

HEALTH CONSULTATION

Public Health Evaluation of Fish Contaminant Data in the Housatonic River

LAKE ZOAR, LAKE LILLINONAH, WEST CORNWALL, AND BULL'S BRIDGE IN KENT, CONNECTICUT

March 26, 2019

**Connecticut Department of Public Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry**

SUMMARY

INTRODUCTION

The Housatonic River is approximately 149 miles long, beginning in the Berkshire mountains in western Massachusetts (MA) and flowing south, through western Connecticut into the Long Island Sound (Appendix A). The General Electric (GE) facility, which produced and handled polychlorinated biphenyls (PCBs) from the 1930s to 1977 in its Pittsfield, Massachusetts facility, caused significant contamination of Housatonic River sediments and fish in the MA portion of the river. The PCB contamination in the Connecticut portion of the Housatonic River also originates from the GE Pittsfield Facility. This has resulted in fish becoming contaminated with PCBs to the extent that fish consumption advisories have been in place in several parts of the Housatonic River in Connecticut since 1977. The Connecticut Department of Public Health (CTDPH) reviews Housatonic River fish tissue data sampled biennially by the Patrick Center for Environmental Research. After reviewing these data, CTDPH evaluates whether the current fish consumption advisory needs to be modified to protect public health based on the level of PCB contamination. CTDPH has evaluated fish tissue data from 2016 and the results of this evaluation are the focus of this document.

CONCLUSION

CTDPH reached one important conclusion in the health consultation:

CTDPH has concluded that eating brown trout and smallmouth bass from West Cornwall, Lake Lillinonah, Lake Zoar, and Bull's Bridge over a long period of time could harm people's health if they do not follow the consumption advisory. Non cancer health effects from exposure to high levels of PCBs include liver and immune system damage and impaired reproductive system. Exposure to PCBs has been related to liver cancer. There has been an association with lower birth weight, decreased motor activity, and decreased short term memory in children born to parents who ate PCB contaminated fish (ATSDR 2000). If community members adhere to the consumption advisory, exposure to PCBs in fish would not be significant enough to cause adverse health effects. CTDPH concludes that this consumption advisory is necessary to protect public health while allowing community members to benefit from the nutritional advantages of eating fish.

Basis for
Conclusion

The 2016 fish tissue data show that of the two fish species that were sampled from four locations along the Housatonic River, both continue to show the presence of PCBs in their tissue. CTDPH uses these fish tissue data to issue a fish consumption advisory for the northern section of the Housatonic River above Derby Dam. The current PCB levels (based on 2016 data) are elevated enough to warrant a continued consumption advisory. After an increase in PCB levels in two species in the 4 stations in the last two sampling events in 2012 and 2014, there was a decrease in PCB levels in smallmouth bass in 2016 in all stations except for one. Since PCB levels have consistently been elevated in smallmouth bass in the upper part of the Housatonic River and its Lakes, the current consumption advisory of “do not eat-high risk, one meal per 2 months-low risk” will be maintained in that location. CTDPH has decided to maintain the advisory of “do not eat-everyone” for brown trout because PCB levels in this species have continued to be consistently elevated throughout the Housatonic River and its Lakes.

It is also important to note that other species, (eel, catfish, and carp) despite not having been sampled for PCBs, have been placed in the Category E advisory (do not eat-everyone) for many years to be protective of public health since PCBs are known to bioaccumulate in these species in other Connecticut water bodies.

Next Steps

CTDPH will update its Housatonic River fish consumption advisory in 2019 in response to the 2016 fish sampling data. The advisory will be printed in our annual brochure and distributed to towns and local health departments along the Housatonic River. Our annual brochure will also be posted on the CTDPH website.

FOR MORE
INFORMATION:

If you have concerns about your health, you should contact your health care provider. Please call The CTDPH at (860)-458-FISH (3474) for more information on Connecticut’s fish consumption advisories.

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BACKGROUND AND STATEMENT OF ISSUE

The Housatonic River is approximately 149 miles long, beginning in the Berkshire mountains in western Massachusetts and flowing south, through western Connecticut into the Long Island Sound (Appendix A). Its major tributaries are the Williams, Green and Konkapot Rivers in Massachusetts, the Tenmile River in New York, and the Blackberry, Hollenbeck, Aspetuck, Candlewood, Shepaug, Pomperaug, Naugatuck, and Still Rivers in Connecticut. It receives the Naugatuck River at Derby, Connecticut, and the Still River south of New Milford, Connecticut. The General Electric (GE) facility, which produced and handled polychlorinated biphenyls (PCBs) from the 1930s to 1977 in its Pittsfield, Massachusetts facility, caused significant contamination of Housatonic River flood plain soils, sediments and fish in the Massachusetts portion of the river. PCB contamination has been and continue to be transported into the Connecticut portion of the river over the years. This has resulted in fish becoming contaminated with PCBs to the extent that fish consumption advisories have been in place in several parts of the Housatonic River in Connecticut since 1977. The Patrick Center for Environmental Research (Patrick Center), which is a part of the Academy of Natural Sciences of Drexel University, samples fish in the Housatonic River for GE on a biennial basis. GE, in turn, reports this information to the Connecticut Department of Public Health (CTDPH) and the Connecticut Department of Energy and Environmental Protection (CTDEEP). The sampling locations were chosen in the 1970s and remain in place for the purpose of evaluating temporal trends. CTDPH biennially reviews new fish tissue data sampled by the Patrick Center from the Housatonic River and evaluates whether the current fish consumption advisory needs to be modified to protect public health based on the level of PCB contamination. This sampling program has been in place since 1984 (EPA 2005). CTDPH evaluated fish sampling data from 2016 and the results of this evaluation are the focus of this document.

Potentially Exposed Population

Since the area surrounding the Housatonic River in Connecticut is very large, the demographics described here include only the towns surrounding the four stations where fish sampling occurred: West Cornwall, Bull's Bridge in Kent, Lake Zoar, and Lake Lillinonah (Appendix A). Table 1 shows that potentially exposed populations are large because the Lakes are surrounded by several towns. We believe that this is a reasonable estimate of a population that may be affected. We understand that 100% of the population in these towns won't fish, but there are likely to be people outside of these towns who will fish.

Table 1. Estimate of Potentially Exposed Populations along the Housatonic River[^]

Sampling Station	Surrounding Towns	Total Population	Area (square miles)
West Cornwall*	Cornwall	1,420	46
Bull's Bridge	Kent	2,979	50
Lake Zoar	Monroe, Oxford, Newtown, Southbury	79,626	194
Lake Lillinonah	Brookfield, Bridgewater, Newtown, Southbury, New Milford, Roxbury	74,428	182

[^]United States Census Bureau 2010

*Indicates a village within a larger town

Health Comparison Values and Fish Tissue Contaminant Levels

In the summer and fall of 2016, thirty brown trout were sampled from West Cornwall and analyzed for PCB content as part of the Housatonic River's biennial fish monitoring program described previously. In addition, 40 smallmouth bass from the four stations along the Housatonic River (West Cornwall, Bull's Bridge, Lake Zoar, and Lake Lillinonah) were also sampled. All of the fish fillets (brown trout and smallmouth bass) contained PCB levels exceeding CTDPH's Modified Great Lakes Protocol PCB value for fish consumption which is described below (Patrick Center for Environmental Research 2016).

1. Health Comparison Values

In order to set safe levels of PCBs in fish associated with fish consumption advisories (which in the Housatonic River, allows for some fish consumption while remediation to risk-based clean up levels occur), CTDPH uses a modified version of the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (GLP) (1993). The GLP is a framework for setting risk-based fish consumption advisories in the Great Lakes states. A detailed description of the GLP as well as CTDPH's modified version is described in Appendix B.

2. Fish Contaminant Levels

The 2016 contaminant data show that average PCB concentrations in all of the fish species from the four Housatonic River sampling locations exceeded the concentration where CTDPH issues a consumption advisory (0.1 ppm). Table 2 gives the average congener-based¹ PCB concentrations in four locations along the Housatonic River in the 2 fish species sampled in 2016.

Smallmouth Bass

The average smallmouth bass PCB concentrations for Lake Zoar and Lake Lillinonah were 1.22 and 0.99 ppm, respectively, while the average for West Cornwall and Bull's Bridge were 1.54 and 1.40 ppm, respectively.

Brown Trout

Brown trout were only sampled at the West Cornwall station. The average PCB concentration in this fish species was 3.22 ppm.

Table 2. PCB Concentrations in Two Species of Fish Caught in Four Locations along the Housatonic River in 2016

Location	Species	Number of Samples ⁺	Average (Congener*) PCBs (ppm [^])	Range (Congener Based) PCB (ppm)
West Cornwall	Smallmouth Bass	10	1.54	0.68-2.10
Bull's Bridge	Smallmouth Bass	10	1.40	0.65-3.05
Lake Lillinonah	Smallmouth Bass	10	0.99	0.38-2.08
Lake Zoar	Smallmouth Bass	10	1.22	0.16-4.14
West Cornwall	Brown Trout	30	3.22	0.73-7.46

⁺All samples were individual fillets and not composites

^{*}The congener-based analysis method sums the concentrations of all individual congeners (up to 121) quantitated by the analytical method.

[^]Parts per Million

¹ The congener-based analysis method sums the concentrations of all individual congeners (up to 121) quantitated by the analytical method.

3. Time Trends

It is also informative to evaluate trends in contaminant levels in fish tissue over time. Figures 1-5 in Appendix C gives the trend over time for average PCB contamination in the four locations in the two species of fish sampled. Since the 1980s and until 2010, the average PCB levels have generally decreased in all of the locations in these 2 fish species sampled from a high of 7.25 ppm in West Cornwall in brown trout in 1992 to a low of 0.50 in smallmouth bass in Lake Lillinonah in 2010. It is important to note, however, that after several years of mostly decreasing levels of PCBs in several fish species, the levels have increased during the previous two sampling periods in some species and locations (2012 and 2014). Average PCB concentrations in fish sampled from the Lake Lillinonah and Lake Zoar were at the highest levels they have ever been in 2014. In addition, in other sampling locations on the Housatonic River, PCB levels in fish sampled in 2014 are higher than they have been in 20 years. However, PCB levels decreased in smallmouth bass in 3 of the 4 stations (except for Bull's Bridge) sampled in 2016. PCB levels in brown trout continued to increase in 2016.

4. Data Evaluation Issues

In calculating average congener-based PCB concentrations, CTDPH used average concentrations for each species and sampling location rather than 95% upper confidence limits (UCLs). A 95% UCL provides a conservative estimate of the average concentration and is unlikely to underestimate the “true” average. However, there is a tendency to sample larger fish (an intentional bias) in the Housatonic River Sampling Program which is the source of the data used in this health consultation. This provides conservatism because larger fish tend to have higher PCB concentrations. For this reason, CTDPH decided that it was not necessary to calculate 95% UCLs. CTDPH is confident that the average PCB concentrations provide a conservative estimate of the “true” average.

DISCUSSION

Exposure Pathway Analysis

To determine if community members are exposed to contaminated fish in the Housatonic River and its Lakes, CTDPH evaluated the environmental and human components that lead to human exposure. CTDPH evaluated the fish tissue data and considered how people may be exposed to contaminants in the fish. The only possible complete pathway of exposure is via ingestion (eating the fish). An exposure pathway consists of five elements (ATSDR 2005):

1. A source of contamination;
2. Transport through an environmental medium;
3. A point of exposure;
4. A route of human exposure; and
5. A receptor population.

ATSDR categorizes an exposure pathway as either completed, potential, or eliminated. In a completed pathway, all five elements exist and indicate that exposure to a contaminant has occurred in the past, is occurring, or will occur in the future. In a potential exposure pathway, at least one of the five elements has not been confirmed, but it may exist. Exposure to a contaminant may have occurred in the past, may be occurring, or may occur in the future. An exposure pathway can be eliminated if at least one of the five elements is missing and will never be present (ATSDR 2005).

Environmental data show that fish in the 4 locations sampled along the Housatonic River and its Lakes (Zoar and Lillinonah) are contaminated with PCBs. Individuals who catch and eat fish from these water bodies would likely be exposed to PCBs in the fish. In addition, their families and friends would also be exposed to PCBs if they eat the fish.

Public Health Implications for Adults and Children

When determining the public health implications of exposure to hazardous contaminants, CTDPH considers how people might come into contact with contaminants and compares contaminant concentrations with health protective levels. When contaminant levels are below health-based comparison values, health impacts from exposure to those levels are unlikely. Contaminant levels exceeding comparison values do not indicate that health impacts are likely, but instead warrant further investigation. In this health consultation, CTDPH used a modified Great Lakes Protocol for fish consumption to set a health protective value (HPV) for PCBs in fish as described in the Environmental Contamination section of this document. As stated previously, this modified protocol is a risk-based protocol which takes into account detection limit issues and the somewhat greater concern for higher risk individuals.

Ingestion of two species of fish in the upper part of the Housatonic River and its Lakes which contain elevated levels of PCBs is a completed exposure pathway and is evaluated in this health consultation. Using CTDPH's Modified Great Lakes Protocol for Fish Consumption, we have classified each fish species according to its appropriate consumption category (restriction level). As previously mentioned, Table 2 also gives 5 restriction level categories; "A" being the least restrictive and "E" being the most restrictive. CTDPH has concluded that the two fish species from Lake Lillinonah, Lake Zoar, Bull's Bridge, and West Cornwall contain elevated PCB levels where adverse health effects from ingestion of these fish can not be ruled out. Ingestion of these fish represents a public health hazard to individuals who do not follow the consumption advisory. However, if community members adhere to the current consumption advisory, exposure to PCBs in fish would not be significant enough to cause adverse health effects. Non cancer health effects from exposure to high levels of PCBs include liver and immune system damage and impaired reproductive system. Exposure to PCBs has been related to liver cancer. There has been an association with lower birth weight, decreased motor activity, and decreased short term memory in children born to parents who ate PCB contaminated fish (ATSDR 2000). CTDPH believes that this updated consumption advisory is necessary to protect public health while allowing community members to benefit from the nutritional advantages of eating fish.

Table 3 gives the updated 2019 CTDPH fish consumption based on the 2016 data and compares it to the 2017 previous advisory. Please note that it has not changed since the previous update in 2017. As a risk management decision, the fish consumption advisory for the Lake on the Housatonic River extends to Lake Housatonic even though it was not sampled in the 2016 sampling event. In addition, the PCB contamination is not believed to extend past Derby Dam, so the section of the river below Derby Dam is not included in the Housatonic River fish consumption advisory. Furthermore, for remediated related purposes associated with the federal USEPA Consent Decree, the Derby Dam is considered the ‘end point’ for PCB releases associated with GE-Pittsfield facility. Below the Derby Dam, there are additional sources of PCBs which may be difficult to distinguish from PCBs originating from the GE-Pittsfield facility. It is also important to note that other species, (eel, catfish, and carp) despite not having been sampled for PCBs, have been placed in the Category E advisory for many years to be protective of public health since past studies have shown that PCBs are known to bioaccumulate in these species in other Connecticut waterbodies.

1. Smallmouth Bass

Environmental data indicate that average PCB levels in smallmouth bass from all 4 stations are above the concentration where CTDPH issues a consumption advisory according to CTDPH’s modified Great Lakes Protocol for fish consumption (Table 2). The average PCB levels in Bull’s Bridge (1.40 ppm) Lake Lillinonah (0.99 ppm), Lake Zoar (1.22 ppm), and West Cornwall (1.54 ppm) are all within or approaching the Category D restriction level (Appendix B, Table 1).

CTDPH has decided to maintain the advisory at the Category D restriction level for both the Lakes and the upper part of the Housatonic River for the following reasons:

- A. Past fish sampling has indicated moderately high levels of PCB contamination in this river.
- B. The previous two rounds of data (2012 and 2014) show that PCB levels in smallmouth bass had increased enough to further restrict consumption in the Lakes on the Housatonic River in 2014. Most importantly, the increase in PCB levels in fish sampled in 2014 was consistent across both species and all stations. In 2016, although PCB levels have decreased in all stations except for one (Bull’s Bridge), they still remain in the D Classification Level.
- C. The increase in PCB levels in fish in 2012 and 2014 may be due to weather related events and ongoing remedial activity in the Pittsfield, MA area of the Housatonic River and may be at the beginning of a downward trend.

2. Brown Trout

In 2016, brown trout in the West Cornwall station had an average PCB level (3.22 ppm) which is in the Category E restriction level. In addition, PCB levels in brown trout have increased in this round of sampling and in the previous 2 rounds (2012 and 2014)

possibly due to weather related events and the remedial work now occurring on the upper part of the Housatonic River near Pittsfield, MA.

CTDPH has decided to maintain the advisory of Category E restriction level for the upper portion of the Housatonic River and its Lakes for the following reasons:

- A. Past fish sampling has indicated moderately high levels of PCB contamination in this river.
- B. The increase in PCB levels in fish in 2012, 2014, and 2016 may be due to weather related events and ongoing remedial activity in the Pittsfield, MA area of the Housatonic River.

CTDPH believes that this updated consumption advisory is necessary to protect public health while allowing community members to benefit from the nutritional advantages of eating fish.

Table 3. Updated 2019 Advisory for Four Fish Species in the Housatonic River and Its Lakes

Location	Fish Species	Restriction Category	Consumption Advisory	
			Previous (2017)	Updated (2019)
Housatonic River above Derby Dam [^]	Smallmouth Bass	D	1 Meal per 2 Months /Do Not Eat –High Risk	No Change
	Brown Trout	E	Do Not Eat-Everyone	No Change
Lakes Housatonic, Zoar, and Lillinonah	Smallmouth Bass	D	1 Meal per 2 Months /Do Not Eat –High Risk	No Change

[^]Includes West Cornwall and Bull’s Bridge sampling locations.

EVALUATION OF COMMUNITY CONCERNS

The following is a list of general concerns that CTDPH has received in past years through community meetings and inquiries from the public and community leaders:

1. I eat fish often in the Housatonic River. Why have I not gotten sick?

The PCBs present in fish in the Housatonic River are not present at levels that will make you acutely (immediately) sick. They are chronic toxins (i.e. they take a long time to cause an effect). The health effects of concern for PCBs are potential cancers and developmental problems in children/fetuses. PCBs accumulate in your body over time. The more PCB contaminated fish you eat, the greater the PCB levels that will build up in your body. PCB exposure is a particular concern to pregnant women because the exposure their unborn child receives through the mother may be linked with developmental, behavioral, and learning problems in children.

2. I have eaten lots of fish from the Housatonic River. Is there medicine I can take to get rid of these chemicals?

There is no medicine or other procedure to get rid of the chemicals your body has accumulated from eating fish. The chemicals will very slowly leave your body over time. If you follow the advisory you will decrease your exposure and allow your body the time needed to reduce the levels of the chemicals.

3. I am concerned that there are not enough signs along the river to alert people to this advisory. In addition, I am concerned that there may be a language barrier preventing people from understanding these signs.

Signs are typically posted by conservation officers at every access point along the Housatonic River. If you need more signs, contact the CTDEEP, Bureau of Natural Resources, Fisheries Division to request signs. Consumption advisory signs in other languages have been prepared and are posted in areas where these populations are thought to fish.

CONCLUSIONS

Another round of fish tissue data shows that two different fish species from four locations along the Housatonic River continue to have elevated levels of PCBs. CTDPH uses this fish tissue data to issue a fish consumption advisory for the northern section of the Housatonic River above Derby Dam. Current PCB levels (based on 2016 data) are elevated enough to warrant a continued consumption advisory. Before 2012, there was a general decrease in PCB levels over time in all species and sampling stations. After an increase in PCBs levels in the past two sampling events, PCB levels have begun to decrease in smallmouth bass and most sampling stations in 2016. CTDPH has decided to maintain the advisory of “do not eat-everyone” for brown trout because PCB levels in these species continue to be consistently elevated throughout the Housatonic River and its Lakes. Since PCB levels have consistently remained elevated in smallmouth bass in the upper part of the Housatonic River and its Lakes, the current consumption advisory of “do not eat-high risk, one meal per 2 months-low risk” will be maintained in that location.

CTDPH has concluded that eating two fish species from West Cornwall, Lake Lillinonah, Lake Zoar, and Bull’s Bridge over a long period of time could harm people’s health if they do not follow the consumption advisory. Non cancer health effects from exposure to high levels of PCBs include liver and immune system damage and impaired reproductive system. Exposure to PCBs has been related to liver cancer. There has been an association with lower birth weight, decreased motor activity, and decreased short term memory in children born to parents who ate PCB contaminated fish (ATSDR 2000). If community members adhere to the current consumption advisory, exposure to PCBs in fish should not be significant enough to cause adverse health effects. CTDPH believes that this updated consumption advisory is necessary to protect public health while allowing community members to benefit from the nutritional advantages of eating fish. It is also important to note that other species, (eel, catfish, and carp) despite not having been sampled for PCBs, have been placed in the Category E advisory for many years to be protective of public health since PCBs are known to bioaccumulate in these species in other Connecticut water bodies.

RECOMMENDATIONS

1. CTDPH recommends that the CTDEEP continue to request a biennial PCB fish sampling plan and report from GE for the Housatonic River. CTDPH also recommends that CTDEEP continue to consult and share information with CTDPH throughout this process. It is important to note, however, that the historic CT-GE Cooperative Agreement is transitioning from a voluntary program to a more formal Baseline Monitoring Plan which includes a biota monitoring component under the uncontested portions of the final modification of the Resource Conservation and Recovery Act (RCRA) permit associated with the GE-Pittsfield site.

2. CTDPH recommends that the CTDEEP Fisheries Division continue to work with CTDPH to educate fishing populations along the Housatonic River about the consumption advisory.
3. CTDPH recommends that GE sample supplemental fish species (such as northern pike and panfish) in the next round of sampling, so that we can evaluate whether to adjust our fish consumption advisory for those fish species, as they were not included in the 2014 or 2016 sampling events.

PUBLIC HEALTH ACTION PLAN

Actions Taken

1. CTDPH and CTDEEP Fisheries Division have worked together to educate the general public and minority fishing populations along the Housatonic River about the consumption advisory. CTDEEP has posted signs along the river to inform the public about the consumption advisory.
2. CTDPH added questions to the 2008 CTDEEP CREEL (angler) survey to gain information about the level of knowledge of the fish consumption advisory. Almost all of the anglers surveyed were knowledgeable about the fish consumption advisory and only one angler who knew of the advisory chose to ignore it.
3. CTDPH performed a ‘Train the Trainer’ session on Fish Consumption Advisories in August 2011 for the Hispanic Health Council because an earlier consumer survey indicated that Hispanics have a low knowledge of the advisory.
4. CTDEEP in consultation with CTDPH, worked with the United States Environmental Protection Agency (USEPA) and the Commonwealth of Massachusetts to draft and establish a permit under which GE will be required to remediate PCB contamination within the Housatonic River Watershed. Specific requirements have been incorporated into this permit to address the downstream transport of PCBs into Connecticut, manage PCB contaminated sediments within project areas in Connecticut, and conduct remedial activities in Massachusetts sufficient to lower fish tissue concentrations initially to 1.5 mg/kg and continue monitoring until fish tissue levels are below 0.00018 mg/kg in order to allow for long-term unrestricted consumption of fish from the Housatonic River in Connecticut. As part of this permit, GE will be required to conduct environmental monitoring in Connecticut and work to communicate fish consumption advisory information to the public. Because of the changing circumstances, CTDEEP did not request that GE sample biota in 2018.

5. CTDEEP and CTDPH submitted comments to the USEPA on the GE Draft Baseline Monitoring Plan for the Housatonic River in September 2017 with regard to fish species Connecticut desires to be monitored as well as additional sampling sites. The fish sampling species not only includes brown trout and largemouth bass, but also additional fish species such as panfish and northern pike.

Actions Planned

1. CTDPH and CTDEEP will continue to work together to educate the general public as well as minority subsistence fishing populations along the Housatonic River about the consumption advisory.
2. CTDPH will update its Housatonic River fish consumption advisory in 2019 in response to the 2016 fish sampling data. The advisory will be printed in our annual brochure, "If I Catch It, Can I Eat It" and distributed to towns and local health departments along the Housatonic River as well as posted on the CTDPH website.
3. CTDPH will continue to evaluate new fish contaminant data and will update its current Housatonic River fish consumption advisory as needed.
4. CTDPH and CTDEEP will work collaboratively with the USEPA to establish appropriate monitoring requirements for the Connecticut portion of the Housatonic River, including requirements to continue fish sampling periodically as required by the permit and Consent Decree.
5. CTDPH and CTDEEP will work collaboratively with the USEPA to establish the necessary actions for GE to take in order to improve public awareness of the advisories including the production and posting of appropriate signs and development of educational materials, as required by the permit and the Consent Decree.
6. Because largemouth bass are very similar to smallmouth bass, CTDPH modified the 2017 Fish Consumption Advisory to include largemouth bass. The 2017 fish consumption advisory denotes smallmouth and largemouth bass as 'bass.'

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REPORT PREPARATION

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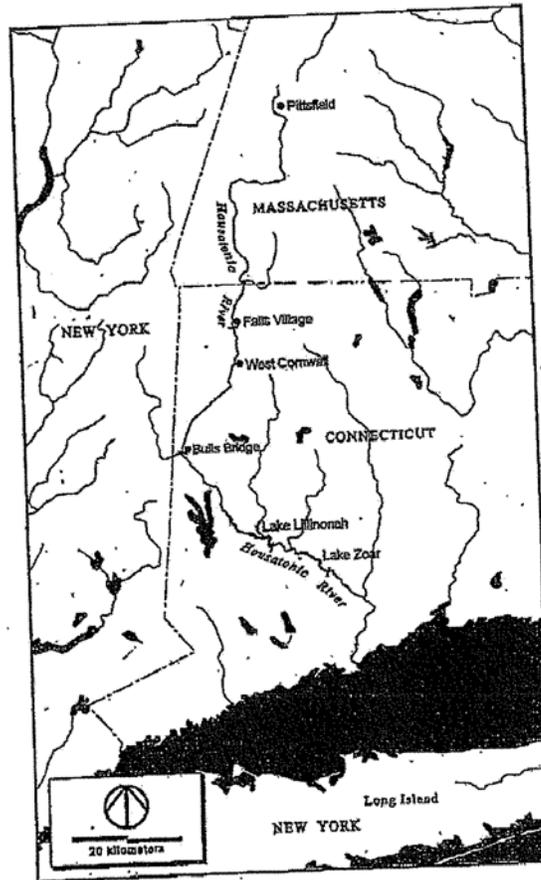
Environmental Epidemiology and Occupational Health Program

Appendix A

Map of Sampling Locations along the Housatonic River

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Appendix B

In order to set safe levels of PCBs in fish associated with fish consumption advisories (which in the Housatonic River, allows for some fish consumption while remediation to risk-based clean up levels occur), CTDPH uses a modified version of the Protocol for a Uniform Great Lakes Sport Fish Consumption Advisory (GLP) (1993).

Figure 1. Risk Based PCB Fish Concentrations for Different Meal Frequencies Developed in the Great Lakes Protocol

- No advice for consumption for concentrations ≤ 0.05 ppm (assuming 1 meal every 1.6 days or 140 grams fish/day).
- One meal per week for concentrations 0.06 to 0.2 ppm
- One meal per month for concentrations 0.21 to 1.0 ppm
- One meal every other month for concentrations 1.1-1.9 ppm
- No consumption > 1.9 ppm

Figure 1 provides the risk-based PCB fish concentration cutoffs for different meal frequencies developed in the GLP. The GLP is a framework for setting risk-based fish consumption advisories in the Great Lakes states. Using the GLP, the Great Lakes Task Force developed a Health Protective Value (HPV) for PCBs of $0.05 \mu\text{g}/\text{kg}/\text{day}$ by using a “weight of evidence” approach which considered all of the existing toxicological values and studies (mostly human and monkey). The “weight of evidence” approach differs from a reference dose which typically uses a single critical study. The HPV is a unique value developed specifically for the Great Lakes sport fish advisory process (Great Lakes Sport Fish Advisory Task Force 1993). The development of the HPV was based on some key assumptions: average meal size for a 70 kg adult of one-half pound (227 grams) and a 50% reduction in PCB fish fillet content (skin on, scales off fillet) through trimming and cooking losses of fatty portions of the fish. The goal of the advisory program was to limit PCB exposure to $3.5 \mu\text{g}/\text{day}$ ($0.05 \mu\text{g}/\text{kg}/\text{day} * 70 \text{ kg} = 3.5 \mu\text{g}/\text{day}$). At this exposure level, cancer risks would not be expected to exceed 1 excess cancer in 10,000 exposed people and non cancer health effects would not be likely. Concerning non-cancer health effects, there are several animal and human studies that resulted in a variety of adverse health effects from exposure to PCBs. The main effects from exposure to PCBs in animals include hepatic, dermal, immunological, and neurobehavioral development. Because the most sensitive effects are immunological and neurobehavioral development, the GLP Task Force tended to weigh more heavily on these studies when developing its HPV (Great Lakes Sport Fish Advisory Task Force 1993).

The ATSDR minimum risk level (MRL) for chronic exposure to PCBs is $0.02 \mu\text{g}/\text{kg}/\text{day}$; less than half the HPV. Derivation of the ATSDR MRL is based on a Lowest Observed Adverse Effect Level (LOAEL) for immunological effects of $0.005 \mu\text{g}/\text{kg}/\text{day}$ and is divided by an uncertainty factor of 300 for extrapolation from monkeys to humans, and

10 for human variability. As stated previously, development of the HPV is based on a “weight of evidence” approach and considered all toxicological values and studies. Cancer risks estimates for PCBs at the HPV of 0.05 µg/kg/day using the United States Environmental Protection Agency (US EPA) Cancer Slope Factor (CSF) of 7.7 (mg/kg/day)⁻¹ (95% upper bound confidence level estimate) and 5.5 (mg/kg/day)⁻¹ (most likely estimate) are 3.8 x 10⁻⁴ and 2.7 X 10⁻⁴ respectively. If a population were exposed to PCB levels of 0.05 µg/kg/day (HPV) every day for 70 years (a lifetime), there would be a theoretical excess cancer risk of approximately 2 persons in a population of 10,000. CTDPH considers this theoretical excess cancer risk to be on the upper end of a generally acceptable range (1 in 10,000 to 1 in 1,000,000).

CTDPH’s version of the GLP takes into account detection limit issues and the somewhat greater concern for higher risk individuals (Ginsberg and Toal, 1999). CTDPH currently issues consumption advisories for PCBs levels exceeding 0.1 ppm (parts per million), the point where practical quantification of PCBs in fish becomes certain², whereas the GLP recommends consumption advisories at PCBs levels exceeding 0.05 ppm.

High risk individuals include pregnant women, women planning to become pregnant within a year, breastfeeding women, or children under the age of six. Pregnant women or women planning to become pregnant are particularly sensitive because PCBs can be passed through the mother to the unborn fetus and can result in central nervous system (CNS) effects as well as others. Children under the age of six are also particularly vulnerable because they tend to eat more per body weight. In addition, the developing organs (brain and thyroid gland) of children can sustain permanent damage if exposure to PCBs occurs during critical growth stages. Breastfeeding women are also in the high risk group because PCBs can pass through breast milk and expose young children to PCBs. Low risk individuals include the remaining population. Table 1 gives the details of CTDPH’s fish consumption advisory as it relates to PCB levels in fish samples. In addition, CTDPH gives each fish consumption category a Restriction Category for ease of reference.

Regarding the issue of higher risk individuals, the animal toxicology studies support an HPV that is in the same range for reproductive and other (immunological, dermal) endpoints. This suggests that *in utero* development is no more sensitive to PCBs than endpoints seen in adult animals. However, the evidence of low dose effects in humans is strongest for *in utero* effects (central nervous system development). This creates a somewhat greater concern for pregnant women and women planning pregnancy (Ginsberg and Toal 1999).

Two short term studies in mink and rats also resulted in low dose developmental effects from exposure to PCBs. Therefore, CTDPH believes that there may be a greater sensitivity during *in utero* exposure such that recent exposures that do not involve a cumulative body burden (which is important to adult toxicity) could produce an adverse health effect. This uncertainty over PCBs pharmacokinetics and developmental outcomes

² The detection limit for PCBs was 0.1 ppm when CTDPH’s Modified Great Lakes Protocol for Fish Consumption was derived in 1999. The calculated detection limit for total PCBs during this 2014 fish tissue analysis was 0.03 ppm (Patrick Center for Environmental Research, 2016).

supports a prudent avoidance (do not eat) approach for pregnant women for markedly elevated PCB concentrations (e.g. over 1 ppm). CTDPH’s recommendation of “do not eat” for high risk groups for PCB levels in fish of 1.1-1.9 ppm differs from the GLP’s approach which recommends a “1 meal per 2 months” restriction for fish consumption for all risk groups for PCB levels of 1.1-1.9 ppm (Ginsberg and Toal 1999). In addition, CTDPH’s recommendation (Table 2) also differs from the GLP’s approach which recommends a “one meal per week” restriction for all risk groups for PCB levels of 0.06-0.20 ppm.

Setting limits based on cancer risk less than 1 in 10,000 would lead to severe restrictions on fish consumption overall (local or commercial) due to the widespread occurrence of low levels of PCBs in fish. This would result in the benefit of fish consumption to be lost in the interests of minimizing cancer risks. Given that the number of frequent consumers of locally caught fish in Connecticut may not be large, the theoretical 1 in 10,000 cancer risk is of less concern than if this were a population-wide exposure (Ginsberg and Toal 1999). Therefore, both CTDPH and The Great Lakes Protocol focus on prevention of non-cancer health effects of PCBs.

Table 1. CTDPH’s Modified Great Lakes Protocol for Fish Consumption[^]

Restriction Category (Level)	PCB Level (ppm [*])	Consumption Advisory	
		Low Risk [@]	High Risk [#]
A	< 0.1	No Consumption Advice	No Consumption Advice
B	0.1-0.2	One meal per week	One meal per month
C	0.21 - 1.0	One meal per month	One meal per month
D	1.1 - 1.9	One meal every 2 months	Do not eat
E	> 1.9	Do not eat	Do not eat

[^] (Ginsberg and Toal, 1999)

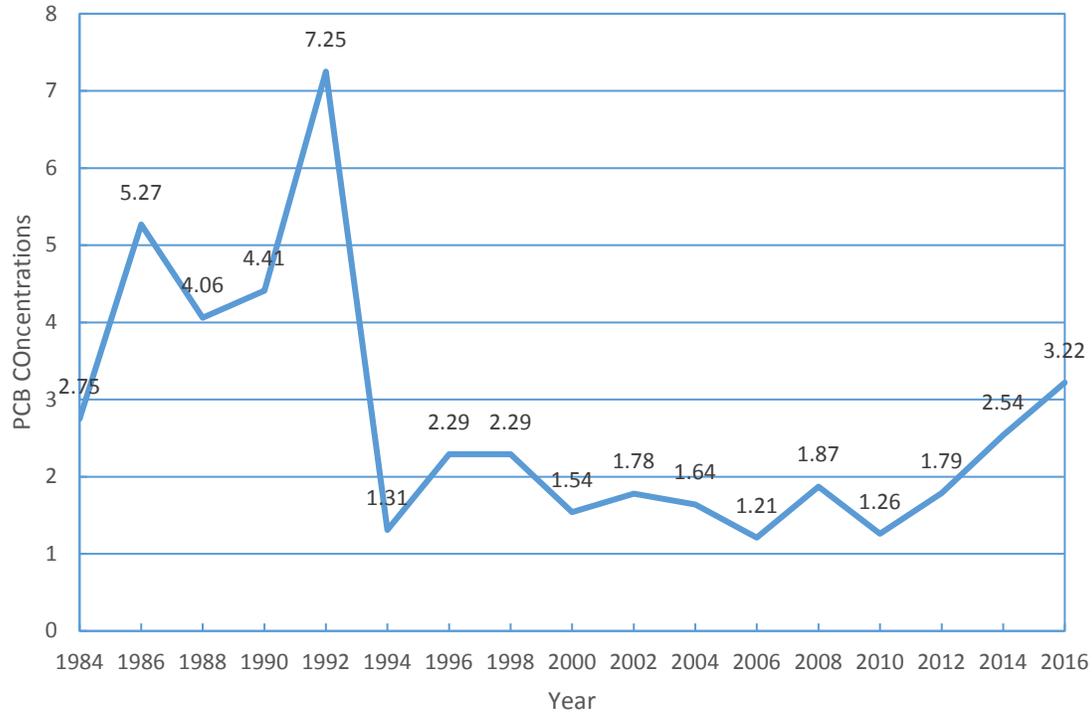
^{*}Parts per million

[@]Includes all other groups not included in the high risk group

[#] Includes pregnant women, women planning to become pregnant within a year, nursing women, and children under 6 years old

Appendix C

Figure 1. Average Congener-Based[#] PCB Concentrations in Brown Trout in the Upper Part of the Housatonic River from 1984-2016*

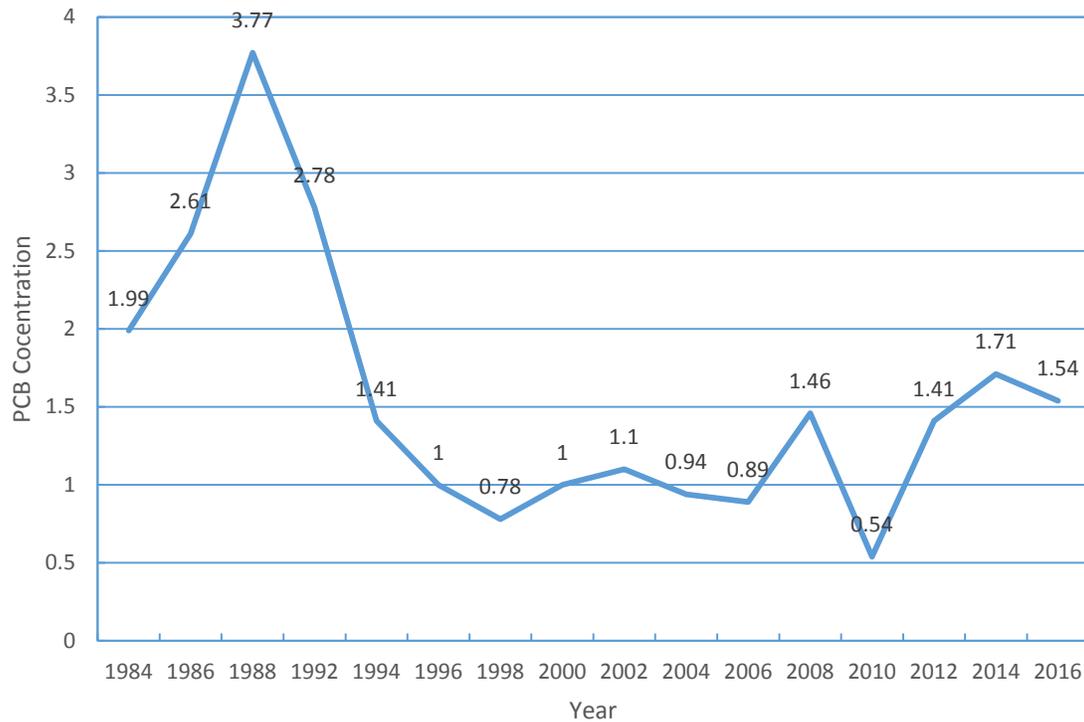


[#]The congener-based analysis method sums the concentrations of all individual congeners (up to 121) quantitated by the analytical method.

* Results for 1984-1990 were estimated by the Patrick Center for Environmental Research (2009) from aroclor-based data using regressions of the natural logarithm (ln) of the congener-based PCB concentration versus the ln of the aroclor-based PCB concentration of each fish species that were established with data from 1992 and 1994. The aroclor-based analysis method is a measurement of commercial mixtures of PCB compounds. Congener analysis was not performed before 1992.

@parts per million

Figure 2. Average Congener-Based[#] PCB Concentrations in Smallmouth Bass from the West Cornwall Sampling Station of the Housatonic River, 1984-2016^{*+}



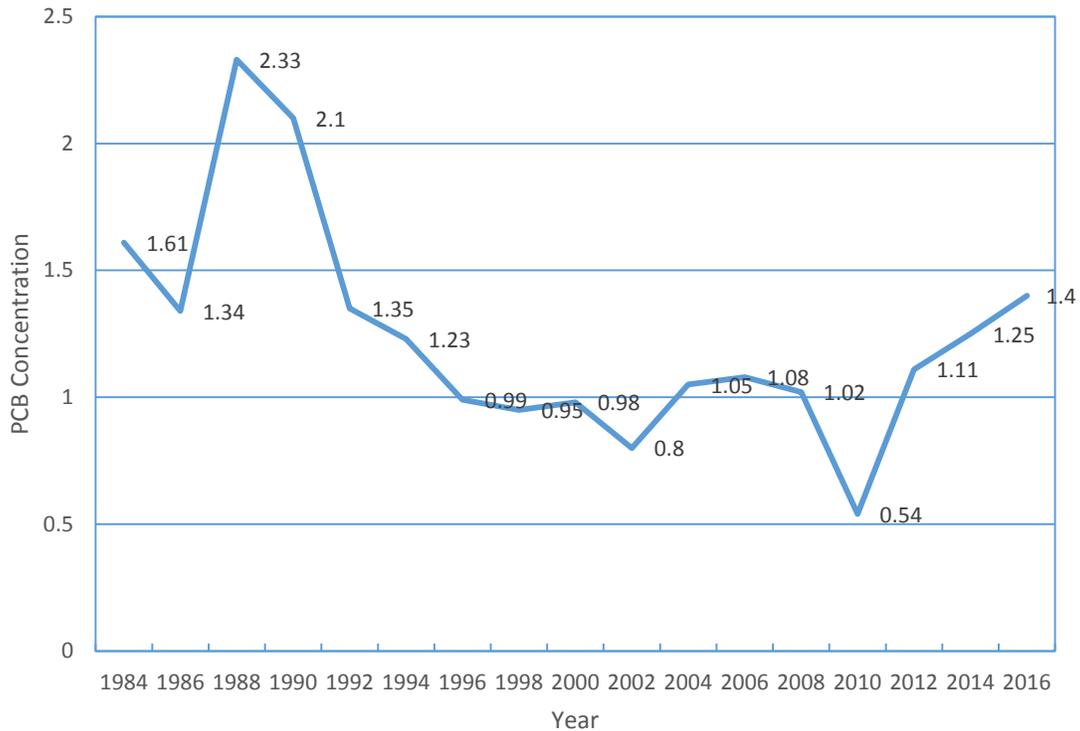
[#]The congener-based analysis method sums the concentrations of all individual congeners (up to 121) quantitated by the analytical method.

^{*} Results for 1984-1990 were estimated by the Patrick Center for Environmental Research (2009) from aroclor-based data using regressions of the natural logarithm (ln) of the congener-based PCB concentration versus the ln of the aroclor-based PCB concentration of each fish species that were established with data from 1992 and 1994. The aroclor-based analysis method is a measurement of commercial mixtures of PCB compounds. Congener analysis was not performed before 1992.

[@]parts per million

⁺Not sampled in 1990

Figure 3. Average Congener-Based[#] PCB Concentrations in Smallmouth Bass from Bull's Bridge Sampling Station in the Upper part of the Housatonic River, 1984-2016*

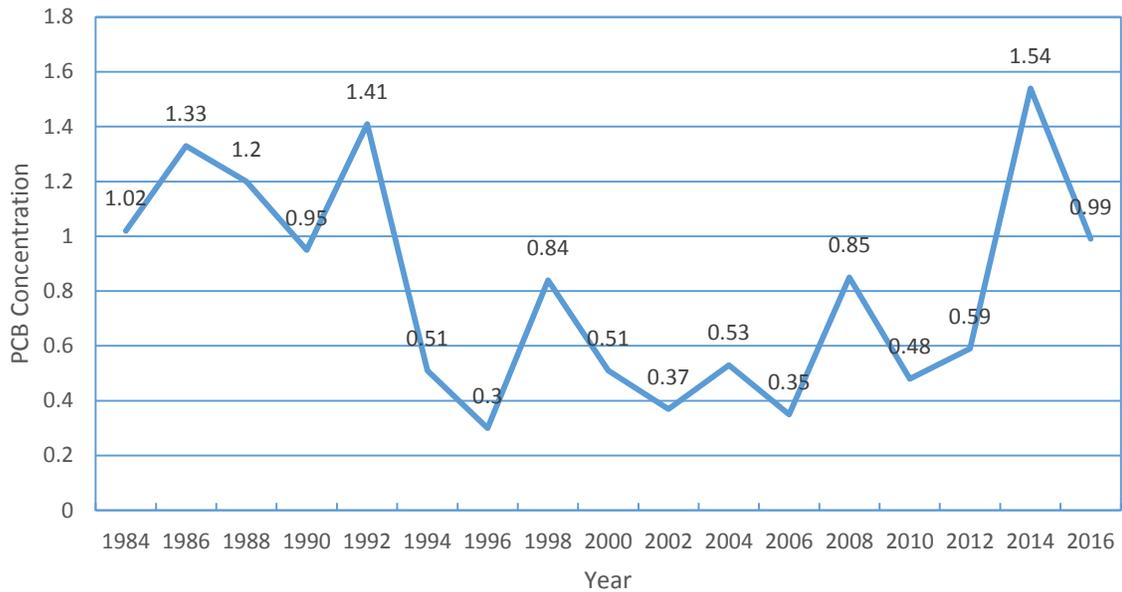


[#]The congener-based analysis method sums the concentrations of all individual congeners (up to 121) quantitated by the analytical method.

* Results for 1984-1990 were estimated by the Patrick Center for Environmental Research (2009) from aroclor-based data using regressions of the natural logarithm (ln) of the congener-based PCB concentration versus the ln of the aroclor-based PCB concentration of each fish species that were established with data from 1992 and 1994. The aroclor-based analysis method is a measurement of commercial mixtures of PCB compounds. Congener analysis was not performed before 1992.

@parts per million

Figure 4. Average Congener-Based[#] PCB Concentrations in Smallmouth Bass from Lake Lillinonah, 1984-2016*

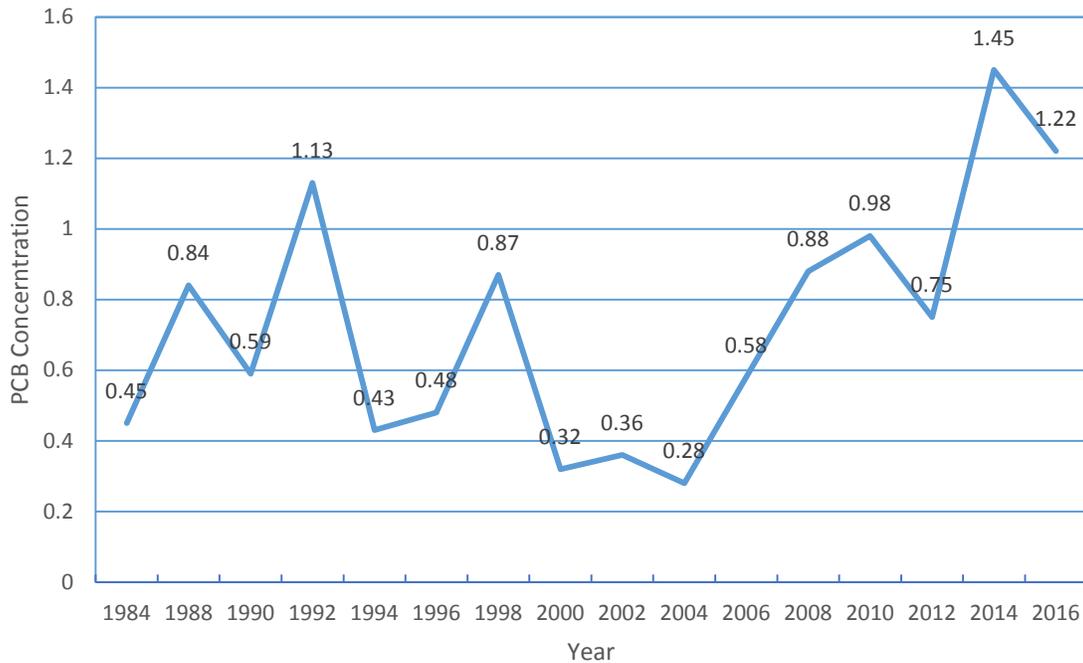


[#]The congener-based analysis method sums the concentrations of all individual congeners (up to 121) quantitated by the analytical method.

* Results for 1984-1990 were estimated by the Patrick Center for Environmental Research (2009) from aroclor-based data using regressions of the natural logarithm (ln) of the congener-based PCB concentration versus the ln of the aroclor-based PCB concentration of each fish species that were established with data from 1992 and 1994. The aroclor-based analysis method is a measurement of commercial mixtures of PCB compounds. Congener analysis was not performed before 1992.

@parts per million

Figure 5. Average Congener-Based[#] PCB Concentrations in Smallmouth Bass from Lake Zoar, 1984-2016^{*+}



[#]The congener-based analysis method sums the concentrations of all individual congeners (up to 121) quantitated by the analytical method.

^{*} Results for 1984-1990 were estimated by the Patrick Center for Environmental Research (2009) from aroclor-based data using regressions of the natural logarithm (ln) of the congener-based PCB concentration versus the ln of the aroclor-based PCB concentration of each fish species that were established with data from 1992 and 1994. The aroclor-based analysis method is a measurement of commercial mixtures of PCB compounds. Congener analysis was not performed before 1992.

⁺Not sampled in 1986

@parts per million