TABLE 1. Numbers of juvenile alewife and blueback herring taken by trawling at 5 mile intervals in the Potomac River in 1968

	Alewife	Blueback
June	200	0
July	449	8646
August	96	1491
September	200	2967
October	207	9989
November	6	36
Totals	1158	24287

TABLE 2. Vertical distribution of river herring in the Potomac River in per cent of monthly catch

Month	Surface	Midwater	Bottom
ALEWIFE			
July	96	4	0
August	73	22	5
September	11	66	23
October	12	36	52
November	0	17	83
BLUEBACK			
July	65	35	0
August	55	41	4
September	92	7	1
October	64	35	1
November	8	92	0

TABLE 3. Catch of juvenile alewife and blueback herring in channel and shoal water during daylight and darkness, October 28-29, 1968

	Daylight		Darkness	
	Shoal	Channel	Shoal	Channel
Total fish	7687	7170	538	1927
Avg. no. per tow	961	598	67	160
Total of alewife	81	66	20	32
Avg. no. per tow	10	6	3	3
Total of bluebacks	7603	7098	517	1894
Avg. no. per tow	633	592	65	158

A MANAGEMENT SURVEY OF PUBLIC FISHING IN DELTA REGIONS OF EASTERN ARKANSAS

By RICHARD W. BROACH
Arkansas Game and Fish Commission

ABSTRACT

Intensive agricultural endeavor and accompanying environmental degradation have virtually eliminated the native fishery of eastern Arkansas' delta regions. Unsatisfied public demands for outdoor recreation have, of course, increased as corresponding opportunities have been reduced.

The fisheries management biologist in eastern Arkansas is faced with a multitude of perplexing management problems which in many respects are unique to the heavily farmed regions of southeastern United States.

Managed lakes and impoundments in northeast Arkansas will fall, generally, into one of three categories or classifications:

I. Ridge or foothill impoundment which receive surface runoff from a primarily timbered or pastured watershed (little or no row crop farming in the watershed). The soils of the watersheds of these lakes fall within the Loessial Hills Association and, to a lesser extent, the Ozark Highlands Association.

II. Oxbow or overflow lakes which receive surface runoff from an intensively farmed watershed. (Soils fall within the Loessial Terraces or Bottomlands and Terraces Associations).

III. Floodplain impoundments which are designed for absolute topographic isolation from the watershed and must be maintained by pumping or water gate manipulation. (Soils are similar to those of Class II lakes.)

Empirically determined management procedures as applied in distinct situations for maximum benefits to public recreational opportunities are reviewed in detail.

INTRODUCTION

The alluvial delta of eastern Arkansas, biological desert that it is today (from a fish and wildlife standpoint), once provided, and in the not-too-distant past, unexcelled hunting and fishing opportunities. These opportunities are rapidly diminishing in the wake of vast unilateral land treatment and flood control measures, however, public enthusiasm for outdoor recreation remains keen. Streams and natural lakes that once provided high quality sport fishing no longer produce, and competition among anglers has become intense where fishable waters remain.

The environment has been raped in the name of agricultural improvement and yet, somehow, the wildlife agency is expected to revitalize game and fish populations and return outdoor recreation to its former era of excellence.

Our Game and Fish Commission inherited this situation in eastern Arkansas and, seemingly, public pressure on the Commission to meet adequacy in outdoor recreation increased in direct proportion to agricultural improvements and accompanying declines in recreational opportunity. Perhaps the first step in returning sport fishing opportunity to the public is an educational process.

The public needs to understand that rehabilitation of ruined streams and natural lakes is in most cases beyond the scope of the wildlife agency. We will have to instigate a substitute for the natural fishery.

METHODS

In 1965, 603,000 anglers devoted some 12 million fisherman-days in pursuit of their sport in Arkansas' 810,000 acres of water.[1] Roughly 1/6 of this total was accounted for in the delta regions of eastern Arkansas.

At the same time, the White River Basin Comprehensive Plan of Development for eastern Arkansas calls for the construction of 3,500 miles of group lateral and major outlet ditches which will essentially eliminate the remaining fishery resources of the channeled streams and will ultimately result in hundreds of thousands of acres of bottomland timber being cleared for agricultural purposes.[2]

Ecologists throughout the nation have in recent years exhibited growing concern over the destruction of aquatic ecosystems through federal drainage programs. Charles H. Wharton of Georgia State College states

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1 National Survey of Needs for Hatchery Fish—Arkansas.

2 U. S. Corps of Engineers, Comprehensive Plan for Development, White River Basin, 1968.

that "Foremost among the things which can destroy this nation is the failure to recognize and teach the true relationship of man to the natural world".[3]

Assuming that man himself, with strontium 90 in his bones, iodine 131 in his thyroid, DDT in his fatty tissues and asbestos in his lungs [4] can survive, the cost to what people consider to be the satisfactions of life, including all forms of outdoor recreation, will be tremendous if destruction of the inland ecosystem is not curbed on other fronts in the State of Arkansas. In far too many respects, however, ecological awareness has come too late for eastern Arkansas.

Efforts to keep abreast of changing environmental factors in the fishery of eastern Arkansas include population investigations which seek to establish environmental conditions as revealed through species composition.

Typical of a "ruined environment" fish population is the composition data collected by standard sampling procedure from St. Francis Lake in Poinsett County, Arkansas.

St. Francis Lake was formed by a widening of the St. Francis River at the "sunk lands" which are a product of the New Madrid earthquake of 1812. (Reelfoot Lake in Tennessee was also formed by the New Madrid earthquake.) Fish populations of the lake typify the St. Francis River which receives large amounts of agricultural pollution.

A situation of imbalance as indicated by large numbers of stunted forage fishes and the conspicuous absence in significant quantity of large highly piscivorous game fishes such as the largemouth bass which we would normally consider to be at the top of the food chain, is indicative of environmental degradation in the case of St. Francis Lake. Extreme turbidity produced by unchecked runoff from agricultural lands greatly impedes the foraging activities of any sight feeding fish. Also, biological magnification of chlorinated hydrocarbon pesticides is felt to be a factor significant in the general reduction of predacious fishes. Genetically based, resistance to pesticides can, for example, allow certain forage fishes to tolerate residues of persistent pesticides in excess of 200 p.p.m. in body tissues.[5] Top piscivorous game fishes, being less prolific, could not keep pace with a genetically selective defense mechanism and would succumb to the lethal effects of metabolizing large doses of toxicant.

Certain management efforts are nevertheless expended on similar natural lakes which exhibit a relatively high degree of topographic security. Overflow lakes in this category are managed on a renovation and restocking basis. Procedures followed for renovation include chemical eradication of the standing fish population and restocking with hatchery fingerlings.

The actual eradication phase of renovation or the "fish kill" by chemical (rotenone) draws considerable public interest in Arkansas.

These kills are widely publicized and the public is invited to be present and pick up edible fish. Considerable public recreation is created by the renovation process and edible rough fishes are made available to the people for culinary purposes.

The longevity of the effects of renovation and restocking of any oxbow lake is dependent to a large extent on the duration and intensity of seasonal overflows, however, we can generally expect satisfactory sport fishing for some five years following renovation.

Assuming that such drastic management procedures will be required on a five year cycle for an overflow lake in the delta, chemical costs for maintenance of the fishery approximate \$3.50 per acre, per year. Ac-

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3 Wharton, Charles H. The Alcevy River—A Unique Natural Heritage—Georgia State College.

4 Time, August 15, 1969, Environment.

5 Ferguson, Denzel E., The Ecological Consequences of Pesticide Resistance in Fishes, Thirty-Second North American Wildlife and Natural Resources Conference, March, 1967.

FISH POPULATION SAMPLE
ST. FRANCIS LAKE—POINSETT COUNTY
JULY 30-31, 1969

Species	Number Of Fish In Group	Weight Pounds	Percent of Total Number	Percent of Total Weight
Largemouth Bass—Adult	1	1.9		
Largemouth Bass—Intermediate	5	3.8		
Largemouth Bass—Young	4	..		
Black Crappie—Adult	3	1.1		
Black Crappie—Intermediate	3	0.4		
White Crappie—Adult	10	3.6		
White Crappie—Intermediate	16	1.2		
Flathead Catfish—Adult	2	9.6		
Shortnose Gar—Adult	1	3.3		
Shortnose Gar—Intermediate	34	37.5		
Spotted Gar—Intermediate	35	19.9		
Longnose Gar—Adult	4	48.7		
Longnose Gar—Intermediate	36	34.0		
Bowfin—Adult	93	264.0		
Total Predator Population	247	429.0	21.80	46.22
Bluegill—Adult	32	4.4		
Bluegill—Intermediate	25	1.1		
Warmouth—Adult	15	2.3		
Warmouth—Intermediate	7	0.2		
Pumpkinseed—Intermediate	3	0.1		
Bigmouth Buffalo—Adult	2	11.9		
Bigmouth Buffalo—Intermediate	102	178.2		
Smallmouth Buffalo—Intermediate	124	158.7		
Drum—Adult	13	16.6		
Drum—Intermediate	6	1.9		
German Carp—Adult	4	13.7		
German Carp—Intermediate	52	105.7		
Total Edible Forage	385	494.8	33.66	53.32
Gizzard Shad—Adult	5	3.4		
Gizzard Shad—Intermediate	2	0.8		
Gizzard Shad—Young	500	..		
Pirate Perch—Adult	1	..		
Madtom—Adult	2	..		
Total Non-Edible Forage	510	4.2	44.54	0.46
Total Non-Predator Population	895	499.0		
Total Population	1,142	928.0	100.00	100.00

Predator—Non-Predator ratio by weight—1:1.16.
Area Sampled—One Acre, Average Depth—7 feet.
Chemical Used—20 pounds 7.2% powdered rotenone.
Collectors—Bill Bailey, Rudolf Lane, Thurman McCann.
Visibility—6 to 8 inches.

celerated fishing license sales accompanying the "kill" may offset a substantial portion of the first year's investment in chemical.

It should be noted that environmental factors of these overflow lakes in eastern Arkansas presently favor populations of "rough" fishes (carp, buffalo, gar, bowfin, etc.) and as addition agricultural activity in the watershed will undoubtedly further deteriorate the aquatic environment, no material investment is made in a natural lake of this type which would be projected into a plan of management to exceed five years duration. We feel that increasing siltation and agricultural chemicals from the watershed could, within a relatively short time, completely preclude the feasibility of continued management. In effect, we are fishing on borrowed time in overflow lakes of the eastern Arkansas delta.

Although many of the esthetic attractions of natural lakes are lacking in artificial impoundments, management efforts are rewarded with a much higher degree of success on man-made fishing reservoirs throughout the agricultural plain. This is especially true of reservoirs constructed by the Game and Fish Commission specifically for fish production. Structural features are incorporated in the designs of our lakes which permit any desired degree of water level manipulation for fisheries management purposes and necessary topographic isolation from unfavorable environmental conditions is provided (Figure 1 and 2).

Hill impoundments are mentioned in a comprehensive management survey of the delta because of the recreation provided population centers in heavily farmed regions. A weekend exodus of delta residents to the hills is in many cases the only answer to meeting recreational needs. The topographically isolated lake as constructed by the Game and Fish Commission is proving highly successful in the delta, however, project costs for this type of impoundment are relatively high and the number of available impoundments is limited at the present time.

Hill impoundments, on the other hand, are in many cases acquired through a cooperative function in federal flood control projects (primarily PL-566 Programs). Multipurpose flood control impoundments, ironically enough, partially compensate for recreational opportunities lost through federal management projects. It should be noted, however, that a significant portion of the financial burden of converting these impoundments into fishable waters with free public ingress and egress is placed upon the state wildlife agency in any cooperative plan of this nature.

Hill areas contiguous to the delta provide lake sites free of agricultural pollutants and furnish high quality sport fishing for residents of the agricultural plain. Watersheds of hill lakes in the Crowley's Ridge and Ozark Foothill areas are largely timbered and pastured. The productivity potential, of course, is much lower than impoundments of the Bottomland Soils Association.

Lakes in hill regions generally range from 300 to 700 surface acres in size and preferably have a 10:1 or less watershed to surface area ratio.

Lakes of this description are initially stocked with the standard variety of warm water fishes—largemouth bass, *Micropterus salmoides;* chain pickerel, *Esox niger;* white bass, *Roccus chrysops;* white crappie, *Pomoxis annularis;* bluegill, *Lepomis macrochirus;* channel catfish, *Ictalurus punctatus;* buffalo fishes, *Ictiobus sp.;* Israeli carp, *Cyprinus carpio;* and gizzard shad, *Dorosoma cepedianum.*[6]

Management techniques on the hill lakes include fall and winter drawdowns, periods of open commercial fishing, selective chemical fish removal, and corrective stockings of hatchery fish. The effectiveness of management efforts is determined by annual fish population studies.

By far, the most successful type of man-made impoundment has been the topographically isolated reservoir. Located on the flat delta lands, these reservoirs combine the advantages of productivity associated with bottomland soils and relatively shallow water depths and absolute isolation from agricultural pollution.

The inherent disadvantages of the isolated reservoir are somewhat higher construction and maintenance costs (levee usually encompasses the entire lake) and heavy infestations of aquatic weeds. (These reservoirs are generally timbered and large amounts of dried organic matter in the form of fallen timber tend to produce extremely transparent water conditions. Sunlight penetration in relatively shallow impoundments creates optimum conditions for aquatic vegetation.)

[6] Special Publication No. 2, American Fisheries Society.

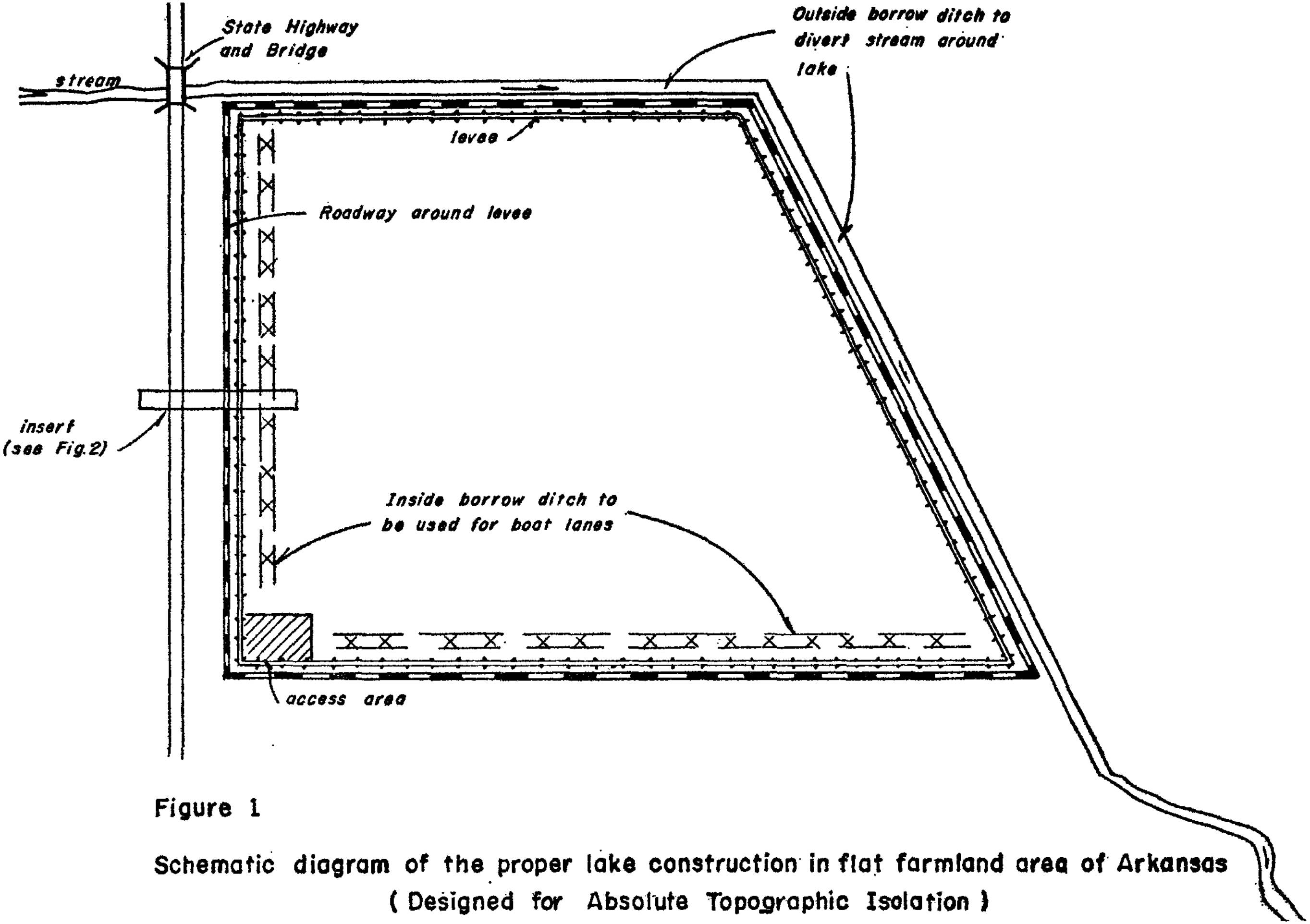

Figure 1

Schematic diagram of the proper lake construction in flat farmland area of Arkansas
(Designed for Absolute Topographic Isolation)

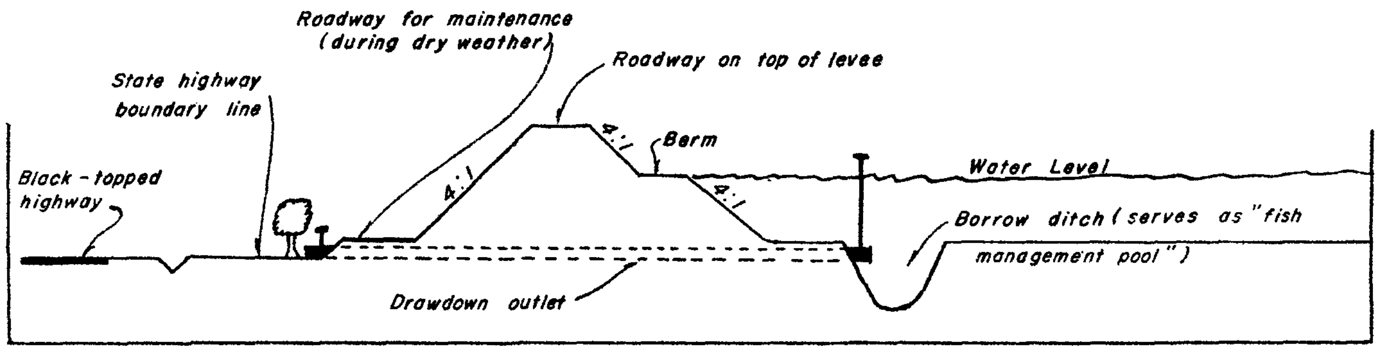

Figure 2

Cross Section of Levee for a Topographically Isolated Impoundment

Drawdown facilities in these delta reservoirs frequently serve the dual purpose of providing water for adjacent green timber duck shooting areas and fall and winter drawdown for fisheries management and vegetation control.

Hulsey (1956) reported the effects of a drastic fall and winter drawdown on one of the larger flood control lakes in north central Arkansas. A concentrated fish population in winter months permitted commercial fishermen to remove a large percentage of the total population of commercial fishes, non-edible forage species were increased approximately threefold, and a marked increase in the number and size of young basses was recorded following the drawdown.[7]

The effects of water level fluctuation which expose significant areas of normally inundated lake bottom to drying also release soil nutrients in forms which can readily be utilized in the basic food chain. Additional fixed nitrogen, phosphates, and ionizable salts become available as a result of bottom aeration and extension of terrestrial plants.[8]

The benefits of selective or partial fish removal by chemical means has been repeatedly demonstrated to be highly effective in Arkansas. Mathis (1964) reported an overall increase in stranding fish populations and restoration of a balanced predator—non-predator condition in Grand Lake following selective fish removal by chemicals.[9]

If chemical manipulation of the fish population is found to be necessary, material and application costs are reduced in proportion to the extent of water volume reduction. As the direct benefits of a drawdown in population dynamics are coupled with desirable effects in aquatic vegetation control, we feel that the installation of facilities which permit any desired degree of water level fluctuation in delta reservoirs is highly advantageous.

In anticipation of problematic vegetation, minimum water depths outside of borrow ditches are maintained at seven feet at normal pool elevation and herbivorous fishes are included in initial stockings as a biological means of weed control. In this respect, we have found the Israeli carp to be a fairly effective means of control for filamentous algae, pondweed (*Pontamogeton*) *Elodea*,[10] and the more succulent types of vegetation. Proliferation of tougher vegetation such as coontail, (*Ceratophyllum demersum L.*) is apparently not inhibited by the foraging activities of the Israeli carp.

Initial observation of food habits indicates that the grass carp, *Ctenopharyngodon idellus*, used in combination with the Israeli carp, may prove to be a much more satisfactory biological means of control for all types of aquatic weeds. (The grass carp has not been cleared for stocking at the time of this writing. If proper clearance is obtained grass carp will be stocked in a number of Game and Fish Commission reservoirs for vegetation control.)

Chemical and mechanical methods of weed control are not deemed to be economically feasible for large scale use.

Two standard methods of monitoring fish populations are employed by the Arkansas Game and Fish Commission: (1) Shoreline seining, which is normally conducted in the spring or early summer following the initial bass and bluegill spawn, and (2) the rotenone method of population sampling which is generally recognized as the best method available for obtaining more complete information about fish populations in impoundments.[11]

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7 Hulsey, Andrew H., Effects of A Fall and Winter Drawdown on A Flood Control Lake, Tenth Annual Conference, Southeastern Association of Game and Fish Commissioners.

8 Lambou, Victor W., 1962, Comments on Proposed Dam on Old River, Batchelor, Louisiana, Louisiana Wildlife and Fisheries Commission.

9 Mathis, W. P., An Attempt to Improve Stream Fishing by Manipulating Lakes in the Stream Basin, 1964, Arkansas Game and Fish Commission.

10 Mathis, Observations on Control of Vegetation in Lake Catherine.

11 Lambou, Victor W. and Herbert Stern, Jr., An Evaluation of Some of the Factors Affecting the Validity of Rotenone Sampling Data, Louisiana Wildlife and Fisheries Commission.

Shoreline seining is useful in determining population balance by the relative abundance or scarcity of recent reproduction and provides sound data on forage for young largemouth bass which are usually "cropped" from hatchery ponds in June or July and stocked where bluegill spawn will support additional predators.

Rotenone sampling is usually conducted on each major impoundment on an annual basis in July or August and provides a more comprehensive means of determining deficiencies, if any, in the fish population. We accept the rotenone method of sampling as being qualitatively accurate and quantitatively indicative. Data supplied through sampling provide a demonstrable basis for management procedures designed to manipulate the fish population in a desirable direction.

The need for drawdowns, selective fish removal by commercial harvest or chemical means, or corrective stocking is determined primarily by rotenone sampling information.

The following population data was collected from Mallard Lake, a 300 acre topographically isolated Game and Fish Commission reservoir, during July of 1969. Mallard Lake was completed and initially stocked with fingerlings during the winter of 1967-68.

FISH POPULATION SAMPLE
MALLARD LAKE—MISSISSIPPI COUNTY
JULY 16-17, 1969

Species	Number Of Fish In Group	Weight Pounds	Percent of Total Number	Percent of Total Weight
Largemouth Bass—Adult	4	4.2		
Largemouth Bass—Intermediate	20	14.0		
Largemouth Bass—Young	50	..		
White Crappie—Adult	8	3.1		
White Crappie—Intermediate	2	.5		
White Crappie—Young	25	..		
Black Crappie—Adult	9	3.6		
Black Crappie—Young	25	..		
Channel Catfish—Intermediate	132	82.1		
Total Predators Population	275	107.5	42.80	26.40
Bluegill—Adult	18	4.1		
Bluegill—Intermediate	102	5.8		
Bigmouth Buffalo—Adult	5	27.4		
Israeli Carp—Adult	11	57.6		
Israeli Carp—Intermediate	3	9.5		
Drum—Intermediate	1	.9		
Total Edible Forage	140	105.3	21.80	25.80
Gizzard Shad—Adult	155	189.4		
Gizzard Shad—Intermediate	73	5.1		
Total Non-Edible Forage	228	194.5	35.40	100.00
Total Non-Predator Population	368	299.8		
Total Population	643	407.3	100.00	100.00

Remarks: Growth and population density of channel catfish indicates possible under harvest. Excellent bluegill reproduction. Good carry-over of young-of-the-year largemouth bass. Additional shad reproduction is anticipated.

Predator: Non-Predator ratio by weight—1:2.78.

Area Sampled: One acre—Average Depth: 6 feet.

Chemical Used: 25 pounds of 5% powdered rotenone.

Collectors: Broach and Bailey.

SUMMARY

1. The native fishery of Arkansas environmentally degraded delta region has essentially been lost to intensive agricultural endeavor and federal water management projects while accompanying dredging, drainage, and agricultural pollution have reduced recreational opportunities to a fraction of the former potential.

2. The need for outdoor recreation has increased more rapidly than the human population. The problem: More fishermen and fewer fishable bodies of water.

3. The solution: Replace the native fishery (streams and overflow lakes) with man-made reservoirs designed for absolute topographic isolation from unfavorable environmental factors.

Natural lakes in the delta to be managed only on a "short term" basis.

CONCLUSIONS

Much effort and material expense can be put forth in an effort to restore a native fishery in a ruined environment with extremely low returns. The angler must be acclimatized to the fact that attempted maintenance of a fishery that has been lost through environmental destruction can be extremely extravagant and that the answer to meeting his recreational needs lies in a somewhat unique man-made substitute.

A satisfactory substitute for the native fishery can best be provided in heavily farmed delta regions in eastern Arkansas with the topographically isolated reservoir.

THE EFFECTS OF INORGANIC FERTILIZERS AND ORGANIC MATTER UPON THE PRODUCTION OF MACROBENTHOS IN PONDS [1]

By RICHARD A. COLLINS

State College of Arkansas
Conway, Arkansas

INTRODUCTION

Numerous investigators, including Smith and Swingle (1939), Surber (1943), Swingle (1947), and Ball (1949), have demonstrated an increase in fish biomass in North America associated with the addition of inorganic fertilizers to ponds. These same authors and others reported increases in phytoplankton after the addition of inorganic nutrients, a phenomenon so well established that it is common practice in pond management today.

Patriarche and Ball (1949) used four ponds, two fertilized and two unfertilized, in a study of the effects of fertility on the increase of benthos. A definite increase was shown in only one of two fertilized ponds.

Howell (1941) reported an increase in benthos in one pond fertilized for three years in comparison to an unfertilized pond. However, Howell observed that the concentration of bottom organisms increased in the experimental pond as the water level of the pond decreased.

McIntire and Bond (1962) more clearly demonstrated that both plankton and benthos were increased by the use of inorganic fertilizers. When compared to a control pond, nitrate plus phosphate distinctly increased the benthos in two experimental ponds.

[1] This paper is a part of a doctoral dissertation submitted to the Graduate School, Southern Illinois University, in partial fulfillment of the requirements for the degree of Doctor of Philosophy.