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CHLORINATED HYDROCARBONS IN FISH FROM LAKE MICHIGAN

by

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Project 16020 PBE

August, 1973

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ABSTRACT.

Lake Michigan fish representing 13 species from 11 regions were captured in the fall of 1971 and analyzed for chlorobiphenyls (PCBs) and DDT and analogs. The presence of the major chlorinated hydrocarbons was confirmed by GC/MS, and additional confirmations of PCBs were obtained through perchlorination. The major PCBs in Lake Michigan fish are the tetra-, penta-, hexa- and heptachlorobiphenyls although lesser chlorinated PCBs were present in fish from nearshore waters. Mean concentrations of PCBs in the fish expressed as Aroclor 1254 (wet weight) ranged from 2.7 µg/gm in smelt to 15 µg/gm in lake trout. Essentially all trout and salmon greater than 12 inches in length contained PCBs at concentrations greater than the FDA tolerance level of 5 µg/gm. The concentrations of DDT (sum of analogs) ranged from less than 1 µg/gm in suckers to approximately 16 µg/gm in large lake trout.

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SECTION I

CONCLUSIONS

1. The predominant chlorinated hydrocarbons in Lake Michigan fish on a weight basis are chlorobiphenyls (PCBs) and DDT and its analogs.

2. The PCB mixtures are comprised primarily of the tetra-, penta-, and hexachlorobiphenyls, although fish from the nearshore waters often contain appreciable quantities of di- and trichlorobiphenyls.

3. The data reported as total DDT is comprised of approximately 50 to 60 percent p,p'DDE, 20 to 30 percent p,p'DDT, and lesser amounts of o,p'DDT and pp'TDE.

4. Mean concentrations of PCBs in the 1971 populations of fish averaged over the entire lake range from 2.7 μg/gm in smelt to 15 μg/gm in salmon. In general, trout and salmon greater than 12 inches in length contain PCBs at concentrations greater than the FDA action level of 5 μg/gm in food for human consumption.

5. Large variations in the concentration of PCBs were observed and were dependent on species, lipid content, length, and season of sampling. All of these factors must be recognized in the design of future monitoring work on Lake Michigan fish.

6. The concentration of DDT ranged from less than 1 μg/gm in suckers to approximately 16 μg/gm in large lake trout. In general, large trout and salmon contained from 7 to 12 μg/gm DDT, also exceeding the FDA tolerance level of 5 μg/gm DDT in human food.

7. Although the mobility of fish precludes the possibility of explicitly determining the variation of chlorinated hydrocarbons with region of Lake Michigan, the trend of higher concentrations of the PCBs in the southern end of the lake was observed in most of the species analyzed. This trend was more pronounced in the analysis of bottom fauna as presented in Appendix B in which the concentrations of PCBs varied from 0.06 μg/gm in

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Pontiporeia captured in 100 feet of water near Sturgeon Bay, Wisconsin, to 0.45 ug/gm in those from Waukegan, Illinois. Decreasing concentrations of PCBs were also observed in fauna from greater depths along each transect.

8. The present methodology for the analysis of PCBs in tissue is adequate for the determination of PCBs containing four or more chlorine atoms per molecule. However, the silicic acid separation procedure does not allow explicit determination of PCBs with fewer numbers of chlorines due to their greater polarity.

9. The use of perchlorination as an analytical method for PCBs provides rapid confirmation and data similar to direct GLC analyses when the predominant PCB mixture is known.

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SECTION II

RECOMMENDATIONS

1. Luecshow (1972) recommended that the concentrations of PCBs in Lake Michigan fish should be determined. This study has satisfied this recommendation for the 1971 fish populations and has provided "baseline" data for future work aimed at detecting trends in the PCB and DDT concentrations. Because of the recent restrictions on PCB and DDT uses, the Lake Michigan system provides a unique opportunity to demonstrate the effect legislative and other regulatory actions may have on a large body of water. It is recommended that comprehensive sampling of selected fish species be conducted at two-year intervals and that these fish be analyzed for PCBs and DDT. Such studies should be modeled after the limited studies presently underway at the Great Lakes Fishery Laboratory in Ann Arbor, Michigan.

2. Detailed information is needed regarding the quantities of PCBs in use after the restrictions Monsanto Company has voluntarily imposed. It is recommended that the Environmental Protection Agency initiate appropriate investigations to assure that the "open system" use of PCBs is, in fact, curtailed and that significant quantities of PCBs are not being imported.

3. Further studies concerning the impact of PCBs and DDT on the biological resources of Lake Michigan are needed and should be stimulated by Federal funding.

4. Detailed searches for potentially hazardous chemicals heretofore unidentified should be conducted on Lake Michigan fish in order that the significance of such chemicals can be evaluated as early as possible and appropriate regulatory action be considered before the concentrations become sufficient to further jeopardize the usefulness of the Lake Michigan resources.

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SECTION III

INTRODUCTION

The literature is replete with data concerning the occurrence of chlorinated hydrocarbons in the environment and the effects of these synthetic chemicals on test animals. Concomitant with such studies are attempts to correlate the composition of organochlorine chemicals in organisms (or their environment) to observed effects in the biological communities and to formulate regulatory policies in accordance with existing evidence. However, the complex nature of ecosystems and of the mixtures of potentially hazardous chemicals found in the ecosystems often preclude explicit interpretation of data, as has been exhibited in the numerous hearings before the U.S. Senate and state agencies concerning DDT and related compounds. Thus, from the outset, large-scale field studies such as this effort which provide data on a few variables run the risk of producing data of limited value and adding to an already superfluous literature.

The purpose of this study is to identify and quantitate the major organochlorine compounds in the 1971 populations of fish from different regions of Lake Michigan. The study was recommended by the four states surrounding Lake Michigan in the Lake Michigan pesticide report which was requested by the Lake Michigan Interstate Pesticide Committee and prepared by L. A. Luecchow of the Wisconsin Department of Natural Resources. The forthcoming results are put in perspective by the following brief review of factors which produced the need for this study.

It has been established that Lake Michigan is unique in that it contains much higher concentrations of agricultural pesticides than the other Great Lakes due, in part, to the large useage in the watershed in comparison to the flushing period for the lake and to the relatively low biomass density. Previous studies have shown that the fish from Lake Michigan approached the FDA action levels for dieldrin in 1969 and that a major fraction exceeded the action levels for DDT (Reinert, 1970). More recent data (Reinert, 1972) from carefully designed monitoring (Reinert, 1971)

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indicates that the average DDT concentration in Lake Michigan fish remained essentially the same between 1967 to 1970 and suggested that the levels have begun to decrease.

Although not realized in the early analyses by Reinert, other work (Veith, 1970) has shown that the concentration of PCBs (similar to Aroclor 1254) were greater than 15 µg/gm in large fish collected from Lake Michigan in 1969. Thus, it is apparently in Lake Michigan rather than the other Great Lakes that the potentially hazardous and persistant chemicals from our industrialized technology are most concentrated. It follows, then, that consideration must be given to the effect these chemicals have on the biological communities sustained by Lake Michigan and the possibility of stemming or even reversing the trend of increasing levels of organochlorine compounds in the Lake Michigan system.

Despite the comparatively high levels of DDT, dieldrin and PCBs in Lake Michigan, there is no direct evidence that the chemicals are endangering the aquatic life in the lake. The concentration of each of the chemicals appears to be below 10 ng/l in the pelagic waters and less than 100 ng/l in the nearshore waters, all of which are below the "no effect" level for the respective chemicals for most aquatic organisms. However, the lack of direct evidence of damage may simply reflect the difficulty in adequately measuring such effects in this environment.

There is considerable indirect evidence which suggests that the build-up of organochlorine compounds may be a threat to the future of the biological resources of the lake. It is beyond the scope of this introduction to review the literature concerning the pesticides and PCBs, and the reader is referred to existing comprehensive reviews (Zitko and Choi, 1971; NIH, 1972; Quinby, 1972; Task Force, 1972).

Consider first the major effort of the states surrounding Lake Michigan to stock the lake with brown, lake and rainbow trout and with coho and chinook salmon. Between the years of 1963 and 1970, over 600,000 rainbow trout have been released by Wisconsin alone (Kornon, 1970). In 1971, the State of Michigan stocked 3.2 million coho, 2.1 million chinook, 2.1 million lake trout and 200,000 rainbow trout. The first widespread spawning of lake trout in Lake Michigan since 1940 occurred in 1971 (GLFL, 1972). This

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massive stocking program has produced an unparalleled sport fishery and provides a valuable protein source for human food as well as animal feeds. Essential to the establishment and maintenance of this fishery is the successful reproduction of the adult fish. However, Reinert (1970) has previously pointed out that DDT and dieldrin levels in eggs are similar to those which inhibited reproduction in the studies of Burdick et al. (1964) and Macek (1968). In addition, Jensen et al. (1970) have shown that 15 µg/gm of PCBs (lipid basis) in salmon eggs produced 50 percent mortality and complete mortality can be expected when the eggs contain 25 µg/gm PCBs (lipid basis). All of these data concerning the effects of organochlorine compounds on reproduction were obtained individually, and little is known of possible combined effects when the tissue contains mixtures of the toxicants.

Even though the continued stocking of fish may maintain a food resource in spite of possible adverse effects of the residues on reproduction in Lake Michigan fish, many fish contain body burdens which make the fish unfit as a food resource for humans. The U.S. Food and Drug Administration has established a tolerance level of 5 µg/gm, 5 µg/gm and 0.3 µg/gm for DDT, PCBs and dieldrin, respectively, in food to be sold for human consumption. Since the lake supports a sizeable commercial fishery in addition to the sport fishery, the presence of these chemicals below the "no effect" level in water may still endanger these industries due to the large partition coefficient for lipid/water systems. Indeed, numerous catches of commercial fish being shipped to markets have been seized, and tons of large salmon have been withdrawn from state give-away programs in Michigan because the DDT and PCB residues exceeded the 5 µg/gm concentration.

Concern has also arisen with respect to the impact the organochlorine compounds in the Lake Michigan biota (principally fish) is having on other animals which use this food supply. Most notably is the effect of Lake Michigan fish on mink reproduction in the North Central states. Before DDT and dieldrin levels in these fish were well documented, Hartsough (1965) indicated that Lake Michigan fish were suspected as the factor leading to poor mink reproduction. Aulerich et al. (1970) clearly demonstrated the fish had been the cause of the reproductive failure. Aulerich

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and Ringer (1970) found that DDT and DDD did not have significant adverse effects on mink. Furthermore, dieldrin was lethal at 2.5 µg/gm in the food for extended periods but did not appear to effect reproduction at twice this level during the gestation period. Aulerich et al. (1971) concluded that coho salmon per se did not cause reproduction problems but that the disorder is associated with other species of fish and "appears to be dependent upon the species of fish and its environment." Finally, after the earlier reports that PCBs were present in Lake Michigan fish, Ringer et al. (1972) demonstrated that 10 µg/gm of Aroclor 1254 in coho salmon produced 71 percent mortality in mink and that a mixture of 10 µg/gm PCBs and 0.5 µg/gm dieldrin in coho food produced 100 percent mortality. No kits were born alive when the diet contained 5 µg/gm or greater Aroclor 1254 alone. This evidence clearly indicates that the biological resources of Lake Michigan may seriously endanger other species even though the levels of toxicants are not sufficiently great to produce a dramatic effect within the aquatic communities.

Equally important is the coincidence of high levels of chlorinated hydrocarbon in herring gull and other bird populations with reproductive failures and subsequent population decline. Ratcliffe (1970) and Anderson (1970) have clearly shown that major changes in eggshell thickness have occurred since 1945 and that the phenomenon may be a major factor in the decline, if not extinction, of many species of birds. The effect is found in predators and most notably in fish-eating birds. In general, egg shell thinning of 10 to 15 percent (relative to pre-1940 eggs) may produce an effect in the population, 15 to 20 percent is associated with readily observable egg breakage, and 50 percent thinning has been associated with virtually total reproductive failure (Risebrough et al., 1970; Keith et al., 1970).

Anderson (1970) found the Great Lakes Herring Gulls contained the highest chlorinated hydrocarbon levels in eggs ever reported for that species. He also found that the Lake Michigan gull, which declined dramatically in the early 1960's but recovered in the late 1960's, had egg shell thinning which varied from nine percent in 1953-1956 to 18 percent in 1965. However, since 1965, the degree of thinning has decreased to eight percent in 1969. In comparison, gulls on Lake Huron and Lake Superior have

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exhibited thinning of seven and eight percent, respectively, and those from the east coast have remained essentially unchanged from earlier eggs.

Anderson (1970) also showed that double-crested cormorants from Wisconsin had 20 percent thinner eggs and produced eggs with the highest DDE concentrations of this species from interior North America. Golden eagles which primarily feed on mammals do not show as dramatic egg shell thinning as do the Bald Eagles which feed on fish. Despite the lack of detailed data in the literature, it is not unreasonable to suggest that the disappearance of Bald Eagles from the shores of Lake Michigan may also be linked by correlation to the chlorinated hydrocarbons in the food resources of the lake.

The Lake Michigan system is also unique in that the use of the major persistent chemicals have been curtailed in the watershed by a variety of actions. Although it is likely the use of the chlorinated pesticides in agriculture was diminishing in the late 1960's, the Lake Michigan Enforcement Conference recommended regulatory actions on many uses in 1968. This recommendation led to restrictions on DDT in Illinois, Michigan and Wisconsin, including the sale of this compound. A more detailed summary is presented by Luecshow (1972).

The realization that the widespread use of PCBs has resulted in the widespread occurrence of these potentially hazardous chemicals in the environment moved Monsanto Company, the sole producer of PCBs in the United States, to restrict the sales of PCBs in 1970 and by April, 1971, only "close system" uses were able to purchase PCBs from Monsanto. However, there is no data to confirm the fact that PCB useages are significantly reduced.

As previously discussed, the FDA has placed a 5 µg/gm action level on PCBs in food for human consumption. Moreover, on March 18, 1972, this restriction was extended to food packaging materials. On May 2, 1972, the Environmental Protection Agency announced that all discharges to the aquatic environment involving PCBs will be restricted to the lowest possible level and that the desired limit will be 0.01 µg/l PCBs. These restrictions were re-enforced by the recommendation of the joint task

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force headed by the Council on Environmental Quality and the Office of Science and Technology (Task Force, 1972) which called for all current uses of PCBs, except capacitors and transformers, to be discontinued.

In summary, the use of chlorinated hydrocarbons in the agriculture and industry in the Lake Michigan watershed over the last few decades has resulted in the contamination of this valuable, mesotrophic body of water. Indirect evidence exists that these chemicals are having subtle detrimental effects on the species near the top of the food chain, and some of the food resources have been deemed unfit for human consumption. However, the Lake Michigan watershed has also realized unparalleled legislative action regarding the use of these hazardous, persistent chemicals in the last two years. At the recommendation of the Lake Michigan Interstate Pesticide Committee, this study was funded to establish detailed data on PCBs and DDT in Lake Michigan fish which will serve as a 1971 baseline in determining future trends of the levels of these chemicals in the lake and the impact cooperative legislative actions have had in managing the quality of large lakes.

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SECTION IV

MATERIALS AND METHODS

This section describes the procedures used in collecting samples for the study and in analyzing the tissue for major chlorinated hydrocarbons. Special emphasis has been placed on preparation of reagent chemicals used in the study.

A. Sample Collection

The intent of the field sampling phase of this study was to collect 20 samples of yellow perch (10-12 inches), white sucker (10-12), carp (12-25), chub (8-10), lake trout (20-25), coho salmon (20-25) and alewife (6-8) from each of the following regions of Lake Michigan: central basin--north, central basin--south, Green Bay, Sheboygan - Manitowoc, Milwaukee - Racine, Chicago - Indiana Harbor, Benton Harbor, Saugatuck, Grand Haven, Muskegon and Grand Traverse Bay. The above field objectives suggested by the Lake Michigan Interstate Pesticide Committee were not explicitly attainable due, in part, to the availability of each species in the regions of interest and to the availability of fishing vessels in the respective regions of the lake. Thus, the majority of the fish were captured as available during September and October of 1971 through the use of gill nets, pond nets and trawls. To minimize variations in the concentration of chlorinated materials with size of fish, the length of the fish taken for analysis was limited as much as possible to the size ranges suggested by the Committee. Figure 1 is an illustration of Lake Michigan in which the sampling areas are indicated by dashed lines.

Where possible, the samples were transferred directly from the ship to insulated boxes lined with acetone-rinsed aluminum foil which contained dry ice. However, many of the samples which were collected by research biologists from state agencies were placed in cardboard cartons or polyethylene bags and frozen immediately. When grinding these samples, the containers were sampled to determine whether significant amounts of

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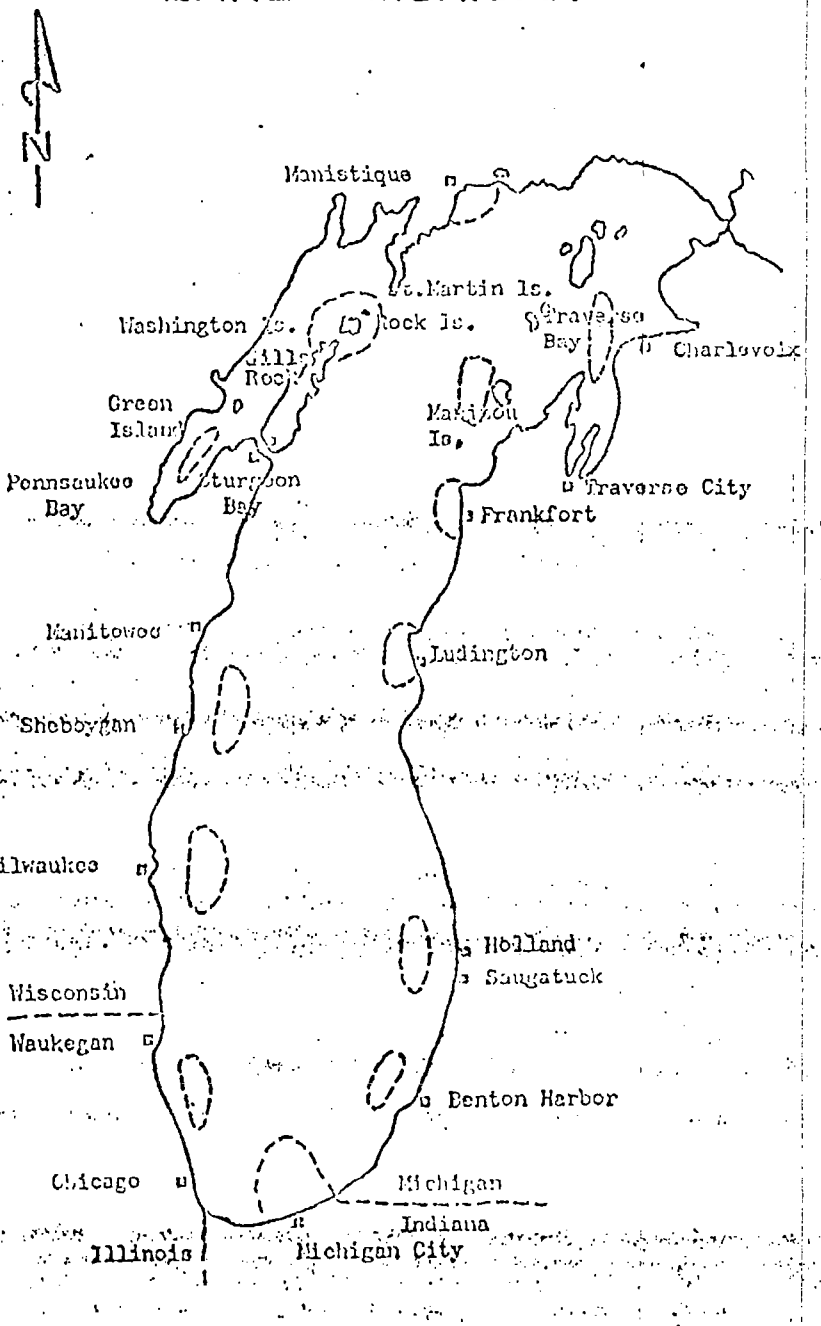
FIGURE 1, SAMPLING REGIONS OF LAKE MICHIGAN



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contaminants were present in the materials in contact with the frozen fish. All samples were transported directly to the University of Wisconsin at Madison.

B. Reagents

Spurious gas chromatograph peaks which arise from the contamination of the sample in the laboratory are not an uncommon problem in trace analyses. These contaminants not only add to the anonymity of the GLC interpretation but also often make true quantitative analyses an impossibility. Previous work by the author has indicated that most reagents used in pesticide analysis contain contaminants which may interfere with the analysis. Moreover, contamination of the sample may arise from objects worn or brought into the laboratory by personnel such as adhesive bandages, order forms, etc. and the laboratory is regulated accordingly. Also, the following reagent cleaning procedures were established to minimize the possibility of sample contamination during the analyses.

1. The Na_2SO_4 (Fischer Scientific Co.) was washed with three volumes of 1:1 hexane/acetone and dried at 130° C. To prevent further contamination from cap liners or containers, the Na_2SO_4 was stored in large glass bottles with Al foil liners in the cap.

2. The Florisil media (Kensington Chemical, Fisher Scientific) was extracted in an all-glass Soxhlet extractor for 24 hours with the azeotrope of hexane and acetone in an effort to remove traces of organic impurities. The solvent was evaporated from the Florisil at 100° C, and the solid was heated at 650° C for 2.5 hours for activation. If not used immediately after heating, the Florisil was warmed to 105° C prior to its use.

3. The silicic acid (Mallinckrodt Chemical, AR grade, Ramsey and Patterson) was used directly from the reagent bottle.

4. The hexane (Skelly B) was redistilled in glass from Dri-Sodium (Fisher Scientific).

5. The acetone (Fisher Scientific, HCB) was redistilled in glass from Dri-Sodium.

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6. The ethyl ether and methylene chloride (Mallinckrodt Chemical) were pesticide quality solvents and were used directly out of the reagent bottle after periodic checks showed that interferences were not present for the experimental conditions of this study.

7. Glass wool was soaked in acetone and then rinsed with an acetone in hexane mixture (1:1).

8. Glassware was washed thoroughly with hot detergent and rinsed with hot water, twice with distilled water and with a mixture of acetone and hexane (1:1).

C. Sample Preparation

The fish were stored frozen at -20° C until analysis. The storage period for the majority of the fish was restricted to several weeks but did not exceed two months in order to minimize dessication and possible chemical changes in the tissue during storage. The frozen fish were fragmented with a cleaver and homogenized while frozen using a Hobart meat grinder. The frozen tissue was first passed through the grinder to obtain a free-flowing, granular product in which bone, fat and muscle tissue could be recognized. The entire sample was thoroughly mixed and passed through the grinder twice more to yield a uniform light pink sample. The homogenate was sampled by quartering several times and removing aliquots for immediate analysis and for bulk samples which have been stored for possible future work.

During the homogenizing operation, considerable effort was expended to assure that the tissue came in contact only with metal surfaces which were rinsed with acetone. The grinder was cleaned with hot water after each fish was ground. The bearing and seal of the grinder was inspected periodically to make certain no lubricants could enter the grinding chamber. Since several of the assistants on this project worked only part-time between classes, care was taken to clean hands thoroughly to assure that contaminants were not introduced from outside sources of PCBs such as carbon papers, inks, etc.

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D. Extraction

Because of the large number of samples which were to be extracted for this study, the 12 extractor unit in Figure 2 was built at the Water Chemistry Laboratory. The unit featured two rows of six extractors, each heating mantle independently spring-loaded such that the extractors could be set up or removed individually by pressing down on the mantle and lifting the extractor off. Since many of the organic solvents require less than 115 volts on the heater for refluxing, pairs of the heaters were connected in series, thus dropping approximately 60 volts across each heater. This arrangement precluded the need for voltage transformers and provided enough power to maintain about eight extractions each hour in the extractors. The main power cord was connected to a timed relay, allowing the extraction to be carried out unattended.

Approximately 10 gm of frozen tissue was weighed into a tared beaker and then ground with 50 gm anhydrous Na_2SO_4 until the mixture appeared dry. The mixture was tamped into a glass extraction thimble fitted with an extra course glass frit and placed into the Soxhlet extraction apparatus. The receiver flasks were filled with 170 ml of hexane/ethyl ether (1:1), and the samples were extracted for three to four hours.

E. Column Cleanup

Sample cleanup was conducted as indicated in Figure 3. Briefly, the extracts were concentrated to 20 ml and 2 ml were withdrawn for the non-volatile residue analysis. After further concentration of the extract, the bulk of the oil and fat was removed through liquid chromatography on Florisil as shown in Figure 4.

The Florisil column consisted of a 25 mm O.D. glass column which was filled with 19 gm of Florisil (Reynolds, 1969). The column was fitted with a glass frit and Teflon stopcock at the bottom and was topped with 10 gm anhydrous Na_2SO_4 to prevent deactivation from water in the extract. The extracts (15 ml) were placed on the dry column and eluted with six percent ethyl ether in hexane (200 ml) at 3 to 5 ml/min to obtain PCBs, DDE, DDD, DDT, heptachlor, aldrin and toxaphene, if present. The receiving flask was changed, and the column was eluted with 15 percent ethyl ether

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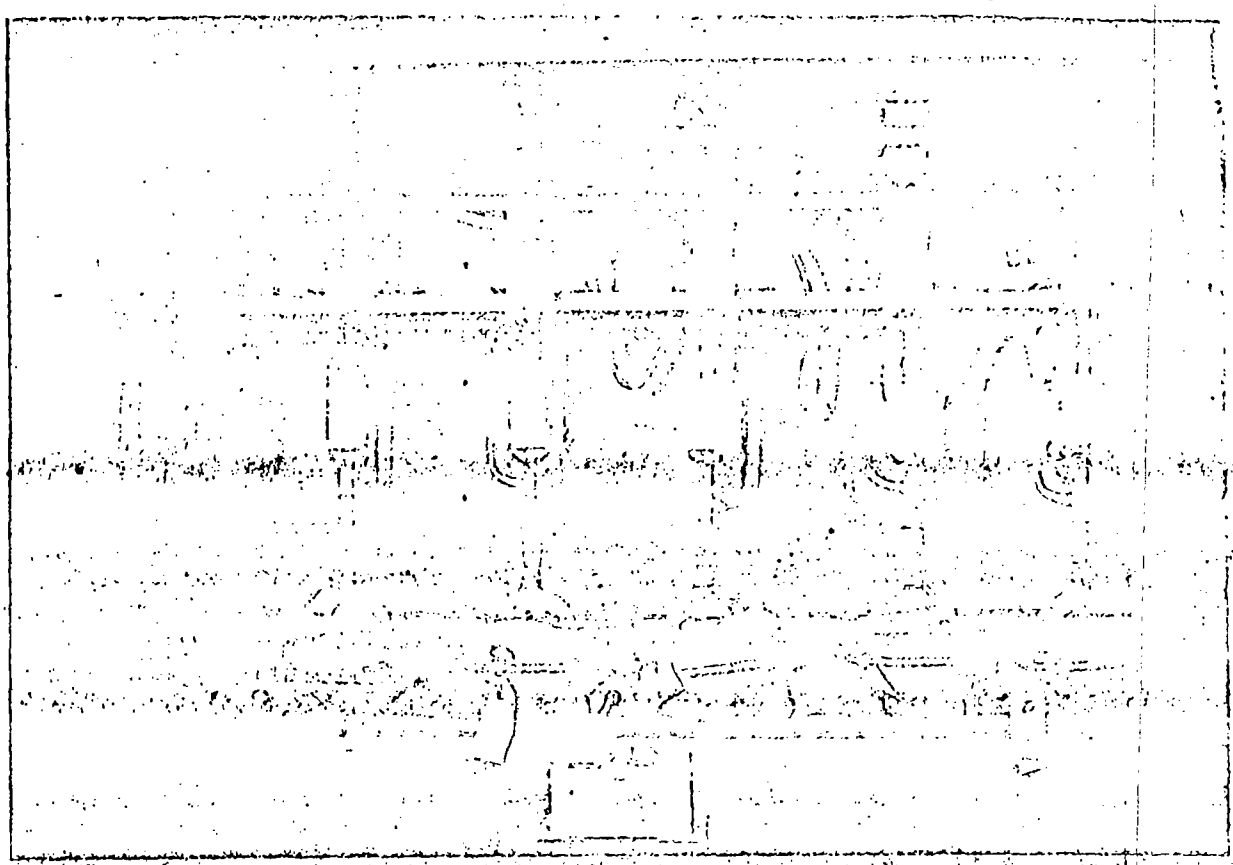

Figure 2. Apparatus for Multiple Extraction Fish Tissue Using Soxhlet Extractors

Each unit is held in place by spring tension on the heating mantles. Samples are added or removed by pressing down on the individual mantles.

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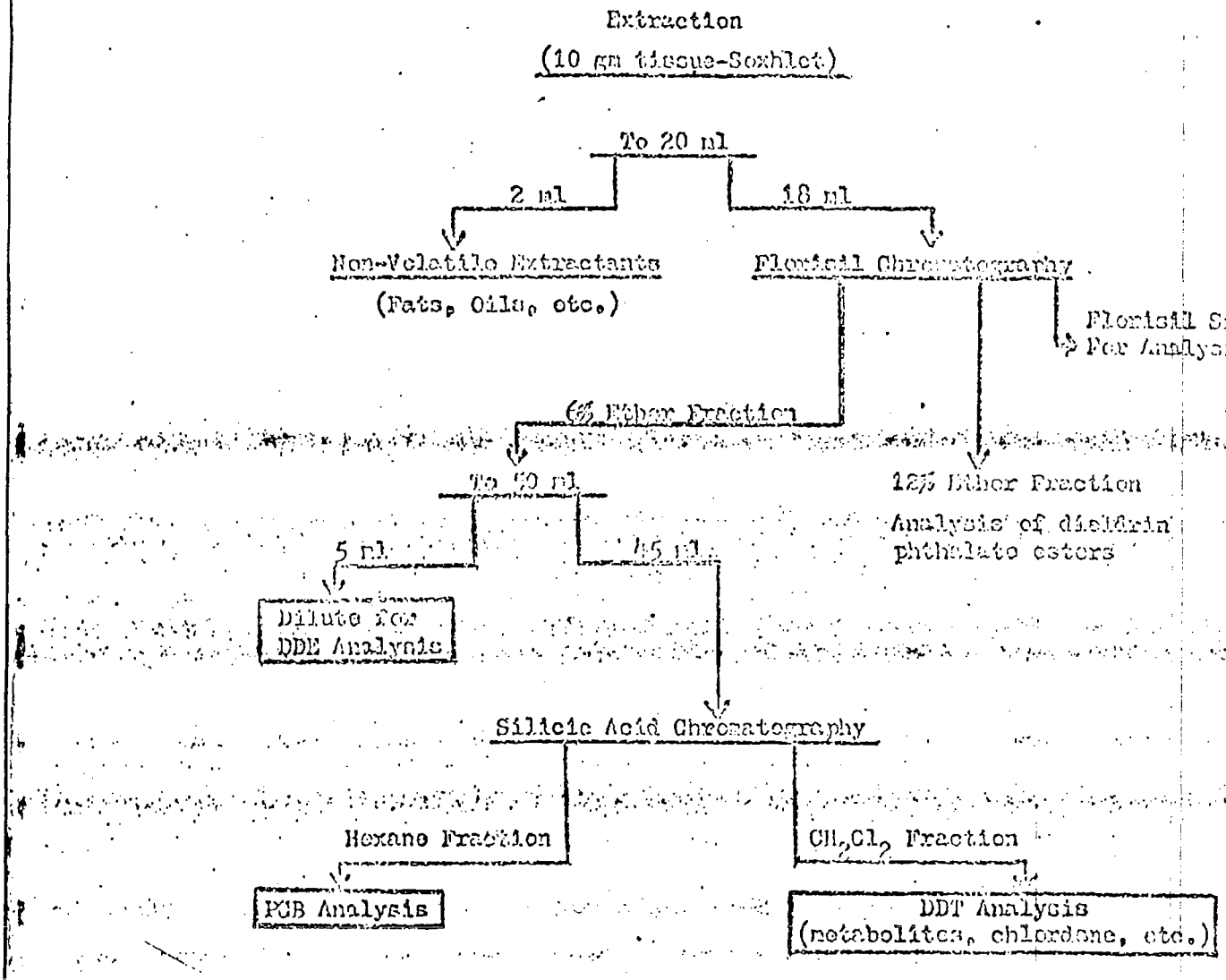
Figure 3. Analysis Scheme for Lake Michigan Fish



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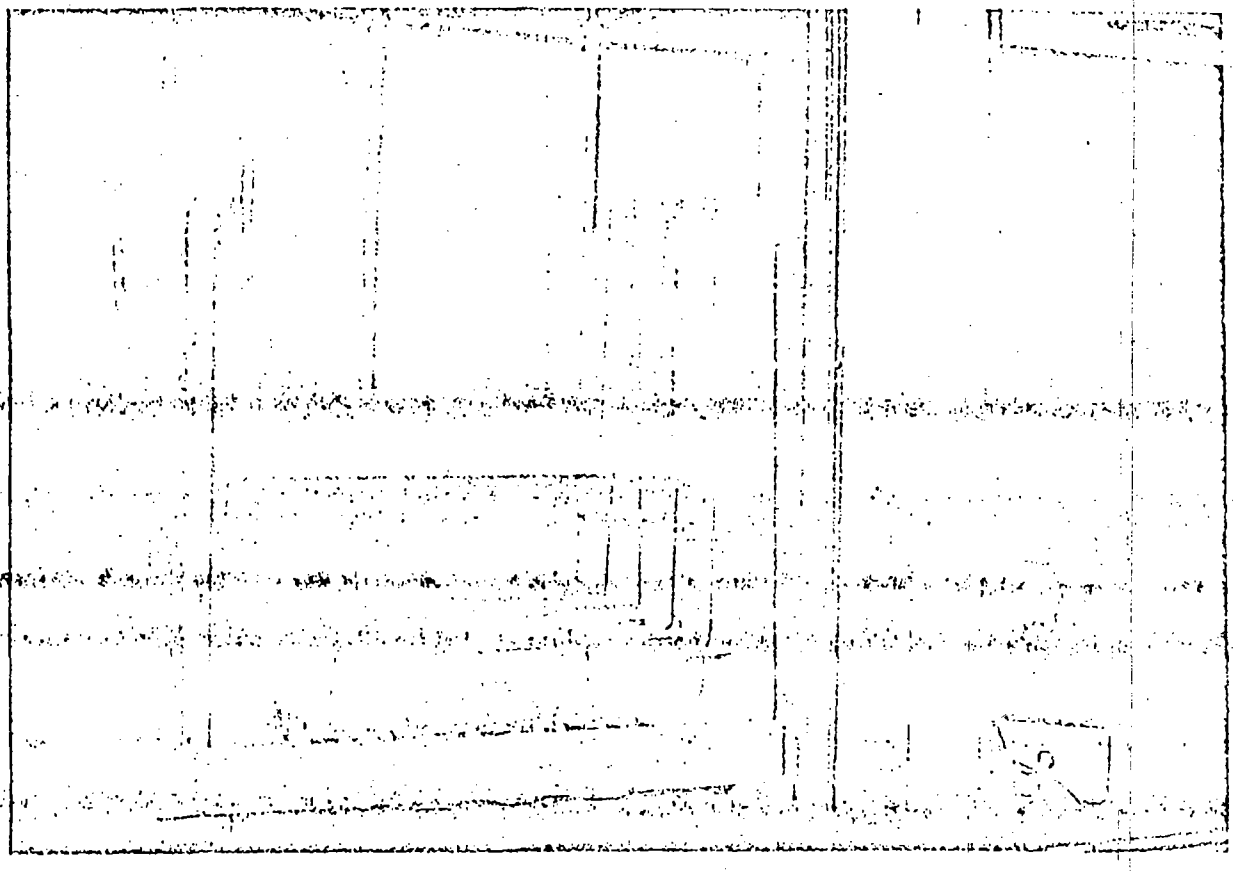

Figure 4. Apparatus for Multiple Cleanup of Extracts by Florisil Chromatography

Approximately 32 extracts were passed through this primary fractionation step each day.

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in hexane (200 ml) to obtain dieldrin, heptachlor epoxide, lindane and some of the phthalate esters, if present. The samples were concentrated to appropriate volumes for GLC analysis. In general, the 19 gm Florisil column was suitable only for removing the bulk of the co-extracted non-volatile materials, dieldrin and related compounds from the chlorobiphenyls and DDT family of pesticides.

F. Liquid Chromatography on Silicic Acid

The six percent (ether in hexane) fraction from the Florisil column contained primarily PCBs and DDT and derivatives thereof (Veith, 1970). Because a mutual interference exists in GLC analyses of samples containing residues of both these groups of compounds, separation of the PCBs from DDT was necessary prior to analyses.

Although PCBs can be separated from DDT on alumina, silicic acid (Armour and Burke, 1970) and charcoal (Berg et al., 1972), previous work by the author has demonstrated that the separation of DDE from the PCBs, particularly those with three or less chlorine atoms per molecule, cannot be consistently attained in routine analyses. However, due to the comparatively large concentration of p,p'DDE with respect to other chlorinated hydrocarbons in Lake Michigan fish, the extracts can be diluted and analyzed for DDE without significant error (see example in Figure 5). Therefore, prior to the fractionation of the six percent ether eluate from the Florisil column, an aliquot (nine percent of sample) was diluted approximately tenfold and analyzed directly for DDE. The remainder of the sample was subjected to further separation on silicic acid.

The silicic acid separation was conducted according to the procedure of Armour and Burke (1970) with minor modifications. Because more than 20 samples were passed through silicic acid each day, large quantities of silicic acid of uniform deactivation were necessary to assure consistent separations. To accomplish this, 500 grams of silicic acid (Mallinckrodt, 100 mesh, AR) were weighed into flasks in five 100 gram portions after the powder was dried at 130° C overnight. Water (2.1 to 2.7 percent) was added by buret to deactivate the media, and the individual flasks were sealed and shaken vigorously in a wrist-action shaker for four hours. The media in the flasks were then combined and blended in a sealed bottle and

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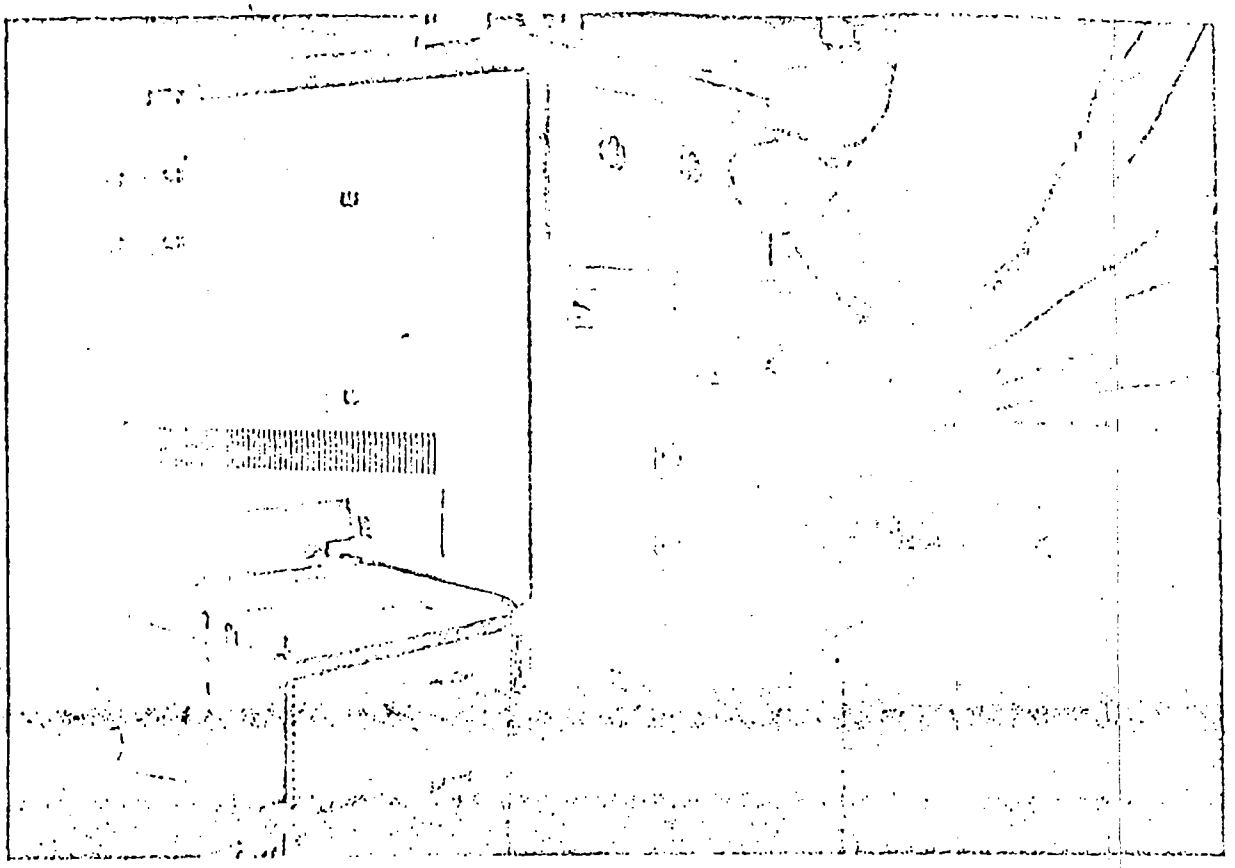
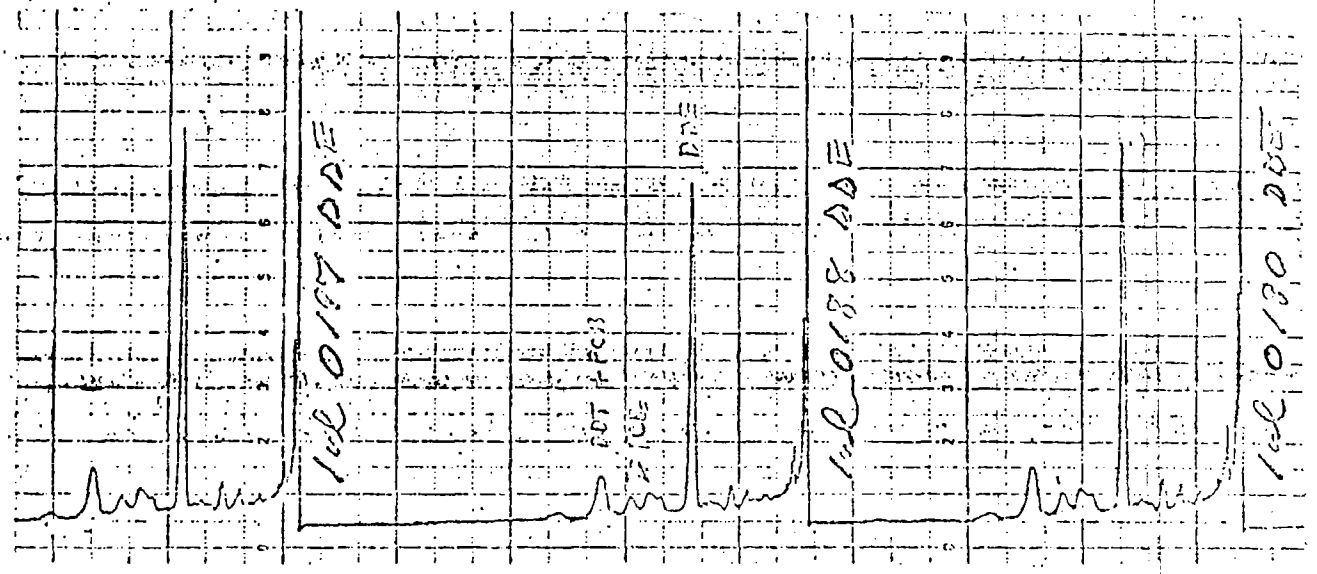


Figure 5. GLC Analysis of DDE on a Varian 1745 Gas Chromatograph. Below-A typical chromatogram for Lake Michigan fish with interference-free response of DDE in the presence of PCBs.



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allowed to equilibrate approximately 18 hours in a desiccator. Celite 545 was not used in the procedure because of the impurities present in the commercially available material.

The chromatography columns were prepared by pouring a slurry of 20 grams of the deactivated silicic acid and hexane into a 22 mm (I.D.) shell column fitted with pressure fittings on top. After the sample was placed on the column, it was eluted first with 250 ml of hexane and then with 250 ml of a 1:1 mixture of hexane and methylene chloride. Since the samples were analyzed immediately by GLC, it was generally possible to adjust the water content daily in order that the DDT and DDD remain in the methylene chloride fraction but the trichlorobiphenyl isomers remain in the pure hexane fraction.

G. Instrumentation

Quantitative gas chromatographic analyses were conducted on an Aerograph 1745-20 gas chromatograph equipped with dual concentric-tube electron capture detectors (^3H, 250 mc) and illustrated in Figure 5. The columns were 2.0m x 1.8 mm (I.D.) glass coils packed with ov-101 (three percent) on 120/140 mesh Gas Chrom Q. The carrier gas (purified N_2) was maintained at 20 ml per minute, and the injector, column and detector temperatures were 240° C, 180° C and 220° C, respectively. The chromatograms were recorded on a Varian Model A-25 dual pen recorder.

H. Quantitative Analysis

Previous work (Veith, 1971) has shown that the fish from Lake Michigan contain mixtures of PCBs which closely resemble Aroclor 1254 produced by Monsanto Company, although PCBs both heavier and lighter than those most abundant in Aroclor 1254 were also present. Figures 6a and 6b compare chromatograms of Aroclor 1254 and a typical Lake Michigan fish extract, respectively. The fish extract contains predominantly those PCBs which elute at 70, 84, a doublet near 100, 125, 145 and 176 (relative to pp'DDE). In addition, the chromatogram shows several of the lighter PCBs and the 203, 232 and 280 PCBs (relative to DDE).

Because the majority of the fish from Lake Michigan contain apparent Aroclor 1254 primarily and a large number of samples were to be analyzed

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Figure 6. Comparison of PCB Mixtures in Fish and Commercial Mixtures (Standard)

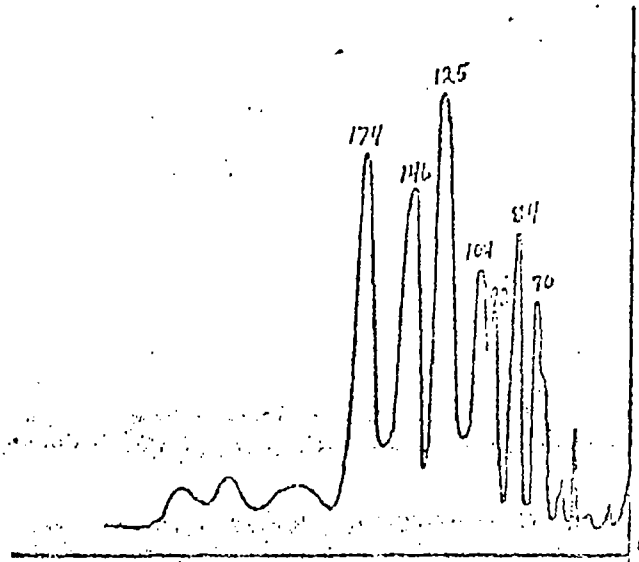

Figure 6a. Chromatogram of Aroclor 1254. Peak Number Relative to p,p'-DDE = 100.

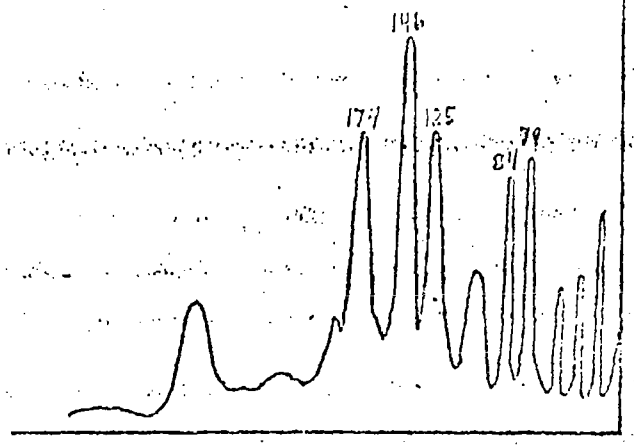

Figure 6b. SA Chromatogram of Lake Michigan Fish.

Relative Response

← Elution Time

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in this study, all of the fish were analyzed for Aroclor 1254 only. Thus, in the absence of evidence of other major, unknown contaminants in the PCB (hexane) fraction from the silicic acid separation, the data is likely to be conservative; and those fish from nearshore regions which have some Aroclor 1242 and/or 1248 present may have more PCBs in the tissue than is reported by this study.

As stated previously, pp'DDE cannot be consistently removed from the PCBs and was analyzed separately. The interference of pp'DDE to the quantitation of the PCBs was overcome by excluding the doublet at 98 and 104 from the calculations. The heights of peaks at 70, 84, 125, 146 and 174 were summed to give a number which, when compared to a standard curve prepared similarly, produced the mass estimation. With this method, the amount of pp'DDE in the sample could vary considerably without effecting the PCB analysis. Figure 7 illustrates a standard curve prepared from the peak height data.

I. Evaluation of Analytical Methods

The methods used throughout this study are well proven (with the possible exception of work on the silicic acid column). In general, the methods will account for greater than 85 percent of the residues in the tissue and exhibit less than 10 percent variability. Thus, when analyzing a sample from the environment where the sample history is largely unknown, there may be more significant error in interpreting chromatograms than in the manipulation of the extract.

The extraction of hydrophobic chlorinated hydrocarbons from tissue using ethyl ether and hexane is quantitative, even under mild conditions. For example, Stalling (1971) found that 97 $\pm$ 3 percent of the chlorinated pesticides added to fish tissue was extracted by rinsing the tissue with 200 ml of cold solvent. The exhaustive extraction with Soxhlet extractors as used in this study is essentially 100 percent. Previous work by the author (Veith, 1970) has shown that the recovery of PCBs for extraction and clean-up was 87 $\pm$ 3 percent. Thus, approximately 10 percent of the residues are lost on the clean-up columns or in the transferring of samples between vessels. Both of these losses can be minimized by rinsing with sufficient amounts of solvents.

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Figure 7. Standard Curve for Aroclor 1254
Prepared by Summing the Heights of Peaks
70,81,125,146,and 174 Relative to pp'DDE

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The analysis of PCBs in spiked tissues of six fish from northern Wisconsin (contain negligible quantities of PCBs) indicated that the present method permitted recovery of 85.1 $\pm$ 4.3 percent. The recovery of DDT was likely the same as PCBs while that of DDE was near 90 percent.

More important than what can be recovered under spiking conditions is the reproducibility with which a sample can be prepared, cleaned up and analyzed. Of particular concern in this study is the sampling of a large fish which, because of the large quantity of tissue to be homogenized, may give rise to considerable variability. Table 1 presents the results of multiple analyses of selected fish during this study. The data indicate that the relative standard deviation for the PCB analyses ranged from five percent in the smaller fish to 14 percent in the large coho salmon. It is likely that the decrease in precision in the coho is due to the difficulty of homogenizing the larger fish in addition to the inherent variability of interpreting the chromatograms of the hexane fractions from the silicic acid columns. The analyses with the poorest precision was that of the DDT analyses where the relative standard deviation ranged from eight percent to 23 percent and appeared to average approximately 14 percent. It is likely that this reduced precision results from losses during silicic acid chromatography which is necessary to quantitate the DDD and DDT isomers. The precision of the DDE analyses were lower than that of DDT which would be anticipated because of the fewer manipulations of the extracts. The relative standard deviation ranged from seven percent to 18 percent, but the average deviation was approximately 10 percent. The fat analyses, due to the relatively simple procedure, were the most precise and exhibited relative standard deviations ranging from five to seven percent.

To further evaluate the quantitative analysis of PCBs, replicate samples were sent to Analytical Bio Chemistry Laboratories, Inc. in Columbia, Missouri, for analysis. Table 2 presents the results of this collaborative study. In general, the concentrations of PCBs in the fish as determined by the two laboratories were in close agreement, although several of the concentrations determined by ABC Labs were a factor of two lower than that determined by this study. Of particular interest, however, is the fact that the analyses of total PCBs (ABC Labs) did not

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Table 1. Precision of Chlorinated Hydrocarbon Determinations for PCBs, DDE, DDT and Fat in Selected Lake Michigan Fish.

Species	Replicates	Aroclor 1254 (µg/gm)	p,p'-DDE (µg/gm)	p,p'-DDT (µg/gm)	Fat (percent)
Coho Salmon (25 inches)	6	15.2 (2.2)[a]	7.5 (0.6)	3.2 (0.6)	4.2 (0.2)
Coho Salmon (27 inches)	6	13.1 (1.3)	5.5 (0.4)	1.8 (0.4)	10.0 (0.6)
Whitefish (13 inches)	6	4.1 (0.2)	0.35 (0.04)	0.56 (0.04)	16.2 (0.9)
Chub (10 inches)	6	5.7 (0.4)	3.4 (0.3)	2.2 (0.3)	18.2 (1.3)
Alewife (8 inches, composite)	6	4.0 (0.2)	1.1 (0.2)	1.0 (0.2)	5.7 (0.3)

[a]standard deviation in parentheses

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Table 2. Collaborative Determination of PCBs in Lake Michigan Fish

Species	This Study Aroclor 1254 (µg/gm)	ABC Labs.[a] Total PCBs (µg/gm)
Chub	3.7	3.9
Chub	6.1	1.6
Chub	5.7(6)	2.9
Chinook Salmon	11.5	11.3
Coho Salmon	12.3	6.5
Coho Salmon	11.8	10.2
Lake Trout	7.0	7.8
Perch	5.2	5.0

[a] Analytical Bio Chemistry Laboratories, Inc.
Columbia, Missouri

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result in concentrations significantly greater than that determined in the analysis of Aroclor 1254 alone. This observation will be discussed further in the next Section V of the report.

J. Confirmation of the PCBs

In addition to preliminary analysis of the extracts with a Varian Mat CH-5 mass spectrometer, the presence of PCBs in selected samples from each sampling area were confirmed by the perchlorination of the PCBs to decachlorobiphenyl and the subsequent analysis of the product by GLC (Berg et al., 1972). Briefly, the aliquots of the hexane fraction of the silicic acid columns were evaporated to dryness in a 5 ml vial fitted with a Teflon-lined screw cap. Antimony pentachloride (0.2 ml) was added to the residue, and the vial was sealed and held at 180° C for six hours. Approximately 1 ml of 6N HCl was added to the products to destroy the $SbCl_5$, and the solution was extracted with five 1 ml portions of hexane. The hexane was passed through a disposable pipet containing anhydrous Na_2SO_4 to remove traces of the aqueous solution. The sample was collected in a graduated centrifuge tube and was diluted to the proper volume for GLC analysis. The GLC analyses were conducted on a Micro-Tec MT-220 gas chromatograph equipped with a ^{63}Ni electron capture detector. The column was 1/4 in. x 3 ft. and was packed with three percent Dexsil 300 on Gas Chrom Q. The column, injector and detector were held at 225° C, 250° C and 285° C, respectively.

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SECTION V

QUALITATIVE ANALYSIS OF LAKE MICHIGAN FISH

A substantial effort has been made in this study to examine the extracts of Lake Michigan fish on a qualitative basis. The purpose of this effort is to confirm the presence of the PCBs and DDT (and metabolites) and to determine whether significant quantities of unrelated materials are present and interferring with the quantitative analyses. The presence of PCBs in the extracts were confirmed by perchlorinating the extracts and subsequently analyzing the decachlorobiphenyl formed by GC/MS analyses of selected extracts.

A. Perchlorination

Perchlorination is a particularly useful technique because it gives both qualitative and quantitative information concerning the extract. A group of fish extracts comprising approximately five percent of the total number of samples and representing all regions of Lake Michigan were perchlorinated according to the procedure in Section IV. Without exception, the perchlorination of the extracts produced decachlorobiphenyl, and the quantity of PCBs indicated by the decachlorobiphenyl formed (after correcting to 54 percent chlorine) was generally within 25 percent of that found by the direct analysis of the extract by GLC. Figure 8 illustrates a series of chromatograms of the perchlorination products of the extracts. The large peak eluting at approximately ten minutes is the decachlorobiphenyl and the unreacted PCBs (if present) elute as a small peak on the tail of the solvent.

Although it is often difficult to determine the amount of the various PCB mixtures present in the extract from the amount of the decachlorobiphenyl formed during perchlorinating, good agreement is expected between the estimates from GLC and perchlorination when the fish extract contains predominantly one PCB mixture. Figure 9 presents data obtained from the perchlorination corrected to 54 percent chlorine and plotted against that

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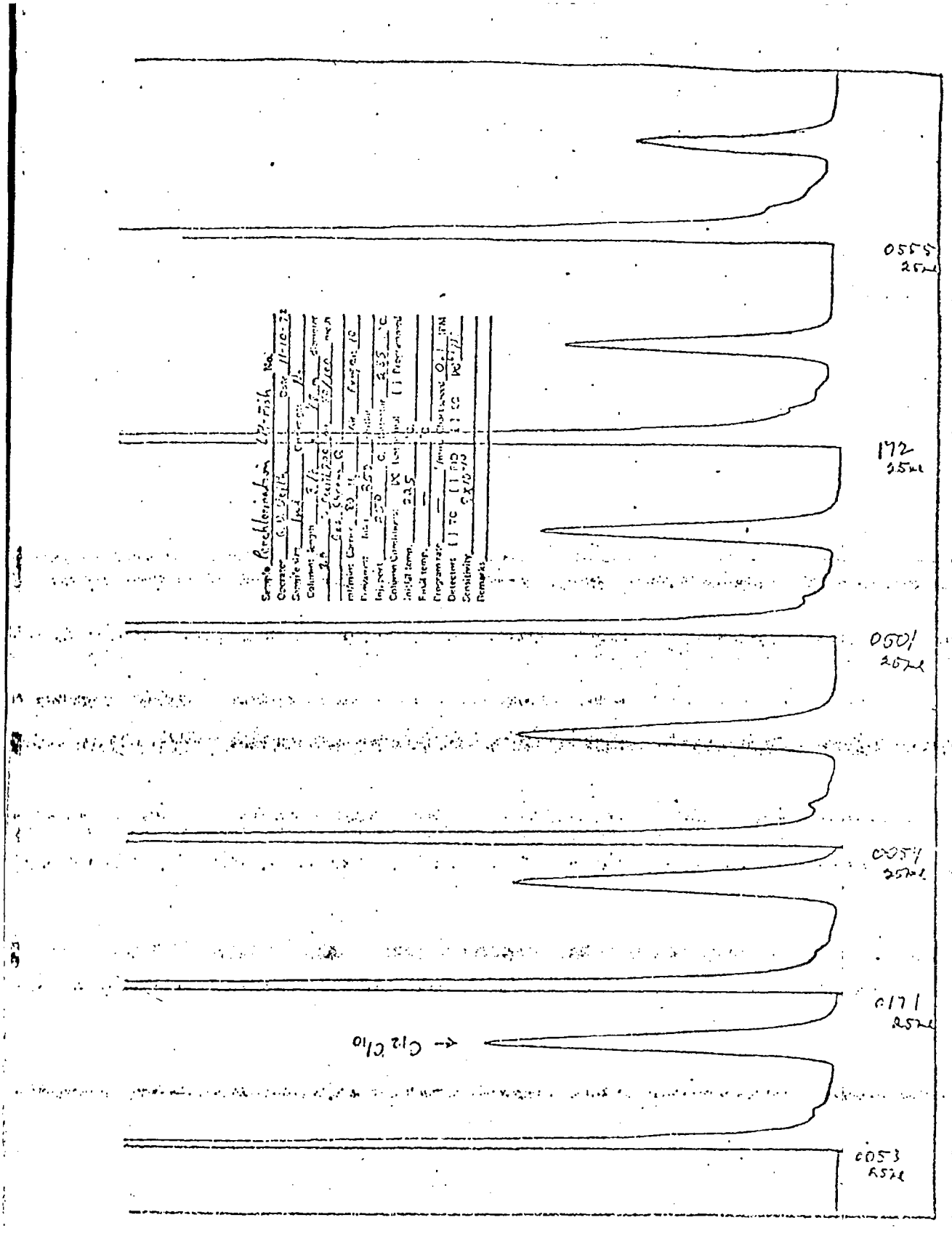

Figure 8. GLC Analyses of $C_{12}Cl_{10}$ from the Perchlorination of Lake Michigan Fish Extracts

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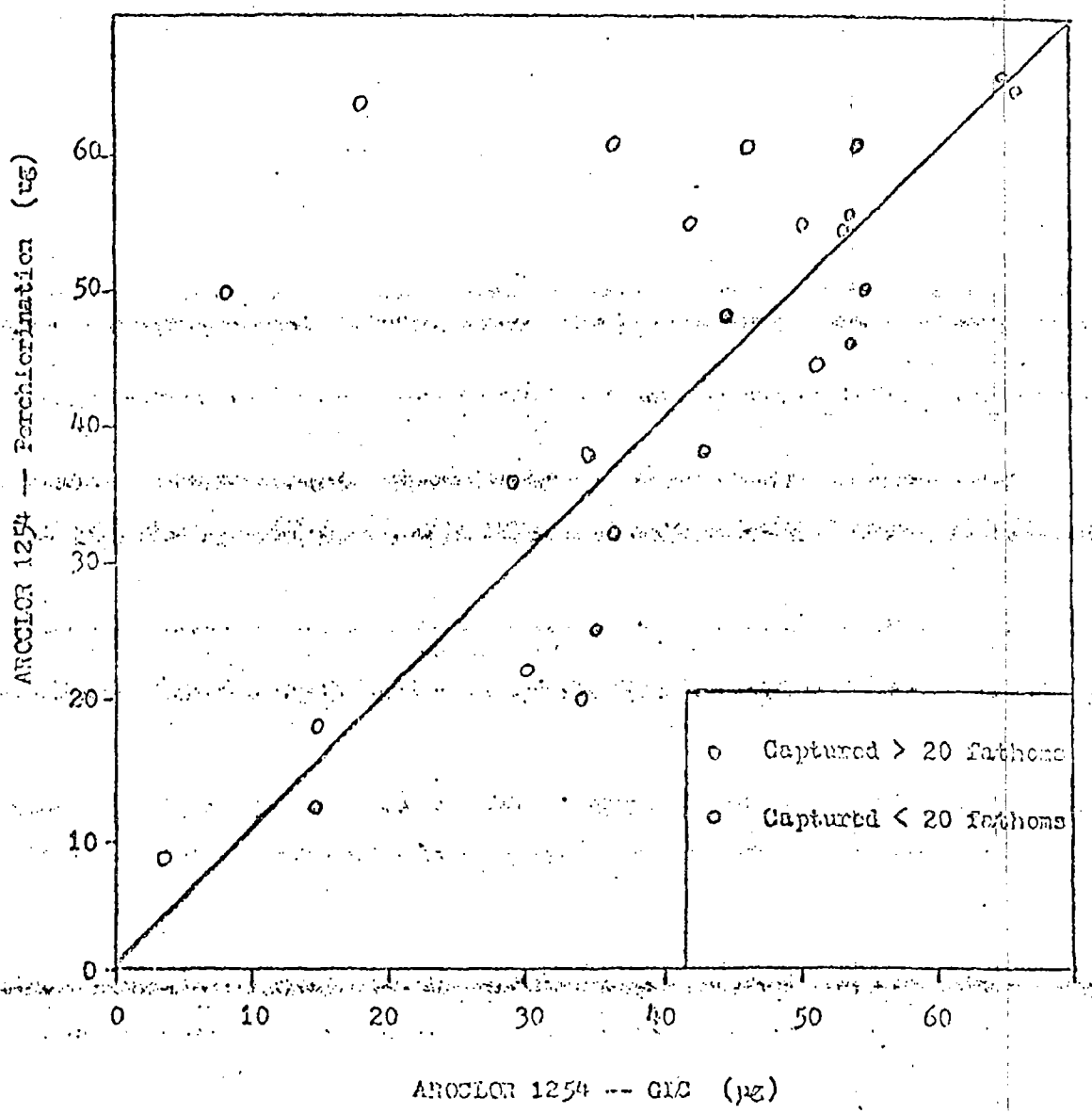
Figure 9. Comparison of PCB Analysis via Direct GLC and Perchlorination-GLC



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obtained from the gas chromatograph prior to perchlorination. The data are expressed as total micrograms in the aliquots of the sample extracts. Figure 9 indicates that much of the data from the two methods agree well but that a number of the perchlorination estimates differ widely from the GC analysis.

These data were examined more closely to determine the cause of the discrepancy. For the majority of points in Figure 9 where the PCBs determined by perchlorination was much lower than that by GLC, it was generally found that the perchlorination products contain small amounts of unreacted PCBs as illustrated in Figure 10. Thus, it is likely that the data below the line in Figure 9 resulted from incomplete chlorination, presumably due to varying amounts of residual oil in the extract which consumed some of the $SbCl_5$. This difficulty could be overcome by increasing the quantity of $SbCl_5$ and by perchlorinating replicates.

The points above the line represent fish which generally contained appreciable quantities of PCBs other than Aroclor 1254. For example, Figures 11a and 11b compare chromatograms of Aroclor 1254 and a chub captured from 50 fathoms of water off Saugatuck, Michigan. It can be seen that the fish extract resembles Aroclor 1254 closely. The results of the perchlorination indicated that 48 µg PCBs were present in the extract whereas the direct analysis indicated 45 µg (as Aroclor 1254). However, the data from the smelt caught in nearshore waters off Door County, Wisconsin, contained a substantial amount of the early-eluting PCBs as shown in Figure 12. Accordingly, the GLC estimate of PCBs was lower than that of the perchlorination method as evidenced by the two points in the upper left corner of Figure 9. It must be pointed out, however, that the apparent error in the analysis of the smelt is not as great as indicated in Figure 9 if the decachlorobiphenyl formed is expressed as Aroclor 1221 (the early peaks) rather than as Aroclor 1254. For example, the smelt contained some apparent Aroclor 1221 and 19 µg Aroclor 1254 but produced approximately 84 µg $C_{12}Cl_{10}$ (64 µg as Aroclor 1254). If the 45 µg of $C_{12}Cl_{10}$ (as Aroclor 1254) not accounted for by the GLC determination is expressed as Aroclor 1221, the GLC analysis was low by 17 µg (approximately 1.7 µg/gm on a whole fish basis). Thus, the perchlorination of the extracts has confirmed without exception the

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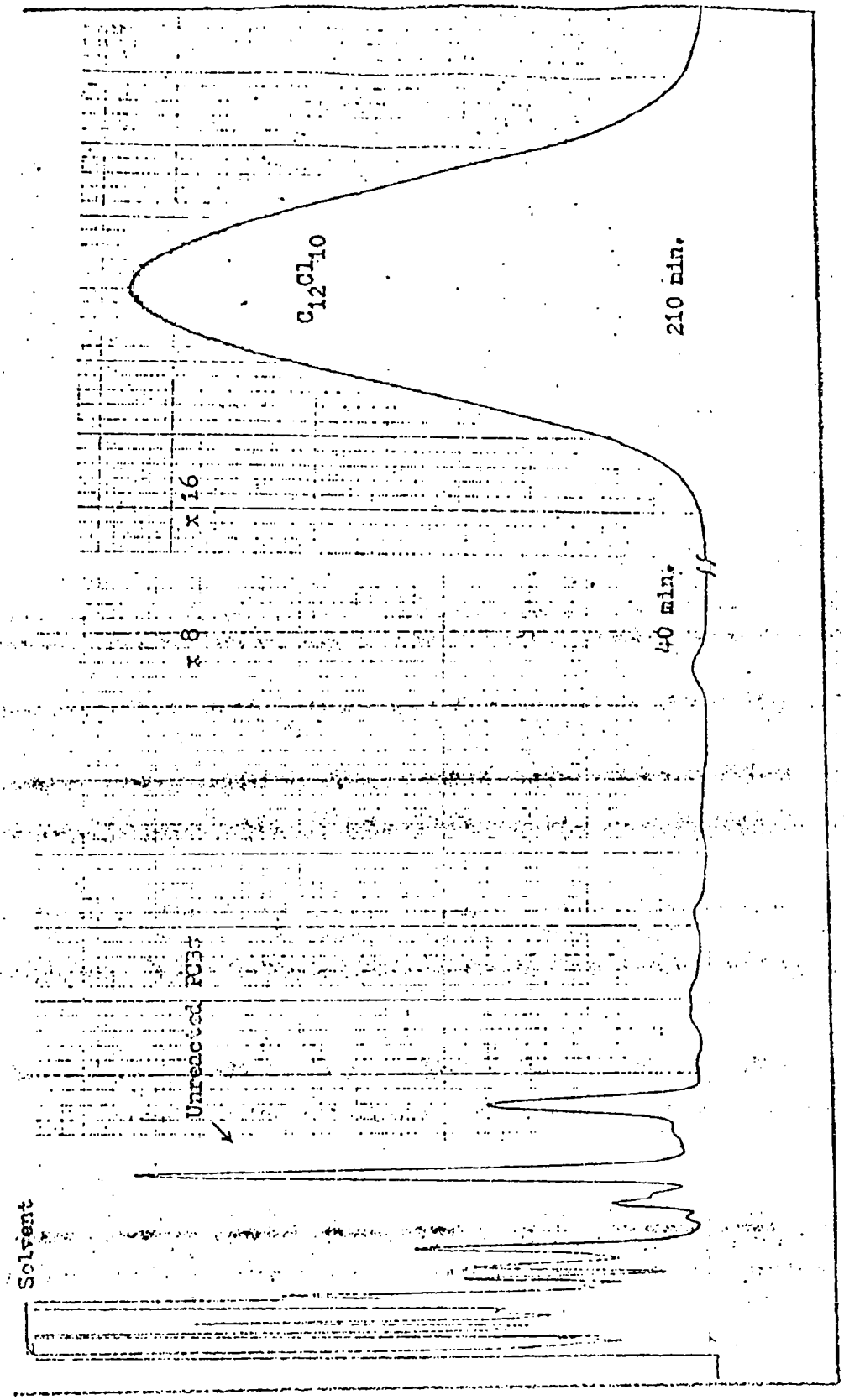

Figure 10. Chromatogram of Products from an Incomplete Perchlorination of Fish Extracts on a 6 ft. Column at 180° C

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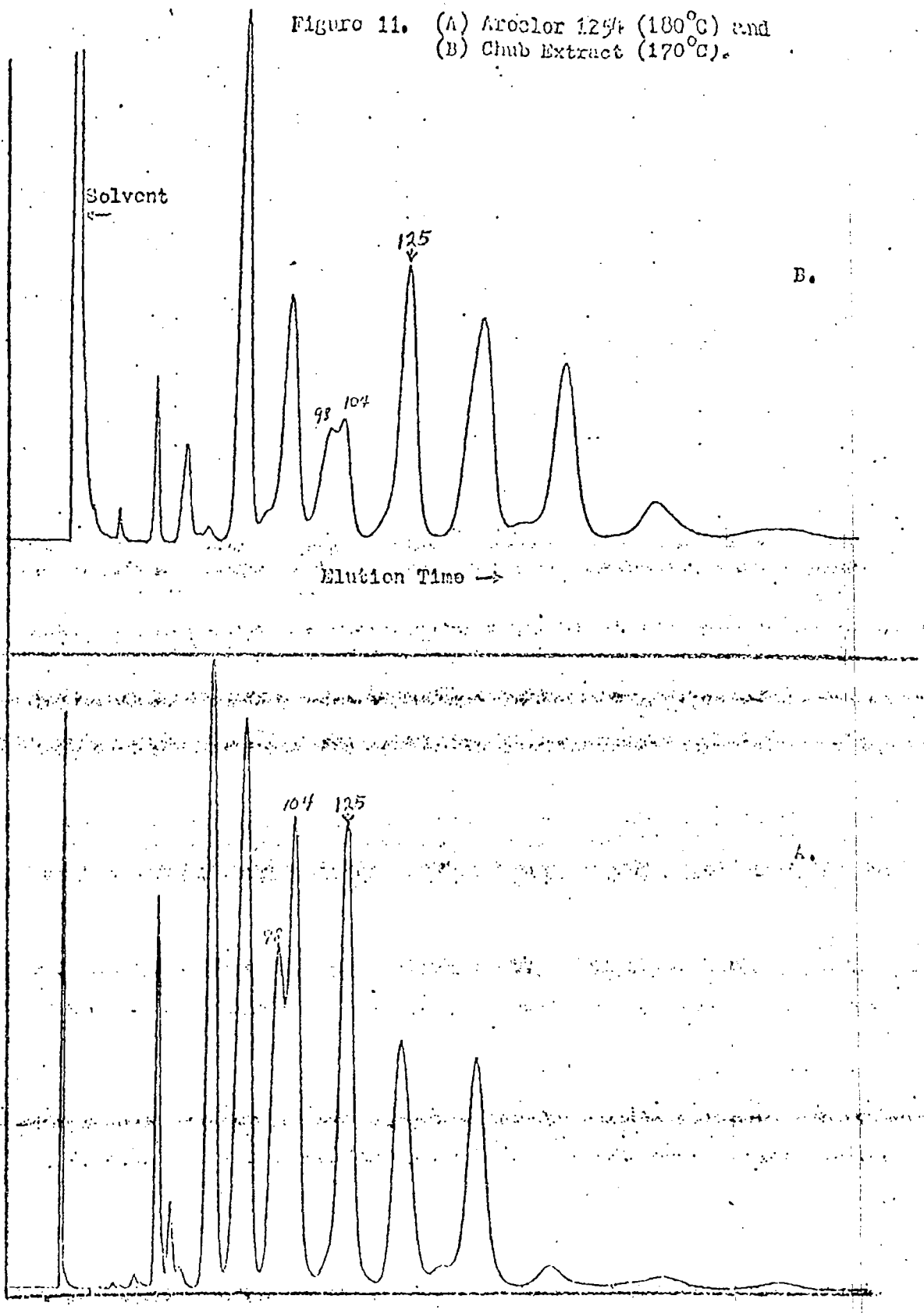
Figure 11. (A) Aroclor 1254 (180°C) and
(B) Chub Extract (170°C).



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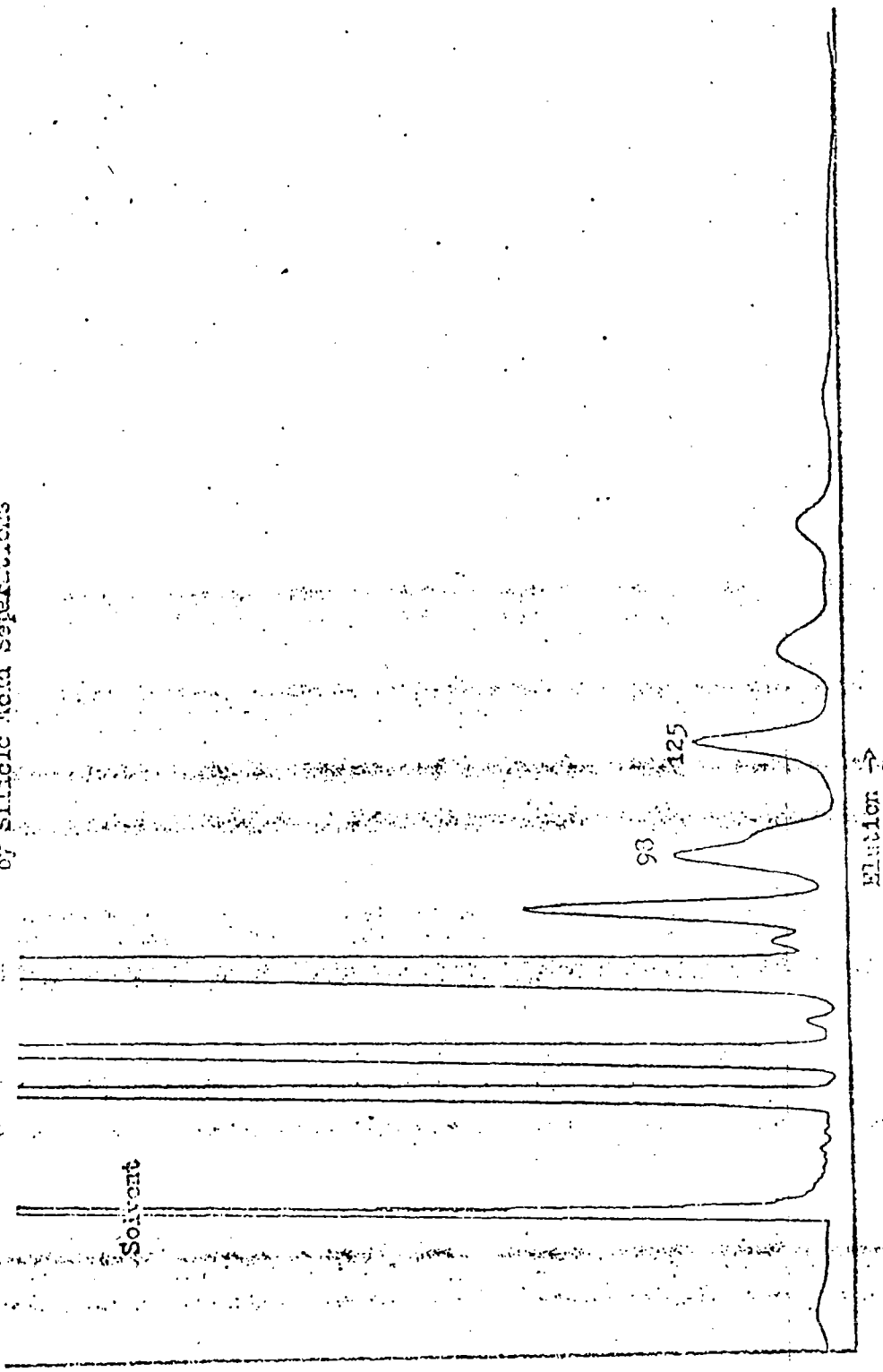

Figure 12. Chromatogram of Smelt (Dear County) Showing Early-Eluting PCBs. Note: Some Trichlorobiphenyls are Removed by Silicic Acid Separations

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presence of PCBs in all samples examined and substantiated the estimates of total PCBs for the fish captured in deep water. Those fish taken from the near-shore environment are more likely to have the lighter PCBs present due to the runoff from the watershed (Veith; 1970, 1971). Therefore, the data presented in this report may be considered conservative estimates of the total PCBs present.

B. Mass Spectrometry

To further examine the extracts on a qualitative basis, composites of five extracts of trout and salmon from Green Island, Manitowoc, Milwaukee, Michigan City, Saugatuck, Ludington, and Grand Traverse Bay were prepared, and the composites were examined by GLC/mass spectrometry at the National Water Quality Laboratory in Duluth.

Figure 13 presents a chromatogram of the fish extract from Michigan City, Indiana. After each sample was introduced into the gas chromatograph, the solvent was vented for 45 seconds, and the mass spectrometer was set to the repetitive scan mode. The data system acquired 50 to 600 a.m.u. spectra approximately every seven seconds, providing 300 to 500 spectra per sample. The mass-converted spectra were examined by several methods for PCBs, DDE and related materials. The first was using the data system to compile ion intensity data for a specific m/e to form a mass chromatogram. For example, in the search for PCBs, the typical mass chromatograms included those of m/e = 256, 290, 324, 358, 392 which represent molecular ions for the tri-, tetra-, penta-, hexa- and heptachlorobiphenyl, respectively. In addition, searches for the molecular ions from the ^{37}Cl isotopes such as m/e = 325, 360, etc. were plotted.

Figure 14 compares mass chromatograms for m/e 292, 326 and 360 for the sample from Michigan City. The data show the composition of PCBs in the mixture in that the early peaks contain tetrachlorobiphenyl, and the 5-4 and 6Cl peaks elute later in the mixture. All of the trout and salmon composite samples gave similar results, thus substantiating that the PCBs present were those found predominantly in Aroclor 1254.

Mass chromatograms for molecular ions of other pesticides and related materials produced no evidence for compounds which were present in

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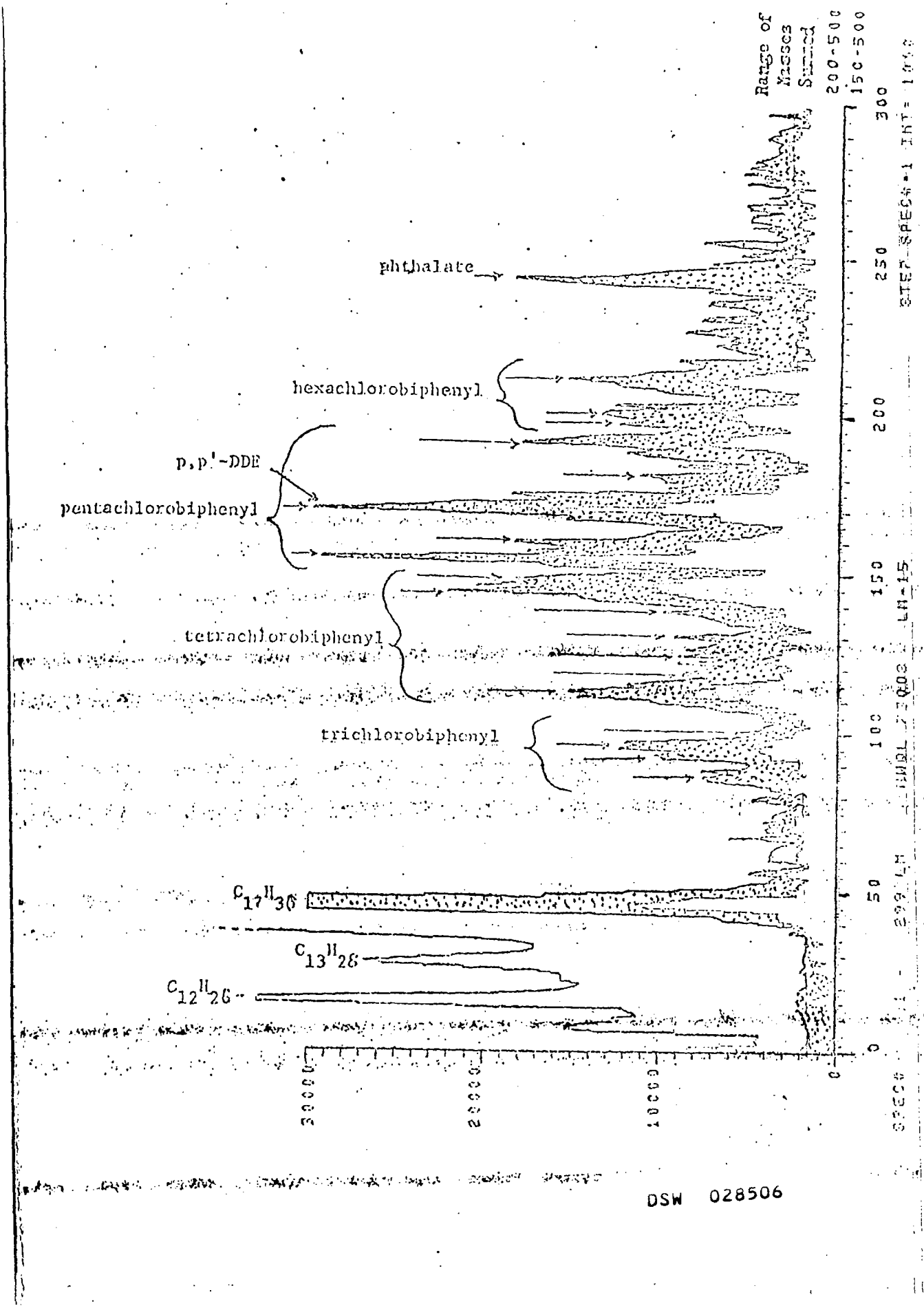

Figure 13. Chromatogram of Composite Sample of Lake Trout From Michigan City, Indiana, on GC/MS System

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Figure 14a. Mass Chromatogram of PCB Components of Michigan City Trout Extract

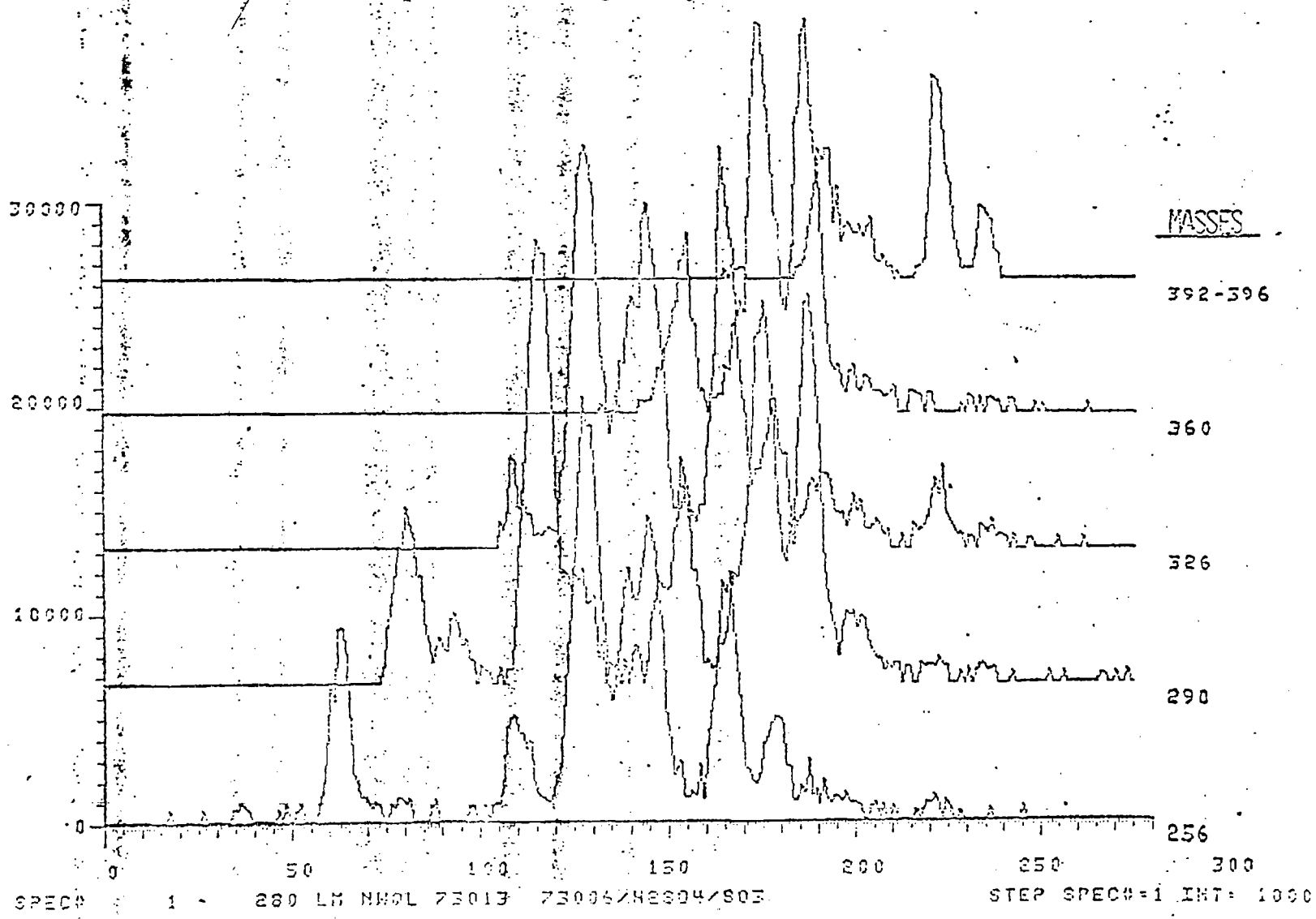

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Figure 14b. Mass Chromatogram of Pentachlorobiphenyl in Michigan City Trout Extract

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quantities sufficiently great to cause errors in the quantitative analyses.

Locating the major components of the PCBs in the mixture also allowed for the selection of spectra which were obtained when the greatest quantity of material was eluting from the gas chromatograph. These spectra were plotted for numerous points throughout each run, and the spectra were analyzed to make certain the data arose from PCBs. A summary of the data is presented in Figures I through VI in Appendix B for the major regions of Lake Michigan. Figure Ia is a spectrum of an early-eluting peak which has a molecular ion at m/e - 256. This corresponds to a trichlorobiphenyl, and the characteristic isotope effect between m/e - 256 to 262 as well as the presence of an M - 35 peak at 221 indicates the presence of chlorine. Similarly, Figure Ib shows the presence of a M - 290 for a tetrachlorobiphenyl, and figures Ic and d show the presence of M - 392 indicating heptachlorobiphenyls. Figures II through VI further substantiate the presence of the PCBs common to Aroclor 1254 through Lake Michigan.

In addition to examining many of the spectra obtained in the GC/MS, the spectra were put in a format suitable for a library search in the computer facilities at Battel Memorial Institute in Columbus, Ohio. Tables 3 and 4 present the results of a typical library search in which the spectra of interest was found to best resemble spectra of the various components of the Aroclor mixtures. Table 3 shows that spectrum 150 in the analysis of trout from Milwaukee (LM-1) produced 21 "hits" and, although only five were called for, all five have similarity indexes between 0.48 and 0.52 (generally considered a close match), and all are pentachlorobiphenyls. Table 4 shows that spectrum 230 of the Milwaukee trout extract matched (similarity indexes of 0.24 to 0.53) the spectra of the pentachlorobiphenyls also.

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Table 3. MS Library Search for 5Cl - PCBs in the Milwaukee Lake Trout Composite Sample

```
SAMPLE ID?
      150
PAPER TAPE?Y
FN= DWK;LM-1,150/LM;%
TT=LAKE MICH-1;%
134,8;145,8;146,16;149,43;162,7;171,7;184,80;186,22;193,6;72;%
194,4;205,7;219,22;220,22;254,100;256,100;258,22;289,22;291,38;77;%
324,52;326,87;328,60;330,21;34;%
END
OPTIONS? N
DATA FOR TOP OF GC PEAK?Y
 21 HITS
PRINT SIM. INDEX?Y
POLYCHLORINATED BIPHENYL (AROCLOR 1254-6) (SEWL) 324 C12.H5.CL5 BSR 01
66
FILE KEY= 10766
SI=0.5241

POLYCHLORINATED BIPHENYL (AROCLOR 1254-9) (SEWL) 324 C12.H5.CL5 BSR 01
69
FILE KEY= 10769
SI=0.5137

POLYCHLORINATED BIPHENYL (AROCLOR 1254-7) (SEWL) 324 C12.H5.CL5 BSR 01
67
FILE KEY= 10767
SI=0.5125

PCB (JA04C,53,251,1970,1254111,PK6) 324 C12.H5.CL5 BSR 0069
FILE KEY= 10669
SI=0.5099

POLYCHLORINATED BIPHENYL (AROCLOR 1254-8) (SEWL) 324 C12.H5.CL5 BSR 01
68
FILE KEY= 10768
SI=0.4785
```

DSW 028510

STLCOPCB4012472

Table 4. MS Library Search for 6 Cl - PCBs in the Milwaukee Lake Trout Composite Sample

```
SAMPLE ID?
      230
PAPER TAPE?Y
FN= DWK:LM-1,230/LM:%
TT= LAKE MICH-1;%
144,50;145,81;146,42;147,28;162,10;169,10;183,27;184,30;193,7;76;%
206,8;218,85;220,60;254,43;256,41;258,13;288,84;290,100;324,30;77;%
326,78;328,30;329,14;360,95;362,80;43;%
END
OPTIONS? N
DATA FOR TOP OF GC PEAK?Y
 10 HITS
PRINT SIM. INDEX?Y
POLYCHLORINATED BIPHENYL (AROCLOR 1254-15) (SEWL) 358 C12.H4.CL6 BSR 0
172
FILE KEY= 10772
SI=0.5394

POLYCHLORINATED BIPHENYL (AROCLOR 1254-13) (SEWL) 324 C12.H5.CL5 BSR 0
171
FILE KEY= 10771
SI=0.3632

POLYCHLORINATED BIPHENYL (AROCLOR 1254-17) (SEWL) 358 C12.H4.CL6 BSR 0
173
FILE KEY= 10773
SI=0.2792

POLYCHLORINATED BIPHENYL (AROCLOR 1254-5) (SEWL) 324 C12.H5.CL5 BSR 01
65
FILE KEY= 10765
SI=0.2365

5,8-DITHIAINDENO(2,1-C)FLUORENE 290 C18.H10.S2 APM 0139
FILE KEY=  6143
SI=0.0726
```

DSW 028511

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The use of computer library searches, however, should be used only to assist the analyst and cannot be regarded as a strict confirmation of a particular chemical. Not only may the computer library searches produce misleading information, but also useful data may be lost. For example, Table 5 represents searches for spectra 167 and 208 in the sample from Manitoboc (the search for spectrum 147 was aborted due to a lack of a base peak.) Neither of these searches produced useful results due to the fact that the spectra are abbreviated to eliminate interfering peaks from hydrocarbons. However, inspection of the data in Table 5 or in Figure 15 reveals the presence of 5-Cl and 6-Cl PCBs by respective molecular ions.

Moreover, computer library searches are of limited value in detecting minor components evident in mixed spectra obtained when several compounds elute simultaneously from the GLC. Figure 15 is a spectrum of a pentachlorobiphenyl (M^+ = 324) in which the molecular ion for DDE at m/e = 316 is observed. This is expected since the PCBs which elute with DDE contain five chlorines and are commonly found as evidenced by Figures IIIB and VIB. As discussed previously, however, the presence of DDE in some of the pentachlorobiphenyl components did not introduce an error in the quantitative analysis because the doublet (5-Cl PCBs) eluting at 98 and 104 relative to DDE were omitted from the calculations.

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Table 5 MS Library Search for Spectra 167 and 208 of the Manitowoc Lake Trout Composite Sample.

```
SAMPLE ID?
      167
PAPER TAPE?Y
FN= DWK;LM-4,167/LM;2
TT= LAKE MICH-4;2
148,3;149,8;183,4;185,16;207,4;218,4;219,5;254,19;256,16;71;%
258,7;289,4;291,8;324,13;326,22;328,13;330,4;55;%
END
OPTIONS? N
NO HITS
S, E, OR P?S
SAMPLE ID?

167
PAPER TAPE?Y
FN= DWK;LM-4,146/LM;2
TT= LAKE MICH-5;2
149,10;150,15;184,5;185,5;220,30;222,19;256,2;257,2;290,25;73;%
292,30;7;%
END
UNREC. INPT. CHAR. ABORT
S, E, OR P?S
SAMPLE ID?
      167
PAPER TAPE?Y
FN= DWK;LM-4,167/LM;2
TT= LAKE MICH-4;2
148,3;149,8;183,4;185,16;207,4;218,4;219,5;254,19;256,16;71;%
258,7;289,4;291,8;324,13;326,22;328,13;330,4;55;%
END
OPTIONS? N
NO HITS
S, E, OR P?S
SAMPLE ID?
      208
PAPER TAPE?Y
FN= DWK;LM-4,208/LM;2
TT= LAKE MICH-4;2
183,3;184,6;218,5;220,3;254,9;256,6;258,3;288,5;290,6;66;%
324,7;326,12;328,6;330,3;360,6;362,5;45;%
END
OPTIONS? N
NO HITS
```

DSW 028513

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Figure 15 Mass Spectrum 282 of the Monitored Lake Trout Sample Illustrating the Presence of both DDE and a Pentachlorobiphenyl in the Peak

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C. Other Confirmations

Several composite samples were prepared from the methylene chloride fractions of the silicic acid separation, and the samples were examined by GC/MS. Figure 16 shows the "total"-ion-current chromatograph for the extract of trout from Michigan City, Indiana. The detection of components of this mixture is enhanced by plotting the sum of ion intensities for each spectrum as illustrated in Figure 17. Many of the components appear to be materials with considerable hydrocarbon characteristics--presumably triglycerides. The contribution of these components to the mass chromatogram is removed by considering only the sum of ion intensities within the range of m/e 150 to 400 as plotted in Figure 18. All of the components which eluted prior to spectrum 115 are trichlorobiphenyls which are separated from the heavier PCBs on silicic acid and appear in the fraction with DDT. The retention volume of DDE, DDD, and DDT isomers in the temperature program used corresponds to the region between spectrum 120 and 160. The presence of these chlorinated hydrocarbons in the extract is seen in Figure 19 which are mass chromatograms of m/e 246 and 235. The large peak at spectrum 126 is DDE, op'DDD appears at 139, DDT appears at 152, and pp'DDD and op'DDT elute as a partially resolved doublet near spectrum 139.

One of the major concerns in determining the quantity of DDD or DDT in the samples has been the possibility that the PCBs interfere with the analyses, giving high results. Although the routine checks of the silicic acid separation procedure indicated the DDT and DDD isomers were completely separated from the interfering PCBs, the composite of the methylene chloride fractions were also analyzed for molecular ions of the PCBs. In general, ions which arise from the 5, -6- and 7-Cl PCBs were low and insignificant. For example, Figures 20a and b are mass chromatograms which have been plotted as absolute intensities with no scale expansion. Figure 20c is the mass chromatogram for pentachlorobiphenyls which has been expanded tenfold. Even though the ion intensities cannot be compared in the strict sense to give relative masses of the two compounds in the mixture, the data indicates that PCB interference in the DDT analysis is less than 10 percent and likely insignificant after silicic acid separation in these composite samples.

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Figure 16, Total Ion Current Chromatogram of the Polar Aliant Fraction (Silicic Acid) of a Green Bay Trout Extract

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Figure 18. Mass Chromatogram for Masses 150-400
for the Green Inland Trout Extract

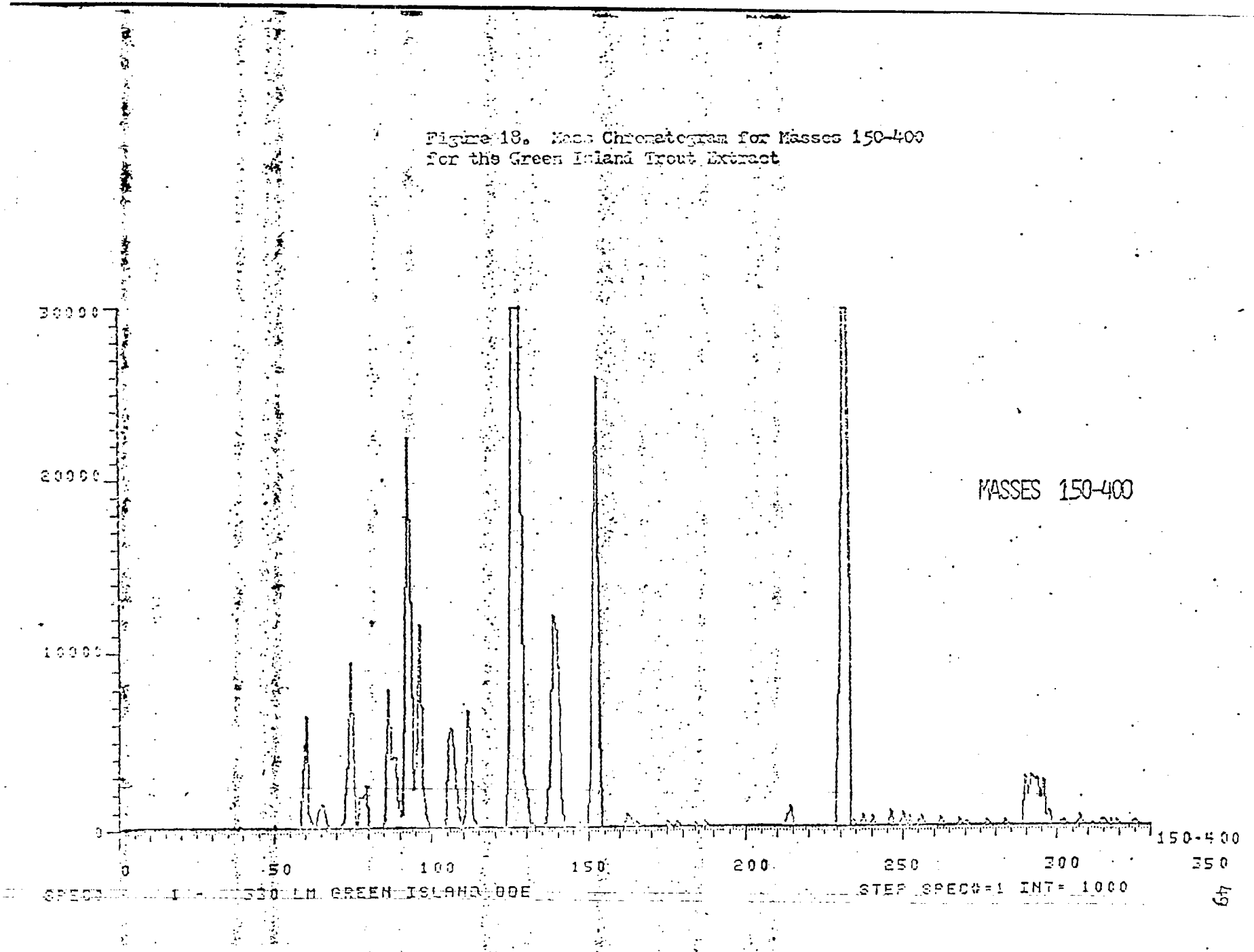

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Figure 19. Mass Chromatogram for Masses 246 and 235 for the Green Island Trout Extract

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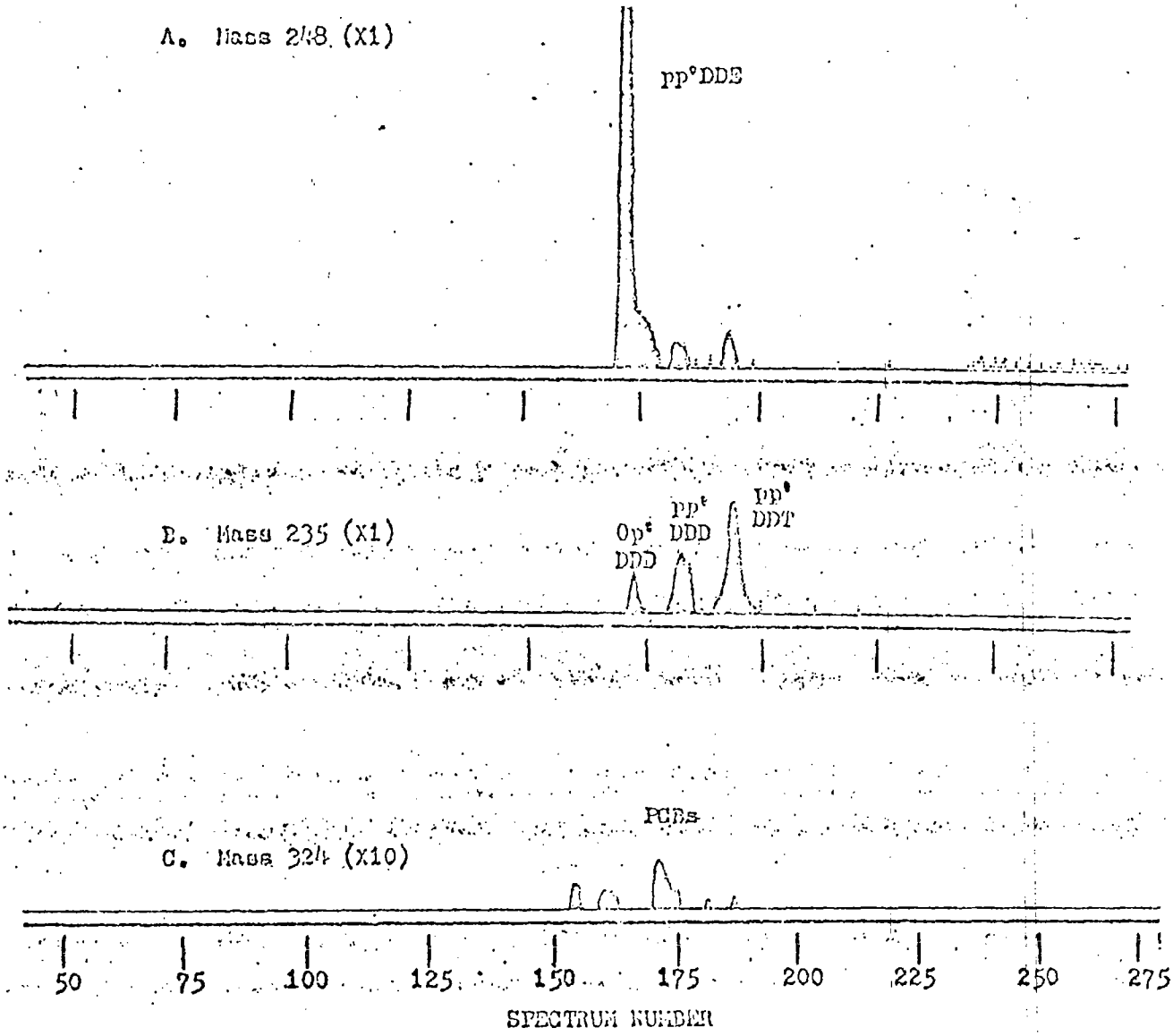
Figure 20 Selected Mass Chromatograms of the GC/MS Analysis of the DDE Fraction



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The major component eluting in spectrum 230 in Figure 18 has not been identified as yet. However, it contains no chlorine and appears to arise from the lipids. Figure 13 has indicated that a number of major components elute early in the chromatogram and that they have been identified as saturated, linear hydrocarbons. The predominant component eluting in spectrum 47 in Figure 13 has been identified as n-heptadecane with the substantiating data including mass spectra as in Figure 21, retention time, and bromination and related chemical reactivity studies. The presence of the C_{12}, C_{13}, and C_{17} hydrocarbons at comparatively high concentrations without the presence of C_{14}, C_{15}, and C_{16} hydrocarbons suggest that the hydrocarbons may be due to metabolic activities within the food chain rather than contamination of the waters by petroleum products. Considerable more research is needed to determine the source of these hydrocarbons.

The qualitative analysis also indicated the presence of several phthalate esters in the fish from Lake Michigan. In general, the di-n-butyl, a di hexyl, and a dioctyl (presumably di-2-ethylhexyl) phthalate were found, although some fish had lesser or undetectable quantities of the dihexylphthalate. The presence of these chemicals are readily detected by plotting the mass chromatogram for m/e 149, since m/e 149 is a predominant ion in the phthalate ester fragmentation. However, the low abundance of ions above 149 precludes explicit identification of the phthalate and GLC retention volume data were used to make the assignments presented here. The dihoxyl-phthalate was not detected by electron capture GLC.

Also detected in some extracts was a dioctyl adipate. Figure 23a illustrates a m/e 147 mass chromatogram which is somewhat specific for the adipate esters. Although the adipate was found in the Green Bay trout extract and several others, no evidence was found for adipates in the trout from Michigan City and Saugatuck regions as evidenced by Figure 23b. A spectrum of the dioctyl-adipate from the Sheboygan trout extract is presented in Figure 24. The abundant m/e 147 ion is apparent; however, like the phthalates, the ion abundances in the parent ion region are low in electron impact spectra. The base peak at m/e 129 as well as the other major ions are often obscured by interference co-eluting from the column.

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Figure 21. Mass Spectrum of Heptadecane
in Michigan City Trout Extract

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Figure 22. Mass Chromatogram M/Z 149 of Grand Traverse Bay Trout Extract

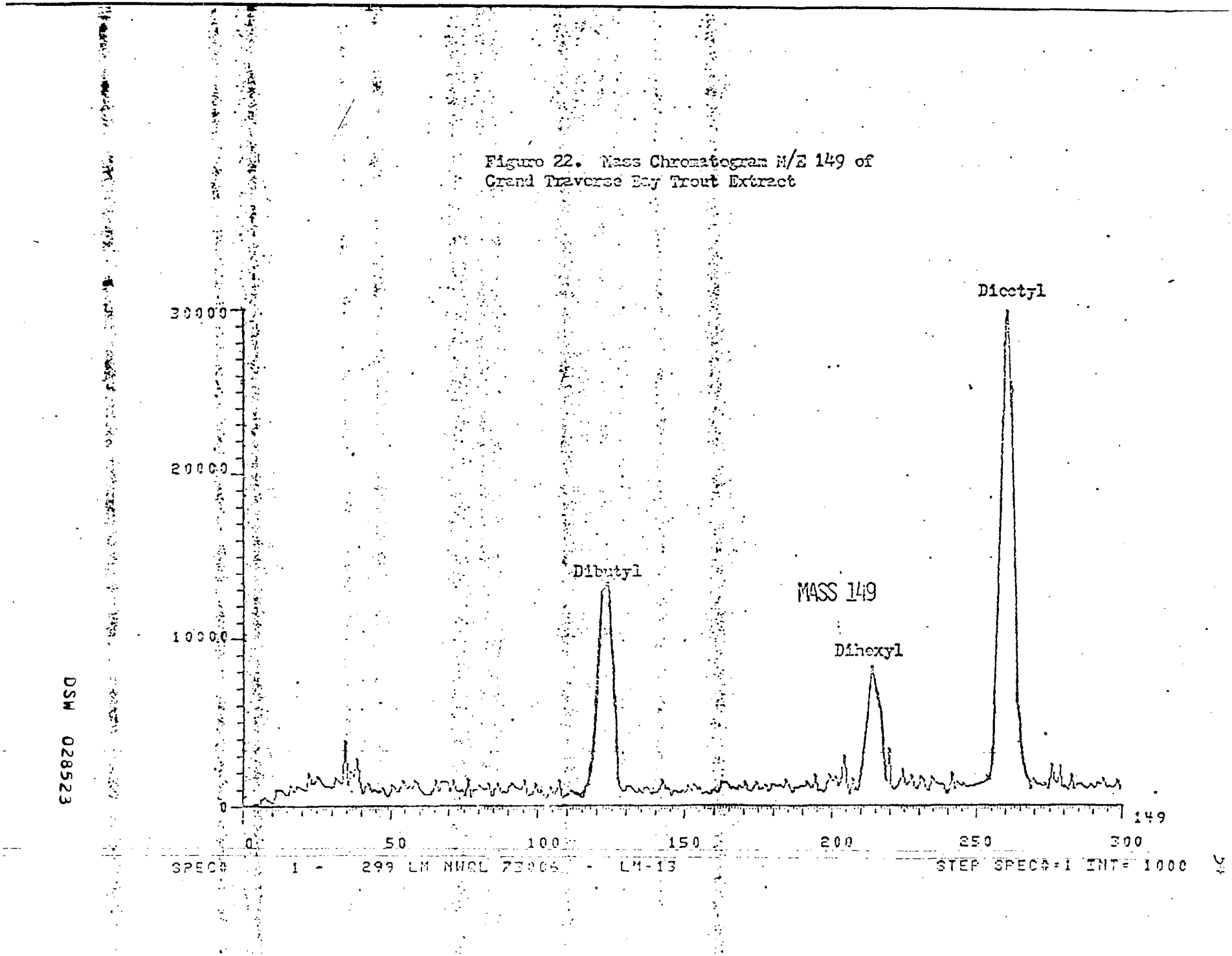

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Figure 23. Mass Chromatogram M/E 147
for Adipates in Green Bay Trout

DSW 028524

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Figure 27b. Mass Chromatogram M/z 147
for Aldrites in Michigan City Trout

STLCOPCB4012487

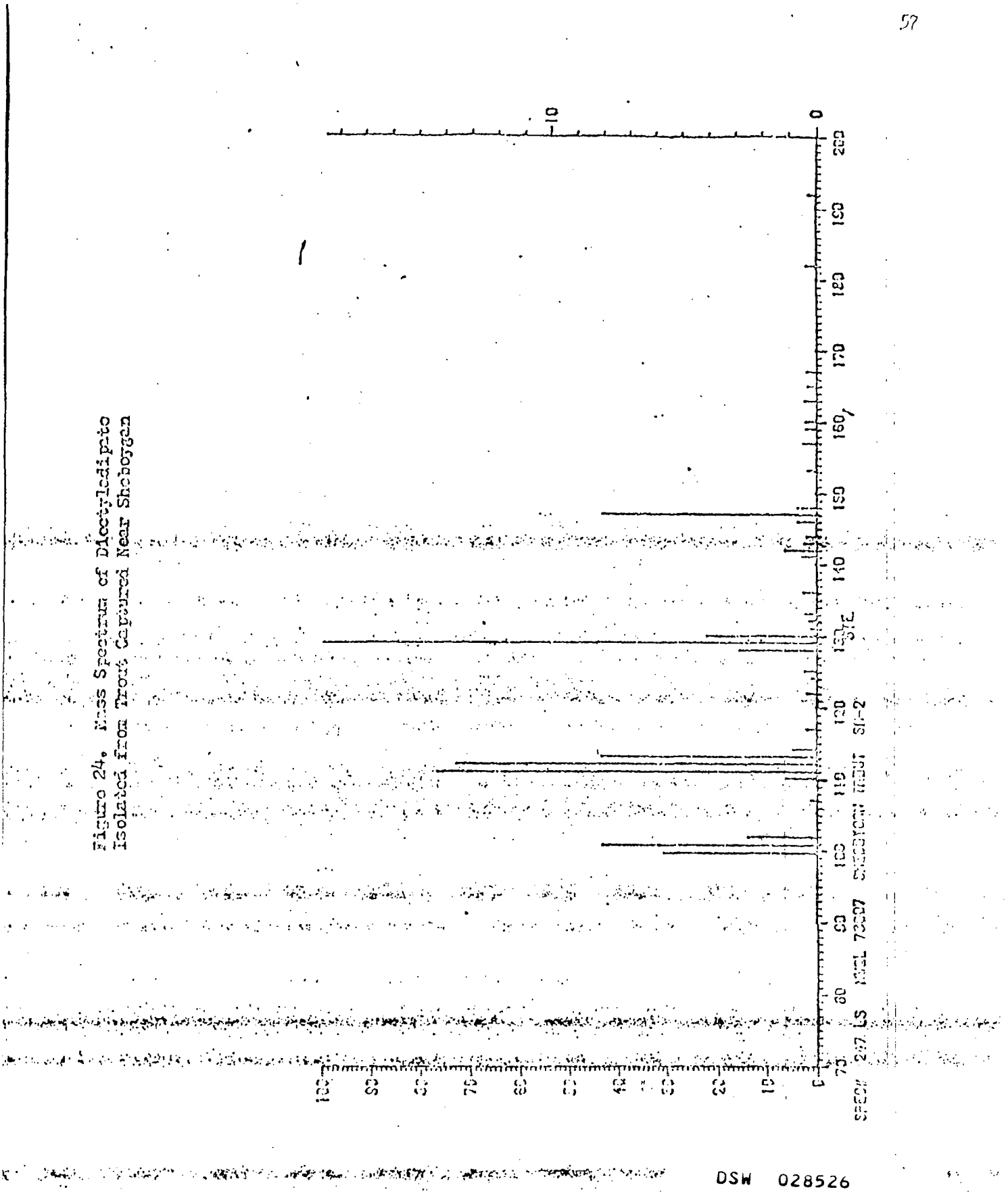

Figure 24. Mass Spectrum of Dicotyledipto
Isolated from Trout Captured Near Sheboygan

DSW 028526

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It must be emphasized that the elution behavior for pthalate esters and related esters do not behave as the pesticides on column chromatography and "quantitation" of these compounds must be considered estimates only.

The search for other potentially toxic chemicals in Lake Michigan fish is inherently open-ended. No evidence of lindane, hexachlorobenzene, chlordane, or other chlorinated pesticides has been found. However, the difficulty of obtaining explicit confirmation for dieldrin which is likely and often reported at concentrations of 0.3 ug/gm in the larger fish as well as spiked samples indicates that the GC/MS techniques employed may have to be refined for confirmations of minor components which may be present below approximately 0.1 ug/gm.

Of particular interest is the search for the chlorinated naphthalenes which may interfere with the PCB determination, if present. In all of the extracts analyzed by GLC and GC/MS, there was no evidence of the chlorinated naphthalenes. To further examine the extracts, the extracts were perchlorinated, and the products were analyzed by direct probe mass spectrometry. Figure 25 presents a spectrum in which the ions arising from decachlorobiphenyl are readily apparent. However, there is no evidence of ions at m/e 400 which is the parent ion region for octachloronaphthalene which results from the perchlorination. Sensitivities studies with this technique leads to an estimated detection limit of approximately 0.01 ug/gm.

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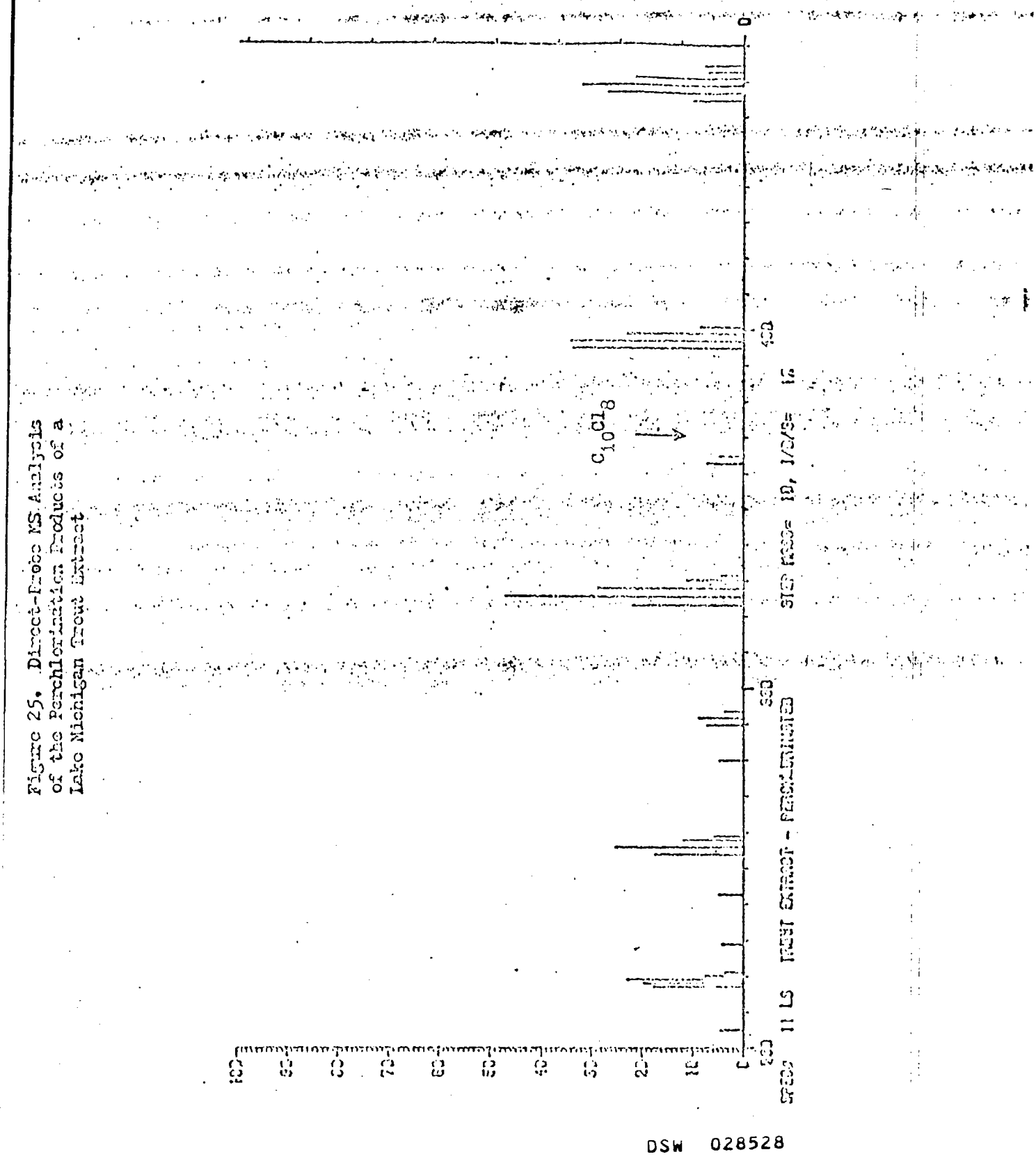

Figure 25. Direct-Probe MS Analysis of the Perchlorination Products of a Lake Michigan Trout Extract

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SECTION VI

RESULTS AND DISCUSSION

This section of the report presents data regarding the concentrations of PCBs and DDT (and metabolites) in the Lake Michigan fish collected in this study. Also presented are preliminary data regarding concentrations of two of the phthalate esters in the Lake Michigan fish.

A. Polychlorinated Biphenyl

Approximately 850 of the fish collected from Lake Michigan were analyzed for PCB mixtures resembling that of Aroclor 1254. A generalized summary of these results is presented in Table 6 in which the range and average concentrations of PCBs (as Aroclor 1254) is reported for 13 species of fish. The mean concentrations ranged from 2.7 µg/gm in smelt to 15 µg/gm in lake trout. The data show that the larger fish such as brown, lake and rainbow trout and chinook and coho salmon contained PCBs at concentrations two to three times the 5 µg/gm action level established by the FDA. The mean PCB concentrations in suckers, smelt and whitefish were considerably less than 5 µg/gm and the mean concentrations in the alewife, carp, chub and perch were approximately 5 µg/gm, ranging from 4.2 to 6.0 µg/gm. As is expected, the larger fish with greater percentage fat contain greater concentrations of PCBs.

Table 6 also indicates that the mean concentration of DDT (total DDT defined as the sum of p,p'DDT, o,p'DDT, p,p'DDE, and p,p'DDE) in Lake Michigan fish ranged from 1.2 ug/gm in carp and smelt to 7.1 ug/gm in lake trout. As was found in the analyses of PCBs in these fish, the fish containing higher lipid concentrations contained greater concentrations of DDT.

Table 7 summarizes more detailed data collected for the 13 species of fish captured in Lake Michigan. The data show that the ratio of PCB/TotalDDT (a ratio often calculated and cited but not often applicable) ranged from 1.3 in red suckers which were caught primarily in the northern waters to 7.6 in carp. Of particular interest are the facts that the ratio of PCB/DDT in the majority of the fish was between 1.7

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Table 6. Summary of PCB and Total DDT Concentrations In 1971 Lake Michigan Fish

Species	Numbers of Fish Analyzed	PCB's Mean	PCB's S.D.	Total Mean	Total S.D.
Alewife	85	4.6	2.1	2.2	1.1
Brown Trout	17	7.3	2.8	4.2	1.6
Carp	42	4.2	3.6	1.2	0.9
Chub	287	6.0	2.2	3.8	2.0
Chinook Salmon	21	11.4	4.0	6.8	2.5
Coho Salmon	56	11.5	5.7	6.3	2.8
Lake Trout	134	15.5	3.2	7.1	3.7
Perch	44	5.8	3.5	1.6	1.1
Rainbow Trout	11	9.3	4.1	4.2	1.8
Red Sucker	16	3.0	0.7	2.6	0.7
Smelt	38	2.7	1.3	1.2	0.6
White Sucker	51	3.9	3.6	1.6	1.2
Whitefish	43	3.0	1.9	1.4	0.6

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Alewife

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	101	.100	.735
PERCENT FAT	85	6.5	3.9
PP'DDE	85	1.7	.8
PCB	76	4.6	2.1
OP'DDT	53	.08	.04
PP'DDT	53	.5	.3
PP'DDD	53	.20	.10
TOTAL DDT	85	2.2	1.1
PCB/TOTAL DDT	76	2.4	1.4
PP'DDE/PP'DDT	53	3.6	2.5
OP'DDT/PP'DDT	53	.2	.1
PP'DDE/TOTAL DDT	85	.8	.2
OP'DDT/TOTAL DDT	53	.0	.0
PP'DDT/TOTAL DDT	53	.2	.1
PP'DDD/TOTAL DDT	53	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Brown Trout

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	13	3.676	1.000
PERCENT FAT	17	15.5	4.1
PP'DDE	17	2.7	1.0
PCB	17	7.3	2.8
OP'DDT	17	.16	.05
PP'DDT	17	1.1	.3
PP'DDD	17	.49	.11
TOTAL DDT	18	4.2	1.6
PCB/TOTAL DDT	17	1.8	.9
PP'DDE/PP'DDT	15	2.6	1.0
OP'DDT/PP'DDT	17	.1	.0
PP'DDE/TOTAL DDT	17	.6	.2
OP'DDT/TOTAL DDT	17	.0	.0
PP'DDT/TOTAL DDT	17	.3	.1
PP'DDD/TOTAL DDT	17	.1	.0

DSW 028531

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: CARP

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	51	2.163	1.998
PERCENT FAT	51	10.0	7.0
PP'DDE	49	.7	.9
PCB	42	4.2	3.6
OP'DDT	19	.05	.04
PP'DDT	12	.2	.2
PP'DDD	30	.20	.27
TOTAL DDT	49	.9	1.2
PCB/TOTAL DDT	40	7.6	9.7
PP'DDE/PP'DDT	12	6.5	9.0
OP'DDT/PP'DDT	12	.3	.1
PP'DDE/TOTAL DDT	49	.6	.2
OP'DDT/TOTAL DDT	19	.0	.0
PP'DDT/TOTAL DDT	12	.1	.1
PP'DDD/TOTAL DDT	30	.3	.1

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Chinook Salmon

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	27	3.137	.826
PERCENT FAT	21	5.0	3.9
PP'DDE	22	5.2	1.5
PCB	21	11.4	9.0
OP'DDT	18	.21	.11
PP'DDT	18	1.3	.9
PP'DDD	18	.52	.32
TOTAL DDT	22	6.8	2.5
PCB/TOTAL DDT	21	1.7	.6
PP'DDE/PP'DDT	18	5.3	3.7
OP'DDT/PP'DDT	18	.2	.0
PP'DDE/TOTAL DDT	22	.6	.1
OP'DDT/TOTAL DDT	18	.0	.0
PP'DDT/TOTAL DDT	16	.2	.1
PP'DDD/TOTAL DDT	18	.1	.0

DSW 028532

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: CHUB

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	175	.249	.270
PERCENT FAT	249	20.0	5.9
PP'DDE	227	2.5	1.1
PCB	231	6.0	2.2
OP'DDT	155	.22	.09
PP'DDT	154	1.6	.9
PP'DDD	156	.43	.20
TOTAL DDT	237	3.8	2.0
PCB/TOTAL DDT	228	2.2	2.2
PP'DDE/PP'DDT	148	1.9	3.3
OP'DDT/PP'DDT	155	.2	1.3
PP'DDE/TOTAL DDT	227	.7	.3
OP'DDT/TOTAL DDT	155	.0	.0
PP'DDT/TOTAL DDT	154	.4	.1
PP'DDD/TOTAL DDT	156	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: COHO SALMON

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	50	2.724	1.275
PERCENT FAT	62	6.5	2.1
PP'DDE	62	4.8	2.3
PCB	54	11.5	5.7
OP'DDT	51	.20	.08
PP'DDT	51	1.3	.7
PP'DDD	51	.44	.16
TOTAL DDT	53	6.3	2.8
PCB/TOTAL DDT	56	2.1	1.3
PP'DDE/PP'DDT	50	4.1	2.1
OP'DDT/PP'DDT	51	.2	.1
PP'DDE/TOTAL DDT	62	.7	.2
OP'DDT/TOTAL DDT	51	.0	.0
PP'DDT/TOTAL DDT	51	.2	.1
PP'DDD/TOTAL DDT	51	.1	.0

DSW 028533

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Fourhorn Sculpin

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	13	.020	.007
PERCENT FAT	13	5.9	.9
PP'DDE	13	1.0	.6
PCB	12	2.7	1.1
OP'DDT	9	.05	.04
PP'DDT	9	1.2	1.0
PP'DDD	9	.15	.09
TOTAL DDT	13	2.9	1.7
PCB/TOTAL DDT	12	1.4	.9
PP'DDE/PP'DDT	9	1.5	.4
OP'DDT/PP'DDT	9	.1	.0
PP'DDE/TOTAL DDT	13	.7	.2
OP'DDT/TOTAL DDT	9	.0	.0
PP'DDT/TOTAL DDT	9	.4	.1
PP'DDD/TOTAL DDT	9	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Lake Trout

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	58	1.617	1.324
PERCENT FAT	153	16.6	9.3
PP'DDE	142	5.0	2.4
PCB	134	15.5	12.3
OP'DDT	122	.26	.12
PP'DDT	122	2.0	1.0
PP'DDD	122	.63	.24
TOTAL DDT	149	7.1	3.7
PCB/TOTAL DDT	133	2.5	5.4
PP'DDE/PP'DDT	115	3.1	3.9
OP'DDT/PP'DDT	122	.2	.1
PP'DDE/TOTAL DDT	142	.7	.2
OP'DDT/TOTAL DDT	122	.0	.0
PP'DDT/TOTAL DDT	122	.3	.1
PP'DDD/TOTAL DDT	122	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Perch

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	57	.198	.046
PERCENT FAT	56	6.1	1.7
PP'DDE	44	1.0	.4
PCB	44	5.6	3.5
OP'DDT	27	.08	.04
PP'DDT	27	.7	.7
PP'DDD	29	.24	.16
TOTAL DDT	47	1.6	1.1
PCB/TOTAL DDT	44	4.8	3.7
PP'DDE/PP'DDT	24	3.0	3.8
OP'DDT/PP'DDT	26	.1	.0
PP'DDE/TOTAL DDT	44	.8	.2
OP'DDT/TOTAL DDT	27	.0	.0
PP'DDT/TOTAL DDT	27	.3	.2
PP'DDD/TOTAL DDT	29	.1	.1

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Rainbow Trout

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	11	4.189	1.344
PERCENT FAT	10	14.4	3.3
PP'DDE	11	3.4	1.3
PCB	11	9.3	4.1
OP'DDT	6	.16	.05
PP'DDT	6	1.7	.3
PP'DDD	6	.35	.11
TOTAL DDT	11	5.2	1.6
PCB/TOTAL DDT	11	2.3	1.0
PP'DDE/PP'DDT	6	3.8	1.4
OP'DDT/PP'DDT	6	.2	.0
PP'DDE/TOTAL DDT	11	.8	.2
OP'DDT/TOTAL DDT	6	.0	.0
PP'DDT/TOTAL DDT	6	.2	.1
PP'DDD/TOTAL DDT	6	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: Red Sucker

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	16	.902	.227
PERCENT FAT	16	8.6	1.2
PP'DDE	16	1.6	.5
PCB	16	3.0	.7
OP'DDT	14	.09	.05
PP'DDT	14	.7	.3
PP'DDD	14	.33	.10
TOTAL DDT	16	2.4	.7
PCB/TOTAL DDT	16	1.3	.5
PP'DDE/PP'DDT	14	3.1	2.9
OP'DDT/PP'DDT	14	.2	.1
PP'DDE/TOTAL DDT	16	.6	.2
OP'DDT/TOTAL DDT	14	.0	.0
PP'DDT/TOTAL DDT	14	.3	.1
PP'DDD/TOTAL DDT	14	.1	.0

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL,1971.

SPECIES: Smelt

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	36	.051	.026
PERCENT FAT	39	5.8	1.8
PP'DDE	41	.8	.4
PCB	38	2.3	1.3
OP'DDT	39	.09	.02
PP'DDT	39	.3	.2
PP'DDD	39	.12	.04
TOTAL DDT	42	1.2	.6
PCB/TOTAL DDT	38	2.6	1.5
PP'DDE/PP'DDT	33	2.8	1.3
OP'DDT/PP'DDT	39	.1	.0
PP'DDE/TOTAL DDT	41	.7	.2
OP'DDT/TOTAL DDT	39	.0	.0
PP'DDT/TOTAL DDT	39	.3	.1
PP'DDD/TOTAL DDT	39	.1	.0

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TABLE 7

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: Whitefish

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	37	1.109	.432
PERCENT FAT	37	17.6	9.9
PP'DDE	34	.8	.3
PCB	33	3.0	1.9
OP'DDT	34	.07	.08
PP'DDT	34	.5	.2
PP'DDD	34	.25	.11
TOTAL DDT	37	1.4	.6
PCB/TOTAL DDT	33	2.8	2.5
PP'DDE/PP'DDT	31	2.1	1.4
OP'DDT/PP'DDT	34	.2	.3
PP'DDE/TOTAL DDT	34	.7	.2
OP'DDT/TOTAL DDT	34	.0	.0
PP'DDT/TOTAL DDT	34	.3	.1
PP'DDD/TOTAL DDT	34	.2	.1

GROSS MEAN CONCENTRATIONS OF MAJOR CHLORINATED HYDROCARBONS FOR LAKE-MICHIGAN FISH CAUGHT IN FALL, 1971.

SPECIES: White Sucker

VARIABLE	NUMBER PRESENT	MEAN	STANDARD DEVIATION
FISH WEIGHT (KG)	37	1.131	1.405
PERCENT FAT	53	5.9	2.3
PP'DDE	54	1.0	.5
PCB	51	1.9	3.6
OP'DDT	37	.05	.04
PP'DDT	42	.5	.6
PP'DDD	45	.26	.21
TOTAL DDT	54	1.6	1.2
PCB/TOTAL DDT	51	3.4	3.5
PP'DDE/PP'DDT	42	3.8	2.5
OP'DDT/PP'DDT	37	.1	.1
PP'DDE/TOTAL DDT	54	.7	.2
OP'DDT/TOTAL DDT	37	.0	.0
PP'DDT/TOTAL DDT	42	.2	.1
PP'DDD/TOTAL DDT	45	.2	.0

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and 2.8, and that only the carp, red suckers, and perch contained ratios outside this range. This ratio may become important in future studies to determine the relative rates of elimination of the chemicals from the Lake Michigan system now that the inputs to the Lake have been decreased.

The mean ratios of o,p'DDT/p,p'DDT ranged from 0.1 to 0.3 with the ratio in the majority of the fish being 0.2. Since technical DDT generally contains about 30 percent of the o,p'DDT isomer (ratio of 0.4), the data from Lake Michigan fish suggest that the degradation and/or other removal mechanisms in the lake are slightly greater for the o,p' isomer than for the p,p' isomer.

The data also show that greater than 80 percent of the "total DDT" residue is accounted for by p,p'DDE and p,p'DDT.

Not only does the PCB concentration vary considerably among the 13 species captured, but also the range of concentrations in a single species in the lake was generally greater than 100 percent (the range in red suckers was less; however, all were captured in the same region). Although some variation in concentration is expected because of the normal analytical precision, Table 7 reveals much larger ranges which are undoubtedly due to other factors which limit the usefulness of mean concentrations presented. Previous research has shown (Reinert, 1970) that the lipid content, size of fish, season of capture and concentration in the water may affect the observed concentration of chlorinated hydrocarbons in tissue considerably. Accordingly, the data in Table 7 must be considered in more detail.

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The above summary data for PCBs is presented in Table 8 where the regional variations and variations due to lipid content are expressed. The concentration of PCBs in alewives (on a fresh weight basis) were greater in southern Lake Michigan than in the northern regions, although anomolies are apparent. It is apparent that most of the alewives captured south of a line between Saugatuck and Sheboygan contained between 4.4 and 5.5 µg/gm PCBs whereas those caught north of the line contained between 3.5 and 4.4 µg/gm. An interesting exception is the high concentration, 8.9 µg/gm, in the alewives from Rock Island just off the Door County Peninsula in Wisconsin.

The analyses of brown trout suggested similar trends in that those from Michigan City at the southern end of the lake contained 11.9 µg/gm while those from Sheboygan and Gills Rock contained 7.9 and 6.7 µg/gm, respectively.

The carp from Michigan City also had higher levels of PCBs than did those from the northern region. In contrast to the 11.0 µg/gm found in the Michigan City carp, those from Saugatuck and Sheboygan contained 4.6 and 1.7 µg/gm, respectively.

The PCBs in chubs in southern Lake Michigan ranged from 4.9 µg/gm near Milwaukee to 8.1 µg/gm near Saugatuck. In general, the chubs from the northern regions were below 5 µg/gm. The concentration of PCBs in the five groups of chubs collected over three months near Sheboygan varied without trend between 3.7 and 6.1 µg/gm, although the mean was below 5 µg/gm. The variation is somewhat less when the data is expressed on a lipid basis. For example, the PCBs in the 8/27 and 10/15 chubs was 5.0 and 3.7 µg/gm--wet weight, respectively. In contrast, the concentration of PCBs in the lipids was 23 µg/gm and 21 µg/gm, respectively. Thus, much of the observed variability is due to lipid content of the fish analyzed.

One hundred percent of the chinook salmon captured in Wisconsin contained greater than 5 µg/gm PCBs and mean concentrations ranged from 24 µg/gm in Milwaukee to 9.9 µg/gm in Strawberry Creek.

Little trend in the concentration of PCBs in coho salmon was observed with sampling region. With the exception of coho caught early in 1971

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

Number	Species	Location	Date (1971)	% Over 5 µg/gm	PCB(µg/gm as Aroclor 1254) Wet Weight	S.D.	Lipid Basis	S.D.
10	ALWF	MICHIGN CITY	1015	40	4.4	2.0	164	172
10	ALWF	BENTON HRBR	902	40	4.8	1.1	60	31
2	ALWF	WAUKEGAN	823		2.5	.1	47	11
12	ALWF	SAUGATUCK	911	41	5.3	2.2	51	21
4	ALWF	SHEBOYGAN	1015	50	5.5	1.4	79	50
14	ALWF	LUDDINGTON	703	18	4.4	1.4	207	154
10	ALWF	FRANKFORT	1005	20	3.7	1.2	62	35
3	ALWF	MANITOU IS	910	33	3.8	2.2	51	47
3	ALWF	ROCK IS	911	66	8.9	12.0	182	256
6	ALWF	ST MARTINS I	911	16	3.5	1.3	82	17
1	BRTR	MICHIGN CITY	1015	100	11.9	.0	51	
5	BRTR	SHEBOYGAN	713	100	7.9	3.0	92	16
10	BRTR	GILLS ROCK	916	70	6.7	2.5	64	22
7	CARP	MICHIGN CITY	1129	100	11.0	2.2	72	27
15	CARP	SAUGATUCK	1015	26	4.6	4.8	71	24
11	CARP	SHEBOYGAN	723		1.7	.8	30	14
9	CARP	PENSAUKEE BR	1101	33	4.2	1.4	30	10
5	CARP	MANITOU IS	916	80	5.8	.8	30	9
10	CHUB	BENTON HRBR	902	60	5.8	1.2	24	5
10	CHUB	SAUGATUCK	616	80	8.1	1.9	96	33

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

Number	Species	Location	Date (1971)	% Over 5 μg/gm	PCB(μg/gm as Aroclor 1254) Wet Weight	S.D.	Lipid Basis	S.D.
24	CHUB	SAUGATUCK	618	95	7.8	2.2	43	16
15	CHUB	SAUGATUCK	619	86	6.9	1.8	34	12
11	CHUB	MILWAUKEE	919	36	4.6	1.2	20	8
13	CHUB	SHEBOYGAN	713	61	5.1	1.5	31	15
13	CHUB	SHEBOYGAN	722	76	6.1	1.8	21	5
6	CHUB	SHEBOYGAN	819		3.8	.6	15	2
7	CHUB	SHEBOYGAN	827	57	5.0	1.3	23	5
6	CHUB	SHEBOYGAN	1015		3.7	.8	21	5
43	CHUB	LUDDINGTON	703	93	7.4	1.8	41	12
6	CHUB	FRANKFORT	1005	12	4.7	.9	28	6
10	CHUB	MANITOU IS	910	30	4.6	1.1	24	6
6	CHUB	WASHINGTON I	909		4.1	.6	16	3
6	CHUB	ROCK IS	911	66	5.6	2.5	97	46
7	CHUB	ROCK IS	919	57	5.6	1.6	23	7
8	CHUB	ROCK IS	916	12	4.0	.7	16	3
9	CHUB	ST MARTINS I	719		3.9	.6	16	4
9	CHUB	MANISTIQUE	527	33	4.8	.7	26	6
1	CISC	GREEN ISLAND	721		3.8	.0	24	
1	CKSM	MILWAUKEE	1015	100	24.0	.0	117	
8	CKSM	MANITOWOC	1021	100	11.3	3.1	209	73

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

Number	Species	Location	Date (1971)	% Over 5 µg/gm	PCB(µg/gm as Aroclor 1254) Wet Weight	S.D.	Lipid Basis	S.D.
10	CKSH	STRAWBERRY CR	1021	100	9.9	2.8	373	154
2	CKSH	GILLS ROCK	916	100	12.7	.7	270	80
8	COHO	MICHIGN CITY	917	12	3.6	1.7	91	24
8	COHO	MICHIGN CITY	927	87	17.3	8.4	255	120
6	COHO	MICHIGN CITY	1007	100	14.0	4.0	349	120
9	COHO	SHEBOYGAN	1021	100	12.1	2.8	276	36
4	COHO	LUDDINGTON	822	100	11.2	3.3	108	29
10	COHO	PLATTE RIVER	1007	100	12.9	1.3	226	99
11	COHO	GILLS ROCK	916	90	12.6	4.1	166	63
1	CRFH	ROCK IS	916		6	.0	11	
4	LKTR	MICHIGN CITY	1015	100	14.9	2.0	89	19
5	LKTR	MICHIGN CITY	900	100	21.2	6.8	121	98
10	LKTR	SAUGATUCK	821	100	11.9	3.8	70	20
7	LKTR	SAUGATUCK	710	100	15.5	2.9	71	23
9	LKTR	SAUGATUCK	1001	100	18.7	4.7	113	43
1	LKTR	MILWAUKEE	919	100	21.2	.0	90	
7	LKTR	MILWAUKEE	919	100	21.1	6.0	114	33
12	LKTR	MILWAUKEE	1015	100	10.9	3.6	127	74
1	LKTR	SHEBOYGAN	701	100	14.9	.0	58	
36	LKTR	SHEBOYGAN	713	100	12.5	3.7	82	27

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

PCB(µg/gm as Aroclor 1254)

Number	Species	Location	Date (1971)	% Over 5 µg/gm	Wet Weight	S.D.	Lipid Basis	S.D.
10	LKTR	LUDDINGTON	701	100	6.1	1.8	51	14
8	LKTR	LUDDINGTON	709	100	6.5	1.7	58	11
8	LKTR	G. TRAVERSE B.	1019	75	11.3	5.3	56	22
19	LKTR	GREEN ISLAND	721	100	9.0	1.7	98	12
10	LKTR	GILLS ROCK	916	100	14.7	6.4	63	30
1	LGUY	GREEN ISLAND	721		2.5	.0	90	
14	PRCH	MICHIGN CITY	1015	14	4.2	.7	72	21
9	PRCH	WAUKEGAN	828	88	6.1	1.5	70	27
10	PRCH	MILWAUKEE	1013	90	10.9	3.1	203	76
3	PRCH	LUDDINGTON	706	100	6.2	1.3	139	57
2	PRCH	FRANKFORT	1012	50	5.4	1.8	69	
10	PRCH	PENSAUKEE BR	825	10	2.7	2.1	49	28
1	RBTR	MICHIGN CITY	1015	100	12.0	.0	66	
9	RBTR	GILLS ROCK	916	77	8.8	4.3	47	22
7	ROSU	ROCK IS	911		2.8	.9	33	11
9	ROSU	ST MARTINS I	911		3.2	.5	37	8
12	SCUL	SAUGATUCK	1016		2.7	1.1	46	25
15	SMLT	MICHIGN CITY	1015		3.2	.9	45	15
13	SMLT	SHEBOYGAN	1015		2.7	.2	18	14
5	SMLT	GREEN ISLAND	721		2.6	1.1	57	27

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Table 8. PCB Concentrations
1971 Lake Michigan Fish

Number	Species	Location	Date (1971)	% Over 5 ppm	PCB (ppm as Aroclor 1254) Wet Weight	S.D.	Lipid Basis	S.D.
8	SMLT	ROCK IS	9-11	25	2.9	1.7	49	28
4	SMLT	ST MARTINS I	7-19		1.3	.3	31	8
6	WHSU	MICHIGAN CITY	10-15	100	10.6	4.0	100	44
3	WHSU	SAUGATUCK	10-15	66	6.0	2.9	149	49
5	WHSU	SAUGATUCK	10-16		2.3	.4	40	11
7	WHSU	PENSAUKEE BR	8-06	14	3.2	3.1	97	35
14	WHSU	G TRAVERSE B	10-19		2.3	.7	68	26
1	WHSU	GREEN ISLAND	7-21		2.1	.0	20	
10	WHSU	ROCK IS	9-11		2.5	.9	96	25
4	WHFH	MICHIGAN CITY	10-15	100	6.1	.9	25	1
7	WHFH	SAUGATUCK	6-19		2.7	.5	16	3
2	WHFH	SAUGATUCK	6-21		3.1	1.3	19	6
7	WHFH	GRAND HAVEN	9-06	71	5.8	.9	25	5
13	WHFH	G TRAVERSE B	10-19		1.8	.3	13	4
10	WHFH	ROCK IS	9-11		1.5	.2	9	1

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near Michigan City, the mean concentration of PCBs ranged from 11 μg/gm in those near Ludington to 14 μg/gm in those near Michigan City.

The PCBs in lake trout were most concentrated in the trout from Michigan City, Saugatuck and Milwaukee where mean concentrations were generally between 15 and 22 μg/gm. The trout from the northern areas such as Sheboygan, Ludington, Grand Traverse Bay and Gill's Rock were considerably lower, and the mean concentrations ranged between 8 and 15 μg/gm.

The concentration of PCBs were unexpectedly high in the perch caught near Milwaukee in that the mean of the 10 fish was 11 μg/gm. In contrast, perch from other regions appear to be less by a factor of two, and those from lower Green Bay contained only 2.7 μg/gm.

Rainbow trout were only caught near Michigan City and Gill's Rock. The Michigan City trout had 12 μg/gm PCBs while those from Gill's Rock averaged only 8.8 μg/gm PCBs.

The concentration of PCBs in suckers and smelt were generally between 2 and 4 μg/gm, although the average concentration in the three white suckers from Saugatuck was 6.0 μg/gm. With the exception of whitefish caught at Grand Haven and Michigan City, the PCB concentration in whitefish was less than 3 μg/gm.

B. DDT and Analogs

The concentrations of pp'DDT, op'DDT, pp'TDE and pp'DDE are summarized in Table 9 along with the total DDT and percentage of fish which contained over the 5 μg/gm action level established by the FDA. The total DDT in alewives ranged from 1.6 μg/gm near Waukegan to 5.0 near the Manitou Islands. There was no trend in the variations with region. A brown trout from Michigan City contained 6.4 μg/gm total DDT whereas those from Sheboygan and Gill's Rock averaged 4.4 μg/gm. With the exception of the carp from Michigan City which averaged 4.6 μg/gm total DDT, the average concentrations in Lake Michigan carp were 1.0 μg/gm or less.

The total DDT in chubs ranged from 3.8 μg/gm at Frankfort to 6.2 μg/gm at Sheboygan. There are no trends for DDT in chubs observed in

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (ug/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 ug/gm
10	ALWF	MICHIGN CITY	1015	1.4	.19	.5	.08	2.2	10
10	ALWF	BENTON HRBR	902	1.6	.23	.5	.08	2.7	
2	ALWF	SAUGATUCK	823	1.0	.16	.5	.07	1.6	
9	ALWF	SAUGATUCK	911	1.6	.22	.8	.10	2.7	11
1	ALWF	SHEBOYGAN	1015	2.2	.20	.7	.07	3.2	
9	ALWF	FRANKFORT	1005	1.3	.16	.4	.06	1.9	
1	ALWF	MANITOU IS	910	3.2	.31	1.3	.16	5.0	
4	ALWF	ROCK IS	911	1.1	.11	.7	.04	1.9	
5	ALWF	ST MARTINS I	911	1.0	.14	.3	.05	1.5	
1	BRTR	MICHIGN CITY	1015	3.7	.70	1.7	.22	6.4	100
4	BRTR	SHEBOYGAN	713	2.6	.46	1.2	.18	4.4	25
10	BRTR	GILLS ROCK	910	2.8	.48	1.0	.14	4.4	40
2	CARP	MICHIGN CITY	1129	3.3	.31	.3	.14	4.0	50
16	CARP	SAUGATUCK	1015	.6	.20	.1	.02	.9	0
8	CARP	SHEBOYGAN	723	.2	.07	.0	.01	.3	
4	CARP	PENSAUKEE BY	1101	.8	.19	.0	.01	1.0	
10	CHUB	BENTON HRBR	902	2.5	.31	1.5	.19	4.5	30
8	CHUB	SAUGATUCK	910	1.9	.47	1.6	.19	4.2	37
14	CHUB	SAUGATUCK	918	2.4	.63	2.4	.25	5.7	64
3	CHUB	SAUGATUCK	919	1.8	.47	2.1	.21	5.1	66

DSW 028546

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (µg/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 µg/gm
9	CHUB	MILWAUKEE	919	3.4	.30	2.0	.20	6.0	60
2	CHUB	SHEBOYGAN	723	1.3	.40	2.2	.24	4.1	50
11	CHUB	SHEBOYGAN	722	3.4	.34	2.0	.24	5.9	01
5	CHUB	SHEBOYGAN	819	2.6	.35	1.3	.16	4.4	20
5	CHUB	SHEBOYGAN	827	3.2	.47	2.3	.28	6.2	80
7	CHUB	SHEBOYGAN	1015	2.4	.28	1.7	.17	4.5	42
20	CHUB	LUDDINGTON	703	2.0	.58	2.2	.28	5.0	40
6	CHUB	FRANKFORT	1005	2.2	.33	1.2	.10	3.8	
2	CHUB	MANITOU IS	910	3.1	.50	1.30	.20	5.0	50
9	CHUB	WASHINGTON I	902	3.2	.34	1.9	.18	5.6	60
5	CHUB	ROCK IS	911	2.8	.20	1.1	.08	4.4	20
16	CHUB	ROCK IS	914	2.7	.42	2.0	.22	5.4	50
5	CHUB	ROCK IS	910	2.6	.20	1.3	.14	4.5	40
10	CHUB	ST MARTINS I	712	2.2	.24	1.1	.17	3.8	
5	CHUB	MANISTIQUE	527	2.9	.42	1.8	.14	5.2	80
1	CISC	ROCK IS	911	.8	.32	.5	.10	1.7	
1	CKSH	MILWAUKEE	1015	6.0	1.67	4.7	.92	13.0	100
7	CKSH	MANITOWOC	1021	6.3	.52	1.2	.21	8.3	100
9	CKSH	STRAWBERRY CR	1021	4.0	.29	1.0	.17	5.4	80
1	CKSH	GILLS ROCK	910	5.0	.44	1.2	.20	7.3	100

DSW 028547

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Table 9 . Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (µg/gm) pp DDS	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 µg/gm
5	COHO	MICHIGN CITY	917	.8	.17	.5	.00	1.6	
7	COHO	MICHIGN CITY	927	5.3	.40	1.2	.20	7.2	85
5	COHO	MICHIGN CITY	1007	4.5	.41	1.4	.18	6.5	60
9	COHO	SHEBOYGAN	1021	5.0	.57	1.4	.27	8.0	100
3	COHO	LUDDINGTON	828	6.8	.39	.9	.19	8.3	100
9	COHO	PLATTE RIVER	1007	5.5	.40	1.4	.24	7.6	100
8	COHO	GILLS ROCK	916	4.9	.45	1.2	.20	6.7	87
3	LKTR	MICHIGN CITY	1015	2.9	.68	3.1	.35	7.2	100
2	LKTR	MICHIGN CITY	908	9.5	1.12	3.8	.45	14.9	100
9	LKTR	SAUGATUCK	821	4.7	.05	2.1	.27	7.0	88
6	LKTR	SAUGATUCK	710	6.9	.70	2.0	.24	9.8	100
8	LKTR	SAUGATUCK	1001	6.7	.84	2.8	.27	10.6	100
2	LKTR	MILWAUKEE	914	10.1	.36	3.0	.47	14.5	100
5	LKTR	MILWAUKEE	915	10.0	1.05	3.3	.45	15.4	100
10	LKTR	MILWAUKEE	1015	2.2	.44	1.3	.15	4.1	80
20	LKTR	SHEBOYGAN	717	4.7	.51	1.7	.24	6.8	84
10	LKTR	LUDDINGTON	701	3.3	.52	1.0	.22	5.0	80
6	LKTR	LUDDINGTON	704	3.2	.03	2.0	.30	6.1	66
9	LKTR	G TRAVERSE B	1019	6.0	.73	2.0	.30	9.0	77
11	LKTR	GREEN ISLAND	721	3.0	.50	1.5	.21	6.0	72

DSW 028548

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (µg/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 µg/gm
8	LKTR	GILLS ROCK	916	5.7	.62	1.9	.24	8.3	62
1	LOUY	GREEN ISLAND	721	.5	.14	.3	.03	.9	
10	PRCH	MICHIGN CITY	1015	.8	.15	.5	.04	1.3	
9	PRCH	MILWAUKEE	1013	1.1	.30	.7	.08	2.1	
2	PRCH	LUDDINGTON	706	2.2	.30	.8	.13	3.6	
2	PRCH	FRANKFORT	1013	1.7	.43	2.2	.14	4.5	
3	PRCH	PENSAUKEE PR	825	.4	.10	.0	.01	.5	
8	RBIR	GILLS ROCK	916	3.1	.34	.2	.16	4.5	40
6	RDSU	ROCK IS	911	1.7	.30	.6	.09	2.7	
8	RDSU	ST MARTINS I	911	1.5	.35	.8	.09	2.7	
2	COHO	GILLS ROCK	916	6.0	.52	1.5	.24	8.7	100
9	SCUL	SAUGATUCK	1016	1.4	.15	1.2	.06	2.8	11
11	SMLT	MICHIGN CITY	1015	.9	.11	.4	.05	1.5	
3	SMLT	SHEBOYGAN	1015	.6	.12	.3	.03	1.0	
4	SMLT	GREEN ISLAND	721	.7	.12	.2	.02	1.0	
9	SMLT	ROCK IS	911	1.0	.14	.5	.05	1.0	
3	SMLT	ST MARTINS I	719	.7	.09	.2	.04	1.0	
2	WHFH	MICHIGN CITY	1015	.9	.32	.5	.06	1.4	
3	WHFH	SAUGATUCK	819	.6	.21	.5	.06	1.3	
6	WHFH	GRAND HAVEN	906	.7	.38	.8	.10	1.9	

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Table 9. Concentration of DDT and Metabolites in 1971 Lake Michigan Fish (Wet-Weight Basis)

Number	Species	Location	Date	Concentration (ug/gm) pp DDE	pp TDE	pp DDT	op DDT	Total DDT	% Over 5 ug/gm
12	WHFH	G TRAVERSE B	1019	1.2	.25	.4	.03	2.0	
6	WHFH	ROCK IS	911	.7	.16	.4	.01	1.4	
3	WHSU	MICHIGN CITY	1015	1.8	.02	1.8	.06	4.6	66
7	WHSU	SAUGATUCK	1015	.7	.14	.2	.03	1.0	
7	WHSU	PERSAUKEE BR	806	.3	.15	.2	.04	.7	
14	WHSU	G TRAVERSE B	1019	1.4	.31	.4	.03	2.1	
1	WHSU	GREEN ISLAND	721	.7	.19	.4	.03	1.3	
12	WHSU	ROCK IS	911	.8	.20	.3	.04	1.4	

DSW 028550

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Table 9 . Similarly, the total DDT in coho was somewhat constant throughout the lake, and the mean concentration ranged between 6.5 µg/gm to 8.8 µg/gm for the coho caught in the fall of 1971. The five coho caught near Michigan City in the spring averaged only 1.6 µg/gm total DDT.

As was previously discussed, the concentration of chlorinated materials is dependent on the size of the fish. Thus, lake trout from Michigan City averaged 14.9 µg/gm total DDT on 9/8/71 while those caught on 10/15/71 averaged only 7.3 µg/gm. The difference is likely due to the size differences. The lake trout from Milwaukee also contained approximately 15 µg/gm in October, but the smaller trout caught near Milwaukee averaged only 4.2 µg/gm total DDT. The DDT in the northern areas of the lake were less than 8 µg/gm, and approximately 60 to 70 percent of the lake trout contained over 5 µg/gm total DDT.

The perch from lower Green Bay had the lowest DDT content (0.5 µg/gm) while perch from other areas contained between 1.3 and 4.5 µg/gm total DDT. None of the perch contained greater than 5 µg/gm total DDT.

The concentration of DDT in smelt, whitefish and suckers averaged approximately 1 to 2 µg/gm, although the white suckers from Michigan City averaged 4.6 µg/gm total DDT.

C. Phthalate Esters

A group of Lake Michigan fish were selected for analysis of n,n dibutyl phthalate (DBP) and 2-ethylhexyl phthalate (DEHP) by Analytical Bio-Chemist Laboratories, Inc. of Columbia, Missouri. Although the presence of DBP was indicated in most of the fish, DEHP was indicated in only five percent of the samples analyzed. The data presented in this section must be regarded as preliminary--subject to confirmatory mass spectral data and further evaluation of the procedures used for the phthalate ester analysis in fish.

Table 10 presents the data concerning the concentration of DBP in the selected fish. The mean DBP concentration in chubs ranged from 0.8 µg/gm near Saugatuck to 3.7 µg/gm at Benton Harbor. Although sufficient data were not obtained to determine trends of DBP in the lake, the concentrations in the fish from the northern regions were all

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Table 10. Concentration of n,n Dibutyl phthalate in Selected Lake Michigan Fish (GLC Data Only)

Species	Region	No. of Fish in Sample	Concentration[a] (µg/gm)
Chubs	Sheboygan	3	1.5
Chubs	Rock Is.	2	1.1
Chubs	Milwaukee	4	1.1
Chubs	Benton Harbor	2	3.7
Chubs	Saugatuck	3	0.8
Chubs	Manitou Is.	1	1.5
Lake Trout	Green Bay	1	1.4
Lake Trout	Sheboygan	1	1.4
Lake Trout	Milwaukee	2	1.8
Lake Trout	Saugatuck	2	2.3
Lake Trout	Ludington	2	0.8
Lake Trout	West Arm Grand Traverse Bay	1	1.1
Perch	Green Bay	2	1.9

[a] means for more than one sample

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less than 1.5 µg/gm whereas the two chubs from Benton Harbor in southern Lake Michigan contained 2.1 and 3.7 µg/gm DBP.

The levels of DBP in lake trout and perch were similar in magnitude in that the range observed was from 0.8 µg/gm in the trout from Ludington to 2.3 µg/gm near Saugatuck. The perch from lower Green Bay were found to contain 1.8 and 2.0 µg/gm DBP.

The concentration of DEHP in five fish from Lake Michigan are presented in Table 11. The levels ranged from 1.0 µg/gm in a lake trout from Ludington to 65 µg/gm in the whitefish captured in the west arm of Grand Traverse Bay. In the limited data available, it is noted that the fish from Milwaukee and Sheboygan contained 22 and 14 µg/gm, respectively, which is considerably more than the 1.0 and 2.0 µg/gm in the fish from Ludington and Saugatuck, respectively.

D. Summary

There are insufficient data on PCBs in Great Lakes fish to adequately relate the results of this work on Lake Michigan fish with those from other Great Lakes. The concentration of PCBs ranged from less than 2 µg/gm in the small fish of low lipid content to over 20 µg/gm in the larger fish. Based on unpublished data provided by the Ontario Pesticide Residue Laboratory, the concentration of PCBs in Lake Michigan coho salmon appears to be two to three times greater than coho from Lake Huron, approximately 1.5 times greater than those in Lake Ontario and approximately ten times greater than those from Lake Erie and Lake Superior. Approximately 50 to 80 percent of the chubs from Lake Michigan contain greater than 5 µg/gm PCBs and essentially 100 percent of large salmon and trout contain greater than 5 µg/gm PCBs.

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Table 11. Concentration of 2-Ethylhexylphthalate in Selected Fish from Lake Michigan (GLC Data Only).

Species	Region	Concentration (µg/gm)
Chub	Sheboygan	14
Chub	Milwaukee	22
Chub	Saugatuck	2.0
Lake Trout	Ludington	1.0
Whitefish	West Arm Grand Traverse Bay	65

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SECTION VII

REFERENCES

Anderson, D.W. 1970. Chlorinated Hydrocarbons: Their Dynamics and Eggshell Effects on Herring Gulls and Other Species. Ph.D. Thesis (Wildlife Ecology and Zoology) University of Wisconsin, Madison, 166 p.

Armour, J.A. and Burke, J.A. 1970. Method for Separating PCBs from DDT and its Analogs. J. Assoc. Official Analyt. Chem., 53, 761-768.

Aulerich, R.J. and Ringer, R.K. 1970. Some Effects of Chlorinated Hydrocarbon Pesticides on Mink. Am. Fur Breeder, June, 10-11.

Aulerich, R.J., Ringer, R.K., Schaible, P.J. and Seagran, H.L. 1970. An Evaluation of Processed Great Lakes Fishery Products for Feeding Mink, Foodstuffs, 42, 48-49.

Aulerich, R.J., Ringer, R.K., Seagran, H.L. and Yeatt, W.G. 1971. Effects of Feeding Coho Salmon and Other Great Lakes Fish on Mink Reproduction. Can. J. of Zoology, 49, 611-16.

Berg, O.W., Dimsdy, P.L. and Rees, G.A.V. 1972. Column Chromatographic Separation of PCBs from Chlorinated Hydrocarbon Pesticides, and Subsequent Gas Chromatographic Quantitation in Terms of Derivatives, Bull. Environ. Contam. Toxicol. 7, 338-347.

Burdick, G.E., Harris, E.J., Dean, H.J., Walker, T.M., Skea, J. and Colby, D. 1964. The Accumulation of DDT in Lake Trout and the Effect on Reproduction. Trans. Amer. Fish Soc. 93, 127-136.

GLFL. 1972. Annual Progress Report--1971. Great Lakes Fishery Laboratory, Ann Arbor, Michigan, March.

Hartsough, G.R. 1965. Great Lakes Fish Now Suspect as Mink Food. American Fur Breeder, 38, 25 and 27.

Johansson, N.S., Jonsson, S. and Olsson, M. 1970. PCB Indications of Effects on Salmon. PCB Conference, Swedish Salmon Institute, Stockholm, September, Mimeo., 59-68.

Keith, J.O., Woods, L.A. and Hunt, E.G. 1970. Reproductive Failure in Brown Pelicans on the Pacific Coast. Trans. North Amer. Wildl. and Nat. Resources Conf. 35, in press.

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REFERENCES (Continued)

Kernon, L. 1970. Rainbow and Brown Trout--Lake Michigan 1970. Report of the Department of Natural Resources, Green Bay, Wisconsin, mimeo, 6 p.

Luecchow, L.A. 1972. Lake Michigan Pesticide Conference Pesticide Report, Final Report to EPA, by Wisconsin Department of Natural Resources, Madison, Wisconsin, 139 p.

Macek, K.J. 1968. Reproduction in Brook Trout, Salvelinus fontinalis, Fed Sublethal Concentrations of DDT. J. Fish Res. Board Can. 25, 1787-96.

NIH, 1972. Environ. Health Perspectives, 1, entire volumn.

Quinby, G.E. 1972. Polychlorobiphenyls (PCBs) and Related Chlorophenyls; Effects on Health and Environment, 1. Bibliography 1881-1971. Oak Ridge National Laboratory, TIMC-1, ORNL-EIS-72-20.

Ratcliffe, D.A. 1970. Changes Attributable to Pesticides in Egg Breakage Frequency and Eggshell Thickness in Some British Birds. J. Appl. Ecol. 7, 67-113.

Reinert, R.E. 1970. Pesticide Concentrations in Great Lakes Fish. Pesticide Monitoring J. 3, 233-40.

Reinert, R.E. 1971. Contribution in the 1970 Annual Progress Report of the Great Lakes Fishery Laboratory, Ann Arbor, Michigan, 73-80.

Reinert, R.E. 1972. Contribution in the 1971 Annual Progress Report of the Great Lakes Fishery Laboratory, Ann Arbor, Michigan, March, 132-35.

Reynolds, L.M. 1969. Polychlorobiphenyls (PCBs) and Their Interference with Pesticide Residue Analysis. Bull. Environ. Contam. Toxicol. 4, 128-43.

Ringer, R.K., Aulerich, R.J., Zabik, M. 1972. Effect of Dietary Polychlorinated Biphenyls on Growth and Reproduction of Mink, Presented at ACS, New York, New York, August, Division of Air, Water and Waste, 149-154.

Stalling, D.L. 1971. Analysis of Organochlorine Residues in Fish: Current Research at the Fish - Pesticide Research Laboratory, Route 1, Columbia, Missouri, 65201, mimeo., 30 p.

Task Force, 1972. Polychlorinated Biphenyls and the Environment. Interdepartmental Task Force on PCBs, National Technical Information Service, Springfield, Virginia, COM-72-10419.

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REFERENCES (Continued)

Veith, G.D. 1970. Environmental Chemistry of the Chlorobiphenyls in the Milwaukee River, Ph.D. Thesis (Water Chemistry), University of Wisconsin, Madison, 180 p.

Veith, G.D. and Lee, G.F. 1971. PCBs in Fish from the Milwaukee River. Proc. 14th Conf. Great Lakes Res., 157-69.

Zitko, V. and Choi, P.M.K. 1971. PCB and Other Industrial Halogenated Hydrocarbons in the Environment, Fisheries Research Board of Canada Technical Report No. 272.

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SECTION VIII

ACKNOWLEDGMENTS

The collection of fish from Lake Michigan for this study was completed through the cooperative efforts of the U.S. BSFW Great Lakes Fishery Laboratory; state agencies from Michigan, Indiana, Illinois and Wisconsin; and numerous private research and commercial fishing organizations. Their assistance, essential to this study, is sincerely appreciated.

Drs. John Carr, La Rue Wells and Robert Reinert of the Great Lakes Fisheries Laboratory provided all of the fish from the sampling areas near Frankfurt, Manistee, Ludington, Saugatuck and Benton Harbor, Michigan. A special thanks goes to La Rue Wells who not only coordinated the sampling of the GLFL with this study, but also expended considerable effort in transporting and freezing several hundred pounds of fish when scheduling conflicts prevented me from meeting the research vessel.

Samples collected from the Grand Traverse Bay and Beaver Island areas were obtained with the assistance of Merrill Keller and Lee Moffit of the Michigan Department of Natural Resources, Great Lakes Fishery Station at Charlevoix, Michigan.

Robert A. Koch of the Michigan City office of the Indiana Department of Natural Resources collected some of the lake trout from the Michigan City area. The remaining samples from Michigan City were captured with the assistance of William Ritter of Ritter Brother's Fish Company in Michigan City.

Although no samples were obtained from the Chicago area of Lake Michigan, the assistance of Robert Schacht of the Illinois Environmental Protection Agency and A. C. Lopinot and Paul Vidal of the Illinois Department of Conservation is appreciated.

Samples collected from Waukegan, Illinois, were provided by a fish population study of Industrial Bio-Test Laboratories, Incorporated of Northbrook, Illinois. Permission for the sampling was granted by Steven

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Hastings of Commonwealth Edison Company of Chicago with the cooperation of William Johnson of Industrial Bio-Test Laboratories. Bruce Muench and Jay Smith captured the fish for this study.

The Milwaukee area was sampled by the Wisconsin Department of Natural Resources and by Leland La Fond of Milwaukee. Ronald Poff of the Department of Natural Resources transported the fresh fish to the Water Chemistry Laboratory in Madison, Wisconsin. In addition, James Moore and Russell Daley of the Department of Natural Resources collected the trout from the Sheboygan and Green Island areas. Herman Schwarz of Schwarz Fish Company in Sheboygan provided fish from Sheboygan and assisted in coordinating the collection of fish from area fishermen. Donald Euers, Lake Michigan Enforcement Coordinator for the State of Wisconsin, collected and transported trout from pond nets which are operated by Marvin Weberg near Gills Rock to a Green Bay freezer plant for pickup. Steve Ellefson of Washington Island assisted immeasurably in the collection of samples for the Washington Island area as well as northern Lake Michigan. All of the fish collected from lower Green Bay were captured by Norbert, Francis and Arthur Swaer of Pensaukee, Wisconsin.

A special thanks goes to the technical assistants who conducted the analyses on this project. Joan Karnauskas, Judy Capelli, William Rasmis, Gaylord Plummer, Ronald Kamalesak and Richard Pyter assisted in coding the samples and conducted the tissue preparation, extraction and cleanup of the fish. Robert Philbin assisted in much of the analytical work and wrote the necessary computer programs for the compilation and analysis of data. Donald Mazzi conducted the majority of GLC analyses. Kathryn Berkert and Wally Gunthier prepared solvents, sorbents and glassware for this study and assisted in preparing the samples for GLC analysis.

A special thanks is extended to Dr. Gary Glass of the EPA National Water Quality Laboratory in Duluth, Minnesota, who as Project Officer for this study, provided continual guidance to the study and assisted immensely in establishing priorities in sample collection and analysis.

In addition, the National Water Quality Laboratory provided the mass spectrometry facilities for the qualitative analyses, and the assistance of Dr. Douglas Kuehl in obtaining the data is appreciated.

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This study was supported by the Environmental Protection Agency Project 16020 FBE, the University of Wisconsin Engineering Experiment Station and the University of Wisconsin Department of Civil and Environmental Engineering.

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SECTION IX
APPENDICES

A. Summary of Data on Fish Analyzed for PCBs and DDT

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Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
[illegible]														

*Number of fish, if composite sample

DSW 028562

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Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
1076	ALWF	1015	4143 8655	12	2	05.8	00.024	7.0	4.4	.5	.06	.5	.23	1.7
1068	ALWF	1015	4143 8655	12	2	05.[illegible]	00.022	5.1	5.6	.5	.10	1.4	.21	2.2
1063	ALWF	1015	4143 8655	12	2	06.0	00.030	1.1	4.0	.3	.06	1.7	.10	2.1
1077	ALWF	1015	4143 8655	12	2	06.0	00.025	3.1	5.1	.4	.08	2.0	.17	2.6
1066	ALWF	1015	4143 8655	12	2	06.5	00.034	4.2	3.5	.7	.07	1.4	.25	2.4
1074	ALWF	1015	4143 8655	12	2	06.0	00.027	7.2	1.3	.2	.03	.3	.10	.7
1061	ALWF	1015	4143 8655	12	2	07.0	00.024	1.4	7.0	1.5	.22	3.1	.41	5.2
1064	ALWF	1015	4143 8655	12	2	05.5	00.027	6.6	4.7	.3	.06	1.7	.12	2.1
1070	ALWF	1015	4143 8655	12	2	05.5	00.026	7.0	1.8	.2	.03	.6	.15	1.0
0405	ALWF	0802	4210 8640	25	2	06.7	00.041	9.0	3.3	.2	.08	1.3	.50	2.0
0404	ALWF	0802	4210 8640	25	2	07.4	00.051	12.0	5.7	.5	.13	2.4	.29	3.7
0402	ALWF	0802	4210 8640	25	2	07.0	00.042	10.3	6.6	.7	.09	1.8	.22	2.8
0401	ALWF	0802	4210 8640	25	2	07.5	00.052	9.3	4.5	1.0	.09	2.2	.27	3.6
0405	ALWF	0802	4210 8640	25	2	06.5	00.033	4.4	6.2	.2	.13	3.0	.32	3.9
0403	ALWF	0802	4210 8640	25	2	07.0	00.045	6.2	4.1	.5	.06	1.7	.21	2.1
0399	ALWF	0802	4210 8640	25	2	06.0	00.037	5.4	3.5	.5	.06	2.1	.12	2.7
0407	ALWF	0802	4210 8640	25	2	07.0	00.045	9.0	4.2	.6	.06	1.4	.20	2.2
0398	ALWF	0802	4210 8640	25	2	07.4	00.054	12.8	4.4	.5	.05	1.4	.12	2.1
0400	ALWF	0802	4210 8640	25	2	07.0	00.041	10.0	5.3	.3	.05	1.1	.16	1.6
0495	ALWF	0802	4325 8740	10	2	06.5	00.033	6.0	2.5	.4	.06	1.1	.15	1.7

*Number of Fish, if composite sample

DSW 028563

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Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													
[illegible]	[illegible]													

*Number of fish, if composite sample

DSW 028564

STLCOPCB4012526

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDS	pp' TDE	Total DDT
									(ug/gm)					
0948	BRTR	0916	4517 8700		1	26.0	05.675	17.5	9.0	1.3	.18	4.2	.66	6.3
0946	BRTR	0916	4517 8700		1	21.5	02.724	16.6	6.1	1.0	.11	.2	.39	1.7
0953	BRTR	0916	4517 8700		1	21.0	02.351	11.9	8.6	1.1	.14	3.3	.47	5.4
0943	BRTR	0916	4517 8700		1	25.0	04.707	11.9	6.7	.6	.13	2.7	.49	3.9
0949	BRTR	0916	4517 8700		1	22.0	03.832	11.9	11.7	1.3	.13	4.2	.68	6.4
0944	BRTR	0916	4517 8700		1	19.0	02.457	10.3	3.3	.0	.08	2.0	.28	3.0
1054	CARP	1129	4143 8695	12	1	23.0	07.700	15.0	11.1	.5	.13	4.0	1.18	5.8
1053	CARP	1129	4143 8695	12	1	22.0	05.415	12.7	10.5	.2	.10	2.7	.44	3.4
1272	CARP	1015	4240 8620	03	1	07.0	00.102	6.0	2.0	.0	.00	.3	.05	.3
1273	CARP	1015	4240 8620	03	2	06.0	00.050	4.2	2.4	.0	.00	.3	.06	.3
1271	CARP	1015	4240 8620	03	2	05.0	00.021	2.2	2.0	.0	.00	.1	.07	.2
1265	CARP	1015	4240 8620	03	1	06.0	00.059	2.2	1.8	.0	.00	.1	.05	.1
1268	CARP	1015	4240 8620	03	1	06.0	00.082	3.4	1.7	.0	.00	.3	.05	.3
1167	CARP	1015	4240 8620	03	1	20.0	02.125	20.4	17.7	.5	.12	3.9	.53	5.5
1277	CARP	1015	4240 8620	03	2	0.50	00.042	3.4	2.5	.0	.00	.1	.10	.2
1178	CARP	1015	4240 8620	03	1	23.0	04.430	22.4	12.5	.1	.00	1.8	.66	2.6
1137	CARP	1015	4240 8620	05	1	22.0	03.030	21.5	6.3	.3	.05	.5	.33	1.3
1184	CARP	1015	4240 8620	10	1	17.0	01.050	17.7	9.2	.0	.00	.4	.27	.7
1276	CARP	1015	4240 8620	03	2	05.5	00.049	1.9	2.1	.0	.00	.1	.06	.2
0291	CARP	0723	4345 8730	02	1	20.0		3.0	1.5	.0	.00	.1	.04	.1

*Number of fish, if composite sample

DSW 028565

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Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
0285	CARP	0723	4345 8730	02	1	21.0	.	11.2	2.1	.1	.01	.2	.11	.4
0292	CARP	0723	4345 8730	02	1	19.2	.	4.3	1.3	.0	.00	.1	.05	.1
0289	CARP	0723	4345 8730	02	1	16.5	.	5.5	1.6	.0	.01	.1	.07	.2
0284	CARP	0723	4345 8730	02	1	20.5	.	5.5	3.4	.1	.02	.2	.10	.4
0287	CARP	0723	4345 8730	02	1	21.0	.	6.5	2.8	.0	.01	.3	.12	.5
0283	CARP	0723	4345 8730	02	1	19.0	.	4.6	1.1	.0	.00	.1	.01	.1
0254	CARP	0723	4345 8730	02	1	18.0	.	3.6	1.1	.0	.00	.1	.04	.2
1212	CARP	1101	4445 8750	05	1	19.0	01.970	13.3	6.5	.0	.00	.9	.18	1.1
1214	CARP	1101	4445 8750	05	1	21.0	02.360	16.4	4.9	.0	.00	.6	.21	.6
1213	CARP	1101	4445 8750	05	1	21.0	02.350	16.5	3.7	.1	.02	.5	.15	.7
1217	CARP	1101	4445 8750	05	1	20.0	01.720	13.9	5.4	.0	.00	1.0	.22	1.2
0454	CHUB	0902	4210 8640	25	1	07.0	00.098	19.0	5.9	2.6	.24	3.5	.32	6.3
0455	CHUB	0902	4210 8640	25	1	09.0	00.230	20.1	7.3	2.1	.22	3.6	.44	6.4
0447	CHUB	0902	4210 8640	25	1	09.5	00.115	19.3	5.2	1.5	.21	2.0	.37	4.1
0446	CHUB	0902	4210 8640	25	1	09.2	00.156	23.4	5.2	.7	.11	1.3	.19	2.3
0451	CHUB	0902	4210 8640	25	1	09.0	00.207	27.5	5.6	1.8	.23	3.0	.37	5.4
0457	CHUB	0902	4210 8640	25	1	08.5	00.120	15.5	4.0	.6	.06	1.0	.16	1.9
0456	CHUB	0902	4210 8640	25	1	09.3	00.233	19.6	4.3	1.3	.17	2.7	.26	4.4
0448	CHUB	0902	4210 8640	25	1	10.0	00.157	17.7	4.1	1.3	.18	2.5	.31	4.3
0449	CHUB	0902	4210 8640	25	1	11.3	00.327	24.7	5.1	1.7	.22	2.5	.37	4.7

*Number of fish, if composite sample

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Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(µg/gm)

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
[illegible]	CHUB	[illegible]						10.6	7.1	2.6	.31	2.4	.57	6.1
[illegible]	CHUB	[illegible]						26.7	[illegible]	1.5	.20	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]						17.7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]						12.6	7.0	2.1	.29	2.2	[illegible]	[illegible]
[illegible]	CHUB	[illegible]						10.3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CHUB	[illegible]						10.[illegible]	[illegible]	1.6	.21	1.0	[illegible]	[illegible]
[illegible]	CHUB	[illegible]						[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
0077	CHUB	1015	4345 0720		1	09.5	00.100	20.9	4.1	.9	.30	2.4	.24	3.6
0079	CHUB	0703	4355 8640	22	1	10.3	.	20.0	5.7	1.7	.24	1.4	.49	3.8
0126	CHUB	0703	4355 8640	19	1	10.7	.	16.0	6.4	3.5	.30	2.9	.52	7.6
0073	CHUB	0703	4355 8640	22	1	10.5	.	24.0	7.5	2.4	.28	.7	.52	3.9
0057	CHUB	0703	4355 8640	22	1	11.5	.	20.0	9.4	1.9	.26	1.9	.71	4.8
0126	CHUB	0703	4355 8640	19	1	10.6	.	13.1	9.1	2.3	.29	2.4	.80	5.7
0130	CHUB	0703	4355 8640	19	1	11.3	.	20.1	9.1	1.6	.24	3.1	.42	5.4
0087	CHUB	0703	4355 8640	22	1	10.3	.	21.2	6.2	2.1	.31	1.1	.66	4.1
0081	CHUB	0703	4355 8640	22	1	10.3	.	12.2	4.5	2.5	.26	1.0	.64	4.3
0086	CHUB	0703	4355 8640	22	1	10.5	.	19.3	5.6	3.2	.30	2.2	.54	5.2
0054	CHUB	0703	4355 8640	22	1	10.6	.	23.3	11.3	3.1	.22	3.3	.64	7.7
0095	CHUB	0703	4355 8640	22	1	09.5	.	14.3	11.6	5.7	.40	2.1	1.09	9.3
0088	CHUB	0703	4355 8640	22	1	10.3	.	25.4	6.5	2.0	.26	1.3	.49	4.1
0141	CHUB	0703	4355 8640	19	1	10.5	.	24.4	9.3	1.9	.23	3.5	.46	6.0
0145	CHUB	0703	4355 8640	19	1	08.5	.	21.4	6.9	1.6	.21	1.5	.46	3.9
0034	CHUB	0703	4355 8640	22	1	10.0	.	17.4	7.4	2.2	.33	1.6	.74	4.9
0056	CHUB	0703	4355 8640	22	1	10.5	.	16.4	8.5	2.7	.33	2.1	.56	6.2
0099	CHUB	0703	4355 8640	22	1	09.3	.	25.4	9.6	3.3	.22	3.2	.51	6.3
0050	CHUB	0703	4355 8640	22	1	09.6	.	16.4	4.5	3.3	.32	2.3	.71	5.5
0091	CHUB	0703	4355 8640	22	1	09.3	.	19.6	6.5	.5	.16	2.2	.21	3.1

*Number of fish, if composite sample

DSW 028568

STLCOPCB4012530

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ppm/ww)					
0175	CHUB	0722	4345 8730	35	1	12.0		26.5	5.1	3.4	.39	3.9	.47	7.7
0180	CHUB	0722	4345 8730	35	1	11.4		25.0	5.0	2.2	.24	2.7	.43	5.4
0107	CHUB	0722	4345 8730	35	1	11.0		24.8	5.0	1.9	.20	3.3	.41	5.3
0109	CHUB	0722	4345 8730	35	1	11.8		25.8	3.8	1.5	.16	2.8	.19	4.5
0108	CHUB	0722	4345 8730	35	1	11.3		27.3	5.8	1.6	.24	3.3	.26	5.4
0196	CHUB	0819	4345 8730	47	1	13.0	00.224	22.3	3.7	.76	.11	2.4	.20	4.1
0509	CHUB	0819	4345 8730	47	1	13.5	00.224	30.9	7.7	.63	.13	2.6	.25	4.0
0597	CHUB	0819	4345 8730	47	1	12.2	00.162	21.5	3.3	1.4	.10	2.3	.10	3.5
0600	CHUB	0819	4345 8730	47	1	13.3	00.232	24.2	4.1	1.2	.10	2.1	.59	3.1
0599	CHUB	0819	4345 8730	47	1	13.3	00.177	24.5	4.5	1.2	.11	2.1	.25	3.7
0607	CHUB	0827	4345 8730	47	1	13.0	00.133	18.4	5.0	3.3	.22	3.3	.15	5.8
0601	CHUB	0827	4345 8730	47	1	13.0	00.131	15.4	3.3	1.3	.11	2.2	.35	4.1
0608	CHUB	0827	4345 8730	47	1	14.0	00.170	21.8	7.7	2.7	.34	4.7	.59	8.5
0610	CHUB	0827	4345 8730	47	1	13.0	00.171	17.8	2.2	.57	.07	1.3	.17	1.5
0604	CHUB	0827	4345 8730	47	1	13.0	00.181	22.2	5.3	1.2	.08	3.4	.40	5.2
0820	CHUB	1015	4345 8730	47	1	12.0	00.122	16.0	2.3	.62	.07	1.4	.09	2.2
0839	CHUB	1015	4345 8730	47	1	13.0	00.177	22.4	4.1	1.0	.11	2.4	.21	3.7
0840	CHUB	1015	4345 8730	47	1	13.5	00.191	14.2	2.1	1.0	.10	2.3	.29	3.4
0842	CHUB	1015	4345 8730	47	1	13.0	00.159	14.8	2.3	.57	.07	3.3	.32	3.8
0825	CHUB	1015	4345 8730	47	1	13.0	00.177	15.5	3.1	1.1	.15	2.7	.20	3.5

*Number of fish, if composite sample

DSW 028569

STLCOPCB4012531

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	DPH	No.*	Length	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
[illegible]	CHUM	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Number of fish, if composite sample

DSW 028570

STLCOPCB4012532

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
[illegible]	CHUB	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0115	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0160	CHUB	0615	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0147	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0105	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0152	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0150	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0158	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0101	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0112	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0121	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0112	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0109	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0117	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0103	CHUB	0613	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0114	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0107	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0102	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0110	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0113	CHUB	0610	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Number of fish, if composite sample

STLCOPCB4012533

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
1161	CHUB	0911	9520 8695	19	1	16.0	00.700	5.0	3.1	.7	.07	1.9	.23	2.9
1164	CHUB	0911	9520 8695	19	1	25.5	01.760	5.2	15.1	2.9	.13	4.9	.75	8.2
1159	CHUB	0911	9520 8695	19	1	23.0	01.300	5.9	6.3	1.2	.09	3.1	.29	4.7
1163	CHUB	0911	9520 8695	19	1	23.0	01.970	6.6	7.9	.2	.03	2.4	.19	2.8
1165	CHUB	0911	9520 8695	19	1	21.0	01.570	9.7	5.6	.8	.08	2.4	.31	3.6
0550	CHUB	0914	9520 8635	43	1	09.5	00.199	26.1	5.8	2.1	.27	2.5	.40	5.4
0546	CHUB	0914	9520 8635	43	1	08.8	00.178	22.2	6.8	3.6	.35	3.3	.76	8.0
0545	CHUB	0914	9520 8635	43	1	08.3	00.123	26.7	9.3	1.5	.20	2.6	.32	4.6
0503	CHUB	0916	9520 8695	17	1	10.5	00.293	20.1	4.0	1.7	.19	2.0	.35	5.0
0511	CHUB	0916	9520 8695	17	1	10.5	00.266	29.3	3.9	.9	.13	1.9	.19	3.1
0508	CHUB	0916	9520 8695	17	1	09.5	00.182	16.8	3.3	1.0	.07	2.5	.27	3.9
0509	CHUB	0916	9520 8695	17	1	11.0	00.231	24.8	3.9	1.4	.13	4.0	.31	5.8
0812	CHUB	0719	9530 8525	30	1	11.5	00.223	21.4	4.0	1.3	.21	2.3	.44	4.2
0809	CHUB	0719	9530 8525	30	1	11.5	00.259	23.9	2.5	.8	.20	1.7	.45	3.2
0813	CHUB	0719	9530 8525	30	1	10.0	00.216	26.6	2.9	1.1	.12	2.3	.27	3.8
0814	CHUB	0719	9530 8525	30	1	10.5	00.293	21.6	3.1	.8	.14	1.5	.48	3.0
0810	CHUB	0719	9530 8525	30	1	10.0	00.250	24.6	4.3	1.1	.16	2.3	.27	3.8
0807	CHUB	0719	9530 8525	30	1	11.5	00.324	16.7	3.1	1.3	.17	2.1	.33	3.8
0806	CHUB	0719	9530 8525	30	1	12.0	00.336	21.9	3.9	1.2	.17	2.9	.29	4.6
0805	CHUB	0719	9530 8525	30	1	10.5	00.262	18.9	4.1	.6	.17	2.0	.41	3.2

*Number of fish, if composite sample

DSW 028572

STLCOPCB4012534

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	(ug/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0815	CHUB	0719	4530 8525	30	1	09.5	00.137	13.9	3.0	1.0	.11	2.1	.19	3.4
0622	CHUB	0527	4550 8615	40	1	10.6	00.165	13.0	5.0	1.8	.21	2.4	.56	5.0
0641	CHUB	0527	4550 8615	40	1	10.1	00.163	17.1	5.3	1.5	.00	3.6	.39	5.4
0630	CHUB	0527	4550 8615	40	1	09.0	00.176	15.3	4.6	1.7	.19	2.6	.92	5.1
0636	CHUB	0527	4550 8615	40	1	10.6	00.226	23.7	4.6	1.5	.10	2.7	.27	4.6
0089	CKSH	1015	4305 8745	10	1	22.5	01.936	20.4	24.0	4.7	.53	6.6	1.67	13.6
0099	CKSH	1021	4410 8740		1	24.0	03.178	5.0	16.4	2.0	.31	8.3	.65	11.3
0893	CKSH	1021	4410 8740		1	22.5	02.497	6.0	12.0	1.2	.19	4.8	.66	6.9
0905	CKSH	1021	4410 8740		1	24.0	02.497	7.2	14.0	1.2	.22	5.7	.53	7.7
0098	CKSH	1021	4410 8740		1	24.0	03.059	5.4	7.1	1.0	.16	4.9	.40	6.5
0097	CKSH	1021	4410 8740		1	22.0	04.313	3.9	10.9	1.0	.16	6.0	.40	7.6
0094	CKSH	1021	4410 8740		1	22.0	02.954	4.9	14.2	1.5	.29	9.5	.50	11.9
0895	CKSH	1021	4410 8740		1	23.0	02.724	5.9	7.8	.7	.12	5.1	.36	6.3
0919	CKSH	1021	4446 8720		1	25.0	03.178	3.5	12.3	1.2	.19	5.0	.46	6.8
0907	CKSH	1021	4446 8720		1	23.0	02.270	5.0	0.9	.9	.19	3.9	.31	5.3
0900	CKSH	1021	4446 8720		1	25.0	02.724	3.3	14.2	.3	.06	6.2	.19	6.7
0915	CKSH	1021	4446 8720		1	27.0	03.178	4.4	7.3	1.3	.23	4.1	.47	5.9
0913	CKSH	1021	4446 8720		1	25.0	03.178	2.4	6.7	1.3	.20	5.4	.62	7.5
0917	CKSH	1021	4446 8720		1	23.0	02.497	2.4	11.9	.9	.10	4.2	.35	5.5
0910	CKSH	1021	4446 8720		1	25.0	3.059	1.6	0.6	1.0	.20	3.0	.49	5.5

*Number of fish, if composite sample

DSW 028573

STLCOPCB4012535

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(µg/gm)

Sample Number	Species	1971 Date	Location	Dsh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0916	CKSH	1021	9496 8720	1	21.0	02.095		3.6	8.3	1.1	.25	4.9	.51	6.8
0918	CKSH	1021	9496 8720	1	21.0	02.095		1.0	7.6	.8	.11	2.0	.30	4.0
0966	CKSH	0916	9517 8700	1	20.0	04.760		5.2	12.9	1.2	.20	5.5	.49	7.3
0642	COHO	0917	9193 8655	03	1	18.5	00.850	7.2	2.6	.5	.06	.6	.16	1.4
0645	COHO	0917	9193 8655	03	1	20.5	00.990	8.2	2.6	.8	.08	.9	.20	1.6
0644	COHO	0917	9193 8655	03	1	20.0	00.980	7.2	3.2	.5	.07	.9	.17	1.6
0649	COHO	0917	9193 8655	03	1	19.1	01.183	7.6	2.7	.5	.09	.8	.17	1.5
0647	COHO	0917	9193 8655	03	1	19.2	01.200	3.8	3.0	.6	.10	.8	.17	1.7
0999	COHO	0927	9193 8655	1	21.0	01.350		7.2	32.2	1.3	.21	5.0	.57	7.1
1000	COHO	0927	9193 8655	1	24.0	02.750		5.9	19.9	1.2	.24	6.7	.92	8.6
1002	COHO	0927	9193 8655	1	24.5	03.070		7.9	18.9	1.0	.16	5.6	.40	7.3
1007	COHO	0927	9193 8655	1	24.0	03.520		6.9	15.6	1.4	.25	6.2	.50	8.3
1004	COHO	0927	9193 8655	1	23.0	02.315		7.5	16.3	1.6	.23	4.5	.69	7.1
1010	COHO	0927	9193 8655	1	24.0	02.025		1.6	.3	.05	.7	.15	1.3
1023	COHO	1007	9193 8655	1	19.0	01.655		4.1	19.0	2.0	.22	6.3	.51	9.0
1025	COHO	1007	9193 8655	1	20.0	01.660		3.2	14.5	.9	.13	4.5	.26	5.8
1020	COHO	1007	9193 8655	1	20.0	02.900		5.2	18.3	2.2	.29	6.5	.50	9.6
1021	COHO	1007	9193 8655	1	19.0	01.970		3.5	11.2	1.0	.15	3.3	.37	4.8
1024	COHO	1007	9193 8655	1	13.5	00.540		6.9	10.1	1.0	.09	1.9	.34	3.3
0926	COHO	1021	9496 8720	1	27.0	03.859		4.0	11.6	1.4	.28	3.8	.55	6.0

*Number of fish, if composite sample

DSW 028574

STLCOPCB4012536

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0926	COHO	1021	4345 8730		1	28.0	04.086	4.3	12.0	1.2	.17	5.9	.48	7.7
0923	COHO	1021	4345 8730		1	27.0	03.905	4.4	10.9	1.9	.33	5.7	.70	8.7
0929	COHO	1021	4345 8730		1	24.0	03.432	3.5	10.0	1.3	.35	7.0	.64	9.2
0924	COHO	1021	4345 8730		1	20.0	03.669	4.7	15.1	1.3	.27	8.3	.62	10.5
0930	COHO	1021	4345 8730		1	27.0	04.313	3.7	12.3	1.3	.22	6.8	.52	8.9
0931	COHO	1021	4345 8730		1	23.0	03.632	3.7	8.0	1.7	.31	6.6	.70	9.4
0933	COHO	1021	4345 8730		1	23.0	02.729	6.9	17.3	1.1	.24	7.5	.39	9.2
1318	COHO	0928	4355 8640		1	27.8	.	9.1	11.3	1.2	.20	5.8	.40	7.2
1316	COHO	0928	4355 8640		1	25.2	.	9.6	6.5	.6	.22	5.8	.47	7.0
1331	COHO	0929	4355 8640		1	26.8	.	9.6	12.8	.9	.16	9.3	.32	10.7
0775	COHO	1007	4443 8610		1	27.5	.	6.0	12.9	1.6	.24	4.9	.47	7.1
0781	COHO	1007	4443 8610		1	24.0	.	5.1	11.0	1.2	.19	5.1	.40	6.9
0773	COHO	1007	4443 8610		1	24.5	.	6.3	15.9	1.1	.21	6.4	.37	8.1
0783	COHO	1007	4443 8610		1	27.0	.	6.9	14.3	1.5	.23	6.0	.40	8.1
0784	COHO	1007	4443 8610		1	26.5	.	6.5	12.5	1.0	.18	5.6	.40	7.2
0779	COHO	1007	4443 8610		1	26.0	.	5.4	12.9	1.9	.29	5.7	.59	8.4
0782	COHO	1007	4443 8610		1	24.5	.	5.7	12.9	1.2	.17	5.4	.37	7.2
0771	COHO	1007	4443 8610		1	25.0	.	5.9	11.6	1.4	.34	5.9	.56	8.2
0774	COHO	1007	4443 8610		1	26.5	.	6.9	12.6	2.1	.34	6.1	.66	9.3
0950	COHO	0914	4517 8700		1	26.0	03.869	7.0	10.4	1.4	.22	6.0	.47	8.1

*Number of fish, if composite sample

DSW 028575

STLCOPCB4012537

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(ug/gm)

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0962	COHO	0916	9517 8700		1	27.0	04.767	7.0	11.9	1.6	.22	4.9	.54	7.2
1030	COHO	0916	9517 8700		1	26.0	03.610	7.0	10.9	1.7	.26	7.0	.58	9.6
0972	COHO	0916	9517 8700		1	28.0	04.994	7.1	16.4	1.2	.27	6.7	.41	8.6
0961	COHO	0916	9517 8700		1	16.0	01.135	8.2	3.2	.6	.08	1.4	.22	2.7
1029	COHO	0916	9517 8700		1	24.0	03.190	7.3	15.1	.8	.14	3.6	.38	5.0
1020	COHO	0916	9517 8700		1	25.0	03.150	7.5	15.2	.6	.20	5.3	.51	6.6
0969	COHO	0916	9517 8700		1	25.5	03.859	7.5	12.2	1.6	.25	6.8	.61	9.3
0959	COHO	0916	9517 8700		1	23.5	02.791	9.6	9.9	1.5	.20	4.3	.42	6.4
0955	COHO	0916	9517 8700		1	25.5	01.066	9.6	17.2	1.3	.24	5.5	.49	7.5
1013	LKTR	1015	9193 8655	12	1	20.5	01.415	14.3	15.9	2.5	.24	5.1	.59	8.4
1014	LKTR	1015	9193 8655	12	1	24.0	02.085	16.7	13.6	3.6	.50	10.1	1.27	15.5
1011	LKTR	1015	9193 8655	12	1	22.0	02.035	17.9	12.9	3.5	.34	3.9	.83	8.6
1018	LKTR	0908	9145 8650	10	1	24.5	02.445	15.0	21.9	3.7	.50	10.1	1.13	15.5
1019	LKTR	0908	9145 8650	10	1	22.0	01.865	20.4	24.3	3.9	.39	8.7	1.10	14.1
0235	LKTR	0621	9240 8620	10	1	22.2	. .	16.1	12.0	1.8	.20	4.9	.56	7.4
0252	LKTR	0621	9240 8620	10	1	21.0	. .	19.1	7.4	1.6	.29	2.5	.50	4.9
0250	LKTR	0621	9240 8620	10	1	23.8	. .	16.3	11.3	1.3	.18	3.7	.41	5.6
0249	LKTR	0621	9240 8620	10	1	22.3	. .	17.4	15.4	2.4	.34	4.8	.91	8.5
0236	LKTR	0621	9240 8620	10	1	23.2	. .	16.5	5.0	.9	.16	4.5	.30	5.9
0246	LKTR	0621	9240 8620	10	1	20.3	. .	16.5	10.7	2.8	.39	6.0	.80	10.0

*Number of fish, if composite sample

DSW 028576

STLCOPCB4012538

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dpth	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(w/rm)					
0245	LKTR	0621	4240 8620	13	1	20.6	.	17.6	8.2	2.5	.10	4.4	.50	9.7
0242	LKTR	0621	4240 8620	13	1	20.8	.	19.9	14.6	2.4	.30	5.0	.72	8.4
0248	LKTR	0621	4240 8620	10	1	24.5	.	15.9	13.9	2.6	.34	5.4	.95	9.3
1319	LKTR	0710	4240 8620	10	1	24.4	.	19.0	18.2	2.8	.35	8.8	.81	12.8
1317	LKTR	0710	4240 8620	10	1	25.8	.	15.0	18.3	.3	.23	9.5	.80	10.9
1327	LKTR	0710	4240 8620	10	1	21.4	.	21.4	12.3	2.1	.19	6.9	.59	9.8
1321	LKTR	0710	4240 8620	10	1	22.6	.	20.7	14.4	3.5	.29	4.9	.93	9.0
1315	LKTR	0710	4240 8620	10	1	23.6	.	22.8	13.0	2.5	.24	6.3	.69	9.7
1320	LKTR	1001	4240 8620	15	1	20.9	.	18.1	11.4	2.5	.20	2.8	.59	6.1
1326	LKTR	1001	4240 8620	15	1	22.5	.	16.1	12.3	1.9	.19	4.0	.53	6.8
1330	LKTR	1001	4240 8620	15	1	22.8	.	15.3	17.7	.3	.33	6.9	1.02	8.6
1324	LKTR	1001	4240 8620	15	1	24.8	.	24.3	19.1	4.0	.45	8.3	1.09	13.8
1333	LKTR	1001	4240 8620	15	1	23.0	.	13.6	21.1	1.9	.29	4.6	.62	7.4
1315	LKTR	1001	4240 8620	15	1	22.5	.	17.9	17.1	3.3	.26	4.6	.90	9.1
1332	LKTR	1001	4240 8620	15	1	23.0	.	18.9	20.4	4.3	.43	10.5	1.06	16.3
1310	LKTR	1001	4240 8620	15	1	22.6	.	12.9	25.6	3.7	.03	11.7	.90	16.3
1090	LKTR	0919	4305 8745	10	1	26.8	09.290	23.9	21.2	3.2	.46	9.2	1.00	13.8
1056	LKTR	0919	4305 8745	10	1	28.0	04.980	19.0	25.5	3.9	.59	15.0	1.22	20.7
1055	LKTR	0919	4305 8745	10	1	25.5	02.870	18.4	31.7	1.7	.53	13.4	1.12	16.7
1083	LKTR	0919	4305 8745		1	24.5	02.995	15.5	17.7	5.5	.49	7.5	1.15	14.6

*Number of fish, if composite sample

DSW 028577

STLCOPCB4012539

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drb	No*	Length	Wt	% Fat	PCB (µg/gm)	pp' DDT (µg/gm)	op' DDT (µg/gm)	pp' DDE (µg/gm)	pp' TDE (µg/gm)	Total DDT (µg/gm)
1004	LKTR	0719	4305	0745		1	24.5	02.945	19.7	17.8	2.3	.31	7.2	.06	10.7
1005	LKTR	0719	4305	0745		1	25.0	03.225	16.9	21.1	2.9	.41	10.1	.93	14.9
0887	LKTR	1015	4305	8745	10	1	19.0	01.076	12.1	11.3	1.1	.16	2.6	.09	4.3
0895	LKTR	1015	4305	8745	10	1	13.5	01.012	12.2	6.9	1.0	.14	2.7	.35	4.2
0891	LKTR	1015	4305	8745	10	1	13.5	00.269	5.2	0.3	.0	.08	1.0	.27	2.2
0888	LKTR	1015	4305	8745	10	1	19.9	01.112	14.9	.0.6	.9	.13	2.8	.32	4.1
0880	LKTR	1015	4305	8745	10	1	13.0	00.265	7.5	13.5	1.0	.10	1.5	.32	2.9
0884	LKTR	1015	4305	8745	10	1	19.5	01.365	16.6	15.9	1.5	.26	2.3	.70	4.7
0886	LKTR	1015	4305	8745	10	1	23.5	02.220	20.7	13.7	2.3	.24	3.9	.61	7.0
0892	LKTR	1015	4305	8745	10	1	13.0	00.292	5.8	17.8	.9	.06	1.6	.36	2.9
0896	LKTR	1015	4305	8745	10	1	13.0	00.329	5.9	6.1	.6	.07	1.2	.21	2.1
0673	LKTR	0713	4345	8730				00.245	9.0	12.1	.9	.12	3.9	.36	5.3
0313	LKTR	0713	4345	8730	15	1	24.4		19.0	15.7	3.1	.98	7.1	.83	11.5
0269	LKTR	0713	4345	8730	15	1	25.5		23.0	20.2	1.2	.29	8.2	.42	10.1
0270	LKTR	0713	4345	8730	15	1	17.5		17.0	9.8	1.6	.25	2.7	.48	5.1
0234	LKTR	0713	4345	8730	05	1	24.0		16.0	15.7	2.3	.37	7.8	.65	10.7
0253	LKTR	0713	4345	8730	05	1	19.5		16.0	9.4	1.2	.20	3.7	.39	5.4
0231	LKTR	0713	4345	8730	05	1	23.5		16.0	12.1	2.5	.32	5.3	.72	8.9
0263	LKTR	0713	4345	8730	15	1	21.5		18.1	12.9	2.6	.34	5.7	.80	7.9
0319	LKTR	0713	4345	8730	15	1	26.0		18.1	16.9	3.9	.33	7.0	.93	12.2

*Number of fish, if composite sample

DSW 028578

STLCOPCB4012540

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

(µg/gm)

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0671	LKTR	0713	4345 6730				00.177	8.1	12.8	.7	.12	2.7	.33	3.8
0674	LKTR	0713	4345 6730				00.169	8.2	7.1	.6	.07	1.8	.17	2.6
0273	LKTR	0713	4345 6730	15	1	15.5		10.2	7.9	1.4	.19	2.1	.37	4.1
0675	LKTR	0713	4345 6730				00.754	13.2	10.6	1.1	.09	3.9	.32	5.4
0672	LKTR	0713	4345 6730				00.174	8.3	12.0	.7	.09	3.2	.29	4.4
0271	LKTR	0713	4345 6730	15	1	20.0		16.3	12.6	1.1	.14	2.6	.30	4.1
0265	LKTR	0713	4345 6730	15	1	23.5		21.3	17.3	2.8	.47	3.9	1.01	8.2
0311	LKTR	0713	4345 6730	15	1	25.5		19.4	12.9	2.3	.26	5.6	.69	8.8
0262	LKTR	0713	4345 6730	15	1	19.0		15.8	9.8	1.1	.14	2.6	.31	4.2
0233	LKTR	0713	4345 6730	05	1	25.2		16.5	15.9	2.5	.40	6.6	.78	10.3
0670	LKTR	0713	4345 6730				00.223	8.6	6.1	.7	.09	2.0	.29	3.1
0230	LKTR	0713	4345 6730	05	1	22.8		17.6	12.9	2.7	.36	5.3	.68	8.1
0264	LKTR	0713	4345 6730	15	1	25.5		23.7	13.3	2.0	.33	4.6	.58	7.5
0316	LKTR	0713	4345 6730	15	1	20.0		15.7	8.7	1.6	.20	3.0	.52	5.3
0310	LKTR	0713	4345 6730	15	1	21.5		16.7	12.1	1.5	.25	5.3	.55	7.6
0315	LKTR	0713	4345 6730	15	1	26.0		21.0	12.0	2.7	.31	6.2	.73	9.9
0274	LKTR	0713	4345 6730	15	1	22.0		17.0	8.9	1.3	.27	2.9	.49	5.0
0676	LKTR	0713	4345 6730				00.210	14.0	12.0	1.1	.15	3.7	.32	5.2
0669	LKTR	0713	4345 6730				00.148	10.9	16.0	.4	.09	3.4	.12	4.1
0310	LKTR	0701	4355 6690	13	1	20.5		20.0	6.3	1.5	.21	2.4	.55	4.6

*Number of fish, if composite sample

DSW 028579

STLCOPCB4012541

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dpth	No*	Lgth	Wt	% Fat	(ug/gm) PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0214	LKTR	0701	4355 8640	13	1	22.6		19.1	8.7	2.2	.40	3.7	.67	7.0
0213	LKTR	0701	4355 8640	13	1	20.2		18.3	5.6	1.6	.20	1.9	.59	4.3
0215	LKTR	0701	4355 8640	13	1	20.3		18.3	6.1	1.5	.12	2.2	.46	4.3
0304	LKTR	0701	4355 8640	13	1	21.8		18.3	9.7	1.7	.22	3.9	.52	6.3
0223	LKTR	0701	4355 8640	13	1	21.2		17.9	9.1	1.8	.35	4.9	.69	7.7
0309	LKTR	0701	4355 8640	13	1	20.0		16.9	8.2	1.6	.21	3.3	.54	5.7
0308	LKTR	0701	4355 8640	13	1	22.0		17.2	11.3	2.1	.23	3.8	.60	6.7
0306	LKTR	0701	4355 8640	13	1	21.7		13.7	9.0	1.7	.20	2.8	.66	5.3
0216	LKTR	0704	4355 8640	10	1	21.0		19.2	9.5	2.4	.33	4.4	.73	7.9
0219	LKTR	0704	4355 8640	10	1	20.4		11.3	8.2	2.0	.39	4.0	.79	7.9
0256	LKTR	0704	4355 8640	10	1	20.6		13.3	6.7	1.5	.24	2.0	.48	4.2
0210	LKTR	0704	4355 8640	10	1	21.3		19.4	7.8	1.9	.29	2.5	.67	5.4
0305	LKTR	0704	4355 8640	10	1	21.6		19.6	9.4	2.1	.27	3.6	.52	6.5
0221	LKTR	0704	4355 8640	13	1	20.0		15.0	6.0	1.9	.31	1.9	.61	4.7
0751	LKTR	1019	4455 8535		1	24.0		16.0	12.2	2.6	.30	4.7	.78	8.3
0766	LKTR	1019	4455 8535		1	24.0		25.0	20.2	2.5	.49	12.0	.89	16.0
0753	LKTR	1019	4455 8535		1	20.5		24.2	12.5	2.4	.39	10.0	.93	13.6
0755	LKTR	1019	4455 8535		1	20.6		24.3	14.1	2.6	.30	5.6	.76	9.3
0754	LKTR	1019	4455 8535		1	25.0		19.3	10.6	2.0	.24	5.7	.56	8.5
0757	LKTR	1019	4455 8535		1	24.6		15.4	5.9	1.1	.17	2.5	.46	4.2

*Number of fish, if composite sample

DSW 028580

STLCOPCB4012542

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(µg/gm)

Sample Number	Species	1971 Date	Location	Dsh No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0760	LKTR	1019	4905 6535	1	26.0	.	15.6	12.6	1.0	.20	4.3	.69	7.0
0752	LKTR	1019	4905 6535	1	18.0	.	15.7	8.2	.7	.19	2.3	.48	3.7
0282	LKTR	0721	4905 8730	20 1	22.0	.	23.0	5.6	.8	.10	3.3	.22	4.4
0320	LKTR	0721	4905 8730	20 1	24.0	.	18.1	8.0	1.1	.12	3.3	.45	4.9
0279	LKTR	0721	4905 8730	20 1	23.0	.	19.1	10.9	1.1	.19	3.5	.42	5.2
0209	LKTR	0721	4905 8730	20 1	22.5	.	21.2	9.9	1.8	.27	4.5	.53	7.0
0276	LKTR	0721	4905 8730	20 1	23.0	.	14.3	10.7	1.7	.26	4.3	.54	6.8
0324	LKTR	0721	4905 8730	20 1	24.8	.	16.5	11.3	1.8	.22	5.0	.57	7.2
0211	LKTR	0721	4905 8730	20 1	22.0	.	20.6	7.3	2.3	.17	3.4	.43	6.3
0321	LKTR	0721	4905 8730	20 1	23.5	.	18.7	11.3	1.8	.19	2.2	.49	4.8
0281	LKTR	0721	4905 8730	20 1	23.5	.	21.7	9.2	1.8	.27	3.3	.50	5.9
0208	LKTR	0721	4905 8730	20 1	23.0	.	20.8	9.5	1.9	.41	5.1	.79	8.2
0212	LKTR	0721	4905 8730	20 1	23.5	.	20.8	9.8	1.5	.25	4.5	.64	6.9
1044	LKTR	0916	4917 8700	1	19.0	01.390	19.1	8.4	.9	.12	3.0	.33	4.5
1049	LKTR	0916	4917 8700	1	19.0	01.080	17.1	7.0	.9	.10	2.3	.35	3.6
1048	LKTR	0916	4917 8700	1	21.0	01.570	17.1	12.5	1.5	.23	5.0	.48	7.1
1036	LKTR	0916	4917 8700	1	25.0	03.550	15.1	10.7	1.8	.28	6.6	.56	9.2
1043	LKTR	0916	4917 8700	1	22.0	03.315	10.3	24.7	2.9	.34	9.4	.69	12.0
1045	LKTR	0916	4917 8700	1	19.5	01.185	12.3	7.5	.7	.10	2.8	.34	3.9
0967	LKTR	0916	4917 8700	1	24.0	03.170	10.6	14.2	3.6	.33	7.4	1.13	12.8

*Number of fish, if composite sample

DSW 028581

STLCOPCB4012543

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(µg/gm)

Sample Number	Species	1971 Date	Location	Dth	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
1050	LKTR	0916	9517 8700		1	26.0	03.640	22.7	22.1	3.5	.45	7.5	1.06	12.6
0205	LOUY	0721	9505 8700	20	1	15.0		6.1	2.5	.3	.03	.5	.19	.9
1290	PRCH	1015	9193 8655	12	1	06.0	00.072	5.0	3.8	.4	.04	.9	.15	1.5
1207	PRCH	1015	9193 8655	12	1	08.0	00.095	7.0	2.5	.2	.02	.8	.09	1.1
1297	PRCH	1015	9193 8655	12	1	08.0	00.079	5.1	5.2	.3	.05	1.1	.20	1.7
1305	PRCH	1015	9193 8655	12	1	08.0	00.086	6.3	5.0	.4	.04	.9	.15	1.5
1309	PRCH	1015	9193 8655	12	1	07.5	00.097	4.1	4.9	.5	.03	.7	.19	1.5
1303	PRCH	1015	9193 8655	12	1	07.5	00.083	5.5	4.3	.1	.02	.7	.05	.9
1300	PRCH	1015	9193 8655	12	1	07.5	00.061	6.5	4.9	.4	.04	.7	.16	1.2
1292	PRCH	1015	9193 8655	12	1	07.5	00.086	9.6	4.3	.3	.04	.6	.15	1.1
1308	PRCH	1015	9193 8655	12	1	08.0	00.106	7.7	4.9	.5	.06	.7	.20	1.5
1290	PRCH	1015	9193 8655	12	1	08.0	00.099	6.9	3.8	.4	.05	.8	.17	1.4
0790	PRCH	1013	9305 8795	10	1	09.5	00.196	5.0	14.3	.5	.05	1.0	.25	1.8
0792	PRCH	1013	9305 8795	10	1	09.0	00.164	5.1	8.0	.7	.11	1.0	.25	1.9
0793	PRCH	1013	9305 8795	10	1	10.5	00.253	6.1	12.6	1.2	.16	1.4	.63	3.4
0799	PRCH	1013	9305 8795	10	1	09.5	00.166	6.2	8.9	.4	.06	.8	.21	1.5
0794	PRCH	1013	9305 8795	10	1	09.5	00.187	5.5	12.2	.6	.08	1.3	.27	2.3
0791	PRCH	1013	9305 8795	10	1	09.5	00.148	3.8	12.5	.6	.07	1.1	.27	2.1
0795	PRCH	1013	9305 8795	10	1	08.5	00.111	9.6	8.9	.5	.06	1.3	.29	2.1
0796	PRCH	1013	9305 8795	10	1	09.5	00.221	6.2	13.9	.8	.11	1.0	.41	2.4

*Number of fish, if composite sample.

DSW 028582

STLCOPCB4012544

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Drh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(us/gm)					
0790	PRCH	1013	4305 8795	10	1	08.5	00.134	5.0	4.8	.4	.00	.7	.12	1.3
0337	PRCH	0706	4355 8640	11	3	10.5	.	4.0	6.5	.1	.03	2.4	.12	2.7
0335	PRCH	0706	4355 8640	11	4	11.0	.	5.7	5.4	1.7	.22	2.1	.47	4.5
0719	PRCH	1012	4440 8625	11	1	11.3	.	9.0	6.2	1.7	.19	2.2	.39	4.4
0795	PRCH	1012	4440 8625	11	1	12.0	.	6.4	4.5	2.0	.09	1.3	.40	4.7
0343	PRCH	0825	4445 8750	07	1	08.5	00.132	4.4	1.5	.1	.02	.4	.12	.6
0347	PRCH	0825	4445 8750	07	1	08.8	00.165	7.9	0.1	.0	.00	.3	.06	.3
0339	PRCH	0825	4445 8750	07	1	08.6	00.190	4.9	1.5	.0	.00	.4	.11	.5
1033	RDTR	0916	4517 8700		1	24.0	04.100	22.0	7.3	1.0	.15	1.9	.32	3.3
0960	RDTR	0916	4517 8700		1	20.0	02.497	19.5	1.6	.3	.07	1.6	.13	2.1
0973	RDTR	0916	4517 8700		1	20.0	05.676	16.5	14.0	1.0	.10	5.0	.37	6.0
1036	RDTR	0916	4517 8700		1	24.0	04.036	21.8	7.3	1.0	.19	3.4	.62	5.4
1031	RDTR	0916	4517 8700		1	23.0	02.640	19.9	8.2	1.1	.16	3.1	.39	4.7
1134	RDSU	0911	4520 8645	19	1	15.0	00.550	5.1	2.3	.4	.07	1.0	.33	2.0
1133	RDSU	0911	4520 8645	19	1	15.0	00.770	0.2	3.3	.7	.09	1.5	.37	2.6
1130	RDSU	0911	4520 8645	19	1	19.5	01.490	9.4	1.5	.2	.09	2.2	.16	2.6
1137	RDSU	0911	4520 8645	19	1	17.0	00.765	9.4	2.3	.5	.07	1.5	.27	2.3
1129	RDSU	0911	4520 8645	19	1	18.0	01.145	8.5	4.1	1.0	.11	2.6	.42	4.1
1140	RDSU	0911	4520 8645	19	1	18.0	00.930	7.0	3.3	.4	.07	1.5	.25	2.3
1125	RDSU	0911	4530 8650	19	1	17.0	01.000	10.2	3.2	1.1	.15	1.9	.59	3.7

*Number of fish, if composite sample

DSW 028583

STLCOPCB4012545

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dnh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(µg/gm)					
1118	RDSU	0911	9530 0650	19	1	16.5	00.863	6.4	3.4	.7	.08	.2	.29	1.3
1120	RDSU	0911	9530 0650	19	1	16.5	01.005	8.5	2.8	.9	.06	1.5	.21	2.2
1119	RDSU	0911	9530 0650	19	1	17.5	00.800	8.5	3.3	1.1	.10	1.7	.02	3.3
1120	RDSU	0911	9530 0650	19	1	16.5	00.730	6.6	2.6	.7	.08	1.8	.31	2.9
1121	RDSU	0911	9530 0650	19	1	17.0	00.760	10.7	2.5	.7	.10	1.5	.39	2.6
1120	RDSU	0911	9530 0650	19	1	15.5	00.700	8.9	3.2	.7	.08	1.9	.29	3.0
1116	RDSU	0911	9530 0650	19	1	17.0	01.195	9.9	3.5	.7	.08	1.6	.31	2.6
1252	SCUL	1016	9290 0620	50	3	05.4	00.029	4.1	4.8	3.1	.04	2.6	.31	6.0
1240	SCUL	1016	9290 0620	50	4	04.6	00.022	6.1	2.4	.8	.05	1.4	.12	2.4
1241	SCUL	1016	9290 0620	50	5	04.6	00.017	6.5	2.3	.5	.05	.9	.10	1.5
1248	SCUL	1016	9290 0620	50	4	05.0	00.022	5.5	3.7	2.1	.07	2.2	.27	4.6
1253	SCUL	1016	9290 0620	50	6	03.6	00.012	5.5	1.8	.4	.03	.6	.09	1.1
1256	SCUL	1016	9290 0620	50	6	04.2	00.014	5.8	1.8	.4	.04	.8	.09	1.3
1250	SCUL	1016	9290 0620	50	2	05.4	00.036	6.5	4.0	2.0	.12	2.5	.23	4.8
1249	SCUL	1016	9290 0620	50	3	05.0	00.023	7.9	2.1	.6	.07	1.0	.10	2.0
1239	SMLT	1015	9193 0655	12	3	07.6	00.050	9.0	3.6	.9	.03	1.0	.12	1.5
1229	SMLT	1015	9193 0655	12	1	08.5	00.011	6.1	4.6	.7	.07	1.0	.22	2.0
1233	SMLT	1015	9193 0655	12	1	08.5	00.070	7.2	3.6	.9	.06	1.0	.12	1.5
1236	SMLT	1015	9193 0655	12	2	07.9	00.047	9.2	3.2	.8	.09	.9	.11	1.4
1241	SMLT	1015	9193 0655	12	3	06.5	00.030	7.2	2.3	.2	.03	.8	.10	1.1

*Number of fish, if composite sample

DSW 028584

STLCOPCB4012546

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dth	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
									(ug/gm)					
1249	SMLT	1015	4143	0655	12	4	05.5	00.021	5.7	1.5	.2	.02	.4	.05	.7
1240	SMLT	1015	4143	0655	12	3	06.5	00.030	5.7	1.9	.2	.03	.9	.06	1.2
1246	SMLT	1015	4143	0655	12	4	05.6	00.021	7.8	3.1	.3	.03	.7	.06	1.0
1234	SMLT	1015	4143	0655	12	1	06.5	00.072	7.8	4.3	.4	.04	1.0	.15	1.6
1243	SMLT	1015	4143	0655	12	2	06.5	00.036	7.8	3.4	.3	.03	.9	.07	1.3
1231	SMLT	1015	4143	0655	12	1	08.5	00.080	6.8	4.3	.6	.06	1.1	.17	1.9
0842	SMLT	101	4345	0730		4	05.5	.	5.1	.7	.2	.03	.8	.15	1.2
0843	SMLT	1015	4345	0730		2	07.0	.	2.7	.8	.4	.04	.5	.12	1.0
0841	SMLT	1015	4345	0730		9	04.5	.	3.9	.5	.2	.02	.3	.10	.7
0171	SMLT	0721	4505	0730	20	2	05.5	.	5.3	2.2	.1	.01	.3	.11	.5
0172	SMLT	0721	4505	0730	20	1	04.6	.	3.5	1.0	.1	.01	.3	.06	.9
0170	SMLT	0721	4505	0730	20	2	06.5	.	3.5	3.5	.1	.01	.4	.09	.6
0168	SMLT	0721	4505	0730	20	2	09.5	.	4.9	2.7	.4	.05	2.0	.23	2.7
0527	SMLT	0911	4520	0645	14	2	06.7	00.043	8.1	5.1	.3	.05	1.8	.15	2.2
0519	SMLT	0911	4520	0645	14	1	08.0	00.061	5.3	2.4	.5	.09	.7	.16	1.4
0522	SMLT	0911	4520	0645	14	1	08.3	00.077	9.3	2.8	.4	.04	.8	.11	1.3
0517	SMLT	0911	4520	0645	14	2	07.2	00.046	5.6	5.8	.0	.03	.8	.10	1.3
0520	SMLT	0911	4520	0645	14	2	07.0	00.039	8.4	2.8	.3	.03	.8	.11	1.2
0523	SMLT	0911	4520	0645	14	1	08.0	00.066	4.6	1.4	.4	.04	.5	.10	1.1
0524	SMLT	0911	4520	0645	14	2	07.0	00.042	5.0	1.8	.3	.06	.6	.13	1.1

*Number of fish, if composite sample

STLCOPCB4012547

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDS	pp' TDE	Total DDT
									(µg/gm)					
0005	SHLT	0719	4530 8525	30	2	09.0		3.2	1.3	.4	.05	.7	.09	1.2
0004	SHLT	0719	4530 8525	30	3	06.5		4.3	1.0	.1	.05	.8	.10	1.1
0002	SHLT	0719	4530 8525	30	9	04.5		4.6	1.7	.1	.03	.5	.07	.7
0994	WHFH	1015	4143 8655	12	1	19.0	01.360	27.1	6.9	.9	.06	.6	.32	1.9
0992	WHFH	1015	4143 8655	12	1	18.0	01.350	24.2	5.6	.5	.06	.9	.31	1.3
0325	WHFH	0619	4240 8620	07	1	13.3		17.1	1.9	.6	.09	.6	.24	1.5
0326	WHFH	0619	4240 8620	07	1	14.8		22.3	2.8	.5	.10	.7	.21	1.5
0331	WHFH	0621	4240 8620	10	1	14.0		16.3	2.5	.3	.05	.9	.19	1.0
1090	WHFH	0906	4306 8625	19	1	16.0	01.135	19.0	5.5	.3	.03	.6	.21	1.1
1092	WHFH	0906	4306 8625	19	1	21.0	01.550	21.2	6.5	1.0	.09	.7	.41	2.2
1089	WHFH	0906	4306 8625	19	1	17.5	01.530	23.3	5.0	.6	.07	.6	.29	1.5
1093	WHFH	0906	4306 8625	19	1	17.0	01.390	22.7	4.6	.5	.06	.5	.23	1.3
1094	WHFH	0906	4306 8625	19	1	16.0	01.110	22.7	7.3	1.2	.21	.9	.62	2.9
1091	WHFH	0906	4306 8625	19	1	17.5	01.530	26.9	5.5	1.2	.13	.6	.53	2.5
0704	WHFH	1019	4455 8535	1	1	19.0		20.0	1.5	.1	.21	.9	.06	1.3
0701	WHFH	1019	4455 8535	1	1	18.5		12.0	1.9	.5	.06	1.3	.30	2.2
0690	WHFH	1019	4455 8535	1	1	18.0		19.1	1.0	.3	.06	1.2	.26	1.9
0702	WHFH	1019	4455 8535	1	1	19.0		13.2	2.3	.4	.07	1.6	.23	2.3
0695	WHFH	1019	4455 8535	1	1	19.5		14.2	1.8	.5	.06	1.1	.24	1.9
0696	WHFH	1019	4455 8535	1	1	18.0		15.3	1.8	.4	.06	1.2	.29	2.0

*Number of fish, if composite sample

DSW 028586

STLCOPCB4012548

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

(ug/gm)

Sample Number	Species	1971 Date	Location	Dsh	No*	Lgth	Wt	% Fat	PCB	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0692	WHFH	1019	9455 8535		1	18.0	.	12.3	1.7	.4	.06	1.3	.24	2.1
0697	WHFH	1019	9455 8535		1	19.0	.	13.9	2.0	.4	.07	1.7	.29	2.5
0694	WHFH	1019	9455 8535		1	21.5	.	9.4	1.8	.3	.04	.0	.27	1.5
0705	WHFH	1019	9455 8535		1	18.0	.	10.5	1.1	.7	.09	1.2	.21	2.2
0699	WHFH	1019	9455 8535		1	19.0	.	10.7	1.6	.4	.04	1.2	.26	1.9
0693	WHFH	1019	9455 8535		1	19.0	.	12.8	2.1	.5	.08	1.2	.32	2.0
1119	WHFH	0911	9520 8645	14	1	18.5	01.220	14.0	1.5	.5	.05	.7	.10	1.4
1111	WHFH	0911	9520 8645	14	1	16.0	00.865	14.9	1.3	.4	.04	.7	.15	1.3
1107	WHFH	0911	9520 8645	14	1	16.0	00.925	13.5	1.5	.4	.04	.7	.12	1.3
1101	WHFH	0911	9520 8645	14	1	18.0	01.270	17.5	1.5	.3	.07	.7	.17	1.3
1105	WHFH	0911	9520 8645	14	1	17.0	01.210	17.6	1.8	.6	.06	.8	.22	1.6
1103	WHFH	0911	9520 8645	14	1	18.0	01.260	13.6	1.3	.2	.04	.8	.12	1.2
1108	WHFH	0911	9520 8645	14	1	18.0	01.255	17.6	1.8	.5	.06	.6	.17	1.4
1106	WHFH	0911	9520 8645	14	1	17.0	00.991	12.9	1.3	.5	.05	.6	.22	1.4
0905	WHSU	1015	9143 8655	12	1	16.0	01.310	9.4	7.1	.8	.00	1.5	.55	2.8
0904	WHSU	1015	9143 8655	12	1	18.0	01.370	13.8	14.2	2.2	.00	2.0	.99	5.2
1166	WHSU	1015	9240 8620	03	1	18.5	02.030	5.0	7.9	.5	.04	.8	.39	1.8
1169	WHSU	1015	9240 8620	05	1	16.0	00.700	3.8	5.0	.2	.02	.6	.15	1.0
1173	WHSU	1015	9240 8620	09	1	13.5	00.460	7.0	1.9	.1	.02	.4	.09	.5
1172	WHSU	1015	9240 8620	09	1	14.0	00.510	6.1	2.6	.2	.04	.5	.15	.8

*Number of fish, if composite sample

STLCOPCB4012549

Appendix A. Summary of Data on Fish Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dph	No*	Lgth	Wt	% Fat	(µg/gm) PCB	pp' DDT	op' DDT	pp' DDS	pp' DDE	Total DDT
1170	WHSU	1018	9240 8620	09	1	11.0	00.430	5.2	1.6	.2	.03	1.7	.12	2.0
1171	WHSU	1018	9240 8620	09	1	11.0	00.360	5.4	2.5	.0	.00	.4	.05	.4
1174	WHSU	1018	9240 8620	09	1	12.0	00.450	4.6	2.6	.1	.02	.4	.12	.6
0302	WHSU	0806	9445 8750	06	1	11.5	00.324	3.1	1.7	.0	.01	.2	.05	.3
0297	WHSU	0806	9445 8750	06	1	12.0	00.398	6.8	2.5	.2	.02	.5	.11	.8
0298	WHSU	0806	9445 8750	06	1	13.5	00.396	4.5	3.1	.0	.00	.3	.05	.4
0300	WHSU	0806	9445 8750	06	1	12.5	00.392	5.6	2.1	.0	.01	.3	.09	.4
0299	WHSU	0806	9445 8750	06	1	13.0	00.403	7.8	10.0	1.5	.22	.3	.59	2.6
0296	WHSU	0806	9445 8750	06	1	12.0	00.384	4.9	2.6	.0	.00	.3	.05	.4
0685	WHSU	1019	9455 8535		1	16.5		5.0	3.1	.5	.00	2.1	.47	3.1
0686	WHSU	1019	9455 8535		1	17.0		4.1	3.2	.6	.07	1.7	.38	2.7
0683	WHSU	1019	9455 8535		1	17.0		2.1	1.9	.2	.02	1.0	.20	1.4
0682	WHSU	1019	9455 8535		1	15.0		3.1	1.4	.3	.03	.9	.21	1.4
0677	WHSU	1019	9455 8535		1	17.5		3.3	2.4	.3	.01	1.4	.27	1.9
0681	WHSU	1019	9455 8535		1	17.0		2.4	1.6	.4	.05	1.5	.29	2.2
0682	WHSU	1019	9455 8535		1	18.0		3.8	2.7	.3	.02	1.2	.32	1.9
0687	WHSU	1019	9455 8535		1	17.5		1.8	1.5	.1	.00	.9	.22	1.2
0685	WHSU	1019	9455 8535		1	16.5		4.8	2.0	.3	.04	1.4	.30	2.1
0680	WHSU	1019	9455 8535		1	18.5		4.9	2.5	.2	.03	1.2	.34	1.8
0678	WHSU	1019	9455 8535		1	18.0		6.9	3.5	1.5	.10	2.4	.67	4.7

*Number of fish, if composite sample

DSW 028588

STLCOPCB4012550

Appendix A. Summary of Data on Fish
Analyzed for PCBs and DDT.

Sample Number	Species	1971 Date	Location	Dpb	No*	Length	Wt	% Fat	PCB (µg/gm)	pp' DDT	op' DDT	pp' DDE	pp' TDE	Total DDT
0691	WHSU	1019	9455 8535		1	15.0	.	3.9	2.9	.6	.05	1.4	.37	2.3
0679	WHSU	1019	9455 8535		1	19.0	.	.7	1.3	.2	.01	.9	.15	1.2
0204	WHSU	0721	9505 8730	20	1	19.0	.	10.0	2.1	.8	.08	.7	.19	1.3
1140	WHSU	0911	9520 8645	19	1	16.5	01.046	7.2	4.7	.6	.04	1.5	.35	2.5
1152	WHSU	0911	9520 8645	19	1	18.0	01.230	6.3	1.5	.5	.03	.7	.17	1.4
1142	WHSU	0911	9520 8645	19	1	18.0	01.330	6.4	1.3	.1	.01	.6	.09	.8
1145	WHSU	0911	9520 8645	19	1	18.0	01.065	7.4	1.7	.2	.03	.7	.17	1.1
1151	WHSU	0911	9520 8645	19	1	18.5	01.260	3.5	1.7	.2	.02	.9	.11	1.3
1149	WHSU	0911	9520 8645	19	1	19.0	00.665	9.6	2.5	.9	.09	1.0	.21	2.2
1153	WHSU	0911	9520 8645	19	1	18.0	01.220	9.6	3.8	.5	.05	.9	.30	1.8
1144	WHSU	0911	9520 8645	19	1	17.5	01.090	6.7	1.8	.3	.04	.8	.17	1.3
1154	WHSU	0911	9520 8645	19	1	17.0	00.910	5.8	2.6	.4	.05	1.2	.17	1.9
1143	WHSU	0911	9520 8645	19	1	17.0	01.115	2.6	2.3	.2	.03	.8	.12	1.2
1155	WHSU	0911	9520 8645	19	1	16.0	00.950	4.0	2.7	.3	.04	.8	.27	1.4
1150	WHSU	0911	9520 8645	19	1	20.0	01.420	6.9	2.9	.3	.03	.7	.22	1.2

*Number of fish, if composite sample

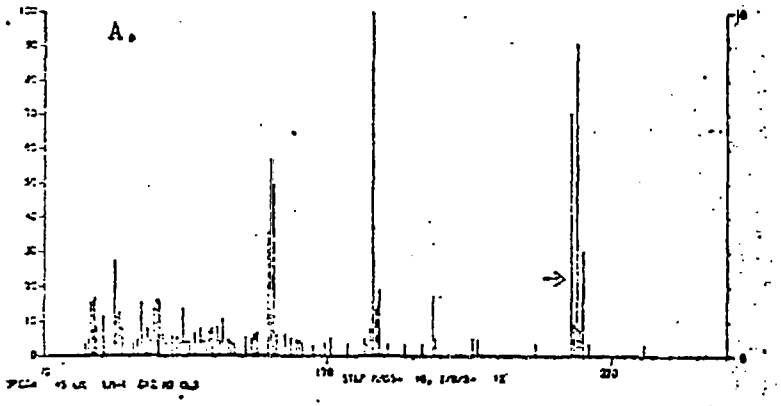
DSW 028589

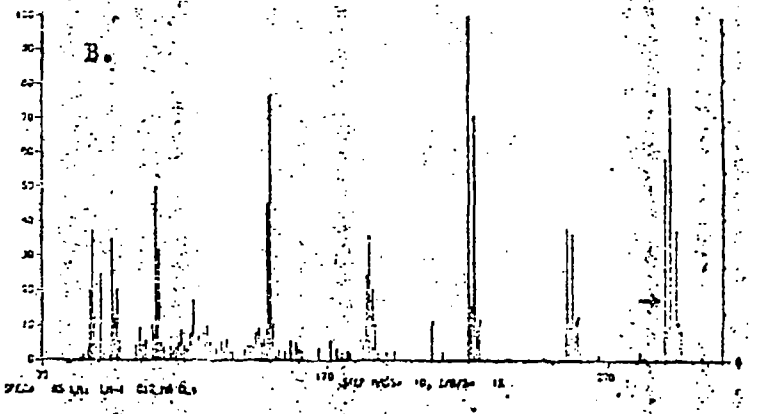
STLCOPCB4012551

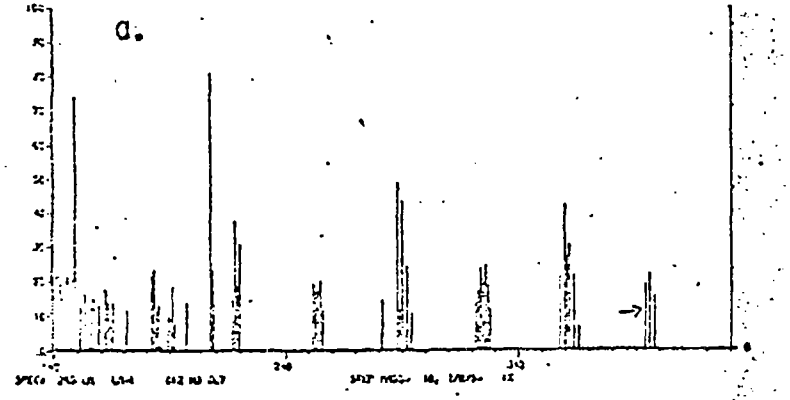
Appendix B. Selected Mass Spectra of Composite Samples of Lake Michigan Fish

DSW 028590

STLCOPCB4012552







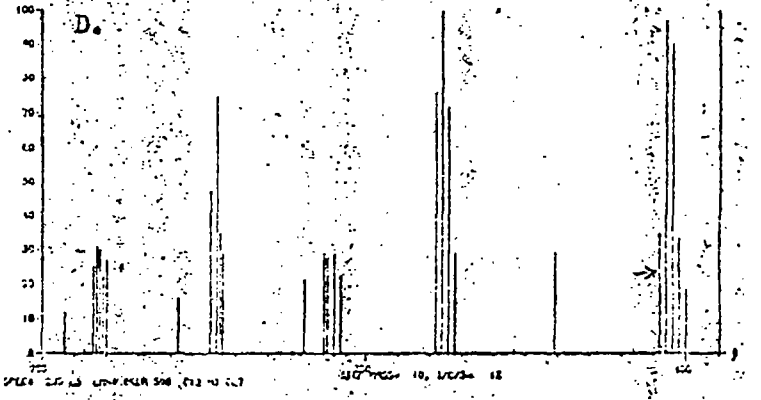


Figure I. Mass Spectra of Major PCBs in Lake Trout from the Milwaukee Area

DSW 028591

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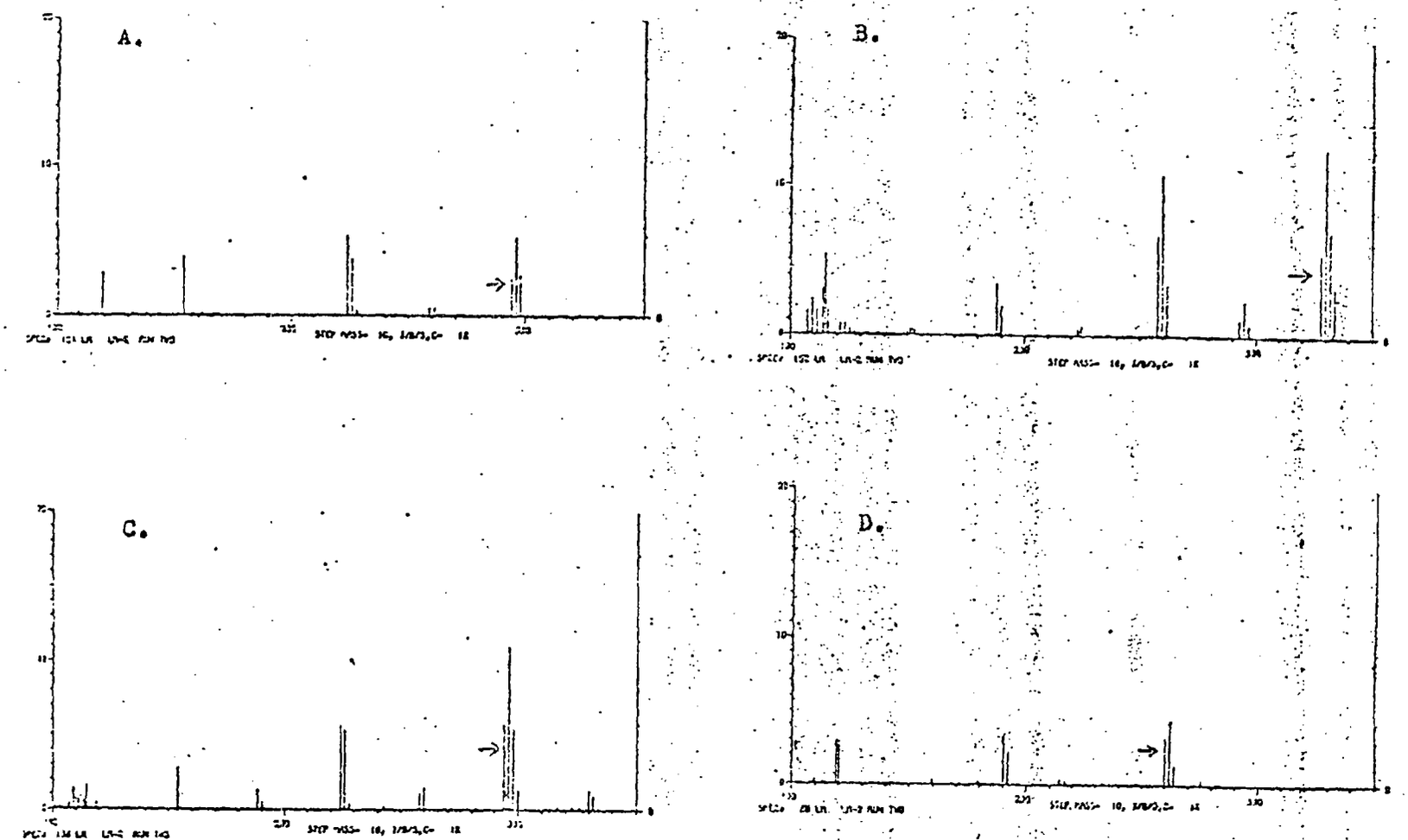

Figure II. Mass Spectra of Major PCBs in Lake Trout from the Saugatuck Area

DSW 028592

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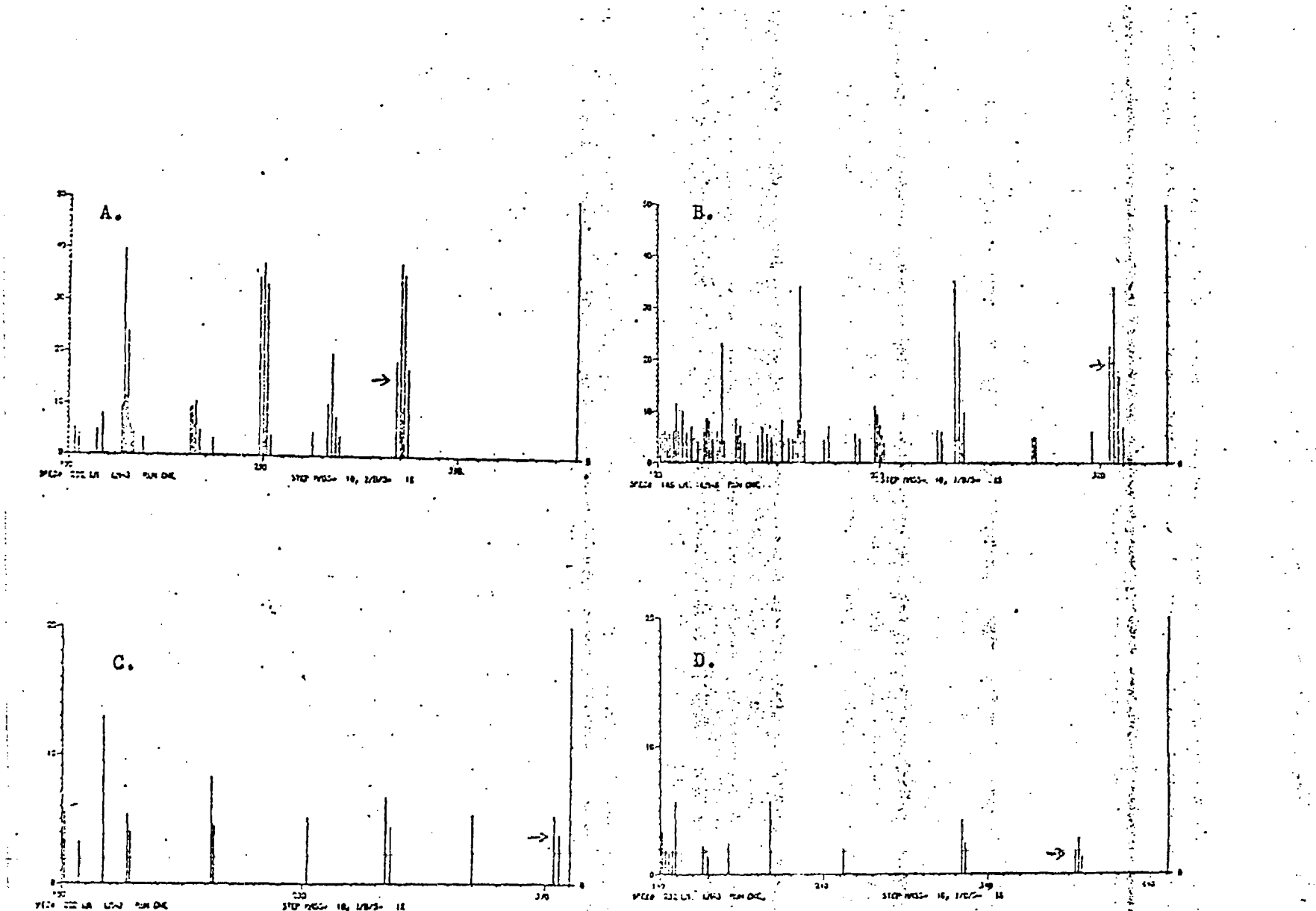

Figure XII. Mass Spectra of Major PCBs in Lake Trout from the Ludington Area.

DSW 028593

STLCOPCB4012555

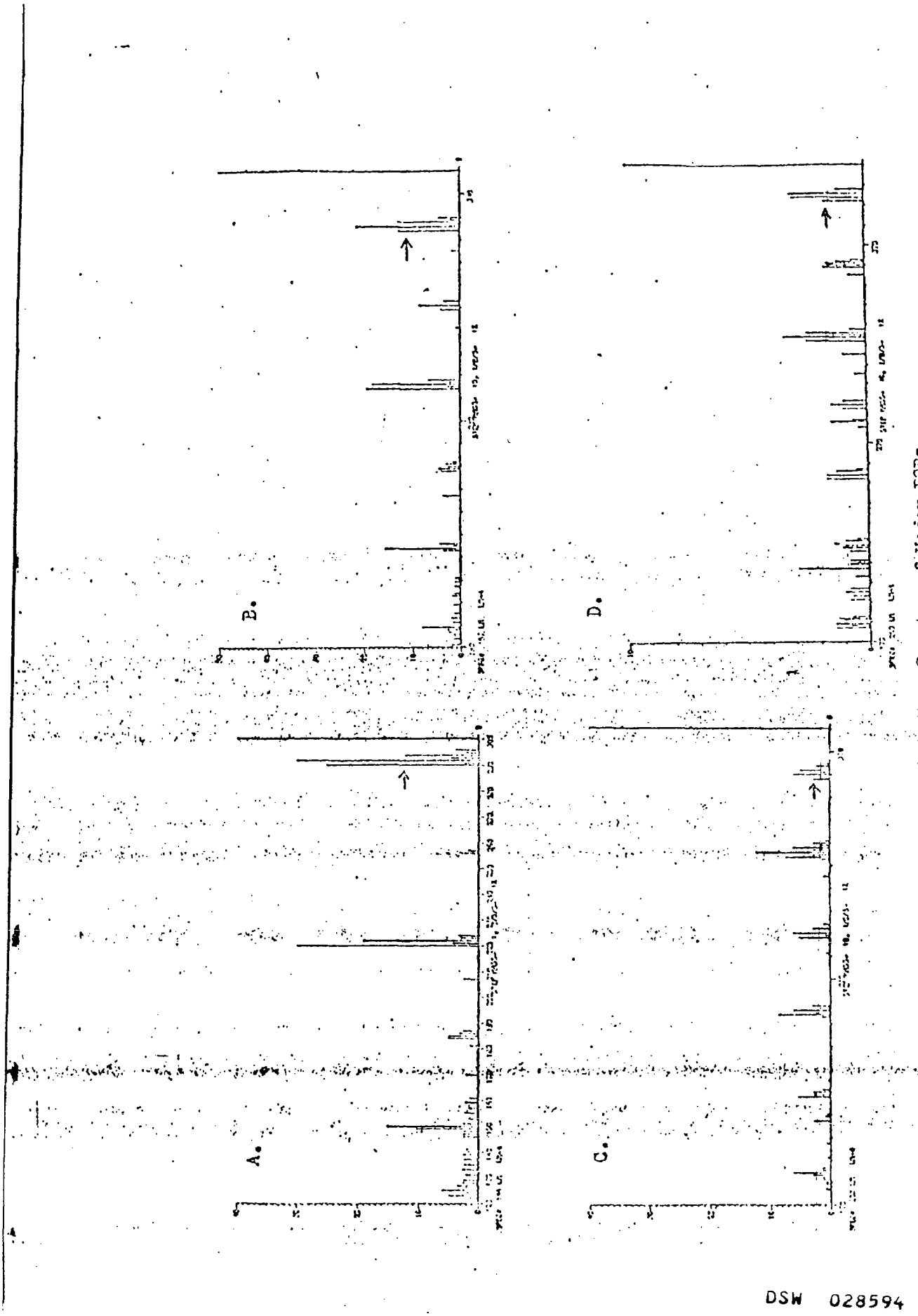

Figure IV. Mass Spectra of Major PCBs
in Lake Trout from the Manitouoc Area

DSW 028594

STLCOPCB4012556

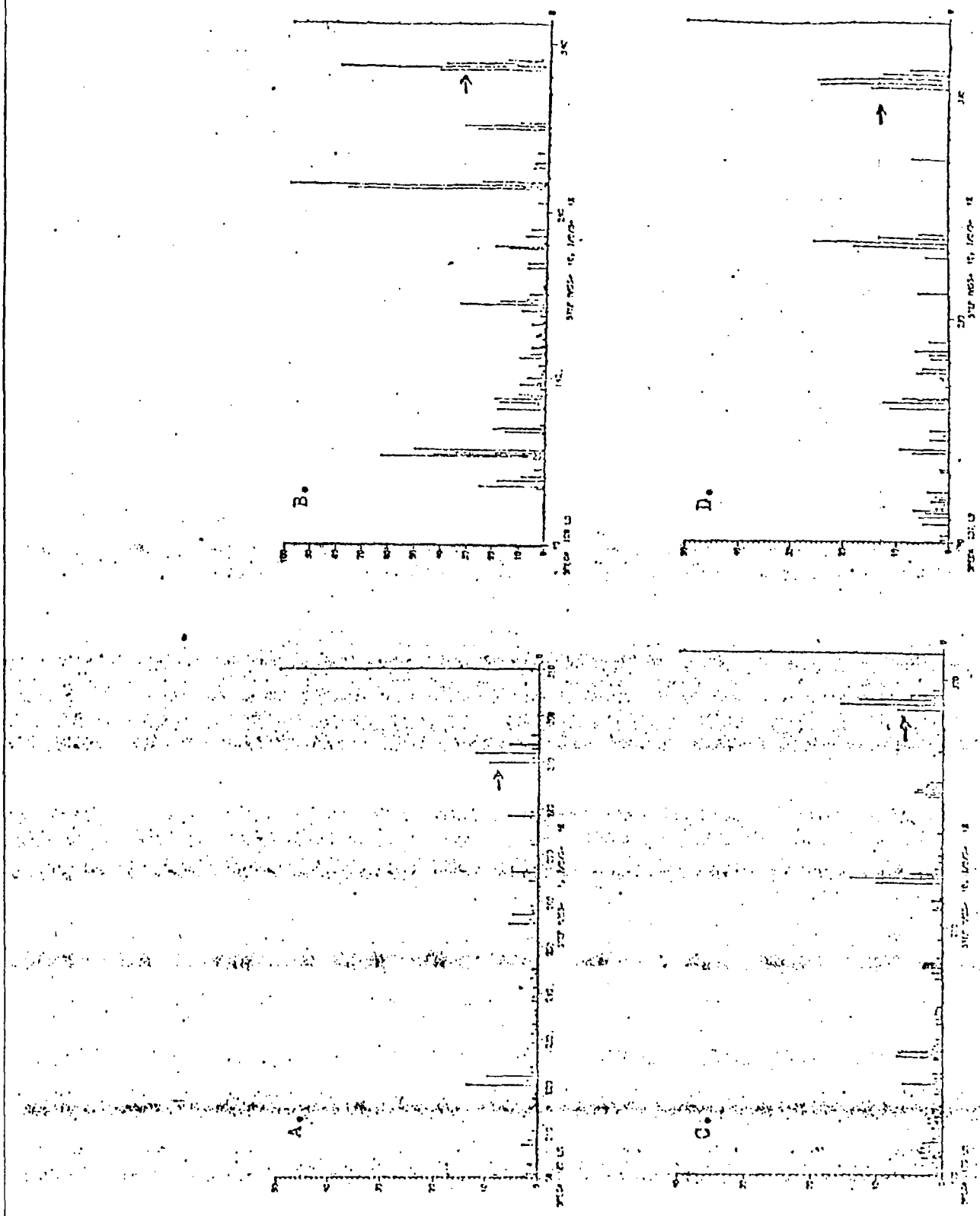

Figure V : Mass Spectra of Major PCBs
in Lake Trout from Traverse Bay

DSW 028595

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Figure VI.4 Mass Spectra of Major PCBs
in Lake Trout from the Michigan City Area

DSW 028596

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Appendix C. Other Field Studies
Supported by Grant 16020 FBS

Due to conflicts arising from changes in the funding period of this grant, the scheduled sampling of major rivers around the lake was not possible. Ship time for the University of Wisconsin Sea Grant Program vessel was obtained for one week in May, 1972. The cruise consisted of transects normal to the shore at Sturgeon Bay, Manitowoc, Sheboygan, Milwaukee, Waukegan, Indiana Harbor, and Michigan City in which plankton, water, sediments, and bottom organisms were sampled for PCB and pesticide analysis. The results will be presented and discussed in the forthcoming Ph.D. thesis of Mr. Richard Flotard of the Water Chemistry Program. The cruise also provided samples for two other graduate studies on trace metals in Lake Michigan by the Water Chemistry Program as well as a study of the food chain transport of PCBs into bird populations on Lake Michigan by the Department of Wildlife Ecology.

Although the data is only partially analyzed at this time, a brief examination of the available data as presented in the following table shows that the PCB levels in Pontinevela are approximately five times greater off Waukegan than those from Sturgeon Bay. The trend of decreasing levels is also observed in samples from increasing depth (and distance from shore), suggesting that gradients of PCB levels in the water exit along the shore and with depth or distance from the shore.

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Appendix C. Concentration of PCBs and DDT in Pontiporeia from the Western Shore of Lake Michigan[a] (Spring, 1972).

Sampling Region	Depth (ft)	Concentration (ug/gm-wet) PCBs[b]	DDT	DDD	DDE	"Total" DDT
Sturgeon Bay	100	0.06	0.03	0.08	0.03	0.14
Manitowoc	50	0.21	0.03	0.01	0.04	0.08
	100	0.11	0.04	0.01	0.05	0.10
	150	0.17				
Sheboygan	100	0.32	0.04	0.02	0.05	0.11
	150	0.23				
Waukegan	27	0.89				
	100	0.45	0.08	0.03	0.09	0.20
	150	0.34				

[a] Data from Ph.D. thesis (Water Chemistry) of Richard Plotard at the University of Wisconsin, partially supported by this study.

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