Environment Canada

Surveys of Trace Contaminants in the St. Clair River, 1985

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Abstract

The Water Quality Branch of Environment Canada carried out four water quality surveys on the St. Clair River between August and October of 1985 to determine the ambient concentrations of selected organic contaminants at major confluences of the river. Forty-litre water samples were collected at Point Edward, Port Lambton, Chenal Écarté, the North Channel, the South Channel, and the Detroit River at Peach Island. Water samples were analyzed for organochlorine pesticides, polychlorinated biphenyls, chlorobenzenes, octachlorostyrene, and hexachlorobutadiene.

Concentrations of organochlorine pesticides were fairly uniform in the St. Clair River and were similar to those found in Lake Huron water. Concentrations remained in the parts per trillion (ng/L) range. Discharges of industrial chemicals such as hexachlorobenzene, hexachlorobutadiene, and octachlorostyrene, just downstream from Sarnia, were detected at the nanogram per litre range along the Canadian shore at Port Lambton, but not above Sarnia. Chenal Écarté and the South Channel received major portions of the industrial chemicals carried by the St. Clair River.

Résumé

La Direction de la qualité des eaux d'Environnement Canada a réalisé quatre études de la qualité de l'eau à la hauteur des principaux confluents de la rivière St. Clair, d'août à octobre 1985, afin de déterminer les concentrations de certains contaminants organiques. On a prélevé 40 L d'échantillons à Point Edward, Port Lambton, dans le chenal Écarté, le chenal nord et le chenal sud ainsi que la rivière Detroit à l'île Peach. On a dosé les pesticides organochlorés, les biphényles polychlorés, les chlorobenzènes, l'octachlorostyrène et l'hexachlorobutadiène.

Les concentrations de pesticides organochlorés étaient assez uniformes dans la rivière et semblables à celles qui ont été mesurées dans l'eau du lac Huron; elles étaient de l'ordre des nanogrammes par litre (ng/L). Des rejets de substances chimiques industrielles telles que l'hexachlorobenzène, l'hexachlorobutadiène, l'octachlorostyrène, immédiatement en aval de Sarnia, ont été décelés; leur teneur était de l'ordre des nanogrammes par litre (ng/L) le long de la rive canadienne à Port Lambton, mais non en amont de Sarnia. Le chenal Écarté et le chenal sud recevaient la plus grande partie des substances industrielles transportées par la rivière.

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INTRODUCTION

The St. Clair River is an important international waterway that is subjected to extensive use as a major shipping channel and as a receiving water for numerous industrial and municipal effluents from the petrochemical complex in the Sarnia area. Indeed, water quality problems resulting from municipal and industrial discharges, combined sewer overflows, and pollutants in sediments have led the International Joint Commission to categorize the river as a class A area of concern. Sediments along the Ontario shoreline of the upper St. Clair River contain sufficient levels of polychlorinated biphenyls (PCBs) to render them unacceptable for open water disposal if dredged (Thornley and Hamdy, 1984). Also, elevated concentrations of PCBs in some sport fish species from the St. Clair River have resulted in a limited consumption advisory from the Ontario Ministries of the Environment and Natural Resources in 1982 and 1984/85. In addition, elevated levels of hexa-chlorobenzene have been found in samples of carp from western Lake St. Clair (Kuehl *et al.*, 1981), and octachlorostyrene has been identified in Lake St. Clair great blue heron (Reichel *et al.*, 1977), carp (Kuehl *et al.*, 1981), and walleye (Kuehl *et al.*, 1976). Furthermore, HCB, OCS, P5CB, and HCBD were most frequently identified in tissues of caged clams after three weeks of exposure (Kauss and Hamdy, 1985). Finally the chemical spills of perchloroethylene from Dow Chemical in August of 1985 and the subsequent discovery of a black tarry substance (the "blob") overlying the sediment prompted an immediate investigation by the Canadian and the Ontario governments (Environment Canada and the Ontario Ministry of the Environment, 1986).

Despite recent interest in trace organic contaminants, historical water quality data for the St. Clair River were focused on nutrients, dissolved major ions, and certain metals (Ontario Ministry of the Environment, 1977; Sylvestre, 1985). During the past ten years, however, enhanced analytical capabilities for detecting and identifying low levels of trace organic contaminants, together with increased concern over their impact on the environment, have resulted in an increased effort to sample these contaminants throughout the Great Lakes basin. Nevertheless, few actual measurements of these chemicals in ambient St. Clair River water have been made. A study of the St. Clair River by the Ontario Ministry of the Environment (Bonner and Meresz, 1981) identified 84 volatile organic compounds, which were mostly low molecular weight aromatics and halogenated hydrocarbons. Most of the 1-L water samples collected by Kauss (Kauss and Hamdy, 1985) contained detectable concentrations of HCB, with the exception of samples collected near the sources. Studies of sediment and biota and numerical dispersion studies (McCorquodale *et al.*, 1983; Hamdy and Kinkead, 1979) showed that industrial contaminants in the St. Clair River were mainly confined to a narrow band along the Ontario shore. The apparent absence of trace organics reported in ambient water samples was likely due to the inability to measure trace quantities with the existing methodologies. However, by extracting large-volume water samples, it is now feasible to quantify persistent contaminants to the sub-nanogram level. Sub-nanogram levels of organochlorine pesticides and PCBs were quantified in the open waters of Lake Superior (Chan, 1984), Lake Huron (Filkin *et al.*, 1983; Neilson, 1984), and Lake Ontario (Biberhofer and Stevens, 1985).

The objective of this study was to characterize the ambient levels and the spatial distributions of selected trace chemicals in the St. Clair River.

MATERIALS AND METHODS

Sampling Locations

Sampling locations were selected largely on the basis of evaluating waters entering and exiting major channels on the St. Clair River. The St. Clair River begins as the outlet for Lake Huron and flows approximately 64 km in a southerly direction to Lake St. Clair. The upper and middle reaches of the river consist of about 45 km of regular channel, where most of the petrochemical industrial complex is located on the Ontario shore. The lower reach of the St. Clair River is the delta region known as the St. Clair flats. In this reach, the river is divided into several channels and extends into Lake St. Clair.

Two sampling locations were selected at Point Edward, one on each side of the international border, upstream from both the Lambton water treatment plant and the petrochemical complex of Sarnia. These two stations are essentially Lake Huron stations and were selected to provide a baseline for St. Clair River water. The next set of six sampling locations was located along a cross-channel transect at Port Lambton, which is located downstream away from the influence of most of the chemical industries and about 2 km upstream from the point where the river branches off into Chenal Écarté and the St. Clair River delta. Water quality measured across the Port Lambton transect was expected to provide an indication of the effects of the combined discharges upstream from Port Lambton and the distribution of contaminants across the river before it discharges into the channels. Stations were located at the entrance to each of the three channels: Chenal Écarté, the North Channel, and the South Channel. The remaining two stations were located on Lake St. Clair just upstream from Windsor and Detroit. These two stations were to evaluate the impact of Lake St. Clair on St. Clair River contaminants. The sampling locations are shown in Figure 1.

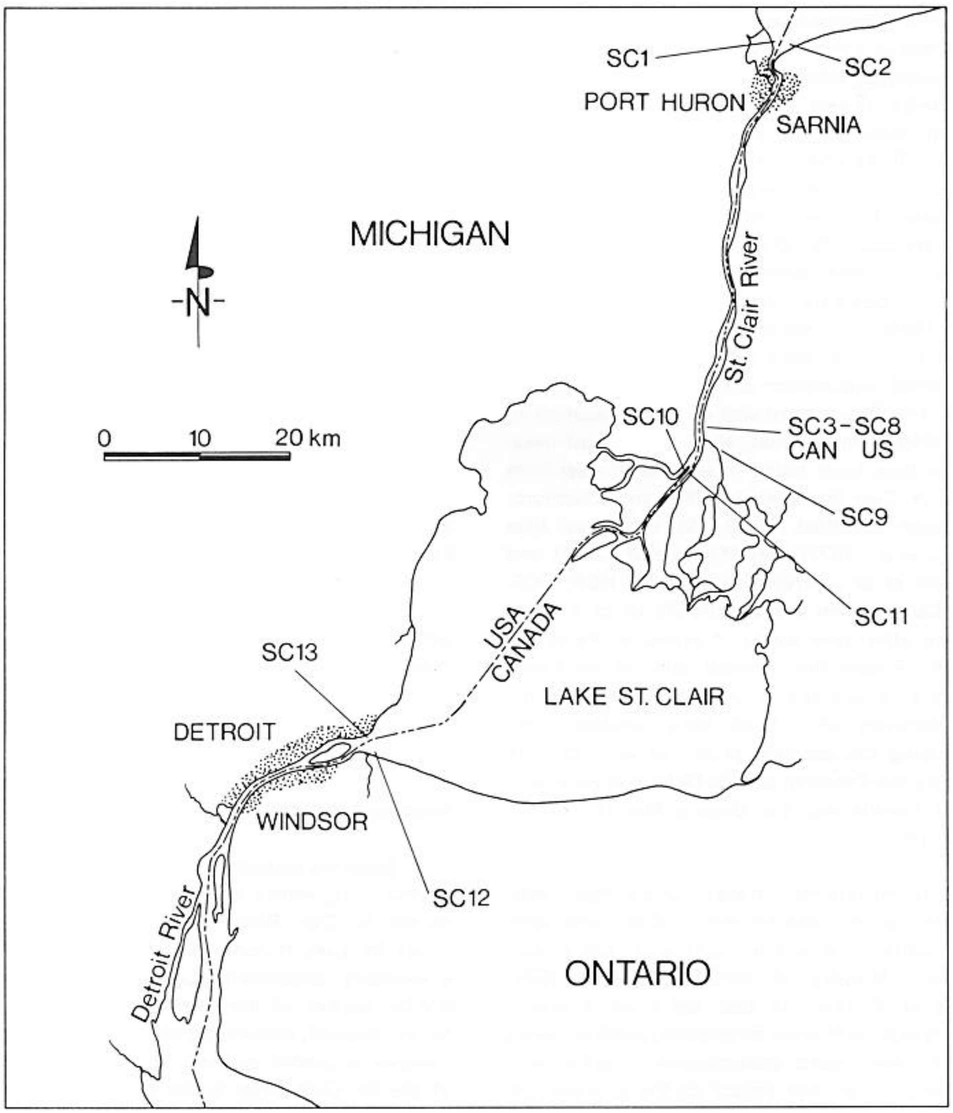

Figure 1. Map of study area and sampling locations.

Field and Laboratory Methods

At each sampling location, water was pumped aboard the research vessel *Advent* from mid-depth using a March 5C-MD submersible pump. The water passed through a Westfalia centrifuge, which removed most of the suspended material, and was then collected in two 20-L preconditioned stainless steel containers. The samples were transported to the National Water Quality Laboratory in Burlington where they were kept refrigerated until analysis. In the laboratory, the water samples were analyzed for organochlorine pesticides (OCs), chlorobenzenes (CBs), polychlorinated biphenyls (PCBs), octachloro-styrene (OCS), and hexachlorobutadiene (HCBD). The water samples were spiked with surrogate standards (brominated benzenes and 2,3,5,6 tetrachloro-biphenyls) and extracted with a countercurrent continuous extractor developed by the National Water Research Institute (NWRI) (Goulden and Anthony, 1985). The extracts underwent the normal pre-concentration and cleanup procedures before gas chromatographic analysis. Detailed analytical methods are described in the *Analytical Methods Manual* (Environment Canada, 1979).

RESULTS AND DISCUSSION

Percent recovery of the spiked compounds in the water samples is shown in Table 1. These brominated compounds were spiked directly into the water samples at concentrations of 1-2 ng/L at the time of analysis. Percent recoveries for the lower molecular weight bromobenzenes were generally lower than for the higher molecular weight compounds.

The results of each survey are listed in Tables 2 to 5. The analytical detection limit is 1 ng, which translates into 0.025 ng/L for a 40-L water sample.

Table 6 lists the range of concentrations of OCs, CBs, and PCBs measured in the Great Lakes by various investigators. Levels of these contaminants are generally in the nanogram per litre range, although variations can range from one to two orders of magnitude.

Organochlorine Pesticides (OCs)

Within the organochlorine pesticide group of compounds, α-BHC, lindane, dieldrin, and heptachlor epoxide were found at all locations, while compounds such as chlordane, endosulfans, heptachlor, aldrin, and DDTs were either not detected or detected in only a few samples. The most abundant were α-BHC, lindane, and dieldrin, and their distributions were also very similar (Figs. 2, 3, 4). Generally, the levels of these compounds were fairly uniform. The downstream stations were slightly higher than those of Sarnia, and there was little or no spatial variation across the river at Port Lambton. A comparison of these figures with

Table 1. Percent Recovery for St. Clair River Surveys.

	Number	Min.	Max.	Mean	Std. dev.	C.V.
August 7, 1985						
1,3-DBB	10	85.00	122.00	106.40	11.09	0.10
1,3,5-TBB	10	109.00	147.00	127.80	9.85	0.08
1,2,4,5-TeBB	10	131.00	170.00	151.10	11.68	0.08
2,3,5,6-TeCBPh	10	100.00	127.00	117.90	7.80	0.07
August 27, 1985						
1,3-DBB	8	73.00	88.00	78.75	4.63	0.06
1,3,5-TBB	8	87.00	108.00	98.13	6.64	0.07
1,2,4,5-TeBB	8	115.00	150.00	134.13	12.50	0.09
2,3,5,6-TeCBPh	8	104.00	132.00	118.00	8.85	0.07
September 23, 1985						
1,3-DBB	13	79.00	105.00	91.77	8.36	0.09
1,3,5-TBB	13	96.00	131.00	113.46	11.82	0.10
1,3,4,5-TeBB	13	110.00	179.00	137.38	21.41	0.16
2,3,5,6-TeCBPh	13	97.00	164.00	119.69	18.18	0.15
October 17, 1985						
1,3-DBB	10	61.00	87.00	76.20	7.21	0.09
1,3,5-TBB	10	65.00	93.00	82.40	8.49	0.10
1,2,4,5-TeBB	10	94.00	137.00	115.60	13.88	0.12
2,3,5,6-TeCBPh	10	88.00	117.00	102.80	8.65	0.08

Lake Huron values (Table 6) suggested that they were consistent with Lake Huron background concentrations and indicated the absence of significant inputs along the river.

Levels of OCs at the outlet of Lake St. Clair were comparable to those of the St. Clair River, an indication of the ubiquitous distribution of these compounds within the Great Lakes basin.

Polychlorinated Biphenyls (PCBs)

The distribution of the PCBs was very similar to that of the OCs; the mean concentration was about 1.2 ng/L, with no marked spatial variation downstream from Port Lambton. At Sarnia, however, station SC1 on the U.S. side consistently showed a higher concentration, about twice as high as SC2 on the Canadian side (Fig. 5). The higher PCB reading on the U.S. side could be significant. A likely explanation is water from Saginaw Bay, where there are known discharges of PCBs (Anderson *et al.*, 1982) flowing down along the U.S. shore into the St. Clair River.

PCB concentrations at the head of the Detroit River were similar to those of the St. Clair River.

Chlorobenzenes (CBs)

Several chlorobenzene isomers were found in the St. Clair River, notably, 1,2-dichlorobenzene (1,2-DCB), 1,4dichlorobenzene (1,4-DCB), and hexachlorobenzene (HCB). The levels of 1,2-DCB at Port Lambton were generally higher than those upstream from Sarnia, where the levels were at or near detection level. The mean concentration of 1,2-DCB at Port Lambton from the September survey was much higher than the other surveys (Fig. 6) and is suspected to indicate a possible discharge of chlorobenzenes at the time. Results for HCB were most noteworthy in that the concentrations of this compound at Port Lambton were relatively higher than at background stations, and that the levels declined rapidly to near the detection limit towards the U.S. shore (Fig. 7). Farther downstream, elevated concentrations of HCB were confined to Chenal Écarté and the South Channel. This pattern was repeated for pentachlorobenzene (Fig. 8).

Chlorobenzenes are by-products of the electrolytic production of chlorine and the production of chlorinated solvents. Kauss and Hamdy (1985) also found elevated concentrations of HCB in both water samples and tissues of caged clams collected at stations along the shoreline between Sarnia and Corunna, Ontario. These observations clearly demonstrated that there were inputs of chlorobenzenes downstream from Sarnia and that the resulting plume was confined to a narrow band along the Canadian shore.

Concentrations of chlorobenzenes at the outlet of Lake St. Clair were generally lower than those observed at Port Lambton and Chenal Écarté, suggesting that some chlorobenzene is lost in Lake St. Clair.

Hexachlorobutadiene (HCBD) and Octachlorostyrene (OCS)

The spatial distributions of HCBD and OCS closely resembled those of HCB suggesting that they have a common source. Concentration of HCBD at the head of the St. Clair River was barely quantifiable (less than 0.01 ng/L). At Port Lambton, however, levels of HCBD along the Canadian shore were in the range of 3-9 ng/L. This plume continued downstream into Chenal Écarté and the South Channel (Fig. 9). The same pattern was evident with OCS, although the levels of OCS were almost two orders of magnitude smeller (Fig. 10). Pugsley *et al.* (1985) studied the distribution of OCS in both clams and sediments in the Huron-Erie corridor, and concluded that the primary source of OCS was along the St. Clair River shore.

The concentration of HCBD measured at Port Lambton is comparable to the α-BHC concentrations and exceeds those of PCBs. However, considering that α-BHC and PCBs have known baseline loadings from the upper Great Lakes and that HCBD is virtually undetected in Lake Huron, the levels of HCBD in the St. Clair River represent a substantial localized input of HCBD downstream from Sarnia. Assuming a flow of 5100 m^3/s, an average concentration of 3 ng/L, and that HCBD was confined to the eastern half of the river, a conservative estimate of HCBD input from the water phase amounts to only 240 kg/a, or 0.66 kg/d. Similarly, bottom sediments along the Sarnia shoreline in the vicinity of the township ditch to Dow and Suncor (Environment Canada and the Ontario Ministry of the Environment, 1986) showed dramatic increases in HCBD and OCS concentrations (parts per million range).

SUMMARY AND CONCLUSIONS

Concentrations of organochlorine pesticides in the St. Clair River were relatively uniform in the parts per trillion range, similar to those measured in Lake Huron water, and suggested no apparent inputs along the river. Industrial chemicals, such as chlorobenzenes, hexachlorobutadiene, and octachlorostyrene, discharged by the chemical industries in Sarnia were detected at Port Lambton in the parts per trillion range. The plume of these contaminants was confined to within 300 m of the Canadian shoreline, Chenal Écarté, and the South Channel.

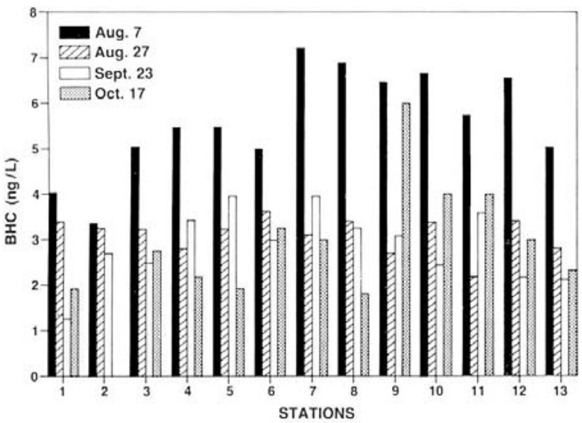

Figure 2. BHC levels in St. Clair River surveys, 1985.

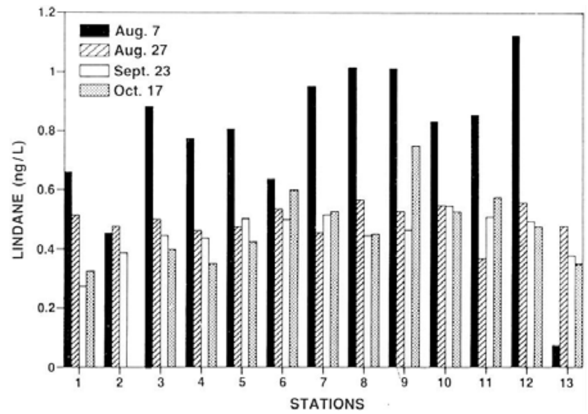

Figure 3. Lindane levels in St. Clair River surveys, 1985.

Table 2. St. Clair River Survey Results, August 7, 1985 (ng/L, 40-L sample).

Parameter	Sampling stations												
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13
1,3-DCB			0.358	0.410	0.183				0.318		0.065		0.285
1,4-DCB	0.807	1.263				0.495	1.295	1.593		0.565		0.793	1.095
1,2-DCB	0.082	0.201	0.518	0.828	0.573	0.140	0.243		0.180			0.161	
TCB (135)			0.094	0.050	0.009	0.008			0.062			0.030	0.017
TCB (124)	0.029	0.034		0.420	0.283	0.068	0.108	0.049	0.378	0.088	0.340	0.383	0.104
TCB (123)	0.005	0.048	0.102	0.071	0.083	0.069	0.087	0.084	0.039		0.030	0.025	0.035
TCB (1245)													
TCB (1235)													
TCB (1234)				0.050							0.077		0.017
P5CB			0.178	0.092	0.041				0.148		0.072	0.041	0.039
Hexachlorobenzene	0.020	0.019	1.568	0.660	0.343	0.061	0.040		1.198	0.075	0.535	0.268	0.217
α-BHC	4.025	3.350	5.025	5.475	5.475	5.000	7.200	6.875	6.450	6.650	5.725	6.550	5.025
Lindane	0.660	0.453	0.883	0.773	0.807	0.638	0.950	1.015	1.010	0.830	0.853	1.120	0.073
Heptachlor													
Aldrin													
Heptachlor epoxide	0.127	0.108	0.130	0.094	0.087	0.097	0.143	0.138	0.117	0.101	0.203	0.149	0.096
γ-Chlordane										0.022			
α-Chlordane	0.041			0.018		0.019		0.027	0.025	0.023	0.059		0.026
a-Endosulfan													
p,p'-DDE													
Dieldrin	0.260	0.260	0.310	0.270	0.227	0.265	0.253	0.415	0.275	0.288	0.290	0.360	0.250
Endrin													
o,p'-DDT													
p,p'-TDP													
p,p'-DDT													
β-Endosulfan													
Mirex													
Methoxychlor													
PCBs	3.525	2.080	1.430	1.585	1.240	1.450	1.800	1.183	1.335	l.518	1.273	1.270	1.128
HCBD	0.015	0.009	3.400	3.400	0.923	0.109	0.061	0.029	2.438	0.134	1.413	0.092	0.019
OCS			0.063	0.027	0.013				0.041		0.018	0.013	

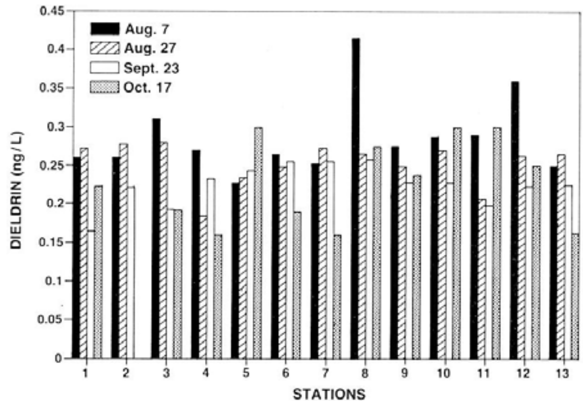

Figure 4. Dieldrin levels in St. Clair River surveys, 1985.

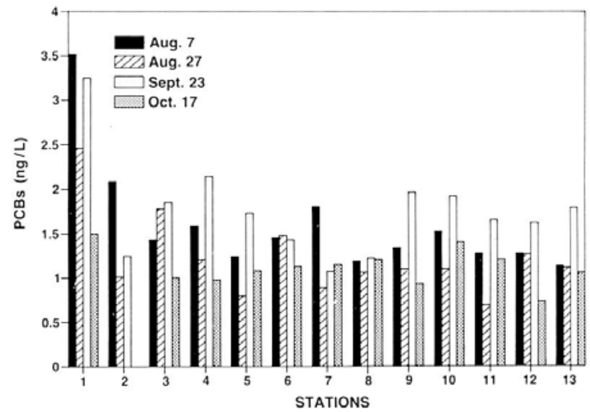

Figure 5. PCB levels in St. Clair River surveys, 1985.

Table 3. St. Clair River Survey Results, August 27, 1985 (ng/L, 40-L sample).

Parameter	Sampling stations												
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SCl2	SCl3
1,3-DCB			0.360	0.353	0.045				0.548		0.141	0.175	
1,4-DCB	1.123	0.540	0.488	1.418	1.700	0.948	0.900	1.020	0.755	1.548	0.470	0.688	0.290
1,2-DCB			0.890		0.283	0.213	0.084		0.074	0.159	0.608	0.503	
TCB (135)				0.024	0.011	0.012	0.015		0.055		0.163	0.025	0.024
TCB (124)	0.127	0.086		0.149	0.122	0.090	0.090	0.039		0.072	0.046	0.066	0.020
TCB (123)													
TCB (1245)													
TCB (1235)													
TCB (1234)													
P5CB			0.093	0.103	0.030				0.191		0.041	0.058	0.022
Hexachlorobenzene	0.021		1.013	l.110	0.313	0.117	0.034	0.023	2.115	0.049	0.383	0.565	0.199
α-BHC	3.400	3.250	3.225	2.800	3.225	3.625	3.100	3.400	2.700	3.375	2.178	3.400	2.800
Lindane	0.515	0.478	0.500	0.463	0.475	0.535	0.455	0.565	0.525	0.548	0.368	0.558	0.478
Heptachlor													
Aldrin													
Heptachlor epoxide	0.100	0.110	0.121	0.085	0.085	0.111	0.092	0.168	0.095	0.095	0.072	0.097	0.084
γ-Chlordane													
α-Chlordane								0.035		0.030	0.020		
α-Endosulfan													
p,p'-DDE	0.063												0.021
Dieldrin	0.273	0.278	0.280	0.185	0.234	0.248	0.273	0.265	0.249	0.270	0.207	0.263	0.265
Endrin													
o,p'-DDT													
p,p'-TDP													
p,p'-DDT													
β-Endosulfan													
Mirex													
Methoxychlor													
PCBs	2.460	1.010	1.778	1.203	0.793	1.478	0.885	1.058	1.093	1.098	0.685	1.263	l.110
HCBD	0.005	0.005	4.975	8.025	2.243	0.588	0.130	0.035	10.650	0.191	2.368	2.800	0.121
OCS			0.029	0.080	0.018				0.085		0.019	0.024	0.011

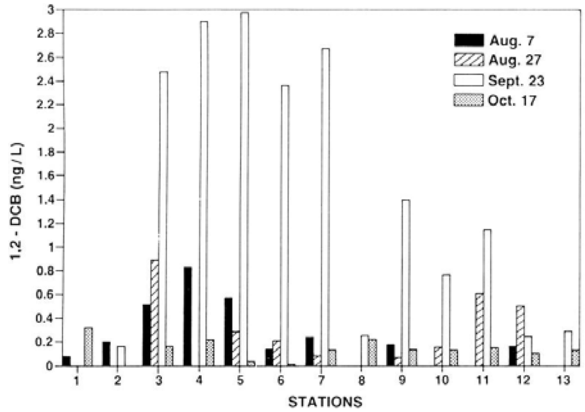

Figure 6. 1,2-DCB levels in St. Clair River surveys, 1985.

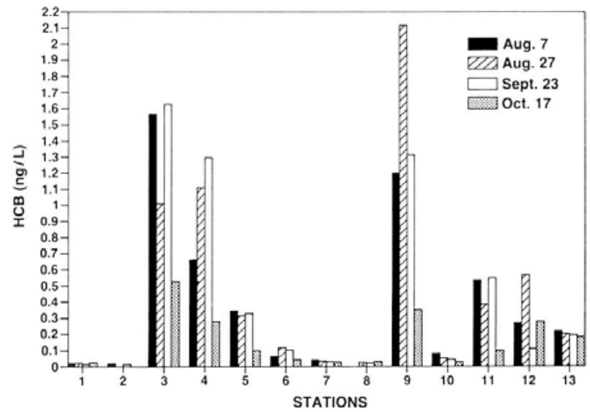

Figure 7. HCB levels in St. Clair River surveys, 1985.

Table 4. St. Clair River Survey Results, September 23, 1985 (ng/L, 40-L sample).

Parameter	Sampling stations												
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13
1,3-DCB													
1,4-DCB	0.985	0.858	1.158	1.065	1.148	1.270	1.423	1.235	1.170	0.943	1.080	1.068	1.138
1,2-DCB		0.164	2.478	2.900	2.975	2.363	2.675	0.255	1.403	0.768	1.150	0.246	0.290
TCB (135)												0.037	
TCB (124)	0.103	0.102			0.074	0.075	0.084	0.066		0.056	0.094	0.068	0.057
TCB (123)	0.022	0.018					0.009	0.011		0.008			
TCB (1245)													
TCB (1235)													
TCB (1234)				0.023							0.063		0.013
P5CB			0.191	0.141	0.035				0.130		0.073	0.023	0.033
Hexachlorobenzene	0.014	0.014	1.628	1.295	0.325	0.100	0.027	0.019	1.313	0.041	0.545	0.105	0.189
α-BHC	1.26	2.700	2.485	3.425	3.950	2.975	3.950	3.250	3.075	2.443	3.575	2.168	2.120
Lindane	0.273	0.388	0.445	0.438	0.503	0.500	0.515	0.445	0.463	0.545	0.508	0.493	0.378
Heptachlor													
Aldrin													
Heptachlor epoxide	0.068	0.075	0.064	0.078	0.084	0.087	0.087	0.092	0.082	0.088	0.071	0.079	0.072
γ-Chlordane													
α-Chlordane													
α-Endosulfan													
p,p'-DDE	0.067	0.030		0.036	0.024	0.023		0.020	0.020	0.022	0.016	0.024	0.026
Dieldrin	0.165	0.222	0.194	0.233	0.244	0.255	0.255	0.258	0.228	0.228	0.198	0.224	0.225
Endrin													
o,p'-DDT													
p,p'-TDP													
p,p'-DDT													
β-Endosulfan													
Mirex													
Methoxychlor													
PCBs	3.250	1.245	1.845	2.145	1.725	1.430	1.065	1.218	1.958	1.913	1.648	1.618	1.780
HCBD	0.006	0.004	3.475	3.325	1.168	0.265	0.028	0.014	3.475	0.122	1.610	0.036	0.106
OCS			0.048	0.030					0.033				

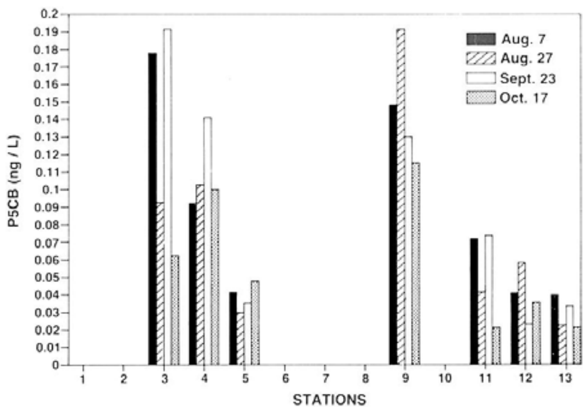

Figure 8. P5CB levels in St. Clair River surveys, 1985.

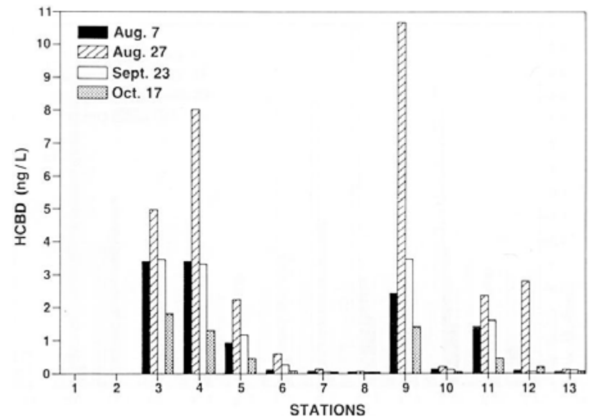

Figure 9. HCBD levels in St. Clair River surveys, 1985.

Table 5. St. Clair River Survey Results, October 17, 1985 (ng/L, 40-L sample).

Parameter	Sampling stations												
	SC1	SC2	SC3	SC4	SC5	SC6	SC7	SC8	SC9	SC10	SC11	SC12	SC13
1,3-DCB	0.095		0.525	0.325	0.045	0.875			0.325		0.045		
1,4-DCB	1.125		1.725	1.225	0.475	0.125	1.225	1.575	1.225	1.000	1.050	0.800	0.825
1,2-DCB	0.325		0.165	0.220	0.038	0.007	0.135	0.225	0.135	0.130	0.153	0.105	0.130
TCB (135)			0.068	0.030	0.013	0.160			0.045		0.015	0.045	0.024
TCB (124)	0.065		0.250	0.300	0.228		0.185	0.238	0.250	0.050	0.095	0.155	0.048
TCB (123)			0.030	0.023			0.005	0.007	0.038		0.011		
TCB (1245)													
TCB (1235)													
TCB (1234)											0.019		
P5CB			0.063	0.100	0.048				0.115		0.021	0.035	0.021
Hexachlorobenzene	0.024		0.525	0.275	0.095	0.040	0.025	0.028	0.350	0.025	0.093	0.275	0.180
α-BHC	1.925		2.750	2.175	1.925	3.250	3.000	1.800	6.000	4.000	4.000	3.000	2.325
Lindane	0.325		0.400	0.350	0.425	0.600	0.525	0.450	0.525	0.525	0.575	0.475	0.350
Heptachlor													
Aldrin													
Heptachlor epoxide	0.080		0.065	0.073	0.108	0.073	0.063	0.093	0.080	0.105	0.250	0.217	0.078
γ-Chlordane													
α-Chlordane													
α-Endosulfan													
p,p'-DDE					0.030	0.033			0.019	0.023	0.022	0.022	0.017
Dieldrin	0.223		0.193	1.160	0.300	0.190	0.160	0.275	0.238	0.300	0.300	0.250	0.163
Endrin													
o,p'-DDT													
p,p'-TDP													
p,p'-DDT													
β-Endosulfan													
Mirex													
Methoxychlor													
PCBs	1.500		1.000	0.975	1.075	1.125	1.150	1.200	0.925	1.400	1.200	0.725	1.050
HCBD	0.013		1.800	1.300	0.450	0.075	0.017	0.015	1.400	0.019	0.450	0.190	0.065
OCS			0.028	0.012					0.015			0.013	0.008

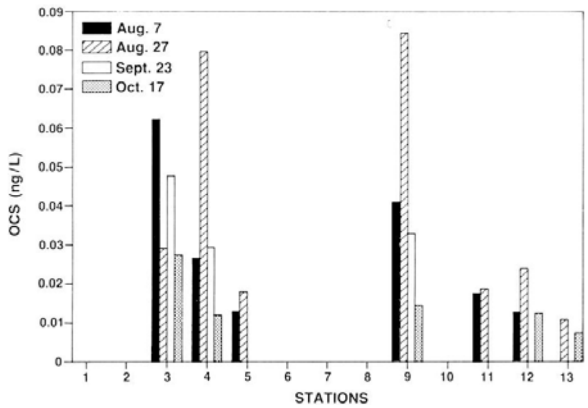

Figure 10. OCS levels in St. Clair River surveys, 1985.

Table 6. Trace Contaminants Concentrations in the Great Lakes and St Clair River (ng/L).

Parameter	Lake Superior [1]	Lake Huron [2]	Lake Ontario [3]	St. Clair River
1,3-DCB		0.025		0.045-0.875
1,4-DCB		0.025-0.547		0.125-6.00
1,2-DCB		0.025-0.535		0.006-3.00
TCB (135)		0.004		0.008-0.162
TCB (124)		0.004-0.187	0.022-1.36	0.008-0.700
TCB (123)		0.008-0.022	0.008-0.672	0.005-0.102
TCB (1245)		0.004		
TCB (1235)		0.004	0.009-0.322	
TCB (1234)		0.004-0.031	0.014-0.572	0.013-0.062
P5CB		0.004-0.014	0.009-0.220	0.014-0.19
Hexachlorobenzene	0.011-0.051	0.003-0.032	0.017-0.103	0.014-1.625
α-BHC	2.89 -15.89	4.32-12.19	4.36-8.81	1.25-7.25
Lindane	0.278-2.25	0.475-0.835	0.806-1.85	0.275-1.125
Heptachlor	0.014-0.036			
Aldrin	0.044-0.359			
Heptachlor epoxide	0.063-0.255	0.071-0211	0.167-0.375	0.062-0.250
γ-Chlordane	0.080-0.300		0.026-0.062	
α-Chlordane	0.060-0.183		0.008-0.046	0.018-0.060
α-Endosulfan	0.004-0.175			
p,p'-DDE	0.007-0.041			0.016-0.060
Dieldrin	0.080-0.412		0.259-0.631	0.160-0.425
Endrin	0.024-0.084	0.002-0.035	0.044-0.145	
o,p'-DDT	0.016-0.195			
p,p'-TDP	0.032-0.069			
p,p'-DDT	0.010-0.513			
β-Endosulfan				
Mirex				
Methoxychlor	0.289-0.561		0.032-0.086	
PCBs	1.166-5.113	0.079-0.394	0.32-3.1	0.675-3.500
HCBD				0.004-8.00
OCS				0.007-0.085

[1] Chan (1984). [2] Neilson (1984). [3] Biberhofer and Stevens (1985).

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REFERENCES

Anderson, M.L., C.P. Rice, and C.C. Carl. 1982. Residue of PCB in a cladophora community along the Lake Huron shoreline. J. Great Lakes Res., 8(1):196-200.

Biberhofer, J., and R.J.J. Stevens. 1985. Organochlorine contaminants in ambient waters of Lake Ontario. Water Quality Branch, Ontario Region, Inland Waters Directorate, Environment Canada, Burlington, Ont. In press.

Bonner, R.F., and O. Meresz. 1981. St. Clair River organics study. Identification and quantitation of organic compounds. Ontario Ministry of the Environment, Laboratory Services Branch Report, Toronto, Ont.

Chan, C.H. 1984. Organochlorine pesticides and PCBs in open waters of Lake Superior. Water Quality Branch, Ontario Region, Inland Waters Directorate, Environment Canada, Burlington, Ont. Unpub. rep.

Environment Canada. 1979. *Analytical Methods Manual.* Water Quality Branch, Inland Waters Directorate, Ottawa, Ont.

Environment Canada and the Ontario Ministry of the Environment. 1986. St. Clair River Pollution Investigation (Sarnia Area). Report of the St. Clair River Investigation conducted under the auspices of the Canada-Ontario Agreement Respecting Great Lakes Water Quality, submitted to the Honourable Tom McMillan, Minister of Environment, Government of Canada, and the Honourable James Bradley, Minister of Environment, Government of the Province of Ontario, January 28, 1986. National Water Research Institute, Inland Waters Directorate, Environment Canada, Burlington, Ont.

Filkins, J.C., J.M. Towsend, and S.G. Rood. 1983. Organochlorines in offshore waters of the Great Lakes, 1981. Cranbrook Institute of Science, Bloomfield Hills, Mich. Unpub. rep.

Goulden, P.D., and D.H.J. Anthony. 1985. Design of a large sample extractor for the determination of organics in water. National Water Research Institute, Contribution 85-121, Environment Canada, Burlington, Ont.

Hamdy, Y.S., and J.D. Kinkead. 1979. St. Clair River organics study. Water dispersion in the St. Clair River. Ontario Ministry of the Environment Report, Toronto, Ont.

International Joint Commission. 1979. Great Lakes Water Quality 1978. Appendix B. Surveillance Subcommittee Report to the Implementation Committee, Great Lakes Water Quality Board, July 1979. Windsor, Ont.

International Joint Commission. 1982. Report on Great Lakes Water Quality. Great Lakes Water Quality Board, Windsor, Ont.

International Joint Commission. 1983. Report on Great Lakes Water Quality. Great Lakes Water Quality Board, Windsor, Ont.

Kauss, P.B., and Y.S. Hamdy. 1985. Biological monitoring of organochlorine contaminants in the St. Clair and Detroit rivers using introduced clams. J. Great Lakes Res., 11(31:247-63.

Kuehl, D.W., H.L. Kopperman, G.D. Veith, and G.E. Glass. 1976. Isolation and identification of polychlorinated styrenes in Great Lakes fish. Bull. Environ. Contam. Toxicol., 16:127-32.

Kuehl, D.W., H.L. Johnson, B.C. Butterworth, E.N. Leonard, and G.D. Veith. 1981. Quantification of octachlorostyrene and related compounds in Great Lakes fish by gas chromotography-mass spectrometry. J. Great Lakes Res., 7:330-35.

McCorquodale, J.A., E.H. Imam, J.K. Bewtra, Y.S. Hamdy, and J.D. Kinkead. 1983. Transport of pollutants in natural streams. Can. J. Civil Eng., 10:9-17.

Neilson, M.A.T. 1984. Organochlorine pesticides, polychlorinated biphenyls and chlorobenzenes in centrifuged Lake Huron water samples 1984. Water Quality Branch, Ontario Region, Inland Waters Directorate, Environment Canada, Burlington, Ont. Unpub. rep.

Ontario Ministry of the Environment. 1977. Great Lakes Water Quality Data Summary: St. Clair River 1976. Great Lakes Survey Unit, Planning and Co-ordination Section, Water Resources Branch, Toronto, Ont.

Pugsley, C.W., D.N. Hebert, G.W. Wood, G. Brotea, and T.W. Obal. 1985. Distribution of contaminants in clams and sediments from the Huron-Erie corridor. I-PCBs and octachlorostyrene. J. Great Lakes Res., 11(3):275-89.

Reichel, W.L., R.M. Pronty, and M.L. Gay. 1977. Identification of polychlorinated styrene compounds in heron tissues by gas-liquid chromotography-mass spectrometry. J. Assoc. Off. Anal. Chem., 60:60-62.

Sylvestre, A.S. 1985. Review of WQB/OR sampling on the St. Clair River 1967-1983. Water Quality Branch, Ontario Region, Inland Waters Directorate, Environment Canada, Burlington, Ont. Unpub. rep.

Thornley, S., and Y.S. Hamdy. 1984. An assessment of the bottom fauna and sediments of the Detroit River. Ontario Ministry of the Environment, Southwestern Region and Water Resources Branch Report, Toronto, Ont.