Changes in the Fish Population of Lake Murray Following the Reduction of Gizzard Shad Numbers[1]

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Gizzard shad (*Dorosoma cepedianum*) have been alternately praised and maligned in their role as the principal fish in southern United States flood-control impoundments. The advantages of shortening the food chain from basic nutrients to predator game fish in vegetation—free reservoirs as provided by this prolific, plankton-feeding species has long been recognized by fishery workers. However, population studies in recent years have indicated that shad typically constitute 50 to 80 percent of the total standing crop, and many biologists now believe that such overwhelming abundance depresses the abundance and growth of more desirable fishes, and that angling success is correspondingly decreased. Efforts to selectively kill gizzard shad have been made in a few small Oklahoma lakes since 1953, and the employment of this technique was climaxed by the aerial application of 2000 gallons of emulsifiable rotenone to 5,728-acre Lake Murray on April 2, 1955, under the direction of Clay Wilson, Jr., fishery biologist, Oklahoma Game and Fish Department. Fishing success had declined steadily in this big recreation lake after outstanding largemouth bass and crappie fishing had been experienced during the early years of impoundment, and drastic management measures were deemed advisable.

Lake Murray, located in Carter and Love Counties in south-central Oklahoma, was formed when Anadarche Creek was impounded, creating 5,728 acres of water at spillway elevation. Dam construction was begun in 1933 and the closure was made in 1936. After closure the State Game and Fish Department and the U. S. Fish & Wildlife Service stocked the lake with a variety of species, including spotted and largemouth bass, warmouth, green sunfish, redear sunfish, bluegill, white and black crappie and channel catfish.

The gradual inundation of brushy second growth was protracted over a period of ten years, and water first went over the spillway in 1946. Four years later, in 1950, the lake again reached spillway elevation (747 feet m.s.l.) and flowed into lower drainages.

Evaporational loss accounts for fluctuations that have occurred in the elevation of the lake. The recent drought (1954-56) reduced the lake to about 14 feet below spillway elevation. When the lake was opened to fishing in the spring of 1938 it had risen to occupy an area of about 3,600 acres. Phenomenal catches of largemouth black bass were common and the lake quickly became popular with fishermen from an extensive area.

In 1950 the summer survey crew of the Fishery Research Laboratory conducted an investigation using rotenone on three coves. The recovered fish were counted, measured, weighed and recorded. Fishery inventories were continued by Clay Wilson, Jr., in 1953 and 1954, and the accumulated data indicated that gizzard shad represented 80 percent by number and 60 percent by weight of the standing crop in the lake. On April 2, 1955, the Fisheries Division of the State Game and Fish Department treated the entire lake with emulsifiable rotenone by the use of airplanes at a cost of $13,500 ($2.35 per acre). Although this operation was designed specifically to reduce the over-abundance of gizzard shad, the occasion did permit collection of additional data concerning the relative abundance of species.

Limited field investigations were conducted during 1955 to determine the effects of reduction of gizzard shad numbers on the total fish population, and a more intensive study was carried out during the summer of 1956. 14 months after rotenone treatment. As an experimental procedure, one

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cove was treated with rotenone on six successive dates between July 9, and October 23, 1956, in order to determine what the prolonged effects of repeated rotenone sampling were on a single habitat (e.g., the extent of replacement by migration, changes in the species and size-range composition), as well as gaining information relative to the fish population of the entire lake.

Duck Trap Cove located on the west side of the east arm of Lake Murray, was selected for the study because of exposure, size and accessibility. The prevailing winds of the region blow across the long axis of the cove thereby reducing the loss to recovery of fish floating out of the study area. An area of six acres was selected which included the upper end of the cove and extended toward the mouth a distance of 1000 feet and included about 30 acre-feet of water. The width of the outer extent of rotenone treatment was about 460 feet.

At the outset of the study temperatures ranged from 89.5°F. at the surface to 84.6°F. at 14 feet, the greatest depth found in the cove. Aquatic vegetation was represented by both submerged and emergent forms. Considerable lotus, cattail, bulrush, and *Jussiaea* were in the upper end and in deeper water *Potamogeton*, *Chara*, and *Nitella* occurred as far out as the mouth of the cove.

Methods

Duck Trap Cove was treated with rotenone in a concentration of 1 ppm on the morning of each sampling day (Table I) and complete pickup was continued for 2 or 3 days. Measurements, numbers, and weights were taken as well as many scale and spine samples.

Results of 1956 Population Study

An examination of the 1956 data (Table I) shows that gizzard shad was the most abundant fish as well as constituting the greatest weight of any one species. Drum were next in both numbers and pounds with the bluegill accounting for about 17 percent of the numbers and only about 8 percent by weight. All other species combined accounted for a little over 26 percent for both numbers and weights. Orangespotted sunfish, flathead catfish, and river carpsucker did not occur in the collections after the third observation on July 25. Green sunfish were absent from three of the collections while warmouth were missing from two. All species showed considerable variation of percentages in the samples through the period of study.

Comparison of Pre- and Post-Poisoning Populations

In 1950, gizzard shad comprised 78.4 percent of the total number and 60.3 percent of the total weight of fish taken in rotenone samples (Tables II, III). Freshwater drum, abundant in later studies, accounted for less than 0.1 percent of the numbers and 1.0 percent of the weight. All sunfishes combined amounted to only 13.1 percent by numbers and 4.5 percent by weight. Largemouth and spotted bass combined constituted 0.9 percent by numbers and 8.6 percent by weight. Channel catfish comprised 0.9 percent as to numbers and 1.6 percent of the total weight. The two species of crappie were more abundant, amounting to 6 percent of the total number and 7.3 percent by weight. The remaining species—carp, white bass, flathead catfish and river carpsucker—combined represented only 0.4 percent of the total by number, but accounted for 15.6 percent of the weight, carp comprising 13 percent of this figure.

The data of the 1955 study were vastly different for all species except flathead catfish and river carpsucker, which both maintained very low positions as to number and weight. Gizzard shad continued to lead the field with percentages of numbers and weights of 58.0 and 49.0 percent, respectively. Freshwater drum moved from an extremely low position to

11.8 percent of the total number and 10.6 percent of the total weight, to constitute the greatest gain for any species over the 1950 population. The sunfishes, treated in the aggregate, were reduced from 13.1 to 4.5 percent by numbers, and 4.5 to 1.2 percent by weight. Channel catfish numbers declined to 0.2 percent for both numbers and weights. Seven percent of the fish collected were carp, constituting 9.3 percent of the total weight. The black basses experienced an increase in numbers amounting to 2.1 percent of the total, but were reduced in percentage of weight to 1.0. Black and white crappie treated together experienced a loss both as to numbers and weight amounting to 3.7 and 5.6 percent, respectively. Because of the method of general and widespread distribution of the rotenone on this occasion, white bass were killed in greater numbers. The two percentages-number and weight- were greatly increased, being 12.6 and 25.8, respectively. White bass were introduced into Lake Murray in 1949.

In the 1956 study, gizzard shad accounted for 34.7 percent of the total number of fish and amounted to 46.0 percent of the total weight. Drum showed an increase, accounting for 22 percent of the numbers and 24.0 percent of the total weight. The sunfishes amounted to 21 percent of total number, but accounted for only 5 percent of the total weight. Channel catfish numbers amounted to 8.6 percent of the sample and 15 percent of the weight. Carp decreased in numbers from 7.0 to 3.6 percent, and from 9.3 to 2.5 percent in weight. It is worthy of note that three species drum, channel catfish, and carp were very markedly different in the collections of 1955 and 1956. Drum and channel catfish experienced a tremendous increase in both numbers and weights, while carp were reduced about 4 times by weight and to about one half in numbers.

The black basses increased to 5.6 percent of the total number and 3.9 percent of the total weight. The crappies amounted to only 3.2 percent of total number collected, and 1.8 percent by weight. Only 0.7 percent of the fish were white bass, and they accounted for 1.6 percent of the total weight. However, it was observed during the summer operations that white bass were active just beyond the mouth of the cove under study, and true representation in the population is considerably higher.

Gizzard shad length-frequencies were plotted for both periods of study (Figure 1). The poisoning operation of 1955 resulted in a total recovery of 1,818 shad of which 292, or 22 percent, were 10 inches or more in length. The total shad recovery in 1956 was 1,943, of which only 161, or 8 percent, were 10 inches or more in length. This indicates that a significant reduction in the adult population of approximately 65 percent had been accomplished by the shad reduction operation in 1955.

Comparison of Fish Populations of Six Reservoirs

To compare percentages of numbers and weights of Lake Murray gizzard shad with some other lakes in Oklahoma reference is made to Tables II and III. The percentages of Claremore City Lake, numbers and weights, exceeds the maxima for Lake Murray by 13.3 percent and 7.8 percent. Lower Spavinaw Lake percentages for both numbers and weights exceed the minima of Lake Murray, weights for Lower Spavinaw were 18.1 percent higher than the greatest percent of Lake Murray (60.3 percent). Percentagewise, i.e., considering numbers, Lower Spavinaw was 11.5 percent greater than the highest comparable value for Murray.

By weight Upper Spavinaw exceeded Lake Murray by 13.4 percent and since numbers were not taken during the study on that lake no comparisons can be made in that area.

Grand Lake studies indicated that in it both numbers and weights exceeded those of Lake Murray by 18 percent and 6.2 percent respectively. It should be noted that the maximum figures for Murray were used for this comparison.

Greenleaf figures for comparing weights, since the study did not include numbers, showed a percentage less than that of Lake Murray when its maximum was used, however, when Murray's minimum was considered a difference of 13.1 percent was noted, the greater number being that of Greenleaf. Since Lake Murray drum showed such a great increase in both numbers and weights comparisons were made with the other five lakes. Murray's 1956, 24 percentage by weight was almost two times greater than the percentage of Claremore City Lake and much greater than all others. The carp percentages by weight were much below Claremore and Lower Spavinaw and 1.3 percent below Upper Spavinaw, and had the same percentage as Grand Lake. The exceptionally low percentage of .7 percent for Greenleaf was exceeded 3 times by Lake Murray. Channel catfish in Lake Murray in 1956 represented 15 percent of the weight and 8.6 percent of the total recovery of fish during the study and was considerably greater than any of the other five lakes.

It is interesting to note that no significant changes in growth rate of any species has been observed in pre- and post-poisoning samples despite the analysis of over 1,000 scale and spine samples.

Conclusion

It was concluded that the general poisoning of Lake Mruray in the spring of 1955 had materially reduced the adult gizzard shad population and further that with the drastic reduction of the total population of Duck Trap Cove that there was a definite migration or invasion of species into the unsaturated or unoccupied niches of Duck Trap Cove.

LITERATURE CITED

1. Buck, D. Homer. 1956. Effects of turbidity on fish and fishing. Okla. Fisheries Research Laboratory, Report No. 56, March 1956.

2. Jackson, Samuel W. Jr. 1953. Rotenone survey of Black Hollow on Lower Spavinaw Lake, November 1953. Proc. Okla. Acad. Sci. (1954): 10-14.

3. Jenkins, Robert M. 1951. A fish population study of Claremore City Lake. Proc. Okla. Acad. Sci. 30(1949): 84-93.

4. ..... 1953. Growth histories of the principal fishes in Grand Lake (O' The Cherokees) Oklahoma, through thirteen years of impoundment. Okla. Fish. Res. Lab. Rep. 34: 1-87 multilith.

5. Thompson, William H. 1950. Investigation of the fisheries resources of Grand Lake. Okla. Fish. Res. Lab. Rep. 18; 46 pp. mimeograph.

TABLE I. Numbers of various fishes by percent collected by rotenone in Duck Trap Cove, Lake Murray, in six successive samples, July 9—October 23, 1956.

Species	Percent of total number							Percent of total weight	Number of fish
	Dates of sampling 1956								
	July 9-12	July 16-17	July 24-25	Aug. 7	Aug. 28-29	Oct. 23-24	Average		
Gizzard shad	39.0	15.5	69.0	45.6	24.0	15.2	34.7	46.0	1972
Drum	21.4	38.3	14.8	23.0	20.7	12.6	22.5	24.0	975
Bluegill	15.3	23.3	7.4	17.3	16.5	20.2	16.7	3.3	665
Channel catfish	5.7	4.1	5.6	8.0	24.7	3.8	8.6	15.0	385
Carp	2.2	0.2	0.4	1.1	1.2	16.5	3.6	2.5	53
Largemouth bass	3.6	5.6	0.6	2.2	4.1	4.2	3.4	3.2	134
White crappie	1.3	3.5	0.3	....	1.1	8.5	2.4	1.5	109
Longear sunfish	7.7	3.5	0.7	....	3.6	2.1	2.3	0.4	138
Spotted bass	1.0	1.5	....	....	0.5	6.9	2.2	0.6	59
Redear sunfish	0.7	2.8	0.4	0.7	0.2	1.1	1.0	1.2	38
Black crappie	0.4	0.6	0.4	....	3.0	3.2	0.8	0.3	20
White bass	0.1	0.2	0.1	1.1	0.2	....	0.7	1.7	28
Warmouth	0.1	0.2	....	....	0.2	3.7	0.7	0.1	10
Green sunfish	0.1	0.2	....	....	....	1.6	0.3	*	10
Orangespotted sunfish	0.1	0.4	....	....	....	....	0.1	*	3
Flathead catfish	0.1	....	0.1	....	....	....	*	*	2
River carpsucker	....	0.1	0.1	....	....	....	*	*	2
Goldfish	....	....	0.1	....	....	....	*	*	1
Number of fish	1382	536	1388	452	659	188			4604

* Less than 0.05 percent.

TABLE II. Number of various fishes by percent in total sample taken in cove-poisoning operations on six Oklahoma lakes, 1949-1956.

Lake	Date(s)	Percent of total number of sample									
		Gizzard shad	Drum	Sun-fishes**	Channel catfish	Carp	Black basses	White, black crappies	White bass	Flathead catfish	Suckers ***
Murray	Aug. July 1950	78.4	*	13.1	0.9	0.3	0.9	6.0	0.1		*
Murray	April 1955	58.0	11.8	4.5	0.2	7.0	2.1	3.3	12.6	*	*
Murray	July-Aug. Oct. 1956	34.7	22.0	21.0	8.6	3.6	5.6	3.2	0.7	*	*
Claremore (8)	August 1949	48.0	7.9	33.2	5.2	0.2	0.2	3.4		0.2	
Lower Spavinaw (2)	November 1953	89.9	2.0	0.4	0.7	0.5	2.2	0.2	1.3	*	
Upper Spavinaw (1)	Summer 1955	Numbers of fish not available									
Grand (5)	Summer 1949	92.4	1.8	1.0	1.4	*	0.4	0.5	*	0.1	0.2
Greenleaf	July 1951	Numbers of fish not available									

* Less than one tenth of one percent.

** Sunfishes—bluegill, longear, redear, warmouth, orangespotted and green sunfishes.

*** Suckers—spotted, hog, river carpsucker, black redhorse, white sucker.

TABLE III. Percent of total weight of sample represented by various fishes taken in cove-poisoning operations on six Oklahoma lakes, 1949-1956.

Lake	Date(s)	Percent of total weight of sample									
		Gizzard shad	Drum	Sun-fishes**	Channel catfish	Carp	Black basses	White, black crappies	White bass	Flathead catfish	Suckers ***
Murray	July Aug. 1950	60.3	0.1	4.5	1.6	13.0	8.6	7.3	*		2.6
Murray	April 1955	49.0	10.6	1.2	0.2	9.3	1.0	1.7	25.8	*	0.6
Murray	July-Aug. Oct. 1956	46.0	24.0	5.0	15.0	2.5	3.9	1.8	1.6	*	*
Claremore (3)	August 1949	52.5	15.2	9.1	8.2	5.1	3.6	2.4		1.5	
Lower Spavinaw (2)	November 1953	78.4	3.1	0.1	5.4	5.1	1.7	0.1	0.9		4.2
Upper Spavinaw (1)	Summer 1955	73.7	*	9.5	*	3.8	6.8	*	*	*	1.5
Grand (5)	August 1949	66.5	7.8	2.5	3.6	2.5	3.4	1.5	0.5	1.7	8.5
Greenleaf	July 1951	59.1	4.2	24.2	1.8	0.7	5.0	*	*	0.1	4.5

* Less than one tenth of one percent.

** Sunfishes—bluegill, longear, redear, warmouth, orangespotted and green sunfishes.

*** Suckers—spotted, hog, river carpsucker, black redhorse, white sucker.

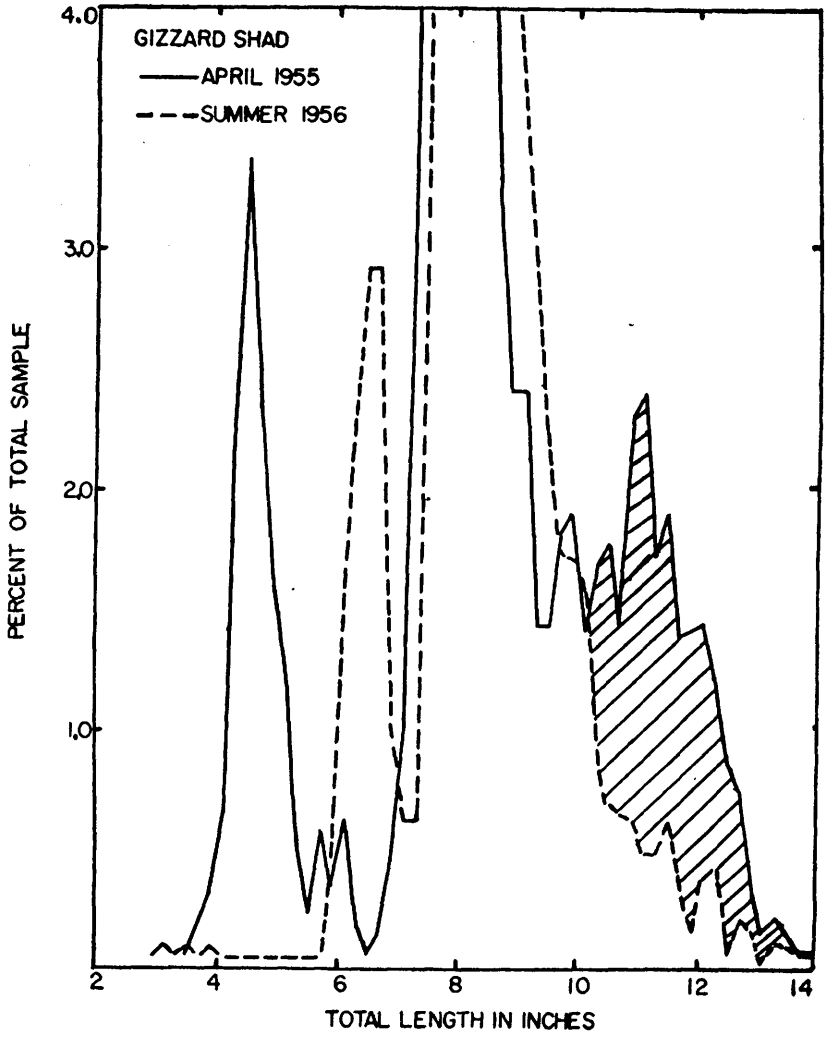

FIGURE 1. Length-frequency distribution of gizzard shad in Lake Murray, April 2, 1955 (solid line), and July-August, 1956 (dotted line). Fish are grouped in 0.2-inch length intervals.