Deepwater Macrobenthic Survey of Honeoye Lake

Comprehensive Field Inventory and Data Summary
July 2005

by

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Continuing the Role of Finger Lakes Community College
in assisting the
Honeoye Valley Association
and the
Honeoye Lake Watershed Taskforce

Abstract

Alum inactivation of deepwater sediment phosphorus has been proposed for spring 2006 in Honeoye Lake. A pre-treatment survey was conducted in summer 2005 to assess benthic species richness and total abundance, and to calculate several biotic community indices. Replicates from three different water depths were collected by standard Ponar dredge. Eighteen samples were within the 325 hectare proposed treatment zone and nine were in the immediately adjacent edge of the littoral zone.

Sediment at deep sites (9 m) had the lowest richness (6 taxa) with a density of 960 individuals/m^2. Midge fly larvae (*Chironomus* sp.) and annelid worms (*Branchiura sowerbyi*) dominated while phantom midge larvae (*Chaoborus punctipennas*) were frequent. Sediment from moderately deep sites (7 m) had intermediate richness (9 taxa) with a density of 833 individuals/m^2. These samples also contained abundant midge fly larvae and annelids, as well as finger nail clams (*Pisidium* sp.) and statoblasts of the bryozoan, *Pectinatella magnifica*. Sediment of shallow sites (5 m) had the highest richness (17 taxa) with a density of 1528 individuals/m^2. In addition to midge fly larvae and annelids, these sites also contained adult zebra mussels (*Dreissena polymorpha*), banded mystery snails (*Viviparous georgianus*), two other snails (*Valvata tricarinata* and *Physa* sp.), a leech (Hirudinea), aquatic sowbugs (*Asellus* sp.), scuds (*Gammarus* sp.), alder fly pupae (*Sialis* sp.) and a roundworm (Nematoda). Incidental capture of pelagic organisms while the dredge was traveling to the bottom sediment was also quantified for all replicate samples.

Future surveys that will be conducted after alum treatment may reveal changes in benthic community structure related to the treatment and, if changes are detected, could also document recovery time for affected macrobenthic organisms.

Introduction

Benthic macro-invertebrates are large organisms that live in aquatic sediments, including worms, insects, snails, clams and crustaceans. They have brief aquatic stages in their life history, usually between one and two years. They are ideal indicators of environmental quality due to their sensitivity to habitat conditions like dissolved oxygen levels and nutrient concentrations. Sampling benthic communities is a scientifically established method of assessing stream health (Bode et al. 2002) and has recently been added to the lake manager's "tool box" to survey conditions in large water bodies (Doyle 2005). This inventory fulfills the need for a pre-treatment survey of the deepwater macrobenthos of Honeoye Lake prior to proposed alum precipitation of the sediment. The results establish a baseline data set, thus allowing for future comparisons with any post-treatment surveys. Other studies (Cooke and Kennedy 1978, Narf 1985, Smeltzer 1990, James et al. 1991, Cooke et al. 1993, Welch and Schrieve 1994) have described positive impacts on deepwater macrobenthos following alum inactivation of sediment phosphorus and this is anticipated for Honeoye Lake.

Methods

Sediment samples were collected by standard Ponar dredge from Honeoye Lake on July 22 and July 25, 2005. Three transects were established, each beginning in the deepest area of the lake and then extending into shallower water (Figure 1). The northern and southern transects (A and C, respectively) extended westward while the middle transect (B) extended eastward. Along each transect, three replicates were collected at each of the following depths: 5 m, 7 m and 9 m, resulting in a grand total of 27 samples. GPS coordinates were recorded for all nine sample locations.

Water quality profiles for dissolved oxygen, temperature, conductivity and pH were monitored at 1m intervals at each sample location utilizing a YSI data-logger and sonde. Integrated water column samples collected at each location through use of weighted Tygon tubing were analyzed for total alkalinity.

Dredged sediment was sieved through a U.S. Standard No. 30, 500 µm mesh wash frame. The macro-invertebrates and coarse particulate organic matter (CPOM) remaining on the screen were transferred to glass storage bottles, stained with Rose Bengal dye and preserved in 70% ethyl alcohol.

Individual samples were sorted under a stereo-dissecting microscope using low magnification, and tentative identifications were made to the lowest practical taxon using Thorp and Covich (2001). Follow-up taxonomic determinations were conducted at the New York State Museum. Both benthic and pelagic organisms, captured when the dredge dropped through the water column on the way to the bottom, were present in the samples. All organisms were counted and identified. For future reference, vouchers are permanently housed in the aquatic collections at Finger Lakes Community College.

FIGURE 1 – Deepwater macrobenthos sampling locations in Honeoye Lake, New York.

Species-area curves were constructed to validate that adequate replicate sampling had occurred at each water depth. Replicates were treated as sub-samples; pooled data were used to characterize the macrobenthic community found at each water depth.

Seven indices were used to estimate benthic macro-invertebrate community health as recommended by Bode et al. (2002). Species richness refers to the number of different species present in the pooled data while NCO richness indicates only the non-chironomid and oligochaete species that were present. Higher richness values are often associated with cleaner water conditions. Total abundance was the count of individuals regardless of species. Community diversity was estimated using the H' index (Shannon and Weaver 1948). This index combines species richness with community balance (evenness). High scores indicate diverse, balanced communities while low scores suggest environmentally stressed communities. Dominance is a measure of the lack of community balance. Dominance-3 is the combined percent contribution of the three most numerous species. The percent oligochaetes index reveals the relative dominance of annelid worms in the sample. Finally, percent model affinity (PMA) is a similarity measure to a "model, non-impacted community" based on percent abundance in seven major groups. For Ponar dredge samples collected from lake bottoms, the PMA model is: 20% Oligochaeta, 15% Mollusca, 15% Crustacea, 20% non-Chironomidae Insecta, 20% Chironomidae and 10% Other.

<u>Results</u>

The deepwater macrobenthos of Honeoye Lake sampled in this study contained at least 19 different taxa of macro-invertebrates. Midge fly larvae (*Chirononus* sp., *Procladius* sp. and Tanypodinae sp.) and annelid worms (*Branchiura sowerbyi*) were present in all 27 dredges. Less frequently encountered were finger nail clams (*Pisidium* sp. and *Sphaerium* sp.), statoblasts of the bryozoan, *Pectinatella magnifica,* adult zebra mussels (*Dreissena polymorpha*), banded mystery snails (*Viviparous georgianus*), two other snails (*Valvata tricarinata* and *Physa* sp.), a species of leech (Hirudinea), aquatic sowbugs (*Asellus* sp.), scuds (*Gammarus* sp.), alder fly larvae (*Sialis* sp.), phantom midge fly larvae (*Chaoborus punctipennas*), true fly pupae (*Dixa* sp.), and a species of roundworm (Nematoda). Another annelid and a second Diptera pupae were collected but could not be identified. Pelagic organisms accidentally captured as the dredge traveled through the water towards the bottom included two species of water flea (*Leptodora kindtii* and *Daphnia pulicaria*), veligers of zebra mussels (*Dreissena polymorpha*), water mites (*Hydrachna* sp.) and even a fish fry (Centrarchidae)! Distributional patterns and statistical summaries are provided in the Appendix.

Abundance of organisms varied within replicates but pooled community data suggested patterns in structure and composition along a water depth gradient (Figures 2 and 3). Sediment at deep sites (9 m) had the lowest richness (6 taxa) with a density of 960 individuals/m^2. Midge fly larvae (*Chironomus* sp.) and annelid worms (*Branchiura sowerbyi*) dominated while phantom midge larvae (*Chaoborus punctipennas*) were frequent. Sediment from moderately deep sites (7 m) had intermediate richness (9 taxa) with a density of 833 individuals/m^2. These samples also contained abundant midge fly larvae and annelids, as well as finger nail clams (*Pisidium* sp.) and statoblasts of the bryozoan, *Pectinatella magnifica*. Sediment of shallow sites (5 m) had the highest richness (17 taxa) with a density of 1528 individuals/m^2. In addition to midge fly larvae and annelids, these sites also contained adult zebra mussels (*Dreissena polymorpha*), banded mystery snails (*Viviparous georgianus*), two other snails (*Valvata tricarinata* and *Physa* sp.), a leech (Hirudinea), aquatic sowbugs (*Asellus* sp.), scuds (*Gammarus* sp.), alder fly pupae (*Sialis* sp.) and a roundworm (Nematoda).

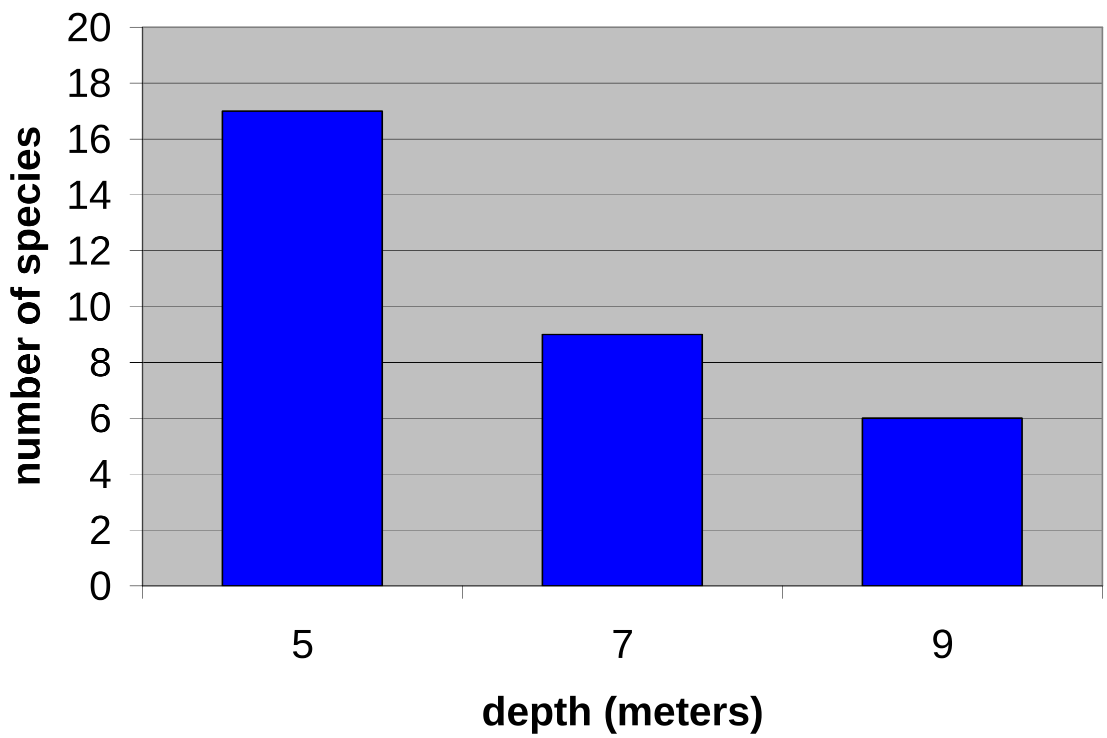

FIGURE 2 – Species richness based on pooled replicates (n = 9) dredged from three water depth zones in Honeoye Lake during July 2005.

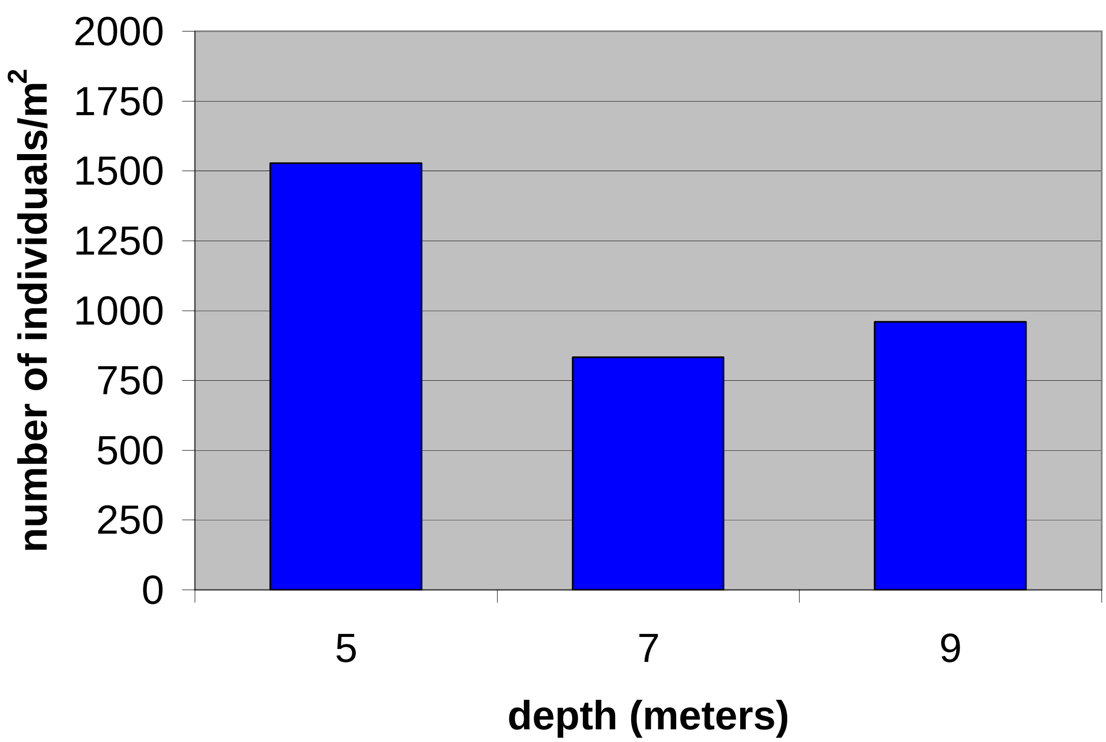

FIGURE 3 – Density based on pooled replicates (n = 9) dredged from three water depth zones in Honeoye Lake during July 2005.

Data from July 2005 water quality profiles detected a weak thermal stratification with a fragile metalimnion between 5 and 6 m (Table 1). The resistance to mixing at this depth zone is moderate but strong winds, when present, could disrupt the stratification. Dissolved oxygen levels declined with depth, with the poorest conditions occurring in the 9 m zone (Table 2). Anoxia is known to stress and impact benthic communities. Conductivity averaged 244 μS, increasing slightly near the bottom. Lake water pH averaged 8.30 and lake water alkalinity averaged 75 mg $CaCO_3$/L. The secchi disk readings for the two July sample days averaged 3.8 m of clarity.

TRANSECT "A" TEMPERATURE PROFILES (C°)			
	5 m	7 m	9 m
surface 0	27.29	27.29	27.50
1	27.25	27.29	27.49
2	27.20	27.27	27.47
3	27.16	27.21	27.44
4	27.09	27.17	27.28
5	26.79	26.04	25.33
6		24.09	23.97
7		21.98	21.92
8			19.95
bottom 9			19.57
TRANSECT "B" TEMPERATURE PROFILES (C°)			
	5 m	7 m	9 m
surface 0	27.74	27.60	27.50
1	27.74	27.59	27.50
2	27.72	27.56	27.49
3	27.68	27.53	27.45
4	27.61	27.51	27.50
5	25.71	25.91	25.47
6		24.66	24.61
7		20.83	22.33
8			19.84
bottom 9			19.38
TRANSECT "C" TEMPERATURE PROFILES (C°)			
	5 m	7 m	9 m
surface 0	27.30	27.06	27.21
1	27.22	27.06	27.16
2	27.07	27.03	27.07
3	27.02	26.99	26.82
4	26.91	26.91	26.64
5	26.52	26.78	26.14
6		25.86	25.95
7		22.10	22.24
8			19.87
bottom 9			19.71

TABLE 1 – Temperature profiles taken at 1 meter intervals from three water depth zones along transects in Honeoye Lake during July 2005.

TRANSECT "A" DISSOLVED OXYGEN PROFILES (mg/L)			
	5 m	7 m	9 m
surface 0	8.23	8.50	8.28
1	8.13	8.36	8.20
2	8.22	8.31	8.11
3	8.18	8.28	7.91
4	7.60	8.27	7.46
5	6.25	5.27	2.73
6		1.89	1.18
7		0.87	0.61
8			0.63
bottom 9			0.68
TRANSECT "B" DISSOLVED OXYGEN PROFILES (mg/L)			
	5 m	7 m	9 m
Surface 0	8.81	8.65	8.78
1	8.79	8.64	8.72
2	8.78	8.64	8.68
3	8.78	8.65	8.45
4	8.75	8.61	8.61
5	3.09	4.56	3.93
6		2.43	2.65
7		0.90	0.71
8			0.64
bottom 9			0.58
TRANSECT "C" DISSOLVED OXYGEN PROFILES (mg/L)			
	5 m	7 m	9 m
Surface 0	8.56	8.14	8.26
1	8.40	8.12	8.21
2	8.19	8.07	8.14
3	7.93	7.99	7.88
4	7.78	7.88	7.60
5	7.06	7.72	6.59
6		5.34	5.89
7		0.79	0.82
8			0.56
bottom 9			0.45

TABLE 2 – Dissolved oxygen profiles taken at 1 meter intervals from three water depth zones along transects in Honeoye Lake during July 2005.

Indices of benthic macro-invertebrate community health summarized by depth zones are presented in Table 3. All indices show progressive deterioration in health moving from shallow sites to the deep locations. Of particular significance are the decreases in species richness, PMA and diversity (H') in the 9 m depth zone.

INDEX	5 m	7 m	9 m
species richness	17	9	6
NCO richness	13	6	3
density (m^2)	1528	833	960
H'	1.8248	1.2266	0.8479
dominance-3	67.4	90.8	97.8
% Oligochaetes	15.3	47.8	24.5
PMA	66.8	52.3	46.6

TABLE 3 – Indices of benthic macro-invertebrate community health for three water depth zones sampled in Honeoye Lake during July 2005. Analyses based on pooled replicate data for each depth zone.

Discussion

The mixing regime on Honeoye Lake has been variously described as cold, monomicitc to polymictic. The lake is winter-stratified beneath a thick ice layer that can approach 50 cm. After ice-out in late March, surface water warms to 4ºC and a density driven spring turnover event occurs. Over the summer months, a weak thermocline may establish but due to the lake's shallow depth it is fragile at best. Winds may overcome the resistance to mixing of this fragile thermocline but wind effectiveness depends on several factors. Because the long axis of the lake is perpendicular to the prevailing wind direction and because the lake basin is surrounded by high topography, strong summer winds are uncommon and unpredictable. Without wind-generated mixing, anoxia in the deeper zones is a common phenomenon and it appears to have a significant effect on the macrobenthos.

Mean benthic richness decreases with depth in Honeoye Lake, probably related to stress created by the low dissolved oxygen levels associated with periodic, prolonged bouts of anoxia. As a result of the high primary productivity of the lake, significant accumulations of biological waste (CPOM) buildup on the lake bottom raising the organic matter content of the substrate as well as its biochemical oxygen demand (BOD_5). The organic waste load represents a major food source for microbes that utilize dissolved oxygen during their role as decomposer organisms.

No significant trends in mean abundance were detected. High variability in the sample data is likely caused by the clumped distribution of organisms such as zebra mussels. Abundance may also be affected by small scale variability in the texture of the bottom substrate, ranging from extremely soft, fluffy sediment to rather coarse particles (e.g., shell fragments, woody debris, allochthonous input). More patterning in sediment type was observed in the 5 m dredge samples. Softer sediment seemed to have a higher carrying capacity for macro-invertebrates like midge fly larvae, while harder substrates, with their associated hiding places, contained higher numbers of crustaceans like amphipods and aquatic sow bugs.

Just as in streams, macro-invertebrates are good indicators of water condition. Using the assessment profiles for Ponar samples from soft lake sediment that are recommended by Bode et al. (2002), the 9m and 7 m depth zone benthic communities in Honeoye Lake are judged to be severely impacted based on low species richness, low diversity (H') and the high dominance-3 indices, and moderately impacted based on the intermediate PMA scores. There are noticeable improvements in the 5m depth zone. It is judged to be slightly impacted based on high species richness and high diversity (H'), but moderately impacted based on the dominance-3 index and the PMA score. In stream studies, biological indicators (e.g., Type I, II and III macro-invertebrates) are most often related to anthropomorphic pollution events. In Honeoye Lake, the deepwater macrobenthos indicators suggest instead an environment severely stressed by repeated episodes of anoxia brought on by the combination of natural lake productivity, warm water temperatures during the summer months and minimal wind generated mixing.

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Acknowledgements

Taxonomic assistance provided by Clifford Siegfried and Brian Tarpinian, New York State Museum. Constructive comments on draft report received from Robert Bode, Jay Bloomfield and Webster Pearsall, New York State Department of Environmental Conservation, plus Bill Hershey, Terry Grondahl and Jack Starke, concerned Honeoye Lake residents.

<u>Appendix</u>

Capture data and statistical summaries for three water depth zones in Honeoye Lake during July 2005.

	(all dredge samples taken from a water depth = 5 meters)										
benthic organisms	A 3-1	A 3-2	A 3-3	B 3-1	B 3-2	B 3-3	C 3-1	C 3-2	C 3-3	POOLED TOTAL	DENSITY per m^2
Branchiura sowerbyi	12	6	5	8	24	13	11	24	7	110	233
unidentified annelid	0	0	0	0	0	0	0	0	0	0	0
Chironomus sp.	28	24	74	0	0	0	12	9	1	148	314
Procladius sp.	4	0	14	4	3	1	0	2	0	28	59
Tanypodinae sp.	0	0	2	0	0	0	0	0	0	2	4
Dreissena polymorpha	1	1	2	0	34	169	0	0	3	210	445
Pisidium sp.	0	0	0	4	0	0	0	0	0	4	8
Sphaerium sp.	1	0	0	0	0	0	0	0	0	1	2
Vivaparous georgianus	0	0	0	1	0	0	0	0	1	2	4
Valvata tricarinata	0	0	0	0	0	0	0	0	1	1	2
Physa sp.	0	0	2	0	0	1	0	0	0	3	6
Gammarus sp.	2	17	27	1	8	16	0	0	2	73	155
Asellus sp.	37	46	32	1	7	3	1	1	0	128	271
nematode	0	0	0	0	0	0	0	0	0	0	0
Sialis sp.	0	0	0	0	1	1	1	0	1	4	8
Chaoborus punctipennas	0	0	0	0	0	0	1	0	0	1	2
Diptera (*Dixa*?) pupae	0	1	1	0	0	0	0	0	0	2	4
Diptera sp. 2 pupae	0	0	1	0	0	0	0	0	0	1	2
leech	0	0	0	2	0	0	1	0	0	3	6
RICHNESS	7	6	10	7	6	7	6	4	7	17	
ABUNDANCE	85	95	160	21	77	204	27	36	16	721	1528
benthic resting stages											
bryozoan statoblasts	19	14	6	8	13	0	2	0	0	62	131
pelagic organisms											
Daphnia pulicaria	13	2	0	7	0	0	6	3	4	35	74
Leptodora kindtii	0	0	0	0	0	0	0	0	0	0	0
zebra mussel veligers	6	0	14	25	9	1	1	0	0	56	119
water mite	0	0	0	0	1	0	0	0	0	1	2
fish fry	0	0	0	0	0	0	0	0	0	0	0
RICHNESS	2	1	1	2	2	1	2	1	1	3	
ABUNDANCE	19	2	14	32	10	1	7	3	4	92	195

benthic organisms	(all dredge samples taken from a water depth = 7 meters)									POOLED TOTAL	DENSITY per m^2
	A 2-1	A 2-2	A 2-3	B 2-1	B 2-2	B 2-3	C 2-1	C 2-2	C 2-3		
Branchiura sowerbyi	44	22	43	2	14	8	26	13	16	188	398
unidentified annelid	0	0	0	0	0	0	0	0	0	0	0
Chironomus sp.	25	26	22	0	12	1	20	19	21	146	309
Procladius sp.	0	0	4	2	0	3	0	2	0	11	23
Tanypodinae sp.	0	0	0	0	0	0	0	0	0	0	0
Dreissena polymorpha	0	0	0	0	0	0	0	0	2	2	4
Pisidium sp.	1	1	1	5	14	1	0	0	0	23	49
Sphaerium sp.	0	0	0	0	0	0	0	0	0	0	0
Vivaparous georgianus	0	0	0	0	0	0	0	0	0	0	0
Valvata tricarinata	0	0	0	0	0	0	0	0	0	0	0
Physa sp.	0	0	0	0	0	0	0	0	0	0	0
Gammarus sp.	0	0	0	0	0	0	0	0	0	0	0
Asellus sp.	0	0	0	0	0	0	0	0	0	0	0
nematode	0	0	0	1	0	0	0	0	0	1	2
Sialis sp.	0	0	0	0	0	0	0	0	0	0	0
Chaoborus punctipennas	0	3	6	0	3	2	1	1	1	17	36
Diptera (*Dixa*?) pupae	0	0	0	0	0	0	0	1	0	1	2
Diptera sp. 2 pupae	0	0	0	0	0	0	0	0	0	0	0
leech	0	0	0	1	0	3	0	0	0	4	8
RICHNESS	3	4	5	5	4	6	3	5	4	9	
ABUNDANCE	70	52	76	11	43	18	47	36	40	393	833
benthic resting stages											
bryozoan statoblasts	0	0	0	12	7	17	0	2	0	38	81
pelagic organisms											
Daphnia pulicaria	12	12	140	102	222	617	32	21	21	1179	2498
Leptodora kindtii	0	0	0	2	0	0	0	0	0	2	4
zebra mussel veligers	14	6	11	24	46	144	0	1	0	246	521
water mite	0	0	0	0	0	1	0	0	0	1	2
fish fry	0	0	1	0	0	0	0	0	0	1	2
RICHNESS	2	2	3	3	2	3	1	2	1	5	
ABUNDANCE	26	18	152	128	268	762	32	22	21	1429	3028

benthic organisms		(all dredge samples taken from a water depth = 9 meters) A 1-1	A 1-2	A 1-3	B 1-1	B 1-2	B 1-3	C 1-1	C 1-2	C 1-3	POOLED TOTAL	DENSITY per m^2
	Branchiura sowerbyi	11	8	25	4	8	16	18	14	6	110	233
	unidentified annelid	0	0	1	0	0	0	0	0	0	1	2
	Chironomus sp.	42	36	55	23	19	38	57	40	2	312	661
	Procladius sp.	0	0	0	0	0	0	0	0	0	0	0
	Tanypodinae sp.	0	0	0	0	0	0	0	0	0	0	0
	Dreisenna polymorpha	0	0	0	0	0	0	0	0	0	0	0
	Pisidium sp.	0	0	0	0	1	0	0	0	4	5	11
	Sphaerium sp.	0	0	0	0	0	0	0	0	0	0	0
	Vivaparous georgianus	0	0	0	0	0	0	0	0	0	0	0
	Valvata tricarinata	0	0	0	0	0	0	0	0	0	0	0
	Physa sp.	0	0	0	0	0	0	0	0	0	0	0
	Gammarus sp.	0	0	0	0	0	0	0	0	0	0	0
	Asellus sp.	0	0	0	0	0	0	0	0	0	0	0
	nematode	0	0	0	1	2	1	0	0	0	4	8
	Sialis sp.	0	0	0	0	0	0	0	0	0	0	0
	Chaoborus punctipennas	6	6	4	0	0	2	0	0	3	21	44
	Diptera (Dixa?) pupae	0	0	0	0	0	0	0	0	0	0	0
	Diptera sp. 2 pupae	0	0	0	0	0	0	0	0	0	0	0
	leech	0	0	0	0	0	0	0	0	0	0	0
	RICHNESS	3	3	4	3	4	4	2	2	4	6	
	ABUNDANCE	59	50	85	28	30	57	75	54	15	453	960
benthic resting stages												
	bryozoan statoblasts	0	0	0	0	0	1	0	4	4	9	19
pelagic organisms												
	Daphnia pulicaria	20	16	29	8	4	1	1	0	3	82	174
	Leptodora kindtii	0	0	0	0	0	0	0	0	0	0	0
	zebra mussel veligers	12	16	28	2	30	7	5	1	23	124	263
	water mite	0	0	0	0	0	0	0	0	0	0	0
	fish fry	0	0	0	0	0	0	0	0	0	0	0
	RICHNESS	2	2	2	2	2	2	2	1	2	2	
	ABUNDANCE	32	32	57	10	34	8	6	1	26	206	436