BUFFALO RIVER FISHERIES ASSESSMENT

Report on the results of the 1992 larval

and adult fish survey

By

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ABSTRACT

A fish survey was conducted in the lower Buffalo River from May to July of 1992. The survey included both adult and larval fish found in five reaches of the river. Adult fish were surveyed using an electrofishing boat once a week. Larval fish were collected using plankton nets twice a week, once during the day and once during the night. Thirty-two adult species and sixteen larval species were found, for a total of 36 different species present. The most common adult species were emerald shiner (Notropis atherinoides), gizzard shad (Dorsoma cepedianum), pumpkinseed (Lepomis gibbosus), golden shiner (Notemigonus crysoleucas) and brown bullhead (Ameiurus nebulosus). The most common larval species were gizzard shad, crappies (Pomoxis sp.), rainbow smelt (Osmerus mordax), yellow perch (Perca flavescens) and the temperate basses (Morone sp.). There was a higher density of adult fish in the river in May and early June indicating a combination of resident and migrating fish. Larval fish started to appear around May 18th but were not seen in great numbers until the middle of June. The highest density of larval fish was 23.57 larvae per 10 m^3 and occurred on June 11^{th}. When comparing night and day larval collection, it was found that a significantly greater number of larval fish were collected during the night tows. There was no significant difference in larval density between the shallow and deep tows. There was not a clear relationship between adult and larval activity. This may be due to the fact that electrofishing occurred during the day whereas many fish spawn at night. In 1992, successful hatching for some fish appeared to be delayed due to a drop in bottom temperature that occurred at the end of May.

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INTRODUCTION

The United States - Canada International Joint Commission (IJC) designated the lower Buffalo River as one of 43 Areas of Concern (AOC) in the Great Lakes due to poor water and sediment quality. The AOC's are areas that exhibit environmental degradation and where some beneficial uses of the water or biota are impaired (NYSDEC 1989). The IJC then requested that the responsible jurisdictions prepare a "remedial action plan" (RAP) for the AOC. The RAPs define environmental problems and identify actions needed to restore the AOC (NYSDEC 1989). The Buffalo River AOC is the lower six mile section of the river from Cazenovia Creek to the mouth (Figure 1).

Impairments to the Buffalo River include a likely degradation of fish and wildlife populations and a loss of fish and wildlife habitat (NYSDEC 1989). The goal of the USFWS Lower Great Lakes Fishery Resources Office is to protect, restore, maintain and enhance the fishery resources of the lower Great Lakes. This would include improving or restoring fish and wildlife habitat in and along the river. As a first step in fish habitat restoration, a knowledge of present habitat use by fish is needed. The purpose of this study is to determine the fish community of the Buffalo River and any fish that are successfully reproducing in the lower river. Along with the fish survey, phytoplankton, zooplankton, and benthos were also surveyed by other investigators and will be presented elsewhere. This fishery survey is the start of a monitoring program that will create a baseline of biotic data from which restoration success can be measured.

Degradation of the river started with the growth of the city of Buffalo and the use of the river for municipal wastes in the early 1800's. It continued with pollution loadings from grain milling, dye, steel, coke, oil and acid manufacturing industries built along the river (Sauer 1979). The pollution problem was compounded by the deepening and widening of the river for use as a harbor which increased residence time for pollutants in the river (Sauer 1979). During the summer when precipitation was low there was little or no discharge from the river (Sweeney and Merckel 1972). By the 1920's the Buffalo River was described as a septic basin, with 0 % dissolved

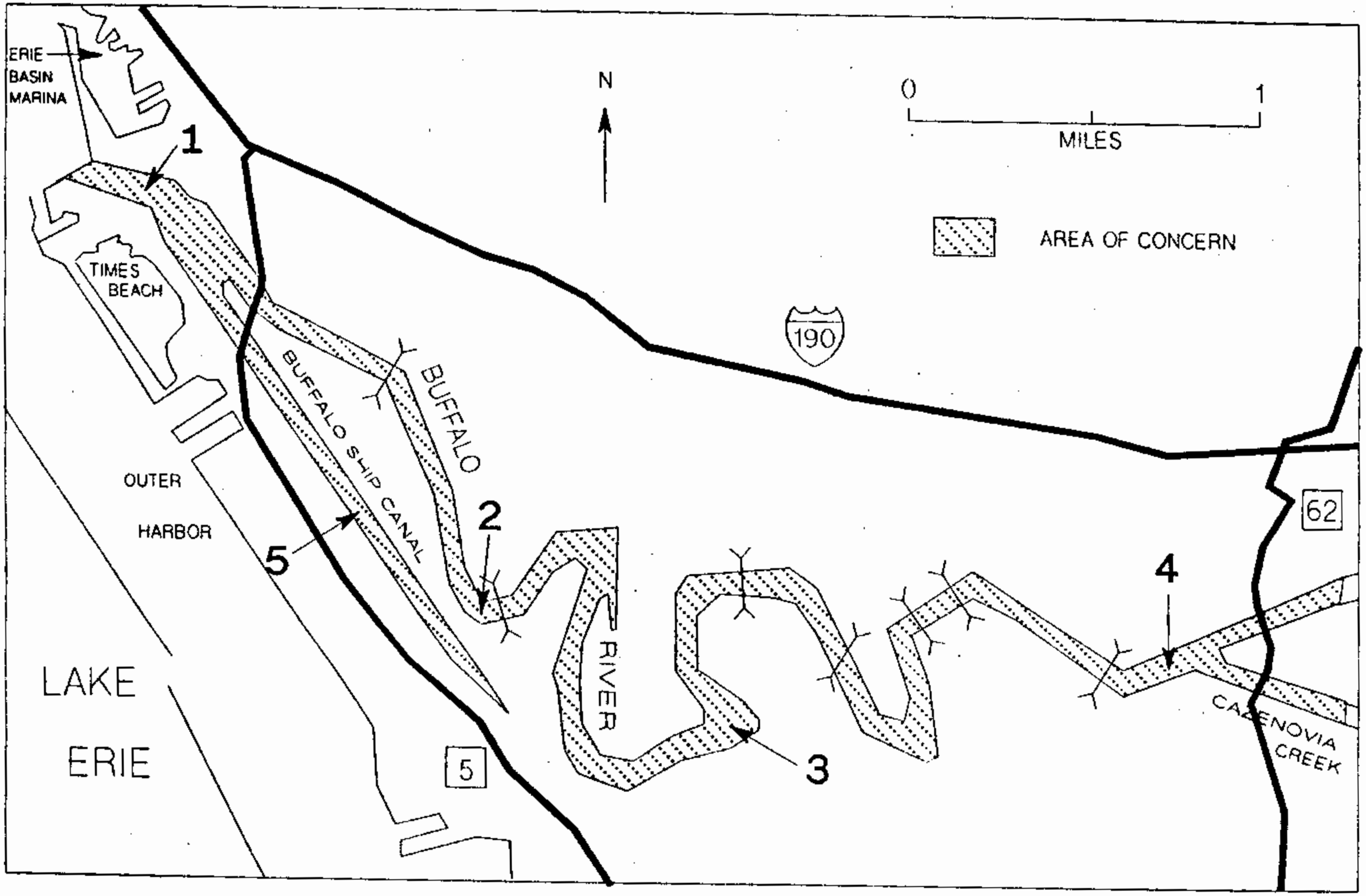


Figure 1. Location of sampling reaches in the Buffalo River AOC (adapted from NYDEC 1989).

oxygen and high carbon dioxide (Wagner 1928). No fish were found in the river at this time (Greeley 1928). These conditions remained the same until the 1960's.

The low summer flows created two major problems. First, industries along the river did not have an adequate source of cooling water. During stagnant conditions the heated discharge of an industry was recycled into its intake pipes. This created surface temperatures in the river greater than 40°C (Sweeney and Merckel 1972). Also, when precipitation increased in the fall, the pollutants accumulated over the summer were carried in a "slug" into the Buffalo Harbor and Niagara River. Detrimental effects to fish and wildlife were noted to result from these "slugs" (Sweeney and Merckel 1972). To alleviate these problems the Buffalo River Improvement Corporation (BRIC) was formed in 1967. A pumping station was built to bring Lake Erie water to industries as cooling water that was then discharged into the Buffalo River to augment the flow. BRIC serviced four industries during the 1970's pumping approximately 100 million gallons per day (Sweeney and Merckel 1972, Sauer 1979). This augmentation was approximately 20% of the total flow annually and 90% of the total flow during the summer months (Sauer 1979). At the same time there was a decrease in industrial wastes due to pollution abatement programs (Sweeney and Merckel 1972). These changes caused an almost immediate improvement in water quality. In 1972, for the first time in over 40 years, oxygen was present throughout a surface to bottom profile. There was an increase in abundance and diversity of benthic fauna. Sweeney and Merckel (1972) also noted that fish had migrated from Lake Erie and were being caught at the confluence of the Buffalo and Cayuga Creeks for the first time in more than 30 years. Due to plant closings along the river in the late 1970's and early 1980's, industrial discharges have been further reduced. The BRIC flow augmentation has also decreased with these closings to approximately 15.5 million gallons per day (Irvine et al. In press).

A biological survey of the river in 1981 (Makarewicz et al. 1982) revealed carp, white sucker, brown bullhead and pumpkinseed as year-round residents, and golden, emerald and spottail shiners, freshwater drum and other fish migrating into the river to spawn. Makarewicz et al. (1982) found ichthyoplankton in small numbers at each of their river stations. In a subsequent survey in 1988, the investigators found eight different ichthyoplankton species compared to four species collected in 1981 (Adrian and Merckel unpubl.).

The two aforementioned studies were based on very limited ichthyoplankton sampling. Makarewicz et al. (1982) sampled once a month from May to July and Adrian and Merckel (unpubl.) sampled every two weeks from the beginning of June to the first of August. In order to make a more detailed assessment of fish reproduction in the river, ichthyoplankton sampling was performed by U.S. Fish and Wildlife Service staff twice a week from the beginning of May into July of 1992. This document reports the results of that survey.

METHODS AND MATERIALS

Adult and larval fish were collected from five reaches on the Buffalo River in the spring of 1992 (Figure 1). Selection for the five reaches was based on past studies of the river (Makarewicz et al. 1982, Adrian and Merckel unpubl., Sweeney and Merckel 1972, Oleszko 1976, Ward 1980). Reach 1 is at the mouth of the river. Reach 2 is just downstream of Ohio Street bridge. Reach 3 is in the turning basin just upstream of Cargill Superior grain elevator. Reach 4 is just downstream of Cazenovia Creek. Reach 5 is located in the Buffalo Ship Canal by the sand piles (Figure 1).

Each reach was electrofished weekly from May to July for adult fish. The sampling was conducted with a boat-mounted electrofisher using 700-800 volts of pulse direct current. The electrofishing path followed the shoreline in depths less than 3 meters at each reach for approximately 30 minutes. The fish were netted and put into a holding tank on the boat. At the end of the electrofishing period, the fish were identified to species (Werner 1980, Eddy 1969), measured for standard length (mm) and then released in the same reach. When a large number of one species was collected, only the first 20 were measured.

Ichthyoplankton were collected twice a week from May 4 to July 9. The biweekly sampling was generally conducted once during the day between 0800 and

1400 h and once during the night between 1900 and 0200 h. Night sampling occurred on 5/14, 5/21, 5/28, 6/11, 6/25, 7/2 and 7/9. Fish larvae were collected using two 0.5-m plankton nets constructed of 560 μm mesh. Tows were made at two depths, one near the surface (1.0 - 2.5 m) and one below midwater (2.5 - 6.5 m), and replicated for a total of four tows at each reach on each date. The nets were towed for approximately 12 minutes at a speed of 50 cm per second in a circular pattern approximately the width of the river at each reach. A General Oceanics (Model 2030) flowmeter was placed in the mouth of each net to estimate the volume filtered. Samples were preserved in 10% formalin for later identification. At the same time the larval fish were sampled, air temperature, surface and bottom temperature, depth, and secchi depth were recorded at each reach. The reaches were always sampled in the order of Reach 4, Reach 3, Reach 2, Reach 5, and Reach 1.

In the laboratory larval fish were sorted and identified to the lowest possible taxonomic group using the key by Auer (1985). The total length of each fish was measured. If there were more than 20 of the same species in a sample, only the first 20 were measured.

An Analysis of Variance (ANOVA) test was run to determine if there was a difference in larval fish density between night and day, and deep and shallow. The interactions over the sampling period from May to July were analyzed.

RESULTS

ADULT FISH

A total of 36 fish species from 14 families were found in the Buffalo River (Table 1). Of these, a total of 32 adult fish species from 12 families were electrofished (Table 1). The greatest number of adult fish species was found at Reach 3 and the lowest number at Reach 1 (Table 2). Reach 3 also had the highest catch per unit effort (CPU) (Table 2). Emerald shiner, the most commonly caught adult fish overall, and gizzard shad, the second-most common, together made up 47% of the total catch (3,566). The remainder of the adult fish catch was mainly pumpkinseed, golden shiner, brown bullhead, largemouth bass, carp and spottail shiner. Although emerald shiners were the most abundant adult species, they were seen only in May and early June. They may have been in the river to spawn, but no larvae of this species were collected.

LARVAL FISH

A total of 16 larval fish species from 8 families were found in the Buffalo River (Table 1). Gizzard shad, the most abundant species, made up 36% of the total collected followed by the crappies (Pomoxis sp.) at 21% of the total (3,008). The remainder of the catch was mainly rainbow smelt, yellow perch, temperate basses (Morone sp.) and the sunfishes (Lepomis sp.) (Table 1). Reach 1 had the greatest diversity of larval fish species followed by Reach 2 and Reach 5 (Table 3). Reach 2 had the highest abundance of larval fish followed by Reach 3. Reach 3 also had the highest individual sample density.

Larval fish distribution in the river by species were as follows (Table 3):

- Gizzard shad, Lepomis sp., Pomoxis sp. and yellow perch were found at all reaches;
- Gizzard shad larvae were most common at Reach 3;
- Lepomis sp. larvae were most common at Reach 4;
- Pomoxis sp. larvae were most common at Reach 5;

Table 1. Name and total number of each fish species taken by electrofishing and by plankton net in the Buffalo River in 1992.

Scientific Name	Common Name	Electrofishing	Plankton Net
Lepisosteidae			
Lepisosteus osseus	longnose gar	1	--
Clupeidae			
Alosa pseudoharengus	alewife	82	34
Dorsoma cepedianum	gizzard shad	691	1074
Cyprinidae			
Carassius auratus	goldfish	87	2
Cyprinus carpio	carp	119	12
Notemigonus crysoleucas	golden shiner	297	2
Hybopsis storeriana	river chub	2	--
Cyprinella spiloptera	spotfin shiner	1	--
Notropis hudsonius	spottail shiner	108	2
Notropis atherinoides	emerald shiner	985	--
Pimephales sp.		--	22
Pimephales notatus	bluntnose minnow	60	--
Catostomidae			
Carpiodes cyprinus	quillback	1	--
Catostomus commersoni	white sucker	84	--
Hypentilium nigricans	northern hog sucker	1	--
Moxostoma sp.	redhorse species	65	--
Ictaluridae			
Ameiurus nebulosus	brown bullhead	236	--
Esocidae			
Esox lucius	northern pike	19	--
Esox masquinongy	muskellunge	3	--
Osmeridae			
Osmerus mordax	rainbow smelt	--	348
Salmonidae			
Oncorhynchus mykiss	rainbow trout	5	--
Percopsidae			
Percopsis omiscomaycus	trout-perch	1	10
Gadidae			
Lota lota	burbot	--	2

Table 1. cont.

Scientific Name	Common Name	Electrofishing	Plankton Net
Percichthyidae			
Morone sp.		--	306
Morone americana	white perch	1	--
Morone chrysops	white bass	4	--
Centrarchidae			
Ambloplites rupestris	rock bass	46	--
Lepomis sp.		--	265
Lepomis gibbosus	pumpkinseed	340	--
Lepomis macrochirus	bluegill	8	--
Micropterus dolomieu	smallmouth bass	53	--
Micropterus salmoides	largemouth bass	181	--
Pomoxis sp.	crappie species	--	618
Pomoxis annularis	white crappie	5	--
Pomoxis nigromaculatus	black crappie	3	--
Percidae			
Perca flavescens	yellow perch	48	307
Percina caprodes	logperch	--	1
Stizostedion v. vitreum	walleye	1	3
Sciaenidae			
Aplodinotus grunniens	freshwater drum	28	--
Total number of species	36	32	16

Table 2. Name and total number of each adult fish species taken by electrofishing at each reach in the Buffalo River in 1992.

Common Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
longnose gar	--	--	--	--	1
alewife	27	38	1	--	16
gizzard shad	20	126	312	127	106
goldfish	1	2	74	8	2
carp	27	24	39	23	6
golden shiner	4	41	203	43	6
river chub	--	1	1	--	--
spotfin shiner	--	--	1	--	--
spottail shiner	47	14	15	32	--
emerald shiner	333	204	100	328	20
bluntnose minnow	--	3	41	16	--
quillback	--	--	--	1	--
white sucker	6	--	45	7	26
northern hog sucker	--	--	--	--	1
redhorse species	51	--	4	2	8
brown bullhead	5	27	178	18	8
northern pike	5	--	8	3	3
muskellunge	2	1	--	--	--
rainbow trout	--	2	2	1	--
trout-perch	--	--	1	--	--
white perch	--	--	--	1	--
white bass	1	--	--	3	--
rock bass	28	--	--	--	18
pumpkinseed	10	26	221	34	49
bluegill	--	1	2	2	3
smallmouth bass	30	6	2	4	11
largemouth bass	39	21	56	17	48
white crappie	--	1	1	3	--
black crappie	--	1	--	--	2
yellow perch	15	7	22	--	4
walleye	--	1	--	--	--
freshwater drum	18	1	6	1	2
total no. of species	19	21	23	21	20
total no. of fish	669	548	1335	674	340
total effort (min.)	320	327	302	327	223
CPU (fish/min.)	2.1	1.7	4.4	2.1	1.5

Table 3. Name and total number of each larval fish species taken by plankton net at each reach in the Buffalo River in 1992. The maximum density for that species from one tow at each reach is shown in **bold** as the number/100 m^3.

Common Name	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5
alewife	22	3	---	---	14
	9.6	**1.3**			**11.4**
gizzard shad	98	436	534	172	62
	28.4	**95.4**	**179.0**	**72.0**	**10.6**
goldfish	---	1	---	1	---
		1.4		**1.4**	
carp	3	5	2	3	---
	1.4	**5.0**	**4.2**	**1.5**	
golden shiner	---	---	1	---	1
			1.4		**1.5**
spottail shiner	---	---	2	---	---
			2.8		
<u>Pimephales</u> sp.	7	---	---	14	1
	5.3			**7.1**	**1.5**
rainbow smelt	135	73	1	---	142
	68.3	**29.0**	**1.4**		**44.9**
trout-perch	---	3	---	---	7
		1.5			**3.9**
burbot	2	---	---	---	---
	1.6				
<u>Morone</u> sp.	48	247	9	---	42
	15.7	**54.6**	**4.2**		**11.5**
<u>Lepomis</u> sp.	5	4	24	256	7
	2.6	**2.9**	**7.1**	**103.4**	**2.8**
<u>Pomoxis</u> sp.	14	81	173	3	357
	6.3	**15.6**	**52.2**	**1.4**	**56.9**
yellow perch	102	35	31	54	86
	24.4	**7.9**	**8.0**	**21.4**	**29.2**
logperch	1	---	---	---	---
	1.4				
walleye	3	---	---	---	---
	2.9				
Total no. of species	12	10	8	8	10
Total no. of fish	442	897	777	507	717
Max. larval density * (number /100 m^3)	87.5	130.7	235.7	140.7	72.8

* This value is from one tow at that reach.

- Yellow perch larvae were most common at Reach 1;
- Alewife and rainbow smelt larvae were only found at the lower reaches and mostly at the mouth (Reach 1);
- Morone sp. were also found mostly in the lower reaches but were most common at Reach 2;
- The minnows were found in very small numbers at all reaches; and,
- Burbot, log perch and walleye were found only at Reach 1.

In looking at the success of the night versus day ichthyoplankton sampling, an ANOVA was performed on the data for each reach. There was a significantly higher number of fish collected at night at Reaches 1, 2 and 5 ($F=43.9$, $P=0.0001$ for Reach 1; $F=111.82$, $P=0.0001$ for Reach 2; $F=137.46$, $P=0.0001$ for Reach 5). At Reach 4 the number of fish collected during the day was higher than at night but was not significantly different ($F=3.03$, $P=0.093$). This may have been due to the fact that the night sample usually occurred at dusk at this reach. At Reach 3 the number of fish collected during the night was slightly higher than during the day in the shallow net but lower than day in the deep net. This resulted in no overall difference between day and night larval fish densities for Reach 3 ($F=0.58$, $P=0.453$). There was no significant difference in densities between the shallow and deep nets at all reaches except Reach 3 ($F=15.32$, $P=0.0005$). The difference at Reach 3 may be due to one very high density that occurred in the shallow net at night on June 11th which was 23.57 larvae per 10 m^3.

Among the larval fish species, alewife, gizzard shad, rainbow smelt, Pimephales sp., troutperch, Morone sp. and yellow perch were found mostly in the night tows (Table 4). Carp were found more in day tows. Lepomis sp. and Pomoxis sp. were approximately equally collected in day and night tows. Most fish were about equally distributed in deep and shallow tows, except troutperch which showed up mostly in deep tows and Lepomis sp. which showed up more in shallow tows (Table 4). For those fish that were found in less than 5 tows it is difficult to assess if where they were collected is representative of preferred locations.

Table 4. Percent of each species found in the day/shallow, day/deep, night/shallow or night/deep tows from 5/4 to 7/9, 1992. Night sampling occurred on 5/14, 5/21, 5/28, 6/11, 6/25, 7/2 and 7/9.

Species	Day/Shallow	Day/Deep	Night/Shallow	Night/Deep
alewife	8	0	50	42
gizzard shad	23	8	42	27
goldfish *	0	100	0	0
carp	0	60	40	0
golden shiner *	36	0	64	0
spottail shiner *	0	100	0	0
Pimephales sp.	10	15	56	19
rainbow smelt	4	11	36	49
trout-perch	0	0	33	64
burbot *	0	50	50	0
Morone sp.	18	20	33	29
Lepomis sp.	36	19	33	12
Pomoxis sp.	28	25	29	18
yellow perch	14	24	25	37
logperch *	0	0	0	100
walleye *	0	100	0	0

* Species that were found in less than five tows.

ADULT/LARVAL FISH RELATIONSHIPS

The number of adult fish was generally higher in spring which would indicate a combination of resident fish and migratory fish coming in the river to spawn (Figure 2). Larval fish first started to appear on May 18th (Figure 3). This followed a sharp increase in bottom temperature (Figure 4). The increase in bottom temperature was then followed by a drop and a second sharp increase. Following the second increase in bottom temperature larval fish density increased significantly starting around June 11th (Figure 3). The density of larval fish peaked in the later part of June and was decreasing at all reaches except Reach 1 by July 9th.

The density of the most common larval fishes is compared with the number of adult fishes captured in Figures 5 through 12. The highest adult gizzard shad numbers occurred on May 6th at Reaches 1, 3 and the ship canal and on May 27th at Reach 2 (Figure 5). The highest density of larval gizzard shad occurred at Reach 3 on June 11th. Larval densities started to increase on this date or later at all reaches (Figure 6). The larvae collected around June 11th ranged in length from 3.2 mm to 8.5 mm. Based on incubation and larval growth information (Auer 1982, Mansueti and Hardy 1967), it was estimated that these fish were spawned around June 1st. This seems to indicate that eggs laid by fish that spawned in early May did not hatch successfully. Adult crappies were not found in great numbers in the Buffalo River even though their larvae was the second most abundant in the ichthyoplankton tows (Figure 7). No adult crappies were found at Reach 1. No adults were found in the ship canal until the end of June but larvae were collected as early as May 21st. Larval densities started to increase around the end of May and the beginning of June and seemed to be ending by July except in the ship canal (Figure 8).

The third most common larval fish was the rainbow smelt (Table 1) but no adults of this species were found. This may be due to the fact that smelt come in at night to spawn (Smith 1985), and electrofishing was performed only during the day.

Yellow perch adults were also not found in great numbers (Figure 9). They were most common at Reach 3 but none were seen at Reach 4. This is probably because yellow perch are also night spawners and are in deep water during the day

Figure 2. Total adult fish electroshocked at each reach for each date during the sampling period.

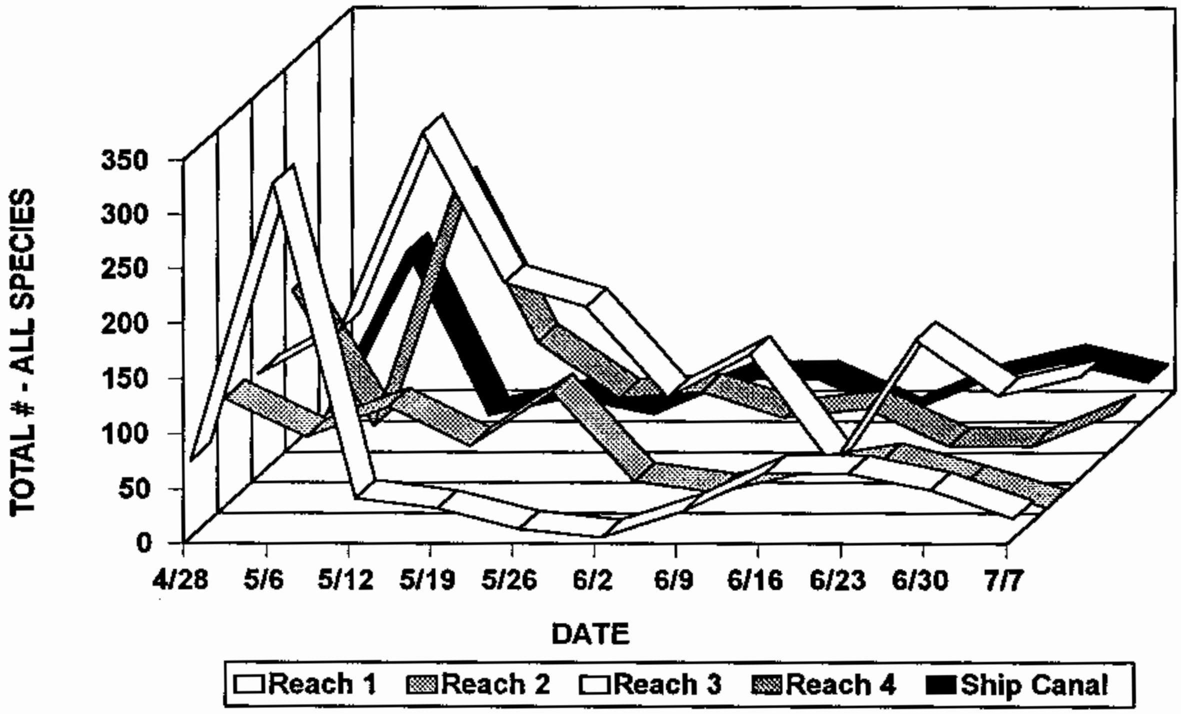


Figure 3. Total larval fish density at each reach for each date during the sampling period.

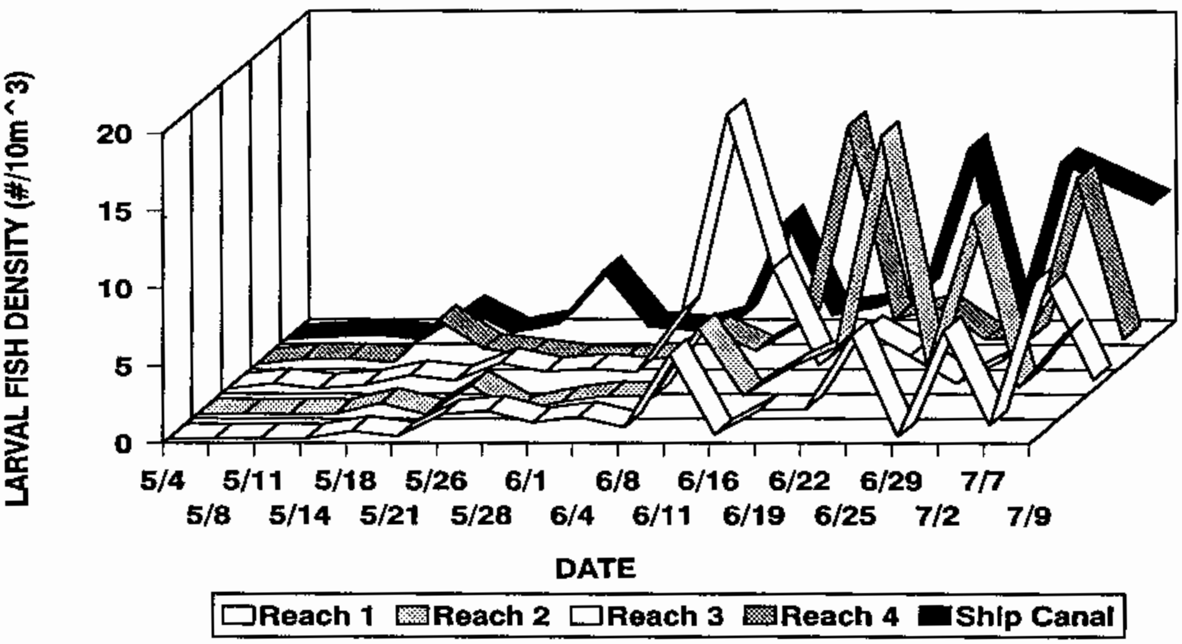


Figure 4. Bottom temperature by reach during the sampling period.

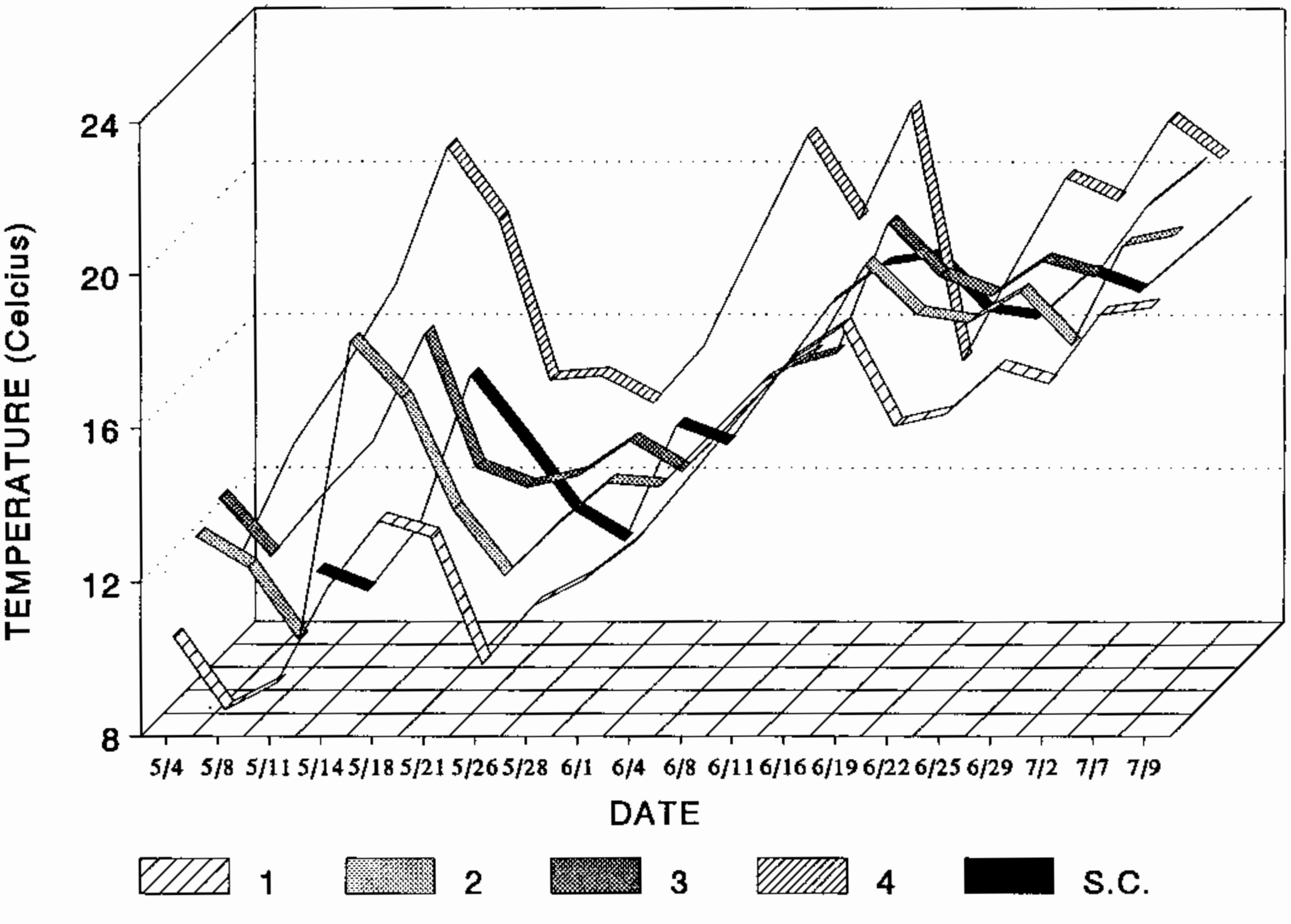


Figure 5. Gizzard shad adults
All reaches

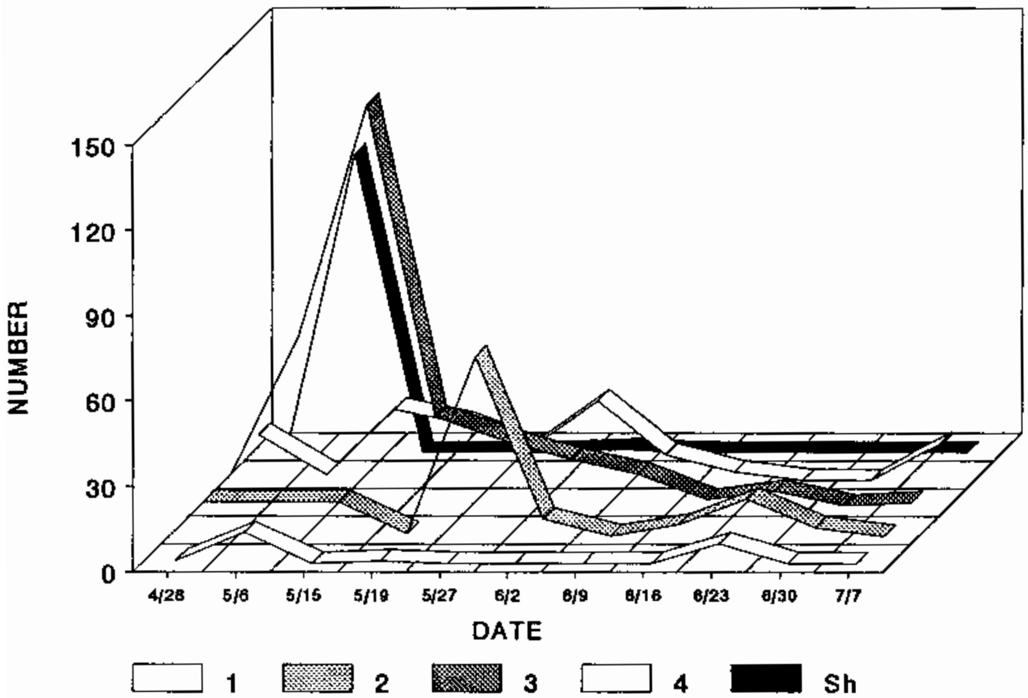


Figure 6. Gizzard shad larvae
All reaches

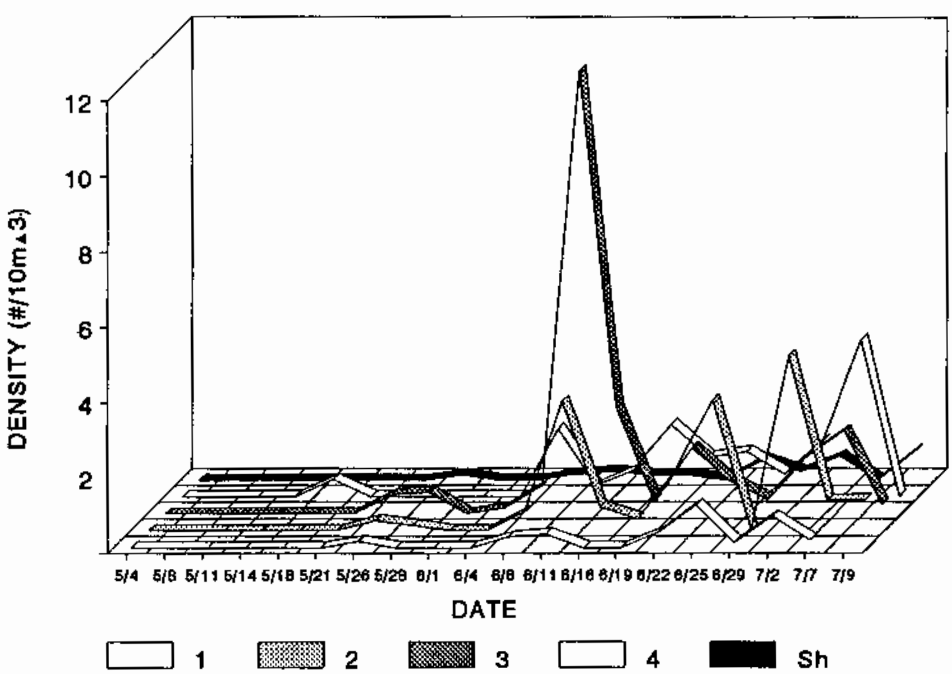


Figure 7. POMOXIS sp. adults
All reaches

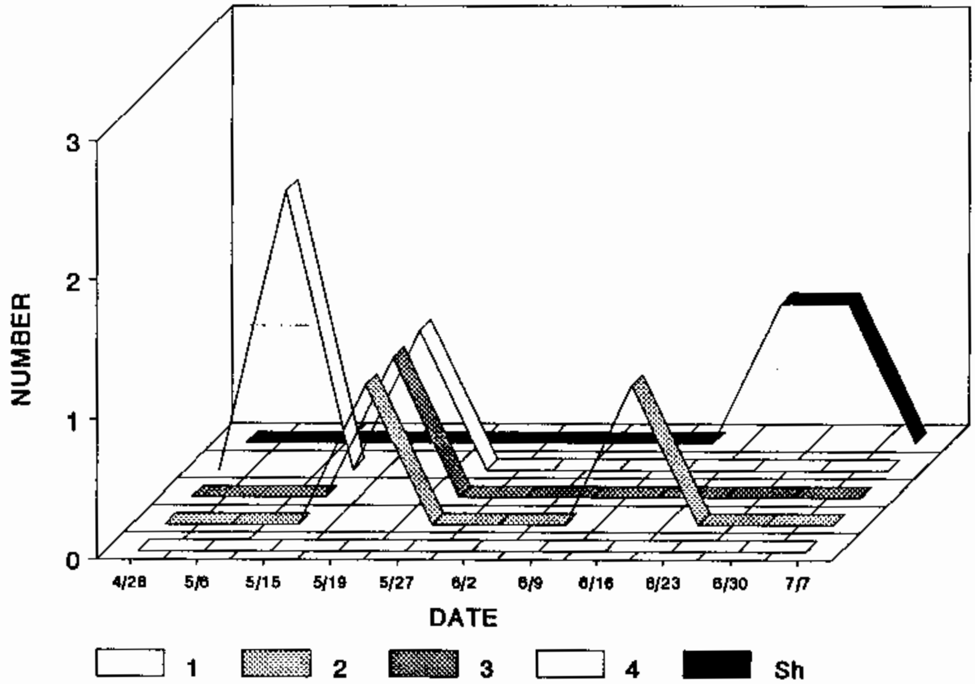


Figure 8. POMOXIS sp. larvae
All reaches

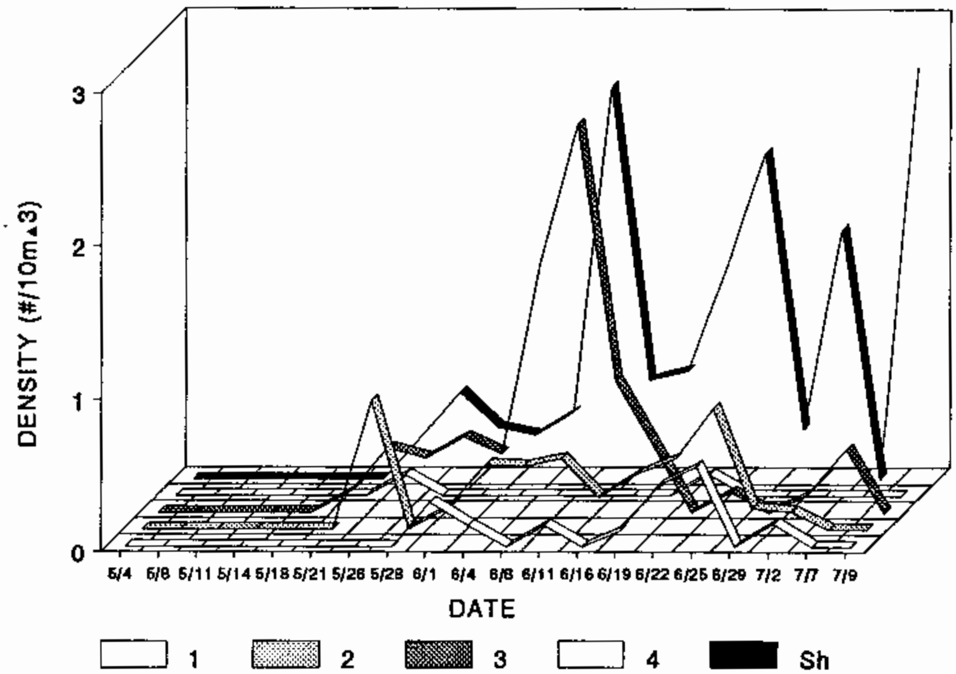


Figure 9. Yellow perch adults
All reaches

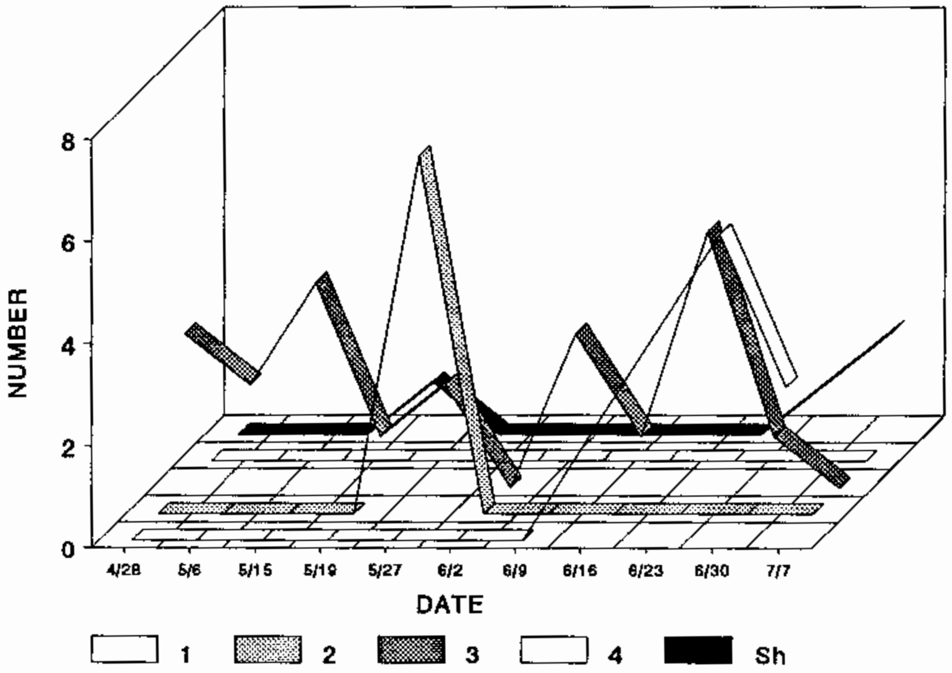


Figure 10. Yellow perch larvae
All reaches

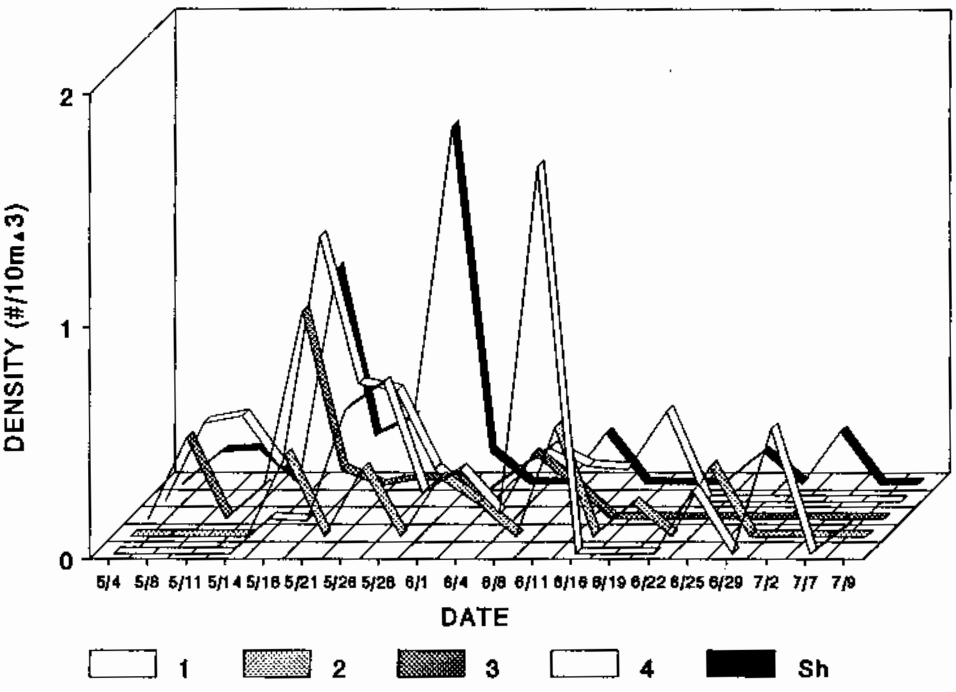


Figure 11. LEPOMIS sp. adults
All reaches

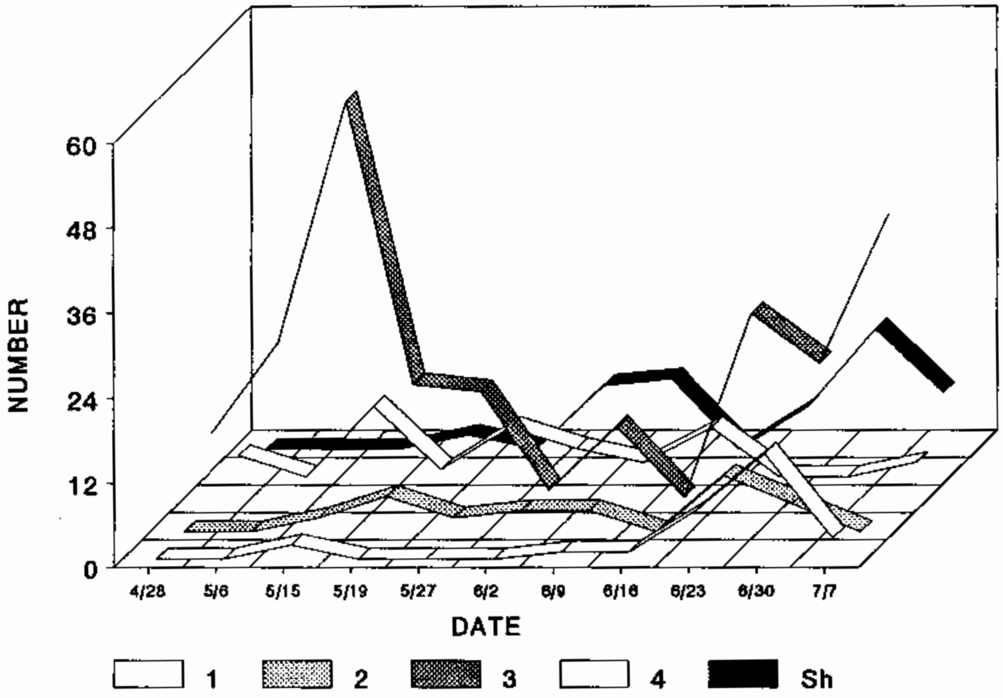
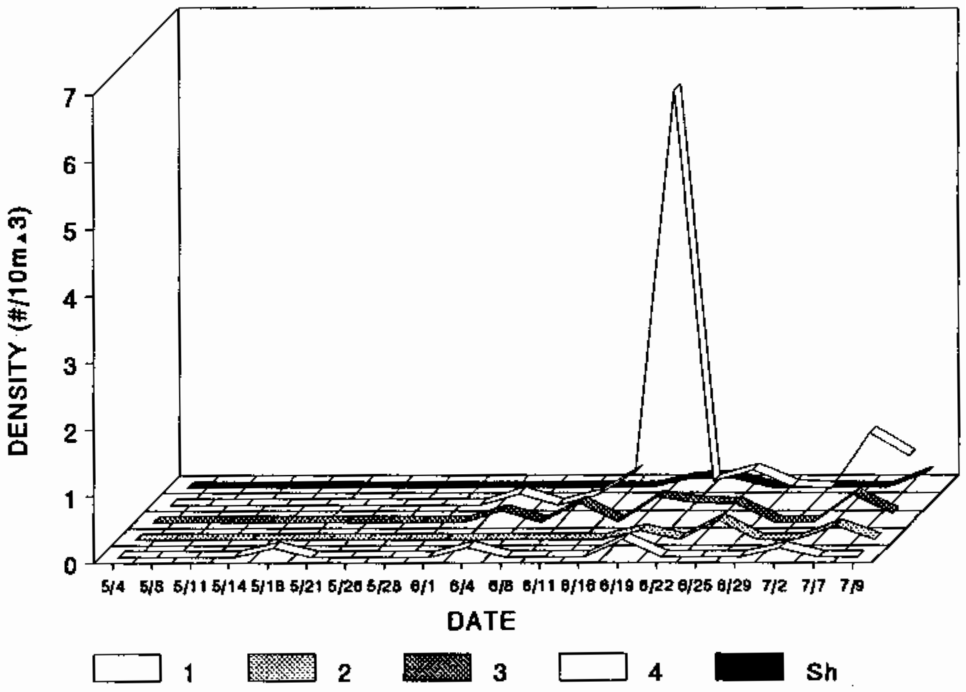


Figure 12. LEPOMIS sp. larvae
All reaches



(Scott and Crossman 1973). Yellow perch larval densities peaked on May 18th at Reaches 3 and 4, May 18th and 28th in the ship canal and May 28th and June 11th at Reaches 1 and 2 (Figure 10).

The sunfishes, pumpkinseed and bluegill, were common in both adult and larval sampling (Table 1). Adult pumpkinseed were much more common than bluegill. Pumpkinseed adults were most common at Reach 3 (Figure 11). The larvae started to appear on June 4th except at Reach 1, where one larval fish was collected on May 18th. A peak larval abundance of 6.2/10 m^3 occurred on June 19th at Reach 4 (Figure 12). The larval fish collected on June 4th were spawned from 5 to possibly 10 days previous based on incubation and growth information (Auer 1982). This seems to indicate that the eggs of the earlier spawners, like the gizzard shad, did not hatch successfully.

Three walleye larvae were collected at Reach 1 on May 18th. They were all yolk-sac larvae in the size range of newly hatched fish (Auer 1982). From velocity data collected on the three major tributaries of the Buffalo River, the average flow in the river for the period May 15-18 was estimated to be .023 m/sec (USGS 1993, Meredith and Rumer 1987). This means that a larvae could have moved downstream approximately 1,976 meters a day. Therefore, if these larvae were 2 days old they could have hatched from a point upstream of the Ohio Street Bridge or anywhere in the ship canal.

Another factor in larval fish drift in the Buffalo River are the periods of reverse flows. Backflows as much as .158 m/sec have been recorded (Sargent 1975). This means that larvae collected from Reach 1 could have drifted into the river from the outer harbor or Lake Erie. At the present time there is no measurement taken that can give information on the occurrence of reverse flows in the Buffalo River. Therefore, it is unknown whether any backflows occurred just before the walleye larvae were collected.

While electrofishing in the ship canal on June 30th schools of young-of-the-year (YOY) fish were noted close to shore. A few taken with a dip net were identified later as largemouth and smallmouth bass. These two species were not collected by the plankton nets.

DISCUSSION

The total number of adult fish species found in the river during this study has not changed significantly from the Makarewicz et al. (1982) or the Adrian and Merckel (unpubl.) studies. A survey conducted in 1991 by the New York Department of Conservation also found a similar number of adult species (Gerry Mikol pers. comm.). However, there has been an increase in the number of species of larval fish found in the Buffalo River. Makarewicz et al. (1982) found only 4 species of larval fish: gizzard shad, carp, emerald shiner, and yellow perch. Adrian and Merckel (unpubl.) found 6 species in 1988: bowfin, alewife, gizzard shad, smelt, Morone sp. and Centrarchidae. The increase in the number of larval fish species found in this study from the previous studies is probably due, in part, to the more intensive sampling regime rather than only fish habitat or water quality improvements.

Of the larval fish found in the previous studies, two were not collected during this study, emerald shiners and bowfins. Adult emerald shiners were collected in large numbers in May but were very scarce in June and July. They begin spawning when water temperature reaches 22°C (Auer 1982), but bottom temperatures were not that high until July. The low bottom temperatures may be the reason for their lack of spawning success. Bowfins spawn at temperatures between 16 and 19°C. Since these temperatures were reached by the middle of June, low bottom temperature is probably not the reason for not finding this species during this study.

Although more larval species were found during this study it should be noted that there were two larval species, largemouth bass and smallmouth bass, which were not collected by the plankton nets but were found in the river. This could be due to the ability of some fish to avoid the nets or the larvae inhabiting areas where the nets could not sample, such as the shallow nearshore water. A second method of larval fish collection such as a light trap could be used to overcome some of these problems.

Since many adult fish spawn at night and return to deeper water during the day, day-electrofishing may not be giving an accurate picture of the spawning activity in the river. This is indicated in the results where there were few or no adult fish found for the most common larval fish. Of the larval fish collected alewife, rainbow smelt, Pimephales sp., yellow perch and walleye generally spawn at night (Scott and Crossman 1973). Night electrofishing may show a better correlation between adult and larval fish activity.

Comparison of the night and day collection of larval fish indicates that the plankton nets were more successful at night. This may reflect true density differences between night and day due to movements of larvae to cover during the day for predator avoidance or the larvae could be better able to avoid the nets during the day.

Lastly, a factor important in the timing of spawning and the hatching of the larvae is temperature. This may be disturbed by lake effects on the Buffalo River. The lower river can exhibit characteristics similar to tidal influences in estuaries. Because the axis of Lake Erie is oriented in the direction of the prevailing winds, seiches commonly occur. When the water level rises in the eastern basin due to a seiche, Lake Erie water will migrate up into the Buffalo River (Irvine et al. In press). Because the lake temperature can be significantly different than the river temperature the two waters would not mix. Instead, the lake water enters like a wedge either on top or underneath the river water. In the spring the lake temperature is lower than the river and would be denser, therefore it would enter the river on the bottom. This could be the reason for the bottom temperature dropping on May 18th through the 26th (Figure 4). The drop in temperature seemed to have affected the success of the earlier spawning of gizzard shad and sunfishes. Temperature is an important factor in the initiation and continuation of spawning for the gizzard shad (Scott and Crossman 1973). Low temperatures during spring and early summer can adversely affect spawning success (Williamson and Nelson 1985). Young-of-the-year are particularly susceptible to mortality caused by sudden or extreme changes in temperature.

RECOMMENDATIONS

While the 1992 survey is a good start to the fishery habitat baseline data for the Buffalo River, continuing the survey for several more years is necessary due to year-to-year variations in weather and hydrodynamics which may affect spawning success. In the subsequent surveys some changes in the methods are recommended:

1. Electrofishing should be conducted at night, since many fish may be spawning at night only. A second sampling method such as a trawl net could also be used during the day to sample the deeper midstream areas of the river.

2. Larval fish collection should probably be continued twice a week on order to capture those fish that spawn and hatch in a very short period. To avoid the fluctuating patterns in density seen over the sampling period, sampling should only be done during the day or night. The night is preferred since greater numbers were collected at that time.

3. A second method of ichthyoplankton sampling such as a light trap is recommended to sample for those larval fish that are in the areas where the plankton nets cannot be towed.

4. A couple of upstream reaches should be added to compare with the reaches in the lower river. These upstream areas may be able to support more desirable fish species that cannot utilize the river where it has been most impacted by past contamination from municipal and industrial sewage.

5. Electrofishing should be extended into the Buffalo Harbor to identify fish that may use it as a staging area for possible spawning in the Buffalo River.

In measuring progress toward restoration of the Buffalo River, it is important to monitor all levels in the biotic community. Besides fish, this would include benthic macroinvertebrates, zooplankton and phytoplankton. It is known that there is degradation of the benthos of the Buffalo River, but there is no apparent degradation to phytoplankton or zooplankton populations (NYSDEC 1989). Benthic macroinvertebrates are already monitored extensively in other rivers and streams, specifically for water quality. Phytoplankton and zooplankton as well as benthos are important as food for fish and should be monitored to insure any changes in the fish populations are not related to changes in the food web. The baseline data could be compared to post-restoration data to identify any significant changes in the biological community.

Other impairments in the Buffalo River due to pollution are the tainting of fish and wildlife and fish tumor and other deformities (NYSDEC 1989). Monitoring of pollution-related stresses to fish can also be used to determine the effects of changes to the system. Past studies which looked at the frequency of tumors and deformities in brown bullheads and other fish should continue. Other studies that could be used to monitor pollution related stresses in fish include DNA analysis for gene mutations and fish blood analyses.

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