8-2001

Ecological Health of Sediments Located in the Rochester Embayment, Lake Ontario, NY

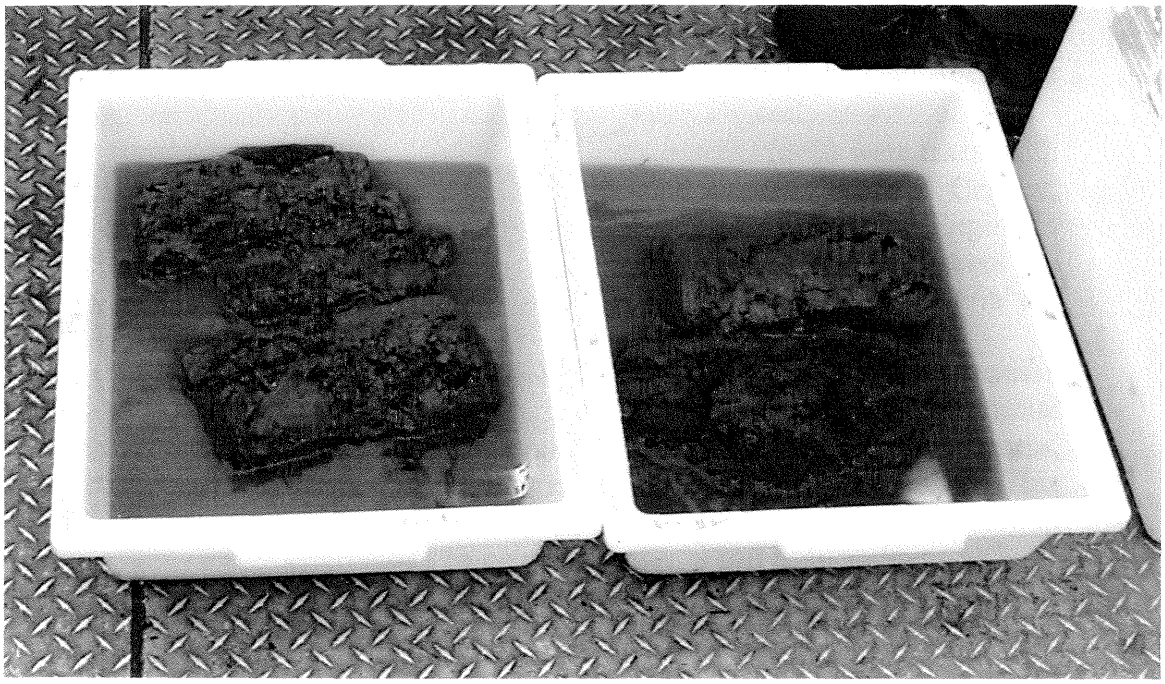
Joseph C. Makarewicz
The College at Brockport, jmakarew@brockport.edu

Mary Arnold
The College at Brockport

Theodore W. Lewis
The College at Brockport, tlewis@brockport.edu

Carole Beal
Monroe County Department of Health

Ecological Health of Sediments Located in the Rochester Embayment, Lake Ontario, NY



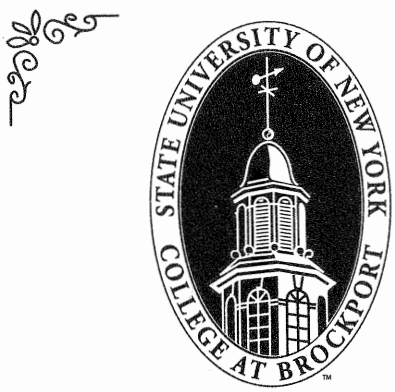
Joseph C. Makarewicz, Mary Arnold, Theodore W. Lewis

Environmental Science Program
Center for Applied Aquatic Science and Aquaculture
Department of Biological Sciences
SUNY Brockport
Brockport, NY

and

Carole Beal
Monroe County Department of Health
Rochester, New York

August 2001



DRAKE MEMORIAL LIBRARY

FACULTY PUBLICATIONS

DRAKE MEMORIAL LIBRARY

ALUMNI PUBLICATIONS

Executive Summary

1. The objective of this study was to provide a preliminary evaluation of benthic macroinvertebrate community health, and thus water quality, within the Rochester Embayment of Lake Ontario. The Rochester Embayment is one of 42 Great Lakes Areas of Concern.
2. To achieve this objective, replicate benthic samples (n=3) were taken with a Petite Ponar Dredge at four sites (Genesee River at Portland Cement, Inc.; Genesee River Plume in Lake Ontario; Army Corp of Engineers Dredge Disposal Site in Lake Ontario; and in Lake Ontario adjacent but north of RG&E's power generating facility at Russell Station) in the Rochester Embayment on 11 August 2000.
3. After discussions with the various Rochester RAP committees, the decision was made to follow the New York State Department of Environmental Conservation's procedure for evaluating ecological health of streams, rivers and lakes using the Biological Assessment Profile (BAP). This standardized multimetric method provided a semi-quantitative approach to evaluate macroinvertebrate community health in soft sediments.
4. Based on the BAP procedure, two locations (the Army Corps Dredge Disposal Site in Lake Ontario and the Russell Station Site) were identified as having severely impacted macroinvertebrate communities - an indication of poor water quality.
5. Two sites were observed to have moderately impacted macroinvertebrate community, the Genesee River Site at Portland Cement, Inc. and the Genesee River Plume in Lake Ontario.
6. The conclusion of a severely impacted community at the Russell Station Site has to be viewed with caution. Rather than being impacted by chemical or organic matter pollution, there is some evidence suggesting that siltation may be the cause of the low species richness observed.
7. Clearly, this study is not conclusive. More samples are required over a larger area of the embayment. However, the data do suggest that a moderate to severely impacted benthic community exists in the Rochester Embayment of Lake Ontario.

Introduction

In 1997, the Monroe County Department of Health (MCDOH), in cooperation with the New York State Department of Environmental Conservation (NYSDEC), completed the Rochester Embayment Remedial Action Plan (RAP). The Rochester Embayment is defined as the approximately 35 square mile portion of Lake Ontario around the mouth of the Genesee River (the "Embayment"), and the six mile reach of the Genesee River, up to the Lower Falls, that is influenced by water levels in Lake Ontario (the "River") (Fig. 1).

As part of RAP preparation, use impairments were determined for the Embayment and the River. It was determined that the River suffers from degradation of benthos. However, no data existed for the "Embayment", so it was not known whether the same problem existed in the "Embayment". As part of the RAP process, a RAP technical committee voted unanimously to make this study the highest priority of all the studies that were evaluated. Besides the objective of determining the health of benthic communities within the Rochester Embayment, two of the Monroe County RAP Committees who are developing "delisting" criteria for identified use impairments required data on macroinvertebrates in the "Embayment". These Committees are reviewing monitoring data to determine when use impairments can be "delisted". One of the Committees is focusing on toxic-related use impairments (Toxics Oversight Committee) and the other is focusing on the habitat use impairment (Habitat Oversight Committee). The Committees have determined that macroinvertebrate indicators of benthic and/or ecosystem health are required for making delisting decisions about three use impairments:

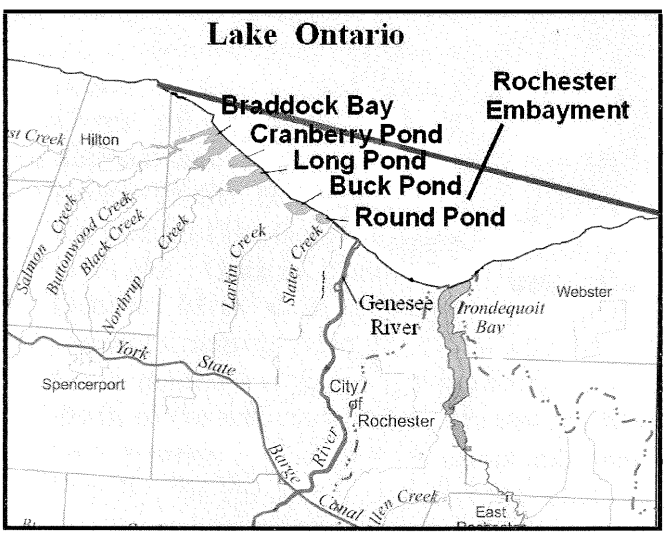


Fig. 1. The Rochester Embayment

a. Degraded fish and wildlife populations
b. Degradation of benthos
c. Loss of fish and wildlife habitat

Thus a second objective of this study is to provide data required by two of the RAP sub-committees to consider in delisting decisions.

The ecological health of the sediments in the Rochester Embayment was evaluated using the benthic macroinvertebrate community as an indicator. Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit stream and lake bottoms; freshwater forms are primarily aquatic insect larvae, worms, clams, snails and crustaceans. Macroinvertebrate community assessment utilizes macroinvertebrate community parameters such as species richness and biotic indices to

assess overall water quality. Because the organisms are relatively immobile in sediments and are thus at the mercy of toxics, organic sewage pollution, non-chemical impacts (such as siltation), etc, they provide an overall, integrated indication of water quality, including synergistic effects and effects of substances lower than detectable limits. Thus the presence or absence of benthic macroinvertebrate taxa can indicate stress or impact from environmental stressors. Generally though, it is not possible to identify the stressor based on macroinvertebrate community analysis.

Methods

Four sediment sampling sites, picked in consultation with the Toxics Oversight and the Habitat Oversight Committees of the Monroe County Remedial Action Plan Committee, were sampled as follows: in Lake Ontario adjacent but north of the Rochester Gas and Electric's Russell Station, the Army Corps of Engineers' dredge disposal site northeast of the mouth of the Genesee River, the plume of the Genesee River in Lake Ontario, and the Genesee River at the Portland Cement Company (Fig. 2).

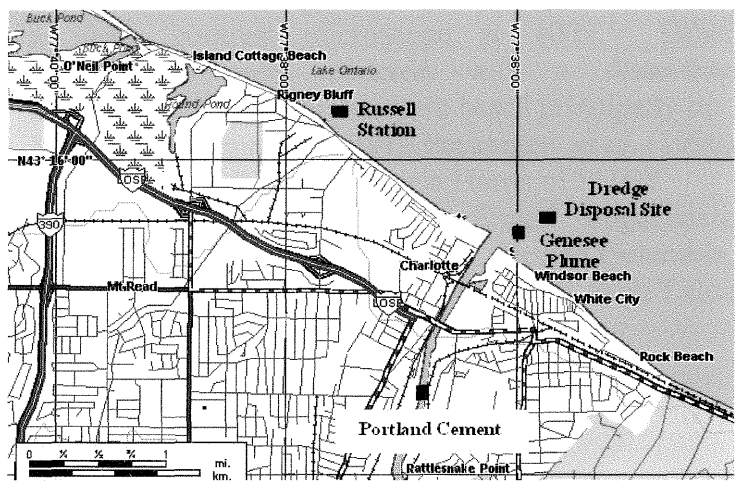


Figure 2. Sampling Sites

Confirmation that we were at the dredge disposal site was indicated by the decrease in the depth of the water from the surrounding lake bottom and by coordinates supplied by the GPS system. The Genesee River site was upstream (south) of the dredged channel. Initially, the Russell Station Site was taken at a 3m depth. No sediments were retrieved and we progressively moved into deeper water by 3m increments until sediment was retrieved. Positioning of the vessel was accomplished by determination of depth with an electronic fathometer (Raytheon, Inc.) and Global Positioning System (Garmin, Inc.).

Several precautions were taken to ensure sample integrity. For example, a chain of custody procedure was followed ensuring that all samples were taken, preservatives added and handled by trained personnel. All containers were pre-coded to ensure exact sample identification, cleaned prior to sampling, and remained sealed until needed.

Replicate benthic samples (n=3) were taken with a Petite Ponar Dredge (Fig. 3) with the aid of a crane and gas powered winch at four sites (Fig. 2) on 11 August 2000 from the SUNY College at Brockport R.V. Madtom. One "scoop" of sediment from each replicate was removed for total organic carbon analysis (Gaudette *et al.*1974). In addition, a composite sample was formed for particle size analysis (Plumbe 1981). Water temperature and conductivity were determined *in situ* with a YSI Electronic meter. Samples for biota were sieved (U.S. Standard No. 30 – 0.590mm sieve) in the field to

remove sediments and non-biota (APHA, 1992) and the contents of the sieve preserved in 95% ethanol.

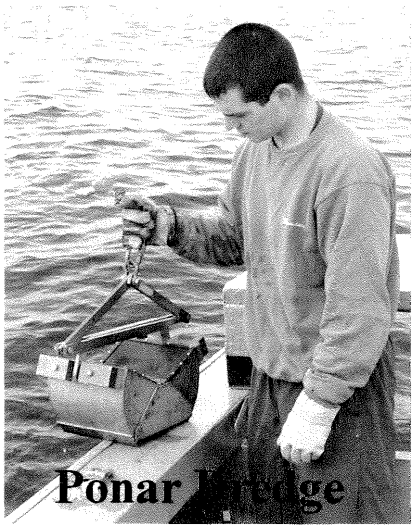


Figure 3. Ponar Dredge

In the laboratory, samples were distributed homogeneously over the bottom of a white enameled tray divided into grids. Approximately 100 organisms were removed from randomly chosen blocks. In some cases, less than 100 organisms were observed in the entire sample. Oligochaetes were mounted on slides in Amann's lactophenol, while Chironomid head capsules were excised and mounted in CMCP. Chironomids and oligochaetes were enumerated with a phase contrast microscope at 400x. Other invertebrates were counted with a dissecting microscope. Identifications were based principally on Merritt and Cummins (1984), Peckarsky *et al.* (1990) and Pennak (1989). Dr. Patricia Harris of SUNY Brockport assisted and confirmed oligochaete identification, while Dr. Ian Walker of Okanagan University College, British Columbia, Canada confirmed chironomid identification using digital images produced from Leica imaging software at SUNY Brockport.

Definitions

Species Richness: This is the total number of species or taxa found in the sample. Higher values are associated with clean water conditions.

Biotic Index: The Hilsenhoff Biotic Index considers abundance of individual taxa and their tolerance to environmental conditions. High values for the index are indicative of poor water quality, while low values are indicative of clean water conditions.

Percent Model Affinity: This is a measure of similarity to a non-impacted community based on percent abundance of seven major groups of macroinvertebrates (Novak and Bode 1991). The non-impacted model for lakes followed Bode (Personal Communication): 20% Oligochaeta, 15% Mollusca, 15% Crustacea, 20% Non-Chironomidae insects, 20% Chironomidae, and 10% other. The higher the value of the PMA index, the closer the macrophyte community sampled resembles the non-impacted model or healthy ecological benthic community.

Species Diversity: The Shannon Weiner Index combines species richness and evenness. A high value usually indicates diverse, well-balanced communities, while low values indicate stress or impact.

Dominance-3: Dominance is another measure of community balance or evenness of the distribution of individuals among the species. Dominance-3 is the combined percent

contribution of the three most numerous species. High values indicate unbalanced communities strongly dominated by one or more very numerous species.

Results

Particle size analysis of sediments indicated that both the Genesee River and Genesee River plume in Lake Ontario consisted of sand with non-detectable levels of organic carbon (Table 1). Sediments in the River plume in Lake Ontario were predominately coarse sand (34.7%), while sediments in the Genesee River at the Portland Cement site were predominately very fine and fine sands (58.9%). Sediments at the Russell Station site and Army Corp's Disposal site were organic (average > 0.60% organic carbon) and consisted mostly of silt (>63%) (Table 1).

Water depth was greatest at the Russell Station site in Lake Ontario (14.3m) and the shallowest in the Genesee River at the Portland Cement Company (4.1m). Water temperatures at all sites was within 1°C (range: 21.2 to 22.0°C). Similarly, water conductivity among sites was similar with the exception of the Portland Cement site on the Genesee River. Conductivity at this site was twice as high (660 µmhos/cm) as any other site (Table 1), reflecting higher dissolved solids in the river water.

A total of 1,263 macroinvertebrates were counted and identified (Table 2). There were clear differences in the macroinvertbrate communities among the four sampling sites.

Russell Station Site: Values for species richness (number of species), species diversity, and the percent model affinity were the lowest observed when compared to all other sites (Table 3). The low species diversity and the overwhelming dominance of three species (DOM-3= 96.7%) reflect the high abundance (88.5% of the organisms observed) of zebra mussels (*D. polymorpha* and *D. bugensis*) at this site. All of these indices usually suggest a stress or impact on the community.

Army Corps of Engineers Disposal Site in Lake Ontario: Tubificid worms of the families Naididae and Tubificidae were the dominant group of organisms (52.4% of the total) followed by the zebra mussels (27.0%). Species richness was relatively low at this site with an average of 8.7 taxa for the three sites (range=8-10, Table 3).

Genesee River site near the Portland Cement Company: Tubificid worms were again prevalent (57.8% of the total). This was also the only site where insects were prevalent. For example, the Family Chironomidae accounted for 33% of the organism observed at this site. This was the only site where zebra mussels were scarce (0.7% of the total abundance).

Genesee River Plume in Lake Ontario: Species diversity (1.93) and species richness (average = 11.7 taxa) were comparatively high at this site (Table 3). The plume of the Genesee River was dominated by two groups: tubificid worms (35%) and dreissinids (43.2%)(Table 2).

Discussion

Information gained from monitoring benthic macroinvertebrate communities has been widely used to measure the status of ecological conditions of streams and lakes. Benthic macroinvertebrates are good indicators of ecosystem health because they are relatively sedentary within the sediments-water interface and deeper sediments (Dauer *et al.* 1987). Both short-term disturbances such as hypoxia and long-term disturbances such as accumulation of sediment contaminants affect the population and community dynamics of benthic invertebrates (Jackson *et al.* 2000).

There are several indices that are available to evaluate stress or impact on the macroinvertebrate community associated with sediments. After discussions with the various Rochester RAP committees, the decision was made to follow the New York State Department of Environmental Conservation's procedure for evaluating ecological health of streams, rivers and lakes (Bode *et al.* 1996). Further modifications of this procedure were provided by Bode (R. Bode, Personal Communication, NYSDEC, Stream Monitoring Unit).

The overall assessment of water quality is accomplished by the Biological Assessment Profile (Bode *et al.* 1996). This scaled ranking of the various indices transforms values from the five indices onto a common scale of water quality ranging from 0 to 10. After all the index values are converted to a common scale value, they are averaged to form a score suggesting the overall assessment of water quality and health of the macroinvertebrate community. A zero represents poor water quality and a stressed or impacted macroinvertebrate community, while a 10 would be excellent water quality and thus a healthy macroinvertebrate community.

For the Rochester Embayment, the various community indices and the Biological Assessment Profile (BAP) indicate that two sites possessed severely impacted macroinvertebrate communities – an indication of poor water quality, while two sites were moderately impacted.

Genesee River and the Genesee River Plume

Sediments in the Genesee River and in the Genesee River Plume in Lake Ontario were generally sandy in nature although larger particles of sand were observed at the Plume site. Both sites had similar community indices that indicated a moderately impacted benthic community (Table 3). Previous assessments in 1990 by Bode et al. (Cited in Rochester Embayment Remedial Action Plan Stage 1, 1993) at sites below the Kodak discharge in the Genesee River indicated a moderate to severely impacted benthic community. Thus it would appear that no major change has occurred in the health of the benthic community of the Genesee River over the past ten years. Our conclusion is at variance with the conclusion presented in the "Environmental Report Card" (MCHD 1999). The Environmental Report Card states that in "1993 and 1995 data collections done in the Genesee River seem to indicate a continuing improvement close to the mouth of the river".

In 1972, Nalepa and Thomas (1976, Cited in Rochester Embayment Remedial Action Plan Stage 1, 1993) observed that oligochaete worms dominated the shallow area of the embayment. The site in the Genesee River Plume is actually a shallow site (7.3m) in Lake Ontario (Fig. 2). In 2000, this shallow area in the Embayment was dominated by oligochaete worms (35% of the total abundance) as in 1972, but with the addition of a new co-dominant species – Dreissena spp. (43.2%). Both Dreissena and oligochaete worms have high tolerance levels to polluted conditions. Again it would appear that conditions within the benthic community of the nearshore region of Lake Ontario within the Rochester Embayment have not changed in the past 20 years.

Army Corps of Engineers Dredge Disposal Site

The Army Corp of Engineers' Dredge Disposal site in Lake Ontario had the second lowest species richness and species diversity and the second highest Hilsenhoff Index and Dominance Index. The Biological Assessment Profile was low (2.11, Table 3). All of these indices indicate a severely impacted site. Disposal of contaminated dredge spoils (Rochester Embayment Remedial Action Plan, Stage 1 1993) from the Genesee River, which last occurred in 1999, has had a detrimental affect on the macroinvertebrate community of this site. Cyanide, arsenic, and barium are some of the contaminants previously observed as being in the "heavily polluted" range in sediments from the Genesee River (Rochester Embayment Remedial Action Plan Stage 1, 1993). Even so in 1992, sediments from the Genesee River were deemed suitable for open lake disposal (Rochester Embayment Remedial Action Plan Stage 1, 1993). The low BAP observed could be simply due to burying of benthic macroinvertebrate communities by dredge spoils being continuously placed over them. This possibility can not be ruled out, but is unlikely since disposal of dredge spoils had occurred one-year previously.

As mentioned previously, Nalepa and Thomas (1976, Cited in Rochester Embayment Remedial Action Plan Stage 1, 1993) observed that oligochaete worms dominated the shallow area of the embayment in 1972. Similarly in 2000, the Disposal Site benthic community was dominated by pollution tolerant oligochaete worms (52.4% of the total abundance). Since the dredge disposal site is a small portion of the total area of the Rochester Embayment, it may not reflect conditions of the entire embayment.

Russell Station Site

Due to its location west of the Genesee River and its influence, we initially speculated in our proposal that the Russell Station site was the most likely site to be unimpacted – to have a healthy benthic community. As evidence of this condition, a healthy benthic macroinvertebrate community was observed in 1976 (RG&E 1977, Rochester Embayment Remedial Action Plan Stage 1, 1993). This was not the case in 2000 as the BAP indicated a severely impacted benthic macroinvertebrate community. Even if we apply a correction (1.5 times the sediment quality scale) for sampling depths greater than 5 meters (Bode *et al.* 1996), a severely impacted benthic macroinvertebrate community is suggested by the indices. The number of species was low (average = 6) while dominance was concentrated in two species of zebra mussels (88.5% of the abundance). Percent model similarity to a non-impacted community was also low; thus the conclusion of an impacted benthic community indicative of poor water quality.

Previous work in this area (RG&E 1977) was not directly comparable because of the difference in sampling methodology and analytical techniques. However, macroinvertebrate species richness appeared to be much higher in this area in 1976 than presently. Since zebra mussels have invaded the area since the 1976 samples of RG&E, the possibility that zebra mussels have impacted the macroinvertebrate community exists. However, Kilgour *et al.* (2000) note that zebra mussels had no significant effects on changes in benthic community composition in Lake Ontario on soft and hard sediment. However, Haynes *et al.* (1999) observed that short-term increases in benthic macroinvertebrate abundance on hard substrate on a reef were succeeded by a return or decline below abundance levels that existed prior to the introduction of zebra mussels. At present, we have no good explanation for the difference observed in macrobenthic invertebrate communities over a 24-year period. The 24-year data gap is compelling.

We must view our conclusion of severe impact at the Russell Station site with considerable caution. Unlike the Genesee River where a history of toxic chemical and organic pollutant release exists (Rochester Embayment Remedial Action Plan Stage 1, 1993), there is little or no evidence for any chemical or organic impacts in the Russell Station area. Furthermore, there have been no operational changes in the power generating facility since 1976 (P. Sawyko, Personal Communcation, RG&E) when a healthy benthic macroinvertebrate community was observed. It is true that the location of Rochester Gas and Electric's Russell Station power generating plant is due south of our sampling location. However, heated discharge water flows from the Russell Station into Slater Creek (Fig. 2) and then directly into the nearshore surface waters of Lake Ontario (RG&E 1977) east of our sampling site. It would seem unlikely that any thermal or other impacts resulting from Russell Station would occur at a site west of Slater Creek. Generally, currents in Lake Ontario move water and materials from west to east; that is away from the sampling site.

A more likely explanation is scouring of the bottom and siltation in the Russell Station area. There was evidence of natural scouring of the bottom and subsequent deposition near this site. Initially, we attempted to take samples at depths of 3m, 5m, and 8m. No sediment was collected, just cobble and rocks with occasional attached zebra mussels. Visual inspection of the bottom also suggested an area scoured by currents. A strong relationship between exposure and wind-generated wave action is an important environmental factor in determining composition and abundance of benthic macroinvertebrates in large lakes (Barton and Carter 1982). They observed a decrease in abundance and variety of animals in nearshore communities exposed to wind-generated waves. Similarly, Evans and Stewart (1977) demonstrated that the disturbance of sediments by wave action adversely affects the abundance of benthic organisms in waters as deep as 6 to 9 meters. Lewis (2001) observed no intact invertebrates in March of 2000 at seven sampling sites reaching to a depth of 3.5 m in Lake Ontario. Thus we are not surprised by the lack of invertebrates in the shallower depths at this location.

At the 11-m depth site near Russell Station, an organic sediment (Table 1) was readily collected similar in organic content and particle size as the Army Corp of

Engineers' Dredge Disposal Site. The ability to collect sediment at this site, its organic nature, the dominance of silt in the sediment and the location just north of a scoured area suggest a deposition site. A macroinvertebrate community affected by sediment deposition may have a BAP similar to an impacted area (Bode *et al.* 1996). Our current hypothesis is the macroinvertebrate community north of Russell Station is impacted by siltation and not organic or chemical pollution. The occurrence of turbidity events during wind-related storms along the south coast of Lake Ontario are generally well known to industrial users. Makarewicz (1991) has documented the occurrence of turbidity blooms along the south shoreline of Lake Ontario and how they negatively impact phytoplankton and zooplankton communities.

Summary

The various biological indices utilized suggest that a moderate to severely impacted benthic community exists in portions of the Rochester Embayment of Lake Ontario. Clearly, this study is not conclusive. Field sampling was limited geographically to four sites with three sites located either in or in close proximity to the Genesee River and to the dredge disposal site. Further field sampling is warranted with a sampling design that encompasses a larger, more representative area of the embayment.

Acknowledgements

Dr. Patricia Harris of SUNY Brockport assisted and confirmed oligochaete identification, while Dr. Ian Walker of Okanagan University College, British Columbia, Canada, confirmed chironomid identification using digital images produced from Leica imaging software. Robert Bode of the New York State Department of Environmental Conservation kindly provided literature on the NYSDEC Biological Monitoring Program and timely advice on several questions. Paul Sawyko kindly provided unpublished reports completed by Rochester, Gas and Electric. Dr. James Haynes and Paul Sawyko provided a critical review. We gratefully acknowledge their considerable time and effort.

Literature Cited

APHA. 1999. Standard Methods for the Examination of Waste and Wastewater. American Public Health Association, 19th ed. New York, N.Y.

Barton, D.R. and J.C.H. Carter. 1982. Shallow water epilithic invertebrate communities of eastern Georgian Bay, Ontario in relation to wave exposure. Can. J. Zool. 60: 984-993.

Bode, R.W., M.A. Novak, and L.E. Abele. 1996. Quality Assurance Work Plan for Biological Stream Monitoring in New York State. Stream Monitoring Unit, Division of Water. NYSDEC, Albany, NY

Dauer, D.M., R.M. Ewing, and A.J. Rodi. 1987. Macrobenthic distribution within the sediment along an estuarine gradient, Inter. Rev. Ges. Hydrobiologie. 72: 529-538.

Evans, M.S. and J.A. Stewart. 1977. Epibenthic and benthic microcrustaceans from a nearshore area in southeastern Lake Michigan. Limnol. Oceanogr. 22: 1059-1066.

Gaudette, H.E., W.R. Flight, L. Toner, D.W. Folger. 1974. An inexpensive titration method for the determination of organic carbon in recent sediments. Journal of Sedimentary Petrology. 44(1): 249-253.

Haynes, J. T. Stewart and G. Cook. 1999. Benthic macroinvertebrate communities in southwestern Lake Ontario following invasion of Dreissena: Continuing change. J. Great Lakes. Res. 25: 828-838.

Jackson, L.E., J.C. Kurtz and W.S. Fisher. 2000. Evaluation Guidelines for Ecological Guidelines. EPA/620/R-99/005. U.S. Environmental Protection Agency. Office of Research and Development. Research Triangle Park. 107pp.

Kilgour, B.W., R.C. Bailey and E.T. Howell. 2000. Factors influencing changes in the nearshore benthic community on the Canadian side of Lake Ontario. J. Great Lakes Res. 26: 271-286.

Lewis, T.W. 2001. A benthic survey invertebrate survey of the mouth of Eagle Creek marina, Lake Ontario, NY. Report to Bald Eagle Marina.

Makarewicz, J.C. 1991. Feasibility of shore side monitoring of the Great Lakes. J. Great Lakes Res. 17: 344-360.

Merritt, R. W., and K. W. Cummins (eds.). 1984. An Introduction to the Aquatic Insects of North America. Kendall/Hunt Publishing Co. Dubuque, Iowa.

MCHD (Monroe County Health Department).1999. Health Action: Priorities for Monroe County. Environmental Health Report Card. Available from Monroe County Health Department. P.O. Box 92832, Room 976. Rochester, NY.

Novak, M.A. and R.W. Bode. 1992. Percent model affinity, a new measure of macroinvertebrate community composition. J. North American Benthological Society. 11: 80-85.

Peckarsky, B. L., P. R. Fraissinet, M. A. Penton, and D. J. Conklin, Jr. 1990. Freshwater Macroinvertebrates of Northeastern North America. Cornell University Press. Ithaca.

Pennak, R. W. 1989. Freshwater Invertebrates of the United States. John Wiley and Sons, Inc. New York.

Plumbe, R.H. 1981. Procedures for Handling and Chemical Analysis of Sediment and Water Samples. Technical Report EPA/CE-81-1. U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Rochester Embayment Remedial Action Plan. Stage 1. 1993. Copies available from Monroe County Department of Planning and Development, 47 South Fitzhugh Street, Rochester, NY

Rochester Gas and Electric. 1977. Final Report. Benthic Survey (1976). Biological Monitoring Program. Russell Power Station. RG&E Report # B-07-013. Bio Systems Research, Ins. pp. 34.

Table 1. Physical data and site locations of benthic sampling sites in the Rochester Embayment. ND= not detected.

	Russell Station	Disposal Site	Genesee River Plume	GeneseeRiver @Portland Cement
Distance from mouth of Genesee River Revetment	2.1 miles	1.52 miles	0.48 miles	2.62 miles
Date	11 August 2000	11 August 2000	11 August 2000	11 August 2000
Time	0715	1819	1947	1039
% Cloud Cover	80%	80%	70%	50%
Wind Speed/Direction	5 mph/SW	2-3mph/S	O mph	O mph
Air Temperature (°C)	15.5	18.2	21.4	24.4
Wave Height (m)	0.3	flat	flat	flat
Water Depth (m)	14.3	11.3	7.3	4.1
Surface Water Temp (°C)	21.2	21.2	21.3	22.0
Conductivity (µmhos/cm)	304	295	299	660
Secchi Disk (m)	6.3	5.5	2.8	0.39
Sediment Type	Organic mud	Organic mud	Sand	Sand
Total Organic Carbon (%) (Mean and range)	0.60 (0.56 - 0.65)	0.62 (0.25 - 0.91)	ND* (n = 2)	ND (n=3)
Particle Size (percent)				
Silt and smaller	63.84	71.01	2.24	7.17
Very fine sand	31.20	27.40	13.39	20.40
Fine sand	1.08	0.40	16.52	38.51
Medium sand	0.08	0.06	2.58	1.89
Coarse sand	1.24	0.36	34.65	14.37
Very coarse sand	0.93	0.33	12.62	4.98
Gravel and larger	1.63	0.44	18.00	12.69

* A third sample was taken but was inadvertently lost.

Table 2. Results of macroinvertebrate analysis of sediments from the U.S. Army Corp's of Engineers Disposal Site in Lake Ontario, the Genesee River Plume in Lake Ontario, the Genesee River at the Portland Cement Company, and due north of Rochester Gas and Electric's Russell Station in Lake Ontario. Location coordinates are listed in Table 1. Values represent the number of organisms in each taxonomic category. Tolerances values indicate the organisms' ability to withstand various types of pollution (Bode *et al.* 1996).

	Tolerance Value	Disposal Site In Lake Ontario			Genesee River Plume In Lake Ontario			Genesee River at Portland Cement Company			Russell Station on Lake Ontario		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
Phylum Annelida													
Class Oligochaeta													
Order Tubificida													
Family Naididae *Stylaria lacustris*	8	2	1	1	22	3	6	4	1		15	1	1
FamilyTubificidae	10	55	49	64	4	18	9	79	92	48	3	3	9
Phylum Arthropoda													
Class Crustacea													
Order Amphipoda													
Family Gammaridae *Gammarus sp.*	6		1		1	1		1		1			
Order Isopoda													
Family Talitridae *Hyalella azteca*	8			1					6				
Class Hydrachnidia													
Order Acariformes													
Family Hygrobatidae *Hygrobates*	6	3	4	2		1							
Class Insecta													
Order Coleoptera													
Family Haliplidae *Haliplus*	5				1								

Table 2 (Continued).

	Tolerance Value	Disposal Site In Lake Ontario			Genesee River Plume In Lake Ontario			Genesee River at Portland Cement Company			Russell Station on Lake Ontario		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
Order Diptera													
Suborder Nematocera													
Family Ceratopgonidae													
Bezzia	6				1	1							
Probezzia	6				2								
Family Chironomidae													
Subfamily Chironominae													
Chironomus	10				2	4	1	9	16	13			
Cryptochironomous	8				2	2			1	3			
Dicrotendipes	8									1			
Harnischia	8					2							
Micropsectra	7		1			1		2	8	5			
Parachironomous	10	1											
Paratanytarsus	6									2			
Polypedilum	6				5	3	1	10	19	15			
Rheotanytarsus	5.5								1				
Tribelos	7											1	
Subfamily Orthocladiinae										1			
Cricotopus sp.	7					1							
Subfamily Prodiamesinae													
Monodiamesa sp.	7						1						
SubfamilyTanypodinae													
Coelotanypus	4									1			
Clinotanypus	8									2			

Table 2. (Continued).

	Tolerance Value	Disposal Site In Lake Ontario			Genesee River Plume In Lake Ontario			Genesee River at Portland Cement Company			Russell Station on Lake Ontario		
		#1	#2	#3	#1	#2	#3	#1	#2	#3	#1	#2	#3
Procladius	9					1		3	1	14			
Order Trichoptera													
Family Polycentropodidae										1			
Phylocentropus	5	2	1			1							
Phylum Mollusca													
Class Bivalvia													
Dreissena bugensis	8	35	29	24	21	33	10		2		105	120	69
Dreissena polymorpha	8		2		7	10	3	1				1	15
Family Sphaeridae													
Sphaerium	6	5	12	6	1	4		7	2	12		1	1
Class Gastopoda													
Family Hydrobiidae									2		1		
Family Valvatidae													
Valvata sp.	8	7	22	3							2		1
Valvata bicarinata	8					1	2						
Valvata piscinalis	8				4	1							
Valvata tricarinata	8										1		
Species Richness		8	10	8	13	18	8	9	12	6	6	6	6
Number Counted		110	122	101	73	88	33	116	151	119	127	127	96
Total Organisms Identified		1263.00											

Table 3. Macroinvertebrate community indices for the four samples sites. Values are the average for three samples. SW= Shannon-Weiner Diversity Index. PMA=Percent Model Affinity. HIL= Hilsenhoff Biotic Index. SR = Species Richness. DOM-3 =is the combined percent contribution of the three most numerous species. BAP is the Biological Assessment Profile.

	SW	PMA	HIL	SR	DOM-3	Average BAP	Assessed Impact
Army Corps Disposal	1.32	40.53	8.75	8.7	83.9	2.11	Severe
Genesee Plume	1.93	51.17	7.93	11.7	71.2	4.32	Moderate
Genesee River	1.46	54.63	8.86	11.7	78.8	3.16	Moderate
Russell Station	0.59	24.50	8.05	6.0	96.7	1.2	Severe