The Fish Populations of Big Walnut Creek

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Abstract

The fish population of six pools in a central Indiana stream were studied during the fall of 1965 and 1966. Data is presented on population estimates, standing crops, scale radius-total length relationships, length-weight relationships and average growth rates of important species as well as morphome try and bottom characteristics of the pools.

Catostomids dominated the fish population and comprised 50% to 90% of the total weight of the standing crop. Golden and black redhorse (*Moxostoma erythrurum* and *M. duquesnei*) were abundant throughout the stream. Silver and shorthead redhorse (*M. anisurum* and *M. breviceps*) were common in the pools below a low-head dam, while hog suckers (*Hypentelium nigricans*) were especially abundant above. Carpsuckers (*Carpiodes carpio, C. cyprinus* and *C. velifer*) were found in considerable numbers below the dam and sporadically above. From 5% to 28% of the total weight was contributed by centrarchids, primarily smallmouth bass (*Micropterus dolomieui*), longear sunfish (*Lepomis megelotis*) and rock bass (*Ambloplites rupestris*). Minnows generally totaled less than 5% except in the most shallow pool.

Carp (*Cyprinus carpio*), gizzard shad (*Dorosoma cepedianum*) and western silvery minnow (*Hybognathus nuchalis*) were restricted to the portion of the stream below the dam and made up 14% to 30% of the total weight of fish here.

Pools above the dam averaged approximately 365 pounds of fish per acre while those below averaged approximately 750 pounds per acre. The larger standing crop in the lower pools results mainly from the addition of carp and gizzard shad to the fish community and secondarly from the fact that these pools are slighly larger in surface area and considerably deeper.

Many species appear to vacate shallow areas and congregate in deep areas in late fall. The standing crop of fish in the deepest pool below the dam in mid-November of 1965 was estimated to be in excess of 3000 pounds per acre, while in October of 1966 it was estimated at 880 pounds per acre.

Introduction

This paper summarizes the results of a two-year study of the fishery resources of Big Walnut Creek near Greencastle, Indiana. The study was undertaken to gather preimpoundment data and to give insight into the fishery resources of Big Walnut Creek prior to the construction of a proposed multiple-purpose reservoir by the U. S. Army Corps of Engineers. Another objective of the study was to determine if the Greencastle waterworks dam (six-foot head) has had any influence on the upstream migration and distribution of fish in Big Walnut Creek.

Information was collected relating to the abundance and distribution of fish in the pools, age and growth relationships of the primary species, and data contributing to the population dynamics of stream fishes.

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Description of Study Area

Big Walnut Creek flows through agricultural bottomland with an average gradient of 5 to 10 feet per mile. The stream is from 30 feet to 80 feet wide and flows clear and sustained throughout the year.

Four pools were studied in the fall of 1965 and two additional stations were added in the fall of 1966. The stations are numbered in accordance to their relationship to the Greencastle waterworks dam: 1A—the first station above the dam, 1B—the first station below the dam, etc. All stations varied in depth, width, volume of water, and bottom composition and are believed to be representative of the major pool habitats in the study area (Table 1).

TABLE 1

Hydrologic parameters and bottom characteristics of the pool stations.

	Station					
Parameter	1A	2A	3A	4A	1B	2B
Pool length - m.	147.8	136.9	208.5	100.6	124.1	137.2
Average width - m.	10.9	7.9	15.4	14.1	15.7	15.4
Average depth - cm.	28.2	33.5	26.3	37.1	32.5	56.1
Volume - cubic m.	457.9	363.4	844.2	526.4	633.8	1,181.0
Area - acres	0.40	0.27	0.79	0.35	0.48	0.52
Sand - %	59.3	52.9	56.4	26.5	59.9	28.3
Mud - %	29.3	24.5	7.1	10.3	25.1	12.4
Gravel - %	4.3	14.7	29.5	45.6	5.9	49.6
Rock - %	7.1	7.8	7.1	17.7	9.1	9.7

Methods

Fish were captured by the use of a floating, 50-foot electric seine with 24-inch copper drop electrodes spaced at 28-inch intervals along the seine. Hand electrodes at each end of the seine were utilized for fringe species. The seine was powered by a portable 2-cycle, 7.8 amp., 115-volt AC generator rated at 900 watts and was a modification of one used by Larimore (10), originally described by Funk (4). It allowed a complete sweep of the stream except in a few wide parts of the pools. The stunned fish were picked up in dip nets and retained in a holding net for processing. As few as four persons were needed for the operation, but six to eight usually participated.

After a single run of the pool the fish collected were processed for length, weight, and scale samples. Total lengths were measured to the nearest millimeter, and weights were recorded to the nearest gram. Scales were removed from the suckers between the origin of the dorsal fin and the lateral line, while scales of the sunfish and bass were removed below the lateral line near the distal half of the pectoral fin.

Whenever possible the populations were estimated by the Petersen method, marking the fish by clipping a fin on one day and recapturing

the next. This sufficed for species populations which were abundant throughout the stream, but several species were abundant in some pools and scarce in others. Enough data was collected on the latter species to indicate a fairly consistent relationship of the number of individuals captured in one pass through the pools to the estimated population size. This "catchability" ratio was used to estimate the population size where populations were small and for minnows in one pool.

The scales of the suckers were mounted dry between two glass slides and read for age on a Bausch & Lomb Tri-Simplex Micro-Projector with maximum 40x magnification. Bass and sunfish scales were washed and impressed on plastic for projection.

As the redhorse increases in age the scale takes on a "shouldered" appearance, and the anterior margin becomes quite irregular (12). Because of this the scale measurements were taken on the dorsoventral axis instead of the conventional anterio-posterior scale axis. All scale measurements were recorded to the nearest millimeter under 20x magnification. Due to the time of capture, the distance from the last annulus to the margin of the scale was counted as a completed annular mark. In many instances the redhorse scales contained a disruption in the circuli midway between the focus and the first definite annulus. It was decided that it was probably due to a change in the feeding habits of the young redhorse in their first year of growth. No reference to this circulus disruption could be found in the available literature.

Scale data were processed on a 1620 IBM computer using a modification of Gerking's program (8). The programs computed the correlation coefficients and the regression line formula for the scale radius and the total length of the fish, length-weight relationships using the standard logarithmic method, and back-calculations of age and length relationships.

Fish Populations and Standing Crops

Fifty-two species were identified during the study (2). Most of these were species which contributed little to the overall standing crop, some because they normally inhabited riffles and only occasionally strayed into pools and others because they occurred in very low numbers. Typical and important pool residents, their estimated population size for each pool and their contribution to the total weight of fish in each pool are summarized in Tables 2 and 3.

Golden and black redhorse (*Moxostoma erythrurum* and *M. duquesnei*) are perhaps the most typical residents of the pools, comprising well over half of the standing crop of fish in pools above the dam and contributing substantially to those below. Black redhorse appear to be less abundant below the dam than above, while silver and shorthead redhorse (*Moxostoma anisurum* and *M. breviceps*) become abundant only below the dam. Hog suckers (*Hypentelium nigricans*) also are abundant residents, especially above the dam. All of these typical stream species, together with the other species of suckers and the carpsuckers, occupy the central part of the pools near the bottom.

TABLE 2

Estimated size of fish populations in the pools of Big Walnut Creek (* indicates that the population estimate is based on an average catchability ratio; — indicates that the species was not taken; + indicates that the species was taken, but population was not estimated).

Species	Year	1A	2A	3A	4A	1B	2B
Golden Redhorse	1965		207	343	217		1019
	1966	171	83	50	262	178	
Black Redhorse	1965		157	384	117		171
	1966	196	207	92	184	115	39
Silver Redhorse	1965		6*	4*	6		351
	1966	—	—	—	8*	24	41
Shorthead Redhorse	1965		2*	6*	10		264
	1966	—	*	—	—	—	10*
White Sucker	1965		4	12*	18		2*
	1966	10	4	80	16*	2*	2*
Spotted Sucker	1965		—	—	—		2*
	1966	3	8	—	2*	12	6*
Hog Sucker	1965		108	462	108		4*
	1966	72	75	95	224	49	13*
Carpsuckers	1965		—	2*	—		248
	1966	40	—	12	4*	46	98
Smallmouth Bass	1965		121	10	18*		12*
	1966	21	48	54	18*	22	20*
Rock Bass	1965		48	12*	3		15*
	1966	24	49	8*	20*	22*	16*
Longear Sunfish	1965		289	100*	70*		92
	1966	253	210	84*	56*	87	280
Bluegill Sunfish	1965		—	—	—		4*
	1966	4	—	—	4*	55	14*
Grass pickerel	1965		5*	—	—	—	—
	1966	2*	18	—	—	—	—
Gizzard Shad	1965		—	—	—		515
	1966	—	—	—	—	195	118
Carp	1965		—	—	—		72
	1966	—	—	—	—	12*	45
Striped Shiner	1965		96	612	210		12*
	1966	354	67	266	50*	56	+
Other minnows	1965		+	7000	+		+
	1966	+	+	5100	+	+	+

Shorthead redhorse and hog suckers were always located near the upstream riffles, while the others exhibited no pronounced preferences.

Another group of fishes was always found near the edges of pools and was especially abundant when cover in the form of tangled roots or fallen trees was present. Smallmouth bass (*Micropterus dolomieui*), rock bass (*Ambloplites rupestris*) and longear sunfish (*Lepomis megalotis*) were present in significant numbers in all stations. Grass pickerel (*Esox americanus vermiculatus*) joined this contingent in the upper part of Big Walnut Creek while carp (*Cyprinus carpio*), spotted bass (*Micropterus punctulatus*) and channel catfish (*Ictalurus punctatus*) were important edge species below the dam.

The importance of cover to these important sport fishes was illustrated by the changes that occurred in the smallmouth bass popula-

tion of one pool during the study. In the fall of 1965, pool 2A contained a number of fallen, partially-submerged trees, exposed roots, large boulders and undercut banks. It also supported approximately 120 smallmouth bass weighing in aggregate about 30 pounds. Spring floods removed some trees and also caused sediment accumulation behind those that remained. The population decreased to about 50 fish weighing 17 pounds by the fall of 1966. An intensive effort in May 1967 revealed that approximately nine bass weighing less than four pounds remained. Further deterioration of the habitat had occurred in the interim. The standing crop of rock bass remained stable at 7 pounds during the period, while that of longear sunfish dropped only slightly from 19 pounds in 1965 to 14 pounds in 1966 and 1967.

The low dam has been surprisingly effective in limiting the upstream migration of three species of fish. Carp (*Cyprinus carpio*), gizzard shad (*Dorosoma cepedianum*) and the silvery minnow (*Hybognathus nuchalis*) were plentiful below the dam but apparently absent above. All of the carp captured were large. Therefore, it seems likely that they do not reproduce in this part of the stream and that those that are present have migrated from farther downstream. The dam is probably not a perfect barrier, but is effective enough to prevent a significant carp population from being established above it. Gizzard shad and the silvery minnow were present much farther downstream 25 years ago (5) and have worked their way up to, but not beyond, the dam in the ensuing years.

The estimates of population size for the more abundant redhorse and the carpsuckers are quite reliable. An average of 50% of the estimated population of redhorse, carpsuckers and suckers (except hog suckers) was captured in any one pass through a pool. As mentioned before, a "catchability" ratio was used to arrive at estimates of less abundant populations. Hog suckers were probably less catchable (ratio $= 0.22$) because of their tendency to stay in riffles as well as pools. Smallmouth bass, gizzard shad and striped shiner (*Notropis chrysocephalus*) had averages of 0.35, while longear sunfish averaged 0.25. A ratio for minnows based on mark and recapture data for pool 3A in 1965 was used to arrive at the 1966 population estimate for this mixed group. This was the only pool studied that contained a large minnow population.

The total estimated quantity of fish in the pools varied greatly from one pool to another as might be expected and ranged from 91 to 1652 pounds per pool and from 134 to 3181 pounds per acre. The 1966 estimate for pool 4A is believed to be high because generator trouble postponed recaptures for two weeks and some marked fish did move out of the pool during this period. A more realistic estimate of the standing crop is probably 135 to 140 pounds per acre.

The other estimates are believed to be more accurate. Even the extremely high standing crop estimated in pool 2B during 1965 is believed to be fairly accurate, although the recapture rate was unusually low here for all species. This deep pool literally teemed with fish when visited on November 12 and 13, 1965. The standing crop was more

TABLE 3

Standing crops of fish in pounds per pool and pounds per acre (in parenthesis). A + indicates small, unestimated population, — indicates absence of species.

Species	Year	Station					
		1A	2A	3A	4A	1B	2B
Golden redhorse	1965		60(118)	55(70)	36(103)		336(646)
	1966	63(157)	25(93)	7(9)	64(180)	62(129)	98(192)
Black redhorse	1965		45(274)	48(61)	18(50)		56(108)
	1966	52(130)	58(216)	14(18)	29(81)	33(69)	18(35)
Silver redhorse	1965		7(26)	2(3)	1(3)		604(1161)
	1966	—	—	—	2(6)	15(30)	41(79)
Shorthead redhorse	1965		1(3)	3(3)	2(6)		103(198)
	1966	—	3(10)	—	—	—	4(8)
White sucker	1965		2(7)	2(2)	5(15)		1(1)
	1966	5(11)	2(6)	12(15)	7(19)	1(1)	1(1)
Spotted sucker	1965		—	—	—		1(1)
	1966	1(1)	2(6)	—	1(1)	6(12)	3(6)
Hog sucker	1965		21(78)	29(373)	15(43)		1(1)
	1966	22(55)	15(55)	18(23)	31(87)	12(23)	2(3)
Carpsucker	1965		—	1(1)	—		141(271)
	1966	16(40)	—	1(1)	1(1)	20(43)	58(112)

Smallmouth bass	1965		31(116)	4(5)	5(13)		7(13)
	1966	5(12)	17(65)	13(16)	9(25)	5(11)	8(15)
Rock bass	1965		7(27)	2(2)	1(1)		2(5)
	1966	4(10)	7(27)	1(1)	3(9)	3(6)	3(5)
Longear sunfish	1965		19(73)	4(6)	2(6)		2(5)
	1966	12(30)	14(50)	3(4)	2(5)	4(8)	15(30)
Bluegill sunfish	1965		—	—	—		1(1)
	1966	1(1)	—	—	1(1)	6(12)	1(2)
Grass pickerel	1965		1(3)	—	—		—
	1966	1(1)	3(11)	—	—	—	—
Gizzard shad	1965		—	—	—		195(375)
	1966	—	—	—	—	88(183)	64(123)
Carp	1965		—	—	—		205(394)
	1966	—	—	—	—	43(89)	140(269)
Striped shiner	1965		8(29)	11(14)	7(20)		1(1)
	1966	16(40)	5(20)	10(13)	3(8)	3(6)	1(1)
Other minnows	1965		+	38(48)	+		+
	1966	+	+	28(35)	+	+	+
Total	1965		202(731)	198(249)	91(260)		1652(3181)
	1966	196(488)	151(559)	106(134)	151(423)	300(622)	456(881)

typical, but still higher than any other pool, on October 14 and 15, 1966. Cold temperatures prior to the 1965 estimate are believed to have caused many species to abandon shallow areas for deeper areas. A small, shallow pool near pool 1B had been shocked in late September and was found to contain good populations of the usual species. When it was again shocked on November 19 and 20, 1965, it was almost devoid of fish. However, fish were concentrated in the very deepest part of a long pool just upstream and were absent in the more shallow water. This same phenomenon may explain the decrease of standing crop found in pool 3A in 1966 from the 1965 estimate. On October 21 and 22, 1966, this pool contained only very small golden and black redhorse. A movement of larger individuals of these species out of this shallow pool would explain the 53% reduction in total standing crop.

If the atypical estimates just discussed are omitted, the pools above the dam contain standing crops which average approximately 365 pounds per acre, while those below average 750 pounds per acre. Big Walnut Creek supports significantly more fish than comparable-sized streams elsewhere. Larimore and Smith (11) estimate that the streams of Champaign County, Illinois, support an average of 250 pounds per acre.

Growth Rates of Principle Species

The growth rates of six common stream fishes were determined using individuals of both sexes and data from both years. Golden redhorse and black redhorse were included in this part of the study because of their obvious importance in the stream community; smallmouth bass, rock bass and longear sunfish were selected because of their value to the angling community.

The relationship of body length to scale radius for these species is summarized in Table 4. The anterior scale measurement (x20) was used for all but the black and golden redhorse where an irregular anterior margin necessitated the use of the dorsolateral scale measurement. Separate relationships were initially established for each pool population of golden and black redhorse. Since the regression equations were essentially similar, the data were subsequently combined. In most cases the relationship approached a linear relationship closely enough to justify fitting by the least squares method.

TABLE 4

The relationship of magnified scale radius S in millimeters and total length L in millimeters.

Species	No.	Body — scale relationship	r^2
Golden redhorse	491	$L = 40.000 + 2.546\ S$	.874
black redhorse	301	$L = 38.184 + 3.119\ S$	.916
hog sucker	34	$L = 31.125 + 3.166\ S$	.871
rock bass	36	$L = 12.631 + 2.033\ S$	.936
longear sunfish	55	$L = 32.947 + 1.713\ S$	.454
smallmouth bass	66	$L = 44.051 + 3.126\ S$	.876

A summary of the results of the age and growth study is presented in Table 5. The growth rates of black and golden redhorse were first computed for individual stations. These growth rates were compared for significant differences by the t-test. Since there were no significant differences, all of the data was combined to obtain an overall growth rate for the entire population.

TABLE 5

Calculated mean total lengths and total length increments in millimeters for Big Walnut Creek in the Falls of 1965 and 1966.

Age class	Number of fish	Mean total length (mm)	Total length increment (mm)
	golden redhorse		
I	2	118.8	118.8
II	70	153.3	34.5
III	127	187.1	35.0
IV	113	222.1	33.8
V	133	259.3	37.2
VI	37	285.9	26.6
VII	7	319.2	33.3
VIII	2	369.7	50.5
	black redhorse		
I	0	130.5	130.5
II	69	168.5	38.0
III	145	212.0	43.5
IV	39	250.4	38.4
V	41	282.1	31.7
VI	7	320.2	38.1
VII	1	353.2	33.0
	hog suckers		
I	0	82.3	82.3
II	1	115.8	33.5
III	4	150.2	34.4
IV	18	187.0	36.8
V	8	232.6	45.6
VI	3	267.5	34.9
VII	1	284.4	16.9
	rock bass		
I	0	51.7	51.7
II	3	88.4	36.7
III	15	134.2	45.8
IV	12	154.6	30.4
V	3	200.7	36.1
VI	3	220.7	20.0
VII	1	246.5	25.8
VIII	1	256.6	10.1

TABLE 5—Continued

Age class	Number of fish	Mean total length (mm)	Total length increment (mm)
		smallmouth bass	
I	3	96.4	96.4
II	13	148.9	52.5
III	17	193.4	44.5
IV	21	235.4	42.0
V	9	278.1	42.7
VI	1	325.5	47.4
VII	1	355.8	30.3
		longear sunfish	
I	0	60.8	60.8
II	0	86.8	26.0
III	18	106.1	19.3
IV	25	117.2	11.1
V	12	121.0	3.8

The growth rate of golden redhorse appears to be less than that reported for this species in the Des Moines River (12), in Ohio streams (14) and in the Neosho River in Kansas (3). Excellent growth occurs during the first year, but thereafter a nearly linear growth pattern is exhibited. Black redhorse grow faster than golden redhorse, but the basic pattern is smilar. No growth rates for this species were found in the literature with which to compare these results. The growth rate of rock bass is somewhat better in Big Walnut Creek than in Richland Creek, Indiana (7), but is less than in the lakes of northern Indiana (9). The growth of longear sunfish compares favorably to that in Richland Creek (7) and in the northern lakes (9). The hog sucker grows at a rate comparable with those in New York streams (13). Smallmouth bass grow less well here than in streams of Michigan (1) even though the food supply seems abundant and the growing season is longer.

Length-weight relationships were computed for all species (Table 6) studied without regard to sex, state of maturity, or time and year of collection. All specimens were measured for total length to the nearest millimeter and weighed to the nearest gram. The lengths and weights were fitted logarithmically to the formula: $\log W = \log c + n \log L$ where W = weight, L = length and c and n are constants.

Discussion

Big Walnut Creek has a varied and abundant fish population. Dif ferences in the species composition of the pools are not great, although the low-head dam has been influential as a barrier in limiting carp, gizzard shad and silvery minnow to the downstream pools. The two upper stations provided habitat favorable to some species not found downstream, namely, grass pickerel, creek chubsucker and, incidentally,

TABLE 6

Logarithmic regression equations of weight (W) in grams on length (L) in millimeters for the important species in Big Walnut Creek.

Species	Number	Equation	r^2
Golden redhorse	491	Log W = 1.6786 + .3242 Log L	.95364
Black redhorse	301	Log W = 1.6846 + .3325 Log L	.97063
Hog suckers	34	Log W = 1.6632 + .3294 Log L	.98781
Rock bass	36	Log W = 1.6076 + .3192 Log L	.98898
Smallmouth bass	66	Log W = 1.6674 + .3184 Log L	.93107
Longear sunfish	55	Log W = 1.6639 + .2675 Log L	.81777

the mudpuppy *Necturus maculosus*. The stream above the dam is dominated by the sucker family (Catostomidae) which comprise from 70% to nearly 90% of the total weight of the standing crop. The sunfish family (Centrarchidae) constituted from 5% to 28% of the total weight. Minnows contributed less than 10% except in the most shallow pool where they made up approximately 30% of the total weight.

Catostomids were equally abundant below the dam but, because of the addition of carp and gizzard shad, comprised only about 50% of the standing crop. Reduced contributions from black redhorse and hog suckers were more than compensated for by increases in silver redhorse and three species of carpsuckers (*Carpiodes, carpio, C. cyprinus*, and *C. velifer*). Gizzard shad and carp each comprised approximately 15% to 30%, while centrachids made up only about 6% of the total weight.

Relationships of the total standing crop with various morphometric parameters are poorly developed. Gerking (6) studied the fish populations of six small pools in four different streams in Indiana and found significant positive correlations only between the total weight of fish present and (*1*) the area of the two-foot contour and (*2*) the volume of water within the two-foot contour. In general, deep pools supported greater and shallow pools smaller standing crops, but the addition of carp and gizzard shad to the fish populations downstream appears to have a positive effect on the total weight of fish supported. The number of pools studied is insufficient to draw general conclusions, but an indication of the effect is suggested by comparing pool 1B with the average of the upstream pools. The average "A" pool contained approximately 165 pounds of fish and 548 m^3 of water with a surface area of 0.45 acres and an average depth of 12.2 inches. Pool 1B had a volume of 634 m^3, a surface area of .48 acres and an average depth of 12.8 inches. It also supported approximately 300 pounds of fish, 170 pounds of which were the same species found upstream and 130 pounds of which were carp and gizzard shad. This single comparison suggests that carp and gizzard shad have not seriously affected the other species. The shad would be expected to compete only slightly with other species, feeding as they do by straining microalgae from the mud and water. Carp, however, are extremely efficient feeders on bottom fauna and

probably compete with suckers, redhorse and carpsuckers for food. Any competition for food might be reflected by lower growth rates of the latter species, however, growth rates above and below the dam of the main species are essentially similar.

Summary

1. The fish populations of six pools in Big Walnut Creek were studied during fall of 1965 and 1966. Two were located below a low-head dam near Greencastle, Indiana and four above.

2. All fish were collected with an electric seine powered by a 950 watt, 115 volt generator. One complete pass through the pool was made on each of two successive days. Populations were estimated using the Petersen method. The ratio of fish captured on any one pass to the estimated population varied according to species: carpsuckers, redhorse and most suckers averaged 0.50; smallmouth bass, gizzard shad and striped shiners averaged 0.35; longear sunfish averaged 0.25; and hog suckers averaged 0.22.

3. Scales were removed from important species and used to estimate growth rates. Golden and black redhorse grow rapidly the first year, reaching total lengths of 119 and 130mm. respectively. Growth thereafter is nearly linear at 33 and 37 mm. per year respectively. Longear sunfish, rock bass and hog suckers grew at rates comparable to those found for these species in other streams in the east and midwest, while smallmouth bass grew more slowly.

4. Members of the sucker family predominated in the fish populations, comprising 50% to 90% of the total weight of the standing crop. Centrarchids contributed 5% to 28%, while minnows generally totaled less than 5% except in the most shallow pool where they made up approximately 30%.

5. Carp, gizzard shad and the silvery minnow were restricted to the portion of Big Walnut Creek below the dam. Carp and gizzard shad comprised from 14% to 30% of the total weight of fish in the two pools below the dam.

6. Pools above the dam averaged approximately 365 pounds of fish per acre while those below averaged 750 pounds per acre. The larger standing crop in the lower pools results mainly from the addition of carp and gizzard shad to the fish community and secondarily from the fact that these pools are slightly larger in surface area and considerably deeper.

7. Many species vacate shallow areas and congregate in deep areas in late fall.

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