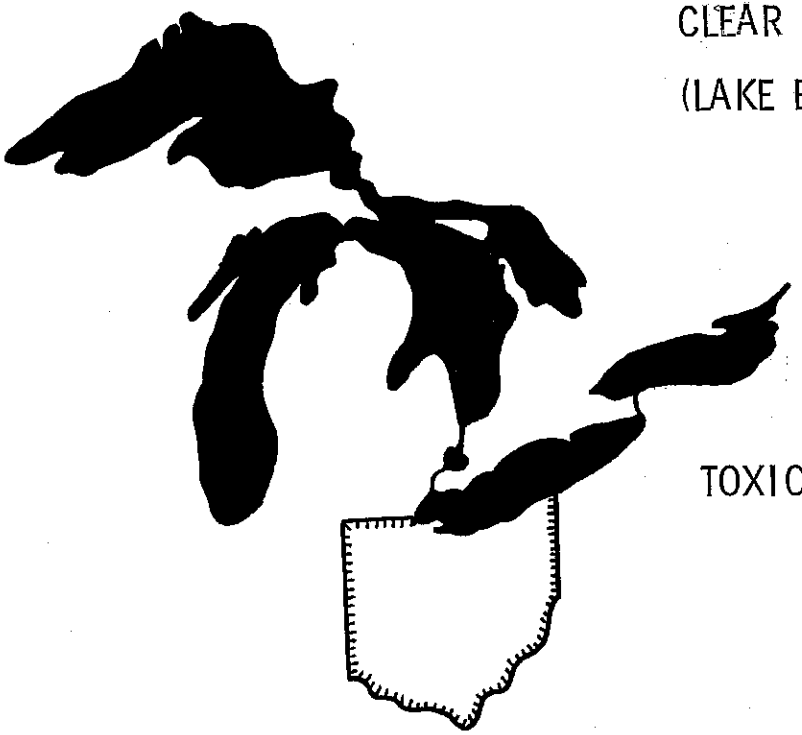

CLEAR TECHNICAL REPORT NO. 241

(LAKE ERIE TAT CONTRIBUTION NO. 16)

# LAKE ERIE INTENSIVE STUDY: TOXIC ORGANIC CONTAMINANTS IN FISH


Prepared by

Brian G. Burby
Mark D. Barnes
and
Charles E. Herdendorf



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THE OHIO STATE UNIVERSITY
CENTER FOR LAKE ERIE AREA RESEARCH
COLUMBUS, OHIO



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# INTRODUCTION

Since the publication of Silent Spring (Carson, 1962) the general public has become increasingly aware of the potentially dangerous effects of pesticides in the environment. Carson's book centered on the group of pesticides commonly known as the organochlorines. These pesticides were initially hailed as ideal because of their toxicity to target organisms and apparently innocuous effects on non-target organisms, particularly fish, birds, and mammals.

DDT is a good example of the fleeting fame this group experienced. In 1948 Paul Muller received the Nobel Prize in Medicine and Physiology for work that led to the discovery of the insecticidal properties of DDT (Brinkley, 1964). This insecticide alone has saved millions of human lives through its use in combating malaria (Williams, 1963). However, adverse environmental effects of DDT, such as eggshell thinning in raptorial birds, mortality of fish eggs and fry, and mortality of bird populations, were subsequently well documented by many scientists. As a result, the sale, manufacture, or use of DDT was banned in 1971 by the U.S. Environmental Protection Agency (USEPA).

The objectives of this study were:

1. to determine the concentrations of major organochlorine contaminants in fishes from selected Lake Erie tributary mouths and identify fish in excess of the U.S. Food and Drug Administration (FDA) and International Joint Commission (IJC) limits on contaminant levels;
2. to determine differences in concentrations of these contaminants between fish of the same species and age group in different tributaries;
3. to estimate the uptake rates of these contaminants by fish in selected tributaries; and
4. to assess, where possible, the relationships between toxic substances in the nearshore areas adjacent to the tributary mouths and contamination of fish tissue. (This objective is dependent upon making valid comparisons between previously generated toxic substances data and results obtained from this study.)

Herbicides, insecticides, and fungicides are the principal kinds of pesticides in use in the United States. Agricultural use consumes approximately 75 percent of current annual pesticide production in the United States. The majority of pesticides currently in use were developed within the last 40 years largely for the alleviation of agricultural pest problems. War-directed research during the 1940's resulted in the development of organochlorine pesticides (Cremlyn, 1978). This group is used primarily

as an insecticide. In 1974 organochlorines comprised 24 percent of agricultural pesticide use, (USEPA, 1980).

In general, organochlorine pesticides are non-polar compounds that are readily retained in adipose tissue. Organochlorine pesticides metabolize slowly. Environmental and biological half-life data show that organochlorine pesticide values range from months to years. This pesticide group acts on target organisms by disrupting nervous system function (Cremlyn, 1978). Organochlorine pesticides act as neurotoxins by binding to the axon, thus interfering with the transmission of nerve impulses.

The decline, and in some cases prohibition, of organochlorine pesticide use is a direct result of their persistence as environmental contaminants. The previously mentioned physical and chemical characteristics of organochlorine pesticides give credence, in some cases, to the justification for their removal. The potential of a particular organic compound for bioaccumulation is indicated by the partition coefficient (P.C.) of the compound, which is defined by the following equation:

$$P.C. = \frac{C_1 \text{ octanol}}{C_2 \text{ water}}$$

where $C_1$ and $C_2$ are the concentrations of the compound in octanol and in water, respectively. Polar compounds will concentrate in water, resulting in a low partition coefficient. Most organo-

chlorine compounds have an affinity for octanol and this results in a high P.C. value. Lipids found in organisms exhibit a similar affinity for organochlorine pesticides. Once these compounds have concentrated in lipid tissue, their degradation and metabolism are very slow.

The bioaccumulative and persistent ability of organochlorine compounds permits their buildup in the environment. Tributaries are ideal areas for organochlorine contaminant buildup due to the variety of routes these chemicals can take when entering these aquatic environments. According to Khan (1977), ranking of the main sources of pesticide pollution of rivers, in order of highest to lowest was: industrial effluent, agricultural runoff, and atmospheric fallout. The degree to which these sources pollute lakes depends on the watershed type(s) associated with each tributary (i.e., agricultural, industrial, or residential).

Organochlorine contaminants generally have low water solubilities and tend to associate with the sediments of streams, tributaries, and nearshore areas of large lakes. This characteristic enables sediments to serve as reservoirs for persistent pesticides. A comprehensive study by Frank (1977) showed that Lake Erie sediments serve as sinks for organochlorine pesticides. The source of these sediments is attributed to the more than 2,775,100 tons of sheet erosion received annually by Lake Erie

(USEPA, 1971). Transport of this sediment is accomplished in large part by the major tributaries of Lake Erie.

Fish can concentrate organochlorine contaminants many times greater than levels found in water. Pesticide concentrations in sediments are generally higher than those found in water due to the sorption of these compounds onto soil particles through cation-anion exchange. A generalized flow chart of transport and fate of pesticides is shown in Figure 1. Fish bioaccumulate pesticides either through water-biota or biota-biota exchange. Biomagnification is defined here specifically as accumulation of pesticides through the biota-biota (predator-prey) pathway (Figure 1). Fish concentrate pesticides primarily through the water-biota pathway (Hamelink et al., 1971). This is in contrast to the previously held belief that biomagnification accounted for the majority of pesticide residue levels in fish tissue (Macek and Korn, 1970). The extent of organochlorine contaminant concentrations in fish tissue depends on the level and duration of exposure, species, route of contaminant movement, and the ability of the fish to accumulate, metabolize, and excrete these contaminants. For example, age group IV carp (Cyprinus carpio) may have higher organochlorine contaminant concentrations than age group I spottail shiners (Notropis hudsonius) from the same tributary. The discrepancy in concentrations could be attributed to the carp being older than the spottail shiners, therefore

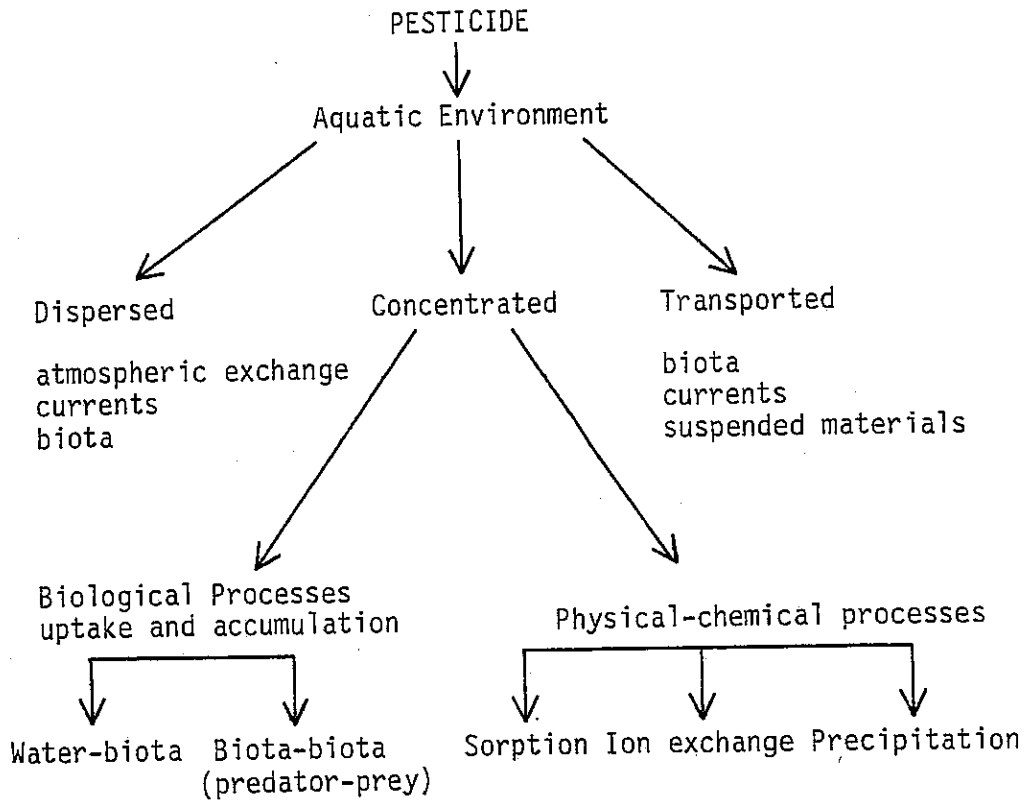



Figure 1. Flow Chart of Pesticides in the Aquatic Environment (Ketchum, 1967).

allowing a longer period of time to accumulate organochlorine contaminants.

Detrimental health effects of organochlorine contamination on the environment have been well documented. This effect can range from a large fish kill on the Rhine River (Greve, 1972) to the death of several Japanese by polychlorinated biphenyl (PCB) poisoning (University of Wisconsin, 1976). Low levels of PCBs and other contaminants are believed to be carcinogenic, mutagenic, and teratogenic. Laboratory tests on mammals have shown that PCBs can cause reproductive failures, gastric disorders, skin lesions, and tumors (Ohio Environmental Protection Agency, 1977). Contamination of fish by organochlorine compounds has caused mortality (immediate and delayed), decreased reproduction, stunted growth, and reduced immunity to disease (Johnson and Mayer, 1972). The kepone contamination of the James River, Virginia, in addition to the harmful effects on the fish population, has had far reaching consequences to that area's industrial and recreational interests (Bors and Stewart, 1977).

The degree of organochlorine pollution in fish from Lake Erie and its tributaries has been reported previously. The FDA began monitoring contaminants in Lake Erie fish in 1970. Carr et al. (1972) reported early results of FDA monitoring. Concentrations of organochlorine contaminants were also determined in Lake Erie

fish by Frank et al. (1978) and Gessner and Griswold (1978). Most recently, the Ohio Department of Agriculture, in cooperation with the Ohio Department of Natural Resources, began testing Lake Erie fish for PCBs in 1979. These efforts have been designed primarily as monitoring studies of organochlorine pesticide concentrations in various fish species. They have not attempted to relate contaminant concentrations to age in the fish tested. Recent evidence indicates that these concentration levels are more dependent upon the age of the fish than body length and weight (Frank, 1974, and Delfino, 1979). Additionally, these previous studies have confined their fish collections to the open waters of Lake Erie. Comparisons between concentrations of contaminants in fish of the same species and age group from different Lake Erie tributaries have not been attempted. The majority of comparisons have been made between fish of different species and age groups from the open water areas of Lake Erie.

Previous studies on the uptake of organochlorine compounds by fish have been performed primarily under controlled laboratory conditions. Other than Skea et al. (1979), no known studies have been attempted to estimate field uptake rates of organochlorine contaminants by fish.

Increasing industrial development, population growth, and chemical production within the Great Lakes region indicate that

the contaminant issue is potentially a dangerous environmental problem. Specifically, organochlorine contamination threatens both fish and human populations due to their toxic nature. Some organochlorine compounds have been cancelled from use or manufacture by the USEPA (Table 1). Previous studies have shown certain Lake Erie fish to be in the excess of some FDA and IJC guidelines for human consumption.

TABLE 1

ORGANOCHLORINE CONTAMINANTS CONSIDERED IN THIS STUDY WHICH HAVE BEEN PARTIALLY OR COMPLETELY CANCELLED[1] FROM USE BY THE UNITED STATES ENVIRONMENTAL PROTECTION AGENCY WITH MAJOR ALLOWABLE USES

| Contaminant | Cancellation Date | Major Allowable Uses |
|---|---|---|
| Aldrin | 26 June 1972 | termites |
| BHC ($\alpha$ and $\beta$) | 21 July 1978 | none |
| Chlordane | 6 March 1978 | termites |
| DDD | 18 March 1971 | none |
| DDT | 31 December 1972 | none |
| Dieldrin | 26 June 1972 | termites |
| Endrin | 24 August 1979 | nuisance birds<br>orchard vermin control |
| Heptachlor | 6 March 1978 | termites |
| Mirex | 1 December 1977 | none |
| PCBs | 1979 | none |
| Toxaphene | 10 March 1972 | soil insects (corn)<br>swine and sheep ectoparasite control |

[1]U.S. Environmental Protection Agency, 1979 (cancelled refers to most recent date of partial or complete cancellation from manufacture and use of the contaminant).

## CHARACTERIZATION OF STUDY AREAS

Collections of fish for this study came from 11 tributary mouths of Lake Erie. Two of these tributaries (Walnut Creek, Pennsylvania and Cattaraugus Creek, New York) yielded insufficient numbers of fish for analysis and subsequently are not discussed in this section. Figure 2 and Appendix E illustrate these study areas. Geological coordinates are listed in Table 2.

### River Raisin

The River Raisin is a low to medium gradient stream which drains primarily a flat agricultural area. The river begins near Hudson, Michigan and flows east, merging with the Saline River before entering Lake Erie at Monroe, Michigan. This covers a total distance of 80 km. Monroe is an industrialized city and must be considered as a primary source of industrial pollution to the River Raisin. The drainage area of the river is 2699 sq. km (IJC, 1976). It has a mean discharge of 19 cms; this ranges from a high of 38 cms to a low of 5 cms. Major agricultural land uses are corn, soybean, alfalfa hay, and wheat.

### Maumee River

The Maumee River is a low gradient stream and drains primarily flat farmlands. It is the largest tributary of the Great Lakes (Reutter et al., 1978). The river begins in Fort Wayne,

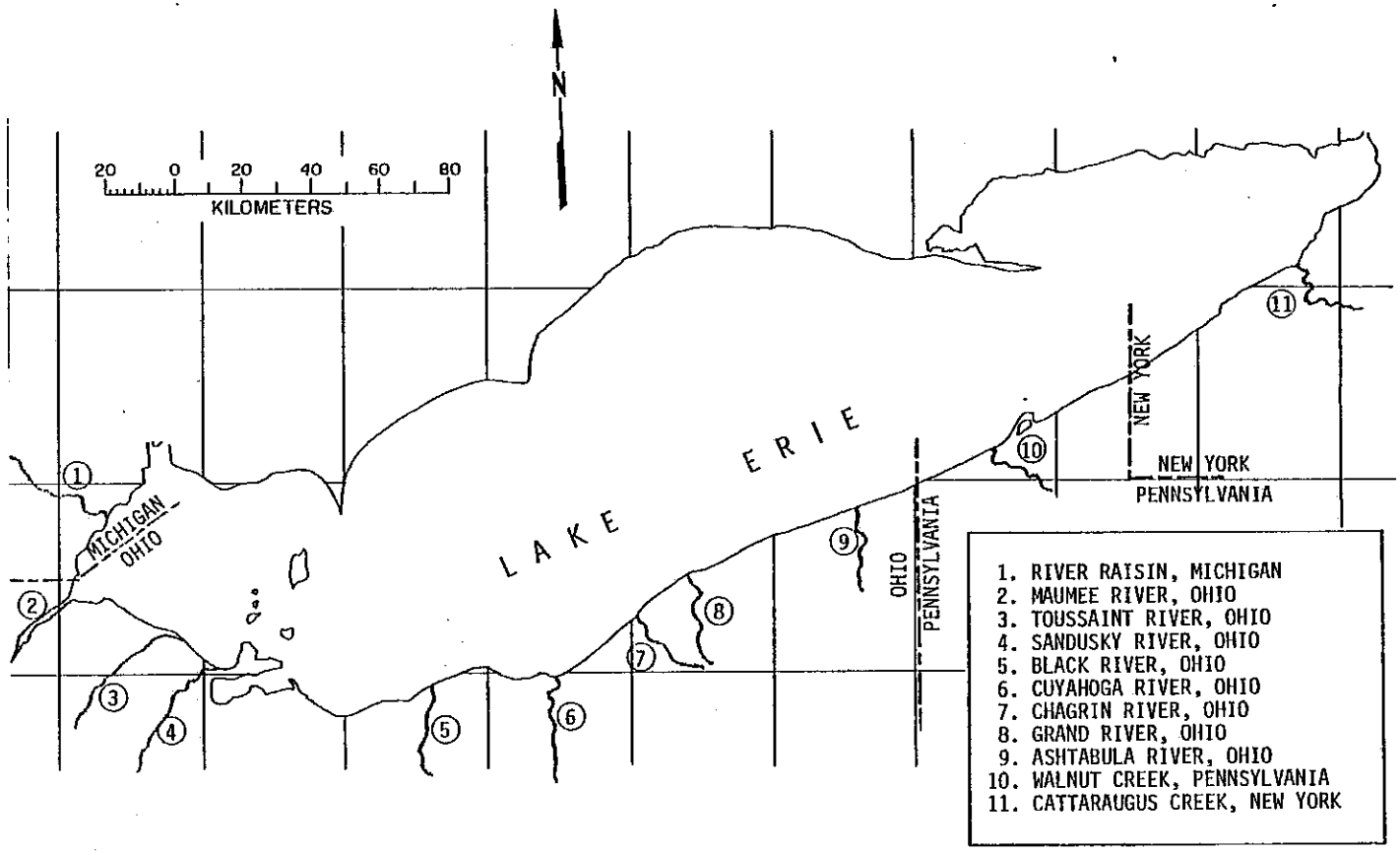



Figure 2. Locations of Lake Erie Tributaries Sampled in Survey of Organochlorine Contaminants in Fishes, August-December, 1979

TABLE 2

GEOGRAPHICAL COORDINATES FOR LAKE ERIE
TRIBUTARY FISH COLLECTION SITES

| Tributary | Latitude (N) | Longitude (W) |
|---|---|---|
| River Raisin, Michigan | 41°54.5' | 83°22.5' |
| Maumee River, Ohio | 41°43.5' | 83°28.5' |
| Toussaint River, Ohio | 41°35' | 83°05.2' |
| Sandusky River, Ohio | 41°26' | 83°02' |
| Black River, Ohio | 41°28.3' | 82°12.8' |
| Cuyahoga River, Ohio | 41°30' | 81°45' |
| Chagrin River, Ohio | 41°40.1' | 81°25.2' |
| Grand River, Ohio | 41°44.6' | 81°16.6' |
| Ashtabula River, Ohio | 41°54.5' | 80°47.9' |
| Walnut Creek, Pennsylvania | 42°4.5' | 80°14.5' |
| Cattaraugus Creek, New York | 42°34.1' | 79°08' |

Indiana at the merger of the St. Joseph and St. Marys rivers. The Maumee River then flows northeast to Toledo, Ohio, where it enters Lake Erie. This is a total distance of about 217 km. Toledo is an industrialized area and is considered to be a major source of pollution to the river.

The average gradient of the river is 0.24 m/km with a mean discharge of 131 cms; this ranges from a high of 2632 cms to a low of 0.896 cms (Herdendorf and Cooper, 1975). The Maumee carries a heavy silt and sediment load from agricultural drainage of northwestern Ohio and northeastern Indiana. Major agricultural land uses are soybean, corn, wheat, and alfalfa hay (IJC, 1976).

Toussaint River

The Toussaint River begins approximately 6 km northeast of Bowling Green, Ohio and continues to flow in a northeast direction where it empties into Lake Erie at the town of Toussaint, Ohio. This distance is approximately 51 km.

The land surrounding the river is very flat and is a heavy agricultural area. Drainage is poor, but the land is very fertile if drained. Major crops of this area are soybean, corn, wheat, and alfalfa hay (IJC, 1976).

Sandusky River

The Sandusky River begins near Crestline, Ohio and flows in a westerly direction to the town of Upper Sandusky. It then turns northward toward Lake Erie. The Sandusky then enters Muddy Creek Bay which joins Sandusky Bay. The Sandusky River drainage basin is 3,680 sq. km. The length of the river is 209.5 km and the average gradient is 0.75 m/km (Krolczyk, 1960). The mean discharge rate of the river is 26.8 cms, ranging from a high of 792.9 cms to a minimum of 0.1 cms (Baker, 1975).

The Sandusky River drains primarily flat farmlands. Major crops of this area include soybean, corn, wheat, and alfalfa hay (IJC, 1976).

Black River

The Black River is located in a highly populated, highly industrialized, and highly polluted portion of the Lake Erie drainage basin. This river begins with the joining of the West Branch and East Branch rivers at Elyria, Ohio. It then flows north, emptying into Lake Erie at Lorain, Ohio.

Flow characteristics of the Black River at Elyria, Ohio show a total drainage area of 955 sq. km (IJC, 1976). A mean annual discharge of 8.5 cms with a maximum of 13.4 cms and a minimum of 3.6 cms is reported. Agricultural land use of this area is

insignificant when compared to the major industrial activities. Major crops for this area are clover and timothy hay, corn, soybean, and wheat.

Cuyahoga River

The Cuyahoga River begins in Geauga County and flows in a southwestern direction to Akron, Ohio. The river then heads north, emptying into Lake Erie at Cleveland, Ohio. This river is highly polluted in the Cleveland area. It is valuable to Cleveland's industrial complex as a route of transport for the steel industry.

The Cuyahoga River at Independence, Ohio has a drainage area of 1831 sq km (IJC, 1976). It has an annual discharge of 21 cms; a high of 32.8 cms to a low of 7.8 cms. Agricultural land use is minimal. Major crops include clover and timothy hay, corn, soybean, and wheat.

Chagrin River

The Chagrin River begins in the central portion of Geauga County. It flows in a southeasterly direction for 24 km and then flows north to Eastlake, Ohio where it empties into Lake Erie. The total distance covered by the river is 29 km. The river basin is located in a rural area with a minimum of industrial activity at the river mouth.

Flow characteristics of the Chagrin River at Willoughby, Ohio show a drainage area of 637 sq km (IJC, 1976). This area has an annual discharge of 8.8 cms; this ranges from a high of 12.6 cms to a low of 4.1 cms. Agricultural land use is greater than in either the Black or Cuyahoga River Basins, but is still low. Major crops include clover and timothy hay, corn, soybean, and wheat.

Grand River

The Grand River empties into Lake Erie at Fairport Harbor, Ohio. It begins in Trumbull County and flows north, where it joins Mill Creek. The river then turns west and flows into Lake County. This is a total distance of 48 km.

The river basin is located in an area that is both rural and industrial. Flow characteristics of the Grand River at Madison, Ohio show a drainage area of 1505 sq km with an annual mean discharge of 18.3 cms; this ranges from a high of 30 cms to a low of 9 cms (IJC, 1976). Major agricultural crops are clover and timothy hay, corn, soybean, and wheat.

Ashtabula River

The Ashtabula River flows in a northwest direction before emptying into Lake Erie at Ashtabula, Ohio. The river basin is found in a predominantly rural area. The total distance covered by this river is 27 km.

The drainage area at Ashtabula is 313.4 sq km (IJC, 1976). Annual discharge is 4.2 cms; this peaks at 5.9 cms to a low of 2.4 cms. Major crops include clover and timothy hay, corn, soybean, and wheat.

## BACKGROUND INFORMATION ON PARAMETERS

### Aldrin

This has been one of the most widely used soil insecticides in the past 20 years (McEwen and Stephenson, 1979). Use on corn has been cancelled in the United States. It is very persistent in the environment, though biological oxidation converts it to Dieldrin.

### Dieldrin

This compound has been widely used as a soil insecticide and was developed along with Aldrin during the late 1940s. Dieldrin is very persistent in aquatic environments. Most uses in the United States have been cancelled since 1972. It is presently used for termite control.

### BHC

This insecticide, containing $\alpha$, $\beta$, and $\gamma$ isomers, has been cancelled from use in the United States since 21 July 1978. Formulations containing only the $\gamma$ isomer (Lindane) are currently used by agricultural and residential interests to control soil insects, houseflies, and cockroaches.

### Chlordane

This insecticide has been used effectively for control of mosquitoes, cockroaches, termites, and agricultural soil insects. It is particularly persistent in soils, therefore potential exists

for movement into the aquatic environment via erosion and sediment transport.

DDT and Metabolites

DDT has been cancelled from use in the United States since 31 December 1972. It was widely used as an effective insecticide against a variety of agricultural and household pests. DDD was also found to have similar insecticidal properties, but it too was cancelled from use as of 18 March, 1971. DDE is a degradation product of both DDT and DDD.

Endosulfan

This insecticide is used against a wide variety of insect pests. The technical product contains $\alpha$ and $\beta$ isomers; $\alpha$-Endosulfan is much less persistent in the environment than $\beta$-Endosulfan. This compound has been found to be very toxic to fish.

Endrin

Endrin is very persistent in the environment and extremely toxic to fish. It was used for the control of insect pests of cotton, wheat, barley, and oats. These uses have been cancelled and it is now primarily applied to control nuisance birds and orchard vermin.

Heptachlor

This insecticide has been cancelled for use on most crops. Present use includes ground treatment for termites. Heptachlor is similar to Chlordane in that it was isolated from this compound in the late 1940s (McEwen and Stephenson, 1979). Heptachlor is metabolized by many animals to form the epoxide (Brooks, 1969), a product that bioaccumulates in animal tissue.

Hexachlorobenzene. The fungicide hexachlorobenzene is used on Ohio crops for seed protection. In 1978 its use was limited to wheat seed treatment (Carter et al., 1980). It has been shown that hexachlorobenzene, when percutaneously absorbed through the skin can cause porphyria (Brown, 1978).

2,4-D. Use of the Herbicide 2,4-D in Ohio is primarily for broad-leaf weed control in corn, wheat, oats, and other cereal crops (Carter et al., 1978). It is an effective and widely used pesticide. It exhibits a high degree of volatility after application, and the isopropyl ester has been found to be highly adsorptive to clays (McEwen and Stephenson, 1979 and Faust and Aly, 1964).

Methoxychlor. Methoxychlor is used as an insecticide and has served as an adequate replacement for DDT. It is relatively non

persistent, owing to the fact that many vertebrates detoxify it to harmless metabolites (McEwen and Stephenson, 1979).

Mirex. Mirex was developed to combat the fire ant problem in the southern U.S. It is extremely persistent in the environment (McEwen and Stephenson, 1979). It has been cancelled from use in the U.S. after it was discovered to be the cause of severe debilitating illnesses in humans.

Toxaphene. This is a persistent insecticide extremely toxic to fish (McEwen and Stephenson, 1979). It is used on range grass, potatoes, corn, and oats for insect control.

Trifluralin. Trifluralin is one of the most frequently used herbicides in the country. It is an effective weed control agent for soybean, wheat, and barley. Trifluralin is extremely volatile. It is readily degraded by bacteria in soil. It is adsorbed onto soil particles and has been found to be toxic and moderately persistent in fish (McEwen and Stephenson, 1979).

PCBs. PCBs are no longer manufactured or sold in the U.S. They are largely of industrial origin, but have been used as carriers for insecticides. PCBs have been used in a variety of industrial products such as transformers, capacitators, paints, plastics,

adhesives, sealants, and hydraulic fluids. Pronounced environmental persistence and ubiquity of this compound has caused widespread alarm with regard to concentrations in aquatic ecosystems (Livingston, 1977).

PCBs were manufactured in a variety of mixtures called Aroclors. Each Aroclor contained a different percent chlorination on a biphenyl molecule. Aroclor 1016 is a mixture which contains 41 percent chlorine and was developed to replace Aroclor 1242 in the manufacture of capacitators (Skea et al., 1979). Aroclor 1254 contains 54 percent chlorination; Aroclor 1260 contains 60 percent chlorination.

Table 3 lists the common names and structural and empirical formulas of the organochlorine contaminants.

TABLE 3

ORGANIC CONTAMINANTS WITH COMMON NAMES AND STRUCTURAL AND EMPIRICAL FORMULAS

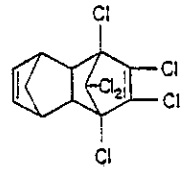
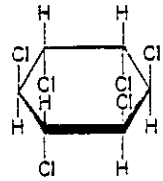
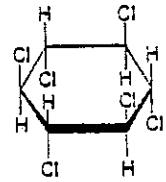
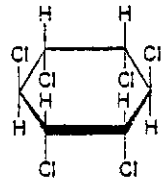
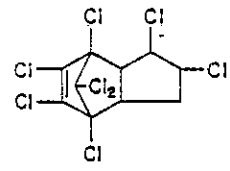
| Contaminant | Common Name[1] | Structural and Empirical Formulas |
|---|---|---|
| Aldrin | N.A. |  $C_{12}H_8Cl_6$ endo-exo |
| α-Hexachlorocyclohexane (HCH) | α-Benzene Hexachloride (BHC) |  $C_6H_6Cl_6$ |
| β-HCH | β-BHC |  $C_6H_6Cl_6$ |
| γ-HCH | Lindane |  $C_6H_6Cl_6$ |
| Chlordane | N.A. |  $C_{10}H_6Cl_8$ |

TABLE 3 (continued)

ORGANIC CONTAMINANTS WITH COMMON NAMES AND STRUCTURAL AND EMPIRICAL FORMULAS

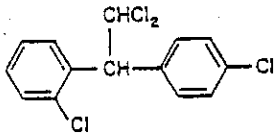
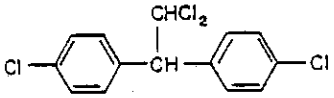
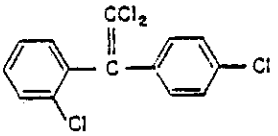
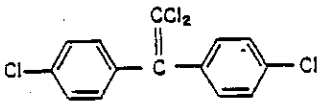
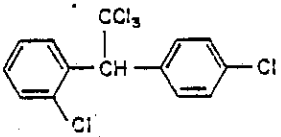
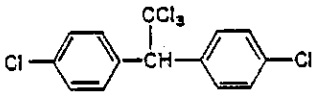
| Contaminant | Common Name[1] | Structural And Empirical Formulas |
|---|---|---|
| o,p'-Dichlorodiphenyl-dichloroethane | DDD |  $C_{14}H_{10}Cl_4$ |
| p,p'-Dichlorodiphenyl-dichloroethane | DDD |  $C_{14}H_{10}Cl_4$ |
| o,p'-Dichlorodiphenyl-dichloroethene | DDE |  $C_{14}H_8Cl_4$ |
| p,p'-Dichlorodiphenyl-dichloroethene | DDE |  $C_{14}H_8Cl_4$ |
| o,p'-Dichlorodiphenyl-trichloroethane | DDT |  $C_{14}H_9Cl_5$ |
| p,p'-Dichlorodiphenyl-trichloroethane | DDT |  $C_{14}H_9Cl_5$ |

TABLE 3 (continued)

ORGANIC CONTAMINANTS WITH COMMON NAMES AND STRUCTURAL AND EMPIRICAL FORMULAS

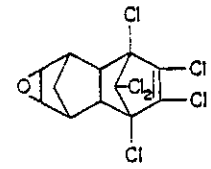
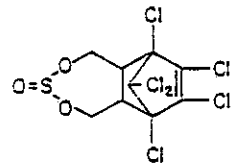
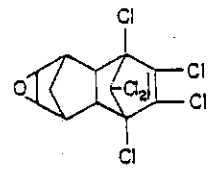
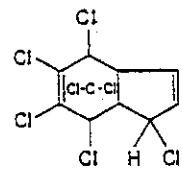
| Contaminant | Common Name[1] | Structural And Empirical Formulas |
|---|---|---|
| Dieldrin | N.A. |  endo-exo $C_{12}H_8Cl_6O$ |
| α-Endosulfan | N.A. |  (GENERAL STRUCTURE) $C_9H_6Cl_6O_3S$ |
| β-Endosulfan | N.A. | |
| Endrin | N.A. |  endo-endo $C_{12}H_8Cl_6O$ |
| Heptachlor | N.A. |  $C_{10}H_5Cl_7$ |

TABLE 3 (continued)

ORGANIC CONTAMINANTS WITH COMMON NAMES AND STRUCTURAL AND EMPIRICAL FORMULAS

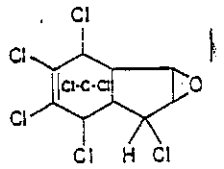
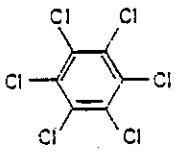
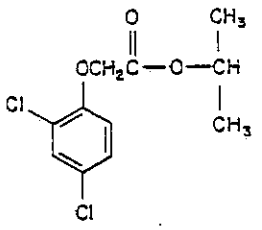
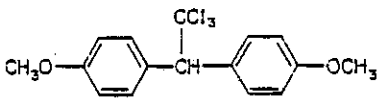
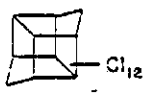
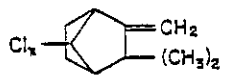
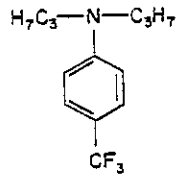
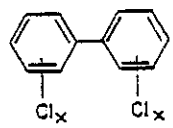
| Contaminant | Common Name[1] | Structural And Empirical Formulas |
|---|---|---|
| Heptachlor Epoxide | N.A. |  $C_{10}H_5Cl_7O$ |
| Hexachlorobenzene | N.A. |  $C_6Cl_6$ |
| 2,4-Dichlorophenoxyacetic Acid (Isopropyl Ester) | 2,4-D |  |
| Methoxychlor | N.A. |  $C_{18}H_{15}Cl_3O_2$ |
| Mirex | N.A. |  $C_{10}Cl_{12}$ |

TABLE 3 (continued)

ORGANIC CONTAMINANTS WITH COMMON NAMES AND STRUCTURAL AND EMPIRICAL FORMULAS

| Contaminant | Common Name[1] | Structural And Empirical Formulas |
|---|---|---|
| Toxaphene | N.A. |  |
| Trifluralin | N.A. |  |
| Polychlorinated Biphenyls<br>Aroclor 1016<br>Aroclor 1254<br>Aroclor 1260 | PCBs |  <br>(GENERAL STRUCTURE) |

[1] N.A. refers to not applicable

## MATERIALS AND METHODS

### Survey Sample Collection - Fall 1979

Samples of 12 common fish of recreational, commercial, or trophic importance were collected in the mouths of 11 Lake Erie tributaries during the period 6 August - 12 December, 1979 (Figure 2, Table 4). Tributaries were selected to represent the Western, Central, and Eastern Basins of the Lake and industrial, agricultural, and residential watersheds. These tributary mouths were located in Michigan, Ohio, Pennsylvania, and New York. Exact locations of tributary sampling sites are illustrated in Appendix E.

Collections were made primarily with experimental gill nets (38 m) and supplemented by bottom trawling and electroshocking. Gill nets were set in the early morning (0700-0900) and retrieved 24 hours later. An attempt was made to collect as large a number of fish and species as possible. Return trips to certain tributaries were necessary because of inadequate collections from previous sampling.

Immediately following removal of gill nets from the water, the fish were stored in acetone-rinsed metal containers. After the fish were grouped together by species, total length and weight were recorded for each fish collected, and the sex of each was

TABLE 4

SUMMARY OF FISH COLLECTIONS IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER 1979, FOR DETERMINATION OF ORGANOCHLORINE CONTAMINANT CONCENTRATIONS

| Tributary | Location of Mouth | Species Collected[1] | Number of Species |
|---|---|---|---|
| Raisin River | Monroe County, MI (Monroe Harbor) | GS, NP, C, ES, SS BBH, YP | 7 |
| Maumee River | Lucas County, OH (Toledo Harbor) | GS, NP, C, SS, WB, YP | 6 |
| Toussaint River | Ottawa County, OH (Locust Point) | GS, C, WB, YP, FWD | 5 |
| Sandusky River | Sandusky County, OH (Head of Sandusky Bay) | GS, C, CCF, WB, YP FWD | 6 |
| Black River | Lorain County, OH (Lorain Harbor) | GS, C, SS, BBH, WB, FWD | 6 |
| Cuyahoga River | Cuyahoga County, OH (Cleveland Harbor) | GS, RS, C, SS, WB, YP, FWD | 7 |

TABLE 4 (continued)

SUMMARY OF FISH COLLECTIONS IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER 1979, FOR DETERMINATION OF ORGANOCHLORINE CONTAMINANT CONCENTRATIONS

| Tributary | Location of Mouth | Species Collected[1] | Number of Species |
|---|---|---|---|
| Chagrin River | Lake County, OH (Eastlake) | GS, ES | 2 |
| Grand River | Lake County, OH (Fairport Harbor) | GS, RS, NP, ES, SS | 5 |
| Ashtabula River | Ashtabula County, OH (Ashtabula Harbor) | GS, RS, NP, ES, SS, WB, YP | 7 |
| Walnut Creek | Erie County, PA (Manchester Beach) | CS | 1 |
| Cattaraugus Creek | Erie-Chatauqua Counties, NY (Sunset Bay) | SS | 1 |

[1]GS = Gizzard shad (Dorosoma cepedianum); RS = rainbow smelt (Osmerus mordax); NP = northern pike (Esox lucius); C = carp (Cyprinus carpio); ES = emerald shiner (Notropis atherinoides); SS = spottail shiner (Notropis hudsonius); CS = common shiner (Notropis cornutus); CCF = channel catfish (Ictalurus punctatus); BBH = brown bullhead (Ictalurus nebulosus); WB = white bass (Morone chrysops); YP = yellow perch (Perca flavescens); FWD = freshwater drum (Aplodinotus grunniens); common and scientific names according to Bailey et al. (1970).

determined by dissection or extrusion of milt or roe. Scales or pectoral spines for age determination were collected from each fish of age class I or older. Scales were removed from young-of-the-year fish when less than 25 were collected in a single sample. When large numbers of young-of-the-year fish were collected in a single sample, scales or pectoral spines were collected from 25-50 individuals of a species. After data collection, each fish was wrapped in acetone-rinsed aluminum foil and labelled separately. Fish were held in frozen storage until sample preparation and homogenization.

Uptake Rate Experiment - Fall 1979

A pilot experiment to develop a field technique for estimating uptake rates of organochlorine contaminants by hatchery-raised young-of-the-year fish was conducted at the mouths of the Maumee and Cuyahoga rivers during the period 20 October - 17 November 1979. A nylon mesh holding pen (1.8 m x 1.8 m x 1.8 m, 6 mm mesh) supported by a framework of polyvinyl chloride (PVC) pipe was constructed to hold fish for the experiment (Figure 3). Two holding tanks were used to transport 111 channel catfish (Ictalurus punctatus) and 108 yellow perch (Perca flavescens). Each tank was filled with well water and equipped with an electrical agitator to provide adequate aeration (Figure 4). These young-of-the-year fish were purchased from Fender's Fish Hatchery, Route 1, Baltic, Ohio 43804.

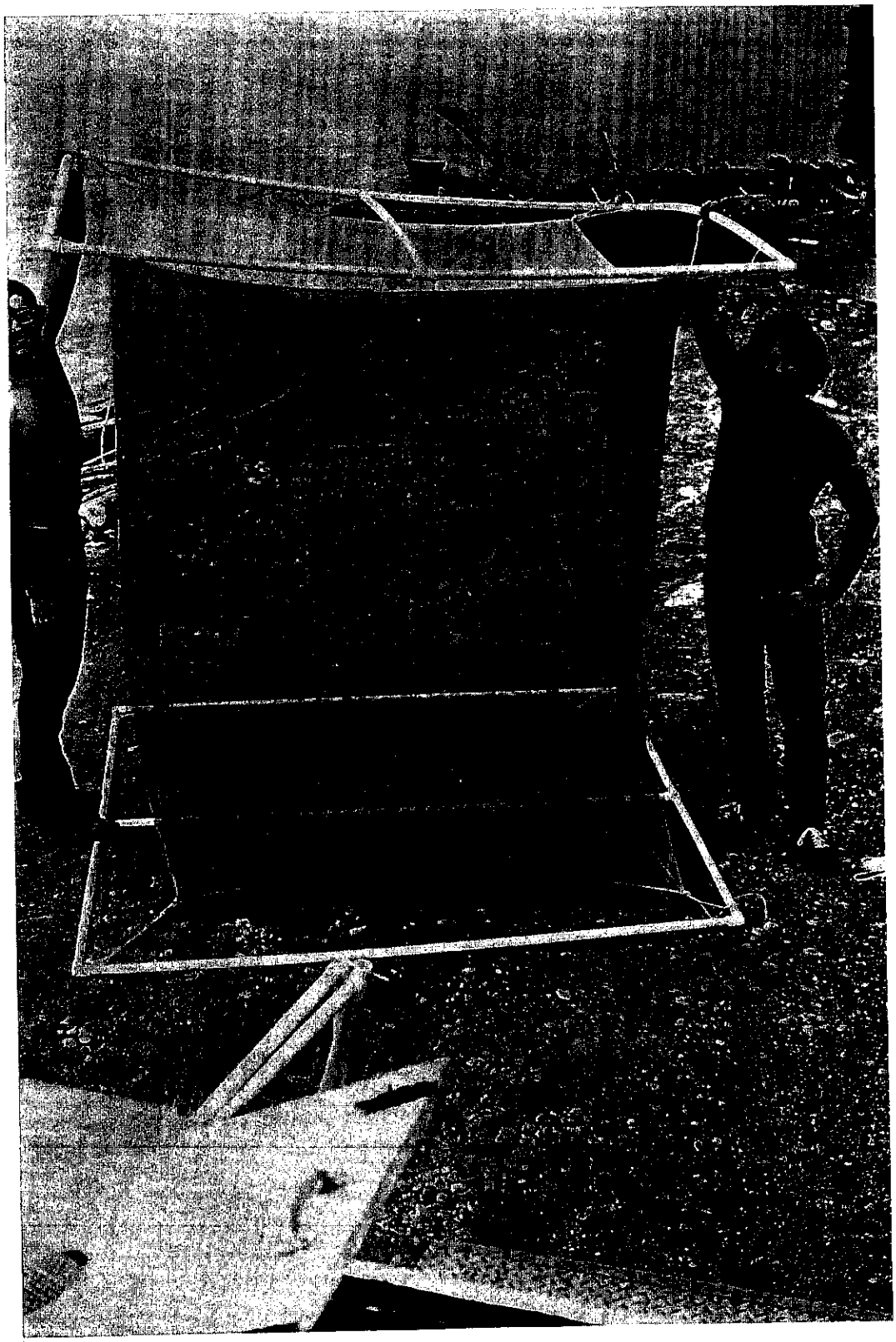


Figure 3. Fish Holding Pen at Cuyahoga River Mouth, 1979

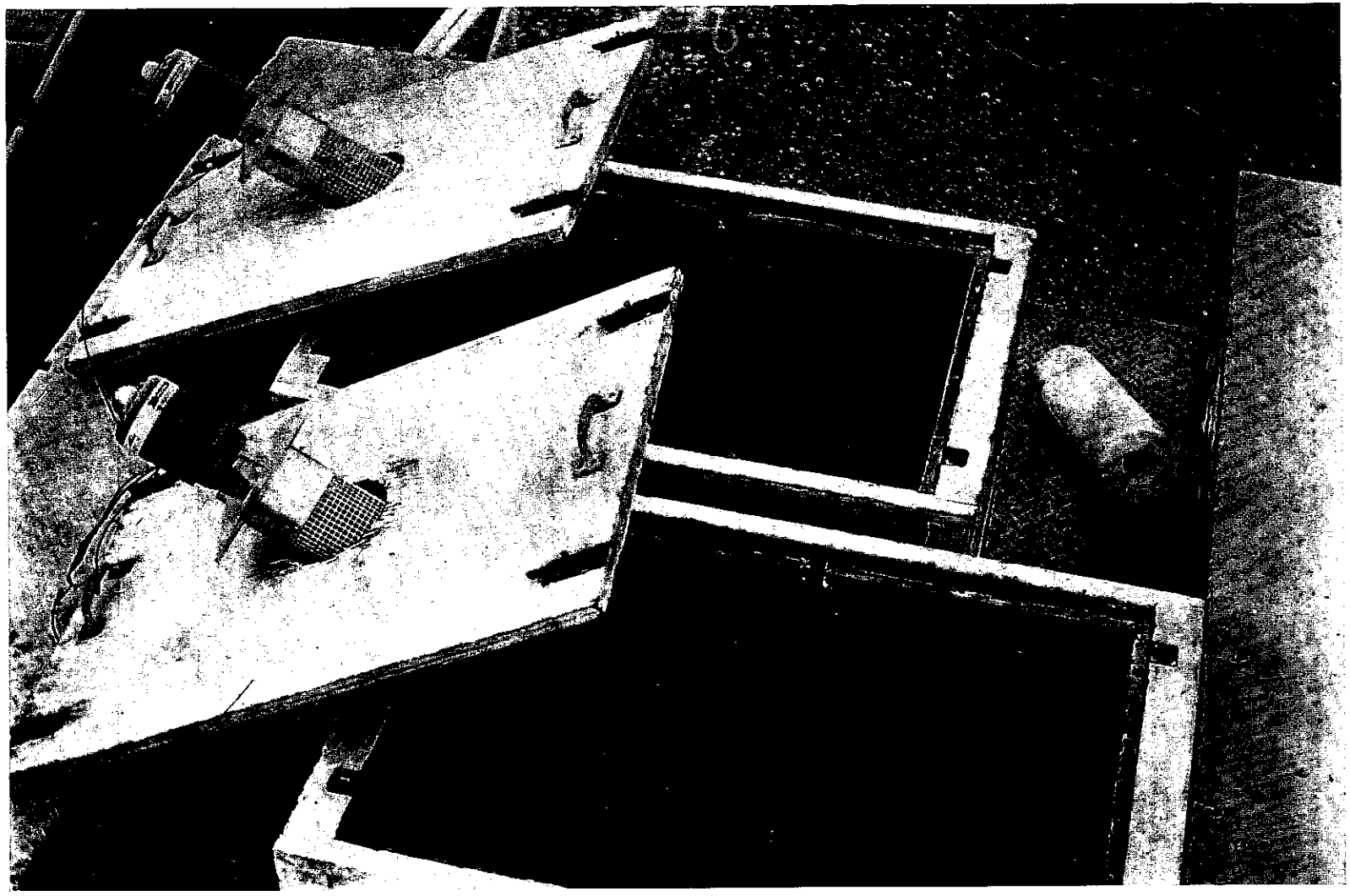


Figure 4. Holding Tanks Used to Transport Young-of-the-Year Channel Catfish and Bluegills to Maumee and Cuyahoga Rivers, 1979

The two holding nets were placed in the Cuyahoga and Maumee Rivers on 20 October 1979. The Cuyahoga River holding net was placed on the east side of the river approximately 100 m from the end of the navigation channel (Appendix E). The location of the Maumee River net was approximately 50 m from the end of the navigation channel at the U.S. Coast Guard Station. Each top corner of the holding net was buoyed by a plastic styrofoam-filled container (Figure 5). The Cuyahoga net was approximately 6 m offshore in a water depth of 2 m. The Maumee River net was set in a depth of 3 m, approximately 1 m offshore. The bottom corners were weighted with bricks to insure stretching from top to bottom (Figures 3 and 5). Contact with the bottom sediment was minimal.

Thirty-three channel catfish and 35 yellow perch were placed into the Cuyahoga River holding net. The Maumee River holding net received 34 channel catfish and 37 yellow perch. The remaining 44 channel catfish and 36 yellow perch were retained as a control group. The experimental fish were held in the holding nets for four weeks and removed on 17 November 1979. Transport and storage of control and experimental fish were conducted as previously described.

Uptake Rate Experiment - Spring 1980

A field experiment to determine uptake rates of organochlorine contaminants by hatchery-raised channel catfish and

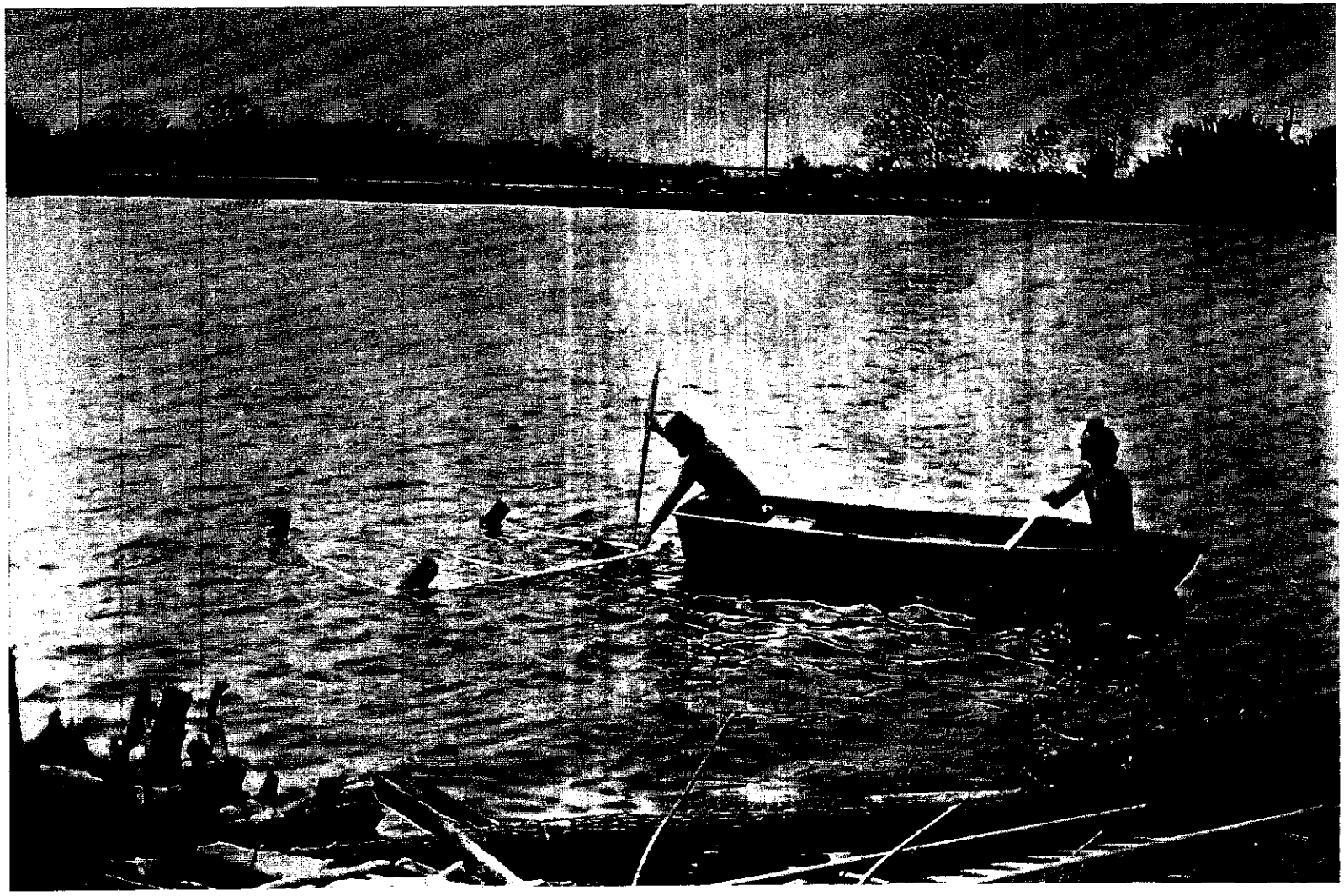


Figure 5. Fish Holding Pen in Cuyahoga River Showing Float Aparatus, 1979

bluegills (Lepomis macrochirus) was conducted at the mouths of the Maumee, Cuyahoga, and Ashtabula rivers during the period 23 May - 4 July 1980. Eight hundred bluegills were purchased from Fender's Fish Hatchery, and approximately 800 channel catfish were purchased from the Osage Catfish Farm, Route 1, Osage Beach, Missouri 65065. Four holding tanks were used to transport these fish to the three experimental sites. Each tank was equipped with an electrical agitator and oxygen bubbler to minimize stress on the fish during transport.

A more durable cage design was employed during the Spring 1980 uptake experiment (Figure 6). Cages were made of a supporting wood framework covered with galvanized steel (1.2 m x 1.2 m x 1.2 m, 9.5 mm mesh). A network of steel pipe (25.4 mm diameter) connected to cinder blocks was fastened to the bottom four corners of each cage to keep them submerged (Figure 7). Each cage had a latch door for fish placement and removal (Figure 7).

Two cages were placed in each of the three experimental sites. The six cages were set into the Maumee, Cuyahoga, and Ashtabula rivers during the period 9 May - 10 May 1980. A steel cable was fastened to each cage and attached on shore to prevent vandalism and damage by boats and wave action. The Maumee River site was identical to the Fall 1979 uptake experiment site. The Cuyahoga River cage was placed on the west bank of the river in

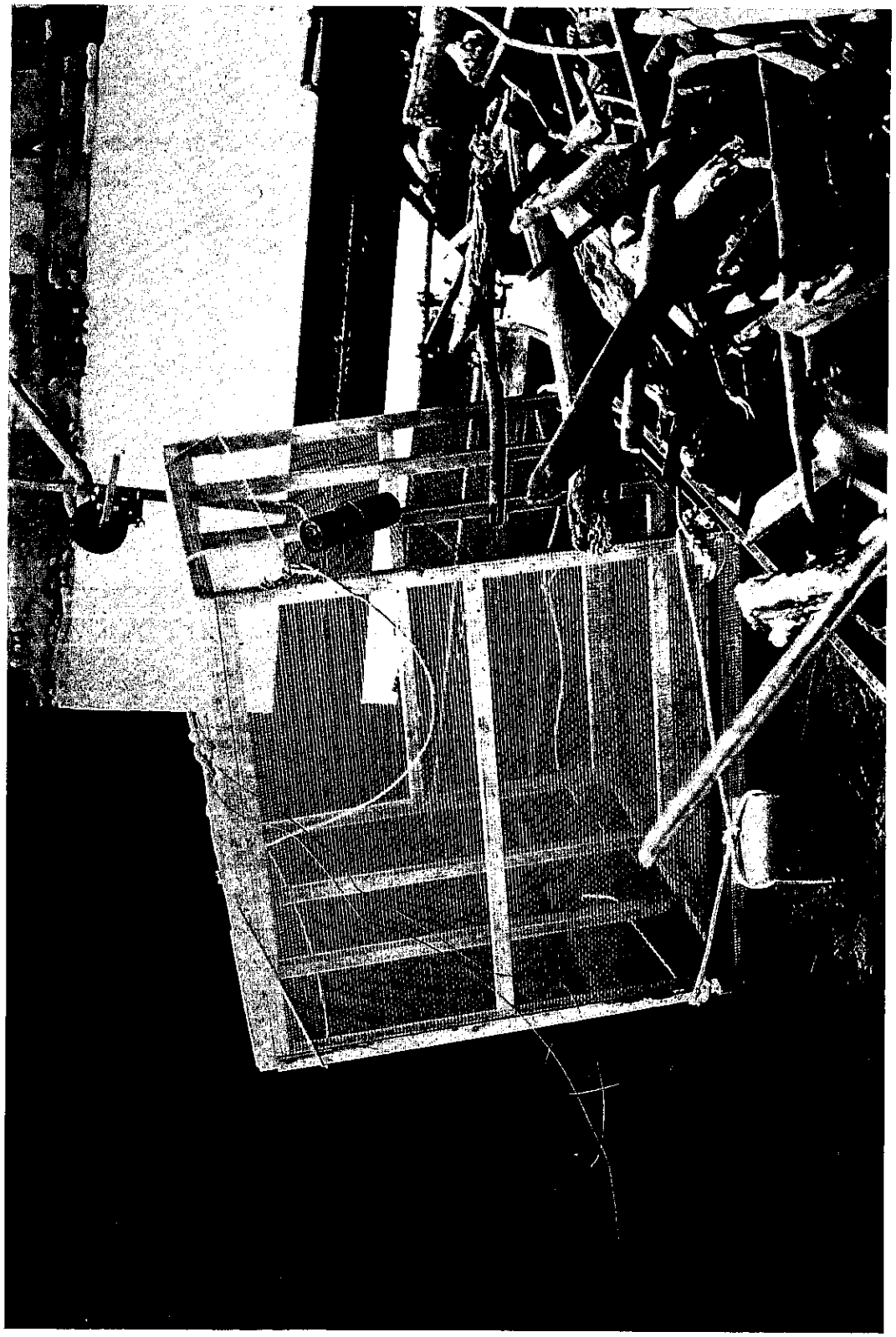


Figure 6. Fish Cage at Mouth of Cuyahoga River, 1980

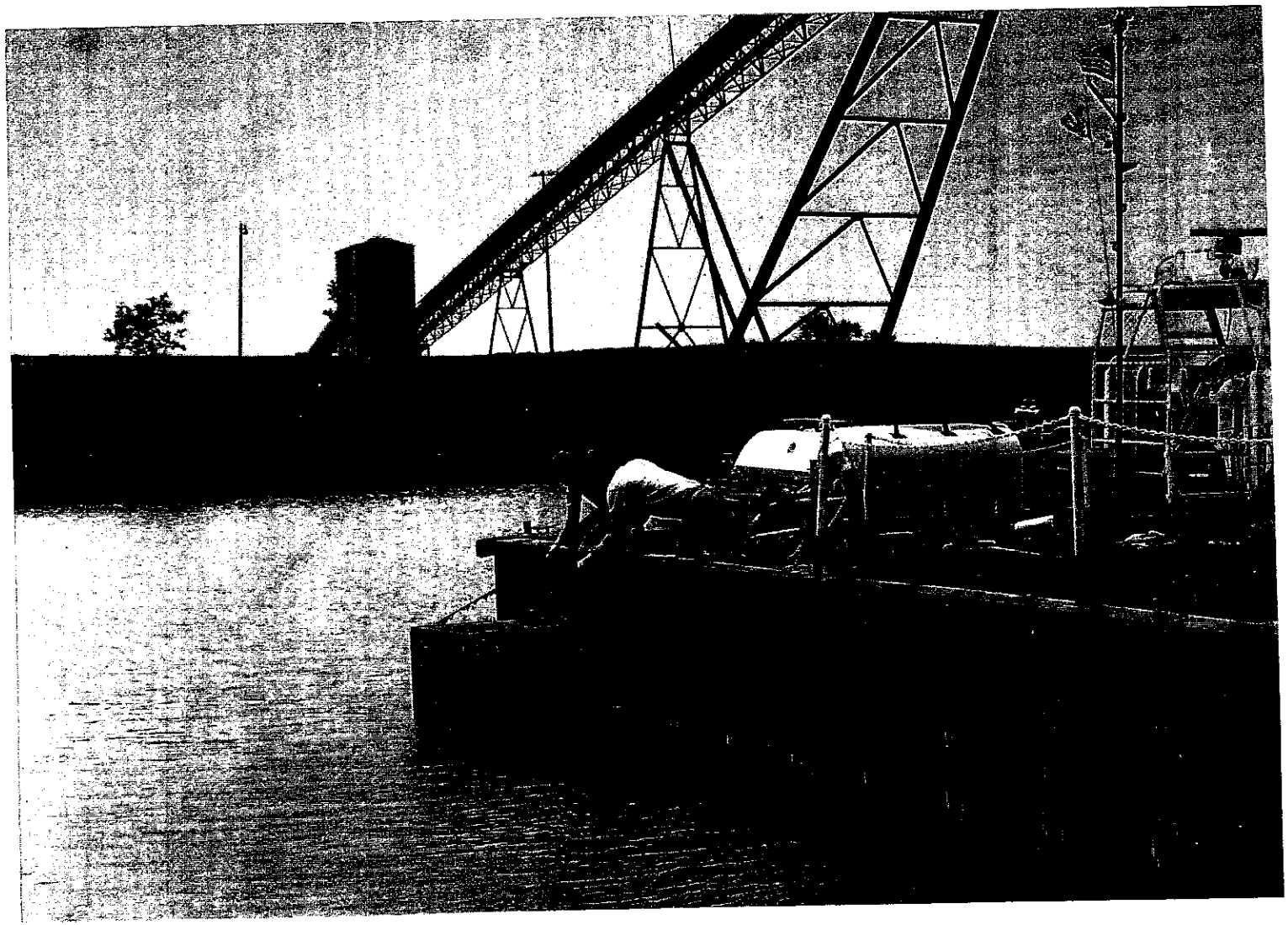


Figure 8. Raising Fish Cage From Ashtabula River for Fish Removal, 1980

the method of Marzolf (1955). Impressions of scales were made on acetate slides using a roller press.

Sample Preparation

Survey Samples - Fall 1979. After determination of age for each fish, the frozen samples from each tributary were sorted and combined into sets for analysis, each set consisting of fish of the same species and age group from the same tributary (Table 6).

Uptake Rate Experiment - Fall 1979. These fish were combined into five sets prior to homogenization and analysis: (1) channel catfish control; (2) yellow perch control; (3) yellow perch experimental - Maumee; (4) channel catfish experimental -Cuyahoga; and (5) yellow perch experimental - Cuyahoga. Net damage resulted in the loss of all experimental channel catfish in the Maumee River.

Uptake Rate Experiment - Spring 1980. A total of 29 samples were frozen prior to homogenization and chemical analysis. These fish comprised control and experimental group samples of channel catfish and bluegills from the Maumee, Cuyahoga, and Ashtabula rivers. The sample breakdown was comprised of the following groups: channel catfish control (1 sample); bluegill control (1 sample); channel catfish experimental - Maumee (6 samples); bluegill experimental - Maumee (6 samples); channel catfish

TABLE 6

SPECIES, AGE GROUPS, NUMBERS AND ANALYSIS OF FISHES COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979 FOR DETERMINATION OF ORGANOCHLORINE CONTAMINANT CONCENTRATIONS

| Tributary | Species[1] | Age Groups | Number | Groups Analyzed |
|---|---|---|---|---|
| Raisin River | Gizzard Shad | 0 | 12 | X |
| | | I | 1 | |
| | | III | 1 | |
| | Northern Pike | I | 4 | |
| | | II | 2 | |
| | | III | 6 | |
| | | IV | 1 | |
| | Carp | III | 1 | |
| | | IV | 3 | X |
| | | VI | 1 | |
| | | VII | 1 | |
| | Emerald Shiner | 0 | 6 | |
| | | I | 4 | |
| | | II | 1 | |
| | Spottail Shiner | I | 4 | X |
| | Brown Bullhead | 0 | 1 | |
| | | II | 2 | X |
| | Yellow Perch | I | 1 | |
| Maumee River | Gizzard Shad | 0 | 57 | X |
| | | I | 1 | |
| | Northern Pike | II | 1 | |
| | | III | 2 | |
| | Carp | III | 1 | |
| | | IV | 2 | X |
| | Spottail Shiner | I | 50 | X |
| | | II | 1 | |

TABLE 6 (continued)

SPECIES, AGE GROUPS, NUMBERS AND ANALYSIS OF FISHES COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979 FOR DETERMINATION OF ORGANOCHLORINE CONTAMINANT CONCENTRATIONS

| Tributary | Species[1] | Age Groups | Number | Groups Analyzed |
|---|---|---|---|---|
| | White Bass | 0 | 4 | X |
| | | I | 1 | |
| | Yellow Perch | I | 2 | |
| | | II | 42 | X |
| Toussaint River | Gizzard Shad | I | 1 | |
| | Carp | III | 3 | |
| | | IV | 10 | X |
| | | V | 2 | |
| | | VI | 1 | |
| | White Bass | 0 | 1 | |
| | | I | 23 | X |
| | | II | 5 | X |
| | Yellow Perch | I | 2 | |
| | | II | 1 | |
| | Freshwater Drum | 0 | 1 | |
| | | I | 14 | X |
| | | II | 2 | |
| | | IV | 7 | |
| | | V | 2 | |
| Sandusky River | Gizzard Shad | 0 | 24 | X |
| | | I | 4 | X |
| | Carp | II | 2 | |
| | | III | 1 | |
| | | IV | 4 | X |
| | | V | 1 | |
| | Channel Catfish | 0 | 1 | |
| | | VI | 1 | X |

TABLE 6 (continued)

SPECIES, AGE GROUPS, NUMBERS AND ANALYSIS OF FISHES COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979 FOR DETERMINATION OF ORGANOCHLORINE CONTAMINANT CONCENTRATIONS

| Tributary | Species[1] | Age Groups | Number | Groups Analyzed |
|---|---|---|---|---|
| | White Bass | 0 | 12 | X |
| | | I | 11 | X |
| | | II | 5 | X |
| | Yellow Perch | 0 | 1 | |
| | | I | 2 | X |
| | | II | 9 | X |
| | Freshwater Drum | 0 | 15 | X |
| | | I | 10 | X |
| | | II | 2 | |
| Black River | Gizzard Shad | 0 | 3 | |
| | | I | 11 | X |
| | | II | 1 | |
| | Carp | IX | 1 | X |
| | Spottail Shiner | I | 7 | X |
| | | II | 3 | X |
| | | III | 1 | |
| | Brown Bullhead | I | 2 | |
| | | II | 2 | X |
| | | IV | 2 | |
| | White Bass | 0 | 3 | X |
| | Freshwater Drum | 0 | 10 | X |
| Cuyahoga River | Gizzard Shad | 0 | 16 | X |
| | Rainbow Smelt | I | 1 | |
| | Carp | III | 1 | |
| | | IV | 1 | X |
| | Spottail Shiner | I | 26 | X |
| | | II | 22 | X |

TABLE 6 (continued)

SPECIES, AGE GROUPS, NUMBERS AND ANALYSIS OF FISHES COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979 FOR DETERMINATION OF ORGANOCHLORINE CONTAMINANT CONCENTRATIONS

| Tributary | Species[1] | Age Groups | Number | Groups Analyzed |
|---|---|---|---|---|
| | White Bass | 0 | 2 | X |
| | Yellow Perch | II | 2 | X |
| | Freshwater Drum | 0 | 2 | |
| Chagrin River | Gizzard Shad | 0 | 55 | X |
| | Emerald Shiner | 0 | 4 | |
| | | I | 12 | X |
| | | II | 35 | X |
| | | III | 4 | |
| Grand River | Gizzard Shad | 0 | 40 | X |
| | | I | 11 | X |
| | | III | 1 | |
| | Rainbow Smelt | I | 48 | X |
| | | II | 7 | |
| | Northern Pike | IV | 1 | |
| | Emerald Shiner | I | 9 | X |
| | | II | 4 | |
| | | III | 37 | |
| | Spottail Shiner | I | 3 | X |
| Ashtabula River | Gizzard Shad | 0 | 52 | X |
| | | I | 4 | |
| | Rainbow Smelt | I | 43 | X |
| | | II | 1 | |
| | Northern Pike | II | 1 | |
| | Emerald Shiner | I | 17 | X |

TABLE 6 (continued)

SPECIES, AGE GROUPS, NUMBERS AND ANALYSIS OF FISHES COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979 FOR DETERMINATION OF ORGANOCHLORINE CONTAMINANT CONCENTRATIONS

| Tributary | Species[1] | Age Groups | Number | Groups Analyzed |
|---|---|---|---|---|
| | Spottail Shiner | I | 2 | X |
| | White Bass | 0 | 2 | X |
| | Yellow Perch | II | 1 | |
| Walnut Creek | Common Shiner | I | 1 | |
| | | III | 16 | |
| Cattaraugus Creek | Spottail Shiner | II | 1 | |

[1]Common and scientific names according to Bailey et al. (1970)

experimental - Cuyahoga (2 samples); bluegill experimental - Cuyahoga (2 samples); channel catfish experimental - Ashtabula (6 samples); and bluegill experimental - Ashtabula (5 samples).

Sample Homogenization

Only certain groups of the total number of fish samples collected were homogenized in preparation for chemical analysis. Choice of these groups was based on the species type, total number of fish from the sample, and age group. This was done to maximize the number of comparisons between species, tributary, and age class. A total of 84 samples were homogenized using a Hobart Model A-200-F mixer with meat chopper attachment. These 84 samples comprised the following groups:

(1) 50 Survey Samples - Fall 1979
(2) 5 Uptake Rate Experiment Samples - Fall 1979
(3) 29 Uptake Rate Experiment Samples - Spring 1980

These samples were passed through the mixer three times, once at setting 1 (low) and twice at setting 3 (high). The homogenates were then wrapped in acetone- and benzene-rinsed aluminum foil. Each sample was labelled separately according to species, age group, number, and tributary (Table 4). The samples were then held in frozen storage.

Analytical Methods

Fall 1979 Survey Samples. Samples were received in a frozen condition at the 111 Wales Avenue facilities of Recra Research, Inc., Tonawanda, New York on 15 March 1980. The samples were immediately logged in and stored in a double-sealed container in a freezer until the time of extraction.

All analyses were performed according to U.S. Department of Health, Education, and Welfare (Food and Drug Administration) methodologies as presented in the Pesticide Analytical Manual, Vol. I (May 1978).

The choice of extraction methods was between Method #211, General Methods for Fatty Foods, and Method #212, General Methods for Non-Fatty Foods. Table 202.14 of the manual lists the approximate percent fat expected in the edible portion of various fish and shellfish. Although many of the fish to be analyzed were not included in the table, it was estimated that the fat content of the fish could range from 0.9-5.2%. Section 212.104 of Method #212 indicated that the method was applicable to samples containing no more than 2 g of fat in 20-100 g of sample (2-10%). Thus, the General Method for Non-Fatty Foods was selected. Data for the Percent Fat analyses, in retrospect, supported the choice of extraction method. The Percent Fat ranged from 1.2-5.0%.

Subsection 212.13a details the actual extraction procedure utilized.

Gas chromatographic (GC) conditions included the use of a Hewlett Packard 5880 GC equipped with a $Ni^{63}$ electron capture detector. Florisil column cleanup generated three elutions per sample which were analyzed for the appropriate organic constitutents. All elutions were qualitatively scanned for carry-over in preceeding and succeeding elutions. GC analyses were performed utilizing 6' x 4 mm glass columns loaded with 1.5% SP2250/1.95% SP2401 on 100/120 mesh Supelcoport.

All results are presented in the table of analytical results (Appendices A and B). Pesticide results are expressed on a g/g basis and are not corrected for percent moisture in the fish.

Percent Fat analyses were performed on an aliquot of the initial solvent extract of the fish. Results were calculated based upon a gravimetric determination following solvent removal by reduced pressure evaporation. All pesticide data were corrected for removal of this aliquot.

Specific information on the samples is listed with the sample identification presented in the data tables. This information was included with the samples upon receipt. Sample identification

thus includes the tributary, species, number of fish which were originally homogenized (N), and the age class.

All values reported as N.D. indicate trace or not detected levels for the working detection limits for that particular sample and/or parameter. Values reported as "less than or equal to" ($\leq$) indicate that a particular compound may be present at trace amounts relative to the particular working detection limit.

Severe emulsion problems during the extraction procedure were encountered with many of the samples. This resulted in extended preparation times. Emulsions were broken with addition of small amounts of anhydrous sodium sulfate as well as various physical techniques.

Results presented as Total Polychlorinated Biphenyls (PCBs) are calculated by merely summing the positive values of the specific Aroclors identified in the sample. Those values expressed as "less than or equal to" ($\leq$) were included.

Results of the pesticide analyses indicated that coelution of the pesticides with PCBs had occurred (as expected) in the initial elution fraction from the Florisil preparation column. GC analysis also indicated that combinations of PCB mixtures (Aroclors) were present as well as pesticides. Chlordane, which

is also a multiple component organic mixture, was also present. Further preparatory work was not performed due to time constraints. Instead, a mathematical correction procedure was used to correct the data for chromatographic coelution. Various mixed standards were analyzed and subjected to this correction procedure to assure its validity. In the presence of copious quantities of PCBs, detection limits of some compounds were necessarily elevated.

Chromatograms of the remaining elution fractions indicated that many interfering compounds were carried through the Florisil column. Based on the peak shapes, these compounds were believed to possibly be amines or organosulfur compounds. Sample extracts which were extremely contaminated were subjected to treatment with metallic mercury and/or spiked with known concentrations of the compounds of interest. This was done in order to ascertain detection limits.

Spring 1980 Uptake Samples. Samples were received in a frozen condition at the 111 Wales Avenue facilities of Recra Research, Inc. on 12 November 1980. The samples were immediately logged in and stored in a double-sealed container in a freezer until the time of extraction. All samples were received as homogenized samples.

All analyses were performed based upon U.S. Department of Health, Education, and Welfare (Food and Drug Administration) methodologies as presented in the Pesticide Analytical Manual, Vol. I (May 1978).

Previous analytical experience with these types of fish had indicated that the fat content was sufficiently low to allow the use of Method #212, General Methods for Non-Fatty Foods. Analysis of the final data indicated that this assumption had been correct.

Procedures for extraction and partitioning were performed according to Section 212.13a. Only 20 grams of fish were extracted in order to maintain an acceptable limit of coextracted fats. A 20 ml aliquot of each sample extract was removed prior to the partitioning step in order to perform the analysis for Percent Fat. Results of the Percent Fat analysis were calculated based upon a gravimetric determination following solvent removal by reduced pressure evaporation. All pesticide data were corrected for removal of this aliquot. The volume of petroleum ether used was increased to 200 ml. This resulted in fewer emulsion problems.

An initial Florisil column cleanup was performed according to Section 252.131. This extract was then placed on a second Florisil column and eluted according to Section 212.14. Prior to the first eluant of Section 212.14, an additional eluate of 200 ml of hexane

was performed. This step was introduced in an attempt to separate PCBs from the majority of the other pesticides according to the method of G.D. Veith and G.F. Lee (1971).

Gas chromatographic (GC) conditions included the use of a Hewlett Packard 5880 GC equipped with a $Ni^{63}$ electron capture detector. Florisil column cleanup generated four elutions per sample which were analyzed for the appropriate organic constituents. All elutions were qualitatively scanned for carry-over in preceeding and succeeding elutions. GC analyses were performed utilizing a 6' x 4 mm glass column loaded with 1.5% SP2250/1.95% SP2401 on 100/120 mesh Supelcoport. Confirmatory analyses were performed utilizing a 6' x 4 mm glass column loaded with 5% SP2250 on 80/100 mesh Supelcoport.

GC analyses were performed on portions of the final extracts which were spiked with dibutyl phthalate. The majority of the pesticides were identified using relative retention times with dibutyl phthalate as the reference.

All results are presented in the table of analytical results (Appendices C and D). Pesticide results are expressed on a µg/g basis and are not corrected for percent moisture in the fish.

Specific information on the samples is listed with the sample identification presented in the data tables. This information was included with the samples upon receipt. Sample identification thus includes the river, species, number of fish which were originally homogenized (N), and the date of sampling.

All values reported as N.D. indicate trace or not detected levels for the working detection limits for that particular sample and/or parameter. Values reported as "less than or equal to" ($\leq$) indicate that a particular compound may be present at trace amounts relative to the particular working detection limit.

Results presented as Total Polychlorinated Biphenyls (PCBs) are calculated by merely summing the positive values of the specific Aroclors identified in the sample. Those values expressed as "less than or equal to" ($\leq$) were included.

Quality Control

Fall 1979 Survey Samples. Percent coefficient of variation is presented as a mean of N determinations. The symbol, N.D., indicates that all N values were below the working detection limit and that the particular compound was "not-detectable". The elevated mean percent coefficients of variation are primarily due to the fact that the majority of the values were near the detection

limits and are not unexpected. Percent coefficient of variation (% C.V.) was calculated using the following equation:

$$\% \text{ C.V.} = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

Percent coefficient of variation data is calculated from five preparatory duplicates and seven GC analytical duplicates. Two of the GC analytical duplicates were performed on the preparatory duplicates.

Due to limited amount of sample, only three samples were measured for percent recovery. Due to expected chromatographic coelution problems concerning the multiple peak response parameters, they were specifically not included in the program. Due to similarities in structures, percent recovery of these parameters could be extrapolated by correlation to the recoveries of those pesticides which were measured.

Percent recoveries ranged from 15 to 85%. According to the Pesticide Analytical Manual, typical recoveries should have been greater than 80%. The poorest recoveries resulted for Dieldrin (17%) and Endrin (15%). This is believed to be the result of the extreme chromatographic interferences which were encountered in the elution fraction containing these two compounds. Without the

TABLE 7

QUALITY CONTROL SUMMARY OF ORGANIC ANALYSIS
OF FISH - 1979 SURVEY SAMPLES

| Parameter | Mean Percent Coefficient of Variation | Mean Percent Recovery |
|---|---|---|
| Percent Fat | 30 | * |
| Aldrin | 18 | 62 |
| α-BHC | 16 | 69 |
| β-BHC | 6 | 62 |
| γ-BHC | N.D. | 85 |
| Chlordane | 2 | * |
| o,p'-DDD | 35 | * |
| p,p'-DDD | 6 | 84 |
| o,p'-DDE | 9 | * |
| p,p'-DDE | 16 | 43 |
| o,p'-DDT | 13 | * |
| p,p'-DDT | 19 | 66 |
| Dieldrin | 10 | 17 |
| α-Endosulfan | 25 | * |
| β-Endosulfan | N.D. | 15 |
| Endrin | 2 | 45 |
| Heptachlor | 25 | 59 |
| Heptachlor epoxide | 17 | 41 |
| Hexachlorobenzene | 20 | * |
| 2,4-D (Isopropyl ester) | N.D. | * |
| Methoxychlor | 25 | * |
| Mirex | 39 | * |
| Toxaphene | N.D. | * |
| Trifluralin | 13 | * |
| Polychlorinated Biphenyls | | * |
| Aroclor 1016 | N.D. | * |
| Aroclor 1254 | 19 | * |
| Aroclor 1260 | 12 | * |
| Total Polychlorinated Biphenyls | 10 | |

*Not Determined
NOTE: N.D. refers to not detectable.

data for these two compounds, the percent recoveries ranged from 41 to 85%.

These low recoveries could have resulted from the severe emulsions which were encountered during the tedious extraction procedure. Coelution with PCBs and the calculation correction procedure could have resulted in values which were calculated to be slightly lower than actual. This could have easily changed the percent recoveries to the expected values. The mean of all percent recoveries, excluding Dieldrin and Endrin, was 62%.

Table 7 contains a summary of the quality control performed on the 1979 survey samples.

Spring 1980 Uptake Samples. The quality control summary for these samples is contained in Table 8. Calculation of percent recovery and coefficient of variation was identical to the 1979 survey samples. The elevated mean percent coefficients of variation are again primarily due to the fact that the majority of the values were near the detection limits. The percent recoveries ranged from 40 to 104%. The average of all the mean percent recoveries is 72%.

TABLE 8

QUALITY CONTROL SUMMARY OF ORGANIC ANALYSIS
OF FISH - 1980 UPTAKE SAMPLES

| Parameter | Mean Percent Coefficient of Variation | Mean Percent Recovery |
|---|---|---|
| Percent Fat | 7 | * |
| Aldrin | 16 | 98 |
| α-BHC | 20 | 40 |
| β-BHC | 18 | 70 |
| γ-BHC | 7 | 65 |
| Chlordane | N.D. | 44 |
| o,p'-DDD | N.D. | 54 |
| p,p'-DDD | 24 | 71 |
| o,p'-DDE | 47 | 103 |
| p,p'-DDE | 14 | 104 |
| o,p'-DDT | 8 | 87 |
| p,p'-DDT | N.D. | 90 |
| Dieldrin | 38 | 54 |
| α-Endosulfan | N.D. | * |
| β-Endosulfan | 7 | 52 |
| Endrin | 9 | 45 |
| Heptachlor | 112 | 96 |
| Heptachlor epoxide | 4 | 74 |
| Hexachlorobenzene | N.D. | 67 |
| 2,4-D (Isopropyl ester) | 0 | * |
| Methoxychlor | 28 | 76 |
| Mirex | N.D. | * |
| Toxaphene | N.D. | 53 |
| Trifluralin | 22 | 63 |
| Polychlorinated Biphenyls | | |
| Aroclor 1016 | N.D. | 90 |
| Aroclor 1254 | 0 | * |
| Aroclor 1260 | 0 | 90 |

*Not Determined
NOTE: N.D. refers to not detectable.

## RESULTS

### Survey Samples - Fall, 1979

Table 9 summarizes the occurrence of organochlorine contaminants in fishes collected in Lake Erie tributary mouths, August-December 1979. The occurrence ranged from 0 to 96%; this included a high of 96% for p,p'-DDD to 0% for Endosulfan ( $\alpha$ and $\beta$ ) and Toxaphene. The overall mean occurrence for all contaminants was 48%. The range for all the organochlorine contaminants was from 0.01 to 15.00 ppm. Most of the contaminants (63%) had maximum concentrations less than 0.50 ppm. Nineteen percent of the contaminants had maximum concentrations greater than 0.50 ppm but less than 1.0 ppm; this group was comprised of Aldrin, Chlordane, o,p'-DDE, p,p'-DDE, and o,p'-DDT. Maximum concentration levels in excess of 1.0 ppm were found for $\gamma$-BHC, Aroclor 1016, Aroclor 1254, Aroclor 1260, and Total PCBs.

The majority of the contaminants (77%) had mean concentration levels less than 0.10 ppm (Table 9). Those contaminants exceeding this level were $\gamma$-BHC, Chlordane, Aroclor 1016, Aroclor 1254, Aroclor 1260, and Total PCBs. Maximum values for each contaminant are reported in Table 10.

### Gizzard Shad

Age Group 0 gizzard shad were analyzed from the following tributaries: Raisin, Maumee, Sandusky, Cuyahoga, Chagrin, Grand,

TABLE 9

SUMMARY OF THE OCCURRENCE OF ORGANOCHLORINE CONTAMINANTS IN FISHES COLLECTED IN LAKE ERIE TRIBUTARY MOUTHS, AUGUST - DECEMBER 1979

| Contaminant | N[1] | Percent[2] | Range[3] (PPM) | Mean[4] (PPM) |
|---|---|---|---|---|
| Aldrin | 31 | 62 | 0.01-0.55 | 0.07 |
| α -BHC | 33 | 66 | 0.01-0.41 | 0.05 |
| β -BHC | 7 | 14 | 0.01-0.34 | 0.07 |
| γ -BHC | 7 | 14 | 0.01-2.30 | 0.42 |
| Chlordane | 38 | 76 | 0.05-0.93 | 0.16 |
| DDT and Metabolites | | | | |
| o,p'-DDD | 14 | 28 | 0.01-0.29 | 0.07 |
| p,p'-DDD | 48 | 96 | 0.01-0.39 | 0.06 |
| o,p'-DDE | 38 | 76 | 0.01-0.57 | 0.08 |
| p,p'-DDE | 41 | 82 | 0.01-0.60 | 0.06 |
| o,p'-DDT | 34 | 68 | 0.01-0.60 | 0.08 |
| p,p'-DDT | 21 | 42 | 0.01-0.22 | 0.04 |
| Dieldrin | 38 | 76 | 0.01-0.17 | 0.05 |
| α -Endosulfan | 0 | 0 | | |
| β -Endosulfan | 0 | 0 | | |
| Endrin | 11 | 22 | 0.01-0.23 | 0.06 |
| Heptachlor | 15 | 30 | 0.01-0.25 | 0.10 |
| Heptachlor Epoxide | 12 | 24 | 0.01-0.10 | 0.07 |
| Hexachlorobenzene | 24 | 48 | 0.01-0.08 | 0.03 |
| 2, 4-D | 2 | 4 | 0.03-0.05 | 0.04 |
| Methoxychlor | 41 | 82 | 0.01-0.46 | 0.06 |
| Mirex | 22 | 44 | 0.01-0.06 | 0.03 |
| Toxaphene | 0 | 0 | | |
| Trifluralin | 34 | 68 | 0.02-0.21 | 0.06 |
| PCBs | | | | |
| Aroclor 1016 | 6 | 12 | 0.20-15.00 | 2.00 |
| Aroclor 1254 | 45 | 90 | 0.05-1.80 | 0.41 |
| Aroclor 1260 | 44 | 88 | 0.05-2.80 | 0.40 |
| Total PCBs | 46 | 92 | 0.10-17.60 | 1.60 |

[1]Refers to number of samples greater than or equal to the detection limit.

[2]Refers to the percent of occurrence out of 50 samples.

[3]Range values include only those concentrations greater than or equal to the detection limit (PCB concentration levels less than or equal to the working detection limit are considered equal to the working detection limit and reported as such).

[4]Mean calculations based on range values.

TABLE 10
MAXIMUM VALUES OF ORGANOCHLORINE CONTAMINANTS IN FISH SAMPLES FROM LAKE ERIE TRIBUTARY MOUTHS, AUGUST - DECEMBER 1979

| Contaminant | Species | Age Group | Tributary | ppm[1] | Number[2] |
|---|---|---|---|---|---|
| Aldrin | Carp | IV | Cuyahoga | 0.07 | 1 |
| | | | Maumee | 0.23 | 2 |
| | | | Raisin | 0.55* | 3 |
| α -BHC | Yellow Perch | II | Maumee | 0.20 | 42 |
| | Emerald Shiner | I | Ashtabula | 0.28 | 17 |
| | White Bass | 0 | Ashtabula | 0.41* | 2 |
| β -BHC | Gizzard Shad | 0 | Ashtabula | 0.34* | 52 |
| | Carp | IV | Raisin | 0.13 | 3 |
| γ -BHC | Gizzard Shad | I | Sandusky | 0.21 | 4 |
| | Gizzard Shad | 0 | Ashtabula | 0.30 | 52 |
| | White Bass | 0 | Ashtabula | 2.30* | 2 |
| Chlordane | Channel Catfish | VI | Sandusky | 0.93* | 1 |
| | Carp | IX | Black | 0.71 | 1 |
| o,p'-DDD | Channel Catfish | VI | Sandusky | 0.29* | 1 |
| p,p'-DDD | Channel Catfish | VI | Sandusky | 0.39* | 1 |
| | Carp | IX | Black | 0.21 | 1 |
| | Carp | IV | Maumee | 0.17 | 2 |
| | Spottail Shiner | I | Raisin | 0.16 | 4 |
| o,p'-DDE | Channel Catfish | VI | Sandusky | 0.24 | 1 |
| | Carp | IX | Black | 0.57* | 1 |
| | Carp | IV | Cuyahoga | 0.17 | 1 |
| | Spottail Shiner | I | Maumee | 0.22 | 50 |
| | Carp | IV | Maumee | 0.17 | 2 |
| | Spottail Shiner | I | Ashtabula | 0.12 | 2 |
| | Spottail Shiner | I | Raisin | 0.10 | 4 |
| p,p'-DDE | Channel Catfish | VI | Sandusky | 0.60* | 1 |
| | Carp | IX | Black | 0.25 | 1 |
| | Spottail Shiner | I | Maumee | 0.11 | 50 |
| | Spottail Shiner | I | Raisin | 0.08 | 4 |
| o,p'-DDT | White Bass | II | Sandusky | 0.15 | 5 |
| | Channel Catfish | VI | Sandusky | 0.60* | 1 |
| | Gizzard Shad | I | Black | 0.49 | 11 |
| | Carp | IX | Black | 0.29 | 1 |
| | Spottail Shiner | I | Raisin | 0.10 | 4 |

TABLE 10 (cont'd)
MAXIMUM VALUES OF ORGANOCHLORINE CONTAMINANTS IN FISH SAMPLES FROM LAKE ERIE TRIBUTARY MOUTHS, AUGUST - DECEMBER 1979

| Contaminant | Species | Age Group | Tributary | ppm[1] | Number[2] |
|---|---|---|---|---|---|
| p,p'-DDT | Channel Catfish | VI | Sandusky | 0.22* | 1 |
| | Carp | IX | Black | 0.12 | 1 |
| Dieldrin | Channel Catfish | VI | Sandusky | 0.14 | 1 |
| | Carp | IX | Black | 0.17* | 1 |
| | Gizzard Shad | I | Grand | 0.12 | 11 |
| | Carp | IV | Raisin | 0.15 | 3 |
| α -Endosulfan | All below working detection limits | | | | |
| β -Endosulfan | All below working detection limits | | | | |
| Endrin | Carp | IX | Black | 0.17 | 1 |
| | Carp | IV | Raisin | 0.23* | 3 |
| Heptachlor | Carp | IV | Maumee | 0.16 | 2 |
| | Gizzard Shad | 0 | Ashtabula | 0.14 | 52 |
| | White Bass | 0 | Ashtabula | 0.25* | 2 |
| | Carp | IV | Raisin | 0.25* | 3 |
| | Spottail Shiner | I | Raisin | 0.13 | 4 |
| | Brown Bullhead | II | Raisin | 0.17 | 2 |
| Hept. Epoxide | Carp | IX | Black | 0.10* | 1 |
| | Carp | IV | Raisin | 0.09 | 3 |
| HCB | Gizzard Shad | 0 | Chagrin | 0.07 | 55 |
| | Carp | IV | Raisin | 0.08* | 3 |
| | Freshwater Drum | I | Toussaint | 0.06 | 14 |
| 2, 4-D (Isop. ester) | Gizzard Shad | I | Black | 0.05* | 11 |
| | Gizzard Shad | I | Grand | 0.03 | 11 |
| Methoxychlor | Gizzard Shad | 0 | Sandusky | 0.13 | 24 |
| | White Bass | II | Sandusky | 0.36 | 5 |
| | Yellow Perch | I | Sandusky | 0.16 | 2 |
| | Carp | IV | Sandusky | 0.10 | 4 |
| | Spottail Shiner | I | Grand | 0.23 | 3 |
| | Gizzard Shad | 0 | Chagrin | 0.11 | 55 |
| | Emerald Shiner | I | Chagrin | 0.46* | 12 |
| | Carp | IV | Raisin | 0.14 | 3 |
| Mirex | Gizzard Shad | 0 | Sandusky | 0.06* | 24 |
| | Spottail Shiner | I | Raisin | 0.05 | 4 |

TABLE 10 (cont'd)
MAXIMUM VALUES OF ORGANOCHLORINE CONTAMINANTS IN FISH SAMPLES FROM LAKE ERIE TRIBUTARY MOUTHS, AUGUST - DECEMBER 1979

| Contaminant | Species | Age Group | Tributary | ppm[1] | Number[2] |
|---|---|---|---|---|---|
| Toxaphene | All below working detection limits | | | | |
| Trifluralin | Carp | IX | Black | 0.10 | 1 |
| | Gizzard Shad | 0 | Maumee | 0.11 | 57 |
| | White Bass | 0 | Maumee | 0.10 | 4 |
| | Smelt | I | Ashtabula | 0.12 | 43 |
| | Emerald Shiner | II | Chagrin | 0.21* | 35 |
| Aroclor 1016 | Gizzard Shad | 0 | Raisin | 1.80 | 12 |
| | Carp | IV | Raisin | 15.00* | 3 |
| | Brown Bullhead | II | Raisin | 8.00 | 2 |
| | Spottail Shiner | I | Raisin | 3.81 | 4 |
| | Carp | IV | Maumee | 2.70 | 2 |
| Aroclor 1254 | Carp | IV | Raisin | 1.70 | 3 |
| | Spottail Shiner | I | Raisin | 1.03 | 4 |
| | Carp | IX | Black | 1.30 | 1 |
| | Channel Catfish | VI | Sandusky | 1.80* | 1 |
| Aroclor 1260 | Carp | IV | Raisin | 0.90 | 3 |
| | Spottail Shiner | I | Raisin | 0.92 | 4 |
| | Channel Catfish | VI | Sandusky | 2.80* | 1 |
| Total PCBs | Freshwater Drum | I | Toussaint | 1.07 | 14 |
| | Gizzard Shad | I | Sandusky | 1.06 | 4 |
| | Channel Catfish | VI | Sandusky | 5.10 | 1 |
| | Carp | IX | Black | 2.47 | 1 |
| | Spottail Shiner | I | Cuyahoga | 1.26 | 26 |
| | Spottail Shiner | II | Cuyahoga | 1.03 | 22 |
| | Carp | IV | Cuyahoga | 1.02 | 1 |
| | Spottail Shiner | I | Maumee | 1.70 | 50 |
| | Yellow Perch | II | Maumee | 1.40 | 42 |
| | White Bass | 0 | Maumee | 1.56 | 4 |
| | Carp | IV | Maumee | 3.78 | 2 |
| | Emerald Shiner | I | Chagrin | 1.22 | 12 |
| | Carp | IV | Raisin | 17.60* | 3 |
| | Spottail Shiner | I | Raisin | 5.76 | 4 |
| | Brown Bullhead | II | Raisin | 9.61 | 2 |
| | Gizzard Shad | 0 | Raisin | 3.20 | 12 |

*Maximum concentration recorded from field samples in 1979.

[1]Concentration in parts per million (μg/g)

[2]Total number of fish in sample

and Ashtabula (Table 6). Age group I samples were analyzed from the Sandusky, Black, and Grand rivers.

Age Group 0. Most of the concentration levels were less than 0.10 ppm. Table 11 lists concentration levels for selected contaminants in gizzard shad from the seven Lake Erie tributaries. These contaminant levels illustrate marked differences between tributaries. The River Raisin sample had the highest concentration of Aldrin (0.16 ppm) and Total PCBs (3.23 ppm). The Ashtabula River sample contained concentrations of 0.34 ppm for β-BHC and 0.30 ppm for γ-BHC. The β-BHC level of 0.34 ppm represented the highest concentration found in all of the 50 fish samples. Concentration levels of not detected (N.D.) to 0.19 ppm were found for Chlordane, o,p'-DDE, Methoxychlor, Mirex, and Trifluralin. The Maumee River sample contained the highest concentration of Chlordane, o,p'-DDE, and Trifluralin. The Sandusky River sample had the highest levels for Methoxychlor and Mirex; the Mirex level of 0.06 ppm was the maximum concentration found in the 50 fish samples. Total PCBs ranged from 0.20 to 3.23 ppm; the peak concentration coming from the River Raisin sample.

Age Group I. Age Group I gizzard shad analyzed from the Sandusky, Black, and Grand Rivers generally showed low levels of organochlorine contaminants. The Black River sample was found to contain a concentration of o,p'-DDT at 0.49 ppm; this

TABLE 11

SELECTED ORGANOCHLORINE CONTAMINANT CONCENTRATIONS (PPM) FOUND IN AGE GROUP 0 GIZZARD SHAD COLLECTED FROM LAKE ERIE TRIBUTARIES, FALL 1979

| Contaminant | Tributary | | | | | | |
|---|---|---|---|---|---|---|---|
| | Raisin N:12 | Maumee N:57 | Sandusky N:24 | Cuyahoga N:16 | Chagrin N:55 | Grand N:40 | Ashtabula N:52 |
| Aldrin | 0.16 | 0.08 | N.D. | N.D. | 0.01 | 0.02 | 0.02 |
| α-BHC | N.D. | 0.02 | N.D. | N.D. | N.D. | N.D. | 0.34 |
| β-BHC | N.D. | 0.01 | N.D. | N.D. | N.D. | N.D. | 0.30 |
| Chlordane | N.D. | 0.19 | 0.13 | N.D. | N.D. | 0.15 | 0.05 |
| o,p'-DDE | 0.06 | 0.15 | N.D. | 0.04 | N.D. | 0.01 | N.D. |
| Methoxychlor | 0.02 | 0.03 | 0.13 | 0.03 | 0.11 | 0.05 | 0.01 |
| Mirex | N.D. | 0.03 | 0.06 | 0.01 | 0.02 | 0.03 | 0.02 |
| Trifluralin | N.D. | 0.11 | 0.03 | 0.07 | 0.05 | 0.06 | N.D. |
| Total PCBs | 3.23 | 0.92 | 0.20 | 0.29 | 0.41 | 0.71 | 0.26 |

NOTE: N refers to total number of fish.
N.D. refers to Not Detected (trace or not present).

was the maximum concentration from all fish samples (Table 6). The Black and Grand river samples contained 2,4-D (Isopropyl ester) concentrations of 0.05 and 0.03 ppm, respectively; this contaminant was not detected in any of the other 50 samples. Total PCBs ranged from 0.79 to 1.06 ppm.

Emerald Shiners

A total of four emerald shiner samples were analyzed from the Chagrin, Grand, and Ashtabula rivers. Each of these three tributaries yielded one age group I sample for analysis. Additionally, an Age Group II sample from the Chagrin was analyzed.

Age Group I. The majority of the organochlorine contaminant levels were found in N.D. or low concentrations. Twenty-one of the 27 contaminants were found at concentrations less than 0.10 ppm. Those contaminants found at higher levels were $\alpha$-BHC, Methoxychlor, Aroclors 1016, 1254, and 1260, and Total PCBs. The Ashtabula River sample contained the highest $\alpha$-BHC concentration of 0.28 ppm. The highest concentration of Methoxychlor was found in the Chagrin River sample at 0.46 ppm. Total PCBs ranged from 0.29 to 1.22 ppm; the peak concentration being found in the Chagrin River sample.

Age Group II. This single group from the Chagrin River contained primarily N.D. or low contaminant concentrations. Trifluralin was detected at 0.21 ppm; this level represents the maximum concentration from all 50 samples.

Spottail Shiner

Eight age group I spottail shiner samples were analyzed from the following tributaries: Raisin, Maumee, Black, Cuyahoga, Grand, and Ashtabula. Additionally, the Black and Cuyahoga rivers had age group II samples analyzed.

Age Group I. The concentration levels of selected organochlorine contaminants varied between tributaries (Table 12). The River Raisin had maximum concentrations of Aldrin, p,p'-DDD, o,p'-DDT, Dieldrin, Heptachlor, Mirex, Aroclors 1016, 1254, and 1260, and Total PCBs (Table 12). Maximum concentrations of Chlordane, o,p'-DDE, p,p'-DDE were found in the Maumee River sample. The Cuyahoga River sample also contained the maximum concentration of Chlordane while the Grand River sample contained the highest Methoxychlor concentration.

Age Group II. The majority of the age group II spottail shiner samples from the Black and Cuyahoga rivers were found to have N.D. or low levels. Only four contaminants (Chlordane,

TABLE 12

SELECTED ORGANOCHLORINE CONTAMINANT CONCENTRATIONS (PPM) FOUND IN AGE GROUP I SPOTTAIL SHINERS COLLECTED FROM LAKE ERIE TRIBUTARIES, FALL 1979

| Contaminant | Tributary | | | | | |
|---|---|---|---|---|---|---|
| | Raisin N:4 | Maumee N:50 | Black N:7 | Cuyahoga N:26 | Grand N:3 | Ashtabula N:2 |
| Aldrin | 0.29 | N.D. | N.D. | 0.04 | N.D. | 0.02 |
| Chlordane | N.D. | 0.20 | 0.08 | 0.20 | 0.10 | 0.17 |
| p,p'-DDD | 0.16 | 0.10 | 0.06 | 0.05 | 0.03 | 0.07 |
| o,p'-DDE | 0.10 | 0.22 | N.D. | 0.03 | 0.08 | 0.12 |
| p,p'-DDE | 0.08 | 0.11 | 0.07 | 0.06 | 0.02 | 0.08 |
| o,p'-DDT | 0.10 | 0.06 | 0.03 | 0.02 | N.D. | 0.08 |
| Dieldrin | 0.10 | 0.05 | 0.02 | 0.05 | 0.04 | N.D. |
| Heptachlor | 0.13 | 0.02 | N.D. | N.D. | N.D. | N.D. |
| Methoxychlor | 0.07 | 0.02 | 0.01 | 0.03 | 0.23 | 0.02 |
| Mirex | 0.05 | 0.01 | 0.04 | N.D. | N.D. | N.D. |
| Aroclor 1016 | 3.81 | 0.50 | N.D. | 0.30 | N.D. | N.D. |
| Aroclor 1254 | 1.03 | 0.68 | 0.30 | 0.54 | 0.14 | 0.28 |
| Aroclor 1260 | 0.92 | 0.52 | 0.32 | 0.42 | 0.16 | 0.32 |
| Total PCBs | 5.76 | 1.70 | 0.62 | 1.26 | 0.30 | 0.60 |

NOTE: N refers to total number of fish.
N.D. refers to Not Detected (trace or not present).

Aroclors 1254 and 1260, and Total PCBs) were found in levels greater than 0.10 ppm (Appendix A).

Smelt

Age group I Smelt were analyzed from the Grand and Ashtabula rivers. All contaminants, with the exception of Chlordane, Trifluralin, Aroclors 1016, 1254, and 1260, and Total PCBs, were at N.D. or low levels (less than 0.08 ppm). The Grand River sample contained a Chlordane concentration of 0.10 ppm. Trifluralin was found in the Ashtabula River sample at 0.12 ppm.

Freshwater Drum

Four freshwater drum samples were analyzed from the Toussaint, Sandusky, and Black rivers; this included two Age Group 0 samples from the Sandusky and Black Rivers and two age group 1 samples from the Toussaint and Sandusky Rivers.

Age Group 0. This age group was found to contain N.D. or very low concentration levels for all 27 organochlorine contaminants. The maximum contaminant level was found to be 0.07 ppm for Methoxychlor in the Sandusky River sample. Individual Aroclors and Total PCBs were less than the detection limit for both samples.

Age Group I. This group was found to have N.D. or low concentrations of contaminants with the exception of the Toussaint

River sample for Chlordane, p,p'-DDD, Aroclors 1016, 1254, and 1260, and Total PCBs (Appendix A). Chlordane was detected at 0.26 ppm while p,p'-DDD was found at 0.11 ppm. Total PCBs for the Toussaint River sample was 1.17 ppm.

Yellow Perch

Four yellow perch samples were analyzed from the Maumee, Sandusky, and Cuyahoga Rivers. Each of these three rivers yielded age group II samples while the Sandusky River also had an age group I sample analyzed.

Age Group I. The single yellow perch sample was found to have N.D. concentration levels for 18 of the 27 contaminants. Only five of the remaining nine contaminants were equal to or in excess of 0.10 ppm; these were Chlordane (0.10), Methoxychlor (0.16), Aroclor 1254 (0.13), Aroclor 1260 (0.25), and Total PCBs (0.38).

Age Group II. Table 13 lists the levels of selected organochlorine contaminants found among the three Lake Erie tributaries. Twenty-one of the 27 contaminants were found at N.D. or low concentration levels (less than 0.10 ppm). The Maumee River sample contained the highest concentration levels for the six selected contaminants (Table 13).

TABLE 13

SELECTED ORGANOCHLORINE CONTAMINANT CONCENTRATIONS (PPM) FOUND IN AGE GROUP II YELLOW PERCH FROM LAKE ERIE TRIBUTARIES, FALL 1979

| Contaminant | Tributary | | |
|---|---|---|---|
| | Maumee N:42 | Sandusky N:9 | Cuyahoga N:2 |
| α-BHC | 0.20 | N.D. | N.D. |
| Chlordane | 0.20 | 0.08 | 0.11 |
| Aroclor 1016 | 0.40 | N.D. | N.D. |
| Aroclor 1254 | 0.53 | 0.14 | 0.17 |
| Aroclor 1260 | 0.47 | 0.21 | 0.19 |
| Total PCBs | 1.40 | 0.35 | 0.36 |

NOTE: N refers to total number of fish.
N.D. refers to Not Detected (trace or not present).

White Bass

A total of nine white bass samples were analyzed from the Maumee, Toussaint, Sandusky, Black, Cuyahoga, and Ashtabula rivers. The sample breakdown by age group was as follows: age group 0; Maumee, Sandusky, Black, Cuyahoga, and Ashtabula rivers, age group I; Toussaint and Sandusky rivers, age group II; Toussaint and Sandusky rivers.

Age Group 0. The majority (19 of 27) of the contaminants were found at concentrations equal to or less than 0.10 ppm. Those contaminants in excess of this limit are listed in Table 14. The Ashtabula River sample was found to contain the highest concentration levels for $\alpha$-BHC, $\gamma$-BHC, and Heptachlor. These levels were the maximum detected for both Age Group 0 white bass and for the 50 fish samples analyzed. Chlordane levels ranged from N.D. to 0.20 ppm; the highest concentration found in the Maumee River sample. Total PCBs ranged from 0.27 to 1.56 ppm; the highest concentration again being found in the Maumee River sample.

Age Group I. All 27 organochlorine contaminants were found in N.D. or low concentration levels (Appendix A). Only three contaminants, Aroclors 1254 and 1260, and Total PCBs, were found at levels exceeding 0.09 ppm. Concentration levels of Total PCBs for the Sandusky and Toussaint samples were 0.63 and 0.41 ppm, respectively.

TABLE 14

SELECTED ORGANOCHLORINE CONTAMINANT CONCENTRATIONS (PPM) FOUND IN AGE GROUP 0 WHITE BASS FROM LAKE ERIE TRIBUTARIES, FALL 1979

| Contaminant | Tributary | | | | |
|---|---|---|---|---|---|
| | Maumee N:4 | Sandusky N:12 | Black N:3 | Cuyahoga N:2 | Ashtabula N:2 |
| α-BHC | 0.06 | 0.01 | N.D. | 0.02 | 0.41 |
| γ-BHC | N.D. | N.D. | N.D. | N.D. | 2.30 |
| Chlordane | 0.20 | N.D. | 0.06 | 0.15 | N.D. |
| Heptachlor | 0.04 | N.D. | N.D. | N.D. | 0.25 |
| Total PCBs | 1.56 | 0.27 | 0.27 | 0.71 | 0.76 |

NOTE: N refers to total number of fish.
N.D. refers to Not Detected (trace or not present).

Age Group II. The Sandusky River sample was found to have N.D. or low concentrations (less than 0.10 ppm) for 20 of the 27 contaminants (Appendix A). Those contaminants equal to or in excess of 0.10 ppm were: Chlordane (0.14), o,p'-DDT (0.15), Dieldrin (0.10), Methoxychlor (0.36), Aroclor 1254 (0.51), Aroclor 1260 (0.35), and Total PCBs (0.86). The Toussaint River sample was found to have N.D. levels for 17 of the 27 contaminants. Only Aroclors 1254 and 1260, and Total PCBs were found at concentrations greater than 0.06 ppm. Total PCBs were found at 0.71 ppm.

Brown Bullhead

Age Group II. Brown bullhead samples were analyzed from the Raisin and Black rivers. The Raisin River sample was found to have N.D. and low concentrations (less than 0.09 ppm) for 20 of the 27 contaminants (Appendix A). Those contaminants found at levels exceeding 0.09 ppm were: Aldrin (0.28), Heptachlor (0.17), Aroclor 1016 (8.0), Aroclor 1254 (0.84), Aroclor 1260 (0.76), and Total PCBs (9.60). The Black River sample was found to contain N.D. or low concentrations (less than 0.08 ppm) for 24 of the 27 contaminants. Only Aroclors 1254 and 1260, and Total PCBs were found in concentrations greater than 0.07 ppm.

Channel Catfish

Age Group VI. A single channel catfish from the Sandusky River comprised this sample. Fifteen of the 27 contaminants were

found in N.D. or low concentrations. The following contaminant levels (ppm) were found to be maximum concentrations for all 50 samples analyzed: Chlordane (0.93), o,p'-DDD (0.29), p,p'-DDD (0.39), p,p'-DDE (0.60), o,p'-DDT (0.60), p,p'-DDT (0.22), Aroclor 1254 (1.8), and Aroclor 1260 (2.8). The o,p'-DDE concentration was 0.24 ppm and Dieldrin was found to be 0.14 ppm.

Carp

Six samples of carp were analyzed for organochlorine contaminants. Age group IV samples were analyzed from the Raisin, Maumee, Toussaint, Sandusky, and Cuyahoga rivers. A single age group IX sample was analyzed from the Black River.

Age Group IV. Table 15 lists selected contaminant levels for this group. These concentrations were among the highest for the 50 fish samples. For example, the River Raisin sample was found to have the maximum concentrations for the following contaminants: Aldrin, β-BHC, Endrin, Heptachlor, Hexachlorobenzene, Aroclor 1016, and Total PCBs (Tables 10 and 15). Additionally, the River Raisin sample was found to have the highest levels of o,p'-DDD, Dieldrin, Heptachlor Epoxide, Methoxychlor, Aroclor 1254, and Aroclor 1260 for all age group IV carp (Table 15). The Maumee River sample contained the highest concentrations of p,p'-DDD and o,p'-DDE. Samples from the Toussaint, Sandusky, and Cuyahoga

TABLE 15

SELECTED ORGANOCHLORINE CONTAMINANT CONCENTRATIONS (PPM) FOUND IN AGE GROUP IV CARP FROM LAKE ERIE TRIBUTARIES, FALL 1979

| Contaminant | Tributary | | | | |
|---|---|---|---|---|---|
| | Raisin N:3 | Maumee N:2 | Toussaint N:10 | Sandusky N:4 | Cuyahoga N:1 |
| Aldrin | 0.55 | 0.23 | 0.02 | N.D. | 0.07 |
| β-BHC | 0.13 | 0.02 | N.D. | N.D. | N.D. |
| Chlordane | N.D. | 0.25 | 0.17 | 0.14 | 0.14 |
| o,p'-DDD | 0.12 | 0.08 | 0.03 | N.D. | 0.03 |
| p,p'-DDD | 0.13 | 0.17 | 0.09 | 0.06 | 0.05 |
| o,p'-DDE | N.D. | 0.17 | 0.04 | 0.08 | 0.17 |
| Dieldrin | 0.15 | 0.04 | 0.06 | 0.05 | 0.02 |
| Endrin | 0.23 | N.D. | N.D. | N.D. | N.D. |
| Heptachlor | 0.25 | 0.16 | N.D. | N.D. | N.D. |
| Hept. Epox. | 0.09 | 0.01 | N.D. | N.D. | 0.06 |
| HCB | 0.08 | 0.02 | 0.03 | N.D. | N.D. |
| Methoxychlor | 0.14 | 0.02 | 0.01 | 0.10 | N.D. |
| Aroclor 1016 | 15.00 | 2.70 | N.D. | N.D. | 0.40 |
| Aroclor 1254 | 1.70 | 0.80 | 0.29 | 0.14 | 0.50 |
| Aroclor 1260 | 0.90 | 0.26 | 0.58 | 0.43 | 0.12 |
| Total PCBs | 17.60 | 3.76 | 0.87 | 0.57 | 1.02 |

NOTE: N refers to total number of fish
N.D. refers to Not Detected (trace or not present)

levels with the control group concentrations shows slight increase or decrease for 14 contaminants. The remaining 13 contaminant concentrations did not change.

Cuyahoga River

Comparisons of the yellow perch sample with the control group concentrations show 12 of the contaminants increasing slightly by the end of the holding period. Nine of the contaminant levels did not change. Six contaminants (o,p'-DDD, o,p'-DDE, p,p'-DDT, Hexachlorobenzene, Mirex, and Trifluralin) increased markedly. Similar comparisons of the channel catfish sample with the control group show slight increases for eight contaminants. Seven contaminants decreased slightly, with o,p'-DDE decreasing markedly from 0.48 to 0.09 ppm. Seven contaminants remained unchanged. Four contaminants (β-Endosulfan, Hexachlorobenzene, Methoxychlor, and Trifluralin) increased markedly.

Hexachlorobenzene and Trifluralin increased substantially in both the yellow perch and channel catfish samples (Figure 10).

## Uptake Rate Experiment - Spring 1980

Samples of approximately 30-50 channel catfish and bluegills were removed from the Maumee, Cuyahoga, and Ashtabula rivers over

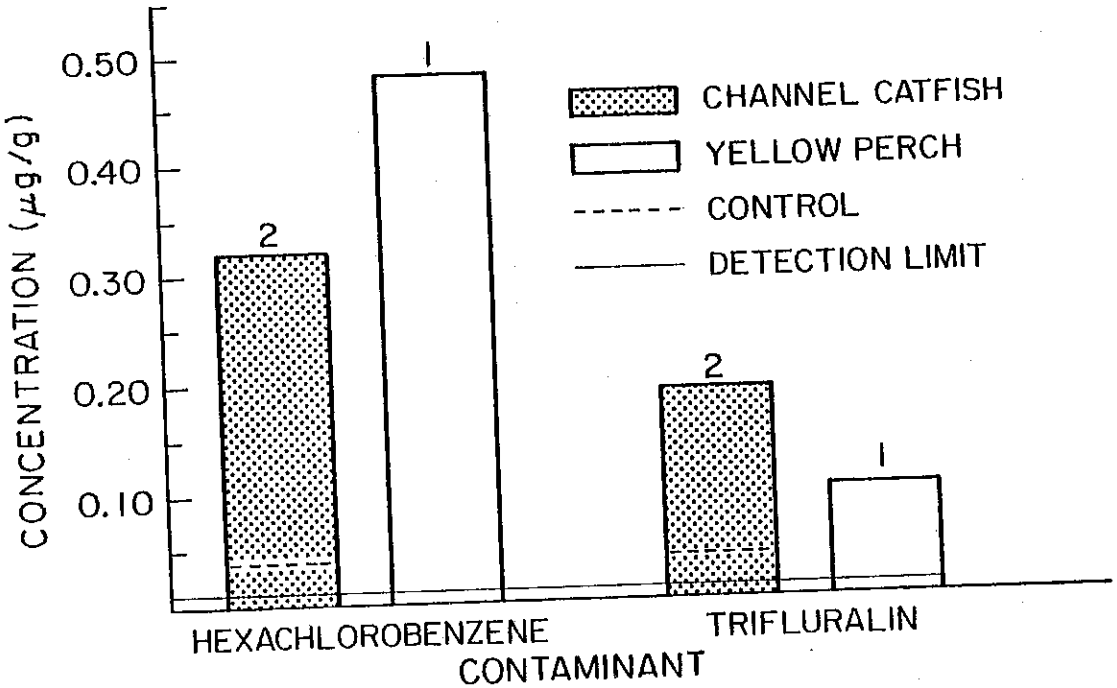



Figure 10. Uptake of Hexachlorobenzene and Trifluralin by Channel Catfish and Yellow Perch - Cuyahoga River 20 October - 17 November, 1979

a six-week period (Table 16). Control group samples for both species were removed at the beginning of the experiment on 23 May.

Table 17 summarizes the occurrence of the organochlorine contaminants by the caged fish. Six contaminants, Chlordane, p,p'-DDT, α-Endosulfan, Hexachlorobenzene, Mirex, Toxaphene, and Aroclor 1016 were not detected in any of the 27 experimental groups. The majority (19 of 27) of the contaminants occurred less than 50 percent of the time in the 27 experimental groups. Six of the eight contaminants found in excess of 50 percent occurrence were detected at concentration levels greater than 0.10 ppm. These six contaminants were: p,p'-DDD, p,p'-DDE, Dieldrin, Trifluralin, Aroclor 1254, and Total PCBs. Additional contaminants found in excess of 0.10 ppm, but occurring in less than 50 percent of the samples, were α-BHC, o,p'-DDE, β-Endosulfan, Heptachlor, and 2,4-D (Isopropyl Ester).

Appendices C and D list the analytical results for the control and experimental group channel catfish and bluegill samples. The control group channel catfish were found to contain detectable concentrations (ppm) of p,p'-DDD (0.03), o,p'-DDE (0.02), and p,p'-DDE (0.09). The control group bluegill sample was found to contain detectable concentrations for only one contaminant - p,p'-DDE (0.03).

TABLE 16

RESULTS OF SAMPLE REMOVAL OF EXPERIMENTAL GROUP
CHANNEL CATFISH AND BLUEGILLS FROM MAUMEE,
CUYAHOGA, AND ASHTABULA RIVER MOUTHS
30 May - 4 July, 1980

| Date | Tributary | | | | | |
|---|---|---|---|---|---|---|
| | Maumee | | Cuyahoga | | Ashtabula | |
| | CCF | BG | CCF | BG | CCF | BG |
| 30 May | X | X | X | X | X | X |
| 6 June | X | X | X | X | X | X |
| 13 June | X | X | N.S. | N.S. | X | X |
| 20 June | X | X | N.S. | N.S. | X | X |
| 27 June | X | X | N.S. | N.S. | X | X |
| 4 July | X | X | N.S. | N.S. | X | N.S. |

NOTE: CCF refers to Channel Catfish
BG refers to Bluegills
N.S. refers to No Sample

TABLE 17

SUMMARY OF THE OCCURRENCE OF ORGANOCHLORINE CONTAMINANTS BY CAGED YOUNG-OF-THE-YEAR FISH RECOVERED FROM THE MOUTHS OF THE MAUMEE, CUYAHOGA, AND ASHTABULA RIVERS 30 MAY - 4 JULY, 1980

| Contaminant | N | Percent | Range (ppm) |
|---|---|---|---|
| Aldrin | 3 | 11 | 0.02-0.04 |
| α-BHC | 4 | 15 | 0.04-0.18 |
| β-BHC | 3 | 11 | 0.02-0.05 |
| γ-BHC | 7 | 26 | 0.02-0.04 |
| Chlordane | 0 | --- | --- |
| o,p'-DDD | 1 | 4 | --- |
| p,p'-DDD | 23 | 85 | 0.02-0.12 |
| o,p'-DDE | 9 | 33 | 0.02-0.11 |
| p,p'-DDE | 22 | 81 | 0.03-0.14 |
| o,p'-DDT | 14 | 52 | 0.02-0.05 |
| p,p'-DDT | 0 | -- | --- |
| Dieldrin | 22 | 81 | 0.02-0.12 |
| α-Endosulfan | 0 | --- | --- |
| β-Endosulfan | 3 | 11 | 0.08-0.12 |
| Endrin | 4 | 15 | 0.02-0.03 |
| Heptachlor | 4 | 15 | 0.02-0.28 |
| Heptachlor Epoxide | 15 | 55 | 0.02-0.06 |
| Hexachlorobenzene | 0 | -- | --- |
| 2,4-D (Isopropyl Ester) | 4 | 15 | 0.12-0.14 |
| Methoxcyhlor | 1 | 4 | --- |
| Mirex | 0 | --- | --- |
| Toxaphene | 0 | --- | --- |
| Trifluralin | 19 | 70 | 0.01-0.16 |
| Aroclor 1016 | 0 | --- | --- |
| Aroclor 1254 | 25 | 93 | 0.05-0.20 |
| Aroclor 1260 | 11 | 41 | 0.05-0.09 |
| Total PCBs | 25 | 93 | 0.05-0.24 |

[1] N values based on total number of channel catfish and bluegill samples greater than or equal to the detection limit.

Maumee River Samples

Twelve contaminants were not detected in any of the channel catfish samples and 16 contaminants were not found in any of the bluegill samples (Table 18). Contaminants present were generally found at levels just above the detection limits. Certain contaminants (p,p'-DDD, p,p'-DDE, Dieldrin, Heptachlor Epoxide, and Aroclor 1254) were found throughout the six-week sampling period in both channel catfish and bluegill samples (Table 18 and Appendix D).

Uptake of p,p'-DDD by channel catfish showed a general increase over the six-week period (Figure 11). The corresponding bluegill samples were found to be at lower concentrations, but the 4 July sample peaked at 0.04 ppm. Levels of p,p'-DDE varied little over the first four weeks for both species, but peak concentrations in the fifth week (27 June) were detected for channel catfish and bluegill samples.

Uptake of Dieldrin showed no real pattern of gradual increase or decrease for either species (Figure 12). Maximum concentrations for both species were attained in the interval 6 June to 13 June. The only detectable concentration (ppm) of Aldrin (0.02) for channel catfish was from the 13 June sample; this corresponds with the maximum Dieldrin concentration (0.11) for channel catfish on 13 June.

TABLE 18

PERCENT OCCURRENCE[1] OF ORGANOCHLORINE CONTAMINANTS BY CHANNEL CATFISH AND BLUEGILLS IN MAUMEE, CUYAHOGA, AND ASHTABULA RIVER MOUTHS - 30 MAY - 4 JULY, 1980

| Contaminant | Maumee | | Cuyahoga | | Ashtabula | |
|---|---|---|---|---|---|---|
| | CCF | BG | CCF | BG | CCF | BG |
| Aldrin | 17 | 17 | 50 | 0 | 0 | 0 |
| α-BHC | 33 | 0 | 50 | 50 | 0 | 0 |
| β-BHC | 0 | 0 | 0 | 0 | 50 | 0 |
| γ-BHC | 0 | 33 | 0 | 0 | 67 | 20 |
| Chlordane | 0 | 0 | 0 | 0 | 0 | 0 |
| o,p'-DDD | 17 | 0 | 0 | 0 | 0 | 0 |
| p,p'-DDD | 100 | 83 | 100 | 100 | 100 | 40 |
| o,p'-DDE | 0 | 0 | 0 | 50 | 83 | 60 |
| p,p'-DDE | 100 | 100 | 100 | 50 | 33 | 100 |
| o,p'-DDT | 33 | 50 | 50 | 0 | 67 | 80 |
| p,p'-DDT | 0 | 0 | 0 | 0 | 0 | 0 |
| Dieldrin | 100 | 100 | 100 | 100 | 50 | 60 |
| α-Endosulfan | 0 | 0 | 0 | 0 | 0 | 0 |
| β-Endosulfan | 33 | 0 | 50 | 0 | 0 | 0 |
| Endrin | 17 | 0 | 50 | 0 | 33 | 0 |
| Heptachlor | 17 | 0 | 0 | 0 | 33 | 20 |
| Hept. Epox. | 83 | 83 | 100 | 100 | 17 | 0 |
| HCB | 0 | 0 | 0 | 0 | 0 | 0 |
| 2,4-D (Isop. est.) | 0 | 0 | 0 | 0 | 33 | 40 |
| Methoxychlor | 0 | 0 | 50 | 0 | 0 | 0 |
| Mirex | 0 | 0 | 0 | 0 | 0 | 0 |
| Toxaphene | 0 | 0 | 0 | 0 | 0 | 0 |
| Trifluralin | 100 | 17 | 100 | 100 | 83 | 60 |
| Aroclor 1016 | 0 | 0 | 0 | 0 | 0 | 0 |
| Aroclor 1254 | 100 | 83 | 100 | 100 | 100 | 100 |
| Aroclor 1260 | 50 | 50 | 50 | 0 | 33 | 40 |
| Total PCBs | 100 | 83 | 100 | 100 | 100 | 80 |

NOTE: CCF = Channel Catfish; BG = Bluegill

[1]Percentages based on number of samples ≥ the detection limit.

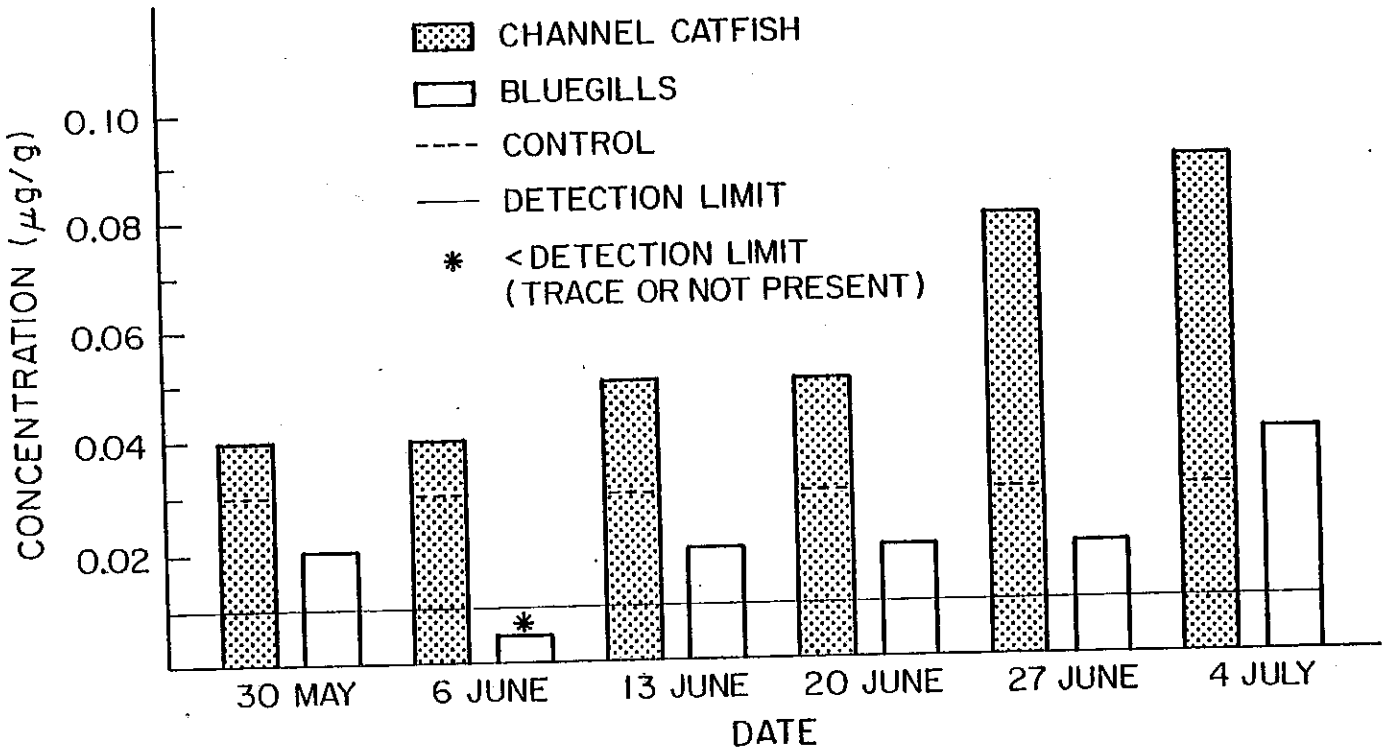



Figure 11. Uptake of p,p'-DDD by Channel Catfish and Bluegills -- Maumee River, 1980

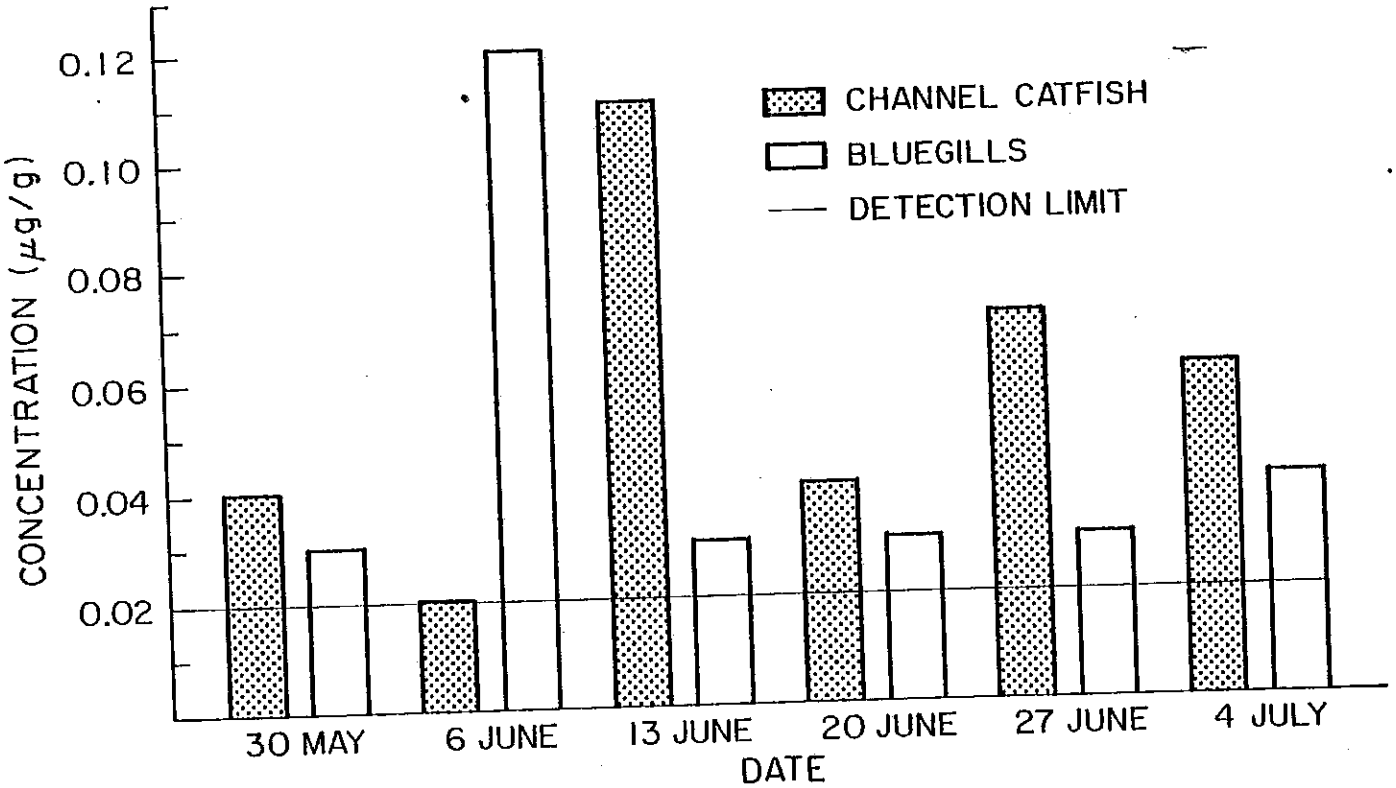



Figure 12. Uptake of Dieldrin by Channel Catfish and Bluegills -- Maumee River, 1980

Uptake of Heptachlor Epoxide shows a general increase through the six-week period for the channel catfish samples (Figure 13). The bluegill samples also show this trend, but at lower levels.

Trifluralin was detected in 100% of the channel catfish samples, but only 17% occurrence was reported for the bluegill samples (Table 18). Figure 14 illustrates the uptake of Trifluralin by both species. Most concentrations were less than 0.03 ppm, but the 13 June levels of 0.04 ppm for channel catfish and 0.02 ppm for bluegill are maximum concentrations for both species.

There was no uptake of Aroclor 1016 by any of the samples (Table 18). Aroclor 1260 was detected in 50% of the channel catfish and bluegill samples. Aroclor 1254 was found in 100% channel catfish samples and 83% of the bluegill samples. Uptake of Aroclor 1254 by both species showed a drop in concentration in the second week (6 June), followed by a gradual increase in the remaining four weeks (Figure 15).

Cuyahoga River Samples

Only two sampling dates were completed on the Cuyahoga River due to the mortality of the caged fish (Table 16). The 6 June channel catfish sample was found to have the following maximum contaminant concentrations (ppm) for all 27 experimental groups

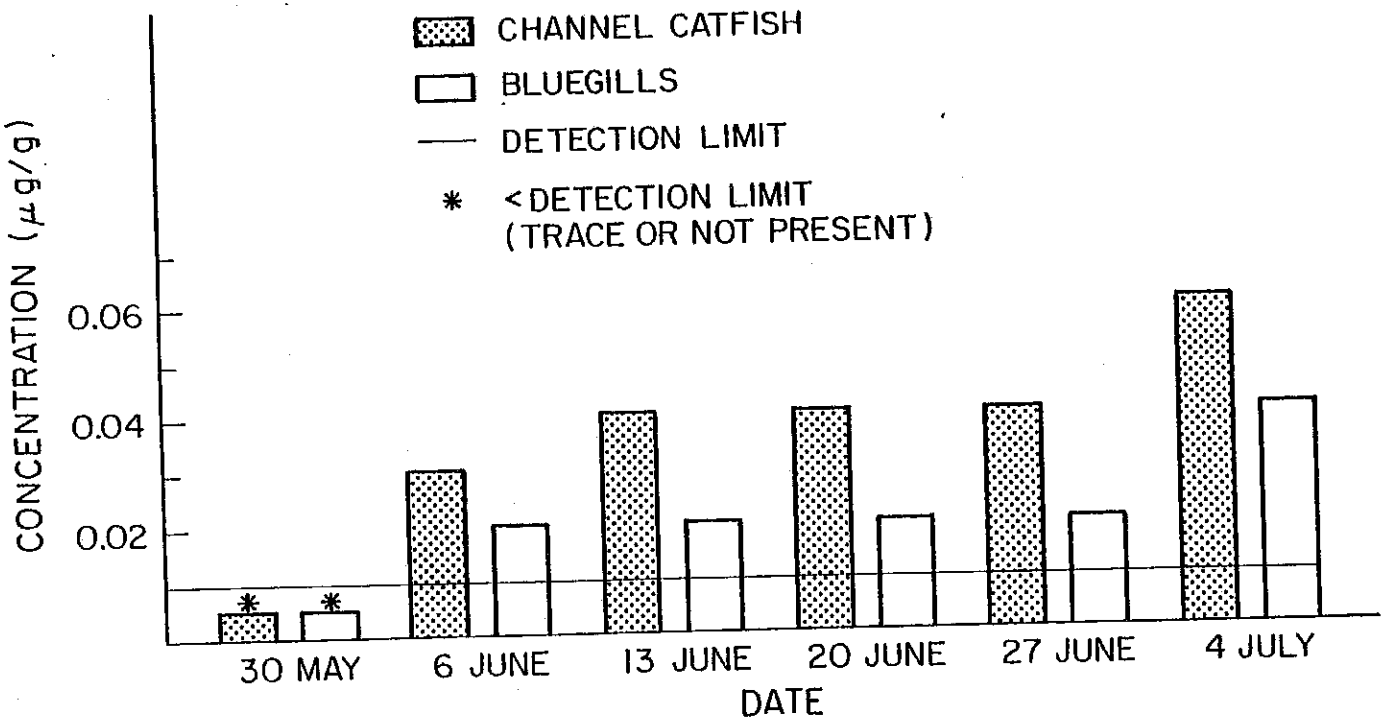



Figure 13. Uptake of Heptachlor Epoxide by Channel Catfish and Bluegills -- Maumee River, 1980

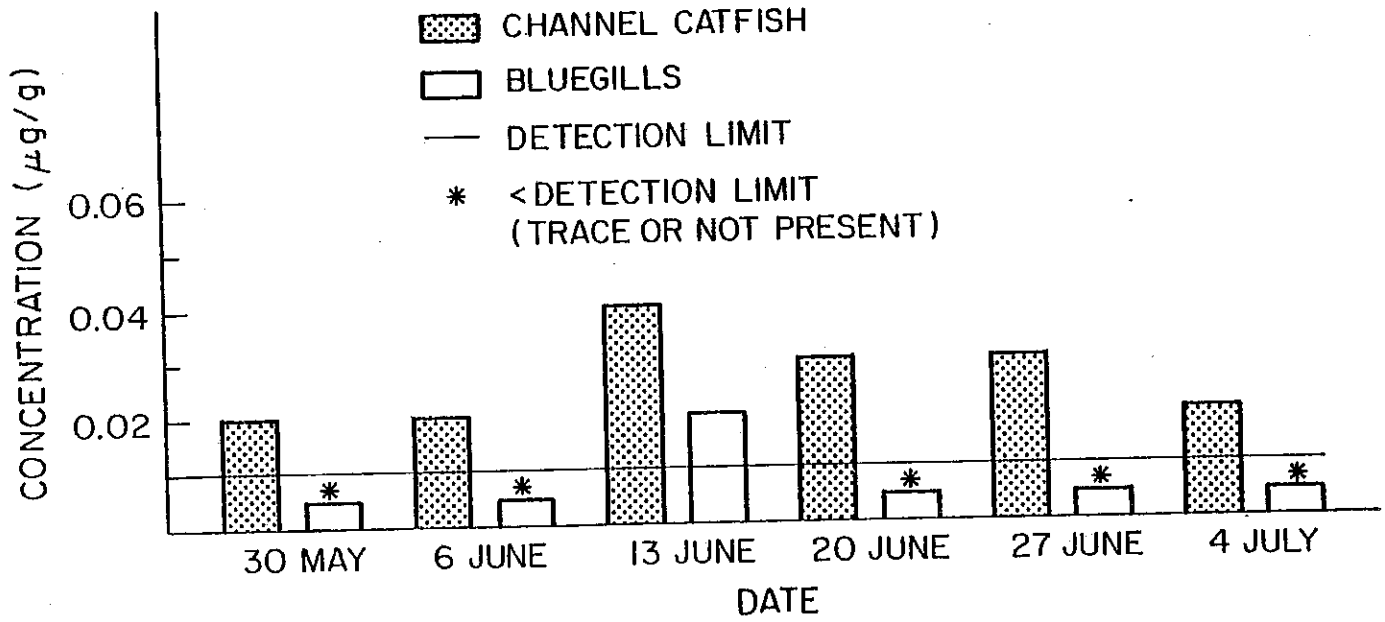



Figure 14. Uptake of Trifluralin by Channel Catfish and Bluegills -- Maumee River, 1980

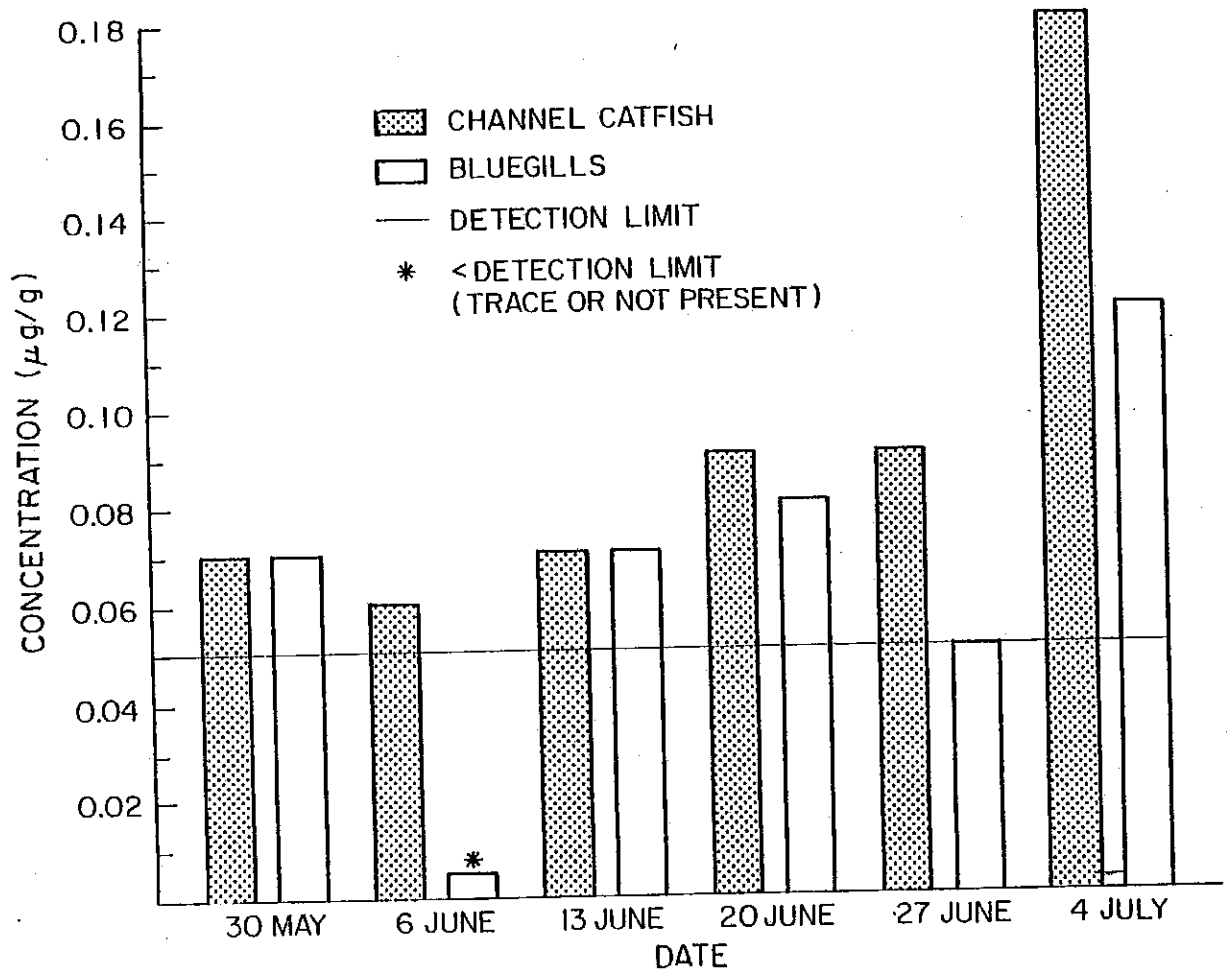



Figure 15. Uptake of Aroclor 1254 by Channel Catfish and Bluegills -- Maumee River, 1980

analyzed: p,p'-DDD (0.12), p,p'-DDE (0.14), β-Endosulfan (0.12), and Trifluralin (0.16). Trifluralin increased markedly in the channel catfish samples (Figure 16). The bluegill sample also increased, but at much lower levels. Certain contaminants (β-BHC, p,p'-DDD, Dieldrin, Heptachlor Epoxide, Trifluralin, and Aroclor 1254) were detected from the two sampling dates in both channel catfish and bluegill samples (Table 18).

Ashtabula River Samples

Twelve contaminants were not detected in any of the channel catfish samples (Table 18). Fifteen contaminants were not detected in any bluegill samples. Concentrations (ppm) of β-BHC (0.05), γ-BHC (0.04), Heptachlor (0.28), and 2,4-D (0.14) in the channel catfish samples were the maximum levels from all 27 experimental groups analyzed.

No general pattern in the uptake of p,p'-DDD was found for either species (Figure 17). The channel catfish were found to have higher concentrations than the bluegill samples, but the control group concentration of 0.03 ppm may have been a factor in elevating the channel catfish levels. Uptake of o,p'-DDE by both species showed a general trend of increase during the first two weeks, followed by a decline and rise in levels in the last four weeks (Figure 18).

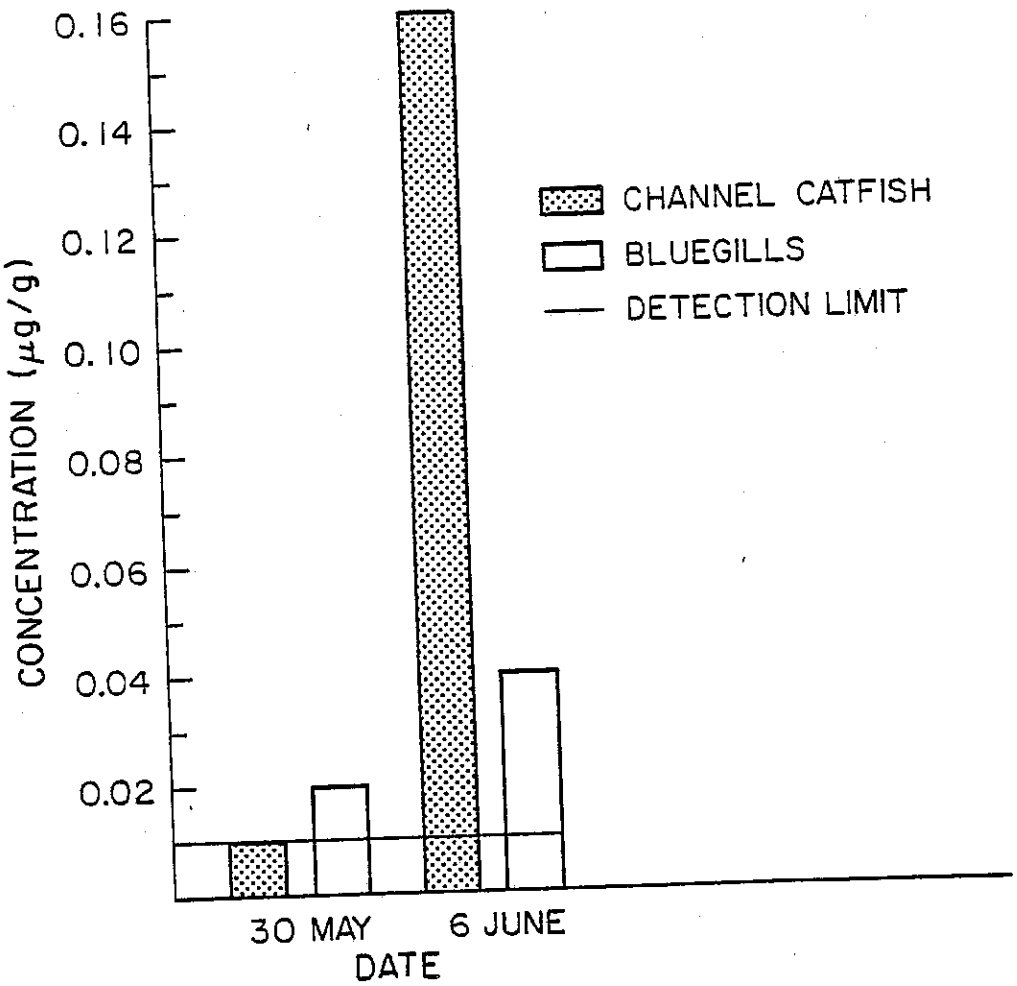



Figure 16. Uptake of Trifluralin by Channel Catfish and Bluegills -- Cuyahoga River, 1980

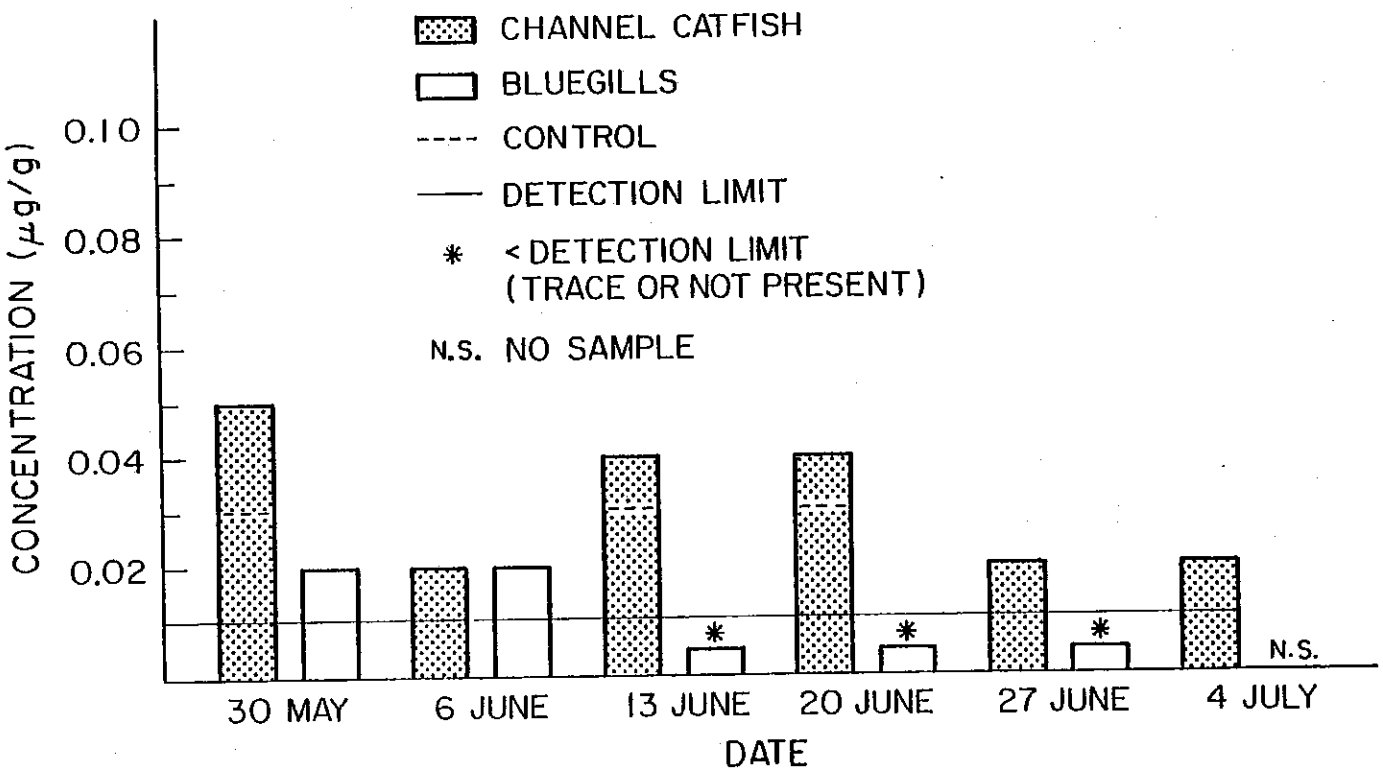



Figure 17. Uptake of p,p'-DDD by Channel Catfish and Bluegills -- Ashtabula River, 1980

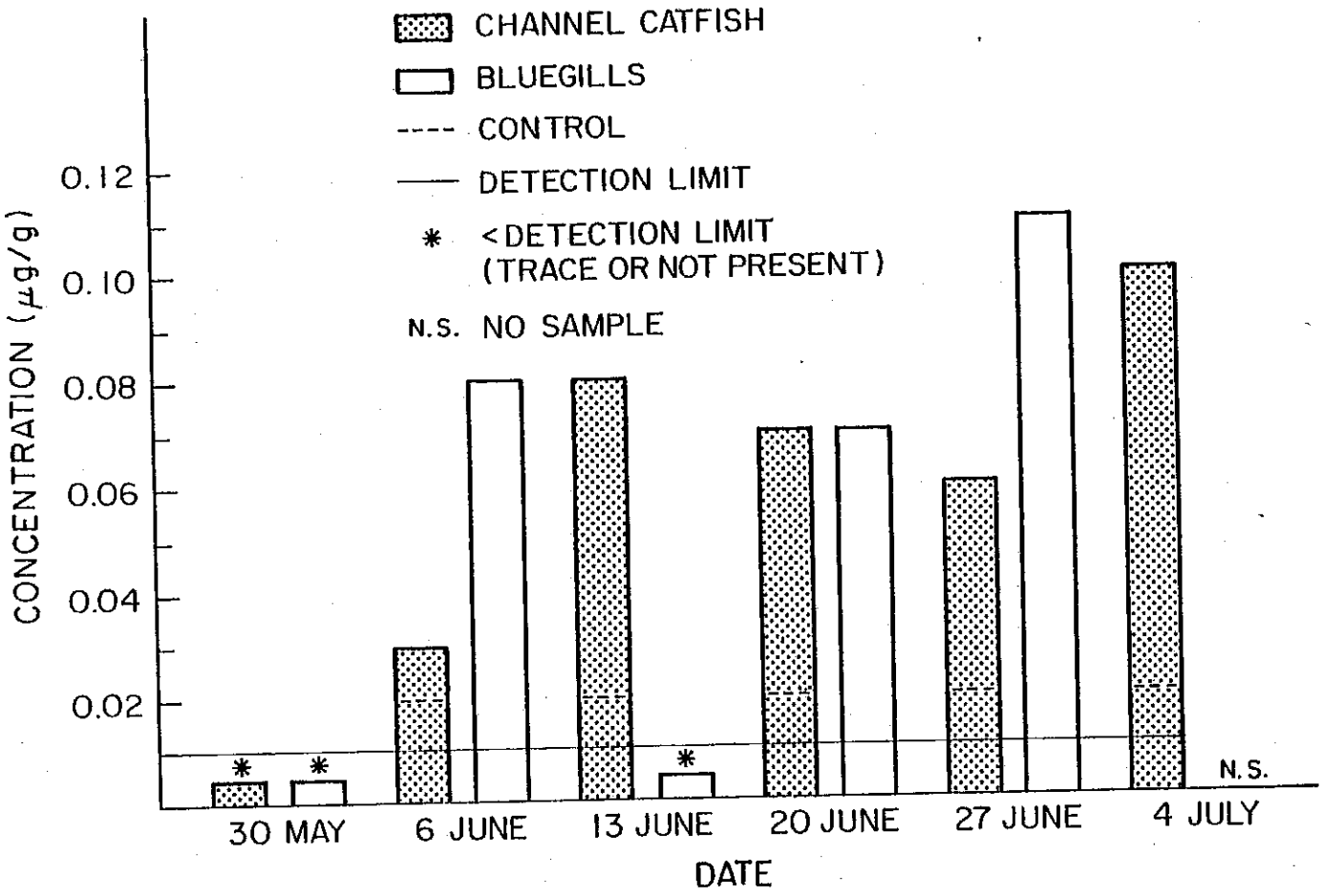



Figure 18. Uptake of o,p'-DDE by Channel Catfish and Bluegills -- Ashtabula River, 1980

Uptake of Dieldrin by both species did not show any pattern. Concentration levels decreased for both species in the last three weeks (Figure 19).

The detection of 2,4-D (Isopropyl Ester) was limited to Ashtabula River samples (Table 18). Uptake of 2,4-D (Isopropyl Ester) was detected in both species during th 13 June to 27 June sampling interval (Figure 20).

Uptake of Trifluralin was detected at low concentrations in both species (Figure 21). Both species showed a drop in concentration in the second week (6 June), followed by an increase and decrease over the remaining sampling dates.

Aroclor 1254 was detected at 0.20 ppm in both channel catfish and bluegill samples; this level represented the maximum concentration from all 27 experimental group samples (Table 17). Channel catfish samples showed increasing Aroclor 1254 levels for the first three weeks of the uptake experiment, then decreased in concentration in the final two weeks (Figure 22). The bluegill samples showed a similar trend at slightly lower concentration levels.

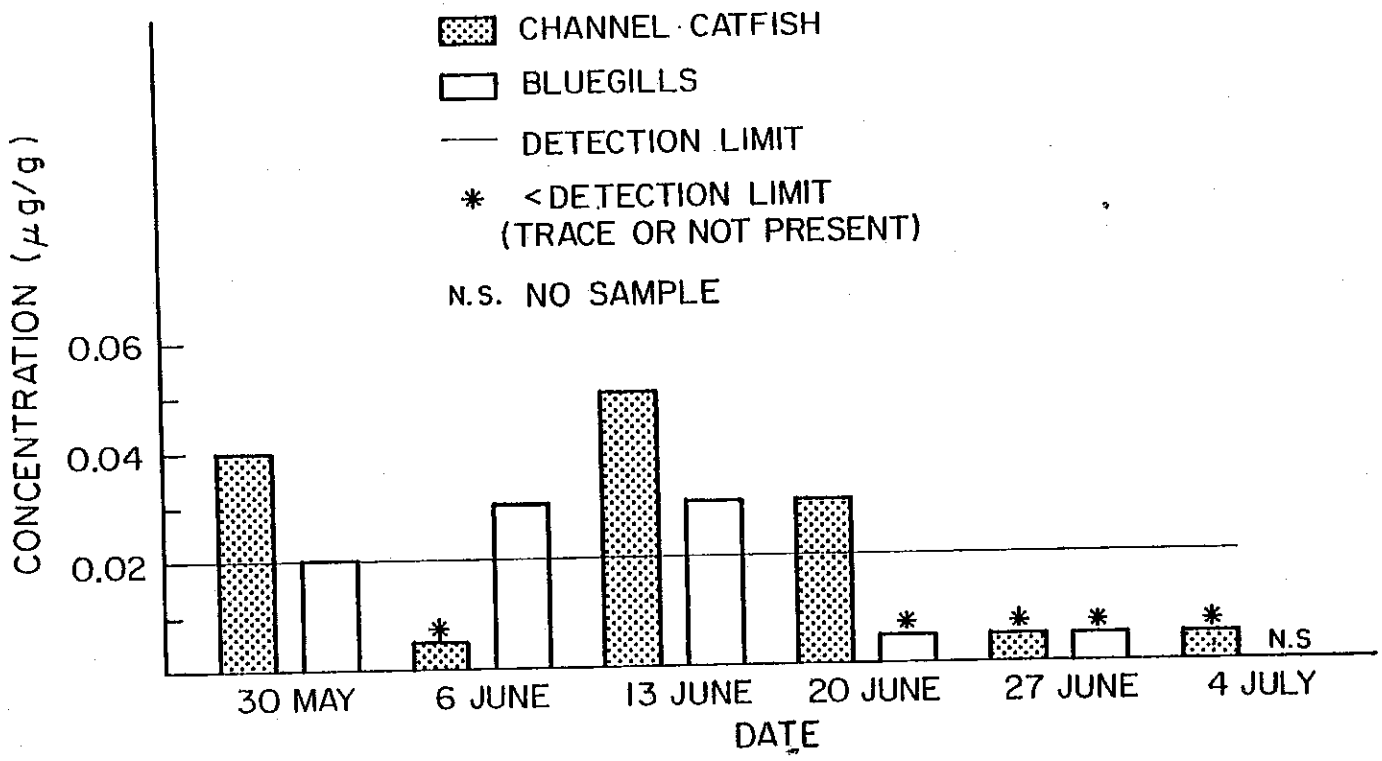



Figure 19. Uptake of Dieldrin by Channel Catfish and Bluegills -- Ashtabula River, 1980

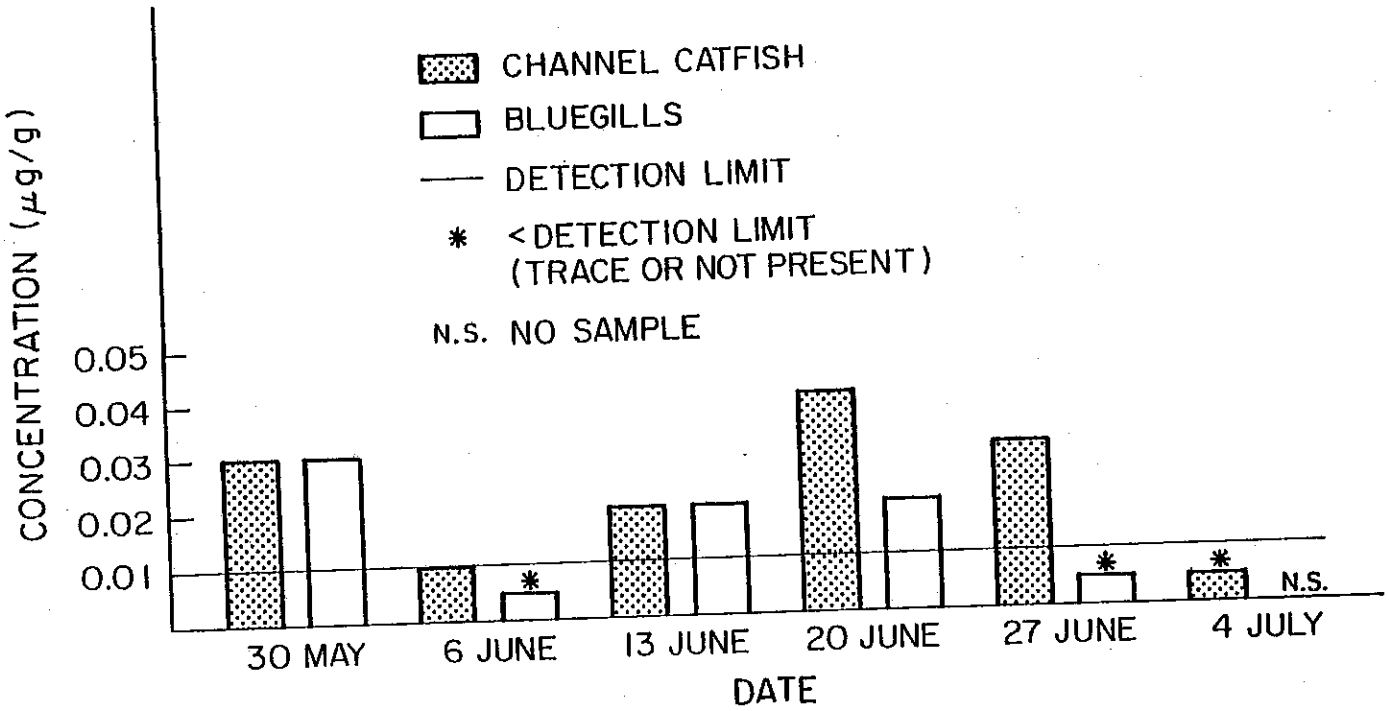



Figure 21. Uptake of Trifluralin by Channel Catfish and Bluegills -- Ashtabula River, 1980

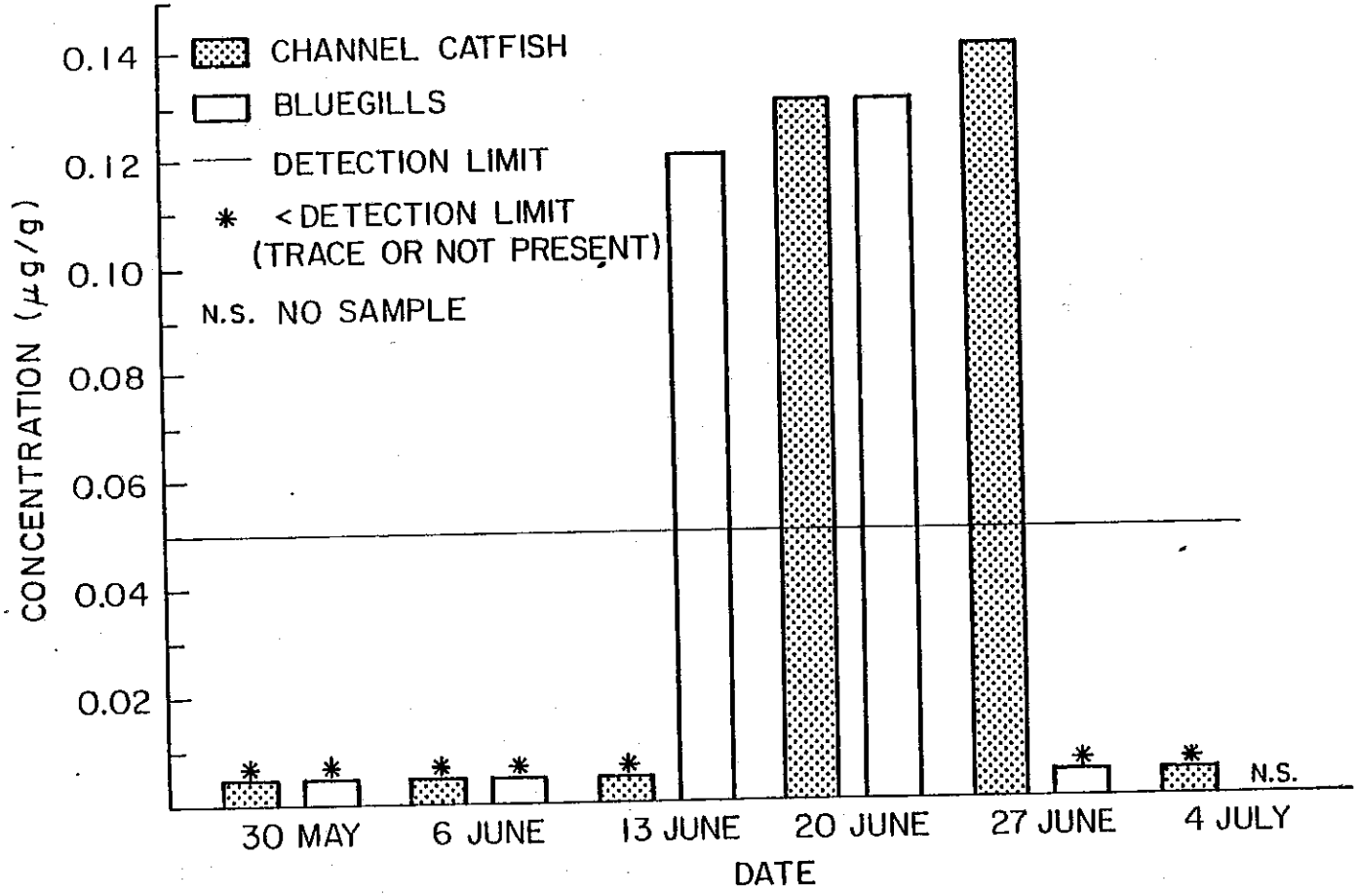



Figure 20. Uptake of 2,4-D (Isopropyl Ester) by Channel Catfish and Bluegills -- Ashtabula River, 1980

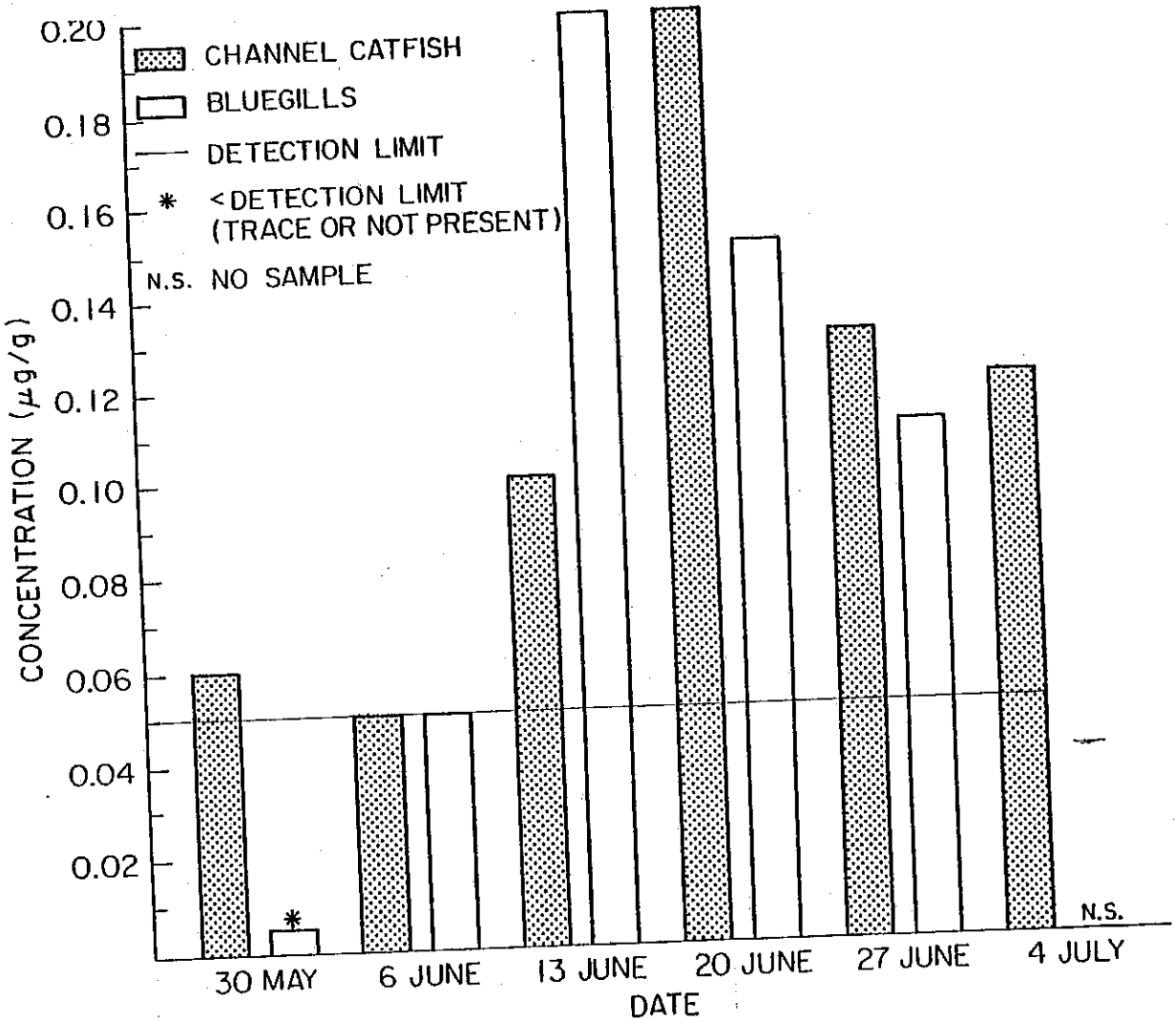



Figure 22. Uptake of Aroclor 1254 by Channel Catfish and Bluegills -- Ashtabula River, 1980

# DISCUSSION

This study was actually two separate but related projects - a survey study of organochlorine contaminant concentrations in fishes from Lake Erie tributaries and a study to determine the uptake rate of these organochlorine contaminants at selected Lake Erie tributaries. Over 900 fish representing 12 different species from 11 tributaries were collected as part of the 1979 survey study. The pilot uptake study of 1979 led to the 1980 uptake experiments at the mouths of the Maumee, Cuyahoga, and Ashtabula rivers. Objectives one and two, as set forth in the introduction of this paper, were achieved through the completion of the survey study. The achievement of objective 3 was met in that the uptake experiments during the spring of 1980 were completed. The determination of uptake rates was dependent upon detection of these organochlorine contaminants in the experimental group fish. However, the majority of the contaminants were found at N.D. or low concentration levels (Appendices C and D).

Certain problems were encountered throughout the study and subsequent analysis. Collections of many species were largely dependent on the sampling conditions and tributary. Many samples analyzed from the survey study consisted of only 3-5 fish. These low N values do not support the representative specimen sample desired in scientific studies such as this. Quality Control

(Q.C.) data of the chemical analysis of the fish samples resulted in the calculation of percent recovery and mean percent coefficient of variation for the 27 contaminants (Tables 7 and 8). In some cases problems were incurred with the samples during the tedious analytical procedures that resulted in low percent recoveries and elevated mean percent coefficient of variance. Additional QC requirements become increasingly cost prohibitive. These values should be kept in mind when analyzing the data.

Some assumptions were made in the study in order to facilitate the analysis of the data. All fish captured at the tributary mouths were considered residents of the river in which they were collected. This assumption discounts, but does not deny, long range fish movements from other streams or areas of Lake Erie. Time of collection is not considered a factor in the contaminant concentrations for the survey samples. The survey samples were collected over the interval August-December 1979. Certain samples may have contained more or less contaminant levels depending on when they were captured. This is a valid consideration, but is not considered in this discussion due to the mixing of collections to achieve homogeneous samples of the same species, age group, and tributary.

I shall approach the discussion of the 1979 survey sample results by examining organochlorine contamint concentration levels

in each tributary. Since the results section presented the survey sample data according to fish species and age class, discussion of the survey samples by tributary will allow for discussion of contaminant levels in fish populations as a function of location (tributary mouths). Additionally, consideration is made of significant differences of contaminant concentrations as a function of fish species.

The 1979 and 1980 uptake rate experiment results will be discussed according to the tributary mouth, experimental fish species, and the time interval during which the experiment was performed.

## SURVEY SAMPLES - FALL 1979

### River Raisin

Samples of gizzard shad, carp, spottail shiner, and brown bullhead were analyzed for organochlorine contaminants (Table 6). Comparison of these groups with other tributary samples of the same species and age group show that these samples were generally found to have the highest concentration levels of contaminants (Tables 9, 10, 11, 12, and 15). Relatively high levels of Aldrin, DDT and metabolites, Dieldrin, Mirex, and Total PCBs were found in the majority of the samples. The spottail shiner, brown bullhead and carp samples were found to be in excess of FDA limits for Total PCBs (Table 19). Aroclor 1016 was found to be in high concentrations in every sample, although this contaminant was

TABLE 19

FISH SAMPLES[1] COLLECTED FROM LAKE ERIE TRIBUTARY MOUTHS FOUND IN EXCESS OF IJC[2] AND FDA[3] LIMITS ON FISH TISSUE CONCENTRATIONS - 1979

| Contaminant | Limit (µg/g) IJC | Limit (µg/g) FDA | Tributary | Species | Age Group | Concentration (ppm) |
|---|---|---|---|---|---|---|
| DDT and Metabolites (sum total) | 1.0 (whole fish) | | Sandusky | Channel Catfish | VI | 2.34 |
| | | | Black | Carp | IX | 1.55 |
| Mirex | <Detection Limit | | Raisin | Spottail Shiner | I | 0.05 |
| | | | Maumee | Gizzard Shad | 0 | 0.03 |
| | | | Maumee | Spottail Shiner | I | 0.02 |
| | | | Maumee | Yellow Perch | II | 0.01 |
| | | | Maumee | White Bass | 0 | 0.03 |
| | | | Maumee | Carp | IV | 0.03 |
| | | | Sandusky | Freshwater Drum | 0 | 0.04 |
| | | | Sandusky | Freshwater Drum | I | 0.02 |
| | | | Sandusky | Gizzard Shad | 0 | 0.06 |
| | | | Sandusky | White Bass | I | 0.02 |
| | | | Sandusky | White Bass | II | 0.04 |
| | | | Sandusky | Carp | IV | 0.02 |

TABLE 19 (continued)

FISH SAMPLES[1] COLLECTED FROM LAKE ERIE TRIBUTARY MOUTHS FOUND IN EXCESS OF IJC[2] AND FDA[3] LIMITS ON FISH TISSUE CONCENTRATIONS - 1979

| Contaminant | Limit (µg/g) IJC | Limit (µg/g) FDA | Tributary | Species | Age Group | Concentration (ppm) |
|---|---|---|---|---|---|---|
| Mirex (cont'd.) | < Detection Limit | | Sandusky | Channel Catfish | VI | 0.02 |
| | | | Black | Spottail Shiner | I | 0.04 |
| | | | Black | Freshwater Drum | 0 | 0.04 |
| | | | Cuyahoga | Gizzard Shad | 0 | 0.01 |
| | | | Chagrin | Gizzard Shad | 0 | 0.02 |
| | | | Chagrin | Emerald Shiner | I | 0.04 |
| | | | Grand | Emerald Shiner | I | 0.01 |
| | | | Grand | Gizzard Shad | 0 | 0.03 |
| | | | Ashtabula | Gizzard Shad | 0 | 0.02 |
| | | | Ashtabula | Emerald Shiner | I | 0.01 |
| Total PCBs | | 5.0 (edible portion) | Raisin | Carp | IV | 17.60 |
| | | | Raisin | Spottail Shiner | I | 5.76 |
| | | | Raisin | Brown Bullhead | II | 9.6 |
| | | | Sandusky | Channel Catfish | VI | 5.1 |

[1] All samples were homogenates of whole fish.

[2] International Joint Commission (1978)

[3] U.S. Food and Drug Administration (New York State Department of Environmental Conservation, 1978)

practically not found in samples from other tributaries (Appendix A).

Explaining these high contaminant levels in fish tissue cannot be based on current use in the environment due to their removal by the EPA (Table 1). The industrial activities of Monroe, Michigan must be considered as a possible source of PCB contamination. Detectable concentrations of Mirex and Aroclors 1254 and 1260 in sediment samples from this tributary have been reported (Appendix F). Previous data has shown high PCB levels in fish samples from the Monroe area (Gessner and Griswold, 1978). The uptake and retention of Aldrin, DDT and metabolites, Dieldrin, and PCBs by River Raisin fish may be related to their presence in sediments of the tributary mouth and nearshore area. Further evidence that may suggest the sediments as a possible contaminant source is found in the fact that the highest concentrations were found in bottom-feeding fish, namely the carp and brown bullhead samples. However, these bottom-feeding species were also the oldest fish analyzed, and therefore would have the longest time to accumulate organochlorine contaminants.

Maumee River

Gizzard shad, carp, spottail shiner, white bass, and yellow perch samples were analyzed for organochlorine contaminant levels

(Table 6). These samples contained relatively high concentrations of Chlordane, o,p'-DDE, Mirex, Aroclor 1016, and Total PCBs (Tables 9, 10, 11, 12, 13, 14, and 15). Comparison of contaminant levels between fish species shows that the highest concentrations were found in the carp sample while the lowest levels were detected in the gizzard shad sample. This may suggest the method of feeding as a possible factor in concentrating contaminants; carp are omnivorous bottom-feeders while gizzard shad are considered planktivores.

Many of the concentrations detected were of contaminants not presently restricted from use by the EPA (Table 1). For example, Chlordane's occurrence in the samples may be related to residential use of this insecticide for termite control (Table 1). The agricultural and industrial activities which surround the Maumee River Basin also can be considered as a probable source of pesticide and PCB contamination.

Contaminant concentrations found in sediment samples correspond to contaminant concentrations in the Maumee River fish samples of this study (Appendix F). The presence of these compounds in sediment samples make them a possible source of contaminants to the Maumee River fish. For example, all of these samples were found to be in excess of FDA limits for Mirex (Table 19).

Toussaint River

The Toussaint River samples consisted of carp, white bass, and freshwater drum. Contaminants for all of these samples were found to be N.D. or very low levels. These low contaminant levels are believed to be an indication of relatively unpolluted nature of this tributary.

Sandusky River

A total of six species representing gizzard shad, carp, channel catfish, white bass, yellow perch, and freshwater drum samples were analyzed. These six species were generally found to have N.D. or low levels of organochlorine contaminants.

Mirex was detected in five of the six species collected (Appendix A). These Mirex concentrations are low, but represent levels of a banned pesticide in excess of IJC standards (Tables 1 and 19).

Low concentrations of Chlordane and Methoxychlor were detected in the samples. The presence of these insecticides is not unusual; both Chlordane and Methoxychlor are used by farmers and residential owners as effective soil insecticides (Table 20).

The channel catfish sample contained maximum concentrations for Chlordane, o,p'-DDD, p,p'-DDD, p,p'-DDE, o,p'-DDT, p,p'-DDT,

TABLE 20

QUANTITIES OF SELECTED PESTICIDES USED ON OHIO CROPS, ACTIVE INGREDIENTS, 1978
(From Carter, et al., 1978)

| Pesticide | Corn | Soybeans | Wheat | Oats, Barley, Rye | Alfalfa | Other Hay | Pasture | Total |
|---|---|---|---|---|---|---|---|---|
| | 1,000 KG | | | | | | | |
| Aldrin | 0.36 | | | | | | | 0.36 |
| γ-BHC | 0.04 | | | | | | | 0.04 |
| Chlordane | 19.36 | | 0.09 | | | | | 1.74 |
| Heptachlor | 4.30 | | | | | | | 4.30 |
| HCB | | | 0.90 | | | | | 0.90 |
| 2, 4-D | 104.90 | | 9.70 | 22.30 | 0.59 | 0.80 | 7.34 | 145.60 |
| Methoxychlor | | | | | 4.58 | 0.45 | | 5.00 |
| Toxaphene | 2.49 | | | 0.49 | | | | 2.98 |
| Trifluralin | | 340.00 | | | | | | 340.00 |
| **TOTAL** | 131.45 | 340.00 | 10.69 | 22.79 | 5.17 | 1.25 | 7.34 | 500.82 |

Aroclor 1254, and Aroclor 1260 (Table 10). The DDT and metabolites were found to be in excess of IJC standards (Table 19). A possible explanation for these high concentrations, particularly the DDT and metabolite compounds, is that this fish was six years old; therefore allowing it a longer time to accumulate organochlorine contaminants than younger fish. Channel catfish, like carp, are bottom-feeders and this also may have an influence.

Black River

Black River samples of gizzard shad, carp, spottail shiner, brown bullhead, white bass, and freshwater drum were analyzed. Comparisons of these samples to different tributaries containing the same species and age class show the Black River samples to contain N.D. or very low concentrations of the 27 organochlorine contaminants (Tables 12 and 14). Only DDT and metabolite concentrations in the age group IX carp sample were found at relatively high levels (Appendix A).

Possible explanations for these low levels may be related to the land use of this area. The Black River flows through an industrialized area of Ohio. Since there is little agriculture use of land, the potential for pesticide contamination of fish is small. The high levels of DDT and metabolites found in the age group IX carp may be attributed to this species age and bottom-

feeding method. Another possible source of DDT and metabolite contamination is their presence in sediment samples (Appendix F).

Cuyahoga River

The Cuyahoga River samples were comprised of gizzard shad, carp, spottail shiner, white bass, and yellow perch (Table 6). Detectable concentrations of Chlordane and Total PCBs were common in all of these samples (Tables 11, 12, 13, 14, and 15). The carp sample contained relatively high concentrations of DDT and metabolites (Table 15). Contaminant levels do not appear to differ appreciably between the various samples, although the carp and spottail shiner groups contain the highest levels of Total PCBs.

These low concentration levels are not unexpected due to the highly industrialized nature of the Cuyahoga River and surrounding area. The presence of Chlordane in the samples may be attributed to residential and industrial use for termite control (Table 1). Levels of DDT and metabolites and PCBs may be related to industrial activity and release of these compounds from the sediment (Table 19).

Chagrin River

Samples of gizzard shad and emerald shiners were analyzed from the Chagrin River (Table 6). Low or N.D. concentration levels

were found for the majority of the contaminants. The emerald shiner samples contained the maximum levels for Methoxychlor and Trifluralin (Table 10). The source of these high contaminant levels may be from the application of Methoxychlor and Trifluralin on hay and soybean crops, respectively (Table 20). Both of these crops are grown in the Chagrin River area.

Grand River

Samples of gizzard shad, rainbow smelt, emerald shiner, and spottail shiner were analyzed from the Grand River (Table 6). Very low or N.D. concentration levels were found in all these samples. The age group I gizzard shad sample was found to contain 0.03 ppm of 2,4-D (Isopropyl Ester). A possible source of this herbicide is from 2,4-D applications on corn and wheat crops of the Grand River area (Table 20). A possible source of organochlorine contaminants is sediment contaminant concentrations in the tributary and nearshore area (Appendix F).

Ashtabula River

The following samples were analyzed from the Ashtabula River: gizzard shad, rainbow smelt, emerald shiner, spottail shiner, and white bass (Table 6). Most organochlorine contaminants were found at N.D. or low concentration levels.

The gizzard shad, emerald shiner, and white bass samples were found to contain very high levels of $\alpha$, $\beta$, and $\gamma$-BHC and Heptachlor

(Tables 10, 11, and 14). Comparisons of these contaminant levels between the different fish species show that the highest levels were generally found in the white bass sample, followed by gizzard shad and emerald shiner samples, respectively. Comparisons of these contaminant levels to other tributaries with the same species and age group show the Ashtabula River samples to contain much higher concentrations (Tables 11 and 14, and Appendix A).

The source of the $\alpha$ and $\beta$-BHC concentration levels probably is not related to 1979 pesticide applications in the area because of the banning of BHC formulations containing and isomers in 1978 (Table 1). $\beta$-BHC is known to be persistent in the environment, therefore its presence in the fish samples probably is related to previous applications of this pesticide on crops of the Ashtabula River area. The $\gamma$-BHC contaminant levels may be a result of agricultural and residential use to control soil insects, houseflies, and cockroaches. A possible explanation for the high Heptachlor levels may be related to previous applications of this insecticide on corn crops and use for termite control (Tables 1 and 20).

Maumee River

The differences existing between the contaminant concentrations of the control group yellow perch sample and the experimental group yellow perch sample were found to be minimal and insignificant (Appendix B). Analysis of the data reveals that although the majority of the experimental group contaminant levels increased over the four-week holding period, the increases were so slight that any suggestion of significant uptake by the experimental yellow perch would be misleading. The data suggests there was no appreciable uptake of organochlorine contaminants by yellow perch over the four-week holding period.

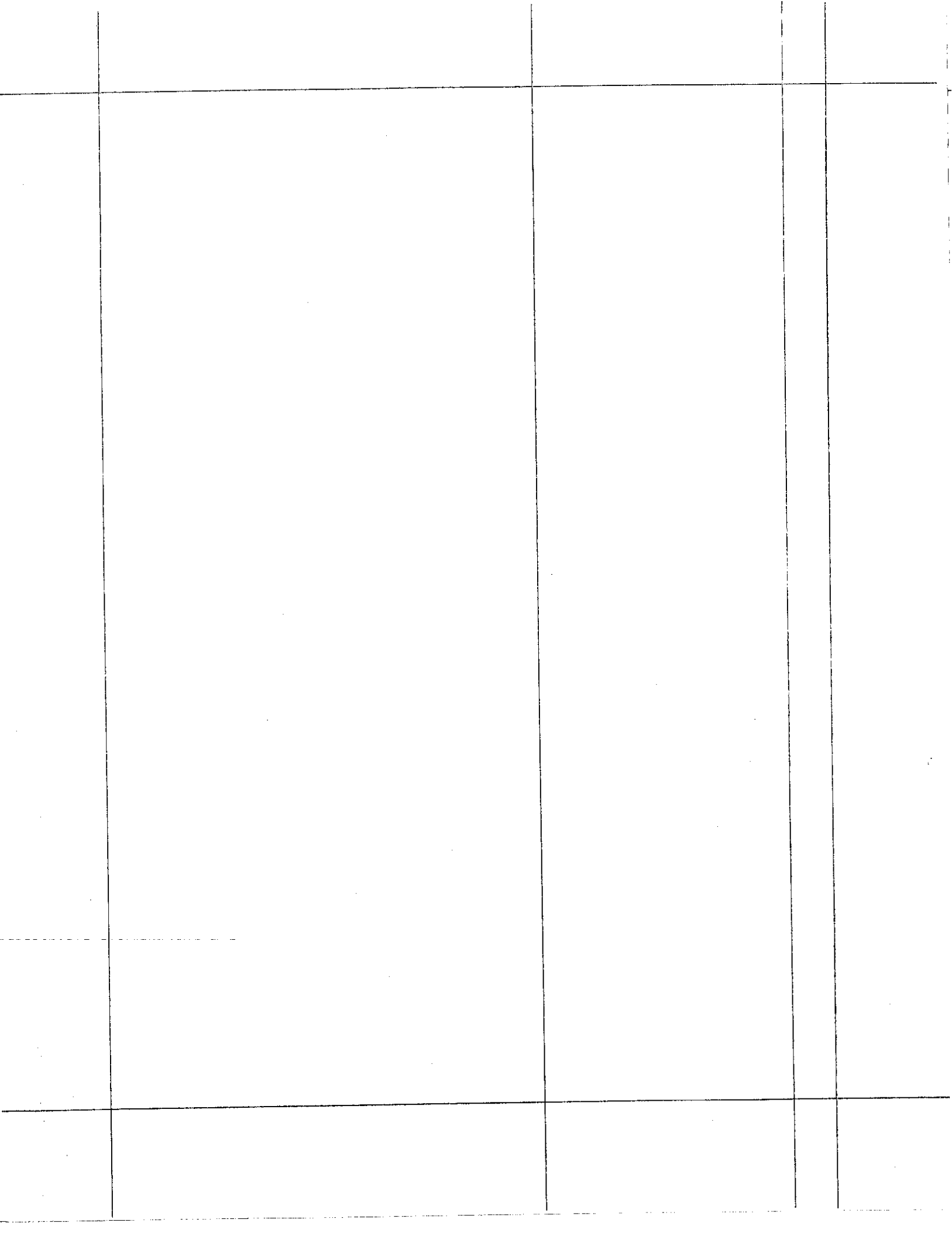
Cuyahoga River

Only one yellow perch and two channel catfish were retrieved from the Cuyahoga River. These low recoveries do not constitute adequate samples and this fact must be considered when analyzing the data. The yellow perch sample was found to increase markedly for o,p'-DDD, o,p'-DDE, p,p'-DDT, Hexachlorobenzene, Mirex, and Trifluralin over the four-week holding period (Appendix B). Sediment samples removed from the Cuyahoga River in 1979 were found to contain detectable levels of o,p'-DDD, o,p'-DDE, and p,p'-DDT (Appendix F). This may suggest that the yellow perch were obtaining these contaminants from concentrations in sediment. The presence of Mirex may also be related to sediment concentrations

of this insecticide from previous applications (Table 1). Hexachlorobenzene and Trifluralin are pesticides presently in use by Ohio farmers. Hexachlorobenzene, a fungicide, is used primarily for wheat seed treatment while Trifluralin, a herbicide, is used as an effective weed controlling agent for soybean crops (Table 20). Since wheat and soybean are major crops of the Cuyahoga River area, the presence of Hexachlorobenzene and Trifluralin in the yellow perch sample may be related to agricultural use of these pesticides.

The channel catfish sample showed marked increases of β-Endosulfan, Hexachlorobenzene, Methoxychlor, and Trifluralin over the four-week holding period (Appendix B). The presence of the insecticide β-Endosulfan is probably related to agricultural and industrial applications in the Cuyahoga area; it is very persistent in soil. Methoxychlor's presence is not uncommon due to its use as an insecticide on hay crops (Table 20). Concentrations of Hexachlorobenzene and Trifluralin increased rapidly over the holding period (Figure 10). Their presence in the fish samples is probably related to agricultural use in the area.

The concentration of o,p'-DDE decreased substantially over the four-week holding period. This may represent elimination or conversion of o,p'-DDE by the channel catfish.



## UPTAKE RATE EXPERIMENT - SPRING 1980

Maumee River

The majority of the experimental group samples were found to contain N.D. or low contaminant concentration levels (Table 18, Appendix D). α-BHC, β-Endosulfan, and Endrin were detected sporadically in the channel catfish samples. The β-Endosulfan and Endrin levels probably reflect agricultural use within the watershed. α-BHC levels may be related to previous agricultural use before elimination of this pesticide by the EPA (Table 1). γ-BHC was detected in the 6 June and 13 June bluegill samples. These levels also are believed to reflect agricultural use within the watershed (Table 20).

A gradual increase of p,p'-DDD was found for channel catfish over the six-week period (Figure 11). Bluegill samples did not exhibit a gradual increase. Levels of p,p'-DDE for both species did not show any pattern of increase or decrease. The channel catfish contained higher p,p'-DDE levels, but it is believed these elevated values are caused by higher control group concentrations (Appendix C). The uptake of p,p'-DDD and p,p'-DDE by the fish may be related to the release of these contaminants from suspended and particulate matter in the sediment (Salem et al., 1978 and Appendix F). The higher levels of these contaminants in channel catfish may be associated with the fact that this species is a bottom-feeder and therefore in close contact with the sediment.

Uptake of Dieldrin by both species did not appear to follow any pattern (Figure 12). Channel catfish samples generally contained the higher concentration levels. Since most uses of Dieldrin have been cancelled the most probable source is from suspended sediment material (Appendix F). Movement of Dieldrin by runoff and erosion has also been documented (Haan, 1971). The 13 June channel catfish sample was found to contain detectable levels (ppm) of both Dieldrin (0.11) and Aldrin (0.02). This may suggest a biological conversion of Aldrin to its Epoxide Dieldrin. Bulkley et al. (1974) showed that Dieldrin levels in channel catfish were seasonal. His study indicated that Dieldrin levels increased within a few weeks after the peak of the corn planting season. Although Aldrin has been banned by the EPA (Table 1) its former use on corn was widespread. This evidence may serve to explain the occurrence of Dieldrin in the fish.

Heptachlor Epoxide was found in 83% of the channel catfish and bluegill samples (Table 18). These levels may be the result of biological conversion of Heptachlor to Heptachlor Epoxide (Brooks, 1969). Heptachlor Epoxide increased gradually for both species; this suggests a continuous source of Heptachlor in the area (Figure 13).

Trifluralin was detected in all of the channel catfish samples but only one of the bluegill samples (Table 18). The 13

June sample for both species showed the maximum concentration levels during the entire sampling period. These peak concentrations may reflect application of Trifluralin to crops by local farmers (Figure 14, Table 20).

Levels of PCBs found in the two species showed that Aroclor 1254 was detected in more samples and in higher concentrations than either Aroclor 1016 or Aroclor 1260 (Table 18). Sediment values also contained much higher concentrations of Aroclor 1254 than 1260 (Appendix F). This may suggest why Aroclor 1254 was found in the majority of the fish samples. The higher levels again were found in the channel catfish; this again may suggest bottom-feeding species concentrate organochlorine contaminants by their association with sediments (Figure 15).

Cuyahoga River

Discussion of the Cuyahoga River samples is difficult due to the mortality of all the fish during the 6 June sampling period. Any analysis of trends and possible relationships for the contaminant levels must therefore be restricted to only two sampling periods.

The following contaminants were detected from the same sampling dates in both channel catfish and bluegill samples: α-BHC, p,p'-DDD, Dieldrin, Heptachlor Epoxide, Trifluralin, and Aroclor 1254. The α-BHC and p,p'-DDD concentration levels may be

attributed to previous pesticide applications prior to EPA removal (Table 1). Heptachlor Epoxide and Dieldrin levels may reflect agricultural use or biological conversion of Heptachlor and Aldrin from sediment sources (Appendix F). The Trifluralin levels are probably due to agricultural use in the Cuyahoga River agricultural areas (Figure 16). Aroclor 1254 levels may be related to the high concentrations of this industrial contaminant found in sediment samples from the Cuyahoga River (Appendix F).

Ashtabula River

Sporadic concentration levels of β-BHC and Heptachlor in the channel catfish samples are believed to be caused by release of β-BHC from sediments and agricultural and residential use of Heptachlor (Table 20 and Appendix F). γ-BHC and Heptachlor levels detected in the bluegill samples were also sporadic and probably reflect agricultural use of these insecticides. It is interesting to note that the survey samples - Fall 1979 collected from the Ashtabula River contained the maximum α, β, and γ-BHC levels for all 50 samples analyzed (Table 10). The presence of these BHC isomers in the uptake experiment samples reinforces the belief that the fish are concentrating these contaminants as a result of past insecticide applications in the Ashtabula River watershed (Tables 17, 18, and 20 and Appendices C and D).

Levels of p,p'-DDD were found to show no uptake pattern for either species during the holding period (Figure 17). Uptake of o,p'-DDE also did not appear to follow any pattern, although the concentration levels were higher for o,p'-DDE than p,p'-DDD. Concentration levels of DDD and DDE found in sediment samples from the Ashtabula River mouth may be a source of these contaminants to the experimental group fish (Appendix F).

Dieldrin levels were detected at low concentrations and did not appear to show any trend or pattern of uptake for either species (Figure 19). The channel catfish and bluegill samples showed N.D. Dieldrin levels during the last two sampling periods. This may be related to biological conversion and elimination of Dieldrin by the fish.

The presence of 2,4-D (Isopropyl Ester) was unusual because it was not found in any other samples and because the detectable levels were found within a three-week period (Figure 20). Since laboratory studies have shown no strong evidence for bioaccumulation of 2,4-D by these species (Sikka et al., 1977), the levels found during the 13 June to 27 June period are probably caused by local agricultural use. Large quantities of this herbicide are used in Ohio for weed control on corn, oat, and wheat crops (Table 20).

Levels of Aroclor 1254 found in both species may be related to the release of this industrial contaminant from suspended sediment particles (Figure 22 and Appendix F). Aroclor 1254 levels were found to gradually increase and peak during the first four weeks; this may suggest bioaccumulation of Aroclor 1254 during periods of high agricultural runoff and erosion (Pionke and Chesters, 1973 and Waldron, 1973).

# SUMMARY AND CONCLUSIONS

In order to determine watershed sources of organochlorine contaminants in Lake Erie fishes, concentrations of 27 major contaminants were determined in whole fish collected in nine Lake Erie tributary mouths during August - December 1979 (Survey Samples). Additionally, field experiments to determine the uptake rate of these contaminants by hatchery-raised young-of-the-year fish were conducted during Fall 1979 and Spring 1980.

Field collections were made using experimental gill nets and ten common species of recreational, commercial, or trophic importance were tested. Length, weight, sex, and age of each fish were determined, and different age groups within each species were analyzed separately in order to make comparisons between fish of the same species and age groups in different tributaries. The Fall 1979 uptake rate experiment involved the placement of hatchery-raised young-of-the-year channel catfish and yellow perch in a nylon mesh holding cage at the Maumee and Cuyahoga rivers for a four-week holding period. At the end of the holding period the fish were removed from the holding pens and analyzed for the 27 contaminants. In the subsequent Spring 1980 uptake rate experiment hatchery-raised young-of-the-year channel catfish and bluegill were held in cages at the mouths of the Maumee, Cuyahoga, and Ashtabula rivers for six weeks. Approximately 30-40 fish were

removed from the cage each week for analysis of the same 27 contaminants. Control groups were retained at the beginning of the holding periods for both the Fall 1979 and Spring 1980 experiments.

Results of the survey samples showed that of the 27 contaminants tested, α-Endosulfan, β-Endosulfan, and Toxaphene were not detected in any of the fish collected from the tributary mouths. Concentrations of Total PCBs exceeded 1.0 ppm in fish samples from the Raisin, Maumee, Toussaint, Sandusky, Black, Cuyahoga, and Chagrin rivers. A white bass sample from the Ashtabula River contained a concentration of γ-BHC in excess of 1.0 ppm. All other contaminants were found in concentrations less than 1.0 ppm. Differences were observed in concentrations of contaminants between fish of the same species and age groups in different tributaries. Certain tributary mouths contained fish samples with higher contaminant concentrations than others. Bottom-feeding species from these tributary mouths were found to contain the highest contaminant concentrations.

The Fall 1979 uptake rate experiment was only partially successful due to the low number of recovered fish from the holding nets. Most of the contaminants were not detected, although a few contaminants increased markedly over the four-week holding period. The Spring 1980 uptake rate experiment also showed that the

majority of the contaminants were not detected. Certain contaminants (p,p'-DDD, p,p'-DDE, Dieldrin, Trifluralin, and Aroclor 1254) were present in the majority of the experimental group fish samples throughout the six-week holding period, but in low concentrations.

Possible sources of organochlorine contamination to the collected fish comprising the Fall 1979 Survey Samples and the young-of-the-year experimental group fish were: pesticide use within watershed, release of contaminants from sediment, and agricultural runoff from precipitation and erosion.

This study resulted in the following conclusions:

SURVEY SAMPLES - FALL 1979

1. In general, the concentrations of organochlorine contaminants found in fish samples from Lake Erie tributary mouths were site dependent.

2. Concentrations of organochlorine contaminants in fishes of the same species and age group varied considerably among the tributary mouths sampled.

3. The highest concentrations of the greatest number of organochlorine contaminants in fish samples were found in the River Raisin and Maumee River.

4. Excessive concentrations (i.e. > 1.0 ppm for pesticides, 5.0 ppm for total PCBs) of the following contaminants were found: γ-BHC (Ashtabula River), total PCBs (River Raisin, Maumee River, and Sandusky River). All other contaminants were found at low concentrations (≤ 1.0 ppm).

5. In general, the highest concentrations of organochlorine contaminants were found in certain bottom feeding species (spottail shiner, brown bullhead, carp, and channel catfish).

6. Hypothesized sources of the organochlorine contaminants in the fish samples are current pesticide applications within watersheds of the tributaries sampled and remobilization of contaminants contained in sediment.

UPTAKE RATE EXPERIMENTS - FALL 1979 AND SPRING 1980

7. Results obtained from the fall 1979 experiment were inconclusive, however, the increase of certain contaminants (Hexachlorobenzene and Trifluralin) over the holding period suggested rapid uptake.

8. The majority of the organochlorine contaminants in the fish samples from the spring 1980 experiment were found in undetectable concentrations (trace or not present).

9. Uptake of certain contaminants (p,p'-DDD, p,p'-DDE, Dieldrin, Heptachlor Epoxide, 2,4-D, Trifluralin, and Aroclor 1254) observable but generally in low concentrations.

10. Results of the spring 1980 study suggest slow uptake of certain contaminants at low concentrations. Possible sources of those contaminants taken up by the experimental group fish are:

    a. current pesticide use within watershed
    b. remobilization of contaminants from sediments
    c. agricultural runoff from precipitation and erosion

It is my opinion that the results from this study indicate the general lack of substantial organochlorine contamination in fish from those Lake Erie tributary mouths sampled and studied. Concentrations of PCBs in bottom-feeding species, particularly from the River Raisin, were found in excess of FDA safety limits for human consumption and may have negative health implications.

# RECOMMENDATIONS

The inherent limitations encountered in this study, as with many field studies, were caused by the inability on the part of the experimenter to effectively control and monitor factors that may affect the degree of organochlorine contamination found in the fish collected from the Lake Erie tributary mouths. Controlled laboratory experiments effectively eliminate these limitations, but sacrifice the "real" field conditions so often preferred by scientists. A major limitation of this study is the inability to make more concrete conclusions on the watershed sources of organochlorine contaminants in fish from Lake Erie tributary mouths. This inability is largely a result of the lack of data on organochlorine contaminant concentrations in water and sediment samples taken concurrently with the field collections of fish. Previous studies (Meeks, 1966) have included the analysis of water and sediment samples, in addition to biota samples, and this has allowed for more precise explanations on the origin and dynamics of organochlorine contaminants in aquatic environments. I recommend that future studies in this area should include water and sediment analysis to avoid these problems.

A further problem encountered during the study was the lack of standardization from previously generated data on organochlorine contaminants in fish from Lake Erie tributaries. Large differences in collection, analytical, and reporting procedures exist and trend analysis will be meaningful only if standardized procedures are adopted. For example, whole fish analyses may imply: the whole fish, the whole fish minus the head, or the whole fish minus the head, tail and gutted. Herdendorf et al. (1978) noted that "Differences in species and size sampled, tissues analyzed and collection data make any comparison between data difficult and unreliable". I recommend that standardized procedures be adopted so that valid comparisons of organochlorine contaminant concentrations in fish tissue from different times and locations may be made.

Cost of analysis of fish tissue for organochlorine contaminants is high. I further recommend that future studies in this area should attempt to: (1) determine which tributaries appear to be problem areas for organochlorine contamination; (2) select only those contaminants which pose potential health hazards; and (3) limit collections to a few representative species. Limiting chemical analytical analysis according to these criteria will minimize the cost of monitoring and uptake studies without reducing the validity of results.

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APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER[1] | RAISIN R. CARP N: 3 AGE: IV | RAISIN R. SPOTTAIL S. N: 4 AGE: I | RAISIN R. BROWN B. H. N: 2 AGE: II |
|---|---|---|---|
| Percent Fat[2] | 1.4 | 2.2 | 1.7 |
| Aldrin | 0.55 | 0.29 | 0.28 |
| α-BHC | N.D. | N.D. | N.D. |
| β-BHC | 0.13 | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | 0.12 | N.D. | N.D. |
| p,p'-DDD | 0.13 | 0.16 | 0.05 |
| o,p'-DDE | N.D. | 0.10 | 0.02 |
| p,p'-DDE | 0.07 | 0.08 | N.D. |
| o,p'-DDT | N.D. | 0.10 | N.D. |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.15 | 0.10 | 0.08 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | 0.23 | 0.04 | 0.07 |
| Heptachlor | 0.25 | 0.13 | 0.17 |
| Heptachlor epoxide | 0.09 | 0.02 | N.D. |
| Hexachlorobenzene | 0.08 | N.D. | 0.04 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.14 | 0.07 | N.D. |
| Mirex | N.D. | 0.05 | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | N.D. | N.D. |
| Aroclor 1016 | 15 | 3.81 | 8.0 |
| Aroclor 1254 | 1.7 | 1.03 | 0.84 |
| Aroclor 1260 | 0.90 | 0.92 | 0.76 |
| Total PCBs | 17.60 | 5.76 | 9.60 |

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ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | RAISIN R. G. SHAD N: 12 AGE: 0 | MAUMEE R. G. SHAD N: 57 AGE: 0 | MAUMEE R. SPOTTAIL S. N: 50 AGE: I |
|---|---|---|---|
| Percent Fat | 4.8 | 5.0 | 2.3 |
| Aldrin | 0.16 | 0.08 | N.D. |
| α-BHC | N.D. | 0.06 | 0.03 |
| β-BHC | N.D. | 0.02 | N.D. |
| γ-BHC | N.D. | 0.01 | N.D. |
| Chlordane | N.D. | 0.19 | 0.20 |
| o,p'-DDD | N.D. | 0.06 | N.D. |
| p,p'-DDD | 0.07 | 0.09 | 0.10 |
| o,p'-DDE | 0.06 | 0.15 | 0.22 |
| p,p'-DDE | N.D. | 0.04 | 0.11 |
| o,p'-DDT | N.D. | N.D. | 0.06 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | N.D. | 0.03 | 0.05 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | 0.06 | 0.05 | 0.02 |
| Heptachlor epoxide | 0.01 | 0.04 | N.D. |
| Hexachlorobenzene | 0.03 | 0.02 | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.02 | 0.03 | 0.01 |
| Mirex | N.D. | 0.03 | 0.02 |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | 0.11 | 0.06 |
| Aroclor 1016 | 1.8 | N.D. | ≤0.05 |
| Aroclor 1254 | 0.67 | 0.50 | 0.68 |
| Aroclor 1260 | 0.76 | 0.42 | 0.52 |
| Total PCBs | 3.23 | 0.92 | 1.70 |

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ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | MAUMEE R. Y. PERCH N: 42 AGE: II | MAUMEE R. W. BASS N: 4 AGE: 0 | MAUMEE R. CARP N: 2 AGE: IV |
|---|---|---|---|
| Percent Fat | 2.8 | 3.4 | 3.4 |
| Aldrin | 0.06 | N.D. | 0.23 |
| α-BHC | 0.20 | 0.06 | 0.04 |
| ß-BHC | N.D. | 0.01 | 0.02 |
| Y-BHC | N.D. | N.D. | N.D. |
| Chlordane | 0.20 | 0.20 | 0.25 |
| o,p'-DDD | N.D. | 0.05 | 0.08 |
| p,p'-DDD | N.D. | N.D. | 0.17 |
| o,p'-DDE | 0.09 | 0.10 | 0.17 |
| p,p'-DDE | 0.07 | 0.03 | 0.08 |
| o,p'-DDT | 0.07 | 0.02 | N.D. |
| p,p'-DDT | 0.01 | N.D. | N.D. |
| Dieldrin | 0.04 | 0.05 | 0.04 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| ß-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | 0.03 | 0.04 | 0.16 |
| Heptachlor epoxide | N.D. | 0.02 | 0.01 |
| Hexachlorobenzene | N.D. | N.D. | 0.02 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.01 | 0.01 | 0.02 |
| Mirex | 0.01 | 0.03 | 0.01 |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.04 | 0.10 | 0.09 |
| Aroclor 1016 | ≤0.4 | ≤0.3 | 2.7 |
| Aroclor 1254 | 0.53 | 0.73 | 0.80 |
| Aroclor 1260 | 0.47 | 0.53 | 0.26 |
| Total PCBs | 1.40 | 1.56 | 3.76 |

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| PARAMETER | TOUSSAINT R. WHITE BASS N: 23 AGE: I | TOUSSAINT R. WHITE BASS N: 5 AGE: II | TOUSSAINT R. F. W. DRUM N: 14 AGE: I |
|---|---|---|---|
| Percent Fat | 1.5 | 2.3 | 1.1 |
| Aldrin | N.D. | 0.01 | 0.01 |
| α-BHC | N.D. | N.D. | 0.02 |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | 0.06 | 0.06 | 0.26 |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.03 | 0.04 | 0.11 |
| o,p'-DDE | 0.02 | N.D. | 0.07 |
| p,p'-DDE | 0.02 | 0.05 | 0.07 |
| o,p'-DDT | 0.03 | 0.05 | 0.07 |
| p,p'-DDT | 0.02 | N.D. | N.D. |
| Dieldrin | N.D. | 0.05 | N.D. |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. | N.D. |
| Hexachlorobenzene | N.D. | N.D. | 0.06 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | 0.01 | N.D. |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | N.D. | 0.05 |
| Aroclor 1016 | N.D. | N.D. | ≤0.3 |
| Aroclor 1254 | 0.17 | 0.25 | 0.28 |
| Aroclor 1260 | 0.24 | 0.46 | 0.59 |
| Total PCBs | 0.41 | 0.71 | 1.17 |

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| PARAMETER | SANDUSKY R. G. SHAD N: 24 AGE: 0 | SANDUSKY R. G. SHAD N: 4 AGE: I | SANDUSKY R. W. BASS N: 12 AGE: 0 |
|---|---|---|---|
| Percent Fat | 3.2 | 3.1 | 2.7 |
| Aldrin | N.D. | 0.06 | N.D. |
| α-BHC | N.D. | 0.03 | 0.01 |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | 0.21 | N.D. |
| Chlordane | 0.13 | 0.12 | N.D. |
| o,p'-DDD | N.D. | 0.04 | N.D. |
| p,p'-DDD | 0.03 | 0.07 | 0.03 |
| o,p'-DDE | N.D. | 0.10 | 0.06 |
| p,p'-DDE | 0.02 | 0.05 | 0.03 |
| o,p'-DDT | 0.04 | N.D. | 0.03 |
| p,p'-DDT | 0.02 | N.D. | 0.02 |
| Dieldrin | 0.04 | 0.05 | 0.02 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | N.D. | 0.02 | N.D. |
| Heptachlor epoxide | N.D. | 0.03 | N.D. |
| Hexachlorobenzene | 0.01 | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.13 | 0.02 | 0.01 |
| Mirex | 0.06 | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.03 | 0.04 | N.D. |
| Aroclor 1016 | N.D. | 0.34 | N.D. |
| Aroclor 1254 | ≤0.1 | 0.34 | 0.16 |
| Aroclor 1260 | ≤0.1 | 0.38 | 0.11 |
| Total PCBs | ≤0.2 | 1.06 | 0.27 |

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| PARAMETER | BLACK R. G. SHAD N: 11 AGE: I | BLACK R. SPOTTAIL S. N: 7 AGE: I | BLACK R. SPOTTAIL S. N: 3 AGE: II |
|---|---|---|---|
| Percent Fat | 2.0 | 2.2 | 2.8 |
| Aldrin | 0.04 | N.D. | 0.01 |
| α-BHC | 0.02 | 0.01 | 0.02 |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | 0.13 | 0.08 | 0.10 |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.06 | 0.06 | 0.05 |
| o,p'-DDE | 0.06 | N.D. | 0.02 |
| p,p'-DDE | 0.03 | 0.07 | 0.03 |
| o,p'-DDT | 0.49 | 0.03 | 0.03 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.04 | 0.02 | N.D. |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | 0.01 | N.D. | N.D. |
| Heptachlor epoxide | 0.03 | N.D. | N.D. |
| Hexachlorobenzene | 0.01 | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | 0.05 | N.D. | N.D. |
| Methoxychlor | 0.01 | 0.01 | 0.02 |
| Mirex | N.D. | 0.04 | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.05 | 0.03 | 0.04 |
| Aroclor 1016 | ≤0.3 | N.D. | N.D. |
| Aroclor 1254 | 0.31 | 0.30 | 0.24 |
| Aroclor 1260 | 0.20 | 0.32 | 0.29 |
| Total PCBs | 0.81 | 0.62 | 0.53 |

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ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | BLACK R. F. W. DRUM N: 10 AGE: 0 | BLACK R. W. BASS N: 3 AGE: 0 | BLACK R. BROWN B. H. N: 2 AGE: II |
|---|---|---|---|
| Percent Fat | 1.5 | 2.0 | 1.7 |
| Aldrin | N.D. | N.D. | 0.02 |
| α-BHC | N.D. | N.D. | 0.02 |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | 0.06 | 0.06 | 0.07 |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.02 | 0.01 | 0.03 |
| o,p'-DDE | N.D. | 0.02 | 0.06 |
| p,p'-DDE | N.D. | 0.02 | 0.03 |
| o,p'-DDT | 0.03 | 0.01 | N.D. |
| p,p'-DDT | N.D. | 0.01 | N.D. |
| Dieldrin | N.D. | N.D. | 0.02 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | 0.01 | N.D. | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. | N.D. |
| Hexachlorobenzene | 0.01 | N.D. | 0.02 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | 0.01 | N.D. |
| Mirex | 0.04 | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | 0.02 | 0.04 |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | N.D. | 0.12 | 0.24 |
| Aroclor 1260 | N.D. | 0.15 | 0.10 |
| Total PCBs | N.D. | 0.27 | 0.34 |

APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | BLACK R. CARP N: 1 AGE: IX | CUYAHOGA R. SPOTTAIL S. N: 26 AGE: I | CUYAHOGA R. SPOTTAIL S. N: 22 AGE: II |
|---|---|---|---|
| Percent Fat | 2.2 | 3.5 | 3.3 |
| Aldrin | 0.09 | 0.04 | 0.03 |
| α-BHC | 0.05 | 0.02 | 0.03 |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | 0.71 | 0.20 | 0.13 |
| o,p'-DDD | 0.11 | N.D. | N.D. |
| p,p'-DDD | 0.21 | 0.05 | 0.05 |
| o,p'-DDE | 0.57 | 0.03 | N.D. |
| p,p'-DDE | 0.25 | 0.06 | 0.08 |
| o,p'-DDT | 0.29 | 0.02 | 0.04 |
| p,p'-DDT | 0.12 | N.D. | N.D. |
| Dieldrin | 0.17 | 0.05 | 0.02 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | 0.17 | N.D. | 0.01 |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | 0.10 | N.D. | N.D. |
| Hexachlorobenzene | 0.02 | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | 0.03 | 0.04 |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.10 | 0.05 | 0.07 |
| Aroclor 1016 | ≤0.5 | ≤0.3 | N.D. |
| Aroclor 1254 | 1.3 | 0.54 | 0.56 |
| Aroclor 1260 | 0.67 | 0.42 | 0.47 |
| Total PCBs | 2.47 | 1.26 | 1.03 |

APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | CUYAHOGA R. G. SHAD N: 16 AGE: 0 | CUYAHOGA R. CARP N: 1 AGE: IV | CUYAHOGA R. Y. PERCH N: 2 AGE: II |
|---|---|---|---|
| Percent Fat | 4.1 | 2.9 | 1.8 |
| Aldrin | N.D. | 0.07 | N.D. |
| α-BHC | 0.04 | 0.03 | N.D. |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | N.D. | 0.14 | 0.11 |
| o,p'-DDD | N.D. | 0.03 | N.D. |
| p,p'-DDD | 0.04 | 0.05 | 0.03 |
| o,p'-DDE | 0.04 | 0.17 | N.D. |
| p,p'-DDE | N.D. | 0.02 | 0.03 |
| o,p'-DDT | N.D. | N.D. | 0.02 |
| p,p'-DDT | N.D. | N.D. | 0.01 |
| Dieldrin | N.D. | 0.02 | 0.02 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | N.D. | 0.06 | N.D. |
| Hexachlorobenzene | N.D. | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.03 | N.D. | 0.01 |
| Mirex | 0.01 | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.07 | 0.07 | N.D. |
| Aroclor 1016 | N.D. | ≤0.4 | N.D. |
| Aroclor 1254 | 0.21 | 0.50 | 0.17 |
| Aroclor 1260 | 0.08 | 0.12 | 0.19 |
| Total PCBs | 0.29 | 1.02 | 0.36 |

APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | CUYAHOGA R. W. BASS N: 2 AGE: 0 | CHAGRIN R. G. SHAD N: 55 AGE: 0 | CHAGRIN R. EMERALD S. N: 12 AGE: I |
|---|---|---|---|
| Percent Fat | 3.9 | 3.6 | 4.5 |
| Aldrin | N.D. | 0.01 | 0.03 |
| α-BHC | 0.02 | 0.02 | 0.02 |
| β-BHC | N.D. | N.D. | 0.01 |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | 0.15 | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.03 | 0.05 | 0.06 |
| o,p'-DDE | 0.06 | N.D. | 0.01 |
| p,p'-DDE | 0.05 | N.D. | N.D. |
| o,p'-DDT | N.D. | N.D. | 0.01 |
| p,p'-DDT | 0.04 | N.D. | 0.01 |
| Dieldrin | 0.04 | N.D. | 0.03 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. | N.D. |
| Hexachlorobenzene | N.D. | 0.07 | 0.03 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | 0.11 | 0.46 |
| Mirex | N.D. | 0.02 | 0.04 |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | 0.05 | 0.04 |
| Aroclor 1016 | ≤0.3 | N.D. | ≤0.3 |
| Aroclor 1254 | 0.19 | 0.23 | 0.19 |
| Aroclor 1260 | 0.22 | 0.18 | 0.73 |
| Total PCBs | 0.71 | 0.41 | 1.22 |

APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | CHAGRIN R. EMERALD S. N: 35 AGE: II | GRAND R. G. SHAD N: 40 AGE: 0 | GRAND R. G. SHAD N: 11 AGE: I |
|---|---|---|---|
| Percent Fat | 2.9 | 4.9 | 3.5 |
| Aldrin | 0.03 | 0.02 | 0.03 |
| α-BHC | N.D. | 0.03 | 0.03 |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | 0.07 | N.D. | 0.02 |
| Chlordane | 0.05 | 0.15 | 0.15 |
| o,p'-DDD | N.D. | N.D. | 0.03 |
| p,p'-DDD | 0.02 | 0.03 | 0.06 |
| o,p'-DDE | 0.01 | 0.01 | 0.06 |
| p,p'-DDE | 0.02 | 0.06 | 0.04 |
| o,p'-DDT | 0.01 | 0.07 | 0.03 |
| p,p'-DDT | N.D. | 0.03 | 0.03 |
| Dieldrin | N.D. | 0.04 | 0.12 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | 0.03 |
| Heptachlor | 0.05 | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. | 0.03 |
| Hexachlorobenzene | N.D. | 0.04 | 0.04 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | 0.03 |
| Methoxychlor | N.D. | 0.05 | 0.01 |
| Mirex | N.D. | 0.03 | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.21 | 0.06 | 0.05 |
| Aroclor 1016 | N.D. | N.D. | ≤0.2 |
| Aroclor 1254 | 0.12 | 0.44 | 0.35 |
| Aroclor 1260 | 0.17 | 0.27 | 0.24 |
| Total PCBs | 0.29 | 0.71 | 0.79 |

APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | GRAND R. SMELT N: 48 AGE: I | GRAND R. EMERALD S. N: 9 AGE: I | GRAND R. SPOTTAIL S. N: 3 AGE: I |
|---|---|---|---|
| Percent Fat | 3.4 | 4.0 | 3.2 |
| Aldrin | N.D. | 0.01 | N.D. |
| α-BHC | 0.02 | 0.03 | 0.02 |
| ß-BHC | N.D. | 0.01 | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | 0.10 | 0.08 | 0.10 |
| o,p'-DDD | 0.03 | 0.02 | N.D. |
| p,p'-DDD | 0.03 | 0.03 | 0.03 |
| o,p'-DDE | N.D. | 0.09 | 0.08 |
| p,p'-DDE | N.D. | 0.02 | 0.02 |
| o,p'-DDT | 0.01 | 0.03 | N.D. |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.02 | 0.01 | 0.04 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| ß-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | 0.03 | 0.02 | 0.04 |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. | N.D. |
| Hexachlorobenzene | 0.01 | 0.05 | 0.03 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.02 | 0.04 | 0.23 |
| Mirex | N.D. | 0.01 | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.03 | 0.05 | 0.04 |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | 0.19 | 0.19 | 0.14 |
| Aroclor 1260 | 0.18 | ≤0.1 | 0.16 |
| Total PCBs | 0.37 | 0.29 | 0.30 |

APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | ASHTABULA R. G. SHAD N: 52 AGE: 0 | ASHTABULA R. SMELT N: 43 AGE: I | ASHTABULA R. EMERALD S. N: 17 AGE: I |
|---|---|---|---|
| Percent Fat | 3.1 | 2.4 | 2.9 |
| Aldrin | 0.02 | N.D. | 0.03 |
| α-BHC | 0.05 | 0.06 | 0.28 |
| β-BHC | 0.34 | N.D. | N.D. |
| γ-BHC | 0.30 | N.D. | N.D. |
| Chlordane | 0.05 | N.D. | N.D. |
| o,p'-DDD | N.D. | 0.01 | N.D. |
| p,p'-DDD | 0.03 | 0.02 | 0.04 |
| o,p'-DDE | N.D. | N.D. | 0.05 |
| p,p'-DDE | N.D. | 0.01 | N.D. |
| o,p'-DDT | N.D. | N.D. | 0.01 |
| p,p'-DDT | N.D. | 0.01 | 0.02 |
| Dieldrin | N.D. | N.D. | 0.02 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | 0.14 | N.D. | 0.09 |
| Heptachlor epoxide | N.D. | N.D. | N.D. |
| Hexachlorobenzene | N.D. | 0.04 | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.01 | 0.07 | 0.08 |
| Mirex | 0.02 | N.D. | 0.01 |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | 0.12 | N.D. |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | 0.13 | 0.07 | 0.18 |
| Aroclor 1260 | 0.13 | 0.12 | 0.32 |
| Total PCBs | 0.26 | 0.19 | 0.50 |

APPENDIX A

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN FISH COLLECTED IN TRIBUTARY MOUTHS OF LAKE ERIE, AUGUST-DECEMBER, 1979

| PARAMETER | ASHTABULA R. SPOTTAIL S. N: 2 AGE: I | ASHTABULA R. W. BASS N: 2 AGE: 0 | |
|---|---|---|---|
| Percent Fat | 2.8 | 3.6 | |
| Aldrin | 0.02 | 0.03 | |
| α-BHC | 0.04 | 0.41 | |
| β-BHC | N.D. | N.D. | |
| γ-BHC | N.D. | 2.3 | |
| Chlordane | 0.17 | N.D. | |
| o,p'-DDD | 0.05 | N.D. | |
| p,p'-DDD | 0.07 | 0.04 | |
| o,p'-DDE | 0.12 | 0.06 | |
| p,p'-DDE | 0.08 | 0.01 | |
| o,p'-DDT | 0.08 | 0.01 | |
| p,p'-DDT | 0.04 | N.D. | |
| Dieldrin | N.D. | 0.02 | |
| α-Endosulfan | N.D. | N.D. | |
| β-Endosulfan | N.D. | N.D. | |
| Endrin | N.D. | N.D. | |
| Heptachlor | N.D. | 0.25 | |
| Heptachlor epoxide | 0.03 | N.D. | |
| Hexachlorobenzene | 0.03 | N.D. | |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | |
| Methoxychlor | 0.02 | 0.03 | |
| Mirex | N.D. | N.D. | |
| Toxaphene | N.D. | N.D. | |
| Trifluralin | 0.07 | N.D. | |
| Aroclor 1016 | N.D. | N.D. | |
| Aroclor 1254 | 0.28 | 0.25 | |
| Aroclor 1260 | 0.32 | 0.51 | |
| Total PCBs | 0.60 | 0.76 | |

APPENDIX B

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN CONTROL AND EXPERIMENTAL FISH FROM CUYAHOGA AND MAUMEE RIVERS, 20 OCTOBER - 17 NOVEMBER 1979

| PARAMETER[1] | (CONTROL) Y. PERCH N: 36 AGE: 0 | MAUMEE R. Y. PERCH N: 17 AGE: 0 | CUYAHOGA R. Y. PERCH N: 1 AGE: 0 |
|---|---|---|---|
| Percent Fat[2] | 1.5 | 1.2 | 2.3 |
| Aldrin | N.D. | 0.01 | 0.06 |
| α-BHC | N.D. | 0.02 | 0.05 |
| β-BHC | N.D. | N.D. | 0.06 |
| Y-BHC | N.D. | N.D. | 0.01 |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | 0.02 | 0.01 | 0.16 |
| p,p'-DDD | N.D. | 0.01 | 0.04 |
| o,p'-DDE | N.D. | 0.05 | 0.10 |
| p,p'-DDE | N.D. | 0.02 | 0.03 |
| o,p'-DDT | N.D. | 0.02 | 0.03 |
| p,p'-DDT | 0.02 | 0.04 | 0.14 |
| Dieldrin | N.D. | 0.01 | 0.04 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | 0.02 |
| Heptachlor | N.D. | N.D. | 0.03 |
| Heptachlor epoxide | N.D. | 0.01 | 0.05 |
| Hexachlorobenzene | N.D. | 0.01 | 0.48 |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | 0.05 | 0.04 | 0.09 |
| Mirex | N.D. | 0.04 | 0.10 |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | 0.04 | 0.10 |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | N.D. | N.D. | N.D. |
| Aroclor 1260 | N.D. | N.D. | N.D. |
| Total PCBs | N.D. | N.D. | N.D. |

APPENDIX B

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN CONTROL AND EXPERIMENTAL FISH FROM CUYAHOGA AND MAUMEE RIVERS, 20 OCTOBER - 17 NOVEMBER 1979

| PARAMETER | (CONTROL) C. CATFISH N: 44 AGE: 0 | CUYAHOGA R. C. CATFISH N: 2 AGE: 0 | |
|---|---|---|---|
| Percent Fat | 4.8 | 4.6 | |
| Aldrin | N.D. | 0.04 | |
| α-BHC | 0.02 | 0.09 | |
| ß-BHC | N.D. | 0.07 | |
| γ-BHC | N.D. | 0.04 | |
| Chlordane | N.D. | 0.13 | |
| o,p'-DDD | 0.17 | 0.10 | |
| p,p'-DDD | 0.06 | 0.03 | |
| o,p'-DDE | 0.48 | 0.09 | |
| p,p'-DDE | 0.04 | 0.02 | |
| o,p'-DDT | 0.07 | 0.04 | |
| p,p'-DDT | 0.04 | 0.04 | |
| Dieldrin | 0.05 | N.D. | |
| α-Endosulfan | 0.05 | N.D. | |
| ß-Endosulfan | N.D. | 0.2 | |
| Endrin | 0.04 | N.D. | |
| Heptachlor | N.D. | 0.02 | |
| Heptachlor epoxide | 0.06 | 0.10 | |
| Hexachlorobenzene | 0.04 | 0.32 | |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | |
| Methoxychlor | 0.01 | 0.11 | |
| Mirex | N.D. | 0.03 | |
| Toxaphene | N.D. | N.D. | |
| Trifluralin | 0.04 | 0.19 | |
| Aroclor 1016 | N.D. | N.D. | |
| Aroclor 1254 | N.D. | N.D. | |
| Aroclor 1260 | N.D. | N.D. | |
| Total PCBs | N.D. | N.D. | |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | MAUMEE R. C. CATFISH N:37 6/20/80 | MAUMEE R. C. CATFISH N:35 6/27/80 | MAUMEE R. C. CATFISH N:46 7/4/80 |
|---|---|---|---|
| Percent Fat | 2.2 | 2.4 | 2.3 |
| Aldrin | N.D. | N.D. | N.D. |
| α-BHC | N.D. | N.D. | 0.04 |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.05 | 0.08 | 0.09 |
| o,p'-DDE | N.D. | N.D. | N.D. |
| p,p'-DDE | 0.08 | 0.13 | 0.07 |
| o,p'-DDT | N.D. | 0.05 | 0.04 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.04 | 0.07 | 0.06 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | 0.08 | 0.09 |
| Endrin | N.D. | 0.03 | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | 0.04 | 0.04 | 0.06 |
| Hexachlorobenzene | N.D. | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | N.D. | N.D. |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.03 | 0.03 | 0.02 |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | 0.08 | 0.08 | 0.18 |
| Aroclor 1260 | 0.06 | 0.06 | 0.06 |
| Total PCBs | 0.14 | 0.14 | 0.24 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | MAUMEE R. BLUEGILL N:36 5/30/80 | MAUMEE R. BLUEGILL N:35 6/6/80 | MAUMEE R. BLUEGILL N:40 6/13/80 |
|---|---|---|---|
| Percent Fat | 1.8 | 1.5 | 1.4 |
| Aldrin | N.D. | N.D. | N.D. |
| α-BHC | N.D. | N.D. | N.D. |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | 0.02 | 0.02 |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.02 | N.D. | 0.02 |
| o,p'-DDE | N.D. | N.D. | N.D. |
| p,p'-DDE | 0.03 | 0.03 | 0.05 |
| o,p'-DDT | N.D. | N.D. | 0.03 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.03 | 0.12 | 0.03 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | N.D. | 0.02 | 0.02 |
| Hexachlorobenzene | N.D. | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | N.D. | N.D. |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | N.D. | 0.02 |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | 0.07 | N.D. | 0.07 |
| Aroclor 1260 | 0.06 | N.D. | ≤0.05 |
| Total PCBs | 0.13 | N.D. | 0.12 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | MAUMEE R. BLUEGILL N:33 6/20/80 | MAUMEE R. BLUEGILL N:32 6/27/80 | MAUMEE R. BLUEGILL N:80 7/4/80 |
|---|---|---|---|
| Percent Fat | 2.2 | 2.0 | 1.8 |
| Aldrin | N.D. | N.D. | 0.02 |
| α-BHC | N.D. | N.D. | N.D. |
| β-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.02 | 0.02 | 0.04 |
| o,p'-DDE | N.D. | N.D. | N.D. |
| p,p'-DDE | 0.04 | 0.06 | 0.03 |
| o,p'-DDT | N.D. | 0.03 | 0.03 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.03 | 0.03 | 0.04 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | 0.02 | 0.02 | 0.04 |
| Hexachlorobenzene | N.D. | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | N.D. | N.D. |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | N.D. | N.D. | N.D. |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | 0.08 | ≤0.05 | 0.12 |
| Aroclor 1260 | ≤0.05 | N.D. | N.D. |
| Total PCBs | 0.13 | ≤0.05 | 0.12 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | CUYAHOGA R. C. CATFISH N:37 5/30/80 | CUYAHOGA R. C. CATFISH N:133 6/6/80 |
|---|---|---|
| Percent Fat | 2.4 | 3.0 |
| Aldrin | N.D. | 0.04 |
| α-BHC | N.D. | 0.06 |
| β-BHC | N.D. | N.D. |
| γ-BHC | N.D. | N.D. |
| Chlordane | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. |
| p,p'-DDD | 0.02 | 0.12 |
| o,p'-DDE | N.D. | N.D. |
| p,p'-DDE | 0.06 | 0.14 |
| o,p'-DDT | N.D. | 0.02 |
| p,p'-DDT | N.D. | N.D. |
| Dieldrin | 0.02 | 0.04 |
| α-Endosulfan | N.D. | N.D. |
| β-Endosulfan | N.D. | 0.12 |
| Endrin | N.D. | 0.03 |
| Heptachlor | N.D. | N.D. |
| Heptachlor epoxide | N.D. | 0.06 |
| Hexachlorobenzene | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. |
| Methoxychlor | N.D. | 0.03 |
| Mirex | N.D. | N.D. |
| Toxaphene | N.D. | N.D. |
| Trifluralin | 0.01 | 0.16 |
| Aroclor 1016 | N.D. | N.D. |
| Aroclor 1254 | ≤0.07 | 0.10 |
| Aroclor 1260 | N.D. | 0.09 |
| Total PCBs | ≤0.07 | 0.19 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | CUYAHOGA R. BLUEGILL N:37 5/30/80 | CUYAHOGA R. BLUEGILL N:248 6/6/80 |
|---|---|---|
| Percent Fat | 2.1 | 4.0 |
| Aldrin | N.D. | N.D. |
| α-BHC | N.D. | 0.13 |
| β-BHC | N.D. | N.D. |
| γ-BHC | N.D. | N.D. |
| Chlordane | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. |
| p,p'-DDD | 0.02 | 0.04 |
| o,p'-DDE | 0.02 | N.D. |
| p,p'-DDE | N.D. | 0.05 |
| o,p'-DDT | N.D. | N.D. |
| p,p'-DDT | N.D. | N.D. |
| Dieldrin | 0.03 | 0.05 |
| α-Endosulfan | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. |
| Endrin | N.D. | N.D. |
| Heptachlor | N.D. | N.D. |
| Heptachlor epoxide | N.D. | 0.06 |
| Hexachlorobenzene | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. |
| Methoxychlor | N.D. | N.D. |
| Mirex | N.D. | N.D. |
| Toxaphene | N.D. | N.D. |
| Trifluralin | 0.02 | 0.04 |
| Aroclor 1016 | N.D. | N.D. |
| Aroclor 1254 | ≤0.07 | 0.07 |
| Aroclor 1260 | N.D. | N.D. |
| Total PCBs | ≤0.07 | 0.07 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | ASHTABULA R. C. CATFISH N:36 5/30/80 | ASHTABULA R. C. CATFISH N:38 6/6/80 | ASHTABULA R. C. CATFISH N:39 6/13/80 |
|---|---|---|---|
| Percent Fat | 3.6 | 1.8 | 2.6 |
| Aldrin | N.D. | N.D. | N.D. |
| α-BHC | N.D. | N.D. | N.D. |
| β-BHC | 0.04 | N.D. | 0.05 |
| γ-BHC | 0.03 | 0.02 | 0.04 |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.05 | 0.02 | 0.04 |
| o,p'-DDE | N.D. | 0.03 | 0.08 |
| p,p'-DDE | 0.04 | 0.03 | N.D. |
| o,p'-DDT | N.D. | N.D. | 0.02 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.04 | N.D. | 0.05 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | 0.03 | N.D. | 0.02 |
| Heptachlor | 0.06 | N.D. | 0.28 |
| Heptachlor epoxide | N.D. | N.D. | 0.02 |
| Hexachlorobenzene | N.D. | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | N.D. |
| Methoxychlor | N.D. | N.D. | N.D. |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.03 | 0.01 | 0.02 |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | ≤0.06 | ≤0.05 | ≤0.1 |
| Aroclor 1260 | N.D. | N.D. | N.D. |
| Total PCBs | ≤0.06 | ≤0.05 | ≤0.1 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | ASHTABULA R. C. CATFISH N:34 6/20/80 | ASHTABULA R. C. CATFISH N:33 6/27/80 | ASHTABULA R. C. CATFISH N:47 7/4/80 |
|---|---|---|---|
| Percent Fat | 2.7 | 3.2 | 2.7 |
| Aldrin | N.D. | N.D. | N.D. |
| α-BHC | N.D. | N.D. | N.D. |
| β-BHC | N.D. | N.D. | 0.02 |
| γ-BHC | 0.02 | N.D. | N.D. |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.04 | 0.02 | 0.02 |
| o,p'-DDE | 0.07 | 0.06 | 0.10 |
| p,p'-DDE | N.D. | N.D. | N.D. |
| o,p'-DDT | 0.02 | 0.02 | 0.02 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.03 | N.D. | N.D. |
| α-Endosulfan | N.D. | N.D. | N.D. |
| β-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | N.D. | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. | N.D. |
| Hexachlorobenzene | N.D. | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | 0.13 | 0.14 | N.D. |
| Methoxychlor | N.D. | N.D. | N.D. |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.04 | 0.03 | N.D. |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | ≤0.2 | 0.13 | 0.11 |
| Aroclor 1260 | N.D. | ≤0.05 | ≤0.05 |
| Total PCBs | ≤0.2 | 0.18 | 0.16 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | ASHTABULA R. BLUEGILL N:32 5/30/80 | ASHTABULA R. BLUEGILL N:33 6/6/80 | ASHTABULA R. BLUEGILL N:34 6/13/80 |
|---|---|---|---|
| Percent Fat | 2.6 | 1.5 | 2.8 |
| Aldrin | N.D. | N.D. | N.D. |
| α-BHC | N.D. | N.D. | N.D. |
| ß-BHC | N.D. | N.D. | N.D. |
| γ-BHC | N.D. | N.D. | N.D. |
| Chlordane | N.D. | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. | N.D. |
| p,p'-DDD | 0.02 | 0.02 | N.D. |
| o,p'-DDE | N.D. | 0.08 | N.D. |
| p,p'-DDE | 0.02 | 0.03 | 0.02 |
| o,p'-DDT | N.D. | 0.02 | 0.04 |
| p,p'-DDT | N.D. | N.D. | N.D. |
| Dieldrin | 0.02 | 0.03 | 0.03 |
| α-Endosulfan | N.D. | N.D. | N.D. |
| ß-Endosulfan | N.D. | N.D. | N.D. |
| Endrin | N.D. | N.D. | N.D. |
| Heptachlor | 0.04 | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. | N.D. |
| Hexachlorobenzene | N.D. | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | N.D. | N.D. | 0.12 |
| Methoxychlor | N.D. | N.D. | N.D. |
| Mirex | N.D. | N.D. | N.D. |
| Toxaphene | N.D. | N.D. | N.D. |
| Trifluralin | 0.03 | N.D. | 0.02 |
| Aroclor 1016 | N.D. | N.D. | N.D. |
| Aroclor 1254 | N.D. | ≤0.05 | ≤0.2 |
| Aroclor 1260 | N.D. | N.D. | N.D. |
| Total PCBs | N.D. | ≤0.05 | ≤0.2 |

APPENDIX D

ANALYTICAL RESULTS OF ORGANIC CONTAMINANT CONCENTRATIONS AND PERCENT FAT IN EXPERIMENTAL GROUP YOUNG-OF-THE-YEAR FISH, 23 MAY-4 JULY, 1980

| PARAMETER | ASHTABULA R. BLUEGILL N:33 6/20/80 | ASHTABULA R. BLUEGILL N:50 6/27/80 |
|---|---|---|
| Percent Fat | 1.9 | 2.6 |
| Aldrin | N.D. | N.D. |
| α-BHC | N.D. | N.D. |
| ß -BHC | N.D. | N.D. |
| γ-BHC | 0.02 | N.D. |
| Chlordane | N.D. | N.D. |
| o,p'-DDD | N.D. | N.D. |
| p,p'-DDD | N.D. | N.D. |
| o,p'-DDE | 0.07 | 0.11 |
| p,p'-DDE | 0.03 | 0.03 |
| o,p'-DDT | 0.02 | 0.02 |
| p,p'-DDT | N.D. | N.D. |
| Dieldrin | N.D. | N.D. |
| α-Endosulfan | N.D. | N.D. |
| ß -Endosulfan | N.D. | N.D. |
| Endrin | N.D. | N.D. |
| Heptachlor | N.D. | N.D. |
| Heptachlor epoxide | N.D. | N.D. |
| Hexachlorobenzene | N.D. | N.D. |
| 2,4-D (Isopropyl ester) | 0.13 | N.D. |
| Methoxychlor | N.D. | N.D. |
| Mirex | N.D. | N.D. |
| Toxaphene | N.D. | N.D. |
| Trifluralin | 0.02 | N.D. |
| Aroclor 1016 | N.D. | N.D. |
| Aroclor 1254 | 0.15 | 0.11 |
| Aroclor 1260 | ≤0.05 | ≤0.05 |
| Total PCBs | 0.20 | 0.16 |

NOTE: N.D. refers to Not Detected (Sample < than Detection Limit)

[1]Units of measure ug/g unless noted otherwise

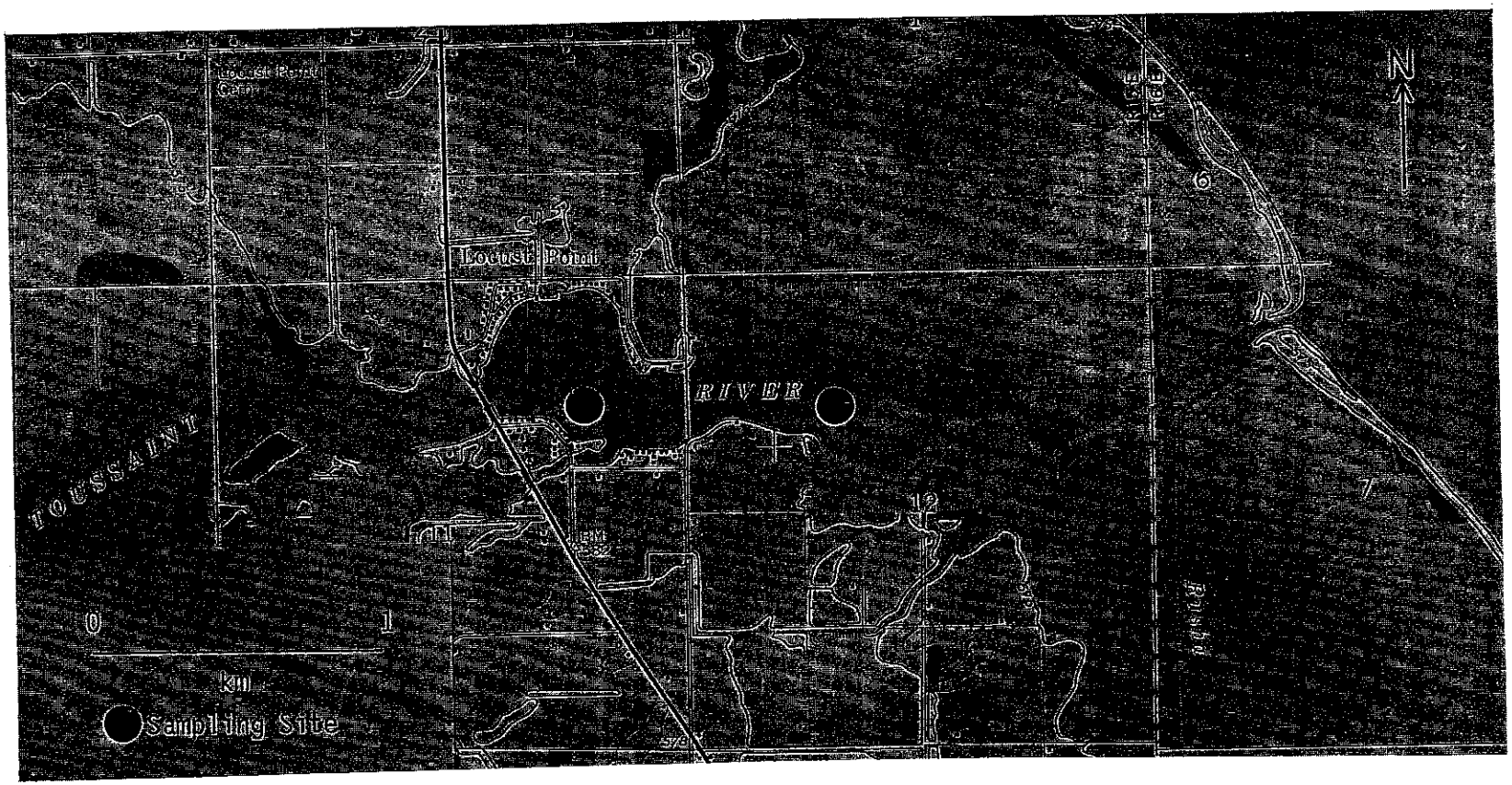
[2]Units of measure % by weight

# APPENDIX E

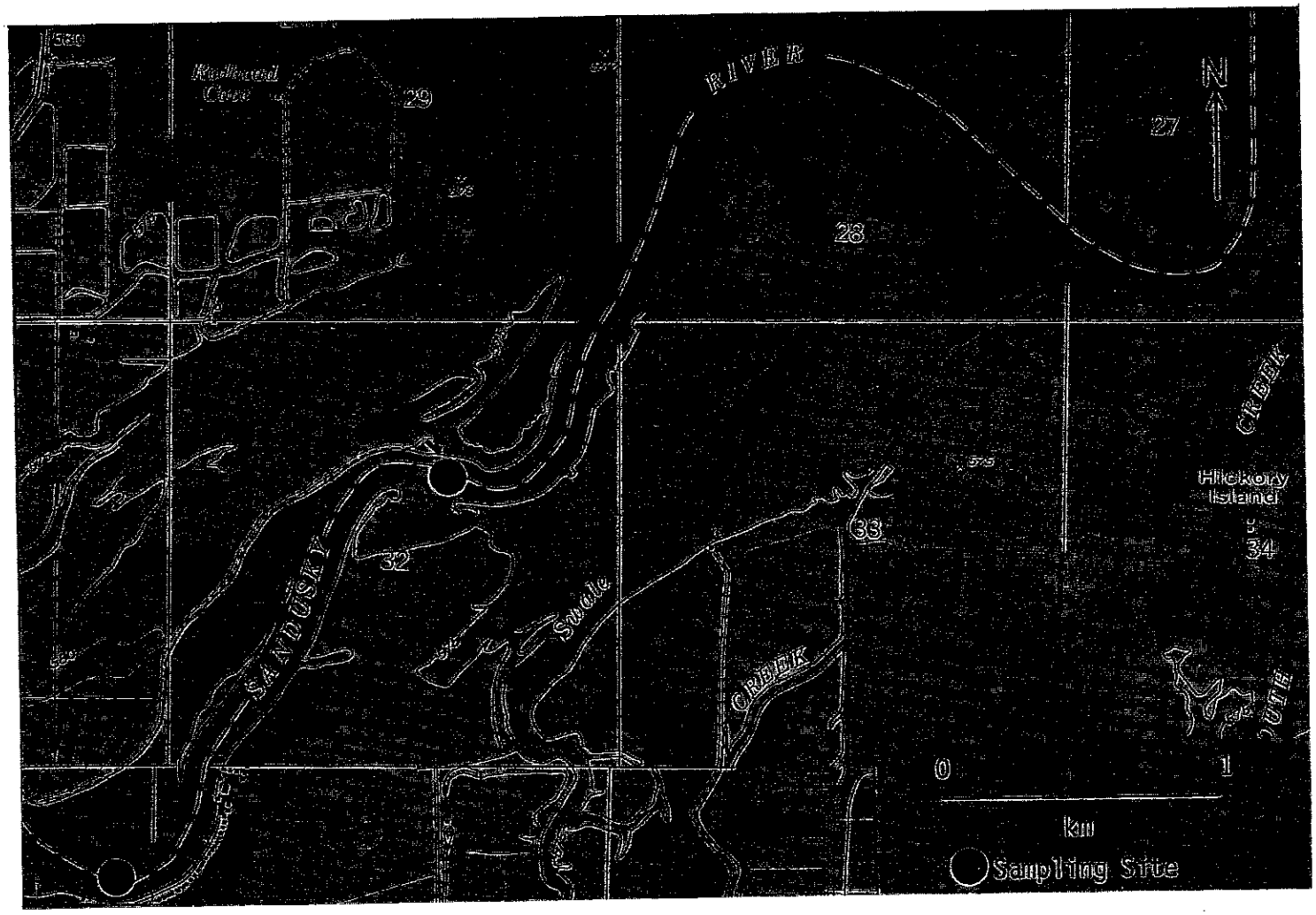
## Locations of Sampling and Uptake Experiment Sites From Lake Erie Tributary Mouths, 1979-1980


Appendix E. Location of River Raisin Sampling Site (From U.S. Geological Survey (U.S.G.S.) Quadrangles Monroe, Michigan and Oregon, Ohio - Michigan 7.5 Series, 1965)

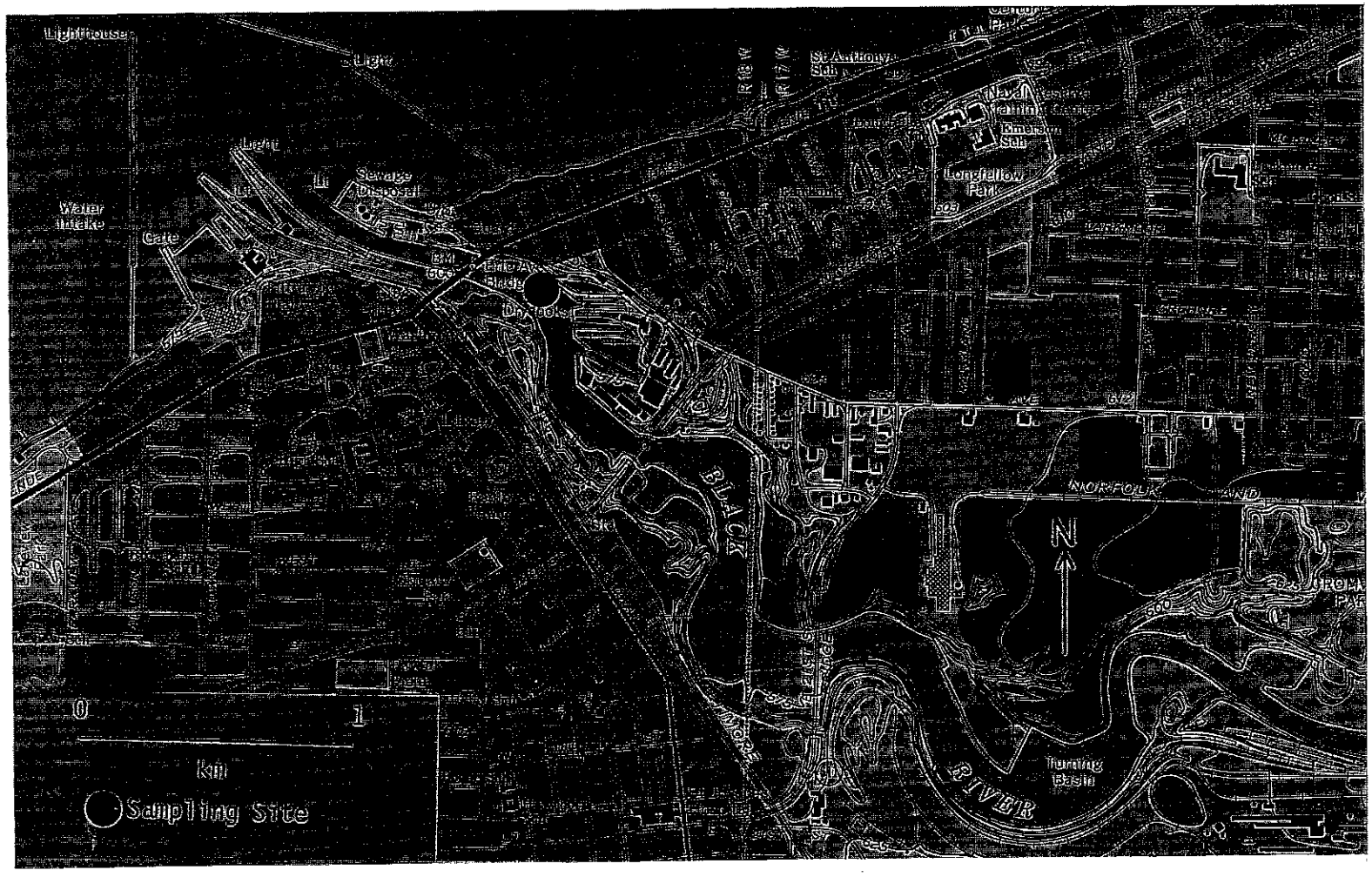

Appendix E. Location of Maumee River, Sampling and Uptake Experiment Sites. From U.S.G.S. - Quadrangle Oregon, Ohio - Michigan, 7.5 Series, 1965



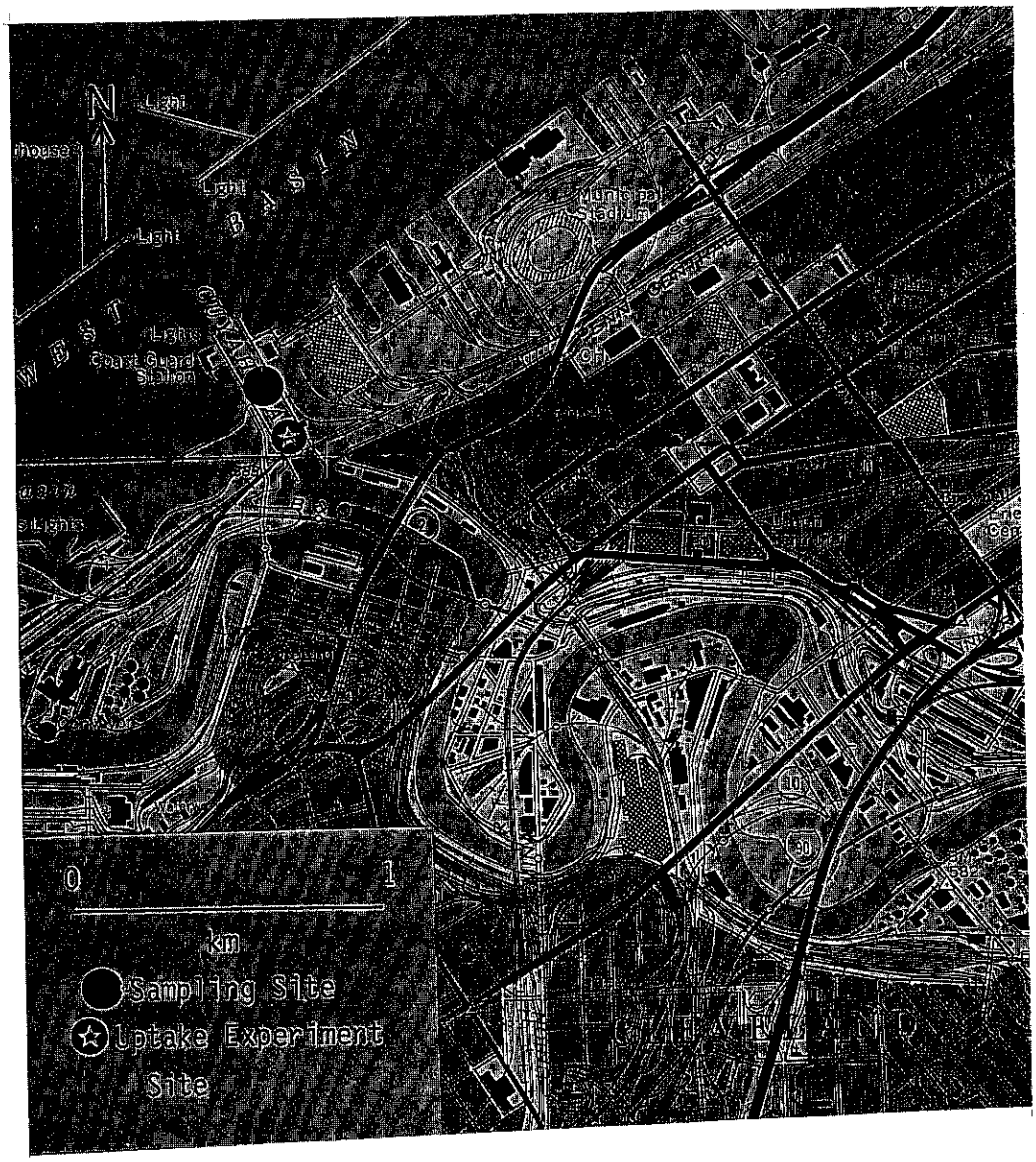

Appendix E. Location of Toussaint River, Ohio Sampling Sites. From U.S.G.S. Quadrangle Lacarne, Ohio, 7.5 Series, 1967



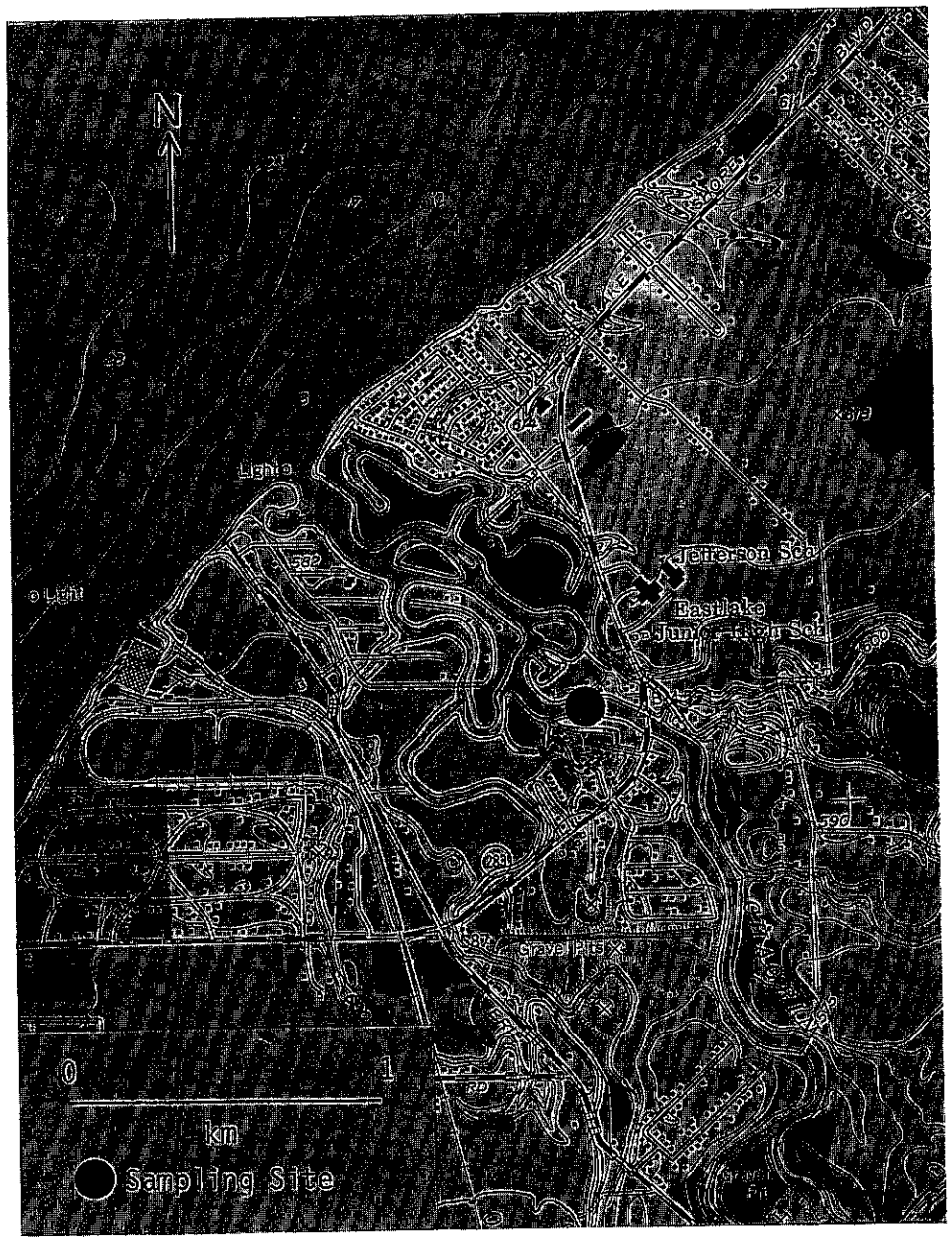

Appendix E. Location of Sandusky River, Ohio Sampling Sites. From U.S.G.S. Quadrangle Wightmans Grover, Ohio. 7.5 Series, 1969



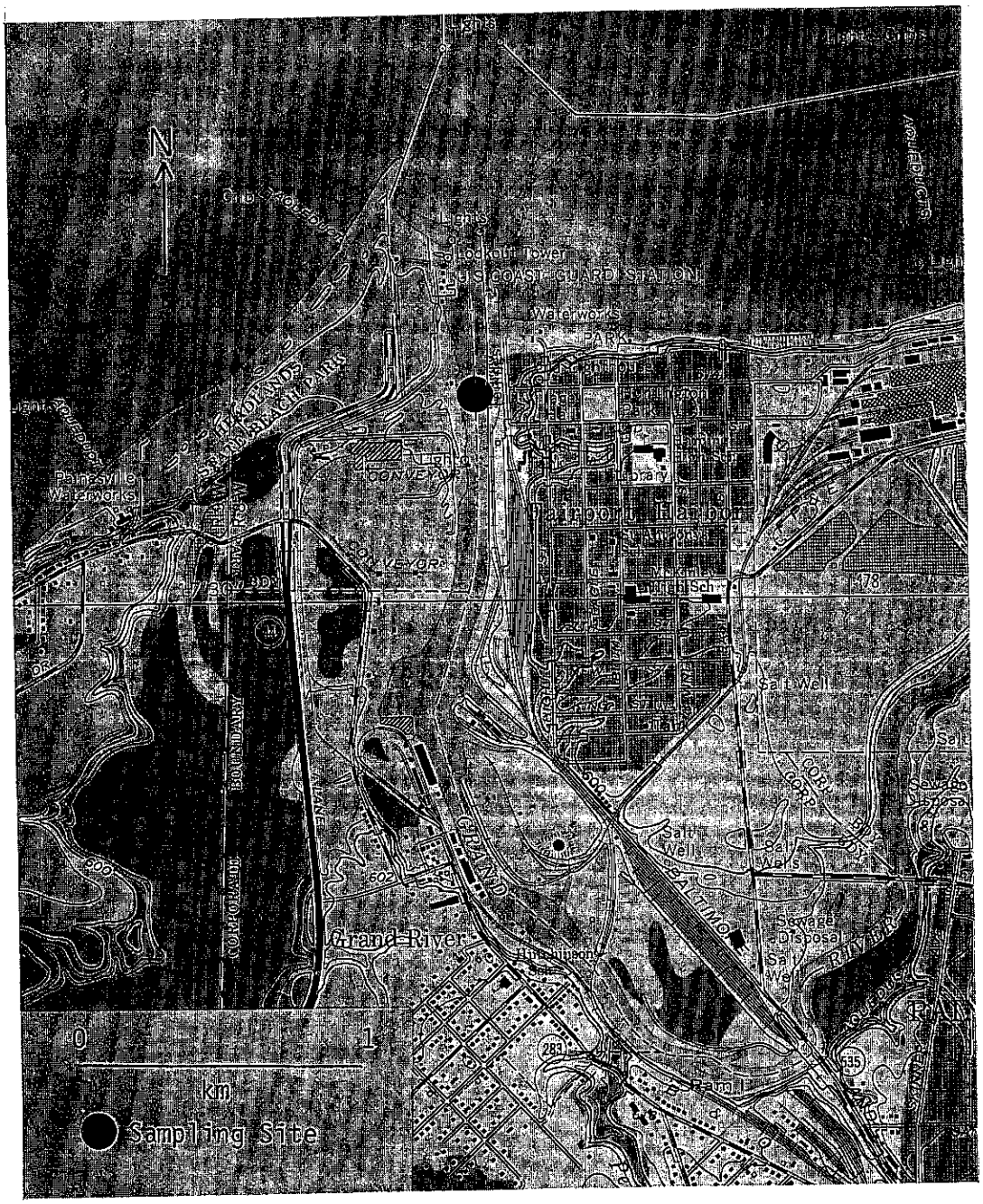

Appendix E. Location of Black River, Ohio Sampling Site. From U.S.G.S. Quadrangle Lorain, Ohio 7.5 Series, 1969



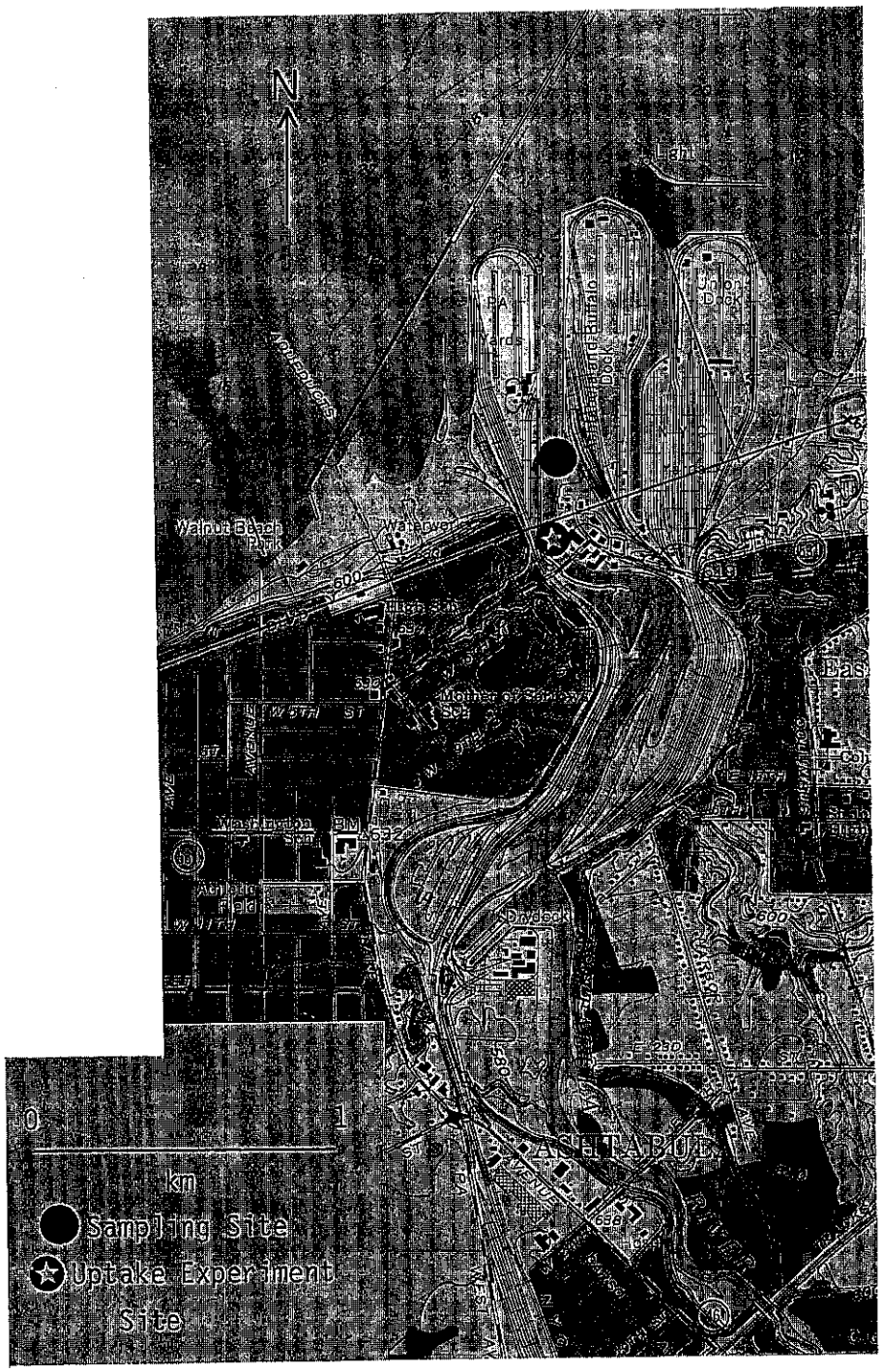

Appendix E. Location of Cuyahoga River, Ohio Sampling and Uptake Experiment Sites. From U.S.G.S. Quadrangles, Cleveland North and Cleveland South, 7.5 Series 1970




Appendix E. Location of Chagrin River, Ohio Sampling Site. From U.S.G.S. Quadrangle Eastlake, Ohio, 7.5 Series, 1970




Appendix E. Location of Grand River, Ohio Sampling Site. From U.S.G.S. Quadrangle Mentor, Ohio, 7.5 Series, 1963




Appendix E. Location of Ashtabula River, Ohio Sampling and Uptake Experiment Sites. From U.S.G.S. Quadrangle Ashtabula North, Ohio 7.5 Series, 1970


Appendix E. Location of Walnut Creek, Pennsylvania Sampling Site. From U.S.G.S. Quadrangle Swanville, Pennsylvania, 7.5 Series, 1975


Appendix E. Location of Cattaraugus Creek, New York Sampling Site. From U.S.G.S. Quadrangle Silver Creek, New York 7.5 Series, 1960

APPENDIX F

CONCENTRATIONS OF ORGANOCHLORINE CONTAMINANTS IN SEDIMENT SAMPLES FROM SELECTED NEARSHORE ZONES OF THE WESTERN[1] AND CENTRAL[2] BASINS OF LAKE ERIE 1978-1979

| Location[3] | Date | Depth (cm) | Contaminant | Concentration (ppm) |
|---|---|---|---|---|
| **Western Basin** | | | | |
| River Raisin (mouth) | 1978 | 0-5 cm | o,p'-DDD | 0.026 |
| | 1978 | 5-10 cm | o,p'-DDD | 0.073 |
| | 1978 | >10 cm | o,p'-DDD | 0.027 |
| | 1978 | 5-10 cm | p,p'-DDD | 0.007 |
| | 1978 | >10 cm | p,p'-DDD | 0.005 |
| | 1978 | 0-5 cm | Mirex | 0.008 |
| | 1978 | 5-10 cm | Mirex | 0.027 |
| | 1978 | 0-5 cm | Aroclor 1254 | 0.07 |
| | 1978 | 5-10 cm | Aroclor 1254 | 0.16 |
| | 1978 | >10 cm | Aroclor 1254 | 0.41 |
| | 1979 | 0-5 cm | Aroclor 1254 | 0.35 |
| | 1979 | 5-10 cm | Aroclor 1254 | 0.12 |
| | 1979 | >10 cm | Aroclor 1254 | 0.08 |
| | 1979 | 5-10 cm | Aroclor 1260 | 0.02 |
| | 1979 | >10 cm | Aroclor 1260 | 0.04 |
| Maumee River (mouth) | 1978 | 0-5 cm | Aldrin | 0.01 |
| | 1978 | 5-10 cm | Aldrin | 0.035 |
| | 1978 | 5-10 cm | o,p'-DDD | 0.005 |
| | 1978 | 0-5 cm | o,p'-DDT | 0.008 |
| | 1978 | 0-5 cm | Dieldrin | 0.007 |
| | 1978 | 0-5 cm | Heptachlor | 0.002 |
| | 1978 | >10 cm | Methoxychlor | 0.02 |
| | 1978 | 0-5 cm | Mirex | 0.013 |
| | 1978 | 5-10 cm | Mirex | 0.008 |
| | 1978 | >10 cm | Mirex | 0.081 |
| | 1978 | 0-5 cm | Aroclor 1254 | 0.08 |
| | 1978 | 5-10 cm | Aroclor 1254 | 0.07 |
| | 1978 | >10 cm | Aroclor 1254 | 0.84 |
| | 1979 | 0-5 cm | Aldrin | 0.01 |
| | 1979 | 5-10 cm | o,p'-DDD | 0.007 |
| | 1979 | 0-5 cm | Aroclor 1254 | 0.12 |
| | 1979 | 5-10 cm | Aroclor 1254 | 0.09 |

APPENDIX F (continued)

CONCENTRATIONS OF ORGANOCHLORINE CONTAMINANTS IN SEDIMENT SAMPLES FROM SELECTED NEARSHORE ZONES OF THE WESTERN[1] AND CENTRAL[2] BASINS OF LAKE ERIE 1978-1979

| Location[3] | Date | Depth (cm) | Contaminant | Concentration (ppm) |
|---|---|---|---|---|
| **Western Basin** | | | | |
| Maumee River (mouth) | 1979 | >10 cm | Aroclor 1254 | 0.40 |
| | 1979 | 0-5 cm | Aroclor 1260 | 0.07 |
| | 1979 | 5-10 cm | Aroclor 1260 | 0.07 |
| | 1979 | >10 cm | Aroclor 1260 | 0.12 |
| Sandusky River (mouth) | 1978 | 5-10 cm | Aroclor 1254 | 0.01 |
| **Central Basin** | | | | |
| Black River (mouth) | 1978 | 0-5 cm | γ-BHC | 0.013 |
| | 1978 | 0-5 cm | Heptachlor | 0.047 |
| | 1978 | 0-5 cm | Aroclor 1254 | 2.13 |
| | 1979 | 5-10 cm | β-BHC | 0.009 |
| | 1979 | >10 cm | β-BHC | 0.005 |
| | 1979 | 5-10 cm | o,p'-DDD | 0.004 |
| | 1979 | >10 cm | o,p'-DDD | 0.006 |
| | 1979 | 5-10 cm | o,p'-DDE | 0.045 |
| | 1979 | >10 cm | o,p'-DDE | 0.052 |
| | 1979 | 5-10 cm | o,p'-DDT | 0.006 |
| | 1979 | >10 cm | o,p'-DDT | 0.006 |
| | 1979 | 5-10 cm | p,p'-DDT | 0.003 |
| | 1979 | >10 cm | p,p'-DDT | 0.003 |
| | 1979 | 5-10 cm | HCB | 0.004 |
| | 1979 | >10 cm | HCB | 0.002 |
| | 1979 | 5-10 cm | Trifluralin | 0.002 |
| | 1979 | 5-10 cm | Mirex | 0.007 |
| | 1979 | 5-10 cm | Aroclor 1254 | 0.23 |

APPENDIX F (continued)

CONCENTRATIONS OF ORGANOCHLORINE CONTAMINANTS IN SEDIMENT SAMPLES FROM SELECTED NEARSHORE ZONES OF THE WESTERN[1] AND CENTRAL[2] BASINS OF LAKE ERIE 1978-1979

Central Basin

| Location[3] | Date | Depth (cm) | Contaminant | Concentration (ppm) |
|---|---|---|---|---|
| Cuyahoga River (mouth) | 1978 | 0-5 cm | γ-BHC | 0.018 |
| | 1978 | 0-5 cm | Aroclor 1254 | 2.22 |
| | 1979 | 0-5 cm | β-BHC | 0.006 |
| | 1979 | 5-10 cm | β-BHC | 0.001 |
| | 1979 | 0-5 cm | o,p'-DDD | 0.043 |
| | 1979 | 5-10 cm | o,p'-DDD | 0.004 |
| | 1979 | 0-5 cm | o,p'-DDE | 0.031 |
| | 1979 | 5-10 cm | o,p'-DDE | 0.028 |
| | 1979 | 0-5 cm | o,p'-DDT | 0.012 |
| | 1979 | 5-10 cm | o,p'-DDT | 0.016 |
| | 1979 | 5-10 cm | p,p'-DDT | 0.01 |
| | 1979 | 0-5 cm | Heptachlor Epox. | 0.001 |
| | 1979 | 5-10 cm | Heptachlor Epox. | 0.001 |
| | 1979 | >10 cm | 2,4-D (Iso. Est.) | 0.15 |
| | 1979 | 0-5 cm | Aroclor 1254 | 2.94 |
| | 1979 | 5-10 cm | Aroclor 1254 | 2.08 |
| | 1979 | >10 cm | Aroclor 1254 | 0.64 |
| Grand River (mouth) | 1978 | 0-5 cm | γ-BHC | 0.002 |
| | 1978 | 0-5 cm | Aroclor 1254 | 0.32 |
| | 1979 | 5-10 cm | β-BHC | 0.003 |
| | 1979 | 5-10 cm | o,p'-DDD | 0.092 |
| | 1979 | 5-10 cm | o,p'-DDE | 0.015 |

APPENDIX F (continued)

CONCENTRATIONS OF ORGANOCHLORINE CONTAMINANTS IN SEDIMENT SAMPLES FROM SELECTED NEARSHORE ZONES OF THE WESTERN[1] AND CENTRAL[2] BASINS OF LAKE ERIE 1978-1979

| Location[3] | Date | Depth (cm) | Contaminant | Concentration (ppm) |
|---|---|---|---|---|
| **Central Basin** | | | | |
| Grand River (mouth) | 1979 | 5-10 cm | o,p'-DDT | 0.044 |
| | 1979 | 5-10 cm | p,p'-DDT | 0.072 |
| | 1979 | 0-5 cm | Dieldrin | 0.002 |
| | 1979 | 5-10 cm | Dieldrin | 0.003 |
| | 1979 | 5-10 cm | Mirex | 0.002 |
| | 1979 | 0-5 cm | Aroclor 1254 | 0.17 |
| | 1979 | 5-10 cm | Aroclor 1254 | 0.42 |
| | 1979 | >10 cm | Aroclor 1254 | 1.07 |
| Ashtabula River (mouth) | 1979 | 0-5 cm | β-BHC | 0.002 |
| | 1979 | 0-5 cm | o,p'-DDD | 0.001 |
| | 1979 | 5-10 cm | o,p'-DDD | 0.001 |
| | 1979 | 0-5 cm | o,p'-DDE | 0.001 |
| | 1979 | 5-10 cm | o,p'-DDE | 0.001 |
| | 1979 | >10 cm | Aroclor 1254 | 0.46 |

[1]Western Basin data from Fay and Herdendorf (1981)

[2]Central Basin data from Richards (1981)

[3]Locations refer to nearshore area at respective tributary mouths. Geographical coordinates were:

| | Latitude (N) | Longitude (W) |
|---|---|---|
| River Raisin | 41° 53'24" | 83°19'54" |
| Maumee River | 41°41'48" | 83°28'00" |
| Sandusky River | 41°27'42" | 82°57'54" |
| Black River | 41°28'12" | 82°11'00" |
| Cuyahoga River | 41°30'18" | 81°42'45" |
| Grand River | 41°45'42" | 81°16'50" |
| Ashtabula River | 41°54'47" | 80°47'55" |