Total Maximum Daily Loads for PCBs
in the Houston Ship Channel

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CHAPTER 1 – INTRODUCTION

Polychlorinated biphenyls (PCBs) are widespread organic contaminants which are environmentally persistent and can be harmful to human health even at low concentrations. A major route of exposure for PCBs worldwide is through food consumption, and this route is especially significant in seafood. The discovery of PCBs in seafood tissue has led Texas Department of State Health Services to issue seafood consumption advisories, and some of these advisories have been issued for the Houston Ship Channel (HSC). Two specific advisories have been issued recently for all finfish species based on concentrations of PCBs, organochlorine pesticides, and dioxins. ADV-20 was issued in October 2001 and includes the HSC upstream of the Lynchburg Ferry crossing and all contiguous waters, including the San Jacinto River Tidal below the U.S. Highway 90 bridge. ADV-28 was issued in January 2005 for Upper Galveston Bay (UGB) and the HSC and all contiguous waters north of a line drawn from Red Bluff Point to Five Mile Cut Marker to Houston Point. These two advisories represent a large surface water system for which TMDLs need to be developed and implemented.

1.1   SCOPE OF THE PROJECT

The scope of the TMDL PCB project includes studies and implementations related only to PCBs in the HSC System including Upper Galveston Bay. The work included in the scope currently includes project administration, participation in stakeholder involvement, and development of a detailed plan for completing the PCBs TMDL. The latter task is the bulk of the work and includes the following according to the Work Order task numbers:

3.1.1 Collection and analysis of levels of PCBs in environmental media and sources relevant to the HSC-UGB area.

3.1.2 Characterize the permitted and actual loading of PCBs from specific facilities or discharges.

3.1.3 Review current technical literature to characterize the state of the science on PCB sources, transport, and fate, which will be used to define the temporal and spatial trends within the project area.

3.1.4 Identify data and information gaps important to the project.

1.2   DESCRIPTION OF THE REPORT

This document comprises the first quarterly report of the TMDL PCB project and summarizes the results of the activities undertaken by the University of Houston for Work Order No.582-6-70860-13 during the period from September 11, 2006 to November 30, 2006.

This report reflects the progress made towards tasks 3.1.1 and 3.1.3 of the Work Order. Chapter 2 gives a historical summary of PCBs in production, use, distribution, analytical chemistry, and regulation in the United States. It is taken from a variety of historical summary sources, and it serves to a give a greater context for understanding the views and state of PCBs in the environment today. In addition, Chapter 2 presents the results of a detailed literature review of PCB physical/chemical properties, health effects, sources, and fate and transport. Chapter 3 presents from the literature some of the well-established and up and coming chemical analysis and sampling methods for PCBs. Chapter 4 summarizes PCB environmental data and information from the HSC and from other similar PCB TMDL studies. Finally, Chapter 5 presents a summary of the activities conducted during the reporting period and outlines the activities to be conducted in the next quarter.

CHAPTER 2 –BACKGROUND AND PROPERTIES OF PCBS

2.1   BRIEF HISTORY AND BACKGROUND OF PCBS

Polychlorinated Biphenyls (PCBs) are a class of organic chemicals which were first produced on an industrial scale in 1929 by the Swan Chemical Company. This company was later purchased by Monsanto Industrial Chemicals which became the main U.S. producer of PCBs for nearly their entire domestic production life. (De Voogt, 1989)

In the early years of PCB production, their main use was as a dielectric fluid in transformers, but like many industrial products in that era, the end of WWII significantly diversified the application of these chemicals and increased their levels of production. From the late 1940s until the early 1970s, PCBs found a wide range of applications. The main applications were dielectric fluids, heat transfer fluids in heat exchangers, and as heat resistant hydraulic fluids. Many other smaller miscellaneous applications for PCBs were also developed including plasticizers, carbonless copy paper, lubricants, inks, laminating agents, impregnating agents, paints, adhesives, waxes, additives in cements and plasters, casting agents, dedusting agents, sealing liquids, fire retardants, immersion oils, and pesticides. (De Voogt, 1989) This latter class of applications represents only suspected uses of PCBs and demonstrates that beyond the mainline uses, they became so widely utilized that records do not even exist to verify all of their applications.

The environmental history of PCBs begins in 1966 when Soren Jenson, a Swede, discovered the presence of PCBs in fish, human hair, and museum eagle feathers. He speculated at that time that PCBs might be found in many places all over the globe and that they might represent human and environmental health hazards. (Shifrin, 1998) The discovery prompted an interest in environmental distribution, persistence, and toxicology of PCBs in what had previously been a field of research concerned only with their useful properties and their production chemistry. The interest became an intensified effort to understand the effects and dangers of PCBs when in 1968 a group of people consuming

rice oil contaminated with PCBs at levels of 1000 ppm in Yusho, Japan showed some serious health effects. (Shifrin, 1998)

It was then only a short number of years for the concern with PCBs to turn into an outright national ban on their production and investigation of how to quantify and remove them from the environment. In 1971, Monsanto voluntarily limited its production of PCBs due to the growing public and scientific concerns of their effects (De Voogt, 1989), and in 1976 the Toxic Substances Control Act (TSCA) was passed which called for a ban on all production, distribution, and use of PCBs. (USEPA, 2003) Monsanto's compliance with TSCA resulted in a complete cessation of PCB production in mid-1977, and PCBs have not been produced industrially in the U.S. ever since. (De Voogt, 1989) Long-life PCB applications such as transformers were still allowed under strict regulations for operations and disposal, but those uses will eventually be completely phased out as the old technologies are replaced.

From the time of Jenson's discovery and into the 1970s, the international scientific and health community made it a priority to discover how toxic PCBs really were and what to do about them. It was clear that they were toxic enough to be banned from production, but the exact degree of toxicity would be something which was argued about in the scientific literature even until today.

The technology to analyze PCB samples from the environment was not well developed enough to characterize what specific PCBs were present and to what degree. So in addition to a rapid development of toxicological study, the analytic chemists performed a great deal of research from the mid-1970s to the present to quantify PCBs. That research did not culminate into any standard method of PCB analysis until the EPA issued Method 608 in the SW-846 manual in 1982, which was used only for PCB Aroclor mixtures. (Shifrin, 1998) Moreover the complete list of PCB congeners[*] could not be quantified using GC until Schultz et al. performed the first successful analysis in 1989. (Shifrin, 1998) The EPA has more recently provided a measure of congener-specific

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[*] Congener is a term in chemistry that refers to one of many variants or configurations of a common chemical structure. For PCBs, each configuration of the base compound biphenyl containing two or more chlorines is its own congener.

analysis in Method 8082. Method 8082 can be used to get Aroclors and is listed to measure 19 of the total 209 congeners. (USEPA, 1996) A complete congener distribution high resolution PCB analysis in standard methods 1668 and 1668A(USEPA, 1999). This body of work brings the analysis of today's samples to high levels of detection and resolution though regulations themselves do not require such resolution as yet.

PCBs are generally not produced, distributed, processed, or used for any application. They are, however, nearly ubiquitous in the environment even in polar regions far from anywhere they were ever produced or used. Thus, recent studies have focused on three main areas: toxicology, chemical analysis, and fate and transport.

2.2   PROPERTIES, SOURCES, AND FATE AND TRANSPORT OF PCBS

2.2.1   Physical and Chemical Properties

Physicochemical properties of PCBs have been extensively studied since they became and environmental issue in the late 1970s as evidenced by the extensive body of literature available. However, because their properties are difficult to measure, the reported constants for some of the environmentally-relevant properties range within several orders of magnitude.

2.2.1.1 Chemical Classification, Structure, and Nomenclature of PCBs

Polychlorinated Biphenyls are a member of a class of compounds called polychlorinated aromatic hydrocarbons (PCHs). PCHs are compounds containing multiple aromatic rings bonded together in combination with multiple chlorine atoms which are usually bound up on one of the carbon joints on an aromatic ring. PCBs are distinct within PCHs in that their chemical structure is based off of the biphenyl molecule as shown in Figure 2.1.
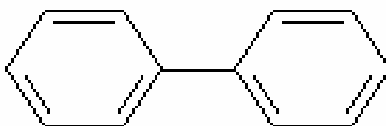
Figure 2.1 Structure of Biphenyl

As can be seen biphenyl is simply two C6 aromatic rings joined together a by a single covalent bond. A PCB is a biphenyl which has at least two chlorine atoms attached somewhere on one or both of the two aromatic rings. A general PCB structure for this arrangement is shown in Figure 2.2.
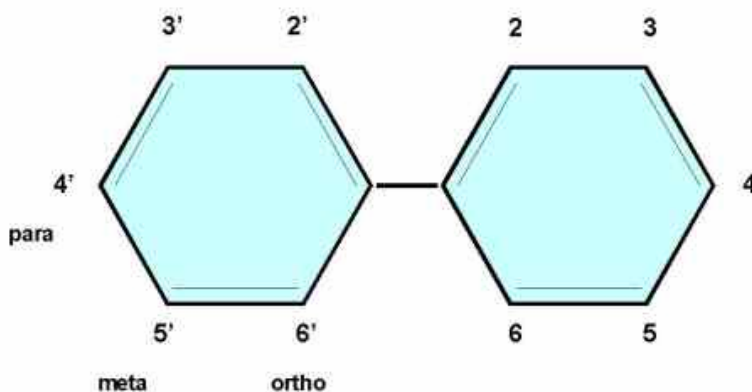
Figure 2.2 General Structure of a PCB

Each ring has two ortho, two meta, and one para position on it, and the particular number and arrangement of chlorines in these positions gives 209 theoretical combinations each of which is called a congener.

There are two systems of nomenclature for each of the 209 congeners. The first is the IUPAC system of nomenclature which simply lists the positions of each chlorine on the biphenyl, followed by the Greek prefix for the number of chlorines on the biphenyl

and finally simply the word "biphenyl". So, for example, a biphenyl with 4 chlorines at the 2, 3, 4', and 6 positions would be called 2,3,4',6-Tetrachlorobiphenyl. The second nomenclature system was developed by Ballschmiter et al. (1980) and is simply a number of the PCB congeners in order of increasing chlorination and increasingly higher position numbers of that chlorination. Under their system for example, 2,3,4',6-Tetrachlorobiphenyl is called PCB64. A full table of all congeners under their IUPAC and Ballschmiter (BZ) nomenclature has been created by the EPA and is available at http://www.epa.gov/toxteam/pcbid/table.htm.

PCBs were not normally produced industrially (and there are no non-anthropogenic sources of PCBs) as a single pure congener product. One of the reasons for the congener mixture was because of the production chemistry. The reaction was always conducted at near atmospheric pressure as a batch chlorination of biphenyl with anhydrous chlorine gas. The result was a broad mixture of many PCB congeners which were subsequently separated and purified into more specific fractions. Each fraction, however, still contained several congeners. (De Voogt, 1989)

The mixtures were always marketed as technical grade liquids under various trade names such as *Aroclor* in the U.S., *Kanechlor* in Japan, and *Clophen* in Germany to name but a few. (De Voogt, 1989) The Aroclor mixtures had a number designation which followed the Aroclor name to signify the number of carbon atoms in biphenyl and the percentage of chlorine by mass in the mixture as a whole. Thus, Aroclor 1260 contains 12 carbon items that make up the biphenyl skeleton and 60% chlorine by mass when the congener composition of the entire mixture was taken into account. The chlorine percentage gave the mixture different physical properties to make each mixture more suited for particular applications.

2.2.1.2 Water Solubility

The hydrophobic nature of PCBs means that in general water solubilities are low. The EPA agrees with this assessment but acknowledges that though all of the PCBs have

low solubilities, the differences in solubility among the congeners can still vary within several orders of magnitude. (USEPA, 2003)

Huang and Hong (2002) found that for coplanar PCBs, within a homolog group, the congeners that have greater ortho substitution generally have greater water solubility. They also found that the aqueous solubility of 12 PCB congeners increased exponentially with temperature. Huang and Hong crafted a model to predict the solubility of all 209 PCB congeners based on the melting point and chlorine substitution pattern, but they acknowledged that more needed to be known in the area of solubility of coplanar PCBs specifically and PCBs in general. Shiu (2000) performed a comprehensive review of literature PCB solubilities, which is another source of some useful values.

Solubility data from the Huang (2002)study and Mackay (1992)are given in Appendix A.

2.2.1.3 Vapor Pressure

In general, the vapor pressures of all PCBs are low though there are order of magnitude variations among them. (USEPA, 2003)   Bidleman showed that with each addition of chlorine, the vapor pressure decreased by around a factor of 4.5. Some representative data was found for vapor pressures by Bidleman (1984) and Paasivirta (1999) and is presented in Appendix A.

2.2.1.4 Henry's Law Constant

Henry's law constants are useful in many aspects of PCB transport in water, but the most direct use of Henry's law constants is in the characterization of water-air volatilization equilibrium.

A representative set of Henry's Law constants for some congeners is given in Appendix A by Bamford (2000) and Fang (2006).

2.2.1.5 Octanol/Water Constants

The octanol-water partitioning coefficient (K_{ow}) is an extremely important constant for each PCB congener since it describes the partitioning behavior of congeners between water, soil, and biota. Hawker and Connell (1988) presented a paper which analyzed 13 congeners and used those results to get predicted K_{ow}'s based on assumed log-log relationship between K_{ow} and GC retention time. That relation is of the form

$$\log K_{OW} = 1.47 \log \alpha + 5.52$$

where α is the GC retention time. The paper by Hawker and Connell (1988) has been cited in at least 370 articles and is a good source for K_{ow} values.

A summary of PCB K_{ow} values reported in the literature is presented in Appendix A..

2.2.1.6 Organic Carbon-Normalized Partition Coefficient

The organic carbon-normalized partition coefficient is a measure of partitioning of a compound between a soil/sediment particle and water. It is usually denoted as K_{OC} where the OC stands for organic carbon. The organic carbon amount in the soil/sediment matrix is important because the K_{OC} value is highly dependent on the level of organic carbon as evidenced by the equations below that are given and elucidated more fully by Hansen (1999).

The octanol-water coefficient can be measured experimentally, and there are empirical correlations available to relate K_{ow} to K_{OC}. A more rigorous method, however, to measure K_{OC} is to measure the distribution coefficient, a non-equilibrium constant denoted as K_D. It describes the soil-water partitioning for trace amounts of PCBs and is defined as

$$K_D = C_S / C_W$$

where C_S and C_W are the concentrations of the chemical in the soil and water phases, respectively. Once this trace partitioning constant is found experimentally, a general relationship for K_{OC} is

$$K_{OC} = K_D / f_{OC}{}^\dagger$$

where f_{OC} is the fraction of organic carbon in the soil/sediment matrix. Strictly speaking the distribution coefficient is not proportional to K_{OC} because the distribution coefficient is not based on equilibrium (C_S and C_W are not at equilibrium values), and K_{OC} is an equilibrium value. The partition coefficient K_P is truly an equilibrium constant (C_S and C_W are at equilibrium values) which K_D will approach with time, and it is the K_P which is technically proportional to the K_{OC} as shown

$$K_{OC} = K_P / f_{OC}$$

Hansen was speaking, however, in a context in which K_{OC}'s were being measured and evaluated in experimental situations, and it is often more practical to assume that the K_D is being measured and to use it like a K_P rather than to wait what could be a prohibitive amount of time to reach equilibrium.

Thus it is seen that the organic carbon-normalized partition coefficient can be found two ways. One way uses empirical correlations relating K_{OC} to the PCB water-octanol relationship, and the second way uses the PCB soil-water partitioning relationship at low PCB concentrations with the fraction of organic carbon in the media of concern.

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† In the application of K_{OC} to soils and sediments, this relation should hold up quite well. It should be remembered, however, that the polarity of the organic matter will also play a large role in PCB partitioning. Thus, in biological media such as lipids, which are highly polar, this relationship will not be enough to fully conceptualize and model PCB transport.

Thus, for the purposes of the PCB TMDL project, the characterization of sediment-water partitioning of PCBs would depend heavily on the understanding of the organic carbon content and behavior of either suspended particles in the water column or deposited sediments. In the interest of providing some quantitative values (while acknowledging that there are many other values that could have been chosen) for K_{OC} the data from two studies both provided in Hansen (1999) on three kinds of soils which were averaged together are presented in Appendix A. It should be noted that this dataset will certainly show trending in partitioning behaviors between different congeners, but there is no reason to assume that the soil used to get these K_{OC} values is in anyway similar to sediment media that might be found in the HSC.

2.3   TOXICITY AND HEALTH ASPECTS

2.3.1   Health Effects

The health effects of PCB exposure can be grouped into two categories: occupational/accidental exposure and environmental exposure. The reason for the categorization of exposure is that generally occupational/accidental exposure to PCBs is resultant from some large quantity event-based (acute) exposure while environmental exposure is more long-term and accumulative (chronic). The effects of the different exposure types in humans can be quite different.

2.3.1.1 Occupational/Accidental Exposure

There have not been large data sets on heavy dose human exposure of PCBs other than a few well known exposure accidents from which many conclusions have been drawn. The two refernced incidents happened in 1968 and 1978 in Fukuoka, Japan and Taiwan, respectively. Both exposures involved PCB contamination of rice, and the symptoms of that exposure have since been called Yusho rice oil disease. (George, 1988)

The Agency for Toxic Substances and Disease Registry (ATSDR) characterizes symptoms of PCB exposure in "Yusho rice oil disease". Skins affects from the exposure include chloracne and rashes. In addition, there is evidence of liver damage. (ATSDR, 2000)

The full range of health effects that have been observed to one degree or another by the ATSDR include the following: liver, thyroid, dermal and ocular changes, immunological alterations, neurodevelopmental changes, reduced birth weight, reproductive toxicity, and cancer. (ATSDR, 2000) Many of these effects arise at increasingly higher dosages of PCBs.

2.3.1.2 Environmental Exposure

Most of the general population will encounter PCBs through environmental exposure in air, water, soil, and food. Yet the primary exposure pathway is through food, especially fish. (ATSDR, 2000) PCBs can be found in nearly all world populations to some degree due to their large-scale global transport. This ubiquity in populations occurs in both diets that include fish and diets that do not include fish. Studies involving non-fish eating individuals showed mean serum concentrations of PCB in the range of 0.9-1.5 ppb. (ATSDR, 2000) Thus when human PCB exposure amounts are discussed, this background level of PCBs found in nearly all populations needs to be considered before assessing a population as having a higher PCB health risk.

Studies involving animals which consumed large quantities of food containing PCBs showed symptoms of immunal system changes, behavioral alterations, and impaired reproduction. (ATSDR, 2000) It is likely that an individual who consumed PCB-contaminated food which led to PCB bioaccumulation in adipose tissue could show similar effects.

2.3.1.3 Carcinogenicity

The toxicological community has not been able thus to far to say with absolute certainty that PCBs are carcinogenic. Both the Department of Health and Human Services (DHHS) and the International Agency for Research on Cancer (IARC) list PCBs as probably carcinogenic. These carcinogenic determinations were made based mainly on the overwhelming amount of animal exposure data, which unequivocally show PCBs to be carcinogenic to animals. The combination of definitive evidence in animals combined with the suggestive evidence in humans makes PCBs as a chemical class a very likely carcinogen. (ATSDR, 2000)

2.3.1.3 General Toxic Effect and Exposure Levels

ATSDR acknowledges that although there is a strong evidence of toxicity from exposure to PCBs, it is difficult to link a particular health effect to a particular congener. This difficulty results from the fact that observations of exposure are usually made on congener mixtures. So separating out one congener's effect from another is difficult and the interactions between the different congeners have not yet been determined. (ATSDR, 2000)

So in the knowledge that PCBs do exhibit toxicological effects (though these effects are not linked to particular congeners or Aroclors), the ASTDR has derived some Minimum Risk Levels (MRLs). The intermediate-duration oral exposure (15-364) days is 0.03 ug/kg/day, and the chronic-duration oral exposure (>364 days) is 0.02 ug/kg/day. An inhalation MRL could not be determined due to insufficient human and animal data. (ATSDR, 2000)

2.3.2   Toxic Equivalency Factors

PCBs are part of a larger class of toxic compounds that include polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs). The correlation between the similar toxicological properties of PCDDs and PCDFs was noted by the Ontario Ministry of the Environment in 1983, and the Ministry at that time drafted the first document that attempted to standardize the way that different PCDDs and PCDFs (all generally called "dioxins") were to be toxicologically quantified. (USEPA, 2003) The method that was developed employed the use of Toxic Equivalency Factors (TEFs), and the concept is still used as the standard today.

The way that TEFs are used is to quantify the toxicity of any one congener relative to a reference congener. This can be done for any PCDD, PCDF, or a "dioxin-like" PCB. The referenced compound that was originally chosen was 2,3,7,8-TCDD. It is shown to have the highest toxicity of all dioxins and dioxin-like PCBs, and its toxicity is also the best understood. So the TEF for 2,3,7,8-TCDD is 1.0, and every other congener has a TEF which is some fraction of 1.0. The TEFs are essentially used as a means to scale the concentration of each congener in the environment by its toxicological potency. When these potencies are added together, a Toxic Equivalency Quotient (TEQ) results

$$TEQ = \sum_{n=1}^{k} C_n * TEF_n$$

The method has been altered slightly throughout its history, but in that time it has become widely accepted by the environmental community with specific approvals from the USEPA, NATO, WHO and others. (USEPA, 2003)

2.3.2.1 PCBs in the TEF Scheme

Of the 209 PCB congeners, only 12 show "dioxin-like" toxicity. Most PCB congeners have some relevant level of toxicity to be considered, but the TEF scheme focuses only on organic compounds whose toxicological properties are similar to dioxins. In 1994, the WHO European Centre for Environmental Health and the International Programme on Chemical Safety attempted to gather all of the toxicological literature available on all of the PCB congeners in order to make a list of those with dioxin-like toxicity. The criteria that were used to determine which congeners made the list were:

1. Structural similarity to PCDDs and PCDFs
2. Ability to bind to the Ah receptor in the human body
3. Dioxin-specific biochemical and toxic response
4. Persistence and accumulation in the food chain

The final list (1998 latest revision) contained only 12 of the potential 209 congeners. For these select 12, TEFs were assigned (Table. 2.1) These 12 are PCB-77, PCB-81, PCB-105, PCB-114, PCB-118, PCB-123, PCB-126, PCB-156, PCB-157, PCB-167, PCB-169, and PCB-189.

Table 2.1 PCB TEFs in the TEQ-WHO$_{98}$ Scheme

IUPAC Number	Chlorination Level	TEF
PCB-77	Tetra-chlorinated	0.0001
PCB-81	Tetra-chlorinated	0.0001
PCB-105	Penta-chlorinated	0.0001
PCB-114	Penta-chlorinated	0.0005
PCB-118	Penta-chlorinated	0.0001
PCB-123	Penta-chlorinated	0.0001
PCB-126	Penta-chlorinated	0.1
PCB-156	Hexa-chlorinated	0.0005
PCB-157	Hexa-chlorinated	0.0005
PCB-167	Hexa-chlorinated	0.00001
PCB-169	Hexa-chlorinated	0.01
PCB-189	Hepta-chlorinated	0.0001

Source: (USEPA, 2003)

TEFs in connection with PCBs are mentioned here because they are linked topics. It is noted, however, that this focus of this project is towards a total PCB TMDL. Thus, while dioxin-like toxicity is an important consideration, it will not be a focal point of this study since all PCBs need be considered regardless of how much toxicological similarity they have to dioxins.

2.3.3   Toxicity as Related to Chemical Structure of Congeners

It is valuable to mention a structural distinction in PCB called coplanarity or what is seen in the literature as "coplanar PCBs". This structural class of PCB compounds has physical and chemical properties which often differ from the rest of PCBs, but the greatest differences in coplanar PCBs are that these PCBs are far more toxic than non-coplanar PCBs.

PCBs (as shown in section 2.2.1.1) can be extremely varied in chemical structure as mainly determined by the points of chlorine substitution on the aromatic rings. Experience and study have shown that PCBs which are chlorinated at both meta positions and one or two para positions assume a chemical conformation of coplanarity, a situation

where both phenyl rings are in the same plane. Incidentally, these substitutions often mean that the ortho position on the rings is either "mono-ortho" or "non-ortho" substituted, which is another way of referring to coplanar PCBs. (Metcalfe, 1995)

Many sources have pointed that coplanar PCBs have been shown to exhibit greater toxicity than other PCB congeners. This is reflected quantitatively by the TEF schemes which include only particular PCBs in their structure. Similarly the EPA presents only 12 of the 209 PCB congeners as having "dioxin-like toxicity". The EPA states that these PCBs are structurally similar in that they have "four or more lateral chlorines (chlorines at the meta and para positions) and one or no chlorines at an ortho position." (USEPA, 2003) The scientific literature also shows that coplanar PCBs are studied heavily as a contaminant subclass ever since congener-specific GC analysis was made more accurate and available.

The explanation given for the greater toxicity of coplanar PCBs is a chemical analogy. The fact that these PCBs become structurally coplanar gives them a molecular size, configuration, and chlorination pattern fairly similar to 2,3,7,8-TCDD. (Huang, 2002) Thus for many of the reasons that 2,3,7,8-TCDD has the highest TEF in the TEF scheme so coplanar PCBs are also more toxic over their non-coplanar cousins.

Thus, non- and mono-ortho PCBs present a higher level of toxicity among the larger class of PCBs. The toxicity is variable depending on the species, but the toxicity is still higher in general. (Ayris, 1997) Furthermore, in the greater picture of TEQ from all dioxin-like compounds, coplanar PCBs can play a significant role due to the combination of moderate toxicity and relatively higher concentration. This is so much so that even in environments where there are also high levels of PCDDs and PCDFs, there are often more toxic equivalents as resulted from coplanar PCBs than from PCDDs and PCDFs. (Smith, 1990)

Tanabe (1987)found that coplanar PCBs were a smaller fraction of the total PCB concentration in marine and terrestrial biota collected from areas around Japanese seas. Non-coplanar PCBs were on the order of parts per million while the coplanar PCBs were on the order of parts per billion. Yet these coplanar PCBs still are much higher than the

parts per trillion concentrations normally found in PCDD/Fs in these environments. Thus, these PCBs present as great a risk or greater a risk than dioxins due to the higher concentrations despite a much lower level of toxic potency.

The high levels of PCBs in portions of the Laurentian Great Lakes have been known for quite some time, and these lakes also contain concentrations of PCDD/Fs. In this environment, coplanar PCBs may account for over 95% of the dioxin like activity affecting the biota of the Great Lakes. (Metcalfe, 1995)   In genera,l it is seen that studies from Japan, Sweden, Finland, and North America on species including fish, wildlife, and humans have all shown that 90% of the toxic burden from Halogenated Aromatic Hydrocarbons (HAHs)was from coplanar PCBs and not from other PCBs, dioxins, or dibenzofurans. (Metcalfe, 1995)

Some studies show that in air, coplanar PCBs may not be a majority of the TEQ in air media. Kurokawa et al. found in atmospheric samples over both summer and winter that the contribution of coplanar PCBs to total dioxin toxicity was only 4.9%. (Kurokawa, 1996) The significance of understanding the levels and behavior of coplanar PCBs then can be seen in aquatic environments and merits special consideration in any study seeking to lower the risk in PCB-contaminated waters.

2.3.4   Maximum Contaminant Levels

The Maximum Contaminant Levels (MCLs) for PCBs in various media and food products are shown in Table 2.2. The toxicity and especially the potentially carcinogenic activity of PCBs drive the MCLs to fairly conservative values.

Table 2.2 Federal PCB MCLs in Various Media and Food

Media	Level	Agency
Drinking Water	0.5 ppb	USEPA
Lakes and Streams	0.17 ppt	USEPA
Infant and Junior Foods	0.2 ppm	FDA
Eggs	0.3 ppm	FDA
Milk and Dairy Products	1.5 ppm	FDA
Fish and Shellfish	2 ppm	FDA
Poultry and Red Meat	3 ppm	FDA

Source: (ATSDR, 2000)

On the issue of the rationale behind the drinking water standard set by the EPA, they state that, "given present technology and resources, this is the lowest level to which water systems can reasonably be required to remove this contaminant should it occur in drinking water." The Maximum Contaminant Level Goal (MCLG) for PCBs is zero. (USEPA, 2006)

2.3.5   Regulatory Views on Toxicity

2.3.5.1 National Regulations

There are three main national regulations for PCBs:

1. The Clean Water Act of 1972 (Amended several times since)
2. The Toxic Substances Control Act (TSCA) of 1977
3. The Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) of 1980

The Clean Water Act gives the federal government authority to assign and enforce the MCLs that were mentioned previously. Even more relevant to this project, section

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303(d) of the Clean Water Act is the statute that authorizes the TMDL program for noncompliant water bodies.

The TSCA was the first piece of legislation that mentioned PCBs directly within its writing. The TSCA ended the production, distribution, and importation of PCBs into this country in 1977. There were also provisions in the act that required all transformers that used PCBs to be sealed and eventually phased out. The EPA also established a "TSCA spill policy" in 1987 that dictated the following cleanup levels of all PCBs spilled post-1987.

Table 2.3 TSCA-Mandated PCB Clean-up Levels

Media	Access Type	Enforceability	Clean Soil Depth	Level
Soil	Restricted	Required	N/A	25 ppm
Soil	Unrestricted	Required	10 in	10 ppm
Soil	Unrestricted	Required	0 in	1 ppm
Soil	Restricted	Recommended	N/A	$100ug/100 \ cm^2$
Soil	Unrestricted	Recommended	N/A	$10ug/100 \ cm^2$

CERCLA (commonly referred to as Superfund) affects PCBs only as they relate to cleanup at sites polluted prior to 1987. The cleanup levels for these sites are made on a case-by-case basis, and the "starting points" for PCB sites are 1 ppm for residential and 10-25 ppm for industrial. (Shifrin, 1998)

An attempt was made in 1994 to consolidate all of the statutes, policies, and guidance materials on PCBs into PCB Disposal Amendments commonly known as the "PCB megarule". (Shifrin, 1998) That rule was finally enacted on June 29, 1998, and its main adjustments to TSCA involve more flexibility and clarification in the disposal and handling of PCBs and PCB wastes. (USEPA, 1998)

2.3.5.2 State of Texas Regulations

Surface water quality is regulated in the State of Texas under Title 30 Texas Administrative Code Chapter 307. The Texas Surface Water Quality Standards (§307.1-307.10) include human health water quality criteria for total PCBs (based on Aroclors) of 1.3 ng/L and 0.885 ng/L in freshwater and saltwater, respectively. These concentrations are lower than the MCL for drinking water due to the fact that the highest exposure potential of PCBs in waters is through the bioaccumulation potential and consumption of contaminated fish (Webster et al. 1998). Additionally, fresh and saltwater criteria differ because it is assumed that consumption rates are higher for saltwater species.

The Texas Department of Health based its health assessment of PCBs in the Houston Ship Channel (TDH, 2001 and 2006) on a screening level of 47 ng-Aroclor/g-tissue. This screening value was derived from an EPA chronic oral reference dose (RfD) for Aroclor 1254 of 0.00002 mg/kg/day .

There also is a state established PCB Advisory Group made up of volunteers whose purpose is to discuss the current Texas regulation on PCB analysis. This regulation is currently listed under Title 30 Texas Administrative Code 350.76(d), and it specifies Aroclor-based analysis methods. The advisory seeks to provide legislative advisory to a changeover from an Aroclor based analysis to a congener specific analysis method. Their information may be found on the TCEQ website at http://www.tceq.state.tx.us/remediation/trrp/pcb_group.html. More discussion on current analysis methods is given in Section 3.1.

2.4   MAJOR SOURCES OF PCBS

As was noted in the historical section of this report, PCBs have not been produced in the Unite States since 1977. An estimate of the amount of PCBs produced globally between 1929 and 1979 is 1.5 million metric tons. (De Voogt, 1989) Large–scale disposal continued for some time after the cessation of production, but at present there are few primary sources of PCBs to the environment. Most PCBs that enter a particular water body or biosphere are transported from another contaminated environment and are thus secondary sources.

2.4.1   Primary PCB Sources

The EPA states that "no significant release of newly formed dioxin-like PCBs is occurring in the United States." While the EPA acknowledges that waste combustion can yield small amounts of PCBs, they contend that these sources are not significant and that all significant sources of PCBs are from past production, use, and disposal. (USEPA, 2003) The EPA's statement is directed mostly towards the "dioxin-like" PCBs (which are nearly synonymous with the coplanar PCBs as discussed in a previous section), but since most of the historical primary sources released both coplanar and non-coplanar PCBs, it is reasonable to say that there are no significant releases of any newly formed PCBs (dioxin-like or not dioxin-like).

PCBs were once sourced to the environment by way of production, use, and disposal. Now disposal is likely the only they enter the environment. There are four main methods of disposal that still occur (USEPA, 2003):

- Large Amount PCB Disposal (>2 pounds): Dielectric fluids from transformers and large capacitors, which are disposed according to regulations.
- Small Amount PCB Disposal (<2 pounds): Disposal of small capacitors, light fixtures, and waste papers in municipal landfills.

- Leaks and spills from devices that still contain PCBs.
- Illegal PCB disposal

The EPA gives four quantified primary sources for PCBs as estimated in 1995 which are shown in Table 2.4. All are quite small in comparison to the total annual production of PCBs during any year between 1929 and 1977.

Table 2.4 Primary Source Quantities Listed by the EPA in 1995

Source Type	Receptor Media	Amount (g TEQ_P-WHO_{98}/yr)
Cigarettes	Air	0.016
Backyard Barrel Burning	Air	42.3
Municipal Sludge Disposal	Land	51.1
Municipal Sludge Disposal	Products	1.7

Source: (USEPA, 2003)

2.4.2   Recent Studies Concerning Primary Sources

Studies have shown that urban centers still supply an air source of PCBs by virtue of the difference in air concentrations of PCBs over time in urban areas as compared with rural areas. The specific increases are on the average around 7 times higher for urban areas over rural areas with greater emphasis placed on lighter weight PCB congeners. The cause of the urban source is believed to be domestic burning of coal and wood based on meteorological dependencies which followed the patterns of combustion-generated PCDD/Fs. (Lohmann, 2000) Urban sources were confirmed earlier by Halsall (1995), and they noted the additional detail that the strength of these urban sources varied with season. The summer source air concentration was shown to be greater than the winter source concentration by as much as 5 times due to previously deposited PCBs experiencing greater volatilization in warmer weather.

Some researchers have noted that what might be seen as a secondary source of PCB emissions is in fact a re-emission from water, soil, and sediment concentrations.

Temperature increases can volatize more old sources of PCBs and make them appear as new sources. (Breivik, 2004)

It should also be noted that PCB coproduction was at least considered a possibility for a new primary source after the production ban of PCBs. It was estimated in 1982 that the USA alone produced 50 tons of PCBs annually as byproducts in the production of other organic chemicals. The EPA in 1982 rated at least 80 chemicals (54 major classes shown in Table 2.5) with the potential of having PCB byproducts in them. (De Voogt, 1989) Byproduct PCBs were a large enough consideration that the EPA produced a report on the GC/MS analysis of PCBs in commercial products. (Erickson, 1988) More recent data has not been found on this topic, and the EPA has not listed coproduction of PCBs with other industrial and commercial products as a source to the environment. Therefore, it is not clear if coproduction is considered to be a major source.

Table 2.5 Potential PCB Coproduction Chemicals or Chemical Classes

Ally amines	Chlorinated, brominated methanes
Allyl alcohol	Chlorinated, flourinated ethylenes
Aluminum chloride	Chlorinated, flourinated methanes
Aminochlorobenzotrifluoride	Chlorinated, fluorinated ethanes
Aminoethylethanolamine	Chlorinated, unsaturated paraffins
Benzene phosphorous dichloride	Chlorobenzaldehyde
Benzophenone	Chlorobenzyl hydroxyethyl sulfide
Benzotrichloride	Chlorobenzyl mercaptan
Benzoyl peroxide	Chlorobenzyl peroxide
bis (2-chloroisopropyl) ether	Dimethoxy benzophenone
Carbon tetrafluoride	Dimethyl benzophenone
Chlorendic acid/anhydride/esters	Diphenyl oxide
Chlorinated acetophenones	Epichloryhydrin
Chlorinated benzenes	Ethylene diamine
Chlorinated benzotrichlorides	Glycerol
Chlorinated benzotrifluorides	Hexachlorobutadiene
Chlorinated benzylamines	Hexachlorocyclopentadiene
Chlorinated ethanes	Linear alkyl benzenes
Chlorinated ethylenes	Methallyl chlorides
Chlorinated methanes	o-Phenylphenol
Chlorinated naphthalenes	Pentachloronitrobenzene
Chlorinated pesticides	Phenylchlorosilanes
Chlorinated pigments/'dyes	Phosgene
Chlorinated propanediols	Propylene oxide
Chlorinated propanols	Tetrachloronaphthalic anhydride
Chlorinated propylenes	Tetramethylethylene diamine
Chlorinated, brominated ethylenes	Trichlorophenosy acetic acid

In the discussion of contemporary primary PCB sources, it is important to remember that :

- The concentrations and variations in concentrations which are being measured to characterize a source are quite small and thus are easily invalidated by measurement errors.

- What might be seen as a secondary source of PCB emissions is in fact a re-emission from water, soil, and sediment concentrations. Temperature increases can volatize more old sources of PCBs and make them appear as new sources. (Breivik, 2004)

These considerations as well as the incomplete conclusions just presented show that the current state of contemporary anthropogenic PCB emissions coming by unintentional means requires more study to understand and quantify how much might really be produced and which congeners are more likely from those production sources. (Breivik, 2004)

2.4.3   Secondary Sources

Secondary sources are more appropriately covered under the topic of environmental fate and transport, and that is where the details and mechanisms of those sources will be. In a general sense, however, it is useful to see how all of these secondary sources work in concert to transport PCBs even on a global scale.

Swackhamer (1996) developed a total mass balance on the Great Lakes PCB system in 1996 which shows a reasonable concept for secondary PCB sources in any large body of water. The balance showed that the Great Lakes were mostly in a steady state of total influx to out flux of PCBs, but the internal transport processes are the mechanisms by which that steady state is maintained. The major sources Swackhamer lists and discusses are atmospheric deposition (mainly to water in this case although it also occurs to land) and its reverse process, volatilization from water to air. The other "sources" which should be considered include the partitioning from water to sediment and sediment back to water. These would only be considered sources insofar as the reference sink is just the sediment or just the bulk water phase outside of the sediment pore spaces.

2.5   ENVIRONMENTAL FATE AND TRANSPORT

2.5.1   Atmospheric Deposition and Air Transport

In general, transport of PCBs in air to water bodies happens via two sequential mechanisms. Once the PCBs have entered the air (via combustion, soil desorption, or water-air volatilization), they will be transported over the globe with distances depending on their half-life in the atmosphere. Within this mechanism, they will either move as free phase vapor or sorbed onto atmospheric particulates. If the PCBs make their way to a place where they can either be sorbed onto soil or dissolved into a body of water, they will either be wet deposited as rain or dry deposited via mass transfer across a water-air interface.

2.5.1.1 Air Transport

The general concept that one finds in atmospheric PCBs is that PCBs are partitioned between gas and particles phase.   The partitioning between these phases depends generally on the amount of chlorines that are on the congener. More chlorination means that there is a greater tendency to remain in the particle phase.   This translates to a lower vapor pressure. Therefore, it is also reasonable to say that lower vapor pressure leads to greater partitioning to the particle as well.

Another parameter to consider is temperature where a lower temperature is more favorable for congeners to remain on the particles. (Atkinson, 1996) This temperature dependency seems generally intuitive as one considers that increased temperature means that each particle has more energy. More energy means that more of the particles will be in the more energetic gaseous state over the particle bound state.

The quantification of PCB molecules as being particle-bound versus being in the gas phase is important in understanding atmospheric half-life. Atmospheric deposition to

water or land can occur in either phase, but half-life is highly related to the phase. The only significant PCB degradation reaction that occurs in the atmosphere is the reaction with the OH radical (Atkinson, 1996), and this reaction is believed to occur primarily on gas-phase PCBs. Atkinson (1996) has documented this reaction rate thoroughly to yield general comparative half-lives of 0.8-3 days for air-phase PCBs and 5-50 day half-lives for particle-bound PCBs. These half-lives enable PCBs to travel great distances from an original primary or secondary source with the result that regions having little PCB contamination history can become a sink for them. But one should note that these half-life determinations are made without a strong body of quantitative kinetics understanding of the OH radical reaction with particle-bound PCBs. (Wania, 2002)

While the understanding of the fundamental kinetics of the OH radical reaction is helpful, atmospheric transport of PCBs cannot simply be predicted on the basis of the OH radical reaction. One also needs to consider the variability of OH radical concentration in the atmosphere as well as temperature, which affects the rate of the reaction and the amount of PCB which can easily react in the air due to gas/particle partitioning. (Wania, 2002)

Another factor to consider in time of transport is the volatility of the congener. More volatile PCBs travel farther than less volatile ones with the result that PCB mixture compositions will change with distance. (Agrell, 1999) In addition, Wania (2002) estimates that lighter PCB congeners remain in the atmosphere for 1 month while heavier congeners could spend more than a year in the atmosphere. These determinations are made based on modeling the combinatorial effects of OH radical degradation, air-particle partitioning, and relative congener volatilities. These factors and potentially others need always to be considered in PCB air transport. Another important conclusion from the differences in travel and half-life between congeners is that the composition of a PCB mixture will change throughout the transport. This compositional change makes the accurate analysis of an environmental sample all the more crucial in the area of resolving specific congeners, and it also means that tracing an air signature back to an original Aroclor is more difficult.

2.5.1.2 Deposition

The scale of travel distance for PCBs to places as remote as the arctic (Hung, 2001) shows that deposition from the atmosphere to water sources is a significant transport mechanism to understanding the temporal flux of PCBs to a region. In the case of these more remote areas, it is not only a significant source, but it is the only source of PCBs.

Some site-specific studies will convey some conceptual information about the nature of atmospheric PCB deposition. For example, PCBs were found in the Andes mountains in snow samples. This transport was likely by atmospheric transport and deposition processes, which in this case were wet deposition. PCB 52 was among the highest of the congeners present in the snow, which is similar to results found in Canadian snow (Barra, 2005)

The Andean snow example illustrates how precipitation can eventually get to water bodies by runoff and snowmelt (with some clear losses occurring on the way from PCBs sorbing to soils). Studies have been performed in the Baltic Sea which illustrate the dynamics of the volatilization-deposition balancing processes. In fact, gaseous air/sea exchange is one of the most important processes governing the fate of PCBs in the Baltic Sea. (Axelman, 2001) The general congener specific patterns of net volatilization to net deposition are that the higher chlorinated, more hydrophobic PCB congeners have much lower volatilization tendency, and thus they are more likely to remain transported in the surface water on particulate organic matter. (Bruhn, 2003) The opposite would obviously be true that lower chlorinated, less hydrophobic PCBs have a greater escaping tendency to the air. So from a depositional standpoint, water bodies should enrich in higher chlorinated congeners with time . And unfortunately for the state of the aquatic systems, these higher chlorinated congeners are also more recalcitrant and contain the greater toxicity coplanar PCBs.

One final note on deposition to water bodies in the example of the Baltic sea is that the determination of net direction of flux is difficult. Bruhn et al. note that the partitioning conditions in the surface water body, and the amount of PCB already present from other sources (such as sediment desorption to water) would determine if the surface water is a net PCB source or sink. One example of this is in the Baltic Sea where there is even disagreement about whether the surface water is a net sink or source based on parallel studies. (Bruhn, 2003) Thus the decision of whether the surface water system in question is in equilibrium, net PCB flux to water, or net PCB flux to atmosphere is highly dependent on local conditions and may not even be understood well enough in the environmental community to ascertain with certitude.

2.5.2   Water Transport

Characterizing PCB contaminant levels is complicated for at least two main reasons. Firstly, the levels of contaminant that one deals with are of a very small order due to low solubility of PCBs as well as high dilution amounts in large bodies of water. The second reason for the complication is that PCBs are distributed in the water column between a truly aqueous dissolved PCB phase and a PCB phase which is bound to suspended particles. This latter consideration becomes significant when PCB water concentrations are taken and reported since some sampling methods seek to get only the dissolved PCB concentration while others get an aggregate concentration that combines both PCB phases. Zhou et al. found that mass balances are extremely hampered by the distribution between solid particles and aqueous concentrations of PCBs. In that study, the concentrations did not follow a theoretical dilution line for different regions of the water body, and they speculate that reason for this non-conservative behavior is that PCBs are often removed from the water column by partitioning to suspended particles. (Zhou, 2001)

The main transport and fate mechanisms within the water column itself are:

- Vaporization to air which can occur from either the particle-bound or aqueous phases.

- Solid-aqueous phase partitioning of PCBs either to sediments or suspended particles (these particles may or may not be considered sediment depending on size and source).

- Transport from one body of water to another via particle bound PCBs.

- Elimination and transformation of PCBs in the water through microbially mediated reactions.

2.5.2.1 Volatilization

Many studies have been performed to characterize the volatilization of PCBs all of which should be considered in their specific environmental context before being applied broadly.

As in the case of atmospheric deposition to water, the general state of the water body can be characterized as transient or steady-state. Data from the Wadden Sea in the Netherlands showed in general an equilibrium between the air and water PCB concentrations in time that varied over different seasons. Variations from equilibrium were very minor. (Booij, 2001) This brings up the general issue of seasonal variations in volatilization rates, and these seasonal variations occur largely because of temperature changes with season.

PCB volatilization is a function of temperature, and it is a stronger function of temperature with the increasing level of chlorine on the congener. (Breivik, 2004) The presumable reason for the greater response of higher chlorinated PCBs to temperature is that these PCBs are in general less volatile than the lighter PCBs. Thus since a good portion of lower chlorinated PCBs will already volatize at many ambient air temperatures, the higher chlorinated PCBs will not volatize in more significant levels until the temperature is increased. Hence the greater response to temperature changes.

Lake Superior shows this trend in response to temperature change as the volatilization occurred at its highest rate in the fall when temperatures were higher and there was actually a net deposition in the spring when temperatures were colder. But the net yearly flux was a loss from the water due to volatilization, not a gain from deposition. (Hornbuckle, 1994) This could indicate that volatilization is more sensitive to temperature swings that deposition, but this has not been proven in a general sense.

Another Lake Superior study conducted showed PCB concentrations from 1978-1992 decreasing in time but that the loss from the water was heavily dominated by volatilization and not by sedimentation.(Jeremiason, 1994) The decrease in lake PCB concentrations from 1978-1992 was clearly related to the historical decrease in global industrial PCB production, but the study showed that even after those effects were removed, PCB levels were decreasing with volatilization as the main mechanism for the decrease.

The kinetics of degradation by volatilization were also available from two Great Lakes studies. One study showed that the decay of PCB concentrations in the water column was first order with a rate constant of 0.20 yr^{-1}. The main mechanism for this decay was volatilization even as atmospheric deposition was occurring. (Jeremiason, 1998) Pearson et al. reported a first order water PCB degradation rate in neighboring Lake Michigan of 0.078 yr^{-1} in the second study. (Pearson, 1996)

As is the case with many of these transport mechanisms, PCB mixture composition is important to ascertain as well as overall PCB levels. To that end, Dachs et al. found that in the Mediterranean, the higher chlorinated congeners were higher in relative proportion closer to the coast and that the lower chlorinated congeners were in higher proportion out in the open waters. The main reason given for this was the distance which lower chlorinated PCBs can travel in the atmosphere versus higher chlorinated PCBs. (Dachs, 1997)

2.5.2.2 Solids Partitioning

For suspended particles, the understanding of water to solid partitioning is crucial to predicting and quantifying sorbed PCB concentrations. One important consideration to keep in mind (as in the case of volatilization) is that temperature is a strong determinant of partitioning. (Burkhard, 1985)

PCB sorption onto suspended particles is also strongly correlated to levels of Particulate Organic Carbon (POC). A study in the Netherlands found that POC is the key factor to the concentration of PCBs in boundary layer water from particle sorbed with PCBs. They found their POC levels to be on the order of 7-16 g/L. (Booij, 2003) Marti et al. found the correlation of POC and PCB water concentrations particularly useful when combined with the variable of water depth. They noticed a general trend of decrease in PCB with increasing depth that correlated to a decrease in POC. The effect was particularly pronounced in the first 200 meters. (Marti, 2001)

Other researchers have made more detailed observations about the role of solid particles in PCB contaminant levels. Sobek (2004) found that the greatest source of POC (at least in total mass of particles) was from phytoplankton. They contend that POC is also believed to be a large source of deep water PCB concentrations, and more study is needed to understand the nature of this partitioning especially as it relates to phytoplankton as the biogenic source of POC.

Marti (2001)also consider biogenic POC by making the distinction in water-suspended particle partitioning between large and small-size particles. The small-size particle partitioning appears to be governed more by the physical partitioning process whereas as larger particles, generated more from biogenic processes, acquire sorbed PCBs from the food chain process. The latter process (which correlates to the phytoplankton source discussed by Sobek (2004)) would favor higher chlorinated congeners since these congeners are more bioaccumulative and would be present in higher proportion within an organism.

As depth increases in the water column, one needs to consider solid-aqueous partitioning in terms of deposited sediment as well as in suspended particles. The Booij et al. study in the Netherlands on "pore water" (water moving in and out of sediment beds) data showed aqueous PCB concentrations of 37 pg/L for the lower chlorinated congeners and as low as 0.01 pg/L for the higher chlorinated congeners. This was in an area near a former chlorobenzene waste discharge. (Booij, 2003) The difference in concentrations shows the greater affinity of the higher chlorinated congeners for sediment particles and leads to the conclusion that these congeners can accumulate and persist in sediment beds more than the lower chlorinated congeners.

2.5.2.3 General Behavior in the Water Column

The less volatile, more lipophilic congeners can concentrate in the water column over time relative to the more volatile congeners. In a China study, all water samples contained most of the possible congeners, but three highly chlorinated congeners accounted for 94% of the total PCB concentration. (Zhou, 2001) The reasons for this enrichment include lower volatility, higher lipid solubility, more adsorption to sediments, and more resistance to microbial degradation. (Wan Ying, 1986) This increased concentration of higher chlorinated congeners seen by Zhou (2001) occurred in a scenario where runoff to the water column was a more major source than PCBs which could reenter the water column from sediments as was the case with Booij (2003).

2.5.3   Sediment Transport

2.5.3.1 Kinetics of Sediment Transport

PCB desorption/sorption processes from sediment are continually being characterized in the literature. Whereas many considered the process to be equilibrium

controlled, that view of the process has changed in the last 10 years to be more kinetic based. Gong et al. stated that in 1998, the standard toxic chemical fate and transport models for PCB desorption all assumed that PCBs desorbed by instantaneous equilibrium. (Gong, 1998) Cheng et al. rationalized this assertion further by stating that transport from resuspension of contaminated sediments needs to be considered kinetically especially for high K_{ow} contaminants of which PCBs are a prime example.   (Cheng, 1995) These authors and others set out to prove that the process needs to be modeled and conceptualized kinetically.

Some specifics of the kinetic understanding of PCB sediment desorption are presented here. A two stage kinetic model is accurate to describe PCB desorption from suspended sediments. The first stage is a fast release and the second stage is much slower. (Gong, 1998) Also, the rates at which individual congeners will desorb is based on their K_{ow} with the relationship being inverse. A higher K_{ow} has a lower rate of desorption due to the congener's hydrophobicity.   (Wu, 1986) The general half-lives of PCBs are given by ASTDR as months to years with half-life increasing with the level of chlorination. (ATSDR, 2000)

The Lake Superior study performed by Jeremiason et al. showed that PCBs on settling solids declined in a first order way with a rate constant of 0.26 yr^{-1}. The time trend data also showed that PCBs did not ultimately accumulate on the bottom lake sediment but instead recycled back into the water column at the bottom 5 m of the lake.(Jeremiason, 1998)

2.5.3.2 General Behavior of Sediment Transport

The Hudson River system showed high concentrations of PCBs, which was mostly attributable to sediment. Model predictions show that increasing amounts of cohesive sediment deposition combined with PCB flux to the water column from noncohesive sediments from pore water will lower the overall PCB sediment concentrations. (Connolly, 2000) Thus a distinction in sediment type between that

which is cohesive and that which is non-cohesive increases the accuracy of PCB transport predictions.

In the Baltic Sea, the highest concentrations of PCB sediment were found in the areas of highest sedimentation, not in areas close to probable pollutant sources. (Konat, 2001) So as in the case of the Hudson River, the sediment load was a significant source of PCBs to the system and should be focused on as much or more than historical waste PCB sources.

2.5.3   Biological Fate

The three main PCB fate processes to be considered in aquatic life are bioconcentration, biomagnification, and bioaccumulation.

A mechanism called bioconcentration occurs when an aquatic organism absorbs the PCB from water through the skin or gills. It is a real mechanism when the concentration in the organism is greater than the concentration in the surrounding water. (Harrad, 2001) In other words, PCB uptake into fish may be occurring in many waters, but if that uptake does not result in a net increase in concentration within the organism, then the effect is not quantifiable and therefore only marginally useful in transport analysis.

Biomagnification occurs when the concentration of PCB in the organism exceeds the concentration of the PCB in the dietary uptake. This can be difficult to quantify within a certain aquatic organism since there is an uptake from water (bioconcentration) as well as diet. (Harrad, 2001) It should also be noted that within biomagnification a biotransformation of PCBs can occur whereby one PCB congener is transformed to another or eliminated, which will alter the relative congener proportions. This effect can especially be at issue if the proportional augmentation tends toward the increase of coplanar PCBs.

Bioaccumulation is the combined effect of biomagnification and bioconcentration. Strictly stated, it is when the concentration within an organism exceeds

the concentration within the water when all routes of exposure are considered. (Harrad, 2001)

There is a distinction made for food-based bioaccumulation as a specific form of bioaccumulation that occurs when PCB concentration increases as one moves up the food chain. The reason that it occurs is because PCBs are transported through the food chain via the lipids that are consumed in the prey. When the lipid content within a predator is higher than the content in the prey, the new PCB concentration in the lipid of the predator will be increased. (Harrad, 2001)

One study illustrated this effect in Channel Catfish (a species found in the HSC) in the Clinch River/Watts Bar Reservoir. PCB levels in general were higher in Channel Catfish as compared with Largemouth Bass sampled in the study. The explanation the study gave was that the difference came from the "mode of benthic feeding" in the catfish and their higher body lipid content. Thus, higher body lipid content produces that bioaccumulative effect. (Adams, 1999)

One final note on metabolite biochemistry is that metabolism of PCBs can only happen when there is an adjacent pair of carbons that have no chlorine substitution. .This means that non-ortho and mono-ortho substituted PCBs (coplanar) that also have chlorine substitutions at the meta and para sites should be more resistant to metabolic breakdown. (Metcalfe, 1995) Hence these compounds are more susceptible to biomagnification within an organism.

2.5.3.1 Biological Variables

The biological processes heretofore mentioned are all characterized by experimental factors. The definitions used here were all given by Harrad (2001).

Bioconcentration is characterized by the bioconcentration factor (BCF), which is most appropriately expressed as the ratio of the concentration of the PCB in the organism (C_B) to the concentration of freely dissolved PCB in the water (C_{WD}) (PCB not absorbed through food uptake.)

$$BCF = C_B / C_{WD}$$

Biomagnification is quantified by the biomagnification factor (BMF). It is the ratio of the chemical concentration in the organism (C_B) and the concentration found in the organism's diet (C_D).

$$BMF = C_B / C_D$$

Bioaccumulation is measured with a bioaccumulation factor (BAF) and as stated previously attempts to take into account both of previous two factors. It is the ratio of chemical concentrations in the organism (C_B) and the water (C_W) and is usually a field-measured parameter.

$$BAF = C_B / C_W$$

The USEPA derives BAFs using this concept of bioaccumulation by defining a food-chain multiplier (FM) factor to quantify the bioaccumulation. The formula for the BAF in the EPA system is BAF=FM x BCF. (Harrad, 2001)

The BCF, BMF, and BAF are all experimentally measured factors that technically exist only in an accurately quantifiable way when equilibrium conditions are prevalent. It was noted in section 2.5.3.1 that a current understanding of sediment PCB adsorption and desorption is best described as kinetic rather than equilibrium controlled. The use of the biological variables needs then be considered in light of the kinetic processes occurring in the sediments at the base of the water column. The biological variables as described in this section may need to have their accuracy or application qualified, or they may need to be declared as erroneous altogether. One would need to characterize how kinetic the sediment transport is and then how much that transport affects the biological uptake being considered to justify the use of the equilibrium biological variables.

2.5.3.2 Factor Predictors

In trying to determine BAFs, which are the most useful in calculating the net transport of PCBs from the environment to aquatic organisms, it is important to note that

a high K_{ow} will decrease the usefulness of any BCF (which is derived normally under laboratory conditions). This is because the BCF measures the uptake of the PCB from the water to the organism, and since PCBs have a high K_{ow}, most of the exposure of the organism to PCBs comes from food and not from water. (Harrad, 2001) So, a method of calculating BAF that does not take into account BCF is a better estimator in the case of PCBs.

Octanol-water partition coefficients have frequently been in use in the determination of suitable Bioaccumulation Factors (BAFs) for quite some time as they are well known, and the models that use them are fairly easy to employ. One study shows that K_{ow} consistently under predicts the bioaccumulative effect of PCBs in both kinds of lipids involved in biota. These two types are neutral triglycerides and phospholipids. The error in triglycerides is considerably smaller than in phospholipids. Thus the error in BAF using K_{ow}'s in a food web model will be greater in lower trophic level organisms, where phospholipids make up a greater percentage of the total lipid amount. The authors conclude that the use of K_{ow} for BAFs is only sometimes justifiable. (Jabusch, 2005) Metcalfe and Haffner state that the uptake and elimination of non-ortho PCBs in aquatic biota cannot be predicted only from K_{ow}. (Metcalfe, 1995)

In a general sense, the researcher must decide how much effort must be given to the accuracy of a BAF especially when considering that transport mechanism relative importance to all other transport mechanisms. This consideration is valid because there are empirical models, semi-empirical models, and theoretical models for calculating BAFs, and all of these models require different degrees of effort to be used. Empirical models usually involve the calculation of a BCF from the laboratory or a BAF from the field. With the current understanding of the mechanisms of bioaccumulation, especially that which results from metabolic means of food uptake, these models are usually the most accurate albeit often more difficult and time consuming. The understanding of mechanisms within the organism is growing, which renders theoretical models more and more useful. (Harrad, 2001)

2.5.4   Forensics

The EPA effectively summarized the concepts behind forensic source discovery. Most PCB releases to the environment occurred as a mixture of PCB congeners in an Aroclor mixture. When PCBs are found in the environment today, however, the mixtures that one finds are normally different from the original source Aroclor. This change in composition occurs through partitioning, chemical transformation, and preferential bioaccumulation. (USEPA, 2003)

The forensic analysis of PCB mixture fingerprint could be attempted for primary PCBs from the middle of the century or from sources that still exist today. From a practical standpoint, however, the only sources which affect the water quality issues and what to do about them are the contemporary sources. Thus, these sources are where forensic analysis has found the most utility as seen in the following paragraph.

A Chicago study showed that some quantifiable air sources of PCBs were a sludge drying bed, a landfill, and transformer storage yard. The sum total of these sources was 90 kg/yr, which was not deemed to be significant due to the dispersion modeling performed. (Hsu, 2003) A study performed in San Francisco bay attempted to trace PCB fingerprints to particular Aroclor mixtures, and that was done with relative certainty. The authors then were able to speculate that sewage inputs or atmospheric deposition may be a continuing source to the bay. (Johnson, 2000) And a study conducted using Principle Component Analysis (PCA) on sediment samples in Green Bay, Wisconsin showed that a source of PCBs to Outer Green Bay was from the Fox River and not from Lake Michigan. (Cacela, 2002)

So the forensic process can be useful at characterizing both primary and secondary sources. In the case of the Green Bay study, the source identification required 1,189 sediment samples, which illustrates the time and expense that can be required to positively identify a source. Such identification, however, would be valuable to any TMDL study.

CHAPTER 3 – ANALYSIS AND SAMPLING METHODS

3.1 ANALYSIS METHODS

PCBs may be quantified as individual congeners, as Aroclor equivalents, or as homologue groups (i.e. monochlorobiphenyl, dichlorobiphenyl, etc). Historically, the most common PCB analysis has been through Aroclor analysis (EPA Methods 608 and 8082). However, the analysis of Aroclor may yield significant error in determining both total PCBs and their total toxicity. This is because the Aroclor method assumes that the distribution of PCB congeners in environmental samples and parent Aroclor compounds is similar (U.S. EPA, 2000).

Cogliano (1998) found that bioaccumulated PCBs are more toxic and persistent than the original Aroclor mixtures. Thus, the U.S. EPA (2000) recommends analysis of homologue groups or PCB congeners. However, it acknowledges that all health-based assessments are based on Aroclors. EPA (2000) suggests summing 18 congeners to compare to total PCB or Aroclor-based screening values, as recommended by the National Oceanic and Atmospheric Administration (NOAA) (1985). The 18 congeners the agency includes are PCB-8, PCB-18, PCB-28, PCB-44, PCB-52, PCB-66, PCB-77, PCB-101, PCB-105, PCB-118, PCB-126, PCB-128, PCB-138, PCB-153, PCB-169, PCB-170, PCB-180, and PCB-187.

Though the EPA uses these 18 NOAA congeners, the literature shows that some do not use these same 18 or use them in the same way. Some historical context will help demonstrate why. Two technical reports were created by NOAA (1985,1984) in successive years which gave the specifics of the NOAA method. These two reports were mainly created in order to aid NOAA's work in the National Status & Trends (NS&T) programs, which are currently the Benthic Surveillance Project and the Mussel Watch Project. A later NOAA technical memo called NOS ORCA 71 (1993) catalogued the history of the congener list through the original two technical reports and through what

was done in practice. It states that in 1984-1985, the NS&T program only quantified 8 PCB congeners (only two of these are in the NOAA 18 as defined by EPA) in order to extrapolate total PCB concentrations. That number was increased to 9 congeners by the NS&T program in 1986 to represent the nine chlorination levels of PCBs (C_2 to C_{10}), and it included 6 congeners from the EPA list. Then in 1987, the NS&T program added an additional 9 congeners to make a total of 18. All of those additional 9 are in the list that EPA recommends. Finally NOS ORCA 71 stated that in addition to taking a slightly different list of the 18 congeners that the total of the congeners should be multiplied by a factor of two as per statistical correlations found in the dataset. The congener lists for the different years and standards are listed in Table 3.1

Table 3.1 NOAA Method Congener Lists

Institution	NOAA NS&T	NOAA NS&T	NOAA NS&T	NOAA, EPA Recommended
Year	1984-1985	1986	1987	2000*
Congener Count				
1	7	8	8	8
2	31	28	18	18
3	47	52	28	28
4	101	101	44	44
5	153	153	52	52
6	185	170	66	66
7	194	195	101	77
8	206	206	105	101
9	-	209	118	105
10	-	-	128	118
11	-	-	138	126
12	-	-	153	128
13	-	-	170	138
14	-	-	180	153
15	-	-	187	169
16	-	-	195	170
17	-	-	206	180
18	-	-	209	187
Total Count	*8*	*9*	*18*	*18*
∑PCB Multiplier	*NA*	*NA*	*2*	*1*

*The 2000 "NOAA, EPA Recommended" method is referenced by EPA to a NOAA 1989 document which is most likely a mistaken reference. A document matching that title and edition could only be found for the NOAA (1985) document mentioned in the preceding paragraph.

The varied history of the NOAA methods available makes it difficult to determine which of the two main NOAA 18 methods should be used. NOAA (1989,1993,1998) have themselves referenced the NOAA NS&T 1987 method including the two multiplier in several Mussel Watch Project reports. Additionally, the wider literature shows that both Lauenstein (2002) and Fikslin (2003) have also used this method. So it is fair to say that there are many instances where the EPA's approved methodology is not used and other methods of representative congener totals are worth considering.

The main issue at hand concerning the analysis methods for environmental PCB samples is the federal approval of EPA Method 8082. This method was the first standard

method for PCB analysis and was adopted in July 1982 with the classic "SW-846" manual of analytical methods for solid wastes. At the time of the methods release, the quality of the analytical chemistry was not at a sufficient level to resolve all 209 PCB congeners. So the 8082 method attempted to establish the concentration of PCBs by assessing Aroclor levels in a sample. This simplification seemed reasonable at the time because the persistence of PCBs was known, and this persistence was assumed to preserve the Aroclor mixtures in their original industrial composition. Since this was the only method available on a large scale, all of the regulatory requirements for site characterization, water quality, etc. were written in terms of Aroclor concentrations, which were essentially taken as synonymous values with $\sum$PCB.

As has been evidenced by the previous chapter on fate and transport of PCBs, it is clear that the environment can significantly alter PCB mixture compositions from their original source Aroclor. The weathering that takes place from deposition, biomagnifications, partitioning, etc. can render any determination of Aroclor-based PCB concentrations completely inaccurate. At present, regulations remain as an Aroclor-based standard which may not provide an impetus for a changeover from Aroclor analysis to congener-specific based analysis. Even the EPA now states that it is "both imprecise and inappropriate" to extrapolate a concentration of PCB in the environment based on Aroclor content and the knowledge of the original manufactured Aroclor composition. (USEPA, 2003) What follows are some examples from the literature of the need for congener-based methods and what some of those methods could be.

A study performed by Sather (2003)compared the standard EPA Method 8082 results of Aroclor determination to a congener specific analysis using High Resolution Gas Chromatography/ High Resolution Mass Spectrophotometry (HRGC/HRMS) . The second method combined the full congener distribution to assign Aroclor values to the sample in order to establish a comparator for the two methods. The comparison reveals that method 8082

- Overestimates total PCBs for higher trophic level samples

- Has high variability

- May not be appropriate for nonbiotic samples

- Estimates the original source of Aroclor rather than what currently exists in the environment

The congener specific method in this study on the other hand showed an accuracy of PCB concentration for all trophic level samples, a true measure of total PCBs rather than any overestimation, and Aroclor levels that can still be assigned but they represent the true Aroclor composition currently in the sample.

There are methods that are in between a full congener analysis and the Aroclor based analysis. Duinker (1988) suggests the analysis of 6 representative PCB congeners which span wide range of chlorine substitution levels. The idea behind this type of analysis is basically that different chlorine substitution classes of PCBs can be extrapolated from a representative congener from that class.

The EPA has realized the need to go to more congener-specific methods just as the rest of the PCB analysis community has. Thus, the development of EPA Method 1668A, a method that performs a complete congener analysis in PCB samples extracted from water, soil, sediment or tissue. (USEPA, 1999)

3.2 SURFACE WATER, SEDIMENT, AND TISSUE SAMPLING

The literature on PCB sampling shows that there is a great volume of work in the area of water sampling. Tissue and sediment sampling do not have much new work in the literature which suggests that these techniques are well established and acceptable. The analysis of all of these matrices in the lab is still a subject of discussion based on the previous section, but this section will discuss only recent developments in water sampling.

3.2.1   Water Sampling Methods

The general trend in water seems to be moving from a direction focused on high volume sampling with samples that must be taken back to the lab for analysis to lower volume sampling techniques that can do partially or complete analytical processing of PCBs in the field. Within this current direction, there are a few main water field sampling methods seen:

- High Volume Sampling
- Semi-Permeable Membrane Devices (SPMDs)
- Buried Passive Samplers
- Solid-Phase MicroExtraction (SPME)

High volume sampling as used in the previous Dioxin TMDL project and in the literature is a water sampling method which is designed to collect the particle-bound and dissolved phase PCBs separately at low detection limits. Water is first pumped through Glass Fiber Filters (GFFs) followed by some stainless steel columns packed with XAD-2 resin. The GFFs collect the particle-bound PCBs (up to a minimum size particle at which point anything smaller passes through) while the XAD-2 resins collect the dissolved phase PCBs. These two elements are packaged and stored separately for individual analysis.

High volume is a sampling method which requires sample volumes that can be anywhere from 100 L to 1000 L for ultra trace measurements. (Datta, 2004) The high volume method is necessary in order get at such small concentrations, but it presents some difficulties including transport of high water volumes and the alteration of the sample concentration through reaction or sorption to the container during transportation. Therefore, the focus in improved high volume sampling methods is towards some pre-concentration and pre-analysis in the field to reduce errors by the time the sample reaches

the lab. Datta (2004) proposed a simple, inexpensive, non-battery operated method for accomplishing this.

Semi-permeable membrane devices (SPMDs) can be used to determine the contaminant concentration in both air and water. They work using thin polyethylene tubing or some other nonpolar dense polymer to "dissolve" the contaminant in the membrane-like layer which will later have the contaminant extracted and analyzed (possibly even in the field). (Huckins, 1993) The small pore size often used in these membranes limits a water concentration measurement to what is truly dissolved in the water. The influences of particle-bound contaminants are minimized. Also SPMDs give an integrated measure of PCB concentrations thereby limiting the inaccuracies that can result from episodic events which can skew data. (Booij, 2001) It must be remembered that integrated PCB concentration given through SPMDs is a time-integrated concentration. Therefore its use in characterizing actual water concentration levels may be limited. It may be more useful in characterizing the PCBs levels which are bioavailable to aquatic life (Echols, 2000) or in the state of equilibrium/disequilibrium with PCBs between the atmosphere and a water body (Booij, 2001).

Buried passive samplers are used in the field to measure pore water concentration from sediments. They sit passively in a sediment deposit on the bottom of water body and receive sediment pore water for a specified time period. A specific form of this method that uses LDPE strips as sorbents of PCBs from water in the vicinity of sediments was used in the Netherlands. (Booij, 2003) This mechanism of measurement is in principle not dissimilar from SPMDs.

A method related to SPMD is Solid-Phase Microextraction (SPME). The sample is introduced into a chamber containing silica fibers coated with a specific polymeric phase. The distribution of sample between the head space or sample matrix and the polymer phase provides quantitation. The value in this method would be that quantifying the signal is fairly easy as compared to high volume sampling or SPMD, and the field sampling is very convenient while on a sampling cruise. (Zeng, 2004) SPME is also believe to be superior to other methods of analytical extraction such as of Liquid Liquid

Extraction (LLE) and Solid-Phase Extraction (SPE) because SPME does not require large volumes of toxic solvents and is more sensitive than LLE or SPE. (Herbert, 2005) The method is still in more nascent and experimental stages.

Head Space SPME (HS-SPME) is a variant of SPME. The method specifically for soils and sediments, it was developed by Llompart (1999), and it showed good sensitivity and linearity.

There were also less conventional methods which were compared to SPMD by Echols et al. The group used caged fish to assess bioavailable PCBs in the water column and was able to keep the fish at a particular depth using the cages. One valuable insight they learned is that caged fish can provide a different kind of information concerning PCB concentrations and profiles because caged fish give a more real time look at PCBs while sediments and water samples demonstrate an accumulative. long-term effect. (Echols, 2000)

3.2.2   Error Minimization in Field Sampling

A few authors mentioned some practical error considerations that should be remembered when getting water PCB samples.

The determination of truly dissolved phase PCBs is difficult in practice due to low concentrations, high affinity of the contaminant for the sampling equipment, and incomplete separation of PCB between particles and the aqueous phase. (Booij, 2003)

The first issue mentioned in the previous statement was dealt with to some degree in two articles presented by Wolska (2005) and Rawa-Adkonis (2006). Choosing the correct container material to take a PCB sample is just as important as the method used to analyze that sample. For many of the materials that are commonly used absorb PCBs on their surfaces, and at the low concentrations found in aqueous samples, this can be significant. Studies have shown that 40-80% of a PCB sample may be absorbed onto Polytetrafluroethylene PTFE surface, which is commonly used in environmental sampling. Glass can also generate a drop of 10-25%. Wolska recommends using an

extraction solvent immediately on the sample in the field that goes with it during transport. (Wolska, 2005)This extraction solvent should be applied whether the sample is a small volume sample or even a large volume sample that is taken over time through pumping. (Rawa-Adkonis, 2006)

CHAPTER 4 – EXISTING DATA

4.1 – HOUSTON SHIP CHANNEL PCB DATA

4.1.1   Texas Department of Health Fish Advisories

In January and July 1999, the Texas Department of Health (TDH; now the Texas Department of State Health Services--DSHS) collected twenty-four finfish[3] and eight composite blue crab samples from four sites in the Houston Ship Channel System to complete a Health Assessment. The locations included the Turning Basin, the Lynchburg Ferry/San Jacinto State Park, the San Jacinto River near I-10, and Tabbs Bay near Houston Point. Results from the 1999 Health Assessment showed the presence of PCBs (Aroclor 1260) in 3 out of 12 finfish samples from the Lynchburg Ferry and the San Jacinto River (Table 4.1). The maximum and average concentrations for the samples above detection limits were 0.330 and 0.068 ng/g, respectively. Based on the results from the 1999 studies, it was recommended by the TDH to extend the existing advisory for the Houston Ship Channel to include all species of finfish due to the presence of pesticides and PCBs in concentrations that exceed health-based comparison values.

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[3] Seven hybrid bass, five smallmouth buffalo, three sheepshead, three red drum, one freshwater drum, two southern flounder, two common carp, and one blue catfish.

Table 4.1 PCB Results from 2001 TDH Health Assessment (in µg/kg-wet wt edible tissue)

SUBSITE	DATE	SAMPLE #	SPECIES	LENGTH		WEIGHT		Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
San Jacinto River 1 Km upstream of I-10 bridge	1/13/1999	SAJ-1	Striped/white bass	20.25"	52 cm	4.75 lb	2100 g	<40	<40	<40	<40	<40	<40	320
		SAJ-2	Striped/white bass	20"	51 cm	3.75 lb	1700 g	<40	<40	<40	<40	<40	<40	<40
29° 47' 53" N 95° 03' 31" W		SAJ-3	Freshwater Drum	17.75"	45 cm	3.5 lb	1500 g	<40	<40	<40	<40	<40	<40	330
		SAJ-4	Southern Flounder	17.75"	45 cm	2.25 lb	1000 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream segment 1001		SAJ-5	Blue Catfish	14.25"	36 cm	1.0 lb	450 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream sequence 01000		SAJ-7	Smallmouth Buffalo	19.75"	50 cm	5.75 lb	2300 g	<40	<40	<40	<40	<40	<40	170
	8/10/1999	SAJ-8	Blue Crab - composite (4)	7-7.5"	18-19 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40
		SAJ-9	Blue Crab - composite (4)	7-7.5"	18-19 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40
Tabbs Bay near the Hog Island shoreline (at ruined bridge)	1/12/1999	TAB-1	Southern Flounder	18.5"	46.5 cm	2.25 lb	1000 g	<40	<40	<40	<40	<40	<40	<40
		TAB-2	Red Drum	25.5"	64 cm	5.75 lb	2600 g	<40	<40	<40	<40	<40	<40	<40
29° 41' 51" N 94° 58' 56" W		TAB-3	Red Drum	26"	66 cm	6.25 lb	2800 g	<40	<40	<40	<40	<40	<40	<40
		TAB-4	Red Drum	22"	57 cm	6.25 lb	2800 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream segment 2426		TAB-5	Sheepshead	18.5"	47 cm	4.0 lb	1700 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream sequence 01000		TAB-6	Sheepshead	21"	53 cm	5.5 lb	2500 g	<40	<40	<40	<40	<40	<40	<40
29° 41' 23" N 94° 59' 19" W	1/12/1999	TAB-7	Blue Crab - composite (5)	6.5-8"	16-20 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40
		TAB-8	Blue Crab - composite (5)	6-7"	15.5-18 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40

SUBSITE	DATE	SAMPLE #	SPECIES	LENGTH		WEIGHT		Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Houston Ship Channel at San Jacinto Park (CM 125)	1/13/1999	HSC-1	Striped/white bass	22"	56 cm	6.0 lb	2700 g	<40	<40	<40	<40	<40	<40	<40
		HSC-2	Striped/white bass	23"	58.5 cm	8.0 lb	3600 g	<40	<40	<40	<40	<40	<40	<40
29° 45' 15" N 95° 05' 42" W		HSC-3	Striped/white bass	21.25"	54 cm	5.0 lb	2200 g	<40	<40	<40	<40	<40	<40	<40
		HSC-4	Smallmouth Buffalo	19.25"	49 cm	3.75 lb	1700 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream segment 1005		HSC-5	Smallmouth Buffalo	21"	53 cm	5.5 lb	2400 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream sequence 04000														
Houston Ship Channel at Buffalo Bayou Turning Basin	1/14/1999	HSC-6	Common Carp	22.5"	57 cm	7.0 lb	3100 g	<40	<40	<40	<40	<40	<40	<40
		HSC-7	Common Carp	24"	61 cm	8.75 lb	3900 g	<40	<40	<40	<40	<40	<40	<40
29° 44' 51" N 95° 17' 40" W		HSC-8	Striped/white bass	20"	51 cm	5.75 lb	2600 g	<40	<40	<40	<40	<40	<40	<40
		HSC-9	Striped/white bass	22.75"	58 cm	6.75 lb	3000 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream segment 1007		HSC-10	Smallmouth Buffalo	23.5"	60 cm	10.5 lb	4700 g	<40	<40	<40	<40	<40	<40	<40
TNRCC stream sequence 23000		HSC-11	Smallmouth Buffalo	23.25"	59 cm	7.75 lb	3700 g	<40	<40	<40	<40	<40	<40	<40
Houston Ship Channel at San Jacinto Park (CM 125)	1/14/1999	HSC-12	Sheepshead	17.5"	45 cm	3.75 lb	1700 g	<40	<40	<40	<40	<40	<40	<40
		HSC-13	Blue Crab - composite (5)	all 6"	all 15 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40
		HSC-14	Blue Crab - composite (5)	all 5.5"	all 14 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40
Houston Ship Channel at Buffalo Bayou Turning Basin	7/15/1999	HSC-15	Blue Crab - composite (4)	all 5.5"	all 14 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40
		HSC-16	Blue Crab - composite (4)	all 5.5"	all 14 cm	nr	nr	<40	<40	<40	<40	<40	<40	<40

< = value is less than the laboratory reporting limit
nr = value not recorded
Source: Texas Department of Health (Kirk Wiles, personal communication 2006)

In 2004, the DSHS, with input from the Galveston Bay Estuary Program (GBEP) Seafood Safety Task Force, selected five previously sampled sites to verify the status of contamination in the HSC with regards to PCBs. These included a site near the Houston Yacht Club in UGB, one near Morgan's Point in Tabbs Bay, a site within the HSC near the Lynchburg Ferry crossing, the tidal portion of the San Jacinto River immediately upstream of IH-10, and the HSC turning basin. Results from four sampling events conducted in 2004 were obtained from DSHS and are included in Table 4.2.

Table 4.2 PCB Results from 2005 DSHS Health Assessment (in µg/kg-wet wt edible tissue)

SUBSITE	DATE	SAMPLE #	SPECIES	LENGTH (mm)	(in)	WEIGHT (g)	(lb)	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Houston Ship Channel (Site 1)	2/18/2004	HSC17	Black drum	580	22.8	3178	7.0	<40	<40	<40	<40	<40	<40	<40
Yacht Club Marina		HSC18	Black drum	542	21.3	2361	5.2	<40	<40	<40	<40	<40	<40	<40
29° 37.176 N 94° 59.807 W		HSC19	Spotted seatrout	497	19.6	1226	2.7	<40	<40	<40	<40	43	<40	90
		HSC20	Spotted seatrout	455	17.9	953	2.1	<40	<40	<40	<40	250	<40	130
		HSC21	Red drum	593	23.3	2452	5.4	<40	<40	<40	<40	<40	<40	<40
		HSC22	Red drum	739	29.1	4540	10.0	<40	<40	<40	<40	<40	<40	<40
		HSC23	Southern Flounder	394	15.5	726	1.6	<40	<40	<40	<40	<40	<40	<40
		HSC31	Blue crab^c9	160	6.3			<40	<40	<40	<40	<40	<40	<40
	3/10/2004	HSC35	Blue crab^c11	153	6.0			<40	<40	<40	<40	<40	<40	<40
Houston Ship Channel (Site 2)	2/19/2004	HSC24	Spotted seatrout	625	24.6	2633	5.8	<40	<40	<40	<40	<40	<40	90
Tabbs Bay / Morgan's Point		HSC25	Spotted seatrout	662	26.1	2951	6.5	<40	<40	<40	<40	<40	<40	<40
29° 41.190 N 94° 58.565 W		HSC26	Black drum	560	22.0	2406	5.3	<40	<40	<40	<40	<40	<40	<40
		HSC27	Black drum	599	23.6	3541	7.8	<40	<40	<40	<40	<40	<40	<40
		HSC28	Blue catfish	530	20.9	1680	3.7	<40	<40	<40	<40	<40	<40	<40
		HSC29	Blue catfish	530	20.9	1725	3.8	<40	<40	<40	<40	<40	<40	<40
		HSC30	Hydrid striped bass	620	24.4	3496	7.7	<40	<40	<40	<40	<40	<40	60
	3/12/2004	HSC32	Blue crabs^c14	164	6.4			<40	<40	<40	<40	<40	<40	<40
		HSC43	Blue crabs^c15	166	6.5			<40	<40	<40	<40	<40	<40	<40
Houston Ship Channel (Site 3)	2/10/2004	HSC1	Blue catfish	461	18.1	1044	2.3	<40	<40	<40	<40	<40	<40	<40
Lynchburg Ferry	2/11/2004	HSC2	Blue catfish	463	18.2	1090	2.4	<40	<40	<40	<40	<40	<40	<40
29° 45.758 N 95° 04.845 W	2/19/2004	HSC3	White bass	413	16.3	953	2.1	<40	<40	<40	<40	<40	<40	<40
	3/11/2004	HSC4	Blue catfish	415	16.3	681	1.5	<40	<40	<40	<40	<40	<40	<40
	3/12/2004	HSC12	Black drum	537	21.1	2406	5.3	<40	<40	<40	<40	<40	<40	<40
		HSC15	Blue crab^c14	141	5.6			<40	<40	<40	<40	<40	<40	<40
		HSC33	Channel catfish	534	21.0	1544	3.4	<40	<40	<40	<40	<40	<40	<40
		HSC34	Smallmouth buffalo	742	29.2	8217	18.1	<40	<40	<40	<40	55	<40	150
		HSC44	Blue crab^c13	140	5.5			<40	<40	<40	<40	<40	<40	<40
Houston Ship Channel (Site 4)	2/10/2004	HSC36	Spotted seatrout	535	21.1	1589	3.5	<40	<40	<40	<40	<40	<40	63
San Jacinto River I-10 Bridge	3/11/2004	HSC37	Spotted seatrout	499	19.6	1362	3.0	<40	<40	<40	<40	<40	<40	72
29° 47.790 N 95° 03.453 W		HSC38	Red drum	737	29.0	3995	8.8	<40	<40	<40	<40	<40	<40	<40
		HSC39	Red drum	638	25.1	2497	5.5	<40	<40	<40	<40	<40	<40	<40
		HSC40	Blue catfish	577	22.7	2406	5.3	<40	<40	<40	<40	<40	<40	<40
		HSC41	Blue catfish	560	22.0	2043	4.5	<40	<40	<40	<40	<40	<40	52
		HSC42	Hydrid striped bass	600	23.6	3405	7.5	<40	<40	<40	<40	<40	<40	<40
	4/7/2004	HSC45	Blue crab^c15	136	5.3			<40	<40	<40	<40	<40	<40	<40
		HSC46	Blue crab^c16	148	5.8			<40	<40	<40	<40	<40	<40	<40
Houston Ship Channel (Site 5)	2/10/2004	HSC5	Smallmouth buffalo	546	21.5	3269	7.2	<40	<40	<40	<40	<40	<40	<40
HSC Turning Basin		HSC6	Common carp	445	17.5	1453	3.2	<40	<40	<40	<40	<40	<40	<40
29° 44.824 N 95° 17.661 W		HSC7	Blue catfish	639	25.2	3087	6.8	<40	<40	<40	<40	<40	<40	310
		HSC8	Smallmouth buffalo	620	24.4	3859	8.5	<40	<40	<40	<40	<40	<40	<40
		HSC9	Blue catfish	605	23.8	2497	5.5	<40	<40	<40	<40	<40	<40	1170
		HSC10	Blue catfish	522	20.6	1725	3.8	<40	<40	<40	<40	<40	<40	<40
		HSC11	Common carp	521	20.5	2043	4.5	<40	<40	<40	<40	<40	<40	160
	4/7/2004	HSC47	Blue crab^c16	122	4.8			<40	<40	<40	<40	<40	<40	<40
		HSC48	Blue crab^c16	126	5.0			<40	<40	<40	<40	<40	<40	<40

< = value is less than the laboratory reporting limit
^c = composite blue crab tissue sample and the number (c2) corresponds to the number of composited blue crabs; composite sample length and weight are calculated means
Source: Texas Department of State Health Services, Seafood and Aquatic Life Group (Kirk Wiles, personal communication 2006)

PCBs (identified as Aroclor 1260) were detected in eleven fish samples. Three of those fish also contained Aroclor 1248 (see Table 5.2). The highest concentration of PCBs (1170 µg/kg) occurred in a blue catfish from the HSC turning basin. Blue crab samples, on the other hand, did not exhibit quantifiable concntrations of PCBs.

4.1.2   Dioxin TMDL Project

During the summer 2002, fall 2002, and spring 2003, UH gathered tissue, sediment, and water PCB concentration data along with the dioxin sampling activities. Unlike the TDH studies, the dioxin TMDL project quantified both the 209 PCB congeners and the Aroclors in all media and results were presented in the Final Report for WO7. (Rifai, 2004) Table 4.3 presents results from the congener-based PCB data, while Table 4.4 summarizes the Aroclor data. Results for individual samples are included in Appendix B.

Table 4.3 Summary of Total PCB Results from the Dioxin TMDL Project

Matrix	Unit	Summer 2002				Fall 2002			
		min	max	mean	n	min	max	mean	n
Water	ng/L	0.18	1.624	0.565	31 (*5*)	0.123	2.606	0.682	18 (*3*)
Sediment	ng/g-dry wt	0.1	1445.5	61.4	45	0.1	1117.2	82.9	16
Fish	ng/g-wet wt	2.2	866.1	81.8	45 (*31*)	36.2	115.9	64.4	13 (*9*)
Crab	ng/g-wet wt	2.2	69.5	18.2	45 (*1*)	1.9	20.2	10.9	13 (*0*)

Matrix	Unit	Spring 2003			
		min	max	mean	n
Water	ng/L	0.965	1.811	1.365	4 (*4*)
Sediment	ng/g-dry wt	No sediment samples collected			
Fish	ng/g-wet wt	8.0	303.8	104.2	26 (*19*)
Crab	ng/g-wet wt	No crab samples collected			

Notes: non-detects assumed equal to half the detection limit for total PCB calculation.
Total PCB calculated as sum of 18 congeners recommended by NOAA (NOAA EPA list in Table 3.1).
n= number of samples, number in parenthesis indicate the number of samples that exceeded the health-based quality criteria (0.885 ng/L for water and 47 ng/g for tissue samples)

Table 4.4 Summary of Aroclor Results from the Dioxin TMDL Project

Matrix/Units	Aroclor Mixture	#Detected/ # Sampled	Min	Max	Mean[a]
Summer 2002					
Water (ng/L)	All	0/18	ND	-	NC
Sediment (ng/g)	1016	0/47	ND	-	NC
	1221	1/47	ND	61	NC
	1232	0/47	ND	-	NC
	1242	1/47	ND	61	NC
	1248	5/47	ND	2400	1469
	1254	7/47	ND	1200	520
	1260	7/47	ND	470	230
Catfish (ng/g)	1016	0/27	ND	-	NC
	1221	0/27	ND	-	NC
	1232	0/27	ND	-	NC
	1242	0/27	ND	-	NC
	1248	0/27	ND	-	NC
	1254	8/27	ND	160	107
	1260	8/27	ND	480	127
	Total Aroclors	10/27	ND	480	119
Crab (ng/g)	1016	0/30	ND	-	NC
	1221	0/30	ND	-	NC
	1232	0/32	ND	-	NC
	1242	0/32	ND	-	NC
	1248	0/32	ND	-	NC
	1254	1/32	ND	66	NC
	1260	9/32	ND	61	44
	Total Aroclors	2/32	ND	59	59
Fall 2002					
Water (ng/L)	All	0/20	ND	-	NC
Sediment (ng/g)	All	0/17	ND	-	NC
Catfish (ng/g)	1016	0/15	ND	-	NC
	1221	0/15	ND	-	NC
	1232	0/15	ND	-	NC
	1242	0/15	ND	-	NC
	1248	0/15	ND	-	NC
	1254	8/15	ND	180	84
	1260	0/15	ND	-	NC
	Total Aroclors	7/15	ND	80	64
Crab (ng/g)	All	0/14	ND	-	NC

[a] non-detects not included in calculation
ND=not detected; NC=not calculable
Samples for Aroclor analysis were not collected in Spring 2003

4.2   OTHER RELEVANT SURFACE WATER STUDIES

Surface water PCB can be found for many large water bodies and has been mentioned for several already in this report such as the Great Lakes, the Hudson River, the Baltic Sea, and the Mediterranean Sea. The most relevant surface water studies for this project would seem to be those studies which actually involve the determination of a TMDL. Therefore an effort was undertaken to gather reports from these other water studies.

4.2.1   Shenandoah River Valley

All data and facts presented on the Shenandoah River Valley PCB TMDL were taken from the 2001 Final TMDL Report. (USEPA, 2001)

Fish consumption advisories were issued along certain segments of the Shenandoah River Valley as part of Virginia's 1998 303(d) TMDL Priority List, and the water quality criteria that was decided upon based on the weight percentage of several Aroclors was 0.55 ng/L total PCB concentration in the Virginia portion of the river and 0.044 ng/L in the West Virginia portion of the river.

Sampling was conducted April 26-April 29, 2001 to get more insight into the spatial variations of PCB in the watershed and to determine what additional PCB sources there might be. Sampling media from this sampling event and from previous water quality studies included sediment, water column, fish, and clams. There were additional anthropogenic sources discovered. One was a landfill and one was a Superfund site that formerly served as a polymer fibers production facility.

The model used to develop the TMDL was segmented series of plug-flow reactors which received one-dimensional steady-state flows from the PCB sources in the water shed to the stream. The final TMDLs were as follows:

- Main Stem and South Fork Shenandoah River: 208.23 g/yr

- North Fork Shenandoah River: 0.833 g/yr
- Main Stem Shenandoah River: 214.7 g/yr

4.2.2   San Francisco Bay

In 1998, the State Water Resources Control Board listed San Francisco Bay (SFB) for PCB impairment because 90% of fish samples collected and tested for PCBs showed levels high enough to warrant human health concern.

The sources of PCBs in SFB are listed as atmospheric deposition, surface waters, urban runoff, and sediments. Between 10,000-50,000 kg of PCBs are present in sediments from legacy sources, and Coyote and Guadalupe Creeks are the largest source of PCBs to the system contributing 1 kg/yr PCBs. The San Francisco Regional Water Quality Control Board (SFRWQCB) also listed several companies in the area as sources to area because these companies import PCBs from outside the United States. Apparently the import of PCBs is still allowed though its production in this country is not. (Brook, 2002)

SFB is still in the TMDL process, and some data on sampling completed by Johnson (2000) and Thompson (2000) is available.

4.2.3   Lake Worth, Texas

All information for this site was taken from the TCEQ TMDL report on "One Total Maximum Daily Load for Polychlorinated Biphenyls (PCBs) in Fish Tissue in Lake Worth." (TCEQ, 2005)

A PCB TMDL process was initiated at Lake Worth on the heels of a fish consumption advisory issued by the Texas Department of Health in April 2000. The goal of the TMDL is to lower the concentration in fish tissue to <0.04 mg/kg which serves as the surrogate metric for contaminant load.

The main source of PCBs to the lake is believed to be from an Air Force aircraft manufacturing facility. The facility is already being remediated and regulated under CERCLA. Thus there are not any new sources to the lake. The strategy for the problem at this site is mainly to use monitored natural attenuation to get the fish tissue criteria back to an acceptable level. The study states a belief that more active forms of remediation may just exacerbate the problem through such means as sediment resuspension. No actual load number is planned for the study unless the stakeholders call for it.

CHAPTER 5 – SUMMARY AND FURTHER ACTIVITIES

5.1   SUMMARY AND CONCLUSIONS

A literature review was conducted for the PCB TMDL project. The review included the topics of background production and regulation history, chemical context, chemical properties, health effects, environmental fate and transport, sampling and field work considerations, existing data for the HSC, and data for PCB TMDL situations in other regions around the U.S.

Polychlorinated biphenyl (PCB) refers to any one of 209 environmentally persistent compounds (congeners) which were heavily produced, distributed, and used in the U.S. from 1929 until the late 1970s. They were produced domestically as commercial mixtures called Aroclors, and they are now found in the environment in "weathered" compositions that differ from Aroclors in most environmental media including soil, sediment, water, air, and biota. In the environment, they exhibit hydrophobic properties, which means that their water solubilities are low, and they have a high tendency to partition onto air suspended particles, water suspended particles, sediments, and biotic lipids. Their vapor pressure decreases with increasing chlorination which yields particle bound PCB samples with an enrichment of the higher chlorinated congeners.

The health effects of PCBs are not completely and thoroughly understood due to a small number of human exposure incidents, but there are certainly acute effects at high concentrations as well as more chronic effects such as immunal system changes. Their carcinogenicity is listed as probable by most agencies, and human exposure comes in small doses from water, soil, and air with the primary exposure route through food and especially seafood. There is also a health related link to the dioxin class of chemicals as a subset of PCB called "coplanar" PCBs exhibit toxicological similarity to dioxins due to structural similarities.

Truly new sources of PCBs are generally believed to be rare though literature potentially linking PCBs to chemical coproduction and domestic waste incineration has been published. Most PCB sources are believed to be secondary in nature as PCBs

moves from on region to another through the air transport processes of wet and dry deposition. Within a region, PCBs are transferred from air to water and back, from water to fish via direct uptake and the food web, and into sediments and suspended particles in petitioning equilibria. Through these processes, some PCB congeners are enhanced and some diminished by way of atmospheric reactions, metabolism, and congener-selective transport mechanisms.

Sampling procedures for PCBs are fairly standard and non -problematic though getting reliable and accurate trace concentrations in water can be difficult. The analytical chemistry for PCB samples is an area of growth and dynamics as the scientific and regulatory community has moved from Aroclor analysis to representative PCBs used to define homolog groups to complete congener profiles. The tension between what is cost and time efficient and what is most accurate in gauging total PCB concentrations is an area of professional judgment on the part of the researcher.

Houston Ship Channel sampling performed by the Texas Department of Health (TDH) in 1999 led to the recommendation to extend a fish advisory to all species of finfish, and the Dioxin TMDL Project as conducted by the University of Houston collected PCB samples in tissue, sediment, and water in conjunction with ongoing dioxin sampling performed in 2002 and 2003. This project quantified all 209 congeners in the sampling, which had not previously been done by the TDH in any other study, and this analysis lead a large amount of data which was presented in this report directly both in the body and in the appendix. There are also other relevant U.S. PCB TMDL projects, some of which are ongoing and others which have final TMDLs established.

There is now a good base of background PCB knowledge as presented in this report, and there is some recent data to draw from the Dioxin TMDL Project. More sampling and monitoring activities will need to be conducted in order to better characterize a TMDL that is more specific to PCBs. This monitoring and analysis will need to take into account potential past and present PCB loads, mechanisms of transport within the HSC system, and likely exposure risks to humans and aquatic life.

5.2   ACTIVITIES TO CONDUCT DURING THE NEXT QUARTER

During the next quarter, the PCB TMDL project team will focus its efforts mainly on "Task 3: Develop a Detailed Plan for Completing the PCB TMDL" from the work plan. Subtaks 3.1.1, collecting analyzing existing data and literature, and Subtask 3.1.3, a detailed literature review, were focused on heavily in this quarter. These efforts will be ongoing, but more attention will be given to the other two subtasks within Task 3:

Subtask 3.1.2: Identification of relationships between observed PCB concentrations and rainfall, point source discharges, and land use classifications in order to discover permitted and actual loadings from specific facilities.
Subtask 3.1.4: Identify the major data and information gaps pertinent and important to the Houston Ship Channel PCB situation.

More information gathering will be done to complete these two subtasks, but more of the efforts will likely be taken towards the analysis of existing data to make what conclusions can reasonably be made. Whatever then remains as inconclusive will be used to develop computer simulations and a field sampling strategy to get the information and inferences necessary to move towards more certainty on the PCB situation.

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APPENDIX A

CONGENER PHYSICAL AND CHEMICAL PARAMETERS

Table A-1 Extended List of Congener-Specific Physical Parameters

Congener Number	K_H Pa-m^3-mo^l-1	P_{vap} Pa	Log K_{oc} unitless	Log K_{ow} unitless	Solubility umol/L
0*	-	7.05E+00	-	4.09	-
1	5.13	1.89E+00	-	4.46	29.15
2	-	9.79E-01	4.58	4.69	13.25
3	-	9.18E-01	4.71	4.69	6.36
4	-	-	4.74	4.65	4.48
5	-	-	-	4.97	-
6	-	-	4.85	5.06	-
7	-	1.84E-01	4.76	5.07	5.6
8	6.01	-	4.76	5.07	4.48
9	-	1.84E-01	-	5.06	8.96
10	-	-	-	4.84	6.28
11	-	8.65E-02	-	5.28	1.59
12	-	-	-	5.22	-
13	-	-	-	5.29	-
14	-	-	-	5.28	-
15	-	7.13E-02	4.79	5.3	0.269
16	-	-	4.78	5.16	-
17	-	-	4.81	5.25	-
18	8.11	-	4.79	5.24	1.55
19	-	-	4.71	5.02	-
20	-	-	4.94	5.57	-
21	-	-	-	5.51	-
22	-	-	4.98	5.58	-
23	-	-	-	5.57	-
24	-	-	-	5.35	-
25	-	-	-	5.67	-
26	-	-	4.8	5.66	0.975
27	-	-	4.79	5.44	-
28	13.13	4.36E-02	4.98	5.67	0.621
29	12.12	4.44E-02	-	5.6	0.544
30	-	9.55E-02	-	5.44	0.777
31	-	3.41E-02	4.96	5.67	-
32	-	-	-	5.44	-
33	-	-	-	5.6	0.311
34	-	-	-	5.66	-
35	-	-	-	5.82	-
36	-	-	-	5.88	-

Table A-1 Extended List of Congener-Specific Physical Parameters

Congener Number	K_H Pa-m^3-mo^l-1	P_{vap} Pa	Log K_{oc} unitless	Log K_{ow} unitless	Solubility umol/L
37	-	-	-	5.83	0.058
38	-	-	-	5.76	-
39	-	-	-	5.89	-
40	-	9.79E-03	5.14	5.66	0.103
41	-	-	-	5.69	-
42	-	-	-	5.76	-
43	-	-	-	5.75	-
44	11.86	-	5.1	5.75	0.342
45	-	-	4.94	5.53	-
46	-	-	5	5.53	-
47	-	-	-	5.85	0.308
48	-	-	-	5.78	-
49	-	-	5.09	5.85	0.0548
50	28.86	-	-	5.63	-
51	-	-	-	5.63	-
52	11.34	6.90E-03	5.1	5.84	0.103
53	-	2.73E-02	-	5.62	-
54	-	-	-	5.21	-
55	-	-	-	6.11	-
56	-	-	-	6.11	-
57	-	-	-	6.17	-
58	-	-	-	6.17	-
59	-	-	-	5.95	-
60	-	-	5.38	6.11	-
61	-	-	-	6.04	0.0685
62	-	-	-	5.89	-
63	-	-	-	6.17	-
64	-	-	-	5.95	-
65	-	-	-	5.86	-
66	14.17	6.16E-03	5.38	6.2	0.0147
67	-	-	-	6.2	-
68	-	-	-	6.26	-
69	-	-	-	6.04	-
70	-	5.44E-03	5.26	6.2	-
71	-	-	-	5.98	-
72	-	-	5.27	6.26	-
73	-	-	-	6.04	-

Table A-1 Extended List of Congener-Specific Physical Parameters

Congener Number	K_H Pa-m^3-mo^l-1	P_{vap} Pa	Log K_{oc} unitless	Log K_{ow} unitless	Solubility umol/L
74	-	-	-	6.2	-
75	-	-	-	6.05	0.312
76	-	-	-	6.13	-
77	4.46	2.21E-03	5.71	6.36	0.0093
78	-	-	-	6.35	-
79	-	-	-	6.42	-
80	-	-	-	6.48	0.0041
81	9	-	-	6.36	0.011
82	-	-	-	6.2	-
83	-	-	-	6.26	-
84	-	-	-	6.04	-
85	-	-	-	6.3	-
86	-	-	-	6.23	0.0613
87	12.97	2.26E-03	5.82	6.29	0.0123
88	-	-	-	6.07	0.0369
89	-	-	-	6.07	-
90	-	-	-	6.36	-
91	-	-	-	6.13	-
92	-	-	-	6.35	-
93	-	-	-	6.04	-
94	-	-	5.39	6.13	-
95	-	-	8.62	6.13	-
96	-	-	-	5.71	-
97	-	-	5.91	6.29	-
98	-	-	-	6.13	-
99	-	2.93E-03	-	6.39	-
100	-	-	-	6.23	-
101	15.75	4.16E-03	5.78	6.38	0.0306
102	-	-	-	6.16	-
103	-	-	-	6.22	-
104	39.4	-	-	5.81	0.0478
105	3.09	8.20E-04	6.07	6.65	0.0051
106	-	-	-	6.64	-
107	-	-	-	6.71	-
108	-	-	-	6.71	-
109	-	-	-	6.48	-
110	-	-	5.8	6.48	0.0123

Table A-1 Extended List of Congener-Specific Physical Parameters

Congener Number	K_H Pa-m^3-mo^l-1	P_{vap} Pa	Log K_{oc} unitless	Log K_{ow} unitless	Solubility umol/L
111	-	-	-	6.76	-
112	-	-	-	6.45	-
113	-	-	-	6.54	-
114	10.2	-	-	6.65	0.0081
115	-	-	-	6.49	-
116	-	-	-	6.33	0.0145
117	-	-	-	6.46	-
118	7.34	1.93E-04	5.99	6.74	0.0063
119	-	-	-	6.58	-
120	-	-	-	6.79	-
121	-	-	-	6.64	-
122	-	-	-	6.64	-
123	6.3	-	-	6.74	0.0028
124	-	-	-	6.73	-
125	-	-	-	6.51	-
126	0.958	4.45E-04	5.87	6.89	0.0041
127	-	-	5.82	6.95	-
128	0.89	3.41E-04	-	6.74	0.00166
129	-	-	-	6.73	0.00166
130	-	-	-	6.8	-
131	-	-	-	6.58	-
132	-	-	-	6.58	-
133	-	-	-	6.86	-
134	-	-	-	6.55	0.00111
135	-	-	-	6.64	-
136	-	-	-	6.22	0.0111
137	-	-	-	6.83	-
138	2.88	5.14E-04	6.2	6.83	-
139	-	-	-	6.67	-
140	-	-	-	6.67	-
141	-	-	-	6.82	-
142	-	-	-	6.51	-
143	-	-	-	6.6	-
144	-	-	-	6.67	-
145	-	-	-	6.25	-
146	-	-	6.18	6.89	-
147	-	-	-	6.64	-

Table A-1 Extended List of Congener-Specific Physical Parameters

Congener Number	K_H Pa-m^3-mo^l-1	P_{vap} Pa	Log K_{oc} unitless	Log K_{ow} unitless	Solubility umol/L
148	-	-	5.95	6.73	-
149	-	1.12E-03	6.05	6.67	-
150	-	-	-	6.32	-
151	-	-	6.02	6.64	-
152	-	-	-	6.22	-
153	6.5	8.34E-04	6.19	6.92	0.00236
154	17.34	-	-	6.76	-
155	-	-	-	6.41	0.0083
156	6.8	2.15E-04	-	7.18	0.003
157	24.9	-	-	7.18	0.0008
158	-	-	-	7.02	-
159	-	-	-	7.24	-
160	-	-	-	6.93	-
161	-	-	-	7.08	-
162	-	-	-	7.24	-
163	-	-	-	6.99	-
164	-	-	-	7.02	-
165	-	-	-	7.05	-
166	-	-	-	6.93	-
167	10.4	3.05E-04	-	7.27	0.003
168	-	-	-	7.11	-
169	8.6	1.82E-06	-	7.42	0.00036
170	0.128	-	-	7.27	-
171	-	-	-	7.11	0.00506
172	-	-	-	7.33	-
173	-	-	-	7.02	-
174	-	-	6.3	7.11	-
175	-	-	-	7.17	-
176	-	-	-	6.76	-
177	-	-	6.35	7.08	-
178	-	-	-	7.14	-
179	-	-	-	6.73	-
180	0.425	1.45E-04	6.37	7.36	-
181	-	-	-	7.11	-
182	-	-	-	7.2	-
183	-	5.06E-04	6.32	7.2	-
184	-	-	-	6.85	-

Table A-1 Extended List of Congener-Specific Physical Parameters

Congener Number	K_H Pa-m^3-mo^l-1	P_{vap} Pa	Log K_{oc} unitless	Log K_{ow} unitless	Solubility umol/L
185	-	-	-	7.11	0.00114
186	-	-	-	6.69	-
187	3.034	-	-	7.17	-
188	15.77	-	-	6.82	-
189	25.1	-	-	7.71	-
190	-	-	-	7.46	-
191	-	-	-	7.55	-
192	-	-	-	7.52	-
193	-	-	-	7.52	-
194	-	-	-	7.8	-
195	0.079	-	-	7.56	-
196	-	-	-	7.65	-
197	-	1.87E-04	-	7.3	-
198	-	-	-	7.62	-
199	-	-	-	7.2	-
200	-	-	-	7.27	-
201	1.069	-	-	7.62	-
202	-	-	-	7.24	-
203	-	1.30E-04	-	7.65	-
204	-	-	-	7.3	-
205	-	-	-	8	-
206	-	-	-	8.09	-
207	-	-	-	7.74	-
208	-	-	-	7.71	-
209	-	-	-	8.18	-

Sources Used:

1) Henry's Law Constants (K_H) - Bamford, Poster and Baker, 2000,Fang, Chu and Hong, 2006

2) Vapor Pressure (P_{vap})- Bidleman, 1984,Paasivirta, Sinkkonen, Mikkelson, Rantio and Wania, 1999

3) Sorption Partition Coefficients (Log K_{oc}) - Hansen, Paya-Perez, Rahmanet al, 1999

4) Octanol-Water Coefficients (K_{ow}) - Hawker and Connell, 1988

5) Solubility - Huang and Hong, 2002,Mackay, Shiu and Ma, 1992

Notes:

1) A '-' indicates that data was not supplied for that congener for that particular constant.

2) Congener 0 is the unchlorinated biphenyl molecule and is not technically a PCB. However, many sources
   include the physical values for biphenyl to see structure-property relationship trends better.

APPENDIX B

PCB DATASET FROM DIOXIN TMDL PROJECT SAMPLING

Table B-1 Total PCB Concentrations in Water (ng/L)

Station ID	Date	Volume (L)	PCB 8	PCB 30/18	PCB 28/20	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 113/90/101	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 138/163/129	PCB 153/168	PCB 169	PCB 170	PCB 193/180	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
Summer 2002																							
13343	08/20/2002	706	0.0051	0.0242	0.0361	0.0439	0.0595	0.0292	0.0034	0.0453	0.0105	0.0238	< 0.0003	0.0053	0.0357	0.0279	< 0.0001	0.0096	0.0174	0.0133	0.3906	0.3905	0.3905
13344	08/21/2002	709	< 0.0069	0.0271	0.0324	0.0969	0.1368	0.0472	0.0033	0.0733	0.0104	0.0228	< 0.0003	0.0048	0.0367	0.0310	< 0.0003	0.0072	0.0141	0.0120	0.5625	0.5613	0.5613
16496	08/22/2002	731	< 0.0082	0.0341	0.0315	0.0821	0.1081	0.0369	0.0038	0.0534	0.0118	0.0264	< 0.0003	0.0059	0.0397	0.0354	< 0.0003	0.0081	0.0161	0.0131	0.5135	0.5119	0.5119
13342	08/23/2002	509	0.0194	0.0477	0.0509	0.0974	0.1259	0.0373	0.0037	0.0747	0.0136	0.0403	< 0.0003	0.0067	0.0511	0.0511	< 0.0001	0.0106	0.0208	0.0181	0.6695	0.6693	0.6693
13337	08/24/2002	524	0.0202	0.0424	0.0443	0.0916	0.1164	0.0410	0.0036	0.0687	0.0145	0.0399	< 0.0003	0.0076	0.0553	0.0553	< 0.0003	0.0141	0.0248	0.0197	0.6598	0.6595	0.6595
13309	08/25/2002	532	0.0201	0.0303	0.0306	0.0545	0.0677	0.0289	0.0024	0.0545	0.0100	0.0252	< 0.0002	0.0048	0.0391	0.0427	< 0.0002	0.0084	0.0162	0.0154	0.4509	0.4508	0.4508
16618	08/26/2002	505	0.0174	0.0566	0.0554	0.0905	0.1164	0.0457	0.0044	0.0673	0.0147	0.0327	< 0.0002	0.0059	0.0455	0.0475	< 0.0001	0.0101	0.0188	0.0166	0.6459	0.6458	0.6458
13338	08/26/2002	544	0.0145	0.0368	0.0349	0.0717	0.0938	0.0379	0.0035	0.0662	0.0143	0.0369	< 0.0004	0.0086	0.0607	0.0588	< 0.0005	0.0142	0.0256	0.0222	0.6011	0.6006	0.6006
11264	08/27/2002	268	0.0247	0.1463	0.1392	0.2698	0.3108	0.1377	0.0125	0.1493	0.0381	0.0754	< 0.0007	0.0142	0.1045	0.0896	< 0.0004	0.0250	0.0560	0.0313	1.6247	1.6241	1.6241
15979	08/27/2002	522	0.0213	0.0971	0.0950	0.1759	0.2107	0.0715	0.0077	0.1073	0.0259	0.0536	< 0.0005	0.0126	0.0900	0.0747	< 0.0004	0.0222	0.0490	0.0274	1.1426	1.1422	1.1422
11270	08/28/2002	508	0.0224	0.1128	0.1157	0.2087	0.2480	0.0846	0.0089	0.1181	0.0325	0.0669	< 0.0005	0.0138	0.0984	0.0807	< 0.0004	0.0224	0.0508	0.0278	1.3132	1.3128	1.3128
15908	08/29/2002	503	0.0133	0.0199	0.0264	0.0501	0.0791	0.0203	0.0016	0.0402	0.0064	0.0181	< 0.0003	0.0038	0.0322	0.0332	< 0.0003	0.0066	0.0149	0.0107	0.3771	0.3768	0.3768
13336	08/29/2002	523	< 0.0069	0.0327	0.0424	< 0.0765	0.1128	0.0346	0.0033	0.0574	0.0117	0.0300	< 0.0003	0.0071	0.0518	0.0501	< 0.0003	0.0120	0.0260	0.0182	0.5446	0.5150	0.5150
11252	08/30/2002	703	0.0121	0.0259	0.0299	0.0637	0.0920	0.0245	0.0023	0.0384	0.0077	0.0188	< 0.0002	0.0038	0.0284	0.0282	< 0.0001	0.0062	0.0138	0.0101	0.4059	0.4057	0.4057
17971	08/31/2002	522	0.0121	0.0456	0.0492	0.0931	0.1374	0.0354	0.0037	0.0529	0.0113	0.0259	< 0.0004	0.0044	0.0370	0.0356	< 0.0003	0.0080	0.0167	0.0119	0.5804	0.5801	0.5801
13363	08/31/2002	560	< 0.0037	0.0152	0.0216	0.0350	0.0543	0.0163	0.0011	0.0334	0.0048	0.0145	< 0.0003	0.0028	0.0225	0.0248	< 0.0004	0.0046	0.0104	0.0086	0.2719	0.2696	0.2696
11200	09/02/2002	508	0.0091	0.0102	0.0122	0.0110	0.0122	0.0047	0.0004	0.0181	0.0035	0.0075	< 0.0002	0.0032	0.0240	0.0220	< 0.0002	0.0079	0.0213	0.0126	0.1803	0.1800	0.1800
16622	09/02/2002	529	< 0.0127	0.0195	0.0204	0.0195	0.0420	0.0093	0.0009	0.0236	0.0041	0.0093	< 0.0002	0.0023	0.0174	0.0155	< 0.0005	0.0054	0.0129	0.0087	0.2219	0.2198	0.2198
11292	09/03/2002	610	0.0170	0.0682	0.1098	0.0951	0.1066	0.0377	0.0041	0.0607	0.0182	0.0385	< 0.0005	0.0098	0.0770	0.0646	< 0.0003	0.0234	0.0485	0.0300	0.8098	0.8094	0.9489
11292-dup	09/03/2002	716	< 0.0190	0.1345	0.1480	0.1480	0.1592	0.0482	0.0059	0.0838	0.0216	0.0461	< 0.0005	0.0115	0.0894	0.0712	< 0.0001	0.0240	0.0490	0.0307	1.0896	1.0883	
11280	09/04/2002	501	< 0.0172	0.0828	0.1038	0.1651	0.2371	0.0547	0.0059	0.0918	0.0224	0.0499	< 0.0003	0.0098	0.0699	0.0539	< 0.0002	0.0172	0.0337	0.0246	1.0383	1.0364	1.0364
14560	09/04/2002	622	< 0.0058	0.0087	0.0130	0.0235	0.0341	0.0109	0.0007	0.0246	0.0037	0.0111	< 0.0002	0.0024	0.0186	0.0235	< 0.0002	0.0038	0.0072	0.0079	0.1989	0.1980	0.1980
13341	09/05/2002	509	< 0.0122	0.0187	0.0279	0.0395	0.0585	0.0193	0.0014	0.0432	0.0092	0.0253	< 0.0002	0.0061	0.0472	0.0424	< 0.0001	0.0120	0.0236	0.0196	0.4052	0.4039	0.4039
13339	09/06/2002	304	< 0.0148	0.0365	0.0497	0.0849	0.1138	0.0378	0.0042	0.0720	0.0171	0.0428	< 0.0004	0.0093	0.0734	0.0635	< 0.0002	0.0168	0.0329	0.0306	0.7004	0.7000	0.7000
13340	09/06/2002	367	< 0.0124	0.0175	0.0234	0.0338	0.0474	0.0166	0.0012	0.0398	0.0076	0.0221	< 0.0002	0.0050	0.0422	0.0373	< 0.0002	0.0092	0.0180	< 0.0036	0.3373	0.3370	0.3370
16213	09/10/2002	557	0.0124	0.0110	0.0151	0.0230	0.0293	0.0145	0.0011	0.0294	0.0055	0.0160	< 0.0002	0.0035	0.0307	0.0334	< 0.0002	0.0064	0.0133	0.0115	0.2561	0.2560	0.2560
13589	09/10/2002	512	0.0141	0.0125	0.0154	0.0195	0.0275	0.0104	0.0015	0.0248	0.0041	0.0117	< 0.0002	0.0022	0.0213	0.0227	< 0.0001	0.0040	0.0092	0.0078	0.2089	0.2088	0.2088
11193	09/11/2002	508	0.0531	0.0262	0.0346	0.0360	0.0630	0.0179	0.0017	0.0531	0.0150	0.0368	< 0.0001	0.0084	0.0539	0.0415	< 0.0001	0.0106	0.0203	0.0154	0.4876	0.4875	0.4875
15464	09/11/2002	318	< 0.0101	0.0116	0.0189	0.0201	0.0283	0.0126	0.0010	0.0267	0.0049	0.0138	< 0.0002	0.0028	0.0223	0.0252	< 0.0003	0.0053	0.0099	0.0099	0.2220	0.2200	0.2200
11261	09/12/2002	532	0.0141	0.0419	0.0568	0.1028	0.1276	0.0445	0.0047	0.0602	0.0160	0.0348	< 0.0003	0.0068	0.0461	0.0382	< 0.0001	0.0105	0.0197	0.0154	0.6402	0.6400	0.6400
11287	09/12/2002	508	0.0077	0.0317	0.0498	0.0537	0.0626	0.0191	0.0028	0.0400	0.0108	0.0226	0.0003	0.0065	0.0459	0.0360	< 0.0002	0.0114	0.0222	0.0157	0.4391	0.4391	0.4391
16499	09/13/2002	509	0.0086	0.0291	0.0344	0.0741	0.1055	0.0275	0.0031	0.0530	0.0108	0.0271	< 0.0003	0.0059	0.0464	0.0409	< 0.0001	0.0110	0.0218	0.0196	0.5190	0.5188	0.5183
16499-dup	09/13/2002	529	0.0091	0.0308	0.0365	0.0756	0.1021	0.0285	0.0030	0.0529	0.0108	0.0268	< 0.0002	0.0055	0.0463	0.0408	< 0.0001	0.0102	0.0198	0.0187	0.5178	0.5177	

Table B-1 Total PCB Concentrations in Water (ng/L) - Cont'd

Station ID	Date	Volume (L)	PCB 8	PCB 30/18	PCB 28/20	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 113/90/101	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 138/163/129	PCB 153/168	PCB 169	PCB 170	PCB 193/180	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
Fall 2002																							
11261	10/21/2002	422	0.0175	0.0429	0.0453	0.0995	0.1173	0.0377	0.0030	0.0382	0.0100	0.0258	< 0.0002	0.0047	0.0469	0.0419	< 0.0001	0.0065	0.0133	0.0107	0.5613	0.5611	0.5611
13341	10/24/2002	651	0.0060	0.0152	0.0209	0.0402	0.0482	0.0172	0.0014	0.0353	0.0061	0.0187	< 0.0002	0.0055	0.0584	0.0424	< 0.0002	0.0120	0.0252	0.0221	0.3751	0.3749	0.3749
13342	10/29/2002	712	0.0150	0.0725	0.0742	0.1053	0.1320	0.0479	0.0041	0.0618	0.0147	0.0344	0.0002	0.0070	0.0520	0.0421	< 0.0002	0.0108	0.0218	0.0176	0.7135	0.7134	0.7134
16499	10/30/2002	715	< 0.0170	0.1930	0.2154	0.3301	0.3455	0.1399	0.0080	0.1622	0.0340	0.0713	0.0004	0.0151	0.1189	0.0881	< 0.0001	0.0215	0.0400	0.0338	1.8341	1.8340	1.8340
13363	10/31/2002	727	0.0296	0.1076	0.1188	0.1513	0.1967	0.0624	0.0044	0.0605	0.0168	0.0362	< 0.0003	0.0061	0.0426	0.0316	< 0.0003	0.0074	0.0154	0.0133	0.9011	0.9009	0.9009
15979	11/01/2002	662	0.0826	0.3310	0.3580	0.3988	0.5181	0.1903	0.0136	0.1918	0.0468	0.1073	0.0005	0.0189	0.1360	0.0967	< 0.0003	0.0255	0.0491	0.0409	2.6061	2.6059	2.6059
13336	11/05/2002	570	0.0256	0.0542	0.0793	0.0860	0.0935	0.0467	0.0042	0.0526	< 0.0191	0.0386	< 0.0007	0.0070	0.0491	0.0404	< 0.0004	0.0158	0.0232	0.0156	0.6463	0.6407	0.6407
11280	11/06/2002	703	0.0523	0.0737	0.1127	0.0825	0.0896	0.0390	0.0044	0.0626	0.0218	0.0498	< 0.0010	0.0108	0.0811	0.0612	< 0.0012	0.0283	0.0418	0.0262	0.8388	0.8377	0.8377
11292	11/07/2002	722	0.0342	0.0479	0.0573	0.0542	0.0686	0.0229	< 0.0029	0.0429	0.0130	0.0291	< 0.0005	0.0089	0.0568	0.0429	< 0.0005	0.0169	0.0321	0.0233	0.5537	0.5525	0.5525
13344	11/08/2002	711	0.0115	0.0222	0.0322	0.0406	0.0489	0.0194	0.0016	0.0328	0.0080	0.0214	< 0.0002	0.0035	0.0267	0.0245	< 0.0002	0.0063	0.0097	0.0080	0.3177	0.3175	0.3175
13355	11/11/2002	498	0.0249	0.0325	0.0434	0.0456	0.0546	0.0217	0.0020	0.0450	< 0.0116	0.0267	< 0.0003	0.0058	0.0390	0.0349	< 0.0004	0.0139	0.0197	0.0133	0.4314	0.4275	0.4275
13338	11/12/2002	476	0.0475	0.0525	0.0624	0.0855	0.1113	0.0439	0.0034	0.0840	0.0197	0.0462	< 0.0006	0.0101	0.0714	0.0588	< 0.0007	0.0166	0.0313	0.0269	0.7723	0.7717	0.7717
14560	11/13/2002	703	0.0199	0.0245	0.0253	0.0344	0.0458	0.0158	< 0.0019	0.0286	0.0060	0.0149	< 0.0005	0.0030	0.0202	0.0185	< 0.0005	0.0046	0.0087	0.0077	0.2793	0.2778	0.2778
11252	11/14/2002	706	0.0174	0.0317	0.0351	0.0452	0.0557	0.0239	< 0.0017	0.0395	0.0067	0.0174	< 0.0004	0.0027	0.0225	0.0217	< 0.0005	0.0052	0.0101	0.0091	0.3457	0.3449	0.3296
11252-dup	11/14/2002	707	0.0163	0.0272	0.0294	0.0446	0.0569	0.0231	< 0.0023	0.0359	0.0061	0.0165	< 0.0003	0.0025	0.0182	0.0170	< 0.0005	0.0047	0.0088	0.0072	0.3158	0.3142	
17971	11/18/2002	708	0.0116	0.0407	0.0531	0.0689	0.0922	0.0410	0.0030	0.0404	0.0109	0.0271	< 0.0002	0.0045	0.0339	0.0297	< 0.0002	0.0075	0.0133	0.0110	0.4890	0.4888	0.4803
17971-dup	11/18/2002	711	0.0105	0.0406	0.0450	0.0727	0.0882	0.0345	< 0.0030	0.0457	0.0110	0.0248	< 0.0005	0.0048	0.0323	0.0284	< 0.0007	0.0072	0.0135	0.0105	0.4729	0.4719	
15464	11/19/2002	702	0.0083	0.0111	0.0138	0.0158	0.0222	0.0108	0.0007	0.0131	0.0030	0.0091	< 0.0002	0.0017	0.0124	0.0138	< 0.0002	0.0032	0.0057	0.0053	0.1501	0.1500	0.1500
11193	11/20/2002	709	0.0395	0.0312	0.0389	0.0377	0.0508	0.0186	0.0015	0.0339	0.0094	0.0264	< 0.0002	0.0042	0.0319	0.0250	< 0.0001	0.0055	0.0124	0.0093	0.3762	0.3761	0.3761
11200	11/21/2002	707	0.0122	0.0154	0.0191	0.0113	0.0137	0.0045	< 0.0004	0.0089	0.0021	0.0055	< 0.0002	0.0012	0.0091	0.0085	< 0.0001	0.0020	0.0050	0.0042	0.1232	0.1229	0.1229
Spring 2003																							
11264	06/02/2003	702	< 0.0214	0.1142	0.0876	0.2236	0.2835	0.0912	< 0.0048	0.1168	0.0211	0.0456	< 0.0023	0.0080	0.0570	0.0442	< 0.0010	0.0137	0.0239	0.0205	1.1760	1.1717	1.1398
11264-dup	06/02/2003	701	< 0.0190	0.1070	0.0827	0.2254	0.2568	0.0827	0.0056	0.1084	0.0197	0.0414	< 0.0022	0.0083	0.0571	0.0428	< 0.0011	0.0126	0.0227	0.0193	1.1113	1.1080	
11280	06/11/2003	700	< 0.0191	0.1089	0.1043	0.1571	0.1729	0.0504	0.0061	0.0786	0.0203	0.0457	< 0.0004	0.0091	0.0714	0.0586	< 0.0002	0.0150	0.0296	0.0204	0.9670	0.9658	0.9658
15487	06/17/2003	706	0.2732	0.1262	0.1418	0.1204	< 0.1119	0.0524	0.0081	0.1020	0.0382	0.0708	< 0.0009	0.0239	0.1700	0.1218	< 0.0004	0.0482	0.0836	0.0510	1.5442	1.5435	1.5435
11270	06/18/2003	702	0.0387	0.1477	0.1809	0.2821	0.3162	0.1182	0.0161	0.1524	0.0484	0.0983	< 0.0010	0.0209	0.1510	0.1111	< 0.0003	0.0308	0.0568	0.0409	1.8114	1.8110	1.8110

Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA

If either the dissolved or suspended concentration was non-detected, the total concentration in water is reported here as less than the sum of the detected concentration and the MDL for the non-detected phase. If a congener was non-detected in both phases, the total concentration in wat is reported as less than the sum of the MDLs for both phases.

[a] Non-detects assumed to be 1/2 detection limit

[b] Non-detects assumed to be zero

[c] Average of duplicate samples, otherwise concentration of a single sample

Exceeds the WQS (0.885 ng/L)

Table B-2 PCB Concentrations in Sediment (ng/kg-dry wt.)

Station ID	Date	PCB 8	PCB 30/18	PCB 28/20	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 113/90/101	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 138/163/129	PCB 153/168	PCB 169	PCB 170	PCB 193/180	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
Summer 2002																						
11272	07/25/2002	87	78.6	190	241	247	238	< 48.1	227	88.6	223	< 48.1	< 48.1	283	257	< 48.1	92.2	213	132	2693.6	2597.4	2597.4
11298	07/29/2002	579	767	1780	2710	3200	1400	271	4550	1230	2800	< 47.3	880	6370	4440	< 47.3	2750	6130	4040	43944.3	43897.0	43897.0
11274	07/30/2002	9030	8670	22300	7580	7400	16800	2100	8570	5290	9890	139	2230	11600	7330	< 47.9	1590	3530	1700	125773.0	125749.0	125749.0
11111	07/31/2002	215	90.3	336	189	195	119	50	275	133	372	< 49.5	72.9	545	511	< 49.5	152	287	183	3774.7	3725.2	3725.2
11092	08/01/2002	578	711	1670	1110	1270	1080	122	1670	488	1330	< 98.7	318	1580	1490	< 98.7	485	1060	670	15730.7	15632.0	15632.0
11258	08/01/2002	< 48.8	< 48.8	72.4	57.2	64	< 48.8	< 48.8	56.3	< 48.8	< 48.8	< 48.8	< 48.8	51.4	< 48.8	< 48.8	< 48.8	< 48.8	< 48.8	618.5	301.3	301.3
13340	08/06/2002	< 49.9	121	< 49.9	< 49.9	< 49.9	< 49.9	< 49.9	1740	300	1060	< 49.9	239	1580	1410	< 49.9	575	1230	828	9282.6	9083.0	9083.0
13341	08/06/2002	127	122	339	536	702	< 49.5	53.9	1100	292	834	< 49.5	258	1800	1580	< 49.5	455	1040	522	9835.2	9760.9	9760.9
11193	08/08/2002	1090	75.7	259	326	585	283	< 49.6	934	369	976	< 49.6	217	1480	1060	< 49.6	321	663	322	9035.1	8960.7	8960.7
11347	08/12/2002	97.8	136	400	698	1070	775	157	6520	3940	8260	58.1	1590	9000	4940	< 49.9	1270	1970	910	41816.9	41791.9	41791.9
11382	08/12/2002	< 49.8	370	1130	1290	1550	809	178	2190	851	1600	< 49.8	569	3150	1970	< 49.8	858	1810	1010	19409.7	19335.0	19335.0
11305	08/13/2002	246	429	939	1740	1130	103	102	2200	559	1250	< 48.6	496	4630	3840	< 48.6	1980	4720	2100	26512.6	26464.0	27159.0
11305-dup	08/13/2002	315	490	1120	2090	1340	148	137	2370	679	1580	< 49.7	735	5700	4870	< 49.7	1460	3150	1670	27903.7	27854.0	
13337	08/14/2002	326	234	929	1050	1120	< 49.6	103	926	323	830	< 49.6	175	1210	1010	< 49.6	293	631	380	9614.4	9540.0	9540.0
13363	08/16/2002	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	< 49.1	56	< 49.1	< 49.1	< 49.1	473.4	56.0	56.0
13589	08/16/2002	< 50.5	< 50.5	88.7	93.6	121	77.2	< 50.5	< 50.5	< 50.5	< 50.5	< 50.5	< 50.5	165	126	< 50.5	< 50.5	< 50.5	< 50.5	974.5	671.5	671.5
15464	08/16/2002	< 49.6	< 49.6	69.9	55.2	56	54.6	< 49.6	< 49.6	< 49.6	< 49.6	< 49.6	< 49.6	54.7	52.2	< 49.6	< 49.6	< 49.6	< 49.6	640.2	342.6	342.6
17970	08/18/2002	< 48.6	< 48.6	88.7	57.9	69.4	69.3	< 48.6	69.1	< 48.6	63.6	< 48.6	< 48.6	102	95	< 48.6	< 48.6	< 48.6	< 48.6	858.0	615.0	615.0
13355	08/18/2002	< 45	< 45	88.7	50.7	60.3	65.6	< 45	86.4	< 45	72.5	< 45	< 45	130	106	< 45	< 45	< 45	< 45	885.2	660.2	660.2
11261	08/19/2002	92.7	112	238	390	433	278	< 49.6	460	123	283	< 49.6	92.5	708	715	< 49.6	238	571	404	5212.6	5138.2	5138.2
13343	08/20/2002	68.2	96.2	253	245	282	247	< 49.1	236	105	235	< 49.1	65.5	399	284	< 49.1	93.8	191	121	2995.4	2921.7	2921.7
11264	08/20/2002	646	921	1830	3170	3830	2370	257	4910	1890	4260	< 49	1090	6030	4080	< 49	892	1620	834	38679.0	38630.0	38630.0
16618	08/20/2002	550	229	352	469	669	317	< 43.9	677	186	564	< 43.9	84.2	601	468	< 43.9	153	319	194	5898.1	5832.2	5832.2
16496	08/21/2002	198	165	547	969	1140	949	107	1700	325	947	< 47.3	239	1550	1520	< 47.3	< 47.3	987	650	12064.0	11993.0	11993.0
11302	08/21/2002	875	766	1790	1090	1040	< 48.8	157	1170	564	1200	< 48.8	346	2570	1870	< 48.8	548	1220	606	15885.2	15812.0	15812.0
13338	08/21/2002	746	1100	1990	3500	3820	1700	233	3990	902	2370	< 48.3	501	3690	3370	< 48.3	910	1960	1380	32210.3	32162.0	33420.5
13338-dup	08/21/2002	845	1040	2110	3840	4090	3060	243	3910	940	2490	< 46.8	490	3580	3250	< 46.8	981	2190	1620	34725.8	34679.0	
13342	08/21/2002	197	221	632	1300	1510	773	122	2030	446	1170	< 48.7	245	1720	1500	< 48.7	620	1130	833	14497.7	14449.0	14449.0
13344	08/21/2002	212	202	608	845	969	939	128	1120	394	1040	< 48.7	252	1770	1570	< 48.7	399	693	585	11774.7	11726.0	11726.0
13339	08/22/2002	238	247	643	1230	1480	694	118	1880	410	1100	< 47.1	275	1920	1740	< 47.1	522	1170	1060	14774.1	14727.0	14727.0
16499	08/22/2002	304	315	783	1750	1960	1240	131	2340	524	1250	< 46.9	353	2840	2970	< 46.9	1060	2550	1870	22286.9	22240.0	22240.0
17971	08/24/2002	275	267	808	2270	1560	907	174	2600	643	1680	< 49.7	501	5270	5620	< 49.7	2630	5590	3260	34104.7	34055.0	35217.0
17971-dup	08/24/2002	208	263	862	2980	2250	1070	179	3220	652	1730	< 44.8	645	5860	6110	< 44.8	2220	4960	3170	36423.8	36379.0	
11287	08/26/2002	667	684	1380	1700	1730	880	154	2120	602	1400	< 49.2	382	2600	2110	< 49.2	763	1620	1120	19961.2	19912.0	19912.0
11252	08/27/2002	< 47.3	52.3	131	135	147	149	< 47.3	80	85	63.1	< 47.3	< 47.3	86	83	< 47.3	< 47.3	< 47.3	< 47.3	1200.6	1011.4	684.2
11252-dup	08/27/2002	< 48.9	< 48.9	91.3	71.2	77.2	60	< 48.9	57.3	< 48.9	48.9	< 48.9	< 48.9	< 48.9	< 48.9	< 48.9	< 48.9	< 48.9	< 48.9	674.9	357.0	
13336	08/27/2002	116	106	326	231	260	375	< 47.8	387	132	446	< 47.8	69.8	531	678	< 47.8	147	274	202	4352.5	4280.8	4324.2
13336-dup	08/27/2002	152	119	362	340	361	470	< 49.4	416	107	388	< 49.4	53.5	396	566	< 49.4	147	286	204	4441.6	4367.5	
11273	08/28/2002	20200	64300	124000	265000	306000	171000	17000	105000	45800	83700	423	12900	82600	63300	244	13800	25500	17400	1418167.0	1418167.0	1445307.7
11273-dup	08/28/2002	24700	61500	132000	264000	317000	161000	19000	140000	48800	80200	669	12600	81100	61300	79.3	16700	32300	19500	1472448.3	1472448.3	
11270	08/28/2002	2960	2560	6170	11200	10900	8660	458	10200	1540	6320	< 49	987	6770	6730	< 49	1210	2660	2040	81414.0	81365.0	81365.0
11280	08/29/2002	< 1490	2210	4830	8420	8220	4070	580	11000	2660	6950	< 97.7	1370	11500	10500	< 97.7	4950	11700	6600	96402.7	95560.0	95560.0
13309	08/30/2002	67.5	87.8	196	197	225	224	< 44.6	244	97.7	240	< 44.6	53.6	325	249	< 44.6	57.7	118	69.1	2518.3	2451.4	2451.4
14560	08/30/2002	132	157	378	450	460	496	< 46.5	531	186	487	< 46.5	124	879	800	< 46.5	226	477	306	6158.8	6089.0	6089.0
16622	09/03/2002	84.7	152	394	619	728	368	51.6	836	210	478	< 48.5	123	699	670	< 48.5	185	451	345	6442.8	6394.3	6394.3
11200	09/03/2002	< 45.6	< 45.6	88.9	46.6	53.1	58.3	< 45.6	50.2	< 45.6	46.9	< 45.6	< 45.6	78.1	62.3	< 45.6	< 45.6	< 45.6	< 45.6	712.4	484.4	419.8
11200-dup	09/03/2002	< 47.9	< 47.9	96.2	< 47.9	52.1	60	< 47.9	< 47.9	< 47.9	< 47.9	< 47.9	< 47.9	75.1	71.7	< 47.9	< 47.9	< 47.9	< 47.9	666.5	355.1	
15979	09/04/2002	11300	4310	6480	13300	21000	7710	956	21300	5330	14800	63.7	2900	22400	20000	< 46.8	4840	11300	6970	174983.1	174959.7	154092.0
15979-dup	09/04/2002	9060	3290	5240	10500	15800	5640	735	16900	3990	9020	59.2	2100	17600	15600	< 45.9	3640	8480	5570	133247.2	133224.2	
11292	09/05/2002	1010	2090	5020	8410	6320	3480	523	8120	2260	5530	54.5	1850	15400	14200	< 49.7	4750	10300	7270	96612.4	96587.5	96587.5
11300	09/05/2002	4900	4680	10300	17800	23300	10200	1960	43500	9750	25500	293	8190	55800	48500	57.8	9890	21800	15700	312120.8	312120.8	311932.3
11300-dup	09/05/2002	8170	6810	13700	20100	25600	10900	1880	39000	9480	24000	299	7750	53800	46300	54.7	9000	20000	14900	311743.7	311743.7	
15908	09/11/2002	< 46.9	53.5	126	127	< 46.9	74	< 46.9	151	< 46.9	83.9	< 46.9	< 46.9	81.1	88.3	< 46.9	< 46.9	47.5	51	1070.9	883.3	883.3
16213	09/11/2002	126	66.2	167	245	290	194	< 45.7	428	79.9	463	< 45.7	54.7	376	482	< 45.7	97.2	198	204	3539.6	3471.0	3471.0
Fall 2002																						
13338	10/22/2002	200	209	517	693	777	568	63.9	820	247	634	< 48.8	131	872	795	< 48.8	261	536	373	7745.7	7696.9	7696.9
13336	10/22/2002	154	174	448	656	746	513	58.9	845	236	613	< 47.5	139	988	907	< 47.5	299	626	421	7871.4	7823.9	7823.9
13340	10/23/2002	150	124	305	645	906	528	57.7	1670	301	1130	< 45.8	244	1780	1730	< 45.8	574	1150	915	12255.5	12209.7	12209.7
11252	10/24/2002	92.2	82.4	222	291	330	272	< 47.2	397	103	299	< 47.2	59.3	387	402	< 47.2	123	240	201	3571.7	3500.9	3500.9

| 17970 | 10/24/2002 | 56.6 | 65.3 | 157 | 159 | 204 | 146 | < 48.7 | 215 | 49.8 | 167 | < 48.7 | < 48.7 | 156 | 143 | < 48.7 | < 48.7 | 63.9 | 49.7 | 1754.1 | 1632.3 | 1632.3 |

Table B-2 PCB Concentrations in Sediment (ng/kg-dry wt.) - Cont'd

Station ID	Date	PCB 8	PCB 30/18	PCB 28/20	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 113/90/101	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 138/163/129	PCB 153/168	PCB 169	PCB 170	PCB 193/180	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
16499	10/24/2002	172	172	404	863	1090	566	84.5	1630	300	802	< 39.9	197	2400	2980	< 39.9	1010	2580	2040	17330.4	17290.5	17290.5
11261	10/26/2002	104	114	281	498	573	411	55.7	611	195	487	< 48	92.5	592	488	< 48	192	381	255	5378.2	5330.2	5330.2
13344	10/27/2002	217	232	655	1160	1280	1070	131	1550	369	1200	< 46.1	219	1430	1460	< 46.1	420	828	664	12931.1	12885.0	12885.0
17971	10/28/2002	307	289	657	1160	1230	848	95.5	1330	317	956	< 48.3	190	1420	1340	< 48.3	460	935	656	12238.8	12190.5	12190.5
13342	10/30/2002	213	220	641	1290	1460	943	129	1560	457	1170	< 46.6	261	1810	1560	< 46.6	510	991	786	14047.6	14001.0	14001.0
11193	10/31/2002	694	87.6	241	448	653	312	52.8	1330	285	696	< 49.7	217	1710	1770	< 49.7	528	1240	921	11235.1	11185.4	11185.4
13363	11/06/2002	< 49.5	< 49.5	100	92.4	120	79.8	< 49.5	129	< 49.5	72.8	< 49.5	< 49.5	82.4	84.6	< 49.5	< 49.5	< 49.5	< 49.5	1008.5	761.0	761.0
15464	11/06/2002	< 48.3	< 48.3	97.4	67.1	77	61.9	< 48.3	62.5	< 48.3	< 48.3	< 48.3	< 48.3	< 48.3	< 48.3	< 48.3	< 48.3	< 48.3	< 48.3	679.9	365.9	365.9
11200	11/21/2002	< 50	< 50	76.3	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	< 50	501.3	76.3	76.3
11280	12/02/2002	107	2600	5050	7810	6480	4440	472	8480	2120	5490	< 49.9	1520	11700	11300	< 49.9	3750	9040	5300	85708.9	85659.0	103601.5
11280-dup	12/02/2002	2710	3630	6690	11600	9790	6120	641	13200	3230	8080	62.9	2040	14600	14100	< 48.5	5440	12300	7310	121568.2	121543.9	
11292	12/10/2002	20900	33800	49500	59700	81300	45600	4620	110000	24500	47900	431	20800	189000	167000	82.3	54800	133000	74300	1117233.3	1117233.3	1117233.3
Spring 2003																						
11092	04/30/2003	1030	894	1730	1360	1500	736	111	1230	374	956	< 46.5	231	1750	1410	< 46.5	288	628	< 46.5	14297.8	14228.0	14228.0
11258	04/30/2003	222	358	664	819	851	770	79	633	231	557	< 47.7	116	793	674	< 47.7	214	460	278	7766.7	7719.0	7719.0
9128.0	04/30/2003	< 248	< 248	593	786	881	620	< 248	899	274	688	< 248	496	1240	1040	< 248	276	580	383	9128.0	8260.0	8260.0
11274	05/01/2003	1710	2110	4780	4560	4920	3700	520	2930	1390	2820	< 49.2	560	3200	2150	< 49.2	630	1340	772	38141.2	38092.0	41617.5
11274-dup	05/01/2003	1550	2030	4870	6290	6440	4070	491	3750	1600	3350	< 49	706	4360	2970	< 49	599	1320	747	45192.0	45143.0	
11111	05/01/2003	136	111	279	266	309	203	< 47.6	296	72.6	221	< 47.6	< 95.2	353	383	< 47.6	78.2	149	114	3089.8	2970.8	2970.8
11302	05/01/2003	278	487	1150	1430	1460	969	< 239	1750	698	1500	< 239	499	3400	2600	< 239	831	1850	1050	20310.5	19952.0	19952.0
11298	05/02/2003	619	905	1710	2390	2770	1460	< 229	3830	1090	2380	< 229	815	5750	4210	< 229	1930	4240	2810	37252.5	36909.0	36909.0
11273	05/03/2003	11500	42000	80400	118000	134000	132000	11400	70000	23500	38200	539	7590	48600	39700	< 231	9990	20700	12200	800134.5	800019.0	810877.0
11273-dup	05/03/2003	11100	43300	79300	130000	144000	124000	11400	73000	23800	42400	615	8230	51500	40400	< 240	8990	18700	11000	821855.0	821735.0	
11305	05/04/2003	< 795	916	1350	2950	1530	948	< 244	2990	884	2050	< 244	900	6140	4750	< 244	1660	3700	2050	33581.5	32818.0	32818.0
11347	05/04/2003	< 239	310	593	601	695	518	< 239	945	522	1140	< 239	478	1720	1160	< 239	394	761	418	10494.0	9777.0	9777.0
13339	05/04/2003	100	78.7	207	231	275	190	< 49.9	328	95.2	250	< 49.9	< 99.9	424	363	< 49.9	98.6	210	161	3136.3	3011.5	3011.5
11287	05/05/2003	486	1010	1880	1390	1340	458	71.4	1100	388	927	< 47.4	337	2260	1810	< 47.4	473	1060	685	15722.8	15675.4	15675.4
11382	05/05/2003	< 235	521	1220	1330	1510	630	< 235	1100	502	938	< 235	< 471	1580	1050	< 235	349	699	397	12531.5	11826.0	11826.0
11270	05/06/2003	335	431	939	1480	1570	1060	127	1020	505	1050	< 49.5	187	1130	847	< 49.5	294	626	369	12019.5	11970.0	11970.0
11280	05/06/2003	1110	1540	3490	5840	6260	3650	507	9030	2600	6630	< 241	1930	12500	9790	< 241	3060	6370	3590	78138.0	77897.0	77897.0
11292	05/06/2003	673	1180	2480	4260	3070	1920	208	4130	1020	2530	65.5	761	5120	4710	< 47.5	1760	4050	2180	40141.3	40117.5	40812.3
16618	05/06/2003	1090	1040	1600	2360	2840	2510	256	4180	998	2670	< 238	723	6230	5700	< 238	2080	4670	2560	41745.0	41507.0	23751.5
11261	05/11/2003	282	149	368	577	703	158	55.9	645	229	563	< 46.4	122	750	639	< 46.4	188	374	193	6042.3	5995.9	5995.9
13342	05/11/2003	197	194	511	979	1150	742	110	1270	356	923	< 48.8	220	1390	1290	< 48.8	471	904	569	11324.8	11276.0	11276.0
13343	05/11/2003	84	97.2	274	359	428	297	< 48.7	382	126	299	< 48.7	< 97.4	484	431	< 48.7	129	248	173	3933.0	3811.2	3811.2
16496	05/11/2003	458	514	1230	2290	2480	1530	136	2100	626	1570	< 50.3	367	2430	2330	< 50.3	701	1510	833	21155.3	21105.0	21105.0
13309	05/12/2003	< 47.8	< 47.8	70.2	< 57.3	< 47.8	< 47.8	< 47.8	47.8	< 47.8	< 47.8	< 47.8	< 95.5	< 47.8	< 57.3	< 47.8	< 47.8	< 47.8	< 47.8	509.9	70.2	70.2
14560	05/12/2003	50.9	< 48.9	75	66.9	97.3	55.5	< 48.9	158	< 48.9	125	< 48.9	< 97.8	132	117	< 48.9	< 48.9	< 48.9	< 48.9	1122.1	877.6	877.6
15464	05/12/2003	65.2	56.1	122	87	93.5	98.6	< 50	74.7	< 50	58.6	< 50	< 100	65.8	75.5	< 50	< 50	< 50	< 50	1022.0	797.0	797.0
16213	05/12/2003	62.9	58.6	139	106	126	90.3	< 48.8	114	< 48.8	73	< 48.8	< 97.6	115	121	< 48.8	< 48.8	< 48.8	< 48.8	1225.4	1005.8	1005.8
11193	05/13/2003	3760	151	391	809	1930	261	< 47.8	3490	1360	3330	< 47.8	689	3470	2280	< 47.8	625	1060	421	24098.7	24027.0	24027.0
13589	05/22/2003	272	301	567	274	296	214	< 47.2	112	88.3	< 47.2	< 94.4	116	81.4	< 47.2	< 47.2	60.3	< 47.2	2570.8	2382.0	2382.0
11252	05/28/2003	104	86.2	190	238	255	222	< 49	276	83.5	228	< 49	< 98	272	258	< 49	85.9	171	105	2697.1	2574.6	2768.7
11252-dup	05/28/2003	159	104	237	270	290	260	< 48.1	281	91.8	248	< 48.1	< 96.2	313	291	< 48.1	87	204	127	3083.1	2962.8	
13337	05/28/2003	431	444	1130	1480	1470	1270	102	1300	380	971	< 50	233	1670	1590	< 50	396	843	480	14240.0	14190.0	14190.0
13340	05/28/2003	127	105	240	488	640	366	49.7	1100	225	847	< 45.4	182	1340	1290	< 45.4	494	1010	544	9093.1	9047.7	9047.7
13341	05/28/2003	48.3	< 48.3	69.1	< 58	54.3	< 48.3	< 48.3	62.8	< 48.3	< 48.3	< 48.3	< 96.7	154	127	< 48.3	63.5	141	82.1	1048.5	802.1	802.1
13355	05/28/2003	49.4	< 44.5	75.1	53.6	60	< 44.5	< 44.5	46.8	< 44.5	< 44.5	< 44.5	89	47.7	< 53.4	< 44.5	< 44.5	< 44.5	< 44.5	626.3	332.6	332.6
15908	05/28/2003	< 46.3	< 46.3	74.1	65.3	76.5	54.8	< 46.3	76.9	< 46.3	61.9	< 46.3	< 92.7	77.9	77.5	< 46.3	< 46.3	< 46.3	< 46.3	819.6	564.9	564.9
11264	05/29/2003	757	1280	2840	4660	5190	4050	338	3770	1170	2700	< 49	567	3570	3230	< 49	800	1760	1010	37741.0	37692.0	37692.0
11300	05/29/2003	3650	5550	8860	10100	13600	4660	1160	20300	5870	13400	203	4100	28400	25200	219	5250	11600	7250	169372.0	169372.0	169372.0
15979	05/29/2003	283	454	1110	1580	1750	1340	144	1780	552	1250	< 49.6	296	1940	1590	< 49.6	553	1180	639	16490.6	16441.0	16441.0
16622	05/29/2003	238	193	582	590	637	713	49.6	710	160	529	< 49.5	167	834	895	< 49.5	190	423	326	7286.1	7236.6	7236.6

Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA
Values reported to the Method Reporting Limit
[a] Non-detects assumed to be 1/2 reporting limit
[b] Non-detects assumed to be zero
[c] Average of duplicate samples, otherwise concentration of a single sample
         tributary

Table B-3 PCB Concentrations in Catfish Tissue (ng/g-wet wt.)

Station ID	Date	Lipid Content (%)	PCB 8	PCB 18/30	PCB 20/28	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 90/101/113	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 129/138/163	PCB 153/168	PCB 169	PCB 170	PCB 180/193	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
Summer 2002																							
11272	07/26/2002	0.5	0.12	0.23	0.61	0.77	1.1	1.3	< 0.02	1.3	0.6	1.8	0.0067	0.31	2.1	2.4	< 0.0046	0.53	1.4	0.88	15.5	15.5	17.1
11272-dup	07/26/2002	0.5	0.14	0.25	0.7	0.88	1.2	1.6	< 0.023	1.6	0.74	2.1	< 0.0094	0.38	2.6	3.1	< 0.0042	0.67	1.7	1	18.7	18.7	
11274	07/30/2002	0.4	0.16	0.52	2.1	5.9	5	6.2	0.043	5.5	3.7	8.7	0.025	1.8	13	13	< 0.013	2.9	7.1	4.4	80.1	80.0	80.0
11111	08/01/2002	1.7	< 0.01	0.051	0.47	2.5	3.1	2.1	0.023	5.2	1.7	6.4	0.075	1.8	15	19	0.014	3	7	7.1	74.5	74.5	74.5
11258	08/01/2002	1.9	< 0.048	0.093	0.48	3.8	2.9	3.2	0.024	5.1	2.4	6.8	0.05	1.6	11	12	0.008	2.2	4.6	3.8	60.1	60.1	60.1
11092	08/02/2002	1.5	0.065	0.1	0.75	1.1	0.79	1.1	0.015	1.5	0.79	2.7	0.017	0.47	3.1	3.5	< 0.004	0.84	1.7	1.1	19.6	19.6	19.6
13340	08/07/2002	0.8	< 0.038	0.061	0.21	1.1	0.93	0.98	< 0.01	2.2	0.94	3.2	< 0.006	0.75	5.1	6.6	< 0.009	1.7	3.3	2.2	29.3	29.3	29.3
11193	08/09/2002	3.0	< 0.008	0.066	1.1	8.6	9.2	5.8	0.051	6.9	2.9	9.6	0.091	1.9	14	19	0.023	2.7	6.4	4.8	93.1	93.1	93.1
13341	08/09/2002	2.1	< 0.023	0.061	0.53	2.3	2.5	1.8	0.015	5.3	1.5	5.6	0.011	1.1	9.8	15	0.01	2.9	6.2	4.6	59.2	59.2	59.2
11382	08/11/2002	0.9	0.18	1.2	2.8	3.1	2.4	2.6	0.027	3.5	2.2	4.8	0.054	1.2	8.1	8.1	0.01	3.3	6.5	3.4	53.5	53.5	53.5
11305	08/13/2002	3.0	< 0.021	0.42	2.3	6.3	4.7	4.7	0.07	6.8	2.5	6.3	0.029	1.8	14	14	< 0.015	3.6	8.2	5.4	81.1	81.1	72.4
11305-dup	08/13/2002	1.2	0.089	0.4	1.8	4.3	3.2	2.8	0.045	4.5	1.9	5.2	0.023	1.4	13	13	< 0.008	3.1	5.3	3.7	63.8	63.8	
11347-1	08/13/2002	2.3	0.11	0.23	1.5	2.1	2	2.3	0.02	4.5	2.4	6.1	0.082	1.9	16	17	< 0.011	5.3	9.9	6	77.4	77.4	171.0
11347-2	08/13/2002	0.6	0.22	0.58	1.4	1.7	1.7	1.6	0.019	2.8	1.9	4	0.027	1.1	7.1	4.8	< 0.01	1.4	2.7	2.1	35.2	35.1	
11347-2-dup	08/13/2002	0.6	0.29	0.79	4	5.8	6.4	9.3	0.068	18	7.4	18	0.31	6.2	50	50	0.061	18	39	20	253.6	253.6	
11347-3	08/13/2002	2.2	0.35	0.88	6.1	10	8.5	16	0.13	17	13	30	0.4	9.4	65	58	0.06	20	40	23	317.8	317.8	
13337	08/14/2002	1.0	< 0.083	< 0.032	0.78	8	7.5	5.3	< 0.023	7.4	2.4	8.3	0.025	1.6	12	17	< 0.012	1.7	3.5	4.4	80.0	79.9	71.3
13337-dup	08/14/2002	1.0	< 0.012	0.015	0.4	4.7	3.7	3.7	< 0.017	4.7	1.9	6.4	0.013	1.5	11	14	< 0.01	2.1	4.7	3.9	62.7	62.7	
13589	08/17/2002	0.4	< 0.087	< 0.028	0.29	2.8	1.7	3	< 0.034	3.7	1.4	5	< 0.018	1.2	8.2	13	< 0.022	1.8	3.9	2.8	48.9	48.8	48.8
13589-dup	08/17/2002	0.4	< 0.08	0.034	0.31	2.6	2.5	2.5	< 0.022	3.2	1.1	3.5	< 0.053	0.9	6.7	10	< 0.008	1.4	2.8	2.8	40.4	40.3	35.0
13363	08/17/2002	1.3	< 0.004	0.006	0.18	1.2	0.99	1.3	0.008	2.3	0.92	3.3	0.009	0.74	5	8	< 0.004	1.2	2.7	1.9	29.8	29.8	
15464	08/18/2002	1.0	< 0.022	< 0.008	0.048	0.23	0.17	0.11	< 0.013	0.16	< 0.049	0.22	< 0.003	0.032	0.35	0.56	< 0.004	0.055	0.098	0.13	2.2	2.2	2.2
13355	08/18/2002	1.2	< 0.003	0.025	0.14	1.3	0.93	1.4	< 0.006	3	1.6	5.3	< 0.003	1.5	9.8	15	0.01	3.1	6.9	3.5	53.5	53.5	53.5
17970	08/18/2002	1.1	< 0.017	0.015	0.15	0.79	1	0.56	< 0.007	1.1	0.39	1.4	0.015	0.3	2.3	3	< 0.011	0.53	1.2	0.96	13.7	13.7	13.7
16618	08/19/2002	1.4	< 0.003	0.11	0.39	1.9	1.9	1.8	0.011	3.5	1.3	4	0.01	0.89	5.6	7.5	0.007	1.6	3.4	1.5	35.4	35.4	35.4
101x5	08/20/2002	2.1	< 0.036	0.23	1.7	7.6	6.5	6.8	0.039	7.4	4.2	12	0.11	2.1	15	20	< 0.011	3.6	9.7	4.5	101.5	101.5	101.5
13343	08/20/2002	2.1	< 0.031	0.086	0.57	3.4	3.2	3.2	0.043	4.1	2.2	5.8	0.013	1.5	8.7	11	< 0.008	1.9	3.6	2.9	52.2	52.2	52.2
13344	08/21/2002	2.5	< 0.007	0.26	1.1	6.5	7.6	4.4	0.059	11	3.1	11	0.031	2	16	22	0.01	3	6.1	8.1	102.3	102.3	102.3
16496	08/21/2002	2.1	< 0.021	0.24	0.72	4	4.4	2.3	0.055	4.8	1.7	5	0.017	0.8	9.8	12	< 0.009	1.3	2.5	4	53.6	53.6	53.6
13342	08/22/2002	1.8	< 0.004	0.18	0.78	4.7	5	2.9	0.041	6.8	2.4	7.2	0.021	1.6	12	14	< 0.008	2.5	4.8	4.7	69.6	69.6	69.6
11261	08/23/2002	3.1	< 0.031	0.13	1.1	4.7	4.6	4	0.023	4.6	2.8	8	< 0.014	1.5	10	13	< 0.012	2.6	5.5	2.8	65.4	65.4	65.4
13338	08/23/2002	3.5	< 0.096	0.56	1.5	6.1	7.9	5	0.061	9.7	2.9	10	< 0.029	1.9	15	18	< 0.012	3	6.7	5.4	93.8	93.7	93.7
13339	08/23/2002	1.9	< 0.013	0.12	0.69	4.5	4	3.2	0.018	7.1	2.1	7.2	0.019	1.4	11	16	< 0.006	2.2	4.4	4.6	68.6	68.5	63.9
13339-dup	08/23/2002	1.9	< 0.01	0.1	0.59	3.5	3	2.7	0.023	6.1	1.7	6.2	0.019	1.4	10	14	< 0.008	1.8	3.1	5.1	59.3	59.3	
16499	08/23/2002	2.7	< 0.018	0.092	0.56	2.8	2.2	2	0.019	4	1.4	4.4	< 0.042	0.95	7.5	9.9	< 0.008	1.9	4.1	3.1	45.0	44.9	74.3
16499-dup	08/23/2002	2.7	< 0.005	0.17	1.1	5.5	5.2	4	0.043	9.8	2.9	9.4	0.03	2.3	19	26	< 0.02	3.1	7.1	8.1	103.8	103.7	
17971	08/24/2002	1.2	< 0.017	0.14	0.67	3.2	4.3	1.7	< 0.031	5.1	1.3	4.3	0.012	0.75	6.7	8.2	< 0.004	1.6	3.1	4.1	45.2	45.2	45.2
11287	08/25/2002	2.9	0.11	0.67	2.5	4.1	3	3	0.044	4	1.9	5.2	0.022	0.85	7.7	7.9	0.003	2	4.3	3.3	50.6	50.6	50.6
11252	08/26/2002	1.8	< 0.015	0.025	0.37	2.4	2.3	2	< 0.02	3.6	1.6	5.6	0.011	1.1	8.4	12	< 0.005	1.4	3.6	3.4	47.8	47.8	47.8
11302	08/26/2002	1.1	0.15	0.79	2.5	3.3	3	2.5	0.038	3.9	1.8	4.8	0.022	0.87	8.9	9.7	< 0.016	2.3	4.9	4.8	54.3	54.3	54.3
13336	08/27/2002	1.0	< 0.003	0.009	0.086	0.45	0.46	0.33	0.003	0.77	0.27	0.98	< 0.002	0.21	1.5	2.2	0.002	0.34	0.68	0.67	9.0	9.0	19.2
13336-dup	08/27/2002	1.0	< 0.029	< 0.017	0.23	1.5	1.4	1.4	< 0.017	2.5	1	3.7	< 0.014	0.64	4.9	7.4	< 0.014	0.96	1.9	1.9	29.5	29.4	
11270	08/28/2002	1.2	< 0.023	0.3	2.7	9.4	6.7	10	0.036	6.8	5.1	12	< 0.027	2.2	15	20	0.014	3.6	8.2	3	105.1	105.1	105.1
11280	08/28/2002	1.4	0.021	0.35	1.8	5.3	3.8	3	< 0.031	4.8	3.7	10	0.018	2.1	13	21	< 0.011	3.7	8.1	4.6	85.3	85.3	85.3
11298	08/29/2002	0.4	< 0.029	0.15	0.83	1.4	1.3	1.6	< 0.028	1.6	1.4	3.7	< 0.016	0.77	5.4	5.7	< 0.016	1.4	3.1	1.5	29.9	29.9	29.9
11273	08/30/2002	2.1	< 0.009	0.73	8.2	22	15	29	< 0.042	17	10	25	0.051	2.7	17	22	< 0.013	4.4	9.3	5.5	187.9	187.9	187.9
13309	08/30/2002	1.4	< 0.008	0.025	0.26	1.7	1.3	1.2	< 0.011	2.2	1.1	3.9	0.008	0.87	6.6	9.7	< 0.008	1.6	3.5	2.6	36.6	36.6	36.6
14560	08/30/2002	1.7	< 0.009	0.014	0.13	1.2	0.77	0.94	< 0.012	1.5	0.67	2.5	< 0.007	0.45	3.6	6.9	< 0.003	0.84	1.9	1.8	23.2	23.2	23.2
11200	09/03/2002	1.3	< 0.016	0.078	0.3	0.62	0.42	0.53	0.02	0.9	0.67	2.1	0.007	0.54	4.3	5	< 0.01	1.2	3	2.2	21.9	21.9	21.9
16622	09/04/2002	0.4	< 0.012	0.05	0.46	3.6	0.91	7.9	0.11	17	29	100	0.053	22	210	190	< 0.091	47	140	98	866.1	866.1	866.1
15979	09/05/2002	1.9	< 0.003	0.36	2.7	5.3	5.7	4.1	< 0.031	4.7	2.7	7.1	0.019	0.92	7.4	10	< 0.003	1.5	3.6	2.2	58.3	58.3	58.3
11300	09/06/2002	4.8	0.37	1.6	7.1	9	9.7	7.1	0.1	12	3.7	10	0.041	3.1	26	20	< 0.013	5.9	16	9.7	141.4	141.4	141.4
11292	09/11/2002	1.0	0.21	0.93	4.3	3.5	4.4	3.8	0.051	10	2.5	6.4	0.029	2.4	26	20	< 0.017	8	21	13	126.5	126.5	126.5
15908	09/11/2002	2.7	< 0.011	0.025	0.75	2.8	2.7	1.9	< 0.017	5.4	1.5	5.9	0.016	0.93	7.1	13	< 0.006	1.2	2.8	4	50.0	50.0	39.8
15908-dup	09/11/2002	2.7	< 0.012	0.009	0.22	1.5	1.4	1.2	< 0.016	2.4	0.85	3.1	0.007	0.58	4.5	8.5	< 0.007	0.96	2.2	2.2	29.6	29.6	
16213	09/11/2002	2.4	< 0.012	0.012	0.29	2.2	2.3	1.9	< 0.026	4.7	2	7.5	< 0.012	1.8	12	23	< 0.016	3.6	7.9	6.5	75.7	75.7	75.7

Table B-3 PCB Concentrations in Catfish Tissue (ng/g-wet wt.) - Cont'd

Station ID	Date	Lipid Content (%)	PCB 8	PCB 18/30	PCB 20/28	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 90/101/113	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 129/138/163	PCB 153/168	PCB 169	PCB 170	PCB 180/193	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
Fall 2002																							
13336	10/22/2002	1.2	< 0.003	0.042	0.73	3.8	3.1	3.3	< 0.021	5.1	3	8.4	0.11	1.5	11	14	0.014	2.5	5.3	2.4	64.3	64.3	64.3
13338	10/22/2002	3.1	< 0.004	0.024	0.32	2.7	2.2	2.1	< 0.015	5.6	2.6	9.1	0.011	1.9	13	19	0.012	2.7	5.2	3.6	70.1	70.1	72.5
13338-dup	10/22/2002	3.1	< 0.003	0.067	0.91	4.6	5.4	3.8	0.019	7.6	2.9	8.9	0.024	1.7	13	15	0.015	2.3	4.4	4.2	74.8	74.8	
11252	10/24/2002	2.3	< 0.003	0.065	0.72	4.3	5	3.1	0.013	7.5	2.6	7.5	0.02	1.5	11	13	0.012	2	3.8	3.2	65.3	65.3	65.3
16499	10/24/2002	1.9	< 0.004	0.04	0.3	2.3	1.9	1.5	< 0.016	3.2	1.5	4.7	0.018	0.93	7.8	11	0.009	2	4.4	2.8	44.4	44.4	44.4
17970	10/24/2002	2.1	< 0.006	0.04	0.76	3.4	4.2	2.4	< 0.022	6.4	1.5	4.7	0.014	1.3	9.8	12	< 0.008	2.1	4.5	4.3	57.4	57.4	66.5
17970-dup	10/24/2002	2.1	< 0.006	0.021	0.57	4	3.2	3	< 0.022	5.5	2.5	7.9	0.018	1.9	13	19	< 0.011	3	6.9	5.1	75.6	75.6	
11261	10/26/2002	2.1	< 0.01	0.056	0.65	5.1	4.3	4.5	< 0.01	7	3.3	11	0.021	1.9	14	18	< 0.02	3.5	9	4.6	86.9	86.9	86.9
13344	10/27/2002	3.1	< 0.007	0.069	0.72	4.4	4.1	3.5	< 0.026	6.1	2.6	8	0.018	1.6	11	15	< 0.017	2.6	6.2	4.2	70.1	70.1	70.1
13342	10/28/2002	1.4	< 0.009	0.044	0.37	1.9	1.7	1.7	< 0.023	3	1.5	4.4	0.013	0.94	6.7	8.8	< 0.007	1.4	3	2.3	37.8	37.8	37.8
17971	10/28/2002	3.1	< 0.011	0.053	0.75	4.5	3.4	4	< 0.029	5.5	3.4	11	0.026	2.1	17	23	< 0.018	3.4	8.6	5.6	92.4	92.3	92.3
11200-1	11/19/2002	2.2	< 0.059	0.12	0.51	0.83	1.3	1	< 0.009	1.7	0.47	1.4	0.005	0.31	2.4	2.7	< 0.013	0.48	1	1	15.3	15.2	47.7
11200-2	11/21/2002	4.1	0.13	0.51	1.4	3.1	3.6	2.3	0.068	3.3	1	3	< 0.016	0.73	6.1	7.2	< 0.03	1.5	2.8	3.1	39.9	39.8	
11200-2-dup	11/21/2002	4.1	0.097	0.17	2.9	4	2.6	5	0.061	5.1	3.2	8.9	0.033	1.8	14	18	< 0.023	4.6	11	6.8	88.2	88.2	
11193	11/20/2002	0.8	< 0.056	< 0.059	0.48	1.3	1.9	2.1	< 0.016	3.8	1.3	4.1	< 0.004	0.88	7	8	< 0.008	1.2	2.7	3.1	37.9	37.9	37.9
11292	12/02/2002	1.7	0.19	0.53	4.1	4.4	4.5	5.5	< 0.043	7.2	3.9	9.8	0.039	2.6	21	21	< 0.008	6.3	17	7.8	115.9	115.9	115.9
11280	12/05/2002	1.1	< 0.084	0.24	1.1	1.7	2.6	2.1	< 0.037	2.9	1.3	3.8	< 0.02	0.8	5.7	6.3	< 0.006	1.3	3.9	2.5	36.3	36.2	36.2
Spring 2003																							
11273	04/29/2003	3.6	0.035	1.3	4	14	8.6	19	0.039	10	9.3	21	0.034	2.6	16	20	< 0.025	3.4	8.4	3.8	141.5	141.5	141.5
11092	04/30/2003	0.7	0.06	0.046	0.21	0.26	0.23	0.37	< 0.012	0.55	0.28	0.99	< 0.0059	0.21	1.5	1.6	< 0.013	0.33	0.77	0.58	8.0	8.0	8.0
11092-dup	04/30/2003	0.9	0.06	0.047	0.34	0.35	0.24	0.46	< 0.0062	0.53	0.29	1	0.005	0.21	1.5	1.4	< 0.0029	0.32	0.72	0.57	8.0	8.0	8.0
11272	04/30/2003	0.5	0.046	0.12	0.53	0.78	0.97	1.1	< 0.013	1.7	0.85	2.6	< 0.0078	0.55	4	4.5	< 0.013	1.1	3	2.1	24.0	23.9	23.9
11111	05/01/2003	2.1	< 0.02	0.021	0.32	1	0.96	0.93	< 0.017	2.1	0.75	2.8	< 0.024	0.56	3.8	5.2	< 0.0087	0.8	1.8	1.9	23.0	22.9	22.9
11274	05/01/2003	1.8	0.18	0.59	2.4	2.8	2.9	3.4	0.029	4	2.9	7.5	0.022	1.3	7.8	6.9	0.015	1.6	3.3	1.8	49.4	49.4	49.4
11298	05/01/2003	1.6	0.12	0.49	1.4	2.2	3.1	2.2	0.019	3.3	1.2	3.4	0.02	0.71	5.7	6.1	< 0.011	1.5	3.2	2.3	37.0	37.0	37.0
11302	05/01/2003	0.6	0.058	0.33	1.6	1.5	2.2	2.1	0.012	1.9	1.3	3.3	< 0.014	0.7	4.6	5	< 0.02	1.2	2.7	1.9	30.4	30.4	30.4
11347	05/02/2003	1.5	0.21	0.48	4	3.9	3.9	4.5	0.03	6.7	4.2	9.5	0.064	2.5	19	19	< 0.03	4.4	10	6.2	98.6	98.6	101.1
11382	05/02/2003	0.7	0.13	0.27	2.8	3.9	3.1	4.4	0.018	5.5	4.2	9.7	0.049	2.5	20	21	< 0.043	5.7	13	7.4	103.7	103.7	93.0
11382-dup	05/02/2003	1.5	0.14	0.3	2.7	3	3	3.4	0.023	4.8	3	7.3	0.04	2.1	16	16	< 0.0096	4.5	9.9	6.2	82.4	82.4	
11305	05/03/2003	1.2	0.15	0.56	2.6	5.3	4.5	5.2	0.03	8	4.3	9.9	0.06	2.9	25	25	< 0.045	7.3	16	9.1	125.9	125.9	125.9
13339	05/04/2003	2.5	0.023	0.39	1.4	8.1	6.7	7.2	0.035	14	5.1	15	0.048	2.7	19	26	< 0.033	4.1	8.1	8.5	126.4	126.4	126.4
11287	05/05/2003	3.1	0.15	0.74	3	5.8	7.5	5.8	0.044	10	4.2	9.2	0.071	2.7	23	23	< 0.029	5.7	13	6.1	120.0	120.0	120.0
16618	05/05/2003	2.8	< 0.0049	0.05	0.45	7.4	6.4	5.5	< 0.018	14	5.5	18	0.048	3.6	26	34	< 0.037	6.1	14	8.8	149.9	149.8	149.8
11270	05/06/2003	2.6	< 0.0075	0.27	1.3	9.8	9.8	7.2	< 0.0082	12	6	17	0.054	3.5	25	29	< 0.032	5	11	6.5	143.4	143.4	143.4
11280	05/06/2003	3.8	0.027	1.9	5.3	23	13	23	0.062	20	14	34	0.079	5.8	41	49	< 0.05	8.4	19	8.4	266.0	266.0	266.0
11261	05/10/2003	2.9	< 0.006	0.18	0.92	7.1	5.2	7	0.014	9.3	4.8	13	0.051	2.3	15	18	< 0.026	3.7	8.1	5.1	99.8	99.8	99.8
13342	05/11/2003	2.3	< 0.017	0.16	1.4	13	10	13	< 0.059	27	11	33	0.039	6.5	51	65	< 0.088	9.7	20	19	279.9	279.8	279.8
16496	05/11/2003	1.8	< 0.005	0.082	0.64	4	3.1	3.6	0.012	6.9	3	9.8	< 0.005	1.7	12	16	< 0.023	3.1	6.8	4.2	75.0	74.9	107.7
16496-dup	05/11/2003	2.5	< 0.0072	0.097	1.6	7.8	7.7	7.4	< 0.021	14	5.3	17	0.051	3.2	23	28	< 0.042	5.6	11	8.7	140.5	140.4	
13309	05/12/2003	1.1	< 0.021	0.11	0.28	2.7	3.3	2.4	< 0.018	10	2.1	8.5	< 0.01	2.2	18	27	< 0.036	4.3	10	8.1	99.0	99.0	99.0
11193	05/14/2003	0.4	< 0.0096	0.041	0.36	2.4	2.8	2.2	< 0.021	4.4	1.7	5.6	0.016	1.2	8.4	10	< 0.005	1.7	3.9	3.5	48.2	48.2	48.2
11264	05/15/2003	2.7	< 0.007	0.28	1.7	13	9.9	13	0.039	17	9.5	28	< 0.013	4.2	30	41	< 0.056	7.6	16	9.5	200.8	200.7	200.7
11252	05/16/2003	0.5	< 0.0094	< 0.0095	0.054	0.45	0.32	0.37	< 0.0036	0.74	0.32	1.1	< 0.01	0.26	1.7	2.4	< 0.0071	0.39	0.87	0.72	9.7	9.7	9.7
13589	05/16/2003	0.2	< 0.011	0.013	0.097	0.53	0.53	0.44	< 0.002	1.2	0.33	1.2	< 0.0096	0.29	2.1	2.8	< 0.0029	0.48	1.1	0.96	12.1	12.1	12.1
13355	05/28/2003	2.1	< 0.011	0.011	0.21	2.3	1.6	1.7	0.0061	3.7	1.8	6.5	0.012	1.2	10	14	< 0.012	2	4.8	2.4	52.3	52.2	52.2
15908	05/28/2003	2.0	< 0.0089	0.013	0.2	2.6	2.1	1.7	0.0067	4.4	1.8	7.1	0.011	1.4	11	17	< 0.015	2	4.5	2.5	58.3	58.3	58.3
11292	05/30/2003	1.0	0.12	0.45	4.1	7.8	9.3	8.7	0.021	20	9.1	19	0.12	7.1	65	65	< 0.084	20	45	23	303.9	303.8	303.8

Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA

Values reported to the Detection Limit

[a] Non-detects assumed to be 1/2 detection limit

[b] Non-detects assumed to be zero

[c] Average of duplicate samples, otherwise concentration of a single sample

     exceeds TDH Screening Value (47 ng/g)

     tributary

Table B-4 PCB Concentrations in Crab Tissue (ng/g-wet wt.)

Station ID	Date	Lipid Content (%)	PCB 8	PCB 18/30	PCB 20/28	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 90/101/113	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 129/138/163	PCB 153/168	PCB 169	PCB 170	PCB 180/193	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
Summer 2002																							
11272	07/26/2002	1.2	< 0.043	0.027	0.6	0.39	0.046	0.57	0.035	0.064	0.25	0.92	0.0049	0.095	0.7	1	< 0.0032	0.095	0.36	0.14	5.3	5.3	5.3
11298	07/29/2002	0.5	< 0.035	0.039	0.73	1.3	0.24	1.6	0.095	0.34	1.1	3.3	0.012	0.47	3.6	5	< 0.0038	0.61	2.3	1.1	21.9	21.8	21.8
11274	07/30/2002	0.6	0.062	0.032	2	1.8	0.38	2.6	0.2	0.68	1.6	3.2	0.012	0.39	2.8	2.8	< 0.0031	0.39	1.1	0.65	20.7	20.7	20.7
11111	07/31/2002	0.8	0.033	0.038	0.33	0.64	0.11	0.58	0.029	0.12	0.29	1.1	0.009	0.2	1.4	2.1	< 0.003	0.21	0.53	0.45	8.2	8.2	8.2
11258	08/01/2002	0.7	< 0.013	0.06	0.64	3.1	1.2	3.3	0.2	1.6	1.4	4.4	0.02	0.7	5.6	6.5	< 0.011	0.51	1.4	2	32.6	32.6	32.6
11092	08/02/2002	1.5	0.053	0.062	0.95	0.53	0.13	0.73	0.045	0.083	0.35	1.1	< 0.013	0.16	1.1	1.4	< 0.006	0.23	0.55	0.3	7.8	7.8	7.8
13340	08/07/2002	1.1	0.051	0.067	0.2	0.32	0.12	0.31	0.028	0.095	0.24	0.77	< 0.01	0.1	0.78	1	< 0.007	0.1	0.23	0.18	4.6	4.67	4.6
11193	08/09/2002	0.9	< 0.015	0.061	0.83	2.6	1.1	3.3	0.22	1.7	1.5	4.8	0.019	0.76	6.1	7.2	< 0.01	0.43	1.6	2.1	34.3	34.3	34.3
11347	08/12/2002	0.6	< 0.01	0.011	0.97	0.49	0.013	0.76	0.067	0.031	0.6	1.7	0.013	0.25	1.8	2	< 0.004	0.34	1.2	0.53	10.8	10.8	10.8
11382	08/13/2002	0.4	< 0.052	0.014	0.38	0.17	0.016	0.28	0.045	0.038	0.36	1	0.009	0.18	1.4	1.5	< 0.006	0.12	0.63	0.29	6.5	6.4	6.4
11305	08/14/2002	0.6	< 0.089	< 0.028	0.83	2.3	0.055	1.7	0.11	0.12	0.85	2.4	< 0.015	0.51	4.5	5.8	< 0.008	0.78	1.9	1.2	23.1	23.1	23.1
13337	08/14/2002	0.2	< 0.013	< 0.01	0.24	0.54	0.053	0.58	0.038	0.13	0.24	0.81	< 0.01	0.12	0.9	1.2	< 0.01	0.074	0.21	0.25	5.4	5.4	5.4
13341	08/16/2002	0.8	< 0.069	< 0.013	0.19	0.37	0.031	0.26	< 0.033	0.041	0.18	0.59	< 0.004	0.071	0.67	1	< 0.01	0.1	0.17	0.16	3.9	3.8	3.8
15464	08/17/2002	0.1	< 0.099	< 0.029	0.12	0.25	0.025	0.38	< 0.016	0.044	0.11	0.44	< 0.01	0.047	0.38	0.65	< 0.005	< 0.037	0.1	0.12	2.8	2.7	2.7
13363	08/17/2002	1.1	< 0.033	0.043	0.26	0.52	0.14	0.36	0.023	0.2	0.2	0.68	< 0.004	0.14	0.95	1.3	< 0.003	0.13	0.3	0.27	5.5	5.5	5.5
13589	08/17/2002	0.3	< 0.5	< 0.062	< 0.11	0.44	< 0.085	0.44	< 0.058	< 0.11	0.16	0.61	< 0.037	0.084	0.77	1.2	< 0.037	0.071	0.25	0.28	4.8	4.3	3.5
13589-dup	08/17/2002	0.3	< 0.077	< 0.02	0.079	0.28	0.033	0.25	< 0.01	0.044	0.08	0.33	< 0.01	0.056	0.42	0.71	< 0.008	0.056	0.14	0.13	2.7	2.6	
13355	08/18/2002	0.3	< 0.011	< 0.014	0.39	2	0.13	2	0.086	0.22	0.84	3.3	< 0.013	0.41	3.7	6.1	< 0.011	0.33	0.85	1.4	21.8	21.8	15.9
13355-dup	08/18/2002	0.3	< 0.1	< 0.025	0.21	0.82	0.11	0.92	0.036	0.2	0.35	1.4	< 0.007	0.21	1.7	2.8	< 0.01	0.12	0.38	0.71	10.0	10.0	
17970	08/18/2002	1.1	< 0.004	0.018	0.28	1.1	0.2	1.4	0.071	0.52	0.78	2.6	0.01	0.39	3.5	4.5	< 0.003	0.42	1.4	1.2	18.4	18.4	18.4
11261	08/20/2002	0.8	< 0.041	< 0.031	0.96	1.6	0.27	2	0.12	0.48	1.1	3.3	< 0.015	0.56	4.7	5.2	< 0.009	0.62	1.9	1.6	24.5	24.4	24.4
16618	08/20/2002	0.6	< 0.026	0.014	0.82	1.9	0.12	2.5	0.22	0.23	1.7	5.7	0.019	0.54	7	10	< 0.004	0.69	1.6	2.1	35.2	35.2	35.2
11264	08/20/2002	0.9	< 0.033	0.13	1.1	2.2	1.3	2.4	0.16	1.5	1.3	3.8	0.025	0.7	5.5	6.1	< 0.008	0.81	2.1	2.1	31.2	31.2	31.2
13338	08/23/2002	0.6	< 0.03	< 0.014	0.36	0.49	< 0.047	0.59	0.04	0.12	0.5	1.5	< 0.011	0.16	1.2	1.4	< 0.014	< 0.14	0.38	0.19	7.1	6.9	6.9
16499	08/23/2002	0.4	< 0.02	0.022	0.63	1.2	0.14	1.7	0.15	0.33	1.1	3.6	0.015	0.58	4.7	6.6	< 0.006	0.57	1.4	2	24.8	24.7	24.7
13344	08/23/2002	0.8	< 0.016	0.044	0.48	0.67	0.28	0.85	0.064	0.42	0.52	1.5	0.006	0.28	2.4	2.8	< 0.003	0.31	0.94	0.75	12.3	12.3	16.7
13344-dup	08/23/2002	0.8	0.011	0.078	0.65	1.2	0.67	2	0.18	0.97	0.95	2.8	0.012	0.41	4.1	3.7	< 0.007	0.5	1.3	1.5	21.0	21.0	
13342	08/24/2002	1.0	< 0.013	0.041	0.61	1.2	0.41	1.4	0.14	0.81	1.1	3	0.011	0.58	4.5	4.5	< 0.003	0.65	1.6	2.2	22.8	22.8	22.8
17971	08/24/2002	1.0	< 0.017	0.13	0.6	2	1.8	1.4	0.12	2.3	0.89	3.1	0.013	0.47	5.4	6.6	< 0.003	0.52	1.1	1.9	28.4	28.3	28.3
16496	08/24/2002	0.9	< 0.02	0.022	0.57	0.8	0.17	0.95	0.085	0.26	0.66	1.8	< 0.008	0.23	2.3	2.4	< 0.004	0.4	1	0.66	12.3	12.3	12.3
11287	08/25/2002	0.4	< 0.008	0.014	1.1	2.1	0.034	2.9	0.18	0.15	2.1	5.7	0.027	1.1	9	11	< 0.005	2.1	6.8	2.8	47.1	47.1	29.4
11287-dup	08/25/2002	0.7	< 0.039	0.017	0.68	0.73	0.021	0.67	0.073	0.04	0.56	1.5	< 0.006	0.25	2.4	2.7	< 0.01	0.36	1.2	0.58	11.8	11.8	
13339	08/25/2002	1.1	< 0.029	0.087	0.97	1.8	0.84	1.8	0.15	1	1.1	3.6	0.014	0.53	5.6	7.3	< 0.003	0.42	1.3	2.1	28.6	28.6	23.0
13339-dup	08/25/2002	1.1	< 0.02	0.031	0.75	1.4	0.31	1.8	0.11	0.51	1.1	3.3	0.011	0.26	2.7	3.1	< 0.002	0.25	0.7	1	17.3	17.3	
11302	08/26/2002	0.9	< 0.042	0.014	1.1	1.6	0.03	1.5	0.13	0.085	1.4	4	0.021	0.53	6.5	7.7	< 0.005	1	3.8	1.5	30.9	30.9	30.9
13336	08/27/2002	0.3	< 0.005	< 0.005	0.19	0.33	0.019	0.29	0.015	0.039	0.13	0.47	< 0.002	0.063	0.45	0.6	< 0.002	0.062	0.14	0.11	2.9	2.9	2.9
11270	08/28/2002	0.9	< 0.013	0.031	1.3	2.1	0.18	2.7	0.16	0.43	1.8	4.8	0.015	0.74	6.1	6.4	< 0.004	1.3	4.2	1.5	33.8	33.8	33.8
11273	08/28/2002	0.6	0.072	0.31	3.3	3	0.81	5.4	0.33	0.63	2.1	6.1	0.02	0.78	6.7	8.4	< 0.003	0.99	3.6	2	44.5	44.5	69.5
11273-dup	08/28/2002	0.6	0.17	0.83	10	7.2	2.9	19	1	2.5	6.3	15	0.049	1.1	8.8	9.8	< 0.002	1.5	5.3	3	94.5	94.4	
11280	08/28/2002	0.5	< 0.062	0.067	1.4	2.4	0.25	2.9	0.22	0.43	2.7	7.2	0.037	1.1	8.8	11	< 0.013	1.5	4.9	2.1	47.0	47.0	35.8
11280-dup	08/28/2002	0.6	< 0.004	0.03	0.92	1.5	0.087	1.3	0.08	0.16	1.3	3.6	0.015	0.55	4.6	5.9	0.003	0.82	2.5	1.3	24.7	24.7	
11252	08/29/2002	0.6	< 0.01	< 0.007	0.17	0.24	0.013	0.26	0.02	0.028	0.18	0.51	< 0.002	0.085	0.75	0.92	< 0.003	0.086	0.21	0.22	3.7	3.7	4.3
11252-dup	08/29/2002	0.6	< 0.008	< 0.007	0.16	0.36	0.038	0.38	0.025	0.066	0.22	0.79	< 0.003	0.11	0.86	1.2	< 0.003	0.11	0.29	0.27	4.9	4.9	
14560	08/30/2002	0.7	< 0.015	0.013	0.63	0.94	0.06	1.7	0.16	0.26	0.88	2.3	0.012	0.34	3	3.3	< 0.002	0.32	0.93	1	15.9	15.8	15.8
11200	09/02/2002	0.7	< 0.009	0.008	0.23	0.5	0.026	0.67	0.025	0.043	0.63	2	0.005	0.3	2.6	3.8	< 0.002	0.43	1.7	0.75	13.7	13.7	13.7
16622	09/02/2002	0.7	0.015	0.013	0.34	0.59	0.036	0.86	0.04	0.13	0.81	2.6	0.006	0.46	3.9	4.4	< 0.006	0.77	2.6	1.4	19.0	19.0	19.0
13343	09/04/2002	0.7	0.031	0.06	0.57	1.2	0.41	1.4	0.13	0.76	0.86	2.6	0.01	0.4	3.7	4.5	< 0.003	0.5	1	1.3	19.4	19.4	19.4
15979	09/05/2002	0.6	< 0.002	0.012	0.75	1.7	0.036	1.8	0.13	0.12	1.5	4.1	0.015	0.54	5	6.3	< 0.004	0.79	2.3	1.2	26.3	26.3	26.3
11300	09/09/2002	0.2	< 0.014	0.014	0.7	1.1	0.028	1.3	0.12	0.064	1.1	3.3	0.017	0.53	3.6	5.7	< 0.003	0.71	2	0.94	21.2	21.2	21.2
16213	09/10/2002	0.5	< 0.019	0.007	0.12	0.17	0.007	0.098	< 0.007	0.013	0.075	0.29	< 0.003	0.046	0.35	0.68	< 0.002	0.055	0.14	0.11	2.2	2.2	2.2
11292	09/11/2002	0.4	0.068	0.018	4.1	1.8	0.015	1.9	0.13	0.068	1.4	3.6	0.021	0.56	4.3	6.3	< 0.004	1	2.7	1.5	29.5	29.5	29.5
13309	09/11/2002	0.5	< 0.013	0.015	0.23	0.34	0.055	0.4	0.027	0.12	0.24	0.8	< 0.004	0.11	0.76	1.3	< 0.002	0.14	0.39	0.4	5.3	5.3	5.3
15908	09/11/2002	0.5	< 0.002	0.008	0.17	0.21	0.027	0.21	0.02	0.037	0.16	0.54	< 0.003	0.066	0.67	1.1	< 0.003	0.075	0.21	0.19	3.7	3.7	3.7

Table B-4 PCB Concentrations in Crab Tissue (ng/g-wet wt.) - Cont'd

Station ID	Date	Lipid Content (%)	PCB 8	PCB 18/30	PCB 20/28	PCB 44/47/65	PCB 52	PCB 66	PCB 77	PCB 90/101/113	PCB 105	PCB 118	PCB 126	PCB 128/166	PCB 129/138/163	PCB 153/168	PCB 169	PCB 170	PCB 180/193	PCB 187	Total PCBs[a]	Total PCBs[b]	Average Total PCBs[b,c]
Fall 2002																							
1193	10/21/2002	0.7	0.045	0.011	0.37	0.54	0.07	0.65	0.04	0.09	0.41	1.3	0.005	0.18	1.3	1.7	0.016	0.25	0.86	0.38	8.2	8.2	8.2
13336	10/22/2002	1.1	< 0.012	0.011	0.26	0.45	0.056	0.59	0.047	0.2	0.43	1.4	< 0.003	0.23	1.7	1.9	< 0.003	0.18	0.41	0.55	8.4	8.4	8.4
13338	10/22/2002	0.8	0.015	0.015	0.65	1.1	0.03	1.5	0.13	0.17	0.97	2.8	0.013	0.35	3	3.8	< 0.003	0.38	1.1	1.1	17.1	17.1	17.1
13340	10/22/2002	0.6	0.072	0.025	0.14	0.26	0.022	0.3	0.011	0.088	0.18	0.67	0.008	0.054	0.52	0.68	0.012	0.093	0.21	0.2	3.5	3.5	3.5
16499	10/24/2002	0.8	< 0.079	< 0.009	0.56	0.84	0.015	1.1	0.059	0.046	0.64	1.8	< 0.008	0.32	2.3	3.5	< 0.003	0.37	0.94	0.81	13.3	13.3	13.3
17970	10/24/2002	0.6	< 0.011	0.009	0.28	0.58	0.05	0.7	0.043	0.16	0.4	1.3	< 0.005	0.22	1.8	2.2	< 0.002	0.19	0.49	0.55	9.0	9.0	9.0
11261	10/25/2002	0.6	< 0.064	0.012	0.32	0.92	0.053	< 0.74	0.055	0.1	0.5	1.7	< 0.005	0.25	1.8	2.5	< 0.004	0.24	0.78	0.61	10.2	9.8	9.8
13344	10/27/2002	0.6	< 0.031	< 0.01	0.4	1.3	0.083	1.2	0.082	0.13	0.78	2.5	0.012	0.33	2.9	4.1	< 0.004	0.34	1.3	1.1	16.6	16.6	20.2
13344-dup	11/14/2002	0.6	< 0.034	0.011	0.45	1.8	0.072	1.7	0.073	0.17	1.1	3.4	0.009	0.53	4.4	6.1	< 0.006	0.53	1.8	1.7	23.9	23.8	
13342	10/28/2002	0.6	< 0.009	0.012	0.45	0.98	0.063	1.3	0.11	0.32	0.86	2.5	0.014	0.42	3.6	4.4	< 0.004	0.46	1.2	1.2	17.9	17.9	17.9
17971	10/28/2002	0.4	< 0.011	0.014	0.69	1.1	0.062	1.4	0.12	0.25	0.83	2.5	0.011	0.36	2.7	3.1	0.005	0.32	0.72	0.94	15.1	15.1	16.6
17971-dup	10/28/2002	0.4	< 0.009	0.021	0.56	1.2	0.2	1.6	0.12	0.55	0.92	2.9	0.016	0.41	3.2	3.8	< 0.005	0.41	1	1.1	18.0	18.0	
11252	11/13/2002	0.8	< 0.055	< 0.011	< 0.39	0.83	0.021	1.1	0.052	0.11	0.62	2	< 0.006	0.29	2.1	3.1	< 0.005	0.3	0.79	0.83	12.4	12.1	12.1
15464	11/13/2002	0.8	< 0.051	0.011	0.088	0.12	< 0.009	0.15	< 0.013	< 0.013	0.12	0.37	< 0.003	0.043	0.28	0.51	< 0.004	0.042	0.09	0.074	1.9	1.9	1.9
13363	11/16/2002	0.5	< 0.058	< 0.008	0.13	0.2	0.024	0.23	< 0.014	0.052	0.15	0.47	< 0.005	0.064	0.51	0.83	< 0.003	0.06	0.16	0.19	3.1	3.1	3.1

Total PCB concentration calculated as the sum of the 18 congeners recommended by NOAA
Values reported to the Detection Limit

[a] Non-detects assumed to be 1/2 detection limit

[b] Non-detects assumed to be zero

[c] Average of duplicate samples, otherwise concentration of a single sample

    exceeds TDH Screening Value (47 ng/g)

    tributary

Spring 2003 crab samples were not analyzed for PCBs

Table B-5 Aroclors in Water (ng/L)

Station ID	Date	Volume (L)	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total Aroclors
Summer 2002												
11200	09/02/2002	508	< 0.433	< 0.276	< 0.433	< 0.984	< 1.614	< 1.102	< 0.630	< 0.630	< 0.315	< 1.614
11252	08/30/2002	703	< 0.686	< 0.398	< 0.626	< 1.422	< 2.361	< 1.607	< 0.910	< 0.910	< 0.455	< 2.361
11261	09/12/2002	532	< 0.423	< 0.263	< 0.414	< 0.940	< 1.541	< 1.053	< 0.602	< 0.602	< 0.301	< 1.541
11280	09/04/2002	501	< 0.436	< 0.190	< 0.263	< 0.543	< 0.860	< 0.597	< 0.838	< 0.363	< 0.184	< 1.337
11287	09/12/2002	508	< 0.433	< 0.276	< 0.433	< 0.984	< 1.614	< 1.102	< 0.630	< 0.630	< 0.315	< 1.614
11292	09/03/2002	610	< 1.028	< 0.689	< 1.082	< 2.500	< 4.016	< 2.738	< 1.541	< 1.541	< 0.787	< 4.016
13309	08/25/2002	532	< 0.258	< 0.094	< 0.083	< 0.083	< 0.079	< 0.071	< 0.305	< 0.083	< 0.045	< 0.310
13336	08/29/2002	523	< 0.427	< 0.268	< 0.421	< 0.956	< 1.568	< 1.071	< 0.612	< 0.612	< 0.306	< 1.568
13337	08/24/2002	524	< 0.259	< 0.181	< 0.252	< 0.519	< 0.823	< 0.571	< 0.347	< 0.347	< 0.176	< 0.830
13339	09/06/2002	579	< 0.407	< 0.207	< 0.266	< 0.508	< 0.781	< 0.725	< 0.352	< 0.352	< 0.180	< 0.950
13341	09/05/2002	509	< 0.433	< 0.187	< 0.259	< 0.534	< 0.847	< 0.587	< 0.509	< 0.358	< 0.181	< 1.000
13342	08/23/2002	509	< 1.081	< 0.688	< 1.081	< 2.456	< 4.047	< 2.711	< 1.591	< 1.591	< 0.786	< 4.047
13363	08/31/2002	560	< 0.609	< 0.375	< 0.589	< 1.339	< 2.161	< 1.482	< 0.857	< 0.857	< 0.429	< 2.161
13589	09/10/2002	512	< 3.439	< 3.418	< 5.371	< 12.207	< 19.727	< 13.672	< 7.813	< 7.813	< 3.906	< 19.727
14560	09/04/2002	622	< 0.252	< 0.153	< 0.212	< 0.437	< 0.693	< 0.481	< 0.362	< 0.293	< 0.148	< 0.764
15908	08/29/2002	503	< 0.654	< 0.417	< 0.656	< 1.491	< 2.406	< 1.650	< 0.954	< 0.954	< 0.477	< 2.406
16213	09/10/2002	557	< 0.414	< 0.251	< 0.395	< 0.898	< 1.472	< 1.005	< 0.575	< 0.575	< 0.287	< 1.472
16622	09/02/2002	524	< 0.636	< 0.401	< 0.630	< 1.431	< 2.309	< 1.584	< 0.916	< 0.916	< 0.458	< 2.309
Fall 2002												
11193	11/20/2002	709	< 0.183	< 0.212	< 0.183	< 0.183	< 0.183	< 0.155	< 0.183	< 0.183	< 0.102	< 0.212
11200	11/21/2002	707	< 1.909	< 2.016	< 2.016	< 1.909	< 1.909	< 1.909	< 1.485	< 1.485	< 0.318	< 2.016
11252	11/20/2002	706	< 0.425	< 0.425	< 0.637	< 0.637	< 0.850	< 0.850	< 0.850	< 0.850	< 0.319	< 0.850
11252-dup	11/14/2002	707	< 0.212	< 0.212	< 0.424	< 0.424	< 0.530	< 0.636	< 0.636	< 0.424	< 0.212	< 0.636
11261	10/21/2002	422	< 1.422	< 0.711	< 1.777	< 2.133	< 2.133	< 2.133	< 1.066	< 1.066	< 0.711	< 2.133
11280	11/06/2002	703	< 1.920	< 2.027	< 2.027	< 1.920	< 1.920	< 1.280	< 1.209	< 1.209	< 0.320	< 2.027
11292	11/07/2002	722	< 0.091	< 0.104	< 0.091	< 0.091	< 0.348	< 0.358	< 0.091	< 0.091	< 0.050	0.623
13336	11/05/2002	570	< 0.228	< 0.263	< 0.228	< 1.711	< 0.509	< 1.158	< 0.509	< 0.228	< 0.126	< 2.500
13338	11/12/2002	476	< 0.630	< 0.630	< 0.630	< 0.630	< 0.945	< 0.945	< 0.945	< 0.945	< 0.630	< 0.945
13341	10/24/2002	651	< 2.765	< 2.765	< 2.765	< 2.765	< 2.765	< 2.765	< 2.765	< 2.765	< 2.765	< 2.765
13342	10/29/2002	712	< 1.053	< 2.001	< 1.159	< 1.053	< 1.475	< 0.843	< 0.632	< 0.632	< 0.316	< 2.001
13344	11/08/2002	711	< 1.899	< 1.899	< 1.899	< 1.899	< 1.899	< 2.004	< 1.582	< 1.582	< 1.055	< 2.004
13355	11/11/2002	498	< 2.540	< 2.560	< 2.540	< 3.313	< 3.313	< 3.313	< 2.540	< 2.540	< 2.482	< 3.313
13363	10/31/2002	570	< 3.158	< 3.158	< 3.158	< 3.158	< 3.158	< 3.158	< 3.158	< 3.158	< 3.158	< 3.158
14560	11/13/2002	703	< 1.920	< 1.920	< 1.920	< 1.920	< 1.920	< 1.174	< 1.174	< 0.747	< 1.920	< 28.770
15464	11/19/2002	702	< 0.185	< 0.214	< 0.185	< 0.185	< 0.185	< 0.157	< 0.185	< 0.185	< 0.103	< 0.214
15979	11/01/2002	662	< 2.039	< 2.153	< 2.153	< 2.039	< 2.039	< 2.039	< 1.586	< 1.586	< 0.340	< 2.153
16499	10/30/2002	715	< 1.888	< 1.888	< 1.888	< 1.888	< 1.888	< 1.888	< 1.469	< 1.469	< 0.629	< 1.888

| 17971 | 11/18/2002 | 708 | < 0.047 | < 0.053 | < 0.047 | < 0.047 | < 0.044 | < 0.282 | < 0.047 | < 0.047 | < 0.025 | 0.282 |
| 17971-dup | 11/18/2002 | 711 | < 0.211 | < 0.211 | < 0.211 | < 0.211 | < 0.422 | < 0.422 | < 0.422 | < 0.422 | < 0.211 | < 0.422 |

Non-detects assumed as 1/2 MDL
Spring 2003 samples were not analyzed for Aroclors

Table B-6 Aroclors in Sediment (ng/g-dry wt.)

Sample ID	Date	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
Summer 2002								
11193	08/08/2002	< 44	< 44	< 44	< 44	< 44	< 44	< 44
11200	09/03/2002	< 43	< 43	< 43	< 43	< 43	< 43	< 43
11200-dup	09/03/2002	< 47	< 47	< 47	< 47	< 47	< 47	< 47
11252	08/27/2002	< 42	< 42	< 42	< 42	< 42	< 42	< 42
11252-dup	08/27/2002	< 43	< 43	< 43	< 43	< 43	< 43	< 43
11258	08/01/2002	< 40	< 40	< 40	< 40	< 40	< 40	< 40
11261	08/19/2002	< 43	< 43	< 43	< 43	< 43	< 43	< 43
11264	08/19/2002	< 49	< 49	< 49	< 49	< 49	< 49	< 49
11280	08/29/2002	< 96	< 96	< 96	< 96	< 96	120	< 96
11287	08/26/2002	< 50	< 50	< 50	< 50	< 50	< 50	< 50
13337	08/14/2002	< 1800	< 1800	< 1800	< 1800	< 1800	< 1800	< 1800
13309	08/30/2002	< 45	< 45	< 45	< 45	< 45	< 45	< 45
13336	08/27/2002	< 92	< 92	< 92	< 92	< 92	< 92	< 92
13336-dup	08/27/2002	< 84	< 84	< 84	< 84	< 84	< 84	< 84
13338	08/22/2002	< 87	< 87	< 87	< 87	< 87	< 87	< 87
13338-dup	08/22/2002	< 87	< 87	< 87	< 87	< 87	< 87	< 87
13339	08/22/2002	< 110	< 110	< 110	< 110	< 110	< 110	< 110
13340	08/06/2002	< 100	< 100	< 100	< 100	< 100	< 100	< 100
13341	08/06/2002	< 100	< 100	< 100	< 100	< 100	< 100	< 100
13342	08/21/2002	< 110	< 110	< 110	< 110	< 110	< 110	< 110
13343	08/20/2002	< 59	< 59	< 59	< 59	< 59	< 59	< 59
13344	08/21/2002	< 120	< 120	< 120	< 120	< 120	< 120	< 120
13355	08/18/2002	< 48	< 48	< 48	< 48	< 48	< 48	< 48
13363	08/16/2002	< 48	< 48	< 48	< 48	< 48	< 48	< 48
13589	08/16/2002	< 53	< 53	< 53	< 53	< 53	< 53	< 53
14560	08/30/2002	< 64	< 64	< 64	< 64	< 64	< 64	< 64
15464	08/16/2002	< 46	< 46	< 46	< 46	< 46	< 46	< 46
16496	08/21/2002	< 110	< 110	< 110	< 110	< 110	< 110	< 110
16499	08/22/2002	< 94	< 94	< 94	< 94	< 94	< 94	< 94
16618	08/19/2002	< 46	< 46	< 46	< 46	< 46	< 46	< 46
17971	08/24/2002	< 100	< 100	< 100	< 100	< 100	< 100	< 100
17971-dup	08/24/2002	< 89	< 89	< 89	< 89	< 89	< 89	< 89
17970	08/18/2002	< 47	< 47	< 47	< 47	< 47	< 47	< 47

Table B-6 Aroclors in Sediment (ng/g-dry wt.) - Cont'd

Sample ID	Date	Aroclor 1016	Aroclor 1221	Aroclor 1232	Aroclor 1242	Aroclor 1248	Aroclor 1254	Aroclor 1260
11092	08/01/2002	< 100	< 100	< 100	< 100	< 100	< 100	< 100
11111	07/31/2002	< 95	< 95	< 95	< 95	< 95	< 95	< 95
11272	07/25/2002	< 120	< 120	< 120	< 120	< 120	< 120	< 120
11273	08/28/2002	< 71	< 71	< 71	< 71	1700	980	410
11273-dup	08/28/2002	< 79	< 79	< 79	< 79	2400	1200	470
11274	07/30/2002	< 61	< 61	< 61	< 61	310	230	< 61
11298	07/29/2002	< 84	< 84	< 84	< 84	< 84	< 84	< 84
11300	09/05/2002	< 61	61	< 61	61	61	61	61
11300-dup	09/05/2002	< 47	< 47	< 47	< 47	47	47	47
11302	08/26/2002	< 49	< 49	< 49	< 49	< 49	< 49	69
11305	08/13/2002	< 49	< 49	< 49	< 49	< 49	66	< 49
11305-dup	08/13/2002	< 51	< 51	< 51	< 51	< 51	< 51	< 51
11347	08/12/2002	< 44	< 44	< 44	< 44	< 44	< 44	91
11382	08/12/2002	< 49	< 49	< 49	< 49	< 49	< 49	120
Fall 2002								
11193	10/31/2002	< 53	< 53	< 53	< 53	< 53	< 53	< 53
11200	11/21/2002	< 40	< 40	< 40	< 40	< 40	< 40	< 40
11261	10/26/2002	< 55	< 55	< 55	< 55	< 55	< 55	< 55
11280	12/02/2002	< 88.3	< 88.3	< 88.3	< 88.3	< 88.3	< 88.3	< 88.3
11280-dup	12/02/2002	< 93	< 93	< 93	< 93	< 93	< 93	< 93
11292	12/10/2002	< 618	< 618	< 618	< 618	< 618	< 61.8	< 61.8
13336	10/22/2002	< 67.7	< 67.7	< 67.7	< 67.7	< 67.7	< 67.7	< 67.7
13338	10/22/2002	< 56.4	< 56.4	< 56.4	< 56.4	< 56.4	< 56.4	< 56.4
13342	10/28/2002	< 115	< 115	< 115	< 115	< 115	< 115	< 115
13363	11/06/2002	< 58.8	< 58.8	< 58.8	< 58.8	< 58.8	< 58.8	< 58.8
15464	11/06/2002	< 43.9	< 43.9	< 43.9	< 43.9	< 43.9	< 43.9	< 43.9
11252	10/24/2002	< 98.5	< 98.5	< 98.5	< 98.5	< 98.5	< 98.5	< 98.5
13340	10/23/2002	< 99.1	< 99.1	< 99.1	< 99.1	< 99.1	< 99.1	< 99.1
13344	10/27/2002	< 113	< 113	< 113	< 113	< 113	< 113	< 113
16499	10/24/2002	< 75	< 75	< 75	< 75	< 75	< 75	< 75
17971	10/28/2002	< 78.2	< 78.2	< 78.2	< 78.2	< 78.2	< 78.2	< 78.2
17970	10/24/2002	< 46.4	< 46.4	< 46.4	< 46.4	< 46.4	< 46.4	< 46.4

Values reported to the Method Reporting Limit

Tributary

Table B-7 Aroclor in Catfish Tissue (ng/g-wet wt.)

Sample ID	Date	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total Aroclors
Summer 2002											
11200	09/03/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	59
11252	08/26/2002	< 38	< 15	< 38	< 38	< 21	< 59	41	< 31	< 31	59
11261	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11270	08/28/2002	< 38	< 15	< 38	< 38	< 21	160	< 31	< 31	< 31	< 160
11273	08/30/2002	< 38	< 15	< 38	< 38	< 21	< 59	80	< 31	< 31	< 80
11280	08/28/2002	< 38	< 15	< 38	< 38	< 21	160	< 31	< 31	< 31	< 160
11287	08/25/2002	< 38	< 15	< 38	< 38	< 21	< 59	45	< 31	< 31	< 59
11298	08/29/2002	< 38	< 15	< 38	< 38	< 21	79	< 31	< 31	< 31	< 79
11302	08/26/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13309	08/30/2002	< 38	< 15	< 38	< 38	< 21	< 59	47	< 31	< 31	< 59
13336	08/27/2002	< 38	< 15	< 38	< 38	< 21	100	< 31	< 31	< 31	< 100
13336-dup	08/27/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13338	08/23/2002	< 38	< 15	< 38	< 38	< 21	61	< 31	< 31	< 31	< 59
13339	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	100	< 31	< 31	100
13339-dup	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	35	< 31	< 31	< 59
13342	08/22/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	59
13344	08/21/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	59
14560	08/30/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
15908	09/11/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
15908-dup	09/11/2002	< 38	< 15	< 38	< 38	< 21	120	< 31	< 31	< 31	< 120
15979	09/05/2002	< 38	< 15	< 38	< 38	< 21	78	< 31	< 31	< 31	78
16213	09/11/2002	< 38	< 15	< 38	< 38	< 21	95	< 31	< 31	< 31	< 95
16496	08/21/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	59
16499	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	59
16499-dup	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	190	< 31	< 31	< 190
16622	09/04/2002	< 38	< 15	< 38	< 38	< 21	< 59	480	< 31	< 31	480
17971	08/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 54	< 31	< 31	59

Table B-7 Aroclor in Catfish Tissue (ng/g-wet wt.) - Cont'd

Sample ID	Date	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total Aroclors
Fall 2002											
11193	11/20/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11200-1	11/19/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	59
11200-2	11/21/2002	< 38	< 15	< 38	< 38	< 21	67	< 31	< 31	< 31	67
11200-S	11/21/2002	< 38	< 15	< 38	< 38	< 21	69	< 31	< 31	< 31	69
11252	10/24/2002	< 38	< 15	< 38	< 38	< 21	59	< 31	< 31	< 31	59
11261	10/26/2002	< 38	< 15	< 38	< 38	< 21	180	< 31	< 31	< 31	< 180
13336	10/22/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13338	10/22/2002	< 38	< 15	< 38	< 38	< 21	59	< 31	< 31	< 31	< 59
13338-dup	10/22/2002	< 38	< 15	< 38	< 38	< 21	80	< 31	< 31	< 31	80
13342	10/28/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	59
13344	10/27/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
16499	10/24/2002	< 38	< 15	< 38	< 38	< 21	59	< 31	< 31	< 31	59
17971	10/28/2002	< 38	< 15	< 38	< 38	< 21	97	< 31	< 31	< 31	< 97
17970	10/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
17970-dup	10/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59

Values reported to the Detection Limit

Spring 2003 samples were not analyzed for Aroclors

Exceeds the TDH Comparison Value (47 ng/g)

Tributary

Table B-8 Aroclors in Crab Tissue (ng/g-wet wt.)

Sample ID	Date	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total Aroclors
Summer 2002											
11200	09/02/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11252	08/29/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11252-dup	08/29/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11273	08/28/2002	< 38	< 15	< 38	< 38	< 21	< 59	47	< 31	< 31	< 59
11273-dup	08/28/2002	< 38	< 15	< 38	< 38	< 21	< 59	41	< 31	< 31	< 59
11280	08/28/2002	< 38	< 15	< 38	< 38	< 21	66	< 31	< 31	< 31	66
11280-dup	08/28/2002	< 38	< 15	< 38	< 38	< 21	< 59	41	< 31	< 31	< 59
11287	08/25/2002	< 38	< 15	< 38	< 38	< 21	< 59	47	< 31	< 31	< 59
11287	08/25/2002	< 38	< 15	< 38	< 38	< 21	< 59	54	< 31	< 31	< 59
11292	09/11/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11300	09/09/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11302	08/26/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 55	< 31	< 31	59
11382	08/13/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13309	09/11/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13336	08/28/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13338	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13339	08/25/2002	< 38	< 15	< 38	< 38	< 21	< 59	35	< 31	< 31	59
13339-dup	08/25/2002	< 38	< 15	< 38	< 38	< 21	< 59	31	< 31	< 31	< 59
13341	08/16/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13342	08/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13343	09/04/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13344	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	36	< 31	< 31	< 59
13344-dup	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	61	< 31	< 31	61
14560	08/30/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
15908	09/11/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
15979	09/05/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
16213	09/10/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
16496	08/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	46	< 31	< 31	< 59
16499	08/23/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
16618	08/20/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
16622	09/02/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
17971	08/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	50	< 31	< 31	< 59

Table B-8 Aroclors in Crab Tissue (ng/g-wet wt.) - Cont'd

Sample ID	Date	Aroclor-1016	Aroclor-1221	Aroclor-1232	Aroclor-1242	Aroclor-1248	Aroclor-1254	Aroclor-1260	Aroclor-1262	Aroclor-1268	Total Aroclors
Fall 2002											
11193	10/21/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11252	11/13/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
11261	10/25/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13336	10/22/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13338	10/22/2002	< 76	< 30	< 76	< 76	< 42	< 120	< 62	< 62	< 62	< 120
13340	10/22/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
16499	10/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13342	10/28/2002	< 76	< 30	< 76	< 76	< 42	< 120	< 62	< 62	< 62	< 120
13344	10/27/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13344-dup	11/14/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
13363	11/16/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
15464	11/13/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
17971	10/28/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59
17971-dup	10/28/2002	< 76	< 30	< 76	< 76	< 42	< 120	< 62	< 62	< 62	< 120
17970	10/24/2002	< 38	< 15	< 38	< 38	< 21	< 59	< 31	< 31	< 31	< 59

Values reported to the Detection Limit

Spring 2003 samples were not analyzed for Aroclors

Exceeds the TDH Comparison Value (47 ng/g)

tributary