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ORGANOCHLORINE CONTAMINANTS OF WINTERING DUCKS
FORAGING ON DETROIT RIVER SEDIMENTS

Running Title: ORGANOCHLORINES IN DETROIT RIVER DUCKS

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INTRODUCTION

The Detroit River, connecting Lakes St. Clair and Erie, is one of the world's busiest waterways, which passes through a highly industrialized area of the United States and Canada (Fig. 1). Among the principal contaminants found in Detroit River sediments are organochlorines (Fallon and Horvath, 1983), including polychlorinated biphenyls (PCBs). Due to their hydrophobic nature and stability, PCBs tend to collect and persist in organic sediments (Choi and Chen, 1976; Haque et al., 1974; Crump-Wiesner et al., 1973). To the degree that PCBs and other contaminants accumulate in sediments and associated benthos, they become available at higher concentrations to larger bottom-foraging fauna. Thus polluted sediments in many nearshore areas may act as reservoirs of "in-place" contaminants, which continue to enter the food chain long after point sources of pollution are controlled.

Each winter, thousands of migratory waterfowl congregate on the Detroit River, attracted by areas of shallow, ice-free water. These include diving ducks, such as scaups and goldeneyes, which forage on plant and animal matter in the sediments. During 1980-82, Drobney et al. (1982) studied the food habits and nutritional status of 169 lesser scaups (Aythya affinis), greater scaups (A. marila) and goldeneyes (Bucephala clangula) wintering on the lower Detroit River. This was part of a study designed to evaluate the effects of winter navigation on survival of waterfowl. The collections presented us with an opportunity to study the possible uptake and accumulation by ducks of selected organochlorines, including PCB congeners, from polluted sediment. In part, our objective was to identify and compare complex PCB mixtures in these ducks and in their benthic food supply at a foraging site. We thought that Detroit River sediment might be an important source of PCBs, even for transient waterfowl. If so, then distinctive patterns of certain congeners in sediment might be found also in local benthos, ducks and other bottom feeders. Another related goal was to examine the relationship between lipid and PCB concentrations in the ducks during this period of increased fat metabolism.

Weekly counts of waterfowl along the lower Detroit River near its junction with Lake Erie (Fig. 1) showed concentrations of up to 24,000 ducks and geese in late January, 1980, which declined steadily to approximately 5,000 birds in late March, just prior to the final northward migration (Drobney et al., 1982). It is likely that local populations in March included transient ducks from wintering grounds farther south.

Of the 13 ducks analyzed in this study, 11 were collected at Mud Island; the remaining two were collected 8 km southward on the river (Fig. 1). The study site was in shallow (1-3 m) waters on the downstream side of Mud Island, where aquatic macrophytes grow abundantly in the soft bottom during the summer. Sediments there are finely textured with a high organic content. Immediately after ducks were collected at this site, their gut contents were removed and preserved in formalin for later identification (Drobney et al., 1982). Their diets were found to include a wide variety of invertebrate and plant materials. However, the bulk of their food consisted of oligochaete worms (including Tubifex sp.) and tubers of Vallisneria sp. and Potamogeton sp., two species of aquatic flowering plants. The percentages of plant and animal matter found in gut contents are summarized in Table 1 (from Drobney et al., 1982). Their results show that pollution-tolerant oligochaetes may be an important winter food for diving ducks in the Detroit River, as they were for oldsquaw ducks (Clangula hyemalis) in Milwaukee Harbor (Rofritz, 1977). Oligochaetes were reported to have a higher caloric content than other benthos studied by Cummins and Wuycheck (1971).

Since Mud Island was a prominant feeding area for ducks, we also sampled other components of this system: unfiltered water, filterable seston, surficial sediment, oligochaetes and adult carp (Cyprinus carpio), the latter representing a bottom-feeding fish. Sediment samples collected represented only recently deposited material likely to be available to foraging ducks and fish. At Mud Island this was defined as the upper 4-cm zone of a sediment core in which 65% of the total PCB mass occurred at nearly uniform concentrations. Within the next 5-9 cm interval of sediment depth, the PCB concentration rapidly declined. Biological mixing of surficial sediments and associated contaminants has been documented elsewhere in the Great Lakes (Robbins, 1982) and in laboratory microcosms (Karickhoff and Morris, 1985).

Studies have shown that the composition of PCB mixtures in environmental samples is highly variable due to differences in the chemical and biological behavior of congeners (Safe, 1980; Hutzinger et al., 1974). Certain PCBs are more persistent (i.e., conservative) than others, as indicated by the similarity of these congener ratios in the environment to those in commercial PCB mixtures (Ballschmiter and Zell, 1980; Ballschmiter et al., 1978). We evaluated all of the possible ratios of congeners in Mud Island sediment and fauna, and selected 6 congeners that were involved most frequently in the most consistent ratios. The distribution of these "conservative" congeners was compared to that of PCBs as a whole.

METHODS

A detailed description of the field and laboratory methods is included in a more comprehensive report on the Detroit River studies (Smith _et al._, in preparation). The following is a brief summary of methods.

Each water sample (12 L), collected in four, 3.8 L brown glass jugs, was extracted by partitioning twice with dichloromethane in a 15:1 ratio. Combined extracts were concentrated, transferred into n-hexane, dried through sodium sulfate columns and evaporated under nitrogen to volumes of 2-10 ml, as adopted from standard EPA procedures (Thompson, 1974). Excess lipids were removed by treating 2 ml extracts with concentrated sulfuric acid, and subsequently freezing the aqueous layer in an acetone-dry ice bath (Murphy, 1972). Cleaned extracts in hexane were stored temporarily in sealed glass ampules (8°C, dark).

Seston was collected by pressure filtration (<35 kpa) through glass fiber filters (nominally, 0.6 μm porosity). Filters, stored temporarily in glass jars with acetone, were exhaustively extracted by Soxhlet with n-hexane-acetone (1:1), transferred into n-hexane and processed as above.

Oligochaetes were hand-picked from grab samples (Ponar dredge) of sediment, after the larger particles were collected by washing the mud through a 0.5 mm mesh bronze wire sieve (U.S. #30). Frozen oligochaetes (5 g) were mixed with anhydrous sodium sulfate (1:3) and exhaustively extracted by Soxhlet with n-hexane:dichloromethane (1:1) for 6 hours. Extracts were processed as for water and seston samples.

Sediment cores, approximately 15 cm long, were collected by pushing a pole-mounted aluminum tube (5 cm diameter) into the bottom. Three cores were sectioned at 1 cm intervals and equivalent sections were combined. Sediments were exhaustively extracted by Soxhlet with n-hexane-acetone (1:1) and processed as above. The final extracts were treated with reactive copper to remove sulfur (Environment Canada, 1979). Based on preliminary analysis, the upper four 1-cm sections were shown to have similar concentrations of total PCB. Extracts of these sections were combined as representing the mixed zone of sediment.

Extracts of monthly water and seston samples collected during July-November 1982 were combined to form one sample of each. Eleven oligochaete samples from the same period were also combined. Three sediment samples, collected on December 14, 1982, were combined.

Carp were gill-netted on September 17, 1982, and stored frozen, prior to grinding and homogenizing the whole fish. Ducks collected by shotgun during January-March 1980, were eviscerated, defeathered and the head and feet were removed prior to freezing. Homogenized aliquots (20 g) of duck or fish tissue were mixed with sodium sulfate (3:1), and exhaustively extracted with n-hexane-dichloromethane (1:1). Extracts were processed as above. Total lipids in carp and duck tissue were determined gravimetrically after drying at room temperature a 1 ml aliquot of the 10 ml final extract. All solvents used were of "pesticide grade" from Burdick and Jackson, Muskegon, Michigan. All glassware was cleaned rigorously with detergents and solvent rinses, followed by baking at 580°C. Glassware assemblies were refluxed or rinsed again with solvents before use.

For organochlorine analysis we used a Varian 3700 capillary column gas chromatograph fitted with dual Ni^{63} electron capture detectors, auto-samplers and 50 m X 0.2 mm (i.d.) SE-54 thin film, fused silica columns. Chromatographic conditions were as described elsewhere (Smith _et al._, 1984, in preparation). Component peaks were baseline-corrected prior to quantitation. Individual PCB congeners were analyzed with reference to a standard mixture of Aroclors 1016, 1254 and 1260, in which 95 congeners had been identified and 72 of these quantitated using synthetic PCB standards (Mullin et al., 1983; Mullin et al., 1984). Octachloronaphthalene was used as an internal standard to verify retention times. Homolog and total PCB values were based on the appropriate summations of congener values. Other organochlorines were similarly quantitated.

Glassware and solvent blank values for Mud Island water samples averaged 5.7% and 4.5% of sample values for PCBs and other organochlorines, respectively. Corresponding blank values for PCBs in sediment, oligochaetes and ducks averaged less than 3% of those in the samples. Analytical precision calculated for total PCBs in 9 replicate duck samples was 6.48% RSD. For 11 replicate analyses of an Aroclor 1254 standard, the precision was 10.8% RSD. The 72 congener values that were summed for total PCBs represented 84% of the true mass, based on later analysis of the same Aroclor 1254 standard. The Aroclor contained 15 more congeners that were not accounted for by standards at the time of analysis.

RESULTS AND DISCUSSION

Characteristics of the 13 duck samples analyzed are given in Table 2 according to Drobney (1983). The content of water, fat and lean dry mass in each case is given as a percentage of the dressed weight (head, feet, feathers and viscera removed). Most of the variation in dressed weight was due to differences in fat and water content; the percentage of lean dry mass, largely protein, was relatively constant at 21.5 - 28.2% of dressed weight. We also measured lipid (fat) dry weight for an aliquot of the crude extract used for organochlorine analysis. This value was used here to express the concentration of contaminants per unit lipid. Comparison of these two sets of lipid measurements per unit of tissue showed agreement within 9% of the lower value, despite the difference in extraction solvents used (Methods and Table 2).

Table 3 summarizes the concentrations of various organochlorines, including total PCBs, in ducks and other compartments of the Mud Island system. The water, seston, sediment and oligochaete values represent composites of samples collected over a 5-month period. For carp (n=9) and ducks (n=13) the mean and standard deviation are shown, along with the range and percent occurrence of each contaminant. The total PCB values represent a summation of congener concentrations: 72 different congeners were quantitated in carp, and 68 in ducks. The variability of total PCB concentrations in carp and duck species, expressed as %RSD, was: carp, 48.5; lesser scaup, 47.2; greater scaup, 17.3; goldeneye, 23.6.

Mean concentrations of total PCB adjusted for lipid (PCB/% lipid) in ducks were: lesser scaup, 79 mg/kg; greater scaup, 89 mg/kg; goldeneye, 38 mg/kg. Although total PCB values were higher for both scaup species relative to goldeneye, the survey of gut contents from 169 ducks (Table 1) indicates that a higher proportion of animal matter, mainly oligochaetes, was consumed by goldeneyes. However, the gut contents were not available for organochlorine analysis. The seston PCB concentration in the water column (5.2 mg/kg) suggests a greater input of PCBs to the bottom than was indicated by the concentration in sediment (0.63 mg/kg).

At lower concentrations alpha- and gamma-BHC (hexachlorocyclohexane) had a distribution similar to that of PCB in the carp and ducks (Table 3). Hexachlorobenzene concentrations were relatively high in ducks, and particularly in goldeneyes (mean, 1.7 mg/kg). Cis- and trans-chlordanes were found in scaup ducks (means, 0.0025 - 0.0097 mg/kg), but not in goldeneyes. Concentrations of cis- and trans-nonachlor (means, 0.013 - 0.33 mg/kg) were measured in most ducks of all three species. Of the DDT group, 4,4'-DDE levels were highest (means, 0.48 - 1.3 mg/kg), especially in greater scaups. Other organochlorines that occurred less consistently were beta- and delta-BHC, heptachlor epoxide, and alpha- and gamma-chlordane. All standards of organochlorines reported here were shown to be stable under the acid conditions used to clean extracts (Murphy, 1972)

High resolution gas chromatography/mass spectroscopy analysis, applied to extracts of a female greater scaup (no. 50) and female goldeneye (no. 1) by Kuehl (EPA/ERL-Duluth, 1983, personal communication), confirmed the presence of trichlorobiphenyls through nonachlorobiphenyls, cis- and trans-chlordane, cis- and trans-nonachlor, 4,4'-DDE and hexachlorobenzene, other chlorinated benzenes, and octachlorostyrene. Low levels of chlorinated cyclohexanes (alpha-, beta-, gamma-, and delta-BHC) and heptachlor epoxide, reported here, were not confirmed by mass spectroscopy.

Concentrations of the individual congeners comprising PCB mixtures in sediment, oligochaetes, carp and ducks from Mud Island are shown in Table 4. Included are the homolog values representing groups of congeners with two to nine chlorines per molecule. Congeners in Table 4 are identified by their structures and by peak numbers (Ballschmiter and Zell, 1980). The percent composition by congener of PCBs in all 13 ducks is summarized in Fig. 2. Only 18 of the 72 congeners reported accounted for 90% of the total PCB mass in scaups and goldeneyes combined.

The advantages of congener-specific analysis of PCBs have been widely recognized (Mullin et al., 1984; Mullin, et al., 1983; Duinker et al., 1980; Ballschmiter and Zell, 1980). One important benefit is that concentrations of potentially toxic congeners can be measured individually. Toxicities measured with respect to the induction of aryl hydrocarbon hydroxylase (AHH) enzymes and other effects have been reported (Safe et al., 1982), and structural characteristics of these congeners are known (Ballschmiter et al., 1978).

Among the potentially more toxic PCB congeners which occur as major components in ducks, oligochaetes, carp and sediments from Mud Island are 9 tri-, tetra-, penta-, hexa- and heptachlorobiphenyls (Table 4, asterisks). These account for averages of 28.3% of the total PCB mass in lesser scaups, 31.0% in great scaups and 36.8% in goldeneyes. In each species, over 84% of this fraction is represented by only three congeners: 2,3',4,4',5-pentachlorobiphenyl, 2,2',3,4,4',5'-hexachlorbiphenyl and 2,2',3,3',4,4',5-heptachlorobiphenyl. These congeners, respectively, caused embryotoxicity in chickens (Ax and Hansen, 1975), accumulation of rat liver porphyrins (Stonard and Grieg, 1976) and AHH enzyme induction (Parkinson and Safe, 1981).

Previous work (Haseltine and Prouty, 1980; Custer and Heinz, 1980; Heath et al., 1972) has indicated that ducks may be relatively insensitive to environmental levels of PCBs. However, in any study which relates exposure to effects it is relevant to know the bioaccumulated levels of specific congeners in addition to that of total PCBs. The more toxic congeners among hexa- and heptachlorobiphenyls tend to persist and become enriched in fauna (Safe et al., 1982; Ballschmiter et al., 1978), as indicated in Figure 2. At a given level of total PCBs, concentrations of the more toxic components may vary widely among different organisms.

The proportions of congeners were notably different for PCB mixtures in sediment and various fauna from Mud Island. These differences were most apparent when the congener concentrations in fauna were grouped by homolog and expressed as ratios to the corresponding values for sediment. The resulting distribution coefficients (K_d) were plotted for oligochaete/sediment, carp/-sediment and ducks/sediment (Fig. 3). The K_d values for oligochaete/sediment range near unity, indicating that in oligochaetes there was little, if any, biomagnification of sediment PCBs as a whole. However, the plot for oligochaetes shows relatively lower concentrations of tri- through pentachlorobiphenyls and slightly higher levels of hepta- and octachlorobiphenyls than in sediment. In contrast, the carp and duck K_d plots (mean values) indicate much greater elevations of PCB levels over those in sediment. The K_d values for carp homologs ranged from 11 for trichlorobiphenyls to 47 for octachlorobiphenyls. In ducks the range was much greater, from 2.7 from dichlorobiphenyls to 43 for octachlorobiphenyls. Apparently in ducks there was more selective bioaccumulation and/or retention of the heavier, more chlorinated congeners than in carp or oligochaetes.

Although the source of PCBs in oligochaetes was clearly the Mud Island sediment they inhabited, it is less certain where carp and ducks obtained the bulk of their PCB content. Carp may experience varying exposures to PCBs through feeding within different areas of the Detroit River system. However, much greater variability of exposures is likely for ducks due to their seasonal migrations and the greater diversity of food items available to them. Further complicating the effects of varying exposure on PCB composition are the biological differences in uptake and accumulation that may occur in different species.

In order to evaluate sediment as a direct source of PCBs in fauna, we sought to identify congeners that appear to be least affected by selective accumulation processes in different organisms. We expected that the ratios of such congeners would provide a basis for comparing PCB mixtures that was independent of concentration differences. As a first step we compared the variability of all PCB ratios in Mud Island samples. Ballschmiter et al. (1978) used a similar approach to identify conservative ratios of "recalcitrant" congeners for purposes of estimating past loadings of PCB Aroclors 1254 and 1260 to the environment. Similarly, we found that six PCB congeners (Fig. 2), occurring in all Mud Island samples, were most often represented in the most consistent ratios, as indicated by their low root mean square error. Three of the six congeners (peak nos. 170, 180 and 183) were major constituents of the samples (Fig. 2). Among 13 ducks studied, the six congeners comprised 22.1 - 34.5% of the total PCB mass. Their structures are shown in Table 4. One compound, 2,2',3,3',4,4',5-heptachlorobiphenyl (peak no. 170), which constitutes 9.5% (mean value) of the PCB mass in 13 ducks, is known to induce hepatic microsomal monoxygenase enzymes of both the PB- and MC-type (Parkinson et al., 1981; Parkinson and Safe, 1981). The capacity of compounds to induce the MC-type or aryl hydrocarbon hydroxylase (AHH) enzymes is thought to be highly correlated with their toxicity (Poland et al., 1979; Safe et al., 1982). Another of the six congeners, 2,2',3,4,4',5,5'-heptachlorobiphenyl (peak no. 180), which comprises 12.0% of the duck PCBs, is also likely to be a AHH inducer based on its structural characteristics (Safe et al., 1982). Two additional congeners, 2,2',3,4,4',5-hexachlorobiphenyl (peak no. 138) and 2,3,3',4,4',5-hexachlorobiphenyl (peak no. 156), which are known to be AHH inducers (Safe et al., 1982), also form consistent ratios with the six compounds above. The combined toxicity and persistence of these congeners increases their potential for adverse effects on ducks and other fauna that bioaccumulate them selectively. Most of the same congeners were prominent in human subjects exposed to PCBs in the Yusho incident (Bandiera et al., 1984).

We used the six congeners to form three non-redundant ratios identified here by their peak numbers as 180/170, 183/172 and 194/195. The magnitude and variability of the ratios in sediment, oligochaetes, carp and ducks were compared as an indication of similarity within and between sample types. The results of a multivariate analysis of variance indicated no significant differences (α = .05) between the 3 ratios in sediment, oligochaetes and 9 carp. However, carp ratios were significantly different (α = .05) from those in the 13 ducks. Within the 3 duck species, the ratio differences were not significant (α = .05).

While these results are very limited, they suggest the following interpretation. We infer that the PCB compositions of both oligochaetes and carp were strongly influenced by exposure to Mud Island sediment since their ratios were very similar. The different ratios which occurred in ducks suggest that their PCBs were derived from other sources as well. Also, the ducks were collected two years prior to the other samples. However, the striking consistency of these ratios among the 3 species of migratory ducks suggests a different explanation: that their PCBs were largely from a common source (possibly Mud Island sediment), but were proportioned differently as a group by more selective uptake and/or retention of congeners. Their distinctive pattern may be seen in the plots of homolog distribution coefficients described earlier (Fig. 3). The duck PCBs were consistently more enriched in hexa-, hepta- and octachlorobiphenyls than were PCBs in other system compartments, including water and seston.

In order to investigate the possible influence of accelerated fat metabolism on the PCB content of wintering ducks, we examined the relationship between PCB concentrations in lipid and the percentage of lipid in 13 duck carcasses during the February-March period. Tissue composition data collected for all 169 Detroit River scaups and goldeneyes (Drobney, 1983) indicated that the ratio of fat/lean dry mass declined during the January-March period (Fig. 4). Most of the decline occurred in January, and reached a plateau in mid-February for the population as a whole. A smaller increase in percent fat than occurred during late February through early March. The latter trend may have represented an increase in the number of transient birds with higher fat content, or improved feeding conditions. Also, it may be explained by a relative decrease in lean dry mass, as occurs in other wintering duck species (Reinecke et al., 1982; Peterson and Ellarson, 1979). However, this tendency toward increasing fat/lean mass was not apparent in the subset of 13 ducks that we analyzed (Fig. 4).

We used a linear regression analysis to relate the concentration of PCBs in lipid to the percentage of lipid in 13 carcasses (lipid/wet weight). This analysis was applied to both total PCB mass and the fraction of 6 congeners that were selected as most conservative. The results (Fig. 5) showed that concentrations of both were inversely correlated to percent lipid ($r = 0.76$ and 0.71, respectively). Moreover, the 6-congener fraction (PCB_f) as a percentage of total PCBs (PCB_t) appeared to increase as the percent lipid declined. Based on the regression lines, PCB_f/PCB_t would be predicted to increase slightly from 0.25 at 25% lipid to 0.31 at 5% lipid. In other words, PCBs as a whole behaved somewhat less conservatively than the 6-congener fraction during this period.

Stickel (1973) noted that, despite cyclic increases in lipid metabolism, losses of fat-soluble contaminants in birds are usually slow. White et al. (1981) attempted a similar regression analysis of DDE and dieldrin with percent lipid in wintering blue-winged teal, but the results were not significant due to the low concentrations of pesticides present.

CONCLUSIONS

Wintering scaup and goldeneye ducks which foraged on contaminated sediments near Mud Island in the lower Detroit River, were exposed to organochlorines, including sediment PCB concentrations on the order of 0.63 mg/kg. Similar concentrations were found in benthic oligochaetes, confirmed two years earlier as a major component of duck diets at this site. Body burdens of PCBs in the ducks, ranging from 2.7 to 20 mg/kg in the carcass and from 38 to 89 mg/kg in the lipid fraction, were high relative to 1979 means of <1 mg/kg for wing pools of mallards and black ducks from the Atlantic flyway (Cain, 1981). They also exceeded most 1979-1980 levels of PCB in 17 species of dabbling and diving ducks, including greater scaups and goldeneyes, from New York state (Kim et al., 1984). Levels in Detroit River ducks were more comparable to those in greater scaup and goldeneyes wintering on the Baltic Sea (Falandysz and Szefer, 1982). Adult carp from Mud Island contained slightly higher PCB levels of 7.6 to 31. mg/kg. Total PCB levels in all ducks and carp from Mud Island exceeded the 2 mg/kg guideline for edible fish established by the U.S. Food and Drug Administration (1984).

The composition of PCB mixtures in Mud Island ducks, and that in sediment, oligochaetes and carp, followed two distinct patterns. While all of the fauna accumulated larger fractions of the more chlorinated PCBs than did sediment, the highest proportion of hepta- and octachlorobiphenyls was in ducks. This fraction included 6 congeners which formed consistent ratios in the sediment and fauna. Multivariate analysis of variance indicated a significant difference (α = .05) between 3 ratios formed from the 6 congeners in carp and in ducks. There was no significant difference among the 3 duck species.

The greater enrichment of heavier PCB congeners in ducks may have resulted from a more selective process of bioaccumulation and/or from dietary exposure to different PCB sources elsewhere. On the other hand, the similarity of homolog ratios in all 3 duck species suggests exposure to one dominant source of PCBs, possibly Detroit River sediments.

For the 13 ducks, lower fat content was correlated (α = .05) with higher PCB concentrations over a two month period. Since the proportion of 6 conservative congeners in total PCBs increased by 6% as predicted fat levels decreased from 25% to 5%, fat mobilization seemed to have some effect on PCB composition. To the extent that differential loss of less persistent PCBs occurred during fat loss, an increase in the ratio of the 6 congeners to total PCBs was expected.

Some of the principal organochlorines observed in sediment, oligochaetes, carp and ducks from Mud Island were compounds of documented toxicity. These included pesticides as well as 9 PCB congeners that comprised roughly a third of the total PCB mass in ducks. Among the latter were congeners which induce aryl hydrocarbon hydroxylase (AHH) enzymes in the manner of other known toxins (Safe, 1980). Any toxicity of these to scaup and goldeneye ducks remains unknown. Although we are not aware of any adverse conditions among Detroit River ducks which might be attributed to contaminant exposures, such effects would seem more likely to occur when ducks are stressed by cold weather and starvation. It is important to recognize that the contaminants reported here in ducks are likely to represent only part of their total exposure to potentially toxic substances, both organic and inorganic, which occur in Detroit River sediments. Due to biological mixing of recent sediments these substances continue to be available to bottom-feeding ducks and other fauna. As game species, scaups and goldeneyes contaminated by Detroit River sediments may also present a hazard to human populations throughout their extensive flyway.

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LIST OF FIGURES

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FIG. 1

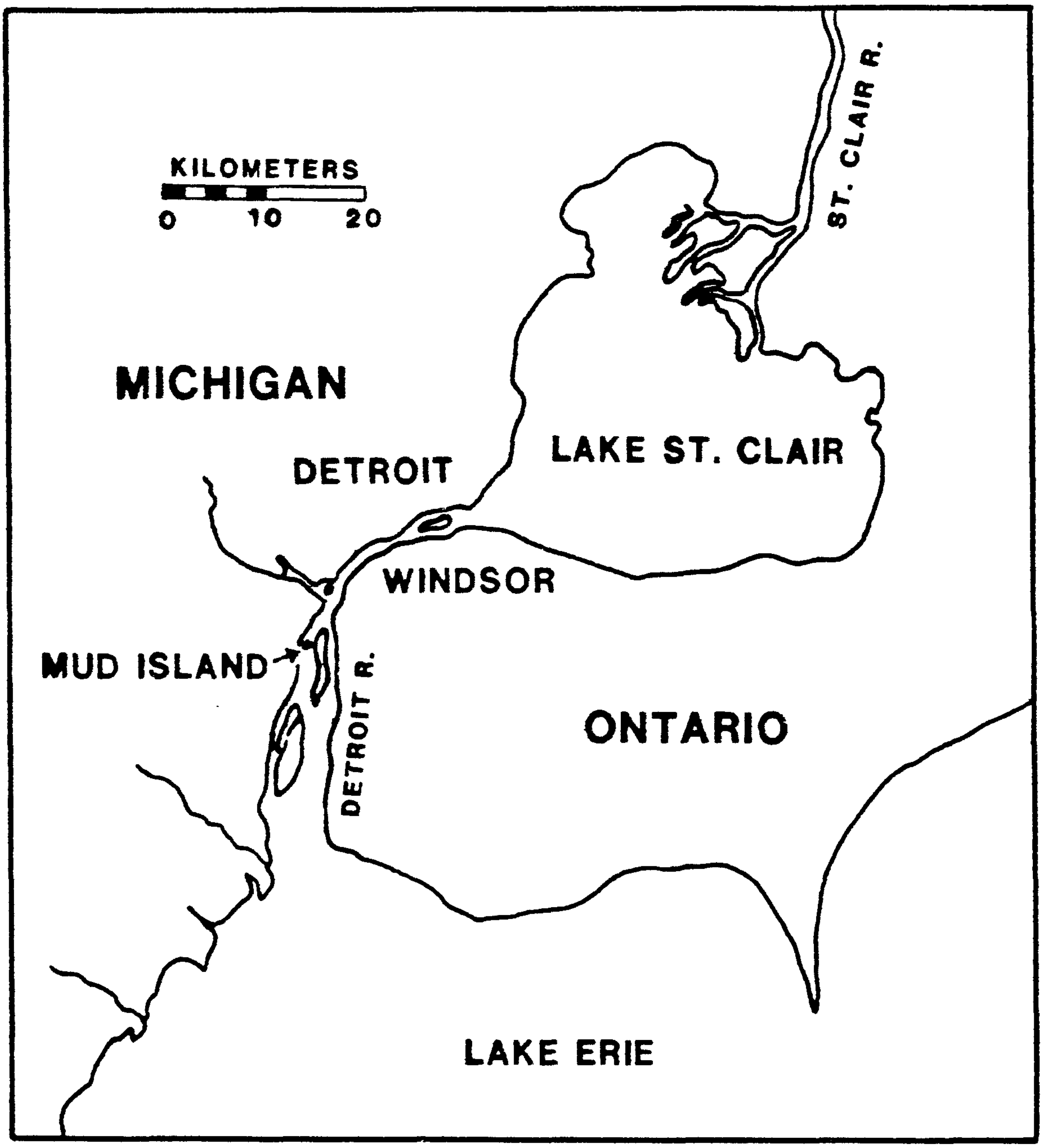

KILOMETERS
0
10
20
MICHIGAN
DETROIT
LAKE ST. CLAIR
ST. CLAIR R.
WINDSOR
MUD ISLAND
DETROIT R.
ONTARIO
LAKE ERIE

FIG. 2

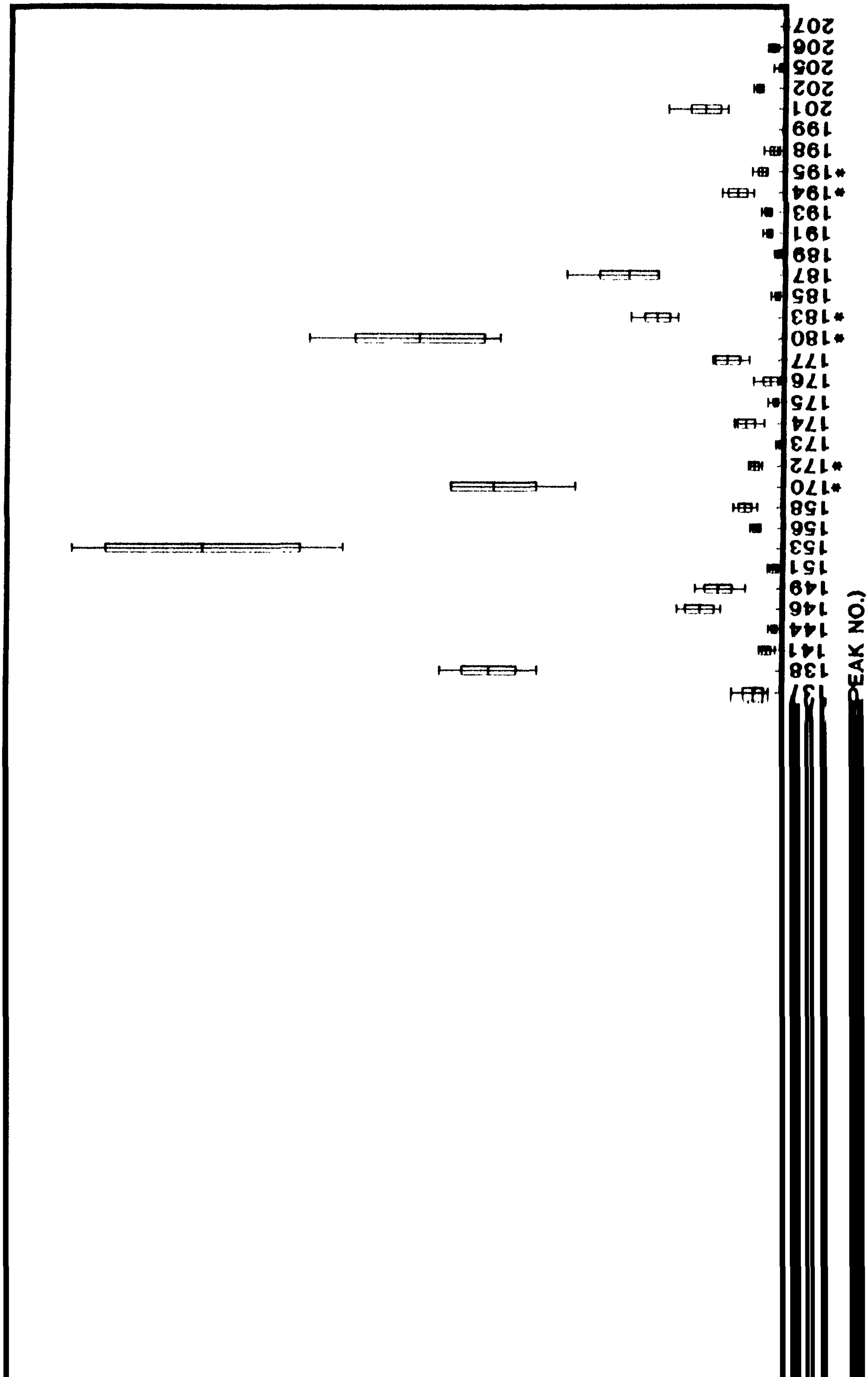

207
206
205
202
201
199
198
*195
*194
193
191
189
187
185
*183
*180
177
176
175
174
173
*172
*170
158
156
153
151
149
146
144
141
138
137
PEAK NO.)

FIG. 3

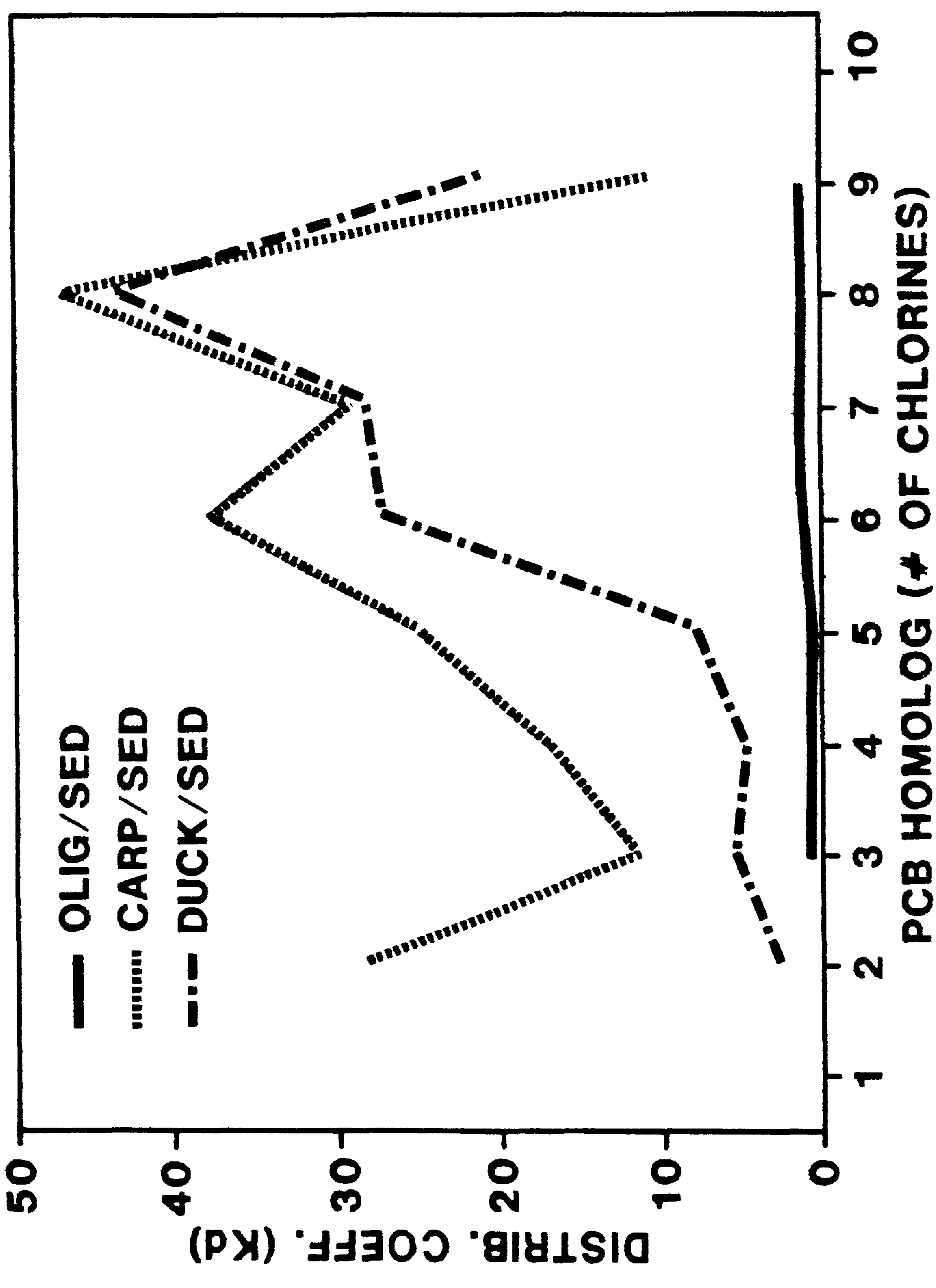
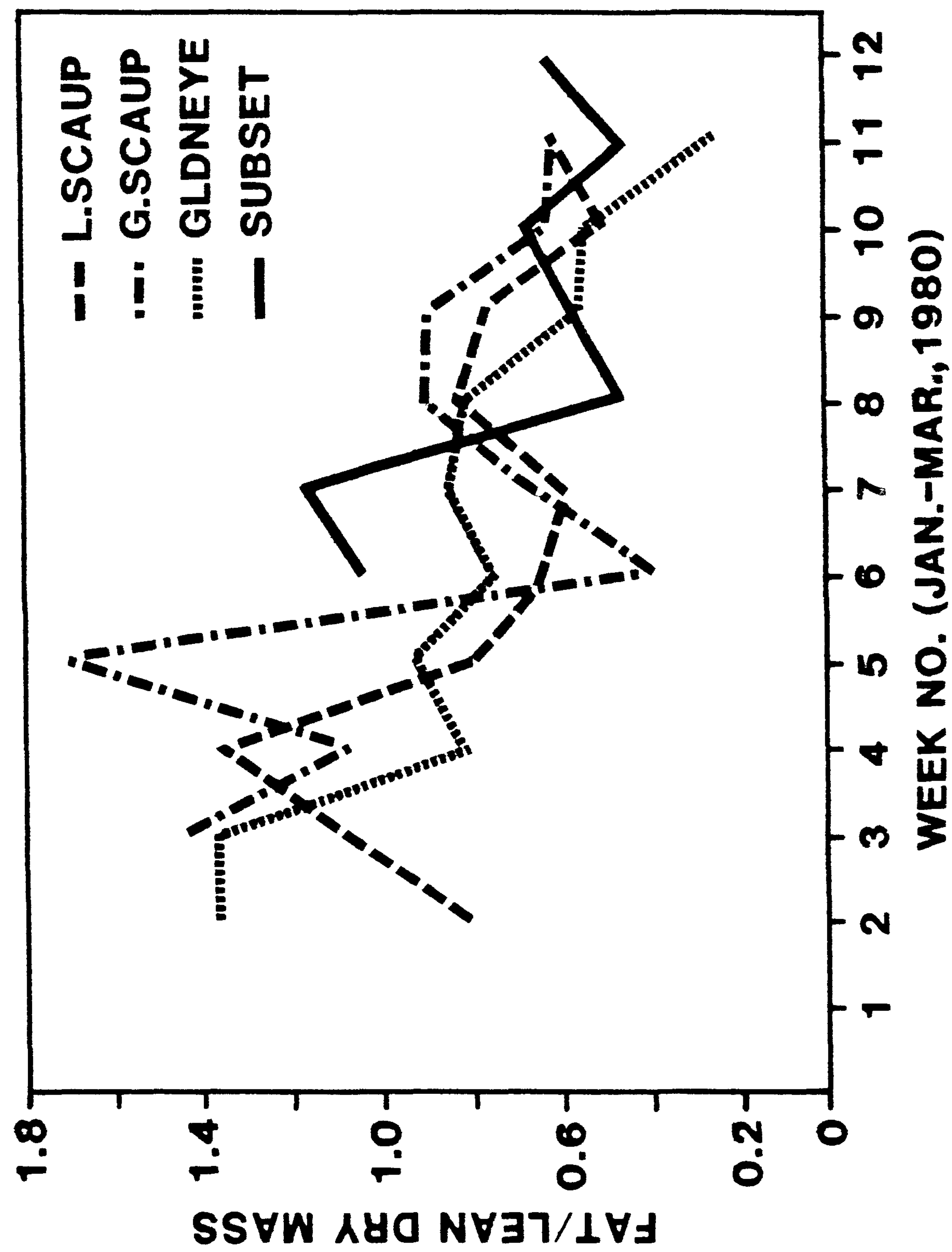
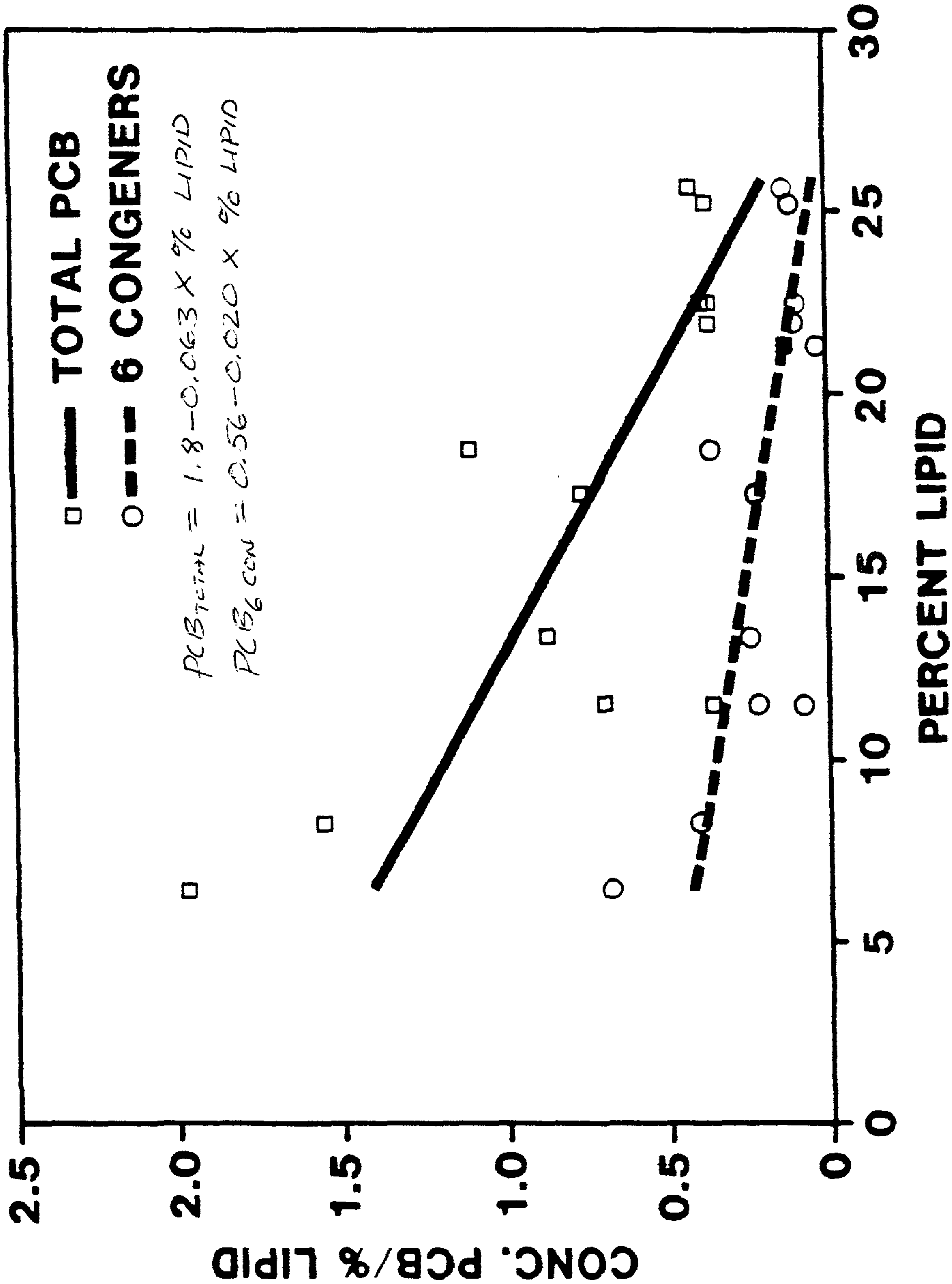

OLIG/SED
CARP/SED
DUCK/SED
PCB HOMOLOG (# OF CHLORINES)
DISTRIB. COEFF. (Kd)
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10

FIG. 4



L.SCAUP
G.SCAUP
GLDNEYE
SUBSET
FAT/LEAN DRY MASS
1.8
1.4
1.0
0.6
0.2
0
WEEK NO. (JAN.-MAR.,1980)
1
2
3
4
5
6
7
8
9
10
11
12

FIG. 5



TOTAL PCB
6 CONGENERS
PCB TOTAL = 1.8 - 0.063 X % LIPID
PCB 6 CON = 0.56 - 0.020 X % LIPID
PERCENT LIPID
0
5
10
15
20
25
30
CONC. PCB/% LIPID
0
0.5
1.0
1.5
2.0
2.5

TABLE 1

	MALE	FEMALE	BOTH
COMMON GOLDENEYE *Bucephala clangula*	27.3 (72.6)	44.0 (55.9)	35.6 (64.8)
LESSER SCAUP *Aythya affinis*	24.6 (75.3)	33.1 (66.9)	27.9 (72.1)
GREATER SCAUP *Aythya marila*	12.7 (87.3)	28.4 (71.6)	18.6 (81.6)

TABLE 2

SPECIES	COLL. NO.	WK COLL.*	AGE/ SEX	TOTAL WT. (G)	DRESSED WT. (G)[1]	% WATER[2]	% FAT[3]	% LEAN DRY MASS[4]
LESSER SCAUP *Aythya affinis*	8	7	jv. F	969.9	710.4	54.2	23.3	22.5
	13	7	jv. F	1029.1	746.8	51.0	27.5	21.5
	53	10	ad. F	974.5	787.8	54.5	18.6	26.9
	59	11	ad. F	778.7	487.2	65.4	6.7	28.0
	72	12	ad. F	710.4	528.2	59.9	13.3	26.8
	79	12	jv. F	714.9	519.1	62.4	12.0	25.6
	82	12	ad. F	710.4	482.7	51.8	23.5	24.7
GREATER SCAUP *Aythya marila*	47	10	ad. F	910.7	601.1	62.9	8.9	28.2
	50	10	ad. F	1006.3	614.7	54.4	22.8	22.8
	66	11	jv. M	969.9	642.1	57.7	17.2	25.1
GOLDENEYE *Bucephala clangula*	1	6	ad. F	796.9	555.5	54.8	23.0	22.2
	2	7	jv. M	1293.2	979.0	49.9	27.3	22.8
	29	8	jv. F	860.6	592.0	62.2	11.9	25.9

[1] Wet weight minus head, feet, feathers and viscera

*Weeks 1-12 are Jan.-March 1980

[2] Recovered by freeze drying.

[3] Recovered by petroleum ether extraction.

[4] Remaining after water and fat extracted.

TABLE 3

COMPOUND	COMPOSITES				CARP	DUCKS		
	WATER ng/ℓ (n=1)	SESTON mg/kg (n=1)	SEDIMENT mg/kg (n=1)	OLIGO-CHAETES mg/kg (n=1)	*Cyprinus carpio* mg/kg (n=9)	LESSER SCAUP *Aythya affinis* mg/kg (n=7)	GREATER SCAUP *Aythya marila* mg/kg (n=3)	GOLDENEYE *Bucephala clangula* mg/kg (n=3)
Total PCB	45.	5.2	0.63	0.44	16.±7.7(100) 7.6 to 31.	10.±4.9(100) 2.7 to 20.	11.±2.0(100) 8.3 to 13.	7.6±1.8(100) 4.2 to 11.
Hexachlorobenzene	0.75	0.22	0.0031	0.0036	0.10±0.043 (100) 0.028 to 0.17	0.33±0.12(100) 0.15 to 0.77	0.37±0.17(100) 0.16 to 0.78	1.7±1.2(100) 0.16 to 4.8
Alpha BHC	12.	0.041	0.0002	0.0019	0.045±0.018 (100) 0.016 to 0.072	0.016±0.013(71) 0.0046 to 0.039	0.013±0.0050(100) 0.0044 to 0.023	0.0098±0.0041(100) 0.0044 to 0.017
Beta BHC	0.11	0.0089	0.0003	-	0.0023(11)	0.013±0.0031(43) 0.0085 to 0.016	0.012±0.0019(100) 0.0086 to 0.015	-
Gamma BHC (Lindane)	1.4	0.012	-	-	0.0063±0.0036(100) 0.0028 to 0.016	0.0050±0.0021(43) 0.0024 to 0.0075	0.0016±0.0004(67) 0.0011 to 0.0022	0.0020(33)
Delta BHC	0.064	0.023	-	-	0.0012(11)	-	0.0024(33)	-
Heptachlor Epoxide	0.056	0.0045	-	-	0.0037±0.0006(33) 0.0026 to 0.0047	0.014±0.0023(29) 0.011 to 0.017	0.014±0.0015(67) 0.012 to 0.017	-
Trans-Chlordane	0.19	0.031	0.0011	0.0018	0.11±0.041(100) 0.035 to 0.19	0.0025±0.0003(57) 0.0021 to 0.0028	0.0029(33)	-
Cis-Chlordane	0.22	0.028	0.0016	0.0027	0.18±0.072(100) 0.048 to 0.31	0.0097±0.0032(43) 0.0057 to 0.014	0.0048±0.0014(100) 0.0030 to 0.0072	-
Trans-Nonachlor	0.26	0.045	0.0044	0.0024	0.16±0.066(100) 0.077 to 0.26	0.17±0.076(100) 0.056 to 0.28	0.33±0.031(67) 0.28 to 0.37	0.081±0.0071(67) 0.071 to 0.091
Cis-Nonachlor	0.038	0.0068	0.0003	0.0007	0.035±0.014(100) 0.014 to 0.062	0.023±0.0097(100) 0.0034 to 0.054	0.049±0.020(100) 0.025 to 0.074	0.013±0.0089(100) 0.0056 to 0.028
4,4' DDE	0.57	0.10	0.012	0.0059	0.38±0.15(100) 0.21 to 0.74	0.80±0.33(100) 0.29 to 1.2	1.3±0.25(100) 0.84 to 1.6	0.48±0.18(100) 0.29 to 0.72
4,4' DDD	0.85	0.16	0.023	0.015	0.48±0.26(100) 0.16 to 1.1	0.093±0.027(100) 0.039 to 0.16	0.14±0.045(100) 0.070 to 0.18	0.080±0.024(100) 0.061 to 0.12
4,4' DDT	0.39	0.059	0.012	-	0.023±0.012(56) 0.010 to 0.046	0.025(14)	0.040±0.0094(67) 0.027 to 0.054	0.040(33)

Mean ± Standard Deviation (% occurrence)
Range

TABLE 4

PCB CONGENER PEAK #	STRUCTURE	SEDIMENT (1-4 cm) (mg/kg) (n=1)	OLIGOCHAETES (Composite) (mg/kg) (n=1)	CARP *Cyprinus carpio* (mg/kg) (n=9)	LESSER SCAUP *Aythya affinis* (mg/kg) (n=7)	GREATER SCAUP *Aythya marila* (mg/kg) (n=3)	GOLDENEYE *Bucephala clangula* (mg/kg) (n=3)
4	2,2'	0.0065	-	0.66 (11)	-	-	0.077 (33)
7	2,4	0.0019	-	0.015±0.0089 (33) 0.0066 - 0.029	0.015±0.0046 (57) 0.0061 - 0.024	0.014±0.0047 (100) 0.0082 - 0.020	-
	Sum of Di-chlorobiphenyls	0.0084	-	0.24±0.29 (33) 0.0066 - 0.69	0.015±0.0046 (57) 0.0061 - 0.024	0.014±0.0047 (100) 0.0082 - 0.020	0.077 (33)
17	2,2',4	0.013	0.0045	0.36±0.69 (100) 0.032 - 2.3	-	-	-
18	2,2',5	0.016	0.0061	0.15±0.14 (100) 0.025 - 0.52	-	0.036 (33)	0.041 (33)
22	2,3,4'	0.0028	0.0016	0.022±0.015 (100) 0.0064 - 0.056	0.0053±0.0004 (29) 0.0047 - 0.0059	-	-
26	2,3',5	0.0033	-	0.065±0.095 (100) 0.012 - 0.33	0.0032 (14)	0.0064 (33)	0.0098 (33)
31	2,4',5	0.044	0.025	0.36±0.30 (100) 0.084 - 1.2	0.63±0.28 (71) 0.31 - 1.1	0.71±0.15 (67) 0.50 - 0.93	0.45±0.13 (100) 0.23 - 0.68
33	2',3,4	0.013	0.0072	0.092±0.052 (100) 0.036 - 0.21	0.018±0.0058 (100) 0.0090 - 0.026	0.0216±0.0057 (100) 0.013 - 0.026	0.029 (33)
	Sum of Tri-chlorobiphenyls	0.092	0.045	1.0±1.3 (100) 0.022 - 4.6	0.47±0.34 (100) 0.20 - 1.1	0.51±0.37 (100) 0.026 - 0.94	0.48±0.11 (100) 0.27 - 0.68
40	2,2',3,3'	0.0052	-	0.041±0.024 (89) 0.0080 - 0.091	-	0.014 (33)	0.012 (33)
42	2,2',3,4'	0.0071	0.0034	0.098±0.075 (100) 0.021 - 0.26	0.0083 (14)	-	0.0098 (33)
43	2,2',3,5	0.0010	-	0.021±0.013 (89) 0.0090 - 0.050	-	0.011 (33)	-
44	2,2',3,5'	0.017	0.0078	0.26±0.17 (100) 0.10 - 0.63	0.013±0.0004 (29) 0.012 - 0.013	0.010±0.0039 (67) 0.0048 - 0.016	-
45	2,2',3,6	0.0030	0.0020	.046±0.038 (100) 0.012 - 0.14	-	-	-
46	2,2',3,6'	0.0017	0.0013	0.013±0.0082 (56) 0.0058 - 0.028	0.011 (14)	-	-
47	2,2',4,4'	0.0048	0.0031	0.14±0.11 (100) 0.027 - 0.41	0.12±0.083 (100) 0.027 - 0.28	0.10±0.039 (100) 0.063 - 0.16	0.063±0.017 (100) 0.029 - 0.091
48	2,2',4,5	0.0038	0.0018	0.058±0.018 (44) 0.025 - 0.11	0.023±0.0021 (29) 0.020 - 0.026	0.045 (33)	0.0088 (33)
49	2,2',4,5'	0.014	0.0072	0.34±0.22 (100) 0.14 - 0.79	0.039±0.024 (100) 0.014 - 0.085	0.030±0.0069 (100) 0.019 - 0.046	0.022±0.0064 (67) 0.013 - 0.032
52	2,2',5,5'	0.021	0.012	0.47±0.31 (100) 0.17 - 1.0	0.048±0.024 (100) 0.014 - 0.082	0.038±0.0081 (67) 0.027 - 0.049	0.021±0.0054 (67) 0.014 - 0.029
53	2,2',5,6'	0.0053	0.0025	0.048±0.041 (44) 0.016 - 0.12	-	-	0.0091 (33)
63	2,3,4',5	0.0010	-	0.028±0.018 (89) 0.010 - 0.062	0.030±0.015 (100) 0.013 - 0.058	0.030±0.0035 (100) 0.023 - 0.036	0.024±0.0046 (100) 0.020 - 0.031
64	2,3,4',6	0.0085	0.0029	0.19±0.12 (100) 0.077 - 0.42	0.014±0.0058 (86) 0.0067 - 0.022	0.011±0.0013 (67) 0.0094 - 0.013	0.010±0.0015 (67) 0.0083 - 0.013
70	2,3',4',5	0.022	0.0087	0.16±0.069 (100) 0.059 - 0.30	0.046±0.026 (100) 0.011 - 0.093	0.044±0.0050 (100) 0.036 - 0.055	0.039±0.0002 (100) 0.038 - 0.039

Mean ± Standard Deviation (% occurrence) Range

TABLE 4 (CONT.)

PCB CONGENER		SEDIMENT (1-4 cm) (mg/kg) (n=1)	OLIGOCHAETES (Composite) (mg/kg) (n=1)	CARP *Cyprinus carpio* (mg/kg) (n=9)	LESSER SCAUP *Aythya affinis* (mg/kg) (n=7)	GREATER SCAUP *Aythya marila* (mg/kg) (n=3)	GOLDENEYE *Bucephala clangula* (mg/kg) (n=3)
PEAK #	STRUCTURE						
74	2,4,4',5	0.0086	0.0048	0.23±0.16 (100) 0.095 - 0.62	0.30±0.13 (100) 0.11 - 0.50	0.26±0.027 (100) 0.21 - 0.30	0.19±0.048 (100) 0.15 - 0.26
81*	3,4,4',5	0.0006	0.0003	0.021±0.012 (100) 0.010 - 0.045	0.31±0.017 (100) 0.0046 - 0.053	0.046±0.016 (100) 0.033 - 0.071	0.017±0.0002 (100) 0.016 - 0.017
	Sum of Tetra-chlorobiphenyls	0.12	0.058	2.09±1.3 (100) 0.84 - 4.7	0.64±0.31 (100) 0.22 - 1.2	0.57±0.066 (100) 0.49 - 0.65	0.38±0.048 (100) 0.28 - 0.46
82	2,2',3,3',4	0.0032	0.0006	0.030±0.016 (100) 0.0071 - 0.061	0.0083±0.0041 (86) 0.0031 - 0.014	0.0074±0.0022 (100) 0.0036 - 0.011	0.0097±0.0003 (67) 0.0093 - 0.010
84	2,2',3,3',6	0.014	0.0066	0.32±0.16 (100) 0.17 - 0.62	0.10 (14)	0.053 (33)	0.067 (33)
87	2,2',3,4,5'	0.0098	0.0027	0.21±0.13 (100) 0.096 - 0.51	0.027±0.0018 (29) 0.024 - 0.029	-	-
95	2,2',3,5',6	0.046	0.027	1.2±0.57 (100) 0.62 - 2.2	0.24±0.18 (71) 0.027 - 0.62	0.17±0.026 (100) 0.14 - 0.21	0.15±0.018 (100) 0.14 - 0.18
97	2,2',3',4,5	0.0043	0.0018	0.059±0.030 (100) 0.019 - 0.10	0.015±0.0080 (100) 0.0046 - 0.032	0.013±0.0017 (100) 0.011 - 0.017	0.014±0.0020 (100) 0.0087 - 0.017
100	2,2',4,4',6	0.0013	0.0011	0.0083±0.0040 (56) 0.0038 - 0.014	0.013±0.0072 (71) 0.0060 - 0.027	0.0073 (33)	0.019±0.0004 (67) 0.018 - 0.019
101	2,2,4,5,5'	0.018	0.011	0.52±0.28 (100) 0.28 - 1.1	0.075±0.040 (100) 0.026 - 0.16	0.082±0.012 (100) 0.061 - 0.096	0.062±0.0057 (100) 0.050 - 0.071
114*	2,3,4,4',5	0.0005	-	0.011±0.0050 (78) 0.0055 - 0.021	0.017±0.0077 (100) 0.0045 - 0.030	0.017±0.0037 (100) 0.014 - 0.023	0.010±0.0006 (100) 0.0091 - 0.011
118*	2,3',4,4',5	0.017	0.0069	0.42±0.26 (100) 0.19 - 1.1	0.52±0.26 (100) 0.15 - 0.98	0.59±0.10 (100) 0.48 - 0.73	0.36±0.041 (100) 0.29 - 0.43
119	2,3',4,4',6	0.0007	-	0.015±0.0080 (100) 0.0058 - 0.030	0.012±0.0051 (86) 0.0047 - 0.025	0.021±0.0075 (100) 0.011 - 0.029	0.010±0.0036 (67) 0.0048 - 0.015
	Sum of Penta-chlorobiphenyls	0.12	0.058	2.8±1.4 (100) 1.4 - 5.7	0.91±0.54 (100) 0.20 - 2.0	0.98±0.15 (100) 0.85 - 1.2	0.66±0.067 (100) 0.55 - 0.78
128*	2,2',3,3',4,4'	0.0046	0.0021	0.13±0.064 (100) 0.058 - 0.26	0.18±0.094 (100) 0.040 - 0.34	0.24±0.054 (100) 0.18 - 0.31	0.13±0.036 (100) 0.086 - 0.18
129	2,2',3,3',4,5	0.0009	0.0006	0.029±0.014 (100) 0.014 - 0.060	-	-	-
131	2,2',3,3',4,6	-	-	0.30±0.081 (22) 0.19 - 0.42	0.089±0.030 (71) 0.030 - 0.15	0.17 (33)	0.054 (33)
134	2,2',3,3',5,6	0.0015	0.0009	0.041±0.019 (100) 0.022 - 0.078	-	-	-
136	2,2',3,3',6,6'	0.0088	0.0034	0.19±0.075 (100) 0.11 - 0.31	0.016 (14)	0.021 (33)	-
137	2,2',3,4,4',5	0.0026	0.0075	0.073±0.031 (100) 0.040 - 0.14	0.091±0.053 (100) 0.015 - 0.19	0.13±0.021 (67) 0.10 - 0.16	0.062±0.012 (100) 0.052 - 0.080
138*	2,2',3,4,4',5'	0.027	0.026	1.0±.66 (100) 0.37 - 2.66	0.95±0.40 (100) 0.23 - 1.6	1.3±0.055 (67) 1.3 - 1.4	0.71±0.13 (100) 0.40 - 0.92
141	2,2',3,4,5,5'	0.0075	0.0063	0.28±0.15 (100) 0.12 - 0.58	0.040±0.016 (100) 0.014 - 0.060	0.063±0.021 (100) 0.033 - 0.084	0.035±0.0056 (100) 0.025 - 0.045
144	2,2',3,4,5',6	0.0055	0.0036	0.20±0.10 (100) 0.094 - 0.41	0.019±0.0083 (100) 0.0071 - 0.035	0.022±0.0033 (100) 0.017 - 0.030	0.020±0.0024 (100) 0.017 - 0.024
146	2,2',3,4',5,5'	0.0054	0.0045	0.23±0.11 (100) 0.095 - 0.44	0.27±0.14 (100) 0.052 - 0.50	0.36±0.078 (100) 0.24 - 0.43	0.19±0.070 (100) 0.09 - 0.31

Mean ± Standard Deviation (% occurrence) Range

TABLE 4 (CONT.)

PCB CONGENER		SEDIMENT (1-4 cm) (mg/kg) (n=1)	OLIGOCHAETES (Composite) (mg/kg) (n=1)	CARP *Cyprinus carpio* (mg/kg) (n=9)	LESSER SCAUP *Aythya affinis* (mg/kg) (n=7)	GREATER SCAUP *Aythya marila* (mg/kg) (n=3)	GOLDENEYE *Bucephala clangula* (mg/kg) (n=3)
PEAK #	STRUCTURE						
149	2,2',3,4',5',6	0.020	0.020	0.88±0.50 (100) 0.37 - 2.0	0.19±0.051 (86) 0.074 - 0.23	0.23±0.047 (100) 0.16 - 0.27	0.16±0.031 (100) 0.089 - 0.21
151	2,2',3,5,5',6	0.0082	0.0091	0.36±0.15 (56) 0.16 - .60	0.025±0.0097 (86) 0.0091 - 0.043	0.021±0.0058 (100) 0.012 - 0.028	0.025±0.0040 (100) 0.018 - 0.032
153	2,2',4,4',5,5'	0.045	0.044	1.9±1.0 (100) 0.75 - 4.1	1.9±0.94 (100) 0.40 - 3.7	2.5±0.50 (100) 1.8 - 2.9	1.4±0.61 (100) 0.66 - 2.5
156*	2,3,3',4,4',5	0.0024	0.0016	0.061±0.024 (89) 0.031 - 0.10	0.090±0.044 (86) 0.021 - 0.17	0.098±0.0091 (100) 0.082 - 0.11	0.064±0.018 (100) 0.043 - 0.094
158*	2,3,3',4,4',6	0.0029	0.0025	0.11±0.044 (79) 0.054 - 0.18	0.11±0.040 (86) 0.031 - 0.16	0.15±0.023 (100) 0.12 - 0.18	0.073±0.015 (67) 0.052 - 0.093
	Sum of Hexa-chlorobiphenyls	0.14	0.13	5.3±2.8 (100) 2.3 - 11.	3.8±1.8 (100) 0.89 - 7.0	4.7±1.4 (100) 2.6 - 5.9	2.9±0.86 (100) 1.5 to 4.4
170*	2,2',3,3',4,4',5	0.031	0.025	0.89±0.49 (78) 0.40 - 1.8	1.0±0.54 (100) 0.20 - 2.1	1.0±0.17 (100) 0.75 - 1.2	0.73±0.23 (100) 0.28 - 1.1
172	2,2',3,3',4,5,5'	0.0026	0.0024	0.082±0.038 (100) 0.033 - 0.14	0.094±0.041 (100) 0.017 - 0.16	0.12±0.018 (100) 0.090 - 0.13	0.060±0.018 (100) 0.027 - 0.091
173	2,2',3,3',4,5,6	0.0002	0.0003	0.011±0.0051 (100) 0.0047 - 0.021	0.0032±0.0017 (57) 0.0014 - 0.0061	0.0029 (33)	0.0055±0.0021 (67) 0.0026 - 0.0084
174	2,2',3,3',4,5,6'	0.013	0.013	0.41±0.20 (100) 0.18 - 0.75	0.10±0.039 (100) 0.036 - 0.14	0.14±0.024 (100) 0.11 - 0.16	0.098±0.017 (100) 0.058 - 0.12
175	2,2',3,3',4,5',6	0.0007	0.0009	0.022±0.0090 (100) 0.012 - 0.038	0.020±0.0078 (86) 0.0044 - 0.029	0.024±0.0051 (100) 0.019 - 0.031	0.019±0.0031 (100) 0.015 - 0.022
176	2,2',3,3',4,6,6'	0.0025	0.0071	0.063±0.030 (100) 0.020 - 0.14	0.035±0.025 (86) 0.0086 - 0.073	0.037±0.021 (67) 0.0068 - 0.067	0.038±0.0075 (100) 0.028 - 0.046
177	2,2',3,3',4',5,6	0.0084	0.0060	0.23±0.11 (100) 0.089 - 0.42	0.18±0.057 (100) 0.049 - 0.23	0.20±0.042 (100) 0.16 - 0.26	0.12±0.033 (100) 0.070 - 0.18
180	2,2',3,4,4',5,5'	0.039	0.031	1.2±0.66 (100) 0.44 - 2.5	1.4±0.79 (100) 0.24 - 3.0	1.3±0.26 (100) 0.86 - 1.7	0.92±0.32 (100) 0.38 - 1.5
183	2,2',3,4,4',5',6	0.014	0.014	0.37±0.18 (100) 0.14 - 0.69	0.44±0.22 (100) 0.090 - 0.86	0.48±0.10 (100) 0.32 - 0.58	0.30±0.082 (100) 0.15 - 0.44
185	2,2',3,4,5,5',6	0.0017	0.0018	0.077±0.038 (100) 0.032 - 0.16	0.015±0.0055 (100) 0.0053 - 0.021	0.020±0.0046 (100) 0.013 - 0.024	0.017±0.0012 (100) 0.016 - 0.019
187	2,2',3,4',5,5',6	0.0092	0.024	0.67±0.38 (100) 0.23 - 1.6	0.51±0.20 (100) 0.15 - 0.82	0.54±0.048 (100) 0.46 - 0.59	0.39±0.096 (100) 0.17 - 0.54
189*	2,3,3',4,4',5,5'	-	0.0006	0.016±0.0084 (100) 0.0067 - 0.034	0.018±0.0071 (100) 0.0041 - 0.030	0.020±0.0038 (100) 0.014 - 0.028	0.014±0.0081 (100) 0.0045 - 0.024
191	2,3,3',4,4',5',6	0.0037	0.0019	0.048±0.021 (100) 0.022 - 0.083	0.052±0.025 (100) 0.010 - 0.096	0.058±0.0098 (100) 0.045 - 0.069	0.032±0.011 (100) 0.016 - 0.051
193	2,3,3',4',5,5',6	0.0014	0.0036	0.054±0.027 (79) 0.023 - 0.11	0.061±0.025 (86) 0.013 - 0.095	0.061±0.0078 (100) 0.048 - 0.071	0.037±0.0090 (100) 0.017 - 0.051
	Sum of Hepta-chlorobiphenyls	0.11	0.12	3.6±2.0 (100) 1.5 - 8.3	3.8±1.9 (100) 0.79 - 7.4	3.8±0.64 (100) 2.7 - 4.6	2.6±0.72 (100) 1.2 - 3.9
194	2,2',3,3',4,4',5,5'	0.0043	0.0034	0.10±0.044 (89) 0.052 - 0.17	0.17±0.10 (100) 0.033 - 0.40	0.15±0.022 (100) 0.11 - 0.19	0.11±0.035 (100) 0.060 - 0.17
195	2,2',3,3',4,4',5,6	0.0022	0.0017	0.056±0.028 (89) 0.026 - 0.11	0.079±0.040 (100) 0.016 - 0.16	0.065±0.0095 (100) 0.049 - 0.081	0.049±0.015 (100) 0.025 - 0.075
198	2,2',3,3',4,5,5',6	0.0013	0.0027	0.030±0.014 (100) 0.014 - 0.055	0.031±0.014 (100) 0.0080 - 0.051	0.034±0.0054 (100) 0.028 - 0.041	0.020±0.0068 (100) 0.0098 - 0.026

Mean ± Standard Deviation (% occurrence) Range