pounds per acre at the time of the last treatment. Lake Trafford (unpublished) also has had large reductions resulting from three treatments. Those lakes which were treated only once have had a rapid recovery of their shad population.

Whether it is necessary to stock bass following the poisoning or if those present in the lake will reproduce heavily enough to cause a satisfactory increase has not been determined. Providing conditions warranted it would seem desirable to stock at a rate of 200 bass per acre (Swingle, 1953).

Continuing studies will provide answers to several questions arising from the past work. To date the technique has been of value to improvement of sport fishing in some Florida lakes.

ACKNOWLEDGMENTS

The author wishes to extend thanks to Harold Moody and the other members of the Florida Fish Management Division for their participation in the selective poisoning program. These studies would not have been conducted without the Dingell-Johnson Federal Aid to States Fisheries programs. Photographs were supplied by members of the Commissions Information Division.

REFERENCES

Berry, Frederick H. 1957. Age and Growth of the Gizzard Shad (*Dorosoma lacepedi*) (Lesueur), in Lake Newnan, Florida. Proceedings of the 11th Annual Conference Southeastern Association of Game and Fish Commissioners.

Huish, Melvin T. 1957. Studies of Gizzard Shad Reduction at Lake Beulah, Florida. Proceedings of the 11th Annual Conference Southeastern Association of Game and Fish Commissioners.

Swingle, H. S., E. E. Prather and J. M. Lawrence 1953. Partial Poisoning of Overcrowded Fish Populations. Circular No. 113, Agriculture Experiment Station, Ala. Polytechnic Institute.

APPRAISAL AND MANAGEMENT RECOMMENDATIONS RESULTING FROM A THREE-YEAR COMPARATIVE FISHERY STUDY OF LAKE CATHERINE, LAKE HAMILTON AND LAKE OUACHITA, ARKANSAS

By JAMES STEVENSON, *Little Rock University*
Little Rock, Arkansas

and

ANDREW H. HULSEY, *Arkansas Game and Fish Commission*
Lonoke, Arkansas

ABSTRACT

A pattern of high original reservoir productivity followed by gradual decline (in terms of angling success and desirable fish production) has been evidenced in a chain of lakes, of different ages, on the Ouachita River, Arkansas. Lake Catherine, formed in 1923, consists of 3,000 acres; Lake Hamilton, created in 1931, consists of 7,200 acres, and Lake Ouachita, impounded in 1953, covers 40,000 acres. A comprehensive fishery study was conducted during the summers of 1955, 1956 and 1957 to investigate and compare the fishery resources of these lakes and formulate management plans.

Comparison of limnological data indicated that the physical-chemical factors of the water of the three lakes were normal and, in fact, appeared to be optimum for good fish production. Fertility, as determined by plankton collections and

bottom fauna studies, was greater in Lake Catherine and Lake Hamilton than in Lake Ouachita. Fish population sampling, with seines, nets and rotenone, revealed that the standing crop of fishes in the older lakes, measured in pounds per acre, exceeded the crop in Lake Ouachita. The ratio of gizzard shad [1] and freshwater drum to game fish was considerably higher in the older lakes. The unbalanced and denser fish populations were reflected in slow growing sport fishes of smaller average size and lower fisherman success.

Management recommendations deal primarily with Lake Catherine and Lake Hamilton since fishing success remains relatively high on Lake Ouachita. Shad and drum removals, with rotenone, are proposed on Lakes Catherine and Hamilton, followed by a heavy stocking of yearling and fingerling predator game fish from the state hatcheries. It is recommended that smallmouth black bass and yellow pikeperch (walleyed pike) be stocked to supplement formerly substantial populations; also, an experimental stocking of rainbow trout be made in the headwaters of Lake Hamilton (tailwater of Blakely Mountain Dam). A maximum harvest of all fishes in all lakes, including the legalized use of gill and trammel nets for commercial fish, is encouraged. Fall and winter drawdowns are recommended to aid in maintaining balanced populations. Water levels should be held steady from May 1st to June 1st each year.

Several of the management recommendations have already been carried to completion, and it is believed all will eventually be applied to these lakes, resulting in improved fishing success.

INTRODUCTION

The chain of lakes on the Ouachita River, in West-Central Arkansas, offers one of the best fishing and recreational spots in the nation. Lake Catherine, formed in 1923, covers 3,000 acres and provides 80 miles of shoreline. Lake Hamilton, created in 1931, is Arkansas' most highly developed lake. It consists of 7,200 acres and has 170 miles of shoreline. Lake Ouachita, impounded in 1953, is the newest and largest lake. It covers 40,000 acres and has 700 miles of shoreline. Lake Ouachita is Arkansas' largest lake located entirely within the state's boundary lines. Here in three counties, with the city of Hot Springs as a focal point, exist 50,200 acres of water and 950 miles of shoreline available to sportsmen.

The pattern of high original reservoir productivity followed by gradual decline (in terms of angling success and desirable fish production) has been evidenced in these lakes. Reports from residents and fishermen on Lake Catherine have indicated that fishing was excellent for the first few years following impoundment, but has declined in recent years. Many believe that the same course is true in Lake Hamilton. On the other hand, Lake Ouachita, since it has been impounded, has attracted thousands of fishermen as a result of the angling success that can be had in this new lake.

An unusual opportunity exists to study factors pertaining to fish production and fishing success in these three lakes of different ages, all located in the same watershed. This study was designed to provide "new lake" data for comparison with "old lake" findings, and to seek preventive and corrective solutions to the problem of decreasing angling returns. In accordance with this objective, a work plan was outlined in which studies might be conducted during the summers over a period of three years at the end of which time, recommendations for management proposals would be made. The present investigation was begun in June, 1955, and was financed by the Federal Aid to Sport Fish Restoration Program (D. J. Program); Arkansas' D. J. Project F-5-R.

The main objectives of this comparative fishery study were as follows:

1. To provide information on the physical and chemical features of Lake Catherine, Lake Hamilton and Lake Ouachita, located in Hot Springs, Garland and Montgomery Counties, Arkansas.
2. To determine the composition of fish populations with respect to abundance of game and non-game species.

[1] Names of fish used are the accepted common names as listed in American Fisheries Society, Special Publication No. 1, 1948.

3. To gather information on distribution, reproduction, age and growth of important game fish species.
4. To formulate a plan of utilization of all fish in the lakes with emphasis on management plans to improve sport fishing.
5. To learn more of the changes occurring in large impoundments with age, that often result in a decline of desirable fish production, and to formulate plans to offset this decline.

DESCRIPTION OF LAKES

The Ouachita River rises in Polk County, Arkansas, and flows in a general southeasterly direction through Arkansas and Louisiana. It is joined by the Tensas and Little River at Jonesville, Louisiana, below which place it is called the Black River. The Black River continues flowing south and enters the Red River 34 miles above its mouth. The Ouachita River is about 500 miles long and the Black River 57 miles long, a combined length of about 557 miles.

Remmel Dam (the oldest), which forms Lake Catherine, is located at about mile 450 and Carpenter Dam, impounding Lake Hamilton, at mile 461. Blakely Mountain Dam (the newest), forming Lake Ouachita, is located at approximately mile 480. During certain high water periods, backwater from the downstream lake reaches to, or near, the control structure of the upstream lake. At maximum power pool storage level, Lake Ouachita extends upstream to about mile 532; therefore, it can be considered that the series of lakes extend from mile 450 to about mile 532, or a total of 82 miles.

Lake Catherine, formed by Remmel Dam, is located in Hot Spring and Garland Counties. The dam was finished in 1923 by the Arkansas Power and Light Company, and the lake filled the same year. It was built primarily for hydro-electric power and recretational purposes. The installed hydro-electric capacity is approximately 10,000 kilowatts. Along the shores are a number of permanent residences, summer cottages, youth camps, a State Park, several public boat landings and a large steam generation plant which obtains its cooling water from the lake. Prior to filling, the lake area was cleared of timber and all was burned or removed. The top of the gates is at elevation 305 ft. m. s. l. (feet, mean sea level). On occasional floods, the lake elevation at the dam sometimes gets as high as 309. This lake is subject to a drawdown of 15 feet below 305, although it is seldom drawn that low. At 305, the area of the lake is approximately 3,000 acres.

Lake Hamilton, formed by Carpenter Dam, eleven miles above Remmel Dam, lies entirely in Garland County. Construction of the dam was completed in 1930 by the Arkansas Power and Light Company and the lake filled in 1931. Its shoreline is well developed with many tourist resort accommodations, permanent and summer residences, seaplane bases, large marine service facilities and public boat landings. It is the site of one of the State Fish Hatcheries. Carpenter Dam has two power units of 28,000 kilowatts each, or a total installed capacity of 56,000 kilowatts. The top of the gates at the dam is at elevation 400. On occasional heavy floods, the water level at the dam has been at elevation 403. The lake is subject to drawdown to 370, however, in the past several years, it has not been lowered below 389. At 400, the lake has a surface area of about 7,200 acres. All timber was removed or destroyed from 370 to above 400. For that area below 370, only such timber as would reach above that elevation was cut except such as may have been used for lumber. Much of it was felled and fired without piling for burning. This left many tree trunks which were tied down to stumps or other objects. When the lake was partially filled, branches protruding above the water were cut off from boats.

Blakely Mountain Dam is located at the head of Lake Hamilton, about ten miles northwest of Hot Springs. Lake Ouachita, created by this dam, lies in Garland and Montgomery counties. The dam was completed and Lake Ouachita began filling in late 1952. The minimum power pool storage is at elevation 535 with maximum power pool storage at 578. The maximum flood control pool storage is at 592. At 578, the lake covers an approximate area of 40,000 acres. Blakely Mountain Dam was constructed by the U. S. Army Corps of Engineers for flood control, hydro-electric power, recreational and other public benefits. The generating power capacity consists of two units with a total capacity of

75,000 kilowatts. At the present time, there are ten commercial boat docks on the lake shore that have been leased and are in operation as recreational and boat rental sites, and there are nine other public access areas with camping and boat launching facilities. Considerable merchantable timber and brush were removed from the impounded area, however, in many of the bays along the northern side, and in a few areas on the southern side of the lake, timber was left standing. Boat lanes were cut through these uncleared regions.

Reference to the map shows these three lakes in series on the Ouachita River.

PROCEDURE AND RESULTS

The map shows the location of areas used for conducting various tests. These stations were selected from the standpoint of their being representative of a large area and accessible to working crews. Six stations were located on Lake Catherine, eight on Lake Hamilton and seven on Lake Ouachita. Most of the stations were coves off the main channel on the north and south sides of the lakes. One station in each lake was established over the channel where physical-chemical tests were made at various depths. Collected data were recorded according to station number.

Analysis of hydrogen-ion concentration, phenolphthalein alkalinity, methyl orange alkalinity, dissolved oxygen and free carbon dioxide, along with temperature readings, were made once a month at each station. Two tests, one at two feet and one at ten feet in Lakes Catherine and Hamilton, and at two feet and twenty feet in Lake Ouachita, were made in each of the cove stations. Samples were collected every ten feet in the channel. A Hellige Comparator was used for determination of hydrogen-ion concentrations. Dissolved oxygen was determined by the unmodified Winkler method. Temperature readings were taken with an H-B reversing thermometer. Samples of bottom soil were collected and sent to the University of Arkansas Agricultural Experiment Station for mineral nutrient determinations.

Hydrogen-ion concentration, alkalinity and free carbon dioxide content of the three lakes remained well within the limits of toleration for good fish habitat. Dissolved oxygen diminished in most cases as the depth increased. Thermal and chemical stratification was observed in all lakes during the summers of 1955 and 1956. In 1957, density currents were present in Lakes Hamilton and Catherine as a result of established continual generation at Blakely Mountain Dam. Particular attention was given to possible trout habitat in the tailwaters below Blakely Mountain Dam and Carpenter Dam. Weekly tests during the summer of 1957 indicated that about five miles of the tailwater below Blakely Mountain Dam was suitable for trout.

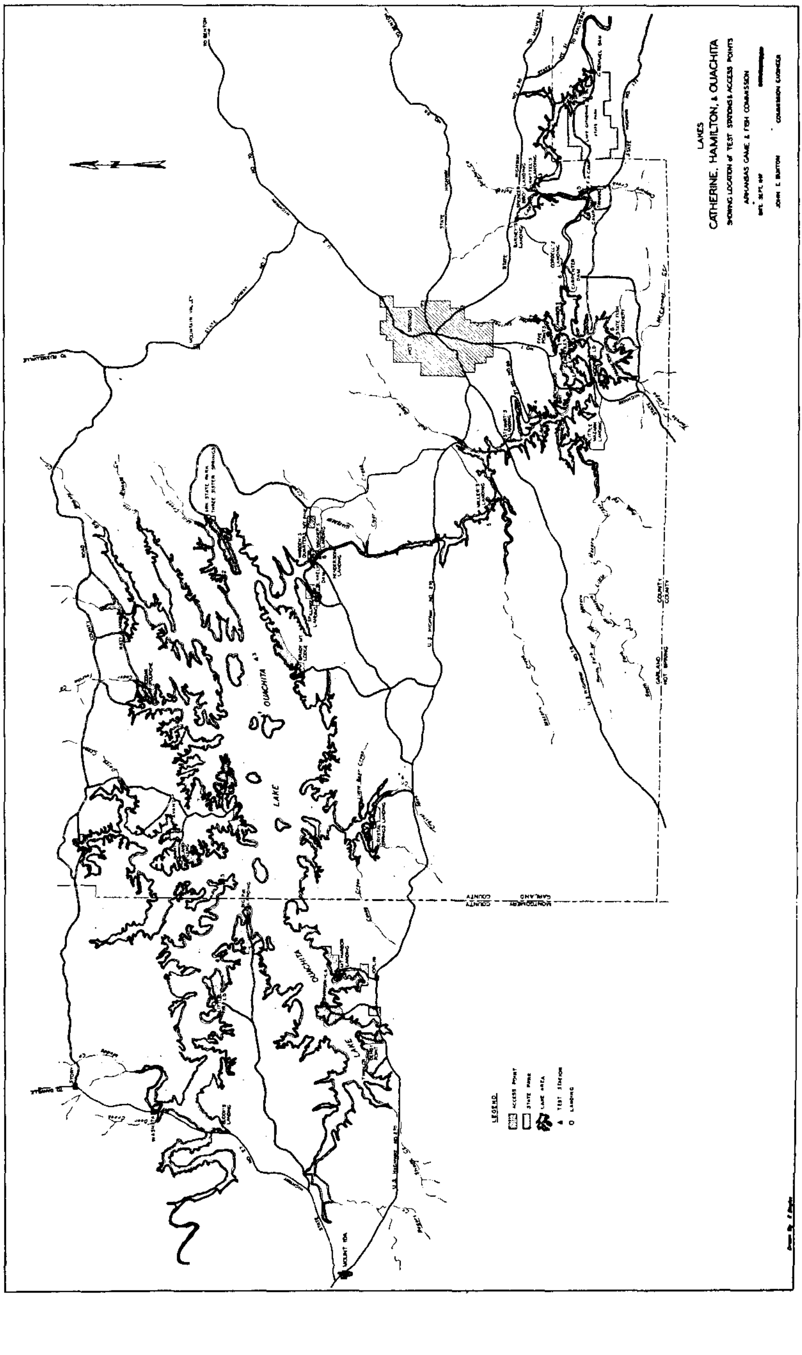
Plankton collections were made at three stations on each lake once a month. Collections were obtained by vertical hauls of a six-inch diameter mouth net of No. 6 bar-mesh cloth through the upper ten feet of water. Samples were preserved in ten percent formalin solutions and later centrifuged to obtain volumetric comparisons.

The standing crop of plankton was the greatest in Lake Catherine, the oldest lake, followed by that in Lake Hamilton. The unit volume of plankton in Lake Ouachita, the newest lake, increased in 1957 over that collected in either of the previous years.

An Ekman Dredge was used to take bottom samples at three stations on each lake once a month. From four to eight samples were collected at each station, however, the number of stations checked might limit conclusions as to the productivity of the entire lake. More organisms were found per sample in the older lakes. Chironomids comprised over 98 percent of all bottom organisms collected.

Twenty and forty-foot ¼-inch bar-mesh seines were used in selected areas to analyze the fish population from degree of success of reproduction of different species. Seining was done during late June and July. Fish collected were recorded as to species and grouped as predators and non-predators. The ratio of predators to non-predators by numbers was taken as a basis for comparing species abundance.

Higher percentages of young-of-the-year predators were found in Lake Ouachita than in the other lakes. Largemouth black bass were present in relative


LAKES
CATHERINE, HAMILTON, & OUACHITA
SHOWING LOCATION of TEST STATIONS & ACCESS POINTS
ARKANSAS GAME & FISH COMMISSION
JOHN E. BURTON
COMMISSION ENGINEER
OUACHITA
LAKE
LEGEND

abundance every year. In 1955, a good collection of young black crappie was made but fewer numbers were found in 1956. In 1957, a late spawn of crappie was observed but it was believed that their chance for escape from predation was small. The ratio of non-predators to predators was considerably higher in Lakes Catherine and Hamilton than in Lake Ouachita. Most of the non-predators in Lake Ouachita consisted of sunfish and gizzard shad. This ratio changed little over the three years.

Sets of gill nets, trammel nets and hoop nets were made in each lake in an effort to sample the fish population and learn the effectiveness and selectivity of different mesh nets in capturing fish. Netting operations were somewhat disappointing possibly because the nets were set during the summer when fish movement was at a minimum. Nevertheless, the number of game fish in relation to rough fish captured was insignificant and it appeared that commercial fish could be harvested more extensively in these lakes without detriment to the sport fish population.

Fish population sampling with rotenone was conducted at from four to six stations on each lake every summer. Areas at stations used for sampling ranged in size from one-half to ten acres in size. The schedule was set up so that each lake was sampled during a different month each summer. One week each month was set aside for rotenone population studies.

Tables I, II and III give the total composite fish collection from the three years' sampling in each lake. ,

The dominant species of fish, by weight, collected in Lake Catherine were gizzard shad and drum. Gizzard shad comprised approximately 56 percent and drum 19 percent, or together, 75 percent of the population by weight. In Lake Hamilton, 50 percent were gizzard shad and 21 percent drum, making a total of 71 percent by weight of the sampled population shad and drum. The gizzard shad population in Lake Ouachita consisted of 48 percent, by weight, of the total, and only three drum were collected.

By numbers, sunfish, of various sizes and species, comprised the highest percentage in all lakes. Seventy-nine percent in Lake Catherine, 59 percent in Lake Hamilton and 85 percent of the population in Lake Ouachita consisted of sunfish.

TABLE I

TOTAL COMPOSITE FISH COLLECTION WITH ROTENONE FROM LAKE CATHERINE DURING JUNE, JULY AND AUGUST OF 1955, 1956 AND 1957, RESPECTIVELY

Species	*No. of Fish in Group*	*Wt. (Pounds)*	*Percent of Number*	*Weight*
Largemouth Black Bass, Adult	130	73.7	0.10	1.53
Largemouth Black Bass, #5-8	285	42.7	0.30	0.86
Largemouth Black Bass, Young	1,295	13.1	1.20	0.27
Spotted Black Bass, Adult	7	3.0	. . .	0.06
Spotted Black Bass, #5-8	33	4.7	0.02	0.10
Spotted Black Bass, Young	192	1.5	0.20	0.03
White Bass, Adult	7	2.9	. . .	0.06
White Bass, #5-8	0	0.0	. . .	. . .
White Bass, Young	31	.6	0.03	. . .
White Crappie, Adult	31	12.7	0.03	0.26
White Crappie, Int.	20	2.7	0.02	0.06
Black Crappie, Adult	43	14.8	0.04	0.30
Black Crappie, Int.	129	16.3	0.10	0.34
Black Crappie, Young	1,135	6.4	1.00	0.13
Channel Catfish, Adult	92	112.5	0.08	2.50
Channel Catfish, Int.	4	1.1	. . .	. . .
Flathead Catfish, Adult	8	9.9	. . .	0.20
Spotted Gar, Adult	36	28.3	0.03	0.57
Spotted Gar, Int.	8	.9	. . .	. . .
Spotted Gar, Young	6	.1	. . .	. . .
Longnose Gar, Young	3	.2	. . .	. . .
PREDATOR POPULATION	3,495	358.1	3.15	7.4

TABLE I—*Continued*

TOTAL COMPOSITE FISH COLLECTION WITH ROTENONE FROM LAKE CATHERINE DURING JUNE, JULY AND AUGUST OF 1955, 1956 AND 1957, RESPECTIVELY

Species	*No. of Fish in Group*	*Wt. (Pounds)*	*Percent of Number*	*Weight*
Bluegill Sunfish, Adult	1,594	251.2	1.44	5.21
Bluegill Sunfish, Int.	4,158	94.2	3.75	1.95
Longear Sunfish, Adult	630	67.7	0.57	1.40
Longear Sunfish, Int.	1,513	139.9	1.36	2.90
Redear Sunfish, Adult	364	103.0	0.33	2.14
Redear Sunfish, Int.	360	15.3	0.32	0.32
Green Sunfish, Adult	70	8.1	0.06	0.17
Green Sunfish, Int.	382	9.1	0.34	0.19
Warmouth, Adult	198	50.8	0.18	1.05
Warmouth, Int.	769	23.3	0.69	0.48
Young Sunfish	77,341	82.5	69.80	1.71
Yellow Bullhead, Adult	35	15.5	0.03	0.32
Yellow Bullhead, Int.	49	2.0	0.04	0.04
Spotted Sucker, Adult	7	6.2	. . .	0.13
Spotted Sucker, Int.	1	.1	. . .	. . .
Redhorse (Suckers), Adult	29	38.0	0.03	0.79
Redhorse (Suckers), Int.	6	1.3	. . .	0.03
Redhorse (Suckers), Young	3	. . .	. . .	. . .
Freshwater Drum, Adult	997	715.7	0.90	14.84
Freshwater Drum, Int.	502	208.4	0.45	4.32
Freshwater Drum, Young	27	.2	0.02	. . .
EDIBLE FORAGE FISH	89,036	1,732.5	80.32	35.9
Gizzard Shad, Adult	10,437	2,438.3	9.42	50.54
Gizzard Shad, Int.	3,271	283.5	2.95	5.87
Gizzard Shad, Young	487	.5	0.44	. . .
Madtoms	75	.4	0.08	. . .
Logperch	381	5.0	0.34	0.10
Blackstripe Topminnows	52	.3	0.05	. . .
Brooksilversides	3,183	5.0	2.84	0.10
Native Minnows	429	.8	0.39	. . .
NON-EDIBLE FORAGE FISH	18,315	2,733.8	16.53	56.7
NON-PREDATOR POPULATION	107,351	4,466.3	96.85	92.6
TOTAL POPULATION	110,846	4,824.4	100.00	100.00

Predator–Non-Predator Ratio by Weight = 1 :12.5.

Area Sampled: 21.85 Acres.

Rotenone Used: 53.5 lbs. of 8.2%; 137 lbs. of 4.4%; 25 gals. of Pro-Noxfish.

TABLE II

TOTAL COMPOSITE FISH COLLECTION WITH ROTENONE FROM LAKE HAMILTON DURING JUNE, JULY AND AUGUST OF 1957, 1955 AND 1956, RESPECTIVELY

Species	*No. of Fish in Group*	*Wt. (Pounds)*	*Percent of Number*	*Weight*
Largemouth Black Bass, Adult	64	49.8	0.10	1.43
Largemouth Black Bass, Int.	204	31.0	0.33	0.89
Largemouth Black Bass, Young	6,342	45.1	10.12	1.30
Spotted Black Bass, Adult	15	8.0	0.03	0.23
Spotted Black Bass, Int.	43	3.4	0.06	0.10
Spotted Black Bass, Young	397	6.7	0.63	0.19
Smallmouth Black Bass, Young	7	.05	. . .	. . .
White Bass, Adult	5	3.1	. . .	0.09
White Bass, Int.	11	1.1	0.02	0.03
Black Crappie, Adult	62	26.4	0.10	0.76
Black Crappie, Int.	152	20.8	0.24	0.60
Black Crappie, Young	1,622	7.5	2.59	0.22
White Crappie, Adult	13	6.6	0.02	0.19
White Crappie, Int.	25	3.5	0.04	0.10
White Crappie, Young	375	2.15	0.60	0.06
Channel Catfish, Adult	42	84.2	0.07	2.43
Channel Catfish, Int.	20	6.6	0.03	0.19
Channel Catfish, Young	15	0.6	0.02	0.02
Flathead Catfish, Adult	7	24.7	. . .	0.71
Flathead Catfish, Young	2	.01	. . .	. . .
Spotted Gar, Adult	10	10.9	0.02	0.31
Spotted Gar, Int.	6	2.1	. . .	0.06
Spotted Gar, Young	2	0.1	. . .	. . .
PREDATOR POPULATION	9,441	344.3	15.07	9.91
Bluegill Sunfish, Adult	1,143	207.7	1.82	5.98
Bluegill Sunfish, Int.	2,080	56.9	3.32	1.64
Longear Sunfish, Adult	508	68.1	0.81	1.96
Longear Sunfish, Int.	1,788	45.4	2.85	1.56
Redear Sunfish, Adult	219	57.8	0.35	1.66
Redear Sunfish, Int.	653	10.7	1.04	0.31
Green Sunfish, Adult	37	5.7	0.06	0.16
Green Sunfish, Int.	358	10.3	0.57	0.31
Warmouth, Adult	40	8.0	0.06	0.23
Warmouth, Int.	64	2.8	0.10	0.08
Orangespotted Sunfish, Int.	1	0.1	. . .	0.02
Young Sunfish	29,990	113.5	47.85	3.27
Freshwater Drum, Adult	759	689.2	1.21	19.85
Freshwater Drum, Int.	106	55.6	0.17	1.60
Freshwater Drum, Young	64	1.1	0.10	0.03
Redhorse (Sucker), Adult	20	23.8	0.03	0.69
Spotted Sucker, Adult	26	24.8	0.04	0.71
Spotted Sucker, Young	33	0.3	0.05	0.01
Yellow Bullhead, Adult	1	0.2	. . .	0.01
Yellow Bullhead, Young	7	0.2	. . .	0.01
Black Bullhead, Young	2	0.1	. . .	. . .
EDIBLE FORAGE FISH	37,898	1,382.3	60.47	39.81

TABLE II—*Continued*

TOTAL COMPOSITE FISH COLLECTION WITH ROTENONE FROM LAKE HAMILTON DURING JUNE, JULY AND AUGUST OF 1957, 1955 AND 1956, RESPECTIVELY

Species	*No. of Fish in Group*	*Wt. (Pounds)*	*Percent of Number*	*Weight*
Gizzard Shad, Adult	7,012	1,676.2	11.19	48.27
Gizzard Shad, Int.	726	21.4	1.16	0.62
Gizzard Shad, Young	3,605	33.9	5.75	1.00
Logperch	339	4.3	0.54	0.12
Madtoms	34	0.2	0.05	0.01
Minnows	3,614	9.9	5.77	0.29
NON-EDIBLE FORAGE FISH	15,330	1,745.9	24.46	50.28
NON-PREDATOR POPULATION	53,228	3,128.2	84.93	90.09
TOTAL POPULATION	62,669	3,472.5	100.00	100.00

Predator–Non-Predator Ratio by Weight = 1 :9.1.

Total Water Area Sampled: 25.2 Surface Acres.

Rotenone Used: 78.7 lbs of 8.2%; 157 lbs. of 4.4%; 20 lbs. of 5.4%; and 26 gals. of Pro-Noxfish.

TABLE III

TOTAL COMPOSITE FISH COLLECTION WITH ROTENONE FROM LAKE OUACHITA DURING JUNE, JULY AND AUGUST OF 1956, 1957 AND 1955, RESPECTIVELY

Species	*No. of Fish in Group*	*Wt. (Pounds)*	*Percent of Number*	*Weight*
Largemouth Black Bass, Adult	130	107.5	0.07	4.08
Largemouth Black Bass, #4-9.5	901	86.3	0.48	3.27
Largemouth Black Bass, Young	5,256	45.0	2.81	1.70
Spotted Black Bass, Adult	15	8.4	...	0.32
Spotted Black Bass, #4-8	104	14.0	0.05	0.53
Spotted Black Bass, Young	1,251	10.6	0.67	0.40
Smallmouth Black Bass, Adult	6	6.1	...	0.23
Smallmouth Black Bass, #6-8	4	.8	...	0.03
Smallmouth Black Bass, Young	6	.1	...	...
Black Crappie, Adult	36	16.5	0.02	0.63
Black Crappie, Int.	59	7.0	0.03	0.27
Black Crappie, Young	10,090	32.0	5.39	1.21
White Crappie, Adult	1	.4	...	...
White Crappie, Young	73	.7	0.04	0.03
Channel Catfish, Adult	6	19.2	...	0.73
Flathead Catfish, Adult	22	58.0	0.01	2.20
Flathead Catfish, Int.	5	2.6	...	0.10
Yellow Pikeperch, Adult	1	2.0	...	0.09
Yellow Pikeperch, Young	1	.1	...	...
Spotted Gar, Adult	2	2.2	...	0.09
Spotted Gar, #14-18	9	.6	...	0.02
Spotted Gar, Young	13	.2	0.01	...
Longnose Gar, #14-18	3	.6	...	0.02
Longnose Gar, Young	5	.1	...	...
Grass Pickerel, Adult	1	.1	...	...
Chain Pickerel, #10	3	.2	...	...
Chain Pickerel, Young	2	.1	...	...
PREDATOR POPULATION	18,105	421.5	9.68	15.95

TABLE III—*Continued*

TOTAL COMPOSITE FISH COLLECTION WITH ROTENONE FROM LAKE OUACHITA DURING JUNE, JULY AND AUGUST OF 1956, 1957 AND 1955, RESPECTIVELY

Species	*No. of Fish in Group*	*Wt. (Pounds)*	*Percent of Number*	*Weight*
Bluegill Sunfish, Adult	458	39.5	0.24	1.50
Bluegill Sunfish, Int.	13,515	153.0	7.23	5.80
Green Sunfish, Adult	333	67.2	0.18	2.55
Green Sunfish, Int.	5,282	79.7	2.82	3.02
Longear Sunfish, Adult	523	89.3	0.28	3.38
Longear Sunfish, Int.	5,172	68.8	2.76	2.61
Redear Sunfish, Adult	63	56.0	0.03	2.12
Redear Sunfish, Int.	3,366	28.6	1.80	1.08
Warmouth, Adult	188	44.1	0.10	1.67
Warmouth, Int.	1,721	26.0	0.92	0.98
Rock Bass, Adult	11	4.1	. . .	0.16
Rock Bass, Int.	5	.7	. . .	0.03
Pygmy Sunfish, Adult	3	.0	. . .	. . .
Sunfish, Young	133,234	240.1	71.25	9.09
Freshwater Drum, Adult	1	4.5	. . .	0.17
Freshwater Drum, Young	2	0.0	. . .	. . .
Yellow Bullhead, Adult	22	12.2	0.01	0.46
Yellow Bullhead, Int.	44	1.7	0.03	0.06
Yellow Bullhead, Young	419	3.4	0.22	0.13
Black Bullhead, Adult	3	2.7	. . .	0.10
Black Bullhead, Int.	12	.5	0.01	0.02
Black Bullhead, Young	2	0.0	. . .	. . .
Redhorse (Sucker). Adult	7	13.1	. . .	0.50
Spotted Sucker, Adult	2	2.4	. . .	0.09
EDIBLE FORAGE FISH	164,388	937.6	87.84	35.52
Gizzard Shad, Adult	2,499	1,272.0	1.33	48.17
Gizzard Shad, Young	302	.9	0.16	0.04
Logperch	298	6.0	0.16	0.23
Madtoms	8	.1	. . .	. . .
Brooksilverside Minnow	1,356	1.7	0.72	0.06
Darters	31	.2	0.02	. . .
Blackstripe Top Minnow	125	.1	0.07	. . .
Bigeye Shiner	1	0.0	. . .	. . .
Gambusia	27	.2	0.01	. . .
NON-EDIBLE FORAGE FISH	4,647	1,281.2	2.48	48.53
NON-PREDATOR POPULATION	169,035	2,218.8	90.32	84.05
TOTAL POPULATION	187,140	2,640.3	100.00	100.00

Predator–Non-Predator Ratio by Weight = 1 :5.26.

Total Area Sampled: 23.7 Acres.

Rotenone Used: 131 lbs. of 8.2%; 165 lbs. of 5.4%; 62.5 gals. of Pro-Noxfish.

Table IV gives the average number and weight in addition to the percent of number and weight of classified groups of fish per surface acre of water as determined from rotenone sampling in the three lakes.

TABLE IV

AVERAGE NUMBER AND WEIGHT, AND PERCENT OF NUMBER AND WEIGHT, OF FISH PER ACRE CALCULATED FROM THE THREE-YEAR ROTENONE SAMPLING

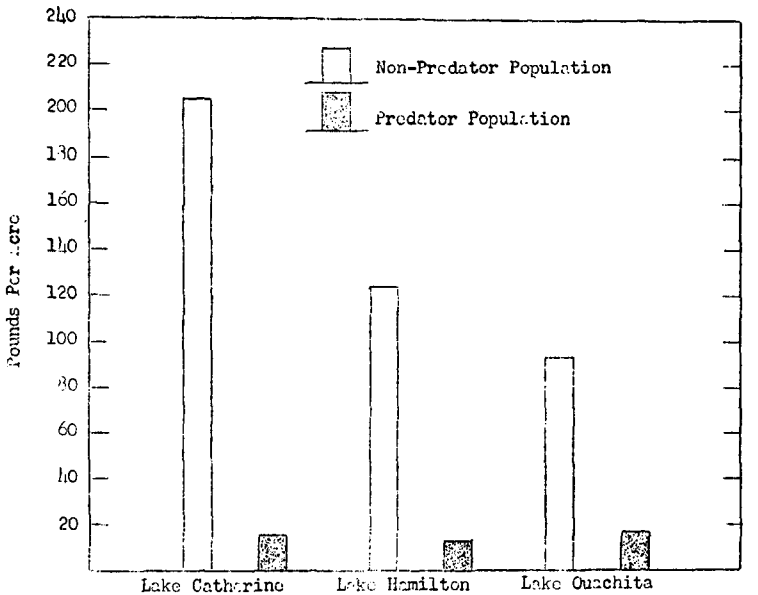
Group	*Number Fish Per Acre*			*Wt. (Lbs.) Per Acre*			*Percent of Number*			*Percent of Weight*		
	Lake Catherine	*Lake Hamilton*	*Lake Ouachita*	*Lake Catherine*	*Lake Hamilton*	*Lake Ouachita*	*Lake Catherine*	*Lake Hamilton*	*Lake Ouachita*	*Lake Catherine*	*Lake Hamilton*	*Lake Ouachita*
Predator Population	159.9	374.6	763.9	16.4	13.7	17.8	3.2	15.1	9.7	7.4	9.9	16.0
Edible Forage Fish	4,074.9	1,503.9	6,936.2	79.3	54.9	39.6	80.3	60.5	87.8	35.9	39.8	35.5
Non-Edible Forage Fish	838.2	608.3	196.0	125.1	69.3	54.1	16.5	24.4	2.5	56.7	50.3	48.5
Non-Predator Population	4,913.1	2,112.2	7,132.2	204.4	124.1	93.6	96.8	84.9	90.3	92.6	90.1	84.0
TOTAL POPULATION	5,073.0	2,486.9	7,896.2	220.8	137.8	111.4	100.0	100.0	100.0	100.0	100.0	100.0

	Lake Catherine	*Lake Hamilton*	*Lake Ouachita*
Predator–Non-Predator Ratio by Number =	1 :30.7	1 :5.6	1 :9.3
Predator–Non-Predator Ratio by Weight =	1 :12.5	1 :9.1	1 :5.3

In a comparison of the number of fish per acre in the three lakes, as collected with rotenone, Lake Ouachita showed the greatest number with 7,896, followed by Lake Catherine with 5,073 and Lake Hamilton with 2,487. Lake Catherine yielded the most by weight with 221 pounds; Lake Hamilton, 138 pounds and Lake Ouachita, 111 pounds per acre. As a basis for comparison, the ratio of the predator-non-predator groups, by weight, gives a more accurate picture of the existing fish population. This ratio was 1:12.5 in Lake Catherine, 1:9.1 in Lake Hamilton and 1:5.3 in Lake Ouachita. These ratios show a marked difference in the fish population in the three lakes with greater abundance of non-predator fish in the older lakes. The non-predators comprising the greatest percentage of this weight were gizzard shad and drum.

Figure 1 shows the relative weights of the predator and non-predator groups per surface area.

Figure 1. -- Fish population (pounds) per acre as determined by three-year rotenone sampling.



	Catherine	Hamilton	Ouachita
Non-predator population (lbs. per acre)	204.4	124.1	93.6
Predator population (lbs. per acre)	16.4	13.7	17.8
TOTAL: (lbs. per acre)	220.8	137.8	111.4
Predator - Non-Predator Ratio	1:12.5	1:9.1	1:5.3

Scales were collected from game fish at the time of rotenone sampling and throughout the summers by the creel census clerk.[2] A record was made of the species, total length and time of collection. Scales were examined on a micro-projector using 45X magnification. Year classes were grouped and comparisons

[2] For a more complete account of age-growth studies see, Hulsey, Andrew H. and James Stevenson, "Comparison of growth rates of game fish in Lake Catherine, Lake Hamilton and Lake Ouachita," Trans. Ark. Acad. Science, Vol. XI, 1958.

made of calculated growth rates. All calculated lengths were obtained by the direct proportion method.

The average growth of all fish was less in the older lakes than in Lake Ouachita. The slower growth rates of largemouth bass and bluegill sunfish were most noticeable. The heavier fish populations with reduced available food and space has undoubtedly affected the growth rates in the older lakes.

The creel census [3] was conducted by employing one man, six days each week, to contact fishermen personally and collect information on fishing methods and success. A schedule was followed so that each lake was checked two days each week and the days of the week rotated among the three lakes. Different sections of each lake were visited at each trip in order to record catches and fishing pressure in various areas. Most information was collected from returning fishermen at public boat landings, however, on several occasions, fishermen were contacted by boat.

Data collected from the creel census revealed a higher catch per man hour on Lake Ouachita than on the other lakes. There was a slight reduction in this rate of catch and a change in species composition on Lake Ouachita during the three years. The rate of catch and species composition remained practically the same on the older lakes.

APPRAISAL AND RECOMMENDATIONS

Thorough knowledge of conditions existing in fishing waters, relative to the production and harvest of usable size fish of the desired species, can be obtained only by continued and comparative studies. The degree of application of this information determines its value. The peak of its usefulness is reached when practical recommendations for management can be applied.

Large reservoirs are often difficult to manage for fish due to their multiple purpose plan of operation, nevertheless, investigations are necessary to learn of the factors responsible for the specific fish producing and harvest conditions characteristic of each one. When the proper effort is made, this systematically (or scientifically) collected data will usually gain the interest of agencies and groups concerned so that, with their cooperation, improvements can be attempted.

For many years, management of these lakes consisted of the enforcement of regulations by game wardens and initial and annual stocking of hatchery-reared fish by the Arkansas Game and Fish Commission. In the early summer of 1950, and again in 1951, in cooperation with the local sportsmen's group, 22,000 pounds of 5-10-5 commercial mineral fertilizer were applied to selected bays of Lake Hamilton and Lake Catherine. Water analysis, quantitative plankton collections and shoreline seining were carried out in conjunction with the fertilization program. Reports from fishermen revealed little concrete evidence of improvements in fishing success.

The data collected during this three-year comparative study show that the physical-chemical factors of the water of the three lakes were normal and, in fact, appeared to be optimum for good fish production. Prior to 1955, inadequately treated sewage from Hot Springs had entered Lake Hamilton through Hot Springs Creek and heavy plankton blooms occurred in that bay of the lake. In the spring of 1955, a modern sewage disposal plant was placed in operation and chlorine treatment given to its effluent. Because of this treatment, water entering the lake at this point was slightly acid and the odor of sewage was no longer detectable. No evidence of pollution was present on any lake during the study.

Chemical and thermal stratification was present in all lakes. During June and July of 1957, subsurface currents were found, believed to be the result of heavy spring and early summer rains and established continual generation at Blakely Mountain Dam. An effort was made to give records of chemical and thermal data at five foot vertical intervals to newspapers for publication to aid fishermen in locating fish. Since power generation began at Blakely Mountain Dam, the physical-chemical characteristics of the upper reaches of Lake Hamilton give indication that this section of the lake may become smallmouth bass and walleye

[3] A complete report of creel census studies is being prepared by the senior author for publication.

habitat. There is a possibility that rainbow trout might survive and grow in approximately five miles of the tailwater below Blakely Mountain Dam (headwater of Lake Hamilton). There was sufficient dissolved oxygen (in excess of 4.0 p.p.m.) to support trout between Blakely Mountain Dam and Highway 270, considering the low temperatures prevailing.

Fertility of the water, as measured by plankton volumes and bottom fauna collections, was greater in Lake Catherine and Lake Hamilton than in Lake Ouachita. This conclusion is also borne out by the reduced light penetration in Lake Catherine and Lake Hamilton (measured with the secchi disc) due to micro-organisms in the water. These lakes are older and shallower and receive most of their water from the bottom of Lake Ouachita.

The standing crop of fishes in Lake Catherine and Lake Hamilton, measured in pounds per acre, exceeds the crop in Lake Ouachita, however, it may be that Lake Ouachita has not yet reached its carrying capacity or that this difference in total weight is due to the species composition of the fish population. The results of fish population sampling with rotenone, seining and netting indicate an over abundance of gizzard shad and drum exists in Lake Catherine and Lake Hamilton. The unbalanced and denser fish population in the older lakes is reflected in slow growing sport fishes of smaller average size and lower fisherman success. Creel census data reveal a surprisingly small harvest of fish from all three lakes.

Subsequent to impoundment, Lake Ouachita provided phenomenal crappie fishing. This continued through the summer of 1956 but diminished in 1957. It would appear that this population was made up of the year class of crappie initially planted in the lake, immediately prior to and at the time of filling, and the first spawn thereafter. Largemouth bass became the dominant species in the creel in 1957. A good spawn of crappie was observed from shoreline seining in 1955, but this has not been evidenced in the more recent creel records. In 1957, young-of-the-year crappie were numerous in rotenone samples and will possibly provide recruitment to the existing crappie population and impetus to fishing success for this species. On the basis of fish populations, success of reproduction and growth data, the sport fishery on Lake Ouachita should exist in good condition for several years.

Largemouth bass and bluegill sunfish were the dominant fish in the fishermen's creels in Lake Hamilton and Lake Catherine. Drum are common in catches on these lakes, many of which are immediately released and consequently the creel clerk is unable to get a true picture of the catch. A type of fishing characteristic of Lake Hamilton (and to a lesser degree, Lake Catherine) where live gizzard shad are used as bait, resulted in catches of large size largemouth bass than in either of the other lakes. The majority of fishermen on both Lake Hamilton and Lake Catherine were more experienced, which accounted for a higher rate of catch being recorded than is actually made by the "average" fisherman. Also, the proximity of these two lakes to two fairly large towns, Hot Springs and Malvern, resulted in local fishermen utilizing them during early morning hours and late evening hours, which helped maintain fishing pressure.

Comparative studies of rates of growth of fish indicated slower growth in the older reservoirs. This slower growth is in accord with heavier populations as determined by population sampling. The more rapid rates of growth in Lake Ouachita are characteristic of growth rates found in new lakes where populations are not large or species overcrowded. The over-abundance of non-game fish in Lake Hamilton and Lake Catherine has undoubtedly affected the growth of all fish in these lakes.

From evaluations of comparative studies conducted during the summers of 1955, 1956 and 1957, the following recommendations for management are given:

1. An intensive shad and drum removal effort should be promulgated in an attempt to aid game fish propagation and growth with the resulting increased fishing success.

Since Lake Hamilton is located above Lake Catherine, it seems that chemical treatment of this lake for the partial removal of shad and drum should be attempted first. If the operation is successful and produces the desired results, and the people request it, the same procedure can then be carried out on Lake Catherine the following year.

Procedure: [4] In October, 1957, when the Arkansas Power and Light Company has drawn down Lake Hamilton an estimated ten feet to facilitate construction work by property owners and for other purposes, the treatment could be carried out at considerable savings in cost of chemical, that is, in relation to the cost of treating a full lake.

After the "selective kill" is made,[5] Lake Hamilton should be stocked heavily with yearling and fingerling bass, crappie and channel catfish during the winter and spring of 1957-1958. The purpose behind such stocking is to obtain larger numbers of yearling and "advanced" fingerling game fish in the population. It is believed that these fish will help control reproduction of shad and drum and, due to their large size, the young shad and drum will not be able to "outgrow" them like they will the naturally spawned bass and crappie which will come off much later than the hatchery fingerlings in the spring of 1958.

In an attempt to hasten the establishment of smallmouth bass (if they will become established in the "changed" portions of Lake Hamilton), it is recommended that smallmouth bass fingerlings be stocked in the upper reaches of Lake Hamilton in the spring of 1958.

If ever walleye can be re-established in Lake Hamilton (it is reported that in years past they were abundant), the time to try them is after the fish population has been thinned by the "selective fish kill." Therefore, it is recommended that walleye fry be stocked in Lake Hamilton in the spring of 1958.

It is possible that rainbow trout will henceforth be able to live in the tailwaters below Blakely Mountain Dam. It is recommended that approximately 4,000 6-inch to 10-inch rainbow trout be stocked in this area as an experiment. Since the resident fish population will be drastically reduced by the "fish kill," these trout should have an excellent chance to do their maximum as limited by the environment.

It is universally known that gizzard shad, when small, are excellent forage fish, however, they, in a few weeks, soon become so large that a large portion of the game fish population are no longer able to use them for food. Therefore, it is recommended that threadfin shad be introduced into Lake Hamilton in an attempt to establish an ideal forage fish which will not outgrow the game fish and will remain at a useable size much longer than the gizzard shad. It it possible that the increased food supply, in the form of threadfin shad, will increase the growth rate of the predacious sport species to such an extent that they will be able to feed on gizzard shad over a longer period of time. It has also been reported by several workers that they have evidence that threadfin shad (in some way) suppress gizzard shad reproduction. If this is true, the threadfin shad will be a very important addition to the fish population.

2. Encourage maximum harvest of all fishes in all lakes.

In this connection, creel limits give the sport fishermen equal opportunity to take part in the harvest of this renewable natural resource and tends to spread the harvest of the sport species out over a longer period of time.

There is a definite under-harvest of the commercial food and rough species. Therefore, it is recommended that all lakes be opened to legal commercial fishing. As a bare minimum, the Arkansas Game and Fish Commission should legalize the use of 4½-inch bar-mesh gill and trammel nets in all lakes, for day and night fishing (24 hours per day) from the 1st day of October to the 1st day of June each year. These nets will help harvest the large buffalo, drum, carp, gar and other large commercial species which otherwise would go underharvested, and which will, to some extent, use and occupy food and space needed by the more highly desired game species.

3. Fall and winter drawdowns have become established as a beneficial aid to maintaining a balanced game-fish population. The mechanics of this biological management technique is that when the fish population is concentrated, the larger predator fishes, such as walleye, bass, crappie and catfish, will eat the smaller forage fishes which tend to become over-abundant, thereby depressing fishing.

---

[4] The list of recommendations made under this heading were carried out during the fall, winter and spring of 1957-1958.

[5] For a complete report on this selective kill see Hulsey, Andrew H. and James Stevenson, "Gizzard Shad Removal in Lake Hamilton", 8 pp., 5 pl. mimeographed report.

Therefore, it would be highly desirable if the Arkansas Power and Light Company would lower the water level in both Lake Hamilton and Lake Catherine each fall (beginning about the 15th of September or the 1st of October) as much as possible without hindering economical power generation, which is, of course, the primary purpose for which the dams were built. There are many side benefits to be derived from a fall and winter drawdown, such as enabling property owners to clean up the debris along the shore, repair boat docks, swimming areas, etc. Of course, a major benefit is flood control. It is assumed that the Arkansas Power and Light Company will lower Lake Catherine "drastically" in the fall of 1958 (at least for a few days) to enable a "selective fish kill" to be carried out. However, the other, less drastic, drawdowns should be performed annually.

4. In order to aid the important sport species of fish, such as bass and crappie, to spawn successfully, the water level of the three lakes should be held as steady as possible from May 1st to June 1st each year. At this time, rising water levels are not nearly as harmful as falling water levels. A fall of as much as six inches a day, over a period of a week during the height of the spawning season, could be very harmful and affect fishing for many years.

5. It is also recommended that this study be continued in much its same form, in order to evaluate the result of the various management procedures carried out and to provide additional recommendations for improving sport fishing on these three, and other similar, reservoirs. Investigations should be made of the possibility of catching concentrations of shad, possibly below the dams, in early spring, or around the steam generation plant on Lake Catherine in the winter, and killing them with rotenone, or other suitable chemical.

ACKNOWLEDGMENTS

The authors wish to express special gratitude to Joe Hogan, Supervisor of Fisheries, Lonoke, Arkansas, for assistance in planning and continued aid throughout the project.

Generous assistance and cooperation were given by the State District Fishery Biologists: Robert Baker, Mountain Home; Donald Brown, Batesville; Bruce Crawford, Centerton; Leroy Gray, Little Rock (formerly with the Commission); Raymond Martin, Texarkana; Billy Gilbreath, Forrest City; and William Mathis, Monticello. Labor and facilities were provided by Dave Fenley and the Hot Springs Hatchery crew while headquarters were set up at this hatchery. Creel census duties were faithfully and intelligently carried out by Clinton Richards of the Hot Springs Hatchery. Game wardens Dale Haltom, George Hatzakas, Hume Sloan and Harold Black assisted in many phases of the project. Continued cooperation and interest of the Hot Springs Chamber of Commerce, Malvern Chamber of Commerce, Arkansas Power and Light Company and U. S. Army Corps of Engineers were responsible for the success of recommended management work.

LITERATURE CITED

American Fisheries Society. 1948. A List of Common and Scientific Names of the Better Known Fishes of the United States and Canada. Spl. Pub. No. 1.

Hulsey, Andrew H. and James Stevenson. 1958. Gizzard Shad Removal in Lake Hamilton, Hot Springs National Park, Arkansas. 8 pp., 5 pl. mimeographed report.

———————. 1958. Comparison of Growth Rates of Game Fish in Lake Catherine, Lake Hamilton and Lake Ouachita, Arkansas. Trans. Ark. Acad. Sci., Vol. XI.