COMPARING POLYCHLORINATED BIPHENYLS IN FARM-RAISED AND WILD-CAUGHT CATFISH FROM SOUTHERN MISSISSIPPI

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Introduction

Polychlorinated biphenyls (PCBs) are among the most thermally stable organic chemicals known. This characteristic has historically made them useful in a wide array of applications including use in electrical transformers and capacitors, varnishes, waxes, synthetic resins, epoxy and marine paints, coatings, cutting oils, heat transfer fluids, hydraulic fluids, and flame retardants.[1] As a result of their widespread use and their stability, these compounds are ubiquitous in the environment, and have been detected in media such as soils, sediment, and biota. Further, the lipophilic nature of these compounds has resulted in bioaccumulation of them in the food chain. As a result, intake of PCBs has been shown to occur primarily through the consumption of food and food products, especially meat, fish and dairy products.[2] In fact, exposure to PCBs via the ingestion of meat, fish and dairy products accounts for 63-100% of the total dietary intake of these compounds in humans with fish being the major contributor.[2]

While there is a substantial amount of data concerning the levels of dioxin-like compounds in fish,[3-13] little data exist for PCBs in both wild-caught and farm-raised fish in the U.S. Additionally, little data exists concerning the levels of all 209 PCB congeners in fish, thereby limiting the ability to establish current background exposures resulting from the consumption of this particular food.

Given the relatively high consumption rates of catfish in the U.S., especially the Southern States, it is believed that catfish could contribute appreciably to the dietary intake of PCBs. For example, research conducted at Mississippi State University estimated the total consumption of catfish to be 281 million pounds and 136 million pounds per year for the U.S. and south central populations, respectively.[14] With states such as Arkansas and Mississippi leading the U.S. in average per capita consumption of catfish at 5.95 and 4.61 pounds per person per year, respectively, there is a clear need to characterize the levels of PCBs in catfish, particularly in the south central states.[14] In this study, we quantified the PCB levels for all 209 congeners in tissue from a number of wild-caught and farm-raised catfish collected throughout Southern Mississippi and this appears to represent the most substantial assessment conducted to date.

Materials and Methods

Sixty-one wild-caught and farm-raised catfish samples from Southern Mississippi were collected in March 2006. Wild catfish (n=33) were caught by local fisherman along the Mississippi, Pearl, and Leaf Rivers. Samples were collected in one location along the Mississippi River (MR), two locations along the Pearl River (PR and the Ross Barnett Spillway or RBS), and two locations along the Leaf River (LR1 and LR2). Immediately after the fish were caught they were measured for length, weighed and then filleted using clean knives and glass plates. Final filet weights were also recorded prior to packaging. Farm-raised catfish samples (n=28) were purchased either directly from a Mississippi farm or from local seafood markets and/or grocery stores (seven stores visited) that obtain catfish from farms in Mississippi. All samples were wrapped individually in aluminum foil (shiny side out), placed in labeled plastic bags and frozen on dry ice in uncontaminated coolers. Samples were kept frozen until analysis.

Fish tissue samples were analyzed by Alta Analytical Laboratory (El Dorado Hills, CA) for the 209 PCB congeners using high resolution gas chromatography-mass spectrometry according to EPA Method 1668. Multiple PCBs co-eluted resulting in data for 168 PCB congeners/congener pairs for each tissue sample. Samples with concentrations below the limit of detection (LOD) were assumed to have a concentration equal to the LOD divided by the square root of two. All data analyses were conducted using Microsoft Excel. The mean, median, and 25th and 75th percentile PCB concentrations were characterized by fish type (wild-caught and farm-raised), sample type (fillet, whole, dressed, and nugget) and collection site. Ninety-five percent confidence intervals for the mean PCB levels were also calculated using Microsoft Excel. All PCB concentrations are presented as wet weight unless otherwise noted.

Results and Discussion

A total of 17 blue, 3 appaloosa, and 1 willow catfish (all wild-caught) were filleted for tissue analysis. Average fish weights and lengths ranged from 2.56 to 18.63 ounces and from 8.94 to 16.04 inches, respectively, as previously described.[15] As demonstrated in Figure 1, farm-raised catfish fillets were larger than wild-caught fillets and had a higher average lipid fraction. Interestingly, though, dressed catfish had a much lower fraction of lipids than other types of farm-raised samples.

Figure 1: Mean percent lipid and mean tissue weight by fish type and sample type.

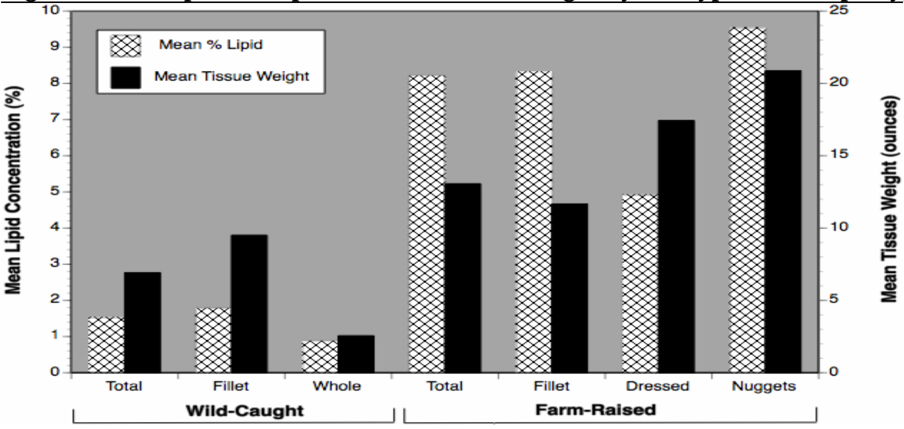


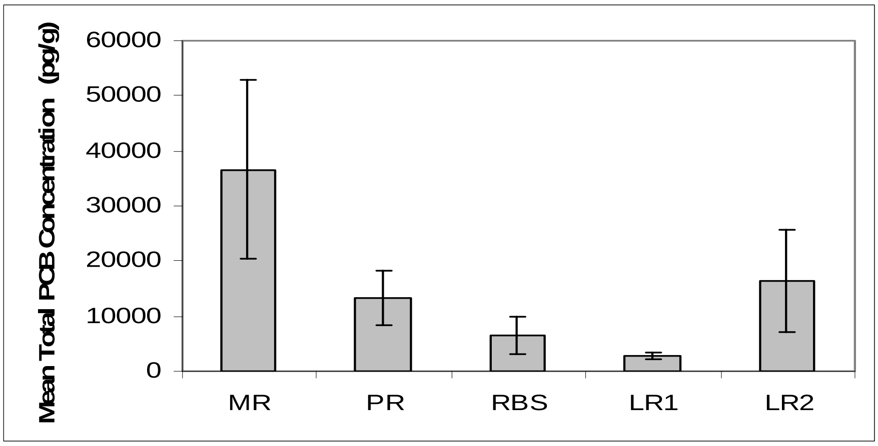
Table 1 shows the mean, range and various percentiles of total PCB concentrations in wild-caught and farm-raised catfish. Concentrations ranged from 1,052 to 72,525 pg/g wet wt for wild-caught fish and from 689 to 2297 pg/g wet wt for farm-raised fish, with average values of 15,626 and 1,376 pg/g wet wt and median values of 9,297 and 1,354 pg/g wet wt, respectively. As expected, there was a statistically significant difference between the mean concentration for wild-caught and farm-raised catfish fillets ($p<0.000$). Although not significantly different ($p=0.30$), whole wild-caught fish had a slightly higher mean concentration than wild-caught fillets even though the whole fish were appreciably smaller in size than the fish from which the fillets were taken (Figure 1). Further examination of the relationships between total PCB concentration and the length and weight of the individual fish indicated that, in this study, neither fish weight ($p=0.66$) nor fish length ($p=0.51$) were good predictors of total PCB concentration. Of course, more comprehensive analyses will be needed to determine specifically what characteristics impact PCB concentrations in catfish from this region of the country.

Table 1: Concentration summary statistics for the 209 PCB congeners by fish type and sample type.

	Concentration (pg/g wet wt)						
	N	Mean	95% CI	25th Percentile	Median	75th Percentile	Range
All Samples	61	9085.05	5621.87 - 12548.23	1296.35	2297.13	9645.75	689.05 - 72524.93
Wild-Caught	33	15625.69	10115.70 - 21135.68	4577.61	9296.75	20239.46	1051.65 - 72524.93
Fillet	24	15209.36	8561.53 - 21857.19	4243.88	9471.25	18198.39	1051.65 - 72524.93
Whole	9	16735.91	6457.38 - 27014.44	6915.18	8830.53	21271.36	4251.37 - 29613.03
Farm-Raised	28	1376.44	1206.10 - 1546.78	972.73	1354.41	1729.90	689.05 - 2297.13
Fillet	23	1379.26	1193.49 - 1565.04	928.30	1454.16	1732.91	689.05 - 2096.33
Dressed	2	1260.41	1189.98 - 1330.85	1242.44	1260.41	1278.38	1224.47 - 1296.35
Nuggets	3	1432.16	583.37 - 2280.95	999.68	1038.48	1667.81	960.87 - 2297.13

Figure 2 shows the mean total concentration and 95% confidence intervals for the wild-caught catfish by collection site. As demonstrated, fish caught in the Mississippi River had the highest mean total PCB concentration followed by those caught at the second site on the Leaf River (LR2). Interestingly, the fish collected at the second site on the Leaf River were some of the smallest captured. In contrast, the first site for the Leaf River (LR1) had the lowest mean total PCB concentration and the smallest sample variability. Evaluation of the concentrations in fish at LR1 and LR2 demonstrated a significant difference in the mean total PCB concentrations ($p=0.02$) indicating a potential source between these two sites. For the Ross Barnett Spillway (RBS), which is part of the Pearl River (PR) just to the northeast of Jackson, wild-caught fish had some of the lowest tissue concentrations next to LR1 while fish collected from the Pearl River near Picayune were slightly higher. However, only a moderate statistical difference in mean PCB concentration was detected for samples from RBS and PR ($p=0.06$).

Figure 2: Mean total PCB concentration by site.



The percent contribution of each of the top ten congeners contributing most to the total concentration ranged from 2.44 – 8.29 for farm-raised catfish and 1.59 – 12.91 for wild-caught catfish (Figure 3). Of the ten congeners in Figure 3, half of them contributed relatively more to total levels in wild-caught fish. For those congeners that contributed more to the total concentrations in farm-raised fish (PCB-43/49, PCB-90/101, PCB-99, PCB-110, PCB-139/149), the differences in relative contribution between wild-caught and farm-raised were appreciably smaller than for the other five congeners. Interestingly, both PCB-153 and PCB-138/163/164 contributed the most of all congeners to the total PCB concentration for wild-caught and farm-raised catfish, while PCB-81 contributed the least to the total PCB concentration (data not shown) for wild-caught and farm-raised fish demonstrating somewhat consistent congener patterns between the two fish types.

Figure 3: Percent contribution of select PCBs to total PCB concentration by fish type.

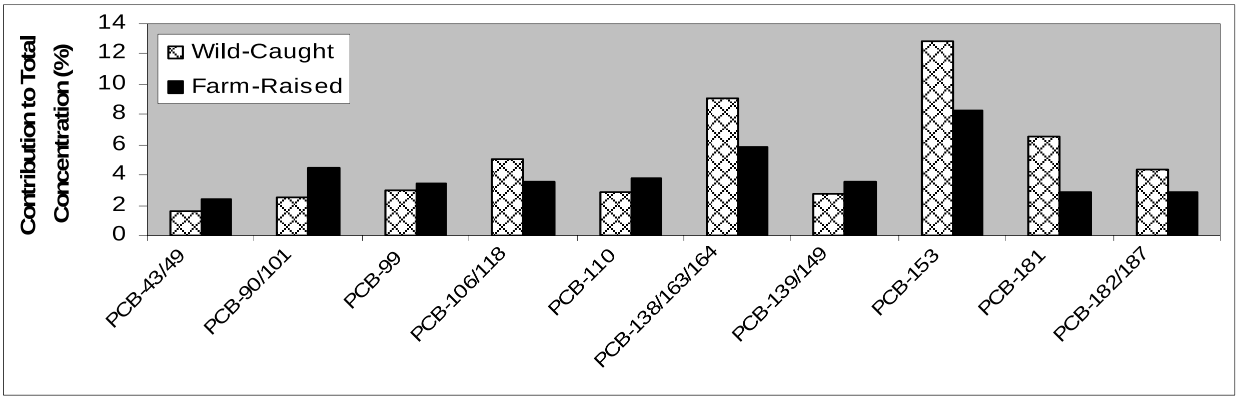


Figure 4: Percent contribution of select PCBs to total PCB concentration by collection site.

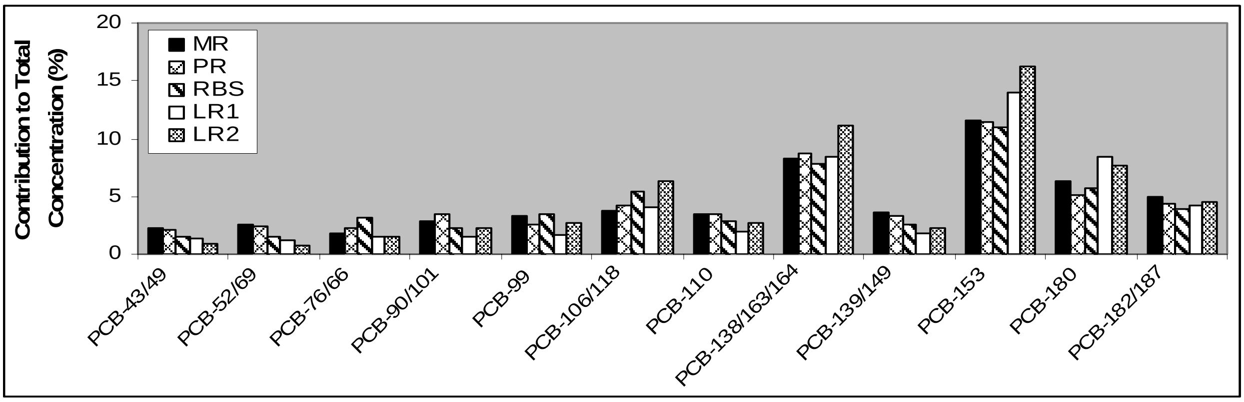


Figure 4 illustrates the percent contribution of select PCBs to total PCB concentration by collection site. As with fish type, PCB-153 and PCB-138/163/164 contributed the most at all sites demonstrating that levels of these PCBs in fish tissue have a regional rather than local pattern. This is further supported by the observation that PCB-81 also contributed the least to the total PCB concentrations in fish tissue collected at four of the five sites: PR, RBS, LR1, and LR2 (data not shown). Taken together, the congener patterns by fish type (Figure 3) and collection site (Figure 4) may be useful in identifying potential point sources of these chemicals for wild-caught fish and understanding why differences exist between farm-raised and wild-caught catfish. These results reveal significant differences in total PCB concentrations exist for farm-raised and wild-caught fillets and that there are moderate to significant differences in total PCB concentrations between some of the collection sites. Overall, congener patterns between wild and farm-raised fish and among fish captured at different sites were similar.

Compared with PCB levels in catfish sampled from a primarily urbanized area,[16] the PCB levels in catfish from rural Southern Mississippi are characterized by a much narrower range of concentrations (257,000 – 534,000 and 1,052 – 72,524 pg/g wet wt, respectively), and a lower average (15,626 vs. 417,000 pg/g wet wt reported by Crimmins et al.[16]) and median concentration (9,297 vs. 460,000 pg/g wet wt reported by Crimmins et al.[16]). This strongly suggests that for PCBs, notable differences exist between urban and rural areas. Compared to the U.S. Food and Drug Administration's tolerance level for PCBs in fish, which is two parts per million for edible portions of a fish (U.S. Code of Federal Regulations, Title 21, Part 109.3), the PCB concentrations in all fish samples collected in this study were relatively low. These results provide valuable information concerning the current background levels of PCBs in catfish in the Southeastern United States. This information will be useful for the determination of intake of these chemicals from this particular food source.

Acknowledgements and Disclaimer
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