CHAPTER 2
FISH SURVEY

R.J. Snyder

2.1 Introduction

Monitoring of biotic communities is an integral part of many aquatic habitat assessments. While chemical monitoring tends to provide a "snapshot" of conditions at the time of sampling, biological monitoring is based on the premise that biological communities are shaped by the long-term conditions of their environment and more accurately reflect the health of an ecosystem.

Fish have a number of advantages as indicators of ecosystem integrity. Fish are good indicators of long-term effects and broad habitat conditions because they are relatively long-lived and mobile (Karr et al. 1986). Typical fish assemblages represent a range of trophic levels and therefore reflect environmental health at a broad level, and moreover, fish are consumed by humans and are therefore critical in assessing impacts of environmental contamination. Finally, fish account for nearly half of the endangered vertebrate species and subspecies in the United States, making their monitoring and enhancement particularly important (Warren and Burr 1994).

To aid in identifying habitat sites for future rehabilitation, we examined fish community health at ten sites in the Buffalo River Area of Concern (AOC). We focused on measures of diversity and abundance, presence of DELT abnormalities, and Index of Biotic Integrity (IBI) scores to evaluate specific sites as well as the Buffalo River as a whole.

2.2 Larval Fishes

2.2.1 Methods

We assessed diversity of larval fishes at the ten study sites in June and August of 2003 and 2004 (four surveys total). Larval fish were collected at each study site using two 0.5 m plankton nets with 560 µm mesh. The nets were towed at a speed of approximately 50 cm per second for 15 min in a circular pattern (shore to shore, but within the dredged channel of the river). One net was towed near the surface (depth of 1.0 – 2.5 m) and one closer to the river bottom (depth of 2.5 – 6.5 m). Larval fish were fixed in 10% Wardsafe preservative and returned to the laboratory for identification and enumeration following Auer (1982). Results from shallow and deep tows at each site were combined for data summaries and analysis.

2.2.2 Results

In 2003-2004, a total of 10 species of larval fishes were collected across all study sites, which is similar to the larval diversity found in 1993 (Table 2.1). Abundance of larval fishes was highest in the June samples from both years and was much lower in the August samples (Figure 2.1). The large number of larval fishes collected at sites 8-10 in June 2004 may be due

to fish moving into the river from nearshore lake habitats, since these sites are relatively close to the mouth of the river.

Table 2.1 Larval Fish Occurrences in the Buffalo River AOC (1993 and 2003-2004)

Species	1993	2003-2004
Alewife	X	X
Bluntnose minnow		X
Carp	X	X
Fathead minnow		X
Gizzard shad	X	X
Lepomis sp.	X	X
Logperch		X
Morone sp.	X	
Pomoxis sp.	X	X
Rainbow smelt	X	
Round goby		X
Yellow perch	X	X
Total # of species:	8	10

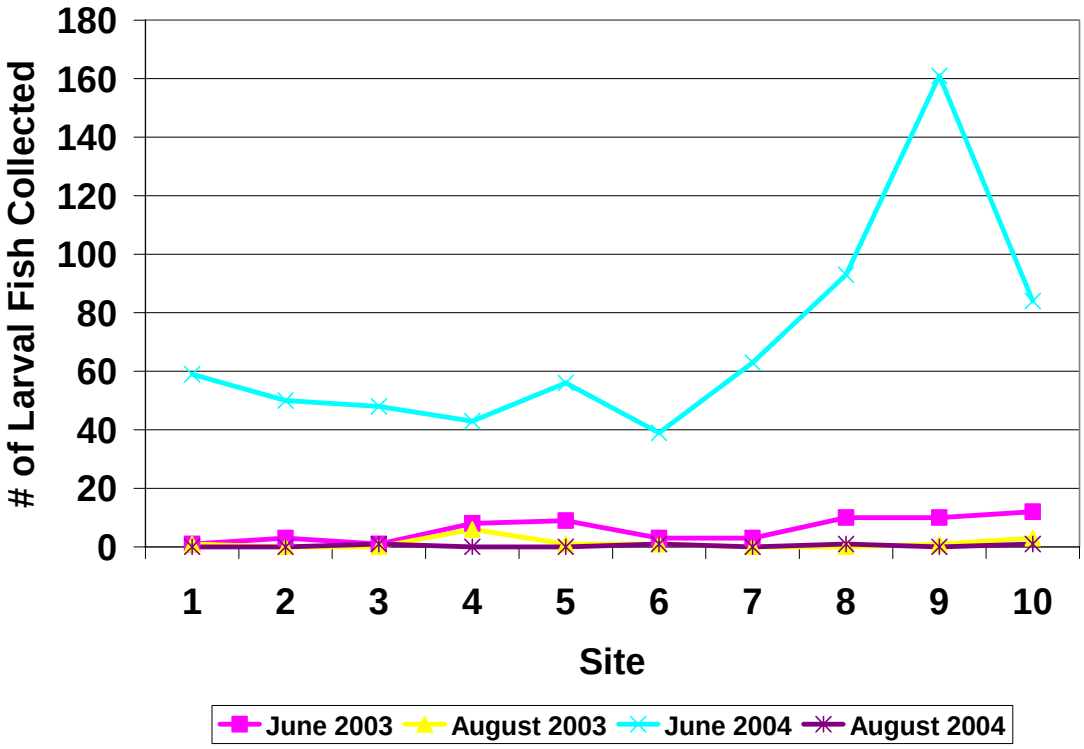

Figure 2.1 Number of larval fishes collected per site (2003-2004)

2.3 Juvenile and Adult Fishes

2.3.1 Methods

We assessed diversity of juvenile and adult fishes with electrofishing surveys, which were carried out in June and August of 2003 and 2004 (four surveys total). Buffalo State College's 18' electrofishing boat, equipped with a Smith-Root type VI-A electrofishing unit, was used for each survey. At each of the ten study sites, a single pass was made along both shorelines for a total of 300 seconds per site. Pulsed direct current was used at a pulse rate of 30-60 pps; output was maintained at approximately 3,000 watts for each survey.

All juvenile and adult fishes were temporarily immobilized by adding clove oil (dissolved in ethanol) to the aerated live well on board the electrofishing boat. Individual fish were then identified, measured for total length, and examined for DELT anomalies before being released.

2.3.2 Species Diversity

Diversity and species composition across all sites was similar in 2003 and 2004 (Table 2.2), ranging from 15-20 different species collected in the river on each sampling date. Species occurrences were similar in 2003-2004 compared to data collected in 1993 (Table 2.2), with a few exceptions. Carp x goldfish hybrids, common shiners, fathead minnows, hogsuckers, logperch, and rudd were taken in 2003-2004 but were not found in 1993. In contrast, rainbow trout, river chubs, white bass, white crappie, and white perch were collected in 1993 and were absent from sampling in 2003-2004 (Table 2.2). However, the data from 2003 and 2004 show significant variation in species occurrences from early to late season (i.e. from June to August) as well as from one year to the next, hence the differences in species composition from 1993 compared to 2003-2004 should be viewed cautiously.

To examine species diversity of juvenile and adult fishes per site, we calculated the average number of fish species occurring for the four sampling dates across both years (Figure 2.2). The average number of species occurring ranged from 3.5 – 7.5 per site. Sites 4, 8, and 9 had the highest average species diversity, while sites 1, 2, 5, and 10 had the lowest diversity (Figure 2.2).

Table 2.2 Juvenile and Adult Fish Occurrences From Electrofishing Surveys (1993 and 2003-2004)

Species	May 1993	June 1993	July 2003	Aug 2003	June 2004	Aug 2004
Bluegill	X	X	X	X	X	X
Bluntnose minnow	X		X			X
Brown bullhead	X	X	X	X	X	X
Carp	X	X	X	X	X	X
Carp x goldfish			X			
Common shiner				X		
Emerald shiner	X	X	X		X	X
Fathead minnow			X			
Freshwater drum	X	X	X	X	X	X
Gizzard shad	X	X	X		X	X
Golden shiner	X	X	X	X	X	X
Goldfish	X	X	X	X		
Hogsucker						X
Largemouth bass	X	X	X	X	X	X
Logperch						X
Northern pike		X	X	X		
Pumpkinseed	X	X	X	X	X	X
Rainbow trout	X					
Redhorse		X			X	
River chub	X					
Rock bass		X	X	X	X	X
Rudd			X			
Smallmouth bass	X	X	X	X	X	X
Spottail shiner	X	X	X	X		X
Walleye	X				X	
White bass	X	X				
White crappie		X				
White perch	X					
White sucker	X	X	X	X	X	X
Yellow perch	X	X	X	X	X	X
Total # of species:	**20**	**19**	**20**	**15**	**15**	**17**

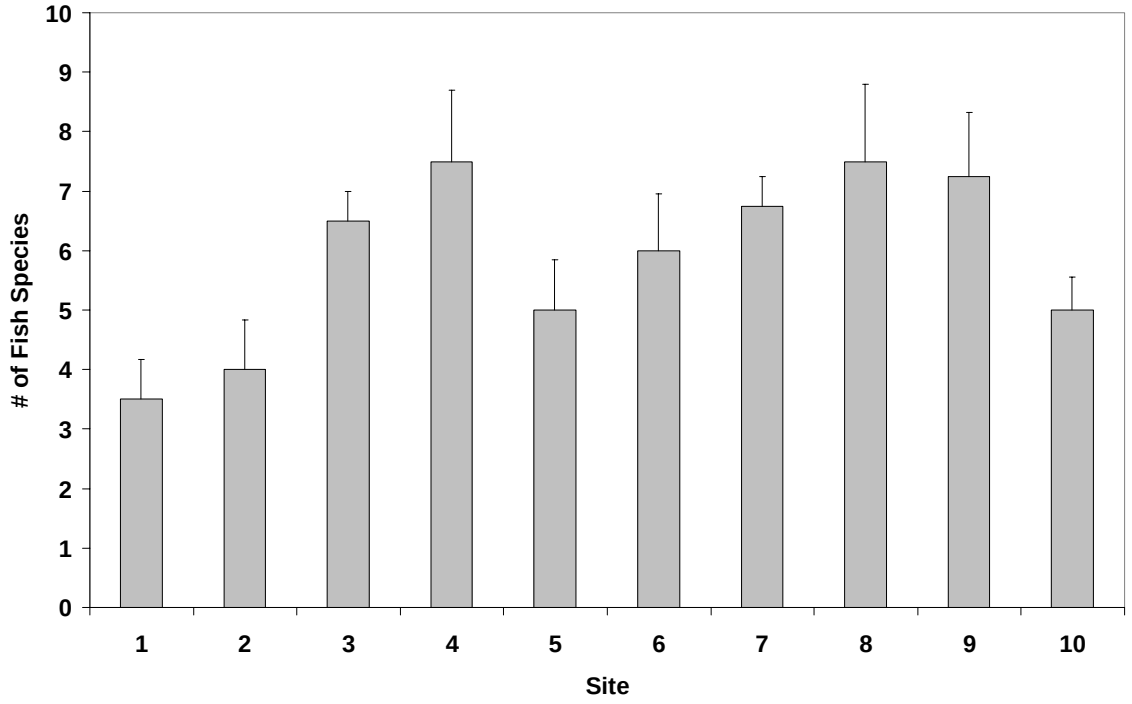

Figure 2.2 Mean number of fish species (± SE) collected per site (2003-2004)

2.3.3 Fish Health (DELT anomalies)

The frequency of occurrence of deformities, eroded fins, lesions, and tumors (i.e. DELT anomalies) depicts the health and condition of individual fish. These abnormalities occur infrequently or are absent from minimally impacted sites but occur frequently below point sources of pollutants and in areas where toxic chemicals are concentrated. The frequency of DELT anomalies provides an excellent measure of the subacute effects of chemical pollution and the aesthetic value of game and nongame fishes.

The frequency of DELT anomalies varied greatly among species collected during this study. For the six most commonly encountered species during this study (species that were found at five or more sites on each sampling date), DELT frequencies ranged from a low of 14% in pumpkinseed to a high of 87% in brown bullhead across all sites and sampling years (Figure 2.3).

To examine the frequency of DELT anomalies on a per site basis, we used data from the six most commonly encountered species listed above. For each species, sites were ranked from 1-10, with 1 representing the site with the highest % DELT and 10 the lowest. We then summed the six ranked scores (one for each species) for each study site to assign each site a single composite fish health score. With this procedure, a high composite health score indicates a site with a greater percentage of healthy individuals while low scores indicate a site with a lower percentage of healthy individuals. The composite health scores ranged from a low of 21.5 for Site 2 to a high of 44 for Site 5 (Figure 2.4).

Figure 2.3 Mean percentage of individuals (± SE) with DELT anomalies in the six most commonly encountered species collected in 2003 and 2004

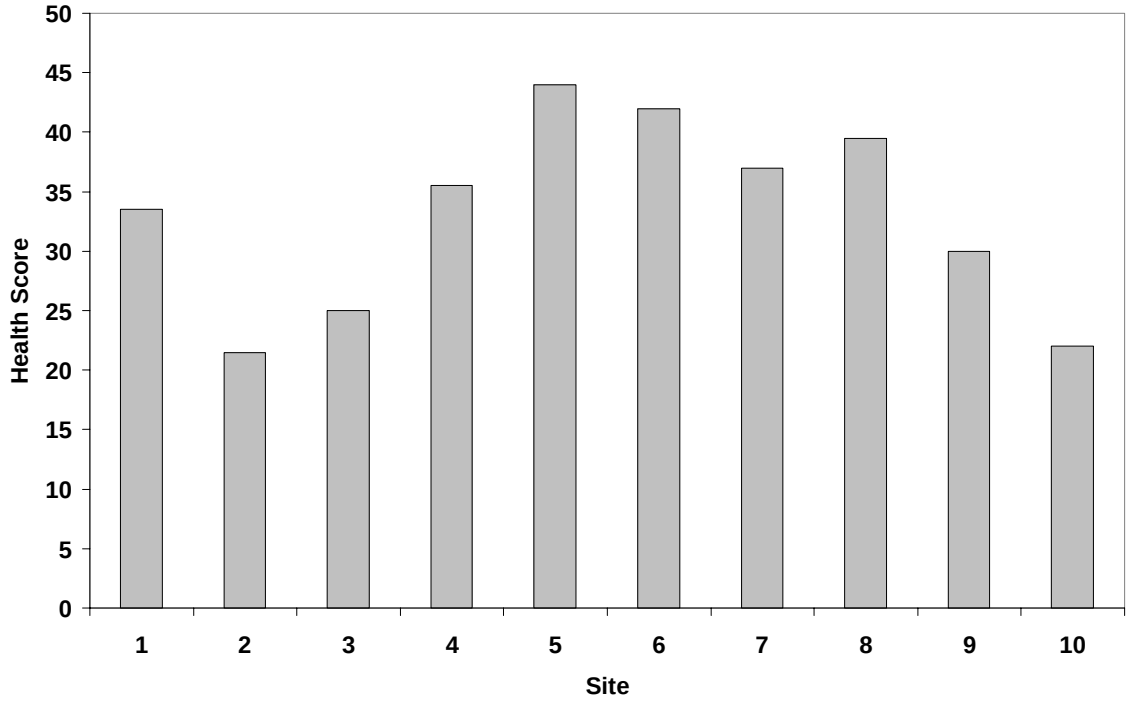

Figure 2.4 Composite fish health scores for each site based on DELT values for the six most commonly encountered species collected in 2003 and 2004. Higher values correspond to a larger percentage of healthy individuals at a particular site

2.3.4 Index of Biotic Integrity

The Index of Biotic Integrity (IBI) uses attributes of the fish association in a stream or river to index human effects on the drainage relative to regional and historical standards (Karr 1981). As originally developed, the IBI consisted of 12 metrics that could be grouped under five categories: species richness and composition, local indicator species, trophic composition, fish abundance, and fish condition. Ideally, these metrics provide information about a broad range of structural and organizational aspects of a river ecosystem, including habitat features of different types and sizes, food sources, productivity, predation, and parasitism (Steedman 1988). Each metric is scored against values that would be expected for an undisturbed stream or river in that particular region. The IBI consists of the sum of the values assigned to each metric in the index.

Many studies have confirmed the general usefulness of the IBI approach. However, since the IBI was originally developed for warmwater streams in the midwestern United States, it is common practice to modify the IBI to take into account local conditions, native fish assemblages, highly degraded habitats, or other factors (Steedman 1988). For this study, we have retained the basic structure of the original IBI (i.e. the same five categories of metrics have been used), but we have modified the metrics to better reflect local conditions (Table 2.3).

Table 2.3 IBI Metrics for the Buffalo River AOC

		Scoring Criteria		
Category	**Metric**	**5**	**3**	**1**
Species Richness	1. Total number of fish species	>15	8-15	<8
Composition	2. Total number of insectivore species	>7	3-7	<3
	3. Total number of sunfish and cyprinid* species	>7	3-7	<3
	4. Percent of individuals that are tolerant	<12%	12-22%	>22%
Trophic Composition	5. Percent of individuals that are omnivores	<20%	20-45%	>45%
	6. Percent of individuals that are insectivores	>65%	30-65%	<30%
	7. Percent of individuals that are top carnivores	>5%	1-5%	<1%
Fish Abundance	8. Total number of individuals caught	>250	75-250	<75
Condition	9. Percent of individuals with DELT	0-2%	2-5%	>5%

* Cyprinid species excluding carp and goldfish

We applied the following scale to convert the total IBI score (i.e. the sum of the scores for each metric) into a quality rating for each of the ten sites in this study: Excellent, 41-45; Good, 34-40; Fair, 27-33; Poor, 20-26; and Very Poor, 9-19. This scale is consistent with those developed and adopted for other studies in this geographic region (Kurtenbach 1994, Greer 2002).

We first calculated IBI scores for each site based on data from the four sampling dates; we then calculated a single IBI for each site as the average of these four values. The mean IBI scores ranged from a low of 15.5 (at sites 1 and 6) to a high of 23 (at sites 4 and 7)(Figure 2.5). Using the stream rating scale given above, all of the sites would be rated as either "poor" (sites 3, 4, 5, 7, 8, 9, and 10) or "very poor" (sites 1, 2, and 6).

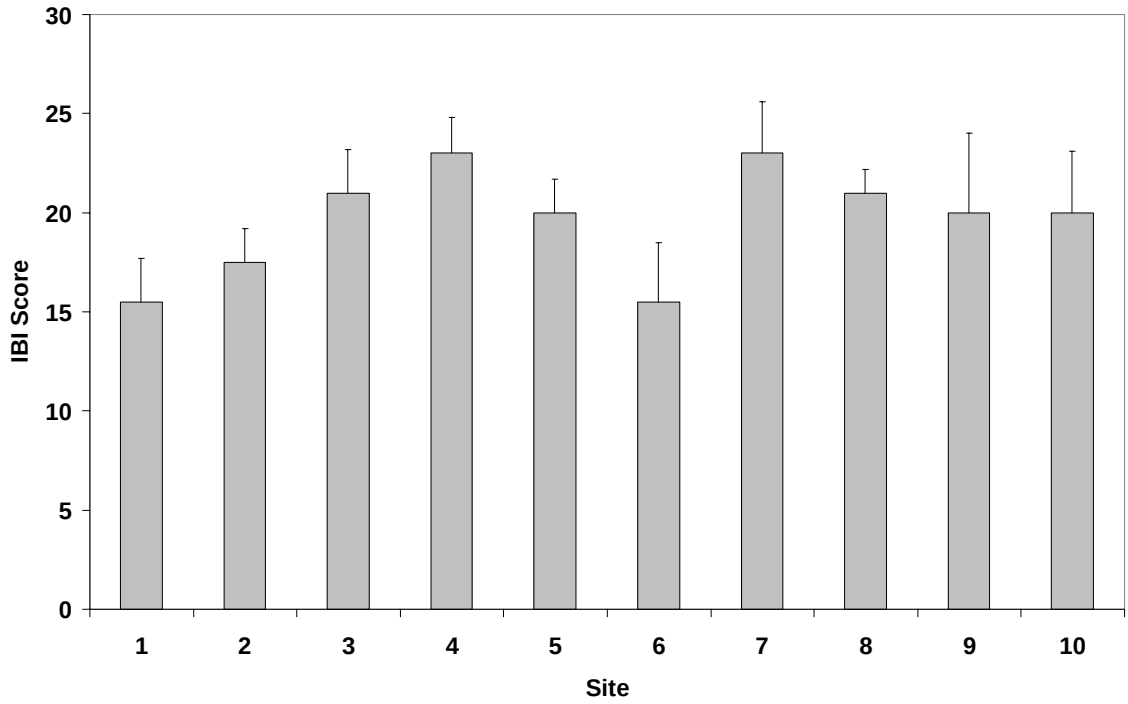

Figure 2.5 Mean IBI scores (± SE) for each study site using data from 2003-2004

2.4 Conclusion

The larval fish sampling showed similar species diversity and abundance in 2003-2004 as compared to 1993 (8-10 species found). No site-specific trends were observed. The large number of larval fish collected in June 2004 compared to the other sampling dates does not appear to correlate with any particular biotic or abiotic factor. However, this large variation in yield among sampling dates does highlight the need for more intensive, fine-scale sampling of larval fishes in future studies.

The juvenile and adult electrofishing surveys showed similar trends to those reported in previous studies from the early 1990's (NYS DEC 1993, Singer et al. 1994). Table 2.2 summarizes fish occurrences from the early 1990's compared to the present study, and overall species number and the specific fishes present are similar. With respect to recreational fisheries in the Buffalo River, the abundance and size of largemouth bass in the present survey is notable. Largemouth bass were more abundant in the 2003-2004 surveys compared to those from the early 1990's, and the mean size was greater as well. Although fish consumption advisories must

be taken into account, the largemouth bass fishery seems to be improving in the Buffalo River AOC.

DELT anomalies varied greatly among species, with a low of 14% in pumpkinseed to a high of 87% in brown bullhead. For the river as a whole, DELT scores averaged 37%, which is much higher than what would be expected for a moderately impacted (2-5%) or an unimpacted (< 2%) river. While it is difficult to establish appropriate background levels for DELT anomalies in the Great Lakes region where virtually all streams and rivers are impacted by human development to some extent (see Premdas et al. 1995), the percentage of fish with DELT anomalies appears to be very high in the Buffalo River AOC. Although data on frequency of occurrence of DELT anomalies is lacking for many species of fishes encountered in this study, brown bullhead have been monitored frequently throughout the Great Lakes region for incidence of cutaneous and oral tumors (an important component of the DELT index). The overall incidence of dermal and oral tumors in bullhead from the Detroit River (an impacted site) was 10.2%, but in the oldest age classes the frequency of occurrence was as high as 100% (Maccubbin and Ersing 1991). Other studies document skin tumor frequencies in bullheads that range from 0% in unimpacted systems (Baumann et al. 1987) to over 90% in heavily impacted areas (Poulet et al. 1994). Given the strong correlation between skin cancers in bullheads and high concentrations of sediment pollutants (Black 1983), it would appear that current brown bullhead populations in the Buffalo River AOC are still being exposed to high levels of environmental contamination (most likely in the form of polynuclear aromatic hydrocarbons and/or metals).

Using standard criteria for interpreting the Index of Biotic Integrity scores, seven sites (#3, 4, 5, 7, 8, 9, and 10) would be rated “poor” and three (#1, 2, and 6) would be rated “very poor”. These scores are similar to those obtained by Greer (2002) for Cazenovia Creek, a tributary of the Buffalo River. The IBI scores for the Buffalo River AOC should be interpreted cautiously, since it can be difficult to apply the IBI to severely altered waterways for which little historical data exists. However, it is clear from the analysis that the low species diversity present in the river and the very high incidence of DELT anomalies remain obstacles to improvement of the fish community in the AOC. Restoration activities focused on increasing the diversity of fish habitats in the river should increase species diversity over time, and remediation of contaminated sediments may also decrease the occurrence of DELT anomalies and lead to overall improvements in fish health.

2.5 References

Auer, N.A. (ed.). 1982. Identification of larval fishes of the Great Lakes basin with emphasis on the Lake Michigan drainage. Great Lakes Fisheries Commission, Ann Arbor, MI 48105. Special Publication 82-3: 744 pp.

Baumann, P.C., Smith, W.D., and W.K. Parland. 1987. Tumor frequencies and contaminant concentrations in brown bullheads from an industrialized river and a recreational lake. Trans. Amer. Fish. Soc. 116: 79-86.

Black, J.J. 1983. Field and laboratory studies of environmental carcinogenesis in Niagara River fish. J. Great Lakes Res. 9: 326-334.

Greer, M.J. 2002. Evaluating ecosystem integrity in Great Lakes tributaries. Clearwaters 32(2): 16-19.

Karr, J.R. 1981. Assessment of biotic integrity using fish communities. Fisheries 6(6): 21-27.

Karr, J.R., Fausch, K.D., Angermeier, P.L., Yant, P.R., and I.J. Schlosser. 1986. Assessment of biological integrity in running waters: a method and its rationale. Ill. Nat. Hist. Surv. Spec. Publ. 5. 28 pp.

Kurtenbach, J.P. 1994. Index of biotic integrity study of northern New Jersey drainages. U.S. EPA, Region 2, Div. of Environmental Assessment, Edison, NJ.

MacCubbin, A.E. and N. Ersing. 1991. Tumors in fish from the Detroit River. Hydrobiol. 219: 301-306.

NYS DEC 1993. Fish and wildlife habitat inventory and assessment of the lower Buffalo River watershed. New York State Department of Environmental Conservation, Region 9, Buffalo, NY. 86 pp.

Poulet, F.M., Wolfe, M.J., and J.M. Spitsbergen. 1994. Naturally occurring orocutaneous papillomas and carcinomas of brown bullheads (*Ictalurus nebulosus*) in New York State. Vet. Pathol. 31: 8-18.

Premdas, P.D., Metcalf, T.L., Bailey, M.E., and C.D. Metcalf. 1995. The prevalence and histological appearance of lip papillomas in white suckers (*Catostomas commersoni*) from two sites in central Ontario, Canada. J. Great Lakes Res. 21: 207-218.

Singer, J., Irvine, K., Snyder, R., Shero, B., Manley, P., and P. McLaren. 1994. Fish and wildlife habitat assessment of the Buffalo River Area of Concern and watershed. State University of New York College at Buffalo, Buffalo, NY. 199 pp.

Steedman, R.J. 1988. Modification and assessment of an index of biotic integrity to quantify stream quality in southern Ontario. Can. J. Fish. Aquat. Sci. 45: 492-501.

Warren, M.L., Jr. and B.M. Burr. 1994. Status of freshwater fishes of the US: overview of an imperiled fauna. Fisheries 19(1): 6-18.

APPENDIX 2.1

NUMBERS AND AVERAGE LENGTHS OF LARVAL FISHES COLLECTED AT EACH SITE AND COLLECTION DATE

Appendix 2.1 Numbers (N) and average total lengths (TL in mm) of larval fishes caught at each site and collection date (shallow and deep tows combined at each site).

	June 2003		August 2003		June 2004		August 2004	
	N	TL	N	TL	N	TL	N	TL
Site 1								
Alewife	-	-	-	-	10	5.3	-	-
Bluntnose minnow	-	-	-	-	4	5.8	-	-
Gizzard shad	1	4.2	-	-	39	4.3	-	-
Lepomis sp.	-	-	1	17.2	-	-	-	-
Yellow perch	-	-	-	-	6	6.4	-	-
Site 2								
Alewife	-	-	-	-	17	4.9	-	-
Bluntnose minnow	-	-	-	-	1	5.9	-	-
Gizzard shad	2	4.1	-	-	22	4.5	-	-
Logperch	-	-	-	-	2	8.7	-	-
Pomoxis sp.	1	3.5	-	-	2	4.4	-	-
Yellow perch	-	-	-	-	6	6.4	-	-
Site 3								
Alewife	-	-	-	-	39	5.0	-	-
Gizzard shad	-	-	-	-	8	4.4	-	-
Pomoxis sp.	-	-	-	-	1	3.9	-	-
Round goby	-	-	-	-	-	-	1	10.0
Yellow perch	1	6.7	-	-	-	-	-	-
Site 4								
Alewife	-	-	-	-	29	4.8	-	-
Bluntnose minnow	1	7.0	-	-	-	-	-	-
Gizzard shad	-	-	1	23.0	3	4.4	-	-
Lepomis sp.	-	-	4	9.9	-	-	-	-
Logperch	-	-	-	-	5	6.8	-	-
Pomoxis sp.	1	4.2	1	7.2	5	4.8	-	-
Yellow perch	6	7.8	-	-	-	-	-	-
Site 5								
Alewife	-	-	-	-	48	5.4	-	-
Bluntnose minnow	2	6.8	-	-	-	-	-	-
Fathead minnow	1	7.5	-	-	-	-	-	-
Gizzard shad	-	-	-	-	4	5.0	-	-
Lepomis sp.	-	-	1	10.8	-	-	-	-
Logperch	-	-	-	-	2	6.8	-	-
Pomoxis sp.	1	4.7-	-	-	2	5.2	-	-
Yellow perch	5	7.3	-	-	-	-	-	-

	June 2003		August 2003		June 2004		August 2004	
	N	TL	N	TL	N	TL	N	TL
Site 6								
Alewife	-	-	-	-	28	5.1	-	-
Bluntnose minnow	2	5.5	-	-	-	-	-	-
Gizzard shad	-	-	-	-	7	4.5	1	4.2
Logperch	-	-	-	-	2	6.5	-	-
Pomoxis sp.	1	4.4	1	7.1	2	4.4	-	-
Site 7								
Alewife	-	-	-	-	51	5.1	-	-
Fathead minnow	1	7.0	-	-	-	-	-	-
Gizzard shad	1	4.4	-	-	8	4.9	-	-
Logperch	-	-	-	-	1	6.4	-	-
Pomoxis sp.	-	-	-	-	3	4.2	-	-
Yellow perch	1	7.3	-	-	-	-	-	-
Site 8								
Alewife	-	-	-	-	75	5.3	-	-
Common carp	-	-	-	-	-	-	1	5.0
Gizzard shad	1	4.3	-	-	8	4.9	-	-
Logperch	-	-	-	-	5	6.9	-	-
Pomoxis sp.	1	4.4	-	-	5	4.4	-	-
Yellow perch	9	6.7	-	-	-	-	-	-
Site 9								
Alewife	-	-	-	-	124	5.4	-	-
Gizzard shad	1	4.8	-	-	24	4.7	-	-
Logperch	-	-	-	-	6	6.2	-	-
Pomoxis sp.	2	4.4	1	6.2	5	4.6	-	-
Yellow perch	7	6.8	-	-	2	7.0	-	-
Site 10								
Alewife	-	-	-	-	79	5.5	-	-
Common carp	-	-	-	-	-	-	1	6.6
Fathead minnow	1	7.2	-	-	-	-	-	-
Gizzard shad	1	4.4	-	-	1	4.6	-	-
Logperch	-	-	-	-	4	6.6	-	-
Pomoxis sp.	1	4.6	3	7.1	-	-	-	-
Yellow perch	9	6.7	-	-	-	-	-	-

APPENDIX 2.2

NUMBERS, LENGTHS, AND SIZE RANGES OF JUVENILE AND ADULT FISHES COLLECTED AT EACH SITE AND COLLECTION DATE

Appendix 2.2a Numbers (N), average total lengths (TL in cm), and size ranges (in cm) of juvenile and adult fishes caught by electrofishing at each site during 2003.

	June 2003			August 2003		
	N	TL	Range	N	TL	Range
Site 1						
Bluegill	2	12.3	11.5-13.0	-	-	-
Brown bullhead	2	33.0	31.0-35.0	-	-	-
Common carp	-	-	-	1	65.0	-
Emerald shiner	1	5.5	-	-	-	-
Golden shiner	-	-	-	1	12.5	-
Largemouth bass	-	-	-	1	37.0	-
Pumpkinseed	3	11.8	10.0-13.0	5	12.7	10.0-15.0
White sucker	2	22.5	22.0-23.0	-	-	-
Site 2						
Brown bullhead	3	29.7	28.0-32.0	1	24.5	-
Common carp	4	55.0	48.0-62.0	3	51.7	28.0-64.0
Emerald shiner	3	7.0	6.5-8.0	-	-	-
Gizzard shad	9	23.9	21.0-28.0	-	-	-
Largemouth bass	-	-	-	2	19.5	17.0-22.0
Pumpkinseed	2	13.0	13.0-13.0	4	13.1	8.0-17.0
White sucker	1	25.0	-	-	-	-
Yellow perch	-	-	-	1	13.0	-
Site 3						
Bluegill	1	13.0	-	-	-	-
Brown bullhead	4	33.8	33.0-35.0	1	32.0	-
Common carp	-	-	-	3	52.7	29.0-67.0
Common shiner	-	-	-	2	8.3	8.0-8.5
Emerald shiner	1	6.0	-	-	-	-
Golden shiner	1	12.5	-	3	13.0	11.0-15.0
Goldfish	-	-	-	2	29.0	28.0-30.0
Largemouth bass	2	24.0	23.0-25.0	4	23.8	20.0-26.0
Pumpkinseed	7	12.6	8.5-16.0	3	13.2	12.5-14.0
Smallmouth bass	1	7.5	-	-	-	-
Yellow perch	1	15.0	-	-	-	-
Site 4						
Bluegill	1	12.0	-	-	-	-
Brown bullhead	5	31.2	22.0-37.0	2	29.8	24.5-35.0
Carp x goldfish	1	20.5	-	-	-	-
Common carp	1	62.0	-	1	27.5	-
Emerald shiner	3	6.2	5.5-7.0	-	-	-
Gizzard shad	14	23.1	20.0-26.0	-	-	-
Golden shiner	-	-	-	2	14.3	11.5-17.0
Goldfish	-	-	-	1	28.0	-
Largemouth bass	8	23.6	16.0-31.0	4	27.5	19.0-35.0
Northern pike	1	57.0	-	-	-	-

	June 2003			August 2003		
	N	TL	Range	N	TL	Range
Site 4 (cont.)						
Pumpkinseed	18	13.9	10.5-18.0	2	12.3	8.5-16.0
Rock bass	-	-	-	1	2.5	-
Spottail shiner	1	8.0	-	-	-	-
White sucker	-	-	-	1	34.0	-
Site 5						
Bluegill	-	-	-	1	18.0	-
Brown bullhead	-	-	-	1	36.0	-
Common carp	-	-	-	1	57.0	-
Emerald shiner	4	6.9	6.0-7.5	-	-	-
Gizzard shad	6	25.7	23.5-28.0	-	-	-
Golden shiner	1	8.5	-	-	-	-
Goldfish	1	26.0	-	-	-	-
Largemouth bass	1	40.0	-	-	-	-
Pumpkinseed	5	13.5	11.0-16.0	-	-	-
Rock bass	1	17.0	-	-	-	-
White sucker	2	31.0	26.0-36.0	-	-	-
Site 6						
Bluntnose minnow	2	7.0	5.5-8.5	-	-	-
Brown bullhead	5	31.8	20.0-56.0	1	25.5	-
Common carp	-	-	-	2	58.0	57.0-59.0
Emerald shiner	1	6.0	-	-	-	-
Freshwater drum	1	40.0	-	-	-	-
Gizzard shad	7	23.2	20.5-25.0	-	-	-
Golden shiner	2	18.5	18.0-19.0	2	12.8	12.0-13.5
Goldfish	-	-	-	1	30.0	-
Largemouth bass	5	26.6	15.0-35.0	-	-	-
Pumpkinseed	3	10.0	5.5-13.0	1	17.0	-
White sucker	1	37.5	-	1	39.0	-
Site 7						
Bluegill	1	17.0	-	-	-	-
Brown bullhead	-	-	-	1	34.0	-
Common carp	1	69.0	-	1	57.0	-
Emerald shiner	36	6.9	5.5-9.0	-	-	-
Gizzard shad	5	20.2	15.5-25.0	-	-	-
Golden shiner	2	15.3	15.0-15.5	-	-	-
Largemouth bass	1	16.0	-	1	26.0	-
Pumpkinseed	11	15.2	11.0-17.5	1	6.5	-
Smallmouth bass	-	-	-	1	4.5	-
Spottail shiner	1	8.0	-	-	-	-
Site 8						
Bluegill	1	19.0	-	-	-	-
Bluntnose minnow	5	6.3	6.0-7.0	-	-	-
Brown bullhead	12	32.2	29.0-36.0	-	-	-

	June 2003			August 2003		
	N	TL	Range	N	TL	Range
Site 8 (cont.)						
Common carp	1	55.5	-	-	-	-
Fathead minnow	1	9.5	-	-	-	-
Freshwater drum	-	-	-	1	61.0	-
Gizzard shad	2	31.5	28.0-35.0	-	-	-
Golden shiner	1	20.0	-	1	7.5	-
Largemouth bass	2	30.0	26.0-34.0	1	24.0	-
Pumpkinseed	8	13.6	10.0-16.0	1	13.5	-
Rock bass	2	11.8	5.5-18.0	-	-	-
Spottail shiner	7	9.5	7.5-10.0	-	-	-
White sucker	1	21.0	-	1	30.0	-
Site 9						
Bluegill	1	14.0	-	-	-	-
Bluntnose minnow	1	8.0	-	-	-	-
Brown bullhead	4	32.0	29.0-34.0	1	33.0	-
Common carp	1	63.0	-	5	60.8	54.0-70.0
Common shiner	-	-	-	1	11.5	-
Gizzard shad	1	24.0	-	-	-	-
Golden shiner	2	18.5	18.0-19.0	4	12.6	11.0-14.5
Largemouth bass	2	33.0	32.0-34.0	-	-	-
Pumpkinseed	8	14.4	9.5-17.0	-	-	-
Rock bass	1	18.5	-	-	-	-
White sucker	1	43.0	-	-	-	-
Site 10						
Bluegill	2	15.5	14.0-17.0	-	-	-
Brown bullhead	2	30.0	28.0-32.0	3	30.7	26.0-36.0
Common carp	-	-	-	3	58.0	55.0-62.0
Gizzard shad	1	16.0	-	-	-	-
Largemouth bass	2	30.5	21.0-40.0	-	-	-
Pumpkinseed	2	16.5	16.0-17.0	-	-	-
Rudd	1	35.0	-	-	-	-
Smallmouth bass	2	21.5	8.0-35.0	1	7.0	-
White sucker	-	-	-	2	32.0	26.0-38.0

Appendix 2.2b Numbers (N), average total lengths (TL in cm), and size ranges (in cm) of juvenile and adult fishes caught by electrofishing at each site during 2004.

	June 2004			August 2004		
	N	TL	Range	N	TL	Range
Site 1						
Brown bullhead	1	30.0	-	-	-	-
Common carp	1	60.0	-	1	59.0	-
Gizzard shad	1	33.0	-	-	-	-
Pumpkinseed	1	13.0	-	-	-	-
Site 2						
Brown bullhead	2	32.8	32.5-33.0	-	-	-
Gizzard shad	2	32.5	32.0-33.0	-	-	-
Largemouth bass	2	27.8	20.0-35.5	-	-	-
Pumpkinseed	2	14.8	14.0-15.5	3	8.8	8.5-9.0
Site 3						
Bluegill	-	-	-	1	7.0	-
Brown bullhead	1	27.0	-	-	-	-
Common carp	2	71.0	56.0-86.0	1	63.0	-
Freshwater drum	1	48.0	-	-	-	-
Gizzard shad	3	31.5	27.5-34.5	-	-	-
Golden shiner	-	-	-	3	13.7	9.5-17.0
Largemouth bass	3	34.7	34.0-35.0	-	-	-
Logperch	-	-	-	1	9.5	-
Pumpkinseed	2	14.8	13.5-16.0	6	11.3	8.0-14.0
White sucker	1	29.5	-	-	-	-
Site 4						
Bluegill	-	-	-	2	11.0	7.5-14.5
Brown bullhead	2	34.0	33.0-35.0	-	-	-
Emerald shiner	-	-	-	2	7.0	7.0-7.0
Gizzard shad	-	-	-	2	20.3	19.5-21.0
Golden shiner	2	14.3	13.0-15.5	3	9.0	7.0-12.0
Largemouth bass	-	-	-	2	28.0	19.0-37.0
Logperch	-	-	-	1	10.0	-
Pumpkinseed	15	11.4	5.5-14.0	11	11.9	8.5-15.0
White sucker	-	-	-	1	17.0	-
Yellow perch	-	-	-	1	12.0	-
Site 5						
Brown bullhead	2	29.5	27.0-32.0	-	-	-
Gizzard shad	-	-	-	1	20.0	-
Golden shiner	-	-	-	1	8.0	-
Largemouth bass	2	35.8	30.0-41.5	3	17.2	16.0-18.0
Pumpkinseed	4	12.1	10.0-15.0	1	7.0	-
Rock bass	-	-	-	1	12.0	-
Smallmouth bass	2	33.0	28.0-38.0	-	-	-

	June 2004			August 2004		
	N	TL	Range	N	TL	Range
Site 6						
Brown bullhead	2	30.3	29.5-31.0	-	-	-
Common carp	1	58.5	-	4	68.6	65.0-72.0
Freshwater drum	1	44.0	-	-	-	-
Gizzard shad	5	30.1	16.0-35.0	-	-	-
Golden shiner	-	-	-	1	15.0	-
Largemouth bass	1	30.0	-	-	-	-
Rock bass	1	17.5	-	-	-	-
White sucker	-	-	-	1	43.0	-
Site 7						
Bluegill	12	16.7	14.5-19.0	-	-	-
Brown Bullhead	4	31.5	27.5-35.0	-	-	-
Common carp	-	-	-	4	58.5	54.0-65.0
Freshwater drum	1	49.0	-	-	-	-
Gizzard shad	1	38.0	-	-	-	-
Golden shiner	-	-	-	1	8.0	-
Largemouth bass	6	34.9	27.5-43.0	3	27.5	23.5-34.0
Logperch	-	-	-	1	10.0	-
Pumpkinseed	8	15.0	14.0-16.5	1	7.5	-
Rock bass	-	-	-	1	12.0	-
Smallmouth bass	1	35.0	-	-	-	-
Spottail shiner	-	-	-	1	7.5	-
Site 8						
Bluegill	2	16.0	15.0-17.0	1	7.5	-
Brown bullhead	5	30.9	30.0-32.0	-	-	-
Common carp	3	48.0	41.0-62.0	-	-	-
Emerald shiner	1	5.0	-	1	5.0	-
Gizzard shad	-	-	-	1	21.0	-
Golden shiner	1	13.0	-	6	9.6	7.5-12.0
Pumpkinseed	20	12.9	10.0-15.0	2	7.8	7.0-8.5
White sucker	1	11.5	-	-	-	-
Yellow perch	1	17.5	-	-	-	
Site 9						
Bluntnose minnow	-	-	-	2	8.0	8.0-8.0
Brown bullhead	1	28.5	-	-	-	-
Common carp	-	-	-	4	63.1	57.0-67.5
Emerald shiner	-	-	-	1	6.5	-
Golden shiner	-	-	-	5	9.2	8.5-10.5
Hogsucker	-	-	-	1	13.5	-
Largemouth bass	4	19.0	13.0-29.0	4	21.0	5.5-33.0
Logperch	-	-	-	1	10.0	-
Pumpkinseed	31	14.0	10.5-17.0	2	9.3	7.0-11.5
Rock bass	4	20.8	20.0-21.0	-	-	-
Smallmouth bass	4	32.1	20.5-43.0	-	-	-
Yellow perch	2	17.3	16.0-18.5	1	15.5	-

	June 2004			August 2004		
	N	TL	Range	N	TL	Range
Site 10						
Brown bullhead	1	34.0	-	-	-	-
Common carp	-	-	-	1	53.5	-
Emerald shiner	1	5.5	-	1	6.0	-
Golden shiner	-	-	-	3	12.3	9.0-15.5
Largemouth bass	1	30.0	-	1	16.5	-
Pumpkinseed	4	14.4	10.5-17.0	-	-	-
Smallmouth bass	2	37.0	31.0-43.0	-	-	-