AN ASSESSMENT OF THE BOTTOM FAUNA AND SEDIMENTS OF THE WESTERN BASIN OF LAKE ERIE, 1979

Ontario

Ministry
of the
Environment

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ACKNOWLEDGEMENTS

This was a joint study with MOE Southwestern Region, London, Ontario and MOE Water Resources Branch, Toronto. Southwestern Region was responsible for benthological collection, enumeration and reporting, under the supervision of Mr. J. D. Westwood. Staff of Great Lakes Surveys Unit provided vessel support for sampling and undertook the assessment of sediment quality.

Special thanks are forwarded to Mr. Jarl K. Hiltunen of the U.S. Fish and Wildlife Service, Ann Arbor, Michigan, for sharing his time, taxonomic expertise and knowledge of the tubificid worms of Lake Erie.

SUMMARY

The composition of the benthic communities has improved since 1967. The benthic communities were dominated by pollution tolerant tubificids, *Limnodrilus hoffmeisteri, L. cervix, L. maumeensis,* and other *Limnodrilus* species; however, other less tolerant *Peloscolex* species of tubificids were also common at a number of stations. Midge larvae (Chironomidae) accounted for a larger percentage of the total organisms collected during 1979 than in the previous studies of Veal and Osmond (1). The burrowing mayfly *Hexagenia limbata* was found near the mouth of the Detroit River, signalling a significant improvement in the benthic community since 1967 when this species was absent.

Macrozoobenthos conditions near the mouth of the Detroit River in 1979 suggest that a reduction has occurred in organic and phosphorus waste loadings as reflected by a definite reduction in pollution tolerant tubificid worms since the previous survey in 1967. If the reduction in loading from the Detroit River continues similar improvements in the macrozoobenthos community of the western basin can be expected.

PCB and Mirex residues in the depositional area off the Detroit River mouth indicated a recent source of sediment contamination. The presence of Mirex in the Western Basin of Lake Erie was detected only during the August 1979 survey. No detectable levels of Mirex have been found in fish samples collected from the Western Basin during the past four years (pers. com. K. Suns). An investigation is presently being carried out to determine the source of these levels.

Trends in heavy metals between 1970 and 1979 cannot be readily determined due to changes in analytical and sampling methods and the process of sediment redistribution. Nevertheless, a qualitative station-by-station comparison suggests that some decrease has occurred.

INTRODUCTION

Regular water quality monitoring by the Ministry of the Environment in the Western Basin of Lake Erie has shown a general reduction in phosphorus levels over the past few years. Similarly, regular phytoplankton monitoring at the Union Water Treatment Plant near Leamington (2), has shown an improving water quality trend. To further verify water quality improvements a survey was carried out in 1979 to document the present status of macrozoobenthos (bottom dwelling organisms) and sediment quality at sixteen locations that had been surveyed by Veal and Osmond in 1967 (1).

Water quality conditions along with substrate characteristics dictate the distribution and abundance of the aquatic macrozoobenthos. The majority of these organisms are relatively immobile and take several months or years to complete their life cycles. Therefore, the study of communities and population densities provides good insight into long-term water quality conditions.

A clean water community is characterized by diverse numbers of taxa and a low number of total individuals, with no one taxa dominating the community. In contrast, a benthic community typical of degraded water conditions is dominated by few pollution-tolerant taxa and high numbers of individuals.

Over the past decade, chemical analysis of sediments has also proven to be a reliable monitoring technique for the identification of trace metals and organic contaminants (4). The chemical quality of the sediments of the Western Basin of Lake Erie have been studied by several investigators in the past (6, 7). Past investigations of the Ministry of the Environment have focused on the fate and transport of mercury in the sediments and fish of the St. Clair River System which resulted from past industrial discharges (8).

METHODS

The Ministry of Environment's survey vessel Monitor IV was used for sample collection and conventional marine scanning radar was used for station location. Sixteen stations were sampled for macrozoobenthos during May and August, 1979. The two sampling periods provided an indication of seasonal changes in species types and total numbers. Station locations were distributed throughout the Western Basin of Lake Erie (Figure 1) based on the sampling grid sampled by Veal and Osmond in 1967 (1).

Two samples were collected with a Ponar grab at each station during each sample period and washed through a standard 30 wire mesh screen (0.59 mm). The remaining sediments and debris were placed in 1-L jars and transported daily to the Amherstburg Water Treatment Plant, where a field laboratory was established. The samples were placed in white enamel pans and the organisms were immediately separated from the sediments and debris by hand sorting with forceps. After sorting, the organisms were counted and identified to order, preserved in 95% ethanol and stored in 30 mL vials. At the end of the survey, the organisms were transported to the Ministry of Environment's Laboratory at London where organisms were identified to genus, and to species where possible.

In conjunction with macrozoobenthos sampling, replicate Shipek grab samples of surficial sediments (0-3 cm) were taken at the 16 sampling stations for chemical analysis during both the May and August, 1979 surveys. Sediment samples were submitted to the MOE main laboratory in Toronto for total metal analysis (zinc, cadmium, lead, mercury, copper, chromium, nickel and arsenic), which included acid digestion and atomic absorption spectrophotometry after methods described by Darcel (4). Samples were partitioned for analysis of loss on ignition, nutrients (total Kjeldahl nitrogen and total phosphorus), and Wentworth particle size. Duplicate samples were transported in solvent rinse containers for analysis of chlorinated hydrocarbons and pesticides including DDT and metabolites (ppDDE, ppDDD, op and ppDDT),

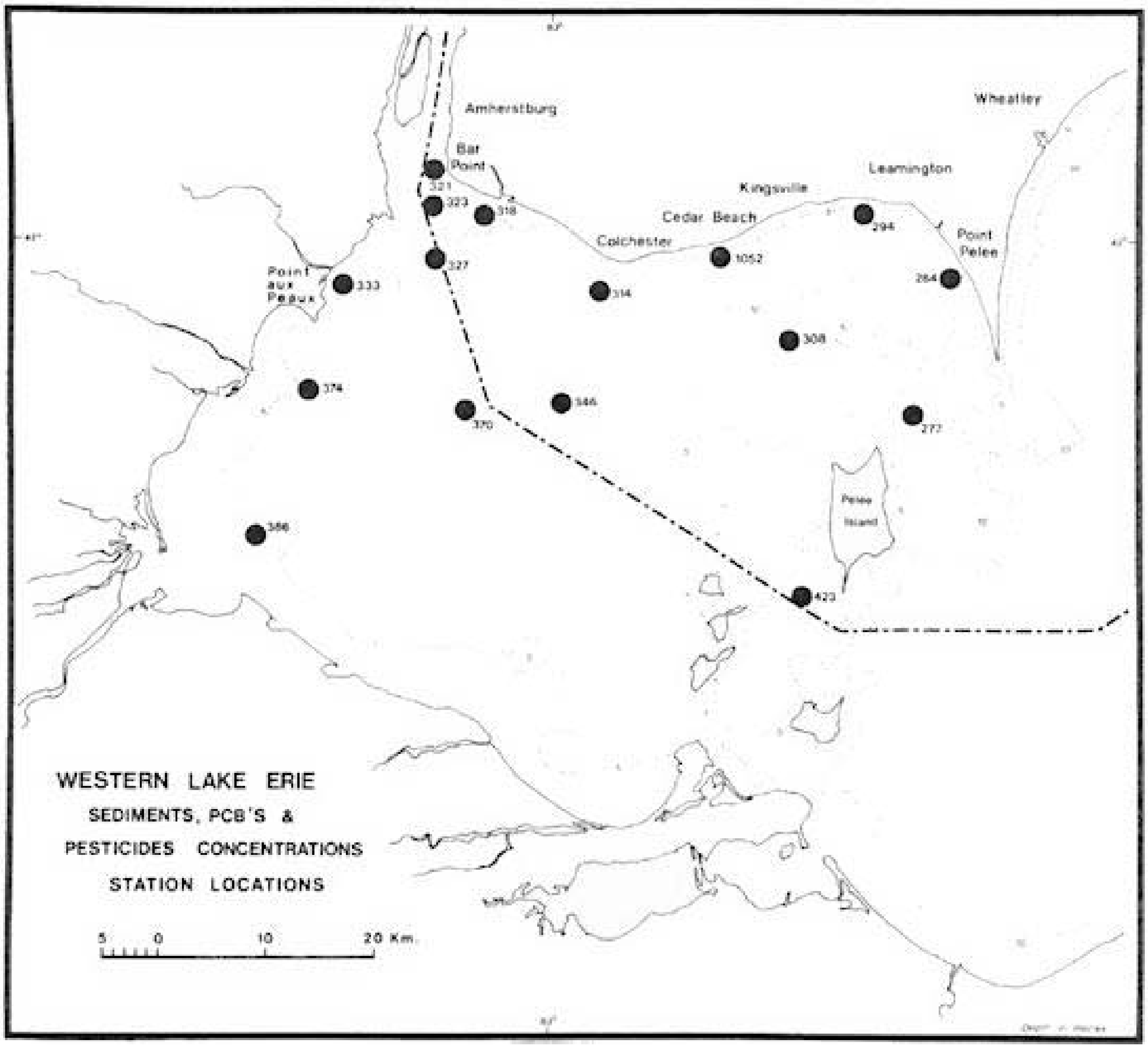

FIGURE 1 The Location Of Benthic And Sediment Sampling Stations In The Western Basin Of Lake Erie, 1979.

Lindane (alpha and beta hexachlorocyclohexane (BHC) isomers), Mirex, hexachlorobenzene (HCB), polychlorinated biphenyls (PCB's), Dieldrin, Endrin, Thiodan (alpha and beta endosulfan), alpha and gamma chlordane, heptachlor and heptachlor epoxide. Organic contaminant analyses were performed according to standard MOE analytical and quality control procedures (5).

DISCUSSION

BOTTOM FAUNA - 1979

Results of macrozoobenthos sampling during May and August, 1979, are presented in Appendices 1 & 2. The benthic communities of the Western Basin of Lake Erie were dominated by tubificid worms, which accounted for 75 percent of the total number of organisms collected during May, 1979 and 74 percent of total organisms during August, 1979. Using the study area divisions of Veal and Osmond (1967), tubificid worm populations at 3 stations in the area of Detroit River mouth (Figure 2) averaged between 1153 and 4295 individuals per meter square. *Limnodrilus* species dominated total numbers in this area; however, *Peloscolex* species were well represented, especially at stations 321 and 323 during May.

The highest density of tubificid worms encountered during the survey (14,233 per meter square) was found at station 386 near Maumee Bay (Figure 2). The tolerant worms *Limnodrilus hoffmeisteri*, and *L. maumeensis*, as well as other *Limnodrilus* species, dominated at this station. *Branchiura sowerbyi* was also found in considerable numbers.

The remaining stations sampled in the Western Basin in 1979 produced less than 1500 tubificid worms per meter square (see Figure 2) with the exception of station 333 near Point aux Peaux and station 284 near Point Pelee. Densities of 2354 and 2276 per meter square were documented at these two locations, respectively.

Midge larvae (Chironomidae) constituted 22 percent during May and 17 percent during August of the total organisms collected. Midge populations were dominated by species of the genera *Procladius, Coelotanypus* and *Chironomus.* During May, the total number of chironomid larvae averaged 358 per meter square and their numbers ranged from 0 per meter square at station 321 to 1457 per meter square at station 386. Total numbers of midge larvae were moderately reduced during the August survey, averaging 274 per meter square and ranging from 89 per meter square at station 333 to 620 per meter square at station 374. The predacious midge *Procladius* dominated chironomid populations at most stations.

Clams belonging to the family Sphaeriidae were present at all stations except station 1052. Total numbers per meter square for all stations averaged 35 during May, and 68 during August. In general, densities of clams were low. Unionidae clams were present in low numbers at four locations, all in Canadian waters.

Larvae of the burrowing mayfly *Hexagenia limbata* were collected in the bottom sediments near the mouth of the Detroit River at stations 321 and 323 during May, and at stations 318, 323 and 327 during August, 1979. Total numbers were low, with 1 to 4 individuals present per grab sample, extrapolated to 20 per meter square.

Other pollution-sensitive taxa were rare in the Western Basin of Lake Erie. The amphipod *Gammarus* was present only in very low numbers at one location in May, and at 5 locations during August. Caddisflies were present at only two locations during the May survey, at station 321 near Detroit River mouth and at station 333. On May 24, 1979, large swarms of adult caddisflies of the family Leptoceridae were observed in the vicinity of station 423 near Pelee Island. Large numbers were observed on the water and in the air, and hundreds landed on the survey vessel during the time station 423 was being sampled. The sediments collected at this station were void of caddisfly larvae. The observation of notable caddisfly emergence suggests that suitable habitat must exist in the immediate area, possibly in the gravel of the littoral zones around the islands.

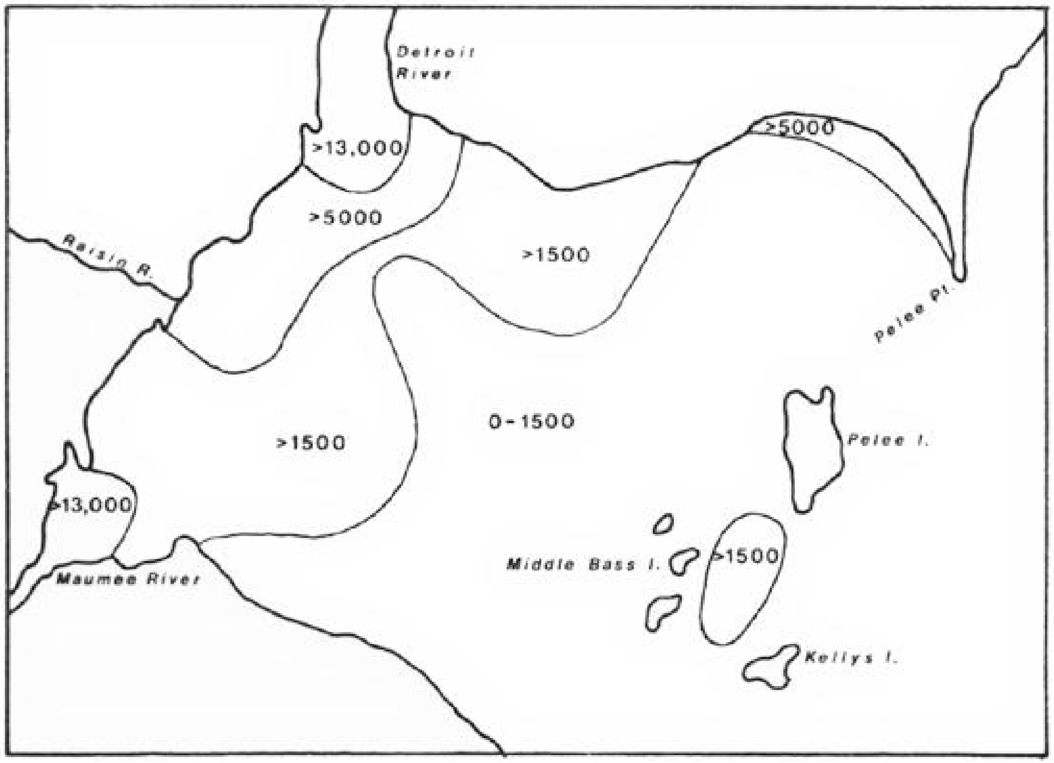

FIGURE 2A. The Number of Tubificids/ m^2 in The Western Basin of Lake Erie, April To August 1967.

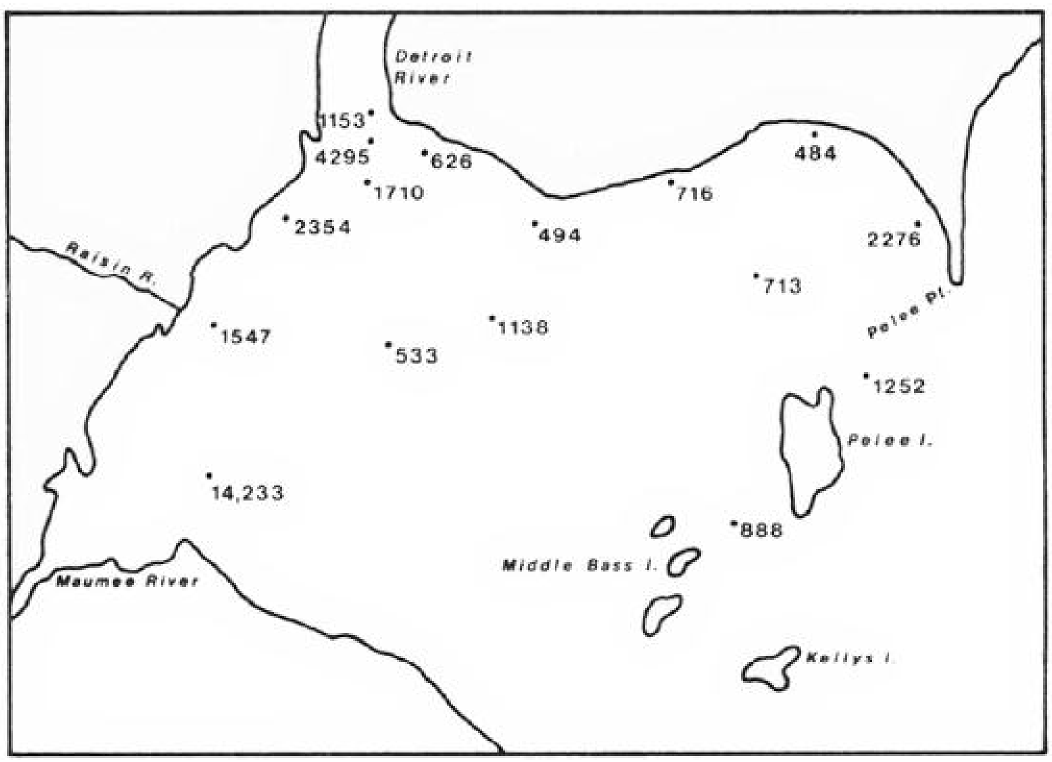

FIGURE 2B. The Number of Tubificids/m^2 in The Western Basin of Lake Erie, May To August 1979.

COMPARISON OF 1967 AND 1979 MACROZOOBENTHOS

Figure 2 depicts the number of tubificid worms per meter square that were obtained at 16 stations sampled in 1967 and again in 1979.

Sampling during May and August, 1979 indicated a significant decline in tubificid worm populations in all areas of the Western Basin, with the exception of station 386 near Maumee Bay where total numbers of tubificid worms have remained at 1967 levels. Total numbers of tubificid worms have declined sharply at the mouth of the Detroit River. While an average of 13,000 worms per meter square was documented in 1967 in this area, sampling in 1979 produced an average of 2386 tubificid worms per meter square, with numbers ranging from 1153 to 4295 per meter square at the three stations. Although *Limnodrilus* species dominated most populations, other less tolerant types such as *Peloscolex* species were common.

The Lumbriculid worm *Stylodrilus herinRianus*, an organism usually associated with clean water communities, was documented at station 321 in Canadian waters during August of 1979. This species was not present during the 1967 study.

Midge (*Chironomidae*) larvae collected during May and August 1979 represented 22% and 17%, respectively, of the total number of organisms compared to only 6% of the total number of organisms during 1967.

A major point of interest is the documentation of the presence of the burrowing mayfly *Hexagenia limbata* at stations 321 and 323 during May of 1979 and at stations 318, 323, and 327 during August of 1979. These stations are within the zone of influence of the Detroit River with Stations 318, 321 and 323 in Canadian waters, and station 327 located farthest from the river mouth in U.S. waters. The study of Veal and Osmond during 1967 did not document the presence of *Hexagenia limbata*. Bottom fauna studies carried out by Osmond on the Detroit River during 1968 (3) indicated a virtual absence of *Hexagenia limbata* at Detroit River mouth and upstream to Stony Island, north of Amherstburg.

SEDIMENT QUALITY

Heavy metals and chlorinated hydrocarbon data are presented in figures 3 to 9. Contaminant concentrations expressed in dry weight, are shown adjacent to the station location for both the May and August 1979 surveys. Since the observed between station differences are generally greater than the between survey differences, the May and August results for most parameters can be averaged to reflect the general contaminant distribution in the basin. They were, however, kept separate to illustrate apparent between survey differences observed in a few parameters which may be suggestive of changes in contaminants loading.

The major sediment inputs to the basin are from the Detroit and Maumee River basins with suspended solids from these sources subject to fluvial sedimentation off their river mouths. However, because of the shallow hydraulic depth of the basin, these sediments are subject to redistribution by wave action under various stages of wave and storm activity. Further evidence of sediment redistribution within the basin was noted by Kinkead and Hamdy (8) for mercury.

Differences between surveys are indicated for individual stations for anthropogenic materials such as DDT, PCBs, and Mirex; and industrial metals such as chromium, lead and zinc. To evaluate differences between the two survey periods for all stations, the Student's t test, at the 95% confidence limit was used. Tests for significant difference between surveys for individual stations or station subgroups were not undertaken due to inadequate sample size. For all heavy metals at the sixteen stations no significant difference was noted between surveys with the exception of iron. Testing of thirteen station pairs of samples with detected PCB residues indicated no significant differences as did the six station pairs with detected total DDT residues.

Concentrations of detected chlorinated hydrocarbons and metals were greatest at station 327 which is located off the Detroit River mouth. Lowest concentrations were generally noted at station 277 midway in the passage between Pelee Point and Pelee Island.

The presence of detected chlorinated hydrocarbon residues in surficial sediments as well as the variation in concentration between surveys for the area off the Detroit River suggests a recent source of sediment contamination. This situation is most notable for PCBs and Mirex. The Detroit River appears to be the primary source of PCB input to the basin.

Mirex was not detected during the May survey but detected during the August survey in the depositional zone off the Detroit River mouth suggesting a source of contamination over the intervening period. Mirex levels detected in sediments of the Western Basin of Lake Erie ranged from 5 to 20 µg/kg. These levels are similar to those observed along the U.S. shoreline of Lake Ontario (PLUARG 1978). Mirex was not found in fish samples collected from the Western Basin during the past four years (pers. com. K. Suns). An investigation into the source of these levels is presently under way.

Appendix 3 shows a comparison of present data with data from a previous 1970 MOE study. Sampling and analytical methods for the 1970 data vary slightly from those of the present study; as such, direct comparisons between the two data sets are difficult.

Sediment redistribution further complicates quantitative trend assessment; nevertheless, a gross comparison of mean metal values between 1970 and 1979 suggests a decline in all measured metal levels (cadmium, copper, chromium, zinc, lead, arsenic and mercury; Appendix 3).

No attempt was made during the present study to statistically correlate contaminant levels in sediment with benthos, due to limitations of the available data.

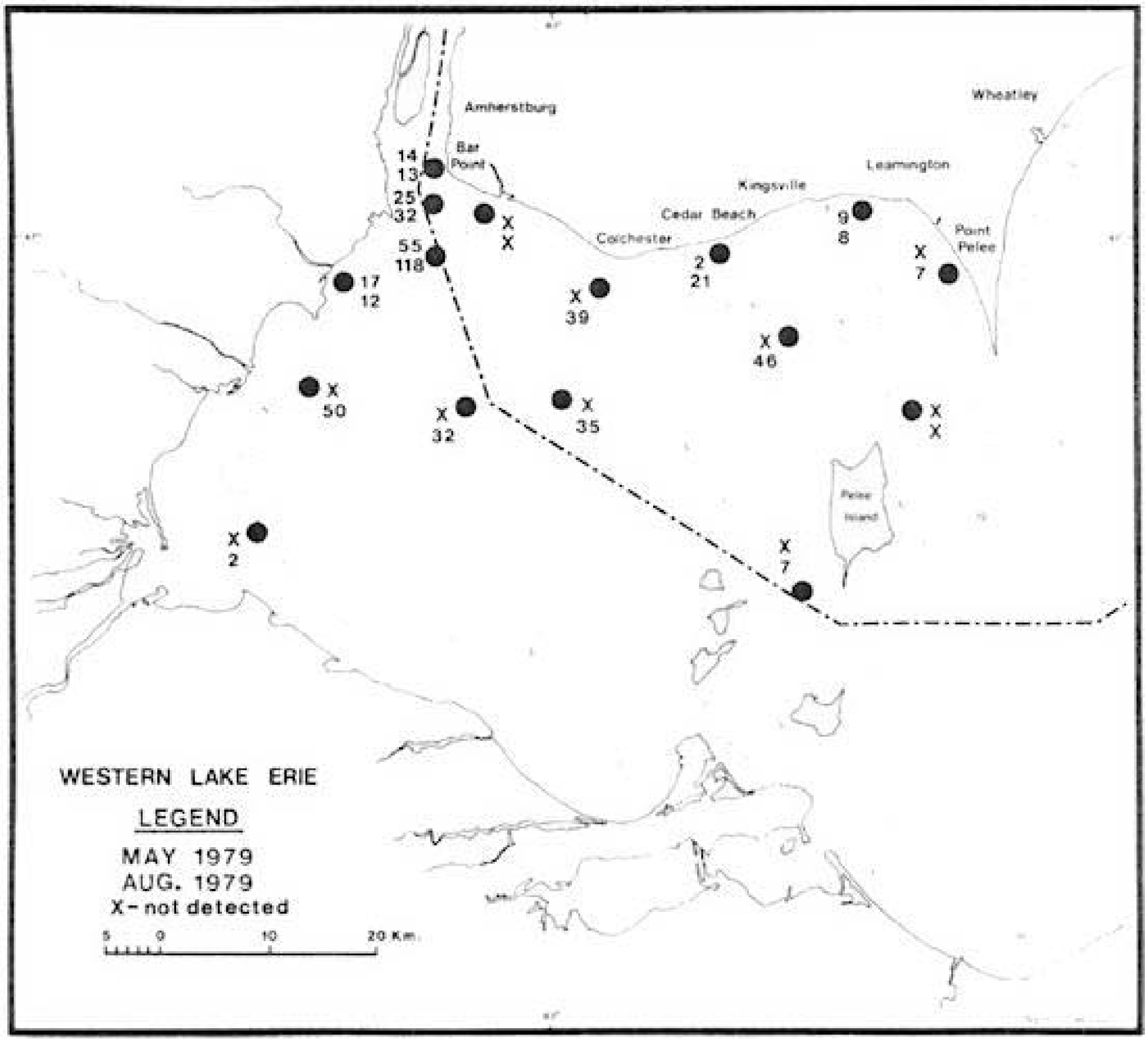

FIGURE 3 Sum Of DDT And Its Metabolites In The Surficial Sediments Of Western Lake Erie - µg kg^{-1}.

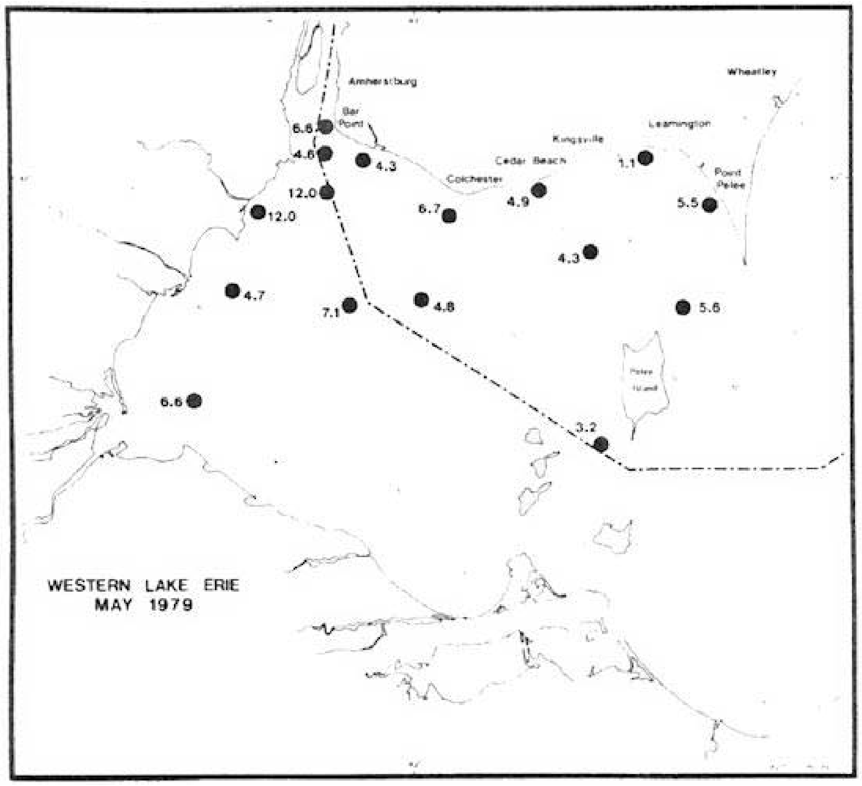

FIGURE 4A Arsenic In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

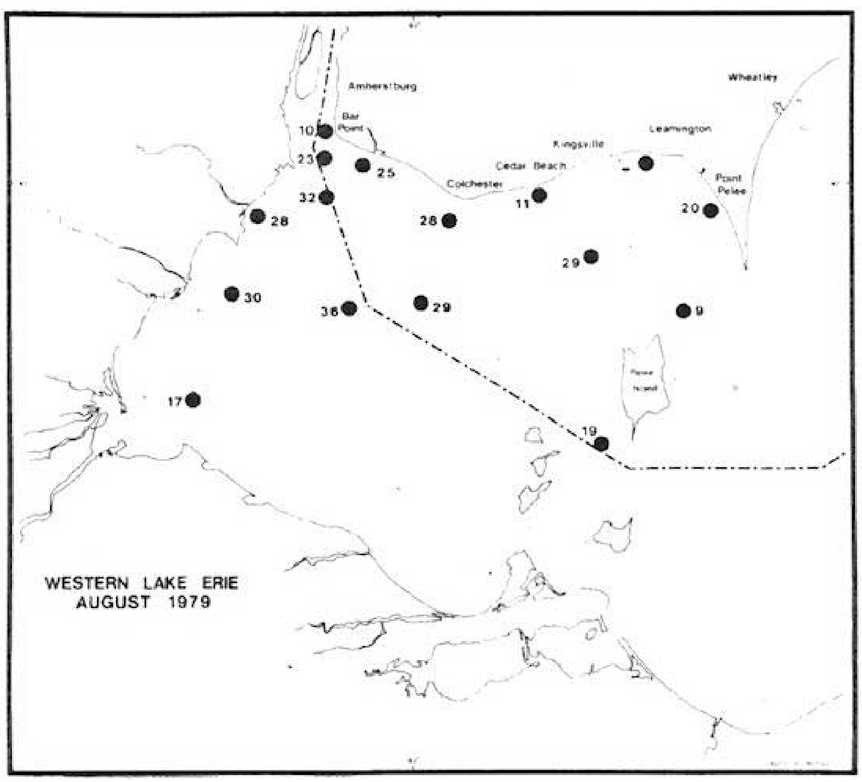

FIGURE 4B Iron In The Surficial Sediments Of Western Lake Erie - mg g^{-1} .

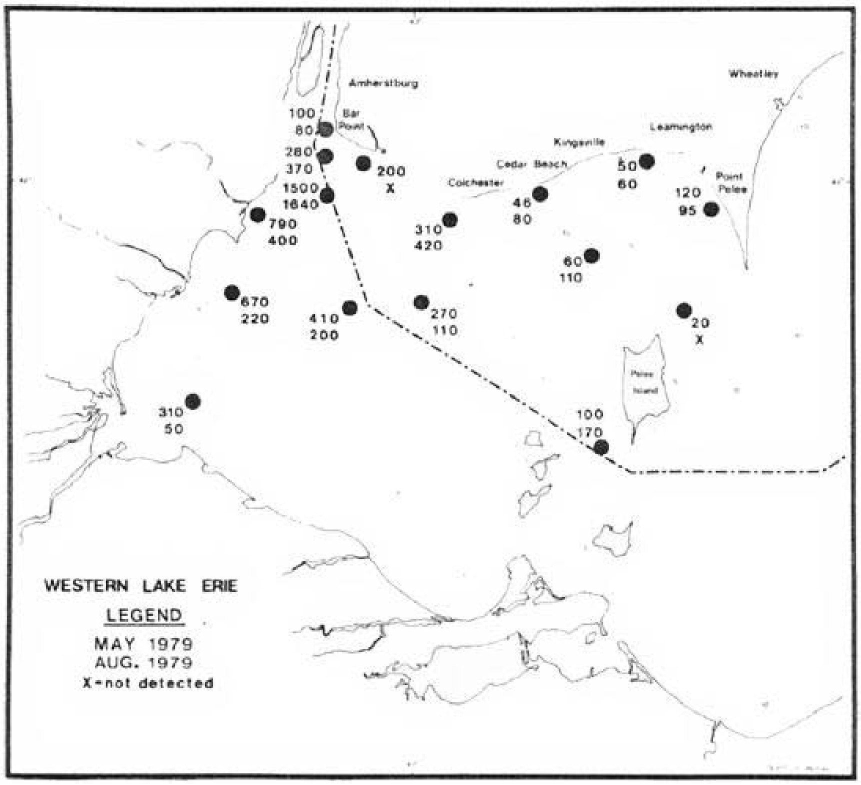

FIGURE 5A PCB's In The Surficial Sediments Of Western Lake Erie - µg kg^{-1}.

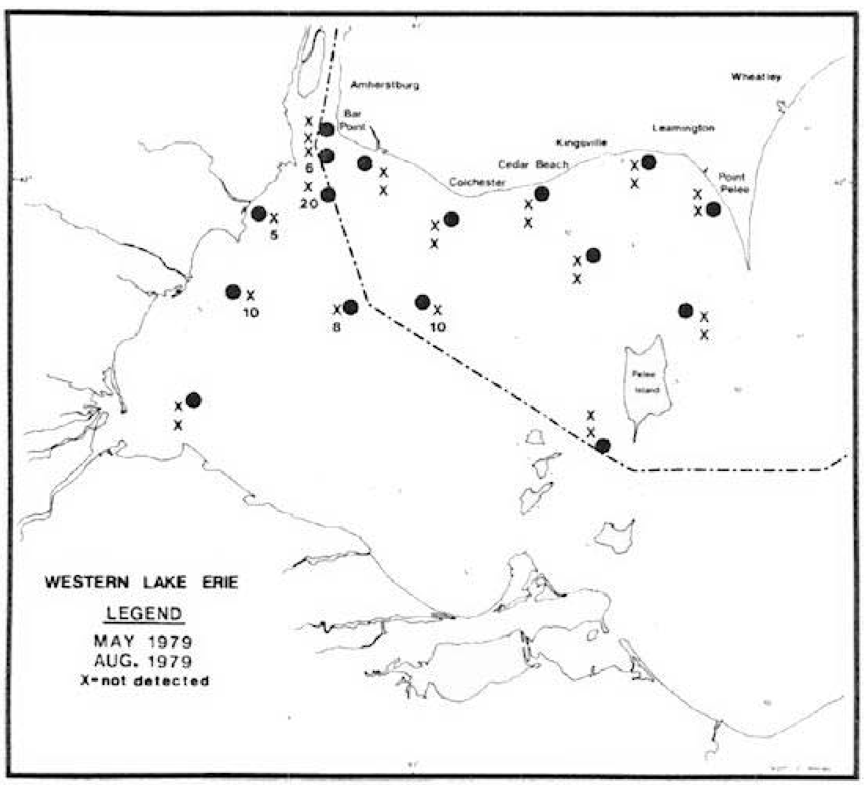

FIGURE 5B Mirex In The Surficial Sediments Of Western Lake Erie - µg kg^{-1} .

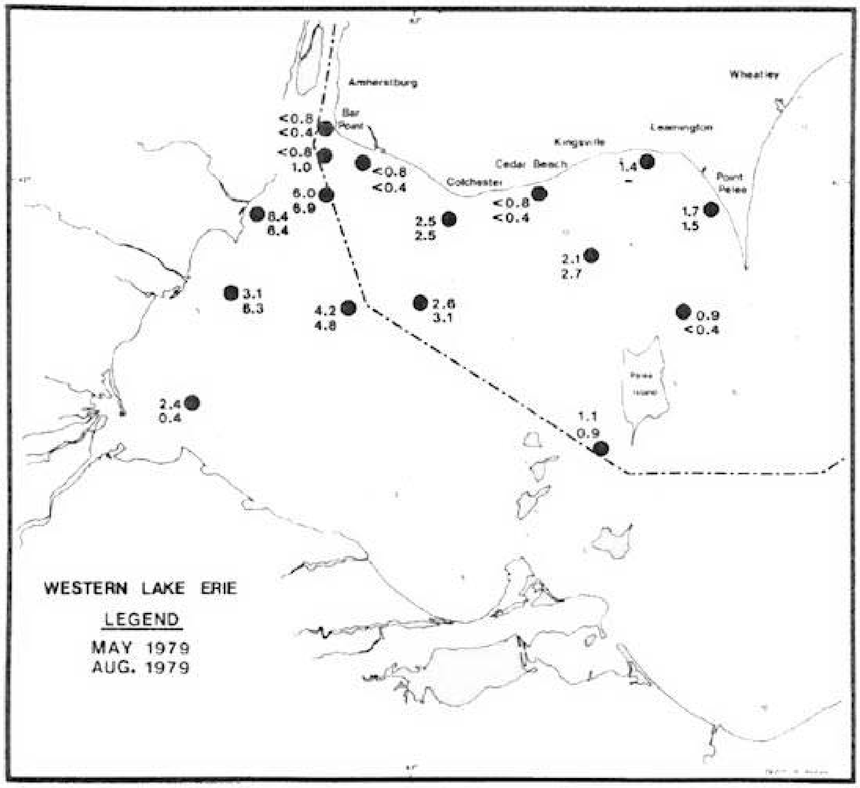

FIGURE 6A Cadmium In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

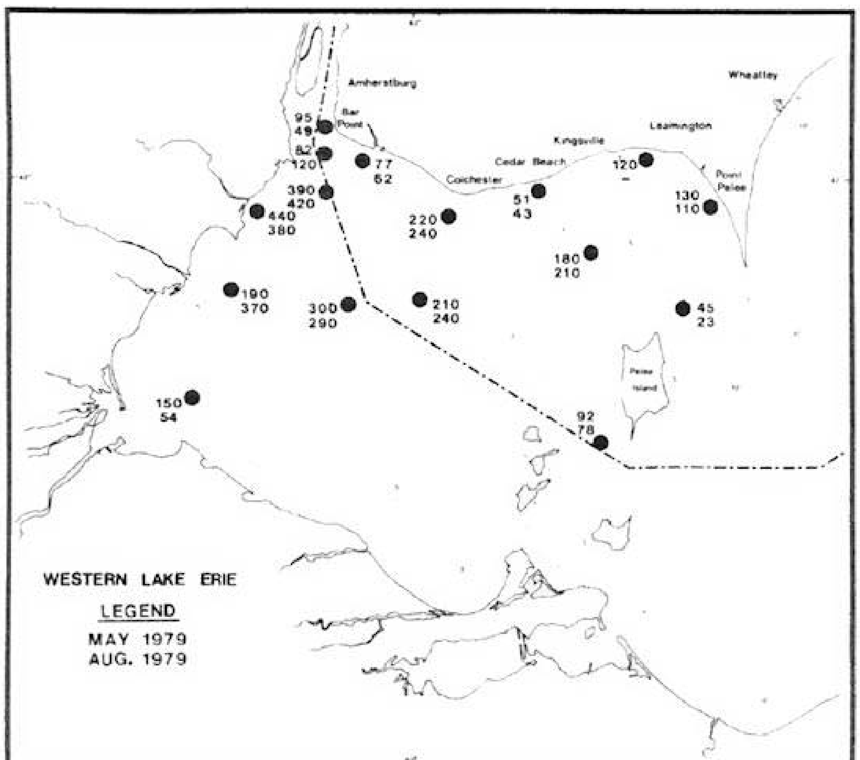

FIGURE 6B Zinc In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

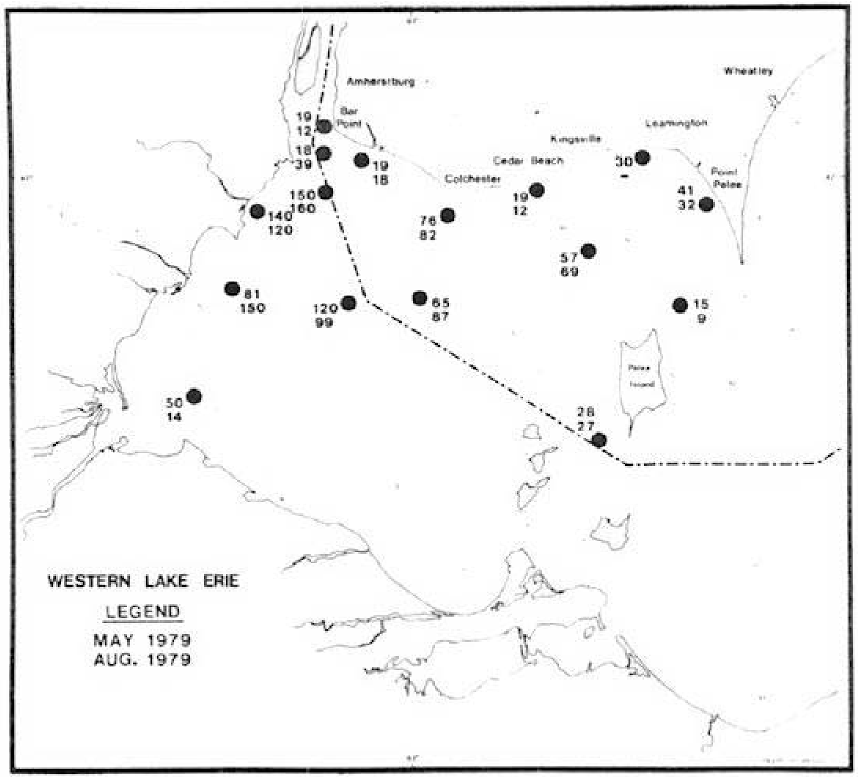

FIGURE 7A Chromium In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

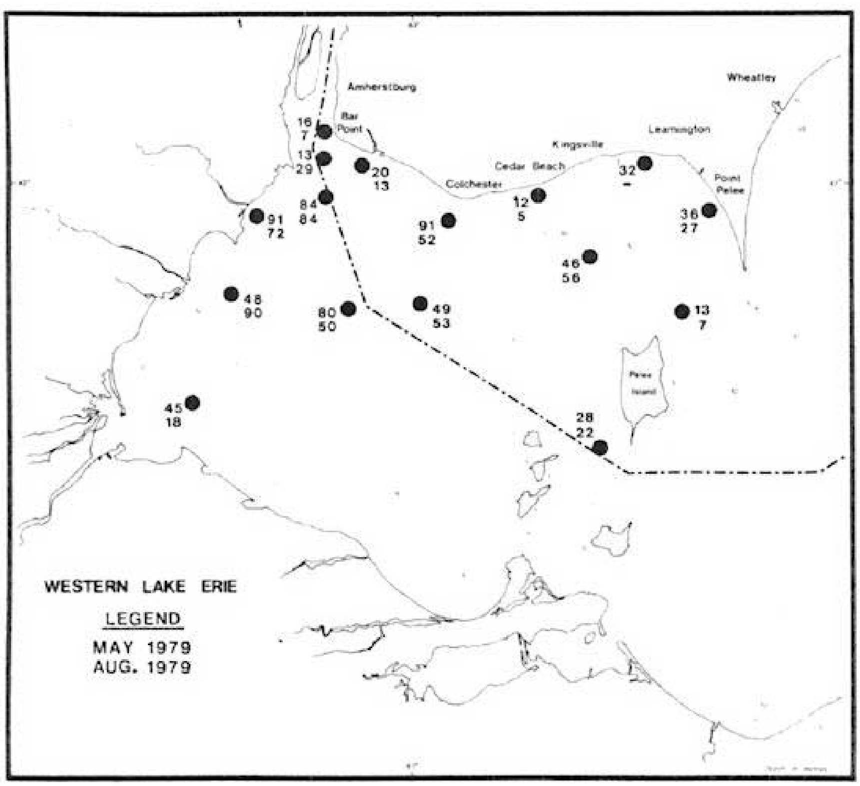

FIGURE 7B Nickel In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

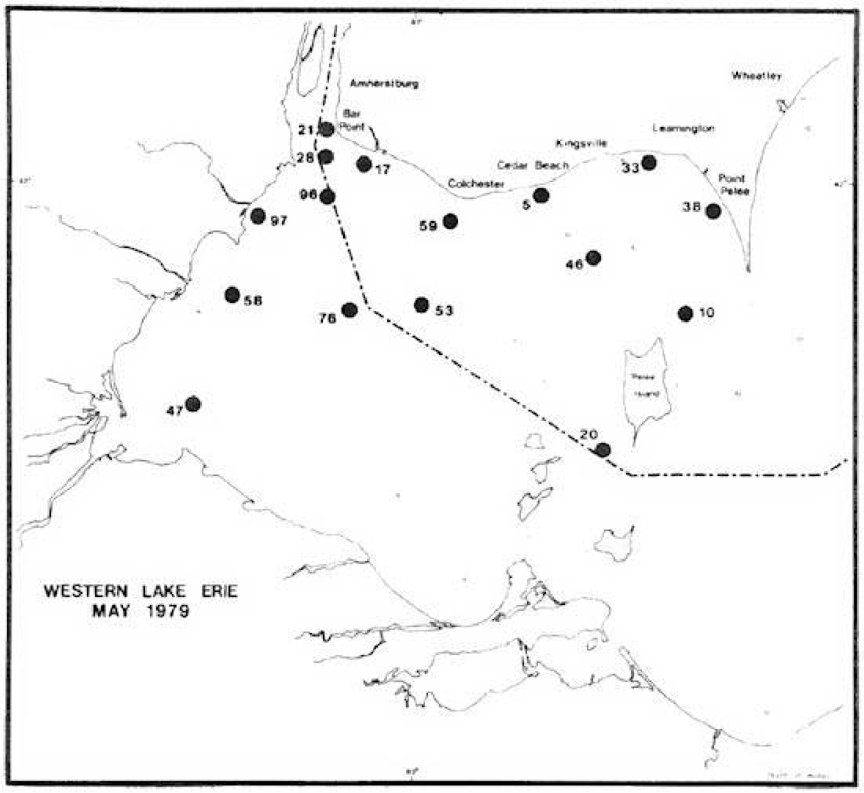

FIGURE 8A Copper In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

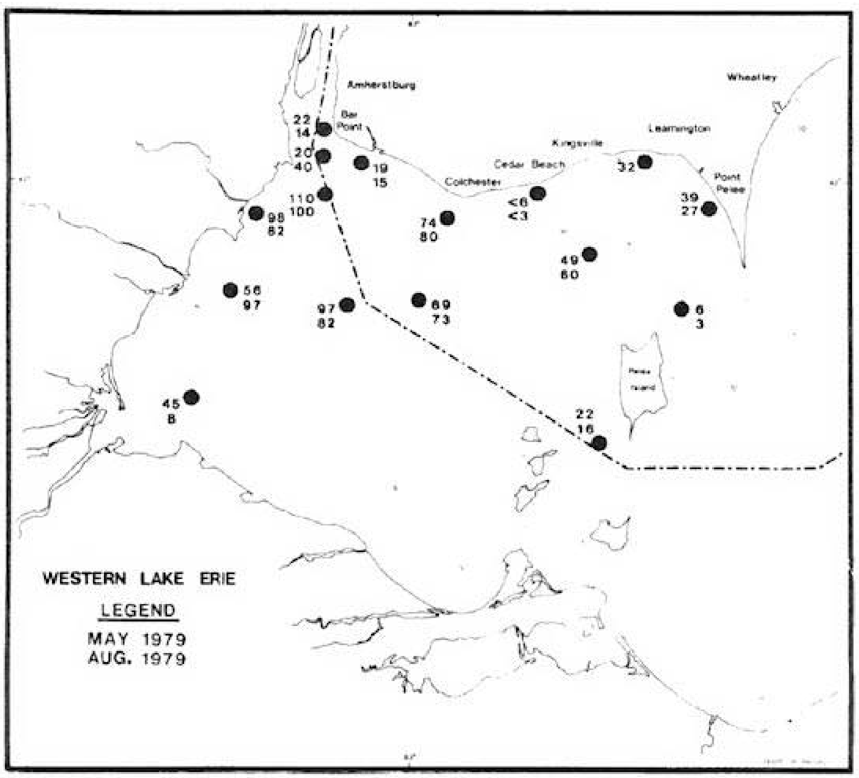

FIGURE 8B Lead In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

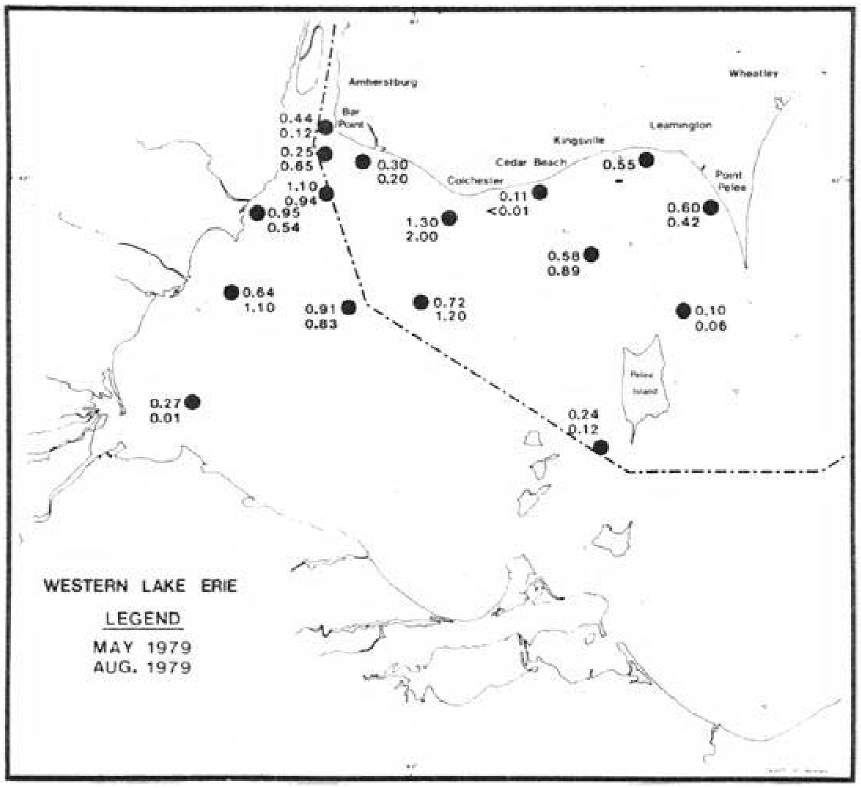

FIGURE 9A Mercury In The Surficial Sediments Of Western Lake Erie - mg kg^{-1}.

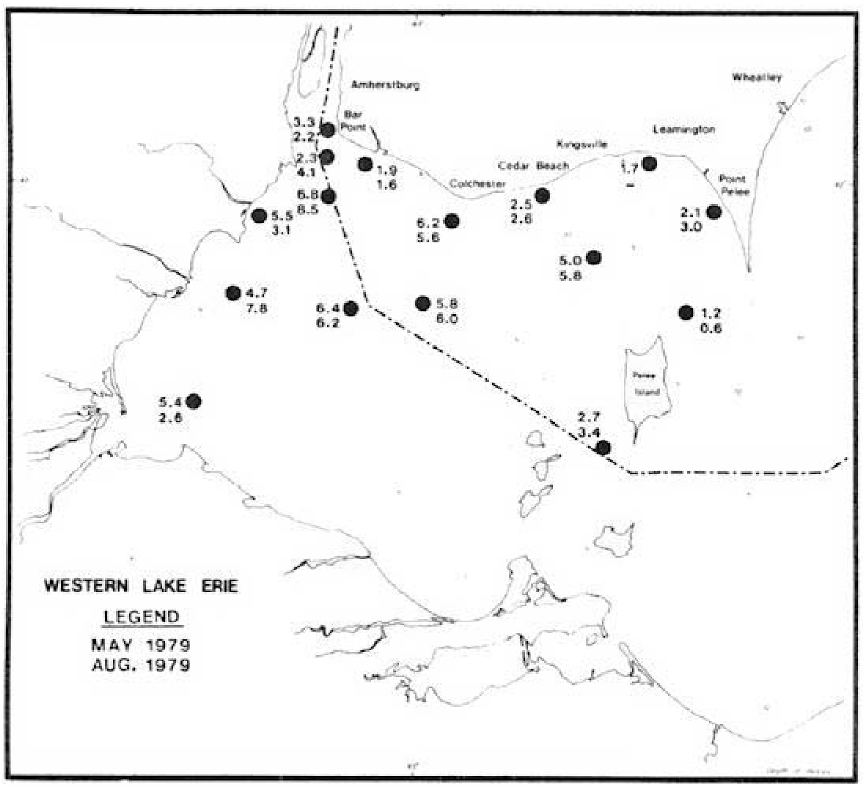

FIGURE 9B % Loss On Ignition Of Surficial Sediment In Western Lake Erie.

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APPENDICES

Appendix 1. Macroinvertebrates collected at 16 stations in the Western Basin of Lake Erie (Numbers per m^2) May, 1979.

ORGANISMS	277	284	294	308	314	318	321	323	327	333	346	370	374	386	423	1052
MAYFLIES																
Hexagenia limbata							20	20								
CADDISFLIES																
Hydropsyche										20						
Ceraclea							20									
AMPHIPODS																
Gammarus sp.							20									
SNAILS																
Amnicola sp.							59		20	20						
Campeloma sp.										20						
Somatogyrus							20									
Valvata sincera									20							
V. tricarinata									20							
CLAMS																
Pisidium	30	49		39			177	59	30	20	30			20	20	
Sphaerium						20	49						20			
Unionidae															20	
TRUE FLIES																
Chironomidae																
Tanypodinae																
Tanypus sp.																20
Ablabesmyia													20			
Procladius sp.	20	217	20	99	611	39		20	128	20	49	99	296	1231	197	404
Psectrotanypus									20			20	20	20	20	20
Coelotanypus sp.	20	89	20	118	246			69			49	69	59	108	148	
Chironominae																
Chironomus sp.		227	20	49	39						30	20	20		69	
Cryptochironomus	20	79	20		20						20				20	
Polypedilum																89
Tanytarsus		20														
Unidentifiable (pupae)		59	20	59	20							20	40	98	30	

Appendix 1. Continued

ORGANISMS	277	284	294	308	314	318	321	323	327	333	346	370	374	386	423	1052
WORMS																
Tubificidae																
Aulodrilus pluriseta	59		20	30						49						
Branchiura sowerbyi			20	39										158	20	
Limnodrilus angustipenis										148						20
L. cervix variant					20			148	79	197	20		49	788		30
L. claparedeianus			20		20		20	148	30	187	20			1048	20	30
L. hoffmeisteri	20		59	20	20	168	266	424	286	69	59		79	2039	20	20
L. maumeensis							49	49	49	108			20	315		
L. profundicola			20				49	108	59	39			49	630		
L. udekemianus					20			128	30	39			30	630		
Peloscolex ferox	128			20			936	778			138	20	20		20	
P. multisetosus							374	148							20	
Potamothrix vejdovskyi	20															
Tubifex tubifex									30							
hair chaetae absent	1881	2955	236	374	394	315	433	2147	946	1468	857	177	867	9742	798	512
hair chaetae present	118		20				20	207	59	89			20		20	20
Naididae																
Nais communis					20											
MITES																20
LEECHES	20				30							20	30	49	20	
FLATWORMS		20	20	20	20		79	59			20	20			20	20
ROUNDWORMS				99												
TOTAL AVG/m^2	2336	3715	515	966	1480	542	2611	4502	1826	2513	1292	465	1639	17236	1482	1205
Total Taxa	9	7	10	10	11	3	15	13	13	14	10	7	13	12	14	10

Appendix 2. Macroinvertebrates collected at 16 stations in the Western Basin of Lake Erie (Number per m^2) August, 1979.

ORGANISMS	277	284	294	308	314	318	321	323	327	333	346	370	374	386	423	1052
MAYFLIES																
Hexagenia limbata						20		20	39							
AMPHIPODS																
Gammarus sp.	20						39	30		20				20		
SNAILS																
Amnicola sp.	20			20		20	20		69		20					
Bithinia tentac ulata										20						
Campeloma sp.				20												
Valvata sincera					79				20		20	20				
V. tricarinata												20				
CLAMS																
Pisidium				39	138	158	20	20	384		39		39	20		
Sphaerium			20	20	49					20		20	39		20	
Unionidae					20			20			20					
TRUE FLIES																
Chironomidae																
Tanypodinae																
Tanypus sp.															20	
Ablabesmyia			20					20	20							
Procladius sp.	20	20	128	39	236	49		59	69	59	59	99	276	69	187	39
Psectrotanypus								20				20				
Coelotanypus sp.		118		39	30		20	20			20		39	197	20	20
Chironominae																
Chironomus sp.		79	167	167	20	79		59			118	20	305	99	325	39
Cryptochironomus	20		20					108	99							20
Tribelos							20	20								
Glyptotendipes							49									
Polypedilum			20				30									187
Rheotanytarsus			20													
Micropsectra			20													
Constempellina								20								
Unidentifiable (pupae)			40				40	40	20	30						40

Appendix 2. Continued

ORGANISMS	277	284	294	308	314	318	321	323	327	333	346	370	374	386	423	1052
WORMS																
Tubificidae																
Aulodrilus pluriseta										207		30				158
Branchiura sowerbyi			20	236											207	
Limnodrilus angustipenis								138								
L. cervix variant	20			69		39		561	502	197	89		177	187	39	20
L. claparedeianus		532	89		20	20		1221			177		424		20	
L. hoffmeisteri	20	89	39	138	148	49		424	266	79	276	187	315	1320	197	99
L. maumeensis		197	69			30		138	138			30	138		39	
L. profundicola														739		
L. udekemianus						30		138	39	79	39					
Peloscolex ferox						20	49	158								
P. freyi																20
P. multisetosus										39						
Potamothrix moldaviensis	20															59
P. vejdovskyi										128						
Tubifex tubifex										39		30				
hair chaetae absent	217	867	335	502	345	611	89	1468	906	798	581	571	906	10510	434	443
hair chaetae present			20					59		749	20	20				
Lumbriculidae																
Stylodrilus heringianus							20									
MITES	20		20						20	20						
LEECHES									99	20	20	69	30	39		
FLATWORMS										20			20			
ROUNDWORMS		1064		581				20							394	
TOTAL AVG/m^2	377	2966	1047	1890	1164	1145	416	4801	2690	2524	1498	1136	2708	13200	1902	1094
Number of Taxa	8	8	15	13	10	13	11	21	13	14	12	11	11	9	12	10

APPENDIX 3. Comparison of Heavy Metal Concentrations In The Surficial Sediments Of Western Lake Erie May 1970 And May 1979.

HEAVY METALS - mg/kg

Lake Erie Stn. No.	Cadmium		Copper		Chromium		Zinc		Lead		Arsenic		Mercury	
	1970	1979	1970	1979	1970	1979	1970	1979	1970	1979	1970	1979	1970	1979
318	2.2	0.8	46	17	75	19	80	77	43	19	7.0	4.3	0.27	0.30
323	9.2	0.8	101	28	362	18	323	82	138	20	9.6	4.6	3.60	0.25
333	3.4	8.4	54	97	95	140	159	440	44	98	4.0	12.0	0.15	0.95
327	8.0	6.0	107	96	320	150	384	390	136	110	10.0	12.0	1.50	1.10
314	3.6	2.5	35	59	91	76	89	220	52	74	6.8	6.7	0.27	1.30
346	4.7	2.6	73	53	205	65	189	210	93	69	7.7	4.8	3.00	0.72
370	6.2	4.2	101	76	321	120	300	300	106	97	8.8	7.1	1.63	0.91
374	13.7	3.1	183	58	50	81	530	190	173	56	12.3	4.7	-	0.64
386	5.9	2.4	100	47	256	50	276	150	92	45	10.0	6.6	0.81	0.27
423	2.7	1.1	36	20	105	28	85	92	38	22	4.9	3.2	0.11	0.10
277	2.4	0.9	30	10	67	15	54	45	30	6	6.3	5.6	0.05	0.10
Mean	5.6	3.0	79	51	177	69	224	200	86	56	7.9	6.5	1.14	0.60
Std. Dev.	3.5	2.4	46	30	118	49	152	131	48	36	2.5	3.0	1.28	0.42
n	11	11	11	11	11	11	11	11	11	11	11	11	11	11