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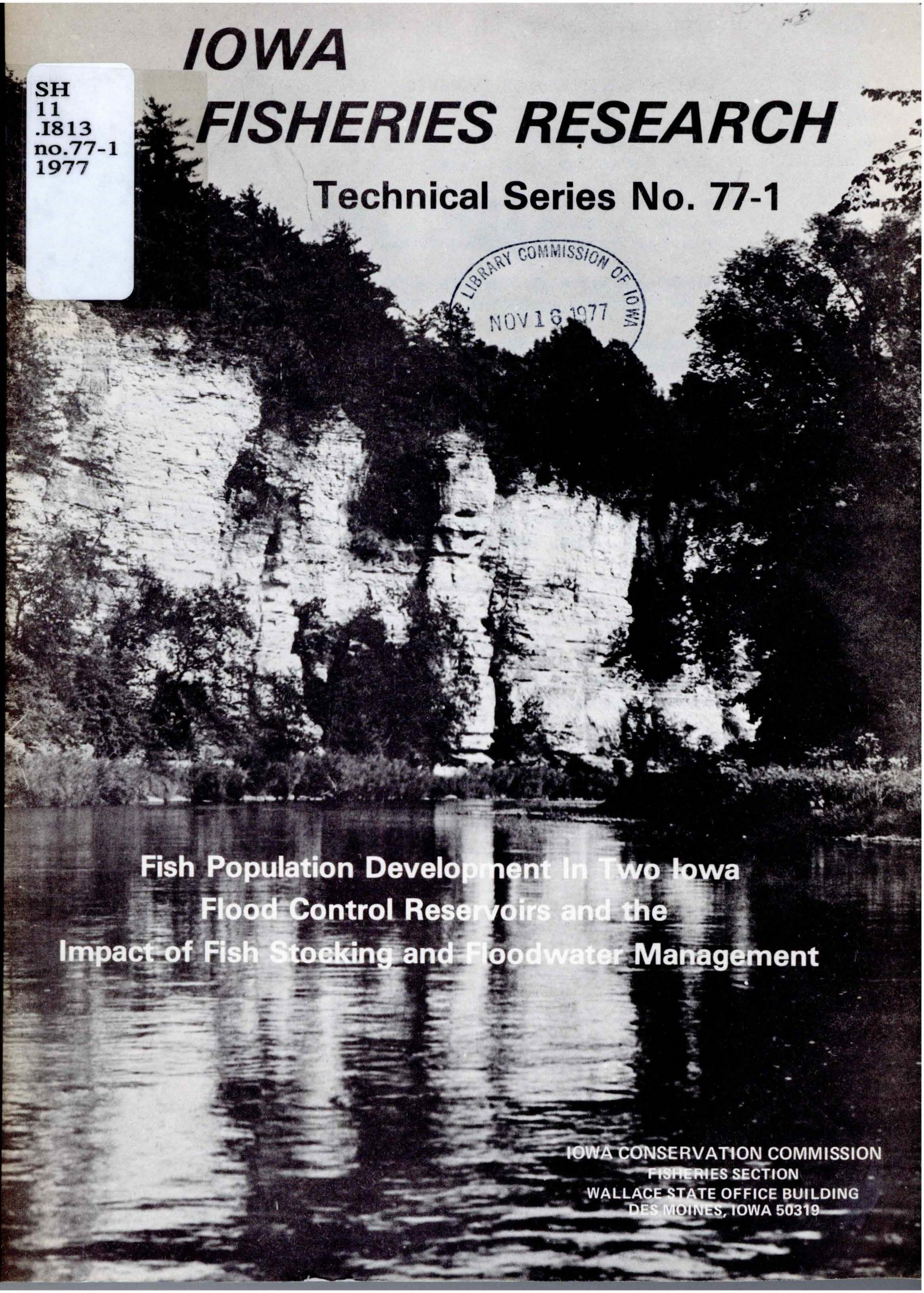

Fish Population Development In Two Iowa Flood Control Reservoirs and the Impact of Fish Stocking and Floodwater Management

IOWA CONSERVATION COMMISSION
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FISH POPULATION DEVELOPMENT IN TWO IOWA FLOOD CONTROL RESERVOIRS AND THE IMPACT OF FISH STOCKING AND FLOODWATER MANAGEMENT[1]

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Fish populations in Lakes Red Rock and Rathbun were studied after impoundment by monitoring relative abundance, species composition, size distribution, age structure, reproductive success, growth, and stocking success. In addition, reservoir operations were recorded to determine its impact. Adult fish were sampled with four trap nets and one experimental gill net from April through October, 1972-75, while young fish and forage species were sampled with a seine net during 10 biweekly intervals each year. Lake Red Rock is characterized by extreme variations in water levels while Lake Rathbun is relatively stable. Fish species suited to river type habitat developed more extensively at Lake Red Rock than at Lake Rathbun. River carpsucker, carp, bullhead, and crappie dominated the fishery at Lake Red Rock while crappie and carp were the most important fish species inhabiting Lake Rathbun. Analysis of variance testing showed no significant change in the species composition in either reservoir; however, catch success within species varied and was dependent on year class success and stockings. Walleye, northern pike, largemouth bass, white bass, channel catfish, and muskellunge were stocked at varying rates, sizes, and intervals at one or both reservoirs. Strong year classes of bluegill, crappie, and largemouth bass were recorded at Lake Rathbun in 1973, a year of high reservoir elevation, as were bass and bullhead at Lake Red Rock. High water at Lake Red Rock in 1974 was beneficial to white bass, crappie and bigmouth buffalo. Fish stocking was important in establishment and maintenance of many fish species. Suggested stocking rates are: 2,500 larval walleye/ha (1,000/ac), 2,500 larval northern pike/ha (1,000/ac), and 250 postlarval largemouth bass/ha (100/ac). Further consideration should be given to stocking at periods of high zooplankton populations and releases of fish of a larger size to insure higher survival. In general, growth of most species was best during the first few years of impoundment, in later years growth was influenced by storage volume and water quality. Recommendations for reservoir management were presented and included shoreline stabilization, stocking guidelines, habitat improvement, commercial fishing, increased conservation pool elevation and fish population assessment.

INTRODUCTION

Large flood control reservoirs provide a major portion of the fisheries resource in the southern region of Iowa. These impoundments were constructed for flood control and water conservation by the U.S. Army Corps of Engineers and fishery development is only incidental. At present, fish management in flood control reservoirs is limited to stocking large numbers of hatchery reared fish. In the future fishery management principles concerning impoundments must include comprehensive knowledge of reservoir fish populations integrated with flood control operations.

Little was known of the overall fishery development and to what extent it was influenced by stocking of large numbers of hatchery reared fish. In addition, the unpredictable and variable characteristics of reservoir water management, during and after flood control periods, occurred during the spawning period of most fish species.

Fish population investigations in large Iowa reservoirs have been primarily devoted to commercial food-fish species. Mitzner (1972a) studied commercial exploitation of several species of fish at Coralville Reservoir and Mayhew (1972b) conducted a similar study at Lake Red Rock. Sport fish research was limited to vital statistics of crappie at Coralville Reservoir (Mitzner, 1972b). Several pre- and post-impoundment studies documented age and growth information, but did not lead to any long range management implications.

The objective of this investigation was to document the development of fish populations at Lake Red Rock and Lake Rathbun by continued monitoring relative abundance, species composition, size distribution, age structure, reproductive success, growth, and stocking success of sport fish following impoundment and to determine the impact of reservoir water management on fish populations.

HISTORY OF LAKES RED ROCK AND RATHBUN

Lake Red Rock and Lake Rathbun are mainstream impoundments constructed by the U.S. Army Corps of Engineers for flood control or downstream flow augmentation (Figures 1 and 2). Lake Red Rock, located on the Des Moines River, is part of the Upper Mississippi River Flood Control Project authorized by the U.S. Congress in 1939. Construction of the impervious filled dam began in September, 1960 and was impounded in March, 1969. Formation of Lake Rathbun, on the Chariton River, was the result of authorization of the Flood Control Act of the U.S. Congress in 1954 and is a segment of the Missouri River Basin Plan. Construction of two earthen dams began in 1964. Impoundment started in November, 1969, and the reservoir filled to conservation pool in October, 1970.

Both reservoirs are located in the southern region of Iowa and have some similar traits, but the most differentiating is the watershed characteristic. Lake Red Rock is located on the lower reach of the Des Moines River, the largest

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[1]Funds for this study were provided by the Federal Aid in Fish Restoration Act (PL 81-618), Project F-88-R, US Fish and Wildlife Service and the Iowa Conservation Commission cooperating.

river in the state. A substantial portion of the north-central and south-central region of the state is included in the drainage basin. Important reservoir tributaries include Whitebreast Creek, South River, Middle River, North River, and discharge from Roberts Creek Reservoir, a 101 ha (249 ac) sub-impoundment. Lake Rathbun was formed by impounding the Chariton River at the upper reach of its watershed. Reservoir tributary streams include: Buck Creek, Honey Creek, and South Fork of the Chariton River. Considerable difference exists in watershed ratios 1,040:1 for Lake Red Rock and 32:1 for Lake Rathbun.

Morphometric characteristics of both reservoirs vary considerably from conservation pool to flood stage, although both are designed for conservation pool (Table 1). At conservation pool Lake Red Rock contains 3,625 ha (8,950 ac) and at flood pool it expands to 26,544 ha (65,540 ac). Lake Rathbun contains 4,544 ha (11,288 ac) at permanent pool elevation and 8,502 ha (21,008 ac) at flood stage. Flood pool stage at both reservoirs is expected about once every 100 years. Minimum discharge at Lake Red Rock is 8.5 CMS (300 CFS) and maximum release is 3,687 (130,000 CFS). Lake Rathbun ranges from about 1 CMS (10 CFS) to 142 CMS (5,000 CFS).

Table 1. Physical characteristics of Lakes Red Rock and Rathbun at conservation pool and flood pool elevation.

	Lake Red Rock			Lake Rathbun		
	Elevation MSL in m (ft)	Maximum depth in m (ft)	Length in km (miles)	Elevation MSL in m (ft)	Maximum depth in m (ft)	Length in km (miles)
Conservation pool	221 (725)	10.7 (35)	17.7 (11)	275.5 (904)	16 (53)	16 (10)
Flood pool	237.8 (780)	27.4 (90)	58 (36)	282.2 (926)	23 (75)	34 (21)

Both reservoirs were surveyed in the National Eutrophication Study (Anonymous, 1976a) that included 15 Iowa waters. Overall trophic quality was judged by six water chemistry parameters. Lakes were ranked in order of increasing eutrophication in which Lake Rathbun was seventh and Lake Red Rock thirteenth.

Domestic and industrial waste has had an acute impact on nutrient levels and dissolved oxygen at Lake Red Rock. Clark (1972) found Lake Red Rock was weakly stratified during summer months and nutrient levels were influenced primarily by inflow. A more detailed account of physical and chemical characteristics of Lake Red Rock can also be found in Mayhew (1972a, 1972b) as well as the Iowa Water Quality Management Plan for the Des Moines River Basin (Anonymous, 1975).

Chronic turbidity at Lake Red Rock is due to prevailing wind action on silt laden substrate in embayments and along unprotected shorelines. Similar problems prevail at Lake Rathbun where wave action on bare clay shoreline banks create considerable disturbance in addition to inflow of suspended materials from tributary streams.

Post-impoundment water chemistry studies of Lake Rathbun were conducted by Mayhew (1974). Thermal stratification usually developed around mid-June through late August. Water chemistry parameters including chemical oxygen demand, ammonia, nitrate and nitrite had wide seasonal variation.

Initial studies of primary and secondary trophic levels were conducted soon after impoundment of Lake Red Rock. Johnson (1972) believed the most important limiting factors to phytoplankton populations were hydraulic retention, turbidity, and weather. Johnson also identified five dominant genera at Lake Red Rock and found their abundance decreased from the upstream to the downstream area of the damsite. Asch and Kingsbury (1970) identified 21 species of zooplankton in Lake Red Rock and noted population fluctuations showed slight correlation with temperature, turbidity, discharge rate, and nutrient levels but none with elevation. Population density increased first at the upper end of the reservoir then to succeeding study sites toward the dam, declines followed the same trend but zooplankton numbers persisted longer at the damsite, these findings were similar to those of McGrath (1972). Macrobenthos are less abundant at Lake Red Rock than other reservoirs and species diversity is relatively low, comprised primarily of Oligochaetes, Chironomids, and *Chaoborus punctipennis*, other macro-organisms are rare (Keith, 1970; Hoekstra, 1973). Mayhew (1977) provided a detailed account of zooplankton population dynamics and the impact of reservoir operations at Lake Rathbun.

Prior to impoundment of Lake Red Rock, Harrison (1962) reported the Des Moines River supports a popular channel catfish fishery supplemented by carp, carpsucker, and freshwater drum. A pre-impoundment netting and electrofishing survey by Harrison (1963) confirmed an abundance of carpsucker followed by carp and channel catfish. Crappie were taken only in small numbers while northern pike, walleye and largemouth bass were not captured. Channel catfish movement and age structure was investigated by Ackerman (1965a and 1965b) to supplement pre-impoundment data.

Pre-impoundment work on the Des Moines River included a comprehensive experimental exploitation study of channel catfish from 1966-1968 (Mayhew, 1972a). The species composition of the net catch from a 32.2 km (20 mi) stretch of stream was dominated by channel catfish, 88% by number and 50% by weight, followed by carp and river carpsucker. Mean annual biomass of catfish in the study area was estimated at 5,354 fish weighing 1,092 kg (2,405 lbs).

Investigations by Wunder (1969) following initial impoundment of Lake Red Rock revealed the new reservoir was dominated by a population of fast growing carp. Carp comprised 66% of the numerical catch by pound nets followed by bullhead, 19% and carpsucker, 10%; while other species constituted < 2% of the catch. Continued dominance of carp and carpsucker was recorded during a three-year commercial food-fish study by Mayhew (1972b), 1969-1971. Carp, river carpsucker, and bigmouth buffalo comprised 83% of the numerical catch. Population estimates were 2.8 million carp, 319,000 river carpsucker, and 187,000 buffalo. As a result of the commercial food-fish investigation a commercial fishery was opened at Lake Red Rock in October, 1973.

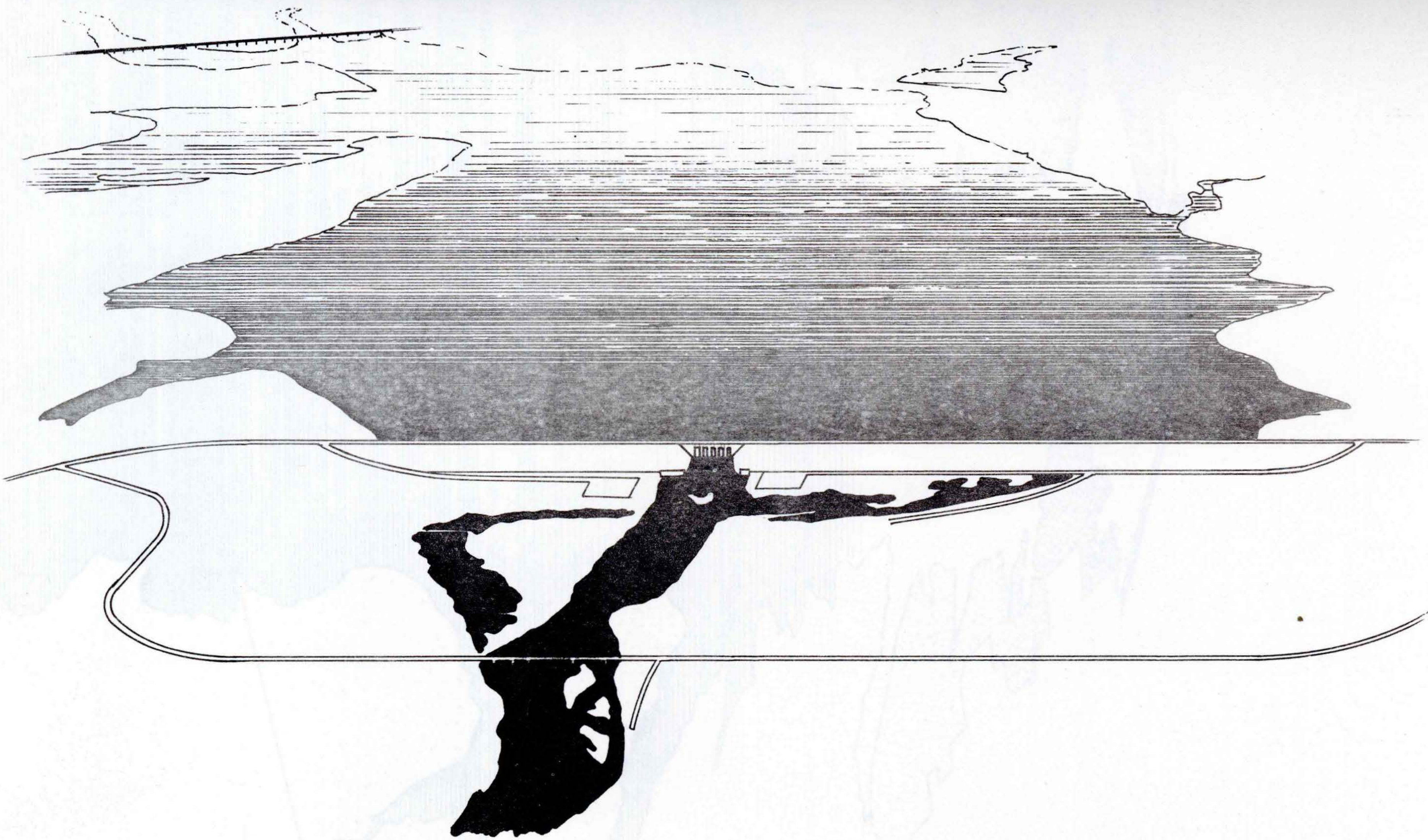

Figure 1. Red Rock Reservoir.

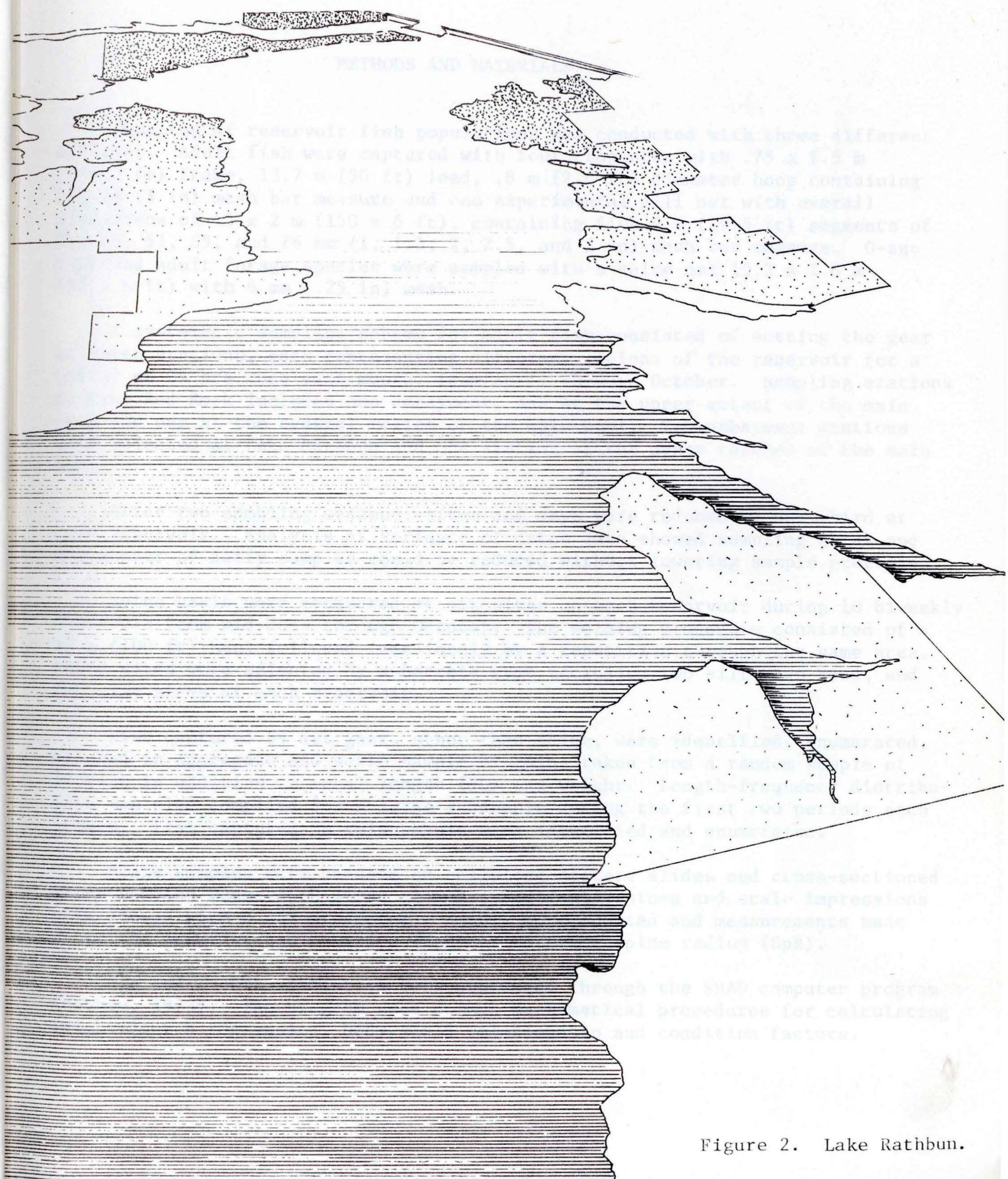

Figure 2. Lake Rathbun.

Lake Rathbun pre-impoundment studies of fish populations began with an annotated list of species indigenous to the Chariton River (Mayhew, 1965a). Mayhew established 18 sampling stations and with seine hauls captured 35 species representing 10 families. Species composition, determined by fish toxicant treatments, was comprised primarily of black bullhead, 28%; carp, 17%; channel catfish, 15%; gizzard shad, 15%; carpsucker, 7%; and white crappie, 4% (Mayhew, 1965b). Channel catfish was the traditional favorite of local anglers.

METHODS AND MATERIALS

Sampling of reservoir fish populations was conducted with three different net gear. Adult fish were captured with four trap nets with .75 x 1.5 m (3 x 5 ft) frame, 13.7 m (50 ft) lead, .8 m (2.6 ft) diameter hoop containing 2.5 cm (1 in) mesh bar measure and one experimental gill net with overall dimensions of 45 x 2 m (150 x 6 ft), containing five 9 m (29.5 ft) segments of 25, 38, 51, 65, and 76 mm (1, 1.5, 2, 2.5, and 3 in) mesh bar measure. 0-age fish and adult forage species were sampled with a seine net 15.2 x 1.8 m (50 x 6 ft) with 6 mm (.25 in) mesh.

A systematic sampling scheme for adult fish consisted of setting the gear at three stations, each representing different regions of the reservoir for a period of 24 hrs once each month, from April through October. Sampling stations at Lake Red Rock included one embayment, one at the upper extent of the main pool and one at the central region of the main pool. Two embayment stations were selected at Lake Rathbun and one station at the upper reaches of the main pool.

After two sampling seasons, sites and days were reduced by one-third at each reservoir. Analysis of variance of catch data showed sampling sites and the number of daily samples could be reduced without lowering sample precision.

Seine hauls were conducted at six sites on each reservoir during 10 biweekly intervals from mid-June through October. The seining procedure consisted of a 30 m (100 ft) haul followed immediately by a repetition through the same area. Seine sites were selected by substrate type including two silt, two sand, and two clay sites at each reservoir.

Fish captured by net gear, other than seine, were identified, enumerated, weighed in aggregate and scale sample or spine taken from a random sample of 50 fish in addition to total length (TL) and weight. Length-frequency distribution was also compiled for a large subsample during the first two periods each season. Fish captured in seine hauls were identified and enumerated.

Scale samples were pressed on cellulose acetate slides and cross-sectioned spine samples mounted on glass slides. Sectioned spines and scale impressions were viewed with a 40X projector. Annuli were counted and measurements made along the anterior scale radius (ScR) or anterior spine radius (SpR).

Age and growth statistics were processed through the SHAD computer program (Mayhew, 1973). The program uses common mathematical procedures for calculating weight-length regression, body-scale relationship and condition factors.

Plate 1. Pound net being raised at Lake Rathbun.

An index of growth in a calendar year was computed by summing increments of back-calculated body lengths for each age group to determine a grand mean (Hile, 1941). Individual increments were then divided by the overall mean to obtain a percentage of growth in comparison to the mean, percentages of age groups represented in each calendar year were then added and 100 subtracted from the sum to derive the index value. Values obtained provided a base of 100; those < 100 represented below average growth and those > 100 were above average growth. Sample size of < 5 fish were excluded.

Catch statistics were used to calculate relative abundance, measured as fish per net day (FND). Species composition by percent number and weight, and age class structure was determined from length-frequency distribution.

Daily pool elevation and discharge rate was obtained from Project Offices located at the damsites of both reservoirs. Pool elevation was averaged for each month and the deviation from conservation pool, discharge rate, and hydraulic retention calculated. Hydraulic retention was computed as the quotient of storage volume and discharge rate, estimated in days.

FISH STOCKING CHRONOLOGY AND NUMBERS

Stocking of hatchery reared fish were conducted from 1969-73 at Lake Red Rock and from 1969 through the study duration at Lake Rathbun (Table 2). Plantings at Lake Red Rock were limited to walleye, largemouth bass, and northern pike. Nearly a million or more northern pike were stocked each year except 1971 when stocking was limited to largemouth bass. Walleye were stocked at 7 to 22 million each year except 1971 and 1972 when none were stocked. Bass stocking numbers ranged from 160,000 in 1969 to 700,000 in 1971 and 1973.

Fish stocking at Lake Rathbun included largemouth bass, white bass, striped bass, walleye, and muskellunge. White bass were released in Lake Rathbun in 1971. About 3 to 11 million walleye were stocked every year at Lake Rathbun exept 1969. Stocking of about 200,000 channel catfish each season was limited to 1969 and 1970. Bass planting ranged from 63,000 in 1970, to 500,000 in 1971 and 1973.

WATER MANAGEMENT OBSERVATIONS

RESERVOIR OPERATIONS

Lake Red Rock is characterized by extreme variation in water levels while Lake Rathbun is relatively stable. The reason for this difference is that Lake Red Rock has a large watershed, greater discharge rate and a larger storage volume. This enables large quantites of water to be stored or discharged creating tremendous reservoir elevation fluctuations.

Although each reservoir has discrete attributes, 1973 was similar at each reservoir. Mean elevation was considerably higher in 1973 than other years, at Lake Red Rock it was 231.3 m (759 ft) in comparison to 221.7 (727 ft), 224.8 (737 ft) and 222.7 m (730 ft) for 1972, 1974, and 1975. At Lake Rathbun mean

Table 2. Chronological order of number and stage of fish stocked in Lake Red Rock and Lake Rathbun.

		Number	Stage
		Lake Red Rock	
1969	Northern pike	1,050,000	Larvae
	Walleye	21,780,000	Larvae
	Largemouth bass	132,000	Postlarvae
	Largemouth bass	570,000	Larvae
1970	Northern pike	400,000	Larvae
	Northern pike	400,000	Postlarvae
	Walleye	8,000,00	Prolarvae
	Walleye	200,000	Postlarvae
1971	Largemouth bass	335,000	Larvae
1972	Northern pike	600,000	Larvae
	Northern pike	1,000,000	Postlarvae
1973	Largemouth bass	133,500	Larvae
	Largemouth bass	30,000	Postlarvae
	Northern pike	2,250,000	Larvae
	Walleye	7,000,000	Larvae
		Lake Rathbun	
1969	Channel catfish	202,000	Postlarvae
1970	Channel catfish	200,000	Postlarvae
	Walleye	3,400,000	Prolarvae
	Muskellunge	34,500	Prolarvae
	Muskellunge	1,000	Postlarvae
	Largemouth bass	424,000	Postlarvae
1971	Largemouth bass	496,000	Postlarvae
	Walleye	11,000,000	Larvae
	Muskellunge	1,010	Postlarvae
	White bass	2,800	Adult
	Striped bass	500,000	Prolarvae
1972	Walleye	9,000,000	Prolarvae
	Striped bass	2,174	Postlarvae
1973	Walleye	9,000,000	Prolarvae
	Largemouth bass	63,335	Postlarvae
1974	Walleye	11,000,000	Larvae
	Striped bass	45,000	Postlarvae
1975	Walleye	11,000,000	Larvae
	Striped bass	55,000	Postlarvae

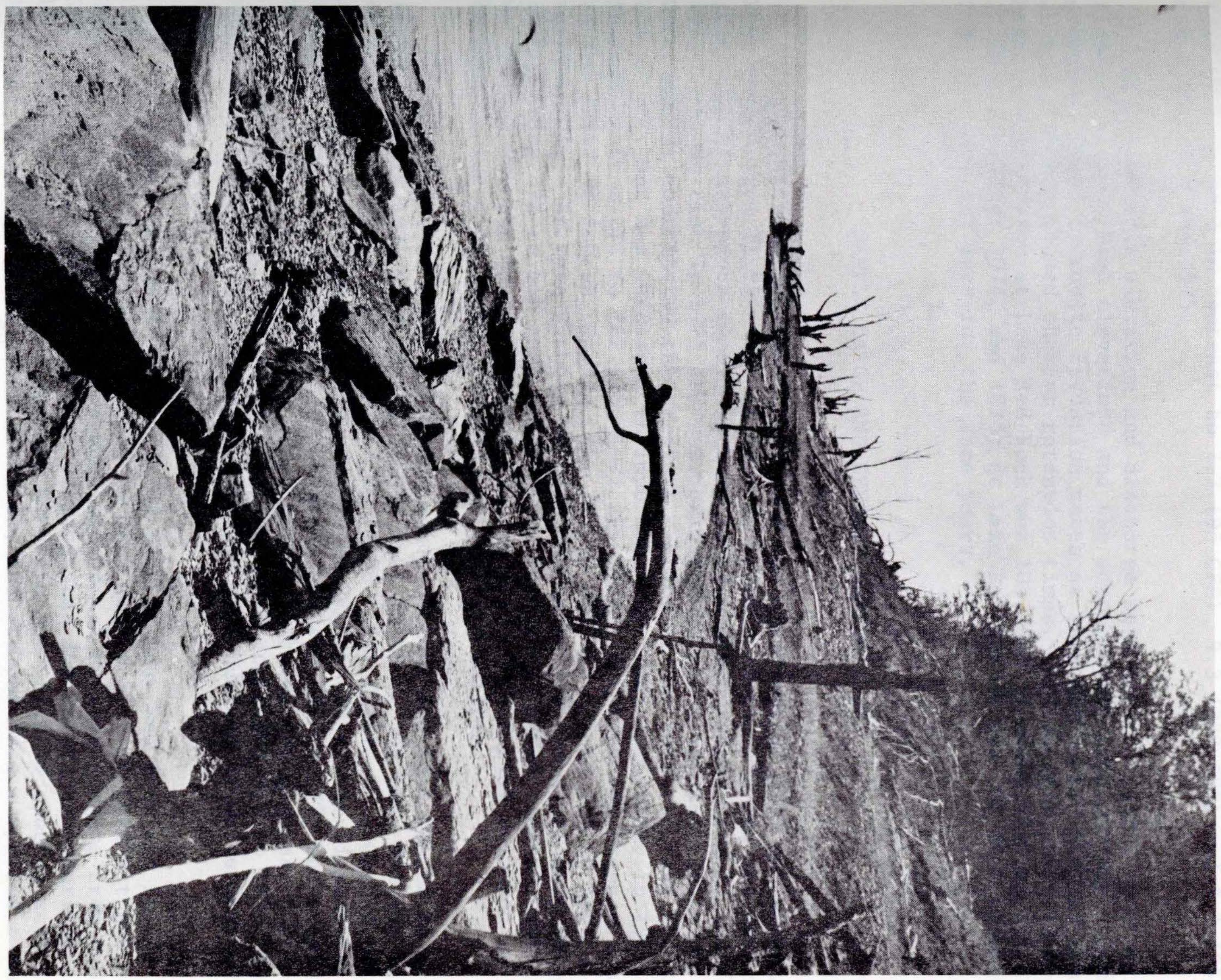

Plate 2. Instable reservoir elevations and wave action at Lake Red Rock create considerable shoreline erosion.

elevation was 277.9 m (912 ft) in 1973 and 275.5 (904 ft), 275.9 (905 ft) and 275.7 m (904 ft) for the same years. Mean monthly discharge rate was also highest at both reservoirs during 1973, 491 CMS (17,312 CFS) at Lake Red Rock in comparison to 195 (6,876 CFS), 251 (8,850 CFS) and 251 CMS (8,850 CFS) for 1972, 1974, and 1975. Mean monthly discharge rate at Lake Rathbun was 21.1 CMS (744 CFS) in 1973 in contrast to 2.7 (95 CFS), 9.3 (328 CFS) and 7.2 (254 CFS) for 1972, 1974 and 1975.

High reservoir elevation and discharge rate period created contrasting flushing rates. High elevations and the accompanying high storage volume produced longer hydraulic retention rates at Lake Red Rock. Similar conditions at Lake Rathbun caused shorter retention times. For example, in 1973 mean hydraulic retention at Lake Red Rock was 105 days in comparison to 45, 34, and 22 days for 1972, 1974, and 1975; at Lake Rathbun it was 208 days compared to 710, 412, and 513 days for the same years.

SAMPLE CATCH AND SPECIES COMPOSITION

The total numerical catch by pound and experimental gill net at Lake Red Rock ranged from 11,954 fish in 1974 to 8,565 fish in 1975 and was comprised primarily of non-sport fish. At Lake Rathbun catch ranged from 13,195 fish in 1972 to 6,390 fish in 1975 and was dominated by sport species (Table 3). Carp usually contributed the greatest portion of the catch at Lake Red Rock, 22% to 31%, but was surpassed in importance by river carpsucker in 1975, increasing from 17% to 26% from 1972 and 1975. Bullhead and crappie usually ranked third or fourth ranging from 11% to 22% and 12% to 21% of the catch, respectively. At Lake Rathbun crappie dominance was surpassed only once contributing 37% to 64% each year. Carp frequently ranked second providing 13% to 38% and was the most important fish in 1973. Other fish captured at Lake Rathbun included bullhead, channel catfish, and walleye.

Total weight of fish in the net catch at Lake Red Rock ranged from 4,075 kg (8,976 lbs) in 1974 to 2,659 kg (5,857 lbs) in 1972. At Lake Rathbun it varied from 3,494 kg (7,696 lbs) to 1,807 kg (3,980 lbs) (Table 4). Carp generally ranked highest at Lake Red Rock comprising 21% to 48% of the biomass followed by river carpsucker, 18% to 33%; bigmouth buffalo, 6% to 22%; and crappie, 6% to 18%. At Lake Rathbun, carp generally contributed the greatest portion of the catch by weight, 22% to 51%, while crappie comprised 20% to 58%. Bullhead was always third in importance (7-14%) but was equalled by white bass in 1975 (10%).

Seine nets captured 21 species of fish at Lake Red Rock and ranged in total catch from 12,379 in 1974 to 1,633 in 1975 (Table 5). At Lake Rathbun, at least 12 species of fish were caught with total catches ranging from 6,080 in 1973 to 2,644 in 1972 (Table 5). Gizzard shad dominated the numerical catch in both reservoirs usually followed by *Notropis sp.* Planted species such as walleye, largemouth bass, northern pike, and striped bass comprised a small portion of the catch.

Lake Rathbun, 1972-75.

Species	Lake Red Rock 1972	1973	1974	1975	Lake Rathbun 1972	1973	1974	1975
G shad	5.5	.6	8.2	4.2	6.9	7.4	5.6	8.3
N pike	.2	1.4	1.6	1.3	---	---	---	---
R carpsucker	17.2	17.0	18.5	25.9	.4	.3	.6	.6
B buffalo	8.1	2.1	3.9	3.9	2.1	3.0	.6	1.2
W sucker	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
Carp	30.2	30.9	24.5	21.9	19.6	37.6	13.1	27.0
Bullhead	18.4	21.6	8.9	11.4	11.2	14.5	7.4	9.6
C catfish	1.6	1.0	.7	.9	7.1	6.5	1.3	2.3
F catfish	.1	< .1	< .1	< .1	---	---	---	---
W bass	.3	1.5	5.7	3.3	.1	.5	1.5	9.6
Y bass	< .1		< .1	< .1			< .1	.1
S bass[a]	---	---	---	---				< .1
Crappie	12.5	13.3	21.4	20.2	40.6	36.6	64.3	37.2
Bluegill	.8	1.1	1.3	.8	3.9	1.6	2.2	1.0
G sunfish	.1	1.2	.2	.1	.8	.7	.6	.1
LM bass	.4	1.8	1.9	1.4	.3	.2	.2	.1
Walleye	.2	1.5	1.3	1.4	6.8	3.8	2.5	1.9
FW drum	3.9	3.6	.8	1.4	< .1	< .1	< .1	< .1
Others[b]	.5	1.1	.8	< .1		< .1		.2
Total number	10,102	8,917	11,954	8,565	13,195	12,649	10,721	6,390

[a]All fish caught were 0-age striped bass.

[b]Others include N redhorse, goldfish, *Notropis sp.*, S gar, Y perch and R sunfish at Lake Red Rock and *Notropis sp.* at Lake Rathbun.

Rock and Lake Rathbun, 1972-75.

Species	Lake Red Rock 1972	1973	1974	1975	Lake Rathbun 1972	1973	1974	1975
G shad	2.8	.1	3.5	.8	2.5	2.1	2.4	3.8
N pike	1.6	1.7	5.9	6.4	---	---	---	---
R carpsucker	17.9	22.3	22.0	32.7	1.1	.6	1.8	2.3
B buffalo	22.1	6.5	10.1	5.9	7.7	8.2	2.2	3.8
W sucker	< .1	< .1	< .1	< .1	< .1	< .1	< .1	< .1
Carp	37.6	47.8	31.4	21.1	38.4	51.0	21.8	45.4
Bullhead	6.5	8.5	4.7	4.7	6.9	4.2	3.2	3.0
C catfish	2.6	1.2	.8	.9	10.2	7.1	2.0	4.2
F catfish	.1	< .1	< .1	< .1				
W bass	.2	.4	1.9	2.9	< .1	.3	1.4	6.0
Y bass	< .1	---	< .1	.1			< .1	< .1
S bass[a]	---	---	---	---				< .1
Crappie	5.8	6.2	14.1	18.4	22.1	20.0	56.7	24.9
Bluegill	.2	.3	.3	.4	1.4	.5	.8	.3
G sunfish	< .1	.3	< .1	< .1	.2	.2	.2	< .1
LM bass	.5	2.1	3.1	2.6	< .1	.4	.5	.4
Walleye	.8	.4	1.2	1.9	8.9	5.2	6.8	5.4
FW drum	1.0	1.3	.2	.7		< .1		< .1
Others[b]	.6	1.0	.7	< .1		< .1		< .1
Total weight	2,659	2,863	4,075	2,826	2,964	3,494	2,586	1,807

[a]All fish caught were 0-age striped bass.

[b]Others include N redhorse, goldfish, *Notropis sp.*, S gar, Y perch and R sunfish at Lake Red Rock and *Notropis sp.* at Lake Rathbun.

Lake Rathbun, 1972-1975.

Species	Lake Red Rock 1972	Lake Red Rock 1973	Lake Red Rock 1974	Lake Red Rock 1975	Lake Rathbun 1972	Lake Rathbun 1973	Lake Rathbun 1974	Lake Rathbun 1975
G shad	6,227	953	8,520	805	2,332	5,250	3,736	2,648
N pike		15			---	---	---	---
R carpsucker	696	6	73	131				
B buffalo	7	64	442	9				
Notropis sp.	4,004	1,284	477	153	122	356	405	274
Carp	210	18	83	29				
C catfish	81	8	12	26			7	6
Bullhead[a]	5	6,988	6	1		4	1	1
W bass	114	203	772	73	5	33	117	70
Y bass								4
S bass	---	---	---	---	2		31	52
Crappie[b]	217	135	1,493	198	2	26	1	
Bluegill	31	79	8	18	44	112	1	7
G sunfish	3	6	1	2	4	4	2	
LM bass	113	595	354	19	17	95	3	25
Walleye	8	20		13			2	24
FW drum	91	8	51	153			5	2
Others[c]	3	11	1	3				
Total	8,954	10,391	12,379	1,633	2,644	6,080	4,311	3,115

[a]Primarily black bullhead.

[b]Black and white crappie at Lake Red Rock and primarily white crappie at Lake Rathbun.

[c]Includes white sucker, goldfish, flathead catfish, smallmouth bass, yellow perch, and logperch at Lake Red Rock.

ANALYSIS OF CATCH SUCCESS

Species composition of the combined net catch remained the same during the entire study. Analysis of variance in the mean FND for each species showed no significant change in the species composition in either reservoir (Tables 6 and 7). At Lake Red Rock the catch was consistently dominated by carp, crappie, river carpsucker, and bullhead. Crappie predominated at Lake Rathbun followed by carp, bullhead, channel catfish, and walleye. White bass increased in numerical catch at both reservoirs.

Pound nets were more efficient in catching fish than experimental gill nets. At Lake Red Rock the average catch ranged from 100 to 205 FND for pound nets and 56 to 93 FND with gill nets (Table 6). Lake Rathbun samples were similar, 101 to 185 FND compared to 72 to 98 FND (Table 7). Crappie, carp, bigmouth buffalo, river carpsucker, bullhead, and largemouth bass catches were greater in pound nets, but the gill nets were more effective for channel catfish, gizzard shad, northern pike and walleye.

Although species composition did not change at either reservoir, catch success varied between years for some fish. At Lake Red Rock catch success of northern pike and largemouth bass was similar for most years but catches in 1974 were significantly higher, 7.1 FND and 6.5 FND compared to average values of 2.5 FND for northern pike and 2.4 FND for bass. Catchability of walleye, carp, and crappie did not vary significantly between years averaging about 5 FND for walleye, 49 FND for carp, and 33 FND for crappie. Catch success of river carpsucker was significantly higher in 1974 than 1973, 49 FND as compared to 22 FND. Catches of channel catfish were higher in 1972, 4.8 FND, than 1973, 2 FND. Bigmouth buffalo catch success was lower in 1973 than any other year, 3 FND compared to mean of 9.6 FND for other years. At Lake Rathbun the catch of walleye was higher in 1972, 24 FND, than any other year, average of 8 FND. Catch success of 147 FND of crappie in 1974 was significantly higher than catches of 65 FND in 1973 and 57 FND in 1975 while catchability of channel catfish was higher in 1972 (20 FND) and 1973 (17 FND) then 1974 (9 FND) and 1975 (8 FND). No difference in catch success between years were recorded for carp and bullhead, averaging 40 FND and 26 FND, respectively. The catch of largemouth bass by net gear was too low at Lake Rathbun to compare. White bass increased in catch success at a significant rate at Lake Rathbun, .2 FND in 1972 to 15 FND by 1975.

Species composition in the seine samples of small fish remained the same at both lakes during the entire study (Table 5). 0-age gizzard shad dominated samples at both reservoirs followed by *Notropis sp.* Young crappie, largemouth bass and river carpsucker were important at Lake Red Rock and white bass, bluegill, and largemouth bass were common at Lake Rathbun.

Total seine catch between years did not differ significantly at Lake Red Rock or Lake Rathbun, but annual catches varied within some species. At Lake Red Rock, 0-age channel catfish, carpsucker and carp, were more abundant in 1972 than any other year. Young gizzard shad were more numerous in 1972 and 1974, while shiners were most abundant in 1972. Seine catches of young crappie, walleye, and freshwater drum did not differ between years. Young northern pike were caught only during 1973 and catches of bullhead and largemouth bass were significantly highest that same year. The 1974 season was the best for white bass and bigmouth buffalo reproduction.

Table 6. Catch success (FND) by pound net, experimental gill net and combined catch at Lake Red Rock, 1972-75.

Species	Pound net				Experimental gill net				Combined catch			
	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975
Carp	39.7	34.1	54.4	32.8	13.5	4.9	7.3	7.8	53.2	39.0	63.7	40.6
Crappie[a]	15.6	13.8	47.9	31.2	8.7	5.6	4.9	3.4	24.3	19.4	52.8	34.5
B bullhead	22.3	21.0	17.9	13.0	15.4	14.3	10.1	20.0	37.7	35.3	27.9	33.0
B buffalo	11.3	2.7	8.8	6.0	.7	.4	.9	.7	12.0	3.0	9.7	6.7
R carpsucker	22.9	18.3	40.2	40.2	5.3	4.5	9.1	3.5	29.1	22.8	49.2	43.7
C catfish	1.4	.9	1.1	.6	3.4	1.1	2.1	3.7	4.8	2.0	3.2	4.3
G shad	3.1	.2	12.7	2.3	18.7	2.0	22.6	17.2	21.8	2.1	35.3	19.5
F drum	3.3	2.5	1.3	1.5	9.2	6.2	2.0	3.3	12.4	8.7	3.3	4.7
Walleye	.2	.1	1.3	1.0	.2	6.2	6.4	4.8	.4	6.3	7.7	5.8
Bluegill	1.1	1.3	3.1	1.3	< .1	.2	.1		1.1	1.4	3.2	1.3
G sunfish	< .1	.9	.4	< .1	.5	1.9	.3	.4	.5	2.7	.7	.5
N pike	.2	.6	2.4	2.0	.3	3.9	4.7	.8	.4	4.5	7.1	2.7
LM bass	.4	1.4	3.5	2.2	.6	2.3	3.0	.5	.9	3.7	6.5	2.7
Goldfish	.1	.6	1.5		< .1	.4			.1	1.0	1.5	
F catfish	.1	< .1	.1	< .1	.1	.1	.1		.1	.1	.1	< .1
N redhorse	.2	< .1	.2	< .1	.3	.1	.1		.5	.1	.2	< .1
W & Y bass[b]	.4	1.4	8.0	5.9	.2	1.1	19.4	5.0	.6	2.5	27.4	10.9
S gar	< .1	.2	.1		.7	.2	.1		.7	.4	.2	
Notropis sp.	< .1	< .1			.2	.4	.2		.2	.4	.2	
R sunfish	< .1	.1	< .1		< .1	< .1			< .1	.1	< .1	
W sucker	< .1	< .1			< .1	.1			< .1	.1		
Y perch	< .1	< .1	< .1		< .1	.1			< .1	.1	< .1	
Total	122.3	100.1	205.1	140.0	78.7	55.6	93.4	71.1	201.0	155.6	298.5	211.1

[a]Primarily black crappie.

[b]Primarily white bass.

Table 7. Catch success (FND) by pound net, experimental gill net and combined catch at Lake Rathbun, 1972-75.

Species	Pound net				Experimental gill net				Combined catch			
	1972	1973	1974	1975	1972	1973	1974	1975	1972	1973	1974	1975
Carp	30.2	51.2	25.5	31.0	6.3	3.2	5.7	5.9	36.5	54.5	31.3	36.9
Crappie[a]	61.8	45.7	127.2	40.7	16.7	19.0	19.9	16.0	78.5	64.7	147.0	56.7
Bullhead	13.7	13.3	10.8	8.8	4.0	26.4	16.6	10.8	17.7	39.7	27.4	19.5
B buffalo	3.4	4.1	1.3	1.5	.2		< .1	< .1	3.6	4.1	1.3	1.6
R carpsucker	.7	.4	1.2	.7		.1		.2	.7	.5	1.2	1.0
C catfish	8.7	6.1	1.1	.9	11.4	11.1	5.9	7.4	20.1	17.2	6.9	8.3
Walleye	6.4	3.3	3.7	1.6	17.9	7.4	5.2	3.0	24.3	10.7	8.9	4.6
G shad	4.7	8.6	6.0	4.1	25.4	6.6	20.9	22.8	30.1	15.2	27.0	26.9
Bluegill	6.4	2.3	4.4	1.2	.1	.1	.6	.2	6.4	2.4	5.1	1.4
G sunfish	12.9	.8	1.1	.1	1.1	.8	.4	< .1	14.0	1.6	1.6	.2
LM bass	.3	.2	.3	.1	.7	.3	.6	< .1	1.0	.5	1.0	.2
W bass	.2	.5	2.0	10.4	.1	.9	3.7	4.6	.2	1.4	5.8	15.0
W sucker	.1	.1	< .1	< .1	.7	.2	.1		.7	.2	.2	< .1
G shiner			< .1			.1	.1			.1	.1	
Y bass			< .1				< .1	.6			< .1	.6
F drum				< .1				.9				.9
S bass[c]								.4				.4
Total	137.4	136.4	185.3	101.1	98.3	76.2	80.0	72.1	235.7	212.7	265.3	173.2

[a]Primarily white crappie.

[b]No significant difference in species composition between years at .05 level.

[c]All striped bass were 0-age.

Smaller variation in year class abundance between years was observed at Lake Rathbun. Little variation was found for most species and no difference was found for gizzard shad, *Notropis sp.*, and channel catfish. 0-age largemouth bass and crappie were dominant in 1973, while the same year class of bluegill was more numerous than the 1974 and 1975 year class. No difference was found between other years. The 1974 year class of white bass was greater than the 1972 group. The 1975 year class of walleye was most dominant.

Fluctuating water levels made it impossible to continuously sample exactly the same seine site, particularly at Lake Red Rock. To compensate, areas of similar habitat, in close proximity to the original site, were sampled. However, selection of the various types of substrate for seine haul sites was not important for determining year class success. Analysis of variance testing showed no difference for catch success of any species between sites of dissimilar habitat at either reservoir.

IMPACT OF RESERVOIR OPERATIONS ON CATCH SUCCESS

Variation in annual catch success of fish at Lake Red Rock was related to storage volume, lower catches were associated with higher storage. Other regimen did not appear related. A similar comparison to water management data from Lake Rathbun did not show the same phenomena. Subjective rank in order of increased floodwater storage in Lake Red Rock, was 1972, 1975, 1974, and 1973. Catch success of major fish species at Lake Red Rock were then compared to the subjective rankings by linear regression.

Cosiderable difference in coefficient of determination values were derived but one paramount fact was evident in that nearly all species at Lake Red Rock were caught at the lowest rate in 1973, the year of highest reservoir volume except stocked sport species and bullhead. Channel catfish, bigmouth buffalo, bullhead and gizzard shad had negative relationships. Stocked sportfish including northern pike, walleye, and largemouth bass had positive relationships.

Regression equations did not result in significant predictable equations except for channel catfish. A dilution affect appeared but it was not of significant magnitude, apparently other factors played a more important role. Positive R^2 values of stocked species were created by recruitment of large plantings of 0-age fish in previous years and was not indicative of reservoir volume. Recruitment of strong year classes was responsible for reduced R^2 values of many fish, particularly crappie, river carpsucker and carp during high reservoir volume. Strong 1972 year classes of river carpsucker and carp were fully vulnerable to net gear by 1974 while some members of the 1974 year class of bigmouth buffalo, a faster growing fish, were caught by nets that same year. Thus, catch success was higher in 1974, a year that had a higher ranking of reservoir volume than 1972 or 1975. A strong 1971 year class of crappie, not documented in seine hauls, is responsible for the high catch of crappie in 1974. Statistical analysis of reservoir operations on the abundance of 0-age fish did not result in any conclusive findings; however, some generalizations are apparent. Strong year classes of bluegill, crappie and largemouth bass were recorded at Lake Rathbun in 1973, a year of high reservoir elevation, as were largemouth bass and bullhead at Lake Red Rock. Another high water year at Lake Red Rock, 1974, was very good for white bass, crappie, and bigmouth buffalo.

Plate 3. Sport fish made up a small portion of the catch at Lake Red Rock.

Near normal pool elevations of Lake Red Rock during 1972 appeared to be conducive for carp, river carpsucker and channel catfish reproduction since catches of 0-age fish of these species were significantly higher that year.

IMPACT OF FISH STOCKING

Fish stocking at Lake Red Rock and Lake Rathbun did not change the species composition significantly in either reservoir but served to establish or maintain most populations. However, the dramatic increase in relative abundance of walleye, northern pike, and largemouth bass at Lake Red Rock was due to plantings. An extremely low catch of these species was recorded in 1972, but in the years following marked increases in catch success was due to complete recruitment of these fish and their progeny. Seine catches of walleye, northern pike and largemouth bass were numerically higher in 1973, a stocking year for all three species. Largemouth bass catches were significantly higher and was the only year 0-age northern pike were taken in seine hauls. Although, northern pike were stocked in 1972, most were fingerlings, larger than fish planted in other years.

Fish stockings at Lake Rathbun were important in establishing several fish species but after an initial impact on population density it appears subsequent releases did not increase the population size. High catch rates were recorded early in this study for walleye and channel catfish but these populations initially declined and then appeared to stabilize. Walleye were stocked each season with no apparent increase in population density. Channel catfish density was constant despite the lack of recent plantings. No striped bass older than 0-age were captured. Muskellunge were not caught during this study but several were caught by anglers. Adult white bass were stocked in 1971 and reproduced each year. Low catches of 0-age fish by seine net and consistent stocking of some species and inconsistent stockings of others did not allow many annual comparisons at Lake Rathbun. For example, walleye were stocked each year of this study but largemouth bass were planted only in 1973.

Analysis of stocking density in relation to annual seine catches was not possible. Low catches by seine net of most stocked fish coupled with inconsistent stocking rates, and four years of data precluded statistical testing.

SEASONAL CATCH DISTRIBUTION

Seasonal catch of fish in net gear did not change significantly at Lake Red Rock, but catches at Lake Rathbun were significantly higher during April and May than in later sampling periods. Catch means at Lake Red Rock ranged from 350 FND during September to 158 FND in July while at Lake Rathbun they ranged from 353 FND during May to 150 FND in October. Analysis of variance testing of catch means between each period showed no significant differences in the seasonal catch at Lake Red Rock while significant differences were found at Lake Rathbun.

Seasonal variations in catch success of carp and crappie were mainly responsible for differences between total monthly catches at Lake Rathbun, whereas variations between monthly catches of carp and channel catifsh at Lake Red Rock were not of a significant magnitude to have an impact on the total monthly catch (Figures 3 and 4). Carp were caught at a significantly higher rate during early periods, April, May and June, at Lakes Red Rock and Rathbun then declined as the season progressed. Catch of channel catfish was higher during mid-season periods, July and August, at Lake Red Rock and bullhead at Lake Rathbun were caught more frequently during early periods, April and May, then decreased into later periods. The net catch of crappie at Lake Rathbun was significantly greater in May than it was in April or October. Seasonal catch curves for other species graphically reflect variations in catchability but they did not differ significantly. Large differences in catch success within periods tended to create wide variances about the means.

Differences in catch success between months were due primarily to behavioral activity patterns. Greater movement of fish enabled net gear to catch more fish while reduced movement decreased catch rates. Factors responsible for movement could include pre- and post-spawning patterns, schooling activity, or feeding behavior.

COMMERCIAL FISHERY AT LAKE RED ROCK

Commercial fishing was authorized in Lake Red Rock in October, 1973 for carp, carpsucker, buffalo, and freshwater drum. Gear was restricted to trammel or gill nets at least 30 m (100 ft) long and having a 7.5 cm (3 in) or more bar mesh size. Catch is reported and compiled each year (Middendorf, 1975, 1976).

Bigmouth buffalo dominated the fishery comprising about 90% of the total catch each year (Table 8). A precise breakdown of the harvest was impossible since the report form was categorized by speices. Commercial fishermen habitually use colloquial common names for fish and often combined carp and carpsucker.

The selective nature of the commerical fishery tended to reduce the mean size of the valuable species in net gear. For example, early in this study the mean weight of bigmouth buffalo increased from .71 (1.56 lbs) to .87 kg (1.92 lbs), 1972-74. Following the opening of commercial fishing the mean weight dropped dramatically to .50 kg (1.10 lbs) in 1975. During the same period carp increased from .32 kg (.70 lbs) to .50 kg (1.10 lbs) then declined to .32 kg (.70 lbs) while river carpsucker rose and stabilized from .27 (.59 lbs) and .42 kg (.93 lbs) from 1972-75. Carpsucker is not valuable averaging about 5¢/lbs compared to 20¢/lbs for buffalo. Numerical composition of bigmouth buffalo in the combined net catch ranged from 2-8% from 1972-75 despite the fact a strong 1974 year class of buffalo recruited in late 1974 and by 1975 many were vulnerable. A significant increase in numerical importance was not recorded yet carpsucker increased in importance.

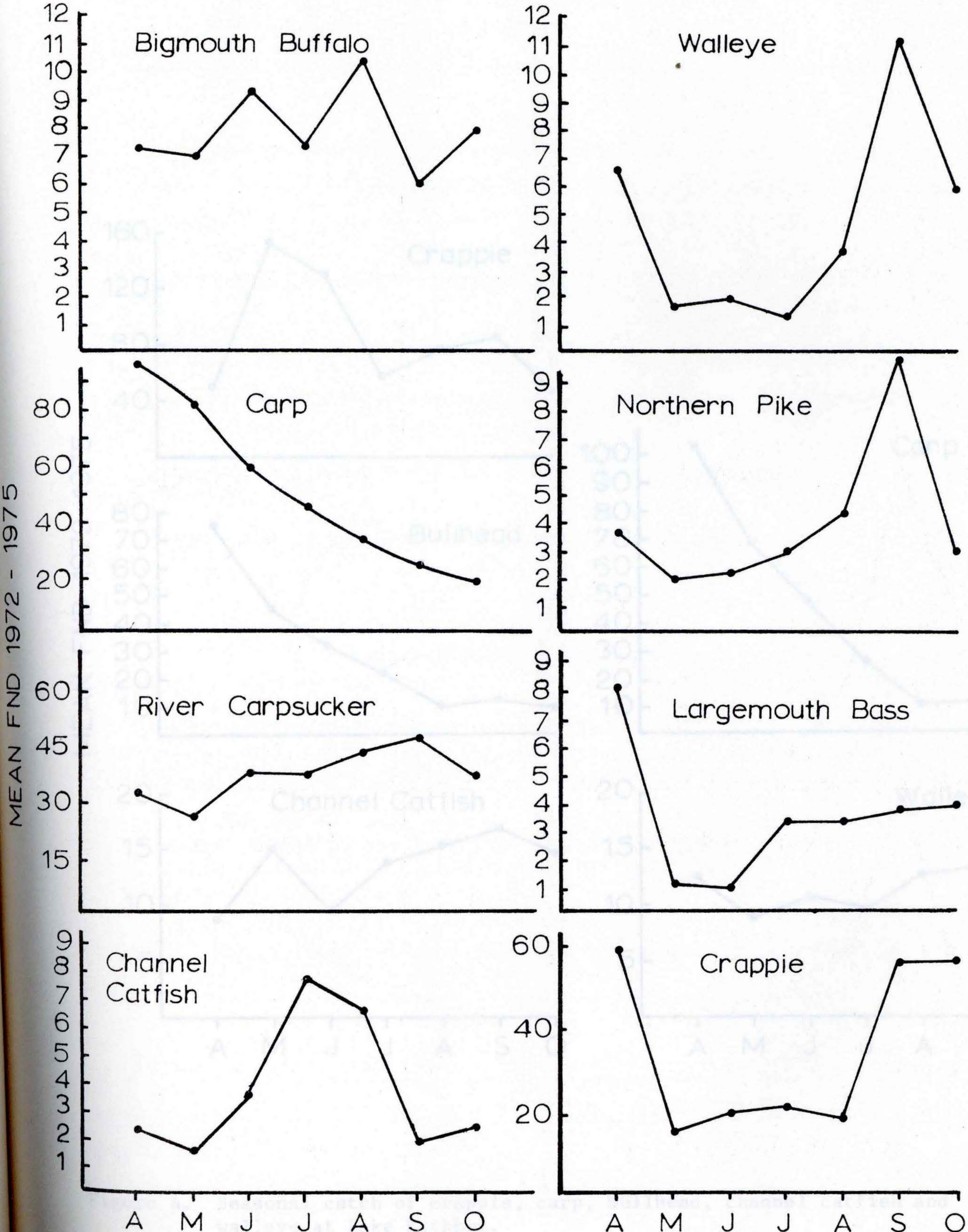

Figure 3. Seasonal catch of bigmouth buffalo, walleye, carp, northern pike, river carpsucker, largemouth bass, channel catfish, and crappie at Lake Red Rock. Catch means are from 1972-75.

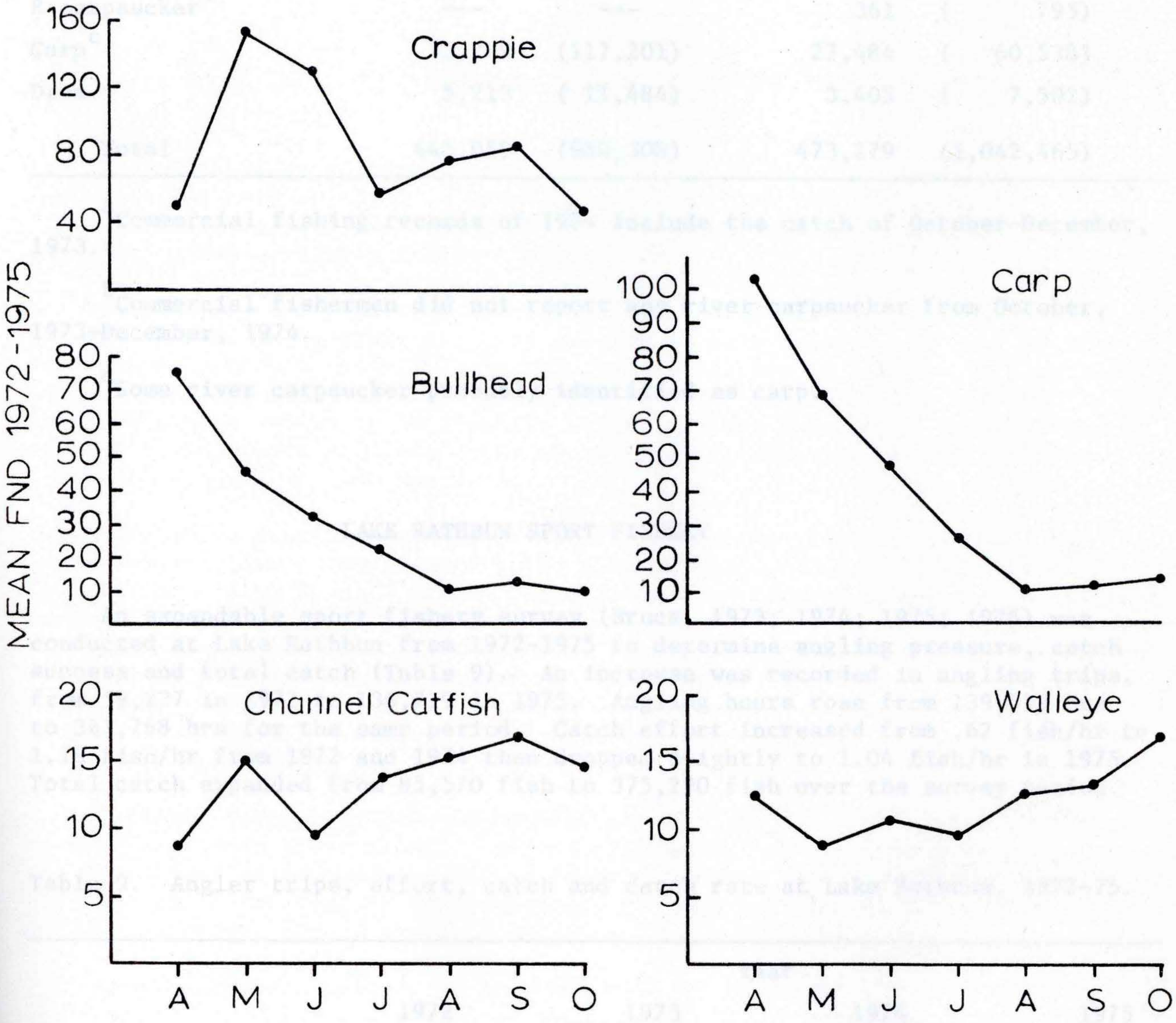

Figure 4. Seasonal catch of crappie, carp, bullhead, channel catfish and walleye at Lake Rathbun.

Table 8. Commercial fishery catch by weight (kg) at Lake Red Rock, 1973-75. Weight in lbs is in parenthesis.

	Year			
	1974[a]		1975	
B buffalo	386,636	(851,623)	442,029	(973,630)
R carpsucker[b]	---	---	361	(795)
Carp[c]	53,209	(117,201)	27,484	(60,538)
Drum	5,213	(11,484)	3,405	(7,502)
Total	445,059	(980,308)	473,279	(1,042,465)

[a]Commercial fishing records of 1974 include the catch of October-December, 1973.

[b]Commercial fishermen did not report any river carpsucker from October, 1973-December, 1974.

[c]Some river carpsucker probably identified as carp.

LAKE RATHBUN SPORT FISHERY

An expandable sport fishery survey (Bruce, 1973; 1974; 1975; 1976) was conducted at Lake Rathbun from 1972-1975 to determine angling pressure, catch success and total catch (Table 9). An increase was recorded in angling trips, from 59,227 in 1972 to 136,719 in 1975. Angling hours rose from 139,599 hrs to 361,768 hrs for the same period. Catch effort increased from .62 fish/hr to 1.19 fish/hr from 1972 and 1974 then dropped slightly to 1.04 fish/hr in 1975. Total catch expanded from 85,570 fish to 375,290 fish over the survey period.

Table 9. Angler trips, effort, catch and catch rate at Lake Rathbun, 1972-75.

	Year			
	1972	1973	1974	1975
Angler trips	59,227	57,104	66,937	136,719
Angler hours	139,599	177,020	204,479	361,768
Fish/hour	.62	.94	1.19	1.04
Total catch	85,570	167,161	243,515	375,290

Initially stocked fish contributed a substantial portion of the fishery but in succeeding years their importance declined (Table 10). Largemouth bass catch was about 16,000 fish in 1972, 13,000 in 1973, but by 1975 it crashed to 4,000. Walleye catch fell from 14,000 fish in 1972 to about 5,000 in 1974 and 7,000 in 1975. The catch of channel catfish remained relatively stable at 4,000 to 6,000 fish each year except during 1974 when total catch dropped to 2,000. Crappie catch increased dramatically from 12,000 fish in 1972 to 335,000 fish during 1975. The total catch of white bass also increased over the same period from 11 to 6,000 fish.

AGE AND GROWTH

Estimates of total body length at each year of life were combined from four years of data to derive a grand average for both reservoirs (Tables 11 and 12). Estimated growth and sample size for these species were also compiled for each year class (Appendix Tables A through O).

In general, older fish were more common at Lake Red Rock than Lake Rathbun, but growth rate was greater for most species at Lake Rathbun. Growth of river carpsucker, bigmouth buffalo, carp and channel catfish at Lake Rathbun exceeded that in Lake Red Rock. Walleye growth was similar at both lakes but that of largemouth bass tended to be slightly better at Lake Red Rock. Growth comparisons of crappie were not made since white crappie dominated at Lake Rathbun and black crappie at Lake Red Rock.

A relative growth index was computed for some species (Table 13). The index values allowed comparisons to be made between growth in a calendar year in relation to the average of all years and common factors suspected of affecting growth. Index values based on an average growth year which represented a basic index value of 100. During calculations of the index values it was noted that extraordinary growth tended to increase or decrease the average proportionatly. Thus, other index values were increased or decreased. Increased or decreased growth was visible by trends in values to accelerate or decline in comparison to prior to preceeding years.

Predator species growth was usually greatest in the first year of impoundment or the first year of stocking. Largemouth bass at Lake Rathbun grew faster in the first year of impoundment with a relative growth index value of 140 which was also the first year of introduction. At Lake Red Rock bass growth was best during the first year of stocking attaining a value of 142.

Growth of black crappie at Lake Red Rock in the first year of impoundment was superior to all seasons with an index value of 164 compared to values of 80 to 96 in other years. Initial impoundment at Lake Rathbun marked the second best season for white crappie growth providing a value of 105 but a value of 106 was attained in 1973 when growth accelerated. Growth of walleye at Lake Red Rock was best during the first year of release, 1970, with an index value of 130, but at Lake Rathbun walleye growth during the initial year stocking, 1970, ranked second at 110 as compared to 133 in 1973. Growth of northern pike at Lake Red Rock was contrary since the first stocking year, 1969, recorded the poorest season of growth with an index value of 83. The greatest value attained by northern pike was 114 during 1973.

Table 10. *Estimated* number of fish caught by anglers at Lake Rathbun, 1972-75.

Species	1972	1973	1974	1975
Crappie[a]	11,562	117,347	211,615	334,759
Walleye	13,585	9,194	4,627	7,131
LM bass	16,113	12,871	7,305	4,128
C catfish	4,861	4,513	1,948	6,005
Bullhead	25,750	11,534	11,202	9,758
Carp	5,885	2,842	2,679	3,378
Bluegill & G sunfish	7,780	8,859	3,166	4,879
W bass	11	167	974	5,629
B buffalo	----	17	----	----
F catfish	23	----	----	----

[a]White and black crappie.

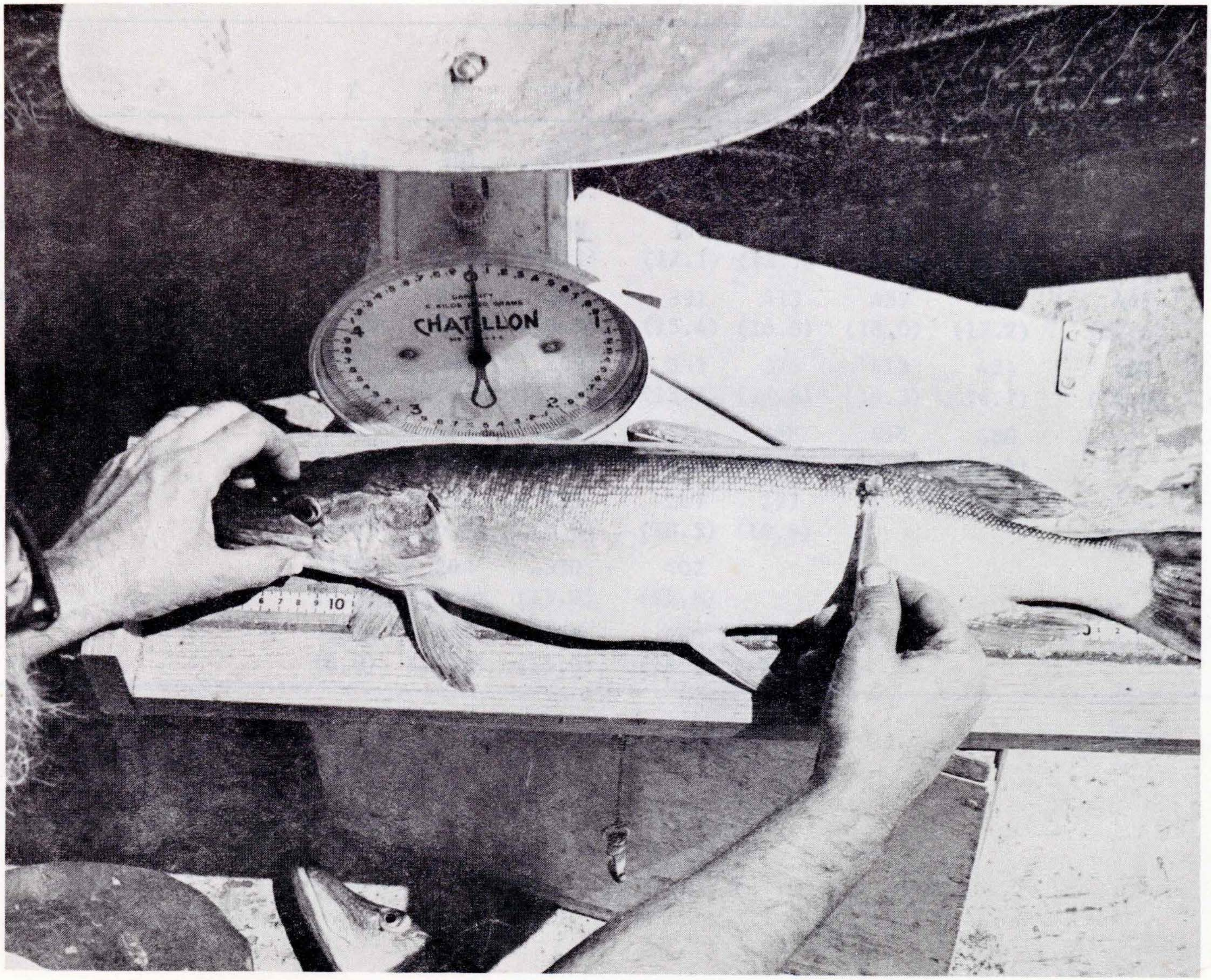

Plate 4. Scale samples were taken from northern pike and other fish species at Lake Red Rock.

Table 11. Grand average back calculated total lengths (mm) at each annulus, Lake Red Rock. (Length in inches is in parenthesis).

	Age								
	I	II	III	IV	V	VI	VII	VIII	IX
N pike	342 (13.5)	501 (19.7)	589 (23.2)	692 (27.3)					
R carpsucker	102 (4.0)	184 (7.3)	258 (10.1)	307 (12.1)	348 (13.7)	380 (15.0)	418 (16.5)		
B buffalo	182 (7.2)	270 (10.6)	342 (13.5)	391 (15.4)	413 (16.3)	457 (18.0)	436 (17.2)	447 (17.6)	
Carp	137 (5.4)	208 (8.2)	269 (10.6)	333 (13.1)	375 (14.8)	413 (16.3)	424 (16.7)	452 (17.8)	486 (19.1)
C catfish	81 (3.2)	160 (6.3)	231 (9.1)	311 (12.3)	388 (15.3)	450 (17.7)	480 (18.9)		
B crappie	107 (4.2)	174 (6.9)	225 (8.8)	267 (10.5)	277 (10.9)				
LM bass	135 (5.3)	263 (10.4)	330 (13.0)	402 (15.8)					
Walleye	152 (6.0)	285 (11.2)	380 (15.0)	460 (18.1)	496 (19.5)				

Table 12. Grand average of back-calculated total lengths (mm) at each annulus, Lake Rathbun. (Length in inches is in parenthesis).

	Age I	II	III	IV	V	VI	VII
R carpsucker	126 (5.0)	240 (9.4)	324 (12.7)	358 (14.1)	386 (15.2)	422 (16.6)	
B buffalo	203 (8.0)	316 (12.4)	386 (15.2)	432 (17.0)			
Carp	166 (6.5)	255 (10.0)	344 (13.5)	400 (15.8)	463 (18.2)	484 (19.0)	
C catfish	87 (3.4)	205 (8.1)	261 (10.3)	343 (13.5)	420 (16.5)	477 (18.8)	546 (21.5)
W crappie	100 (3.9)	170 (6.7)	227 (8.9)	280 (11.0)			
LM bass	152 (6.0)	239 (9.4)	317 (12.5)	372 (14.6)			
Walleye	213 (8.4)	282 (11.1)	374 (14.7)	437 (17.2)	487 (19.2)		

Table 13. Growth indices by calendar year, of common fish species at Lake Red Rock, 1969-74, and Lake Rathbun, 1970-74.

	Lake Red Rock						Lake Rathbun				
	1969	1970	1971	1972	1973	1974	1970	1971	1972	1973	1974
N pike	--	--	83	103	114	99					
R carpsucker	90	96	102	142	82	87	78	106	115	126	75
B buffalo	101	94	99	88	88	128	102	105	90	104	--
Carp	81	91	97	115	91	126	102	104	86	120	92
C catfish	88	102	108	98	127	81	114	142	85	75	84
W crappie							105	97	104	106	88
B crappie	164	96	80	84	89	87					
LM bass	--	142	95	84	105	72	140	101	79	90	91
Walleye	--	130	95	97	92	85	110	88	70	133	99

Growth of fish feeding primarily on invertebrate life generally improved from the onset of impoundment for two or three succeeding years and reached the best year for growth. The highest index value for channel catfish at Lake Rathbun was during the second year of impoundment, 142, while the second best value for channel catfish at Lake Red Rock was in the third year of impoundment, 108. As Lake Rathbun aged growth of river carpsucker continued to improve with index values rising from 78 to 126, until a decline was noted in the last year of this study, 75; carpsucker at Lake Red Rock showed a similar trend rising from 90 to 142 from 1969 to 1972. Index values for carp at Lakes Red Rock and Rathbun increased for the first two or three years of impoundment then reached a maximum, 81 to 115 and 102 to 104, respectively.

Accelerated growth was recorded for many species at Lake Rathbun during the 1973 season but was not the case of most fish in the community at Lake Red Rock. River carpsucker, bigmouth buffalo, carp, white crappie, largemouth bass, and walleye at Lake Rathbun had their best or one of their best growing seasons during the year of highest reservoir volume. At Lake Red Rock the year of highest storage volume marked a decline in growth for many fish including river carpsucker, bigmouth buffalo, carp, black crappie and walleye while best growth was shown for northern pike and channel catfish and increased growth was recorded for largemouth bass.

Apparently, even though the 1973 season was noted as having a similar impact at both reservoirs, floodwater management differed and consequently had a contrasting affect on trophic structure and food chains. High reservoir volume and shorter flushing rates at Lake Rathbun were conducive to improved production at all trophic levels whereas high reservoir volume and longer flushing rate at Lake Red Rock did not benefit biomass elaboration of most species, despite reduced densities. Gizzard shad, the primary prey species at either reservoir, was caught by seine net in 1973 in their greatest numbers at Lake Rathbun but at Lake Red Rock the lowest catch was recorded that year. Although a few species at Lake Red Rock seemed to be benefited by floodwater management of 1973 other factors may have had an overriding impact. For example most northern pike stocked that year were of a large postlarval size. Had these same fish been released at a smaller size or as prolarvae, dependent on zooplankton for initial food, growth would not have been as good.

Near normal pool elevations during 1972 appeared to have a depressing affect on linear growth of 5 of 7 species over the previous year at Lake Rathbun but did not make a dramatic impact at Lake Red Rock, only 3 of 8. Linear growth of bigmouth buffalo, carp, channel catfish, largemouth bass and walleye at Lake Rathbun decreased in 1972 compared to 1971 but that of river carpsucker and white crappie increased.

Opening of a commercial fishery at Lake Red Rock during the fall of 1973 had a positive impact on growth of several commercial species in 1974. Growth of young or older surviving carp and bigmouth buffalo accelerated after commercial exploitation of large and older individuals with index values increasing from 91 to 126 and 88 to 128, respectively. On the other hand, growth of the less popular commercial species, river carpsucker, improved only slightly in 1974 over the previous year as index values rose from 82 to 87.

Condition factors and weight-length relationships were computed annually for some species at each reservoir. Since both parameters were calculated from the same components only the former was used in a comparative manner using statistical procedures. Coefficients of weight-length relationships can be found in Appendix Table P.

Subjective inferences can be drawn from statistical comparisons of condition factors but sound conclusions cannot be made. This judgement is based on numerous reasons including the very nature of the variations in length and weight measurements, sampling bias, and seasonal differences in condition of fish in sample collections and their sizes. Although these facts are recognized there was no intention to collect data in a manner that would reduce any bias.

ANOVA testing indicated a general trend in lower condition factors for most species at both reservoirs during the last two seasons of this study in comparison to the first two (Tables 14 and 15). Comparisons of condition values showed river carpsucker at Lake Red Rock were higher in 1972 and 1973 than 1974 and 1975, testing of condition factors for other species at Lake Red Rock revealed black crappie were in higher condition in 1973 than 1975 and channel catfish were in better condition in 1972-74 than 1975. Carp and bigmouth buffalo had significantly higher condition values in 1973 than any other year. Other comparisons between years for other species at Lake Red Rock were not statistically different. At Lake Rathbun carp were in significantly better condition during 1972 and 1973 than 1974 or 1975 while white crappie were in better condition in 1973 and 1974 than 1975; 1974 also marked a year in which walleye condition values were higher than 1975; comparisons for other species showed no differences.

ACCOMPLISHMENTS, NEEDS, AND RECOMMENDATIONS

Dominant fish populations developed within three years after impoundment at both reservoirs. Predominant fish species at Lake Red Rock were crappie, carpsucker, bullhead, carp, bigmouth buffalo, gizzard shad, and at Lake Rathbun crappie, carp, bullhead, and gizzard shad were established by the initial year of this investigation. Establishment of dominant populations soon after impoundment of Lake Red Rock was also recognized by Mayhew (1972) in an earlier study.

Fish populations were similar in many criteria at both reservoirs but fish species suited to river type habitat developed more extensively at Lake Red Rock. Variations in year class success were most dramatic at Lake Red Rock. Carp were abundant at both reservoirs, populations of river carpsucker and bigmouth buffalo never developed to the same magnitude at Lake Rathbun. Variable reservoir elevations at Lake Red Rock during spring periods, were beneficial to the development of river fish species. Evidence of this phenomena was also reported in Lewis and Clark Lake, SD (Walburg and Nelson, 1966), Lake Francis Case, SD (Gasaway, 1970), Lake Oahe, and Lake Sharpe, SD (Elrod and Hassler, 1971). Benson (1973) indicated these species would not remain dominant after reservoir stability was reached. Lake Red Rock and Lake Rathbun may be extreme examples of this postulation. While carp, river carpsucker and bigmouth buffalo occur in Lake Rathbun young were never encountered in seine hauls and adults of the latter two made up a small portion of the total catch. In addition, adult fish were generally uniform in size indicating one or two dominant year classes

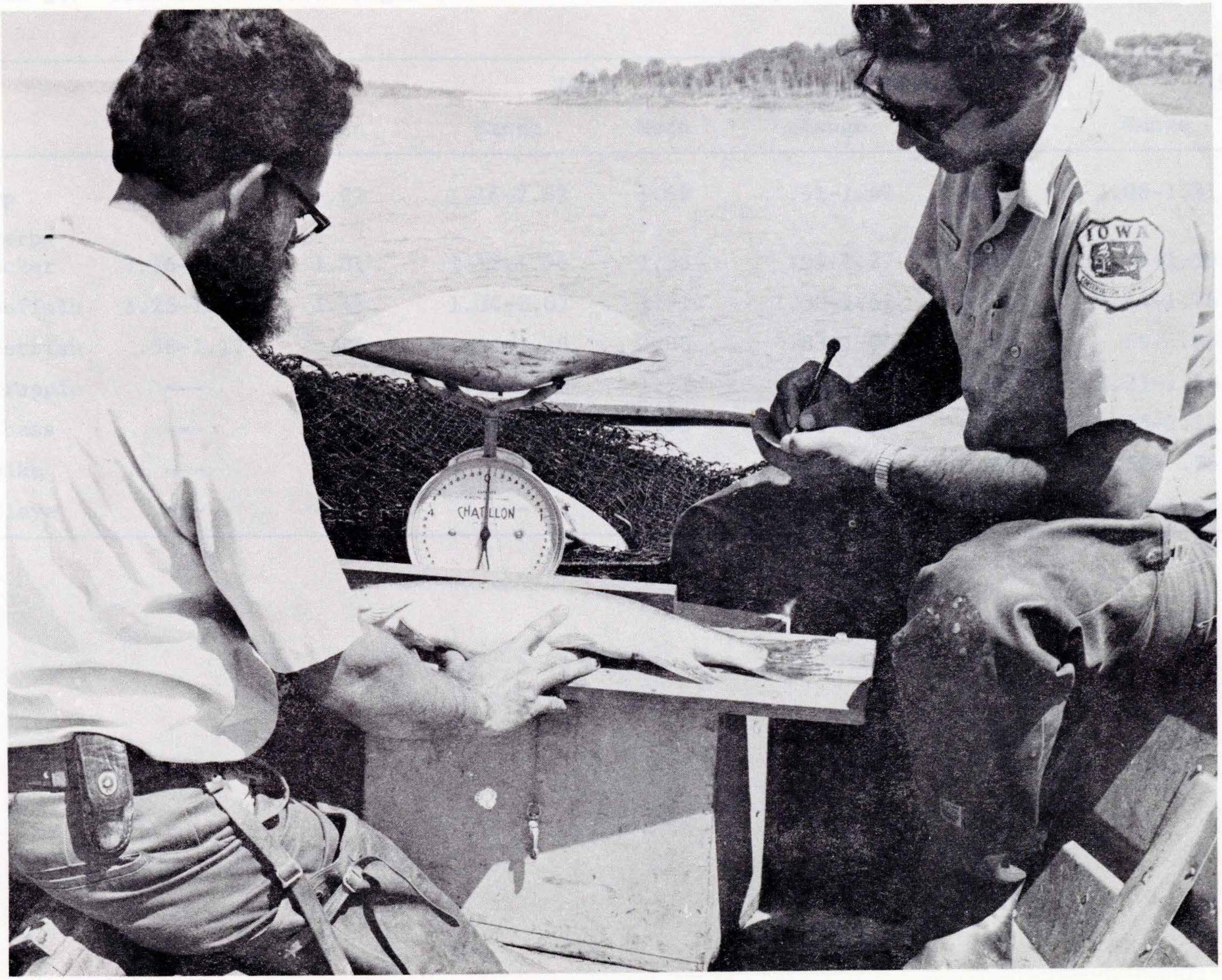

Plate 5. Length and weight measurements and scales were taken from many fish at Lake Red Rock and Lake Rathbun.

Table 14. Condition factor ranges and means for some fish species at Lake Red Rock, 1972-75.

	1972		1973		1974		1975	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Carp	1.09-1.51	1.22	1.16-2.62	1.60	.91-1.42	1.22	1.08-1.31	1.16
R carpsucker	1.16-1.56	1.31	1.17-1.76	1.35	.99-1.27	1.15	1.06-1.39	1.19
B buffalo	1.25-1.54	1.41	1.34-2.07	1.71	1.38-1.62	1.51	1.44-1.76	1.53
C catfish	.58-1.17	.86	.64-1.18	.86	.83-1.06	.85	.59- .86	.73
B crappie	---	----	1.15-2.10	1.71	1.24-1.97	1.60	1.21-1.78	1.51
LM bass	---	----	1.58-1.79	1.70	.86-1.95	1.61	.95-2.11	1.54
N pike	---	----	---	----	.56- .79	.65	.52- .75	.61
Walleye	---	----	---	----	.49-1.13	.92	.78-1.08	.97

Table 15. Condition factor ranges and means for some fish species at Lake Rathbun, 1972-75.

	1972		1973		1974		1975	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Carp	.97-1.36	1.22	.85-1.36	1.17	.94-1.17	1.11	.95-1.18	1.05
R carp-sucker	1.26-1.54	1.39	1.18-1.49	1.37	1.33-1.57	1.43	1.29-1.49	1.41
B buffalo	1.35-1.66	1.55	.84-1.62	1.42	1.30-1.55	1.48	---	----
C catfish	.77-1.28	.99	.83-1.33	.97	.76-1.34	.89	.59-1.15	.90
W crappie	1.04-2.31	1.33	1.23-2.00	1.40	1.15-1.79	1.45	1.00-1.16	1.10
LM bass	---	----	---	----	1.13-2.07	1.57	1.30-1.77	1.51
Walleye	.78-1.04	.87	.81-1.02	.89	.79-1.09	.91	.77- .94	.83

prevailed during initial years of impoundment. At Lake Red Rock young carp, buffalo, and carpsucker were frequently captured by seine, although there was considerable variability in the numerical catch.

Hatchery reared and stocked fish were instrumental in the establishment and maintenance of some fish populations at both reservoirs. Numerical abundance of northern pike, walleye, and largemouth bass did not increase at Lake Red Rock until after recruitment of hatchery reared fish. Dominant year classes of walleye, largemouth bass, and channel catfish at Lake Rathbun were due to early plantings. Initial stockings of all sport fish were very successful. However, despite additional stockings, peak population levels did not continue. Since systematic maintenance stockings of all the aforementioned species, except walleye, was not carried out the dependence on hatchery reared fish is evident. But it is unknown why walleye populations could not be maintained at a stable level despite additional stockings.

While some reservoir fish populations were dependent on stocking, continued annual releases of all species is impractical. Annual releases of walleye and northern pike at Lake Red Rock should be continued. Plantings of largemouth bass each year would be futile, except during periods of high reservoir elevations.

Annual stockings of walleye would also be beneficial at Lake Rathbun, but annual plantings of largemouth bass and channel catfish would not prove practical. Reasons for these recommendations will be discussed in further depth later in this narrative.

Survival of hatchery released fish remain unresolved because of contradictory results. Further investigation into the factors that influence hatchery reared fish survival, particularly walleye, is important. Such a study should examine the food chains, and include physical characteristics of the reservoir along with the size and density of the released fish.

Survival of hatchery released fish could be increased if the time of stocking and size of fish at release were considered. Plantings of fish should be made at periods of peak zooplankton abundance or at a size large enough to utilize available forage. Fish released at a large postlarval state would be less susceptible to predation and have a higher chance of survival.

The worth of continued fingerling stocking of striped bass must be examined in detail before this species becomes a productive part of the fishery. Striped bass have been stocked as fingerling since 1972. Seine hauls produced young quite commonly, but fish other than fingerling were never captured.

It is also difficult to assess the impact of stocking rate variations at either reservoir for reasons described earlier. Thus stocking rates of at least 2,500 larval walleye/ha (1,000 N/ac), 2,500 larval northern pike/ha (1,000 N/ac), and 250 postlarval largemouth bass/ha (100 N/ac) should be continued.

The paucity of habitat diversity in both reservoirs greatly depresses the development of naturally sustained fish populations and illustrates the need of continued stocking of some species. The predominant habitat of the littoral region are wind swept and unstable and embayments contain little cover. These conditions are unsuitable to spawning and rearing of any fish particularly species which release adhesive eggs. Habitat for channel catfish spawning is lacking in the pool, but the streams that flow into the reservoir offer adequate spawning habitat for catfish production. Unstable bottom substrate of the littoral zone and the lack of protective cover is not conducive to Centrarchid reproduction.

Assessment of reservoir fish populations should be carried out with at least two types of gear, trap or pound nets and experimental gill net, to reduce bias of gear selectivity. Experimental gill nets were more effective for the capture of channel catfish, gizzard shad, northern pike and walleye while pound nets tended to catch more fish per effort and were selective for crappie, carp, bigmouth buffalo, river carpsucker, bullhead and largemouth bass.

Fish management in reservoirs is ineffective and generally unproductive without assessment of the fish populations. McWilliams and Mitzner (1974) outlined strategies for the assessment of fish populations in natural and man-made lakes using various types of gear and calculation of sample size with various levels of precision and accuracy. In several aspects findings of this investigation conformed to theirs. Variability in catch effort between annual samples was related to year class abundance, behavioral patterns of some species; crappie, carp, and channel catfish, caused variability in catch success between sampling intervals (Mayhew, 1972b), and the species composition and catch success between sampling sites were similar, the latter fact was due to the uniformity of reservoir habitat.

Fluctuations in relative abundance of fish populations could be determined by use of catch means from several years of data and establishing confidence intervals. Determinations could be computed using the standard procedure such as that found in Snedecor and Cochran (1967). However, these procedures do not compensate for the dilution affect of high reservoir elevations like those experienced at Lake Red Rock. Increases or decreases in relative abundance could be determined in a fluctuating reservoir by subjectively ranking reservoir elevation and computing the resultant regression of catch success on elevation. Nonsignificant results could be handled by the normal method. Significant correlations could be dealt with by assigning confidence intervals to the regression line. Future catches could be compared by assigning a rank to the mean reservoir elevation for that season and positioning the catch on a graph of the regression line and confidence intervals. Points (catch mean) within confidence intervals indicate no significant changes in population abundance while catches outside signify significant decreases or increases in abundance.

Best growth for most species at each reservoir was attained during the first two or three years of impoundment. Predators, largemouth bass, crappie, and walleye, achieved superior growth immediately after reservoir filling or in their first year of release. Growth of fish at lower trophic levels, carp, bigmouth buffalo, river carpsucker and channel catfish, attained good growth at reservoir conception, generally improved growth into the second or third year then a decline. Growth of fish prior to impoundment of Lake Rathbun was not documented but Wunder (1969) and Mayhew (1972b) documented growth of carp, river carpsucker, bigmouth buffalo and channel catfish at initial impoundment. Most of their growth calculations pertained to pre-impoundment years. Mayhew and Wunder found all of the aforementioned species attained improved linear growth after the Des Moines River environment was changed from lontic to a lentic system. Improved growth immediately following reservoir filling can be explained by the fact a large ecological void was opened. Growth in subsequent years, after niches were filled, was not as dramatic.

Growth did not reach a stable state at either reservoir but was influenced more by physical and chemical variables during later years. Storage of a large volume of water in 1973 accelerated the growth of most fish at Lake Rathbun over previous years but a similar condition at Lake Red Rock did not increase many growth rates. One explanation for the differences could be the fact a large portion of Lake Red Rock is steep sloped shoreline whereas the shoreline of Lake Rathbun has a more gentle gradient. Thus, at Lake Red Rock increases in elevation do not increase the surface area or the littoral zone proportional to the changes at Lake Rathbun. Inundation of shorelines at Lake Rathbun by increased water storage opened new areas to productivity. Nelson (1974) noted that growth of all species at Lake Oahe had declined since earlier years of impoundment. During the early years elevation increases covered flat terrain but during subsequent years inundation was only slight because of steep sloped banks. Nelson also calculated multiple regression analysis of growth index like the index used in this study and three physical variables; surface area, average depth, and water level fluctuation on percentage deviation. The coefficient of the multiple determination indicated over 50% of the variation in annual growth of eight species was explained by these variables, average depth was most important and water level fluctuation was least.

Authorization of a commercial fishery at Lake Red Rock in the fall of 1973 was well founded. The resource yielded nearly a million kg of fish (2 million lbs) in two seasons that would have otherwise gone unharvested. However, carpsucker were not represented in the commercial catch with the same magnitude they were in the net catch of this investigation and Mayhew's (1972b). The absence of river carpsucker in the commercial fishery cannot be due to gear selectivity since Mayhew (1972b) used gear similar to that used by commercial fishermen and his catch of carpsucker was well represented. Misidentification of carpsucker as carp could be one source explaining the absence but the main problem is probably the low market value. If a profitable commerical market were to be developed for carpsucker the resource of Lake Red Rock and other reservoirs could be further exploited.

A water level increase of 3.3 m (10 ft) at Lake Red Rock would greatly enhance production of fish populations. An Environmental Impact Statement was prepared for the U.S. Army Corps of Engineers in August of 1975 (Anonymous, 1976b). The document presented an assessment of the operation and maintenance of Red Rock Dam and Lake Red Rock. Basically, some of the adverse environmental impacts included; periodic inundation of terrestrial habitat between conservation pool and flood pool; an estimate of 5.4 million CM (4,400 ac ft) of sediment deposition in the upper reaches of the lake; and resultant unstable aquatic environment. Nine alternatives to the present operational procedures were offered, which included; raising conservation pool by 1 m (3 ft), 1.6 m (5 ft), 2.2 m (7 ft), and 3.3 m (10 ft). From a fishery resource standpoint an increase in conservation pool elevation of 3.3 m (10 ft) would be the best alternative. Chronic siltation will always be a problem at this reservoir until stringent land management regulations are administered, but an increase in reservoir elevation would permanently inundate more habitat, increase the lake surface area and volume, particularly upstream from the main pool area. Thus, deposition of silt would be confined more to the upper reaches, resulting in a less turbid main pool. Reduced turbidity would enhance primary production and higher production at other trophic levels. Greater reservoir volume would reduce flushing rate and increase survival of larval fish. In addition an increase in littoral habitat would be beneficial to the development of Centrarchid populations.

Shoreline instability is a chronic problem at both reservoirs and it is Lake Rathbun's most critical. The seriousness of shoreline degradation was most apparent during field investigations, although a demonstration of the impact of shoreline instability was not designed into this study. Degradation was visible in several forms. Wave action and sheet runoff on unprotected shorelines created excessive turbidity, thus reducing primary production. Sloughing of shoreline material compounded the predicament by silting in small embayments, important to fish reproduction and cover, and a benching effect was created with associated water level drawdowns. The outcome of benching was vast expanses of shallow, instable, and turbid water.

Reservoir operations can have a less dramatic impact on fish populations if elevations were stabilized during critical spawning periods. This problem was particularly apparent at Lake Red Rock. Spring floodwaters were usually stored during April, May, or June while peak discharge rates were in May and June. Discharge of stored floodwater during these months left prime spawning habitat desiccated. If discharge of stored water, at elevations above conservation pool, were delayed until July and August reproductive success of shore spawning fish would be more consistent.

Intensive fisheries management of flood control reservoirs is restricted because of the unpredicatability of reservoir conditions. However, the resource can be more fully utilized. Development of sport fisheries can be accomplished by stockings of species suited to a reservoir environment and continued maintenance releases to stocks with limited natural spawning; e.g., walleye, and northern pike. Releases of white bass could be limited to a single adult plant and stockings of largemouth bass in established flood control reservoirs should be confined to years of unusually high water elevations. Protection of micro-habitat (small embayments) from bank erosion, wind action and runoff is essential to successful management in new or proposed reservoirs. Stability of small embayments has been shown to be the precedent to year class success of many species, particularly Centrarchids spawning near shore. Enhancement of reservoir habitat by creating diversity with rip-rap, stake beds, brush attractors and other physical structures would serve to provide cover for 0-age fish and attract adult fish for the angler harvest. During this investigation test netting showed most of the fish biomass was comprised of commercial species. In such cases, commercial fisheries should be encouraged if it does not conflict with other uses.

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APPENDIX

Table A . Average estimated total length (mm) for carp at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII	VIII	IX
1974									
1973	122 (19)	212 (13)							
1972	84 (30)	186 (28)	252 (19)						
1971	101 (46)	186 (40)	263 (26)	362 (5)					
1970	115 (34)	196 (34)	284 (20)	355 (13)	429 (2)				
1969	142 (30)	225 (30)	310 (30)	375 (18)	394 (4)	442 (4)			
1968	134 (11)	200 (11)	255 (11)	313 (11)	364 (6)	389 (2)	433 (2)		
1967	157 (4)	207 (4)	263 (4)	318 (4)	376 (4)	470 (1)			
1966	166 (7)	228 (7)	281 (7)	330 (7)	369 (7)	410 (7)			
1965	190 (3)	236 (3)	276 (3)	318 (3)	359 (3)	394 (3)	417 (3)		
1964	141 (2)	199 (2)	240 (2)	300 (2)	347 (2)	385 (2)	416 (2)	444 (2)	
1963	153 (3)	216 (3)	268 (3)	324 (3)	363 (3)	403 (3)	431 (3)	460 (3)	486 (3)
Grand Average	137 (189)	208 (175)	269 (125)	333 (66)	375 (31)	413 (22)	424 (10)	452 (5)	486 (3)

Table B . Average estimated total length (mm) for bigmouth buffalo at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII	VIII
1974								
1973	144 (40)	231 (30)						
1972	146 (21)	265 (16)	331 (7)					
1971	186 (21)	270 (18)	340 (16)	424 (6)				
1970	198 (40)	275 (40)	339 (23)	381 (12)	416 (6)			
1969	220 (40)	296 (40)	368 (40)	402 (14)	414 (6)	505 (2)		
1968	201 (8)	268 (8)	322 (8)	372 (8)	394 (5)	446 (4)		
1967	234 (6)	305 (6)	359 (6)	402 (6)	451 (6)	464 (3)	442 (2)	
1966	127 (1)	246 (1)	337 (1)	364 (1)	389 (1)	413 (1)	430 (1)	447 (1)
Grand Average	182 (177)	270 (159)	342 (101)	391 (47)	413 (24)	457 (10)	436 (3)	447 (1)

Table C . Average estimated total length (mm) for channel catfish at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII
1974							
1973	114 (10)	206 (10)					
1972	104 (11)	202 (11)	278 (10)				
1971	72 (30)	163 (30)	280 (21)	325 (13)			
1970	63 (61)	159 (61)	239 (61)	339 (34)	369 (8)		
1969	64 (25)	166 (25)	258 (25)	337 (25)	416 (11)	436 (3)	
1968	72 (8)	155 (8)	232 (8)	327 (8)	389 (8)	466 (1)	504 (1)
1967	80 (1)	116 (2)	168 (2)	306 (2)	389 (2)	438 (2)	438 (1)
1966	81 (4)	110 (4)	162 (4)	231 (4)	378 (4)	458 (4)	499 (4)
Grand Average	81 (150)	160 (151)	231 (131)	311 (86)	388 (33)	450 (10)	480 (6)

Table D . Average estimated total length (mm) for river carpsucker at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII
1974	100 (1)						
1973	101 (9)	198 (9)					
1972	114 (27)	206 (26)	284 (24)				
1971	92 (51)	197 (48)	288 (36)	327 (12)			
1970	98 (36)	191 (36)	285 (27)	337 (15)	363 (2)		
1969	102 (24)	176 (24)	244 (24)	324 (15)	361 (6)		
1968	119 (21)	192 (21)	258 (21)	308 (21)	381 (9)	397 (2)	
1967	106 (19)	174 (19)	238 (19)	293 (19)	335 (19)	392 (6)	402 (3)
1966	86 (4)	138 (4)	206 (4)	253 (4)	300 (4)	351 (4)	434 (1)
Grand Average	102 (192)	184 (187)	258 (155)	307 (86)	348 (40)	380 (12)	418 (4)

Table E . Average estimated total length (mm) at each annulus for walleye at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	I	II	Age III	IV	V
1974	92 (1)				
1973	139 (3)	266 (2)			
1972	176 (54)	295 (54)	373 (32)		
1971	146 (29)	246 (29)	339 (29)	420 (12)	
1970	206 (3)	334 (3)	429 (3)	499 (3)	496 (2)
Grand Average	152 (90)	285 (88)	380 (64)	460 (15)	496 (2)

Table F . Average estimated total length (mm) at each annulus for black crappie at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V
1974	49 (1)				
1973	86 (18)	145 (7)			
1972	95 (53)	154 (44)	206 (35)		
1971	102 (35)	166 (35)	213 (23)	255 (2)	
1970	121 (15)	180 (15)	234 (15)	287 (6)	
1969	161 (4)	215 (4)	244 (4)	274 (4)	
1968	135 (2)	181 (2)	229 (2)	250 (2)	277 (2)
Grand Average	107 (128)	174 (107)	225 (79)	267 (14)	277 (2)

Table G . Average estimated total length (mm) for northern pike at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV
1974	345 (4)			
1973	384 (46)	568 (25)		
1972	365 (42)	511 (42)	596 (15)	
1971	274 (3)	425 (3)	582 (3)	692 (3)
Grand Average	342 (95)	501 (70)	589 (18)	692 (3)

Table H . Average estimated total length (mm) at each annulus for largemouth bass at Lake Red Rock, 1972-75. Sample size is subtended.

Year class	Age I	Age II	Age III	Age IV
1974	53 (1)			
1973	117 (21)	231 (20)		
1972	134 (52)	264 (52)	319 (15)	
1971	170 (11)	268 (11)	336 (11)	389 (3)
1970	202 (1)	287 (1)	335 (1)	414 (1)
Grand Average	135 (86)	263 (84)	330 (27)	402 (4)

Table I. Average estimated total length (mm) at each annulus for channel catfish at Lake Rathbun, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI	VII
1974							
1973	94 (1)	203 (1)					
1972	94 (3)	243 (3)	321 (3)				
1971	120 (24)	254 (24)	288 (2)	322 (1)			
1970	100 (140)	218 (140)	287 (119)	335 (87)	375 (39)		
1969	67 (20)	172 (20)	312 (20)	368 (6)	400 (5)	438 (5)	
1968	45 (1)	138 (12)	278 (12)	407 (12)	471 (1)	516 (1)	546 (1)
1967	87 (1)	204 (1)	261 (1)	281 (1)	433 (1)		
Grand Average	87 (189)	205 (200)	261 (157)	343 (107)	420 (46)	477 (6)	546 (1)

Table J . Average estimated total length (mm) at each annulus for carp at Lake Rathbun, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI
1974	176 (8)					
1973	179 (48)	266 (32)				
1972	183 (28)	287 (21)	380 (6)			
1971	171 (45)	268 (31)	380 (17)	431 (6)		
1970	158 (45)	255 (45)	341 (14)	442 (6)	543 (1)	
1969	162 (21)	253 (21)	351 (21)	372 (5)	457 (1)	484 (1)
1968	115 (8)	206 (8)	290 (8)	366 (8)	413 (5)	
1967	186 (8)	252 (8)	321 (8)	390 (8)	439 (8)	
Grand Average	166 (211)	255 (166)	344 (74)	400 (33)	463 (15)	484 (1)

Table K . Average estimated total length (mm) at each annulus for river carpsucker at Lake Rathbun, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V	VI
1973	162 (6)	281 (6)				
1972	138 (20)	291 (20)	356 (9)			
1971	131 (35)	255 (35)	372 (35)	393 (11)		
1970	97 (26)	212 (26)	350 (12)	400 (12)	399 (2)	
1969	118 (19)	218 (19)	295 (19)	334 (2)	372 (2)	422 (1)
1968	108 (2)	182 (2)	246 (2)	303 (2)		
Grand Average	126 (108)	240 (108)	324 (77)	358 (27)	386 (4)	422 (1)

Table L . Average estimated total length (mm) at each annulus for walleye at Lake Rathbun, 1972-75. Sample size is subtended.

Year class	Age I	II	III	IV	V
1974	183 (12)				
1973	192 (2)	359 (2)			
1972	221 (31)	356 (31)	411 (13)		
1971	237 (36)	299 (23)	390 (16)	431 (5)	
1970	231 (93)	296 (93)	320 (57)	443 (40)	487 (19)
Grand Average	213 (174)	282 (149)	374 (86)	437 (45)	487 (19)

Table M . Average estimated total length (mm) at each annulus for largemouth bass at Lake Rathbun, 1972-75. Sample size is subtended.

Year class	Age I	Age II	Age III	Age IV
1974	154 (3)			
1973	117 (3)	207 (3)		
1972	122 (12)	208 (12)	276 (10)	
1971	144 (20)	212 (20)	278 (20)	308 (9)
1970	224 (4)	330 (4)	398 (4)	437 (4)
Grand Average	152 (42)	239 (39)	317 (34)	372 (13)

Table N . Average estimated total length (mm) at each annulus for white crappie at Lake Rathbun, 1972-75. Sample size is subtended.

Year class	Age I	Age II	Age III	Age IV
1974	75 (8)			
1973	73 (11)	138 (10)		
1972	91 (55)	180 (54)	228 (31)	
1971	106 (52)	173 (44)	229 (31)	252 (14)
1970	115 (30)	175 (30)	228 (20)	281 (8)
1969	116 (12)	177 (12)	222 (12)	315 (1)
1968	122 (4)	174 (4)	226 (4)	270 (4)
Grand Average	100 (172)	170 (154)	227 (98)	280 (27)

Table 0 . Average estimated total length (mm) at each annulus for bigmouth buffalo at Lake Rathbun, 1972-75. Sample size is subtended.

Year class	Age I	Age II	Age III	Age IV
1973	210 (3)			
1972	199 (30)	318 (30)		
1971	195 (28)	291 (10)	368 (10)	
1970	207 (25)	339 (25)	403 (3)	432 (3)
Grand Average	203 (86)	316 (65)	386 (13)	432 (3)

Table P . Coefficients for intercept and slope of weight-length relationships of some species at Lakes Red Rock and Rathbun, 1972-75.

Species	1972				1973				1974				1975			
	a	SD a	b	SD b	a	SD a	b	SD b	a	SD a	b	SD b	a	SD a	b	SD b
Lake Red Rock																
N pike	-----	---	----	---	-----	---	----	---	-5.62	.30	3.16	.11	-6.14	.34	3.33	.12
R carpsucker	-4.82	.19	2.98	.07	-3.83	.27	2.58	.17	-3.58	.31	2.47	.12	-5.05	.14	3.06	.06
B buffalo	-4.97	.19	3.05	.07	-5.35	.22	3.22	.08	-4.89	.19	3.03	.07	-5.14	.14	3.13	.05
Carp	-4.52	.09	2.85	.04	-3.53	.30	2.48	.12	-5.19	.22	3.11	.09	-3.51	.49	2.42	.20
C catfish	-5.71	.22	3.24	.09	-6.53	.34	3.58	.14	-4.96	.31	2.95	.12	-5.94	.16	3.31	.06
B crappie	-----	---	----	---	-4.99	.44	3.08	.19	-6.42	.39	3.69	.17	-5.80	.27	3.41	.12
LM bass	-----	---	----	---	-----	---	----	---	-4.32	.33	2.81	.13	-4.76	.30	2.98	.12
Walleye	-----	---	----	---	-----	---	----	---	-4.23	.46	2.69	.18	-5.91	.24	3.55	.09
Lake Rathbun																
R carpsucker	-5.24	.20	3.15	.49	-----	---	----	---	-4.75	.46	2.96	.18	-5.10	.35	3.10	.13
B buffalo	-4.33	.48	2.81	.19	-----	---	----	---	-2.30	.85	5.74	.33	-----	---	----	---
Carp	-4.56	.14	2.86	.06	-4.30	.32	2.75	.13	-3.25	.42	2.32	.17	-4.47	.16	2.80	.06
C catfish	-4.91	.32	2.96	.13	-5.32	.20	3.11	.08	-3.95	.33	2.56	.13	-5.38	.36	3.12	.14
W crappie	-6.16	.44	3.52	.19	-4.92	.74	3.02	.31	-4.99	.41	3.05	.17	-5.21	.12	3.11	.05
LM bass	-----	---	----	---	-----	---	----	---	-6.63	---	3.71	---	-5.38	.38	3.22	.15
Walleye	-5.60	.28	3.20	.11	-5.07	.45	3.01	.17	-6.64	.47	3.60	.18	-5.23	.11	3.06	.04