Review of Human Ingestion Risk Associated with Total Polychlorinated Biphenyl (PCB) Concentrations in Fish Collected in 2011 from High Rock Lake, Yadkin Pee-Dee River System, North Carolina

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The North Carolina (NC) Division of Public Health's (DPH) Health Assessment, Consultation and Education (HACE) program has completed the review of fish tissue data collected in 2011 for High Rock Lake in the Yadkin Pee-Dee River system of central North Carolina. The data was evaluated for health risks associated with human ingestion of fillet tissue using DPH's current fish consumption advisory protocols [DPH 2012, 2007].

In 2011 and 2012 fish were collected from 3 water bodies in the Yadkin Pee-Dee River system (High Rock Lake, Falls Reservoir and Lake Tillery) to evaluate levels of polychlorinated biphenyls (PCBs). The sampling and analysis project was a joint effort involving the N.C. Department of Environment and Natural Resources (DENR) Division of Waste Management (DWM) and Division of Water Quality (DWQ), the United States Environmental Protection Agency (EPA) and DPH. The objective of the study was to investigate potential risks to human health due to PCB concentrations in sediment and fish tissue in the Yadkin-Pee Dee River system. This study was undertaken as a follow-up to a PCBs in fish tissue study conducted in Badin Lake in 2008 by DPH. The Badin Lake fish study resulted in a fish consumption advisory issued in 2009 for catfish and largemouth bass. A summary of the Badin Lake study and the advisory is provided in the Appendix [Badin 2009].

The 2011-12 Yadkin Pee-Dee River system study included 104 fish tissue samples analyzed for 209 PCB congeners. In 2011, surface sediment samples were collected in High Rock Lake, Badin Lake, Lake Tillery and the uppermost reaches of Blewett Falls. Additional sediments were collected in 2012 in the Falls Reservoir segment of the Yadkin-Pee Dee River system. Sediments were collected at locations of likely direct human contact (such as boat ramps and swimming beaches) and in the center channel to characterize sediment moving through the river system. Sediments were analyzed for Aroclor PCBs. This report summarizes the PCB levels of the fish collected from the uppermost water body sampled in the 2011-12 YRB study, High Rock Lake. The health risks associated with fish tissue from the other 2 water bodies and the sediments will be presented in separate documents [FR 2013a, LT 2013, YRB 2013, FR 2013b].

Fish biologists from DENR collected fish of the size and species most likely to be ingested by local anglers. DENR also prepared the fish for analysis. A total of 45 fillet tissue samples from 3 trophic levels[1] (13 bottom feeders, 17 middle and 15 top predators) were prepared from 120 total fish collected in High Rock Lake. Fish were collected at the lake inlet (northwestern end of the lake) and at 2 major arms on the eastern and western sides of the lake above High Rock Dam on the outlet

[1] The trophic level of an organism is the position it occupies in the food chain of their specific habitat.

(southeastern) end of the lake. Fish were collected from distinct areas of the lake to identify potential differences in PCB exposures throughout the water body. High Rock Lake fish collection locations are identified on Figure 1 in the Appendix.

Analytical samples consisted of fillet tissue from individual fish or fillet tissue composite samples from fish of like species and similar size. Fillet tissue was submitted for analysis to best represent the most likely human ingestion component. Sample preparation was completed according to DENR protocols [DENR 2006] referencing EPA guidance [EPA 2000]. Fish tissues were analyzed for 209 PCB congeners by EPA Method 1668A, a high resolution gas chromatography/high resolution mass spectrometry method (HRGC/HRMS). Tissues were also analyzed for percent lipids. Tissue analyses were performed by the EPA Region 4 Science and Ecosystem Support Division (SESD) Laboratory in Athens, Georgia. PCB data is reported as wet weight tissue. Final data was reported to DPH in December 2012. A PCB 50% loss factor was used to adjust for contaminant loss attributed to trimming and cooking.

Conclusions -

Mulitple PCB congeners were detected above analytical method reporting limits in all tissue samples (see Appendix Table 1). Total fillet PCB concentrations in High Rock Lake fish ranged from 2,600-88,000 ng/kg[2]. Human health ingestion risks were evaluated as total PCB concentrations compared to DPH's total PCB action level (AL, 50,000 ng total PCB/kg wet weight fillet[3]) [DPH 2007]. Three data handling protocols for congeners reported as not detected (ND) at the reporting limit (RL) were evaluated (see ND discussion in the Appendix). The non-detect handling method had no impact on the relationship of individual samples to the Action Level for this data set (Appendix Figure 3). The sample-specific reporting limit multiplied by 0.5 for congeners reported as not-detected was selected for meal limit recommendations for this project. The (RL x 0.5) represents a health-protective consideration of not-detected values and potential contaminant exposure concentrations.

A total of 9 samples (9%), 3 in each water body, all of them catfish species (bottom feeders), exceeded DPH's total PCB Action Level (Appendix Table 2 and Figure 2). No other species exceeded the PCB action level. In High Rock Lake, 3/13 (23%) catfish tissue samples exceeded the Action Level and included 2 channel catfish and 1 blue catfish (Appendix Figure 4). Catfish data were sorted by length (a surrogate measure of fish age). The total PCB to fish length data indicated:

1. All 9 catfish samples with total PCB concentrations greater than the Action Level were >450 mm[4] in length.
2. 50% (9/18) of the catfish >450 mm (18 inches) exceeded the PCB Action Level.
3. The average total PCB concentration for fish >450 mm was 55,400 (± 34,000) ng/kg total PCBs.

[2] ng/kg = nanograms per kilogram, (parts per billion)
[3] 50,000 ng/kg total PCB AL = 0.05 mg/kg (parts per million) total PCB AL
[4] mm = millimeters

4. The average total PCB concentration for fish <450 mm was 18,000 (± 16,000) ng/kg total PCBs.

A summary of High Rock Lake and combined catfish statistics for all 3 water bodies is included in the Appendix Table 3. Appendix Figure 5 is the catfish PCB data sorted by length. A DPH PCB factsheet is included in the Appendix.

Recommendations -

The only consumption concern for PCBs in fish collected in 2011 from High Rock Lake, in the Yadkin Pee-Dee River system, North Carolina, is for catfish:

Do not eat more than 1 meal per week[5] of catfish greater than 18 inches (450 mm) in length from High Rock Lake.

High Rock Lake is in the area covered by the statewide mercury advisory (south and east of U.S. Highway I-85) (http://epi.publichealth.N.C..gov/oee/mercury/safefish.html). The mercury advisory includes wild-caught catfish. The existing statewide mercury advisory (below) is more restrictive for catfish than the above High Rock Lake recommendation.

N.C. Statewide Meal Consumption Limit Recommendations for Mercury in Fish [1,2]	
Women of child-bearing age (15-44 years old), pregnant women, nursing mothers, & children less than 15 years old	**All others**
DO NOT EAT fish HIGH in mercury [3]	Eat only 1 meal per week of fish HIGH in mercury
Eat up to 2 meals per week of fish LOW in mercury	Eat up to 4 meals per week of fish LOW in mercury

[1] High mercury levels have been found in blackfish (bowfin), catfish, jack fish (chain pickerel), warmouth, and yellow perch caught south and east of Interstate 85. High mercury levels have been found in black crappie caught south and east of Interstate 95. High mercury levels have been found in largemouth bass statewide.

[2] See the N.C. DPH Fish Advisories web site for a complete list of fish identified as LOW & HIGH in mercury (http://epi.publichealth.nc.gov/oee/fish/advisories.html#state)

[3] In N.C. wild-caught catfish are identified as HIGH in mercury

[5] N.C. DPH defines a meal as 6 ounces of uncooked fish [DPH 2012].

The final recommendation for High Rock Lake fish consumption based on 2011 fish tissue samples is:

The recommendations of the state-wide fish consumption advisory for mercury are protective for all persons for total PCBs concentrations observed in catfish in High Rock Lake in 2011. No additional restrictions on fish consumption are recommended.

Limitations of the Fish Tissue Study –

The fish tissue sampling was designed to assess potential adverse human health effects related to eating fish taken from High Rock Lake. Limitations of the data provided for this study include:

1. The fish tissue contaminant concentrations and fish consumption recommendations included in this report are relevant only for fish caught in High Rock Lake at the time of collection.
2. Contaminant concentrations in collected fish may not be representative of contaminant concentrations in all areas of the lake that are accessible to anglers or of all fish present or all members of the specified species.
3. The assessment of fish tissue data for this health risk evaluation assumes ingestion of fish fillets. If persons consume other portions of the fish (such as whole body, eggs or liver) the levels of contaminants to which they are exposed may differ from those in this report.
4. Fish consumption advisories are based on average monthly exposures experienced over a lifetime. Ingestion patterns that deviate substantially from the recommended number of meals per week or month may result in substantially different exposures (such as eating all the monthly meals in one or several days).
5. Exposure calculation parameters (i.e., body weight, consumption rate) used to develop the N.C. DPH Action Levels may not be representative of all local exposed populations.
6. Factors applied to contaminant exposure concentrations to account for contaminant loss due to trimming and cooking may not be representative of species-specific exposure effects or specific cooking methods (those that do not allow fat to drip away).
7. Risk calculations do not take into consideration exposures and potential adverse health impacts due to related chemicals that may induce health effects through the same mode of action.
8. Other PCB exposure sources are not considered in the meal recommendations. Commercially caught fish and shellfish may be potentially significant sources of exposure.

Action Items -

Recommended actions after approval of the proposed Yadkin Pee-Dee River system advice for High Rock Lake by DPH risk managers:

1. Alert the following persons/agencies of the fish consumption advisory:
    a. Local Health Directors and Environmental Health Directors for all counties bordering High Rock Lake
    b. DENR Davison of Waste Management project staff
    c. EPA project staff
    d. DPH Public Information Officer (PIO)
    e. DPH Occupational and Environmental Epidemiology Branch (OEEB)
2. Assist PIOs and/or Local Health Departments with language for press releases from DPH and local media.
3. Post the advisory on the DPH Fish Advisories web page.
4. Provide recommendations to bordering counties on an advisory sign format should they choose to post signs.
5. Present the fish tissue data in the proposed May 2013 combined DENR, EPA and DPH community meeting. Proposed location is Albemarle or Badin, Stanly County N.C.
6. Provide public availability sessions as requested in other communities in the Yadkin Pee-Dee River system.
7. Submit additional health risk assessment documents for the Falls Reservoir and Lake Tillery, and the 2 sets of sediment samples included with the Yadkin Pee-Dee River system project. Follow the above steps for dissemination of that data.
8. Submit all Yadkin Pee-Dee River system fish tissue and sediment assessments to Agency for Toxic Substances and Disease Registry (ATSDR) as part of the HACE program's deliverables.

- APPENDIX -

Summary of the 2008 Badin Lake fish tissue total PCBs study:

1. 27 total fish tissue samples, 9 each from 3 regions of the lake
2. Total PCBs greater than the DPH Action Level were found in 3 catfish (2 channel catfish and 1 white catfish) and 1 largemouth bass
3. The fish consumption advisory issued in February 2009 recommended:

Do not eat more than one (1) meal a week of catfish or largemouth bass from Badin Lake. If you are pregnant, may become pregnant, are nursing, or are a child under 15 years of age, do not eat any of these fish. *Elevated levels of polychlorinated biphenyls (PCBs) have been found in some catfish and largemouth bass. Swimming, boating, and handling fish do not present a known health risk.*

Discussion of non-detect (ND) data handling methods for the High Rock Lake study:

Total PCB data were evaluated using 3 treatments for data reported as not-detected (ND). These included:

1. Not-detected (ND) analyte contribution as 0 concentration
2. ND analyte contribution as the sample/congener-specific reporting limit (RL) concentration x 0.5
3. ND analyte contribution at the sample/congener-specific RL concentration

EPA Risk Assessment protocols set no prescribed guidance for the contribution of ND data in human health risk assessments (per personal conversation with EPA Region 4 human health risk assessment staff). EPA considers each sample/site uniquely in determining what approach to use in the risk analysis. The 3 methods evaluated are typical protocols used for risk assessment evaluations of environmental data. Evaluation of the data for this site and the implications of the 3 ND data handling methods ultimately had little impact on the final risk recommendations.

Table 1. Reported PCB congener statistics. High Rock Lake 2011 fish fillet data.

Total # of data points by sample	Number of data points >RL by sample (average)	Number of data points reported as ND by sample (average)
159 [1]	26-156 (65)	3-133 (94)

[1] 50/209 PCB congeners were reported as co-eluting with other congener(s)
ND = not detected at the sample-specific reporting limit concentration,
RL = sample-specific reporting limit concentration
> = greater than

Table 2. Summary of combined catfish species tissue total PCB data collected in High Rock Lake and Lake Tillery in 2011, and Falls Reservoir in 2012, Yadkin Pee-Dee River system, North Carolina.

Catfish species	High Rock Lake		Falls Reservoir		Lake Tillery		Totals (2011-12)	
	no. > AL	total no.	no. > AL	total no.	no. > AL	total no.	no. > AL (%)	total no.
White	0	1	0	0	0	5	0 (0%)	6
Channel	2	10	0	2	3	9	5 (24%)	21
Flathead	0	1	1	1	0	0	1 (50%)	2
Blue	1	1	2	3	0	0	3 (75%)	4
Total no. (%)	**3 (33%)**	**13**	**3 (50%)**	**6**	**3 (21%)**	**14**	**9 (27%)**	**33**

no. > AL = number of tissue samples greater than NC DPH total PCB fish tissue action level

Table 3. Statistical evaluation of combined catfish species collected in High Rock Lake and Lake Tillery in 2011 and Falls Reservoir in 2012, Yadkin Pee-Dee River system, North Carolina. Total number of catfish[1] tissue samples = 45.

High Rock Lake catfish species	13 samples
Percent catfish with PCB > AL	23% (3/13)
Average (sd) total PCB concentration	36,000 ng/kg (28,000)
Median concentration	25,000 ng/kg
Range of concentrations	3,500 – 88,000 ng/kg
95th percentile	82,000 ng/kg
76th percentile	50,000 ng/kg
Median length (mm), weight (g), % lipid	435, 629, 3.3
Combined catfish, all 3 water bodies	33 samples
Average (sd) total PCB concentration	39,000 ng/kg (32,000)
Median concentration	26,000 ng/kg
Range of concentrations	3,500 – 128,000 ng/kg
95th percentile	99,000 ng/kg
75th percentile	50,000 ng/kg
Median length (mm), weight (g), % lipid	466, 900, 2.3
Combined catfish >450 mm [2], all 3 water bodies	18 samples
Percent catfish with PCB > AL	50% (9/18)
Average total PCB concentration	55,000 ng/kg (34,000)
Median concentration	49,000 ng/kg
Range of concentrations	8,700 – 128,000 ng/kg
95th percentile	117,000 ng/kg
Median length (mm), weight (g), % lipid	508, 1,400, 2.9
Combined catfish <450 mm, all 3 water bodies	15 samples
Percent catfish with PCB > AL	0% (0/15)
Average total PCB concentration	20,000 ng/kg (10,000)
Median concentration	24,000 ng/kg
Range of concentrations	3,500 – 36,000 ng/kg
95th percentile	35,000 ng/kg
Median length (mm), weight (g), % lipid	320, 350, 2.2

AL = Action Level, N.C. DPH total PCB AL = 50,000 ng/kg wet weight, g = gram, mm = millimeter, ng/kg = nanograms per kilogram wet weight tissue ("parts per trillion"), sd = standard deviation

[1] catfish statistics include: 5 channel catfish, 3 blue catfish, 1 flathead catfish

[2] 450 mm ≈ 18 inches

Figure 1. Fish and sediment collection locations in the Yadkin Pee-Dee River system, 2011 and 2012.

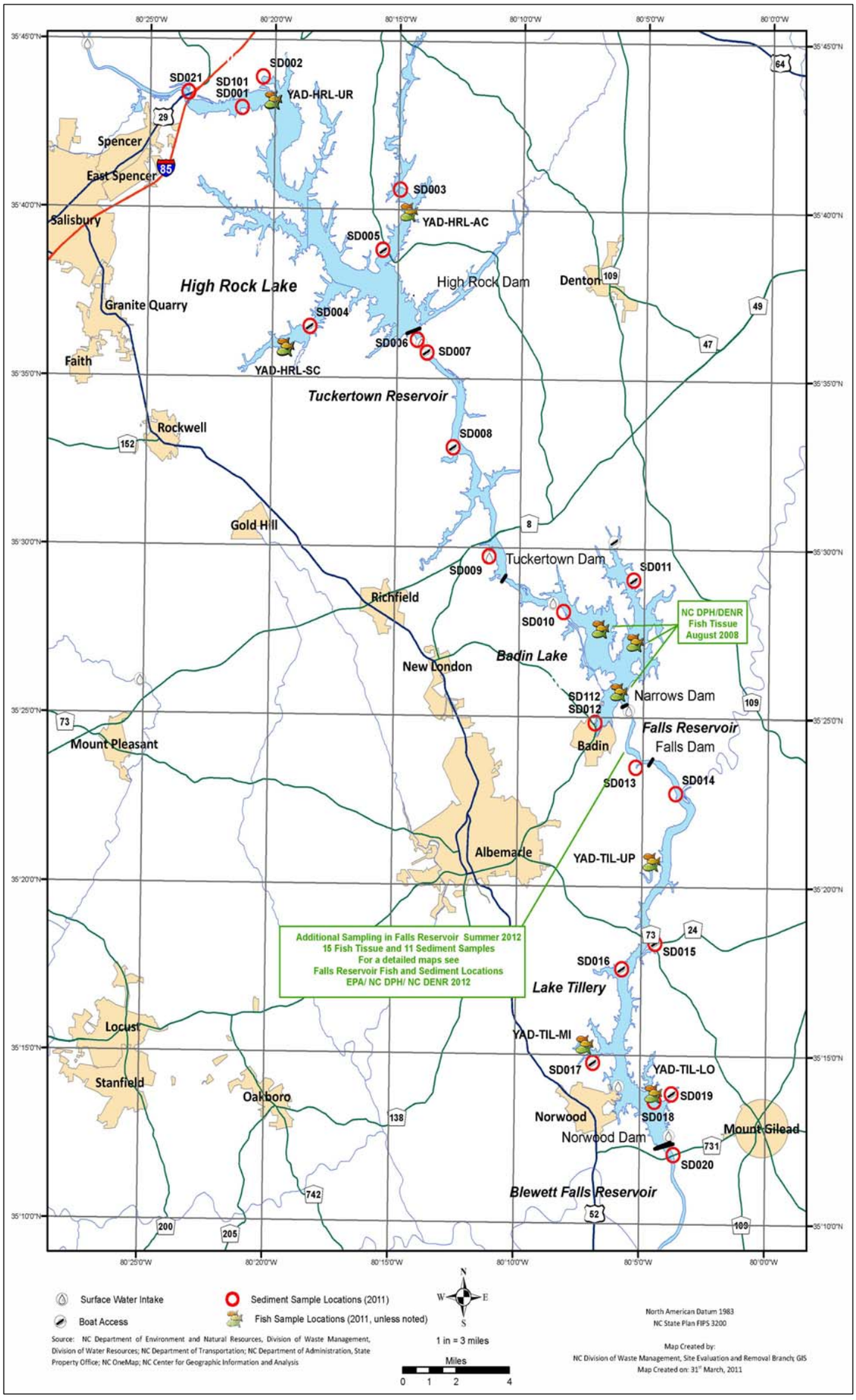


Figure 2. Yadkin Pee-Dee River system, North Carolina (2011, 2012) fish tissue (fillet) total polychlorinated biphenyls (PCBs) data. Samples identified by water body, collection location, trophic level and species common name. HR = High Rock Lake (2011), FR = Falls Reservoir (2012), LT = Lake Tillery (2011). “bottom” = bottom feeder, “mid” = middle trophic level, “upper” = top predator.

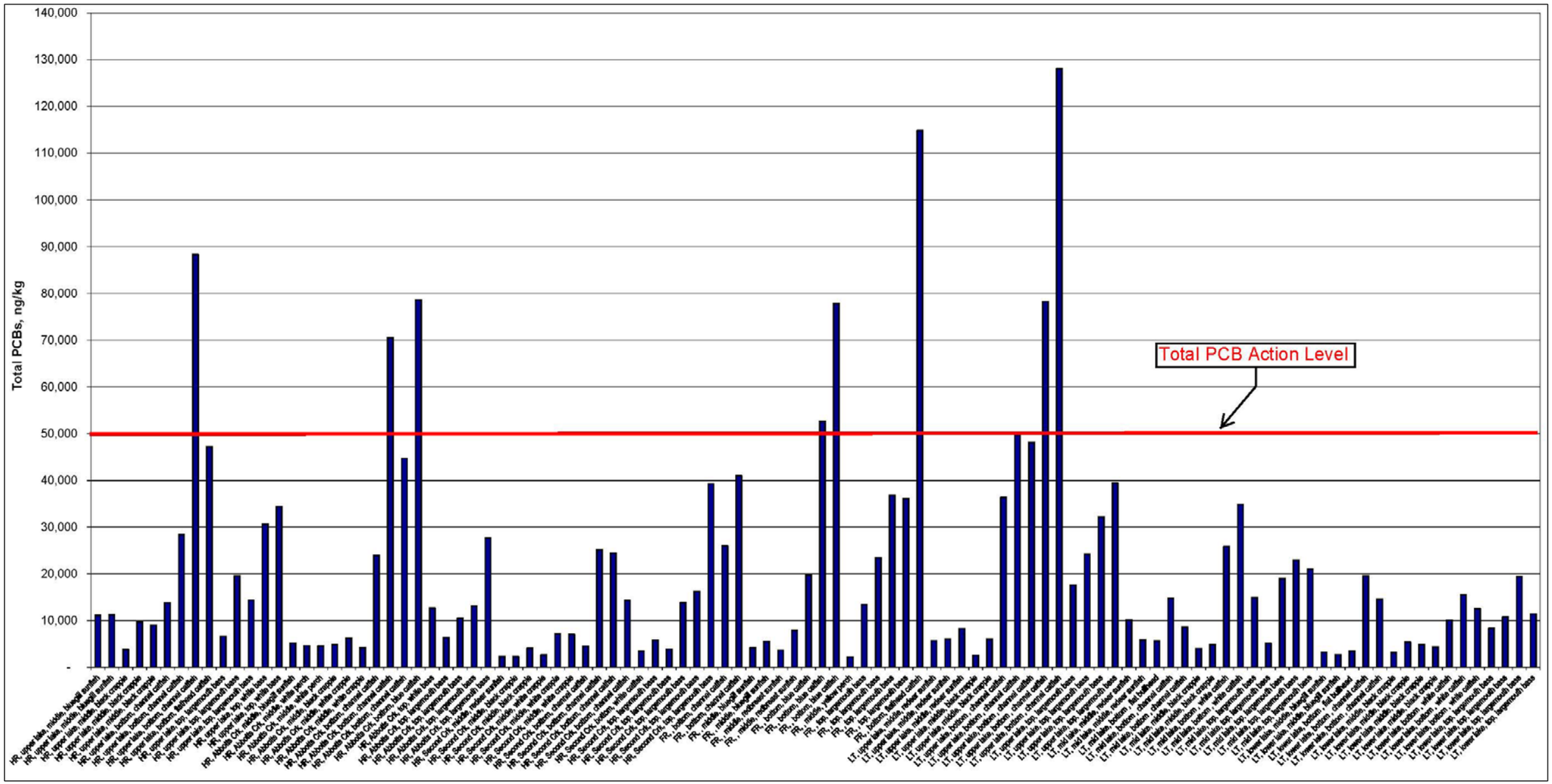


Figure 3. Comparison of High Rock Lake fish fillet tissue total PCB concentrations by the 3 not-detected data handling methods for individual PCB congeners. Yadkin Pee-Dee River system 2011.

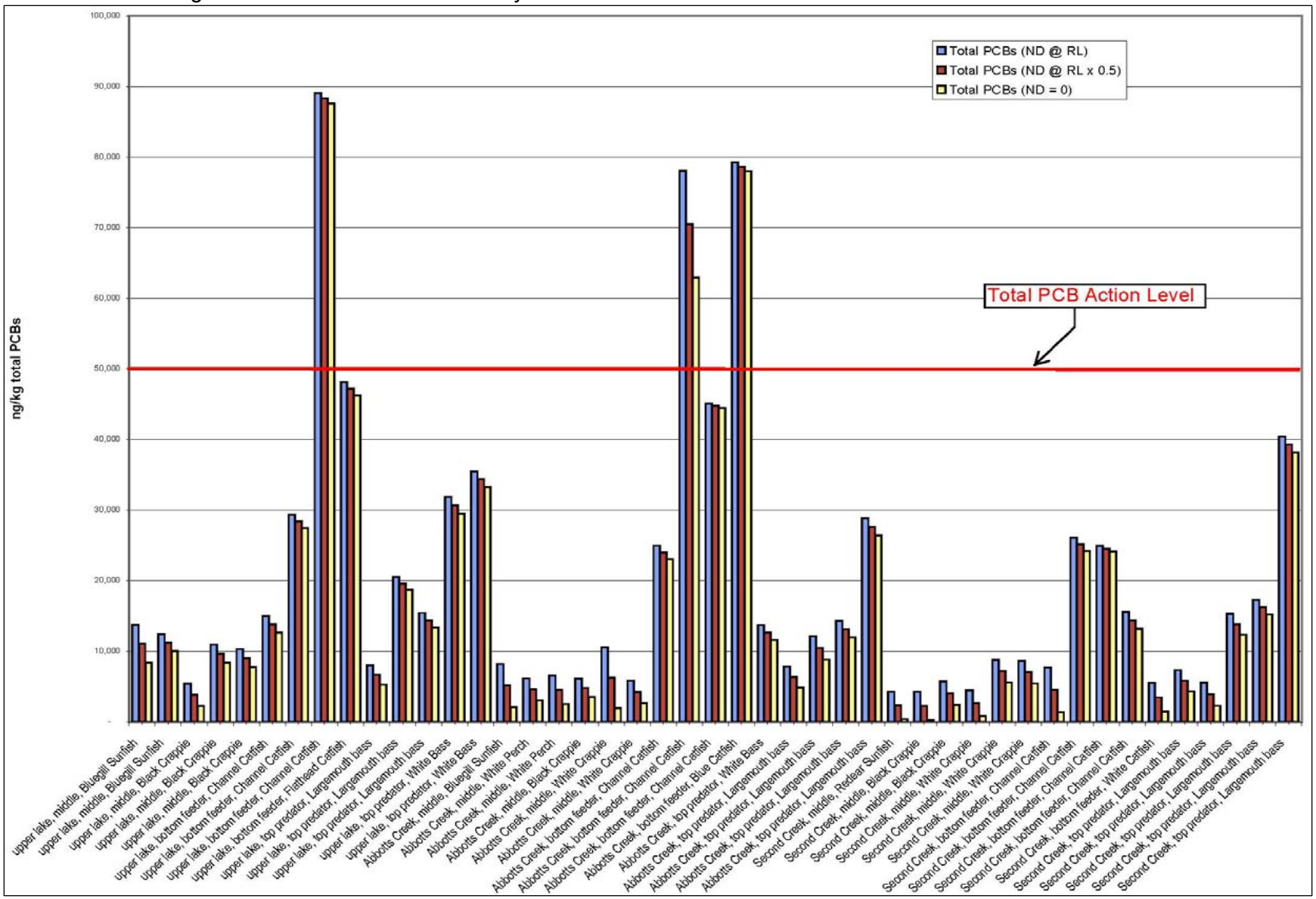


Figure 4. High Rock Lake fish tissue (fillet) total polychlorinated biphenyls (PCBs) data. Yadkin Pee-Dee River system, North Carolina, 2011. Samples identified by water body collection location, trophic level and species common name.

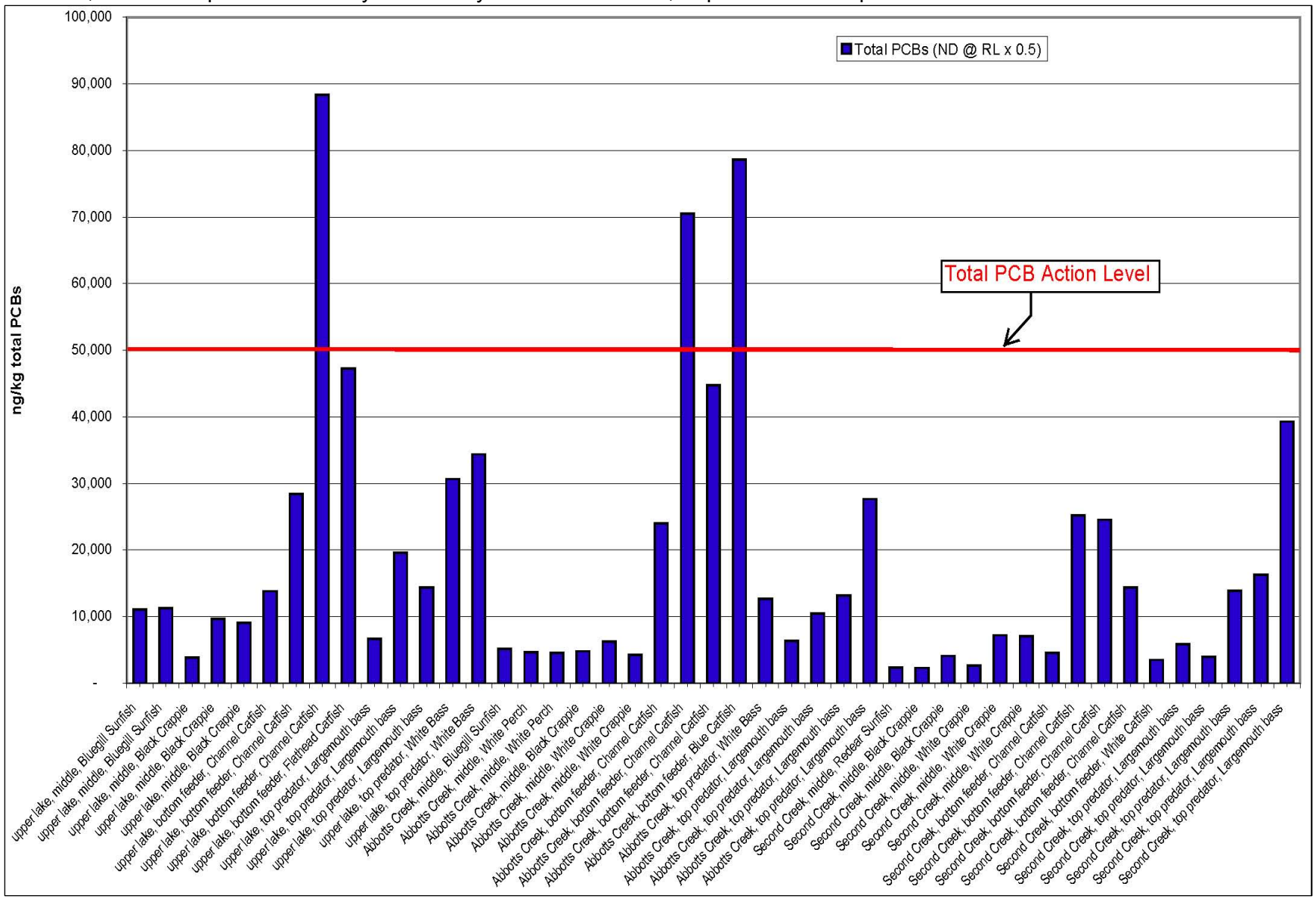
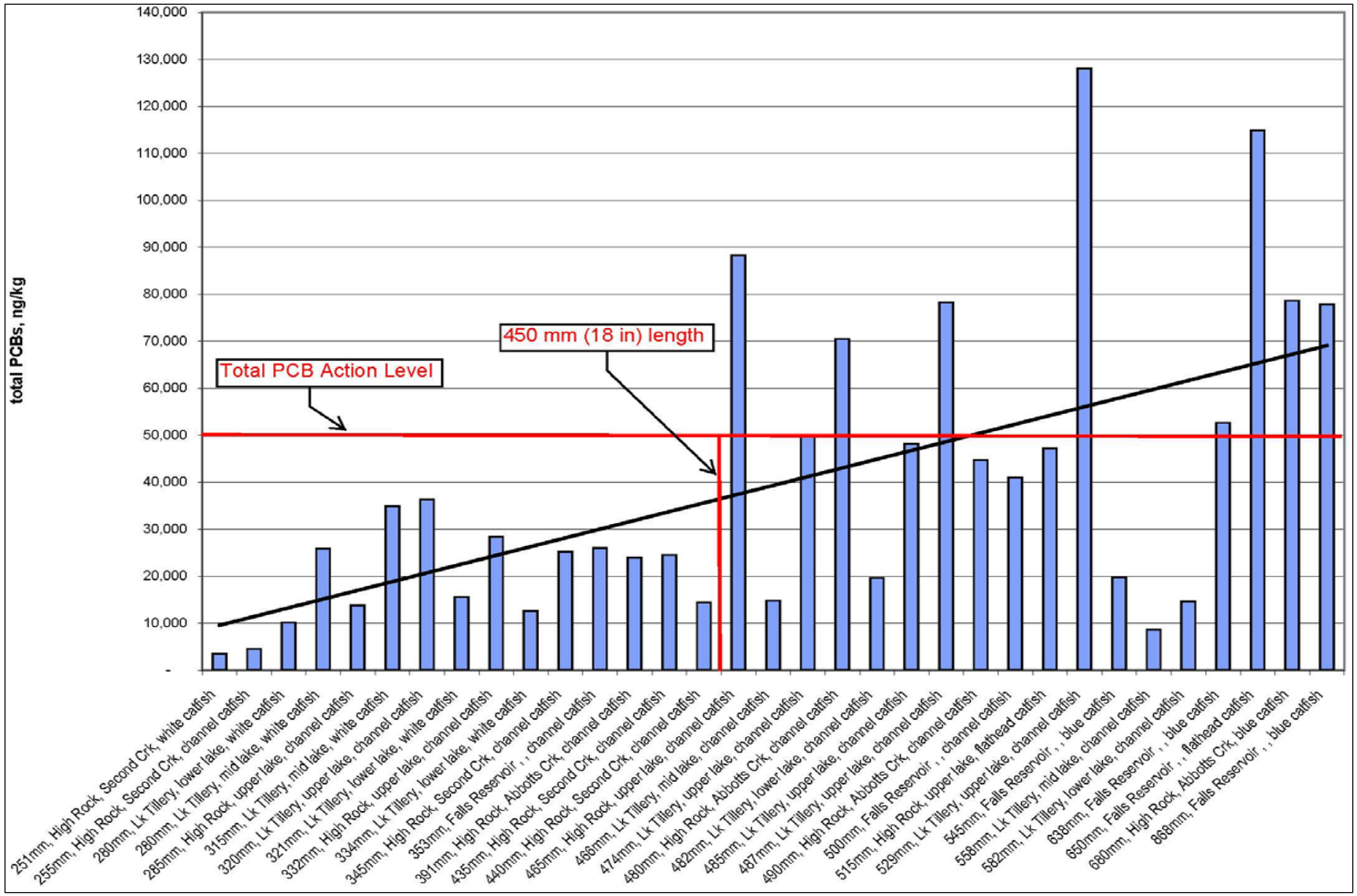


Figure 5. High Rock Lake (2011, Falls Reservoir (2012) and Lake Tillery (2011) fish tissue (fillet) total polychlorinated biphenyls (PCBs) data for all catfish species (white, channel, blue, flathead) sorted by fish length (mm). Yadkin Pee-Dee River system, North Carolina. Samples listed by fish length, water body, water body location and species. 450 mm ≈ 18 inches.



POLYCHLORINATED BIPHENYLS (PCBS)
FACT SHEET AND FAQS
JULY 2008

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

NCPH
North Carolina Public Health

This fact sheet answers the most frequently asked health questions (FAQs) about polychlorinated biphenyls (PCBs). This information is important because PCBs have the potential to cause negative health effects in people. The effects of exposure to any hazardous substance depend on the dose, duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

Polychlorinated Biphenyls

What are Polychlorinated Biphenyls (PCBs)? Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U.S. by the trade name Aroclor. PCBs have been used as coolants and lubricants in transformers, capacitors and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.

What happens when PCBs enter the environment? PCBs entered the air, water and soil during their manufacture, use and disposal; from accidental spills and leaks during their transport; and from leaks or fires in products containing PCBs. PCBs can still be released to the environment from hazardous waste sites; illegal or improper disposal of industrial wastes and consumer products; leaks from old electrical transformers containing PCBs; and burning of some wastes in incinerators. PCBs do not readily break down in the environment and thus may remain there for very long periods of time. PCBs can travel long distances in the air and be deposited in areas far away from where they were released. In water, a small amount of PCBs may remain dissolved, but most stick to organic particles and bottom sediments. PCBs also bind strongly to soil. PCBs are taken up by small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs accumulate in fish and marine mammals, reaching levels that may be many thousands of times higher than in water.

How might I be exposed to PCBs? Using old fluorescent lighting fixtures and electrical devices and appliances, such as television sets and refrigerators, that were made 30 or more years ago can expose you to PCBs. These items may leak small amounts of PCBs into the air when they get hot during operation, and could be a source of skin exposure. Eating contaminated food is another way to be exposed.

The main dietary sources of PCBs are fish (especially sportfish caught in contaminated lakes or rivers), meat and dairy products. Breathing air near hazardous waste sites and drinking contaminated well water can cause exposure. Workplace exposure can occur during repair and maintenance of PCB transformers; accidents, fires or spills involving transformers, fluorescent lights and other old electrical devices; and disposal of PCB materials.

How can PCBs affect my health? The most commonly observed health effects in people exposed to large amounts of PCBs are skin conditions such as acne and rashes. Studies in exposed workers have shown changes in blood and urine that may indicate liver damage. PCB exposures in the general population are not likely to result in skin and liver effects. Most of the studies of health effects of PCBs in the general population examined children of mothers who were exposed to PCBs. Animals that ate food containing large amounts of PCBs for short periods of time had mild liver damage and some died. Animals that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects.

How likely are PCBs to cause cancer? The U.S. Department of Health and Human Services has concluded that PCBs may reasonably be anticipated to be carcinogens. The Environmental Protection Agency and the International Agency for Research on Cancer have determined that PCBs are probably carcinogenic to humans (liver and biliary tract).

How can PCBs affect children? Women who were exposed to relatively high levels of PCBs in the workplace or ate large amounts of fish contaminated with PCBs had babies who weighed slightly less than babies from women who did not have these exposures. Babies born to women who ate PCB-contaminated fish also showed abnormal responses in tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, lasted for several years. Other studies suggest that the immune system was affected in children born to and nursed by mothers exposed to increased levels of PCBs. There are no reports of structural birth defects caused by exposure to PCBs or of health effects of PCBs in older children. The most likely way infants will be exposed to PCBs is from breast milk. PCBs may be passed from mother to unborn child. In most cases, the benefits of breast-feeding outweigh any risks from exposure to PCBs in mothers' milk.

Additional Information

NC Fish Consumption Advisories www.epi.state.nc.us/epi/fish/
Agency for Toxic Substances and Disease Registry www.atsdr.cdc.gov

Polychlorinated Biphenyls Fact Sheet and FAQs – July 2008 N.C. Division of Public Health

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[LT 2013] *Review of Human Ingestion Risk Associated with Total Polychlorinated Biphenyl (PCB) Concentrations in Fish Collected in 2011 from Lake Tillery,* Yadkin Pee-Dee River System*, North Carolina*. Division of Public Health, Department of Health & Human Services, Raleigh, N.C. April 2013.

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