Fish community changes at one Vigo County, Indiana locality over a twelve year period

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Abstract

Seining was conducted over 12 years (28 collections) in a physically and ecologically stable site, at Otter Creek Dam, in Vigo County, Indiana, 5 mi. N. Terre Haute. A total of 52 species of fish was taken, or 52.8% of the species known to occur in Vigo County. Of these, 21 were considered as accidentals (occurred in less than 3 collections and/or represented by no more than 5 individuals). A total of 21,029 fish was taken in the 28 collections. There were 18 major species (those taken in at least 18 collections, with a total of over 100 individuals being collected). Only one species, *Etheostoma blennioides*, occurred in all 28 collections. *Pimephales notatus* and *Etheostoma caeruleum* occurred in 27, while three additional species occurred in 26.

There were pronounced differences in the total numbers of fishes per collection, and in numbers of fishes per species per collection, even though the area was ecologically quite stable. This variation appeared to be primarily seasonal in some species, due to long-term population changes in some, and was erratic in still others. These latter variations were thought to be due to sampling error, to schooling of fish, or to migration or erratic population changes.

Introduction

In recent years there has been much emphasis on ecology and conservation. Organismal data are being collected for purposes of writing environmental impact statements to determine environmental changes that may occur as a result of building a dam or factory, adding hot water or other substance to a river, or otherwise making changes affecting the environment. Some of these changes cause obvious effects on flora and fauna, for example when species or communities are simply eliminated. Sometimes there may be replacement of native fauna or flora by less desirable or undesirable species, such as carp. Sometimes more subtle changes occur, such as in species composition of the community. During short periods of study, one sometimes finds great differences in species composition or in total community size, and the question arises whether the differences are caused by man's manipulation, or whether they represent seasonal or long-term changes in fish populations. In view of schooling behavior, chance differences too, can be prominent in fish studies, particularly when sample sizes are small.

For comparative purposes it seems appropriate to examine rather long-term collecting data from an area which has not been subjected to undue physical changes during that period. Such an area occurs in Vigo County, Indiana, below Otter Creek Dam (Markles Dam). The dam was originally built in 1816, and was operative until 1938, when the accompanying mill burned. Since 1962, when the present collections were begun, no changes have occurred which appear to have affected the site in any major way. Just below the dam is a rather deep pool, then an area of smooth rock bottom, followed by a gravel riffle area,

At the lower end of the study site is another pool. The dam has resulted in water continually flowing over the smooth rock and riffles, keeping sand and silt from accumulating here. This continual cleansing action helps to maintain the stability of the area. The existence of rock, gravel, sand and silt bottomed areas in combination with variable water speed and depth causes this to be one of the most ecologically diverse sites in the area. Also, the stream is fairly large (about 70' wide) so includes large numbers of individuals.

The purpose of this paper is to assess variation in fish population levels and community structure at Otter Creek Dam.

Materials and Methods

Seining occurred periodically between 16 November 1962 and 11 September 1974. Between 1 and 4 collections were made per year except in 1970, when no collections were made. In all collections, seining began in the lower pool, extended through the riffles and bedrock and ended at the upper pool, just below the dam. A fifteen foot seine was used in ten of the earlier collections, while a 30 foot seine was used in the rest. The objectives each trip were to secure and identify as many fish as possible. Seine size and personnel differed between trips, but the author was present on all trips, and attempted to ensure collecting uniformity. A few of the values are estimates rather than actual counts, but are thought to be reasonably accurate. Values were converted to percent of sample to indicate species composition between samples. A total of 28 samples was collected, 1 in 1962, 3 in 1963, 3 in 1964, 3 in 1965, 3 in 1966, 4 in 1967, 3 in 1968, 2 in 1969, 2 in 1971, 2 in 1972, 1 in 1973, and 1 in 1974. Monthly samples were distributed as follows: April (3), May (1), June (1), July (4), August (1), September (10), October (2), November (5), and December (1).

Results

A total of 57 species of fish was taken, or 52.8% of the 108 species of fish known to occur or to have occurred in Vigo County. Numbers of individuals totalled 21,029, averaging 751.0 per collection. The species are listed in Table 1, along with their average number per collection, and percentage of collections in which they occurred.

It seemed of interest to determine the number of new species (not taken previously at the dam) occurring in successive collections, thus giving some idea of how many collections were needed before essentially all the species regularly occurring had been taken. Numbers of new species in successive collections are given in Table 2 both for regularly occurring species, and for accidentals.

Of the 57 species taken, those occurring in at least three collections and represented by at least 5 individuals were considered as of "regular" occurrence. Species not fulfilling these criteria were termed as "accidentals". Twenty-one species were accidentals, the last 20 species in Table 1, and *Pomoxis annularis*. The accidentals constituted 36.8% of the total species taken, but only 58 or 0.27 percent of the total number of individuals. Accidentals occurred sporadically through-

TABLE 1. *List of fish taken in 28 collections during a 12 year period at Otter Creek Dam, Vigo County, Indiana. Species are listed in order of decreasing number taken.*

	Total Number	Av. No. / Collection	No. of Coll.	% Freq.
Pimephales notatus	5192	185.4	27	96.4
Notropis chrysocephalus	3897	139.2	26	92.9
Notropis spilopterus	2958	105.6	25	89.3
Notropis atherinoides	1964	70.1	21	75.0
Campostoma anomalum	1452	51.9	26	92.9
Hybognathus nuchalis	1069	38.2	20	71.4
Ericymba buccata	599	21.4	26	92.9
Etheostoma blennioides	542	19.4	28	100.0
Ethcostoma caeruleum	474	16.9	27	96.4
Notropis umbratilis	403	14.4	25	89.3
Etheostoma nigrum	371	13.3	23	82.1
Phenacobius mirabilis	351	12.5	23	82.1
Semotilus atromaculatus	287	10.3	18	64.3
Noturus miurus	274	9.8	21	75.0
Hypentelium nigricans	191	6.8	21	75.0
Notropis stramineus	174	6.2	24	85.7
Lepomis macrochirus	144	5.1	19	67.9
Etheostoma flabellare	114	4.1	23	82.1
Dorosoma cepedianum	76	2.7	15	53.6
Moxostoma erythurum	72	2.6	16	57.1
Fundulus notatus	55	2.0	15	53.6
Notropis blennius	49	1.8	9	32.1
Percina maculata	45	1.6	10	35.7
Etheostoma spectabile	43	1.5	10	35.7
Micropterus salmoides	27	1.0	12	42.9
Notropis rubellus	27	1.0	8	28.6
Lepomis cyanellus	27	1.0	5	17.9
Pomoxis annularis	20	0.7	1	3.6
Lepomis megalotis	18	0.6	8	28.6
Labidesthes sicculus	13	0.5	4	14.3
Catostomus commersoni	12	0.4	8	28.6
Notemigonus chrysoleucas	11	0.4	6	21.4
Esox americanus	11	0.4	6	21.4
Micropterus dolomieui	8	0.3	5	17.9
Lepomis humilis	7	0.3	6	21.4
Notropis volucellus	7	0.3	5	17.9
Pomoxis nigromaculata	7	0.3	4	14.3
Hybopsis micropogon	6	0.2	2	7.1
Carpiodes cyprinus	4	0.1	3	10.7
Notropis boops	4	0.1	3	10.7
Micropterus punctulatus	3	0.1	3	10.7
Hybopsis storeriana	3	0.1	1	3.6
Ambloplytes rupestris	2	0.1	2	7.1
Ictalurus melas	2	0.1	2	7.1
Cyprinus carpio	2	0.1	2	7.1
Minytrema melanops	1	0.04	1	3.6
Chrosomus erythrogaster	1	0.04	1	3.6
Percina caprodes	1	0.04	1	3.6
Erimyzon oblongus	1	0.04	1	3.6
Lepomis gulosus	1	0.04	1	3.6
Moxostoma duquesnii	1	0.04	1	3.6
Icthyomyzon unicuspis	1	0.04	1	3.6
Ictiobus niger	1	0.04	1	3.6
Carpiodes carpio	1	0.04	1	3.6
Moxostoma valenciennesi	1	0.04	1	3.6
Lepomis microlophus	1	0.04	1	3.6
Ictiobus cyprinella	2	0.04	1	3.6
	21,029			

out the collections (Table 2) with 10 occurring in the first half of the collections, and 11 in the second half. Such species cannot be considered very seriously when one is attempting to determine species change of a community through time, and these will not be considered further here.

TABLE 2. *Summary data for 28 collections from Otter Creek Dam, Vigo County.*

Collection	No. of Species	No. of individuals	First occurrence of species		
			Regular sp.		Accidental
1 Nov. 62	24	495	22	3	25
2 May 63	9	256	2	—	2
3 Sept. 63	18	557	2	—	2
4 Dec. 63	19	2446	2	—	2
5 July 64	22	235	—	—	0
6 Oct. 64	21	760	1	1	2
7 Nov. 64	25	2482	—	1	1
8 June 65	21	1049	1	—	1
9 Sept. 65	27	244	1	1	2
10 Nov. 65	33	1109	1	1	2
11 Aug. 66	22	393	3	2	5
12 Sept. 66	22	239	—	1	1
13 Nov. 66	23	5344	—	—	0
14 July 67	22	419	—	—	0
15 July 67	22	245	1	—	1
16 July 67	18	317	—	—	0
17 Nov. 67	25	829	—	1	1
18 Apr. 68	16	63	—	1	1
19 Sept. 68	21	152	—	2	2
20 Oct. 68	17	147	—	—	0
21 Apr. 69	12	52	—	1	1
22 Sept. 69	23	87	—	—	0
23 Apr. 71	20	307	—	—	0
24 Sept. 71	26	593	—	1	1
25 July 72	24	651	—	—	0
26 Sept. 72	25	665	—	1	1
27 Sept. 73	25	519	—	3	3
28 Sept. 74	23	374	—	1	1
			—	—	—
			36	21	57

Of the regularly occurring species, 28, or 77.8% had been taken by the fourth collection, 35, or 97.2% had been taken by the 11th collection, and all had been taken by the 15th collection.

The most abundant species taken at the dam was *Pimephales notatus*, the bluntnose minnow, and this was one of the four most abundant species in streams of Vigo County (Whitaker and Wallace, 1972). The other species most abundant in Vigo County were *Ericymba buccata*, *Semotilus atromaculatus*, and *Campostoma anomalum*, these being respectively the 5th, 7th, and 13th most abundant species at Otter Creek Dam. All of the more common stream species of Vigo County were regular inhabitants at the site.

One of the factors contributing to the high number of species at Otter Creek Dam is its proximity to the Wabash River, it being only

about three miles from the River; also it contains some mud and sandy bottomed area and some of the water is quite deep, conditions similar to that of the river. The four most abundant small species of the Wabash River in Vigo County are *Notropis atherinoides, N. blennius, N. spilopterus,* and *Pimephales vigilax. Notropis spilopterus* and *N. atherinoides* were prominent at the dam, being the third and fourth most abundant species there, and *N. blennius* was also of regular occurrence.

Another factor helping to create conditions in which a large species diversity can exist is the presence of the permanent gravelrock association at this locality. This has existed for over 150 years, beginning with the construction of the dam. Thus, a species which exists on this type of habitat and happened at some time to have made its way to the dam would have been able to find permanent, stable habitat. In most other areas in Vigo County, one might find gravel-rock at one time, but later it might be covered with sand and silt. I have observed this in Vigo County on several occasions, particularly in upper Otter Creek, and in Brouillettes Creek.

Some of the darters, particularly *Etheostoma blennioides, E. caeruleum,* and *Percina maculata,* the madtom, *Noturus miurus,* and the minnows, *Notropis chrysocephalus,* and *N. umbratilus* are species that are partial to the gravel-rock type of habitat.

Thus it would appear that four main conditions, the large size of the stream, proximity to the river, stable gravel-rock habitat and habitat diversity have contributed to the species diversity found at the dam.

Most localities have few species which occur in adequate abundance so that they are taken in most collections. This locality has 18 species (the first 18 listed in Table 1) easily classed in that group (using criteria as follows; total of over 100 individuals taken, and in at least 18 collections).

Species occurrence and abundance

Only one species, the greenside darter, occurred in all 28 collections. Two species, *Pimephales notatus* and *Etheostoma caeruleum* were taken in 27 collections, while an additional three species occurred in 26; they were *Notropis chrysocephalus, Campostoma anomalum,* and *Ericymba buccata.* Occurrence and abundance of the "major" species throughout the 28 collections is given in Table 3. Also, so that some index of community structure can be obtained, the percentage of individuals that each of these species forms of the total collection is given in parentheses.

It would seem that numbers of fish per collection of the various species might be reasonably similar in view of the habitat stability; however, there is great variation in the total numbers of fish taken per collection (Table 4), and in the numbers of individuals per collection of the various species. The biggest collection was made in November, 1966 (5344 fish) while the smallest was made in April 1969 (when only 52 fish were taken).

TABLE 3. *Occurrence and abundance of "major" species at Otter Creek Dam over 29 collections made during a twelve year period. The first numbers are the actual or estimated numbers of fish taken in the sample. Fish species are referred to by initial and are the first 18 species listed in Table 1.*

Date	Species								
	P.n.	N.c.	N.s.	N.a.	C.a.	H.n.	E.b.	E.b.	E.c.
Nov 62	80 (16.2)	15 (3.0)	10 (2.0)	0	12 (2.4)	0	17 (3.4)	80 (16.2)	80 (16.2)
May 63	60 (23.4)	15 (5.8)	0	0	0	0	0	80 (31.3)	80 (31.3)
Sept 63	80 (14.4)	0	1 (0.002)	0	80 (14.4)	0	80 (14.4)	20 (3.6)	20 (3.6)
Dec 63	600 (24.5)	950 (38.8)	0	13 (0.5)	570 (23.3)	2 (0.1)	41 (1.7)	28 (1.1)	11 (0.4)
July 64	14 (6.0)	32 (13.6)	70 (29.8)	26 (11.1)	11 (4.7)	0	28 (11.9)	4 (1.7)	4 (1.7)
Oct 64	120 (15.9)	75 (9.9)	80 (10.5)	80 (10.5)	110 (14.5)	0	65 (8.6)	15 (2.0)	15 (2.0)
Nov 64	142 (5.7)	1693 (68.2)	305 (12.3)	151 (6.1)	3 (0.1)	7 (0.3)	87 (3.5)	7 (0.3)	15 (0.6)
June 65	16 (1.5)	177 (16.9)	465 (44.3)	246 (23.4)	4 (0.4)	58 (5.5)	14 (1.3)	8 (0.8)	6 (0.6)
Sept 65	28 (11.5)	3 (1.2)	102 (41.8)	29 (11.9)	3 (1.2)	27 (11.1)	3 (1.2)	3 (1.2)	5 (2.0)
Nov 65	233 (21.0)	51 (4.6)	265 (23.9)	253 (22.8)	33 (3.0)	33 (3.0)	9 (0.8)	25 (2.3)	26 (2.3)
Aug 66	42 (10.7)	14 (3.6)	67 (17.0)	0	21 (5.3)	70 (17.8)	39 (9.9)	12 (3.1)	6 (1.5)
Sept 66	99 (41.4)	30 (12.6)	25 (10.5)	0	4 (1.7)	6 (2.5)	3 (1.3)	3 (1.3)	8 (3.3)
Nov 66	3317 (62.1)	668 (12.5)	576 (10.8)	1 (0.01)	542 (10.1)	38 (0.7)	65 (1.2)	9 (0.2)	1 (0.01)

July 67	7 (1.7)	19 (4.5)	109 (26.0)	167 (39.9)	12 (2.9)	40 (9.5)	6 (1.4)	7 (1.7)	2 (0.5)
July 67	10 (4.1)	3 (1.2)	35 (14.3)	88 (35.9)	1 (0.4)	17 (6.9)	4 (1.6)	15 (6.1)	15 (6.1)
July 67	35 (11.0)	9 (2.8)	50 (15.8)	130 (41.0)	2 (0.6)	37 (15.1)	17 (6.9)	3 (0.9)	5 (1.5)
Nov 67	0	9 (1.1)	40 (4.8)	608 (73.3)	7 (0.8)	14 (1.7)	34 (4.1)	26 (3.1)	24 (2.9)
Apr 68	10 (15.9)	9 (14.3)	10 (15.8)	3 (4.7)	1 (1.5)	0	4 (6.3)	1 (1.5)	5 (7.9)
Sept 68	4 (2.6)	1 (0.1)	6 (3.9)	50 (32.9)	1 (0.1)	39 (25.7)	13 (8.6)	5 (3.3)	15 (9.9)
Oct 68	18 (12.2)	1 (0.1)	0	33 (22.4)	1 (0.6)	15 (10.2)	1 (0.6)	18 (12.2)	33 (22.4)
Apr 69	9 (17.3)	2 (3.8)	1 (1.9)	0	0	0	0	10 (19.2)	15 (28.8)
Sept 69	12 (13.8)	1 (1.1)	1 (1.1)	1 (1.1)	2 (2.3)	6 (6.9)	4 (4.6)	7 (8.0)	15 (17.2)
Apr 71	50 (16.3)	50 (16.3)	40 (13.0)	1 (0.3)	3 (1.0)	0	30 (9.8)	15 (4.9)	10 (3.3)
Sept 71	35 (5.9)	6 (1.0)	100 (16.9)	40 (6.7)	4 (0.7)	250 (42.2)	2 (0.3)	15 (2.5)	20 (3.4)
July 72	35 (5.4)	0	100 (15.4)	2 (0.3)	4 (0.6)	200 (30.7)	20 (3.1)	50 (7.7)	3 (0.5)
Sept 72	100 (15.0)	10 (1.5)	75 (11.3)	0	15 (2.3)	150 (22.6)	10 (1.5)	30 (4.5)	15 (2.3)
Sept 73	35 (6.7)	50 (9.6)	200 (38.5)	40 (7.7)	2 (0.4)	20 (3.9)	2 (0.4)	40 (7.7)	20 (3.9)
Sept 74	1 (0.3)	4 (1.1)	225 (60.2)	2 (0.5)	4 (1.1)	40 (10.7)	1 (0.3)	6 (1.6)	0

TABLE 3. (*cont.*)

Date	Species N.u.	E.n.	P.m.	S.a.	N.m.	H.n.	N.s.	L.m.	E.f.
Nov 62	0	40 (8.0)	10 (2.0)	20 (4.0)	16 (3.2)	8 (1.6)	7 (1.4)	25 (5.0)	8 (1.6)
May 63	5 (1.9)	0	0	0	0	0	0	0	5 (1.9)
Sept 63	20 (3.6)	20 (3.6)	65 (11.7)	40 (7.2)	5 (0.9)	60 (10.8)	20 (3.6)	15 (2.6)	5 (0.9)
Dec 63	5 (0.2)	9 (0.4)	190 (7.8)	9 (0.4)	1 (.04)	7 (0.03)	0	0	1 (0.04)
July 64	10 (4.3)	11 (4.7)	0	7 (3.0)	1 (0.4)	1 (0.4)	1 (0.4)	1 (0.4)	1 (0.4)
Oct 64	55 (7.2)	15 (2.0)	15 (2.0)	43 (5.7)	1 (0.1)	0	15 (2.0)	15 (2.0)	0
Nov 64	13 (0.5)	5 (0.2)	7 (0.3)	24 (1.0)	0	0	6 (0.2)	4 (0.2)	3 (0.1)
June 65	19 (1.8)	5 (0.5)	1 (0.1)	7 (0.7)	1 (0.1)	1 (0.1)	4 (0.4)	4 (0.4)	1 (0.1)
Sept 65	11 (4.5)	8 (3.3)	0	0	3 (1.2)	1 (0.4)	1 (0.4)	6 (2.5)	1 (0.4)
Nov 65	51 (4.6)	13 (1.2)	1 (0.1)	30 (2.7)	1 (0.1)	3 (0.3)	34 (3.1)	8 (0.7)	19 (1.7)
Aug 66	29 (7.4)	7 (1.8)	3 (0.8)	17 (4.3)	2 (0.5)	4 (1.0)	4 (1.0)	13 (3.3)	10 (2.5)
Sept 66	14 (5.9)	5 (2.1)	1 (0.4)	17 (7.1)	5 (2.1)	4 (1.7)	2 (0.8)	6 (2.5)	0
Nov 66	38 (0.7)	0	10 (0.2)	42 (0.8)	0	2 (.04)	13 (0.2)	5 (0.1)	1 (0.01)

July 67	0	1 (0.2)	5 (1.2)	0	2 (0.5)	4 (1.0)	3 (0.7)	2 (0.5)	2 (0.5)
July 67	25 (10.2)	3 (1.2)	5 (2.0)	0	5 (2.0)	4 (1.6)	4 (1.6)	2 (0.8)	0
July 67	2 (0.6)	0	9 (2.8)	2 (6.6)	0	1 (0.3)	0	0	1 (0.3)
Nov 67	2 (0.6)	8 (1.0)	1 (0.1)	3 (3.6)	2 (0.2)	0	1 (0.1)	13 (1.6)	6 (0.7)
Apr 68	7 (0.1)	0	2 (3.2)	0	0	0	6 (9.5)	0	1 (1.5)
Sept 68	1 (0.1)	0	4 (2.6)	0	0	4 (2.6)	1 (0.1)	0	0
Oct 68	2 (1.4)	6 (4.1)	1 (0.6)	0	2 (1.4)	0	1 (0.6)	2 (1.4)	10 (6.8)
Apr 69	4 (7.7)	1 (1.9)	5 (9.6)	0	0	0	0	0	1 (1.9)
Sept 69	0	9 (10.3)	3 (3.4)	2 (2.3)	1 (1.1)	9 (10.3)	2 (2.3)	2 (2.3)	1 (1.1)
Apr 71	22 (7.2)	35 (11.4)	3 (1.0)	5 (1.6)	1 (0.3)	3 (1.0)	25 (8.1)	0	8 (2.6)
Sept 71	23 (3.9)	6 (1.0)	3 (0.5)	2 (0.3)	15 (2.5)	15 (2.5)	1 (0.2)	3 (0.5)	10 (1.7)
July 72	15 (2.3)	60 (9.2)	6 (0.9)	2 (0.3)	70 (10.8)	15 (2.3)	10 (1.5)	0	0
Sept 72	20 (3.0)	75 (11.3)	1 (0.2)	15 (2.3)	100 (15.0)	20 (3.0)	5 (0.8)	0	3 (0.5)
Sept 73	7 (1.3)	10 (1.9)	0	0	30 (5.8)	15 (2.9)	4 (0.8)	10 (1.9)	10 (1.9)
Sept 74	3 (0.8)	19 (5.1)	0	0	10 (2.7)	10 (2.7)	4 (1.1)	8 (2.1)	6 (1.6)

TABLE 4. *"Major" fish species at Otter Creek Dam in 28 collections in a twelve-year period. The first values are the actual numbers of fish in the sample, the second are the percent of that sample.*

	Nov '62	May '62	Sept '63	Dec '63	July '64	Oct '64	Nov '64	June '65	Sept '65	Nov '65	Aug '66	Sept '66	Nov '66	July '66
P.	80	60	80	600	14	120	142	16	28	233	42	99	3317	7
notatus	16.2	23.4	14.4	24.5	6.0	15.9	5.7	1.5	11.5	21.0	10.7	41.4	62.1	1.7
N.	15	15	0	950	32	75	1693	177	3	51	14	30	668	19
chrysocephalus	3.0	5.8		38.8	13.6	9.9	68.2	16.9	1.2	4.6	3.6	12.6	12.5	4.5
N.	10	0	1	0	70	80	305	465	102	265	67	25	576	109
spilopterus	2.0		.002		29.8	10.5	12.3	44.3	41.8	23.9	17.0	10.5	10.8	26.0
N.	0	0	0	13	26	80	151	246	29	253	0	0	1	167
atherinoides				0.5	11.1	10.5	6.1	23.4	11.9	22.8			0.01	39.9
C.	12	0	80	570	11	110	3	4	3	33	21	4	542	12
anomalum	2.4		14.4	23.3	4.7	14.5	0.1	0.4	1.2	3.0	5.3	1.7	10.1	2.9
H.	0	0	0	2	0	0	7	58	27	33	70	6	38	40
nuchalis				0.1			0.3	5.5	11.1	3.0	17.8	2.5	0.7	9.5
E.	17	0	80	41	28	65	87	14	3	9	39	3	65	6
buccata	3.4		14.4	1.7	11.9	8.6	3.5	1.3	1.2	0.8	9.9	1.3	1.2	1.4
E.	80	80	20	28	4	15	7	8	3	25	12	3	9	2
blennioides	16.2	31.3	3.6	1.1	1.7	2.0	0.3	0.8	1.2	2.3	3.1	1.3	0.2	1.7

E.	80	80	20	11	4	15	15	6	5	26	6	8	1	2
caeruleum	16.2	31.3	3.6	0.4	1.7	2.0	0.6	0.6	2.0	2.3	1.5	3.3	0.01	0.5
N.	0	5	20	5	10	55	13	19	11	51	29	14	38	0
umbratilis		1.9	3.6	0.2	4.3	7.2	0.5	1.8	4.5	4.6	7.4	5.9	0.7	
E.	40	0	20	9	11	15	5	5	8	13	7	5	0	1
nigrum	8.0		3.6	0.4	4.7	2.0	0.2	0.5	3.3	1.2	1.8	2.1		0.2
P.	10	0	65	190	0	15	7	1	0	1	3	1	10	5
mirabilis	2.0		11.7	7.8		2.0	0.3	0.1		0.1	0.8	0.4	0.2	1.2
S.	20	0	40	9	7	43	24	7	0	30	17	17	42	0
atromaculatus	4.0		7.2	0.4	3.0	5.7	1.0	0.7		2.7	4.3	7.1	0.8	
N.	16	0	5	1	1	1	0	1	3	1	2	5	0	2
miurus	3.2		0.9	.04	0.4	0.1		0.1	1.2	0.1	0.5	2.1		0.5
H.	8	0	60	7	1	0	0	1	1	3	4	4	2	4
nigricans	1.6		10.8	0.03	0.4			0.1	0.4	0.3	1.0	1.7	.04	1.0
N.	7	0	20	0	1	15	6	4	1	34	4	2	13	3
stramineus	1.4		3.6		0.4	2.0	0.2	0.4	0.4	3.1	1.0	0.8	0.2	0.7
L.	25	0	15	0	1	15	4	4	6	8	13	6	5	2
macrochirus	5.0		2.6		0.4	2.0	0.2	0.4	2.5	0.7	3.3	2.5	0.1	0.5
E.	8	5	5	1	1	0	3	1	1	19	10	0	1	2
flabellare	1.6	1.9	0.9	0.04	0.4		0.1	0.1	0.4	1.7	2.5		0.01	0.5

TABLE 4. (*cont.*)

	July '67	July '67	Nov '67	Apr '68	Sept '68	Oct '68	Apr '69	Sept '69	Apr '71	Sept '71	July '72	Sept '72	Sept '73	Sept '74
P.	10	35	0	10	4	18	9	12	50	35	35	100	35	1
notatus	4.1	11.0		15.9	2.6	12.2	17.3	13.8	16.3	5.9	5.4	15.0	6.7	0.3
N.	3	9	9	9	1	1	2	1	50	6	0	10	50	4
chrysocephalus	1.2	2.8	1.1	14.3	0.1	0.1	3.8	1.1	16.3	1.0		1.5	9.6	1.1
N.	35	50	40	10	6	0	1	1	40	100	100	75	200	255
spilopterus	14.3	15.8	4.8	15.8	3.9		1.9	1.1	13.0	16.9	15.4	11.3	38.5	60.2
N.	88	130	608	3	50	33	0	1	1	40	2	0	40	2
atherinoides	35.9	41.0	73.3	4.7	32.9	22.4		1.1	0.3	6.7	0.3		7.7	0.5
C.	1	2	7	1	1	1	0	2	3	4	4	15	2	4
anomalum	0.4	0.6	0.8	1.5	0.1	0.6		2.3	1.0	0.7	0.6	2.3	0.4	1.1
H.	17	37	14	0	39	15	0	6	0	250	200	150	20	40
nuchalis	6.9	15.1	1.7		25.7	10.2		6.9		42.2	30.7	22.6	3.9	10.7
E.	4	17	34	4	13	1	0	4	30	2	20	10	2	1
buccata	1.6	6.9	4.1	6.3	8.6	0.6		4.6	9.8	0.3	3.1	1.5	0.4	0.3
E.	15	3	26	1	5	18	10	7	15	15	50	30	40	6
blennioides	6.1	0.9	3.1	1.5	3.3	12.2	19.2	8.0	4.9	2.5	7.7	4.5	7.7	1.6

E. caeruleum	15 6.1	5 1.5	24 2.9	5 7.9	15 9.9	33 22.4	15 28.8	15 17.2	10 3.3	20 3.4	3 0.5	15 2.3	20 3.9	0
N. umbratilis	25 10.2	2 0.6	2 0.2	7 0.1	1 0.1	2 1.4	4 7.7	0	22 7.2	23 3.9	15 2.3	20 3.0	7 1.3	3 0.8
E. nigrum	3 1.2	0	8 1.0	0	0	6 4.1	1 1.9	9 10.3	35 11.4	6 1.0	60 9.2	75 11.3	10 1.9	19 5.1
P. mirabilis	5 2.0	9 2.8	1 0.1	2 3.2	4 2.6	1 0.6	5 9.6	3 3.4	3 1.0	3 0.5	6 0.9	1 0.2	0	0
S. atromaculatus	0	2 0.6	3 3.6	0	0	0	0	2 2.3	5 1.6	2 0.3	2 0.3	15 2.3	0	0
N. miurus	5 2.0	0	2 0.2	0	0	2 1.4	0	1 1.1	1 0.3	15 2.5	70 10.8	100 15.0	30 5.8	10 2.7
H. nigricans	4 1.6	1 0.3	0	0	4 2.6	0	0	9 10.3	3 1.0	15 2.5	15 2.3	20 3.0	15 2.9	10 2.7
N. stramineus	4 1.6	0	1 0.1	6 9.5	1 0.1	1 0.6	0	2 2.3	25 8.1	1 0.2	10 1.5	5 0.8	4 0.8	4 1.1
L. macrochirus	2 0.8	0	13 1.6	0	0	2 1.4	0	2 2.3	0	3 0.5	0	0	10 1.9	8 2.1
E. flabellare	0	1 0.3	6 0.7	1 1.5	0	10 6.8	1 1.9	1 1.1	8 2.6	10 1.7	0	3 0.5	10 1.9	6 1.6

Further indication of the changing nature of the fish-community is the lack of consistency of the most abundant species in the 28 collections. (More than 28 entries are recorded, since there were several cases of ties between two or three species as most abundant). If a major degree of consistency was maintained, one would expect the same or little change in the most abundant species between collections. *Notropis spilopterus* and *Pimephales* were classed as most abundant 7 times each, *Notropis atherinoides* 6, *Etheostoma caeruleum* 5, *Notropis chryso-Cephalus* and *Hybognathus nuchalis* 3 each, *Etheostoma blennioides* and *Ericymba buccata* 2 each, and *Campostoma anomalum* one. Thus, 9 different species were the most abundant fish (or in a tie for this) at least once during the study. *Notropis atherinoides* was most abundant 4 times in a row (summer and fall of 1967), while *Hybognathus nuchalis* was high three times in a row (between September 1971 and September 1972).

Some of the more important species are discussed below. To indicate seasonal variation, for each species four values are given, designating respectively early spring (April-May), summer (June-August), fall (September-October), and winter (November-December).

Pimephales notatus 32.3, 22.7, 48.4, 728.7

This was the most abundant species present, and was taken in all but one collection. It is interesting that the collection from which it was absent was of above average size (829 individuals taken). There were pronounced seasonal differences in this species, with the largest number being taken in fall and winter. However, within these time periods, there was much variation, particularly in November-December, which yielded the largest number of individuals in any one collection, 3317 in November 1966. This species comprised 62.1% of the sample. Just a year later, it was not taken at all, for reasons unknown. It seems noteworthy that two other species also declined markedly between these two collections, *N. chrysocephalus* and *N. spilopterus*. One individual of *N. atherinoides* was taken in November 1966, while 608 (73.3% of the sample) were taken in November, 1967.

Notropis chrysocephalus 19.0, 36.3, 16.5, 564.3

The second most abundant species over the entire study was *Notropis chrysocephalus*. For this species, November-December was the period of greatest abundance (range 9-1693), followed by June-August, April-May, and with September-October being the poorest (0-75). Its occurrence was erratic, with 15 being taken during November and May of 1962 and 1963, none in September 1963, and then 950 in December 1963. It declined in July and October 1964, but in December, 1963 were collected. Again in September 1966, 30 were taken. It would appear that this species was affected by seasonal factors, with late fall and early winter favoring concentrations of the species at the dam. Unknown factors played a major role, leading to erratic changes in populations.

Notropis spilopterus 12.8, 128.0, 74.1, 199.2

Again population highs occurred in early winter, while the low occurred in early spring. The second largest collection was in summer,

but seasonal variation was not as great in this species as in some others. This species appeared to be somewhat cyclic. It was taken at rates of 0 to 10 over the first four collections. Larger numbers were taken between July 1964 and November 1967, then dropped to 10, 6, 0, 1 and 1 between April 1968 and September 1969. Then numbers taken again increased and were rather high for all the rest of the collections.

Notropis atherinoides 1.0, 94.1, 25.0, 171.0

Again winter was the time of greatest numbers of individuals. Like *N. spilopterus*, this species also showed a long term cyclic turnover, but it was much more distinct. The first three collections yielded no *N. atherinoides*. Then in December 1963, 13 were taken, followed by continued increase through November, 1965, with the exception that in September, 1965, the catch was low. This was followed by low numbers in August and September 1966. Only 1 was taken in November 1966, followed by another period of highs. Thus it appeared that this species had less erratic population levels than some of the other species, that there was a weak seasonal affect, but that it appeared to be strongly affected by long-term changes in population levels.

Campostoma anomalum 1.0, 7.9, 20.5, 194.5

In this species, seasonal effects were pronounced, with greater numbers of fishes taken later in the season (Chi-square = 3027.9, 3 df). Individuals were taken in all collections but two of the early spring collections and usually in fairly low numbers. There were two very large collections (570 on 5 December 1963, and 542 on 3 November 1966) and two somewhat large collections (110 on 5 October, 1964, and 80 on 23 September 1963), but there was no general cyclic type pattern in the collection data for this species. Rather, the large collections occurred erratically, with large numbers of fish in schools, perhaps migratory.

Hybognathus nuchalis 0, 60.3, 50.3, 15.8

Unlike the species discussed previously, largest numbers of this species were taken in summer, followed by September-October. No silvery shiners were taken in early spring. There was some indication of long term population changes, but it was not strongly marked. Only two individuals were taken in the 6 collections through 5 October 1964. The species occurred at moderate levels in all collections but one through 24 October 1968. Only 6 individuals were taken in the next three collections (but two were in spring), then it occurred in its largest numbers in the three collections in 1972 and 1973, averaging 200 per collection, as compared to 18.8 in the other 25 collections. The biggest number taken in any other single collection during the study was 70 (3 August 1966).

Ericymba buccata. 8.5, 18.3, 16.7, 42.3

This species was found in all but two collections. Greatest numbers were taken in fall-winter, but numbers per collections during the other periods were not great. The silverjaw minnow was present throughout the study period, without showing pronounced increases or decreases although the numbers taken in the earlier 14 collections

averaged larger at 32.6 per collection, than the last 14 collections (10.1).

Etheostoma blennioides 26.5, 14.1, 14.7, 29.2

Populations of this species were highest in the spring, late fall and winter, and somewhat lower in summer and early fall, although the differences were not great. This is the only species that was taken in every collection (range of 1 to 80 individuals). There were no markedly large collections, nor no apparent rhythmic oscillations in numbers.

Etheostoma caeruleum 27.5, 5.9, 15.1, 26.2

The occurrence of this species in collections was very similar to that of *E. blennioides* in every respect (even the totals taken were quite close, 542 vs. 474).

Notropis umbratilis 9.5, 14.3, 14.2, 18.2

There was relatively little seasonal variation in this species, and the species occurred in nearly all collections (25). There may have been some long-term population changes, as slightly higher numbers were taken September 1963 through November 1966, and April 1971 through September 1972 than at other periods.

Etheostoma nigrum 9.0, 12.4, 15.7, 12.5

There were no exceedingly large collections, nor was there clear evidence of any rhythmic population fluctuations. The species was of regular occurrence being taken in 23 of the 28 collections. Catches of this species were quite similar during the four time periods, indicating little seasonal change in populations.

Phenacobius mirabilis 2.5, 4.1, 8.5, 36.5

This species generally occurred in low numbers and was taken in 23 of the 28 collections. However, in two consecutive collections, 23 September and 5 December 1963, 65 and 190 suckermouth minnows were taken. Apparently there was a buildup of the species that year, perhaps due to good environmental conditions for reproduction. Many more fish of this species were taken in winter than at other times.

Semotilus atromaculatus 1.3, 5.0, 10.1, 21.3

Semotilus atromaculatus was taken in increased numbers later in the season. This species was rather peculiar in its distribution throughout the collecting period. Creek chubs were taken in fairly good numbers and in most of the 13 collections from 1962 through 1966, but only 5 were taken in the 8 collections from July 1967 through April 1969. Small numbers were taken in the next five collections. The significance of these values is not understood.

Noturus miurus 0.3, 11.6, 15.6, 3.3

This species appeared to increase in abundance from spring through fall, then, contrary to many of the species, fell off drastically. However, these figures mean little because of the occurrence of two very large collections, one in July of 1970, and one in September of

about 100 individuals. This species was taken in low numbers in most collections through July of 1972, when about 70 were taken, then in September 1972 about 100 were taken, and by September of 1973 they had dropped off, and about 30 were taken. It is not known what caused the 1972 population increase.

The above discussion includes all fish taken in numbers of more than 200 during the study. Because of their small numbers, the remainder of the species will not be discussed.

Of the more important species, 8 reach their population highs in fall and winter (*P. notatus, N. chrysocephalus, N. spilopterus, N. atherinoides, C. anomalum, E. buccata, P. mirabilis* and *S. atromaculatus*. One, *H. nuchalis*, reached its high in summer, and the two darters, *E. blennioides* and *E. caeruleum* reached population highs in winter and spring.

Four species, *P. notatus, N. chrysocephalus, C. anomalum,* and *P. mirabilis* each had one rather pronounced population buildup during the study. These could have been the result of exceptionally favorable reproductive conditions one year, producing large year classes. Four species showed cyclic tendencies, *N. atherinoides* strongly, *N. spilopterus* less strongly, and *H. nuchalis* and *N. umbratilis* weakly. It is possible that the high population levels seen in these latter species, are simply two erratic type highs in close succession. Longer term data are needed to determine whether this pattern is recurrent.

The composition of the five larger collections (those in which more than 1000 individuals were taken) was examined to determine if one or a few species made up most of the individuals, and also if the two river species, *N. spilopterus* and *N. atherinoides* increased and decreased together. These collections occurred in December 1963, November 1964, June 1965, November 1965 and November 1966. *Notropis chrysocephalus* and *N. spilopterus* were each the most abundant species in two of these collections, while *P. notatus* was the most abundant in one. *Notropis spilopterus* comprised 44.3% of the fish in the June 1965 collection, while it was not even present in the December 1963 collection. *Notropis atherinoides* ranged from 0.1 to 23.4%. *Notropis spilopterus* and *N. atherinoides* showed some degree of consistency in the five collections, but not much over the 28 collections.

Impressive throughout these data was the lack of similarity between collections. It seems obvious that even in a stream in which environmental changes over a period of time are minimal, there may be extensive changes in the fish community. For this reason one should be cautious in using short term data to draw conclusions concerning the relationship of some variable, such as heat or a chemical additive to a community. Such changes may well be normal community changes such as those discussed which are in no way related to the variable of interest.