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ENVIRONMENTAL QUALITY ASSESSMENT OF LAKE ST. CLAIR IN 1983 AS REFLECTED BY THE DISTRIBUTION OF BENTHIC INVERTEBRATE COMMUNITIES

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SUMMARY

In May of 1983, the Ontario Ministry of the Environment conducted a benthic invertebrate and sediment chemistry survey of Lake St. Clair to evaluate the environmental quality of the lake and determine the impact of major contaminant sources, particularly the St. Clair River, on the aquatic environment of the lake.

Analysis of the invertebrate and sediment chemistry data suggested that the environmental quality of Lake St. Clair, Anchor Bay and the lower reach of the St. Clair River was generally good. Mesotrophic conditions prevailed in the central basin of the lake and Anchor Bay and in the lower part of the St. Clair River, while oligo-mesotrophic conditions were present in the shallower nearshore areas of the lake and Anchor Bay. Sediment concentrations of metals in the lake were low and generally considered non-polluted according to the US EPA's and Ontario MOE's guidelines. Neither the St. Clair or Thames rivers, the two largest tributaries and potential sources of contaminants, had any perceivable effect on the environmental quality of the lake.

Local minor impairments of environmental quality were observed at the mouths of the Puce, Belle and Ruscom rivers and near the town of St. Clair Shores, Michigan. Reduced environmental quality related to organic matter enrichment was observed at deeper sites near the St. Clair River delta.

Notwithstanding these localized minor effects from rivers and shoreline towns, the distribution of benthic invertebrates in the lake was primarily related to the physical characteristics of the environment, eg. sediment grain size and water depth, and not to pollution.

RÉSUMÉ

En mai 1983, le ministère de l'Environnement de l'Ontario a effectué une étude portant sur les invertébrés benthiques et sur la composition chimique des sédiments du lac St. Clair afin d'évaluer la qualité du milieu lacustre et de déterminer les répercussions des principales sources de polluants, notamment la rivière St. Clair , sur ce dernier.

L'analyse des invertébrés et de la composition chimique des sédiments a révélé que la qualité du milieu aquatique du lac St. Clair, de la baie Anchor et du cours inférieur de la rivière St. Clair était généralement bonne. La partie centrale du bassin du lac de même que la baie Anchor et le cours inférieur de la rivière St. Clair sont essentiellement de type mésotrophe. Par ailleurs, la partie moins profonde du lac et de la baie Anchor, près des rives, est de type oligomésotrophe. Les concentrations de métaux dans les sédiments lacustres étaient basses et on a estimé que, dans l'ensemble, ces derniers n'étaient pas pollués selon les critères établis par l'EPA des États-Unis et le ministère de l'Environnement de l'Ontario. Les rivières St . Clair et Thames, les deux principaux affluents et les plus importantes sources possibles de polluants, n'ont pas exercé d'effets perceptibles sur la qualité du milieu lacustre.

On a constaté une détérioration mineure et localisée du milieu aquatique à l'embouchure des rivières Puce, Belle et Ruscom et près de la ville de St. Clair Shores au Michigan. On a également remarqué une baisse de la qualité du milieu aquatique dans les zones plus profondes situées près du delta de la rivière St. Clair , qui présentaient une concentration relativement élevée de matières organiques. Malgré les effets mineurs causés par les rivières et les villes riveraines, la répartition des invertébrés benthiques dans le lac était due principalement aux caractéristiques physiques du milieu, par exemple, la taille des sédiments et la profondeur de l'eau, et non à la pollution.

INTRODUCTION

Lake St. Clair, located between Lake Huron and Lake Erie, is the smallest (surface area = 1100 km^2) and shallowest (mean depth 3m) lake in the Great Lakes system. It supports a large and diverse warm-water fishery and provides valuable habitat for migrating waterfowl. However, the St. Clair River, which is the primary source of water to Lake St. Clair, has been designated as an "Area of Concern" by the International Joint Commission (IJC 1982). Ministry of the Environment studies (eg. OMOE 1979) have shown that waste discharges, primarily heavy metals, chlorinated hydrocarbons and other petrochemical compounds from industries located mainly in the Chemical Valley, south of Sarnia, Ontario, have resulted in impairment of the environmental quality of the river. Impaired environmental quality conditions have also been noted in other tributaries to the lake such as the Thames (Hamdy *et al.* 1977), Sydenham, Puce and Belle rivers (Ministry of the Environment, Southwestern Region, unpublished data). The effect of these tributaries and other waste sources on the aquatic life of Lake St. Clair has not been completely assessed.

In May of 1983, the Southwestern Region and the Water Resources Branch of the Ontario Ministry of the Environment conducted a benthic invertebrate and sediment chemistry survey of Lake St. Clair. The purpose of the study was to evaluate the environmental quality of the lake and to determine the impact of the major waste sources, particularly the St. Clair River, on the aquatic environment of the lake. The study also provided the baseline reference conditions for future studies which will monitor the change in the environmental quality of the lake in response to the implementation of control measures on the municipalities and industries within the drainage basin.

Geographically, this report completes a series of reports that evaluated the environmental quality in the Lake Huron-Lake Erie corridor. Previous studies documented the effects of waste discharges on the environmental quality of the St. Clair River (OMOE 1979), Western Basin of Lake Erie (OMOE 1981) and Detroit River (Thornley and Hamdy 1983).

METHODS

Study Rationale:

Benthic invertebrates have long been recognized for their value as indicators of environmental quality. They have been found to show a wide range of tolerances to various degrees and types of pollution. They are generally abundant in all aquatic habitats, easily collected and readily identified. Because of their low motility and habitat preference, they usually remain in a localized area where they are continuously subjected to the full rigor of the local environment. Since they must endure all environmental extremes over their life-cycle, which may vary from about six months to two years, they indicate the past as well as the present environmental conditions of a site.

In addition, benthic invertebrates occupy an intermediate trophic level in aquatic food-webs. They feed on periphyton (ie. scrapers), leaf litter and other coarse particulate organic matter (ie. shredders), detritus and other fine particulate organic matter (ie. collectors) and invertebrates (ie. predators), and in turn are an important source of food for animals in higher trophic levels, most notably fish and waterfowl. Thus they may be used to evaluate biotic as well as abiotic environmental disturbances.

Unlike water or surficial sediment samples, which only indicate the total concentration of contaminants in the environment at a point-in-time, benthic invertebrates represent the integration of all environmental variables (biotic and abiotic), including the bio-availability of contaminants, over the period of time they have lived in the habitat. The use of *in-situ* organisms therefore circumvents the need for any assumptions about the toxicity of contaminant concentrations in sediments and eliminates the need for the frequent sampling of temporally fluctuating contaminant levels in water in order to assess the effects of contaminants on the life in aquatic systems.

Sampling Design:

Benthic macroinvertebrate samples were collected by the Ontario Ministry of the Environment from May 2 to 13, 1983, at 47 sampling stations in Lake St. Clair, including 5 stations in Anchor Bay and 5 stations in the St. Clair River delta (Figure 1). The sampling stations were originally located in a rectangular grid within the lake; however, the position of stations along the perimeter of the lake was adjusted to better evaluate the effect of specific input sources on the environmental quality of the lake. In addition, 5 stations were located in the delta of the St. Clair River because little information was available on the invertebrate fauna or sediment quality of this area.

A Ponar grab, which enclosed an area of 516 cm^2, was used to sample the benthic fauna. Three samples were collected at each station. Each sample was sieved in a stainless-steel screen pail containing a No. 30 (U.S. Standard Sieve Series) mesh screen (aperture 0.60 mm); the remaining sediment, debris and organisms were then placed into labelled one-litre bottles and stored on ice. These samples were transported to a field laboratory where the organisms were sorted live from the sediment and debris in white enamel trays using forceps. The invertebrates were then placed in 30 ml bottles and preserved with 80% ethanol, except oligochaetes which were preserved with 10% formalin (4% formaldehyde).

The benthic invertebrates were taxonomically identified by Ronald W. Griffiths of Aquatic Ecostudies Limited, Kitchener, Ontario. Generally, the insects, crustaceans and molluscs were identified to the generic level, mature oligochaetes and polychaetes to the specific level, and other invertebrates to class (see Appendix 1 for a list of the major taxonomic references). All organisms were identified except where large numbers of oligochaetes or chironomids were present. In samples with a large number of worms, all individuals which could be identified under a dissecting microscope, eg. *Stylodrilus herringianus, Spiroserma ferox, Potamothrix moldaviensis*, etc., were enumerated and removed from the sample. The remaining individuals were sorted into two groups: hair chaete present and hair chaete absent. A random sample of not less

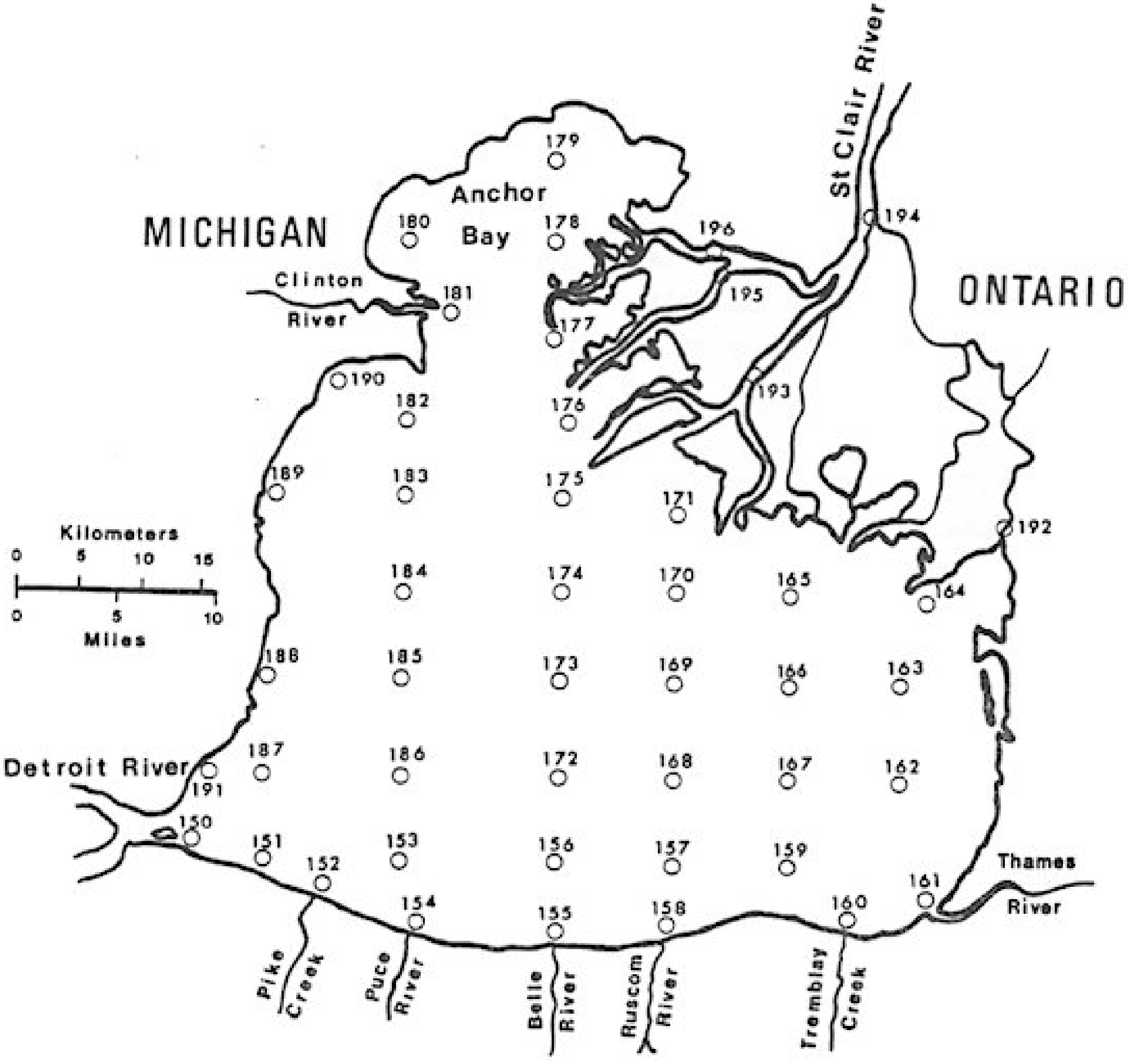

Figure 1: Locations of sampling stations in Lake St. Clair, Anchor By and the St. Clair River, May 1983.

than 20% of the individuals from each group, up to a maximum of 100 individuals, was removed from each group for identification. Similarly, in samples with a large number of midges, all individuals which could be identified under a dissecting microscope, eg. *Chironomus, Procladius, Cryptochironomus*, etc., were enumerated and removed from the sample. The remaining individuals were sorted into three groups: Chironominae, Tanypodinae, Orthocladiinae (including Diamesinae). A random sample of not less than 10% of the individuals from each group, up to a maximum of 50 individuals, was removed for identification. The sub-samples of worms and midges were mounted on glass slides in a clearing medium, left for 24 h at 60°C, then identified under a microscope.

In conjunction with the invertebrate sampling, a Shipek grab was used to collect surficial sediment samples for grain size analysis and chemical analyses. At each sampling station, about the top 3 cm of sediment from three Shipek samples were composited. Sub-samples of this composite were placed in 500 ml wide-mouth glass jars with pulp-lined screw caps (heavy metals and grain size analysis), or in solvent-rinsed 500 ml jars with foil-lined caps (organochlorine pesticides and PCB analysis). The field sampling methods are described in detail in OMOE (1979b).

The sediment samples were submitted to the Ontario Ministry of the Environment's main laboratory in Toronto for analysis of total metals (Fe, Al, Cd, Cr, Cu, Hg, Ni, Pb, Zn), nutrients (total Kjeldahl nitrogen, total phosphorus), organics (loss-on-ignition, total organic carbon), oils and grease (solvent extractables), chlorinated hydrocarbons (Aldrin, Lindane, Mirex, Chlordane, Oxychlordane, Dieldrin, Endrin, Thiodane, DDT and metabolites, Heptachlor, Heptachlor epoxide, Polychlorinated Biphenyls (PCBs), Hexachlorobenzene) and grain size. Grain size analysis was done by dry-sieving for the larger particle fractions and measurement of density changes using a hydrometer for the silt and clay fractions. All chemical analyses were conducted according to the Ministry's Handbook of Analytical Methods (OMOE 1980).

Data Analysis:

Non-hierarchical classification analysis (Gauch 1982) was used to split the sampling stations into groups with similar species assemblages (ie. benthic communities). Classification analysis is a multivariate technique of partitioning objects (eg. sampling stations) into groups based on a set of descriptors (eg. species abundance). The analysis was conducted using the ln(x+1) transformed mean species abundance as descriptors of the sampling stations. Each sampling station therefore was represented by a single sample.

The non-hierarchical classification analysis was conducted using the Fortran program Compclus (Gauch 1979). The analysis was conducted 20 times using the percent difference measure of dissimilarity. Because the analysis randomly assigns stations as group centres, a different solution is obtained with every run. A comparison of these equally-probable solutions was made to determine whether the defined community groups were ecologically real (ie. the stations within a group were actually clustered together in multivariate space and therefore had similar species assemblages) or were an artifact of the analysis (ie. groups were simply imposed on the data). The classification outcome that approximated the average station composition of the community groups was used for this report.

Discriminant analysis (Legendre and Legendre 1983) was used to relate the defined benthic communities to the measured physical and chemical sediment variables in order to interpret the communities in terms of environmental quality. Discriminant analysis is a multivariate technique used to distinguish known groups of objects (eg. benthic communities) on the basis of a series of measured quantitative descriptors (eg. physicochemical variables). Because the physicochemical variables were standardized prior to the analysis, the resultant discriminant axes represent discriminant functions (Legendre and Legendre 1983), which are simply linear combinations of the physicochemical variables that maximize the variance between the benthic communities. An ecological interpretation of each axis was made based on the correlation coefficients (r) between the axis and the original physicochemical variables.

The results of discriminant analyses are typically "good" (ie. the amount of "explained variance" is high). However, the analysis does not imply that a cause-and-effect relationship exists, only that a correlation exists between the biologically-defined groups of stations and a linear combination of the physicochemical variables (ie. the discriminant functions). Although the amount of "explained variance" may be high, this does not mean that the analysis is ecologically interpretable because there is no relationship between "explained variance" and "ecological meaning" (Gauch 1982). The interpretation of the discriminant analysis therefore must be done with an understanding of the mathematical algorithm, the biology (life-histories) of benthic invertebrates, the ecological interrelationships between the aquatic invertebrates, and the interactions between the physicochemical variables.

Fifteen physicochemical variables were used to discriminate between the benthic communities: Grain size represented the physical characteristics of the sediment; iron, aluminum, cadmium, chromium, copper, mercury, nickel, lead, and zinc represented the metal content of the sediment; total phosphorus (P) and total Kjeldahl nitrogen (TKN) represented the nutrient status; loss-on-ignition (LOI) and total organic carbon (TOC) represented the degree of organic accumulation; and solvent extractables represented the degree of oil and grease contamination of the sediment at a station. Specific pesticides variables were not used because the majority of values fell below the detection limits of the analytical procedures.

To satisfy statistical requirements of the analysis (see Green 1979), all variables were log-transformed with the exception of grain size, which did not require transformation. The analysis was conducted using computer programs from the Statistical Analysis System (SAS 1982). Since discriminant analysis is particularly susceptible to rounding errors (Green 1979), double precision was used during the analysis.

In addition to the discriminant analysis, the environmental quality represented by the benthic communities was also assessed by examining the structural and functional organization and the species composition of the communities. Community structure was represented by species richness (number of taxa per sample) and total invertebrate density, while the functional organization was represented by the relative abundance of invertebrates in each of the functional-feeding groups, ie. scrapers, collector-gatherers, collector-filterers, shredders and predators (Merritt and Cummins 1984). Studies have shown that characteristic changes occur in the species richness, invertebrate density and species density in response to specific types of pollutants and general environmental conditions (eg. Hynes 1960; Saether 1979; Winner *et al.* 1980; Wiederholm 1984; Krieger 1985; Lauritsen *et al.* 1985; Wallace *et al.* 1986). Pollution, especially when caused by organic or nutrient enrichment, affects the structure of invertebrate communities by altering the flow of energy through the community (Wuhrmann 1974). Vannote *et al.* (1980) proposed that the resident invertebrate functional-feeding groups of Cummins (1984) can be used to indirectly measure the overall energy dynamics in the environment. They showed that the functional organization of invertebrate communities was characteristic of the physical attributes of the habitat. Thus the presence of various types of pollution can be ascertained by comparing the functional organization of a community with that predicted from the physical attributes of the environment (eg. Rabeni *et al.* 1985; Mayack and Waterhouse 1983). An examination of structural and functional organization and species composition of the communities therefore can be used to elucidate the environmental quality conditions reflected by the invertebrate communities.

Since invertebrate species have specific habitat requirements with respect to sediment grain size, current speed, etc. (Hynes 1970), different benthic communities can be expected in areas of the river with different physical characteristics. Therefore, applying Occam's razor, physical and other "non-pollution" variables were given priority to explain the differences in the species composition between communities. Subsequently, the chemical and other "pollution" variables were used to account for these differences. To help evaluate whether the observed sediment concentration of a chemical variable was sufficient to affect the abundance of a species in a community, the mean concentrations of the chemical variables associated with each benthic community were compared with the U.S. EPA's Guidelines for Pollutional Classification of Great Lakes Harbour Sediments (Table 6: IJC 1982). Only when the mean concentration of a variable indicated that the sediments were heavily polluted, was the variable considered to possibly have had an effect on the abundance of invertebrates.

Each benthic community therefore was interpreted to represent a different degree of environmental quality with respect to specific environmental variables. Zones of varying environmental quality were delineated based on the distribution of the benthic communities in the lake and then related to specific waste sources.

RESULTS AND DISCUSSION

Benthic Communities:

A 101 macroinvertebrate taxa were identified at the 47 sampling stations in the study area (Appendix 2). Based on their species composition, the classification analysis split the stations into six groups (numbered 1 to 6), each representing a different assemblage of invertebrate species or benthic community. The taxonomic composition of the communities is shown in Table 1.

The six communities were distributed in physically different habitats of the study area (Figures 2 and 3). Communities #1 and #5 occurred generally in the shallow (1 to 3m) periphery of the lake and Anchor Bay, while communities #4, #2 and #6 were found in the deeper waters (2 to 7.5m) of the lake, Anchor Bay and Chenal Ecarte (Station 192). Community #3 was present at sampling stations in the St Clair River and at the mouth of the Thames River.

The deep-water lake communities, communities #2, #4, #6, were characterized by the abundance of the mayfly, *Hexagenia*, the midges, *Chironomus, Cryptochironomus, Coelotanypus, Procladius,* the worm, *Limnodrilus hoffmeisteri*, and nematodes. The shallow-water lake communities, communities #1 and #5, were characterized by different invertebrate assemblages. Community #1 was characterized by the presence of the midges, *Pseudochironomus* and *Stictochironomus*, the amphipod, *Gammarus*, and the worm, *Spirosperma ferox* whereas, Community #5 was characterized by the numerical dominance of the midges, *Polypedilum* spp. and *Polypedilum illinoensi*, and the biting midges, ceratopogonidae. The river community, Community #3, was characterized by the numerical dominance of the midges, *Polypedilum* spp, *Pseudochironomus, Stictochironomus* and *Tribelos*, and the amphipod, *Gammarus*.

Table 1: Species composition (mean number per 516 cm^2) of benthic communities in Lake St. Clair, May 1983. P denotes a mean density of less than one individual per sample. Communities are grouped by habitat type.

	Benthic Community					
	5	1	4	2	6	3
	Lake--shallow		- - - - Lake--deep - - - -			River
AQUATIC CATERPILLARS:						
Pyralidae		P			P	P
BEETLES:						
Dubiraphia		P			P	P
TRUE BUGS:						
Corixidae	1.3	P				
CADDISFLIES:						
Cheumatopsyche		P				P
Hydropsyche		P				P
Ceraclea		P				P
Mystacides		P		P		P
Oecetis		P	P	P		P
Setodes		P				
Molanna	P					P
Neureclipsis						P
Phylocentropus			P		P	P
MAYFLIES:						
Baetisca		P				
Caenis	P	P				1.7
Eurylophella	P	P				
Serratella						P
Ephemera				P		
Hexagenia	P	P	16.9	17.0	44.2	3.3
Stenonema						P
TRUE FLIES:						
Ceratopogonidae	16.3	P	P		1.0	3.2
Chaoborus					1.3	
Chironomus	P	P	5.4	2.1	7.2	P
Cladopelma	P	P				
Cladotanytarsus		P				
Cryptochironomus	1.9	2.4	1.3	1.5	27.2	2.8
Demicryptochironomus	P	P	P	P	16.8	
Dicrotendipes			P		1.7	P
Harnischia				P		
Microtendipes			P			
Nilothauma		P				
Paratanytarsus						P
Phaenopsectra						P
Polypedilum	13.0	2.2	2.2		13.5	29.3
P.illinoensi	13.2	P				2.0

Table 1: continued

	Benthic Community					
	5	1	4	2	6	3
	Lake--shallow		- - - - - - Lake--deep - - - - -			River
Pseudochironomus	P	7.5	3.3	P		24.9
Rheotanytarsus		P				
Stictochironomus	P	4.0	7.2	P	6.2	44.7
Tanytarsus				P		
Tribelos			5.7	P	8.8	98.5
Pothastia	P	P	P	P	P	
Epicocladius			P	P	P	
Heterotrissocladius		P	P			
Hydrobaenus	P		1.1		1.0	P
Cricotopus/Orthocladius	P	P				7.3
Parakiefferiella?	P	1.5	P	P	P	
Monodiamesa		P			P	P
Ablabesmyia		P	P	2.0	3.7	P
Clinotanypus		P		P	P	P
Coelotanypus	P	1.1	2.2	6.0	1.5	
Djalmabatista			P		P	
Procladius	P	P	6.6	5.2	16.7	7.5
Thienemannimyia-gp		P				P
Empididae	P					
CRUSTACEANS:						
Gammarus		5.4	14.5	P	2.0	22.7
Hyalella azteca		P	2.1			2.6
Asellus			4.4			1.2
Lirceus			P			5.3
CLAMS:						
Pisidium		2.8	P	1.1	6.5	4.8
Sphaerium		1.2	1.3	P	P	
Unionidae		P	P	P		
SNAILS:						
Bithynia	P		P	P		
Amnicola		P	1.9			
Probythinella		P		P	P	P
Somatogyrus		P	P	P		
Fossaria		P				
Lymnaea						P
Physa		P	P			10.3
Goniobasis		2.4	1.0	P		P
Pleurocera		P		P		
Valvata		P	P			P

Table 1: continued

	Benthic Community					
	5	1	4	2	6	3
	Lake--shallow		- - - - - - Lake--deep - - - - -			River
LEECHES:						
Erpobdellidae			P			P
Glossiphonidae			P	P		P
POLYCHAETES:						
Manaynunkia speciosa		P	2.2	P	P	
WORMS:						
Lumbricidae			P		P	2.6
Stylodrilus herringianus		P	P		P	1.8
Naididae	P	P	P	P	1.3	P
Aulodrilus americanus				P		1.3
A. pleuriseta				P		
Branchiura sowberbyi			P	2.4		P
Isochaetides curvisetosus		P				
Ilyodrilus templetoni		P		P		P
Isochaetes freyi		P				P
Limnodrilus angustipenis			P			
L. cervix	P			P		3.9
L. claparedianus	P	P	3.6	P	P	1.0
L. hoffmeisteri	P	1.9	5.7	4.2	14.5	10.1
L. maumeensis		P			5.7	P
L. udekemianus		P			3.0	1.0
Potamothrix moldaviensis	3.1	P		P	1.2	5.5
P. vejdovskyi	P	P	P			
Quistadrilus multisetosus					9.8	10.2
Spirosperma ferox	P	5.4	21.7	P	2.8	12.4
NEMATODES	P	3.3	11.2	11.5	12.2	P
FLATWORMS		P	P	1.1	2.8	13.9
MEAN NUMBER OF TAXA	6.8	10.4	15.4	10.2	18.8	20.9
MEAN DENSITY OF ORGANISMS	60.3	60.9	141.9	80.4	253.3	369.5

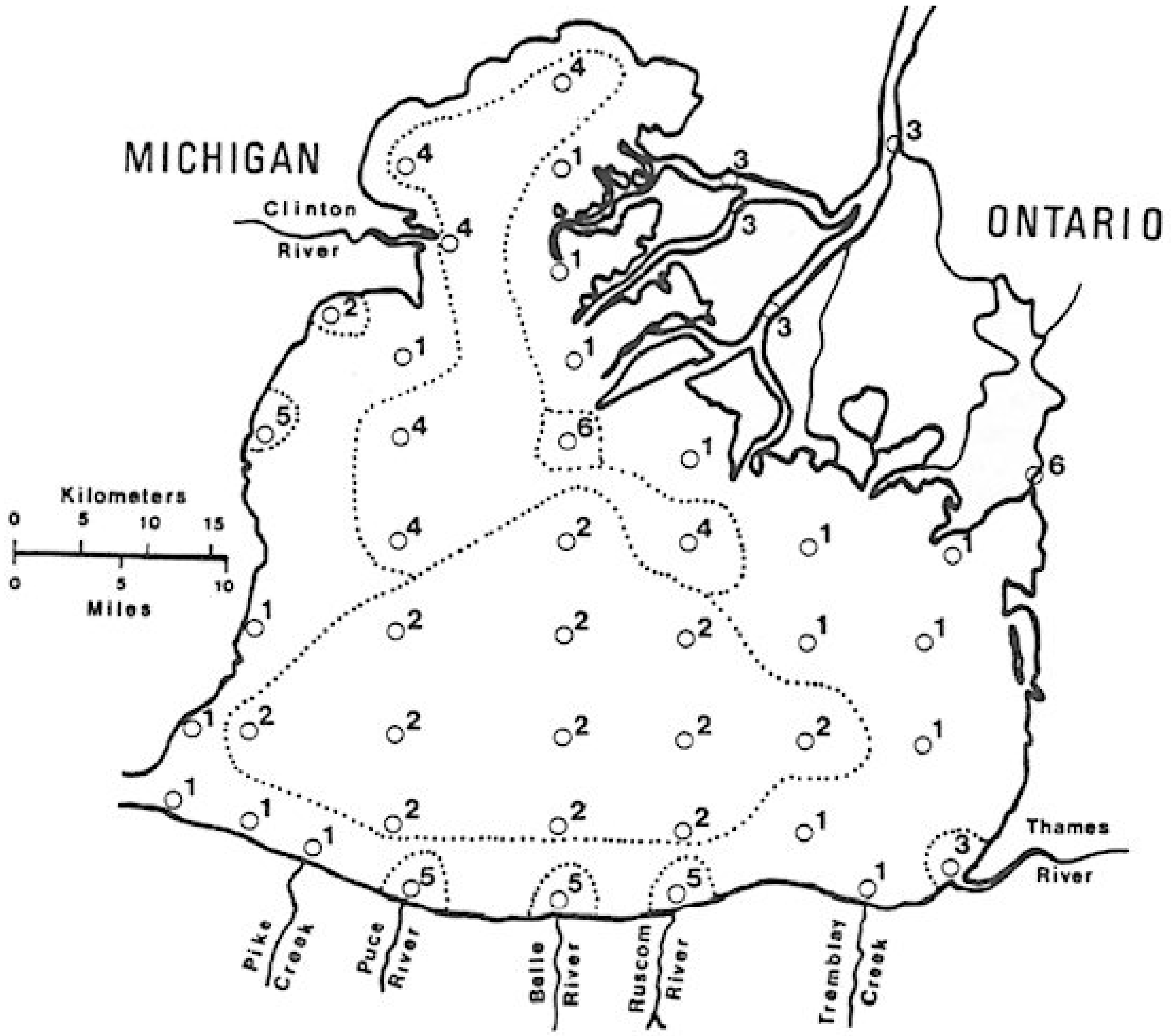

Figure 2: Distribution of benthic invertebrate communities in Lake St. Clair, Anchor Bay and the St. Clair River, May 1983.

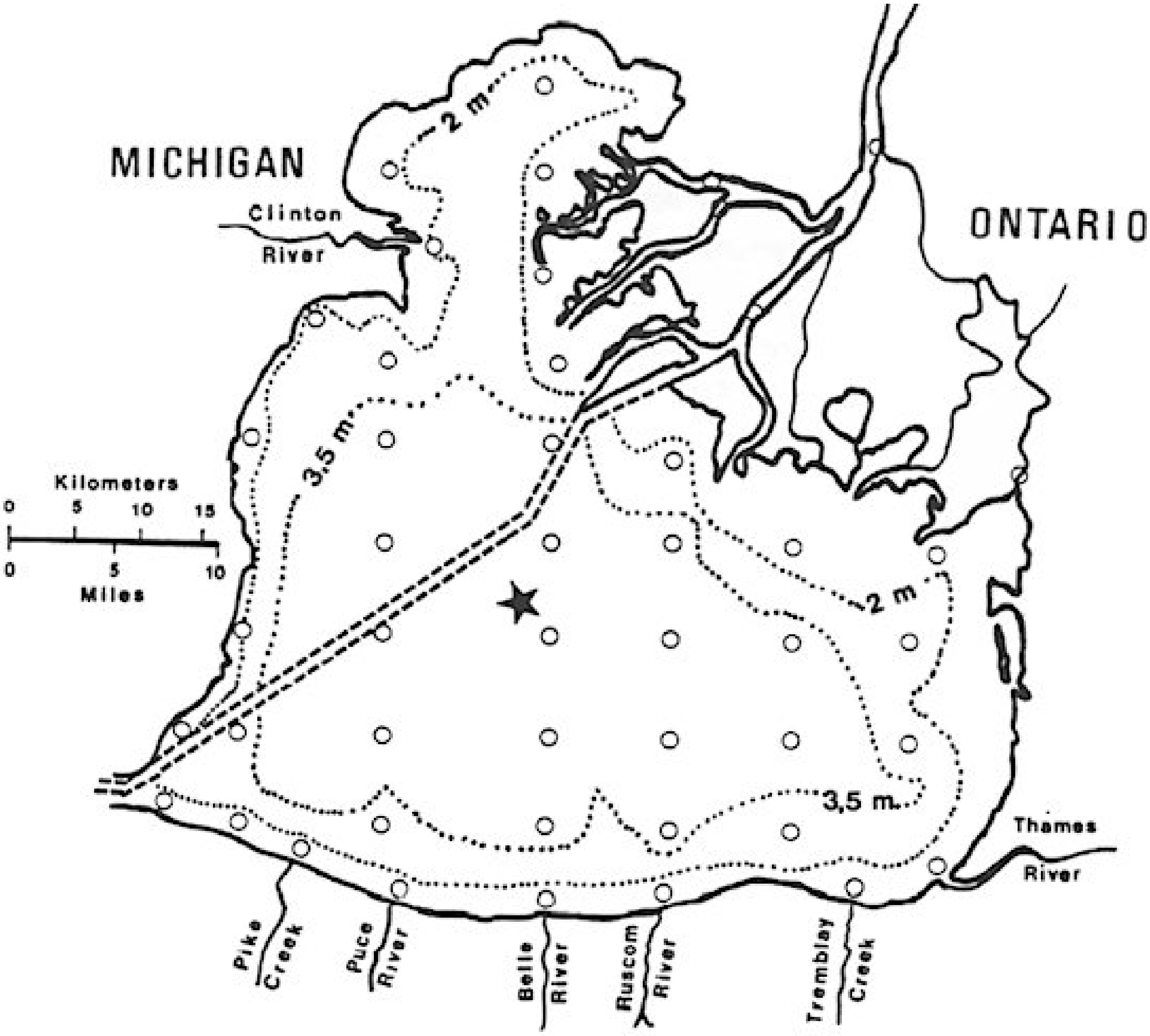

Figure 3: Depth contours of Lake St. Clair and Anchor Bay. Depth contours at low water datum. Star denotes maximum lake depth of 6m. Depth of shipping channel is 7.8m.

Environmental Quality Evaluation:

The discriminant analysis suggested that the six communities were associated with different environmental conditions (Figure 4). It separated the six communities along two discriminant axes: The first discriminant axis (DA I) explained 72.7% of the total variation and showed a significant linear correlation with all variables except oils and grease ($r=0.60$; $p<0.001$)(Table 2). The coefficients of the discriminant function indicated that Al, Fe, Cu, Ni, Pb, grain size, TOC, and TKN were the variables which could best discriminate between the communities along this axis (Table 3).

DA I separated the five lake communities from one another and especially the shallow-water communities from the deep-water communities (Figure 4). This suggests that communities #5 and #1 occurred at sites with coarser (sandy) sediments and lower concentrations of metals, organic carbon and nutrients relative to communities #4, #2 and #6. With the exception of oils and grease for Community #5, Table 4 shows that the mean concentrations of the metals, oils and grease, organic matter, and nutrients were all greater in the sediments associated with the deep-water communities relative to the shallow-water communities. Using the US EPA's Guidelines for Pollutional Classification of Great Lakes Harbour Sediments (Table 6: IJC 1982), sediments associated with Community #2 were considered moderately polluted with respect to their total phosphorus (TP) concentrations, while sediments associated with Community #6 were considered moderately polluted with respect to their TP, TKN and oils and grease concentrations. In addition, concentrations of iron and mercury in sediments associated with communities #2 and #6 exceeded the Ontario Ministry's Guidelines for Open Water Disposal (Persaud and Wilkins 1976; OMOE 1978). Sediments associated with the other lake communities were not considered polluted with respect to these guidelines (Table 4).

However, the high correlations between grain size and heavy metals, nutrients, TOC and LOI (Table 5) suggest that grain size alone may explain the separation of the communities along this axis. Since these variables were tightly correlated with grain size, they may have been spuriously identified as important discriminating variables

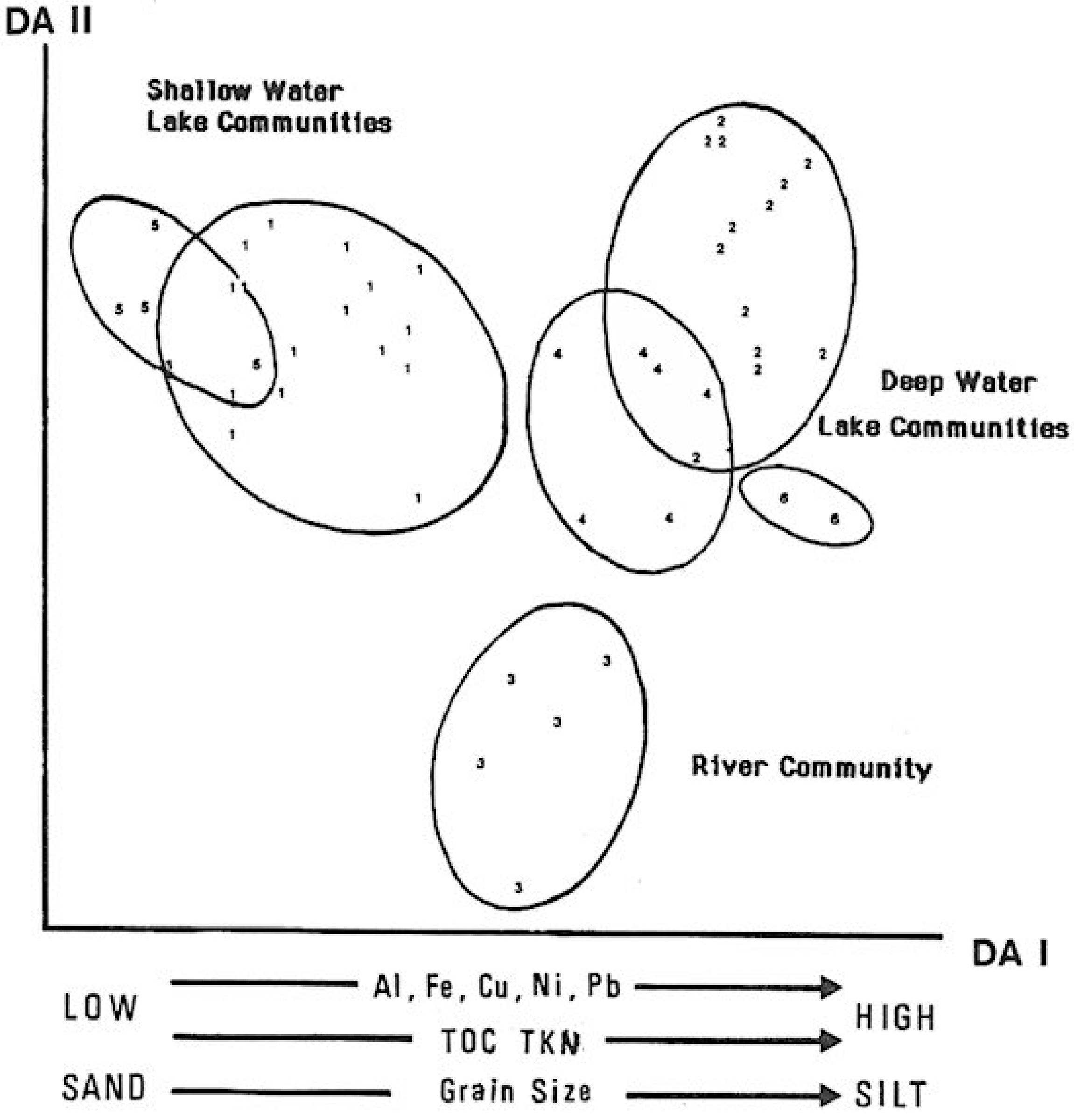

Figure 4: Plot of benthic invertebrate communities in discriminant space as defined by the first two discriminant functions.

Table 2: Correlations (r) between the physicochemical sediment variables and the first two discriminant functions.

	Discriminant Functions	
Physicochemical Variables	I	II
Fe	0.81	0.11
Al	0.94	0.08
Cd	0.67	-0.19
Cr	0.86	0.17
Cu	0.91	-0.20
Hg	0.64	0.12
Ni	0.89	0.00
Pb	0.89	-0.12
Zn	0.89	-0.16
Oils and Grease	0.29	0.21
Loss-On-Ignition	0.71	-0.37
Total Organic Carbon	0.85	-0.34
Total-P	0.68	0.02
Total Kjeldahl-N	0.70	-0.37
Grain Size	0.86	-0.06

Table 3: Coefficients of the physicochemical sediment variables of the first two discriminant functions.

	Discriminant Functions	
Physicochemical Variables	I	II
Fe	-1.58	0.83
Al	6.55	2.55
Cd	-0.21	0.28
Cr	0.51	0.34
Cu	1.83	-3.02
Hg	-0.69	0.42
Ni	-2.89	0.43
Pb	1.49	-0.52
Zn	0.48	-0.40
Oils and Grease	-0.24	0.37
Loss-On-Ignition	-0.05	-1.19
Total Organic Carbon	1.19	-0.39
Total-P	0.01	0.65
Total Kjeldahl-N	-1.35	-0.75
Grain Size	-2.24	0.63

Table 4: Mean values (geometric mean) of physicochemical sediment variables associated with the benthic communities in Lake St. Clair, May 1983. All units are expressed as mg/kg unless otherwise stated. Communities are grouped by habitat type.

	BENTHIC COMMUNITY					
	5	1	4	2	6	3
	Lake--shallow		- - - - - Lake--deep - - - - -			River
Fe (g/kg)	6.14	6.79	8.96	14.16[2]	12.96[2]	9.43
Al (g/kg)	2.31	2.73	5.43	8.87	8.65	4.83
Cd	0.10	0.12	0.28	0.40	0.50	0.38
Cr	8.75	9.67	15.26	23.89	24.42	12.93
Cu	2.89	3.81	10.24	17.86	22.56	15.06
Hg	0.01	0.07	0.17	0.49[2]	0.32[2]	0.23
Ni	4.26	4.61	9.26	15.69	15.97	9.68
Pb	2.35	3.62	13.69	23.11	24.46	15.07
Zn	13.69	20.33	41.17	62.03	65.68	50.92
Oils and Grease (g/kg)	0.59	0.31	0.53	0.79	1.09*	0.26
Loss-On-Ignition (%)	0.65	0.59	1.62	2.45	3.77	3.30
Total Organic Carbon	1.42	2.36	11.50	15.62	24.82	19.87
Total-P (g/kg)	0.20	0.21	0.25	0.48*	0.44*	0.38
Total Kjeldahl-N (g/kg)	0.22	0.22	0.51	0.79	1.18*	1.05*
Grain Size (phi units)	1.58	1.86	3.90	4.65	4.30	3.76

Based on the US EPA Guidelines for Pollutional Classification of Great Lakes Harbour Sediments (IJC 1982):

* means that the sediment is considered moderately polluted,

** means that the sediment is considered heavily polluted.

[2] means that the sediment concentration exceeds the Ontario Ministry of the Environment's Guidelines for Open Water Disposal (OMOE 1978).

Table 5: Correlations (r) between grain size and sediment chemistry variables.

Sediment Chemistry Variable	Grain Size
Fe	0.81
Al	0.92
Cd	0.71
Cr	0.86
Cu	0.93
Hg	0.68
Ni	0.88
Pb	0.87
Zn	0.88
Oils and Grease	0.25
Loss-On-Ignition	0.79
Total Organic Carbon	0.84
Total-P	0.69
Total Kjeldahl-N	0.77

because the analysis assumes that the variables are independent (ie. uncorrelated). Metal concentrations should increase with decreasing sediment particle size, which is equivalvent to increasing grain size measured in phi units, because smaller particles have a larger surface area for metal adsorption. Similarly, nutrient concentations and organic content should increase with decreasing sediment particle size because all these variables are dependent on the physical nature of the environment. For example, depositional areas have smaller particle sizes and higher organic and nutrient concentrations than erosional areas because of the interactions between the various physical variables including water depth and current velocity. Furthermore, a number of studies have shown that sediment particle size does affect the distribution and abundance of benthic invertebrates in the Great Lakes (Cole and Wiegmann 1983; Alley and Mozley 1975; Winnell and Jude 1984; Dermott 1978; Krieger 1984). DA I therefore, suggests that the difference in the species composition of the shallow and deep-water lake communities was primarily a result of the physical characteristics of the habitats as reflected by sediment particle size (Figure 5).

The second discriminant axis (DA II) explained 18.7% of the total variance and correlated poorly with all the measured environmental variables (Table 2). DA II separated the river community, Community #3, from the lake communities (Figure 4). The poor correlations between the measured physicochemical variables and DA II suggests that the difference in the species composition of the river and lake communities was not related to sediment concentrations of metals, oils and grease, organics, or nutrients but to an unmeasured variable(s) which was non-linearly related to the measured environmental variables. The separation of the river community from the lake communities suggests that some river/lake habitat variable could be the possible unmeasured variable. Thus DA II suggests that the difference in the species composition of the river and lake communities was also related to physical characteristics of the habitats and not to the effect of metals or other pollutants.

DA I and DA II therefore can both be interpreted in terms of physical habitat characteristics. Thus the discriminant analysis suggests that the river, shallow-water and deep-water lake communities all reflect similar environmental quality conditions.

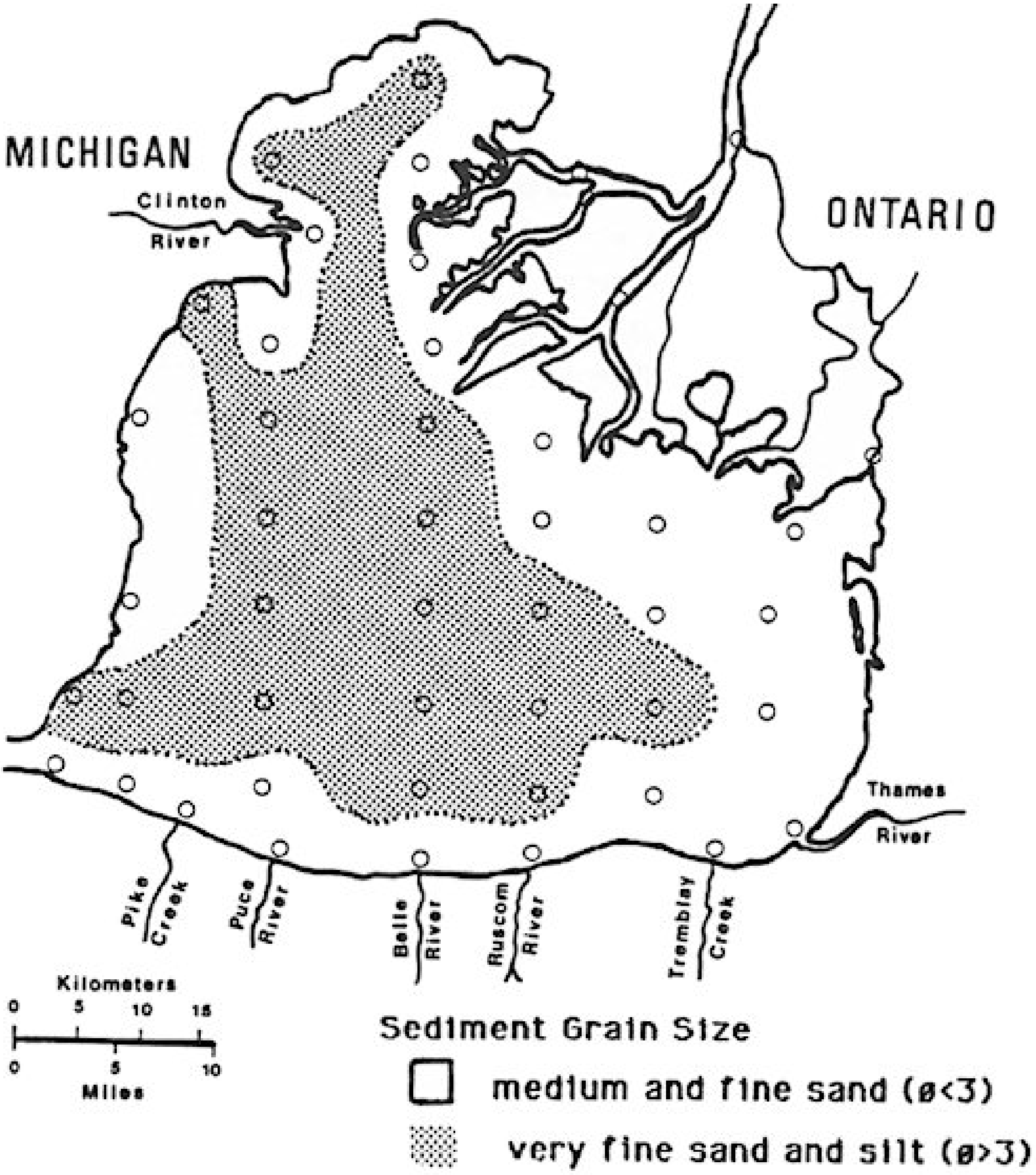

Figure 5: Grain size distribution in Lake St. Clair and Anchor Bay.

An examination of the structure, functional organization and taxonomic composition of the communities supports this general conclusion. The species composition of the deep-water lake communities indicates that mesotrophic conditions prevailed throughout the lake. *Chironomus, Cryptochironomus, Coelotanypus, Procladius* and *Limnodrilus hoffmeisteri*, all of which have been found to be tolerant of eutrophic conditions in the Great Lakes (Brinkhurst *et al.* 1968; Carr and Hiltunen 1965), were abundant in all three communities. However, *Hexagenia*, which is intolerant of low dissolved oxygen conditions (Britt 1955), numerically dominated each community and *Oecetis, Phylocentropus, Pothastia, Heterotrissocladius, Stylodrilus herringianus*, and flatworms, which are indicative of oligotrophic conditions, were present at some stations. In addition, nematodes, *Spirosperma ferox, Gammarus, Stictochironmus*, and *Ablabesmyia,* which are indicative of mesotrophic conditions in the Great Lakes (Cook and Johnson 1974), were common representatives of the deep-water lake communities.

The functional organizations of communities #2 and #6 were very similar (Figure 6), and characteristic of the profundal zones of lakes (Jonasson 1978). Collector-gatherers dominated the communities because of the abundance of fine particulate organic matter in the sediments, while scrapers and shredders were scarce because of the lack of macrophytes and algae. However, the invertebrate abundance of Community #6 was about three times that of Community #2 (Table 1), and in particular, the abundances of species tolerant of very organically enriched conditions, such as the oligochaetes, *Limnodrilus hoffmeisteri, L. udekianus, L. maumeensis* and *Quistadrilus multisetosus*, and chironomids, *Chironomus, Cryptochironomus, Demicryptochironomus* and *Procladius* were much greater. The composition of Community #6 therefore indicates that the sediments were more organically enriched than the sediments associated with Community #2, probably as a result of allochthonous organic inputs from the marshy riparian habitat of the lower St. Clair River. Measurements of the organic content of the sediments (ie. total organic carbon and loss-on-ignition) support these data (Table 4).

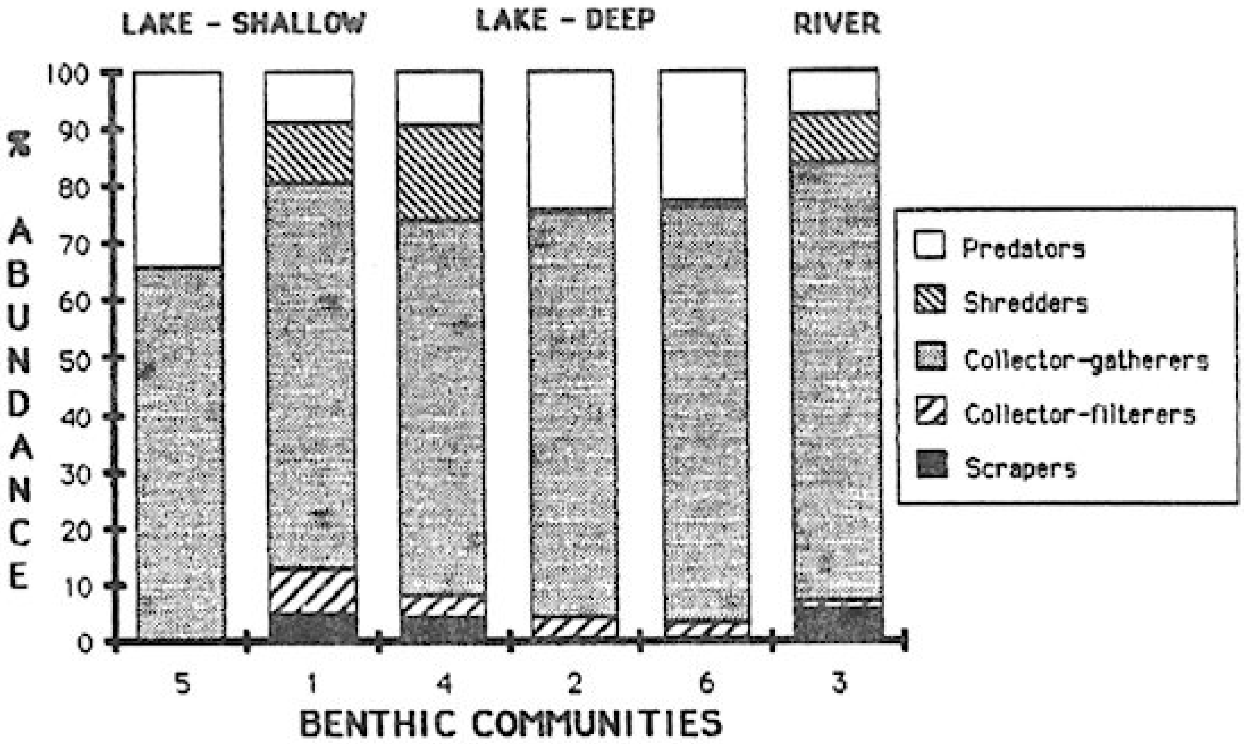

Figure 6: Relative abundance of functional-feeding groups of the benthic communities in Lake St. Clair, May 1983.

Although the concentrations of metals and oils and grease in sediments associated with Community #6 were among the highest measured values (Table 4), little effect of any stress was evident from the species composition of the community (Table 1). The high density of *Hexagenia*, 44.2 individuals per sample, suggests that the concentrations of oils and grease were not great enough to effect the benthic fauna (Hiltunen and Schloesser 1983). Similarly, the abundances of the chironomid, *Stictochironomus*, and oligochaetes and clams, suggest that benthic fauna were not affected by metal toxicity (Waterhouse and Farrell 1985; Brinkhurst and Cook 1974; Fuller 1974).

The functional organization of Community #4 was more characteristic of the littoral zone of lakes (Jonasson 1978). Collector-gatherers still dominated the biota but scrapers and shredders formed a significant component of the community (Figure 6). The increased invertebrate density and species richness relative to Community #2 was probably related to the shallower water depth and to the presence of aquatic macrophytes (Schloesser and Manny 1984), which provide a source of food, shelter from vertebrate predation and a stable habitat for invertebrates. This then would account for the abundance of shredders, such as *Gammarus, Hyalella azteca* and *Asellus*, which feed on coarse particulate organic matter (eg. stems, leaves) and may hide in aquatic weed beds from predators and the abundance of scrapers, such as snails, which feed on periphyton and may utilize the surface of macrophytes as a habitat.

The species composition of the shallow-water lake community, Community #1, reflects slightly better environmental quality conditions than the deep-water communities. Species characterizing this community such as *Pseudochironomus, Stictochironomus, Cryptochironomus, Cheumatopsyche, Hydropsyche, Stylodrilus herringianus*, and *Spirosperma ferox* are all characteristic of sandy littoral sediments of oligo-mesotrophic lakes (Saether 1977; Pinder and Reiss 1984; Brinkhurst and Jamieson 1971). Furthermore, the lack of numerically dominant species, the great diversity of insects, molluscs, and annelids and the occurrence of a number of pollution-sensitive taxa such as *Ceraclea, Mystacides, Oecetis, Amnicola*, and *Stylodrilus herringianus* infers that the littoral environment was not impaired by pollution.

The reduced invertebrate abundance of the shallow-water communities compared with the deep-water communities was probably because of the lower organic matter content of the sediments (Table 4), the increased disturbance from wave action and the coarser particle size of the habitat (Figure 5) and not because of pollution (Cole and Wiegmann 1983; Mozley and Garcia 1972). The concentrations of metals, oils and grease and nutrients in the sediments associated with the shallow-water communities were generally much lower than those in sediments associated with the deep-water communities (Table 4).

Although the functional organization of Community #1 was typical of the littoral zone of lakes, the organization of Community #5 indicated some type of stress (Figure 6). Species richness of Community #5 was the lowest of the communities and the community was dominated by the pollution-tolerant species *Polypedilum illinoensi* and the ceratopogonids or biting midges (Simpson and Bode 1980; Hynes 1960). Although metal concentrations were less than those measured for Community #1, the concentration of oils and grease was almost double (Table 4). The impaired environmental quality reflected by Community #5 therefore may have been a result of the presence of oils and grease in the sediments.

The species composition of the river community, Community #3, was reflective of a productive, non-stressed lotic environment. Species richness was the highest of the communities, the functional organization was characteristic of large rivers (Vannote et al. 1980) and a large variety of pollution-sensitive species such as *Ceraclea, Oecetis, Mystacides, Hexagenia, Stylodrilus herringianus, Aulodrilus americanus*, flatworms, etc., were present. Mesotrophic conditions were indicated by the abundance of *Pseudochironomus, Tribelos, Stictochironomus, Physa, Spirosperma ferox*, and *Gammarus* in the community. The high invertebrate density is a reflection of the productivity of the lotic community. This productivity is probably maintained by the presence of aquatic macrophytes and algae and organic inputs from the marshy riparian habitat along the river, which is the most productive aquatic habitat known.

Lake St. Clair Environmental Quality Zones:

A summary of the environmental quality interpretations of the benthic invertebrates communities is provided in Figure 7. Based on the distributions of these communities, environmental quality zones were established in the lake (Figure 8).

Figure 8 shows that overall, the environmental quality of Lake St. Clair in 1983 was good. Mesotrophic conditions prevailed in the central basin of the lake and Anchor Bay and in the lower part of the St. Clair River, while oligo-mesotrophic conditions were present in the shallower nearshore areas of the lake and Anchor Bay. In addition, neither the St. Clair or Thames rivers, the two largest tributaries to the lake, had any perceivable effect on the environmental quality of the lake.

Minor impairment of environmental quality was observed at the mouths of the Puce, Belle, and Ruscom rivers and near a sewer outfall from St Clair Shores, Michigan. The locally impaired environmental quality may be related to the discharge of oils and grease into the lake. In addition, reduced environmental quality related to organic matter enrichment was observed in deeper parts of the study area near the St. Clair River delta.

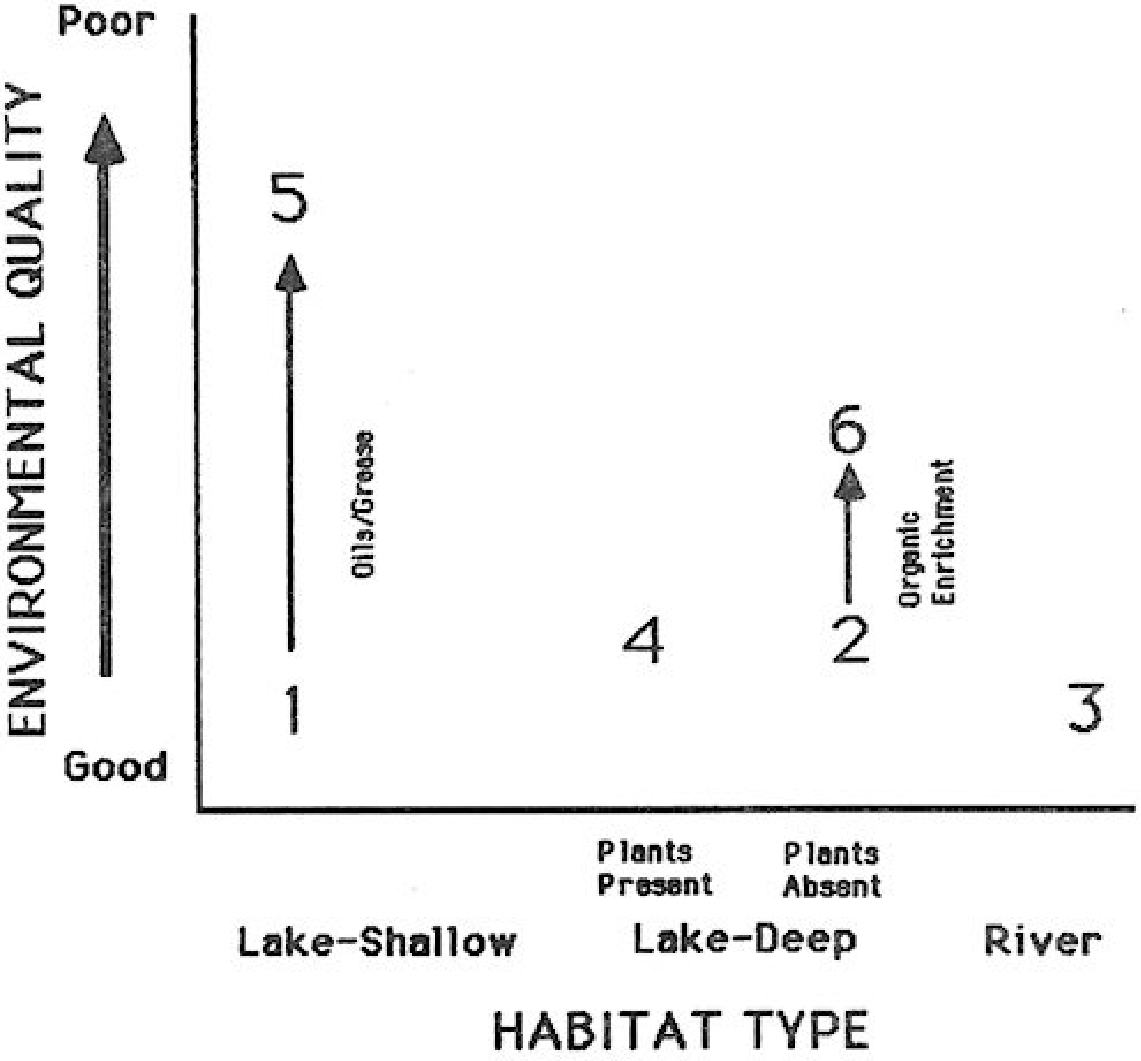

Figure 7: Environmental Quality interpretations of benthic invertebrate communities in Lake St. Clair, May 1983.

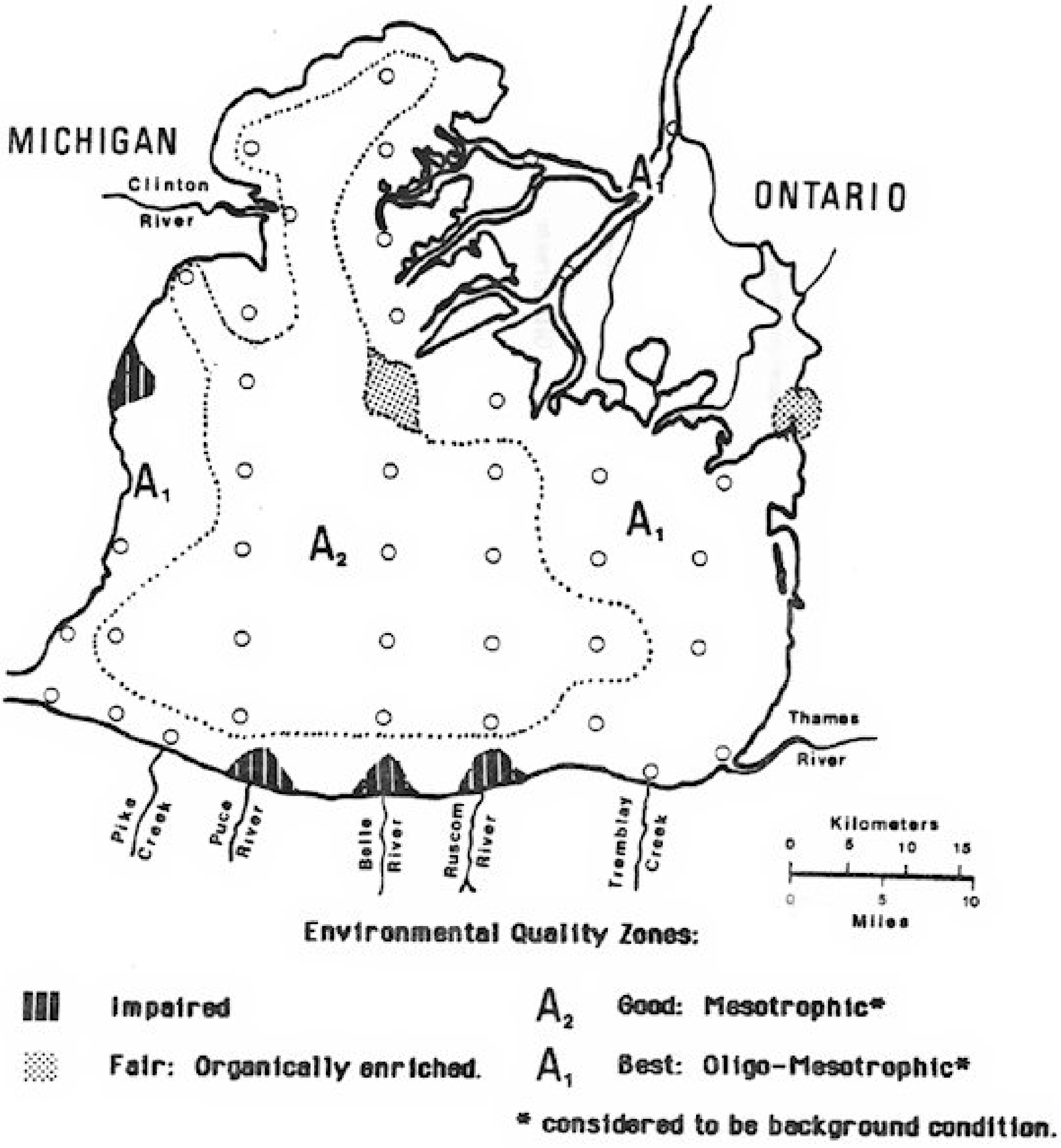

Figure 8: Locations of environmental quality zones in Lake St. Clair, Anchor By and the St. Clair River, May 1983.

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Appendix 1: List of Major Taxonomic References.

List of Major Taxonomic References.

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Appendix 2: Species composition (mean number per 516 cm') of sampling stations in Lake St. Clair, May 1983.

Species composition (mean number per sample) of sampling stations in Lake St. Clair, May 1983. P indicates <1 individual per sample.

	STATION NUMBER									
	150	151	152	153	154	155	156	157	158	159
Arthropods:										
AQUATIC CATERPILLARS:										
Pyralidae		P								
BEETLES:										
Elmidae:										
Dubiraphia			P							
TRUE BUGS:										
Corixidae						4			P	P
CADDISFLIES:										
Hydropsychidae:										
Cheumatopsyche		3								
Hydropsyche		P								
Leptoceridae:										
Ceracles		P								
Mystacides										
Oecetis				P			2	4		
Setodes										
Molannidee:										
Molanna										
Polycentropodidae:										
Neureclipsis										
Phylocontropus										
MAYFLIES:										
Bactiscidae:										
Bactisca		P								
Caenidas:										
Caenis			P						P	
Ephemerellidae:										
Eurylophella		P				P				
Serratella										
Ephemerides:										
Ephemera				P						
Hexagenia				6			20	18	P	
Stenonema										
TRUE FLIES:										
Ceratopogonidae	P	P	1		5	5			3	
Chaoboridae:										
Chaoborus										

	STATION NUMBER									
	150	151	152	153	154	155	156	157	158	159
TRUE FLIES:										
Chironomidae:										
Chironomus						P		5		
Cladopelma						P				
Cladotanytarsus										
Cryptochironomus	P			2	P	P	3	5	6	P
Demicryptochironomus	P		P		P					
Dicrotendipes										
Harnischia										
Microtendipes										
Nilothauma										
Paratanytarsus										
Phaenopsectra										
Polypedilum	20	5	5			P			51	
P.illinoensi			1		P				52	
Pseudochironomus	1	16	8	1	1	2				1
Stictochironomus			11		P		2		3	
Tanytarsus										
Tribelos										
Rheotanytarsus										
Pothastia								1		P
Epicocladius							1			
Heterotrissocladius										
Hydrobaenus						P				
Cricotopus/Orthocladius	1					P				
Parakiefferiella		7		2				I		P
Monodlamesa										
Ablabesmyia				P			6	4		
Clinotanypus										
Coelotanypus				9		P	12	7		
Djaimabatista										
Procladius			2	1	2	P	5	20	P	
Thienemannimyia-gp		P								
Empididae						P				
AMPHIPODS:										
Gammaridae:										
Gammarus		3								P
Taltridae:										
Hyalella azteca		P								
ISOPODS:										
Asellidae:										
Asellus										
Lirceus										

	STATION NUMBER									
	150	151	152	153	154	155	156	157	158	159
Mollusca:										
CLAMS:										
Sphaeridae:										
Pisidium		2		P			2	3		P
Sphaerium		2					3			
Unionidae:										
Anodonta										
Dysnomia triquetra								P		
Lampsilis radiata										
Truncilla truncata			P	P						
Villosa iris		P		P						
SNAILS:										
Bithyniidae:										
Bithynia tentaculata									P	
Hydrobiidae:										
Amnicola										
Probythinella lacustris		P		P				P		
Somatogyrus subglobosus								P		
Lymnaiidae:										
Fossaria										
Lymnaea										
Physidae:										
Physa										
Planorbidae:										
Gyraulus		P								
Pleuroceridae										
Goniobasis livescens	4	3	1	P						P
Pleurocera acuta										
Valvatidae:										
Valvata piscinalis										
V. tricarinata										
Annelids:										
LEECHES:										
Erpobdellidae										
Glossiphonidae										
POLYCHAETES:										
Sabellidae:										
Manayunkia speciosa										

	STATION NUMBER									
	150	151	152	153	154	155	156	157	158	159
WORMS:										
Lumbricidae										
Lumbriculidae										
Stylodrilus herringianus										
Naididae						P				1
Tubificidae:										
Aulodrilus americanus							4			
A. pluriseta										
Branchiura sowerbyi							3	19		
Isochaetides curvisetosus	4									
Ilyodrillus freyi										
I. tempietoni										
Limnodrilus spp.							P		1	
L. angustipenis										
L. cervix						1				
L. claparedianus		P			1				P	
L. hoffmeisteri	2	P	4			P	1		3	
L. maumeensis			1							
L. udekemïanus										
Potamothrix moldaviensis					4	2			4	P
P. vejdovskyi									1	P
Quistadrilus multisetosus										
Spirosperma ferox	9	4	1	1	P	2	P		P	1
Tubificid immature, HCA	2	2	10	3	2	3	P	1	9	1
Tubificid immature, HCP			P						P	
Nematode:										
NEMATODES	P			5	P		15	9	P	
Platyhelminthes										
FLATWORMS		P						p		p
Mean number of Taxa	5.7	14	6.3	8.7	6	9	12.7	13.7	9.3	5.3
Mean number of Organisms	45	54	49	34	18	23	79	100	137	8

	STATION NUMBER									
	160	161	162	163	164	165	166	167	168	169
Arthropode:										
AQUATIC CATERPILLARS:										
Pyralidae										
BEETLES:										
Elmidae:										
Dubiraphia										
TRUE BUGS:										
Corixidae										
CADDISFLIES:										
Hydropsychidae:										
Cheumatopsyche										
Hydropsyche										
Leptoceridae:										
Coracles										
Mystacides	P		P	1	3	1				
Oecetis			2		P					
Setodes										
MolennIdae:										
Molenna										
Polycentropodidae:										
Neureclipsis										
Phylocentropus										
MAYFLIES:										
Baetiscidae:										
Bastisca										
Caenidae:										
Caenis	2	P	P	P	1					
Ephemerellidae:										
Eurylophelia										
Serratella										
Ephemerides:										
Ephemera										
Hexagenia					P		3	23	12	11
Stenonema										
TRUE FLIES:										
Ceratopogonidae	10	1								
Chaoboridae:										
Chaoborus										

	STATION NUMBER									
	160	161	162	163	164	165	166	167	168	169
TRUE FLIES:										
Chironomidae:										
Chironomus				P				10		1
Cladopelma					1					
Cladotanytarsus	1		2							
Cryptochironomus	6	4	8	2	8	1	3	P	3	2
Demicryptochironomus			1	P	2	1	2			P
Dicrotendipes										
Harnischia										P
Microtendipes										
Nilothauma			P			P				
Paratanytarsus										
Phaenopsectra										
Polypedilum	3	31	P							
P.illinoensi		10					P			
Pseudochironomus	50		10	8	11	1	P			
Stictochironomus	3		5	2	4	P	2	P		
Tanytarsus								2		
Tribelos								3		
Rheotanytarsus										
Pothastia	2		1	P	1	P	2	2	2	2
Epicocladius								P		
Heterotrissocladius										
Hydrobaenus										
Cricotopus/Orthocladius										
Parakiefferiella										
Monodiamesa										
Ablabesmyia							P	9	1	
Clinotanypus								P		
Coelotanypus				P	3		2	13	11	8
Djalmabatista										
Procladius		10	1	P				7	4	4
Thienemannimyia-gp		1								
Empididae										
AMPHIPODS:										
Gammaridae:										
Gammarus	P	1	P		P	6	1			1
Taltridae:										
Hysiella azteca			5	P	2					
ISOPODS:										
Asellidae:										
Asellus										
Lirceus										

	STATION NUMBER									
	160	161	162	163	164	165	166	167	168	169
Molluscs:										
CLAMS:										
Sphaeridae:										
Pisidium	P		8	5	10	8	2	3	2	
Sphaerium			2	2	9	P	P	1	1	
Unionidae:										
Anodonta										
Dysnomia triquetra										
Lampsilis radiata										p
Truncilla truncata										
Villosa iris										
SNAILS:										
Bithyniidae:										
Bithynia tentaculata										P
Hydrobiidae:										
Amnicola										
Probythinella iscustris			1		1			1		
Somatogyrus subglobosus			P							
Lymnaiidae:										
Fossaria										
Lymnaea										
Physidae:										
Physa			P		P					
Planorbidae:										
Gyraulus						P		P		
Pleuroceridae										
Goniobasis livescens				1	6	2	P			P
Pleurocera acute							P			
Valvatidae:										
Valvats piscinalis					P					
V. tricarinata										
Annelids:										
LEECHES:										
Erpobdellidae										
Glossiphonidae								p	p	p
POLYCHAETES:										
Sabellidae:										
Manayunkia speciosa			4	P	P		P			P

	STATION NUMBER									
	160	161	162	163	164	165	166	167	168	169
WORMS:										
Lumbricidae										
Lumbriculidae:										
Stylodrilus herringianus										
Naididae	P		8	P	P	P				
Tubificidae:										
Aulodrilus americanus								P		
A. pluriseta										
Branchiura sowerbyi		P								
Isochaetides curvisetosus			2	2		1				
Ilyodrilus freyi	2	1								
I. templetoni			P							
Limnodrilus spp.		1							1	
L. angustipenis										
L. cervix		19							3	
L. claparedianus		1		1						
L. hoffmeisteri		8	3	5	11		P	6	15	4
L. maumeensis		4								
L. udekemianus	2									
Potamothrix moldaviensis		11	P	1		P				
P. vejdovskyi				P	P					
Quistadrilus multisetosus										
Spirosperma ferox			8	3	32	P	6			
Tubificid immature. HCA	12	28	94	7	5	4	14	23	39	7
Tubificid immature, HCP	P		P		P	1		P		
Nematode:										
NEMATODES			32	1	2	2	P	17	7	4
Platyhelminthes:										
FLATWORMS			P	P	P		1	P		
Mean number of Taxa	9.3	11	17.3	15.3	18	9.3	11.3	14	10.7	10
Mean number of Organisms	95	133	201	48	116	32	43	126	102	47

	STATION NUMBER									
	170	171	172	173	174	175	176	177	178	179
Arthropods:										
AQUATIC CATERPILLARS:										
Pyralidae										
BEETLES:										
Elmidae:										
Dubiraphia										
TRUE BUGS:										
Corixidae										
CADDISFLIES:										
Hydropsychidae:										
Cheumatopsyche										
Hydropsyche										
Leptoceridae:										
Ceraclea									p	
Mystacides	5	P								
Oecetis	2			P	P					P
Setodes									P	
Molannidae:										
Molanna									P	
Polycentropodidae:										
Neureclipsis										
Phylocentropus	P									
MAYFLIES:										
Baetiscidae:										
Baetisca										
Caenidae:										
Caenis										
Ephemerellidae:										
Eurylophella										
Serratella										
Ephemeridae:										
Ephemera										
Hexagenia	32	P	17	20	50	60		P	P	17
Stenonema										
TRUE FLIES:										
Ceratopogonidae						P				P
Chaoboridae:										
Chaoborus										

	STATION NUMBER									
	170	171	172	173	174	175	176	177	178	179
TRUE FLIES:										
Chironomidae:										
Chironomus	1			P	2					10
Cladopeima										
Cladotanytarsus										
Cryptochironomus	2	2		P	P	4	P	P	3	2
Demicryptochironomus	2	P			4	15	P	2	P	
Dicrotendipes										
Harnischia										
Microtendipes										
Nilothauma										
Paratanytarsus										
Phaenopsectra										
Polypedilum	1	2				27	P		P	7
P.illinoensi										
Pseudochironomus	11	5							12	
Stictochironomus	3	2		P		12		8	16	
Tanytarsus										
Tribelos	3									6
Rheotanytarsus										
Pothastia			P		4	P				
Epicocladius					P	1				
Heterotrissocladius									1	
Hydrobaenus						2				
Cricotopus/Orthocladius										
Parakiefferiella		1	P	P		P	1	6	9	
Monodfamesa						1		P		
Ablabesmyia	2		P	1	2	2				
Clinotanypus									P	
Coelotanypus	5		1	P	9	2			2	
Djalmabatista						2				
Procladius	6		2	1	9	9			3	
Thienemannimyia-gp										
Empididae										
AMPHIPODS:										
Gammaridae:										
Gammarus	16	3		P		2	P	17	58	24
Taltridae:										
Hyalella azteca	6									P
ISOPODS:										
Asellidae:										
Asellus										24
Lirceus										

	STATION NUMBER									
	170	171	172	173	174	175	176	177	178	179
Mollusca:										
CLAMS:										
Sphaeridae:										
Pisidium	1	3			1	11	1	1	4	P
Sphaerium	P		P	1	P		P	2		
Unionidae:										
Anodonta					P					
Dysnomia triquetra										
Lampsilis radiata			P							
Truncilla truncata										
Villosa iris										
SNAILS:										
Bithyniidae:										
Bithynia tentaculata	P			P						
Hydrobiidae:										
Amnicola	11	P								
Probythinella Iacustris						P				
Somatogyrus subglobosus	P	P								
Lymnsiidae:										
Fossaria								P		
Lymnaea										
Physidae:										
Physa	2	P							P	
Planorbidae:										
Gyraulus	2									
Pleuroceridae										
Goniobasis livescens	2	2		P			2	9	6	
Pleurocera scuts										
Valvatidae:										
Valvata piscinalls										
V. tricarinata		P							P	P
Annelida:										
LEECHES:										
Erpobdellidae										2
Glossiphonidae	1									P
POLYCHAETES:										
Sabellidae:										
Manayunkia speciosa	9	P			5	P				

	STATION NUMBER									
	170	171	172	173	174	175	176	177	178	179
WORMS:										
Lumbricidae										
Lumbriculidae:										
Stylodrilus heringianus						1		1		2
Naididae	P	2			P	3			P	
Tubificidae:										
Aulodrilus americanus										
A. piuriseta										
Branchiura sowerbyi			4							5
Isochaetides curvisetosus										
Ilyodrllus freyi										
I. templetoni										
Limnodrilus spp.										4
L. angustipenis										2
L. cervix										
L. claparedianus						2				21
L. hoffmeisteri	P	2		2	16	21			1	25
L. maumeensis										
L. udekemlanus						6		P		
Potamothrix moldaviensis		1				2		P	2	
P. vejdovskyi										
Quistadrilus multisetosus						11				
Spirosperma ferox	32	14				1		7	5	10
Tubificid immature. HCA	5	21		3	152	35	P	P	1	22
Tubificid immature. HCP		P						P		P
Nematoda:										
NEMATODES	53	2			55	24				1
Platyhelminthes										
FLATWORMS	2				13	P			I	
Mean number of Taxa	22.7	12.7	5.3	8.3	13	19.7	4.3	9	15	17
Mean number of Organisms	220	66	26	33	326	257	6	57	130	189

	STATION NUMBER									
	180	181	182	183	184	185	186	187	188	189
Arthropods:										
AQUATIC CATERPILLARS:										
Pyralidae										
BEETLES:										
Elmidae:										
Dubiraphia										
TRUE BUGS:										
Corixidae										
CADDISFLIES:										
Hydropsychidae:										
Cheumatopsyche										
Hydropsyche										
Leptoceridae:										
Ceraclea										
Mystacides										
Oecetis	P			P	P		P		P	
Setodes										
Molannidae:										
Malanna										
Polycentropodidae:										
Neureclipsis										
Phylocentropus										
MAYFLIES:										
Baetiscidae:										
Baetisca										
Caenidae:										
Caenis										
Ephemerellidae:										
Eurylophella										
Serratella										
Ephemeridae:										
Ephemera										
Hexagenia	8	2		19	24	21	16	6	3	
Stenonema										
TRUE FLIES:										
Ceratopogonidae										4
Chaoboridae:										
Chaoborus										

	STATION NUMBER									
	180	181	182	183	184	185	186	187	188	189
TRUE FLIES:										
Chironomidae:										
Chironomus	18	2		1		2				
Cladopelma										
Cladotanytarsus										
Cryptochironomus		4	1		P		P	2	4	P
Demicryptochironomus			P	1				1	P	
Dicrotendipes	1									
Harnischia										
Microtendipes	4									
Nilethauma										
Paratanytarsus										
Phaenopsectra										
Polypedilum		5								P
P.illinoensi										
Pseudochironomus	3	5		P			P		4	
Stictochironomus	20	15	12	5	P				3	
Tanytarsus										
Tribelos	19	4			3					
Rheotanytarsus										
Pothastia	P						P		3	P
Epicocladius				P			P	P		
Heterotrissocladius				1						
Hydrobaenus	5				2					
Cricotopus/Orthociadius										
Parakiefferieila					4			1		P
Monodiamesa										
Ablabesmyia	P						1	1		
Clinotanypus								P		
Coelotanypus	P	P		4	3	2	2	4	2	
Djalmabatista				P						
Procladius	4	P		12	17	1	5	4	1	
Thienemannimyia-gp									P	
Empididae										
AMPHIPODS:										
Gammaridae:										
Gammarus	15	10	P	10	12	P	1			
Taltridae:										
Hyalella azteca	4	2								
ISOPODS:										
Asellidae:										
Asellus	2				P					
Lirceus	3									

	STATION NUMBER									
	180	181	182	183	184	185	186	187	188	189
Mollusca:										
CLAMS:										
Sphaeridae:										
Pisidium	P	1		P		P	P	P	3	
Sphaerium	2	5	1				P	1		
Unionidae:										
Anodonta										
Dysnomia triquotra										
Lampsilis radiata										
Truncilla truncata		P								
Villosa iris	P	P								
SNAILS:										
Bithyniidae:										
Bithynie tentaculata		P								
Hydrobiidae:										
Amnicola										
Probythinella lacustris								P	P	
Somatogyrus subglobosus										
Lymnaiidae:										
Fossaria										
Lymnaea										
Physidae:										
Physa	P	1								
Planorbidae:										
Gyrauius				P	3					
Pleuroceridae										
Goniobasis livescens	P	1	1	1	2				1	
Pleurocera acuta								P		
Valvatidae:										
Valvata piscinalis										
V. tricarinata	P									
Annelida:										
LEECHES:										
Erpobdellidae										
Glossiphonidae	P	P		P				P		
POLYCHAETES:										
Sabellidae :										
Manayunkia speciosa				1	3			1	P	

	STATION NUMBER									
	180	161	182	183	184	185	186	187	188	189
WORMS:										
Lumbricidae										
Lumbriculidae:										
Stylodrilus herringianus	3	P	1	P						
Naididae										
Tubificidae:										
Aulodrilus americanus										
A. piuriseta							2			
Branchiura sowerbyi							4			
Isochaetides curvisetosus										
Ilyodrilus freyi										
I. templetoni							P			
Limnodrilus spp.										
L. angustipenis										
L. cervix										
L. claparedianus							P			
L. hoffmeisteri				9	P	4	2	2	P	
L. maumeensis										
L. udekemianus										
Potamothrix moldaviensis										2
P. vejdovskyi					P					
Quistadrilus multisetosus										
Spirosperma ferox	3	6	P	47	32				1	P
Tubificid immature. HCA		1	1	2	20	3	5	3	5	6
Tubificid immature, HCP	P	P		P	P					
Nematoda:										
NEMATODES				10	2		24	13	16	
Platyhelminthes:										
FLATWORMS					P					
Mean number of Taxa	15.3	13.3	4.7	12	12	4.7	12	11.3	12.7	3
Mean number of Organisms	117	69	19	127	129	34	66	41	48	13

	STATION NUMBER						
	190	191	192	193	194	195	196
Arthropods:							
AQUATIC CATERPILLARS:							
Pyralidae		P	P	P		P	
BEETLES:							
Elmidae:							
Dubiraphia			P				P
TRUE BUGS:							
Corixidae							
CADDISFLIES:							
Hydropsychidae:							
Cheumatopsyche		P		P			2
Hydropsyche							P
Leptoceridae:							
Ceraclea				P			
Mystacides							P
Oecetis							P
Setodes							
Molannidae:							
Molanna							P
Polycentropodidae:							
Neureclipsis						P	P
Phylocentropus			P	P			
MAYFLIES:							
Baetiscidae:							
Baetisca							
Caenidae:							
Caenis					1		7
Ephemerellidae:							
Eurylophella							
Serratella						P	2
Ephemeridae:							
Ephemera							
Hexagenia	1		29	1	1	10	4
Stenonema						P	
TRUE FLIES:							
Ceratopogonidae			1	1	4	4	6
Chaoboridae:							
Chaoborus			2				

	STATION NUMBER						
	190	191	192	193	194	195	196
TRUE FLIES:							
Chironomidae:							
Chironomus	6		14	2		1	P
Cladopelma							
Cladotanytarsus							
Cryptochlronomus			50		3		7
Demicryptochironomus	P		19				
Dicrotendipes			3	2			
Harnischia							
Microtendipes							
Nilothauma							
Paratanytarsus							4
Phaenopsectra				5			
Polypedilum		P		10	85	19	1
P.illinoensi							
Pseudochironomus					37		87
Stictochironomus				56	36	78	54
Tanytarsus							
Tribelos			18	202	68	218	4
Rheotanytarsus		P					
Pothastia							
Epicocladius							
Heterotrissociadius							
Hydrobaenus					2		
Cricotopus/Orthocladius				5	3	2	27
Parakiefferiella							
Monodiamesa					P		
Ablabesmyia			5			2	
Clinotanypus	1		1			1	
Coelotanypus		9	1				
Djalmabatista							
Procladius	7		25	6	9	10	3
Thienemannimyia-gp							
Empididae					P		P
AMPHIPODS:							
Gammaridae:							
Gammarus		P	2	27	25	17	44
Taltridae:							
Hyalella azteca				8	P	5	
ISOPODS:							
Asellidae:							
Asellus					2	4	
Lirceus				3		22	1

	STATION NUMBER						
	190	191	192	193	194	195	196
Mollusca:							
CLAMS:							
Sphaeridae:							
Pisidium	P	P	2	11	11		2
Sphaerium	2	P	P				
Unionidae:							
Anodonta							
Dysnomia triquetra							
Lampsilis radiata							
Truncilla truncata							
Villosa iris							
SNAILS:							
Bithyniidae:							
Bithynia tentaculata							
Hydrobiidae:							
Amnicola							
Probythinella lacustris							P
Somatogyrus subglobosus							
Lymnaiidae:							
Fossaria							
Lymnaea					P		
Physidae:							
Physa				36	13	1	1
Planorbidae:							
Gyraulus				24	4	4	7
Pleuroceridae							
Goniobasis livescens		2			P		3
Pleurocera acuta							
Valvatidae:							
Valvata piscinalis							
V. tricarinata					P		3
Annelids:							
LEECHES:							
Erpobdellidae						1	
Glossiphonidae						P	P
POLYCHAETES:							
Sabellidae:							
Manayunkia speciosa							

	STATION NUMBER						
	190	191	192	193	194	195	196
WORMS:							
Lumbricidae			P			13	P
Lumbriculidae:							
Stylodrilus herringianus			P	2	P	6	P
Naididae				2	P		P
Tubificidae:							
Aulodrilus americanus				P		1	4
A. pluriseta	1						
Branchiura sowerbyi	P						
Isochaetides curvisetosus							
Ilyodrilus freyi							
I. templetoni	P					P	
Limnodrilus spp.	P		4				
L. angustipenis							
L. cervix							
L. claparedianus	P			3		1	
L. hoffmeisteri	2	3	8	14	21	5	2
L. maumeensis			11				
L. udekemlanus				4			P
Petamothrix moldaviensis	P		P	8	3		5
P. vejdovskyi							
Quistadrilus multisetosus			9	5	35	11	
Spirosperma ferox			4	13	28	5	16
Tubificid immature. HCA	8	1	31	23	6	7	8
Tubificid Immature. HCP	P		P	P	3	P	
Nematoda:							
NEMATODES		1			P		1
Platyhelminthes:							
FLATWORMS		P	5	12	32	4	21
Mean number of Taxa	8.7	6	18	22.7	24	22.3	24.3
Mean number of Organisms	32	19	248	488	435	459	335