ORGANIC CONTAMINANTS IN FORAGE FISH FROM TORONTO AREA STREAMS

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ORGANIC CONTAMINANTS IN FORAGE FISH FROM TORONTO AREA STREAMS

Report prepared by:

K. Suns and G. Hitchin
Biomonitoring Section
Environmental Monitoring and Reporting Branch

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ABSTRACT

Young-of-the-year forage fish were collected in 1992 from 24 sites in Toronto area streams to determine the bioavailability of organic compounds. Of the 20 compounds analysed, only PCBs, p,p′ DDE and chlordane were detected. Twenty-two of twenty-four (92%) of the sites sampled had forage fish with PCB concentrations that exceeded the IJC Aquatic Life Guideline of 100 ng/g. Shiners collected from the lower Etobicoke Creek, the Humber River and Mimico Creek had significantly ($p<0.05$) higher PCB concentrations than fish from other Toronto area streams. However, the variability of PCB spatial distribution within the majority of streams was high, indicating site-specific PCB enrichments. Total PCB and chlordane residues in recent (1992) fish collections were generally lower than residues in fish collected in the early 1980s. Contaminant residue reductions over time were found to be significant ($p<0.05$) at 44% of the sites sampled for PCB, 29% for DDT and 57% for chlordane.

INTRODUCTION

The Toronto Area Watershed Management Plan (TAWMS) was initiated by the Ontario Ministry of the Environment in 1981 to produce a comprehensive water quality management plan. Mimico Creek and the Humber and Don Rivers were to receive special attention during the investigative phase of the Plan. Subsequent to the TAWMS initiative several other studies sponsored by municipal and provincial jurisdictions have been implemented with a variety of objectives.

As a result of Toronto Waterfront being identified as an Area of Concern by the International Joint Commission, the Metro Toronto Remedial Action Plan (MTRAP) was introduced. The objectives of the MTRAP range from the documentation of existing environmental conditions to developing a remedial action plan for restoration of multiple uses in all watercourses.

In support of the MTRAP and the growing concerns about water quality in Toronto area watersheds, samples of young-of-the-year forage fish were collected from selected sites in streams to document the biological availability of organochlorine contaminants and their trends with time. This report presents spatial and temporal trends of organochlorine contaminant residues in forage fish collected from Etobicoke, Mimico and Highland Creeks, and the Humber, Don and Rouge Rivers for a 12 year interval (1981-1992).

METHODS

Young-of-the-year forage fish were collected by seining from selected sites in Toronto area streams (Fig.1). The majority of collections consisted of common shiners (Notropis cornutus). Longnose dace (Rhinichthys cataractae), fathead minnows (Pimephales promelas), and spottail shiners (Notropis hudsonius) were also collected as alternate species from sites in Mimico Creek, the Don River and Lake Ontario (Tables 1-5). Although data were not available to assess species comparability for fathead minnows, PCB uptake and accumulation for common shiners and longnose dace appeared to be similar. Therefore, data for PCB residues in common shiners and longnose dace were treated interchangeably for statistical evaluations.

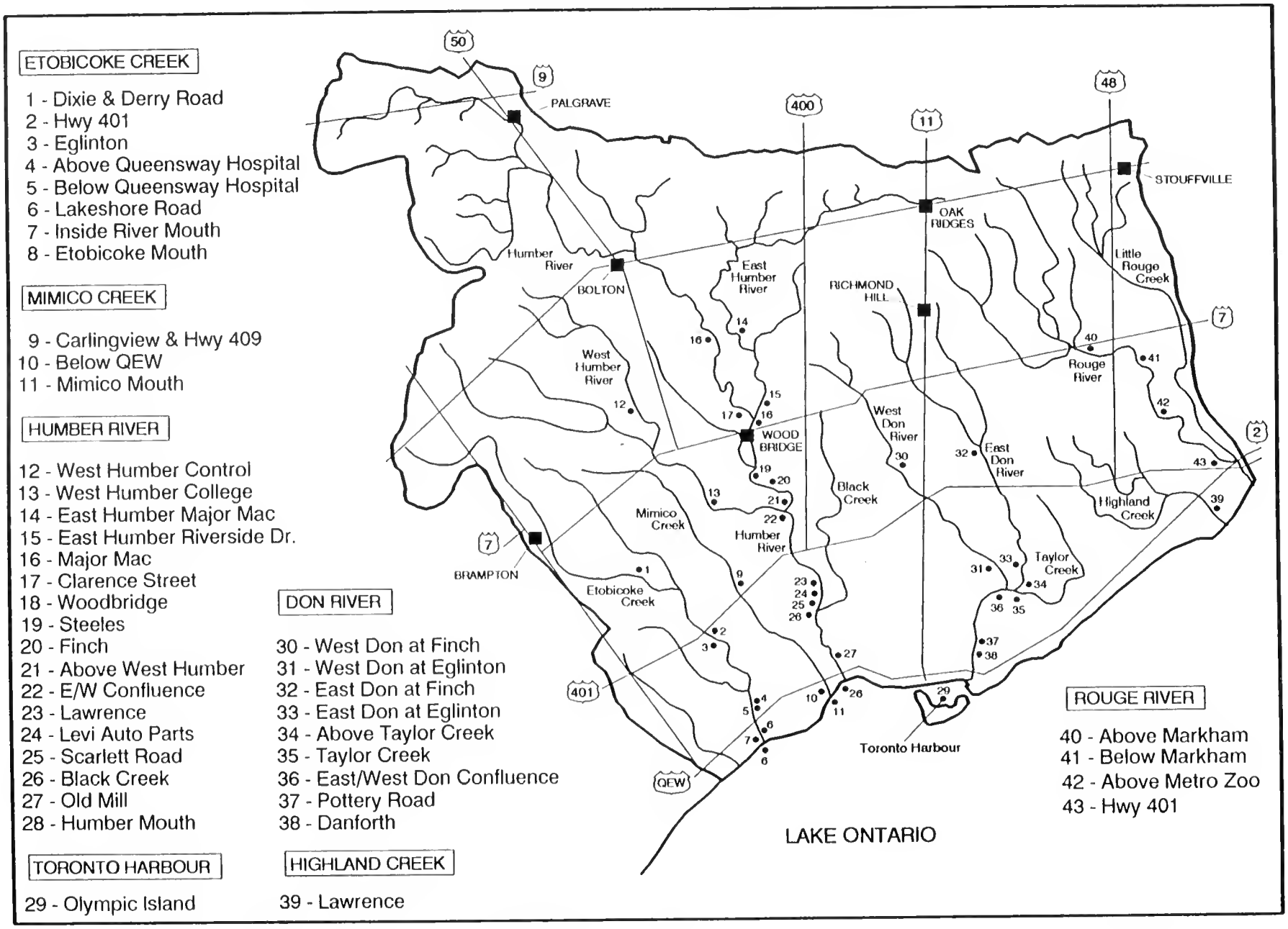
Forage fish were also collected at the mouth of the Humber River to determine the impact of watershed inputs to the nearshore waters of Lake Ontario.

Contaminant concentrations reported in this document were derived from whole fish, composite sample analyses. Each composite sample typically consisted of seven individual fish.

One-Way Analysis of Variance (ANOVA), with Tukey's Multiple Range Test was used to determine statistical significance ($p<0.05$) for spatial comparisons. A minimum of 5 years of data was used as a criterion for selecting data sets for temporal trend assessment using regression analyses. Exponential curves provided the best fit for all the data sets where significant ($p<0.05$) correlations with time were found. Simultaneous statistical analyses were done on lipid-normalized and unadjusted contaminant values for temporal trend assessment. Since similar results were obtained for both data sets, only the unadjusted contaminant values were used in graphical presentations.

The International Joint Commission's Aquatic Life Guidelines (GLWQA 1978), established to protect fish-eating wildlife, were used to assess the significance of contaminant residue accumulations. Fish were analyzed at the Ministry of Environment and Energy's Etobicoke Laboratory. For details of analytical methodology see (Suns et al.1993).

Fig. 1: Juvenile fish sampling sites in Toronto area streams.



RESULTS AND DISCUSSION

Analytical results of the 1992 forage fish survey revealed only PCBs, DDT metabolites and chlordane residues. Furthermore, only PCB residues in fish exceeded the IJC Aquatic Life Guideline of 100 ng/g, adopted for the protection of fish-eating wildlife (Tables 1-5). Therefore, the focus of this report will be on PCBs.

Of the 24 in-stream sites sampled in 1992, twenty-two (92%) had young-of-the-year fish populations with PCB concentrations exceeding the Aquatic Life Guideline (Fig.2). These results show that PCB enrichment was widespread in Toronto area streams. In comparison, only 15 of 37 (41%) Great Lakes nearshore sites sampled in 1991 had forage fish with PCB residues above the guideline. (Suns et al.1993).

A set of fish collections from the lower reaches of streams were used to rank streams according to PCB availability. Shiner samples from Etobicoke Creek, the Humber River and Mimico Creek had significantly ($p<0.05$; ANOVA) higher PCB concentrations than fish from the Don River, Rouge River and Highland Creek (Fig.3A). Considering the persistent nature of organochlorine compounds, it was assumed that fish samples from the lower parts of a stream would most accurately reflect the sum-total of contaminant inputs within each watershed. However, the survey showed that some fish samples from the upper and middle sections of the streams had higher PCB concentrations than samples from downstream locations (Figures 3B-3F). While contaminant residues in fish from downstream locations provided a degree of water quality assessment for stream discharges to Lake Ontario, these samples could not identify or predict upstream sites with PCB enrichment.

Etobicoke Creek

Common shiners collected downstream of the Queensway Hospital had significantly ($P<0.05$; ANOVA) higher PCB concentrations than any other shiner collection from Etobicoke Creek (Fig.3B). Although PCB enrichment at this site has been documented over two consecutive years (1990 & 1992), reasons for it are not known (Table 1). A municipal/industrial landfill site, situated on the east bank of Etobicoke Creek, is adjacent to the fish sampling site. Further investigative work has been initiated by the Municipality of Etobicoke to assess the containment of potential seepage from the landfill (R.Taverner, pers.comm.).

All six common shiner collections from Etobicoke Creek had PCB concentrations in excess of the IJC Aquatic Life Guideline of 100 ng/g (Fig.4). These results show that biologically available PCBs were common in the Etobicoke Creek watershed. It may be concluded that PCB inputs to the nearshore waters of Lake Ontario exist.

Limited data prevented temporal trend assessments in Etobicoke Creek (Table 1; Appendix A).

Fig. 2: Total PCB concentrations (ng/g) in juvenile fish in Toronto area streams in 1992. Approximate location is indicated by street references on left. IJC Aquatic Life Guideline for PCB = 100 ng/g. (N = Not Detected).

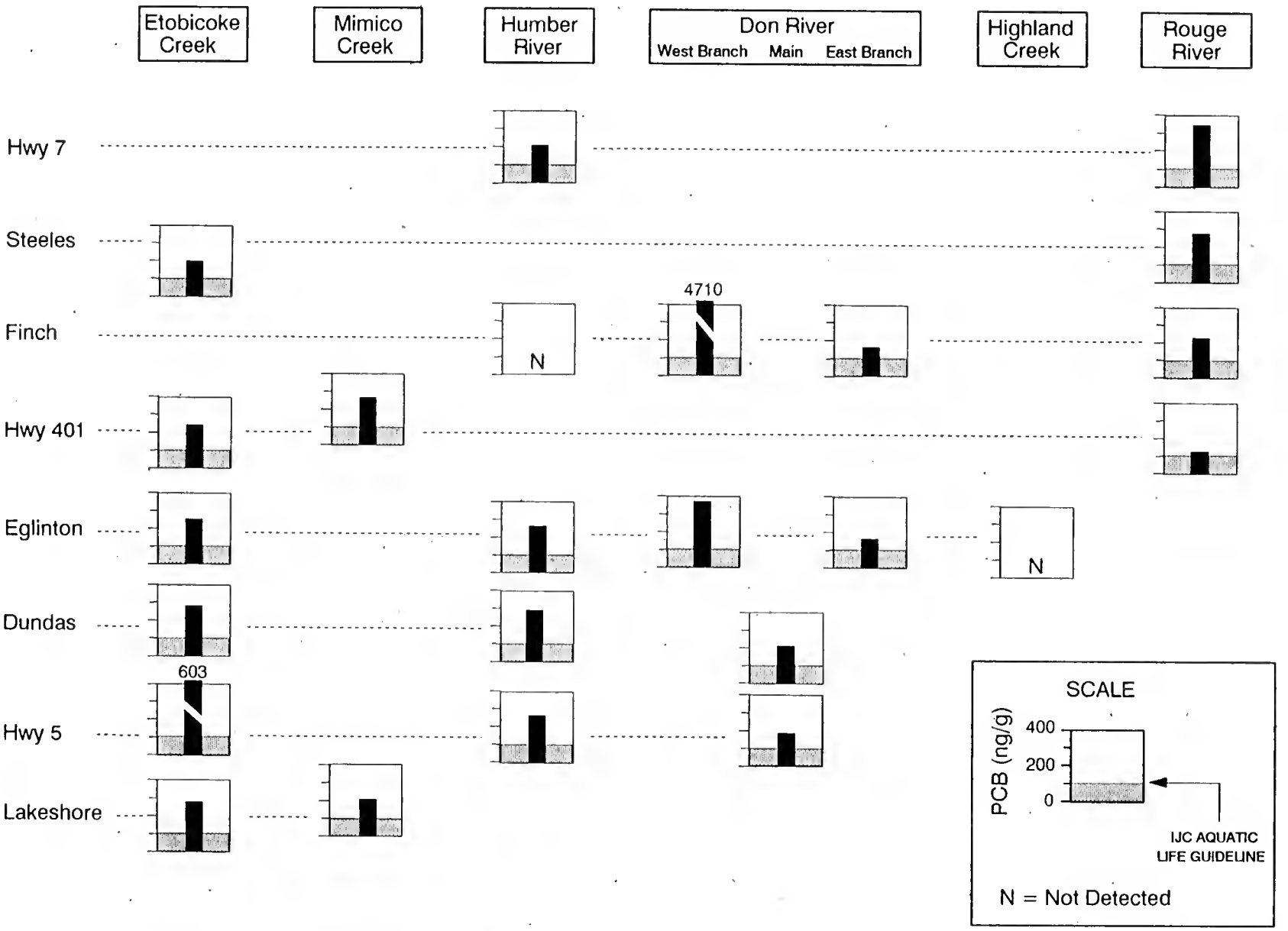


Fig. 3: Site-specific comparison of PCB residues (ng/g) in juvenile fish in Toronto area streams in 1992, using Tukey's multiple range test (95% confidence limits) on log transformed data. All streams are compared using the first station sampled upstream of the river mouth. (■ = common shiner, ▤ = longnose dace, □ = fathead minnow).

Fig. 3A

ALL RIVERS
(first station upstream of river mouth)

RIVER & SITE	MEAN PCB	HOMOGENOUS GROUPS
Highland - Lawrence	ND	■
Rouge - Hwy 401	123	■
Don - Danforth	180	■
Mimico - QEW	248	▤
Humber - Old Mill	255	■
Etobicoke - Lakeshore	269	■

Fig. 3B

ETOBICOKE CREEK

RIVER & SITE	MEAN PCB	HOMOGENOUS GROUPS
Derry Road	193	■
Hwy 401	241	■
Eglinton	246	■
Above Hospital	273	■
Lakeshore Road	269	■
Below Hospital	603	■

Fig. 3C

MIMICO CREEK

RIVER & SITE	MEAN PCB	HOMOGENOUS GROUPS
QEW	248	▤
Carlingview & 409	258	■

Fig. 3D

HUMBER RIVER

RIVER & SITE	MEAN PCB	HOMOGENOUS GROUPS
Finch	ND	■
Woodbridge	202	■
Old Mill	255	■ ■
Scarlett	258	■ ■
Black Creek	283	■

Fig. 3E

DON RIVER

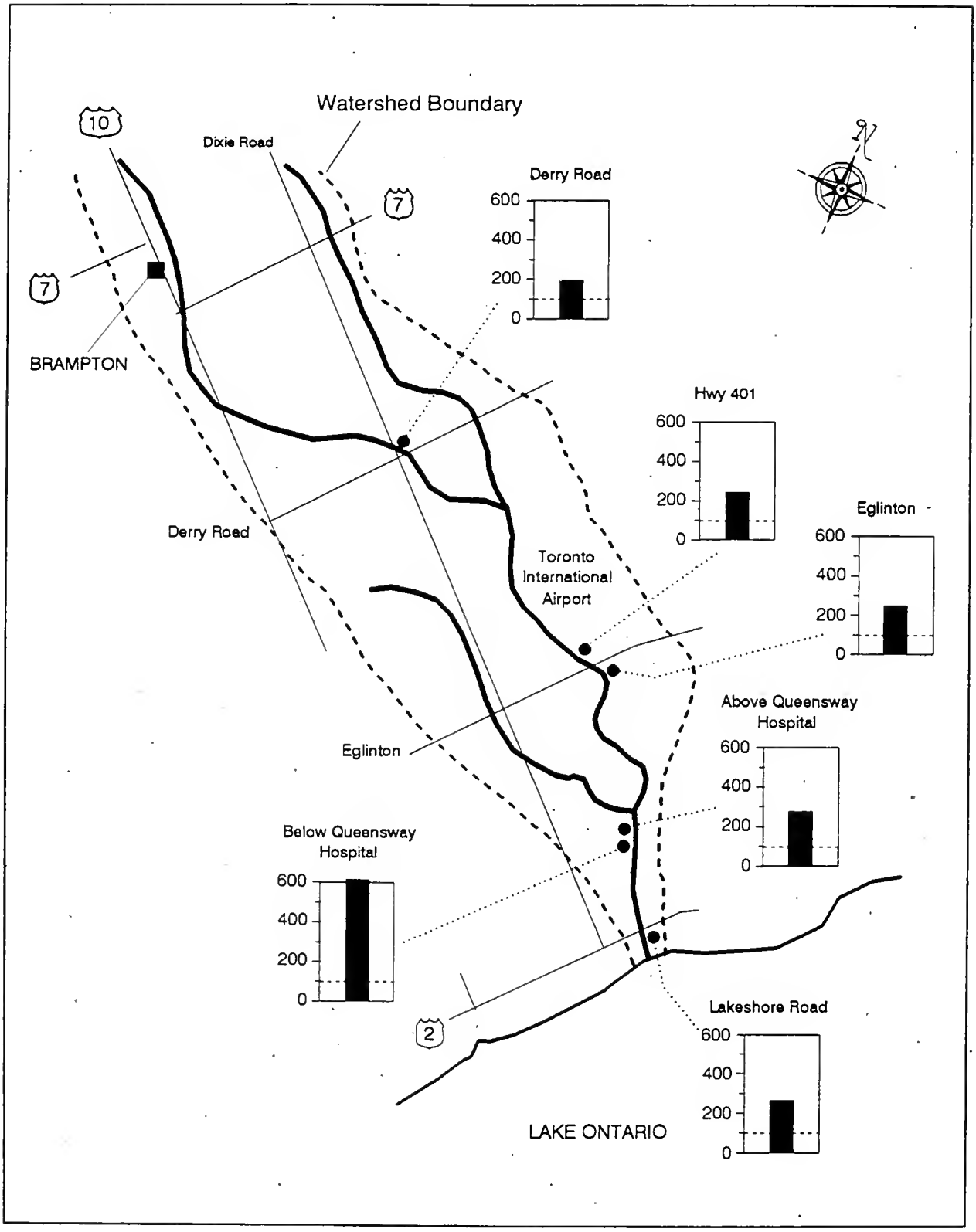
RIVER & SITE	MEAN PCB	HOMOGENOUS GROUPS
Finch (East)	157	■
Eglinton (East)	157	■
Danforth	180	■
Taylor Creek	207	■
Eglinton (West)	360	▤
Finch (West)	4710	□

Fig. 3F

ROUGE RIVER

RIVER & SITE	MEAN PCB	HOMOGENOUS GROUPS
Above Hwy 401	123	■
Above Metro Zoo	218	■
Below Markham	267	■ ■
McCowan	338	■

Fig. 4: Total PCB residues (ng/g) in juvenile common shiners from Etobicoke Creek in 1992. IJC Aquatic Life Guideline for PCB = 100 ng/g.



Mimico Creek

Juvenile fish were not found at most of the sites sampled in Mimico Creek, limiting collectioms to only two sites in 1992.

No significant ($p>0.05$; ANOVA) differences in PCB residues were found at the two sites sampled (Fig. 3C; Fig. 5). However, both fish samples had PCB concentrations in excess of the IJC Aquatic Life Guideline. It is noteworthy that the Metro Toronto RAP Stage I Report states that PCB residues were not found in water sampled from Mimico Creek "using conventional detection levels" (MTRAP 1989). Our results demonstrate the importance of selecting the proper medium for assessing overall impacts of contaminants in the watershed. Based on water sample analyses, one might have concluded that PCBs were virtually absent in the Mimico Creek watershed, yet PCB residues in juvenile fish exceeded the IJC Aquatic Life Guideline.

Only one of the sites sampled in Mimico Creek had sufficient data for temporal trend assessment. Significant ($p<0.05$) PCB and DDT residue declines over time were found in young-of-the-year spottail shiners collected at Lakeshore Road (Fig. 6), Appendix B. These residue reductions in shiners suggest that PCB and DDT inputs from Mimico Creek to Lake Ontario have decreased considerably over the eight year period sampled (1981-1989).

Humber River

Four of five (80%) Humber River sites sampled in 1992 had shiner populations with PCB concentrations above the IJC Aquatic Life Guideline (Fig. 7). Common shiners collected from the Finch Avenue Park site had significantly ($p<0.05$; ANOVA) lower PCB concentrations than any other shiner samples collected from the Humber River (Fig. 3D).

Although PCB availability at present appears to be uniformly distributed throughout the lower part of the the Humber watershed, PCB residue distribution patterns in fish collected during the early 1980s were considerably different (Table 3). Residues of PCBs in shiners from the earlier lower river collections were considerably higher compared to present day values. Significant ($p<0.05$) PCB residue reductions over time were found at only 2 of the five (40%) sites selected for temporal trend assessment (Fig. 8). Significant ($p>0.05$) reductions in chlordane over time were found in common shiners from the Lawrence, Scarlett and Old Mill sites, whereas DDT residues did not change significantly ($p>0.05$).

A number of sites in the Humber River have experienced considerable fluctuations in PCB bioavailability (Table 3). Since several biological and physio-chemical factors may influence PCB uptake in fish, it is difficult to determine whether changes in PCB availability were related to PCB inputs, or merely responses to changing water quality associated with siltation and stream flow.

Fig. 5: Total PCB residues (ng/g) in juvenile common shiners from Mimico Creek in 1992. IJC Aquatic Life Guideline for PCB = 100 ng/g.

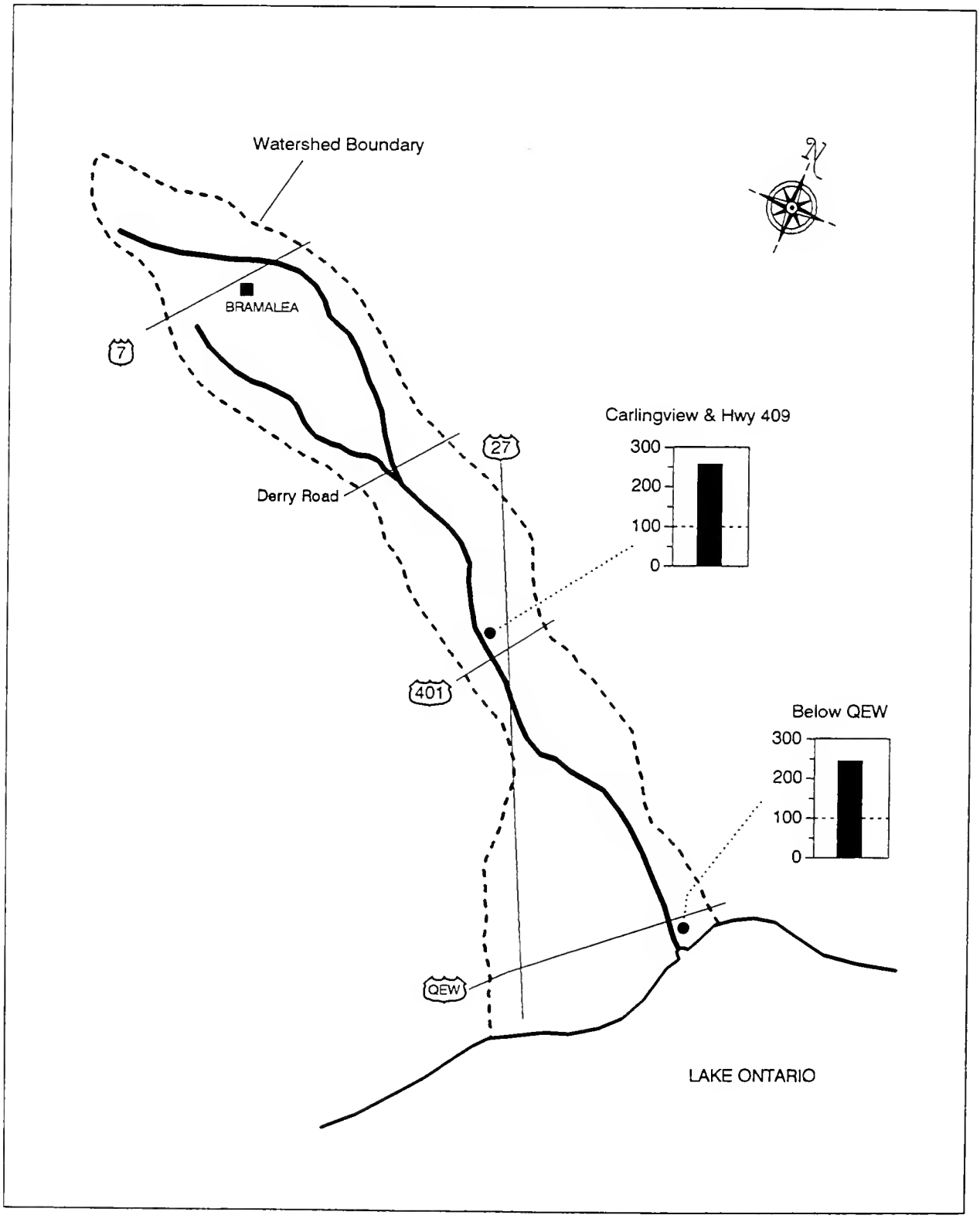


Fig. 6: Temporal trends of total PCB residues (ng/g) in spottail shiners in Mimico Creek at Lakeshore Road from 1981 to 1989. Significant correlations with time are indicated with a dotted line.

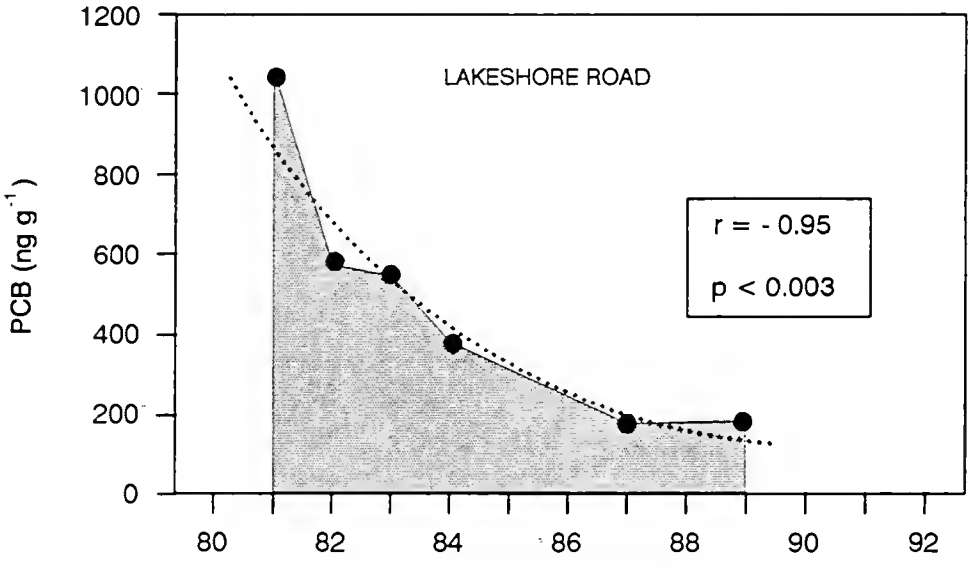


Fig. 7: Total PCB residues (ng/g) in juvenile common shiners at 5 sites in the Humber River and spottail shiners from Lake Ontario near the mouth of the Humber River in 1992. IJC Aquatic Life Guideline for PCB = 100 ng/g. (N = Not Detected).

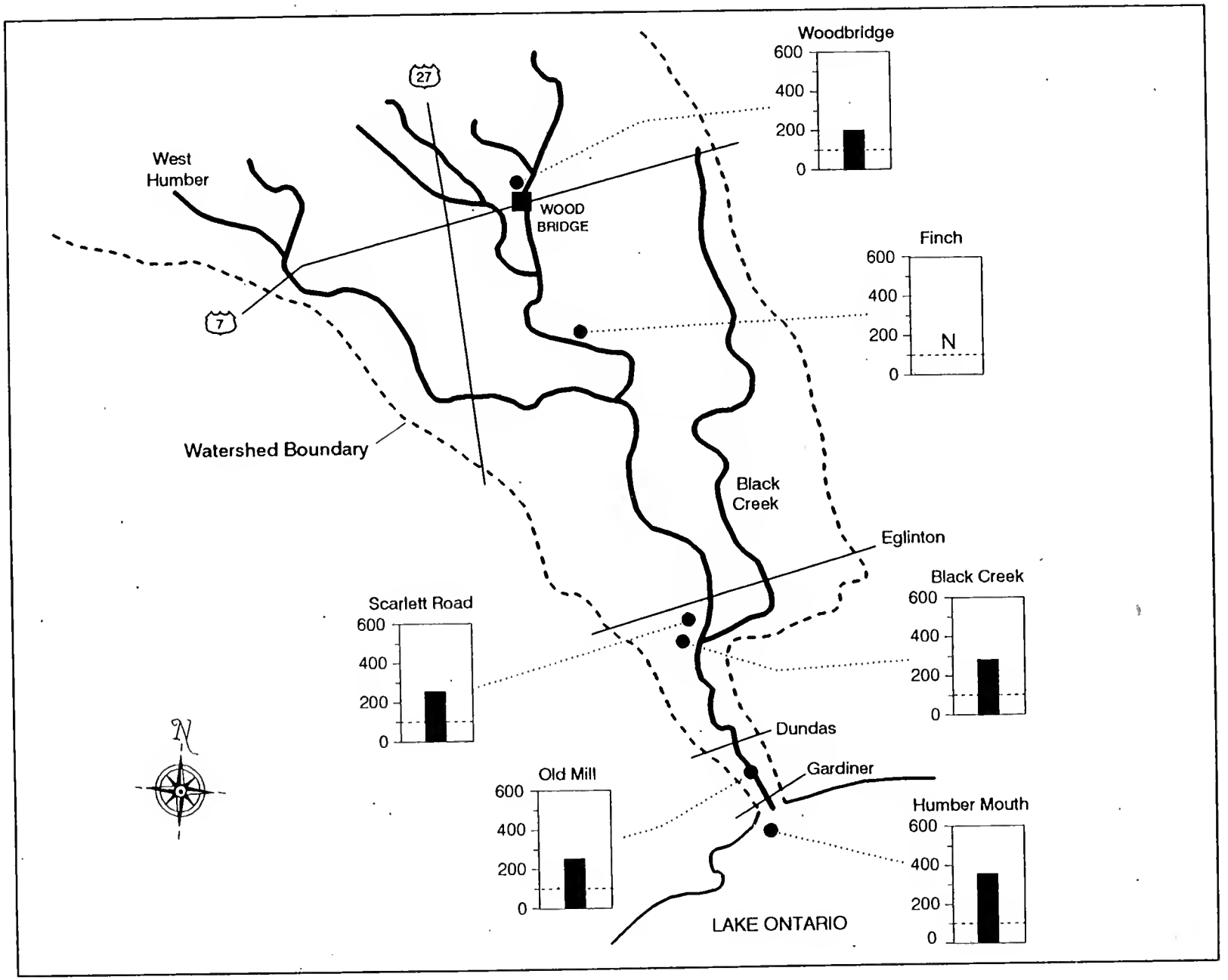


Fig. 8: Temporal trends of total PCB residues (ng/g) in juvenile common shiners at five sites in the Humber River from 1981 to 1992. Spottail shiner data collected near the mouth of the Humber River illustrate the impact of watershed inputs on PCB availability in the nearshore waters of Lake Ontario. IJC Aquatic Life Guideline for PCB = 100 ng/g. (N = Not Detected).

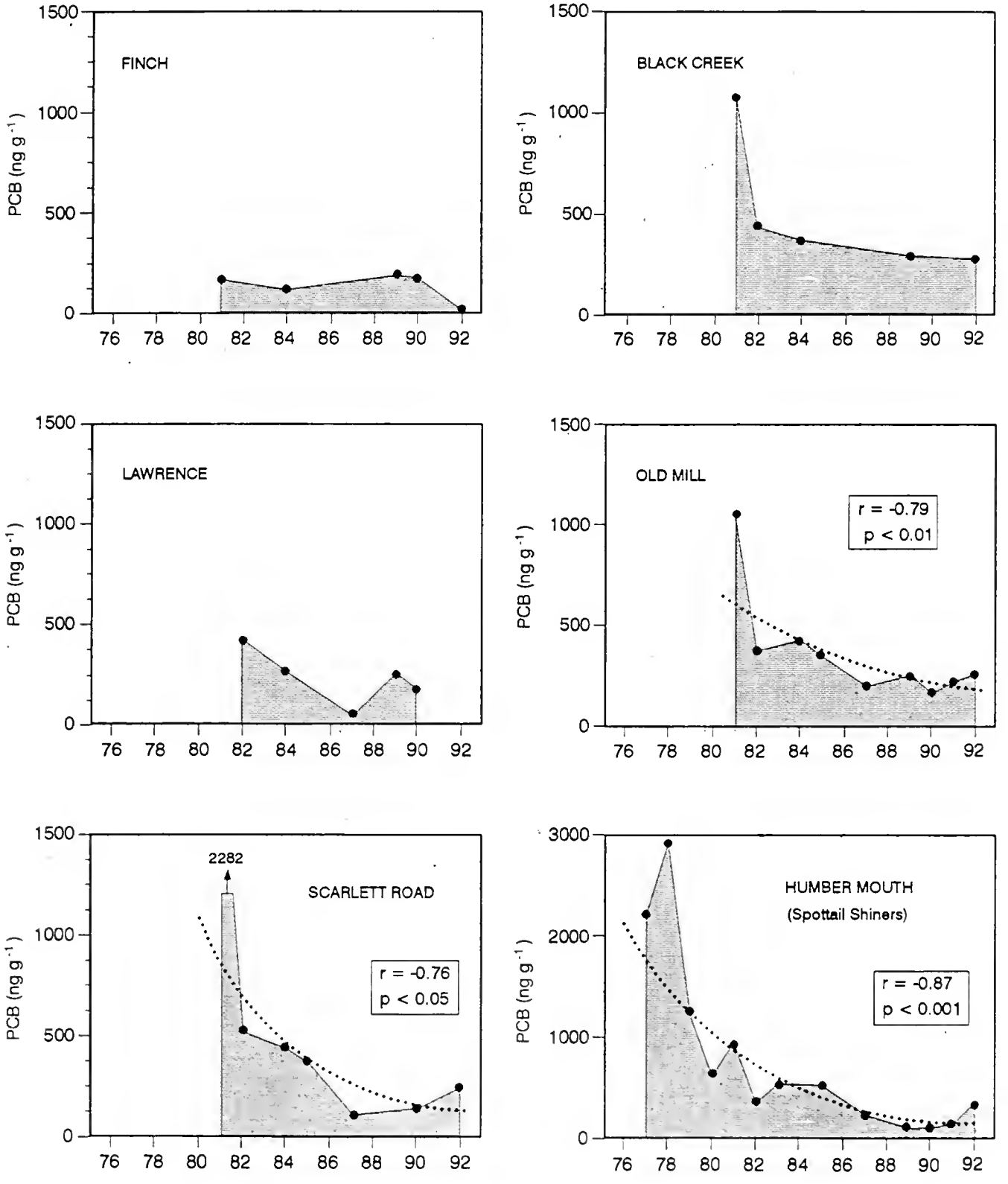
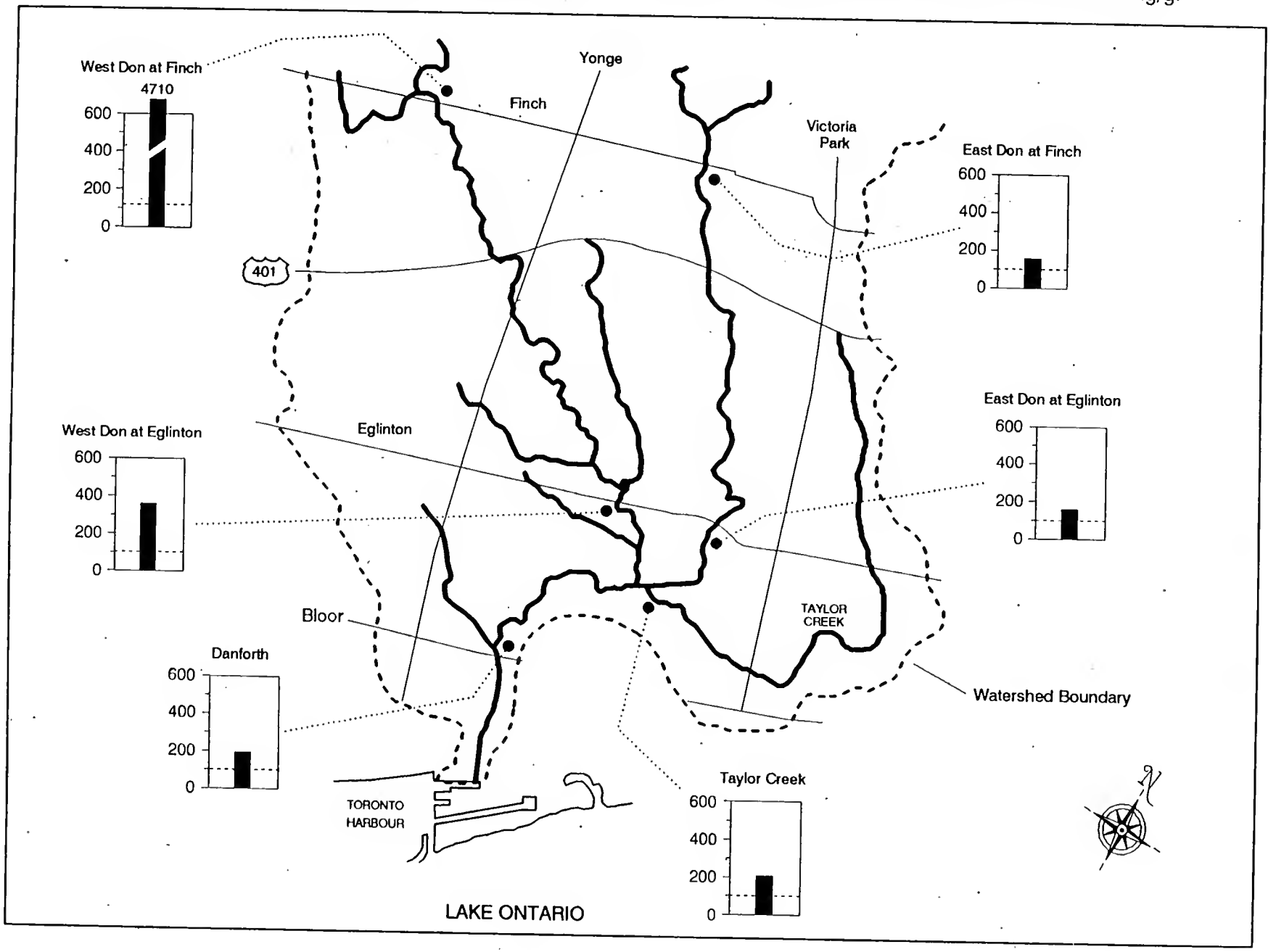


Fig. 9: Total PCB residues (ng/g) in juvenile fish from the Don River in 1992. Common shiners were collected at all sites, except the West Don at Finch (fathead minnows) and the West Don at Eglinton (longnose dace). IJC Aquatic Life Guideline for PCB = 100 ng/g.



It is clear, however, that bioavailable PCB inputs from the Humber River have influenced PCB trends and PCB availability in the nearshore waters of Lake Ontario in Humber Bay (Fig. 8).

Don River

All five sites sampled in the Don River in 1992 had juvenile fish populations with PCB concentrations above the IJC Aquatic Life Guideline. Fish collected from the west branch of the Don River had significantly ($p<0.05$; ANOVA) higher PCB concentrations than fish from the east branch (Fig. 3E; Fig. 9). Residues of PCBs in the two fish samples collected from the east branch at Finch and Eglinton were not significantly ($p>0.05$: ANOVA) different than PCB residues in fish from the lower Don River at Danforth or the Taylor Creek tributary (Fig. 9; Appendix D).

By far the highest PCB concentration (4710 ng/g) was found in fathead minnows collected from the west branch of the Don River, just downstream of the G. Ross Lord Dam at Finch Avenue. Fish collected from 5 sites above the dam in 1993 exceeded the IJC Aquatic Life Guideline for PCBs, with means ranging between 143 and 233 ng/g. However, these values were significantly ($p<0.05$) less than values found in fish just below the dam. Results from a preliminary sediment survey support the conclusion that PCB enrichment is limited to the collection site immediately downstream of the G. Ross Lord Dam. Further investigative work is underway to identify specific sources of PCB inputs.

The magnitude (20X) of PCB accumulations in fish below the G. Ross Lord Dam suggests considerable PCB enrichment when compared to other sampling sites in the Don River (Table 4). Spatial distribution patterns of PCB residues in juvenile fish suggest that PCB enrichment at the G. Ross Lord Dam has influenced PCB bioavailability downstream as far as Eglinton Avenue. However, care should be taken when comparing PCB residues in fathead minnows with those found in common shiners and longnose dace collected further downstream in the Don River. Work with other fish species has shown that species-specific differences in PCB accumulations exist (Suns and Hitchin 1992).

While lindane was not detected in any of the 1992 fish samples, earlier collections from Taylor Creek, a tributary to the lower Don River, exhibited unusually high lindane (BHC) concentrations (Table 4). Longnose dace collected in 1981 had 678 ng/g of lindane, which was the highest lindane concentration ever found in young-of-the-year fish in the Province. Lindane inputs from Taylor Creek have influenced lindane bioavailability in the lower Don River, as evidenced by residue values in fish collected at Pottery Road and Danforth. The historical source of lindane inputs remains unknown. The Phase I Report for MTRAP has documented lindane concentrations "commonly exceeding the Provincial Water Quality Objective" of 1 ng/L in the Don River (MTRAP 1989).

Of the 9 sites sampled in the Don River and its tributaries, only Taylor Creek had a sufficiently large database for temporal trend assessment (Table 4). Trend analyses show that neither PCB or lindane residue reductions were significantly ($p>0.05$) correlated with time, while DDT and chlordane reductions were significant ($p<0.05$).

Highland Creek

Contaminant residue data for Highland Creek fish were only available for two years (1991-1992), negating temporal trend assessment (Table 5). Common shiners collected in 1991 had PCB concentrations of 100 ng/g, while samples collected in 1992 had no quantifiable PCB residues.

The only other site with PCB residues below detection limits was at Finch Avenue in the Humber River in 1992. These two sites are an atypical result among the twenty-four sites sampled in 1992.

Rouge River

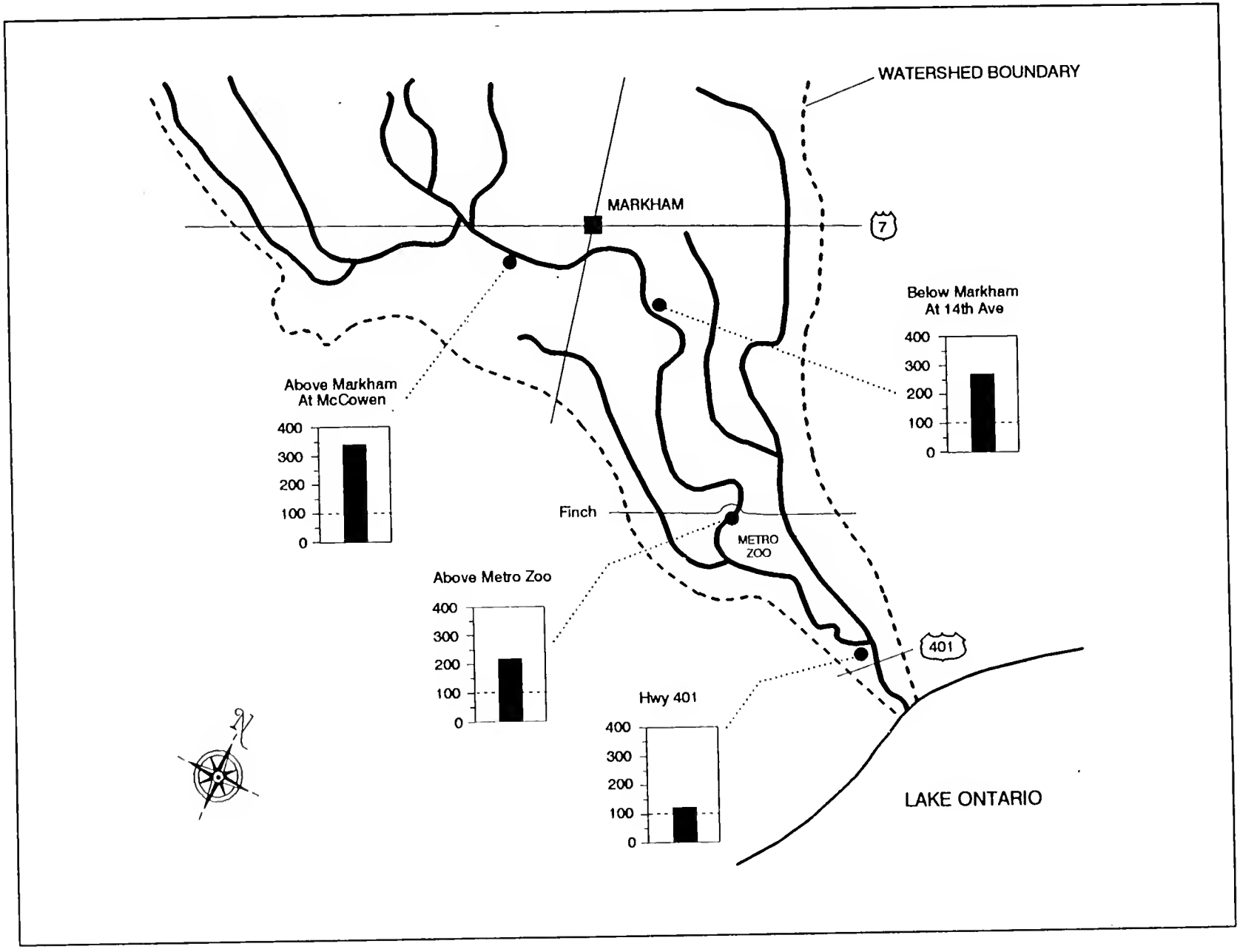
Common shiners collected upstream of Markham at McCowan Road had significantly ($p<0.05$; ANOVA) higher PCB concentrations than other fish collections from the Rouge River, whereas fish samples from the Glenn Rouge Park at Highway 401 had the lowest (Fig. 3F; Fig.10). Reasons for PCB enrichment in the upper Rouge are not known, however, additional fish samples were collected from the upper Rouge in 1993 to identify potential PCB inputs.

None of the sites sampled in Rouge River had sufficiently large data sets for temporal trend assessment Table 6; Appendix E).

OTHER CONTAMINANTS

All shiner samples collected in 1992 had DDT metabolite p,p'DDE residues, however, total DDT concentrations in fish were well below the Fish Flesh Criterion of 200 ng/g, adopted for the protection of fish-eating wildlife (Newell et al. 1987). Mirex, heptachlor, octachlorostyrene, aldrin and toxaphene were not found. Hexachlorobenzene (HCB) and hexachlorocyclohexane (BHC) residues were found at low concentrations in some of the fish samples.

Fig. 10: Total PCB residues (ng/g) in juvenile common shiners from the Rouge River in 1992. IJC Aquatic Life Guideline for PCB = 100 ng/g.



CONCLUSIONS AND RECOMMENDATIONS

Recent collections of juvenile forage fish from Toronto area streams had generally lower PCB concentrations than fish collected in the early 1980's. However, 92% of all in-stream sites sampled in 1992 had fish with PCB concentrations above the International Joint Commission's Aquatic Life Guideline.

To maintain PCB concentrations in forage fish below the IJC Guideline, further source identification and PCB input reductions from watersheds are necessary.

Forage fish surveys have identified PCB enrichment in Etobicoke Creek just below the Queensway Hospital, and in the west branch of the Don River at the G. Ross Lord Reservoir. Further investigative work is necessary to find the sources of these PCB inputs.

Survey results demonstrate that biologically available PCB inputs from Toronto area streams affect the nearshore waters of Lake Ontario.

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ACKNOWLEDGEMENTS

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Table 1: Organochlorine residues in juvenile common shiners from Etobicoke Creek from 1989 to 1992. Values are means ± standard deviation. (198 = Common Shiner).

SAMPLING SITE	YEAR	SPECIE CODE	n	FISH LENGTH (mm)	LIPID (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)
DIXIE/DERRY ROAD	1990	198	5	53-1	3.2-0.3	43-6	8-2	ND	ND	ND	ND
	1992	198	5	48-2	4.0-0.5	193-20	13-3	ND	ND	ND	ND
HWY 401	1992	198	5	50-1	3.1-0.1	241-24	5-1	ND	ND	ND	ND
EGLINTON	1990	198	5	51-1	3.4-0.6	159-66	8-4	ND	6-2	ND	ND
	1992	198	5	50-1	4.2-0.2	246-18	14-4	ND	ND	ND	ND
ABOVE HOSPITAL	1990	198	5	54-3	2.9-0.4	188-22	10-6	ND	TR	ND	ND
	1992	198	4	47-1	5.1-0.5	273-9	28-3	ND	ND	ND	ND
BELOW HOSPITAL	1990	198	4	51-1	4.1-0.2	348-118	44-15	ND	ND	ND	ND
	1992	198	5	46-2	6.5-0.3	603-30	42-12	ND	2-1	ND	ND
LAKESHORE ROAD	1991	198	5	59-3	3.2-0.4	508-205	16-10	ND	ND	ND	ND
	1992	198	5	53-1	3.2-0.6	269-19	29-4	ND	2-1	ND	ND
BOAT RAMP NEAR LAKE	1990	198	5	55-1	5.7-0.5	290-36	20-4	ND	ND	ND	ND

Table 2: Organochlorine residues in juvenile spottail shiners, common shiners and longnose dace from Mimico Creek 1981 to 1992. Values are means ± standard deviation.
Species codes are: (198 = common shiner, 201 = spottail shiner, 211 = longnose dace).

SAMPLING SITE	YEAR	SPECIE CODE	n	FISH LENGTH (mm)	LIPID (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)
CARLINGVIEW / 409	1992	198	4	43-1	7.7-0.2	258-12	11-2	ND	3-2	ND	3-1
BELOW QEW	1992	198	1	47-0	8.4-	200-	18-	ND	5-	ND	ND
	1992	211	4	51-1	5.8-0.4	248-31	24-5	ND	12-1	ND	ND
LAKESHORE ROAD	1981	201	5	68-4	6.4-0.2	1051-105	135-19	ND	47-3	19-2	ND
	1982	201	6	66-7	5.0-0.3	572-45	52-7	TR	14-3	5-2	4-1
	1983	201	7	70-4	5.4-0.4	542-80	41-4	ND	25-3	6-2	13-1
	1984	201	6	69-4	4.5-1.1	378-69	50-16	ND	18-2	TR	TR
	1987	201	7	67-6	4.9-0.5	173-30	35-7	ND	19-5	TR	TR
	1989	201	4	44-2	4.8-0.8	183-54	15-6	ND	13-4	ND	ND

Table 3a: Organochlorine residues in juvenile common shiners (in-stream) and spottail shiners (near the river mouth) in the Humber River from 1977 to 1992. Values are means ± standard deviation.
Species codes are: (198 = common shiner, 201 = spottail shiner).

SAMPLING SITE	YEAR	SPECIE CODE	n	TOTAL LENGTH (mm)	LIPID (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)
WEST HUMBER											
CONTROL WEST	1985	198	4	75-2	2.3-0.5	30-11	13-4	ND	ND	ND	ND
HUMBER COLLEGE	1982	198	5	64-1	4.2-1.9	358-75	17-5	ND	9-5	4-2	TR
	1984	198	4	62-11	4.2-0.7	284-67	23-9	ND	6-3	1-1	3-2
EAST HUMBER											
MAJOR MAC	1991	198	5	59-1	3.4-0.3	ND	10-1	ND	ND	ND	ND
RIVERSIDE DR	1991	198	5	53-1	4.4-0.5	ND	12-2	ND	9-3	ND	ND
HUMBER											
MAJOR MAC	1991	198	5	59-1	4.4-0.3	ND	8-4	ND	ND	ND	ND
CLARENCE	1991	198	5	59-2	1.3-0.2	TR	8-1	ND	TR	ND	ND
WOODBRIDGE	1990	198	5	66-2	4.4-0.4	409-143	2-2	ND	ND	ND	ND
	1991	198	5	57-1	1.9-0.2	65-19	5-2	ND	ND	ND	ND
	1992	198	5	61-4	4.9-0.6	202-69	13-2	ND	ND	ND	ND
STEELES	1982	198	5	63-2	5.0-1.8	222-39	1-1	ND	29-26	TR	ND
	1984	198	5	66-4	3.5-0.5	99-13	16-2	ND	11-6	TR	2-2
FINCH	1981	198	3	57-2	3.8-0.5	160-37	12-3	ND	11-7	5-2	1-1
	1984	198	5	63-3	4.3-0.3	109-36	22-3	ND	14-3	ND	2-1
	1989	198	5	64-3	5.7-0.8	178-148	15-11	ND	4-3	ND	2-2
	1990	198	4	65-3	5.3-0.4	164-49	8-2	ND	ND	ND	ND
	1992	198	4	50-1	4.4-0.5	ND	22-6	ND	7-4	ND	ND
ABOVE WEST HUMBER	1982	198	5	54-3	6.0-3.1	321-15	9-4	ND	22-7	ND	1-1
E/W CONFLUENCE	1982	198	5	57-1	4.3-3.0	357-53	10-5	ND	16-8	4-3	1-1
LAWRENCE	1982	198	5	60-2	11.4-3.2	427-47	27-14	ND	22-3	ND	TR
	1984	198	5	64-3	6.4-0.6	267-33	40-11	ND	11-2	1-1	2-1
	1987	198	6	-	6.4-1.9	52-47	13-9	ND	ND	ND	ND
	1989	198	5	66-2	6.1-1.0	260-50	14-4	ND	TR	ND	2-1
	1990	198	5	54-2	4.3-0.4	179-42	10-6	ND	ND	ND	ND
LEVI AUTO PARTS	1984	198	9	48-3	2.6-0.2	358-47	8-3	ND	9-3	TR	1-0

Table 3b: Organochlorine residues in juvenile common shiners (in-stream) and spottail shiners (near the river mouth) in the Humber River from 1977 to 1992. Values are means ± standard deviation.
Species codes are: (198 = common shiner, 201 = spottail shiner).

SAMPLING SITE	YEAR	SPECIE CODE	n	TOTAL LENGTH (mm)	LIPID (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)
SCARLETT ROAD	1981	198	4	59-1	5.7-0.3	2282-184	13-11	ND	9-2	5-2	2-1
	1982	198	5	61-1	4.2-1.3	508-87	24-7	ND	24-2	3-3	2-1
	1984	198	5	60-2	6.3-0.9	426-57	52-4	ND	17-3	1-1	3-2
	1985	198	5	59-3	8.6-0.6	353-71	25-9	ND	8-1	ND	12-1
	1987	198	5	56-3	4.8-0.5	96-11	10-6	ND	25-9	ND	4-3
	1990	198	5	59-3	2.5-0.5	132-26	20-4	ND	ND	ND	ND
	1992	198	5	55-2	5.4-0.3	258-30	70-24	ND	ND	ND	ND
BLACK CREEK	1981	198	4	55-2	6.1-0.2	1106-195	31-24	ND	12-2	8-2	2-1
	1982	198	5	60-1	4.8-2.0	437-89	37-4	ND	24-2	ND	1-1
	1984	198	5	62-3	4.9-0.8	378-77	40-6	ND	18-6	1-1	2-1
	1989	198	5	62-2	5.7-0.8	302-82	24-9	ND	7-3	ND	3-1
	1992	198	5	52-1	5.9-0.4	283-32	47-17	ND	5-4	ND	ND
OLD MILL	1981	198	5	56-1	3.4-0.3	1054-101	63-21	ND	14-1	16-8	3-1
	1982	198	4	63-1	7.6-3.6	362-39	25-8	ND	22-2	ND	ND
	1984	198	5	65-3	4.9-0.5	419-54	64-11	ND	15-4	2-1	2-0
	1985	198	5	68-2	4.1-0.6	336-133	32-13	ND	8-1	ND	7-1
	1987	198	4	61-3	3.5-0.3	190-87	37-14	ND	15-1	ND	2-1
	1989	198	5	67-3	5.7-1.5	243-97	32-20	ND	4-3	ND	ND
	1990	198	5	57-2	3.2-0.4	162-41	19-2	ND	ND	ND	1-1
	1991	198	5	56-2	3.4-0.4	212-39	21-6	ND	TR	ND	ND
	1992	198	5	52-1	4.7-0.3	255-38	48-12	ND	8-3	ND	ND
NEAR RIVER MOUTH	1977	201	10	62-2	7.3-0.4	2218-263	268-32	5-2	58-16	41-8	-
	1978	201	8	58-5	5.8-0.5	2938-391	406-99	15-4	ND	3-4	-
	1979	201	8	60-6	4.1-1.3	1223-347	76-12	ND	47-9	4-1	-
	1980	201	6	62-5	4.0-0.4	621-66	41-4	ND	36-6	15-5	-
	1981	201	6	65-5	8.0-0.8	954-66	86-41	ND	26-9	9-3	-
	1982	201	6	58-2	3.7-0.4	353-70	28-20	ND	22-1	3-0	ND
	1983	201	7	68-3	5.2-0.4	537-122	48-7	ND	21-2	5-1	ND
	1985	201	7	65-3	5.9-0.7	524-152	46-21	ND	11-4	ND	TR
	1987	201	6	66-3	5.2-0.6	235-33	31-4	ND	9-2	TR	TR
	1989	201	4	62-3	5.3-1.0	106-45	14-7	ND	TR	ND	ND
	1990	201	7	49-2	2.8-0.3	116-29	11-4	ND	ND	ND	ND
	1991	201	5	56-2	3.5-0.2	152-11	9-2	ND	ND	ND	ND
	1992	201	7	60-1	6.1-0.7	356-52	42-13	ND	8-2	ND	ND

Table 4: Organochlorine residues in juvenile common shiners, longnose dace and fathead minnows from the Don River from 1981 to 1992. Values are means ± standard deviation.
Species codes are (198 = common shiner, 209 = fathead minnow, 211 = longnose dace).

SAMPLING SITE	YEAR	SPECIE CODE	n	FISH LENGTH (mm)	LIPID (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)
EAST DON - FINCH	1992	198	3	67-8	4.7-0.4	157-18	30-4	ND	28-6	ND	ND
WEST DON - FINCH	1992	209	5	46-2	3.8-0.5	4710-2877	44-37	ND	TR	ND	ND
EAST DON - EGLINTON	1992	198	5	43-2	4.8-0.2	157-32	16-2	ND	16-1	ND	ND
WEST DON - EGLINTON	1992	211	5	43-2	4.6-0.6	360-38	71-12	ND	8-4	ND	ND
ABOVE TAYLOR CREEK	1981	211	5	40-1	3.2-0.4	208-39	86-16	ND	58-10	ND	1-1
TAYLOR CREEK	1981	211	5	44-2	6.2-0.6	523-42	147-27	ND	65-8	678-60	ND
	1984	211	6	52-3	6.4-1.0	483-25	82-15	ND	64-17	12-7	12-2
	1987	211	4	62-1	5.2-0.3	115-24	45-14	ND	14-2	96-13	2-1
	1990	211	5	50-4	7.5-0.5	150-21	29-10	ND	5-2	14-2	ND
	1992	198	5	41-1	6.9-0.3	207-16	34-6	ND	11-1	ND	ND
	1992	211	2	49-6	5.7-0.4	208-60	39-21	ND	18-1	ND	ND
E/W DON CONFLUENCE	1981	211	5	47-2	5.5-0.4	501-48	123-35	ND	48-3	17-8	TR
	1989	211	2	53-1	7.4-1.7	90-14	17-2	ND	15-1	35-11	ND
POTTERY ROAD	1981	211	5	46-2	7.4-0.9	372-149	83-33	ND	57-21	39-24	ND
DANFORTH	1981	211	5	46-1	7.0-0.7	440-64	69-20	ND	68-5	56-17	ND
	1990	211	5	46-2	4.2-0.8	112-22	9-2	ND	ND	ND	ND
	1991	198	5	55-1	6.8-0.5	176-38	20-4	ND	3-2	ND	ND
	1991	211	5	47-2	4.8-0.6	168-18	16-3	ND	4-2	ND	ND
	1992	198	4	44-2	6.1-0.6	180-30	36-5	ND	9-3	ND	ND
	1992	211	4	43-1	5.1-0.3	257-25	35-7	ND	11-1	ND	ND

Table 5: Organochlorine residues in juvenile common shiners from Highland Creek from 1991 to 1992. Values are means ± standard deviation.

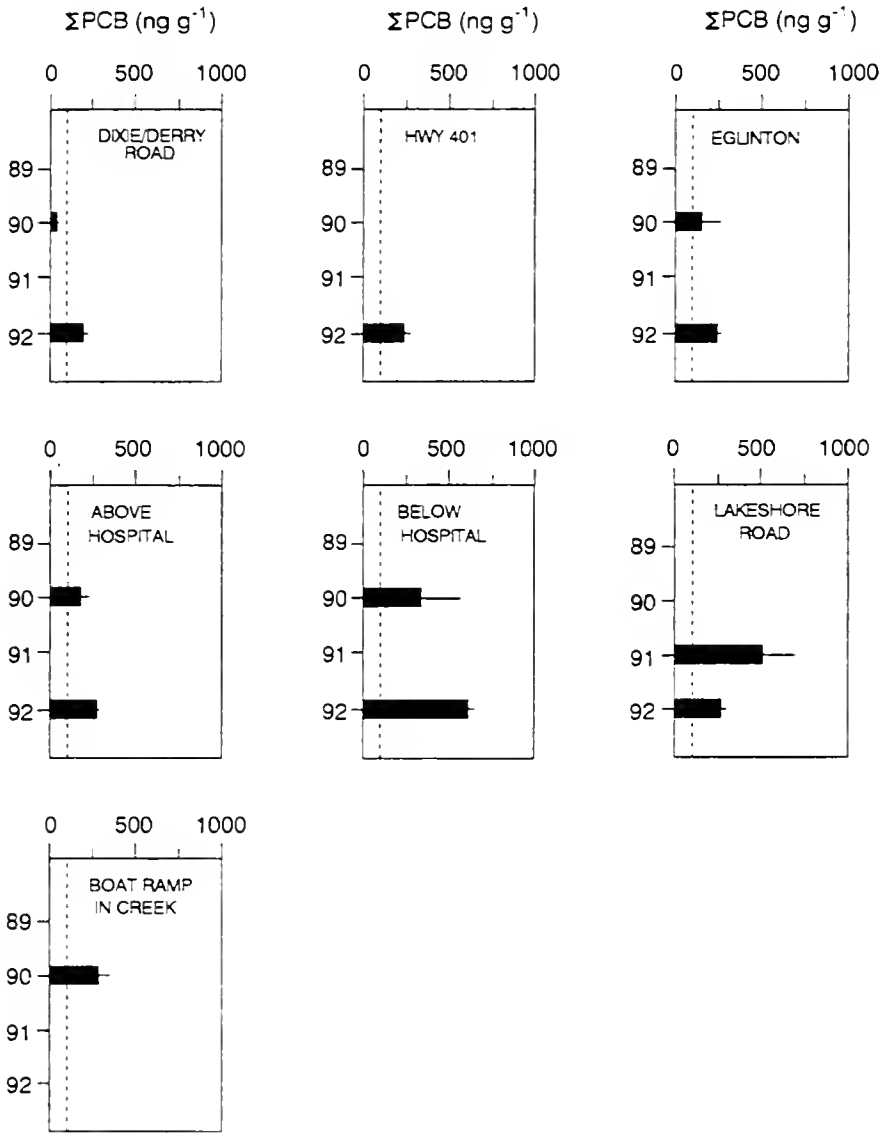
SAMPLING SITE	YEAR	SPECIE CODE	n	FISH LENGTH (mm)	LIPID (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)
LAWRENCE	1991	198	4	53-2	6.5-0.7	100-16	15-2	ND	ND	ND	ND
	1992	198	5	46-1	4.2-0.4	ND	19-3	ND	15-4	ND	ND

Table 6: Organochlorine residues in juvenile common shiners from the Rouge River from 1989 to 1992. Values are means ± standard deviation.

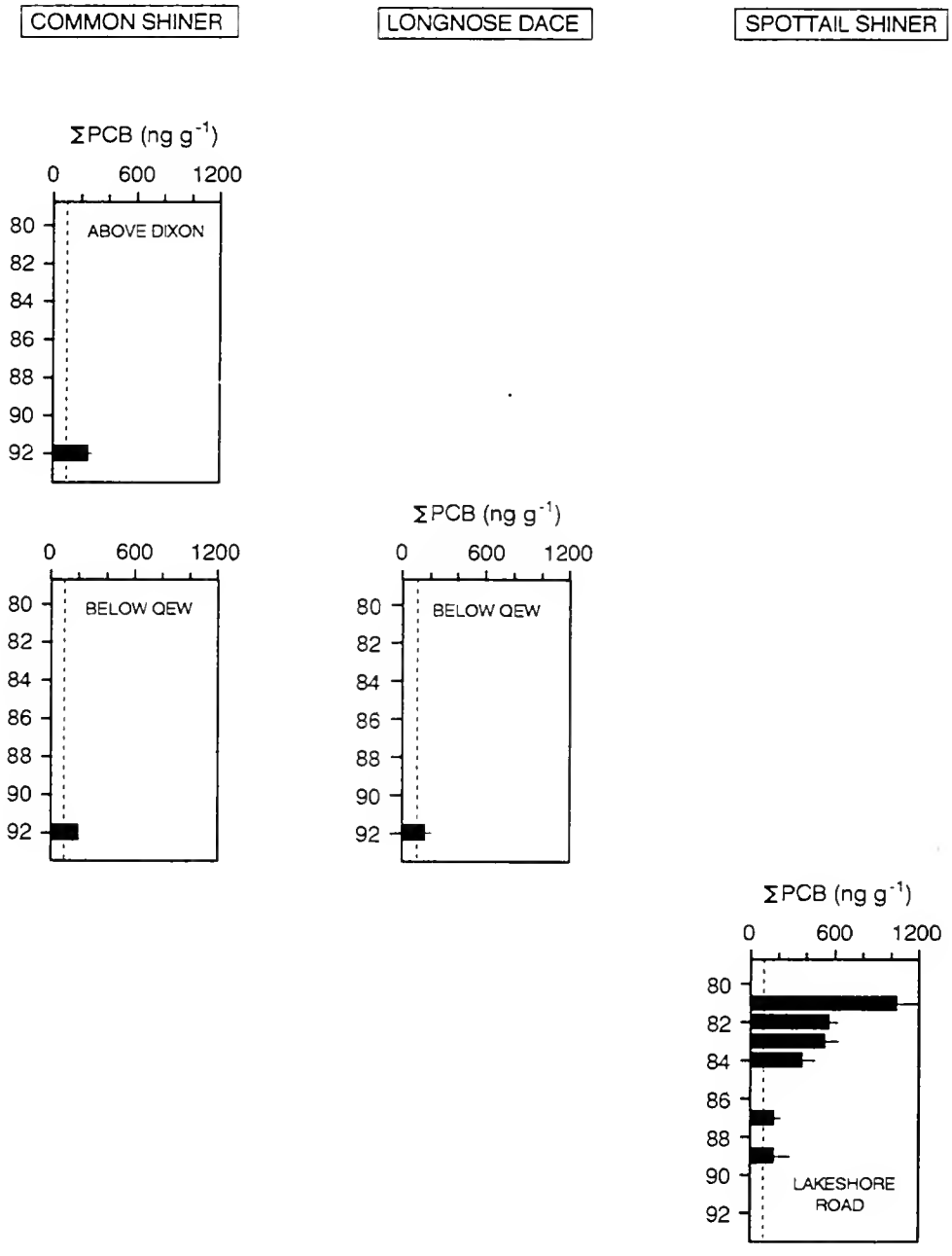
SAMPLING SITE	YEAR	SPECIE CODE	n	FISH LENGTH (mm)	LIPID (%)	PCB (ng/g)	DDT (ng/g)	MIREX (ng/g)	CHLOR DANE (ng/g)	BHC (ng/g)	HCB (ng/g)
ABOVE MARKHAM	1992	198	3	53-2	5.0-0.3	338-80	14-2	ND	3-4	ND	ND
BELOW MARKHAM	1992	198	5	48-1	2.6-0.3	267-70	11-2	ND	ND	ND	ND
ABOVE METRO ZOO	1989	198	4	62-1	8.3-3.6	30-40	ND	ND	ND	ND	ND
	1991	198	3	59-8	5.6-0.4	120-20	13-1	ND	ND	ND	ND
	1992	198	5	51-2	4.2-0.4	218-16	52-13	ND	ND	ND	ND
HWY 401	1991	198	5	53-1	3.4-0.3	80-20	12-1	ND	ND	ND	ND
	1992	198	4	49-1	2.7-1.1	123-17	26-11	ND	4-3	ND	ND

APPENDIX

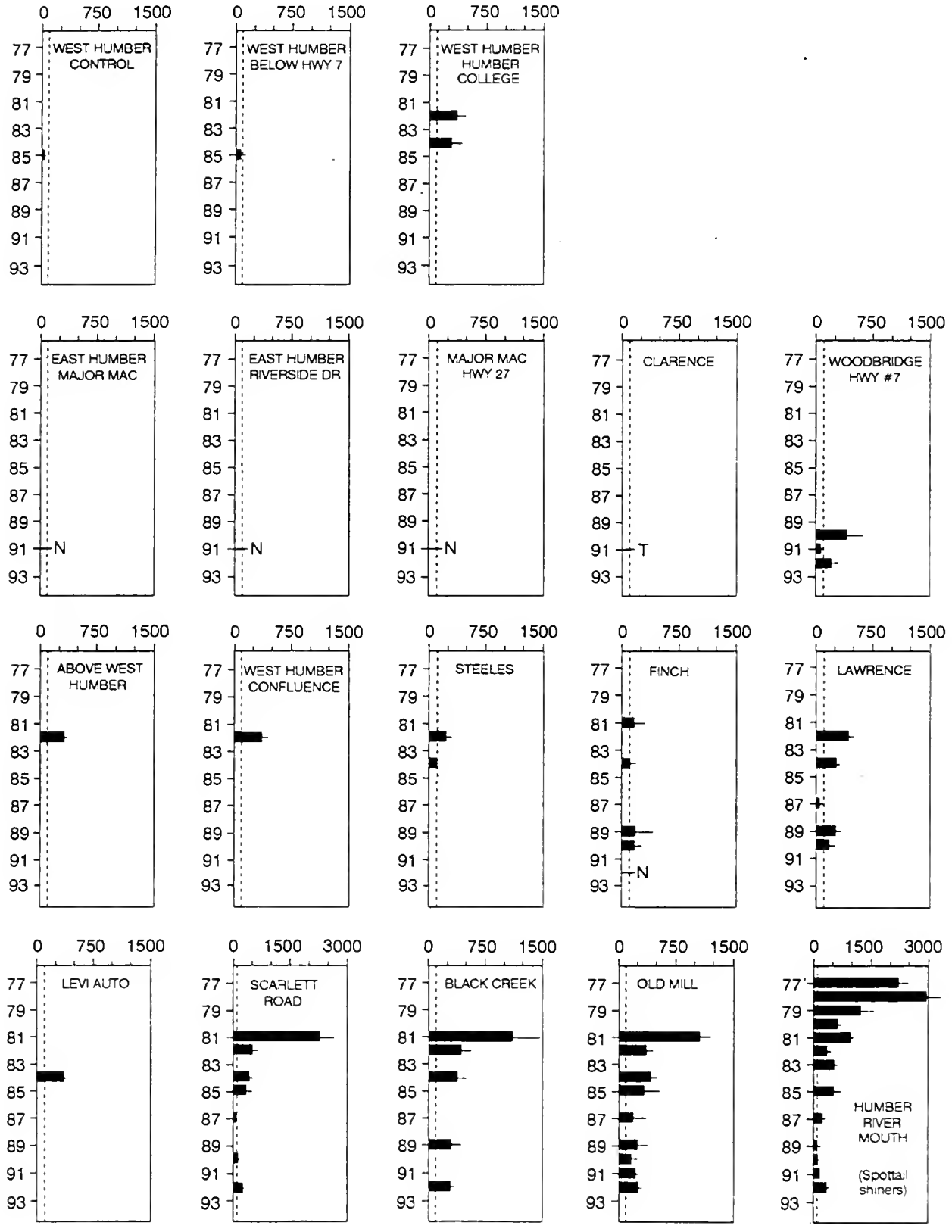
Appendix A: Total PCB residues (ng/g) in juvenile common shiners from Etobicoke Creek from 1990 to 1992. Values are means +/- 95% confidence limits. IJC Aquatic Life Guideline for PCB = 100 ng/g.



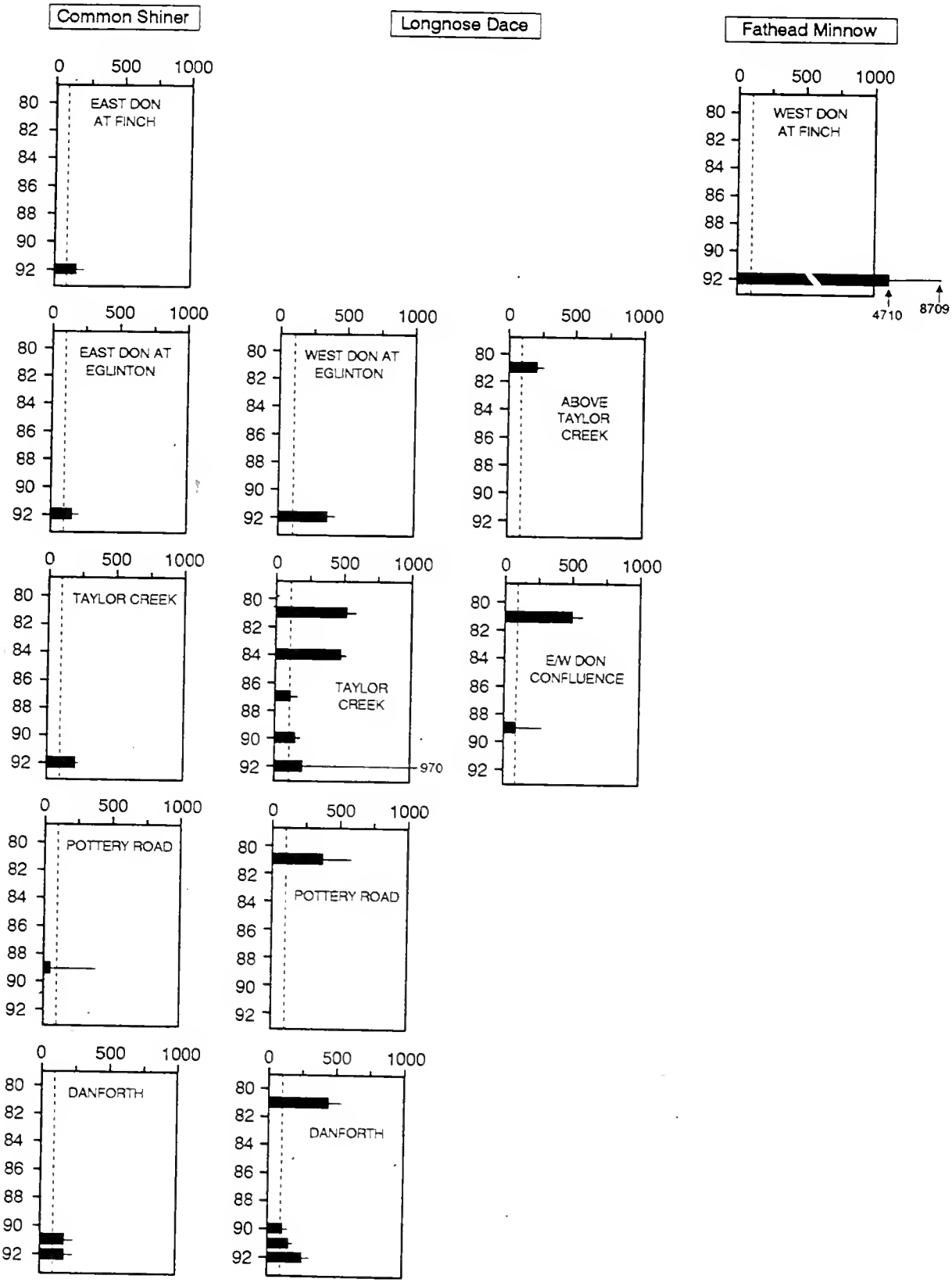
Appendix B: Total PCB residues (ng/g) in juvenile common shiners, spottail shiners and longnose dace from Mimico Creek from 1981 to 1992. Values are means +/- 95% confidence limits. IJC Aquatic Life Guideline for PCB = 100 ng/g.



Appendix C: Total PCB residues (ng/g) in juvenile common shiners (in-stream) and spottail shiners (near the mouth of the Humber River) from the Humber River from 1977 to 1992. Values are means +/- 95% confidence limits. IJC Aquatic Life Guideline for PCB = 100 ng/g. (N = Not Detected, T = Trace).



Appendix D: Total PCB residues (ng/g) in juvenile common shiners, longnose dace and fathead minnows from the Don River from 1981 to 1992. Values are means +/- 95% confidence limits. IJC Aquatic Life Guideline for PCB = 100 ng/g.



Appendix E: Total PCB residues (ng/g) in juvenile common shiners from the Rouge River.from 1989 to 1992. Values are means +/- 95% confidence limits. IJC Aquatic Life Guideline for PCB = 100 ng/g.