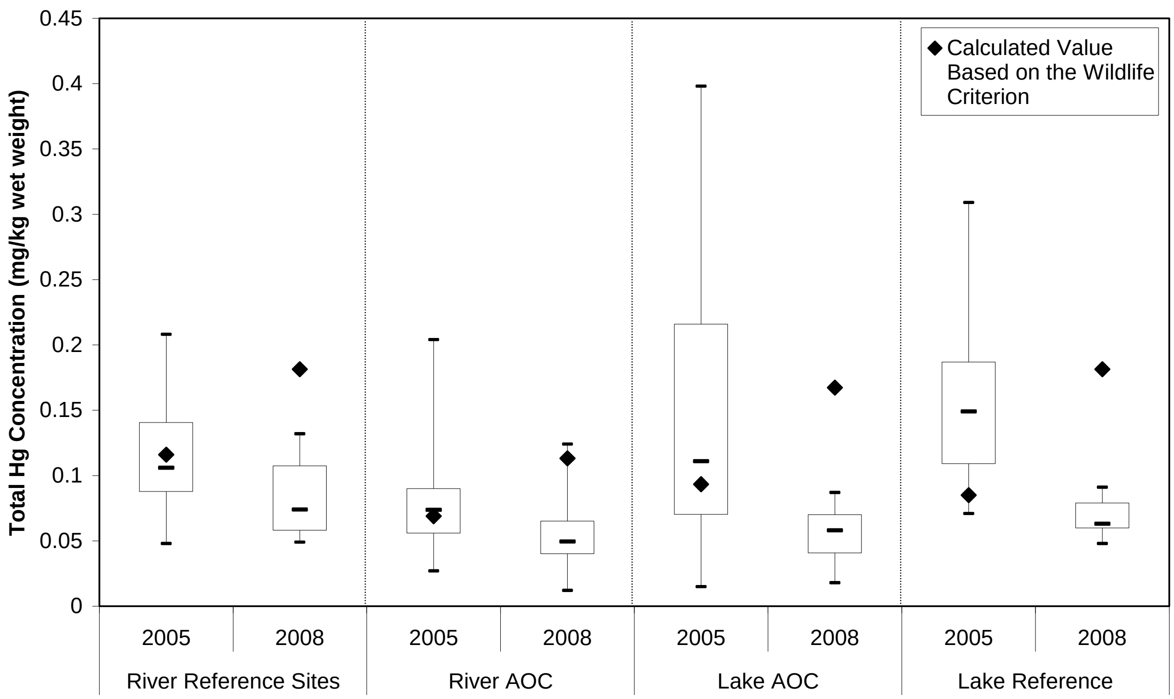
*Human body weight of 70kg and lifetime exposure are assumed. Weighted dose based on assumption of consuming 3.6 g/day of trophic level 3 fish and 11.4 g/day of trophic level 4 fish.

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.)

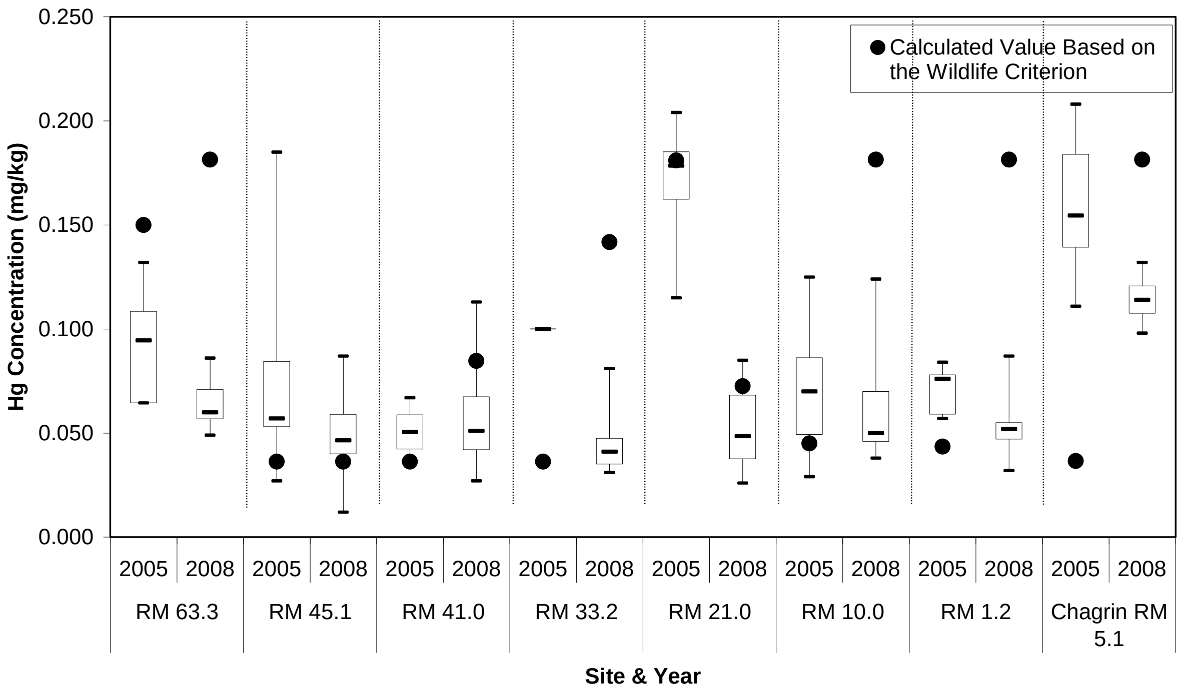
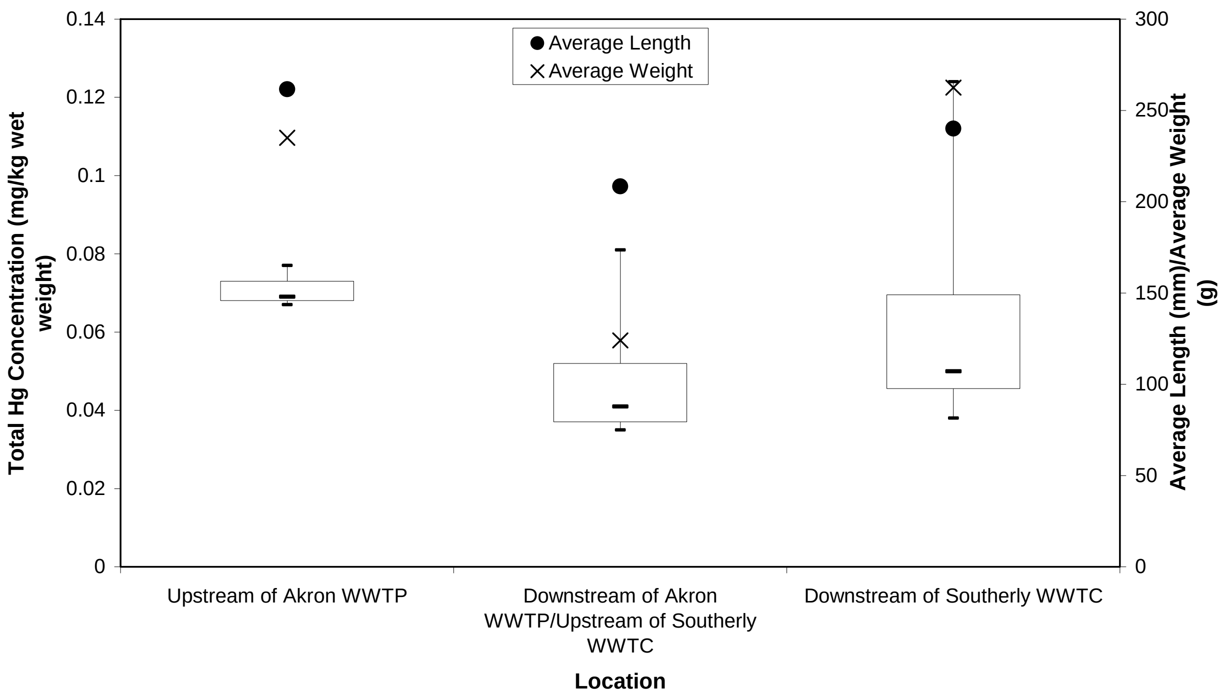
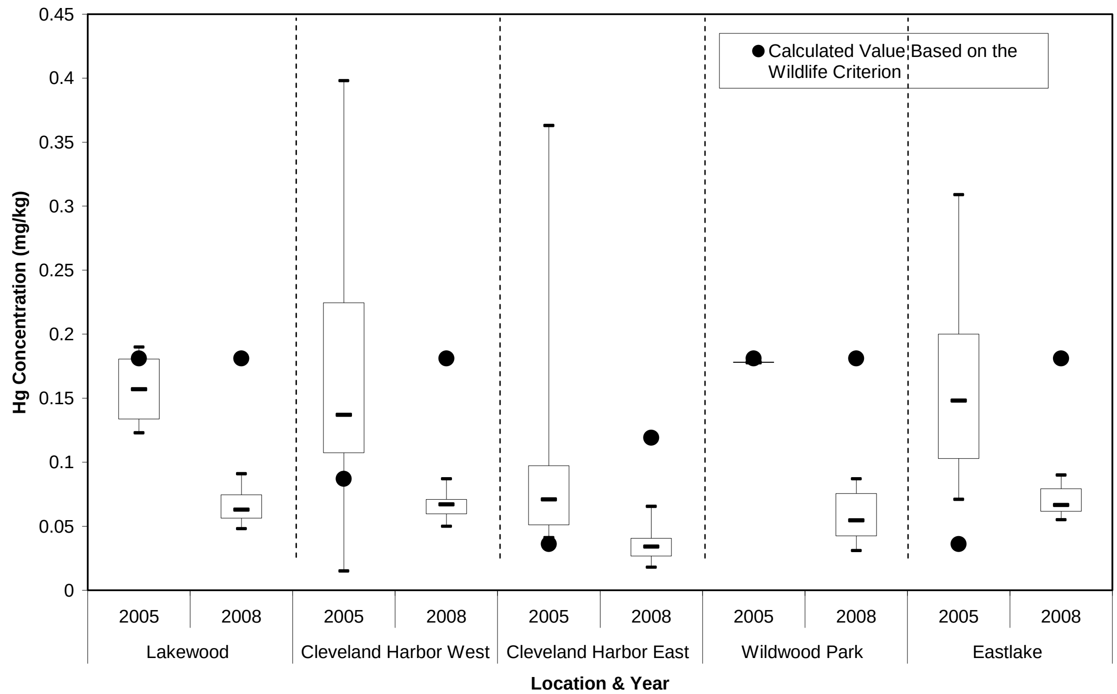


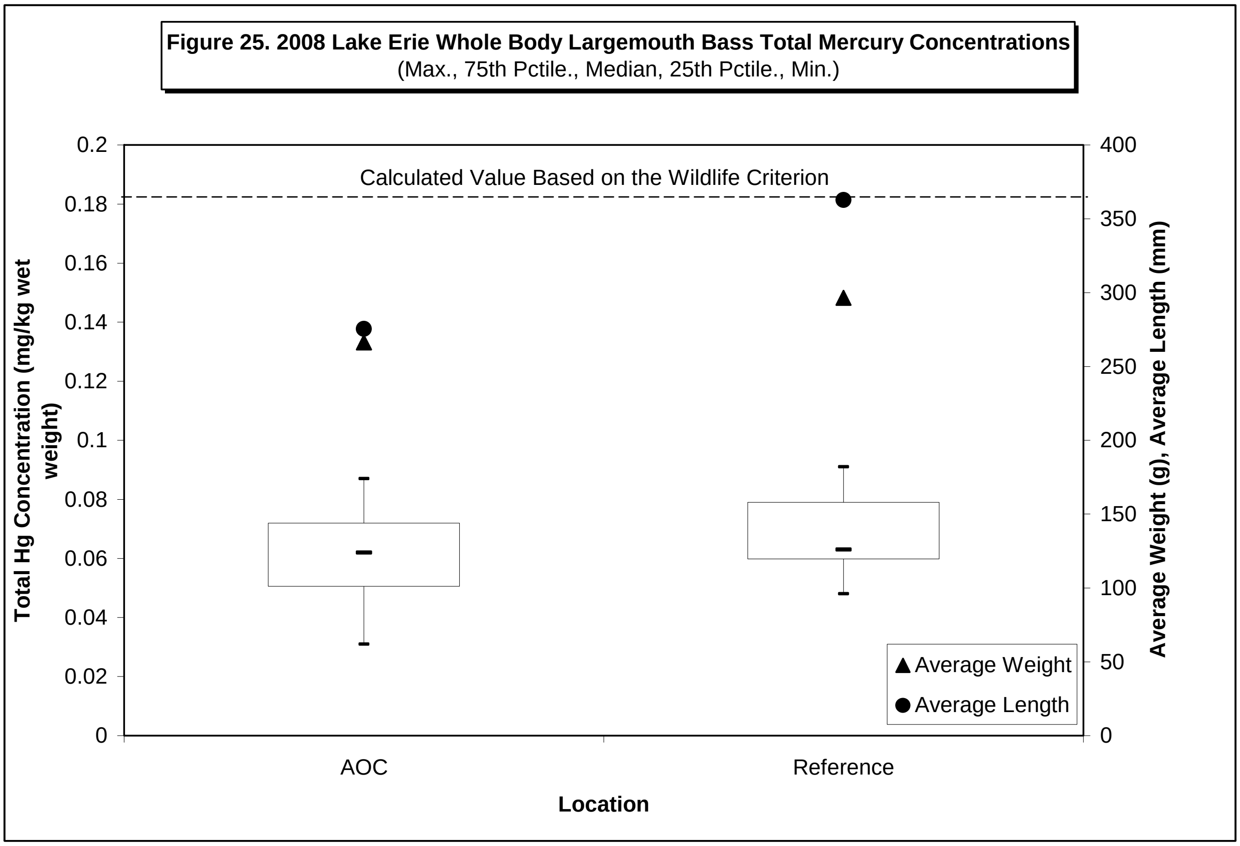
Figure 23. Cuyahoga River Whole Body Smallmouth Bass Total Mercury Concentrations, Weights & Lengths (2008)
(Max., 75th Pctile., Median, 25th Pctile., Min.)



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.

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