SURVEY AND EVALUATION OF ARKANSAS' CHEMICAL REHABILITATION OF LAKES

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Abstract: Arkansas has carried out an extensive program of chemical rehabilitation of lakes and reservoirs since 1953. In the 27-year period since the first renovation, over 220 major lakes and impoundments have been treated with 94,445 kg of 5 percent equivalent rotenone powder and 37,123 liters of 5 percent liquid rotenone. A total of 18,839 ha have been treated on these lakes. Chemical rehabilitation may be required every 3 to 5 years on some lakes in Arkansas. Gizzard shad *(Dorosoma cepedianum)* is usually the problem species but often sunfish, particularly *Lepomis* spp., and other species of fish overpopulate, stunt and require thinning. Thirteen chemical renovations on 7 state lakes were evaluated. In 11 cases, desired goals were achieved. Generally, large gizzard shad populations can be significantly decreased by renovation with the black bass population often receiving the greatest benefit. The results of this study overwhelmingly support the Arkansas Game and Fish Commission's policy of active fishery management utilizing chemical reclamation as a major tool.

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The major philosophy of the Fisheries Division of the Arkansas Game and Fish Commission is wise utilization of the fishery resource. One way of accomplishing this is through manipulation of fish populations for the public's benefit. Since 1953, the Fisheries Division has used the chemical rotenone for partial and selective fish population renovations (Stroud and Martin 1968). These renovations are designed to support 2 basic fisheries management tenets—the creation of expanding fish populations and the manipulation of fish populations to favor high density predator populations.

Selective poisoning of gizzard shad *(Dorosoma cepedianum)* with rotenone has been used as an effective management tool by biologists in the southeast for over 25 years (Bowers 1955). Arkansas initially used this management tool on state lakes for shad control. In later years, partial renovations of various lakes were also undertaken to decrease stunted centrarchid populations and create expanding fish populations.

The success of a lake renovation project is not necessarily immediately evident, but often is visible 1 to 3 years after the treatment. To what extent a biologist has altered the population structure will normally show up in ensuing fish population samples.

Water level manipulation and other fishery management techniques are often used in conjunction with chemical renovation. When the level of a body of water is lowered, this reduces the water area and volume to be treated with rotenone.

Arkansas began its chemical renovation of lakes in 1953, treating 56 ha on 3 public lakes. The total number of major public lakes, including a few small lakes on Commission Wildlife Management Areas, receiving either partial or selective renovation during the 27-year period since 1953 is approximately 220. A total of 18,839 ha have been treated with the equivalent of 94,443 kg of 5 percent rotenone powder and 37,123 liters of 5 percent equivalent liquid rotenone.

Renovations usually are conducted in the fall since (1) fish do not decompose as fast and fewer of them float to the surface after dying; (2) there are less conflicts with swimming and recreational boating; (3) summer cabin owners are usually not present and are not bothered by the dead fish; and (4) the spawning season for bream *(Lepomis* spp.) is over by then in Arkansas. Since renovations are usually carried out in the fall, water temperature

becomes an important factor in the success of the project. Water temperatures between 12° and 22° C are preferred since toxicity of rotenone remains high at temperatures from 7° to 22° C (Marking and Bills 1976).

A variety of types, sizes and techniques are used to carry out fish renovations. The most frequently used techniques are sectional kills where all fish are eradicated from a designated area of the lake and selective kills, where a highly susceptible target species is eliminated by low concentrations of chemical. Occasionally, a combination of both techniques is used. Powdered rotenone is the chemical used in these renovations and in recent years, 1977-1979, most rotenone formulations purchased by the State Game and Fish Commission consisted of approximately 7 percent active ingredient and cost $1.65/kg (75¢/lb.).

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METHODS

The majority of the lakes included in this study are state-owned lakes. They have a long history of fish management and the population data before and after such projects is well documented. The seven lakes evaluated in this paper were selected on the basis of geographical location, size and the number of fish renovations carried out on them.

Annual cove rotenone samples were conducted prior to and following the fish renovations evaluated in this study. Population samples were generally carried out as described by the Reservoir Committee, Southern Division, American Fisheries Society (Surber 1960), except that block-off nets were not used in some lakes. The data collected from these samples were analyzed to determine if the fish renovations conducted on the lakes improved the fish populations. Since Arkansas' fisheries program is geared for the creation of expanding fish populations of the type described by Wood (1951), Arkansas fishery biologists attempt to establish fish populations that compliment each other; enough young-of-the-year bream, shad and other forage to maintain acceptable growth of a large, predator fish population (most often, largemouth bass). Conversely, this requires enough predators to keep the shad and bream from becoming overpopulated and stunted. To achieve this balance among species, an adequately structured population must exist within each species. A large, harvestable portion of each predator fish is obviously desirable. This catchable, adult portion of the population needs an adequate intermediate size class to insure sufficient recruitment. The young-of-the-year size class is the production base for a fish population, and in expanding fish populations, it makes up the largest portion of the fish population by numbers.

In evaluating fish population structure and dynamics in state lakes, Arkansas biologists analyze various parameters of a population, primarily (1) structure and distribution of the three size classes—adult, intermediate and young-of-the-year (in balanced, expanding populations, adults make up approximately 20 percent of population by numbers, intermediates 30 percent and young-of-the-year often at least 50 percent; (2) predator-non-predator ratio; (3) condition factors; and (4) amount of usable forage. All of these factors are considered in a somewhat subjective determination by the biologist managing the lake with the key being a large young-of-the-year portion of the fish population, indicative of an expanding fish population with heavy predator influence. Swingle (1950) stated that balanced populations are those "populations which yield crops of harvestable fish that are satisfactory in amount when the basic fertility of the bodies of water are considered." Using the evaluation criteria listed above together with several of Swingle's values (E

value, modified forms of A, I and S values), the fish renovations conducted on seven Arkansas lakes are analyzed and evaluated in this paper.

RESULTS AND DISCUSSION

Lake Atkins

Fish population samples from Lake Atkins (304 ha) for the years 1968-1970 showed an average gizzard shad population of 235 kg/ha, high for a lake in the hilly, NW region of Arkansas (Fig. 1). Renovation was deemed necessary and the lake was drawn down to the fish management pool. Seventy-nine kilograms of rotenone were used in January, 1971, to kill over 1,814 kg of gizzard shad. Population samples conducted after the kill showed a gizzard shad biomass of 84 kg/ha in 1971, down from 150 kg/ha in 1970. The 1971 renovation project demonstrated a successful reduction of the shad population for several years after treatment.

A second fish renovation was carried out 3 years later (1974) to further thin the adult gizzard shad, which made up over 50 percent of the shad population by numbers. The lake was drawn down from its normal 304 ha to 182 ha and a 20 ha area was treated with 268 kg of 6 percent rotenone and 45 kg of 5 percent rotenone. Approximately 30 percent of the total estimated shad population (7,936 kg) was removed from the fish population.

The following spring the shad biomass was the lowest in seven years, 45 kg/ha (Fig. 1). The bream population had shown a low and fluctuating young-of-the-year class structure before the renovation with young-of-the-year making up 27 percent of the 600 bream/ha. However, after the kill the bream population developed into a more stable population with an abundance of young-of-the-year equalling 67 percent of the 1,006 bream/ha. With this dense forage population to support them, largemouth bass *(Micropterus salmoides)* young-of-the-year increased from 15/ha the year before the renovation to 146/ha the year after the treatment. Crappie young-of-the-year *(Promoxis* spp.) averaging 10/ha in the 3 years prior to the renovation 1972-1974, increased to an average of 918/ha in the 3 years following the 1974 renovation project (Fig. 1).

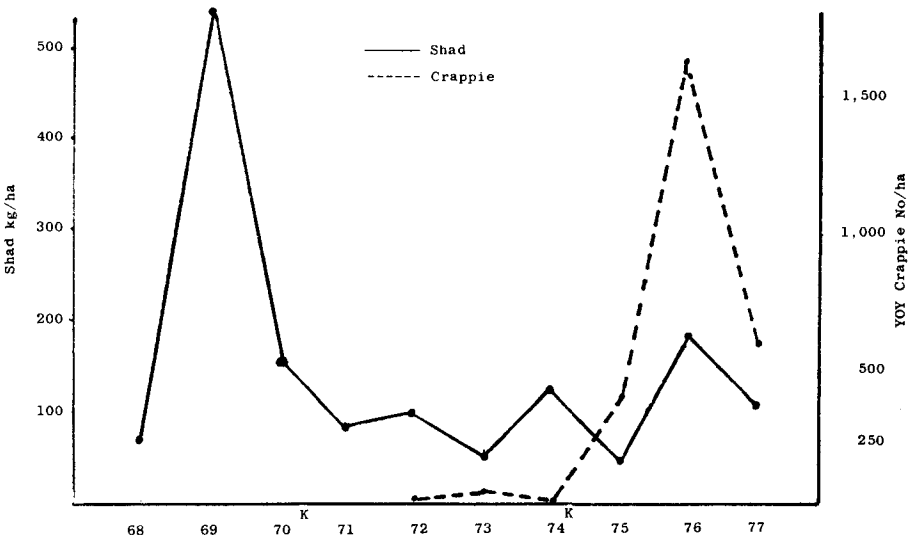

Fig. 1. Effect of 2 management fish kills on the gizzard shad biomass and numbers of YOY crappie in Lake Atkins. 'K' on X-axis indicates date of kill.

Lake Catherine

The Arkansas Power and Light Company impounded the waters of the Ouachita River in western Arkansas for hydroelectric power production in 1924, creating this 917 ha lake. Rough fish removal, mostly shad and drum *(Aplodinotus grunniens)*, has been documented as being successful on Lake Catherine under Dingell-Johnson Project F-5-R (Mathis and Hulsey 1959).

Population samples in 1966-1967 indicated a high density of adult shad, averaging 134 kg/ha. In one of the last major fish renovations in Arkansas using emulsified rotenone as the toxicant, nearly 500 ha of the lake were treated with 5,204 l of Nox-fish in January, 1968. The district fishery biologist reported a heavy shad kill over the entire 17.7 km length of the lake.

The 1968-1970 fish population samples demonstrated a significant drop in gizzard shad biomass, down to 20 kg/ha (Fig. 2). Largemouth bass and spotted bass *(Micropterus punctulatus)* capitalized on an increased young-of-the-year forage crop of bream by expanding from a little over 100/ha before the renovation to 1,000/ha after the project.

Lake Charles

Lake Charles, in northeastern Arkansas, is a 283 ha lake built in 1962 by the Arkansas Game and Fish Commission and the Soil Conservation Service. Cove rotenone samples in

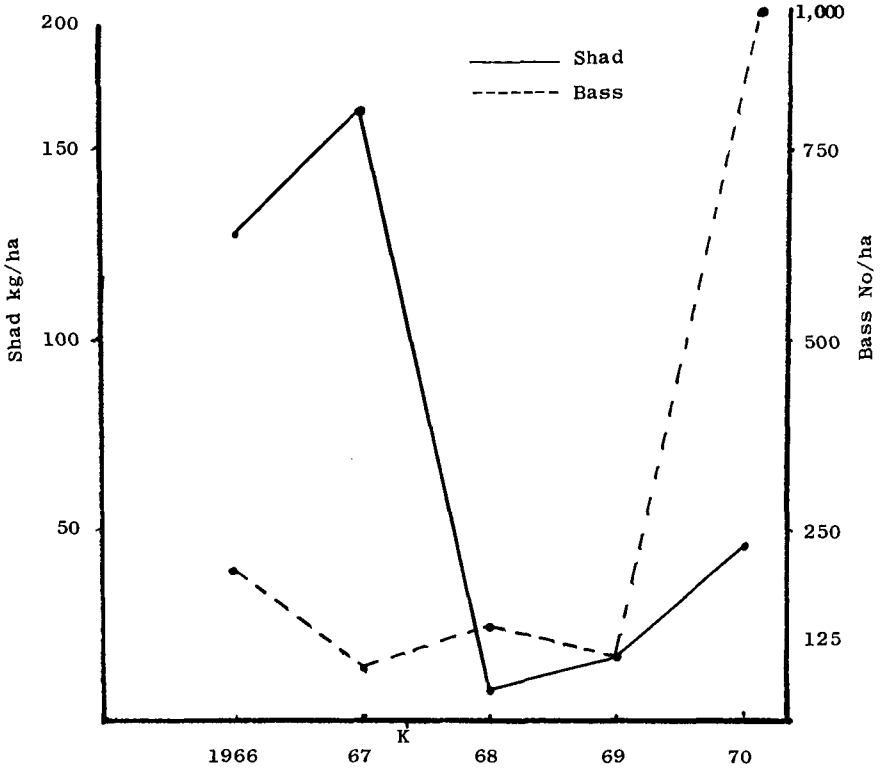

Fig. 2. Effect of a management fish kill on the gizzard shad biomass and numbers of black bass in Lake Catherine. 'K' on X-axis indicates date of kill.

1967-1969 indicated a high shad standing crop (345 kg/ha). To correct this problem, 680 kg of 7 percent rotenone were applied to the lake in 1969. The 1970 fish population sample demonstrated the success of the shad thinning operation. The biomass of gizzard shad decreased to 64 kg/ha (Fig. 3). A good bream and shad young-of-the-year class was subsequently spawned which enabled the largemouth bass to expand from an average of 186/ha in 1967-1969 to 363/ha in 1970. Two years after the 1969 fish renovation, the gizzard shad population again began to overpopulate (Fig. 3) and the crappie population was composed of stunted 100-130 mm fish. Small, intermediate crappie (2,255/ha) made up 79 percent of the crappie population in 1974. In October, 1974, 726 kg of 5.6 percent rotenone were applied to Lake Charles to restore balance. The district fishery biologist estimated a 60 percent shad reduction in the lake. From angler interviews and shoreline counts, an estimated 1,094,257 fish weighing 54,636 kg were eradicated. Gizzard shad made up 99 percent of this by weight and numbers. The total population of the lake was reduced by 26 percent.

Annual samples conducted in the years following the renovation, 1975-1977, demonstrated a sharp decline in gizzard shad biomass (Fig. 3). Young-of-the-year shad increased from 1 percent of the shad population by numbers in 1974 to 28 percent of the shad population in 1975. Stunted crappie were drastically reduced as shown in the 3 population samples following the renovation. Small, intermediate crappie made up 17 percent of the crappie population by number averaging 211/ha. Numbers of largemouth bass increased from an average of 533/ha in the 3 years before the renovation to 877/ha the three years after the 1974 operation.

Lake Conway

Lake Conway, the largest of the Commission-owned lakes at 2,713 ha, is located in central Arkansas. Because the lake is near a large metro area, it receives heavy fishing pressure. An extremely high biomass of shad, 717 kg/ha, was found in this fertile lake in

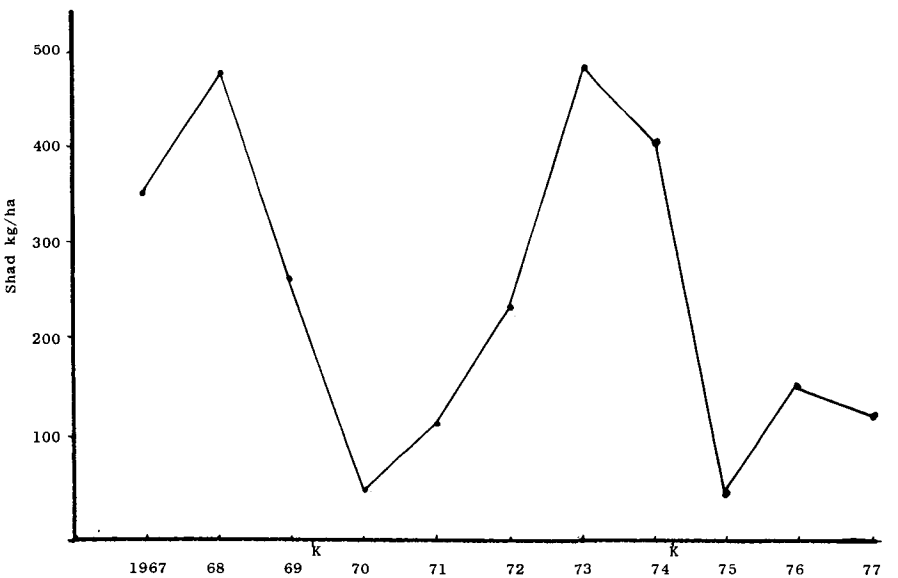

Fig. 3. Effects of 2 management fish kills on the gizzard shad biomass in Lake Charles. 'K' on X-axis indicates date of kill.

1972-1973 (Fig. 4). A population reduction and shad thinning operation was conducted in October, 1973. This sectional kill was done on 121 ha with 1,859 kg of 5 percent rotenone. In excess of 200,000 gizzard shad weighing 18,141 kg were killed. The shad population estimate plummetted in the 1974 fish sample to 128 kg/ha (Fig. 4). Young-of-the-year shad made up more than half of the shad population in the 1975 sample, indicating an excellent spawn. Total numbers of bream declined from 3,003/ha in 1973 before the kill to 1,045/ha in 1975, 1 year after treatment. At the same time, the percent of harvestable adult bream in the total bream population increased from 19 percent to 33 percent in 1975.

Unsatisfactory largemouth bass reproduction, coupled with poor condition of the young-of-the-year bass and a heavy adult gizzard shad population, indicated a downward trend in the population balance in Lake Conway 2 years after the 1973 renovation. Therefore, in September, 1975, 1,134 kg of 6.8 percent rotenone were applied to the lake. The lake was drawn down and by manipulation of the gates in the dam, the rotenone was spread through a large area of the lake. A 50 percent shad kill resulted killing 3,000,000 shad weighing approximtely 113,379 kg.

By 1977, the shad biomass had not decreased in Lake Conway. The young-of-the-year bream population expanded from 50/ha in 1975 to 4,526/ha in 1976-1977. Numbers of largemouth bass increased 288 percent from 1975 to 1976-1977 (Fig. 4). Crappie increased from 175/ha in 1975 to 843/ha in 1976-1977, over 90 percent of which were young-of-the-year. Harvestable adult bream increased 365 percent from 1975 to 1976-1977 (1,270 kg).

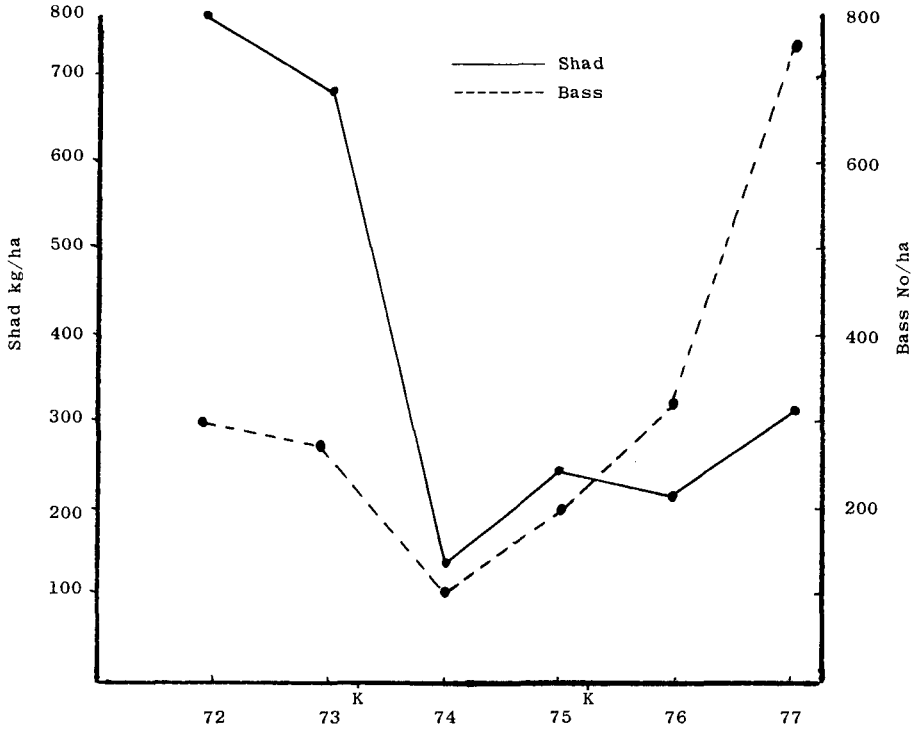

Fig. 4. Effects of 2 management fish kills on gizzard shad biomass and numbers of largemouth bass in Lake Conway. 'K' on X-axis indicates date of kill.

Lake Greenlee

Population samples on this 122 ha eastern Arkansas lake in 1973-1974 indicated an unbalanced fishery overpopulated with intermediate gizzard shad, stunted crappie and bluegill. Also, little bass reproduction was evident. A sectional kill was carried out on the lake in October, 1974. Twenty hectares were treated with 249 kg of 6.5 percent rotenone.

Shoreline counts done on the lake demonstrated a shad population of which 98 percent were 197 mm or longer in total length. Thirty percent (3,946 kg) of the total predicted shad population in Lake Greenlee was removed. Shad accounted for 80 percent of the fish eradicated, signifying the loss of few game fish.

The percent of gizzard shad in the total population decreased after the renovation while population samples indicated that the biomass of shad increased. Evidently, not enough of the lake was treated with toxicant. Young-of-the-year shad numbers did increase slightly, as did largemouth bass numbers. The most significant benefit of the renovation was the thinning of the intermediate bream and crappie. Prior to the kill, intermediate bream accounted for 58 percent of the bream population by number (Fig. 5). After the renovation, intermediate bream made up only 6 percent of the total bream population. Numbers of young-of-the-year bream, which averaged 28 percent of the bream population from 1973-1974, expanded to 88 percent of the bream population in 1975.

Since shad biomass was still relatively high after the 1974 renovation, consecutive renovations were done in 1975 and 1976 to thin the shad population. As a result, the fish population sample in 1977 showed a healthy bream population structure. The young-of-the-year size class continued to form a large, stable base for recruitment making up 81 percent of the bream population (Fig. 5). Large numbers of bream in the 280-350 mm class were collected. Crappie increased from 158/ha, all less than 180 mm, in 1974 to 521/ha in the spring of 1976. Forty-one percent of the crappie were harvestable adults. Largemouth bass increased slightly in numbers and each size group was well represented. Initially, the shad biomass did not decline as drastically as was hoped. In 1977, however, the shad biomass dropped from 312 kg/ha in 1976 to 178 kg/ha, and the percent shad in the total population by weight decreased from 77 percent in 1976 to 43 percent.

Harris Brake Lake

Cove rotenone samples in 1970-1971 indicated a gizzard shad biomass of over 400 kg/ha in 435 ha Harris Brake Lake. A chemical renovation was recommended and 486 kg of 7.2 percent rotenone were applied to the lake killing 13,000 gizzard shad weighing 2,268 kg. Other fish killed in significant numbers ranked according to degree of occurrence were: crappie, bream, and spotted suckers *(Minytrema melanops)*.

Population samples conducted after the renovation indicated a shad biomass averaging 111 kg/ha in 1973-1974. Unfortunately, the percentage of the shad population made up of the young-of-the-year size class also declined. Numbers of crappie were reduced and fewer stunted crappie were collected. The bream population declined initially before expanding and becoming well balanced in adult, intermediate, and young-of-the-year size classes. Largemouth bass increased from 480/ha in 1970-1972 to 1,363/ha in 1973 and young-of-the-year bass, comprising only 33 percent of the bass population by numbers in 1970-1972, increased to a more stable 81 percent of the bass population in 1973.

Results of the 1974-1975 fish population samples, supported by creel data collected during the same time period, indicated a need for another renovation 3 years after the 1972 project. An overabundance of large gizzard shad, combined with a heavy intermediate bream population, necessitated a 61 ha sectional kill on Harris Brake. In October, 1975, 975 kg of 7 percent rotenone were broadcast on the lake. An estimated 4,535 kg of gizzard shad were killed on a 283 ha area. Small numbers of bream and crappie were picked up by the public attending the operation.

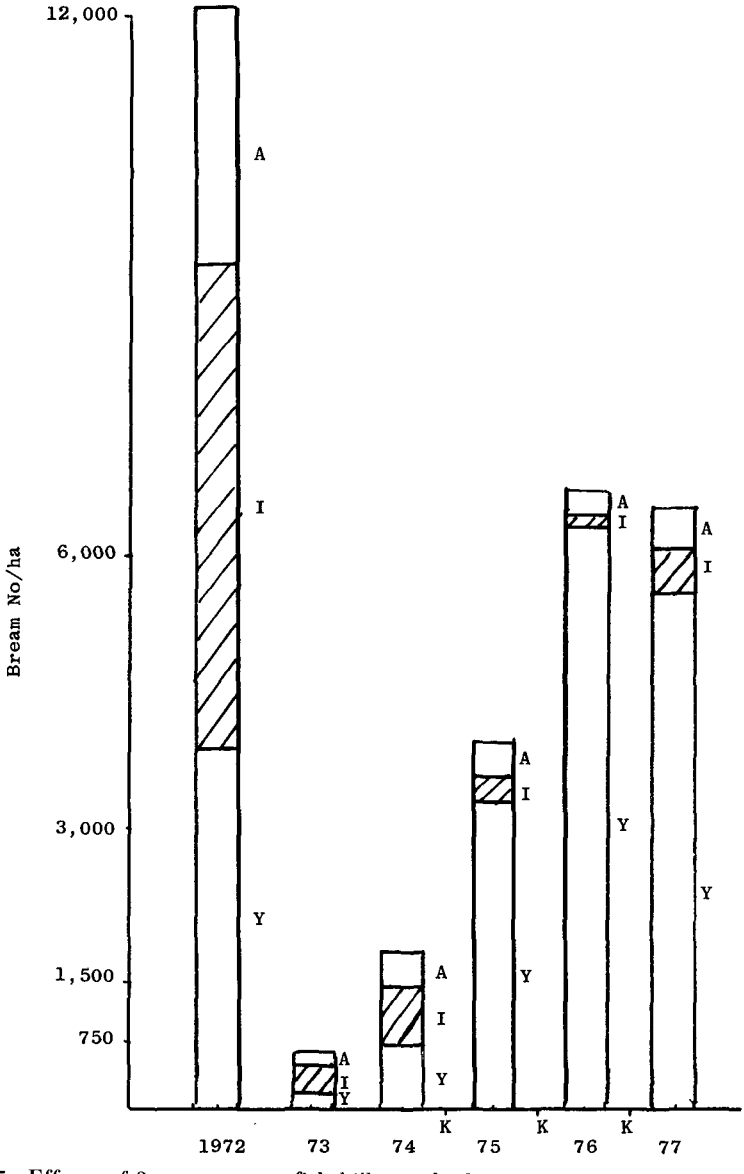

Fig. 5. Effects of 3 management fish kills on the bream population structure in Lake Greenlee. 'K' on X-axis indicates date of kill. A = Adult, I = Intermediate, Y = Young-of-Year.

The shad population in the lake declined sharply after the 1975 renovation, dropping from 120 kg/ha in 1975 to 17 kg/ha in 1976-1977 population samples (Fig. 6). Bream decreased from 9,300/ha in 1975 to 3,260/ha in 1976. Following the usual cycle after a management thinning operation, a successful spawn by bream in 1977 brought numbers up to 7,328/ha, 84 percent of which were forage size young-of-the-year.

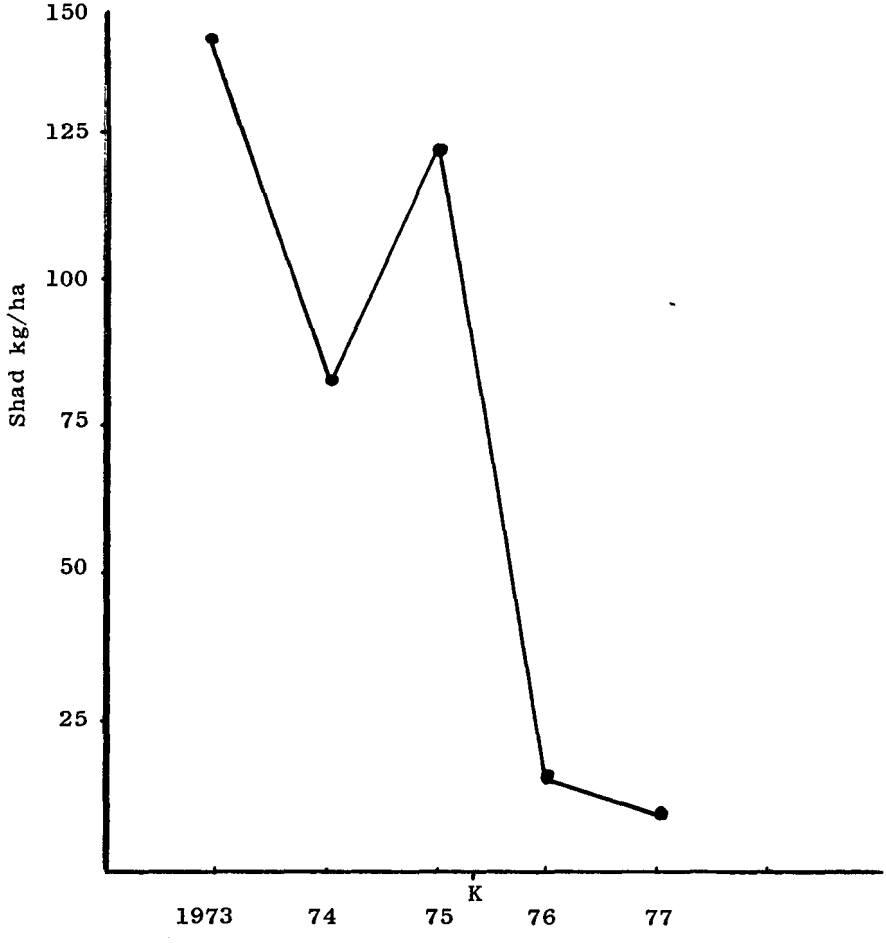

Fig. 6. Effect of a management fish kill on gizzard shad biomass in Harris Brake Lake. 'K' on X-axis indicates date of kill.

Mallard Lake

The same fertile waters that produced the state record largemouth bass also gave rise to a heavy gizzard shad population comprised mostly of large adults and to a stunted bream population in 1970-1972. Therefore, in September, 1972, 101 kg of 5 percent rotenone were applied to effect a selective kill. The shad population after the kill was still high, however, the structure had changed considerably. In 1971, young-of-the-year shad made up only 3 percent of the total shad population. This increased to 85 percent the spring after the rehabilitation project (Fig. 7). The renovation evidently assisted an upward trend in the spawning and survival of young-of-the-year shad. This shad spawn, combined with an extremely young-of-the-year bream crop of over 5,372/ha in 1973, was an excellent forage base for the largemouth bass and crappie to utilize. Numbers of bass and crappie increased from 193/ha and 351/ha respectively in 1972 to 1,205/ha and 990/ha in 1973.

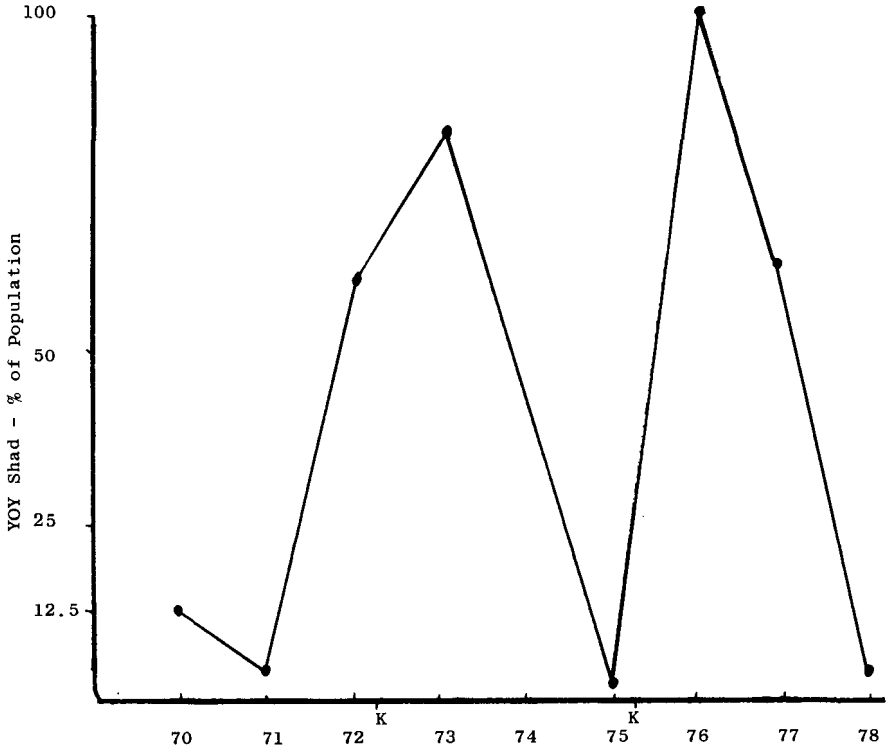

Fig. 7. Effects of 2 management fish kills on numbers of YOY shad in the shad population in Mallard Lake. 'K' on X-axis indicates date of kill.

Population samples over the next 3 years indicated that the shad population was made up almost entirely of adults and intermediate fish. In August, 1975, a 41 ha sectional kill was carried out on Mallard Lake using 408 kg of 7.5 percent rotenone. Over 271,000 shad, 76 percent of the total fish killed by weight, weighing 18,651 kg, were removed from the population. The bream population, the majority of which were intermediates, was thinned by 20,000 fish weighing 1,361.

The year following the renovation, the gizzard shad biomass was very high, 337 kg/ha. However, 99 percent of this was young-of-the-year shad indicating an excellent spawn (Fig. 7). With this plentiful forage population, the crappie population increased from 499/ha in 1975 to 973/ha in 1976. The majority of this increase was young-of-the-year crappie. By 1978, young-of-the-year decreased to a more reasonable 49 percent of the crappie population. The largemouth bass population was affected little by the 1975 renovation project. The bream population was thinned from an average of 9,242/ha in 1976 to 2,312/ha in 1973-1975.

SUMMARY AND CONCLUSIONS

Chemical rehabilitation of lakes in Arkansas has been successful in bringing unbalanced fish populations back into balance. Of the 13 fish renovations evaluated in this paper, 11 were entirely successful in achieving planned goals. The 2 renovation projects in which the primary target species of fish was not reduced as planned, did benefit other fish

populations in the lake. A good example was the 1975 fish control project on Lake Conway. Fig. 4 demonstrates that, while the target fish population of gizzard shad was not reduced in the lake, the largemouth bass population benefitted greatly. A tremendous spawn by the bream population spurred enormous increases in the bass and crappie populations.

Failures in chemical reclamation of lakes do occur and reasons for them may be difficult to discern. Lennon et al. (1971) lists 5 major factors involved with the success or failure of chemical renovation of a body of water: (1) water chemistry; (2) toxicant; (3) formulation of toxicant; (4) differential toxicity of toxicant to various fish species; and (5) method and thoroughness of application. Arkansas has had fish renovations that did not proceed as planned, yet, as long as the majority of lake renovation projects are successful, the benefits derived from the successes far outweigh the few failures.

In the warm water lakes in Arkansas, management fish renovations are sometimes required every 3 to 5 years due to recovery of undesirable fish populations. The cost of these fish renovation projects averages $1.94/ha-m (24¢/acre foot). This is relatively inexpensive when considering that, with few exceptions, most fish renovations are successful not only in the biological sense, but also from a recreational point of view.

In the early years of Arkansas lake rehabilitation program, public reaction opposed fish renovation projects. Recently, public opinion has shifted in favor of lake renovations. The better fishing usually experienced after a renovation project is a prime reason for the lack of public opposition. The recreational value of the renovation projects themselves is demonstrated by large public attendance. Rider and Limbird (1978) reported a total of 1,428 boats participating in the renovation project on Blue Mountain Lake. An estimate of 1,888 boats, with an average of 2.5 occupants per boat, was reported by Rider (1979) for the Nimrod Lake operation. An Army Corps of Engineers' traffic counter totaled over 7,731 cars visiting the area during the Lake Nimrod operation. Using a conservative loading factor of 3.2 people per car, Rider estimated 24,739 people visited Nimrod during the fish renovation activities. It is not unusual to have over 1,000 boats and from 3,000 to 5,000 people attending the larger fish renovations.

The fish most often causing problems in lakes and impoundments in Arkansas is the gizzard shad. Methods of chemical renovation include sectional renovation, selective fish kills, or a combination of both. The long spawning season for bream in Arkansas allows them to sometimes become a serious problem in state lakes. They must often be thinned by sectional kills. At times, other species of fish may also need to be eradicated or their population reduced to insure correct balance in a lake.

In the future, species-specific toxicants may be developed which will aid fishery managers greatly. Until then, rotenone will continue to be important as a selective and general fish toxicant.

In conclusion, Arkansas will continue using chemical renovation of lentic ecosystems as a management tool in conjunction with other routine management techniques (water level manipulation, nursery ponds and the state hatchery system) to keep Arkansas lakes in the best possible condition for the fishing public.

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