GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF CONSUMER & REGULATORY AFFAIRS
ENVIRONMENTAL REGULATION ADMINISTRATION

# THE DISTRICT OF COLUMBIA
# FISH TISSUE ANALYSIS

## DISTRIBUTION OF CHEMICAL CONTAMINANTS IN 1993-95 WILD FISH SPECIES IN THE DISTRICT OF COLUMBIA

Submitted by:

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Interstate Commission on the Potomac River Basin

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**Final Report**

# Distribution of Chemical Contaminants in 1993-1995 Wild Fish Species in District of Columbia


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INTERSTATE COMMISSION ON THE POTOMAC RIVER BASIN

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**Executive Summary**

Polychlorinated biphenyls (PCBs) and chlordanes are suspected to have a long-term presence in the tissue of wild fish within the Potomac and Anacostia Rivers. These two chemicals, and possibly others, pose an ongoing concern for consumers of fish from these rivers in the District of Columbia. Therefore, continued monitoring of these and other contaminants (i.e., U.S. EPA priority pollutants) is important to assess trends in contaminant level and to address public health and environmental concerns. This study represents an important component of the District of Columbia's commitment to evaluate chemical contaminants as they relate to aquatic living resources and human health concerns.

The objective of this work was to determine the concentration and distribution of more than 129 chemical contaminants in fish tissue samples collected from the waters of the District of Columbia. The District of Columbia's Environmental Regulation Administration (ERA) was responsible for the assemblage, collection and preparation (i.e., cleaning and filleting) of fish samples for chemical analysis. Fish were collected and stored using standard procedures developed by the ERA. For this study, twenty fish sample-composites were obtained from ERA's archived inventories that were collected in 1993, 1994 and 1995. However, not all species were collected from the same location each year. All samples were kept frozen with dry ice (-78°C) and delivered to the laboratory (Geochemical and Environmental Research Group, Texas A&M University, College Station, TX) for chemical processing. The results of these analyses were used to assess temporal and spatial trends in the contamination of fish from the District's waters.

The present study indicates that detectable levels of many chemicals were present in the edible portion of certain species of fish collected in the District of Columbia's waters. Of the approximately 129 chemicals investigated, many were detected in one or more species. These chemicals ranged from trace inorganics such as mercury (Hg) and lead (Pb) to organic chemicals like polychlorinated biphenyls (congener specific PCBs) and DDTs (sum of o,p' and p,p' DDT, DDD, and DDE). While sample sizes were not large enough for statistical analysis between species and location, concentrations of many trace inorganics (e.g., Pb and Hg) were greatest in largemouth bass and sunfish (sp). Concentrations of many bioaccumulative organics (e.g., PCBs, polycyclic aromatic hydrocarbons [PAHs], and total chlordane) were highest in channel catfish

and common carp composites collected from the Anacostia River. Again, there were not enough replication in either sample area or species to make a rigorous statistical analysis. Some of the organic contaminant variation can be explained by the lipid content of each fish species. Geographical variations for all organic compounds were not identifiable with the limited data set available.

Previous studies of fish tissue contamination indicated that similar chemicals are persistent, however, because of analytical and sampling differences between studies, a quantitative trend analysis was not possible at this time. PCBs and chlordane had been in elevated concentrations since samples were collected in 1987. The median concentrations of total PCBs (approximately 540 to 620 ng/g wet wt.) and $\alpha+\gamma$ chlordane (47 to 57 ng/g wet wt.) were higher in the Washington, D.C. area from the current data set compared to national data obtained during the National Dioxin Study (median total PCBs for industrial/urban sites: 210 ng/g wet wt., median $\alpha+\gamma$ chlordane: 11 ng/g wet wt.; EPA, 1992). Median or average concentrations of pp'-DDE, a breakdown product of DDT, were slightly lower compared to the national industrial/urban median (79 ng/g wet wt.).

In estimating the health effect of the present data set (i.e., FDA action levels, toxic equivalents for PCBs, and a risk assessment model), results suggested that concentrations of PCBs and chlordane were elevated and of concern in this area. Exceedances of the FDA action or tolerance levels have been observed in previous studies. In 1987, channel catfish exceeded the FDA levels for PCBs and chlordane in 45% and 16% of the samples for PCBs and chlordane, respectively (Block, 1990). Similar percentages for both PCBs and chlordane were observed for the channel catfish samples collected in 1988 (Sommerfield and Cummins, 1989). The data from Pinkney et al. (1993) showed the greatest amount of exceedences (and highest overall concentrations) for channel catfish for PCBs and chlordane of 86% and 57%, respectively. Brown bullhead and common carp samples had lower exceedences, closer to the 1987 and 1988 databases. In the previous study by Velinsky and Cummins (1994), all American eel composites collected in 1991 were above the FDA action level for PCBs as were 33% of the channel catfish samples. Samples collected in 1992 were not above any of the published action levels. In the present study, concentrations of total Hg, dieldrin, total DDT, DDE, total chlordane, and total PCBs did not exceed the published FDA action levels. At a maximum, some fish composite samples had total PCBs concentrations approximately half of the FDA tolerance level, while highest total chlordane concentrations approached the FDA action level of 300 ng/g wet wt. Preliminary toxic equivalent (PCB-TEQ) calculations suggested that specific components of the PCBs were elevated. These dioxin-like PCBs ranged from 18 to 140 pg/g wet wt. (median of 52 pg/g wet wt.) for all fish composites. Higher levels (range of 20 to 994 pg/g wet.) were measured in fish tissue samples collected in 1991 and 1992 (Velinsky and Cummins, 1994). It is unclear what levels are of most concern, but previous studies suggest that these levels may cause an impact to both the fish and human health.

Using a risk assessment model given by the U.S. EPA (EPA, 1992), indications were that the levels of total PCBs, and in some cases chlordane, in this area pose an excess cancer and noncarcinogenic risk (i.e., $95^{th}$ upper bound estimates) greater than $10^{-5}$. For example, for carcinogenic risk, all composite samples were above the total PCBs screening value of 14 ng/g wet wt. (@$10^{-5}$ and 6.5 g/day ingestion). For both total chlordane and dieldrin, 60% of the fish composite samples were above their respective screening value of 80 and 7 ng/g wet wt. Channel catfish, common carp, and brown bullhead composite samples, mainly from the Anacostia River, had concentrations above these screening values. The screening value for total DDTs was not exceeded in any of the fish composite samples. In the the previous study by Velinsky and Cummins (1994), levels of total PCBs and in some cases chlordane in the DC area also exhibited a high excess cancer risk (i.e., $95^{th}$ upper bound estimates) greater than $10^{-5}$. Noncarcinogenic risks were also of concern for many samples. There are many limitations to this model, however the various health effect indicators suggests that PCBs and chlordane are of concern from fish, especially bottom dwelling species, collected in the Washington, D.C. area.

Monitoring of fish tissue in this area should be continued. The data from this report and those in previous studies provide the basis for the continuation of this monitoring to help identify potential human health and ecosystem problems. For this monitoring, consistent and up-to-date analytical methods along with an adequate sampling scheme should be used to help evaluate geographic and species variations. Also, the data from recent local anglers surveys by the District's Fisheries Management Branch should be used to determine the area specific risk assessment of potential health effects to the local population.

## Introduction

Since July of 1989, a fish consumption advisory for the Potomac and Anacostia rivers has been in effect for the waters of the District of Columbia (Appendix I). Based upon polychlorinated biphenyls (PCB's) and chlordane concentrations detected in channel catfish (*Ictalurus punctatus*) and other fish species, the advisory was upgraded in 1993 and warned the public of possible risks to human health from eating channel catfish, common carp (*Cyprinus carpio*) and American eels (*Anquilla rostrata*) captured in D.C. waters. This advisory is based upon research conducted by the Interstate Commission on the Potomac River Basin (ICPRB) with funding by the D.C. Department of Consumer and Regulatory Affairs and the U.S. Fish and Wildlife Service (Velinsky and Cummins, 1992; Block, 1990; Sommerfield and Cummins, 1989). This report details the results of additional fish tissue samples collected in the Potomac and Anacostia rivers and analyzed for chemical contaminants.

Water, sediment, and food are sources of chemicals to aquatic organisms like fish. The bioaccumulation of contaminants is related to their retention in tissue and is a balance between the rate of intake and the rate of loss via metabolic processes, degradation, and excretion. If the rate of intake is greater, contaminants accumulate into specific body parts (e.g., fatty tissue, bone, and liver) dependent on the chemical. In many cases, fish accumulate contaminants that are undetected with routine water quality monitoring; thus fish tissue can provide a good indicator of the environment. The accumulation of chemicals in fish tissue is of concern for both ecosystem health (i.e., food chain transfers) and human health impacts. This study investigated the latter by looking at the concentrations and distributions of chemical contaminants in fish fillets from the Potomac and Anacostia rivers.

PCBs and chlordane are suspected to have a long term presence in the environment. These two chemicals, and possibly others, pose an ongoing concern for consumers of fish using the Potomac and Anacostia rivers in the District of Columbia. In a recent study of the upper Anacostia River, Velinsky et al. (1994) found concentrations of total trace metals (i.e., dissolved+particulate) similar to other areas in Chesapeake Bay. However, there were substantial concentrations of PCBs and $\alpha + \gamma$ chlordane detected in this area of the river. Dissolved, particulate, and total PCB concentrations ranged from 0.8 to 21 ng/L, 7.3 to 23 ng/L, and 8.3 to 31 ng/L, respectively, while dissolved, particulate, and total chlordane ranged from <0.3 to 8.6 ng/L, <0.3 to 4.1 ng/L, and <0.3 to 13 ng/L, respectively. Total PCBs and total $\alpha + \gamma$ chlordane (i.e., dissolved+particulate) exceeded water quality standards in at least 15 more cases. Dissolved concentrations of chlordane and PCBs in all samples were higher than those stated for human health effects (i.e., risk level of $10^{-6}$). These data indicate that both PCBs and chlordane compounds are present and bioavailable to resident fish species (i.e., Velinsky and Cummins, 1994). Therefore, continued monitoring of these and other contaminants (e.g., Hg, DDT, specific aromatic hydrocarbons) is needed to assess trends in contaminant levels, and to address public health and environmental concerns. This study represents an important component of the District of Columbia's commitment to evaluate chemical contaminants as they relate to aquatic living resources and human health concerns.

**Objective and Approach**

The objective of this work was to determine the concentration and distribution of chemical contaminants in fish tissue samples collected from the waters of the District of Columbia. Twenty samples were collected in 1993, 1994, and 1995 (see Appendix II). All samples were collected in the late summer or early fall of each year (Karimi, personal communication) with specific dates provided in Appendix II when available. The results of these analyses were used to assess temporal and spatial trends in the contamination of fish from the District's waters.

The District of Columbia's Environmental Regulation Administration (ERA) was responsible for the assemblage, collection and preparation (i.e., cleaning and filleting) of fish samples for chemical analysis. Fish were collected and stored using standard procedures developed by the ERA. For this study, twenty fish sample-composites were obtained from ERA's archived inventories. Samples were kept frozen with dry ice (-78°C) and delivered to the laboratory (Geochemical and Environmental Research Group, Texas A&M University, College Station, TX) for chemical processing. All transfers of samples were done using chain-of-custody requirements and these forms are available on request from the District of Columbia.

**Study Area**

Fish samples were collected in the tidal freshwater sections of the Potomac and Anacostia rivers around the District of Columbia. The rivers were divided into upper and lower sections (Figure 1): the upper Anacostia River is between the District's boundary at the New York Avenue Bridge and the railroad bridge just downstream of Kingman Lake and the lower Anacostia is from the railroad bridge to Hains Point at the Potomac River. The lower section of the river is the more developed urban center portion of the Anacostia. The upper Potomac River is bounded by Fletcher's Boathouse downstream of Chain Bridge to the 14th Street Bridge, while the lower Potomac River is from the bridge to the Woodrow Wilson Bridge near Jones Point.

The District of Columbia (DC) lies along the fall line at the boundary between the Atlantic Coastal Plain and the Piedmont Plateau and is at the head of navigation of the Potomac estuary (Figure 1). The western and northern sections of the DC area are part of the Piedmont while the mid-section of the city to the south is the Coastal Plain (Reed and Obermeier, 1989).

There are three major rivers or streams in the DC area: the Potomac and Anacostia rivers, and Rock Creek, which drains into the Potomac River just south of Georgetown (Figure 1). Even though the drainage areas of the Anacostia River (310 $km^2$) and Rock Creek (160 $km^2$) are small compared to the Potomac River at Chain Bridge (30,000 $km^2$), both water bodies drain predominantly urban environments and therefore have large inputs of anthropogenic materials (Velinsky et al., 1992). While DC is currently not an highly industrialized area, there are facilities bordering the Potomac and Anacostia Rivers that could adversely affect sediment and water quality. There is also a potential for contamination of the sediments in the rivers due to past shipping and boating uses in the area. Most industrial facilities in the DC area have pretreatment programs that eventually discharge to Blue Plains WasteWater Treatment Plant (WWTP).

Numerous storm and combined sewers drain into the Tidal Basin, Washington Ship Channel, and Anacostia Rivers. There are approximately 30 storm and 6 combined sewers that can discharge into the lower Anacostia River (i.e., south of the Kingman Lake area to Greenleaf Point at the mouth of the Washington Ship Channel). These storm and combined sewers draining into the tidal Anacostia River cover a drainage area of approximately 2.6 $mi^2$, or approximately 27% of the Anacostia drainage area within the District of Columbia (O'Brien and Gere, 1979; ICPRB,

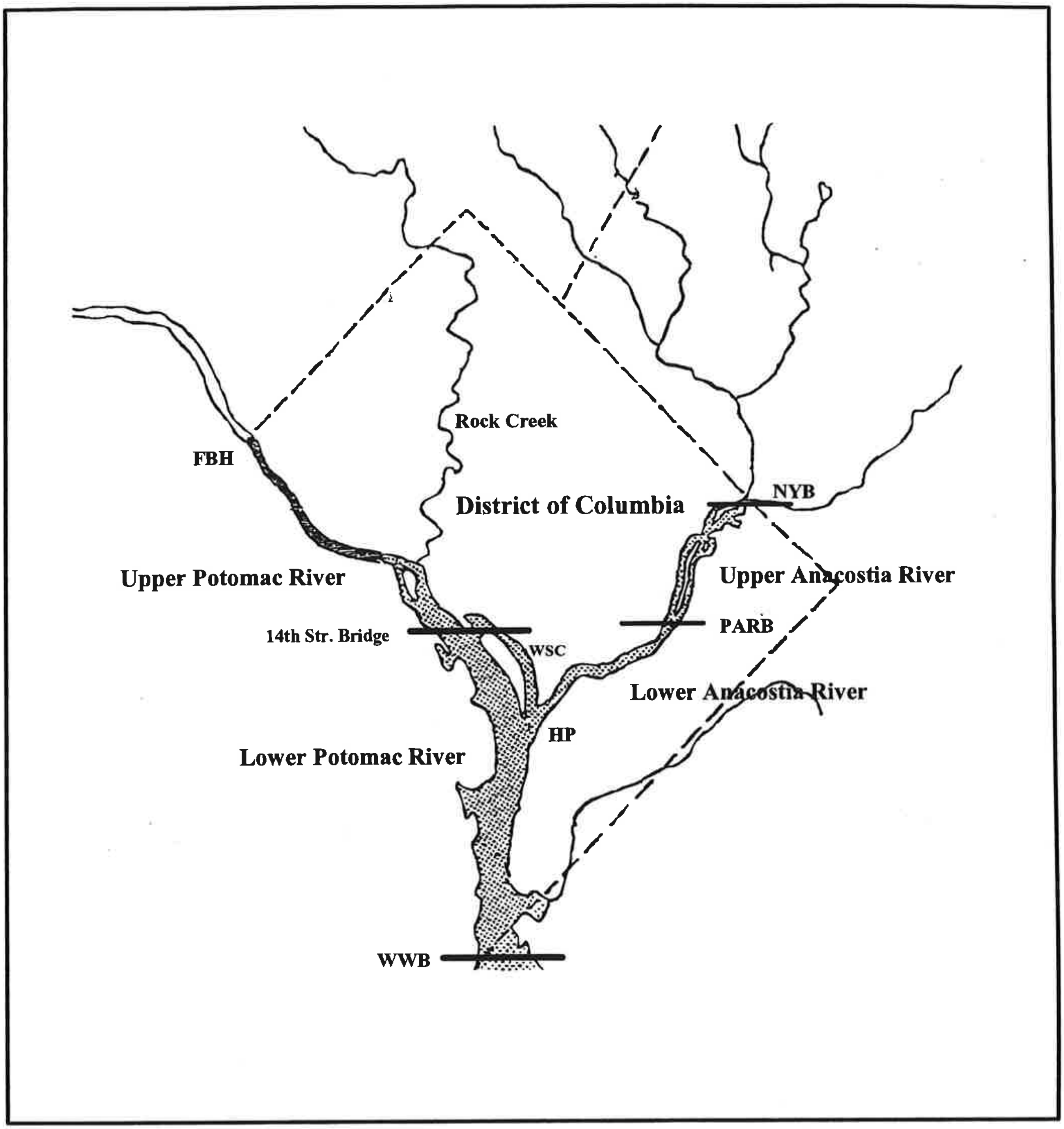



Figure 1. Potomac and Anacostia Rivers within the District of Columbia. The rivers were divided into upper and lower sections where the fish were collected. The upper Anacostia River is between the District's boundary at the New York Avenue Bridge (Route 50) and the railroad bridge just downstream of Kingman Lake and the lower Anacostia (LA) is from the railroad bridge to Hains Point at the Potomac River. The upper Potomac River is bounded by Fletcher's Boathouse (FBH) to the 14th Street Bridge near the Washington Ship Channel (WSC), while the lower Potomac River is from the 14th Street Bridge to the Woodrow Wilson Bridge (WB) near Jones Point. (Adapted from Block, 1990)

1988). Approximately 54% of the total drainage area of the Anacostia Basin, which includes suburban Maryland, is urban (ICPRB, 1988). Within DC, ~95% of the drainage to the Anacostia is developed (ICPRB, 1988). Runoff through the storm and combined sewer system has been shown to cause elevated concentrations of trace metals and organic compounds (e.g., PCBs, PAHs, and chlordane) to the sediments and fish of the Anacostia and Potomac rivers (Velinsky et al., 1992; Velinsky and Cummins, 1994).

## Materials and Methods

A total of 20 composite samples were analyzed; 10 collected in 1993, 8 collected in 1994, and 2 collected in 1995. One additional sample was analyzed that was collected in 1991 and previously analyzed in Velinsky and Cummins (1994). This composite will be used, when appropriate, as an intercalibration sample. Each composite sample was composed of at least three individual fish, unless otherwise noted (see Appendix II). Each individual fish sample contained two fillets (i.e., right and left side of the fish). Also, it should be noted that catfish fillets were skin-off, while all other fish samples were skin-on.

Chemical analyses of the prepared fish composite samples for 129 priority pollutants along with separate analyses for planar and co-planar PCBs and 44 polycyclic aromatic hydrocarbons were performed by Geochemical and Environmental Research Group, Texas A&M University. U.S. EPA approved methods and methods used for NOAA's Status and Trends Mussel Watch Program were used (see Velinsky and Cummins, 1995 for details). Additional laboratory analyses were performed for 16 planar and AHH active (mono- and di- ortho) PCB congeners. These data yielded information concerning specific compounds or congeners PCBs which may have higher enzyme induction activity and possible toxicity compared to other congeners to certain aquatic species and human health (e.g., Ahlborg et al., 1994; McFarland and Clarke, 1989; Swain, 1991).

## Results

In the following sections, the data are given as ranges and median concentrations for 1993, 1994, and 1995 fish samples. All concentrations are presented on a wet weight basis. Appendix II provides a complete listing of the individual fish fillets and the samples that make up each composite. Within Appendix II, when the data were provided by ERA, live weight and length for individual fish are provided. The complete listing of the data along with QA/QC documentation are provided in Appendix IV.

*Water and Lipid Content*

Tissue water contents ranged from 64.5 to 81.5% (73.1 ± 4.9%, mean ± 1σ standard deviation) for the all 1993 samples (n=10). The lipid contents were variable and ranged from 1.2 to 9.8% wet wt. basis (Table 1). Highest lipid content were from channel catfish and lowest were from largemouth bass. Eight composite samples were collected and analyzed for 1994 (Table 1). Tissue water contents ranged from 67.5 to 79.2% (75.1 ± 3.8%, n=8), while the lipid contents were also variable and ranged from 0.5 to 9.0%. Fish samples with the highest lipid content were common carp and channel catfish. Two brown bullhead catfish samples collected in 1995 had similar water content (average = 80%), but different lipid content. For all composite samples, the average water content was 75 ± 5% and lipid content averaged 4 ± 3%.

*Trace Metals*

Trace metals and metalloids (e.g., As, Se, Sb) were determined in composite samples from all three years (Tables 2-4; see Appendix IV). Minimum, maximum, and median or average concentrations are presented in Tables 2-4, along with the number of samples above the method detection level (MDL). Mercury (Hg), lead (Pb), selenium (Se), zinc (Zn), and cadmium (Cd) were detected in all or a majority of the samples. Arsenic (As), chromium (Cr), and nickel (Ni) were detected in at least one of the sample composites. Other metals or metalloids were not detected in any composite.

Concentrations of most trace metals and metalloids were generally highest in the American eel composite (#5-93) from the upper Potomac. The highest concentration of Hg was found in the largemouth bass composite (#1-94) from the lower Potomac, while the highest Pb concentration was measured in the sunfish composite (#8-93) from the lower Anacostia River. The sunfish composite is a mixture of pumpkin seed and bluegill species.

Total cyanide (CN) concentrations ranged from the detection limit of 0.1 to 46 μg/g wet wt.

(Tables 2-4). For both 1993 and 1994 median concentrations were similar (approximately 14

**Table 1. Summary information for 1993, 1994, and 1995 fish composite samples*.**

| Composite ID. | Location | Fish Species | % Moisture | % Lipid |
|---|---|---|---|---|
| 1-93 | Lower Potomac | Largemouth Bass | 77.3 | 1.4 |
| 2-93 | Lower Potomac | Channel Catfish | 72.1 | 9.0 |
| 3-93 | Upper Potomac | Common Carp | 71.0 | 4.8 |
| 4-93 | Upper Potomac | Largemouth Bass | 75.7 | 1.2 |
| 5-93 | Upper Potomac | American Eel | 75.6 | 2.0 |
| 6-93 | Lower Anacostia | Channel Catfish | 68.2 | 9.8 |
| 7-93 | Lower Anacostia | Common Carp | 72.7 | 3.0 |
| 8-93 | Lower Anacostia | Sunfish (sp.) | 72.0 | 2.4 |
| 9-93 | Upper Anacostia | Common Carp | 64.5 | 7.4 |
| 10-93 | Kenilworth Marsh | Brown Bullhead | 81.9 | 2.5 |
| | | | | |
| 1-94 | Lower Potomac | Largemouth Bass | 78.3 | 0.7 |
| 2-94 | Lower Potomac | Common Carp | 72.9 | 7.0 |
| 3-94 | Upper Potomac | Channel Catfish | 79.2 | 4.8 |
| 4-94 | Upper Potomac | Common Carp | 74.0 | 5.4 |
| 5-94 | Lower Anacostia | Largemouth Bass | 77.9 | 0.5 |
| 6-94 | Lower Anacostia | Common Carp | 74.6 | 3.1 |
| 7-94 | Lower Anacostia | Channel Catfish | 67.5 | 9.0 |
| 8-94 | Lower Anacostia | Sunfish (sp.) | 76.2 | 1.8 |
| | | | | |
| 1-95 | Upper Anacostia | Brown Bullhead | 78.1 | 2.3 |
| 2-95 | Upper Anacostia | Brown Bullhead | 82.4 | 0.8 |

*% Lipids on a wet weight basis.

µg/g wet wt.), while in 1995 the two brown bullhead sample composites had no detectable cyanide. In 1993, fish composites from the upper Potomac River and lower Anacostia generally had the highest CN concentrations (>20 µg/g wet wt.). Fish species included largemouth bass, common carp, sunfish (sp.), and American eel composites. In 1994, only one fish composite in the Potomac had higher levels of total CN, while fish composites from the lower Anacostia River had the highest concentrations (up to 46 µg/g wet wt.).

**Table 2. Trace elements and total cyanide for 1993 fish composites*.**

| Chemical | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| Ag | < 0.007 | < 0.007 | < 0.007 | 0 |
| As | < 0.038 | 0.256 | < 0.038 | 3 |
| Be | < 0.03 | < 0.03 | < 0.03 | 0 |
| Cd | <0.003 | 0.033 | 0.004 | 8 |
| Cr | < 0.06 | 0.626 | 0.022 | 5 |
| Hg | 0.025 | 0.112 | 0.055 | 10 |
| Ni | < 0.05 | 0.081 | < 0.05 | 3 |
| Pb | 0.030 | 0.254 | 0.044 | 10 |
| Sb | < 0.03 | < 0.03 | < 0.03 | 0 |
| Se | 0.081 | 0.567 | 0.369 | 10 |
| Tl | < 0.02 | < 0.02 | < 0.02 | 0 |
| Zn | 0.75 | 21.37 | 9.32 | 10 |
| Total CN | 0.20 | 38.1 | 15.3 | 10 |

*Concentrations in µg/g wet weight. (N = 10)

*Volatile Organic Compounds*

Fish composite samples collected in 1993, 1994, and 1995 had similar volatile organic compounds detected (see Appendix IV). Compounds that were detected in a many of the samples included acetone, methylene chloride, 2-butanone, chloroform, benzene, toluene, 2-hexanone, trichloroethane, and meta+para-xylene. Other volatile compounds were either not

**Table 3. Trace elements and total cyanide for 1994 fish composites*.**

| Chemical | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| Ag | < 0.006 | < 0.006 | < 0.006 | 0 |
| As | < 0.032 | 0.266 | 0.204 | 6 |
| Be | < 0.03 | < 0.03 | < 0.03 | 0 |
| Cd | 0.003 | 0.009 | 0.004 | 10 |
| Cr | < 0.05 | 0.125 | < 0.05 | 3 |
| Hg | 0.052 | 0.160 | 0.061 | 10 |
| Ni | < 0.04 | 0.072 | < 0.04 | 1 |
| Pb | < 0.02 | 0.187 | 0.043 | 9 |
| Sb | < 0.03 | < 0.03 | < 0.03 | 0 |
| Se | 0.141 | 0.336 | 0.259 | 10 |
| Tl | < 0.01 | < 0.01 | < 0.01 | 0 |
| Zn | 4.559 | 18.180 | 9.341 | 10 |
| Total CN | 0.30 | 46.3 | 13.1 | 10 |

*Concentrations in µg/g wet weight. (N = 8)

detected or below the method detection limit (Appendix IV). Many of these compounds (e.g., methylene chloride, acetone, and toluene) are used within the laboratory for glassware cleaning of and extraction of pesticides and hydrocarbons. Also, xylene is utilized by the District of Columbia Fisheries to rinse and clean the aluminum foil that is used to store fish fillets. Methylene chloride and acetone were detected in the blanks but at much lower levels than the samples (Appendix IV). However, because the samples were subjected to a greater amount of handling than the blanks (i.e., samples were stored for approximately 8 months), there is a greater opportunity for contamination. Also, the material used in the trapping of the purged compounds (Tenax) can bleed benzene and toluene during analysis. These factors suggest that these data, especially for methylene chloride, benzene, xylenes, and toluene, should be interpreted with caution.

While acetone and methylene chloride were detected in the blank, levels were generally below approximately 50 ng/g wet wt. Detectable concentrations in many of the samples from

**Table 4. Trace elements and total cyanide for 1995 fish composites*.**

| Chemical | Minimum | Maximum | Average |
|---|---|---|---|
| Ag | < 0.004 | < 0.004 | < 0.004 |
| As | < 0.30 | 0.034 | 0.017 |
| Be | < 0.02 | < 0.02 | < 0.02 |
| Cd | 0.004 | 0.006 | 0.005 |
| Cr | 0.047 | 0.091 | 0.069 |
| Hg | 0.034 | 0.051 | 0.042 |
| Ni | < 0.03 | 0.034 | 0.017 |
| Pb | 0.072 | 0.104 | 0.088 |
| Sb | < 0.02 | < 0.02 | < 0.02 |
| Se | 0.089 | 0.139 | 0.114 |
| Tl | < 0.01 | < 0.01 | < 0.01 |
| Zn | 5.108 | 5.920 | 5.514 |
| Total CN | < 0.1 | < 0.1 | < 0.1 |

*Concentrations in µg/g wet weight. (N = 2)

all three years ranged from 2,800 to 33,000 ng/g wet wt and 40 to 150,000 ng/g wet wt., for acetone and methylene chloride respectively. It is unclear why such high concentrations were detected, even above the blank. In the future, samples should be obtained from the river, processed (with extra care), and shipped to the laboratory immediately. This will help to determine if the source of these compounds is from the long storage time. Potential contamination from the aluminum foil, marker pen, tape, and the laboratory should be investigated before or as part of any future program. Other compounds were detected at levels generally below 100 ng/g wet wt. (except for the two 1995 samples; Appendix IV).

*Semi-Volatile Organic Compounds*

Fish collected in 1993 (n=8) contained seven semi-volatile organic compounds above the detection limit (Table 5). Polycyclic aromatic hydrocarbons (e.g., acenaphthene and

**Table 5. Semi-volatile concentration ranges for 1993, 1994, and 1995 fish composite samples*.**

| | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| *1993 Tissue Samples (n=10)*[1] | | | | |
| bis(2-Chloroethyl)ether | 0.00 | 0.01 | 0.00 | 1 |
| 1,4-Dichlorobenzene | 0.12 | 0.38 | 0.21 | 10 |
| 2-Methylnaphthalene | 0.00 | 0.12 | 0.00 | 3 |
| Acenaphthene | 0.00 | 0.03 | 0.00 | 3 |
| Diethylphthalate | 0.00 | 0.03 | 0.00 | 1 |
| Phenanthrene | 0.00 | 0.02 | 0.00 | 1 |
| Di-n-octylphthalate | 0.00 | 0.04 | 0.00 | 1 |
| *1994 Tissue Samples (n=8)* | | | | |
| 1,4-Dichlorobenzene | 0.12 | 0.41 | 0.18 | 10 |
| Acenaphthene | 0.00 | 0.01 | 0.00 | 1 |
| Fluorene | 0.00 | 0.01 | 0.00 | 1 |
| Diethylphthalate | 0.00 | 0.05 | 0.00 | 3 |
| Di-n-butylphthalate | 0.00 | 0.18 | 0.00 | 2 |
| *1995 Tissue Samples (n=2)* | | | | |
| 1,4-Dichlorobenzene | 0.14 | 0.30 | 0.22 | 2 |
| Phenanthrene | 0.00 | 0.03 | 0.01 | 1 |
| Di-n-butylphthalate | 0.11 | 0.11 | 0.11 | 2 |
| Di-n-octylphthalate | 0.39 | 0.56 | 0.47 | 2 |

*Concentrations in µg/g wet weight. [1]Number of fish composite samples.

phenanthrene) were detected only once, while 2-methylnapthalene was detected in three fish composites. Due to the high detection limit for polycyclic aromatic hydrocarbons (PAHs) from this analysis, many hydrocarbons were not detected. A separate analysis, specifically for PAHs, was performed and is discussed in the next section. In all ten sample composites contained detectable concentrations of dichlorobenzene with highest concentrations in a lower Potomac largemouth bass, a lower Anacostia sunfish composite, and an upper Anacostia common carp sample. Phthalate compounds were also detected in the one sample from the Kenilworth Marsh; a brown bullhead catfish. However, certain phthalates are known laboratory contaminants derived from rubber gloves and other plasticware that might be used during extraction and sample preparation (Zitko, 1972).

Five out of fifty-eight semi-volatile organic compounds were detected in the eight fish composite samples from 1994 (Table 5). These compounds included similar phthalates as the 1993 samples and two polycyclic aromatic hydrocarbons: acenaphthene (n=1) and fluorene (n=1). Dichlorobenzene ranged in concentration from 0.12 to 0.41 µg/g wet wt. (median = 0.18 µg/g wet wt.) and was detected in 10 samples.

The two brown bullhead samples collected in 1995 from the upper Anacostia River contained four semi-volatile organic compounds (Table 5). Dichlorobenzene, phenanthrene, and two phthalates were the compounds detected (Table 5; Appendix IV). Again, laboratory contamination could be the source of some phthalates in these samples (Zitko, 1972).

*Polycyclic Aromatic Hydrocarbons*

A separate analysis was performed to better identify and quantify over 40 individual polycyclic aromatic hydrocarbons (PAHs) in the fish samples. Dependent on many analytical factors, detection limits were generally less than 0.5 ng/g wet weight for individual PAHs (see Appendix IV). The data listed in Tables 6-9 provide the minimum, maximum, and median concentrations along with the number of values that are above the method detection limit (MDL). The qualifier "ND" indicates that the analyte was not detected during the analysis, while a concentration listed as < ## indicates that the analyte was detected, but the measured concentration was below the MDL.

Many individual PAHs were detected in all fish composite samples (Table 6-8). Generally, the naphthalenes (parental and alkalyated forms) and other lower molecular weight PAHs were measured in the highest concentrations. Phenanthrene and anthracene, both 3-ring compounds, were detected in all samples, while higher molecular weight compounds were detected less often and at generally lower concentrations (Tables 6-8). Concentrations of benzo[a]anthracene and benzo[e]pyrene, both

Table 6. PAH concentration ranges for 1993 fish composite samples (n = 10)*.

| Compound | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| NAPHTHALENE | 5.39 | 53.29 | 18.09 | 10 |
| C1-NAPHTHALENES | 13.58 | 456.64 | 24.85 | 10 |
| C2-NAPHTHALENES | 5.91 | 955.35 | 13.60 | 10 |
| C3-NAPHTHALENES | 8.42 | 770.27 | 17.11 | 10 |
| C4-NAPHTHALENES | ND | 298.67 | 12.76 | 8 |
| BIPHENYL | < 0.73 | 106.28 | 1.77 | 5 |
| ACENAPHTHYLENE | < 0.77 | 5.00 | 1.52 | 7 |
| ACENAPHTHENE | < 0.68 | 28.27 | 2.78 | 8 |
| FLUORENE | < 0.92 | 60.06 | 3.11 | 8 |
| C1-FLUORENES | ND | 121.54 | < 1.14 | 4 |
| C2-FLUORENES | ND | 89.02 | ND | 3 |
| C3-FLUORENES | ND | 55.08 | ND | 1 |
| PHENANTHRENE | 2.00 | 103.09 | 4.87 | 10 |
| ANTHRACENE | 0.67 | 12.26 | 1.90 | 10 |
| C1-PHEN.+ANTHRACENE | ND | 117.67 | ND | 2 |
| C2-PHEN.+ANTHRACENE | ND | 58.49 | ND | 2 |
| C3-PHEN.+ANTHRACENE | ND | ND | ND | 0 |
| C4-PHEN.+ANTHRACENE | ND | ND | ND | 0 |
| DIBENZOTHIOPHENE | < 0.20 | 15.26 | 0.94 | 5 |
| C1-DIBENZOTHIOPHENE | ND | 37.41 | ND | 1 |
| C2-DIBENZOTHIOPHENE | ND | 33.76 | ND | 1 |
| C3-DIBENZOTHIOPHENE | ND | 18.33 | ND | 1 |
| FLUORANTHENE | 0.71 | 13.75 | 1.90 | 10 |
| PYRENE | < 0.72 | 9.17 | 1.96 | 8 |
| C1-FLUORAN.+PYRENE | ND | 8.38 | ND | 2 |
| BENaANTHRACENE | < 0.21 | 1.35 | < 0.45 | 3 |
| CHRYSENE | < 0.19 | 5.37 | < 0.50 | 2 |
| C1-CHRYSENES | ND | ND | ND | 0 |
| C2-CHRYSENES | ND | ND | ND | 0 |
| C3-CHRYSENES | ND | ND | ND | 0 |
| C4-CHRYSENES | ND | ND | ND | 0 |
| BENbFLUORANTHENE | < 0.02 | < 0.54 | < 0.13 | 0 |
| BENkFLUORANTHENE | < 0.02 | < 0.16 | < 0.08 | 0 |
| BENePYRENE | < 0.07 | 0.55 | < 0.21 | 1 |
| BENaPYRENE | < 0.03 | < 0.26 | < 0.12 | 0 |
| PERYLENE | < 0.06 | < 0.49 | < 0.14 | 0 |
| INDO123cdPYRENE | < 0.03 | < 0.19 | < 0.10 | 0 |
| DIBENZOahANTHRACENE | < 0.02 | < 0.08 | < 0.05 | 0 |
| BENZOghiPERYLENE | < 0.07 | < 0.27 | < 0.16 | 0 |
| TOTAL PAH's | 59.01 | 3426.52 | 155.11 | 10 |

*Concentrations in ng/g wet weight. ND - Not Detected. See text for details.

Table 7. PAH concentration ranges for 1994 fish composite samples (n = 8)*.

| Compound | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| NAPHTHALENE | 7.61 | 17.08 | 10.40 | 8 |
| C1-NAPHTHALENES | 6.37 | 50.10 | 12.43 | 8 |
| C2-NAPHTHALENES | 3.62 | 97.07 | 7.66 | 8 |
| C3-NAPHTHALENES | 6.52 | 78.36 | 10.59 | 8 |
| C4-NAPHTHALENES | ND | 27.01 | 6.26 | 5 |
| BIPHENYL | < 0.61 | 9.23 | < 1.14 | 1 |
| ACENAPHTHYLENE | < 0.22 | 3.27 | 1.12 | 4 |
| ACENAPHTHENE | < 0.50 | 9.90 | 2.71 | 7 |
| FLUORENE | < 0.76 | 7.94 | 2.27 | 7 |
| C1-FLUORENES | ND | 16.92 | ND | 3 |
| C2-FLUORENES | ND | ND | ND | 0 |
| C3-FLUORENES | ND | ND | ND | 0 |
| PHENANTHRENE | 1.35 | 10.71 | 4.14 | 8 |
| ANTHRACENE | 0.61 | 7.81 | 1.80 | 8 |
| C1-PHEN.+ANTHRACENE | ND | < 4.22 | ND | 0 |
| C2-PHEN.+ANTHRACENE | ND | < 3.39 | ND | 0 |
| C3-PHEN.+ANTHRACENE | ND | ND | ND | 0 |
| C4-PHEN.+ANTHRACENE | ND | ND | ND | 0 |
| DIBENZOTHIOPHENE | < 0.21 | 2.19 | 0.62 | 5 |
| C1-DIBENTHIOPHENE | ND | ND | ND | 0 |
| C2-DIBENTHIOPHENE | ND | ND | ND | 0 |
| C3-DIBENTHIOPHENE | ND | ND | ND | 0 |
| FLUORANTHENE | < 0.50 | 4.28 | 1.78 | 7 |
| PYRENE | < 0.49 | 3.12 | 1.67 | 7 |
| C1-FLUORAN.+PYRENE | ND | ND | ND | 0 |
| BENaANTHRACENE | < 0.20 | 1.11 | < 0.31 | 2 |
| CHRYSENE | < 0.26 | 4.73 | < 0.54 | 1 |
| C1-CHRYSENES | ND | ND | ND | 0 |
| C2-CHRYSENES | ND | ND | ND | 0 |
| C3-CHRYSENES | ND | ND | ND | 0 |
| C4-CHRYSENES | ND | ND | ND | 0 |
| BENbFLUORANTHENE | < 0.04 | 1.01 | < 0.19 | 1 |
| BENkFLUORANTHENE | < 0.06 | 0.80 | < 0.13 | 1 |
| BENePYRENE | < 0.13 | 1.05 | < 0.25 | 2 |
| BENaPYRENE | < 0.05 | 1.19 | < 0.16 | 1 |
| PERYLENE | < 0.04 | 1.37 | < 0.14 | 1 |
| I123cdPYRENE | < 0.08 | < 0.88 | < 0.14 | 0 |
| DIBENZOahANTHRACENE | < 0.03 | < 0.61 | < 0.06 | 1 |
| BENZOghiPERYLENE | < 0.11 | < 0.88 | < 0.18 | 0 |
| TOTAL PAH's | 31.43 | 352.21 | 69.59 | 10 |

*Concentrations in ng/g wet weight. ND - Not Detected. See text for details

Table 8. PAH concentration ranges for 1995 fish composite samples (n = 2)*.

| Compound | Minimum | Maximum | Average | # > MDL |
|---|---|---|---|---|
| NAPHTHALENE | 7.20 | 8.95 | 8.07 | 2 |
| C1-NAPHTHALENES | 6.58 | 17.94 | 12.26 | 2 |
| C2-NAPHTHALENES | 18.27 | 59.06 | 38.67 | 2 |
| C3-NAPHTHALENES | 38.85 | 117.40 | 78.12 | 2 |
| C4-NAPHTHALENES | 21.98 | 71.76 | 46.87 | 2 |
| BIPHENYL | < 1.51 | 3.76 | 2.63 | 1 |
| ACENAPHTHYLENE | < 0.70 | 2.18 | 1.44 | 2 |
| ACENAPHTHENE | 3.19 | 9.56 | 6.37 | 2 |
| FLUORENE | 5.20 | 15.97 | 10.58 | 2 |
| C1-FLUORENES | 14.39 | 37.16 | 25.77 | 2 |
| C2-FLUORENES | 11.60 | 23.53 | 17.57 | 2 |
| C3-FLUORENES | 16.99 | 28.31 | 22.65 | 2 |
| PHENANTHRENE | 16.85 | 47.49 | 32.17 | 2 |
| ANTHRACENE | 2.02 | 4.08 | 3.05 | 2 |
| C1-PHEN.+ANTHRACENE | 12.13 | 29.69 | 20.91 | 2 |
| C2-PHEN.+ANTHRACENE | 7.42 | 15.32 | 11.37 | 2 |
| C3-PHEN.+ANTHRACENE | ND | ND | ND | 0 |
| C4-PHEN.+ANTHRACENE | ND | ND | ND | 0 |
| DIBENZOTHIOPHENE | 0.86 | 2.54 | 1.70 | 2 |
| C1-DIBENZOTHIOPHENE | ND | 6.46 | 3.23 | 2 |
| C2-DIBENZOTHIOPHENE | ND | 8.99 | 4.49 | 2 |
| C3-DIBENZOTHIOPHENE | ND | 7.80 | 3.90 | 2 |
| FLUORANTHENE | 12.81 | 30.64 | 21.72 | 2 |
| PYRENE | 6.80 | 15.48 | 11.14 | 2 |
| C1-FLUORAN.+PYRENE | ND | ND | ND | 0 |
| BENaANTHRACENE | < 0.36 | < 0.42 | < 0.39 | 0 |
| CHRYSENE | 2.84 | 4.75 | 3.80 | 2 |
| C1-CHRYSENES | ND | ND | ND | 0 |
| C2-CHRYSENES | ND | ND | ND | 0 |
| C3-CHRYSENES | ND | ND | ND | 0 |
| C4-CHRYSENES | ND | ND | ND | 0 |
| BENbFLUORANTHENE | < 0.20 | < 0.25 | < 0.23 | 2 |
| BENkFLUORANTHENE | < 0.10 | < 0.12 | < 0.11 | 2 |
| BENePYRENE | < 0.49 | 0.64 | < 0.57 | 1 |
| BENaPYRENE | < 0.09 | < 0.13 | < 0.11 | 0 |
| PERYLENE | < 0.11 | < 0.23 | < 0.17 | 0 |
| INDO123cdPYRENE | < 0.09 | < 0.19 | < 0.14 | 0 |
| DIBENahANTHRACENE | < 0.01 | < 0.06 | < 0.04 | 0 |
| BENZOghiPERYLENE | < 0.17 | < 0.17 | < 0.17 | 0 |
| TOTAL PAH's | 209.96 | 570.54 | 390.25 | 2 |

*Concentrations in ng/g wet weight. ND - Not Detected. See text for details

Toxics of Concern (Chesapeake Bay Program, 1991), were generally below the MDL with the exception of a few samples. In 1993, three composite samples had detectable concentrations of benzo[a]anthracene (range 0.23 to 1.23 ng/g wet wt.), while only one sample had detectable concentrations of benzo[e]pyrene (0.55 ng/g wet wt.). In 1994, only two composite samples had detectable concentrations of benzo[a]anthracene (0.99 - 1.11 ng/g wet wt.), while only two samples had detectable concentrations of benzo[e]pyrene (0.58 - 1.05 ng/g wet wt.). In 1995, only benzo[e]pyrene was detected at concentrations above the MDL for one fish composite sample.

Total PAHs is the sum of the individual hydrocarbons listed in Tables 6-8. Concentrations ranged from 60 to 3,400 ng/g wet wt. for all samples. Median (or average) total PAHs concentrations for 1993, 1994, and 1995 were 160, 350, and 390 ng/g wet wt., respectively. The highest concentration was measured from a 1993 channel catfish composite (3,400 ng/g wet wt.) taken in the lower Anacostia River. The next two highest concentrations were from a 1994 channel catfish composite (350 ng/g wet wt.) and 1995 brown bullhead catfish (570 ng/g wet wt.) both from the Anacostia River. Other than these fish composite samples concentrations were generally less than 200 ng/g wet wt. for other samples.

*Organochlorine Pesticides*

Organochlorine pesticide concentration ranges and median values for the fish samples collected in 1993 are presented in Table 9 (also see Appendix IV). Almost all compounds were detected one or more of these samples including hexachlorbenzene (HCB), BHCs, chlordanes and its breakdown products, aldrin, dieldrin, endrin (in only two samples), mirex, DDTs (including DDE, DDD, and DDT). Total chlordane which includes hepta chlor, hepta epoxide, oxychlordane, $\alpha$-chlordane, $\gamma$-chlordane, and cis and trans- nonachlor ranged from 26 to 224 ng/g wet wt. with a median concentration of 80 ng/g wet wt. Total $\gamma+\alpha$ chlordane ranged from 8 to 130 ng/g wet (median = 47 ng/g wet wt.), while total DDT, which is the sum of the 2,4' and 4,4" forms of DDE (1,1-(2,2,2-trichloroethenylidene)bis[4-chlorobenzene]), DDD (1,1-(2,2-dichloroethylidene)bis[4-chlorobenzene]), and DDT (1,1-(2,2,2-trichloroethylidene)bis[4-chlorobenzene]), ranged from 42 to 180 ng/g wet with a median of 75 ng/g wet wt.. The channel catfish composite collected in the lower Anacostia River and lower Potomac River had the highest concentrations of most pesticides, while

**Table 9. Organochlorine pesticide concentration ranges for 1993 fish composite samples*.**

| | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| Total BHC's | 0.40 | 4.93 | 1.23 | 10 |
| Total DDTs | 41.78 | 177.24 | 74.65 | 10 |
| Total Chlordanes | 25.51 | 224.91 | 80.51 | 10 |
| α,γ - Chlordane | 8.11 | 129.97 | 47.09 | 10 |
| | | | | |
| α-BHC | 0.10 | 1.35 | 0.34 | 10 |
| HCB | 0.20 | 13.63 | 2.18 | 10 |
| β-BHC | ND | 0.50 | 0.05 | 5 |
| γ-BHC | 0.17 | 3.48 | 0.87 | 10 |
| δ-BHC | ND | 0.49 | ND | 8 |
| Hepta Chlor | ND | 0.48 | 0.05 | 4 |
| Hepta Epoxide | 0.85 | 9.63 | 3.19 | 10 |
| Oxychlordane | 1.48 | 8.71 | 3.71 | 10 |
| γ-Chlordane | 3.00 | 59.05 | 22.21 | 10 |
| α-Chlordane | 5.11 | 70.92 | 24.88 | 10 |
| Trans-Nonachlor | 10.32 | 46.90 | 31.31 | 10 |
| Cis-Nonachlor | 4.29 | 29.39 | 11.50 | 10 |
| Aldrin | ND | 2.31 | 0.58 | 7 |
| Dieldrin | 2.59 | 25.39 | 10.21 | 10 |
| Endrin | ND | 1.12 | ND | 2 |
| Mirex | ND | 0.88 | 0.31 | 9 |
| 2,4' DDE | ND | 1.28 | 0.33 | 8 |
| 4,4' DDE | 24.03 | 98.70 | 44.60 | 10 |
| 2,4' DDD | 2.50 | 14.32 | 3.79 | 10 |
| 4,4' DDD | 7.27 | 51.11 | 23.78 | 10 |
| 2,4' DDT | 0.62 | 6.33 | 2.82 | 10 |
| 4,4' DDT | 0.70 | 12.87 | 2.40 | 10 |
| Endosulfan II | ND | 0.41 | ND | 1 |

*Concentrations in ng/g wet weight.

**Table 10. Organochlorine pesticide concentration ranges for 1994 fish composite samples*.**

| | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| Total BHC's | 0.28 | 2.20 | 1.01 | 8 |
| Total DDT | 35.93 | 148.41 | 89.56 | 8 |
| Total Chlordane | 29.53 | 168.45 | 103.51 | 8 |
| α,γ - Chlordane | 11.19 | 91.60 | 54.06 | 8 |
| | | | | |
| α-BHC | ND | 0.62 | 0.19 | 7 |
| HCB | 0.36 | 4.98 | 1.59 | 8 |
| β-BHC | ND | 0.22 | ND | 2 |
| γ-BHC | 0.17 | 1.83 | 0.67 | 8 |
| δ-BHC | ND | 0.11 | ND | 0 |
| Hepta Chlor | ND | 0.40 | 0.07 | 2 |
| Hepta Epoxide | 0.59 | 9.07 | 3.86 | 8 |
| Oxychlordane | 2.30 | 7.41 | 3.26 | 8 |
| γ-Chlordane | 3.91 | 42.05 | 25.29 | 8 |
| α-Chlordane | 7.28 | 49.56 | 28.38 | 8 |
| Trans-Nonachlor | 10.74 | 40.52 | 26.95 | 8 |
| Cis-Nonachlor | 4.44 | 22.00 | 12.73 | 8 |
| Aldrin | ND | 2.11 | 0.81 | 7 |
| Dieldrin | 2.52 | 20.27 | 10.40 | 8 |
| Endrin | ND | 0.99 | 0.06 | 3 |
| Mirex | 0.08 | 0.78 | 0.17 | 8 |
| 2,4' DDE | 0.09 | 1.20 | 0.22 | 6 |
| 4,4' DDE | 20.91 | 88.59 | 49.02 | 8 |
| 2,4' DDD | 2.62 | 12.94 | 6.23 | 8 |
| 4,4' DDD | 9.24 | 37.27 | 21.15 | 8 |
| 2,4' DDT | ND | 6.90 | 2.61 | 7 |
| 4,4' DDT | 1.06 | 19.41 | 2.14 | 8 |
| Endosulfan II | ND | 0.34 | ND | 1 |

*Concentrations in ng/g wet weight.

the two common carp composites collected in the Anacostia River had the elevated levels compared to the other 1993 samples.

Similar pesticide compounds were detected in the fish composite samples collected in 1994 (Table 10; Appendix IV). Total chlordane ranged from 30 to 170 ng/g wet wt (median = 104 ng/g wet wt.), with the sum of $\gamma+\alpha$ chlordane ranging from 11 to 92 with a median concentration of 54 ng/g wet wt.. Total DDTs ranged 36 to 148 ng/g wet wt., with median concentrations of 90 ng/g wet wt.. The highest concentrations of total chlordane and DDTs were found in the lower Anacostia River in channel catfish and common carp composites, respectively. Channel catfish and common carp composites (a total of 4 samples out of 8) with total chlordane concentrations >100 ng/g wet were found in the lower and upper Potomac and lower Anacostia Rivers. Fish composites (4 samples out of 8) with total DDT concentrations >100 ng/g wet were found in these same locations from the same fish composites (i.e., common carp and channel catfish composites.

Similar organochlorine pesticides compounds were detected in the two brown bullhead composites collected in 1995 as in both 1993 and 1994 (Table 11; Appendix IV). Total chlordane concentrations ranged from 60 to 150 ng/g wet wt. (average concentration of 103 ng/g wet wt.), while total DDT concentrations ranged from 51 to 98 ng/g wet wt.. These concentrations are similar to those collected in the previous two years.

*Total Polychlorinated Biphenyls, Non-ortho PCBs, mono- and di-ortho PCBs*

Polychlorinated biphenyls (total PCBs; the sum of specific congeners, see Appendix IV) ranged from 300 to 1290 ng/g wet wt. for samples collected in 1993 (Table 12). Four composite samples had concentrations greater than 1000 ng/g wet wt; two channel catfish, one brown bullhead catfish, and one common carp. These samples were collected from the lower Potomac and lower Anacostia rivers. Various congeners (i.e. compounds with different levels and positions of chloride) of the PCBs were also detected in these fish samples (see Appendix IV). Specific congeners, the non-ortho, mono-ortho, and di-ortho substituted congeners, which are more of a potential health concern (see below), were detected in all fish samples (Table 12). Concentrations of the non-ortho substituted congener PCB #77 (3,3',4,4'-tetrachlorobiphenyl), for example, ranged from the 81 to 1840 pg/g wet wt. with a median of 360 pg/g wet wt..

**Table 11. Organochlorine pesticide concentration ranges for 1995 fish composite samples*.**

| | Minimum | Maximum | Average | # > MDL |
|---|---|---|---|---|
| Total BHC's | 0.46 | 0.94 | 0.70 | 2 |
| Total DDTs | 51.32 | 97.93 | 74.63 | 2 |
| Total Chlordanes | 59.75 | 147.91 | 103.83 | 2 |
| α,γ - Chlordane | 30.73 | 83.24 | 56.99 | 2 |
| | | | | |
| α-BHC | 0.31 | 0.59 | 0.45 | 2 |
| HCB | 0.25 | 0.86 | 0.56 | 2 |
| β-BHC | ND | 0.03 | 0.02 | 0 |
| γ-BHC | 0.16 | 0.31 | 0.23 | 2 |
| δ-BHC | ND | ND | ND | 0 |
| Hepta Chlor | 0.05 | 0.10 | 0.08 | 0 |
| Hepta Epoxide | 1.53 | 4.53 | 3.03 | 2 |
| Oxychlordane | 1.09 | 3.03 | 2.06 | 2 |
| γ-Chlordane | 14.10 | 37.71 | 25.91 | 2 |
| α-Chlordane | 16.63 | 45.53 | 31.08 | 2 |
| Trans-Nonachlor | 18.60 | 38.53 | 28.57 | 2 |
| Cis-Nonachlor | 7.75 | 18.48 | 13.11 | 2 |
| Aldrin | 0.59 | 1.40 | 1.00 | 2 |
| Dieldrin | 3.29 | 9.45 | 6.37 | 2 |
| Endrin | ND | ND | ND | 0 |
| Mirex | 0.21 | 0.40 | 0.30 | 2 |
| 2,4' DDE | 0.14 | 0.54 | 0.34 | 2 |
| 4,4' DDE | 31.81 | 49.04 | 40.42 | 2 |
| 2,4' DDD | 2.37 | 5.72 | 4.04 | 2 |
| 4,4' DDD | 15.32 | 39.59 | 27.46 | 2 |
| 2,4' DDT | 0.72 | 1.58 | 1.15 | 2 |
| 4,4' DDT | 0.96 | 1.46 | 1.21 | 2 |
| Endosulfan II | ND | ND | ND | 0 |

*Concentrations in ng/g wet weight.

**Table 12. Total PCBs and specific congener concentration ranges for 1993 fish composite samples*.**

| | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| Total PCBs | 296.7 | 1291.7 | 594.2 | 10 |
| *Non-ortho PCBs* | | | | |
| PCB#77 | 80.9 | 1840.9 | 359.4 | 10 |
| PCB#126 | 30.3 | 247.9 | 97.5 | 10 |
| PCB#169 | 1.2 | 9.1 | 3.9 | 10 |
| *Mono-ortho PCBs* | | | | |
| PCB#123 | 95.3 | 716.8 | 269.0 | 10 |
| PCB#118 | 8360.1 | 70548.9 | 26942.5 | 10 |
| PCB#114 | 158.5 | 1120.9 | 402.6 | 10 |
| PCB#105 | 2260.8 | 20015.9 | 8224.6 | 10 |
| PCB#167 | 1095.0 | 8821.3 | 2590.6 | 10 |
| PCB#156 | 1822.0 | 13247.0 | 4524.9 | 10 |
| PCB#157 | 283.0 | 1863.5 | 726.9 | 10 |
| PCB#189 | 204.4 | 1201.4 | 392.3 | 10 |
| *Di-ortho PCBs* | | | | |
| PCB#138 | 27746.9 | 182189.3 | 66218.3 | 10 |
| PCB#158 | 1716.4 | 16634.7 | 4323.4 | 10 |
| PCB#166 | ND | 321.0 | 127.0 | 9 |
| PCB#128 | 2644.8 | 15816.8 | 7052.6 | 10 |
| PCB#170 | 8910.5 | 49299.5 | 16846.3 | 10 |

*Total PCBs concentrations in ng/g wet wt., congener concentrations in pg/g wet weight.
ND - Not detected. (n = 10).

Concentration ranges of total PCBs and specific congeners are presented in Table 13 for samples collected in 1994. As in 1993, various congeners of these groups were detected in fish composites collected throughout the Washington, D.C. area (Appendix IV). Total PCBs were slightly lower in the 1994 fish samples and ranged from 270 to 940 ng/g wet wt. (median = 630 ng/g wet wt.). Non-ortho, mono-ortho, and di-ortho substituted congeners were also detected in all fish samples (Table 12).

**Table 13. Total PCBs and specific congener concentration ranges for 1994 fish composite samples*.**

| | Minimum | Maximum | Median | # > MDL |
|---|---|---|---|---|
| Total PCBs | 269.8 | 937.9 | 626.9 | 8 |
| *Non-ortho PCBs* | | | | |
| PCB#77 | 19.7 | 536.7 | 257.4 | 8 |
| PCB#126 | 19.2 | 228.8 | 48.5 | 8 |
| PCB#169 | < 0.6 | 6.7 | 1.8 | 7 |
| *Mono-ortho PCBs* | | | | |
| PCB#123 | ND | 643.0 | 167.7 | 7 |
| PCB#118 | 8820.2 | 60701.5 | 16360.8 | 8 |
| PCB#114 | 179.5 | 740.2 | 275.6 | 8 |
| PCB#105 | 2809.7 | 15135.6 | 4932.0 | 8 |
| PCB#167 | 907.9 | 7593.5 | 2088.0 | 8 |
| PCB#156 | 1612.6 | 7963.0 | 3584.2 | 8 |
| PCB#157 | 275.2 | 1231.1 | 485.8 | 8 |
| PCB#189 | 126.7 | 875.7 | 381.6 | 8 |
| *Di-ortho PCBs* | | | | |
| PCB#138 | 21063.8 | 149715.6 | 70333.2 | 8 |
| PCB#158 | 1912.9 | 7014.8 | 3725.5 | 8 |
| PCB#166 | 42.4 | 220.4 | 83.6 | 8 |
| PCB#128 | 2384.4 | 12854.1 | 5796.0 | 8 |
| PCB#170 | 4956.2 | 32832.9 | 15918.4 | 8 |

*Total PCBs concentrations in ng/g wet wt., congener concentrations in pg/g wet weight.
ND - Not detected (n = 8).

Total PCBs, and non-ortho and ortho substituted congeners were detected in the two brown bullhead composites collected in 1995 as in both 1993 and 1994 (Table 14; Appendix IV). Total PCBs concentrations ranged from 340 to 730 ng/g wet wt. (average concentration of 540 ng/g wet wt.). These fish composites were collected from the upper Anacostia River and concentrations are similar to those collected in the previous two years.

**Table 14. Total PCBs and specific congener concentration ranges for 1995 fish composite samples*.**

| | Minimum | Maximum | Average | # > MDL |
|---|---|---|---|---|
| Total PCBs | 343.4 | 734.3 | 538.9 | 2 |
| *Non-ortho PCBs* | | | | |
| PCB#77 | 110.7 | 312.4 | 211.6 | 2 |
| PCB#126 | 79.8 | 132.8 | 106.3 | 2 |
| PCB#169 | 2.4 | 2.6 | 2.5 | 2 |
| *Mono-ortho PCBs* | | | | |
| PCB#123 | 240.5 | 395.6 | 318.1 | 2 |
| PCB#118 | 15043.6 | 27026.0 | 21034.8 | 2 |
| PCB#114 | 334.0 | 633.5 | 483.7 | 2 |
| PCB#105 | 5515.5 | 7975.0 | 6745.3 | 2 |
| PCB#167 | 1485.6 | 2253.2 | 1869.4 | 2 |
| PCB#156 | 2692.0 | 4162.7 | 3427.4 | 2 |
| PCB#157 | 495.8 | 833.7 | 664.7 | 2 |
| PCB#189 | ND | 329.6 | 164.8 | 1 |
| *Di-ortho PCBs* | | | | |
| PCB#138 | 31829.3 | 51942.0 | 41885.7 | 2 |
| PCB#158 | 1887.8 | 3277.6 | 2582.7 | 2 |
| PCB#166 | 78.4 | 121.5 | 100 | 2 |
| PCB#128 | 3724.3 | 5768.8 | 4746.6 | 2 |
| PCB#170 | 12609.3 | 17307.9 | 14958.6 | 2 |

*Total PCBs concentrations in ng/g wet wt., congener concentrations in pg/g wet weight.
ND - Not detected. (n = 2).

## Discussion

The following sections provide a discussion of the variations observed within these data sets (1993-1995). Species and geographical variations will be presented, however the limited data set (i.e., number of samples in each area and of a specific species) will limit this to a qualitative analysis only. Additionally, a comparison is made to previous studies in the local area and a recently completed national fish contamination study (Velinsky and Cummins, 1994; U.S. EPA, 1992). Lastly, a brief discussion of the possible health effects of the levels observed from this data set is presented. Due to the extent of this data set however, only selected parameters will be discussed in more detail. Chemicals include the trace metal Hg and Pb, the PAHs, (i.e., naphthalene and others), total PCBs, total DDT (pp' forms of DDE+DDD+DDT), and total and $\alpha+\gamma$ chlordane. (Table 15). Specific congeners of PCBs will be discussed in relation to the potential health effects of these compounds. These chemicals were selected due to their presence in previous studies, and their inclusion in the Chesapeake Bay's primary or secondary Toxics of Concern List (EPA, 1991).

*Contaminant Variations between Species and Geographic Area*

Contaminant variations between species can be the result of many factors including feeding habits (e.g., top predator versus scavenger), living area (e.g., benthic versus pelagic), physiological differences (e.g., varying lipid content), type of contaminant (e.g., organic versus inorganic or low $K_{ow}$ versus high $K_{ow}$), and uptake mechanism (e.g., particle or sediment versus water). For example, the bioaccumulation (i.e., water plus food) of hydrophobic organic compounds, like PCBs, would be due to an equilibrium partition between the lipid content in a fish and the surrounding water or organic carbon (type and content) of ingested food (Oliver and Niimi, 1983; Barron, 1990). An important consideration is not only the amount of total lipid which is determined by the method used and the type of lipid present in the tissue. For trace metals, the uptake is related to the bioavailability of the metal (i.e., chemical form) which is influenced by pH, reduction-oxidation potential, and temperature (Louma, 1983). Geochemical and physiological processes both are important in determining metal uptake. For example, in certain systems Hg exists in the methylated form (e.g., $CH_3Hg$) which would partition in the lipid fraction of a fish (Driscoll et al., 1994). The concentration measured overall would be a balance between the uptake, depuration, and breakdown of the contaminant (Mackay, 1991).

For this study, five different species of fish were collected and analyzed. Unfortunately, there was not enough replication between species and area in each year to make a quantitative assessment of the differences in contaminant concentrations. Therefore, only a qualitative assessment will be provided. Also, in analyzing these data for differences between species, it was necessary to assume that there

Table 15. Concentrations of selected trace metals and organic contaminants in fish composites collected in 1993, 1994, and 1995*..

| ID | Loc. | Fish | Hg | Pb | % Lipids | TPAHs | Naphth | TPCBs | PCB# 77 | TDDTs | TChlor. | α+γ-Chlor. | Oxychlor. | Dieldrin |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-93 | LP | LMB | 0.083 | 0.040 | 1.4 | 59.0 | 11.9 | 375.6 | 0.12 | 59.7 | 38.8 | 13.1 | 2.4 | 4.8 |
| 2-93 | LP | CC | 0.059 | 0.032 | 9.0 | 133.3 | 21.0 | 1070.2 | 0.21 | 134.7 | 128.1 | 69.5 | 3.3 | 15.5 |
| 3-93 | UP | COC | 0.052 | 0.038 | 4.8 | 200.7 | 18.1 | 633.9 | 0.57 | 65.2 | 82.3 | 48.6 | 2.1 | 14.2 |
| 4-93 | UP | LMB | 0.037 | 0.030 | 1.2 | 60.0 | 15.7 | 296.7 | 0.11 | 41.8 | 25.5 | 8.1 | 1.9 | 2.6 |
| 5-93 | UP | AE | 0.112 | 0.183 | 2.0 | 233.6 | 53.3 | 554.6 | 0.08 | 84.1 | 70.6 | 15.1 | 6.9 | 8.7 |
| 6-93 | LA | CC | 0.059 | 0.046 | 9.8 | 3426.5 | 52.0 | 1291.7 | 0.39 | 177.2 | 182.1 | 94.6 | 4.8 | 25.4 |
| 7-93 | LA | COC | 0.083 | 0.042 | 3.0 | 82.9 | 18.1 | 1064.5 | 0.53 | 129.5 | 140.6 | 71.5 | 4.1 | 10.4 |
| 8-93 | LA | Sun | 0.052 | 0.254 | 2.4 | 91.8 | 5.4 | 455.5 | 0.39 | 60.8 | 74.3 | 23.1 | 8.7 | 10.0 |
| 9-93 | UA | COC | 0.042 | 0.075 | 7.4 | 177.0 | 22.8 | 1063.1 | 1.84 | 121.6 | 224.9 | 130.0 | 8.5 | 22.3 |
| 10-93 | KM | BB | 0.025 | 0.087 | 2.5 | 217.1 | 17.9 | 376.4 | 0.33 | 54.9 | 78.8 | 45.6 | 1.5 | 3.9 |
| 1-94 | LP | LMB | 0.160 | 0.020 | 0.7 | 33.7 | 8.6 | 406.1 | 0.14 | 53.2 | 42.5 | 12.4 | 2.5 | 5.1 |
| 2-94 | LP | COC | 0.059 | 0.043 | 7.0 | 77.7 | 9.5 | 877.1 | 0.54 | 70.6 | 80.8 | 42.4 | 2.3 | 14.2 |
| 3-94 | UP | CC | 0.055 | 0.055 | 4.8 | 68.3 | 11.9 | 727.9 | 0.19 | 117.5 | 126.3 | 65.7 | 4.0 | 12.2 |
| 4-94 | UP | COC | 0.052 | 0.029 | 5.4 | 64.9 | 11.3 | 525.8 | 0.27 | 108.6 | 130.0 | 73.8 | 3.8 | 14.6 |
| 5-94 | LA | LMB | 0.078 | 0.043 | 0.5 | 31.4 | 7.6 | 269.8 | 0.18 | 35.9 | 29.5 | 11.2 | 2.6 | 2.5 |
| 6-94 | LA | COC | 0.091 | 0.039 | 3.1 | 70.8 | 8.8 | 903.7 | 0.43 | 122.3 | 129.9 | 68.2 | 2.7 | 8.6 |
| 7-94 | LA | CC | 0.063 | 0.097 | 9.0 | 352.2 | 17.1 | 937.9 | 0.34 | 148.4 | 168.4 | 91.6 | 4.8 | 20.3 |
| 8-94 | LA | Sun | 0.056 | 0.187 | 1.8 | 102.8 | 11.7 | 308.9 | 0.25 | 49.1 | 51.5 | 15.4 | 7.4 | 6.5 |
| 1-95 | UA | BB | 0.034 | 0.072 | 2.3 | 570.5 | 8.9 | 734.0 | 0.31 | 97.9 | 147.9 | 83.2 | 9.5 | 3.0 |
| 2-95 | UA | BB | 0.051 | 0.104 | 0.8 | 210.0 | 7.2 | 343.0 | 0.11 | 51.3 | 59.8 | 30.7 | 3.3 | 1.1 |

* Concentrations of Pb and Hg in μg/g wet wt.. Naphthalene (Napth), ΣPCB, ΣPAH, ΣDDT, ΣChlor, α+γ chlordane, oxychlordane, and dieldrin concentrations in ng/g wet wt.. PCB# 77 is in pg/g wet wt.. ΣPCB is the sum of 70 individual congeners (see appendix II), ΣPAH is the sum of 40 individual aromatic hydrocarbons, and ΣDDT is the sum of the op'+pp' forms of DDE, DDD, and DDT. Locations (Loc): LP - Lower Potomac, UP - Upper Potomac, LA - Lower Anacostia, UA - Upper Anacostia, and KM - Kenilworth Marsh. Fish ID: LMB - largemouth bass, AE - American eel, CC - channel catfish, Sun- Bluegill or pumpkinseed sunfish, COC - common carp, BB - brown bullhead catfish.

are limited geographical factors which can influence the concentration of inorganic and organic contaminants in the fish tissue. This may not be the best assumption given that sediments in the Anacostia River, especially the lower section, has been shown to be impacted with trace metals and organic compounds compared to the upper Anacostia River and Potomac River (Velinsky et al., 1992; Pinkney et al., 1993). However, fish are highly mobile and may not reside in just one location.

Of the trace elements determined during this study only Hg and Pb will be discussed (see Results or Appendix III for other metals or metalloids). In 1993, six species of fish were qualitatively examined for species variations (Table 15, Figure 2). Mercury concentrations were highest in the single American eel composite (0.11 µg/g wet wt.) which was collected in the upper Potomac River and is approximately twice as high as the overall median of 0.055 µg/g wet wt. Concentrations of Pb were higher in the American eel and bluegill composites (0.18 and 0.25 µg/g wet wt., respectively) compared to the overall median of 0.044 µg/g wet wt. These composites were collected from the upper Potomac and lower Anacostia Rivers.

Similar concentrations of Hg and Pb were measured from the 1994 sample composites. However, only four species were collected in 1994, limiting any comparisons (Table 15, Figure 3). The concentration of Hg was highest (0.16 µg/g wet wt.) in the largemouth bass composite from the lower Potomac River compared to the overall median of 0.061 µg/g wet wt.. As in the 1993 samples, the concentration of Pb was highest (0.19 µg/g wet wt.) in the bluegill composite collected from the lower Anacostia River (overall median = 0.043 µg/g wet wt.).

There are also qualitative concentration differences between species for many organic contaminants (Table 15). In 1993, the channel catfish composite collected in the lower Anacostia River exhibited an extremely high concentration of total polycyclic aromatic hydrocarbons (TPAHs) compared to the overall median concentration, 3.4 µg/g wet wt. and 0.16 µg/g wet wt., respectively (Figure 4). The majority of the aromatic hydrocarbons was composed of the 2-ringed aromatic, naphthalene and its alkalyted components (see below). The parent compound, naphthalene, also exhibited a high concentration in the catfish composite from the lower Anacostia River (52 ng/g wet wt.) but was slightly higher (53 ng/g wet wt.) in the American eel composite collected in upper Potomac River (overall median concentration = 18 ng/g wet wt.).

Overall, median TPAHs and naphthalene concentrations were similar for fish composite samples

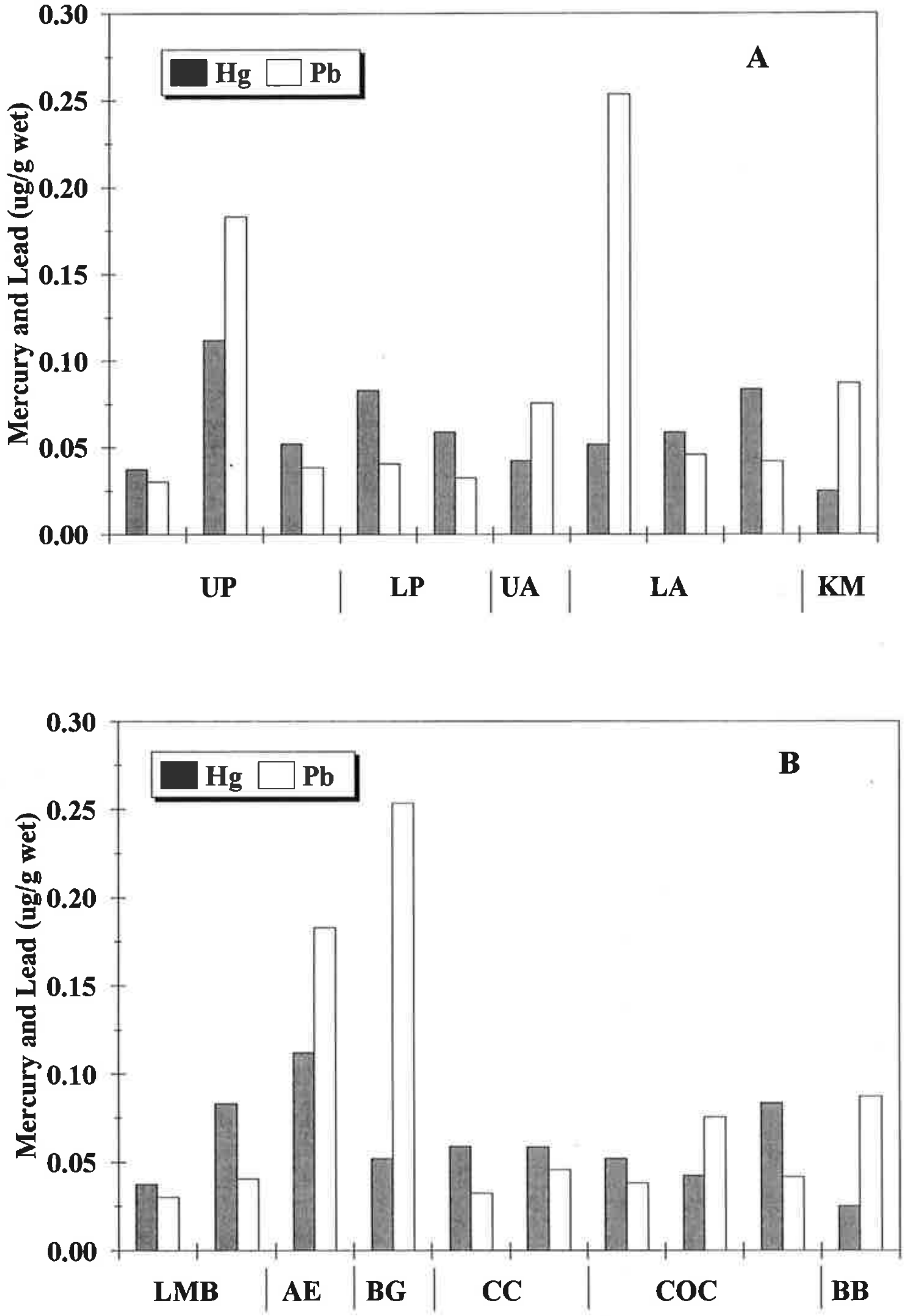
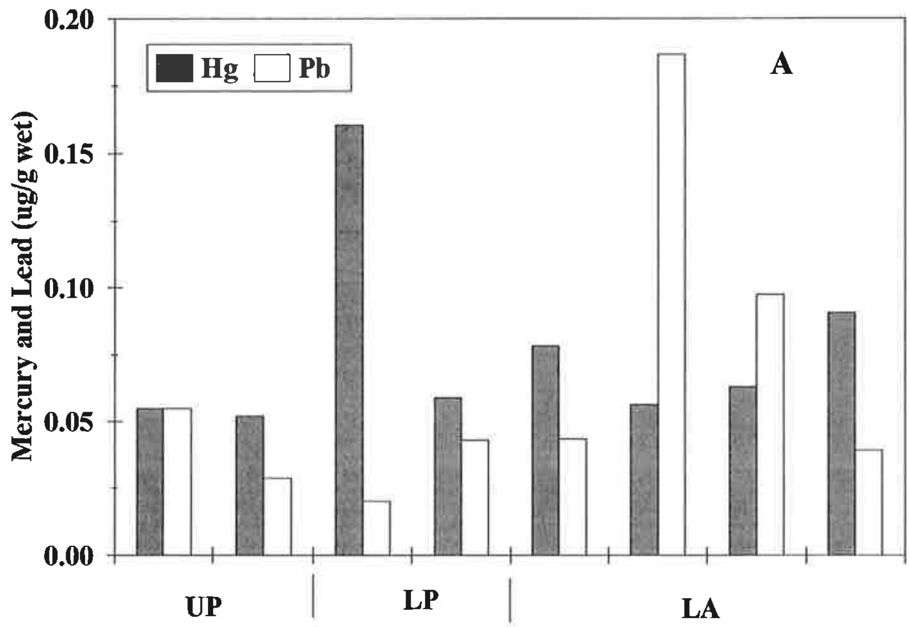



Figure 2. Concentrations of Hg and Pb by location (A) and species (B) for 1993.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.



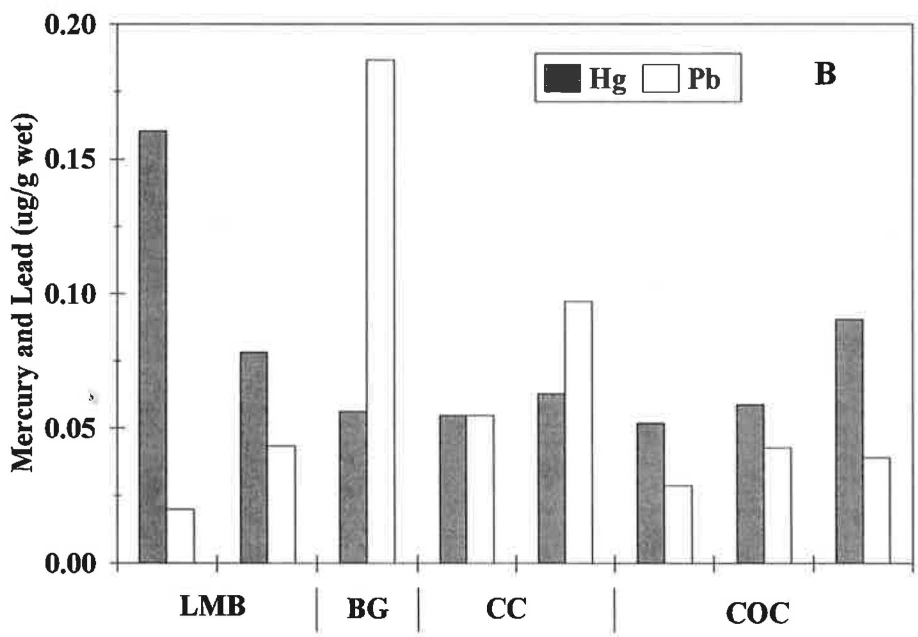




Figure 3. Concentrations of Hg and Pb by location (A) and species (B) for 1994.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.

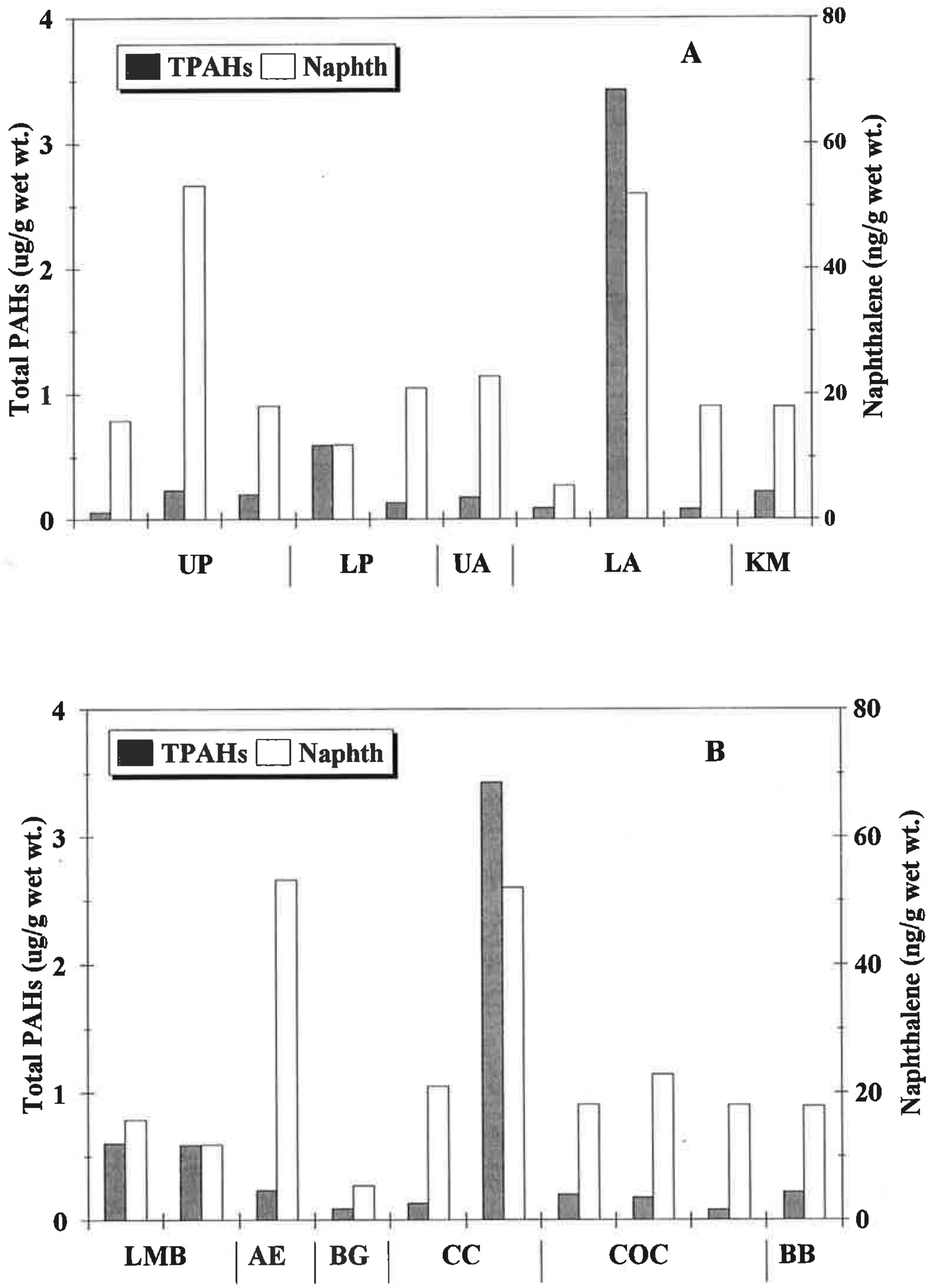



Figure 4. Concentrations of total PAHs and naphthalene by location (A) and species (B) for 1993.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.

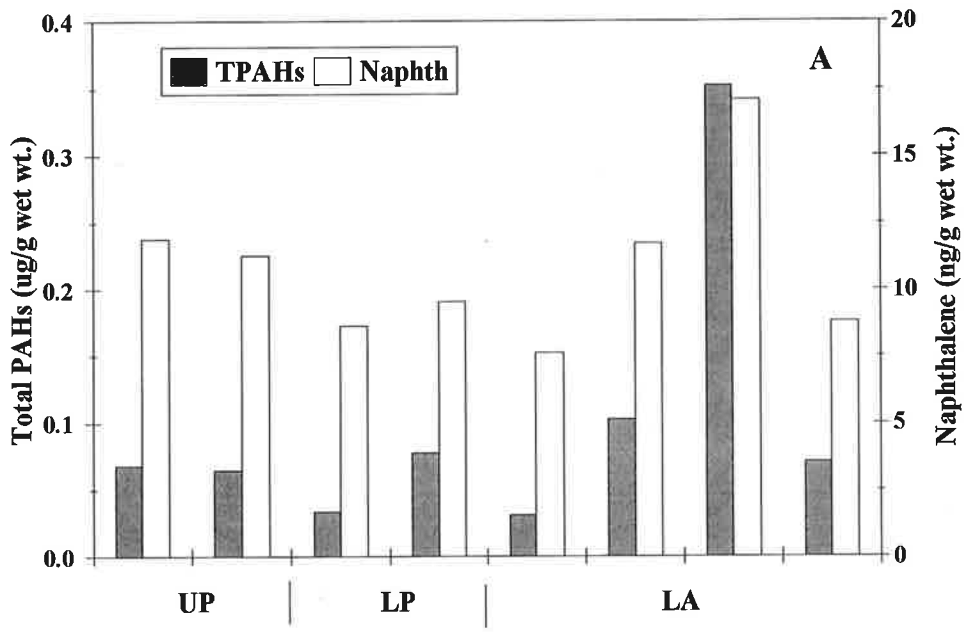
collected in 1994 (0.07 µg/g wet wt. and 10 ng/g wet wt, respectively) compared to 1993 composites (Table 15, Figure 5). Highest concentrations for both TPAHs and naphthalene of 0.35 µg/g wet wt. and 17 ng/g wet wt., respectively, were found in one channel catfish composite from the lower Anacostia River.

Total PCBs and DDTs were highest in channel catfish and two common carp composites collected in 1993 (Table 15, Figure 6). Concentrations of total PCBs for these composites ranged between 1.06 and 1.29 µg/g wet wt. compared to a median concentration for all composites of 0.59 µg/g wet wt.. These samples were collected in the Anacostia River (both upper and lower) and lower Potomac River (Table 15). Concentrations of the planar PCB congener 77 (3,3',4,4' - tetrachlorobiphyenyl) was also highest in these samples with concentrations up to 1800 pg/g wet wt.. While this congener is three orders of magnitude lower in concentrations than total PCBs, it has been shown to be a potentially more toxic congener (see below). Total DDTs (the sum of the DDT, DDE, and DDD) were highest in the same samples as total PCBs with concentrations ranging from 121 to 177 ng/g wet wt. compared to a median of 75 ng/g wet wt.

Concentrations of total PCBs in 1994 were highest in the channel catfish and common carp sample composites (0.72 to 0.94 µg/g wet wt.) compared to the overall median of 0.63 µg/g wet wt. (Table 15, Figure 7). The catfish were collected in the upper Potomac and lower Anacostia rivers, while the common carp were collected from the lower Anacostia and Potomac areas. The planar PCB congener 77 was generally highest in these samples with a range of 197 to 540 pg/g wet wt., compared to the median of 260 ng/g wet wt. Total DDTs concentrations were also highest in the common carp and channel catfish composite samples. Concentrations were between 71 and 122 ng/g wet wt. for common carp and 197 and 337 ng/g wet wt. for channel catfish (median = 90 ng/g wet wt.).

Concentrations of total chlordane and dieldrin were generally highest in channel catfish and common carp composites in the Anacostia River for both 1993 and 1994 (Figure 7 and 8). Highest concentrations of total chlordane and dieldrin were approximately 220 ng/g wet wt. and 25 ng/g wet wt, respectively. Lowest concentrations were measured in largemouth bass and sunfish (sp) species.

Generally, concentrations of these contaminants were variable for both species and location. Unfortunately, there was not enough replication for both species and geographically assessments, however there were qualitative differences. For the trace metals, mercury and lead, concentrations



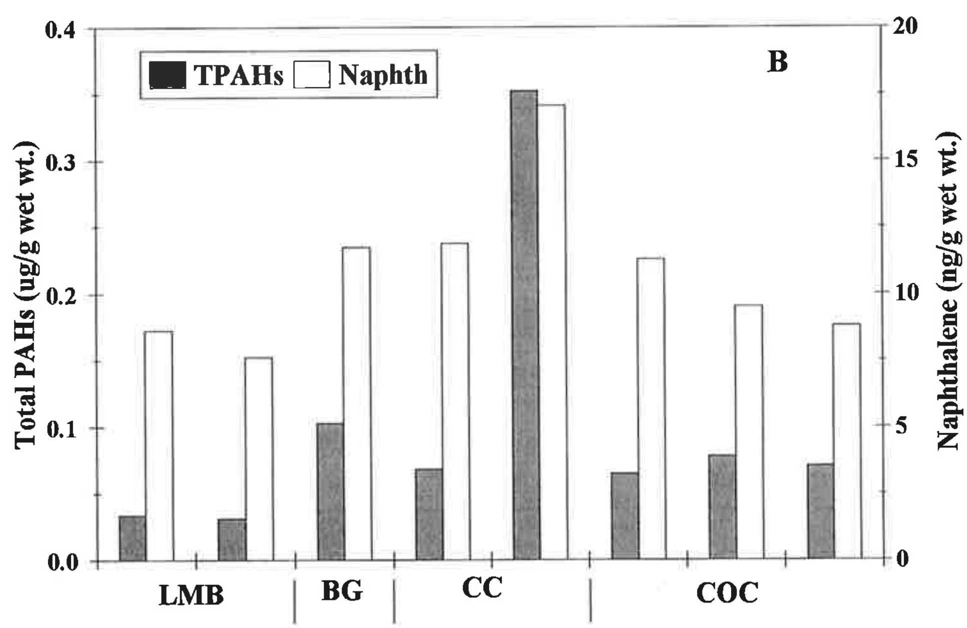




Figure 5. Concentrations of total PAHs and naphthalene by location (A) and species (B) for 1994.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.

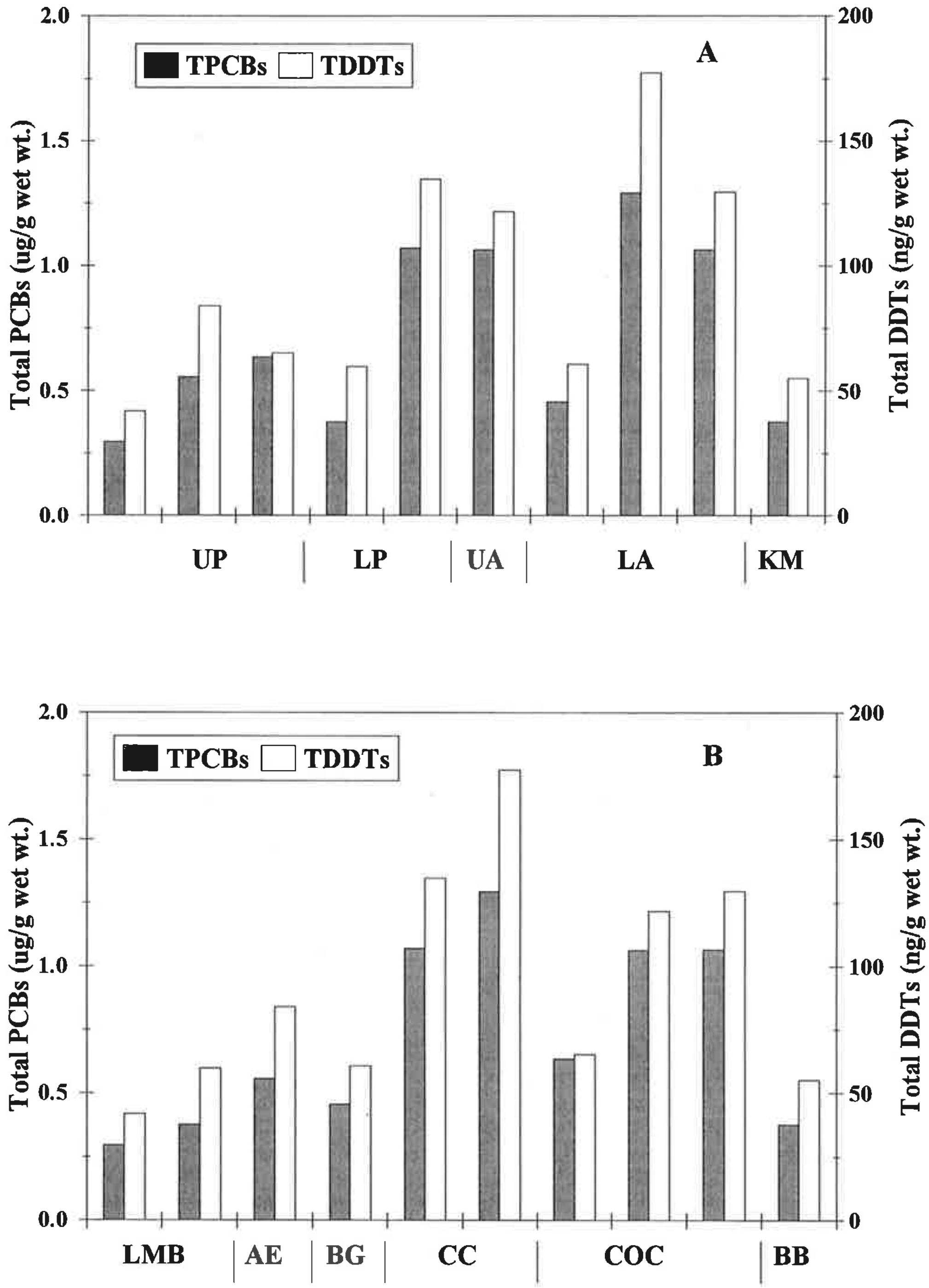



Figure 6. Concentrations of total PCBs and total DDTs by location (A) and species (B) for 1993.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.

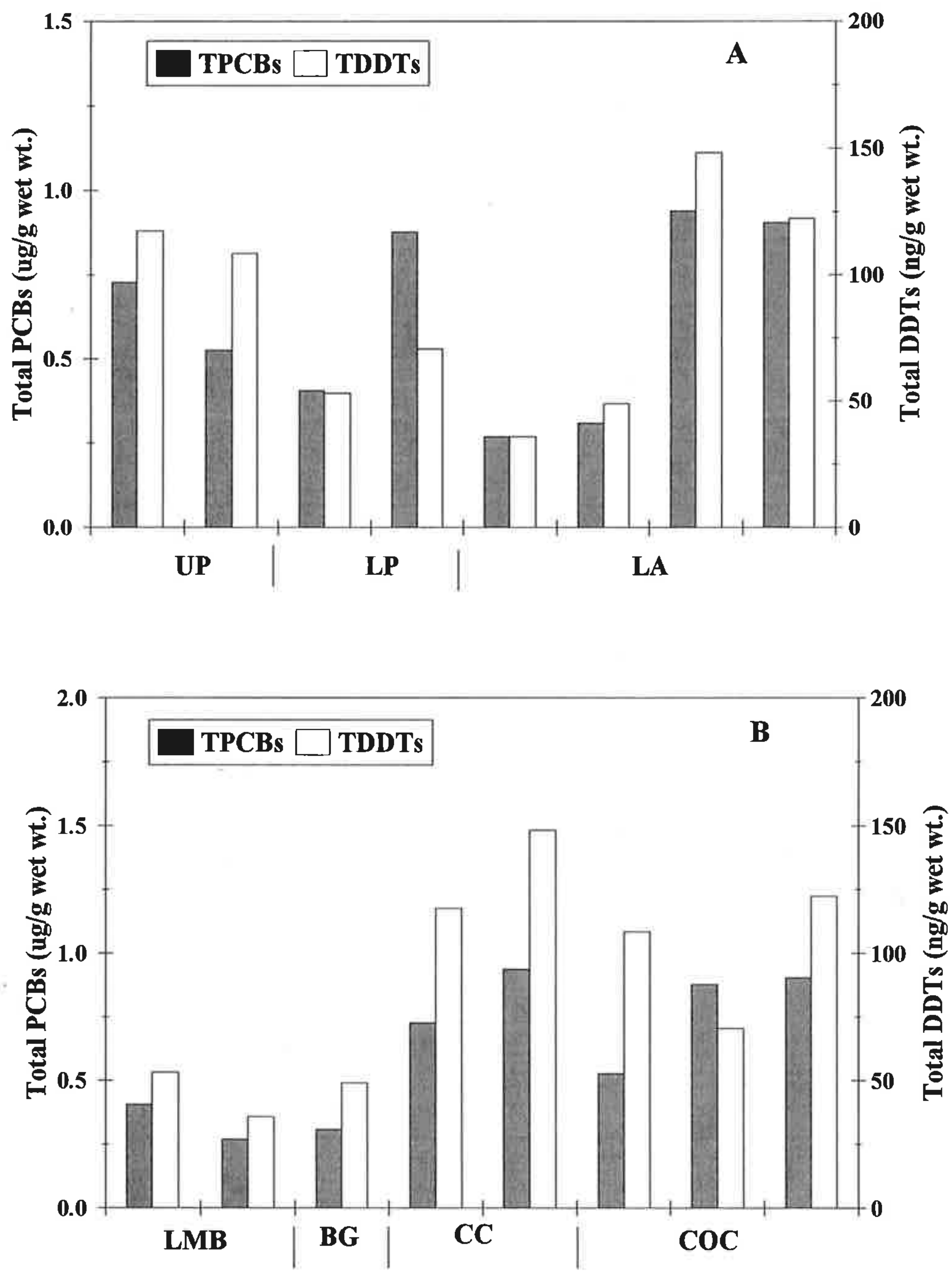
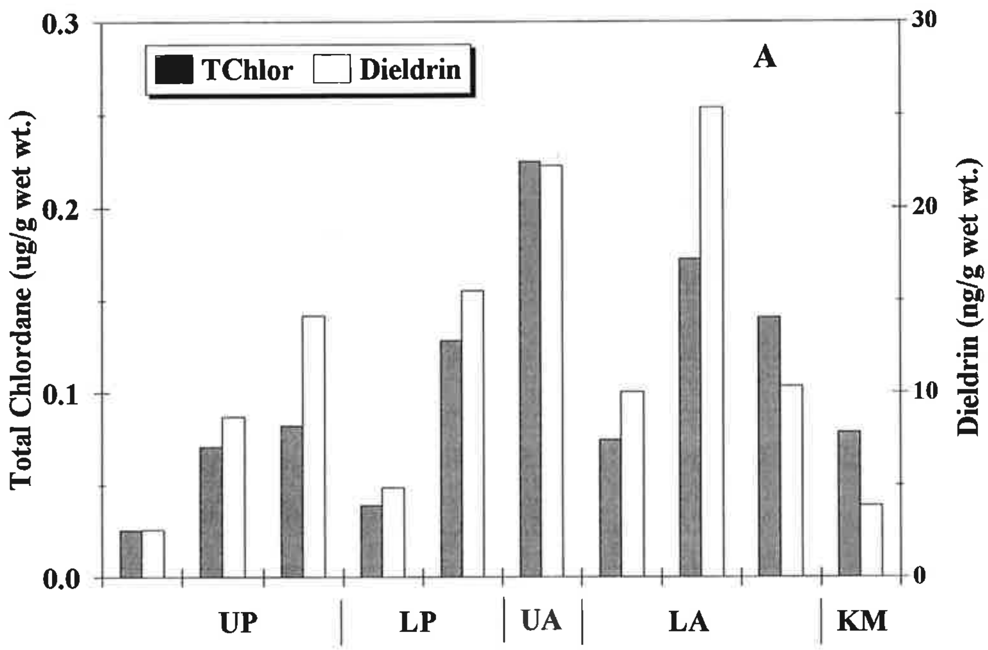



Figure 7. Concentrations of total PCBs and total DDTs by location (A) and species (B) for 1994.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.



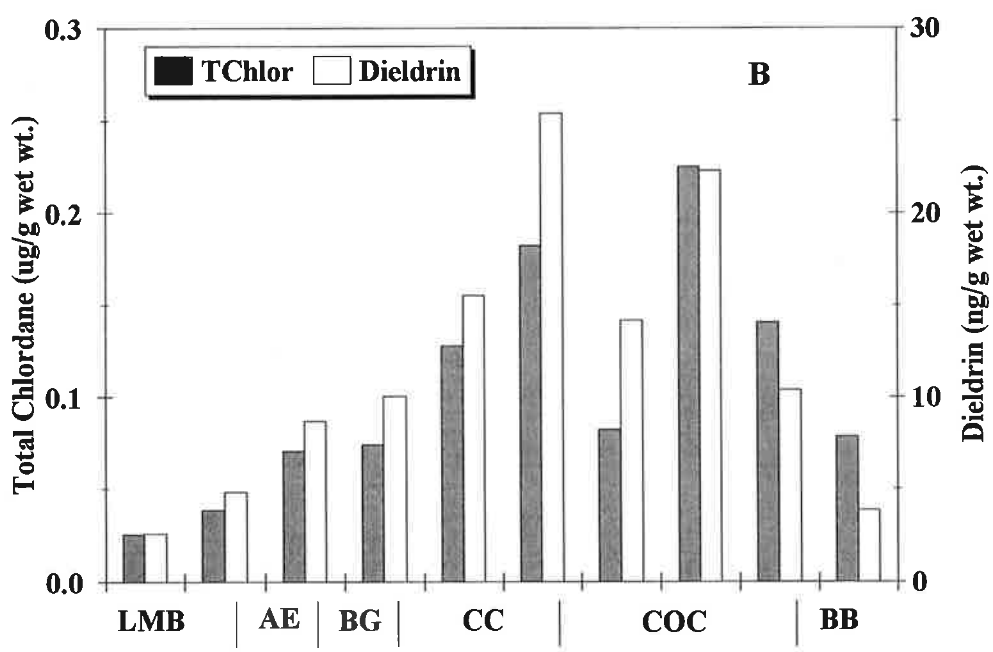
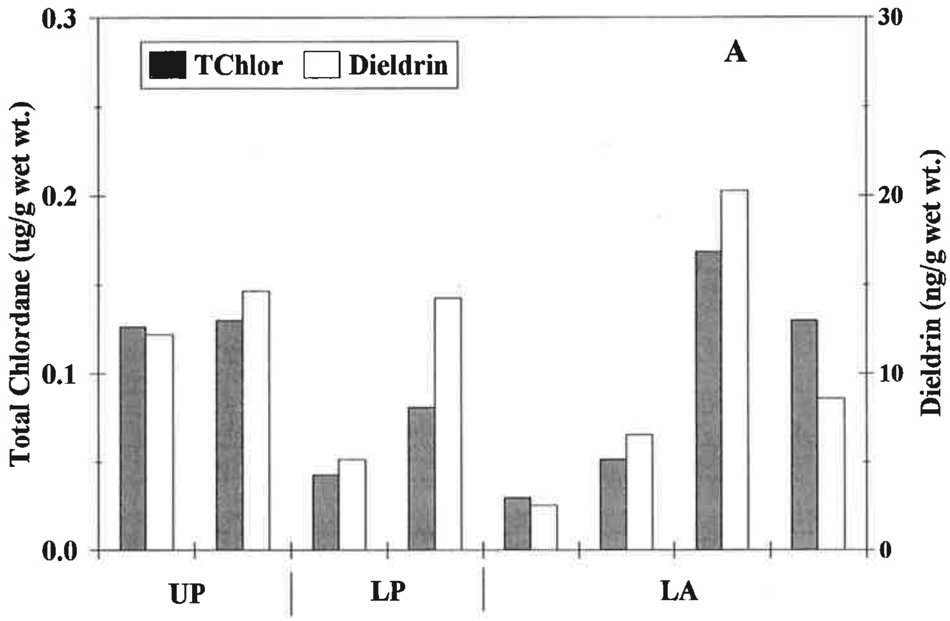




Figure 8. Concentrations of total chlordane and dieldrin by location (A) and species (B) for 1993.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.



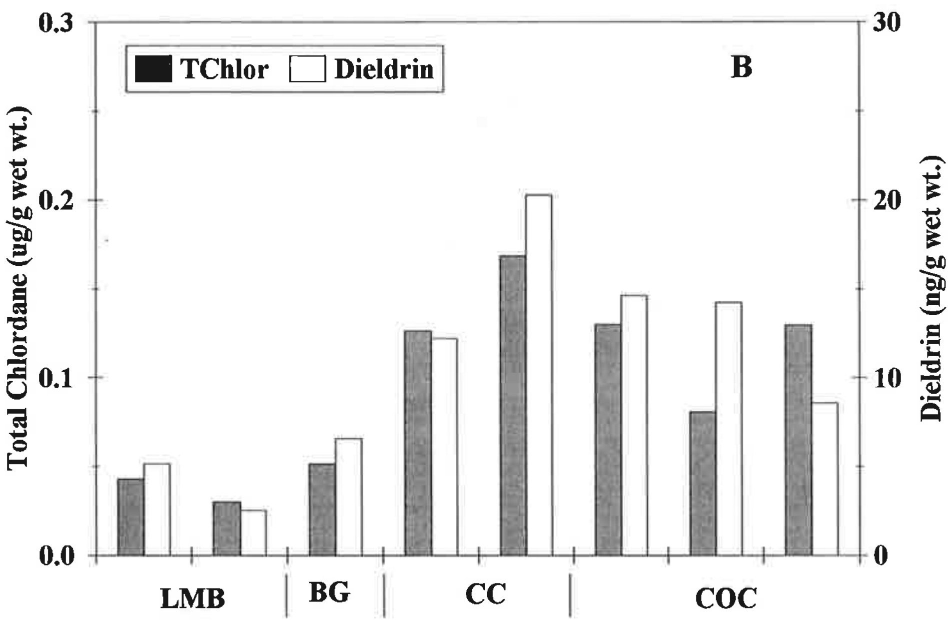




Figure 9. Concentrations of total chlordane and dieldrin by location (A) and species (B) for 1994.

**Key:** LMB - largemouth bass, AE - American eel, CC - channel catfish, BG - Bluegill sunfish, COC - common carp, BB - brown bullhead catfish, PS - pumpkinseed sunfish. UP - upper Potomac, LP - lower Potomac, UA - upper Anacostia, LA - lower Anacostia.

were highest in largemouth bass, American eel, and sunfish composites taken from the four areas. There were not enough samples to determine any geographical differences. The organic contaminants were generally highest in common carp and channel catfish composites, but there was not enough sample coverage for a geographical assessment. With more samples collected for key species in each of the four areas, geographical variations could be assessed.

An important variable in the accumulation of organic contaminants is the lipid content of a fish (e.g., Mackay, 1982; Chiou, 1985; Connolly and Pedersen, 1988; Thomann et al., 1992; Cullen and Connell, 1992). The correlation between lipid content and many organic contaminants has allowed comparison of fish concentrations between species, locations, and seasons, and is a major parameter in many bioaccumulation models (i.e., thermodynamic partitioning, $K_{ow}$). Total lipids are composed of a variety of compounds ranging from neutral (e.g., hydrocarbons, fatty acids), membrane-bound (e.g., phospholipids), and covalently-bound (e.g., wax esters) lipids (Kates, 1972). Physiological differences between species can result in varying amounts of lipids stored in various body parts. The total lipid content is operationally defined dependent for the most part by the solvent used for the extraction (Randall et al., 1991). For this study the weight of methylene chloride extracted dissolved material contained in the fillets is termed total lipid (see Velinsky and Cummins, 1995 for method).

In this study, common carp and channel catfish samples contained the greatest amount of total lipids, while largemouth bass contained the least (Table 1). For all data, a one-way analysis of variance (ANOVA) was used to determine if there was a significant difference in the sample means between species. The analysis showed that there was a significant difference between sample means for total lipids in largemouth bass, channel catfish, common carp, and brown bullhead catfish. Results indicated that channel catfish and common carp contained significantly higher lipid contents than the other species of fish for which there was enough data.

A simple linear regression model was used to determine if there was a relationship between lipid content and the concentration of lipophilic organic contaminants (i.e., PAHs, naphthalene, PCBs, DDTs, chlordane, oxychlordane, and dieldrin). For this regression, all data from 1993, 1994, and 1995 were grouped. For total PCBs, total DDTs, and dieldrin the coefficient of determinations were greater than + 0.7 and were significant at $p<0.05$ ($n=20$) (Table 16). These results indicated that a relationship exists between lipid content and the concentration of these contaminants, and that greater than 70% of the variation in concentration is accounted for by the content of lipid in each species. These differences help explain some of the variations of the more lipophilic organic and inorganic contaminants observed during this study (i.e., higher levels in channel catfish and common carp samples). While this information is important in ecosystem modeling for the prediction of transfers and partitioning of

**Table 16. Simple linear-regression model results between lipid content and various contaminants*.**

| Chemical | Sample Size | Correlation Coefficient ($r^2$) | Coefficient of Determination (r) |
|---|---|---|---|
| Total PAHs | 20 | 0.2235 | 0.4728 |
| Naphthalene | 20 | 0.1502 | 0.3876 |
| Total PCBs* | 20 | 0.6778 | 0.8233 |
| PCB#77 | 20 | 0.1548 | 0.3934 |
| Total DDTs* | 20 | 0.6348 | 0.7967 |
| Total Chlordane* | 20 | 0.5632 | 0.7504 |
| Oxychlordane | 20 | 0.0057 | 0.0755 |
| Dieldrin* | 20 | 0.8575 | 0.9260 |

*Significant at the > 95% level. Total PAHs are the sum of 40 individual aromatic hydrocarbons, total PCBs are the sum of 70 individual congeners, and total DDTs are the sum of the p,p and o,p forms of DDE, DDD, and DDT (see Appendix IV).

contaminants, it is the total concentration of these chemicals that is used for the prediction of human health impacts (see below).

*Aromatic Hydrocarbons in Fish Tissue*

Polycyclic aromatic hydrocarbons (PAHs) are, as a group, highly hydrophobic and lipophilic and therefore these compounds are prone to rapid uptake by freshwater and marine organisms even when exposure is at relatively low concentrations in the water or sediments. The sources of PAHs to many urban environment, like Washington, D.C., are diverse and include atmospheric deposition, stormwater runoff, combined sewer overflows, and direct oil spills (Wade et al., 1994). Many aromatic hydrocarbons have not been found to be naturally occurring in aquatic organisms (i.e., fish) and are believed to be derived from petroleum contamination.

Aromatic hydrocarbons (PAHs) can also help discriminate between combustion sources of hydrocarbons and those derived by the direct discharge of oil. Oil contains a greater percentage of alkyl-substituted compounds (i.e., methyl, ethyl, propyl) in the naphthalene, phenanthrene-anthracene, and chrysene series and refined petroleum products also have a greater abundance of the lower molecular weight compounds (2 to 3 ring groups). The partial combustion of oil and refined petroleum products reduces the amount of alkyl-substituted compounds leaving the parent structure in greater abundance (Youngblood and Blumer, 1975). Some of the general differences between biogenic and petroleum sources of hydrocarbons are summarized in Table 17. These differences will be exploited in the following discussions in evaluating the level and source of hydrocarbon contamination in the fish tissue of the various study areas.

**Table 17. General Characteristics of Biogenic and Petroleum Hydrocarbons*.**

*Natural Biogenic Hydrocarbons*

Narrow range of molecular weight distribution of SHC and PAH (if present), UCM is either low or absent.

Odd- to even-numbered alkane ratio is > 1.

Terrestrial plant material indicated by an alkane distribution from $nC_{23}$ to $nC_{34}$, centered around $nC_{29}$ or $nC_{31}$.

Aquatic organisms have a predominance of $nC_{13}$ to $nC_{21}$ alkanes with an greater amounts of odd-numbered compounds.

*Fossil Fuel or Petroleum Hydrocarbons*

Wider range in molecular wt. distribution of both SHC and PAH, UCM is present in large amounts compared to alkanes and PAHs.

Odd- to even-numbered alkane ratio = 1.

Several homologous series with adjacent members in approximately the same concentrations.

Natural source sources of PAH indicated by less complex distribution with compounds related to structure of precursors (i.e., perylene and retene).

Direct discharge of oil is indicated by PAHs (e.g., naphthalene, phenanthrene-anthracene, and chrysene series) contains many alkyl-substituted species (i.e., $C_1$, $C_2$ and $C_3$).

Combustion products have a greater abundance of un-substituted parent compounds, with homologs which decrease in abundance as the degree of alkyl substitution increases.

UCM present in greater proportion than resolved peaks.

* Taken from Youngblood and Blumer, 1975; Farrington, 1980; Hites et al., 1980; Wakeham et al., 1980; Boehm and Farrington, 1984; Boehm, 1984; Pruell and Quinn, 1985; Pierce et al., 1986. SHC - Saturated aliphatic hydrocarbons, UCM - Unresolved complex mixture, PAH - Polycyclic aromatic hydrocarbons

The accumulation and biological effects (i.e., cancers, mutations, deformations, and death) of PAHs varies widely among the different hydrocarbons and biological species. The bioavailability of hydrocarbons depend on many factors including whether the PAHs are dissolved, adsorbed to suspended particulates or sediment bound. Bioconcentration factors generally tend to increase with the molecular weight and alkylation (Neff et al., 1976; Neff, 1979). Eilser (1987) in his extensive review stated that unsubstituted lower molecular weight PAH compounds (e.g., 2 to 3 ring compounds) exhibit significant acute toxicity and other effects, but are noncarcinogenic. However, many of the higher molecular weight compounds with 4 to 7 rings are less toxic but more carcinogenic, mutagenic, and teratogenic to fish, shellfish, and other aquatic organisms. Brown bullhead, a bottom-dwelling fish, has been show to be susceptible to heptacarcinogenesis due to high levels of PAHs (Stewart et al., 1990), while the common carp also a bottom-dwelling species appears to be highly resistant to this cancer (Baumann et al., 1982). Certain aquatic organisms can metabolize PAHs with the metabolized product having a biological effect as well (Mix, 1984; Van Engel, 1987). For some bivalve mollusks, which metabolize and excrete PAH at slower rates because of missing or less efficient mixed function oxidase (MFO) systems, tissue concentrations of PAHs can be extremely high, and as such have been used an indicator group for PAH contamination (NOAA Status and Trends Program; O'Connor and Beliaeff, 1995).

Finfish, however, can metabolize and excrete PAHs and often exhibit lower concentrations compared to bivalves. West et al. (1984) stated that finfish appear not to accumulate higher molecular weight PAHs which are usually more carcinogenic than lower molecular weight compounds. Anthracene, a 3-ring PAH, was shown to have a substantial reproductive effect on fathead minnows and that this compound was transferred into the fry during reproduction (Hall and Oris, 1991). Steward et al. (1991), using radiolabelled benzo[a]pyrene, showed that this compound was quickly partitioned into various body parts (e.g., liver, muscle, gonads) of the common carp. While only 10% of the labelled compound was found in the muscle tissue, approximately 95% was not metabolized during the study period. The metabolite, benzo[a]pyrene-7,8,-dihydrodiol, was found in significant amounts in the bile of this fish after 72 hours. While the concentration of bioconcentrated PAHs maybe greater in the liver of many fish, high levels have also been found in the neural tissues, probably due to the higher lipid content (Neff et al., 1976; Collier et al., 1980). Yu et al. (1995) showed that cold water fish have a very active enzyme system that can metabolize many PAHs and may eliminate them rapidly via excretion. Exposure to diesel fuel oil resulted in the production of many PAH metabolites (e.g., napthols, phenantrenols, and dibenzothiophenols) after only 120 hours.

Overall, the uptake, metabolism, and depuration of PAHs in finfish is complex. In many cases, once a fish is exposed to PAHs, either from water or sediments, it can reduce its burden rapidly after leaving the contaminated area. Therefore, resident finfish species that are less migratory are preferred for site specific monitoring studies and would potentially indicate a pseudo-steady state balance between uptake and release in body burden levels. Also, the distribution of individual PAHs between tissue, water, and sediments may help identify the sources to the fish.

Distribution of Individual PAHs in Finfish Tissue in the Anacostia and Potomac Rivers

The concentrations of total PAHs were presented previously (see above; Table 6-8). Concentrations ranged from 60 to 3,400 ng/g wet wt. for all samples. Median (or average) total PAHs concentrations for 1993, 1994, and 1995 were 160, 350, and 390 ng/g wet wt., respectively. The highest concentration was measured from a 1993 channel catfish composite (3,400 ng/g wet wt.) taken in the lower Anacostia River. The next two highest concentrations were from a 1994 channel catfish composite (350 ng/g wet wt.) and 1995 brown bullhead catfish (570 ng/g wet wt.) both from the Anacostia River. Other than these fish composite samples, concentrations were generally less than 200 ng/g wet wt..

The distribution of the PAHs were dominated by the 2 to 3 ring aromatic hydrocarbons with the dominant group being naphthalene and alkyl-substituted naphthalenes (e.g., $C_1$, $C_2$, $C_3$, and $C_4$). Generally, 90% or more of the total aromatic hydrocarbons were low molecular weight indicating a petroleum source of hydrocarbons. More specifically, in 1993, between 52 and 91% of the total PAHs were accounted for by the naphthalene group, with an overall average and standard deviation of 74 $\pm$ 11%. A slightly smaller range was observed in 1994 with between 56 and 78% of the total PAHs from naphthalenes, but a similar average of 70 $\pm$ 8%. The two brown bullhead sample composites from 1995 exhibited a lower percentage of 46%.

The molecular distribution of the naphthalenes (i.e., parent and $C_1$, $C_2$, $C_3$, and $C_4$ alkylated naphthalenes) exhibited differences related to species and location. Channel catfish and brown bullhead catfish collected from the Anacostia River showed distributions with higher levels of $C_2$, $C_3$, and $C_4$ alkylated naphthalenes than the parent compound, whereas catfish composites collected in the Potomac River exhibited distributions with greater amounts of parent and $C_1$ alkylated naphthalenes (Figure 9). Common carp composites revealed no comparable trend with location and generally had slightly higher $C_1$ alkylated naphthalenes than parent naphthalene for all locations (Figure 10). Largemouth bass

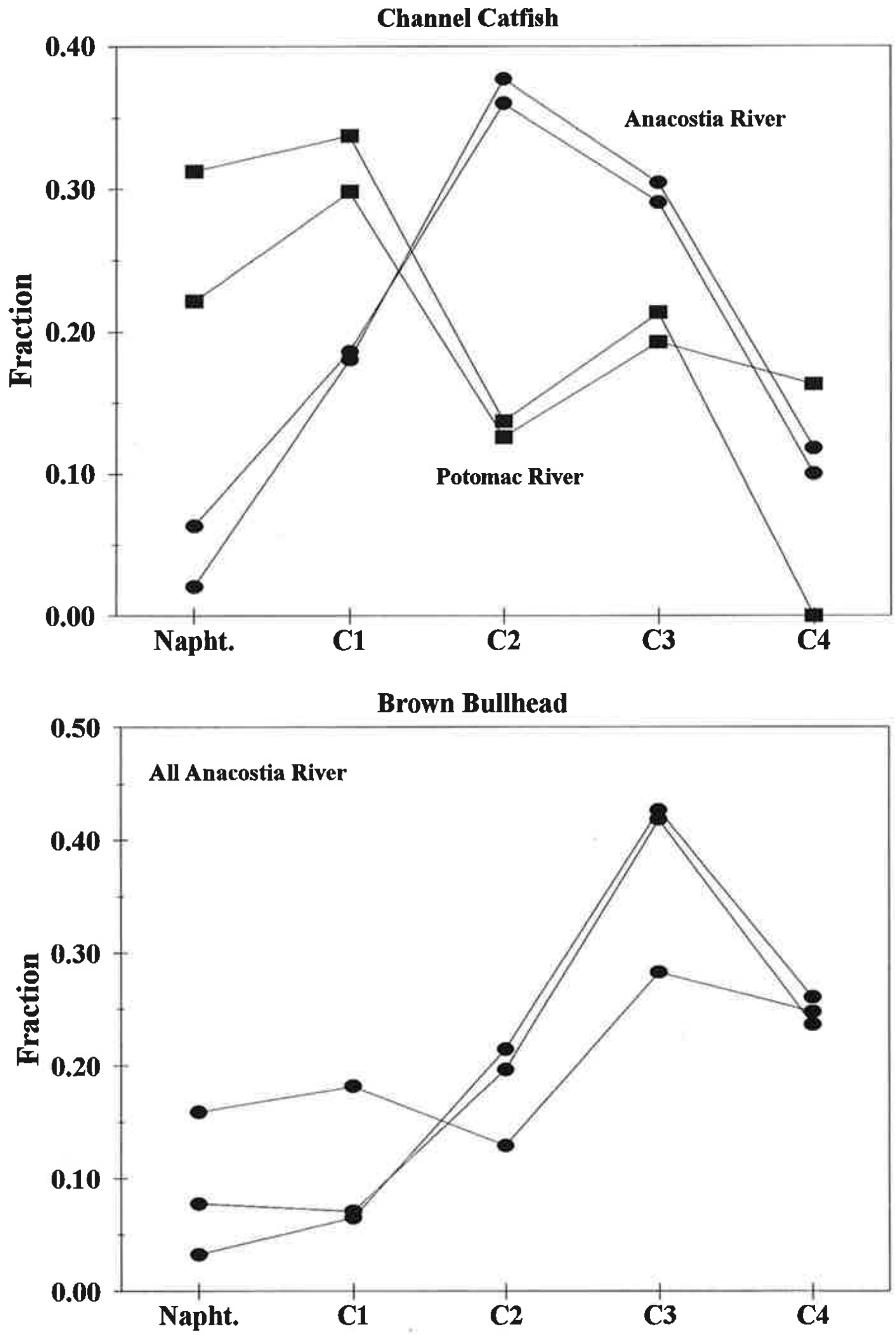
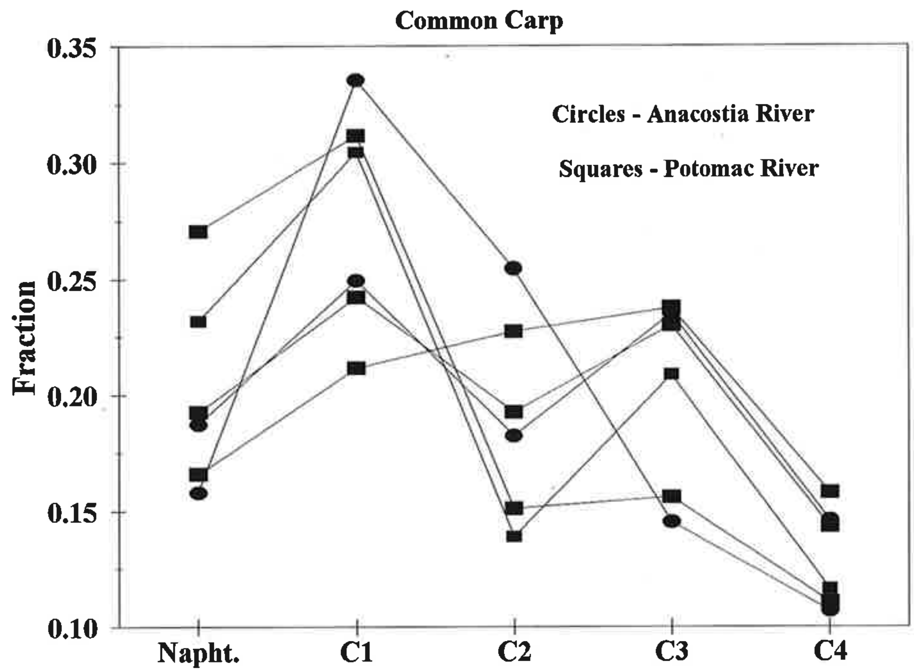



Figure 10. Distribution of naphthalene and alkylated-naphthalenes in channel and brownbull head catfish tissue.



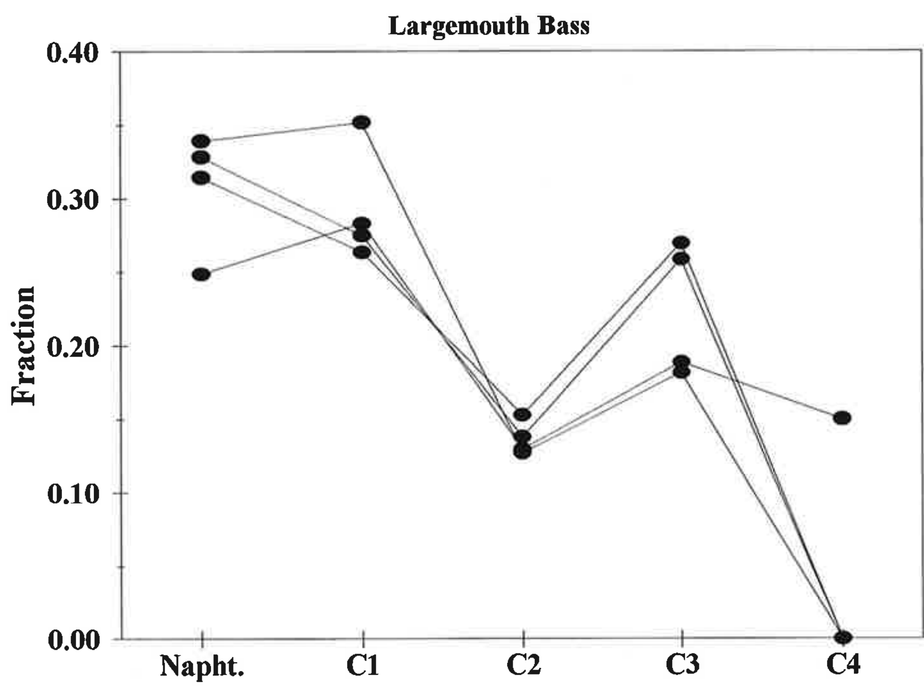




Figure 11. Distribution of naphthalene alkylated-naphthalenes in common carp and largemouth bass fish tissue.

composites exhibited greater amounts of parent naphthalene than substituted naphthalenes regardless of collection area (Figure 10).

These distributions possibly reflect the feeding habits and general location of where the fish were living or accumulated these compounds. For example, catfish, both channel and brown bullhead, are predominately benthic feeders and would likely reflect the concentration, distribution, and availability of sediment bound contaminants. This is apparent from these data in that the catfish distribution reflects the naphthalene distribution measured in the sediments of the Anacostia River (Wade et al., 1994; Figure 11). It is unclear why the two channel catfish composites did not reflect the naphthalene distribution in Potomac River sediments which was similar to the Anacostia River and this may be due to the bioavailability of these compounds in the Potomac. Alternatively, due to the Potomac's larger size, these samples did not accumulate these hydrocarbons from feeding within this area of the river, but in areas with different sources and distribution of aromatic hydrocarbons.

The concentration and distribution of the various aromatic hydrocarbons in the fish composite samples from all areas within the Potomac and Anacostia rivers suggests that these compounds are bioavailable and are accumulating in the edible portion of the fish. Neff (1978) stated that the majority of PAHs would accumulate in the liver and other organs in the fish so these levels are probable an underestimation of the total fish concentration. The PAHs distribution also suggests that petroleum is a dominant source of hydrocarbons to the fish. This is indicated by the higher amounts of lower molecular weight aromatic hydrocarbons (especially naphthalene) and the predominance of higher alkylated naphthalenes concentrations (e.g., $C_2$, $C_3$, and $C_4$) versus the parent compound. The petroleum source is most likely related to the numerous oil spills to the area over the years (e.g., Steuart Petroleum Oil Spill; Colonial Pipeline Oil Spill; Pinkney et al., 1993) and potentially storm water runoff and combined sewer overflows.

*Comparison to the Previous Fish Contaminant Study*

There are four previous studies in which comparisons can be made to the current study (Block, 1990; Sommerfield and Cummins, 1989; Pinkney et al., 1993; Velinsky and Cummins, 1994). These studies collected and analyzed channel catfish, brown bullhead, largemouth bass, sunfish (sp.) and other species. While samples were collected from 1987 to the present, a quantitative trend analysis can

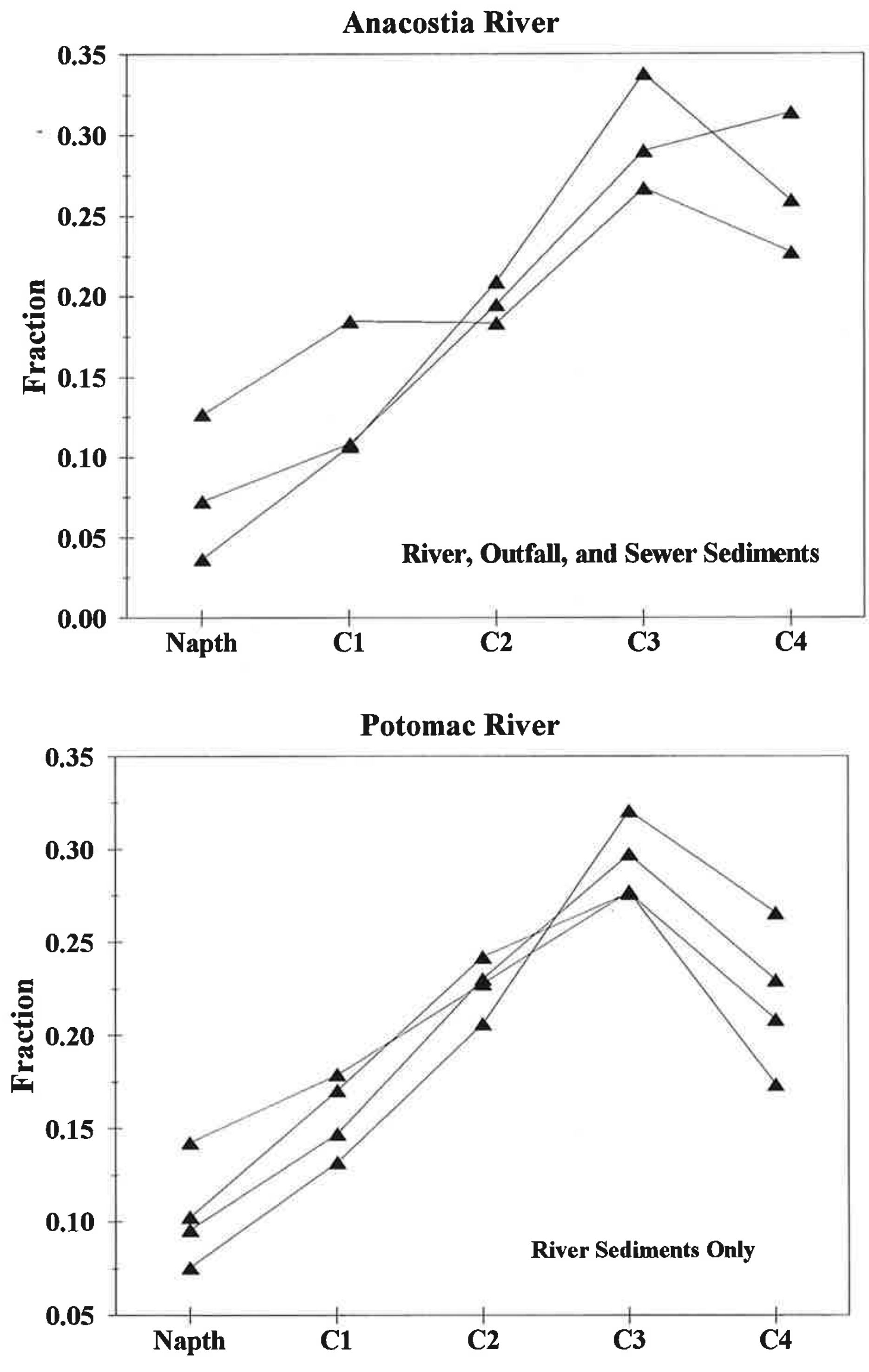



Figure 12. Distribution of napthtalene alkylated-naphthalenes in bottom sediments of the Potomac and Anacostia Rivers (Data taken from Velinsky et al., 1992).

be performed due to the number of samples collected (i.e., small amount of replication), and differences in analytical methodologies between each study. In this section therefore, only a qualitative comparison will be made between these studies.

To help facilitate a comparison between this and the Velinsky and Cummins (1994) study, one sample from the Velinsky and Cummins (1994) study was analyzed by the laboratory used for the current study. The results from this intercalibration for selected parameters are presented in Table 18. Generally, there was a good agreement between the two laboratories. The highest relative percent difference (RPD) was for dieldrin (RPD = 71) and the lowest was for 4,4'-DDD (RPD = 7), with an overall average of 25. Importantly, total PCBs concentrations exhibited an approximately 50% difference between the two laboratories (one of the higher RPDs). Differences between PCB congeners 146, 149, 153, 187, 182, 185, 180, and 172 were greatest, and in many cases there were more co-

**Table 18. Comparison for selected parameters between the current study and Velinsky and Cummins (1994)*.**

| Parameter | Eco Logic #3-91 | Gerg # 3-91 | RPD |
|---|---|---|---|
| Se | 0.370 | 0.319 | 14.7 |
| Hg | 0.221 | 0.158 | 33.2 |
| Cd | < 0.05 | 0.033 | ND |
| Pb | < 0.5 | 0.383 | ND |
| Total PCBs | 2024 | 1257 | 46.7 |
| Total DDTs | 193 | 215 | 10.6 |
| $\alpha$+$\gamma$-Chlordane | 57.0 | 48.5 | 16.0 |
| $\gamma$-Chlordane | 14.0 | 16.5 | 16.2 |
| $\alpha$-Chlordane | 43.0 | 32.1 | 29.1 |
| Dieldrin | 9.5 | 20.0 | 71.2 |
| 4,4' DDE | 110 | 151 | 31.3 |
| 4,4' DDD | 32.0 | 34.3 | 7.1 |
| 4,4' DDT | 51.0 | 29.5 | 53.4 |

*Current study is GERG #3-91 and previous study is Eco Logic #3-91. Concentrations for trace metals are in µg/g wet wt., and for all organic contaminants ng/g wet wt. RPD - relative percent difference.

eluting congeners with the Eco Logic's analytical procedure than with GERG's methods. Also, standard reference material (SRM) analysis was within QA/QC limits for each laboratory. It is not clear as to why there is a large difference for total PCBs at these concentrations. Internally, each laboratory exhibited less than a 20% difference for total congener specific PCBs analysis, and the analysis was within QA/QC limits set for each laboratory (i.e., surrogate recoveries, matrix spikes, etc). For all analytes, including the PCBs, the differences in concentrations between these laboratories should be considered when viewing the differences between the different studies presented below.

Previous Studies in the Local Area

Block (1990) collected fish samples in 1987 from five locations in the District of Columbia, and analyzed whole fish and fillets for total PCBs (i.e., Arochlor 1254+1260), total DDT (i.e., pp-DDE+DDD+DDT), cis+trans chlordane, and dieldrin. Fish species included channel and white catfish (n= 5; number of samples) and largemouth bass (n=5). Sommerfield and Cummins (1989) analyzed individual fillets of channel catfish (n=40), largemouth bass (n=38), and sunfish (sp.) (n=15) collected from various locations within the Potomac and Anacostia Rivers. These samples were collected in 1988 and analyzed for total PCBs (Arochlor 1254+1260) and technical chlordane. Velinsky and Cummins (1994) analyzed fish composite samples (fillets only) for 19 samples collected in 1991 and 14 samples collected in 1992 from the Potomac and Anacostia Rivers. The concentrations in Block (1990) and Sommerfield and Cummins (1989) studies represent individual fillets, not composite samples as in Velinsky and Cummins (1994) and from the current study. It must also be noted that the PCB analyses from the earlier studies were for two specific Aroclors (1254+1260), and the results are not directly comparable to the study of Velinsky and Cummins (1994) and the current study in which PCBs were determined by a congener specific method.

The average, standard deviation ($\pm 1\sigma$), median, and maximum concentrations for channel catfish and largemouth bass from each study are presented in Tables 19 and 20 along with results from this study. The concentrations presented in Tables 19 and 20 for the Block (1990) and Sommerfield and Cummins (1989) studies represent statistical summary results from individual fillets, not composite samples as from the current study. Channel catfish generally had the highest concentrations of all contaminants (Tables 15 and 19). As shown from this study (see above), this is related to the higher lipid content in channel catfish compared to the other species. Median or average concentrations of total PCBs were

Table 19. Summary statistics for channel catfish collections in the Potomac and Anacostia Rivers*.

| | PCBS | DDT | Chlordane | Dieldrin |
|---|---|---|---|---|
| *Samples Collected in 1987*[1] | | | | |
| Mean | 1592 | 285 | 166 | 31.0 |
| Std | 960 | 194 | 129 | 14.0 |
| Median | 1400 | 273 | 146 | 31.0 |
| Max | 2958 | 501 | 380 | 52.0 |
| *Samples Collected in 1988*[2] | | | | |
| Mean | 2099 | NA | 160 | NA |
| Std | 1028 | NA | 350 | NA |
| Median | 1900 | NA | 20 | NA |
| Max | 5430 | NA | 1610 | NA |
| *Samples Collected in 1991*[3] | | | | |
| Mean | 1293 | 121 | 112 | 11.2 |
| Std | 473 | 76 | 74 | 6.2 |
| Median | 1250 | 108 | 88 | 10.1 |
| Max | 2000 | 232 | 234 | 21.0 |
| *Samples Collected in 1992*[3] | | | | |
| Mean | 545 | 70 | 41 | 7.4 |
| Std | NC | NC | NC | NC |
| Median | NC | NC | NC | NC |
| Max | 570 | 73 | 62 | 8.8 |
| *Samples Collected in 1993*[4] | | | | |
| Mean | 1181 | 138 | 82 | 20.4 |
| Std | NC | NC | NC | NC |
| Median | NC | NC | NC | NC |
| Max | 1292 | 159 | 95 | 25.4 |
| *Samples Collected in 1994*[4] | | | | |
| Mean | 833 | 117 | 79 | 16.2 |
| Std | NC | NC | NC | NC |
| Median | NC | NC | NC | NC |
| Max | 938 | 127 | 92 | 20.3 |

*All concentrations are in nanogram per gram wet weight. 1- Block (1990): PCBs are the sum of Arochlor 1242+1260, DDT is the sum of pp-DDE, DDD, DDT, and chlordane is the sum of cis and trans chlordane. 2- Sommerfield and Cummins (1989); PCBs are the sum of Arochlor 1242+1260, DDT was not analyzed (NA), and chlordane is technical chlordane. 3- Velinsky and Cummins (1994): PCBs are the sum of individual congeners, DDT is the sum of pp-DDE, DDD, DDT, and chlordane is the sum of $\alpha+\gamma$ chlordane. NC - Not calculated (n =2 samples). 4- Present Study: PCBs are the sum of individual congeners, DDT is the sum of pp-DDE, DDD, DDT, and chlordane is the sum of $\alpha+\gamma$ chlordane. NC - Not calculated (n =2 samples). See text for further details.

Table 20. Summary statistics for largemouth bass collections in the Potomac and Anacostia Rivers*.

| | PCBS | DDT | Chlordane | Dieldrin |
|---|---|---|---|---|
| *Samples Collected in 1987*[1] | | | | |
| Mean | 248 | 53 | 28 | 16.0 |
| Std | 94 | 31 | 36 | 12.0 |
| Median | 290 | 49 | 10 | 10.0 |
| Max | 350 | 99 | 100 | 41.0 |
| *Samples Collected in 1988*[2] | | | | |
| Mean | 274 | NA | 23 | NA |
| Std | 334 | NA | 9 | NA |
| Median | 175 | NA | 20 | NA |
| Max | 1520 | NA | 50 | NA |
| *Samples Collected in 1991*[3] | | | | |
| Mean | 423 | 52 | 42 | 2.2 |
| Std | 174 | 27 | 36 | 2.4 |
| Median | 445 | 52 | 29 | 1.6 |
| Max | 620 | 80 | 102 | 5.7 |
| *Samples Collected in 1992*[3] | | | | |
| Mean | 430 | 63 | 62 | 8.1 |
| Std | 373 | 50 | 73 | 5.6 |
| Median | 250 | 40 | 18 | 4.4 |
| Max | 950 | 133 | 165 | 16.0 |
| *Samples Collected in 1993*[4] | | | | |
| Mean | 337 | 45 | 11 | 7.7 |
| Std | NC | NC | NC | NC |
| Median | NC | NC | NC | NC |
| Max | 377 | 53 | 13 | 5.0 |
| *Samples Collected in 1994*[4] | | | | |
| Mean | 338 | 74 | 12 | 7.7 |
| Std | NC | NC | NC | NC |
| Median | NC | NC | NC | NC |
| Max | 406 | 100 | 12 | 5.1 |

*All concentrations are in nanogram per gram wet weight. 1- Block (1990): PCBs are the sum of Arochlor 1242+1260, DDT is the sum of pp-DDE, DDD, DDT, and chlordane is the sum of cis and trans chlordane. 2- Sommerfield and Cummins (1989); PCBs are the sum of Arochlor 1242+1260, DDT was not analyzed (NA), and chlordane is technical chlordane. 3- Velinsky and Cummins (1994): PCBs are the sum of individual congeners, DDT is the sum of pp-DDE, DDD, DDT, and chlordane is the sum of $\alpha+\gamma$ chlordane. NC - Not calculated (n =2 samples). 4- Present Study: PCBs are the sum of individual congeners, DDT is the sum of pp-DDE, DDD, DDT, and chlordane is the sum of $\alpha+\gamma$ chlordane. NC - Not calculated (n =2 samples). See text for further details.

similar for channel catfish between 1987 and 1991, with slightly lower concentrations afterwards. Maximum concentrations were measured between 1987 and 1991 (highest in 1988 of 5400 ng/g wet wt.). Largemouth bass median or average PCB concentrations were similar, and approximately three to five times lower than the median or average concentration for the channel catfish samples. Highest concentrations occurred in 1988, otherwise most concentrations were between 250 and 430 ng/g wet wt. Chlordane ($\alpha+\gamma$) median concentrations for channel catfish and largemouth bass were variable (Tables 19 and 20). Median or average chlordane concentrations were higher between 1988 and 1991, with a maximum concentration of 1600 ng/g wet wt.; measured in 1988, and were generally less than 100 ng/g wet wt. for samples between 1992 and 1994. For largemouth bass samples, concentrations were also less than 100 ng/g wet wt. for all years. Median or average concentrations of DDT and dieldrin ranged from 70 to 273 ng DDT/g wet wt. and 7 to 31 ng dieldrin/g wet wt. for channel catfish, and 40 to 74 ng DDT/g wet and 2 to 10 ng dieldrin/g wet for largemouth bass samples. For both largemouth bass and channel catfish samples concentrations remained largely unchanged when comparing either mean or median values (Tables 19 and 20).

The study by Pinkney et al. (1993) was initiated after an oil storage tank spill in January 1992. Samples for brown bullhead, channel catfish, and common carp were taken in August 1992 to investigate potential impacts to fish. The fish were filleted and analyzed with analytical methods similar to the present study. A summary of this data set is presented in Table 21. Concentrations of total PCBs, total DDT, $\alpha+\gamma$ chlordane, and dieldrin, determined in the Pinkney et al. (1993) study, were substantially higher than those determined in the current study (e.g., compare Tables 19 and 20). It is unclear why the organic concentrations determined during the current and past studies were lower than those in Pinkney et al. (1993). This is especially evident between this study and that of Velinsky and Cummins (1994). Since both sets of samples were taken in the same year (and time of year) and prepared similarly (i.e., skin-off fillets), methodological differences could be the cause. However, one sample that was collected during the Velinsky and Cummins (1994) study was analyzed by the same laboratory used by Pinkney et al. (1993) and differences not as large as seen between these data sets. While this is only one sample, it suggests that other factors must have accounted for these differences in concentrations. A closer examination of the QA/QC results indicated no specific cause (e.g., low surrogate recoveries) for these differences. Other factors, such as age and size of the fish and specific locations or collection, need to be accounted for in order to understand these differences.

These data sets provide a first-order overview of the level of chemical contaminants in fish tissue samples from the Washington, D.C. area. However, it should be noted that the chemical methods and sample types (i.e., single fillets versus composites) are not similar across all years which would limit the cross comparison of data. Differences are due, in part, to improvements in laboratory analyses. A consistent and well-documented sampling program using up-to-date methods needs to be in place before long-term trends in the levels of chemical compounds can be ascertained.

**Table 21. Summary statistics for fish fillets collected in August 1992 from the Anacostia River (Pinkney et al., 1993)*.**

| Chemical | PCB | Chlordane | DDT | Dieldrin | Hg |
|---|---|---|---|---|---|
| *Channel Catfish (n=7)* | | | | | |
| Mean | 6755 | 613 | 828 | 58 | 0.116 |
| ± S.D. | 6038 | 510 | 747 | 44 | 0.052 |
| Median | 2794 | 326 | 276 | 37 | 0.099 |
| Maximum | 17951 | 1487 | 2174 | 149 | 0.240 |
| *Brown Bullhead (n=9)* | | | | | |
| Mean | 1986 | 202 | 252 | 21 | 0.033 |
| ± S.D. | 1482 | 137 | 198 | 15 | 0.008 |
| Median | 1225 | 133 | 146 | 12 | 0.034 |
| Maximum | 5507 | 525 | 740 | 55 | 0.049 |
| *Common Carp (n=9)* | | | | | |
| Mean | 3447 | 217 | 475 | 21 | 0.077 |
| ± S.D. | 2455 | 210 | 373 | 19 | 0.028 |
| Median | 2136 | 145 | 338 | 11 | 0.063 |
| Maximum | 6914 | 716 | 1100 | 62 | 0.144 |

*Concentrations are in ng per gram wet weight, except for Hg which is in µg per gram wet weight. PCBs are the sum of individual congeners, Chlordane is the sum of $\alpha+\gamma$ chlordane, and DDT is the sum of op'+pp'-DDE, DDD, and DDT.

### *Comparison to Health Effect Level*

In this section contaminant concentrations are evaluated by various methods used to estimate human health effects. These include comparisons with Food and Drug Administration (FDA) action or tolerance levels, calculations of newly developed toxic equivalency factors for specific PCBs, and risk assessment calculations proposed by the U.S. EPA. These methods are tools which help evaluate the potential health effects of the consumption of fish tissue. However, there are many caveats in using each of these methods that would affect their usefulness, and this analysis is tentative and should be used only as a screening tool.

Food and Drug Administration Action Levels

Table 22 provides current action levels and tolerance levels from the FDA (EPA, 1993a). Pesticide levels are U.S. EPA recommendations to the FDA. These "action or tolerance levels" are for seafood sold through interstate commerce, and can be used to remove seafood from the market place. They were developed to protect humans from the chronic effects of toxic substances consumed in food stuffs. For wild non-commercial freshwater fish, they provide **guidance** for regulatory action (but are not regulatory standards). In fact, FDA recommends that States do not use the action or tolerance levels to set local advisories because local consumption patterns vary considerably (R.G. Kramer, 1994, personnel communication). Food and Drug Administration levels for total PCBs are determined by

**Table 22. Food and Drug Administration (FDA) action or tolerance levels for selected contaminants*.**

| Chemical | Concentration |
|---|---|
| Methyl Mercury | 1.0 |
| Dieldrin | 300 |
| Chlordane | 300 |
| DDT, DDE, and TDE | 5000 |
| Polychlorinated Biphenyls (PCBs) | 2000 |

* Concentrations of methyl mercury are in µg per gram wet weight, pesticides are in ng per gram wet weight. Action levels established by U.S. FDA and PCBs are tolerance levels developed by the U.S. EPA.

Arochlor analyses, and for this comparison it is assumed that the FDA forms of PCBs (and pesticides) are equivalent to the forms determined in this study. Also, because the majority of Hg in fish tissue is in the methylated form (Sensen and Jernelov, 1969; Tollefson, 1989; Gill and Bruland, 1990), total Hg determined in this study will be compared to the FDA action level which is for methyl-Hg.

Concentrations of total Hg, dieldrin, total DDT, DDE, total chlordane, and total PCBs did not exceed the published FDA action levels. For total Hg, the two highest and closest concentration were 0.11 and 0.16 μg/g wet wt. for an American eel and largemouth bass composite both taken from the lower Potomac River. Dieldrin concentrations were at least 12 times lower than the published action level , while total DDT concentrations were at least 25 times lower than the FDA action level.

In two instance did the concentrations of total chlordane come close to the FDA action level of 300 ng/g wet. In these instances, a common carp from the upper Anacostia River collected in 1993 and a channel catfish composite from lower Anacostia River collected in 1994, concentrations of total chlordane (220 and 170 ng/g wet wt., respectively) were close to the FDA limit. The overall median for total chlordane was around 100 ng/g wet wt., with concentrations of just $\alpha+\gamma$-chlordane approximately half of the total chlordane. Total PCBs concentrations were, at most, approximately half of the FDA tolerance level (2000 ng/g wet wt.) except for a channel catfish sample collected in the lower Anacostia River in 1993. This sample exhibited a concentration of total PCBs of 1290 ng/g wet wt.

Exceedances have been observed in previous studies. In 1987, channel catfish exceeded the FDA levels for PCBs and chlordane in 45% and 16% of the samples for PCBs and chlordane, respectively (Block, 1990). Similar percentages for both PCBs and chlordane were observed for the channel catfish samples collected in 1988 (Sommerfield and Cummins, 1989). The data from Pinkney et al. (1993) showed the greatest amount of exceedences (and highest overall concentrations) for channel catfish for PCBs and chlordane of 86% and 57%, respectively. Brown bullhead and common carp samples had lower exceedences, closer to the 1987 and 1988 databases. In the study of Velinsky and Cummins (1994), all American eel composites from 1991 were above the FDA action level for PCBs as were 33% of the channel catfish samples. Samples collected in 1992 were not above any of the published action levels. In this study, no exceedences were found for any contaminant. As pointed out earlier, with the small sample size from these studies, it is too difficult to quantitatively ascertain if a general decrease in the levels and exceedences is occurring for fish collected in this area.

Toxic Equivalency Factors for Polychlorinated Biphenyls

Current methods used to develop consumption advisories for PCBs are based on the quantification of total polychlorinated biphenyls (PCBs) as the sum of specific Arochlors (e.g., 1260, 1254) or the sum of specific PCB congeners. However, there are 209 PCB congeners, and due to the differential cycling and fate (e.g., partitioning, degradation, excretion) of the various congeners, the relative amounts of specific congeners can vary greatly within the environment and in organisms (e.g., fish). Also, individual congeners vary in toxicity dependent on their resistance to degradation, metabolism, and structure. The most toxic PCB congeners are those that elicit the same effect as polychlorinated dibenzo-p-dioxins and furans (McFarland and Clarke, 1989; Safe, 1990). The most potent of these PCB congeners are those that are similar in structure to 2,3,7,8-TCDD. These include PCB congeners that have no or one chlorine substituted in the ortho positions (i.e., termed planar PCBs), and are considered AHH-active congeners because, like 2,3,7,8-TCDD, they induce aryl hydrocarbon hydroxylase (AHH) or ethoxyresorufin O-deethylase (EROD) activities, endpoints in mammalian toxicity (Safe, 1990; Kafafi et al., 1993).

Safe (1990) and others developed a model to estimate the equivalent concentration of 2,3,7,8-TCDD relative to the measured concentrations of specific planar PCBs. This model is based on the assumption that toxicity is controlled by the receptor mediated action of 2,3,7,8-TCDD at specific binding sites, and that specific planar PCBs act on the same binding sites as 2,3,7,8-TCDD to a degree relative to 2,3,7,8-TCDD. Effects of TCDD and related compounds include toxic and biochemical effects such as body weight loss, dermal disorders, liver damage, reproductive disorders, and the induction of CYP1A1 and CYP1A2 gene expression. Importantly, this model also assumes that the equivalent concentrations are additive, so that by multiplying the concentration of the specific planar PCB by its toxic equivalency factor (TEF) then adding these values, an estimate of the total TCDD equivalents can be obtained. This method may provide a better estimate of the potential toxicity of PCBs in the fish tissue. However, it must be recognized that different structure-activity-receptor models provide different TEFs (e.g., de Boer et al., 1993; Kafafi et al., 1993), and that dose-response and exposure may not be adequately described for many risk assessment models. Also, and importantly, models for toxicity from planar PCBs are based on mammalian studies and little information is available regarding the effects to fish from these compounds. For this study, the TEFs reported by Safe (1990) were used (Table 23) and are thought to be a conservative estimate of the toxic potential of the various planar PCBs.

While various researchers have used this approach of assigning TCDD equivalents to specific congeners of PCBs, there are many limitations that can effect the calculations and interpretations. This technique assumes that the calculated PCB-TEQs are additive and does not allow for interactions among active and inactive congeners. Since many of the ortho-substituted PCB congeners are sometimes an order of magnitude higher in concentration than non-ortho substituted, a

**Table 23. Toxic equivalency factors used for this study*.**

| Congener | Toxic Equivalency Factor (TEF) |
|---|---|
| *Polychlorinated Biphenyls (PCBs)* | |
| 77 (3,3',4,4'-tetra) | 0.01 |
| 81 (3,4,4',5-tetra) | 0.01 |
| 105 (2,3,3',4,4'-penta) | 0.001 |
| 114 (2,3,4,4',5-penta) | 0.0001 |
| 118 (2,3',4,4',5-penta) | 0.001 |
| 123 (2',3,4,5',5-penta) | 0.001 |
| 126 (3,3',4,4',5-penta) | 0.1 |
| 156 (2,3,3',4,4',5-hexa) | 0.001 |
| 157 (2,3,3',4,4',5'-hexa) | 0.00002 |
| 167 (2,3',4,4',5,5'-hexa) | 0.001 |
| 189 (2,3,3',4,4',5,5'-hepta) | 0.001 |

* Taken from Safe (1990). Ortho positions in the PCB molecule are in the 2,6 and 2',6' positions.

blocking of active sites could occur. Also, in many cases the relative potency of the non ortho-substituted PCBs have not been determined in a consistent manner. Additionally, the TEFs reported in the literature vary and therefore effect the calculated PCB-TEQs.

Using the data in Appendix IV and the TEFs for PCBs in Table 23, the total TCDD equivalents for PCBs (PCB-TEQ) in pg/g wet weight were calculated (Table 24). Also included in Table 24 is the concentrations of total PCBs. For these calculations, specific congeners of the PCBs that were at the detection limit were set at half the detection limit.

**Table 24. Concentrations of total PCBs and total PCB-TEQ in all fish composite samples*.**

| ID | Location | Species | TPCBs | TPCB-TEQ |
|---|---|---|---|---|
| 1-93 | Lower Potomac | Largemouth Bass | 376 | 18.3 |
| 2-93 | Lower Potomac | Channel Catfish | 1070 | 72.6 |
| 3-93 | Upper Potomac | Common Carp | 634 | 52.2 |
| 4-93 | Upper Potomac | Largemouth Bass | 297 | 19.7 |
| 5-93 | Upper Potomac | American Eel | 555 | 66.6 |
| 6-93 | Lower Anacostia | Channel Catfish | 1292 | 138.6 |
| 7-93 | Lower Anacostia | Common Carp | 1065 | 95.5 |
| 8-93 | Lower Anacostia | Sunfish (sp.) | 455 | 31.1 |
| 9-93 | Upper Anacostia | Common Carp | 1063 | 124.2 |
| 10-93 | Kenilworth Marsh | Brown Bullhead | 376 | 38.4 |
| | | | | |
| 1-94 | Lower Potomac | Largemouth Bass | 406 | 28.0 |
| 2-94 | Lower Potomac | Common Carp | 877 | 52.3 |
| 3-94 | Upper Potomac | Channel Catfish | 728 | 90.7 |
| 4-94 | Upper Potomac | Common Carp | 526 | 23.2 |
| 5-94 | Lower Anacostia | Largemouth Bass | 270 | 20.7 |
| 6-94 | Lower Anacostia | Common Carp | 904 | 77.8 |
| 7-94 | Lower Anacostia | Channel Catfish | 938 | 118.8 |
| 8-94 | Lower Anacostia | Sunfish (sp.) | 309 | 21.1 |
| | | | | |
| 1-95 | Upper Anacostia | Brown Bullhead | 734 | 58.3 |
| 2-95 | Upper Anacostia | Brown Bullhead | 343 | 34.4 |

*Concentrations of total PCBs in ng/g wet wt. and total PCB-TEQ in pg/g wet wt; See text for details.

The concentrations of PCB-TEQ ranged from 18 to 140 pg/g wet wt. (median of 52 pg/g wet wt.) for all fish composites (Table 24). The two highest concentrations (140 and 124 pg/g wet wt) were measured in a channel catfish and common carp composite from the Anacostia River, collected in 1993. The next highest was a channel catfish sample composite (118 pg/g wet wt) from the lower Anacostia

River collected in 1994. The PCBs 118(45%), 126(15%), 105(12%), and 156(10%) (value in ( ) is percentage of total composition) were the dominant congeners controlling the total PCBs-TEQs concentrations.

The concentrations of TPCB-TEQs were generally less than those measured in the study of Velinsky and Cummins (1994). In that study concentrations of similar planar PCBs ranged from 3 to 990 pg/g wet wt. with a median concentration of 150 pg/g wet wt. Overall, the concentrations of total PCB-TEQs are similar to those found in other studies (Eiskus et al., 1994; Sericano et al., 1994; de Boer et al., 1993; Ankley et al., 1991; Williams et al., 1992) from fish tissue, fish livers and bird eggs. Ankley et (1991) suggested that the dioxin like PCBs may have influenced reproductive success of salmon in Lake Michigan. Concentrations of PCB-TEQs ranged from approximately 5 to 40 pg/g wet wt (mean of 11 pg/g wet wt.) and were in greater concentration in eggs from these fish.

There was a significant linear relationship ($r^2 = 0.806$, n=20, $p > 0.05$) between the concentration of PCB-TEQ and total PCBs in these samples indicating that it may be possible to predict the concentration of PCB-TEQ from congener specific total PCBs in this area. Also, this relationship suggests that a similar source and type of PCBs are contaminating the fish within this area. However, differential degradation, metabolism, and excretion of the various congeners must be taken into account to properly address this issue. A further study of the congener distribution in the various species of fish, sediments, and water could yield information as to the source of PCBs to the fish in the waters of the District.

## Risk Assessment for Specific Analytes

This section presents risk assessment estimates to human health based on the concentrations presented in Table 15 (also see Appendix II). This information, along with the previous two sections, is provided as a screening tool to assess the levels of contamination in fish from the District of Columbia. Carcinogenic and non-carcinogenic screening concentrations were estimated for mercury, chlordane, total DDT, dieldrin, and polychlorinated biphenyls using cancer potency factors and reference doses respectively, provided by the EPA (1992; 1993). These calculations were based on EPA carcinogenic risk assessment equations for lifetime exposure with $95^{th}$ percentile upper-bound cancer potency factor estimates (EPA, 1989; 1992; 1993).

Exposure doses were determined using equation (1):

$$D_{ij} = (C_j \times I_j)/W \qquad (1)$$

where: $D_{ij}$ is the estimated dose (mg/kg/day) for chemical i at ingestion rate j; $C_i$ is the concentration of chemical i in fish fillet; $I_i$ is the ingestion rate of the specific population (6.5 g); and W is the selected human body weight (70 kg or 150 lbs).

Risk characterization associated with each chemical was estimated as the probability of excess cancers using equation (2):

$$R_{ij} = 1 - \exp(-D_{ij} \times P_i) \qquad (2)$$

where: $R_{ij}$ is the risk associated with chemical i at an ingestion rate j; $P_i$ is the carcinogenic potency factor for chemical i $(mg/kg/day)^{-1}$ ; and $D_{ij}$ which is the estimated dose of chemical i at an ingestion rate j (mg/kg/day).

To estimate the potential hazards associated with non-carcinogenic toxic effects of these chemicals, the hazard index ($H_{ij}$) was calculated. This is the ratio of the estimated dose of chemical i ($D_{ij}$) and reference dose (RfD) at which non-carcinogenic effects are not expected to occur (EPA, 1992). If the value of $H_{ij}$ is less than one, toxic effects are not expected to occur.

Table 25 provides the dose-response variables used in this risk assessment and is a subset of the data given in the EPA (1992; 1993b) reports. There are many limitations using these data and the model described above (see EPA 1992, 1993b). First, the ingestion rates can vary widely dependent on the specific population that is sampled. The U.S. EPA uses 6.5 g fish/day (ca. 0.5 lb. per month) as the average fish ingestion rate of freshwater and estuarine fish across the U.S.

**Table 25. Dose-response variables used in risk assessment*.**

| Chemical | Cancer Potency Factor $(mg/kg/day)^{-1}$ | Reference Dose (mg/kg/yr) | EPA Cancer Rating |
|---|---|---|---|
| Chlordane | $1.3 \times 10^{0}$ | $6.0 \times 10^{-5}$ | B2 |
| Dieldrin | $1.6 \times 10^{1}$ | $5.0 \times 10^{-4}$ | B2 |
| Total PCBs | $7.7 \times 10^{0}$ | $8.0 \times 10^{-5}$ | B2 |

* Information from various databases given in EPA (1992; 1993) and Kramer (1994, personal communication). B2 -probable human carcinogen. PCB cancer risk data were derived from studies based on Aroclor 1260, while the reference dose is based on Aroclor 1016.

and 140 g fish/day (ca. 9 lbs per month) to represent the upper 95th percentile of sport fisherman and maybe more suitable for subsistence consumers (EPA, 1989; 1993b). For the Washington, D.C. area, an angler survey is needed that would determine a site specific ingestion rate to better quantify the overall risks to the population. For this study, a fish ingestion rates of 6.5 g fish/day was used to determine screening concentrations. Secondly, the endpoint of these calculations is the probability of excess cancer risk; other endpoints are accounted for in the calculation of the non-carcinogenic risks using the reference dose. The risk level used for these calculations is set at $10^{-5}$ for all contaminants. Lastly, many of the variables used for these calculations are derived from laboratory animal studies that may not be applicable to human consumption of these contaminants. Given these caveats, these calculations, along with the other human health tools (see above), do provide a screening method to help determine the potential risk of ingesting fish tissue caught in the waters of the District of Columbia.

Using the equations listed above and the data in Table 25, screening concentrations were calculated that can be used to determine the potential hazard from the ingestion of fish taken from the waters of the District of Columbia (Table 26). These values are based on an ingestion rate of 6.5 g fish per day

**Table 26. Recommended screening values for specific analytes in this study*.**

| Analyte | Noncarcinogens | Carcinogens ($RL = 10^{-5}$) |
|---|---|---|
| Mercury | 0.6 | ND |
| Total Chlordanes | 600 | 80 |
| Total DDT | 5000 | 300 |
| Dieldrin | 600 | 7 |
| Total PCBs | 850 | 14 |

*Concentrations for mercury in µg/g wet wt., and ng/g wet wt. for the other contaminants. Data taken from EPA (1993). Mercury is measured as total mercury using the dose-response data for methylmercury. Total chlordane is the sum of cis+trans chlordane and nonachlor, and oxychlordane. Total DDT is the sum of 4,4' and 2,4' DDT, DDD, and DDE. Total PCBs is based on the dose-response data for Aroclor 1260, and the carcinogenic screening value is an upper bound, noncarcinogenic screening value is based on the RfD used in the Great Lakes Initiative ($8 \times 10^{-6}$ for all PCBs).

and a risk level of $10^{-5}$, and are conservative in nature in light of the caveats associated with these and a risk level of $10^{-5}$, and are conservative in nature in light of the caveats associated with these calculations. At a higher ingestion rate (i.e., 140 g fish per day) and a similar risk level the concentrations would be lower by approximately 20 times.

Comparing the concentrations in Table 26 to all the data in Table 15, there are a number of fish composites that exceed these risk based concentrations. For noncarcinogenic risks, total PCBs (sum of all congeners) exceeded the screening concentrations 35% of the time. Again, these fish included the channel catfish and common carp composites from both the Potomac and Anacostia Rivers. The other contaminants were not above their respective noncarcinogenic risk screening concentration. For carcinogenic risk, all samples were above the total PCBs screening value of 14 ng/g wet wt. For both total chlordanes and dieldrin, 60% of the fish composite samples were above their respective screening value of 80 and 7 ng/g wet wt. Channel catfish, common carp, and brown bullhead samples, mainly from the Anacostia River, had concentrations above these screening values. The screening value for total DDTs was not exceeded in any of the fish composite samples.

**Summary**

The present study indicates that detectable levels of many chemicals were present in the edible portion of certain species of fish collected in the District of Columbia's waters. Of the approximately 129 chemicals investigated, many were detected in one or more species. These chemicals ranged from trace inorganics such as Hg and Pb to organic chemicals like PCBs and DDTs. While trace metals and metalloids detected most often (i.e., Pb, Se, and Hg) did not show any statistical species or geographic variations, concentrations of were greatest in largemouth bass and sunfish (sp). Concentrations of many bioaccumulative organics (e.g., PCBs, PAHs, and total chlordane) were highest in channel catfish and common carp composites collected from the Anacostia River. Again, there were not enough replication in either sample area or species to make a rigorous statistical analysis. Some of the organic contaminant variation can be explained by the lipid content of each fish species. Geographical variations for all organic compounds were not identifiable with the limited data set available.

Previous studies of fish tissue contamination indicated that similar chemicals are persistent, however because of analytical and sampling differences between studies, a quantitative trend analysis was not possible at this time. PCBs and chlordane had been in elevated concentrations since samples were collected in 1987. The median concentrations of total PCBs (approximately 540 to 620 ng/g wet wt.) and $\alpha+\gamma$ chlordane (47 to 57 ng/g wet wt.) were higher in the Washington, D.C. area from the current data set compared to national data obtained during the National Dioxin Study (median total PCBs for industrial/urban sites: 210 ng/g wet wt., median $\alpha+\gamma$ chlordane: 11 ng/g wet wt.; EPA, 1992). Median or average concentrations of pp'-DDE, a breakdown product of DDT, were slightly lower compared to the national industrial/urban median (79 ng/g wet wt.).

In estimating the health effect of these data (i.e., FDA action levels, toxic equivalents for PCBs, and a risk assessment model), results suggested that concentrations of PCBs and chlordane were elevated and of concern in this area for specific species of fish (i.e., primarily bottom dwelling species). Concentrations of total Hg, dieldrin, total DDT, DDE, total chlordane, and total PCBs did not exceed the published FDA action levels. At a maximum, some fish composite samples had total PCBs concentrations approximately half of the FDA tolerance level, while highest total chlordane concentrations approached the FDA action level of 300 ng/g wet wt. Preliminary toxic equivalent (PCB-TEQ) calculations suggested that specific components of the PCBs were elevated. These dioxin-like PCBs ranged from 18 to 140 pg/g wet wt. (median of 52 pg/g wet wt.) for all fish composites. It is unclear as to what levels are of most concern, but studies suggest that these levels may cause an impact to both the wildlife and human health (Safe, 1984; 1990; Tillitt et al., 1991; Bernhoft et al., 1994; Sericano et al., 1994; Bosveld et al., 1995). Using a risk assessment model given by the U.S. EPA (EPA, 1992), indications were that the levels of total PCBs, and in some cases chlordane, in this area pose an excess cancer and noncarcinogenic risk (i.e., $95^{th}$ upper bound estimates) greater than $10^{-5}$. There are many limitations to this model however, the various health effect indicators suggests that PCBs and chlordane are of concern from fish, especially bottom dwelling species, collected in the Washington, D.C. area.

Monitoring of fish tissue in this area should be continued. For this monitoring, consistent and up-to-date analytical methods along with an adequate sampling scheme should be used to help evaluate geographic and species variations. Also, the data from recent local anglers surveys by the District's Fisheries Management Branch should be used to determine the area specific risk assessment of potential health effects to the local population.

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Appendix I. Fish Advisory for the District of Columbia.

# D.C. COMMISSIONER OF PUBLIC HEALTH URGES LIMITED CONSUMPTION OF FISH CAUGHT IN D.C. WATERS

**FOR IMMEDIATE RELEASE**
November 15, 1994

CONTACT: Larry Brown
(202) 279-6080
Martin Levy, M.D.
(202) 727-2317

The District of Columbia Commission of Public Health today issued a public health advisory cautioning the general public not to eat catfish, carp, and eel caught in D.C. waters, and to limit consumption of other fish from the same waters. The advisory applies to fish caught in the Potomac and Anacostia rivers and their tributaries, including Rock Creek, within the boundaries of the District of Columbia. A copy of the advisory is attached.

Dr. Marlene Kelley, Acting Commissioner of Public Health for the District, issued the new health advisory as an update to the advisory issued on the same topic in 1989. She specified that the advisory is restricted to fish caught recreationally in D.C. waters, and does not apply to fish sold in D.C. fish markets, grocery stores, and restaurants. Commercial fishing is prohibited in D.C. waters. The U.S. Food and Drug Administration (FDA) has responsibility for monitoring and regulating contaminants in fish and shellfish sold on the commercial market.

Dr. Kelley issued the updated health advisory based on a review of guidelines on consumption of recreationally-caught fish contaminated with polychlorinated biphenyls (PCBs), developed by federal, state, and independent agencies. Studies by the Department of Consumer and Regulatory Affairs (DCRA) and other agencies consistently show PCBs and other chemical contaminants in fish caught in D.C. waters.

The DCRA has been monitoring chemical contaminants in fish since 1980 in cooperation with the EPA. The most recent study, reported in 1994, was carried out for the city by the Interstate Commission on the Potomac River Basin. Other studies of contaminants in fish from D.C. waters include a 1987 survey by the U.S. Fish and Wildlife Service.

Chemical contaminants pollute the rivers via highway and urban runoff and other sources and accumulate in sediment. Fish absorb chemical contaminants from their food and from water as it passes over their gills. Bottom-feeding fish, such as catfish, carp, and eel, feed on worms and other organisms living in the sediment and therefore are more highly contaminated than other fish. Predator fish, such as largemouth bass, accumulate contaminants found in smaller fish.

According to DCRA Director Hampton Cross, studies of sediments have shown that chemical contaminants tended to be distributed throughout D.C. waters. Sources of pollutants include legal discharges from industry, combined sewage overflow outfalls, silt discharges, illegal dumping, and rainfall.

Dr. Kelley said that the DC Government, in cooperation with the National Park Service, plan to post signs along the rivers to warn anglers about PCBs and other chemical contaminants in fish from D.C. waters. The signs will also remind the general public
Spanish. A copy of the English version of the sign is attached.

Dr. Kelley said the issuance of the advisory and the posting of warning signs were meant to urge anglers and their families and friends to reduce their consumption of contaminated fish and to switch over from more contaminated species, such as catfish, carp, and eel, to less contaminated species, such as sunfish.

Other important measures recommended in the advisory and signs were to practice selective catch-and-release, retaining only younger and smaller fish of legal size, and to skin, trim, and cook the fish in a way that would minimize fat content, since many chemical contaminants accumulate in the fat of the fish. Dr. Kelley said that groups at highest risk for adverse effects from eating contaminated fish on a regular basis include women who are pregnant, are breastfeeding, or expect to bear children, as well as children below 15 years of age.

Dr. Kelley noted that the current advisory is more restrictive than the previous one, which limited consumption of catfish, carp, or eel to a half pound per week, without limits on other fish. However, she cautioned that this should not be taken as an indication that levels of chemical contaminants in fish from D.C. waters are increasing. Studies conducted from 1987 to 1993 show consistent contaminant levels from year to year. Rather, the change comes from applying guidelines which were developed specifically for recreational fishing, while the FDA guidelines applied in the 1989 advisory were developed for fish sold commercially.

Additional information regarding the health advisory may be obtained by contacting Dr Martin Levy, chief of CPH's Bureau of Epidemiology and Disease Control, at (202) 727-2317. Additional information regarding the fish studies may be obtained by contacting Mr. James Collier, program manager of DCRA's Water Resources Management Division, at (202) 645-6601.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DEPARTMENT OF HUMAN SERVICES
COMMISSIONER OF PUBLIC HEALTH,
WASHINGTON, D. C. 20002

GOVERNMENT OF THE DISTRICT OF COLUMBIA
Commission of Public Health

# Public Health Advisory

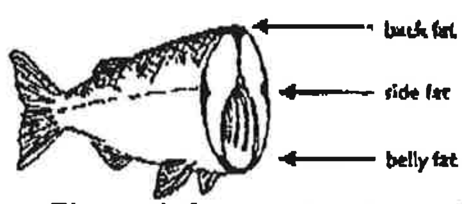
PCBs and other chemical contaminants have continued to bo found in certain fish species caught in the Potomac and Anacostia rivers and their tributaries, including Rock Creek, within the boundaries of the District of Columbia. Because of these findings, the Commission of Public Health advises the general public to limit its consumption of fish from all D.C. waters, as follows:

- **DO NOT EAT:** catfish, carp, or eel
- **MAY EAT:** one half pound per month of largemouth bass, OR one half pound per week of sunfish or other fish
- **CHOOSE TO EAT:** younger and smaller fish of legal size
- **THE PRACTICE OF CATCH-AND-RELEASE IS ENCOURAGED**

These recommendations do not apply to fish sold in fish markets, grocery stores, and restaurants, since commercial fishing is prohibited in D.C. waters.

Because many chemical contaminants tend to concentrate in the fat of the fish, the Commission further recommends that fish caught in D.C. waters not be eaten unless prepared and cooked in a manner that reduces fat content, as follows:

- **ALWAYS SKIN FISH AND TRIM AWAY FAT** by slicing off the belly flap of meat along the bottom of the fish, the fat along the top of the back, and the dark meat along the lateral line on each side of the fish (see diagram below)
- **ALWAYS COOK FISH SO FAT DRAINS AWAY,** preferably by baking, broiling, or grilling the fish; if poaching or deep-fat frying, discard the broth or oil; avoid pan frying or making soups and chowders as these methods retain fat-laden juices



Trim away the fatty areas shown above

Spacing meals out according to the intervals stated helps prevent the contaminants from building up to harmful levels in the body. For example, after eating a meal of largemouth bass, one would wait a month before eating another meal of largemouth bass. Four half pounds of sunfish spaced a week apart are equivalent to one half pound a month of largemouth bass.

Groups at highest risk for adverse effects from eating contaminated fish on a regular basis include women who are pregnant, are breastfeeding, or expect to bear children, as well as children below 15 years of age.

This advisory replaces the advisory issued in 1989.

## FISHING NOTICE

- A DISTRICT OF COLUMBIA FISHING LICENSE IS REQUIRED TO FISH IN THESE WATERS FOR PERSONS SIXTEEN TO SIXTY-FIVE (16-65) YEARS OF AGE

- DISTRICT OF COLUMBIA FISHING REGULATIONS ARE IN EFFECT FOR THESE WATERS

## HEALTH ADVISORY

- FISH FROM THESE WATERS CONTAIN PCBs AND OTHER CHEMICAL CONTAMINANTS
- DO NOT EAT CATFISH, CARP, OR EEL FROM THESE WATERS
- YOU MAY EAT 1/2 POUND PER MONTH OF LARGEMOUTH BASS, OR 1/2 POUND PER WEEK OF SUNFISH OR OTHER FISH
- CHOOSE TO EAT YOUNGER AND SMALLER FISH OF LEGAL SIZE
- ALWAYS SKIN FISH, TRIM AWAY FAT, AND COOK FISH SO FAT DRAINS AWAY
- THE PRACTICE OF CATCH-AND-RELEASE IS ENCOURAGED

## SWIMMING BAN

- SWIMMING IS PROHIBITED IN THESE WATERS DUE TO HIGH LEVELS OF BACTERIA

**FOR MORE INFORMATION CONTACT THE FISHERIES MANAGEMENT BRANCH AT (202) 645-6068**

DEPARTMENT OF CONSUMER AND REGULATORY AFFAIRS
ENVIRONMENTAL REGULATION ADMINISTRATION
WATER RESOURCES MANAGEMENT DIVISION
FISHERIES MANAGEMENT BRANCH
[illegible] MARTIN LUTHER KING JR. AVENUE, S.E., SUITE [illegible]
WASHINGTON, D.C. [illegible]

Appendix II. Fish Identification

**Appendix II. Fish Filet Identifications and Composite Compositions.**

**Table 1. Fish filet samples prior to composting.**

| 1993 FISH TISSUE LIST | | | | | | |
|---|---|---|---|---|---|---|
| Sample # | Date | Station | Species | TL (mm) | Total Wt. (g) | Fillet Wt. (g) |
| 33 | 9/22 | LP | LMB | 310 | 504 | 168 |
| 34 | 9/22 | LP | LMB | 335 | 616 | 168 |
| 40 | 10/25 | UP | BG | 160 | 84 | 56 |
| 41 | 10/25 | UP | BG | 150 | 56 | 28 |
| 42 | 10/25 | UP | PS | 150 | 56 | 28 |
| 43 | 10/25 | UP | BG | 150 | 56 | 28 |
| 44 | 10/25 | UP | BG | 150 | 56 | 28 |
| 45 | 10/25 | UP | BG | 152 | 56 | 28 |
| 46 | 10/25 | UP | PS | 168 | 84 | 56 |
| 47 | 10/25 | UP | BG | 165 | 98 | 56 |
| 48 | 10/25 | UP | BG | 145 | 56 | 28 |
| 49 | 10/25 | UP | PS | 150 | 59 | 53 |
| 50 | 10/25 | LP | BG | 144 | 56 | 42 |
| 51 | 10/25 | LP | BG | 168 | 84 | 56 |
| 52 | 10/17 | LA | PS | 155 | 84 | 56 |
| 53 | 10/17 | LA | BG | 173 | 112 | 34 |
| 54 | 10/17 | LA | PS | 148 | 59 | 56 |
| 55 | 10/17 | LA | BG | 161 | 64 | 58 |
| 56 | 10/17 | LA | PS | 162 | 64 | 58 |
| 57 | 10/17 | LA | BG | 157 | 59 | 50 |
| 58 | 10/17 | LA | BG | 160 | 109 | 56 |
| 59 | 10/17 | LA | BG | 149 | 59 | 50 |
| 60 | 10/17 | LA | BG | 155 | 59 | 50 |

UP - Upper Potomac; LP - Lower Potomac; UA - Upper Anacostia; LA - Lower Anacostia
LMB - Largemouth Bass; BG - Bluegill; PS - Pumpkin seed; AE - American eel; CC - Channel Catfish; BB - Brown Bullhead

**Table 2. Fish filet samples prior to composting.**

| 1993 FISH TISSUE LIST | | | | | | |
|---|---|---|---|---|---|---|
| Sample # | Date | Station | Species | TL (mm) | Total Wt. (g) | Fillet Wt. (g) |
| 61 | 10/17 | LA | BG | 159 | 56 | 50 |
| 68 | 10/07 | LA | BG | 149 | 56 | 50 |
| 69 | 10/07 | LA | PS | 151 | 64 | 50 |
| 70 | 10/07 | LA | BG | 151 | 59 | 53 |
| 71 | 10/07 | LA | BG | 151 | 56 | 45 |
| 72 | 10/07 | LA | BG | 162 | 101 | 56 |
| 73 | 10/21 | LP | PS | 166 | 84 | 53 |
| 74 | 10/21 | LP | PS | 141 | 56 | 42 |
| 75 | 10/25 | UP | AE | 240 | 56 | N/A |
| 76 | 10/25 | UP | AE | 270 | 28 | N/A |
| 77 | 10/28 | UP | AE | 240 | 39 | N/A |
| 78 | 10/07 | LA | COC | 540 | 1456 | 782 |
| 80 | 10/07 | LA | COC | 460 | 1500 | 380 |
| 81 | 10/07 | LA | COC | 470 | 1904 | 548 |
| 82 | 10/07 | LA | COC | 525 | 1904 | 566 |
| 79 | 09/20 | LP | COC | 450 | 1400 | 468 |
| 84 | 09/22 | LP | COC | 480 | 1680 | 640 |
| 85 | 10/06 | LP | COC | 550 | 2150 | 742 |
| 86 | 09/20 | LP | CC | 370 | 622 | 166 |
| 87 | 09/20 | LP | CC | 410 | 645 | 140 |
| 88 | 09/20 | LP | LMB | 295 | 500 | 166 |
| 83 | 10/07 | UA | COC | 490 | 1792 | 582 |
| 89 | 09/20 | LP | AE | 270 | 44 | 40 |

See Table 1 for a description of location and fish types.

**Table 3. Fish filet samples prior to composting.**

| 1993 FISH TISSUE LIST | | | | | | |
|---|---|---|---|---|---|---|
| Sample # | Date | Station | Species | TL (mm) | Total Wt. (g) | Fillet wt (g) |
| 93 | 09/20 | UP | LMB | 290 | 468 | 180 |
| 94 | 09/20 | UP | LMB | 245 | 280 | 106 |
| 95 | 09/20 | UP | BG | 142 | 60 | 42 |
| 96 | 09/20 | UP | BG | 150 | 80 | 44 |
| 97 | 10/28 | LP | PS | 150 | 86 | 48 |
| 98 | 10/28 | LP | PS | 140 | 64 | 42 |
| 99 | 10/28 | LP | PS | 142 | 80 | 46 |
| 100 | 10/28 | LP | PS | 140 | 62 | 40 |
| 101 | 10/28 | LP | PS | 155 | 88 | 62 |
| 102 | 10/28 | LP | PS | 150 | 80 | 46 |
| 103 | 10/28 | LP | PS | 150 | 68 | 42 |
| 104 | 10/28 | LP | BG | 161 | 81 | 46 |
| 105 | 10/28 | LP | BG | 170 | 108 | 81 |
| 106 | 10/28 | LP | BG | 173 | 106 | 68 |
| 107 | 10/28 | LP | BG | 157 | 68 | 46 |
| 108 | 10/28 | LP | AE | 270 | 45 | 26 |
| 109 | 09/20 | UP | BG | 140 | 62 | 40 |
| 110 | 09/20 | UP | BG | 141 | 69 | 50 |
| 111 | 09/20 | UP | BG | 145 | 82 | 52 |
| 112 | 09/20 | UP | BG | 137 | 48 | 32 |
| 113 | 09/20 | UP | PS | 137 | 62 | 30 |
| 114 | 09/20 | UP | PS | 140 | 48 | 32 |
| 115 | 09/20 | UP | PS | 130 | 46 | 36 |

See Table 1 for a description of location and fish types.

**Table 4. Fish filet samples prior to composting.**

| 1993 FISH TISSUE LIST | | | | | | |
|---|---|---|---|---|---|---|
| Sample # | Date | Station | Species | TL (mm) | Total Wt. (g) | Fillet wt (g) |
| 116 | 09/20 | UP | AE | 230 | 18 | 10 |
| 117 | 09/22 | LP | BG | 161 | 90 | 60 |
| 118 | 09/22 | LP | BG | 150 | 70 | 42 |
| 122 | 09/20 | LP | BG | 150 | 70 | 35 |
| 120 | 09/20 | LP | LMB | 310 | 510 | 195 |
| 121 | 09/20 | LP | LMB | 320 | 600 | 220 |
| 119 | 09/20 | LP | CC | 360 | 545 | 105 |
| 123 | 08/24 | LP | CC | 410 | 780 | 180 |
| 124 | 08/26 | LP | CC | 430 | 735 | 160 |
| 125 | 09/22 | LA | CC | 440 | 1120 | 280 |
| 126 | 09/22 | LA | CC | 410 | 665 | 150 |
| 127 | 09/22 | LA | CC | 380 | 770 | 180 |
| 128 | 10/28 | LP | COC | 510 | 1988 | 710 |
| 129 | 10/28 | LP | COC | 520 | 2184 | 820 |
| 130 | 08/24 | LP | AE | 270 | 40 | 35 |
| 131 | 08/24 | LP | AE | 285 | 65 | 60 |
| 132 | 07/27 | LP | AE | 390 | 160 | 120 |
| 133 | 07/27 | LP | AE | 280 | 55 | 40 |
| 134 | 07/27 | LP | AE | 280 | 60 | 40 |
| 135 | 07/27 | LP | AE | 260 | 41 | 30 |
| 136 | 07/27 | LP | AE | 210 | 20 | 15 |
| 137 | 10/06 | LP | PS | 160 | 90 | 55 |
| 138 | 10/06 | LP | PS | 140 | 70 | 35 |

See Table 1 for a description of location and fish types.

**Table 5. Fish filet samples prior to composting.**

| 1993 FISH TISSUE LIST | | | | | | |
|---|---|---|---|---|---|---|
| Sample | Date | Station | Species | TL (mm) | Total Wt. (g) | Fillet wt (g) |
| 139 | 10/06 | LP | PS | 150 | 60 | 35 |
| 140 | 10/06 | LP | PS | 148 | 70 | 40 |
| 141 | 10/06 | LP | BG | 180 | 118 | 65 |
| 142 | 10/06 | LP | BG | 175 | 130 | 80 |
| 143 | 10/06 | LP | BG | 155 | 75 | 50 |
| 144 | 10/06 | LP | BG | 160 | 100 | 70 |
| 145 | 10/06 | LP | BG | 168 | 85 | 50 |
| 146 | 10/06 | LP | BG | 144 | 65 | 35 |
| 147 | 10/06 | LP | AE | 302 | 50 | 40 |
| 159 | 07/29 | LP | AE | 218 | 41 | 36 |
| 155 | 10/29 | LA | PS | 150 | 70 | 33 |
| 156 | 10/29 | LA | PS | 150 | 87 | 55 |
| 157 | 10/29 | LA | PS | 150 | 87 | 60 |
| 158 | 10/29 | LA | PS | 150 | 72 | 36 |

See Table 1 for a description of location and fish types.

**Table 6. Fish filet samples prior to composting.**

| 1994 FISH TISSUE LIST | | | | | | |
|---|---|---|---|---|---|---|
| Sample | Date | Station | Species | TL (mm) | Total Wt. (g) | Fillet wt (g) |
| 1 | 09/27 | LA | COC | 560 | 1132 | 945 |
| 2 | 09/27 | LA | COC | 400 | 1010 | 410 |
| 3 | 09/27 | LA | COC | 620 | 1584 | 1440 |
| 4 | 09/27 | LA | LMB | 350 | 700 | 290 |
| 5 | 09/27 | LA | LMB | 290 | 360 | 140 |
| 6 | 09/27 | LA | LMB | 270 | 250 | 90 |
| 7 | 09/27 | LA | BG | 155 | 83 | 50 |
| 8 | 09/27 | LA | PS | 157 | 100 | 70 |
| 9 | 09/27 | LA | BG | 170 | 118 | 70 |
| 10 | 09/27 | LA | BG | 157 | 100 | 80 |
| 11 | 09/27 | LA | PS | 148 | 80 | 45 |
| 12 | 09/27 | LA | BG | 150 | 80 | 50 |
| 13 | 09/27 | LA | AE | 590 | 450 | 380 |
| 14 | 09/27 | LA | CC | 380 | 540 | 180 |
| 15 | 09/27 | LA | CC | 420 | 935 | 210 |
| 16 | 09/20 | UP | COC | 530 | 1471 | 810 |
| 17 | 09/19 | LP | CC | 460 | 880 | 220 |
| 18 | 09/19 | LP | CC | 490 | 1200 | 240 |
| 19 | 09/19 | LP | CC | 480 | 1494 | 270 |
| 20 | 09/19 | LP | BG | 143 | 65 | 55 |
| 21 | 09/19 | LP | BG | 170 | 110 | 85 |
| 22 | 09/19 | LP | BG | 144 | 77 | 65 |
| 23 | 09/19 | LP | BG | 160 | 90 | 70 |

See Table 1 for a description of location and fish types.

**Table 7. Fish filet samples prior to composting.**

| 1994 FISH TISSUE LIST | | | | | | |
|---|---|---|---|---|---|---|
| Sample # | Date | Station | Species | TL (mm) | Total Wt. (g) | Fillet Wt (g) |
| 24 | 09/19 | LP | BG | 148 | 70 | 60 |
| 25 | 09/19 | LP | BG | 153 | 85 | 65 |
| 26 | 09/19 | LP | BG | 147 | 80 | 65 |
| 27 | 09/19 | LP | BG | 150 | 78 | 60 |
| 28 | 09/19 | LP | BG | 151 | 92 | 72 |
| 29 | 09/19 | LP | BG | 162 | 111 | 85 |
| 30 | 09/19 | LP | BG | 150 | 75 | 60 |
| 31 | 09/19 | LP | Carp | 470 | 1584 | 990 |
| 32 | 09/19 | LP | COC | 370 | 880 | 325 |
| 35 | 09/21 | UP | COC | 420 | 1585 | 226 |
| 36 | 09/21 | UP | COC | 430 | 1358 | 340 |
| 37 | 09/21 | UP | CC | 460 | 1104 | 226 |
| 38 | 09/20 | UP | CC | 460 | 1075 | 226 |
| 39 | 09/21 | UP | BG | 170 | 113 | 57 |
| 62 | 09/20 | UP | BG | 170 | 71 | 57 |
| 63 | 09/20 | UP | BG | 182 | 116 | 71 |
| 64 | 09/20 | UP | BG | 152 | 65 | 57 |
| 65 | 09/20 | UP | BG | 150 | 57 | 34 |
| 66 | 09/20 | UP | BG | 160 | 85 | 57 |
| 67 | 09/20 | UP | BG | 180 | 114 | 65 |
| 90 | 09/19 | LP | LMB | 370 | 862 | 324 |
| 91 | 09/19 | LP | LMB | 260 | 250 | 100 |
| 92 | 09/19 | LP | LMB | 260 | 664 | 102 |
| 148 | 10/17 | LP | COC | 530 | 2400 | 795 |
| 153 | 10/17 | UP | LMB | 250 | 220 | 75 |
| 154 | 10/17 | UP | LMB | 290 | 336 | 120 |

See Table 1 for a description of location and fish types.

**Table 8. Composite composition for 1993, 1994, and 1995 samples.**

| 1993 List of species by sample # for each composite. | | | |
|---|---|---|---|
| **Composite #** | **Site** | **Species** | **Sample #'s** |
| 1-93 | Lower Potomac | LMB | 33,34,88,120,121 |
| 2-93 | | CC | 86,87,119 |
| 3-93 | | COC | 79,84,85 |
| 4-93 | Upper Potomac | LMB | 93,94 |
| 5-93 | | AE | 75,76,77,116 |
| 6-93 | Lower Anacostia | CC | 125,126,127 |
| 7-93 | | COC | 78,80,81,82 |
| 8-93 | | Sunfish (sp.) | 52-61,68-72,155-158 |
| 9-93 | Upper Anacostia | COC | 83 |
| 10-93 | Kenilworth Marsh | BB | 149-152 |
| 1-95 | Kingman Lake | BB | 165-168 |
| 2-95 | Kingman Lake | BB | 169-172 |

| 1994 List of species by sample # for each composite. | | | |
|---|---|---|---|
| **Composite #** | **Site** | **Species** | **Sample #'s** |
| 1-94 | Lower Potomac | LMB | 90,91,92 |
| 2-94 | | COC | 31,32,148 |
| 3-94 | Upper Potomac | CC | 37,38 |
| 4-94 | | COC | 16,35,36 |
| 5-94 | Lower Anacostia | LMB | 4,5,6 |
| 6-94 | | COC | 1,2,3 |
| 7-94 | | CC | 14,15 |
| 8-94 | | Sunfish (sp.) | 7-12 |

See Table 1 for key to species and locations.

Appendix III. Correspondance from the District of Columbia

**GOVERNMENT OF THE DISTRICT OF COLUMBIA**
DEPARTMENT OF CONSUMER AND REGULATORY AFFAIRS
ENVIRONMENTAL REGULATION ADMINISTRATION
2100 MARTIN LUTHER KING, JR. AVENUE S.E.
WASHINGTON, D.C. 20020-5732

MAY 21 1996

May 16, 1996

**MEMORANDUM**

TO: Jim Cummins

*FROM:* Mohsin Siddique

SUBJECT: Your letter concerning Mr. Charles Kanetsky's Review letter dated 3-6-96

This correspondence is in reference to Mr. Kanetsky's concerns about the sample preparation and documentation for the fish tissue work done in 1993 and 1994. One concern was related to the total weights versus fillet weights listed for individual fish. While we have no direct evidence of any problems related to the processing of these fish, a problem may well have developed due to the use of more than one balance. The use of multiple balances, with different accuracies, was necessary because of the wide range in fish weights which were encountered. Generally, for the initial whole fish weights, the large fish were weighed on a spring scale and the small fish on either a spring scale or an electronic balance. The fillets were then weighed on either the same or a different scale, depending on the fillet weights and the scales which were available. Two spring scales were used, one which measured in pounds and one which measured in grams. Both of these scales had different accuracies. Occasionally, an electronic balance with an accuracy of +/- about one gram was used but this was uncommon. It is quite possible that when weights were taken with the spring scale that measured in pounds, then converted into grams, that there could be significant errors, especially for the smaller fish. For the larger fish however, even with this scale the relative errors should not have been a problem. Generally then, the most probable cause of error relating to reported weights was most likely due to problems with the scales which were used.

Another concern related to the number of fish used in each composite sample. Our goal was to obtain three fish with a total fillet weight of 500 grams or more. Unfortunately, during sampliing we were not always able to capture three fish so in certain instances we had either fewer than three fish in the composite, less than 500 grams of fish tissue in the composite, or less than three fish and less than 500 grams in the composite sample. Again, this was because we were directed to gather the fish in the early fall when the fish were supposed to contain their maximum fat content which would allow them the best overwinter survival. During this time of year though many fish have already moved out of the shallows where our sampling is most effective. Under the sampling constraints then we supplied the fish which we could capture, and the composite samples included three fish and 500 grams of tissue when this was available.

A final concern dealt with whether the fillets had been skinned or were supplied with their skin intact. In talking with the people who did the processing, it is my understanding that the skin was removed from all the fillets with the exception of the eels. Also, each fish generally supplied two fillets except occasionally there were numerous small fillets for the small fish.

If any further information is needed concerning this data please contact me at (202) 645-6601 extension 3041.