National Water-Quality Assessment Program

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Scientific Investigations Report 2004-5006

U.S. Department of the Interior
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FOREWORD

The U.S. Geological Survey (USGS) is committed to serve the Nation with accurate and timely scientific information that helps enhance and protect the overall quality of life, and facilitates effective management of water, biological, energy, and mineral resources. Information on the quality of the Nation's water resources is of critical interest to the USGS because it is so integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and that is suitable for industry, irrigation, and habitat for fish and wildlife. Escalating population growth and increasing demands for the multiple water uses make water availability, now measured in terms of quantity and quality, even more critical to the long-term sustainability of our communities and ecosystems.

The USGS implemented the National Water-Quality Assessment (NAWQA) Program to support national, regional, and local information needs and decisions related to water-quality management and policy. Shaped by and coordinated with ongoing efforts of other Federal, State, and local agencies, the NAWQA Program is designed to answer: What is the condition of our Nation's streams and ground water? How are the conditions changing over time? How do natural features and human activities affect the quality of streams and ground water, and where are those effects most pronounced? By combining information on water chemistry, physical characteristics, stream habitat, and aquatic life, the NAWQA Program aims to provide science-based insights for current and emerging water issues. NAWQA results can contribute to informed decisions that result in practical and effective water-resource management and strategies that protect and restore water quality.

Since 1991, the NAWQA Program has implemented interdisciplinary assessments in more than 50 of the Nation's most important river basins and aquifers, referred to as Study Units. Collectively, these Study Units account for more than 60 percent of the overall water use and population served by public water supply, and are representative of the Nation's major hydrologic landscapes, priority ecological resources, and agricultural, urban, and natural sources of contamination.

Each assessment is guided by a nationally consistent study design and methods of sampling and analysis. The assessments thereby build local knowledge about water-quality issues and trends in a particular stream or aquifer while providing an understanding of how and why water quality varies regionally and nationally. The consistent, multi-scale approach helps to determine if certain types of water-quality issues are isolated or pervasive, and allows direct comparisons of how human activities and natural processes affect water quality and ecological health in the Nation's diverse geographic and environmental settings. Comprehensive assessments on pesticides, nutrients, volatile organic compounds, trace metals, and aquatic ecology are developed at the national scale through comparative analysis of the Study-Unit findings.

The USGS places high value on the communication and dissemination of credible, timely, and relevant science so that the most recent and available knowledge about water resources can be applied in management and policy decisions. We hope this NAWQA publication will provide you the needed insights and information to meet your needs, and thereby foster increased awareness and involvement in the protection and restoration of our Nation's waters.

The NAWQA Program recognizes that a national assessment by a single program cannot address all water-resource issues of interest. External coordination at all levels is critical for a fully integrated understanding of watersheds and for cost-effective management, regulation, and conservation of our Nation's water resources. The Program, therefore, depends extensively on the advice, cooperation, and information from other Federal, State, interstate, Tribal, and local agencies, non-government organizations, industry, academia, and other stakeholder groups. The assistance and suggestions of all are greatly appreciated.

Robert M. Hirsch
Associate Director for Water

Contents

Figures

Tables

CONVERSION FACTORS, ABBREVIATIONS, AND ACRONYMS

Multiply	By	To obtain
meter (m)	3.281	foot (ft)
kilometer (km)	0.6214	mile (mi)
square kilometer (km^2)	0.3861	square mile (mi^2)
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)
gram (g)	0.03527	ounce, avoirdupois (oz)
kilogram (kg)	2.205	pound avoirdupois (lb)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

BHC	Benzene hexachloride
BEST	Biomonitoring of Environmental Status and Trends
DCPA	Dimethyl 2,3,5,6-tetrachloroterephthalate
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
E	Estimated
GC	Gas chromatography
GCP	Gulf Coastal Plains
HCB	Hexachlorobenzene
HCH	Hexachlorocyclohexane
MAP	Mississippi Alluvial Plain
MISE	Mississippi Embayment
MRL	Method reporting limit
MVLP	Mississippi Valley Loess Plains
NAWQA	National Water-Quality Assessment
NAS/NAE	National Academy of Sciences and National Academy of Engineering
NCBP	National Contaminant Biomonitoring Program
NWQL	National Water Quality Laboratory
NYFF	New York Fish Flesh Criteria
PCB	Polychlorinated Biphenyl
RPD	Relative Percent Difference
SP	Southeastern Plains
TDDT	Total DDT
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

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By Suzanne R. Femmer, Richard H. Coupe, Billy G. Justus, and Barbara A. Kleiss

ABSTRACT

Whole fish were collected at 52 sites during 1995-99 to evaluate the occurrence and distribution of selected organochlorine compounds in the Mississippi Embayment Study Unit. Samples were collected as part of the U.S. Geological Survey National Water Quality Assessment Program. From 5 to 8 fish were collected at each site; the fish were composited, and an aliquot of the tissue was analyzed for 28 organochlorine compounds, which included pesticides, pesticide degradates, and polychlorinated biphenyls. The use of these organochlorine compounds has been discontinued or severely restricted within the United States, but the continued detection of these compounds or their degradates in the air, water, soil, and biota in national surveys, coupled with known environmental problems associated with these compounds (such as a long half-life and the propensity to accumulate in living tissue), is cause for continued interest in their environmental fate. At least one organochlorine compound was detected in every fish-tissue sample, and as many as 15 different compounds were detected in some. The most frequently detected compounds were the degradates of *p,p'*-dichlorodiphenyltrichloroethane (*p,p'*-DDT); *p,p'*-dichlorodiphenyldichloroethylene (*p,p'*-DDE) was detected in every sample above the method reporting limit, and *p,p'*-dichlorodiphenyldichloroethane (*p,p'*-DDD), was detected in 94 percent of the samples. Polychlorinated biphenyl compounds and dieldrin were detected in 83 and 78 percent of fish-tissue samples, respectively. Because these were whole fish samples, the results are not directly comparable to human health standards, which are based on fish fillets. Comparison of these results, however, to the guidelines for the protection of fish-eating wildlife indicates that concentrations of the *p,p'*-DDT degradates and toxaphene continue to be of environmental concern.

INTRODUCTION

The Mississippi Embayment (MISE) study is one of more than 50 water-quality assessments that have been conducted as part of the U.S. Geological Survey's National Water Quality Assessment (NAWQA) Program. The NAWQA Program seeks to improve scientific and public understanding of water quality in many of the Nation's major river basins and ground-water systems. Collectively, these assessments cover about one-half of the land area of the United States and include water resources that are available to more than 60 percent of the U.S. population.

One of the major objectives of the NAWQA Program is to assess how the use of pesticides affects water quality, in both urban and agricultural settings. Coupe (2000) summarized the occurrence of almost 100 water-soluble pesticides in the surface waters of the MISE Study Unit. However, many organochlorine compounds generally are not present in water at concentrations large enough to be readily detectable with current technology, yet they can be detected in aquatic biota. Therefore, the NAWQA Program includes the assessments of 28 selected organochlorine compounds in aquatic biota; these 28 compounds include pesticides, pesticide degradates, and polychlorinated biphenyl (PCB) compounds.

The organochlorine compounds in this study are anthropogenic chemicals that have been used to control many agricultural and urban pests. Although most of these older, more hydrophobic organochlorine pesticides are no longer available for use in the United States, they are manufactured for use in other nations, especially developing countries. Organochlorine pesticides were used in agricultural and urban settings for decades in the United States since the 1940s. The type and amount of organochlorine pesticide use has changed over the years as changes have occurred in crop type, technology, and regulations. Although the use of most of these organochlorine pesticides has been restricted in the United States, some of these pesticides or pesticides degradates are still frequently detected in the environment. For example, the sale, distribution, and use of dichlorodiphenyltrichloroethane (DDT) was discontinued in the United States in 1972 because DDT was suspected to cause thinning of eggshells in some fish-eating birds, such as cranes, herons, and eagles, resulting in dramatically decreased populations. However, 98 percent of fish samples from a nationwide study had detectable levels of DDT or one of its degradates (Schmitt and others, 1990) almost two decades after its sale was discontinued. Studies completed since the late 1970s indicated a widespread and pervasive contamination of all components of the ecosystem (air, soil, water, and biota) of DDT, its metabolites, and toxaphene in the Alluvial Plain part of the Yazoo River Basin (Cooper and others, 1987; Cooper, 1991; Coupe and others, 2000; Ford and Hill, 1991). Chlordane sales were discontinued in the United States in 1988, but chlordane is still readily detected in the environment (Haag and McPherson, 1997; Schmitt, 2002).

PCBs are not pesticides, but they are used in a variety of industrial products. PCBs were manufactured in the United States from 1929 through 1979 and were used in the production of plastics, paints, adhesives, and as pesticide additives. PCBs are still in use as insulating and cooling liquids in electrical transformers and capacitors and, although the concentration of PCBs in fish tissue has been declining in National surveys, they are still frequently detected, especially in the industrialized parts of the country (Schmitt, 2002).

The persistence of these organochlorine compounds in the environment and their propensity to accumulate in living tissue, coupled with the toxic effects of many of the organochlorine compounds, make them a source of continuing concern to the health of humans and biota (Wong and others, 2000). Large concentrations of these compounds can cause mortality; at small concentrations, they can have an effect on humans and biota through processes such as cancer and reproductive disruption (Colburn and others, 1993). Some State and other Federal agencies have collected fish-tissue data within the MISE Study Unit; however, there has been no detailed study of fish tissue for the entire MISE Study Unit.

Purpose and Scope

This report describes the occurrence and distribution of 28 organochlorine-pesticide, pesticide-degradate, and PCB concentrations in 64 whole fish-tissue samples collected from 52 sampling sites in the MISE Study Unit (fig. 1) during1995-99. The concentrations in fish tissue from the MISE Study Unit are compared to concentrations from other investigations in the United States, and compared to guidelines for the protection of fish-eating wildlife. The fish-tissue concentrations are also compared to characteristics of the watersheds in which the fish-tissue samples were collected.

Description of the Study Unit

About 62 percent of the land use of the MISE Study Unit is agricultural, and some of the smaller drainage basins can be greater than 90 percent agricultural. About 33 percent of the MISE Study Unit is forested; most of these forested areas are near the eastern and western borders of the study unit. Most of the study unit is rural; the only major urban area in the study unit is Memphis, Tennessee, with a population of 650,100 (U.S. Census Bureau, 2000). About 5 percent of the study unit is classified as urban or other land use.

Most of the land area in the MISE Study Unit is comprised of two physiographic provinces; the Mississippi Alluvial Plain (MAP) and the Gulf Coastal Plains (GCP) (Fenneman, 1938). About 57 percent of the MISE Study Unit is comprised of the MAP physiographic province and is an area of little topographic relief. The soils of the MAP are dominated by clays and historically have supported extensive wetlands. These alluvial clays contribute to low permeability soils that limit rainfall infiltration and contribute to overland runoff rapidly entering the streams and waterways. About 35 percent of the MISE Study Unit is comprised of the GCP physiographic province and abuts the eastern edge of the MAP; this part of the Study Unit is characterized by hills of wind-blown silts to the west and rolling to hilly topography with more permeable silts to the east. Soil permeability is greater in the GCP than in the MAP, which results in more surface runoff infiltrating the soil surface. The coarser soils on the steeper slopes of the GCP are more erodible than the soils in the MAP.

The physiographic provinces (fig. 1) strongly correlate with ecoregions defined by Omernik (1987). The MAP Ecoregion overlaps the MAP physiographic province. Streams in the MAP Ecoregion have low gradients, and relief is sometimes less than 12.5 cm/km (Arkansas Department of Pollution Control and Ecology, 1987). About 75 percent (or about 6.5 million hectares) of the original forested wetlands in the MAP Ecoregion have been cleared and drained (Nature Conservancy, 1992) and on average, more than 70 percent of the land in the MAP Ecoregion is used for growing row crops (primarily corn, cotton, and soybean) and small grains (primarily rice and wheat). The subtropical climate with long summers and plentiful rainfall results in the MAP having some of the most productive farmland in the world, but also increases the insect and weed pressure, which requires large amounts of pesticides for control. Because of this, pesticide use generally is higher in the MAP than in most other regions of the United States (Gianessi and Anderson, 1995).

The GCP physiographic province includes the Mississippi Valley Loess Plains (MVLP) and the Southeastern Plains (SP) Ecoregions. The MVLP Ecoregion is a mosaic of forest and cropland, primarily irregular plains with oak-hickory and oak-hickory-pine natural vegetation. Streams in the MVLP Ecoregion tend to be incised, have low gradients, and silty substrates. The SP Ecoregion is a mixture of cropland, pasture, woodland, and forest. The natural vegetation is primarily oak-hickory-pine and Southern mixed forests. Streams of the SP Ecoregion are relatively low gradient (except where modified by humans) with sandy substrates.

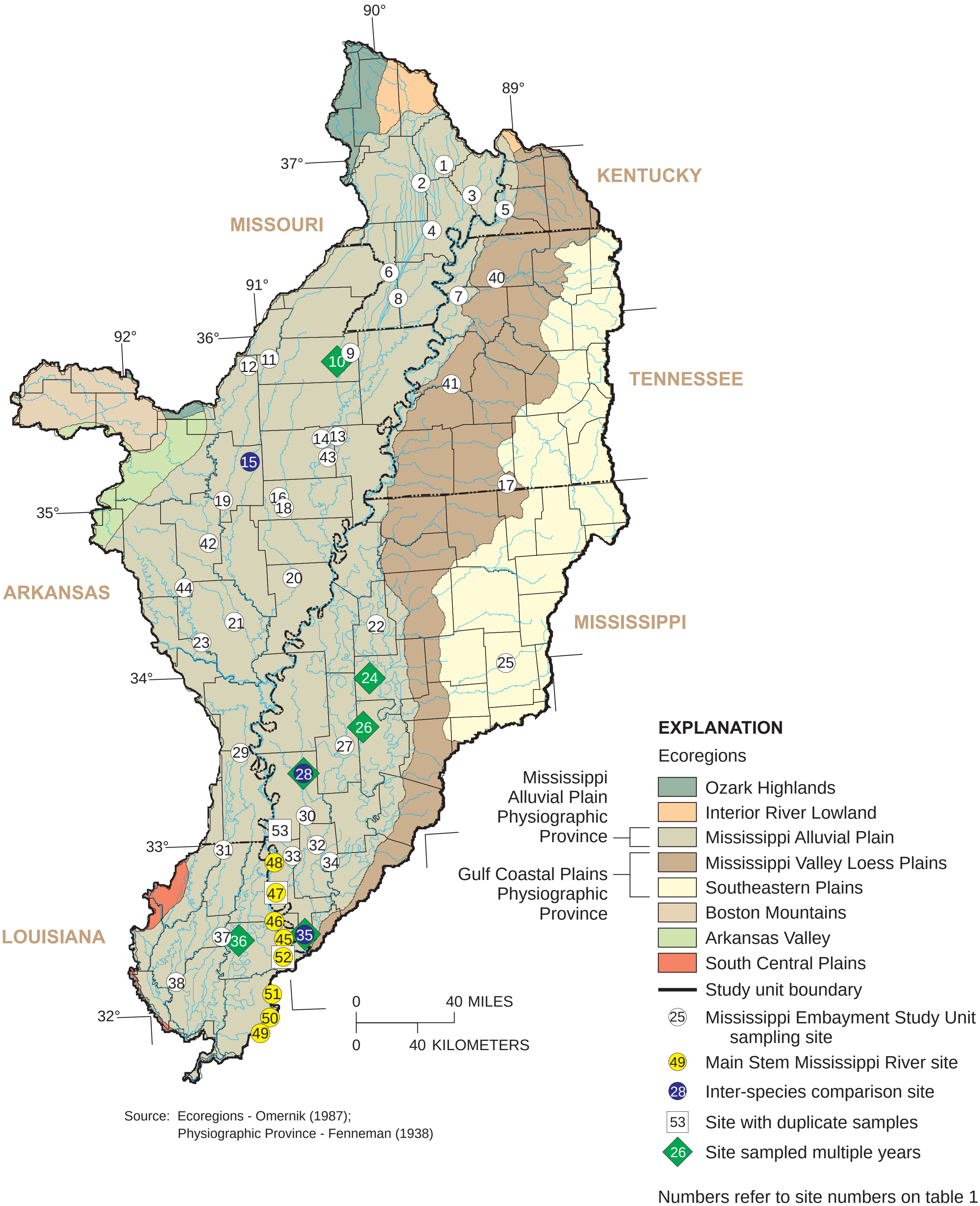

Figure 1. Physiographic provinces, ecoregions, and fish-tissue sampling sites of the Mississippi Embayment Study Unit.

Geology of the MISE Study Unit (fig. 2) mostly consists of formations from the Tertiary and Quaternary periods (Warwick and others, 1997). The upper stratum comprises alluvial Pleistocene and Holocene units. Large rivers flowing through the area formed these units, carving the surface and depositing clay, silt, sand, and gravel to create the alluvium. During the last 2 million years, up to 300 feet of alluvium have filled this valley. The underlying Tertiary period formation comprises Pliocene, Eocene, and Paleocene units. These units are composed of layers of clay, glauconitic clay and sand, marl, and limestone.

Despite the relative flatness of the MAP, this area has a high sediment and water yield due to a combination of climatic factors and soil conditions. The erosive force of rainfall in the southeastern United States, including, the MISE Study Unit, is the highest east of the Rocky Mountains (Schmitt and Winger, 1980). The high silt and clay content of the alluvial plain soils in the Study Unit lowers the soil permeability, which increases runoff and erodibilty of these soils. Because of the past high useage of some organochlorine pesticides in cotton growing areas of the South (U.S. Environmental Protection Agency, 1975), coupled with their longevity and their propensity to adsorb to clay particles, there could be a constant supply of organochlorine pesticides to surface waters of the Study Unit as soils are eroded and move off agricultural fields.

MATERIALS AND METHODS

Fish samples were collected at 52 (fig. 1, table 1) sites in the MISE Study Unit from 1995 though 1999. A total of 64 fish-tissue samples, comprising 5-8 fish per sample, were sent to the National Water Quality Laboratory (NWQL) and homogenized. Tissue aliquots were then analyzed for 28 organochlorine compounds. Protocols developed by the NAWQA Program were followed, and quality assurance methods were employed both in field collection and laboratory analysis. Statistical analysis was used to compare and contrast the data with various physical features of the study unit.

Sample Collection

Of the 64 fish-tissue samples, 17 were collected in 1995, 18 were collected in 1996, 25 were collected in 1998, and 4 were collected in 1999 (table 2). Five of the 52 sites were sampled twice, in different years, to evaluate temporal variability; duplicate samples were collected at three sites to evaluate sampling variability; and three sites were sampled for different species to evaluate interspecies variability. Of the 52 sites sampled, 47 are in the MAP Ecoregion, 4 sites are in the MVLP Ecoregion, and 1 site is in the SP Ecoregion. Of the 47 sites in the MAP Ecoregion, 8 are on the main stem of the Mississippi River; all other sampling sites are on tributaries to the Mississippi River. Streams sampled ranged in size from wadeable streams (drainage basin of less than 100 km^2) to the main stem of the Mississippi River (drainage basin of almost 3,000,000 km^2).

Fish were collected by electrofishing. Common carp (*Cyprinus carpio*) were targeted at all sites (Crawford and Luoma, 1993), but were not found in sufficient quantity at three sampling sites (table 3). At two of the three sites where carp were not collected, black bass (*Micropterus* spp.) were collected, and at the remaining site, spotted gar (*Lepisosteus oculatus*) were collected. Eight fish were targeted for each composite sample, but at some sites, fewer than eight fish were collected and composited into a sample (table 2). The weight, length, sex, and anomalies of each fish in each composite sample were recorded, and scales were collected for age determination. Each fish in the sample was wrapped in aluminum foil, placed in large plastic bags with other fish in the composite, and placed on dry ice and shipped directly to the NWQL in Denver, CO, or were returned to the U.S. Geological Survey (USGS) office on ice in Jackson, MS, where they were frozen and shipped to the NWQL at a later date.

Age Determination

Several scales were removed from each side of each fish from an area behind the pectoral fin and above the lateral line for the purpose of determining the age of the fish. Once removed, the scales were placed into small paper envelopes and allowed to dry. Prior to age determination, each scale was taped between two glass slides with clear, plastic tape. Age was determined by counting annuli by using an inverted microscope which projected an enlarged outline of the scale onto a projection screen. Methods for counting annuli are described by Carlander (1969) and by Summerfelt and Hall (1987). Ages were assigned as whole numbers (years).

Sample Preparation and Analysis

Organochlorine pesticides, pesticide degradates, and PCBs in whole fish tissue were analyzed by the NWQL. Concentrations were reported as micrograms per kilogram wet weight. Analytical methods used by the NWQL for organochlorine pesticides and PCBs in whole fish tissue have been validated in several interlaboratory studies sponsored by the U.S. Fish and Wildlife Service and the U.S. Environmental Protection Agency, and are described in detail in Leiker and others (1995). In summary, whole fish were homogenized into a single composite by using a meat grinder. A 10-g sample aliquot was homogenized with 100 g of granular anhydrous sodium sulfate to remove residual water. After homogenization, two surrogates--*alpha*-HCH d_6 and 3,5-dichlorobiphenyl--were added to the sample, and the sample was Soxhlet extracted overnight in methylene chloride. The extract was then filtered through granular anhydrous sodium sulfate and concentrated to a volume of 5 mL. A 1.0-mL aliquot was removed for percent lipid determination. A 2.0-mL aliquot

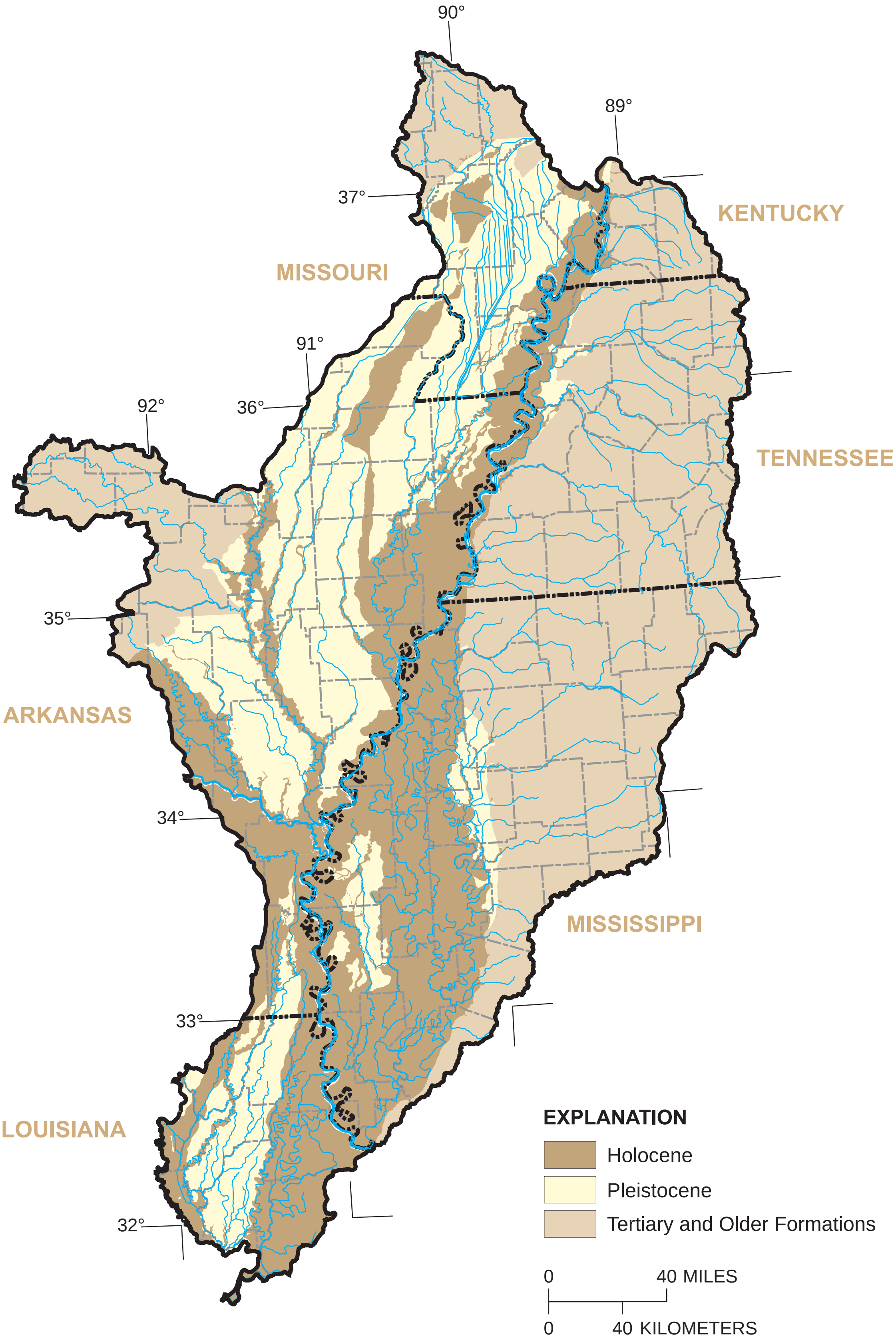

Figure 2. Geologic age of surficial deposits of the Mississippi Embayment Study Unit.

of the extract was injected into an automated gel permeation chromatograph to isolate the analytes of interest from the lipid material that was coextracted. The extract was then solvent exchanged into hexane and further concentrated to a 1.0-mL volume. The extract was fractionated into two components by using alumina/silica adsorption chromatography: nonpolar organics such as PCBs, dichlorodiphenyldichloroethylene (DDE), hexachlorobenzene (HCB), heptachlor, aldrin, and 3,5-dichlorobiphenyl surrogate; and polar organics such as chlordane, toxaphene, DDT, and DDD. The fractions were then concentrated to a 1.0-mL volume and analyzed by dual capillary column gas chromatography (GC) with electron capture detection (Leiker and others, 1995).

Compound identification was based on the GC retention times of both capillary columns compared to those obtained by use of external standard mixtures. The compound quantitation curve was based on the calibration curves of 5, 10, 20, 50, 100, and 200 pg/µL for chlorinated pesticides, 600 pg/µL for mixed aroclor standards for PCBs, and 800 pg/µL for toxaphene. The lower of the two observed concentrations from the two GC columns was reported except where recognized compound coelutions or interferences resulted in single-column quantification (Leiker and others, 1995).

Data Analysis

It is generally acknowledged that some physiological characteristics of fish such as age, sex, weight, length, species, lipid content, and metabolism, can have an effect on the concentration of hydrophobic compounds found in fish tissue. Many researchers normalize for one or more of these characteristics when evaluating concentrations in fish tissue. However, the relation between the physiological characteristics and fish-tissue concentration is not the same for every compound or every environmental condition, and it has been shown that, under some circumstances, normalizing data for lipid content may lead to misleading conclusions (Herbert and Keenleyside, 1995). For example, Schmitt (2002) analyzed fish-tissue data collected in 1995 from the Mississippi River Basin, including some sites in the MISE Study Unit, and attempted to correlate *p,p'*-DDT, the sum of the cyclodiene pesticides, and PCBs with length, weight, and age. The only significant correlation with *p,p'*-DDT was a negative correlation with age for male and female carp. For the cyclodiene pesticides, concentrations in male and female bass were negatively correlated with length, and concentrations in female bass were negatively correlated with weight. However, both female and male carp had positive correlations between length and weight with concentrations of PCBs in tissue. Therefore, a single normalization method was not possible, and Schimtt (2002) chose not to normalize the data when analyzing the data geographically.

Differences in the concentration of hydrophobic compounds, which may vary considerably in source strength, could obscure any relation between concentration and physiological characteristics. Unless it is clear that the source is similar across a geographic area, normalizing may add, rather than decrease variability in the data.

Additionally, because the samples collected by the MISE NAWQA were composites of up to eight fish, with mixed gender, an average value of lipid content, weight, or age would have to be used, and thus, normalizing becomes problematic. Therefore, the data presented here are not normalized, although the percent lipids of the composite sample, the average weight, average total length, and average age of the fish, whenever available, are listed in table 3.

The sampling sites were subdivided into classes based on ancillary data (such as drainage basin size, bed sediment particle size, and soil type) and the Kruskal-Wallis test was used to determine if there were differences in the median organochlorine concentration between classes (Helsel and Hirsch, 1992). The main stem Mississippi River samples were not used in this analysis. An alpha value of 0.05 was used to evaluate the significance of the test results. The classes are significantly different if the probability (p-value) is less than the alpha value. A p-value of less than 0.05 indicates that there is a less than 5 percent chance that the observed difference was by chance. If a significant difference was detected, these differences were further analyzed by applying Tukey's multiple comparison test (Helsel and Hirsch, 1992,) to the rank transformed data. Ancillary data with less than three classes were not analyzed by using Tukey's test. If significant differences were found, the data were graphically displayed by using boxplots. Classes with 10 or less values are nonideal for confident statistical testing and the results should be used with caution. For analysis, concentrations below the method reporting limit (MRL) were represented by a value of one-half the MRL. Total DDT (TDDT) concentrations were calculated as the sum of *o,p'*–DDT and *p,p'*–DDT and their degradates; for this report the concentrations were set to 0 if they were reported as less than the MRL.

Reporting Limits and Quality-Control Procedures

Surrogate compounds were added to the homogenized tissue samples in order to measure the overall method efficiency. These surrogate compounds were not expected to be present in the environment, yet were expected to behave similarly to selected target analytes found in the environment. This method calls for the addition of two surrogate compounds: an organochlorine compound (*alpha*-HCH-d_6) and a PCB, 3, 5-dichlorobiphenyl. These surrogates were used to assess the recoveries for the targeted analytes. The median overall recoveries for these compounds were 93 and 81 percent, respectively (fig. 3). More than 95 percent of the recovery data fell within the expected range of 3 sigma and, therefore, were within analytical control (Leiker and others, 1995).

Generally, the compounds analyzed for in fish tissue in this study (table 2) had a MRL of 5.0 µg/kg, with the exception of toxaphene (MRL of 200 µg/kg) and PCB (MRL of 50 µg/kg). Occasionally, the MRL for some compounds was

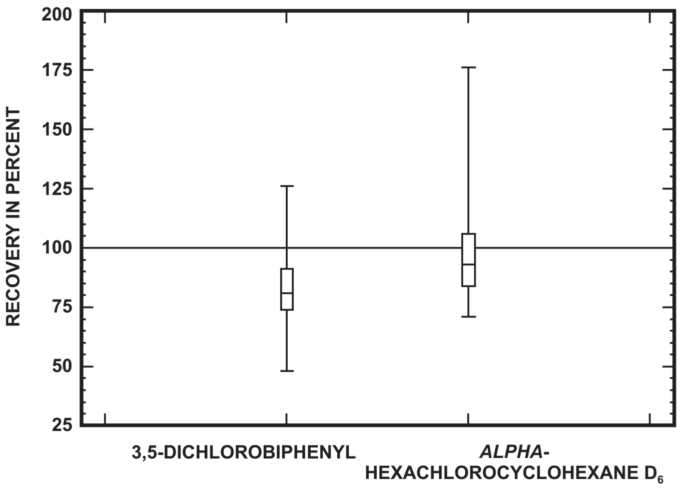

Figure 3. Surrogate recoveries for samples analyzed by the National Water-Quality Laboratory, 1995-99.

higher than shown above, possibly because of matrix interference, instrument problems, or coeluting constituents. There are several reasons a value might be reported as estimated, such as a confirmed value above or below calibration standards, or poor method performance. These estimated values were considered valid data and were used in this report.

In 1995, as part of a quality assurance program with the National Contaminant Biomonitoring Program (NCBP)[1], fish samples from eight sites (map numbers 2, 11, 17, 19, 28, 32, 33, and 36) were collected for both the NCBP and NAWQA programs and sent to their respective laboratories. NAWQA field personnel collected the fish samples, but NCBP protocols were followed for NCBP samples, and NAWQA protocols (which differed slightly from NCPB protocols) were followed for NAWQA samples. Details on the field and laboratory methods used by the NCBP can be found in Schmitt (2002). Results for constituents that are common between the two programs are shown in table 4. In general, data from the two programs compare favorably. Concentrations reported by NCBP and NAWQA programs are usually within the same order of magnitude, and if a constituent was detected by one laboratory, the other usually detected it. The exceptions are the concentrations of *p,p'*-DDT and *o,p'*-DDT. Concentrations of *p,p'*-DDT ranged from 36 to 140 µg/kg from 6 of the 9 samples analyzed by the NWQL, but were reported as <10 µg/kg for the NCBP samples. Two samples analyzed by the NWQL had reportable concentrations of *o,p'*-DDT (35 and 56 µg/kg), whereas, there were no concentrations of *o,p'*-DDT above the MRL from NCBP data.

Field Quality Assurance

The analyses in this report on the relations between the concentration of organochlorine compounds in fish tissue and landscape variables are predicated on the assumption that the samples used to measure the concentrations of organochlorine compounds in fish tissue are representative of the true concentration in the fish population. In order to assess this assumption, duplicate samples were collected and samples were collected at the same site during different years to assess year-to-year variability. At a few sites the target species (carp) was not available and a substitute species (bass or gar) was used to measure organochlorine concentrations in fish tissue. To assess interspecies variability, samples of bass or gar were collected and analyzed concurrently with the carp samples at four sites (two for bass and two for gar).

Duplicate samples were collected at three sites during 1995-99 and represent approximately 5 percent of all samples collected for the fish-tissue study. These duplicate samples are used to evaluate the variability in sampling and the variability due to the analytical methods. At the sampling site, a duplicate sample was processed similarly to the environmental sample and was sent to the NWQL for analysis. An analysis of variance was run on the age, weight, and total length of the individual fish between duplicate samples, and there were no significant differences indicating that the targeted sampling was successful.

In November 1996, duplicate samples were collected at the Mississippi River sites at River Mile 432 (map number 52 and samples 61 and 62, table 2) and at River Mile 475 (map number 47 and samples 55 and 56, table 2). Most compounds were reported below the MRL for both sets of samples. Seven compounds were reported at concentrations above the MRL in both samples at River Mile 432: PCBs (740 and 720 µg/kg), *trans*-nonachlor (16.0 and 10.0 µg/kg), dieldrin (30.0 and 23.0 µg/kg), *p,p'*-DDE (170 and 160 µg/kg), *p,p'*-DDD (19.0 and 14.0 µg/kg), *trans*-chlordane (9.5 and 7.3 µg/kg), and *cis*-chlordane (12.0 and 8.7 µg/kg). Hexachlorobenzene was reported slightly above the MRL in one sample and below the MRL in the other. Four compounds were reported above the MRL in samples from the Mississippi at River Mile 475: PCB (200 and 530 µg/kg); dieldrin (15.0 and 23.0 µg/kg); *p,p'*-DDE, (140 and 120 µg/kg) and *p,p'*-DDD (8.4 and 8.8 µg/kg). Hexachlorobenzene was reported slightly above the MRL in one sample and was not detected in the other; *cis*-chlordane and *trans*-nonachlor were reported with an estimated concentration below the MRL in one sample and were undetected in the other sample.

A duplicate sample was collected in June 1999 at the Steele Bayou (weir E) at the Yazoo National Wildlife Refuge, Miss. (map number 53 and samples 63 and 64, table 2). There were five compounds detected in both samples at concentrations above the MRL: PCB (52.0 and 140 µg/kg), dieldrin (15.0 and 24.0 µg/kg), *p,p'*-DDE (2,300 and 1,500 µg/kg), *p,p'*-DDD (430 and 340 µg/kg), and *p,p'*-DDT (45 and 70 µg/kg). Two compounds were reported above the MRL in one sample and below the MRL in the other: *trans*-nonachlor (<8.8 and 11.0 µg/kg), and *cis*-chlordane (<5.2 and 8.3 µg/kg).

Only 8 of the 28 compounds analyzed for were reported at levels above the MRL in both samples in one or more of the three duplicates. Therefore, for the other 20 compounds not detected in the duplicate samples, no conclusions, other than there was no contamination of the fish tissue from external

[1] The BEST program (Biomonitoring of Environmental Status and Trends) incorporated the NCPB sampling sites and responsibility for the program was changed from the Fish and Wildlife Service to the National Biological Survey/Service, which became the Biological Resources Division of the U.S. Geological Survey (Schmitt and others, 1999).

sources, can be made. The average relative percent difference (RPD = |A-B|/[[A+B]/2]) • 100 for duplicate samples ranged from 21 percent for *p,p'*-DDE to almost 62 percent for PCB (table 5); however, the relative magnitude for most compounds was the same, and the presence of these compounds was confirmed in both samples. Some compounds were reported above the MRL in one sample and not in the other; but in every instance, the concentration reported was near the MRL.

In order to assess temporal variability in organochlorine concentrations in fish tissue, samples were collected over multiple years at five sites in the MISE Study Unit: the Yazoo River (map number 35 and sample numbers 42 and 43, table 2), Tensas River (map number 36 and sample numbers 44 and 45, table 2), Cassidy Bayou (map number 24 and sample numbers 26 and 27, table 2), Quiver River (map number 26 and sample numbers 29 and 30, table 2), and the Bogue Phalia (map number 28 and sample number 32 and 34, table 2). The analysis of variance results by sampling sites for fish weight, age, and total length between sampling years are listed in table 6.

Cassidy Bayou (map number 24) was sampled in October 1995 and in June 1998; concentrations of seven compounds were reported above the MRL in at least one of the samples. Three of these compounds (PCB, dieldrin, and *p,p'*-DDT) had higher concentrations in the 1998 sample and four compounds (toxaphene, *p,p'*-DDE, *o,p'*-DDD and *p,p'*-DDD) had lower concentrations in the 1999 sample.

The Quiver River (map number 26) was sampled in July 1996 and in June 1998. Of the organochlorine compounds that were present in concentrations above the MRL in the July 1996 sample, all had higher concentrations in the 1998 sample. This can be partially explained by an almost three-fold increase in percent lipids (3.2 – 9.1 percent) between sampling years.

Bogue Phalia (map number 28) was sampled for organochlorine compounds in fish tissue in August 1995 and in August 1999. All of the compounds that were detected above the MRL in 1995 (PCBs, toxaphene, mirex, dieldrin, and the degradates of *p,p'*-DDT and *o,p'*-DDT) had lower concentrations in 1999.

The Yazoo River (map number 35) was sampled in September 1995 and in December 1996. Most compounds that were detected in 1995 above the MRL had lower concentrations in 1996. The concentration of PCBs in fish tissue was unchanged from the 1995 sample to the 1996 sample, and mirex was the only constituent to increase in concentration from 1995 to 1996. Toxaphene concentrations decreased from 1,600 µg/kg to below the MRL of 200 µg/kg. Concentrations of DDT and its degradates, and the chlordane degradates were lower in 1996 than in 1995.

The Tensas River (map number 36) was sampled in August 1995 and in September 1999. Most organochlorine compounds detected in August 1995 were present in lower concentrations in 1999. However, concentrations of, *o,p'* and *p,p'*-DDT and *o,p'*-DDD were higher in 1999. Toxaphene, *o,p'*-DDE, and *p,p'*-DDD concentrations were lower by one order of magnitude in 1999 than in 1995. The concentrations of *p,p'*-DDE decreased from 5,300 to 2,500 µg/kg from 1995 to 1999.

One of the methods for putting the multi-year data into perspective is to examine how the variability in the multi-year sampling compares with the variability in the duplicate samples. The variability in the duplicate samples should represent the variability due to sampling and analytical methods as well as the natural variability of the system. The RPD for those constituents reported above the MRL, percent lipids in the duplicate samples, and the RPD and percent lipids for the same constituents in the multi-year sampling are listed in table 5. These data indicated that there was substantially increased variability (with the exception of PCB concentrations) in the multi-year sampling over that of the duplicate samples. This variability did not appear to be linked to the length of time between samples nor to a change in the percent lipids as the mean percent lipids for the duplicate samples were similar to the mean percent lipids for the multi-year samples. The multi-year samples with the most difference between samples (Quiver River) were sampled only 2 years apart, and some of the other sites, which were sampled 4 years apart, showed little difference. The number of multi-year samples is too few to make generalized statements about the trends in the fate of organochlorine compounds in the MISE Study Unit over time, but the implications of these samples (that there can be substantial variability between mutli-year samples) needs to be understood when examining the data.

Bass (3 sites) and gar (1 site) were used instead of carp at a few sites because carp were unavailable in sufficient quantity. In order to understand the interspecies variability in organochlorine and PCB concentrations, carp and bass were collected and analyzed at one site (map number 15, samples 16 and 17, table 2) and carp and gar were collected and analyzed at two sites (map number 28, samples 32 and 33; map number 35, samples 41 and 42, table 2). These data indicate that carp may be slightly more susceptible to organochlorine compound contamination. However, the occurrence and relative magnitude of organochlorine compounds in carp seem to have been reasonably reflected in bass and gar, and the data are comparable for the purposes in this report.

RESULTS AND DISCUSSION

There were many organochlorine compounds detected in fish-tissue samples of the Mississippi Embayment study. A statistical summary of the 28 organochlorine compounds for all samples is listed in table 7. Including duplicate and multi-year samples, 64 samples were available for analysis. The percentage of detections ranged from 0 to 100 percent. Aldrin, *p,p'*-methoxychlor, *o,p'*-methoxychlor, lindane, *alpha*-HCH, heptachlorepoxide, and endrin were not detected at concentrations above the MRL in any of the 64 samples. However, it is worthy of note that aldrin quickly degrades to dieldrin and dieldrin was detected in many samples (Nowell and others, 1999). A degradate of DDT, *p,p'*-DDE, was detected in every sample. Another degradate of DDT, *p,p'*-DDD was detected in 94 percent of the samples. PCBs were detected in 83 percent of the samples, and dieldrin was detected in 78 percent of the fish-tissue samples.

Nowell (1999) compiled a dataset of organochlorine compounds in fish tissue from data collected (1992-95) from 273 sites nationwide in 20 NAWQA Study Units. Although this dataset was not a statistical representation of organochlorine compounds in fish tissue throughout the United States, it did represent the most recent and complete dataset available and facilitates comparison of MISE NAWQA data to that from other areas of the United States. The maximum measured concentrations for eight compounds (toxaphene, *cis*-nonachlor, mirex, *delta*-HCH, *beta*-HCH, *p,p'*-DDD, *p,p'*-DDE, and *p,p'*-DDT) were higher from sites in the MISE NAWQA than from any other site in the national dataset; other compounds, not as closely linked to row crop agriculture, such as PCBs and chlordane, had much higher maximum concentrations in the national dataset. In contrast, only two organochlorine compounds (*p,p'*-DDE, and toxaphene) from the MISE NAWQA data had maximums greater than 1984 data collected by the NCBP from 112 stations nationwide (Schmitt and others, 1990). The maximum concentrations for *p,p'*-DDT and toxaphene in the NCBP 1984 data were from samples collected from the Yazoo River. Comparing the MISE NAWQA data with the national dataset and with the 1984 NCBP data indicated that fish-tissue samples from streams in the MISE Study Unit had some of the highest concentrations of organochlorine compounds in the country.

One to fifteen (4 to 54 percent) of the organochlorine compounds were detected in every whole fish-tissue sample collected in the Mississippi Embayment Study Unit (fig. 4). The maximum number of organochlorine compounds in fish tissue in this study was collected in 1995; 15 of 28 (54 percent) of the organochlorine compounds were detected in the fish tissue from the Tensas River at Tendal, La., although a fish sample collected in 1999 from the Tensas River had 11 of 28 (39 percent) organochlorine compounds detected. The minimum number of organochlorine detections was from LaGrue Bayou near DeWitt, Ark., in 1996, where only one compound was detected (*p,p'*-DDE). The sites with the greatest percentage of detections of organochlorine compounds were generally located in the southern part of the study area (fig. 4).

Samples were collected from eight sites on the main stem of the Mississippi River. Three to 9 (11 to 29 percent) of the organochlorine compounds were detected in fish tissue at these sites. The compounds reported and the magnitude of those concentrations in whole fish were similar among the Mississippi River sites. Every sample from the Mississippi River had detectable concentrations of PCBs, dieldrin, and *p,p'*-DDE; none had reported concentrations above the MRL of toxaphene. Most other compounds that were detected in fish samples from the Mississippi River were only detected at a few sites and were at concentratons near the MRL.

DDT

Detection of DDT in fish tissue was widespread throughout the MISE study area as evidenced by DDT and/or one of its degradates being reported in all 64 fish-tissue samples collected in the MISE Study Unit during 1995–99. This was an expected result given the long half-life of DDT, and the fact that about 80 percent of the domestic use of DDT (prior to its use being discontinued) was on cotton (U.S. Environmental Protection Agency, 1975), and that cotton was historically a major crop in the study unit. All samples had concentrations of *p,p'*-DDE above the MRL; 94 percent had *p,p'*-DDD, 52 percent had *p,p'*-DDT, 34 percent had *o,p'*-DDD, 17 percent had *o,p'*-DDE, and 9 percent had *o,p'*-DDT concentrations above the MRL.

TDDT values ranged from 30 µg/kg (Spillway Ditch, map number 3, sample 3, table 8) to 9,494 µg/kg (Cassidy Bayou, map number 24, sample 26, table 8) and had a median value of 584.5 µg/kg. The national median of DDT and its degradates in fish tissue has decreased throughout recent years as indicated by several national surveys (Nowell and others, 1999). The NCBP found decreasing median concentrations, ranging from 430 to 750 µg/kg during the years 1965–72, 180 to 335 µg/kg during 1972–75, 220 µg/kg during 1976–77, and 90 to 120 µg/kg during 1984–86. The median total DDT concentration of the 1995–99 MISE fish-tissue samples is about 584 µg/kg, substantially above the national median values, except for the first set of data, 1965-72, when DDT was in active use in the United States.

It has been suggested that unexpectedly high ratios of DDT concentrations to TDDT concentrations can be used as an indicator of recent use of DDT (Aguilar, 1984); however, that is not always the case, as high ratios of DDT/TDDT can also indicate movement of contaminated soil into streams (Nowell and others, 1999, p. 343-345). The highest DDT/TDDT ratio found in this study was 12 percent, and most other ratios were below 10 percent. Schmitt and others (1990) suggest that a change in the proportional composition of the DDT mixture in fish tissue from about 70 percent *p,p'*-DDE to 73 percent *p,p'*-DDE indicated a continued weathering of DDT in the environment across the United States. The mean percent *p,p'*-DDE concentration in this study was almost 83 percent. These data do not indicate recent use of DDT or large inputs of contaminated sediments to most streams that were sampled as part of this study, but rather a widespread and pervasive contamination of the environment with DDT from historical use.

Relation with Ancillary Data

Ancillary data such as geology, physiographic region, drainage basin size, land use (basin and buffer zone), bed-

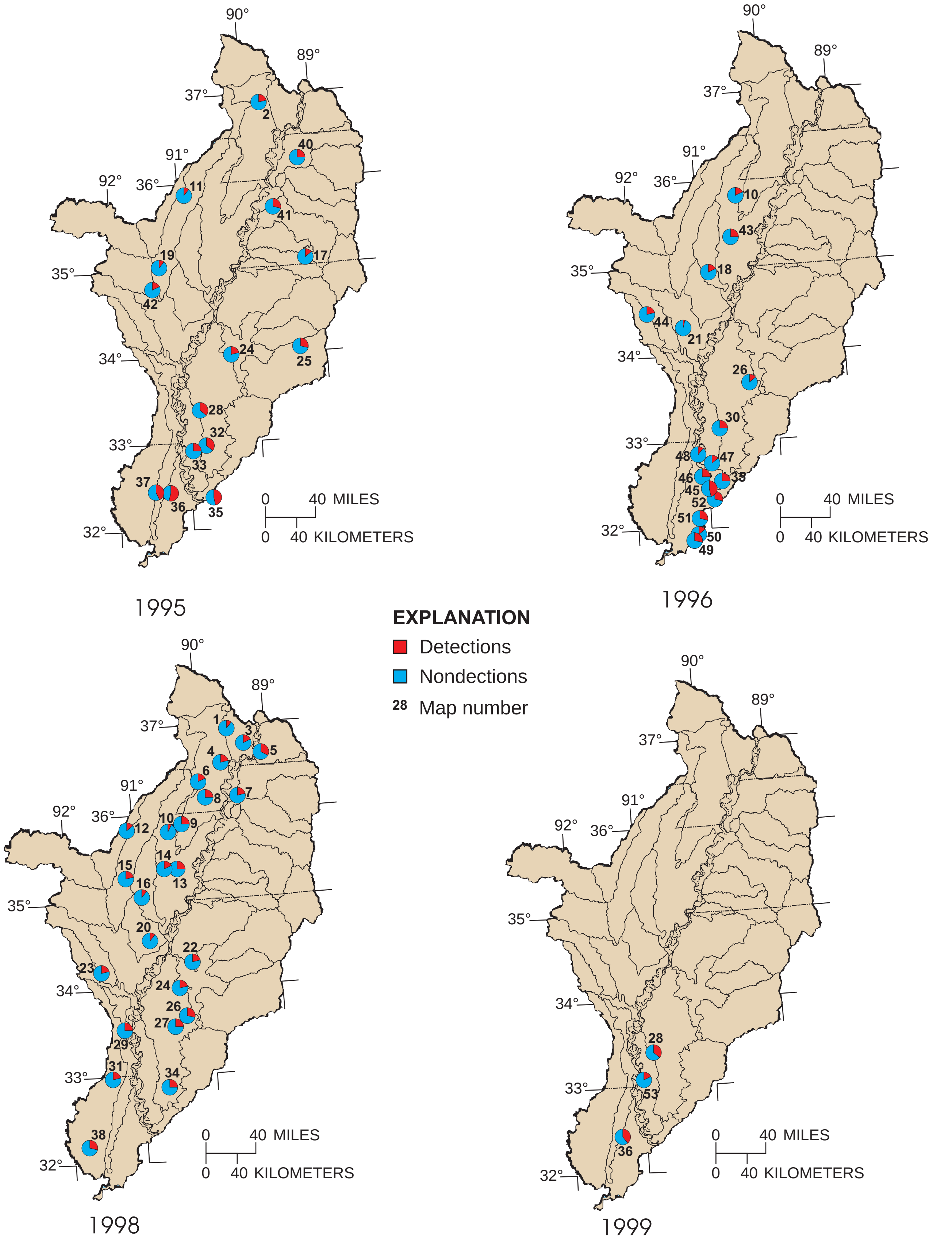

Figure 4. Percent detections of 28 organochlorine compounds in whole fish from 52 sampling sites in the Mississippi Embayment Study Unit, 1995-99.

sediment particle size, and permeability (table 1) were collected and collated for each drainage basin. The Mississippi River sites were not included in this analysis because of the large influence on water quality of the Mississippi River from upstream sources not within the MISE Study Unit. The fish tissue data were classed according to basin characteristics and statistically analyzed for differences among classes. These results should be used with caution as they do not imply cause and effect and could be the result of other factors not accounted for in these analyses.

Agricultural land use dominates the study area and overshadows the other land uses in statistical analysis. The dominant drainage-basin land use was arbitrarily divided into two classes, agricultural (greater than or equal to 55 percent agricultural land use) and nonagricultural (less than 55 percent agricultural land use). This division resulted in the nonagricultural class to have four values which was considered nonideal for analysis. The Kruskal-Wallis test on this nonideal dataset resulted in no significant differences between the two groups. The dominant buffer zone (area within 60 meters of the stream) land-use data were also divided into two classes, agricultural (greater than or equal to 55 percent agricultural land use in the buffer zone) and mixed (less than 55 percent agricultural land use in the buffer zone). This classification resulted in 37 sites in the agricultural class, and 10 sites in the mixed land-use class. Kruskal-Wallis analysis identified no statistically significant differences between organochlorine concentrations and dominant buffer zone land-use classes.

The sampling sites were divided in two classes based on drainage basin size, large (greater than 1,310 km^2) and small (less than 1,310 km^2). This designation resulted in the large class with 21 samples and the small basin class with 30 samples. Analysis by Kruskal-Wallis indicated that PCB concentrations were significantly different between classes (*p*-value of 0.026). The median PCB concentrations were 100 µg/kg for the large basin class and 64.5 µg/kg for the small basin class (fig. 5). One possible explanation for the larger PCB concentrations in larger drainage basins is that there is more probability of including urban areas in the larger basins and the presence of PCBs has been shown to be related strongly to population density and urban areas (Murray and others, 2003).

The dominant geology of the study area consisted of the Tertiary system, and the Pleistocene and Holocene series. Fish-tissue samples in this discussion are described as being in a class named for the geology of the associated deposits. Analyzing the organochlorine data by geologic characteristics resulted in 5 samples in the Tertiary system class, 19 samples in the Pleistocene class, 15 samples in the Holocene class, and 8 samples in the mixed geology class. The Tertiary system class had too few samples for ideal statistical analysis. Analysis by Kruskal-Wallis test indicated that there are significant

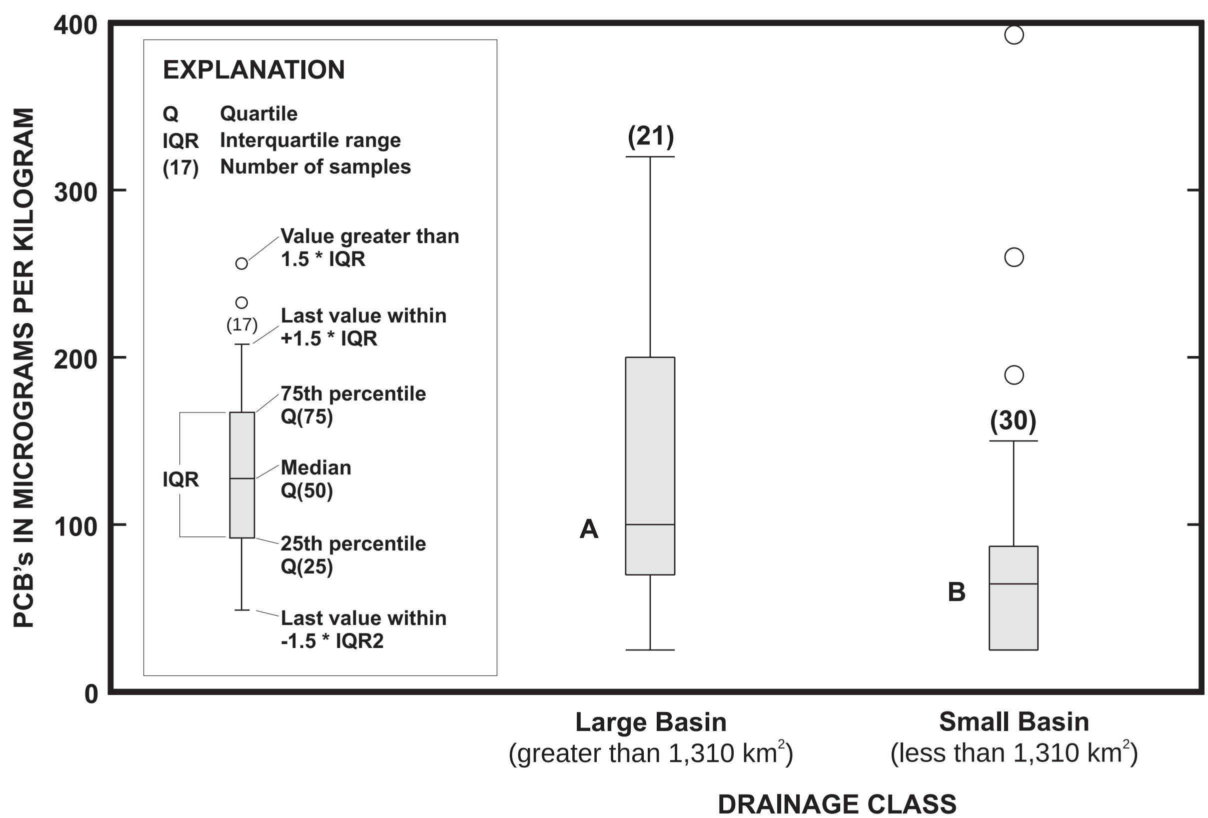

Figure 5. PCB concentrations in whole fish from large (greater than 1,310 km^2) and small (less than 1,310 km^2) drainage basins in the Mississippi Embayment Study Unit, 1995-99.

differences in organochlorine concentrations by geology class for the following compounds: toxaphene (p= 0.000), dieldrin (p=0.025), *p,p'*-DDE (p=0.000), *o,p'*-DDD (p=0.003), *p,p'*-DDD (p=0.000), and *p,p'*-DDT (p=0.000). Further analysis by Tukey's method indicated that toxaphene, *p,p'*-DDE, and *p,p'*-DDD concentrations were significantly different between geology classes and that concentrations were higher in streams located in the Holocene geology than mixed geology, followed by Pleistocene geology (fig. 6). Concentrations of *p,p'*-DDT were significantly higher from the mixed geology, followed by the Holocene and then Pleistocene geology. For dieldrin and *o,p'*-DDD, the concentrations were not significantly different between streams in Holocene or mixed geology, but they were higher and significantly different than streams in Pleistocene geology.

Average soil permeability at sites in the study unit ranged from 1 to 22 cm/hr with a median value of 2.6 cm/hr. These values were divided into three classes, high (3.2 to 22 cm/hr), moderate (1.9 to 3.2 cm/hr), and low (1 to 1.9 cm/hr). There were 12 samples in the high permeability class, 21 samples in the medium permeability class, and 14 samples in the low permeability class. Kruskal-Wallis testing on organochlorine compounds and the permeability classes indicated significant differences between classes for toxaphene (p=0.002), mirex (p=0.028), *p,p'*-DDE (p=0.000), *o,p'*-DDD (p=0.001), *p,p'*-DDD (p=0.004), *p,p'*-DDT (p=0.007), and *o,p'*-DDT (p=0.024). Further analyses by Tukey's method show that, in general, the highest concentrations for the above compounds were found in fish tissue from streams in basins with soils of low permeability (fig. 7).

Particle size designations for streambed material were developed for each site sampled. The percentages of clays, silt, and sand were determined for each site. From these percentages, the sites were categorized by dominant (greater than 55 percent) particle size. If there was not a dominant particle size at a site, the site was designated as a mixed particle size site. Partitioning these sites into dominant particle size classes resulted in the following class sample sizes: clay, 5; silt, 8; sand, 29; and mixed, 5. Although the small size of clay, silt, and mixed classes are nonideal for statistical analysis, Kruskal-Wallis testing indicated significant differences between particle size categories for PCB (p=0.002), toxaphene (p=0.010), dieldrin (p=0.007), *p,p'*-DDE (p=0.015), *o,p'*-DDE (p=0.029), *o,p'*-DDD (p=0.025), *p,p'*-DDD (p=0.004), *trans*-chlordane (p=0.002), and *cis*-chlordane (p=0.000). Analyzing the data by Tukey's method showed that the sites with the smaller particles sizes, (clay or, in some cases, silt) as the dominant particle size had significantly higher concentrations compared to the other sites with larger particle sizes (fig. 8).

Bed-sediment particle size and the soil permeability of the drainage basin probably are related as the streambed material is made up of material from the soil of the drainage basin. There can be some sorting of particle sizes in streams, as the larger particles will settle out according to the velocity of the stream. One explanation for the higher concentrations of some organochlorine compounds in basins with low soil permeability and/or smaller particle sizes is that the clay type particles have larger surface areas, which may weakly adsorb some of these hydrophobic compounds. These clay particles can then be transported into streams by runoff or wind erosion, and the organochlorine compounds may desorb from the clay particles due to equilibrium partitioning or the clay might be ingested by benthic organisms and the organochlorine compounds move into the food chain in this manner.

Comparison with National Standards and Guidelines

The standards for organochlorine compounds in fish tissue that are written for the protection of human health refer to the edible portion of the fish and are not directly comparable to the results in this report. There are, however, guidelines for some organic compounds in whole-fish tissue for the protection of fish-eating wildlife (National Academy of Sciences and National Academy of Engineering, 1973; Nowell and Resek, 1994; table 7). Comparing the MISE fish data with these standards can help identify areas of concern and for further study. There are no suggested standards and guidelines for pentachloroanisole, hexachlorobenzene, and dacthal concentrations for the protection of fish-eating wildlife.

Aldrin, endrin, lindane, and methoxychlor had maximum concentrations less than the MRL of 5 µg/kg, and therefore, do not appear to be a significant concern for fish-eating wildlife in the MISE Study Unit (table 7). Concentrations of PCBs and chlordane exceeded the National Academy of Sciences and National Academy of Engineering (NAS/NAE) guidelines in a few samples; none of the dieldrin concentrations exceeded the guidelines. Concentrations of TDDT and toxaphene exceeded the NAS/NAE guidelines in more than 25 percent of the fish-tissue samples collected in the MISE Study Unit. Almost two-thirds of the TDDT samples exceeded the New York Fish Flesh Criteria (NYFF). Because of the difficulty in analyzing for toxaphene, the usual MRL for toxaphene is quite high (200 µg/kg), compared to the MRL for the other organochlorine compounds. Many fish-tissue samples had a much higher MRL for toxaphene (400 to 1,100 µg/kg). Two hundred micrograms per kilogram is double the NAS/NAE guideline (100 µg/kg). Given the distribution of the concentration of toxaphene in fish-tissue samples shown in table 7, it is possible that more than 50 percent of the fish-tissue samples exceeded the guidelines of 100 µg/kg. These data indicate that of the compounds that have NAS/NAE or NYFF guidelines, only TDDT and toxaphene exceeded the guidelines frequently and could be a concern in the MISE Study Unit, especially the southern part of the study unit. Schmitt (2002) also concluded from 1995 NCBP data that concentrations of TDDT (primarily as *p,p'*-DDE) were great enough in the cotton farming regions of the lower Mississippi River Basin (primarily the MISE Study Unit) to constitute a hazard to fish-eating wildlife.

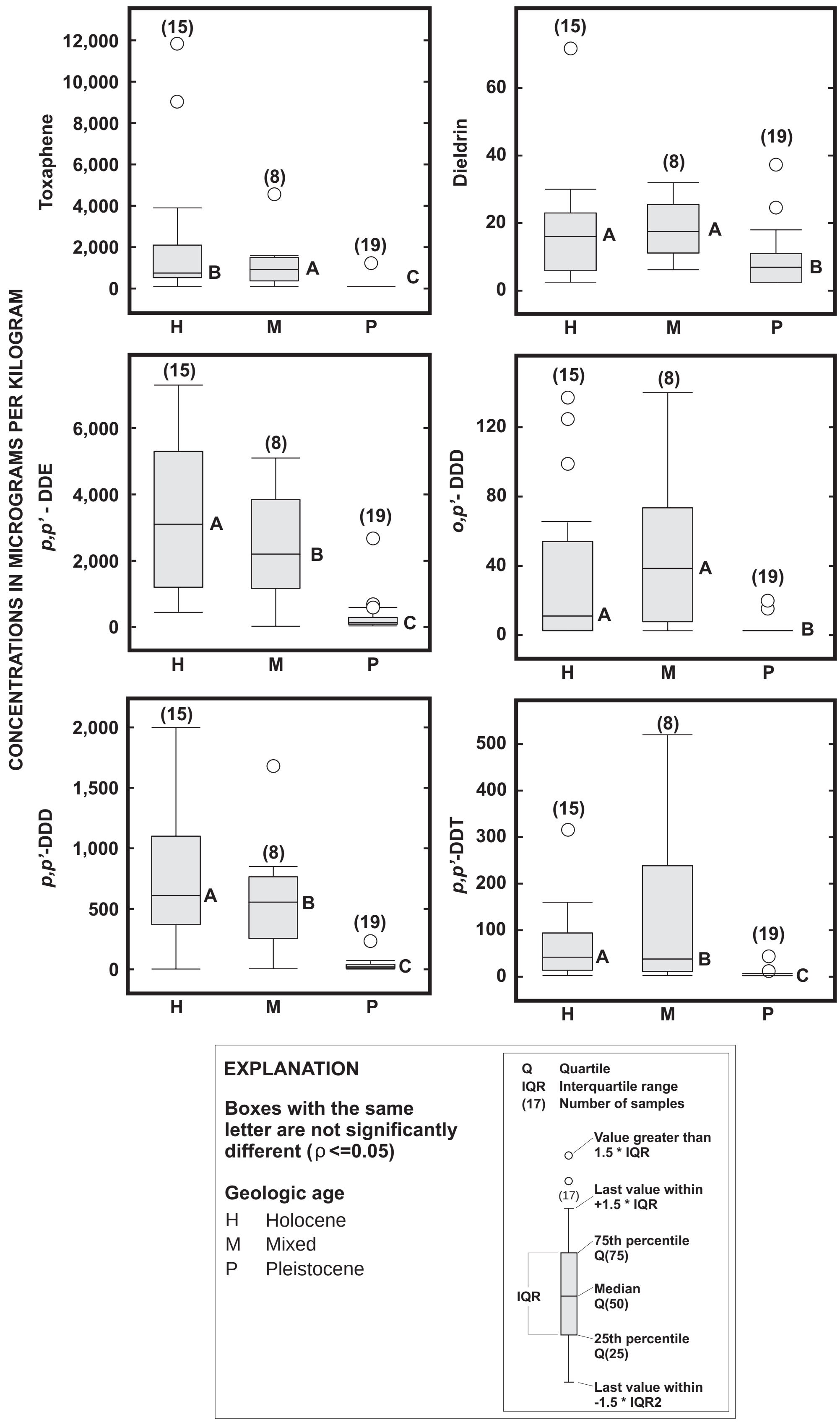

Figure 6. Selected organochlorine concentrations in whole fish collected from sampling sites in which the surficial soils of the drainage basin are primarily of the Holocene, Pleistocene, or mixed geologic age in the Mississippi Embayment Study Unit, 1995-99.

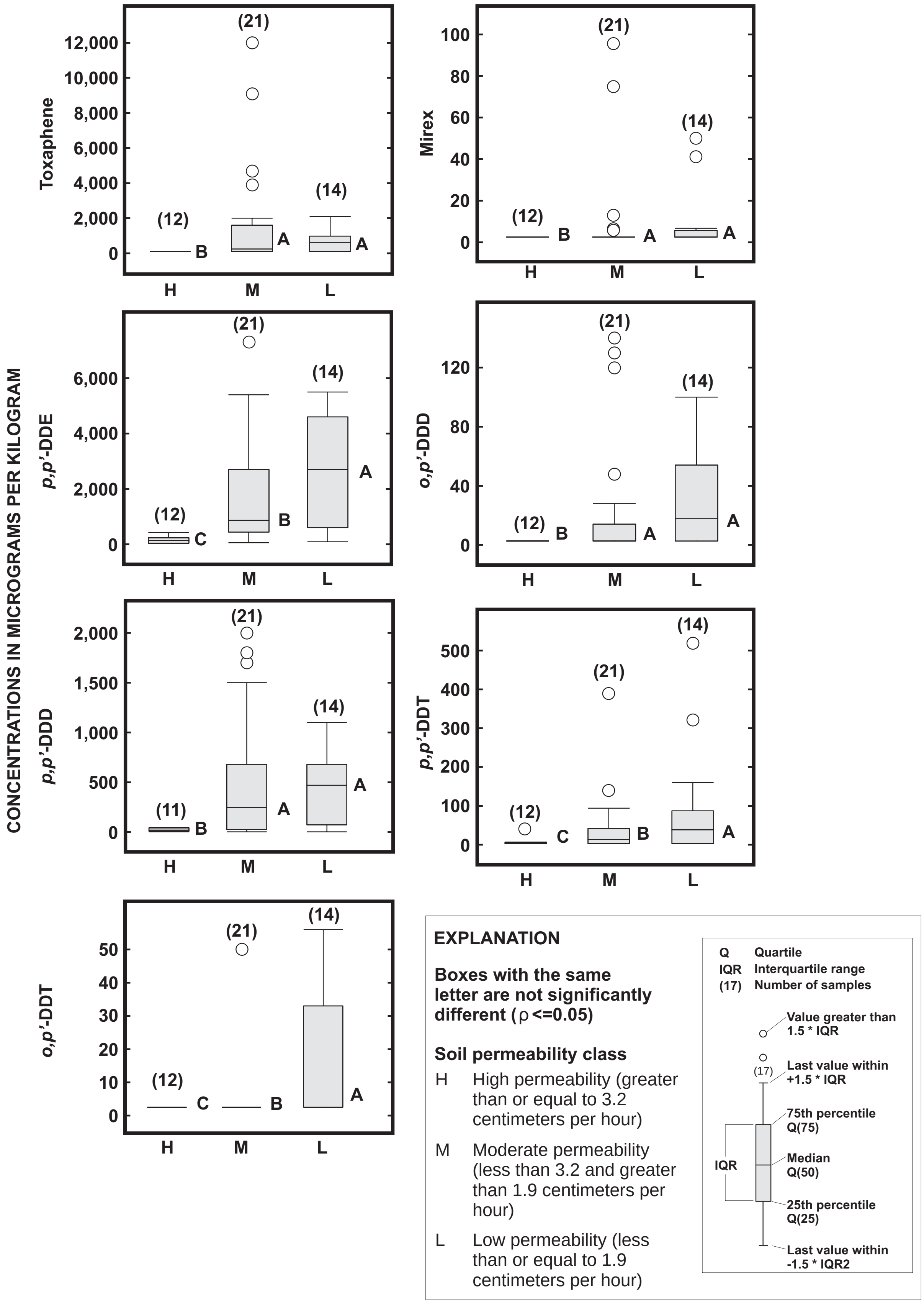

Figure 7. Selected organochlorine concentrations between classes of soil permeability, in the Mississippi Embayment Study Unit, 1995-99.

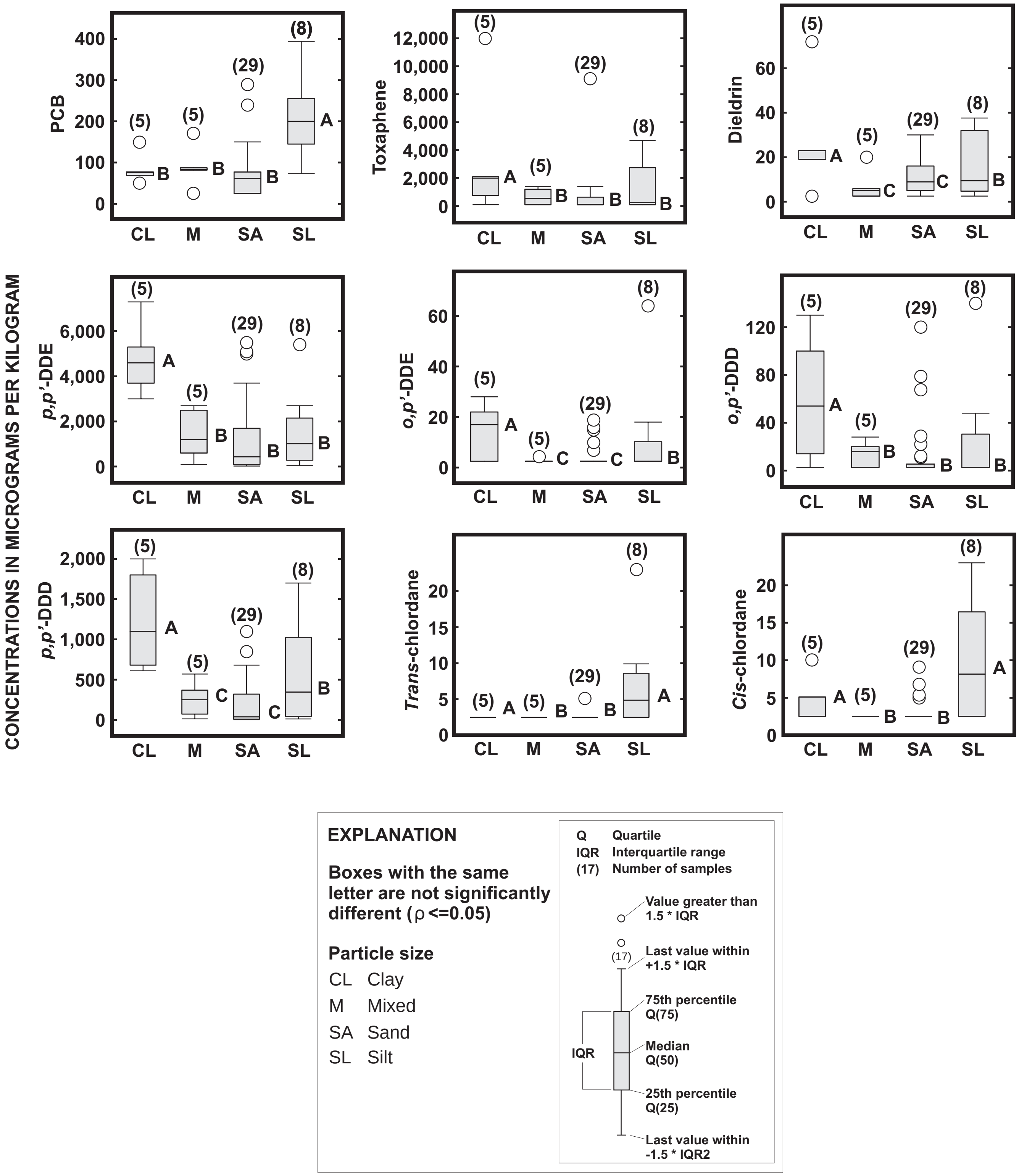

Figure 8. Selected organochlorine concentrations between bed-sediment particle size, in the Mississippi Embayment Study Unit, 1995-99

SUMMARY AND CONCLUSIONS

The Mississippi Embayment Study Unit is located in one of the most agriculturally intensive areas of the United States and, although the use of many organochlorine pesticides and PCBs has been discontinued in the United States, there is concern over their environmental fate, especially in the cotton growing areas of the southeastern United States where historical use of organochlorine pesticides has been extensive. Studies conducted in the 1970s and the 1980s have demonstrated a widespread and pervasive contamination of air, soil, water, and biota by organochlorine compounds, especially the DDT degradates and toxaphene.

During 1995-99, 64 fish-tissue samples were collected at 52 sites and were analyzed for 28 organochlorine compounds. These sites are located in Arkansas, Louisiana, Kentucky, Mississippi, Missouri, and Tennessee, and have drainage basins that range from 48 to almost 3,000,000 (Mississippi River) km^2. The major physiographic province in the study unit is the Mississippi Alluvial Plain, and most (47) of the sites sampled lie within this province, although 8 sites were on the main stem of the Mississippi River. The Gulf Coastal Plain physiographic province lies on the eastern part of the study unit, and the remainder of the sites (5) were within this province.

At least one organochlorine compound was detected in every fish-tissue sample analyzed in this study. A degradate of *p,p'*-DDT, *p,p'*-DDE, was detected in every sample, and another degradate, *p,p'*-DDD was detected in 94 percent of the samples. PCBs were detected in 83 percent of the samples. Aldrin, *p,p'*-methoxychlor, *o,p'*-methoxychlor, lindane (*gamma*-HCH), *alpha*-HCH, heptachlorepoxide, and endrin were not detected in concentrations above the MRL (generally 5.0 µg/kg) in fish tissue at any of the sites. The percentage of detections at each site ranged from 4 (La Grue Bayou near DeWitt, Ark.) to 54 percent (Tensas River at Tendal, La.). The sites with the highest percentages of detections and the highest concentrations were in the southern part of the study unit, excluding the sites located on the Mississippi River.

Comparing the MISE Study Unit data with the entire national NAWQA dataset for sites sampled in 1992-95 and with the 1984 NCBP data indicated that fish-tissue samples from streams in the MISE Study Unit had some of the highest concentrations of organochlorine compounds in the country.

Analyzing the data with respect to land use did not result in any statistically significant differences, probably because the land use in the study unit is overwhelmingly agricultural. Concentrations of some compounds (*p,p'*-DDT , *p,p'*-DDD, *p,p'*-DDE, *o,p'*-DDD, dieldrin, and toxaphene) in fish tissue from sites located in Holocene deposits were significantly higher than from sites located in Pleistocene deposits. Most of the DDT compounds, toxaphene, and mirex had higher concentrations in streams with basins that have low soil permeability. Toxaphene, dieldrin, *p,p'*-DDE, *o,p'*-DDE, *o,p'*-DDD, and *p,p'*-DDD concentrations in fish tissue had higher concentrations from streams with clay as the dominant bed sediment particle size; PCB, *cis*- and *trans*-chlordane and dieldrin, had higher concentrations associated with silt-sized particles.

The standards for organochlorine compounds in fish tissue that were written for the protection of human health refer to the edible portion of the fish and are not directly comparable to the results in this report. There are guidelines for some organic compounds in whole-fish tissue for the protection of fish-eating wildlife; concentrations of total DDT and toxaphene exceeded the guidelines frequently and are a concern in the MISE Study Unit, especially in the southern part of the Study Unit.

Past use of DDT and other organochlorine compounds in the MISE Study Unit have made an indelible mark on the ecosystem of the area. Although the use of most of these pesticides was discontinued in the 1970s and 1980s, some are persistent in the environment. Because of their longevity in the environment and the hydrophobic nature of these organochlorine compounds, especially DDT and DDT degradates, some organochlorine compounds are commonly found in fish tissue of the MISE Study Unit.

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TABLES

Table 1. Description of fish-tissue sampling sites in the Mississippi Embayment Study Unit, 1995-99

[SA, sand; SL, silt; M, mixed; CL, clay; S, small; L, large; A, agriculture; N, nonagriculture; P, Pleistocene; T, Tertiary; H, Holocene; HI, high; LO, low; MO, moderate; MAP, Mississippi Alluvial Plain; G, Gulf Coastal Plain; MVL, Mississippi Valley Loess; SP, Southeastern Plain; km^2, square kilometers; m^3/s, cubic meters per second; m, meters; m/s, meters per second; NA, not available]

Map no. (fig. 1)	Site name	Site number	Latitude	Longitude	Geologic age	Physiographic province and ecoregion	Drainage basin area (km^2)	[1]Drainage area class	Dominant basin land use	Percent of basin in agriculture	Dominant buffer land-use	Discharge at gage (m^3/s)	Channel width (m)	Mean channel depth (m)	Instantaneous velocity (m/s)	Particle size class	[2]Permeability class
1	St. Johns Ditch near Sikeston, MO	07043300	365608	893302	P	MAP	101	S	A	90	A	2.22	10.9	0.52	0.25	SA	HI
2	Little River Ditch no. 1 near Morehouse, MO	07043500	365003	894348	P	MAP	1,144	S	A	85	A	2.96	33.7	0.35	0.13	SA	HI
3	Spillway Ditch at Hwy 102 near East Prairie, MO	07024160	364454	892119	M	MAP	186	S	A	93	A	0.93	10.5	0.40	0.15	SA	HI
4	Little River Ditch no. 251 near Lilbourn, MO	07042500	363320	894012	P	MAP	627	S	A	95	A	3.60	22.4	0.73	0.27	SA	HI
5	Obion Creek near Hickman, KY	07023800	363858	890721	P	G, MVL	784	S	A	77	A	1.22	12.5	0.84	0.17	SL	HI
6	Main Ditch at Hwy 153 near White Oak, MO	07041120	361927	900020	P	MAP	356	S	A	94	A	2.20	19.9	0.33	0.36	SA	HI
7	Running Reelfoot Bayou at Hwy 103, TN	07027050	360944	893036	P	MAP	751	S	A	57	M	0.68	13.9	0.16	0.26	SA	HI
8	Elk Chute near Gobler, MO	07046515	361018	895734	P	MAP	218	S	A	97	A	0.70	11.7	0.20	0.14	SA	HI
9	Cockle Burr Slough Ditch near Monette, AR	07040496	355139	901949	P	MAP	146	S	A	98	A	3.31	53.1	1.06	0.08	SL	HI
10	St. Francis River at Lake City, AR	07040450	354916	902556	T	MAP	6,150	L	N	43	F	11.0	24.6	2.90	0.45	SA	MO
11	Cache River at Egypt, AR	07077380	355128	905600	P	MAP	1,816	L	A	82	A	8.84	21.7	2.34	0.18	SA	MO
12	Village Creek near Swifton, AR	07074660	354910	910505	P	MAP	410	S	A	94	A	4.71	115.8	0.74	0.11	M	MO
13	Tyronza River near Twist, AR	07047700	352229	902805	H	MAP	1,367	L	A	95	A	4.59	19.0	0.81	0.21	SA	MO
14	St. Francis River near Coldwater, AR	07047520	352152	903436	P	MAP	13,774	L	A	70	A	36.1	58.9	1.27	0.46	SA	HI
15	Bayou DeView at Morton, AR	07077700	351507	910637	P	MAP	1,081	S	A	79	A	4.61	28.8	2.62	0.06	SA	MO
16	Second Creek near Palestine, AR	07047947	350221	905440	P	MAP	111	S	A	69	M	2.52	15.1	0.73	0.28	SA	LO
17	Wolf River at LaGrange, TN	07030392	350157	891448	T	G, MVL	543	S	N	32	F	5.04	15.6	1.29	0.30	SA	HI
18	L'Anguille River near Palestine, AR	07047950	345820	905310	P	MAP	1,983	L	A	81	A	8.69	24.6	2.09	0.18	M	LO
19	Cache River near Cotton Plant, AR	07077555	350207	911919	P	MAP	2,996	L	A	83	A	14.6	35.0	2.01	0.22	SA	MO
20	Big Creek at Poplar Grove, AR	07077950	343320	905044	P	MAP	1,160	S	A	87	A	6.33	17.8	2.21	0.23	SL	LO
21	LaGrue Bayou near Dewitt, AR	07078040	341900	911657	P	MAP	594	S	A	77	M	0.00	8.1	0.61	0.00	SA	LO
22	Coldwater River at Marks, MS	07279950	341522	901557	T	MAP	4,937	L	A	65	A	90.7	37.5	4.60	0.50	SL	MO
23	Bayou Meto near Bayou Meto, AR	07265099	341205	913145	M	MAP	2,078	L	A	61	M	0.00	25.5	3.54	0.00	SA	MO
24	Cassidy Bayou at Webb, MS	07280900	335659	902028	H	MAP	536	S	A	89	A	2.41	62.2	0.85	0.04	CL	MO
25	Skuna River at Bruce, MS	07283000	335825	892050	T	G, SP	668	S	N	51	A	0.49	37.4	1.18	0.26	SA	MO
26	Quiver River near Doddsville, MS	07288570	333825	902405	H	MAP	651	S	A	86	A	5.77	16.3	1.65	0.24	SA	LO
27	Big Sunflower River at Sunflower, MS	07288500	333250	903235	H	MAP	2,010	L	A	87	A	15.0	23.2	2.19	0.56	SA	LO
28	Bogue Phalia near Leland, MS	07288650	332347	905047	M	MAP	1,301	S	A	86	A	5.35	37.7	1.34	0.09	SA	LO
29	Bayou Macon near Halley, AR	073676595	333216	911736	H	MAP	376	S	A	93	A	9.80	14.6	1.20	0.45	SA	MO
30	Deer Creek near Holandale, MS	07288770	330859	905047	H	MAP	231	S	A	86	A	0.00	19.2	1.71	0.00	SL	MO

Table 1. Description of fish-tissue sampling sites in the Mississippi Embayment Study Unit, 1995-99 -- Continued

Map no. (fig. 1)	Site name	Site number	Latitude	Longi-tude	Geo-logic age	Physio-graphic province and ecoregion	Drainage basin area (km^2)	[1]Drain-age area class	Domi-nant basin land use	Percent of basin in agriculture	Domi-nant buffer land-use	Discharge at gage (m^3/s)	Channel width (m)	Mean channel depth (m)	Instan-taneous velocity (m/s)	Par-ticle size class	[2]Per-mea-bility class
31	Boeuf River near Arkansas/LA State Line, LA	07367700	325825	912625	H	MAP	1,822	L	A	91	A	6.17	45.0	2.32	0.07	SA	MO
32	Big Sunflower River near Anguilla, MS	07288700	325818	904640	H	MAP	6,675	L	A	84	A	46.0	89.8	3.98	0.15	CL	LO
33	Steele Bayou East Prong near Rolling Fork, MS	07288870	325441	905710	H	MAP	1,122	S	A	74	A	2.88	49.6	2.02	0.08	SA	MO
34	Silver Creek near Bayland, MS	0728872008	325208	904145	H	MAP	48	S	A	88	A	0.00	20.4	0.13	0.00	M	LO
35	Yazoo River below Steele Bayou near Long Lake, MS	07288955	322640	905400	T	MAP	34,850	L	A	56	M	405	91.4	5.92	0.49	SL	MO
36	Tensas River at Tendal, LA	07369500	322555	912200	H	MAP	721	S	A	87	A	2.35	19.3	1.26	0.26	CL	MO
37	Bayou Macon near Delhi, LA	07370000	322725	912830	M	MAP	2,141	L	A	86	A	6.80	55.4	2.02	0.08	CL	LO
38	Big Creek near Sligo, LA	07368580	321220	914911	P	MAP	1,311	L	A	78	A	1.56	48.4	1.75	0.02	M	LO
40	Obion River near Obion, TN	07026040	361423	891304	NA	G, MVL	4,861	L	NA	NA	NA	NA	NA	NA	NA	NA	NA
41	Hatchie River at Rialto,TN	07030050	353814	893614	NA	G, MVL	5,968	L	NA	NA	NA	NA	NA	NA	NA	NA	HI
42	White River at DeValls Bluff, AR	07077000	344725	912645	NA	MAP	60,765	L	NA	NA	NA	NA	NA	NA	NA	NA	NA
43	St. Francis River at Parkin, AR	07047800	352623	903333	NA	MAP	6,643*	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
44	Bayou Meto near Stuttgart, AR	7264500	342715	913658	M	MAP	1,487	L	A	NA	NA	NA	NA	NA	NA	NA	NA
45	Mississippi River at Mile 442	322052090585900	322052	905859	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
46	Mississippi River at Mile 460	323501091065500	323501	910655	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
47	Mississippi River at Mile 475	324050091054100	324050	910541	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
48	Mississippi River at Mile 495	325151091055200	325151	910552	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
49	Mississippi River at Mile 378	314625091212600	314625	912126	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
50	Mississippi River at Mile 402	315847091072700	315847	910727	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
51	Mississippi River at Mile 419	320704091015900	320704	910159	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
52	Mississippi River at Mile 432	321651090575800	321651	905758	M	MAP	2,953,900	L	M	NA	M	NA	NA	NA	NA	SA	NA
53	Steele Bayou at Yazoo National Wildlife Refuge, MS	330743090580300	330743	905803	NA	MAP	indeterminate	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

*Indeterminate drainage area, values represent total drainage area of St. Francis River and St. Francis Bay

[1] Drainage areas were considered large if larger than 1,300 square kilometers and small if less than 1,300 square kilometers

[2] High permeability is equal or greater than 1.25, moderate permeability is greater than 0.75 and less than 1.25, and low permeability is equal to or less than 0.75

Table 2. Organochlorine and PCB concentrations in whole fish from sampling sites in the Mississippi Embayment Study Unit, 1995-99

[Concentrations in micrograms per kilogram; <, less than; E, estimated; NA, not available; white background fish species carp; blue bass; yellow gar]

Map number	Sample number	Sample date	Aldrin	Poly-chlori-nated biphe-nyls	Toxa-phene	Pentchlo-roanisole (µg/kg)	Oxy-chlor-dane	*trans*-Nonach-lor	*cis*-Non-achlor	Mirex	*p,p'*-Me-thoxy-chlor	*o,p'*-Me-thoxy-chlor	Lindane (gamma-HCH)	*delta*-HCH	*beta*-HCH	*alpha*-HCH	Hexa-chloro-benzene
1	1	19980709	<5.00	<50.0	<200	<5.00	<5.00	5.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
2	2	19951018	<5.00	<50.0	<200	<5.00	<5.00	10.0	5.5	<5.00	<5.00	<5.00	<5.00	<5.30	<5.00	<5.00	<5.00
3	3	19980708	<5.00	59.0	<200	<5.00	<5.00	5.5	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
4	4	19980710	<5.00	62.0	<200	<5.00	<5.00	6.6	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
5	5	19980902	<5.00	394.0	<200	<5.00	9.8	24.1	10.8	<5.00	<5.00	<5.00	<5.00	<12.0	<5.00	<5.00	10.0
6	6	19980723	<5.00	<50.0	<200	<5.00	<5.00	10.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
7	7	19980708	<5.00	75.0	<200	5.8	<5.00	5.1	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
8	8	19980625	<5.00	67.0	<200	5.3	<5.00	6.1	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
9	9	19980625	<5.00	190.0	<200	<5.00	<5.00	11.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
10	10	19961015	<5.00	100.0	<200	<5.00	E8.10	<5.00	<5.00	<5.00	<10.0	<10.0	NA	<5.00	<5.00	<5.00	<5.00
10	11	19980722	<5.00	<50.0	<200	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
11	12	19950921	<5.00	<50.0	<200	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
12	13	19980626	<5.00	83.0	<200	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
13	14	19980707	<5.00	77.0	<200	<5.00	<5.00	6.9	<5.00	<5.00	<5.00	<7.00	<5.00	<5.00	<5.00	<5.00	<5.00
14	15	19980707	<5.00	70.0	<200	<5.00	<5.00	5.6	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
15	16	19980624	<5.00	150.0	<200	6.1	<5.00	5.3	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
15	17	19980624	<5.00	74.0	<200	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
16	18	19980623	<5.00	61.0	<200	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
17	19	19951019	<5.00	<50.0	<200	<5.00	<5.00	5.1	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
18	20	19961015	<5.00	82.0	<200	<5.00	<5.00	E7.90	<5.00	<5.00	<10.0	<10.0	<6.00	<5.00	<5.00	<5.00	<5.00
19	21	19950920	<5.00	<50.0	<200	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
20	22	19980603	<5.00	73.0	<200	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
21	23	19961016	<5.00	<50.0	<200	<5.00	<5.00	<5.00	<5.00	<10.0	<5.00	<5.00	<5.00	<5.00	NA	<5.00	NA
22	24	19980604	<5.00	100.0	E390	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<6.00	<5.00	<5.00	<5.00	<5.00	<5.00
23	25	19980602	<5.00	240.0	E640	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<6.00	<5.00	<5.00	<5.00	<5.00	<5.00
24	26	19951016	<5.00	76.0	2,000.0	<5.00	<5.00	<50.0	<5.00	<5.00	<50.0	<50.0	<6.00	<5.00	<5.00	<5.00	<5.00
24	27	19980604	<5.00	150.0	E760	<5.00	<5.00	<6.00	<5.00	<5.00	<12.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
25	28	19951020	<5.00	<50.0	<1100	<5.00	<5.00	5.6	<5.00	13.0	<10.0	<10.0	<5.00	<5.00	<5.60	<5.00	<5.00
26	29	19960718	<5.00	62.0	E530	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
26	30	19980617	<5.00	91.0	E750	<5.00	<5.00	12.0	<10.0	<5.00	<17.0	<28.0	<5.00	<5.00	<5.00	<5.00	<5.00
27	31	19980617	<5.00	290.0	E710	<5.00	<5.00	<7.00	<5.00	<5.00	<6.00	<9.00	<5.00	<5.00	<5.00	<5.00	<5.00
28	32	19950822	<5.00	52.0	1,400.0	<5.00	<5.00	<20.0	<5.00	5.1	<9.00	<12.0	<5.00	<11.0	<10.0	<5.00	<5.00

Table 2. Organochlorine and PCB concentrations in whole fish from sampling sites in the Mississippi Embayment Study Unit, 1995-99 -- Continued

Map number	Sample number	Sample date	Hepta-chlore-poxide	Hepta-chlor	Endrin	Dieldrin	*p,p'*-DDE	*o,p'*-DDE	*o,p'*-DDD	*p,p'*-DDD	*p,p'*-DDT	*o,p'*-DDT	Dacthal (DCPA)	*trans*-Chlor-dane	*cis*-Chlro-dane
1	1	19980709	<5.00	<5.00	<5.00	<5.00	34.0	<6.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
2	2	19951018	<5.00	<5.00	<5.00	25.0	43.0	<5.00	<5.00	14.0	<5.00	<5.00	<5.00	<5.00	5.0
3	3	19980708	<5.00	<5.00	<5.00	19.0	24.0	<5.00	<5.00	E5.50	<5.00	<5.00	<5.00	<5.00	<5.00
4	4	19980710	<5.00	<5.00	<5.00	18.0	140.0	15.0	<5.00	20.0	<5.00	<5.00	<5.00	<5.00	<5.00
5	5	19980902	<5.00	<5.00	<5.00	37.6	42.6	<6.40	<5.00	11.9	<5.00	<5.00	<5.00	7.2	18.9
6	6	19980723	<5.00	<5.00	<5.00	9.6	220.0	<5.00	<5.00	E22.0	<5.00	<5.00	<5.00	<5.00	6.8
7	7	19980708	<5.00	<5.00	<6.00	11.0	97.0	<5.00	<5.00	E9.60	<5.00	<5.00	<5.00	<5.00	<5.00
8	8	19980625	<5.00	<5.00	<5.00	8.9	130.0	<8.00	<5.00	E37.0	6.4	<5.00	<5.00	<5.00	<5.00
9	9	19980625	<5.00	<5.00	<5.00	6.9	290.0	<5.00	<5.00	46.0	6.9	<5.00	<5.00	<5.00	8.3
10	10	19961015	<5.00	<5.00	<5.00	<5.00	550.0	<5.00	E5.50	E29.0	<10.0	<5.00	<5.00	<5.00	<5.00
10	11	19980722	<5.00	<5.00	<5.00	<5.00	58.0	<5.00	<5.00	E8.20	<5.00	<5.00	<5.00	<5.00	<5.00
11	12	19950921	<5.00	<5.00	<5.00	5.0	120.0	<5.00	<5.00	18.0	<5.00	<5.10	<5.00	<5.00	<5.00
12	13	19980626	<5.00	<5.00	<5.00	5.0	87.0	<5.00	<5.00	E13.0	<5.00	<5.00	<5.00	<5.00	<5.00
13	14	19980707	<5.00	<5.00	<5.00	8.8	440.0	<5.00	<8.00	<5.00	12.0	<14.0	<5.00	5.1	5.4
14	15	19980707	<5.00	<5.00	<5.00	7.6	430.0	<5.00	<5.00	42.0	<5.00	<5.00	<5.00	<5.00	<5.00
15	16	19980624	<5.00	<5.00	<5.00	15.0	240.0	<5.00	<5.00	26.0	<5.00	<5.00	<5.00	<5.00	<5.00
15	17	19980624	<5.00	<5.00	<5.00	8.2	70.0	<5.00	<5.00	E7.20	<5.00	<5.00	<5.00	<5.00	<5.00
16	18	19980623	<5.00	<5.00	<5.00	<5.00	91.0	<5.00	<5.00	6.5	<5.00	<5.00	<5.00	<5.00	<5.00
17	19	19951019	<5.00	<5.00	<5.00	<5.00	250.0	<5.00	<5.00	42.0	40.0	<5.00	<5.00	<5.00	<5.00
18	20	19961015	<5.00	<5.00	<5.00	<5.00	600.0	<5.00	E16.0	E73.0	<10.0	<5.00	<5.00	<5.00	<5.00
19	21	19950920	<5.00	<5.00	<5.00	5.4	590.0	<5.00	<5.30	E42.0	<5.00	<5.70	<5.00	<5.00	<5.00
20	22	19980603	<5.00	<5.00	<5.00	<5.00	274.0	<5.00	<5.00	E40.5	<5.00	<5.00	<5.00	<5.00	<5.00
21	23	19961016	<5.00	<5.00	<11.0	<5.00	94.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
22	24	19980604	<5.00	<5.00	<5.00	9.5	1,300.0	<5.00	<5.00	E300	24.0	<5.00	<5.00	<5.00	<5.00
23	25	19980602	<5.00	<5.00	<5.00	13.0	1,700.0	<5.00	<21.0	E120	13.0	<5.00	<5.00	<5.00	<5.00
24	26	19951016	<5.00	<5.00	<50.0	<50.0	E7300	<50.0	130.0	E2000	64.0	<5.00	<5.00	<50.0	<50.0
24	27	19980604	<5.00	<5.00	<14.0	72.0	3,000.0	<5.00	<29.0	E680	94.0	<40.0	<5.00	<5.00	<5.00
25	28	19951020	<5.00	<5.00	<5.00	11.0	680.0	10.0	12.0	320.0	E21.0	<10.0	<5.00	<5.00	<5.00
26	29	19960718	<5.00	<5.00	<5.00	<11.0	E3100	<5.00	<5.00	E600	<10.0	<5.00	<5.00	<5.00	<5.00
26	30	19980617	<5.00	<5.00	<5.00	30.0	5,500.0	<15.0	<55.0	E1100	320.0	<5.00	<5.00	<5.00	9.1
27	31	19980617	<5.00	<5.00	<15.0	20.0	1,800.0	<11.0	22.0	E380	58.0	<37.0	<5.00	<5.00	<5.00
28	32	19950822	<5.00	<13.0	<220	19.0	5,000.0	16.0	79.0	E850	87.0	56.0	<5.00	<6.00	<5.00

Table 2. Organochlorine and PCB concentrations in whole fish from sampling sites in the Mississippi Embayment Study Unit, 1995-99 -- Continued

Map number	Sample number	Sample date	Aldrin	Polychlorinated biphenyls	Toxaphene	Pentchloroanisole (µg/kg)	Oxychlordane	*trans*-Nonachlor	*cis*-Nonachlor	Mirex	*p,p'*-Methoxychlor	*o,p'*-Methoxychlor	Lindane (gamma-HCH)	*delta*-HCH	*beta*-HCH	*alpha*-HCH	Hexachlorobenzene
28	33	19950822	<5.00	52.0	870.0	<5.00	<5.00	<26.0	<5.00	6.7	<12.0	<15.0	<5.00	<5.00	<12.0	<5.00	<5.00
28	34	19990830	<5.00	<50.0	E980	<5.00	<5.00	6.3	<5.00	E4.20	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
29	35	19980616	<5.00	150.0	E650	<5.00	<5.00	<8.00	<5.00	<5.00	<5.00	<8.00	<5.00	<5.00	<5.00	<5.00	<5.00
30	36	19960717	<5.00	260.0	E3900	<12.0	<5.00	<35.0	<420	<5.00	<5.00	<17.0	<10.0	<5.00	<5.00	<9.00	<5.00
31	37	19980616	<5.00	86.0	<200	<5.00	<5.00	7.6	<5.00	<5.00	<5.00	<7.00	<5.00	<5.00	<5.00	<5.00	<5.00
32	38	19950821	<5.00	50.0	2,100.0	<5.00	<5.00	<10.0	<7.00	5.7	<5.00	<25.0	<5.00	<5.00	<5.00	<5.00	<5.00
33	39	19950824	<5.00	60.0	9,100.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<18.0	<5.00	<5.00	<5.00	<5.00	<5.00
34	40	19980608	<5.00	87.0	E550	5.1	<5.00	<5.00	<5.00	<5.00	<12.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
35	41	19950823	<5.00	250.0	4,700.0	<5.30	<5.00	8.6	<5.00	6.3	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
35	42	19950928	<5.00	200.0	1,600.0	11.0	<5.00	15.0	11.0	<5.00	<10.0	<13.0	<5.00	<5.00	<5.00	<5.00	<5.00
35	43	19961205	<5.00	200.0	<200	<5.00	<5.00	<10.0	<10.0	5.8	<10.0	<10.0	<5.00	<5.00	<5.00	<5.00	<5.00
36	44	19950825	<5.00	77.0	12,000.0	<5.00	9.7	19.0	29.0	96.0	<17.0	<5.00	<5.00	6.4	<5.00	<5.00	<5.00
36	45	19990901	<5.00	<50.0	E1400	<5.00	<5.00	10.0	E4.90	75.0	<5.00	<14.0	<5.00	<5.00	<5.00	<5.00	<5.00
37	46	19950918	<5.00	69.0	<1800	<5.00	<5.00	5.6	7.6	41.0	<10.0	<15.0	<5.00	<5.40	<5.00	<5.00	<5.00
38	47	19980601	<5.00	170.0	1,200.0	<5.00	<5.00	<5.00	<5.00	50.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
40	48	19950922	<5.00	150.0	<200	<5.00	<5.00	9.8	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	5.4	<5.00	<5.00
41	49	19951017	<5.00	320.0	<200	<22.0	<5.00	25.0	11.0	<5.00	<5.00	<9.00	<5.00	<9.00	<5.00	<5.00	<5.00
42	50	19950919	<5.00	130.0	<200	<5.00	6.4	7.2	<5.00	<5.00	<10.0	<11.0	<5.00	<6.60	<5.00	<8.00	<5.00
43	51	19961015	<5.00	83.0	<200	<5.00	E5.40	E6.40	<5.00	<5.00	<10.0	<10.0	<7.00	<5.00	<5.00	<5.00	<5.00
44	52	19961016	<5.00	77.0	<200	<9.00	<5.00	E9.90	<5.00	<10.0	<5.00	<5.00	<5.00	<5.00	NA	<5.00	NA
45	53	19961119	<5.00	160.0	<200	<5.00	<5.00	11.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
46	54	19961119	<5.00	180.0	<200	<5.00	<5.00	12.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
47	55	19961120	<5.00	200.0	<400	<10.0	<10.0	<10.0	<10.0	<5.00	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00
47	56	19961120	<5.00	530.0	<400	<10.0	<10.0	E9.40	<10.0	<5.00	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	5.3
48	57	19961120	<5.00	270.0	<400	<10.0	<10.0	<10.0	<10.0	<5.00	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00
49	58	19961121	<5.00	240.0	<200	<5.00	<5.00	E11.0	<10.0	6.1	<10.0	<10.0	<5.00	<5.00	<5.00	<5.00	<5.00
50	59	19961121	<5.00	160.0	<200	<5.00	<5.00	<10.0	<10.0	<5.00	<10.0	<10.0	<5.00	<5.00	<5.00	<5.00	<5.00
51	60	19961122	<5.00	560.0	<400	<10.0	<10.0	E15.0	<10.0	<5.00	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00
52	61	19961122	<5.00	740.0	<400	<10.0	<10.0	E16.0	<10.0	<5.00	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	5.4
52	62	19961122	<5.00	720.0	<400	<10.0	<10.0	E10.0	<10.0	<5.00	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<5.00
53	63	19990628	<5.00	52.0	<200	<5.00	<5.00	<8.80	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00
53	64	19990628	<5.00	140.0	<200	E4.70	<5.00	E11.0	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00	<5.00

Table 2. Organochlorine and PCB concentrations in whole fish from sampling sites in the Mississippi Embayment Study Unit, 1995-99 -- Continued

Map number	Sample number	Sample date	Hepta-chlore-poxide	Hepta-chlor	Endrin	Dieldrin	*p,p'*-DDE	*o,p'*-DDE	*o,p'*-DDD	*p,p'*-DDD	*p,p'*-DDT	*o,p'*-DDT	Dacthal (DCPA)	*trans*-Chlor-dane	*cis*-Chlro-dane
28	33	19950822	<5.00	<5.00	<200	16.0	E5100	19.0	68.0	E680	520.0	53.0	<5.00	<5.00	<5.00
28	34	19990830	<5.00	<5.00	<5.00	6.2	2,700.0	E6.80	29.0	560.0	34.0	32.0	<5.00	<5.00	<5.00
29	35	19980616	<5.00	<5.00	<5.00	9.5	1,000.0	<5.00	11.0	E98.0	16.0	<14.0	<5.00	<5.00	<5.00
30	36	19960717	<5.00	<5.00	<56.0	<78.0	E5400	64.0	<5.00	E1500	<55.0	<5.00	<5.00	E23.0	E23.0
31	37	19980616	<5.00	<5.00	<5.00	8.6	640.0	<5.00	<13.0	E190	14.0	<17.0	<5.00	<5.00	<5.00
32	38	19950821	<5.00	<5.00	<15.0	23.0	3,700.0	28.0	100.0	E1100	87.0	35.0	<5.00	<5.00	<6.00
33	39	19950824	<5.00	<5.00	<5.00	16.0	3,700.0	<12.0	120.0	E1100	E140	<5.30	<5.00	<5.00	<5.00
34	40	19980608	<5.00	<5.00	<11.0	20.0	1,200.0	<5.00	<21.0	E370	160.0	<5.00	<5.00	<5.00	<5.00
35	41	19950823	<5.00	<5.00	<5.00	32.0	2,700.0	<5.00	140.0	E1700	E390	<5.00	<5.00	7.3	8.0
35	42	19950928	<5.00	<5.00	<5.40	32.0	1,600.0	18.0	48.0	550.0	E42.0	<10.0	<5.00	9.9	14.0
35	43	19961205	<10.0	<5.00	<5.00	9.3	730.0	<10.0	13.0	390.0	E10.0	<10.0	<5.00	<10.0	<10.0
36	44	19950825	<5.00	11.0	<9.50	23.0	5,300.0	17.0	E14.0	E1800	E36.0	<5.00	<5.30	<5.00	10.0
36	45	19990901	<5.00	<5.00	<12.0	5.9	2,500.0	E4.30	28.0	570.0	42.0	50.0	<5.00	<5.00	<5.00
37	46	19950918	<5.00	<5.00	<6.80	19.0	4,600.0	22.0	54.0	610.0	E29.0	<10.0	5.2	<5.00	5.1
38	47	19980601	<5.00	<5.00	<5.00	<5.00	2,700.0	<5.00	20.0	250.0	43.0	33.0	<5.00	<5.00	<5.00
40	48	19950922	<5.00	<5.00	<5.00	5.3	36.0	<5.00	<5.00	E10.0	<5.00	<5.00	<5.00	<5.00	6.4
41	49	19951017	<5.00	<6.00	<43.0	27.0	220.0	<6.00	<16.0		5.5	<6.00	<7.00	10.0	15.0
42	50	19950919	<5.00	<5.00	<5.00	<5.00	150.0	<5.20	<5.00	E13.0	<10.0	<10.0	<5.00	<5.00	<5.00
43	51	19961015	<5.00	<5.00	<5.00	<5.00	1,200.0	<5.00	E9.90	E150	E7.90	<5.00	<5.00	<5.00	<5.00
44	52	19961016	<5.00	<5.00	<5.00	8.1	770.0	<5.00	8.9	50.0	<5.00	<5.00	<5.00	<5.00	<5.00
45	53	19961119	<5.00	<5.00	<5.00	20.0	470.0	<5.00	<11.0	150.0	6.0	<11.0	<5.00	7.2	10.0
46	54	19961119	<5.00	<5.00	<5.00	29.0	81.0	<5.00	<5.00	E26.0	<5.00	<5.00	<5.00	8.3	12.0
47	55	19961120	<10.0	<5.00	<10.0	E15.0	140.0	<10.0	<10.0	E8.40	<10.0	<10.0	<10.0	<10.0	<10.0
47	56	19961120	<10.0	<5.00	<10.0	E23.0	120.0	<10.0	<10.0	E8.80	<10.0	<10.0	<10.0	<10.0	E8.30
48	57	19961120	<10.0	<5.00	<10.0	E15.0	130.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
49	58	19961121	<10.0	<5.00	<5.00	50.0	590.0	<10.0	6.9	120.0	<10.0	<10.0	<5.00	<10.0	E11.0
50	59	19961121	<10.0	<5.00	<5.00	18.0	E52.0	<10.0	<5.00	36.0	<10.0	<10.0	<5.00	<10.0	<10.0
51	60	19961122	<10.0	<5.00	<10.0	E23.0	300.0	<10.0	E9.50	90.0	<10.0	<10.0	<10.0	E9.80	E12.0
52	61	19961122	<10.0	<5.00	<10.0	E30.0	170.0	<10.0	<10.0	E19.0	<10.0	<10.0	<10.0	E9.50	E12.0
52	62	19961122	<10.0	<5.00	<10.0	E23.0	160.0	<10.0	<10.0	E14.0	<10.0	<10.0	<10.0	E7.30	E8.70
53	63	19990628	<5.00	<5.00	<5.00	15.0	2,300.0	<5.00	<34.0	430.0	45.0	<44.0	<5.00	<5.00	<5.20
53	64	19990628	<5.00	<5.00	<5.00	24.0	1,500.0	<5.00	<5.00	340.0	70.0	<5.00	<5.00	<5.00	E8.30

Table 3. Physical characteristics of composited fish-tissue samples collected from streams in the Mississippi Embayment Study Unit, 1995-99.

[CCA, Common carp species; LOC, spotted gar species; MSP, black bass species; mm, millimeters]

Map number	Sample number	Number of individuals	Weight (grams)	Species	Average weight (grams)	Average age (year)	Average total length (mm)	Lipids (percent)
1	1	8	14,854	CCA	1,857	4.6	499	7.7
2	2	8	12,509	CCA	1,564	4.2	489	5.1
3	3	5	1,963	MSP	393	3.0	290	6.0
4	4	8	14,069	CCA	1,759	4.8	506	5.2
5	5	8	14,184	CCA	1,773	5.0	507	14.0
6	6	8	16,834	CCA	2,104	5.1	545	8.3
7	7	8	11,634	CCA	1,454	4.0	432	13.0
8	8	5	10,734	CCA	2,147	5.0	532	21.0
9	9	8	19,192	CCA	2,399	5.1	554	8.1
10	10	7	15,339	CCA	2,191	NA	531	8.9
10	11	8	3,547	MSP	443	2.5	301	7.4
11	12	8	13,550	CCA	1,694	3.3	482	4.4
12	13	5	9,614	CCA	1,923	4.4	523	5.0
13	14	8	12,737	CCA	1,592	4.4	491	9.7
14	15	6	9,857	CCA	1,643	4.2	501	5.7
15	16	8	15,909	CCA	1,989	4.3	519	5.8
15	17	5	2,883	MSP	577	3.4	312	3.0
16	18	5	2,329	LOC	466	NA	505	1.8
17	19	8	4,040	MSP	505	3.3	338	4.4
18	20	8	13,794	CCA	1,724	3.2	502	8.4
19	21	8	12,522	CCA	1,565	3.0	496	8.3
20	22	8	10,457	CCA	1,307	4.3	353	3.9
21	23	8	15,976	CCA	1,997	4.0	534	3.4
22	24	8	11,954	CCA	1,494	3.9	399	4.8
23	25	8	19,116	CCA	2,390	5.1	443	7.3
24	26	8	12,607	CCA	1,576	3.0	490	8.4
24	27	8	12,459	CCA	1,557	4.9	389	4.8
25	28	8	17,032	CCA	2,129	4.0	551	13.0
26	29	8	5,408	CCA	676	NA	382	3.2
26	30	8	16,481	CCA	2,060	5.4	512	9.1
27	31	8	16,091	CCA	2,011	4.9	521	6.8
28	32	8	8,832	CCA	1,104	2.8	425	4.3
28	33	8	4,102	LOC	513	NA	528	4.1
28	34	6	8,580	CCA	1,430	4.2	474	3.9
29	35	8	11,669	CCA	1,459	4.4	480	3.8
30	36	8	15,861	CCA	1,983	NA	503	9.4

Table 3. Physical characteristics of composited fish-tissue samples collected from streams in the Mississippi Embayment Study Unit, 1995-99---Continued.

Map number	Sample number	Number of individuals	Weight (grams)	Species	Average weight (grams)	Average age (year)	Average total length (mm)	Lipids (percent)
31	37	8	12,112	CCA	1,514	4.4	453	4.9
32	38	8	6,394	CCA	799	2.8	402	4.6
33	39	8	5,728	CCA	716	2.6	377	7.8
34	40	8	12,116	CCA	1,515	4.4	386	5.0
35	41	8	5,451	LOC	681	NA	565	13.0
35	42	8	23,516	CCA	2,940	3.7	574	14.0
35	43	8	21,463	CCA	2,683	NA	563	12.0
36	44	8	11,651	CCA	1,456	2.8	481	9.3
36	45	5	7,551	CCA	1,510	4.4	482	6.9
37	46	8	15,239	CCA	1,905	3.8	520	6.7
38	47	8	10,174	CCA	1,272	4.1	389	11.0
40	48	8	12,324	CCA	1,541	3.3	484	6.1
41	49	8	16,665	CCA	2,083	3.9	536	14.0
42	50	8	19,558	CCA	2,445	4.2	559	13.0
43	51	8	15,337	CCA	1,917	3.2	527	7.6
44	52	8	14,566	CCA	1,820	4.1	511	7.5
45	53	6	22,764	CCA	3,794	4.7	627	7.7
46	54	8	22,875	CCA	2,859	4.2	545	7.0
47	55	8	19,569	CCA	2,446	4.1	534	7.0
47	56	8	21,121	CCA	2,640	4.57	550	14.0
48	57	8	26,411	CCA	3,301	5.14	596	9.6
49	58	8	19,183	CCA	2,398	4.4	534	28.0
50	59	5	14,597	CCA	2,919	4.5	563	18.0
51	60	8	27,679	CCA	3,460	4.6	598	9.4
52	61	8	26,515	CCA	3,314	4.6	600	9.3
52	62	8	26,544	CCA	3,318	4.5	611	9.7
53	63	8	12,903	CCA	1,613	NA	490	4.2
53	64	8	14,032	CCA	1,754	NA	506	1.5

Table 4. Concurrent samples analyzed by the National Water Quality Laboratory and the National Contaminant Biomonitoring Program, 1995

[Concentrations in micrograms per kilogram; No., number; BEST, Biomonitoring of Environmental Status and Trends; A, Male carp; B, female carp; C, male bass; D, female bass; <, less than; E, estimated; NA, not available; blue is data collected for the National Water Quality Assessment Program; yellow is data collected for the Biomonitoring of Environmental Status and Trends Program]

Site name	BEST Site Id	Map number	Sample date	Poly-chlorinated biphenyls		Toxaphene		Oxychlordane		*trans*-Nonachlor		*cis*-Nonachlor		Mirex	
Little River Ditch no. 1 near Morehouse, MO	212-A	2	18-Oct	<50.0	52	<200	<50	<5.0	<10	10.0	13	5.50	<10	<5.0	<10
	212-B				<50		<50		<10		10		<10		<10
	212-C				<50		<50		<10		<10		<10		<10
	212-D				130		<50		<10		<10		<10		<10
Cache River at Egypt, AR	208-A	11	21-Sep	<50.0	56	<200	<50	<5.0	<10	<5.0	20	<5.0	<10	<5.0	<10
	208-B				53		<50		<10		<10		<10		<10
Wolf River at LaGrange, TN	213-A	17	19-Oct	<50.0	<50	<200	<50	<5.0	<10	5.10	<10	<5.0	<10	<5.0	<10
	213-B				<50		<50		<10		<10		<10		<10
Cache River near Cotton Plant, AR	207-A	19	20-Sep	<50.0	72	<200	<50	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	207-B				<50		<50		<10		<10		<10		<10
Bogue Phalia near Leland, MS	202-A	28	22-Aug	52.0	75	1,400	5,200	<5.0	<10	<20.0	42	<5.0	<10	5.10	<10
	202-B				<50		2,700		<10		21		<10		<10
Big Sunflower River near Anguilla, MS	201-A	32	21-Aug	50.0	100	2,100	8,300	<5.0	<10	<10.0	100	<7.0	<10	5.70	<10
	201-B				<50		1,900		<10		29		<10		<10
Steele Bayou East Prong near Rolling Fork, MS	203-A	33	24-Aug	60.0	59	9,100	2,500	<5.0	<10	<5.0	31	<5.0	<10	<5.0	<10
	203-B				<50		1,900		<10		25		<10		<10
Yazoo River, MS **	80-A	35	23-Aug	200	360	1,600	2,400	<5.0	<10	15.0	32	11.0	<10	<5.0	<10
	80-B				240		820		<10		17		<10		<10
	80-C				120		520		<10		<10		<10		<10
	80-D				160		740		<10		10		<10		<10
Tensas River at Tendal, LA	204-A	36	25-Aug	77.0	86	12,000	3,100	9.70	<10	19.0	38	29.0	<10	96.0	75
	204-B				<50		2,200		<10		29		<10		42

** Note: BEST sampling site located upstream of National Water-Quality Program sampling site

Table 4. Concurrent samples analyzed by the National Water Quality Laboratory and the National Contaminant Biomonitoring Program, 1995 -- Continued

Site name	BEST Site Id	Map number	Sample date	Lindane (*gamma*-BHC)		*delta*-HCH		*beta*-HCH		*alpha*-HCH		Hexachloro-ben-zene		Heptachlor	
Little River Ditch no. 1 near Morehouse, MO	212-A	2	18-Oct	<5.0	<10	<5.30	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	212-B				<10		<10		<10		<10		<10		<10
	212-C				<10		<10		<10		<10		<10		<10
	212-D				<10		<10		<10		<10		<10		<10
Cache River at Egypt, AR	208-A	11	21-Sep	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	208-B				<10		<10		<10		<10		<10		<10
Wolf River at LaGrange, TN	213-A	17	19-Oct	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	213-B				<10		<10		<10		<10		<10		<10
Cache River near Cotton Plant, AR	207-A	19	20-Sep	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	207-B				<10		<10		<10		<10		<10		<10
Bogue Phalia near Le-land, MS	202-A	28	22-Aug	<5.0	<10	<11.0	<10	<10.0	<10	<5.0	<10	<5.0	<10	<13.0	<10
	202-B				<10		<10		<10		<10		<10		<10
Big Sunflower River near Anguilla, MS	201-A	32	21-Aug	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	201-B				<10		<10		<10		<10		<10		<10
Steele Bayou East Prong near Rolling Fork, MS	203-A	33	24-Aug	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	203-B				<10		<10		<10		<10		<10		<10
Yazoo River, MS **	80-A	35	23-Aug	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	<10	<5.0	10
	80-B				<10		<10		<10		<10		<10		<10
	80-C				<10		<10		<10		<10		<10		<10
	80-D				<10		<10		<10		<10		<10		<10
Tensas River at Tendal, LA	204-A	36	25-Aug	<5.0	<10	6.40	<10	<5.0	<10	<5.0	<10	<5.0	<10	11.0	<10
	204-B				<10		<10		<10		<10		<10		<10

Table 4. Concurrent samples analyzed by the National Water Quality Laboratory and the National Contaminant Biomonitoring Program, 1995 -- Continued

Site name	BEST Site Id	Map number	Sample date	Endrin		Dieldrin		*p,p'*-DDE		*o,p'*-DDE		*o,p'*-DDD		*p,p'*-DDD	
Little River Ditch no. 1 near Morehouse, MO	212-A	2	18-Oct	<5.00	<10	25.0	33	43.0	56	<5.0	<10	<5.0	<10	14.0	15
	212-B				<10		30		57		<10		<10		18
	212-C				<10		<10		29		<10		<10		<10
	212-D				<10		<10		12		<10		<10		<10
Cache River at Egypt, AR	208-A	11	21-Sep	<5.0	<10	5.0	17	120	180	<5.0	<10	<5.0	<10	18.0	28
	208-B				<10		10		120		<10		<10		17
Wolf River at LaGrange, TN	213-A	17	19-Oct	<5.0	<10	<5.0	<10	250	100	<5.0	<10	<5.0	<10	42.0	11
	213-B				<10		<10		96		<10		<10		12
Cache River near Cotton Plant, AR	207-A	19	20-Sep	<5.0	<10	5.40	13	590	510	<5.0	<10	<5.30	<10	E42.0	61
	207-B				<10		<10		210		<10		<10		29
Bogue Phalia near Leland, MS	202-A	28	22-Aug	<220	<10	19.0	47	5,000	4,300	16.0	<10	79.0	120	E850	1,500
	202-B				<10		<10		4,200		<10		72		1,200
Big Sunflower River near Anguilla, MS	201-A	32	21-Aug	<15.0	<10	23.0	34	3,700	8,300	28.0	<10	100	250	E1100	2,800
	201-B				<10		16		3,100		<10		73		1,000
Steele Bayou East Prong near Rolling Fork, MS	203-A	33	24-Aug	<5.0	<10	16.0	12	3,700	5,200	<12.0	<10	120	65	E1100	1,000
	203-B				<10		12		3,300		<10		53		800
Yazoo River, MS **	80-A	35	23-Aug	<5.4	<10	32.0	54	1,600	2,000	18.00	<10	48	59	550.00	760
	80-B				<10		41		1,000		<10		34		280
	80-C				<10		24		430		<10		<10		160
	80-D				<10		29		530		<10		<10		200
Tensas River at Tendal, LA	204-A	36	25-Aug	<9.50	<10	23.0	<10	5,300	5,800	17.0	<10	E14.0	87	E1800	1,500
	204-B				<10		14		2,900		<10		70		1,100

Table 4. Concurrent samples analyzed by the National Water Quality Laboratory and the National Contaminant Biomonitoring Program, 1995 -- Continued

Site name	BEST Site Id	Map number	Sample date	*p,p′*-DDT		*o,p′*-DDT		*trans*-Chlordane		*cis*-Chlordane	
Little River Ditch no. 1 near Morehouse, MO	212-A	2	18-Oct	<5.0	<10	<5.0	<10	<5.0	<10	5.0	<10
	212-B				<10		<10		<10		<10
	212-C				<10		<10		<10		<10
	212-D				<10		<10		<10		<10
Cache River at Egypt, AR	208-A	11	21-Sep	<5.0	<10	<5.10	<10	<5.0	<10	<5.0	12
	208-B				<10		<10		<10		<10
Wolf River at LaGrange, TN	213-A	17	19-Oct	40.0	<10	<5.0	<10	<5.0	<10	<5.0	<10
	213-B				<10		<10		<10		<10
Cache River near Cotton Plant, AR	207-A	19	20-Sep	<5.0	<10	<5.7	<10	<5.0	<10	<5.0	<10
	207-B				<10		<10		<10		<10
Bogue Phalia near Leland, MS	202-A	28	22-Aug	87.0	<10	56.0	<10	<6.0	<10	<5.0	<10
	202-B				<10		<10		<10		<10
Big Sunflower River near Anguilla, MS	201-A	32	21-Aug	87.0	<10	35.0	<10	<5.0	<10	<6.0	<10
	201-B				<10		<10		<10		<10
Steele Bayou East Prong near Rolling Fork, MS	203-A	33	24-Aug	E140	<10	<5.3	<10	<5.0	<10	<5.0	<10
	203-B				<10		<10		<10		<10
Yazoo River, MS **	80-A	35	23-Aug	E42	<10	<10	<10	9.90	<10	14.0	<10
	80-B				<10		<10		<10		10
	80-C				75.0		<10		<10		11
	80-D				110.0		<10		<10		<10
Tensas River at Tendal, LA	204-A	36	25-Aug	E36.0	<10	<5.0	<10	<5.0	<10	10.0	<10
	204-B				<10		<10		<10		<10

Table 5. Relative percent difference for selected organochlorine compounds between duplicate and multi-year fish-tissue samples collected in the Mississippi Embayment Study Unit 1995-99

[RPD, relative percent difference; <, less than; NA, not applicable; bold is mean; concentrations in micrograms per kilogram]

Compound	Map number	Duplicate concentrations: Sample 1	Duplicate concentrations: Sample 2	RPD	Map number	Multi-year concentrations: Sample 1	Multi-year concentrations: Sample 2	RPD
PCB	52	740	720	2.74	24	76	150	65.49
	47	200	530	90.41	35	200	200	0.00
	53	52	140	91.67	26	62	91	37.91
				61.61	28	52	<50	NA
					36	77	<50	NA
								34.47
trans-nonachlor	52	16	10	46.15	36	19	10	62.07
					28	<20	6.3	NA
					26	<5	12	NA
					35	15	<10	NA
dieldrin	52	30	23	26.42	26	<11	30	NA
	47	15	23	42.11	35	32	9.3	109.93
	53	15	24	46.15	36	23	5.9	118.34
				38.22	28	19	6.2	101.59
					24	<50	72	NA
								109.95
p,p'-DDE	52	170	160	6.06	24	7300	3000	83.50
	47	140	120	15.38	26	3100	5500	55.81
	53	2300	1500	42.11	28	5000	2700	59.74
				21.18	35	1600	730	74.68
					36	5300	2500	71.79
								69.10
p,p'-DDT	52	19	14	30.30	24	64	94	37.97
	53	45	70	43.48	28	87	34	87.60
				36.89	35	42	10	123.08
					36	36	42	15.38
					26	<10	320	NA
								66.01

Table 5. Relative percent difference for selected organochlorine compounds between duplicate and multi-year fish-tissue samples collected in the Mississippi Embayment Study Unit 1995-99--Continued

Compound	Map number	Duplicate concentrations		RPD	Map number	Multi-year concentrations		RPD
		Sample 1	Sample 2			Sample 1	Sample 2	
p,p'-DDD	53	430	340	23.38	24	2000	680	98.51
					26	600	1100	58.82
					28	850	560	41.13
					35	550	390	34.04
					36	1800	570	103.80
								67.26
trans-chlordane	52	9.5	7.3	26.19	35	9.9	<10	NA
cis-chlordane	52	12	8.7	31.88	35	14	<10	NA
					36	10	<5	NA
Percent lipids	52	7	14	66.67	24	8.4	4.8	54.55
	47	9.3	9.7	4.21	26	3.2	9.1	95.93
	53	4.2	1.5	94.74	28	4.3	3.9	9.76
				49.47	35	14	12	15.38
					36	9.3	6.9	29.63
								41.05

Table 6. Results of analysis of variance on weight, age, and total length for fish collected in subsequent years

[N, there was no significant difference at the 0.05 level, Y+ there was a significant difference and the value increased between years; NA, data not available]

Map number	Sample number	Years	Weight	Age	Total length	Lipids percent
24	26 and 27	1995 and 98	N	Y+	N	8.4 – 4.8
26	29 and 30	1996 and 98	Y+	NA	Y+	3.2 – 9.1
28	32 and 34	1995 and 99	N	N	N	4.3 – 3.9
35	42 and 43	1995 and 96	N	NA	N	14 - 12
36	44 and 45	1995 and 99	N	Y+	N	9.3 – 6.9

Table 7. Statistical summary of concentrations of organochlorine compounds and PCBs analyzed in fish tissue collected in the Mississippi Embayment Study Unit, 1995-99

[Concentrations in micrograms per kilogram; <, less than; MRL, method reporting limit; NYFF, New York Fish Flesh Criteria; NAS/NAE, National Academy of Sciences and National Academy of Engineering]

Organochlorine compound	NYFF criteria	NAS/NAE guidelines	Number of samples	Minimum	Percentiles			Maximum
					25th	50th	75th	
Cyclodiences, chlorinated benzene derivatives, and polychloroterpenes								
Aldrin	[2]120	[1]100	64	<5.0	<5.0	<5.0	<5.0	<5.0
Chlordane	500	[3]100						
trans-Chlordane			64	<5.0	<5.0	<5.0	5.0	25.0
cis-Chlordane			64	<5.0	<5.0	<5.0	8.1	25.0
trans-Nonachlor			64	<5.0	<5.0	5.8	10.0	25.0
cis-Nonachlor			64	<5.0	<5.0	<5.0	5.0	210.0
Oxychlordane			64	<5.0	<5.0	<5.0	<5.0	9.8
Dieldrin	[2]120	[1]100	64	<5.0	5.8	14.0	23.0	72.0
Endrin	25	[1]100	64	<5.0	<5.0	<5.0	5.0	<MRL
Heptachlor	200	[1]100	64	<5.0	<5.0	<5.0	<5.0	11.0
Heptachlorepoxide	200	[1]100	64	<5.0	<5.0	<5.0	<5.0	5.0
Hexachlorobenzene			64	<5.0	<5.0	<5.0	<5.0	10.0
Toxaphene		[1]100	64	<200	<200	<200	665	12,000
Mirex	330		64	<5.0	<5.0	<5.0	<5.0	96.0
p,p'-Methoxychlor			64	<5.0	<5.0	<5.0	5.0	<MRL
o,p'-methoxychlor			64	<5.0	<5.0	<5.0	5.0	<MRL
Dacthal (DCPA)			64	<5.0	<5.0	<5.0	<5.0	5.2
Pentchloroanisole			64	<5.0	<5.0	<5.0	<5.0	11.0
delta-HCH			64	<5.0	<5.0	<5.0	<5.0	6.4
beta-HCH			64	<5.0	<5.0	<5.0	<5.0	6.0
Lindane (*gamma*-HCH)		[1]100	64	<5.0	<5.0	<5.0	<5.0	<MRL
alpha-HCH			64	<5.0	<5.0	<5.0	<5.0	5.0
Total HCH	100							
Diphenyl aliphatics								
p,p'-DDE			64	24	130	510	1,925	7,300
o,p'-DDE			64	<5.0	<5.0	<5.0	5.0	64
o,p'-DDD			64	<5.0	<5.0	5.0	14.1	140
p,p'-DDD			64	<5.0	14.0	50	410	2,000
p,p'-DDT			64	<5.0	<5.0	5.3	37	520
o,p'-DDT			64	<5.0	<5.0	<5.0	5.0	56
Total DDT	[4]200	[4]1000						
Polychlorinated biphenyls								
Polychlorinated biphenyls		500	64	<50	59.8	83.0	182.5	740.0

[1]Applies to total residues of aldrin, BHC, chlordane, dieldrin, endosulfan, endrin, heptachlor, heptachlor epoxide, lindane, and toxaphene, either singly or in combination.

[2]Applies to sum of aldrin and dieldrin

[3]Includes *cis*- and *trans*-chlordane, *cis*- and *trans*-nonachlor, oxychlordane, but not heptachlor epoxide.

[4]Applies to total residues of DDT, DDE, and DDD.

Table 8. DDT and DDT degradate concentrations, total DDT concentrations, and DDT, DDE, and DDD to total DDT ratios for fish-tissue samples collected in the Mississippi Embayment Study Unit, 1995-99

[Concentrations in micrograms per kilogram; NA, not available; <, less than]

Map number (fig. 1)	Sample number	Concentrations							Percent		
		p,p'-DDE	*o,p'*-DDE	*o,p'*-DDD	*p,p'*-DDD	*p,p'*-DDT	*o,p'*-DDT	[2]Total DDT	*p,p'*-DDT	*p,p'*-DDE	*p,p'*-DDD
1	1	34	0.0	0.0	0.0	0.0	0.0	34	0.0	100.0	0.0
2	2	43	0.0	0.0	14.0	0.0	0.0	57	0.0	75.4	24.6
3	3	24	0.0	0.0	5.5	0.0	0.0	30	0.0	81.4	18.6
4	4	140	15.0	0.0	20.0	0.0	0.0	175	0.0	80.0	11.4
5	5	43	0.0	0.0	11.9	0.0	0.0	55	0.0	78.2	21.8
6	6	220	0.0	0.0	22.0	0.0	0.0	242	0.0	90.9	9.1
7	7	97	0.0	0.0	9.6	0.0	0.0	107	0.0	91.0	9.0
8	8	130	0.0	0.0	37.0	6.4	0.0	173	3.7	75.0	21.3
9	9	290	0.0	0.0	46.0	6.9	0.0	343	2.0	84.6	13.4
10	10	550	0.0	5.5	29.0	0.0	0.0	585	0.0	94.1	5.0
10	11	58	0.0	0.0	8.2	0.0	0.0	66	0.0	87.6	12.4
11	12	120	0.0	0.0	18.0	0.0	0.0	138	0.0	87.0	13.0
12	13	87	0.0	0.0	13.0	0.0	0.0	100	0.0	87.0	13.0
13	14	440	0.0	0.0	0.0	12.0	0.0	452	2.7	97.3	0.0
14	15	430	0.0	0.0	42.0	0.0	0.0	472	0.0	91.1	8.9
15	16	240	0.0	0.0	26.0	0.0	0.0	266	0.0	90.2	9.8
15	17	70	0.0	0.0	7.2	0.0	0.0	77	0.0	90.7	9.3
16	18	91	0.0	0.0	6.5	0.0	0.0	98	0.0	93.3	6.7
17	19	250	0.0	0.0	42.0	40.0	0.0	332	12.0	75.3	12.7
18	20	600	0.0	16.0	73.0	0.0	0.0	689	0.0	87.1	10.6
19	21	590	0.0	0.0	42.0	0.0	0.0	632	0.0	93.4	6.6
20	22	274	0.0	0.0	40.5	0.0	0.0	315	0.0	87.1	12.9
21	23	94	0.0	0.0	0.0	0.0	0.0	94	0.0	100.0	0.0
22	24	1,300	0.0	0.0	300.0	24.0	0.0	1,624	1.5	80.0	18.5
23	25	1,700	0.0	0.0	120.0	13.0	0.0	1,833	0.7	92.7	6.5
24	26	7,300	0.0	130.0	2,000.0	64.0	0.0	9,494	0.7	76.9	21.1
24	27	3,000	0.0	0.0	680.0	94.0	0.0	3,774	2.5	79.5	18.0
25	28	680	10.0	12.0	320.0	21.0	0.0	1,043	2.0	65.2	30.7
26	29	3,100	0.0	0.0	600.0	0.0	0.0	3,700	0.0	83.8	16.2
26	30	5,500	0.0	0.0	1,100.0	320.0	0.0	6,920	4.6	79.5	15.9
27	31	1,800	0.0	22.0	380.0	58.0	0.0	2,260	2.6	79.6	16.8
28	32	5,000	16.0	79.0	850.0	87.0	56.0	6,088	2.3	82.1	14.0
28	33	5,100	19.0	68.0	680.0	520.0	53.0	6,440	8.9	79.2	10.6
28	34	2,700	6.8	29.0	560.0	34.0	32.0	3,362	2.0	80.3	16.7
29	35	1,000	0.0	11.0	98.0	16.0	0.0	1,125	1.4	88.9	8.7
30	36	5,400	64.0	0.0	1,500.0	0.0	0.0	6,964	0.0	77.5	21.5

Table 8. DDT and DDT degradate concentrations, total DDT concentrations, and DDT, DDE, and DDD to total DDT ratios for fish-tissue samples collected in the Mississippi Embayment Study Unit, 1995-99--Continued

Map number (fig. 1)	Sample number	Concentrations							Percent		
		p,p'-DDE	*o,p'*-DDE	*o,p'*-DDD	*p,p'*-DDD	*p,p'*-DDT	*o,p'*-DDT	[2]Total DDT	*p,p'*-DDT	*p,p'*-DDE	*p,p'*-DDD
31	37	640	0.0	0.0	190.0	14.0	0.0	844	1.7	75.8	22.5
32	38	3,700	28.0	100.0	1,100.0	87.0	35.0	5,050	2.4	73.3	21.8
33	39	3,700	0.0	120.0	1,100.0	140.0	0.0	5,060	2.8	73.1	21.7
34	40	1,200	0.0	0.0	370.0	160.0	0.0	1,730	9.2	69.4	21.4
35	41	2,700	0.0	140.0	1,700.0	390.0	0.0	4,930	7.9	54.8	34.5
35	42	1,600	18.0	48.0	550.0	42.0	0.0	2,258	1.9	70.9	24.4
35	43	730	0.0	13.0	390.0	10.0	0.0	1,143	0.9	63.9	34.1
36	44	5,300	17.0	14.0	1,800.0	36.0	0.0	7,167	0.5	74.0	25.1
36	45	2,500	4.3	28.0	570.0	42.0	50.0	3,194	2.9	78.3	17.8
37	46	4,600	22.0	54.0	610.0	29.0	0.0	5,315	0.5	86.5	11.5
38	47	2,700	0.0	20.0	250.0	43.0	33.0	3,046	2.5	88.6	8.2
40	48	36	0.0	0.0	10.0	0.0	0.0	46	0.0	78.3	21.7
41	49	220	0.0	0.0	NA	5.5	0.0	226	2.4	97.6	NA
42	50	150	0.0	0.0	13.0	0.0	0.0	163	0.0	92.0	8.0
43	51	1,200	0.0	9.9	150.0	7.9	0.0	1,368	0.6	87.7	11.0
44	52	770	0.0	8.9	50.0	0.0	0.0	829	0.0	92.9	6.0
45	53	470	0.0	0.0	150.0	6.0	0.0	626	1.0	75.1	24.0
46	54	81	0.0	0.0	26.0	0.0	0.0	107	0.0	75.7	24.3
47	55	140	0.0	0.0	8.4	0.0	0.0	148	0.0	94.3	5.7
47	56	120	0.0	0.0	8.8	0.0	0.0	129	0.0	93.2	6.8
48	57	130	0.0	0.0	0.0	0.0	0.0	130	0.0	100.0	0.0
49	58	590	0.0	6.9	120.0	0.0	0.0	717	0.0	82.3	16.7
50	59	52	0.0	0.0	36.0	0.0	0.0	88	0.0	59.1	40.9
51	60	300	0.0	9.5	90.0	0.0	0.0	400	0.0	75.1	22.5
52	61	170	0.0	0.0	19.0	0.0	0.0	189	0.0	89.9	10.1
52	62	160	0.0	0.0	14.0	0.0	0.0	174	0.0	92.0	8.0
53	63	2,300	0.0	0.0	430.0	45.0	0.0	2,775	1.6	82.9	15.5
53	64	1,500	0.0	0.0	340.0	70.0	0.0	1,910	3.7	78.5	17.8
Max								9,494	12.0	100.0	40.9
Median								585	0.0	82.9	13.2
Min								30	0.0	54.8	0.0
Mean								1,714	1.4	83.2	15.0

[1]Values less than minimum reporting levels were set to zero for the purpose of calculating percents and total DDT

[2]Total DDT is the sum of residues of *o,p'*-DDT, *p,p'*-DDD, *o,p'*DDE, *p,p'*-DDT, *p,p'*-DDD, and *p,p'*-DDE

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